B-Line

November 2016

Brookvale to Seaforth B-Line Road Infrastructure

Review of Environmental Factors

Transport Roads & Maritime Services

NSW GOVERNMENT

NSW MAKING IT HAPPEN

Contents

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Tables

Abbreviations

Term	Meaning
AHIMS	Aboriginal Heritage Information Management System
ARI	Average Recurrence Interval
BS 7385	British Standard 7385 Evaluation and measurement for vibration in buildings
CBD	Central Business District
CCTV	Closed Circuit TV
CEMP	Construction Environmental Management Plan
CLM Act	*Contaminated Land Management Act 1997*
CNS	Construction Noise Strategy
CNVMP	Construction Noise and Vibration Management Plan
CPTED	Crime Prevention Through Environmental Design
DBH	Diameter Breast Height
DDA	*Disability Discrimination Act 1992* (Commonwealth)
DECCW	The former NSW Department of Climate Change and Water
DoE	Commonwealth Department of the Environment
DoS	Degree of Saturation
DP&E	NSW Department of Planning and Environment
DSAPT	*Disability Standards for Accessible Public Transport (2002)*
ECM	Environmental Controls Map
EMS	Environmental Management System
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EPI	Environmental Planning Instrument
EPL	Environment Protection Licence

Term	Meaning
ESD	Ecologically Sustainable Development (refer to Definitions)
FM Act	*Fisheries Management Act 1994*
Heritage Act	*Heritage Act 1977*
ICNG	*Interim Construction Noise Guideline* (Department of Environment and Climate Change, 2009).
Infrastructure SEPP	*State Environmental Planning Policy (Infrastructure) 2007*
kN	kilo Newtons
kg	kilograms
LEP	Local Environmental Plan
LGA	Local Government Area
LoS	Level of Service
mm	millimetres
m	metres
NES	National Environmental Significance
Noxious Weeds Act	*Noxious Weeds Act 1993*
NPW Act	*National Parks and Wildlife Act 1974*
NSW	New South Wales
OEH	NSW Office of the Environment and Heritage
POEO Act	*Protection of the Environment Operations Act 1997*
RBL	Rating Background Level
REF	Review of Environmental Factors (this document)
Roads Act	*Roads Act 1993*
Roads and Maritime	NSW Roads and Maritime Services (formerly Roads and Traffic Authority)
RNP	*Road Noise Policy* (DECCW, 2011)
SEPP	State Environmental Planning Policy
SHOROC	Shore Regional Organisation of Councils
SHR	State Heritage Register
t	tonnes
TfNSW	Transport for NSW

Term	Meaning
TMC	TfNSW Traffic Management Centre
TMP	Traffic Management Plan
TPZ	Tree Protection Zone
TSC Act	*Threatened Species Conservation Act 1995*
UDLP	Urban Design and Landscaping Plan
WARR Act	*Waste Avoidance and Resource Recovery Act 2001*

Definitions

Term	Meaning
Average Recurrence Interval	The likelihood of occurrence, expressed in terms of the long-term average number of years, between flood events as large as or larger than the design flood event. For example, floods with a discharge as large as or larger than the 100-year ARI flood will occur on average once every 100-years.
Bus bay/bus indent	A designated spot on the side of a road where buses may pull out of the flow of traffic to pick up and drop off passengers. The aim of the bus bay/indent is to avoid blocking traffic while the bus is stopped. Under the NSW *Road Rules 2014* drivers in the left lane within built up areas must give way to buses indicating an intention to depart a bus bay/indent.
Concept Design	The Concept Design is the preliminary design presented in the REF, which would be refined by the Contractor (should the Proposal proceed) to a design suitable for construction (subject to TfNSW and/or Roads and Maritime acceptance).
Disability Standards for Accessible Public Transport	The Commonwealth *Disability Standards for Accessible Public Transport 2002* ("Transport Standards") (as amended) are a set of legally enforceable standards, authorised under the Commonwealth *Disability Discrimination Act 1992* (DDA) for the purpose of removing discrimination 'as far as possible' against people with disabilities. The Transport Standards cover premises, infrastructure and conveyances, and apply to public transport operators and premises providers.
Ecologically Sustainable Development	As defined by clause 7(4) Schedule 2 of the EP&A Regulation. Development that uses, conserves and enhances the resources of the community so that ecological processes on which life depends are maintained, and the total quality of life, now and in the future, can be increased.
Feasible	A work practice or abatement measure is feasible if it 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.
Noise sensitive receiver	In addition to residential dwellings, noise sensitive receivers include, but are not limited to, hotels, entertainment venues, pre-schools and day care facilities, educational institutions (e.g. schools, TAFE colleges), health care facilities (e.g. nursing homes, hospitals), recording studios and places of worship/religious facilities (e.g. churches).
Proponent	A person or body proposing to carry out an activity under Part 5 of the EP&A Act - in this instance, Roads and Maritime Services.
Reasonable	Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.
Sensitive receivers	Land uses which are sensitive to potential noise, air and visual impacts, such as residential dwellings, schools and hospitals.

Term	Meaning
The Proposal	The construction and operation of the Manly Vale Commuter Car Park, new northbound and southbound B-Line bus stops and supporting infrastructure. Road works, including road works to reduce traffic congestion and facilitate commuter car park access. Bus operations are not considered as part of the Proposal.

Executive summary

Overview

The NSW Government is proposing to deliver transport improvements for the Northern Beaches, including an integrated program of service and infrastructure improvements to support a new B-Line bus service. The B-Line Program of works includes:

- roadworks including new bus lanes, bus bays, minor lane widening and other road improvements to support bus services
- nine B-Line stops at Mona Vale, Warriewood, Narrabeen, Collaroy, Dee Why, Brookvale, Manly Vale, Spit Junction (Mosman) and Neutral Bay including real-time passenger information and improved facilities for customers
- new commuter car parks at Mona Vale, Warriewood, Narrabeen, Dee Why, Brookvale and Manly Vale providing around 900 spaces, as well as bicycle parking, to encourage customers to park and ride
- transport interchange works to ensure integrated pedestrian and bicycle links to commuter car parks and B-Line stops
- modifications to the bus network to provide for a turn-up-and-go B-Line service with an average five minute wait for the bus during peak periods
- a new B-Line double decker bus fleet for improved on-board capacity and comfort.

Roads and Maritime Services (Roads and Maritime) is the government agency responsible for the roadworks necessary to support the B-Line Program and is the proponent for the B-Line roadworks from Brookvale to Seaforth (the Proposal).

The Proposal is part of the B-Line Program – a NSW Government initiative to provide a more frequent and reliable bus service between the Northern Beaches and Sydney's Central Business District (CBD). The program includes on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network. The on-road and off-road elements would be delivered as a number of individual projects, primarily by Roads and Maritime and Transport for NSW (TfNSW).

The new B-Line service is expected to be operational in late 2017.

This Review of Environmental Factors (REF) has been prepared to assess the environmental impacts associated with the construction and operation of the Proposal under the provisions of Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Description of the Proposal

The key features of the Proposal are:

- construction of a new left turn lane from Pittwater Road (northbound) into Cross Street
- closure of the median strip within Pittwater Road at the Orchard Road intersection to prevent vehicles from turning right from Pittwater Road into Orchard Road (eastbound) and vehicles turning right from Orchard Road into Pittwater Road (northbound)
- extension of the existing right turn lane from Burnt Bridge Creek Deviation into Sydney Road (westbound)

- construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound)
- extension of the existing through traffic lane from Sydney Road (east) into Sydney Road (west)
- extension of the existing right turn lane from Manly Road into Sydney Road (eastbound) and widening of the left turn slip lane into Sydney Road (westbound)
- full closure of Heaton Avenue at Manly Road to form a cul-de-sac
- construction of a new indented bus bay on Manly Road (southbound) at the Heaton Avenue intersection
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, retaining wall (at Heaton Avenue), upgrades to fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

Subject to approval, construction for the roadworks between Brookvale and Seaforth is expected to commence in early 2017 and take around nine months to complete. A detailed description of the Proposal is provided in Chapter 3 of this REF.

Need for the Proposal

Improving transport customer experience is a key focus of NSW Government transport initiatives. The B-Line Program has been identified as a key infrastructure project under the 'Building Infrastructure' priority in *NSW: Making it Happen* to be delivered in 2016–2019.

The B-Line Program aims to address the current issues facing Northern Beaches bus customers by providing a more frequent and reliable bus service between Mona Vale and the Sydney CBD.

The Proposal is integral to the delivery of the new B-Line Program, which is included in the NSW Government's Northern Beaches Transport Action Plan. The Transport Action Plan, along with other government initiatives and strategies, aims to support forecasted growth in the Northern Beaches region by improving the transport network across the region.

The specific objectives of the Proposal are to:

- reduce peak and off-peak bus journey times between Brookvale and Seaforth
- improve customer experience with improved frequency, capacity and reliability of bus services
- improve road safety along Pittwater Road, Condamine Street, Burnt Bridge Creek Deviation, Manly Road (the A8 corridor between Brookvale and Seaforth).

Design options considered

Options for improving bus transport on the Northern Beaches were developed during the early planning stages and development of the concept design for the Proposal. Two options were developed including a do nothing option whereby no action would be taken and a preferred option to upgrade the on-road infrastructure along A8 corridor between Brookvale and Seaforth.

The ‘do nothing’ option was not considered a feasible alternative as would not meet the objectives of the Proposal and would therefore be it is inconsistent with NSW Government objectives to provide a more frequent and more reliable bus service through the region.

The preferred option to upgrade road infrastructure along the A8 corridor between Brookvale and Seaforth was selected as part of a design refinement process developed through a series of meetings, field inspections, workshops, and technical specialist input (such as traffic and noise), in consultation with internal and external stakeholders. This option was selected as it met the required design objectives with minimum disruption to existing roads, general traffic and other urban development.

Statutory considerations

The EP&A Act provides for the environmental impact assessment of development in NSW. Part 5 of the EP&A Act generally specifies the environmental impact assessment requirements for activities undertaken by public authorities, such as Roads and Maritime, which do not require development consent under the Act.

State Environmental Planning Policy (Infrastructure) 2007 (the Infrastructure SEPP) is the primary environmental planning instrument relevant to the Proposal.

Clause 94(1) of the Infrastructure SEPP allows for the development of ‘road infrastructure facilities’ by or on behalf of a public authority without consent on any land. Clause 93 defines ‘road infrastructure facilities’ as including elements such as ‘bus lanes, transit lanes, rest areas and road related areas’, ‘associated public transport facilities for roads used to convey passengers by means of regular bus services’ and ‘bus layovers that are integrated or associated with roads’.

As Roads and Maritime is a public authority and the proposed activity falls within the definition of road infrastructure facilities under the Infrastructure SEPP, the Proposal is permissible without consent. Consequently the environmental impacts of the Proposal have been assessed by Roads and Maritime under Part 5 of the EP&A Act.

This REF has been prepared to assess the environmental impacts of the Proposal during construction and operation. The REF has been prepared in accordance with clause 228 of the *Environment Planning and Assessment Regulation 2000* (the EP&A Regulation).

In accordance with Section 111 of the EP&A Act, Roads and Maritime, as the proponent and determining authority, must examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity.

Chapter 5.1.2 of this REF presents the environmental impact assessment for the Proposal, in accordance with these requirements.

Community and stakeholder consultation

Under the Infrastructure SEPP, consultation is required with local councils or public authorities in certain circumstances, including where Council-managed infrastructure is affected.

Consultation has been undertaken with Northern Beaches Council and emergency services during the development of design options for the broader B-Line Program. Consultation with these stakeholders would continue through the detailed design and construction of the Proposal.

The following activities are also proposed to facilitate consultation regarding the Proposal:

- direct notification of affected community stakeholders
- three community information sessions

- shopping centre displays and drop in sessions
- advertisements in the Manly Daily
- letterbox drops
- public display of the REF at various locations
- REF to be made available on the B-Line website
- project infoline: 1800 048 751 and projects@transport.nsw.gov.au

Community consultation activities for the Proposal would be undertaken during the public display period of this REF. The REF would be displayed for a period of four weeks. Further information about these specific activities is included in Section 5 of this REF.

During this period, the REF would also be available for viewing at the following locations:

- Northern Beaches Council office - 1 Belgrave St, Manly
- Northern Beaches Council office - 725 Pittwater Road, Dee Why
- Dee Why Library – 725 Pittwater Road, Dee Why
- Manly Library – Market Place, Manly
- Balgowlah Seaforth Community Library, corner of Frenchs Forest and Sydney Roads, Seaforth

The REF would also be available to download from the B-Line Program website[1]. Members of the public can make enquiries via phone (1800 048 751) or email (projects@transport.nsw.gov.au).

At the conclusion of the public display period for the REF, Roads and Maritime Services will acknowledge receipt of feedback from each respondent. Roads and Maritime will review all feedback received during the public display period, prior to determining whether or not to proceed with, or modify, the Proposal.

A Submissions Report will be prepared summarising the key impacts identified in the REF, demonstrating how Roads and Maritime Services considered issues raised during the public display period, and include a summary of mitigation measures proposed to minimise the impacts of the Proposal. The Submissions Report will be made available on the B-Line website and everyone who made a submission will be individually notified of the outcome

Should the Proposal proceed to construction, the community would be kept informed throughout the duration of the construction period. This would include targeted consultation activities such as door knocks, meetings, newsletters, notifications, advertising, signage and verbal communications would continue during the construction phase. The B-Line website would include frequent updates and the project infoline and email address would continue to operate during the construction phase. Any further community feedback received via these methods would be taken on board and acted upon as appropriate. This may include the development and implementation of additional mitigation measures to minimise potential impacts of the Proposal.

[1] http://b-line.transport.nsw.gov.au/environment-and-planning.php

Environmental impact assessment

This REF identifies the potential environmental benefits and impacts of the Proposal and outlines the mitigation measures to reduce the identified impacts.

The following key impacts have been identified should the Proposal proceed:

- temporary changes to vehicle, pedestrian and cycle movements to, from and around the Proposal area during construction. This includes temporary road and footpath diversions on Pittwater Road around the proposed left turn lane at Cross Street, on Sydney Road at the intersection with Burnt Bridge Creek Deviation and at the intersection of Heaton Avenue and Manly Road
- temporary noise and vibration impacts during construction including exceedances of highly affected noise levels during night works around construction areas
- removal of trees and vegetation that would require planting offsets
- changes to traffic movements and accessibility along and surrounding Pittwater Road, Burnt Bridge Creek Deviation, Manly Road, Sydney Road and Heaton Avenue.

Further information regarding these impacts is provided in Chapter 6 of the REF.

To mitigate the impacts identified above the following key mitigations have been proposed:

- a Construction Environmental Management Plan (CEMP) would be prepared and would outline
    - road closures and alternatives
    - pedestrian and cycle provisions throughout the construction period
    - the consultation process to inform the community of any road, pedestrian or cycle changes
- A Construction Noise and Vibration Management Plan (CNVMP) would be prepared. The CNVMP would include the following:
    - identification of nearby residences and other sensitive land uses
    - description of all approved hours of work
    - description and identification of all construction activities, including work areas, equipment and duration
    - description of what work practices (generic and specific) would be applied to minimise noise and vibration
    - a complaints handling process
    - noise and vibration monitoring procedures
    - overview of community consultation required for identified high impact works.
- A Traffic Management Plan would form part of the CEMP for the construction phase of the Proposal and would outline:
    - road closures and alternatives
    - pedestrian and cycle provisions throughout the construction period
    - the consultation process to inform the community of any road, pedestrian or cycle changes
- Vegetation offsets and/or landscaping would be undertaken in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines*

for Landscape Character and Visual Impact Assessment (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b). All planting would be undertaken in consultation with the Northern Beaches Council, and/or the owner of the land upon which the vegetation would be planted.

Conclusion

This REF has been prepared having regard to sections 111 and 112 of the EP&A Act, and clause 228 of the EP&A Regulation, to ensure that Roads and Maritime takes into account to the fullest extent possible, all matters affecting or likely to affect the environment as a result of the Proposal.

The detailed design of the Proposal would also be designed taking into account the principles of ecologically sustainable development (ESD).

Should the Proposal proceed, potential associated adverse impacts would be appropriately managed in accordance with the mitigation measures outlined in this REF. This would ensure the Proposal is delivered to maximise benefit to the community and minimise any adverse impacts on the environment.

In light of the potential impacts and proposed mitigation measures outlined in this REF, the Proposal is considered unlikely to result in a significant impact upon the environment including any critical habitat or threatened species, populations, ecological communities or their habitats. Accordingly, an Environmental Impact Statement (EIS) or Species Impact Statement (SIS) are is not required for the Proposal, as per Part 5.1 of the EP&A Act.

1. Introduction

This REF assesses the environmental impact associated with the construction and upgrade of sections of road between Brookvale and Seaforth in support of the B-Line Program (the Proposal). Roads and Maritime Services (Roads and Maritime) is the government agency responsible for the roadworks and is the proponent for this Proposal.

The Proposal is part of an integrated program of bus service and infrastructure improvements to deliver the B-Line Program – a NSW Government initiative to provide a more frequent and reliable bus service between the Northern Beaches and Sydney's Central Business District (CBD).

1.1. The B-Line Program

The NSW Government is proposing to deliver transport improvements for the Northern Beaches, including an integrated program of service and infrastructure improvements to support a new B-Line bus service. The B-Line Program of works includes the following elements:

- A new B-Line bus service from Mona Vale to the Sydney CBD. The B-Line would provide a more frequent and reliable service, and would generally operate between the hours of about 5:30am to 12.30am. Service frequencies during this time would generally be as follows:
  - every five minutes during the southbound morning peak and northbound afternoon peak commute periods on weekdays
  - every 10 minutes at other times of the day, and on weekends, up to 11pm
  - every 15 minutes between 11pm and 12.30am every day.
- on-road infrastructure improvements, including new bus lanes, bus bays, minor lane widening and other road improvements to support faster and more reliable bus journeys on the north-south corridor
- nine B-Line stops at Mona Vale, Warriewood, Narrabeen, Collaroy, Dee Why, Brookvale, Manly Vale, Spit Junction (Mosman) and Neutral Bay, including real-time passenger information and improved facilities for customers
- new commuter car parks at Mona Vale, Warriewood, Narrabeen, Dee Why, Brookvale and Manly Vale providing around 900 spaces, as well as bicycle parking, to encourage customers to park and ride
- transport interchange works to ensure integrated pedestrian and bicycle links to commuter car parks and B-Line stops
- modifications to the bus network to provide for the turn-up-and-go B-Line service, improved network legibility and better connections between key centres
- a new double decker bus fleet for improved on-board capacity and comfort.

Subject to approval, construction of the Proposal is expected to commence in early 2017 and take around nine months to complete.

The B-Line service is expected to be operational in late 2017.

Figure 1 provides an overview of the new B-Line service.

1.1.1. Delivery of the B-Line Program

The above listed on-road and off-road elements of the B-Line Program would be delivered as a number of individual projects by the B-Line project team, a collaboration between Roads and Maritime and Transport for NSW (TfNSW).

Roads and Maritime is responsible for the assessment and construction of all on-road infrastructure improvements, including new bus lanes, bus bays, minor lane widening and other road improvements to support faster and more reliable bus journeys through the overall Mona Vale to CBD corridor.

TfNSW is responsible for the assessment and construction of all off-road infrastructure improvements, including new commuter car parks and new B-Line bus stops at Warriewood, Mona Vale, Narrabeen and Manly Vale. Two commuter car parks are to be delivered by third parties at Dee Why and Brookvale.

Proposals to build commuter car parks and B-Line bus infrastructure at Narrabeen, Warriewood and Manly Vale have received planning approval. Other on-road projects associated with B-Line will be assessed and put on public display during late 2016 and early 2017.

Further detail on the new B-Line Program is available at the B-Line website[2].

[2] http://b-line.transport.nsw.gov.au/environment-and-planning.php

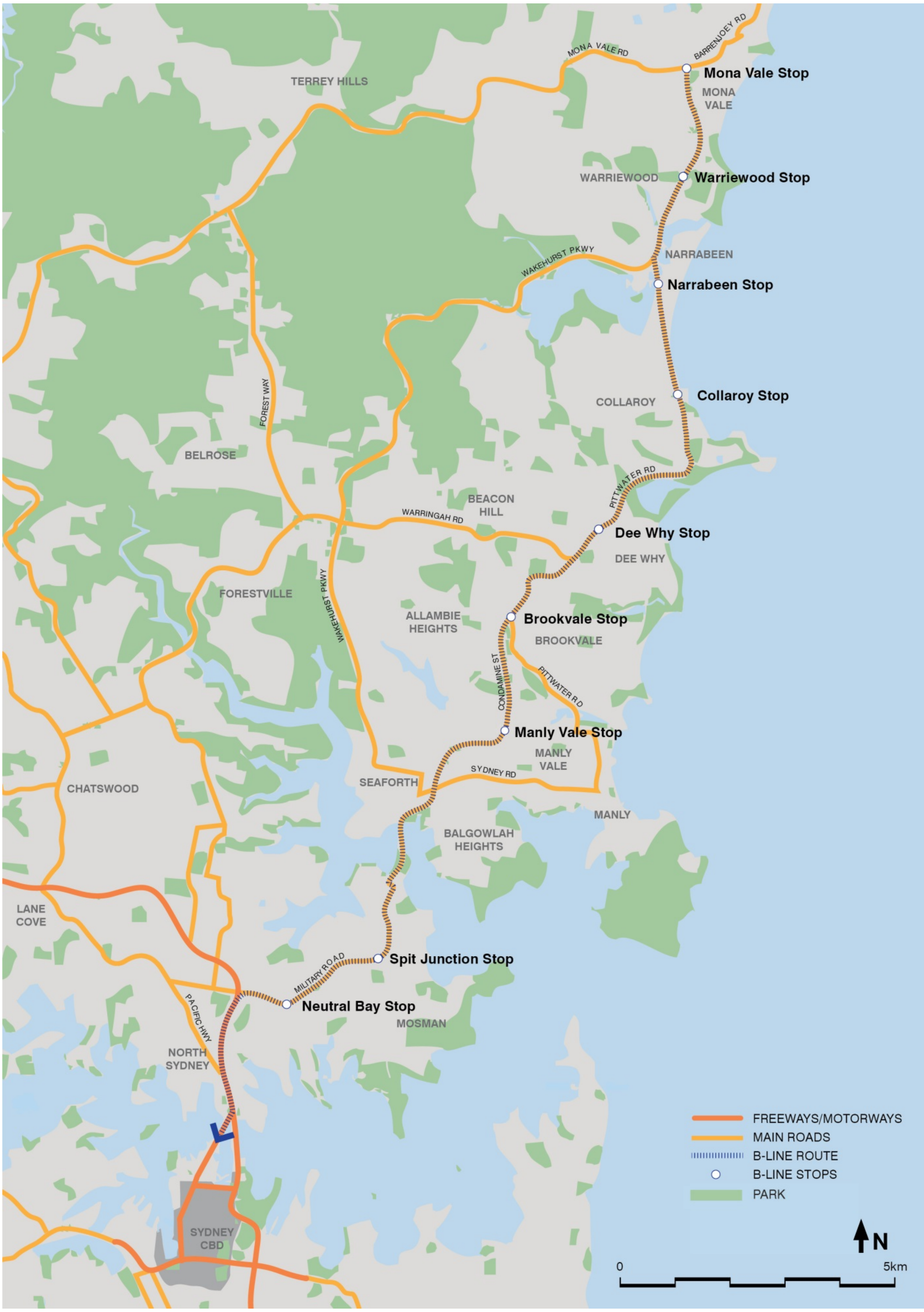


Figure 1 Overview of the new B-Line Program

1.2. Overview of the Proposal

This REF assesses the impacts of the roadworks required to support the B-Line Program along the A8 Corridor, between Orchard Road, Brookvale and Heaton Avenue, Seaforth (the Proposal).

The Proposal has been identified as a critical element to be delivered as part of the B-Line Program. The Proposal aims to:

- reduce peak and off-peak bus journey times between Brookvale and Seaforth
- improve customer experience with improved frequency, capacity and reliability of bus services
- improve road safety along the A8 Corridor between Brookvale and Seaforth.

1.2.1. Key features of the Proposal

The key features of the Proposal include:

- construction of a new left turn lane from Pittwater Road (northbound) into Cross Street
- closure of the median strip within Pittwater Road at the Orchard Road intersection to prevent vehicles from turning right from Pittwater Road into Orchard Road (eastbound) and vehicles turning right from Orchard Road into Pittwater Road (northbound)
- extension of the existing right turn lane from Burnt Bridge Creek Deviation into Sydney Road (westbound)
- construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound)
- extension of the existing right turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- extension of the existing right turn lane from Manly Road into Sydney Road (eastbound) and widening of the left turn slip lane into Sydney Road (westbound)
- full closure of Heaton Avenue at Manly Road to form a cul-de-sac
- construction of a new indented bus bay on Manly Road (southbound) at the Heaton Avenue intersection
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, retaining wall (at Heaton Avenue), upgrades to fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

Subject to approval, construction of the Proposal is expected to commence in early 2017 and take around nine months to complete.

A detailed description of the Proposal is provided in Chapter 3 of this Review of Environmental Factors (REF). The key features of the Proposal are shown in Figure 16, Figure 17 and Figure 18.

1.3. Location of the Proposal

The Proposal is located within the Northern Beaches Local Government Area (LGA) approximately 16 kilometres from the Sydney CBD (refer to Figure 2). The Proposal would be located at various locations along the A8 corridor between Brookvale and Seaforth. Parts of the A8 corridor relevant to the Proposal are Pittwater Road, Burnt Bridge Creek Deviation and Manly Road. The Proposal area has been separated into the following Zones as follows:

- Zone A: along Pittwater Road, between Orchard Road and Cross Street in the suburb of Brookvale
- Zone B: Manly Road/Burnt Bridge Creek Deviation/Sydney Road intersection in the suburbs of Balgowlah and Seaforth
- Zone C: Manly Road/Heaton Avenue intersection in the suburb of Clontarf.

Under the *Warringah Local Environmental Plan 2011*, Burnt Bridge Creek Deviation and Pittwater Road are zoned as infrastructure (classified road). Under the Manly LEP 2013, Burnt Bridge Creek Deviation, Manly Road and Sydney Road are zoned as infrastructure (classified road). An overview of the Proposal area (Zone A, Zone B and Zone C) is shown in Figure 2. The land zoning relevant to the Proposal area is shown in Figure 3.

The area surrounding Zone A is zoned as business development, general industrial and commercial core. Surrounding Zone A is Brookvale Bus Depot, several automotive industry businesses and other commercial businesses.

The area surrounding Zone B is zoned as general residential, neighbourhood centre and public recreation. Surrounding Zone B are several small to medium-sized businesses within the neighbourhood centre, and low to medium density residential dwellings.

The area surrounding Zone C is zoned as public recreation and low density residential. Surrounding Zone C to the south is Fisher Bay Reserve, which is listed as a local heritage item under the Manly LEP. To the east of Zone C are predominately low density residential dwellings.

Figure 2 Overview of the Proposal area

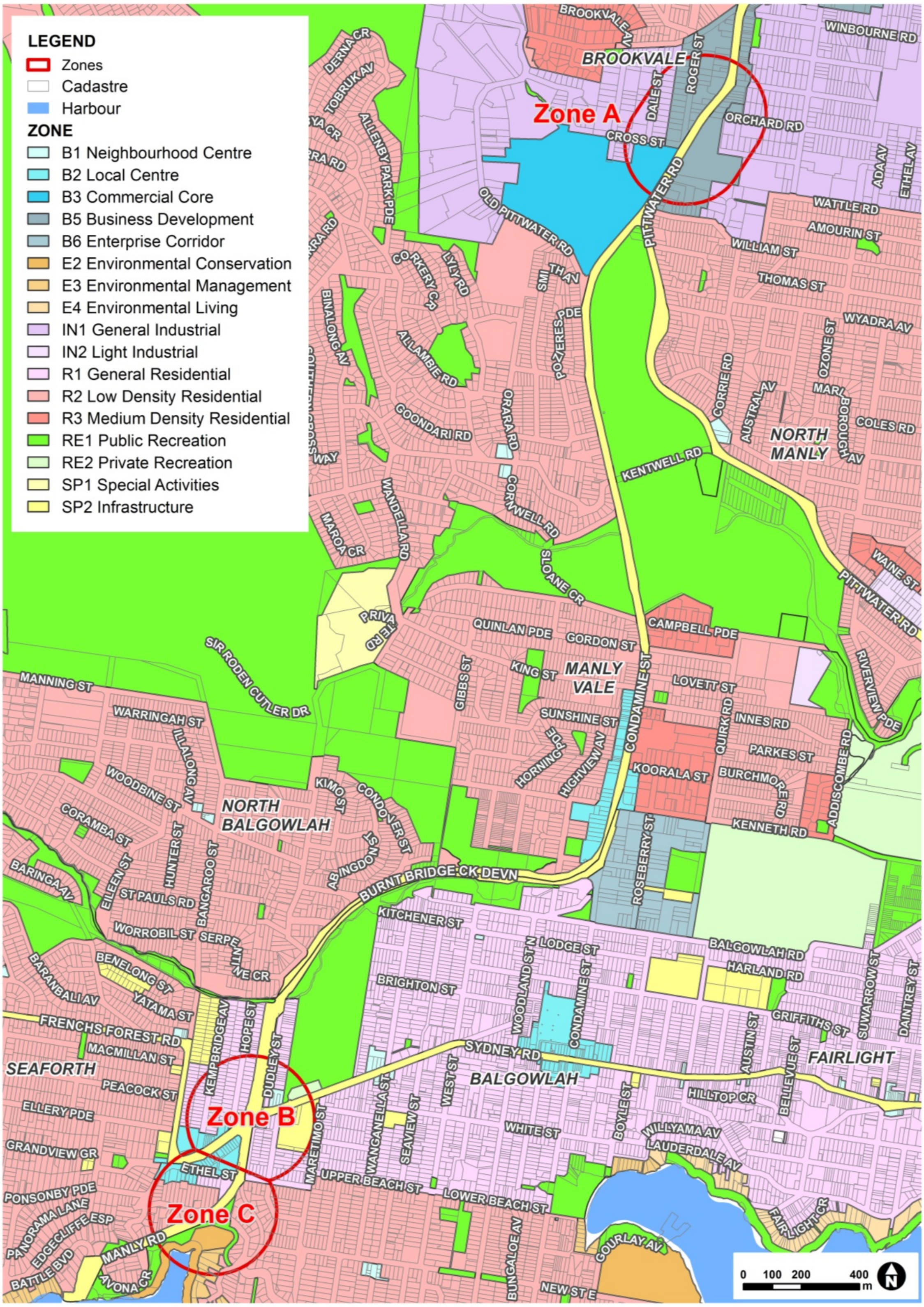


Figure 3 Land zoning relevant to the Proposal area

1.4. Existing infrastructure and land uses

Pittwater Road, Burnt Bridge Creek Deviation, Manly Road and Sydney Road are characteristic of a main arterial road in an urban environment with residential and commercial areas located in close proximity to both sides of the road. The visual landscape along this corridor is dominated by commercial land uses, medium to high residential dwellings and road infrastructure, with some areas of landscaped vegetation and open space along the corridor.

The road corridor reflects the characteristics of a highly modified urban environment with vehicles, signage and advertising dominating the landscape. Street trees currently provide landscape features, screening business and residential frontages, and providing shade for pedestrians.

Zone A is located in a predominately commercial and industrial area. Specific points of interest of the area include:

- Westfield Warringah Mall
- Brookvale Bus Depot
- multiple automotive businesses
- several retail stores and small to medium sized businesses
- cafes and restaurants
- Northern Beaches Community College.

Zone B is located on the major intersection of Burnt Bridge Creek Deviation/Manly Road/Sydney Road. Specific points of interest of the area include:

- Balgowlah Golf Club
- Balgowlah RSL Memorial Club
- Northern Beaches Secondary College
- cafes and restaurants
- low and medium density residential dwellings
- small businesses and retail stores.

Zone C is located on the Manly Road and Heaton Avenue intersection. Specific points of interest of the area include:

- Fisher Bay Reserve
- low density residential housing.

Figure 4**,** Figure 5 and Figure 6 show relevant points of interest surrounding the Proposal area for each zone.

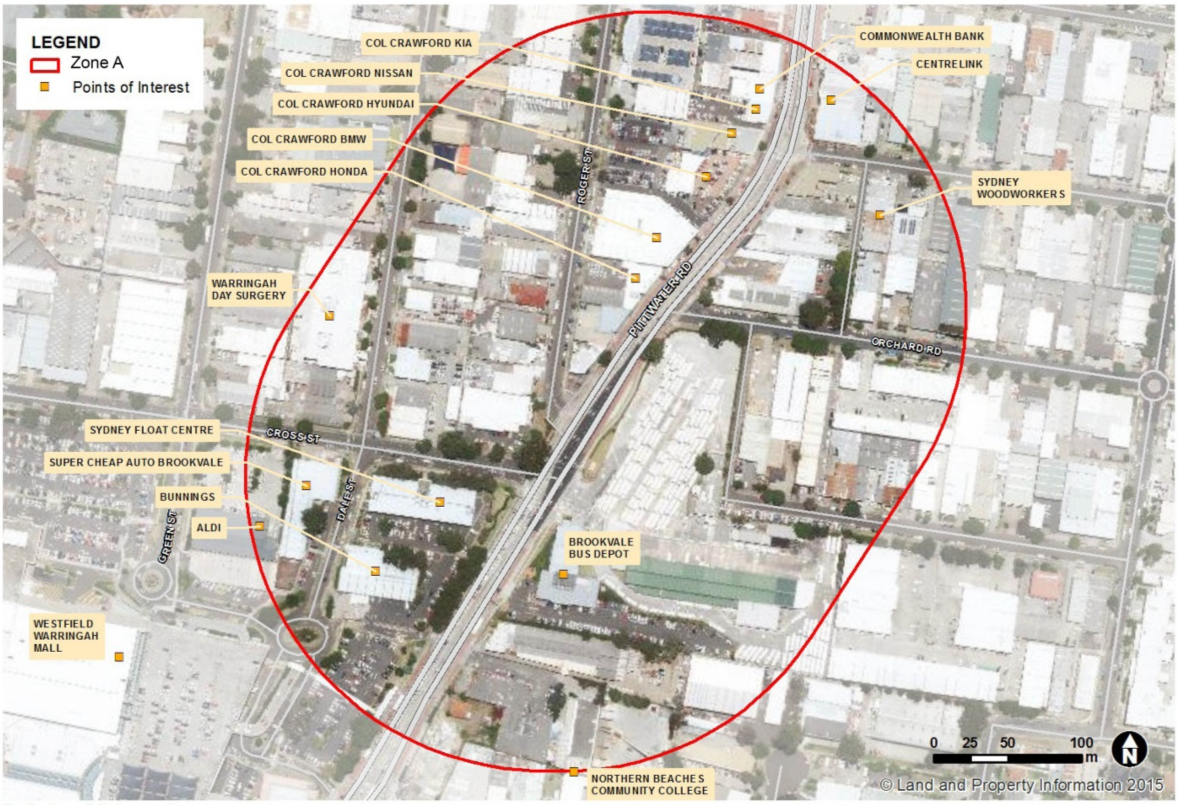


Figure 4 Points of Interest within Zone A

Figure 5 Points of Interest within Zone B

Figure 6 Points of Interest within Zone C

The Proposal area currently accommodates the following transport elements:

- *Bus services:* multiple bus services stop at existing bus stops along the northbound and southbound sides of the A8 corridor and Sydney Road within the Proposal area. These bus services provide local trips around the Northern Beaches and express trips to the Sydney CBD and North Sydney. Existing bus stops are shown in Figure 7**,** Figure 8 and Figure 9
- *Taxi facilities:* there are no designated taxi ranks within the Proposal area
- *Cycling:* there is a dedicated cycleway along Burnt Bridge Creek Deviation north of Zone B. A number of other cycleways connect surrounding areas with the A8 corridor. These are shown in Figure 10 and Figure 11.
- *Pedestrian facilities:* footpaths along Pittwater Road provide access to the existing bus stops and businesses within Zone A. Signalised intersections are located at Cross Street. A signalised intersection is provided across Burnt Bridge Creek Deviation to allow pedestrian movement along the northern side of Sydney Road. There are no footpaths along Burnt Bridge Creek Deviation and Manly Road within the Proposal area.

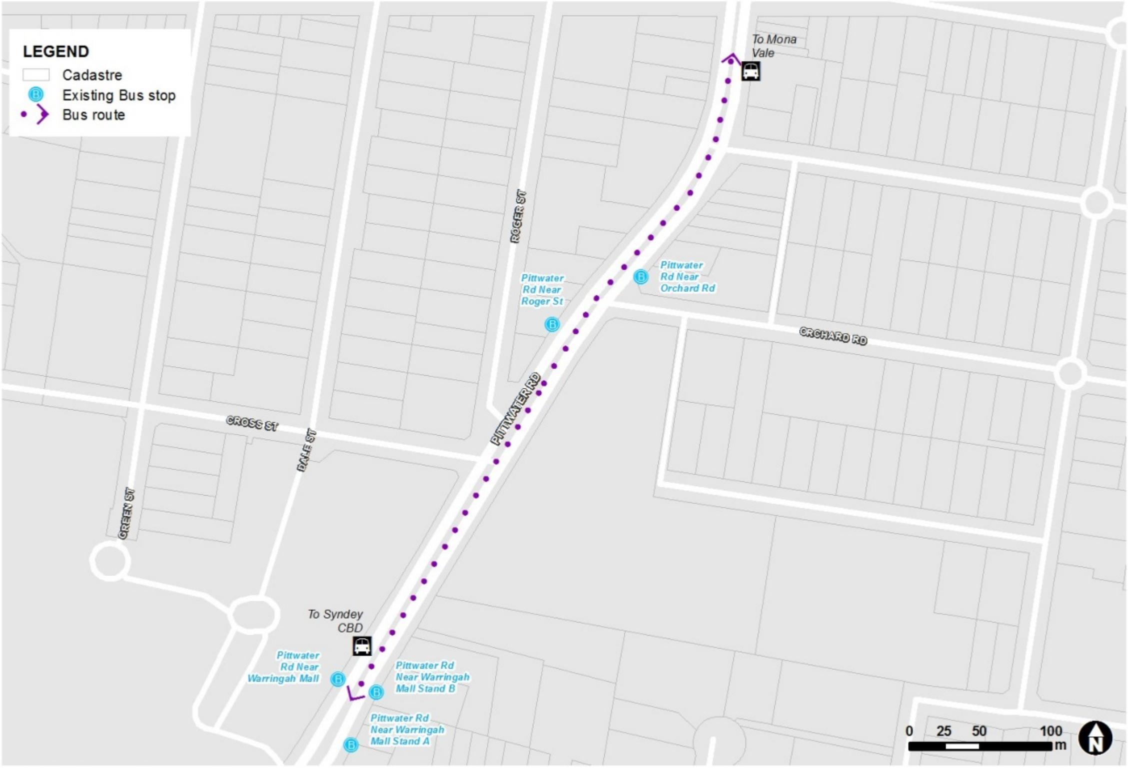


Figure 7 Existing bus routes within Zone A

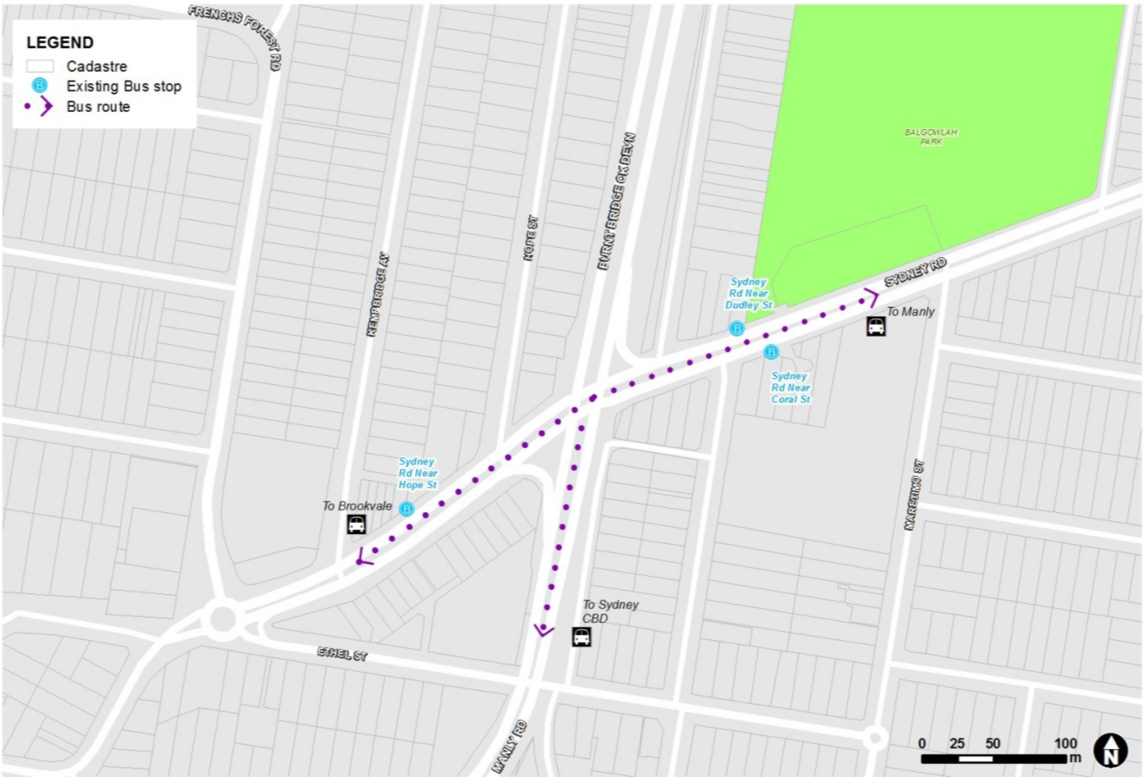


Figure 8 Existing bus routes within Zone B

Figure 9 Existing bus routes within Zone B

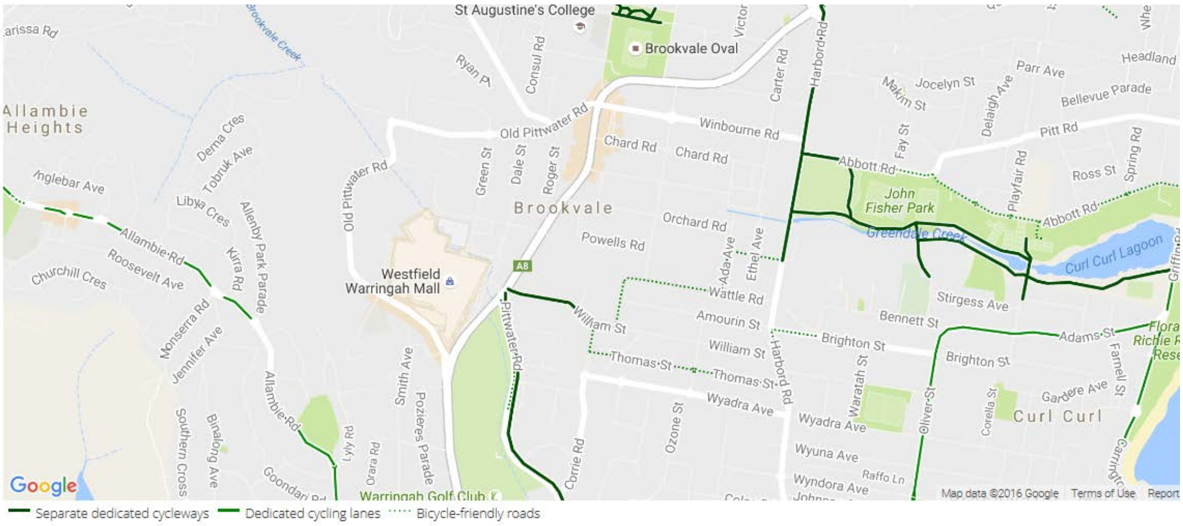


Figure 10 Existing cycleways within the Proposal Area (Brookvale)

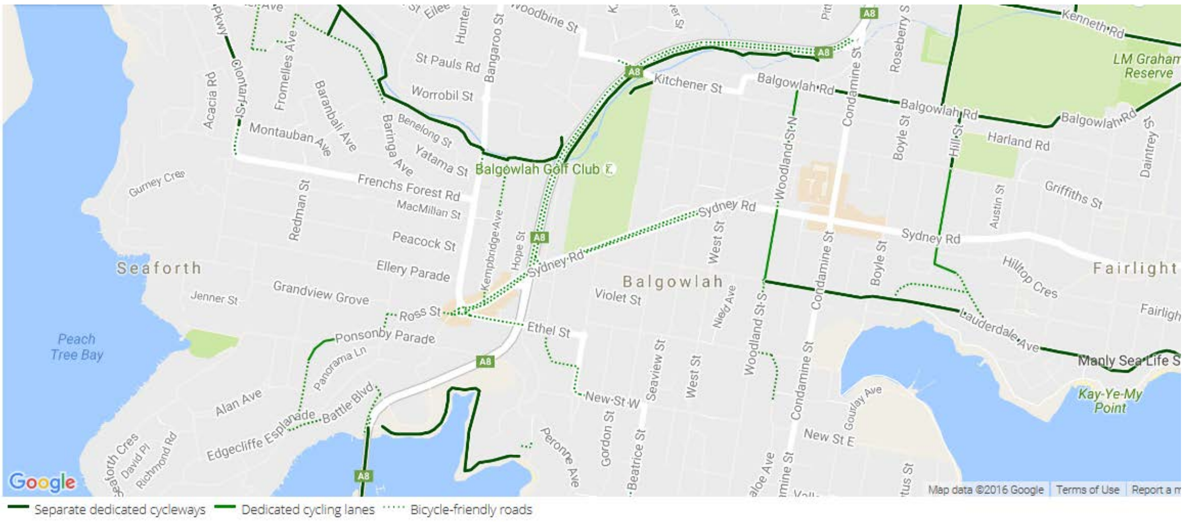


Figure 11 Existing cycleways within the Proposal area (Manly Vale and Balgowlah)

1.5. Purpose of this Review of Environmental Factors

This REF has been prepared by AECOM on behalf of Roads and Maritime to assess the potential impacts of the B-Line roadworks from Brookvale to Seaforth (the Proposal). For the purposes of the Proposal, Roads and Maritime is the proponent and the determining authority under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The purpose of this REF is to describe the Proposal, to assess the likely impacts of the Proposal having regard to the provisions of Section 111 of the EP&A Act, and to identify mitigation measures to reduce the likely impacts of the Proposal. This REF has been prepared in accordance with clause 228 of the *Environment Planning and Assessment Regulation 2000* (the EP&A Regulation).

This assessment has also considered the relevant provisions of other relevant environmental legislation, including the *Threatened Species Conservation Act 1995* (TSC Act), *Protection of the Environment Operations Act 1997* (PoEO Act) and the *Roads Act 1993* (Roads Act).

Having regard to the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), this REF considers the potential for the Proposal to have a significant impact on matters of National Environmental Significance (NES) or Commonwealth land, and the need to make a referral to the Commonwealth Department of Environment for any necessary approvals under the EPBC Act. Refer to Chapter 4 for more information on statutory considerations.

2. Need for the Proposal

This chapter discusses the need and objectives of the Proposal, having regard to the objectives of the B-Line Program generally. This chapter also provides a summary of the options that have been considered during the Proposal's development and why the preferred option has been chosen.

2.1. Strategic justification

2.1.1. Overview

Improving transport customer experience is the key focus of the NSW Government's transport initiatives. The NSW Government's *NSW Making it Happen* identifies 30 key priorities to grow the economy, deliver infrastructure, and improve health, education and other services across the State. 'Building Infrastructure' is one of these key priorities, as the State's growing population continues to place pressure on existing infrastructure. The NSW State Plan predicts that over the next 15 years NSW will require infrastructure to support 40% more train trips, 30% more car trips and 31% more households.

The B-Line Program has been identified as a key infrastructure project under the 'Building Infrastructure' key priority. It is a priority project due to be delivered between 2016 and 2019.

NSW 2021 is the NSW Government's ten year plan to guide budget and decision making. This Plan includes the following goals, targets and priority actions relevant to the B-Line program (NSW Department of Premier and Cabinet, 2011):

- reduce travel times
- minimise public transport waiting times for customers
- improve coordination and integration between transport modes
- grow patronage on public transport
- improve public transport reliability
- improve customer experience with transport services.

Further details of the application of NSW Government policies and strategies are discussed in Section 4.5 of this REF.

2.1.2. Strategic options assessment

During the development of the B-Line Program, Roads and Maritime and TfNSW considered a series of strategic options for improvements to bus travel times along the B-Line Corridor. These included:

- Option 1: continuous bus lanes (24/7)
- Option 2: enhance AM peak direction, congestion points and some off-peak flow
- Option 3: enhance AM and PM peak, congestion points and some off-peak flow.

The strategic options assessment considered the following factors:

- cost estimates
- maximum passenger benefits

- corridor bus travel times (travel time variability and delay)
- parking survey (maximum number of spaces impacted and parking demand offset)
- traffic modelling (SIDRA intersection delays, private vehicle travel time, net change in all passenger delay).

The strategic options assessment indicated that Option 2 (enhance AM peak direction, congestion points and some off-peak flow) was the preferred option. Table 1 provides an overview of the strategic options assessment.

Table 1 Strategic options assessment

Strategic assessment	Option 1	Option 2 (Preferred)	Option 3
Bus travel time and variability	• improved bus travel times and variability in the northern part of the corridor • insufficient capacity at Dee Why and Neutral Bay[2].	• improved inbound bus travel times and variability in the AM peak • some outbound an contra peak improvements through addressing congestion points[2].	• improved bus travel times and variability in the AM and PM peak • Some contra peak improvements through addressing congestion points[3].
Impact on all road users	• permanent 24 hours per day reduction in capacity for general traffic[1].	• minimal impact on road users (two lanes of general traffic would be maintained at all times)[3].	• a PM bus tidal flow would impact on traffic and bus services inbound through Neutral Bay (generally reducing inbound to two lanes)[2].
Impact on parking, business and property	• all kerbside parking removed[1].	• parking impacted by extended clearways • commercial and business parking maintained during the off peak • right turn access to local areas largely maintained[3].	• parking impacted by extended clearways • commercial and business parking maintained during the off peak • right turn bans would decrease access to local areas[2].
Value for money (cost versus benefit)	• over investment in the north and underinvestment in the south[1].	• focussed investment where the Proposal provides the greatest benefit. Value for money approach[3].	• high capital investment than AM option due to additional road widening to maintain local access • pm outbound tidal flow justification is insufficient to warrant impact on the inbound PM traffic[2].

Notes:

1. *Negative impact*
2. *Positive and negative impacts*
3. *Positive impact (improvement)*

2.1.3. Objectives of the B-Line Program

The B-Line Program aims to address key issues relating to the effectiveness of bus transport on the Northern Beaches, including:

- existing low bus speeds during peak periods leading to long travel times on the north-south corridor
- unreliable bus journey times on the north-south corridor
- uneven passenger loadings on buses on the north-south corridor
- crowding at major bus stops on the north-south corridor
- long wait times for bus services in off-peak periods
- customer dissatisfaction with bus stop amenity
- a complex bus network that lacks legibility.

The B-Line Program would provide on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network. Details of separate on-road and off-road infrastructure improvements and enhancements are provided in Section 1.

2.1.4. Objectives of the Proposal

The specific objectives of the Proposal are to:

- reduce the peak and off-peak bus journey times in both directions along Pittwater Road, Burnt Bridge Creek Deviation and Manly Road (the A8 corridor) between Brookvale and Seaforth
- improve customer experience with improved frequency, capacity and reliability of bus services
- improve road safety along the A8 corridor between Brookvale and Seaforth.

The Proposal, as part of the integrated program of bus service and infrastructure improvements to deliver the B-Line Program, aims to contribute to the above identified goals.

2.2. Alternative options considered

Options for improving bus travel times through the A8 corridor from Brookvale to Seaforth were developed through an iterative process stemming from the preparation of the B-Line Program's Strategic and Final Business Cases, completed May 2015 and February 2016 respectively. These documents outlined the strategic need for the Proposal and included preliminary discussion of potential on-road works to be implemented in support of improved travel times for B-Line and local bus services. The specific recommendations for on-road works within the business case were further developed by Roads and Maritime in conjunction with TfNSW, relevant stakeholders (including Sydney Transit Authority) and the project design team. This involved a series of workshops and discussions to examine the Proposal in light of its objectives (see Section 2.1.4) and any potential alternative designs. These discussions were informed by:

- the strategic need for the proposal within the context of delivering the B-Line Program generally

- the scale of potential benefits and improvements to be provided for all users and affected stakeholders including bus passengers, general traffic, nearby landowners, businesses and the community in general
- engineering, environmental and community constraints present throughout the Proposal area
- road safety considerations
- cost-benefit considerations, including minimising the need for property acquisition
- the potential for disruption to existing traffic and the public generally during construction and operation in terms of congestion and public amenity.

This process resulted in the generation of two distinct alternatives for the A8 corridor between Brookvale and Seaforth:

- a ‘do nothing’ option whereby no action would be taken to upgrade on-road infrastructure in support of the B-Line Program
- an option to upgrade selected junctions and provide indented bus bays at certain locations along Pittwater Road/Condamine Street/Burnt Bridge Creek Deviation, Manly Road and Sydney Road, including the closure of Heaton Avenue.

Further specific detail of the scope of the proposed alternatives, and options that were not adopted, are included in the following sections. The options are assessed within this report to determine the preferred option in relation to the objectives outlined in Section 2.1.4.

2.2.1. The ‘do-nothing’ option

Under a ‘do-nothing’ option peak and off-peak bus journey times, bus passenger experience and road safety along the A8 Corridor between Brookvale and Seaforth would remain unchanged. Accordingly NSW Government transport, safety and amenity objectives for this area would not be met. Specifically, the objectives outlined in Section 2.1.4 would not be delivered which would subsequently prevent the delivery of a new, more frequent and reliable bus service along the A8 corridor between Brookvale and Seaforth.

A ‘do nothing’ option was not considered a feasible alternative as it does not meet the objectives of the Proposal identified in Section 2.1.4.

2.2.2. Preferred option

The preferred option would include:

- construction of a new left turn lane from Pittwater Road (northbound) into Cross Street
- closure of the median strip within Pittwater Road at the Orchard Road intersection to prevent vehicles from turning right from Pittwater Road into Orchard Road (eastbound) and vehicles turning right from Orchard Road into Pittwater Road (northbound)
- extension of the existing right turn lane from Burnt Bridge Creek Deviation into Sydney Road (westbound)
- construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound)

- extension of the existing through lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- extension of the existing right turn lane from Manly Road into Sydney Road (eastbound) and widening of the left turn slip lane into Sydney Road (westbound)
- full closure of Heaton Avenue at Manly Road to form a cul-de-sac
- construction of a new indented bus bay on Manly Road (southbound) at the Heaton Avenue intersection
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, retaining wall (at Heaton Avenue), upgrades to fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

This option was selected as it meets the objectives of the Proposal and satisfies relevant NSW Government objectives relating to transport efficiency, amenity and road safety through Brookvale, Manly Vale, Balgowlah and Seaforth.

2.2.3. Alternatives options considered - Brookvale

As part of the concept design development, Roads and Maritime considered a number of alternatives which were ultimately not selected as part of the Proposal. These are provided below.

- **Provide southbound and northbound bus lanes between West Street and Winbourne Road, Brookvale and retain right turn into Mitchell Road:** This option was not chosen as part of the Proposal because it would:
  - require a substantial number of property acquisitions on both sides of the corridor
  - result in a contamination risk due to the acquisition of, and construction within the boundaries of, an existing service station
  - result in substantial costs from property acquisitions, strip acquisitions and contamination management.
- **Reduce median width to 0.5 m between West Street and Winbourne Road:** This option was not chosen as part of the Proposal because it would require replacing median post traffic signals with mast arms traffic signals, which would be likely to increase the number of rear-end crashes (due to increased see-through effect).

2.2.4. Alternatives options considered – Heaton Avenue

As part of the development of the Proposal several options were considered for Heaton Avenue. These included a number of alternatives based around the location of the proposed bus indent. All of these options would include a bus shelter (either a relocation of the existing shelter or a new shelter of a similar size). A description of each alternative as well as a diagram of its location is provided in the following section.

Option A: Indented bus stop north of Heaton Avenue (no closure)

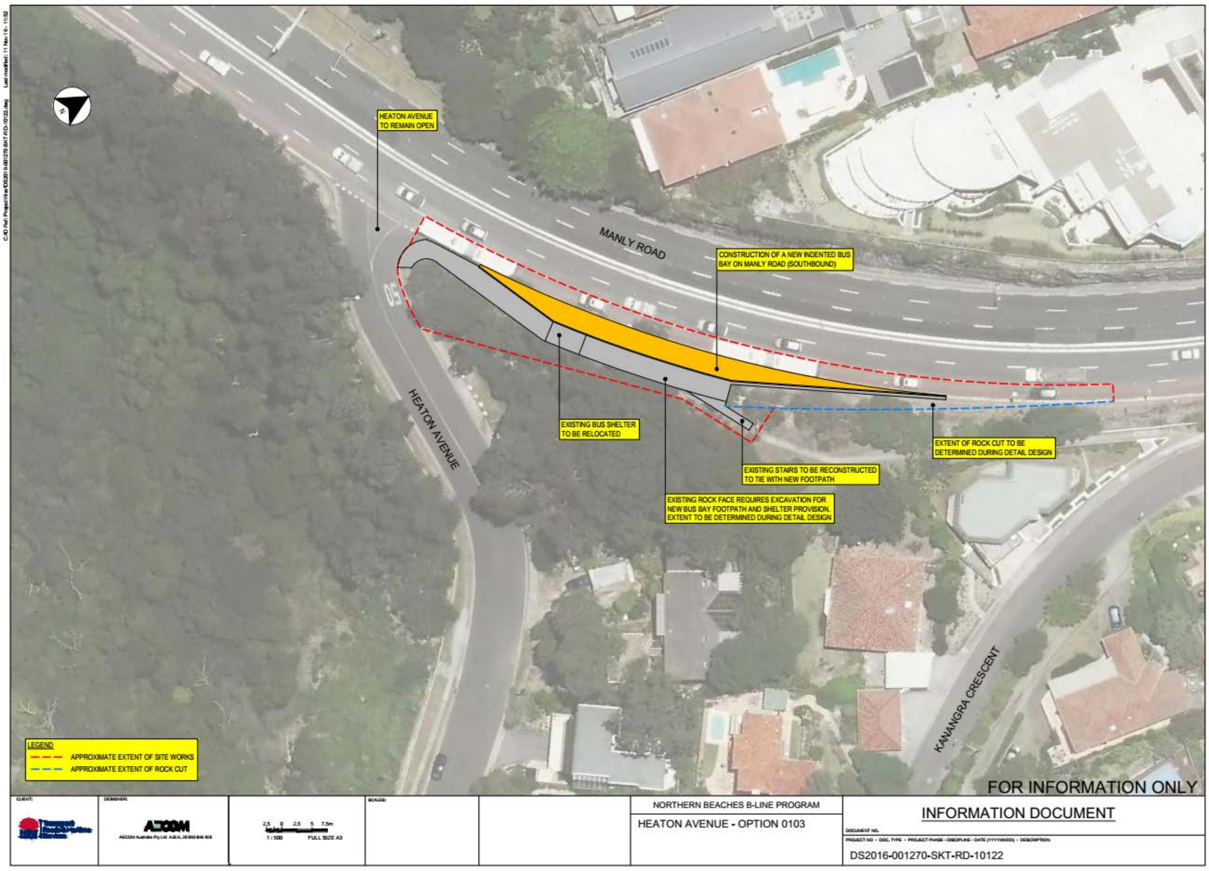


Figure 12 Option A: Indented bus stop north of Heaton Avenue (no closure)

This option would involve the construction of an indented bus stop on Manly Road south of the Ethel Street bridge and north of Heaton Avenue. This option would leave Heaton Avenue open to traffic with current access arrangements. To provide for the required length of the bus stop with tapers at each end, a substantial excavation into the existing rock face on Manly Road would be required. The bus stop would require a minor relocation and the footpath and pedestrian stairs leading to the north would require reconstruction closer to the adjacent private property. Acquisition of the council-owned public open space adjacent to the existing rock face would be required.

Option B: Indented bus stop north of Heaton Avenue (permanent half closure)

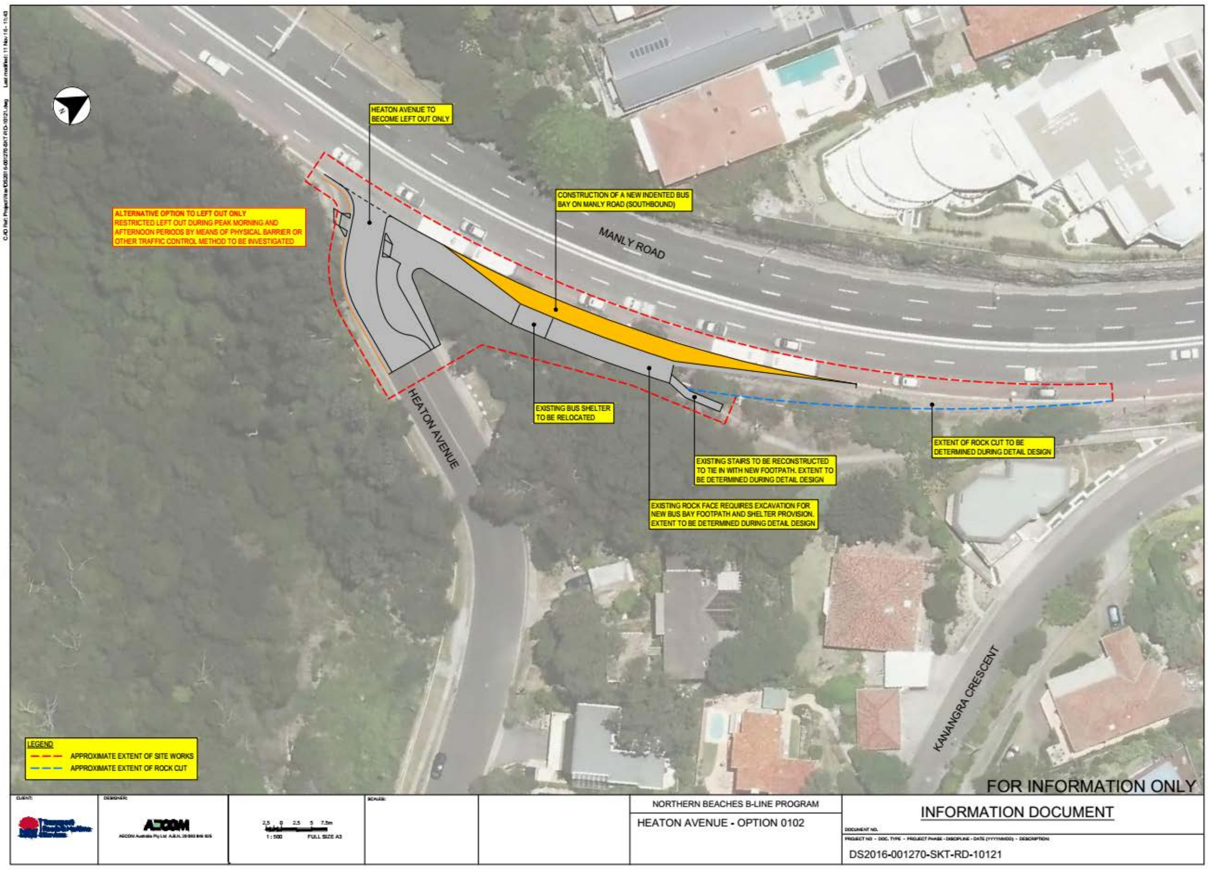


Figure 13 Option B: Indented bus stop north of Heaton Avenue (permanent half closure)

This option would involve the construction of an indented bus stop in the existing rock face on Manly Road south of the Ethel Street bridge and partially across Heaton Avenue. The bus indent in this option would be located south of Option A and would require the closure of the left-in movement from Manly Road into Heaton Avenue. The left-out turn movement from Heaton Avenue to Manly Road would remain.

This option would require a smaller amount of excavation into the existing rock face. It would also require a minor relocation of the bus stop and the reconstruction of pedestrian footpath and stairs. Acquisition of the council-owned public open space adjacent to the existing rock face would be required.

Option C: Indented bus stop north of Heaton Avenue (permanent half closure/peak period full closure)

This option would involve a similar construction to Option B with the exception that a gate would be included to periodically close the intersection of Manly Road and Heaton Avenue, Left-out movements would be prohibited between 6am and 10am Monday to Friday, with the exception of police, RMS and other emergency services vehicles.

Minor widening of Heaton Avenue would also be required to allow vehicles to turn around.

Option D: Indented bus stop across Heaton Avenue (full closure)

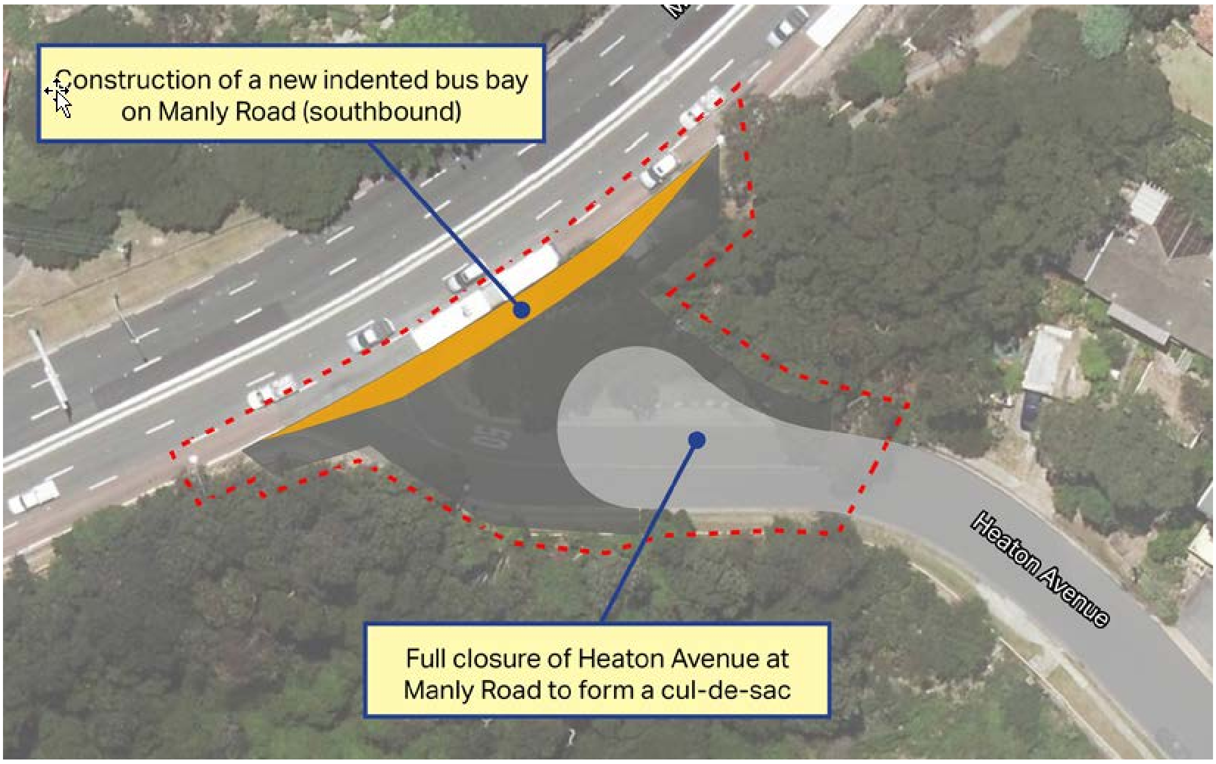


Figure 14 Option D: Indented bus stop across Heaton Avenue (full closure)

This option would involve the construction of an indented bus stop across the existing intersection of Heaton Avenue and Manly Road. This option would result in the full and permanent closure of Heaton Avenue. Some widening of Heaton Avenue would be required to allow vehicles to turn around. No rock excavation would be required and only minor property acquisition would be necessary to facilitate the new turning head. Minor adjustments to the existing footpaths and relocation of the bus stop would be necessary.

Option E: Indented bus stop south of Heaton Avenue (no closure)

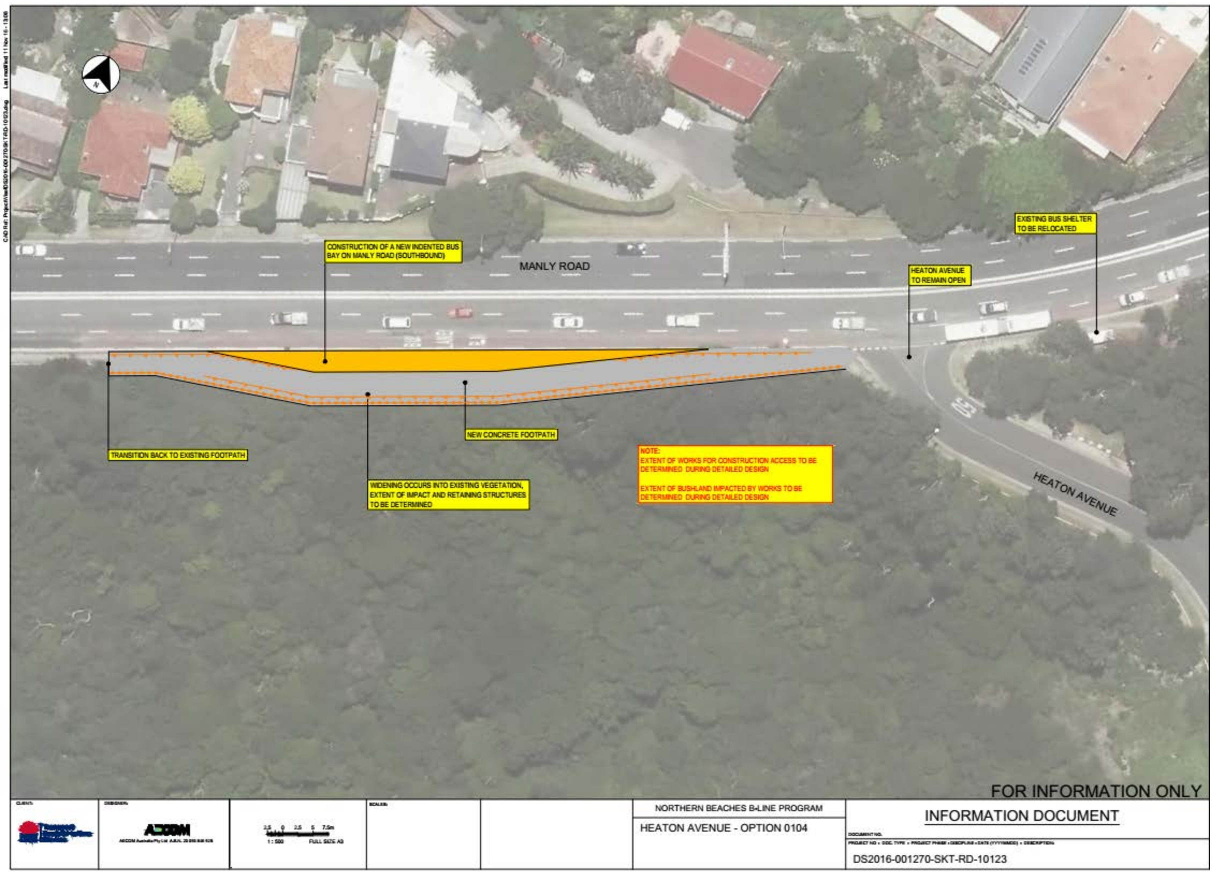


Figure 15 Option E: Indented bus stop south of Heaton Avenue (no closure)

This option would involve the construction of an indented bus stop over the existing embankment on Manly Road to the south of Heaton Avenue. This option would require the construction of a retaining structure and the importation of fill material to provide the base of the bus indent. The relocation of the existing bus stop and footpath would be required.

This option would maintain the same traffic access arrangements at Heaton Avenue as existing.

Option F: Do nothing

This option would make no changes to the existing in-lane bus stop on Manly Road or the Heaton Avenue intersection.

Evaluation of options

A qualitative evaluation of the advantages and disadvantages associated with each of the above options was undertaken. Specific criteria were taken into account to provide an objective assessment of the options, as well an assessment of how well each addressed the overall objectives of this environmental assessment. The criteria employed for the assessment of the Heaton Avenue options are outlined in Table 2. The objectives of the Proposal are outlined in section 2.1.4 of this report.

Table 2 Heaton Avenue options criteria

Criterion	Detail
Cost	Cost of construction. This criterion does not take into account costs of operational efficiencies or inefficiencies.
Visual impact	Impacts upon views from existing residential properties and road/footpath users.
Loss of vegetation	Estimation of amount of vegetation clearing required for each.
Construction noise	Impact of construction noise upon nearby residents.
Constructability	The ease and efficiency with which project elements can be built
Operational traffic	Potential impacts to operational traffic including general traffic, B-Line and local bus services
Road safety	Likely impacts upon road safety arising from the option.

The assessment of the above options for the Heaton Avenue intersection have been undertaken as per the criteria in Table 2 and are presented individually in Table 3 to Table 8 below. The assessments provided been undertaken at a qualitative level only for the purposes of a high level comparison of alternatives.

Table 3 Assessment of Option A: Indented bus stop north of Heaton Avenue (no closure)

	Option A Indented bus stop north of Heaton Avenue (no closure)
Criterion	**Response**
Cost	Construction of the indented bus stop to the north of Heaton Avenue (without any road closure) would: • require substantial rock cutting • has the longest construction duration • requires the most structural elements for construction, (retaining wall, stairs, footpaths, stormwater, etc) These factors combine to make this option the second most expensive of the six options.
Loss of vegetation	The estimated area required for clearing for this option is in the order of 500 m^2 and is made up of: • removal of vegetation including trees to the north and east of the existing bus stop • removal of vegetation at the top of the existing rock cutting. This option requires the removal of the second greatest amount of vegetation after Option E (indented bus stop to the south of Heaton Avenue).

<table>
<tr><th></th><th>Option A
Indented bus stop north of Heaton Avenue (no closure)</th></tr>
<tr><th>Criterion</th><th>Response</th></tr>
<tr><td>Visual impact</td><td>When viewed from Manly Road this option would:
• expose substantial area of new rock face in contrast to the existing weathered rock
• substantially open up the visual scenario through the removal of vegetation
When viewed from Heaton Avenue this option would:
• require a relatively substantial degree of vegetation removal
• require a substantial retaining wall structure facing Heaton Avenue.
This option ranks as the second greatest visual impact of all options.</td></tr>
<tr><td>Construction noise</td><td>Activities associated with construction of this option would include, but not be limited to:
• rock hammering
• rock drilling
• heavy machine operation
• excavation
The majority of construction throughout this location would have to be undertaken at night to prevent peak period traffic impacts. On this basis this option would result in the largest noise impact when compared to other options due to the requirement for high noise rock hammering.
This option would result in the longest duration of noise impact of all options.</td></tr>
<tr><td>Constructability</td><td>This option would involve substantial challenges during planning and construction in order to:
• undertake works only at night
• minimise noise impacts during the early hours of the morning from activities such as rock breaking truck movements
• excavation works on the Manly Road cutting/rock face and the management of material
• manage the construction works to ensure all work material and machinery are either removed or in place for traffic movement the following day
• minimise the impact of construction traffic within the area
• minimise safety risks to the public and workers.
This option would be the equal second most difficult to construct of all the options.</td></tr>
<tr><td>Operational traffic</td><td>For users of the Manly Road kerbside T3 transit lane, including B-Line and local buses, this option:
• does not resolve the delays to traffic in the T3 transit lane resulting from the merging of Heaton Avenue traffic across the T3 transit lane into the general traffic lanes
• resolves the delays to traffic in the T3 transit lane resulting from buses stopping at the existing in-lane bus stop
For Heaton Avenue users this option would:
• retain both left-in and left-out movements to Heaton Avenue
• avoid increases in travel time for some local traffic as a result of the need to divert onto Sydney Road in order to travel south on Manly Road.</td></tr>
</table>

	Option A Indented bus stop north of Heaton Avenue (no closure)
Criterion	**Response**
Road safety	This option: • takes stopping buses out of the kerbside T3 transit lane, reducing the risk of rear end and lane-changing crashes • introduces a risk of merge crashes for buses leaving the indented bus stop • does not address the potential for rear-end crashes as a result of traffic slowing to turn into Heaton Avenue • does not address the safety issues arising from Heaton Avenue traffic entering and merging from T3 transit lane into general traffic lane.
Option A: Outcome of assessment	This option was not selected as it would involve substantial amenity impacts, including likely major night time disturbance from excavation noise, and the substantial cost of excavation. This option would also increase existing road safety risks currently associated with traffic exiting Heaton Avenue once the indented bus stop is constructed (faster kerbside traffic, reduced visibility for both Manly Road and Heaton Avenue traffic). This option meets all objectives for the Proposal except the last i.e. to improve road safety along the A8 corridor between Brookvale and Seaforth. Considering the above factors this option has been ranked as fourth preference overall.

Table 4 Assessment of Option B: Indented bus stop north of Heaton Avenue (permanent half closure)

	Option B: Indented bus stop north of Heaton Avenue (permanent half closure)
Criterion	**Response**
Cost	Construction of the indented bus stop to the north of Heaton Avenue (with half closure of this road): • requires substantial rock cutting (though less than Option A) • has the third longest construction duration • has the third most structural elements required for construction, (retaining wall, stairs, footpaths, stormwater, etc). These factors combine to make this option the third most expensive of the six options.
Loss of vegetation	The estimated area of vegetation removal required is in the order of 430 m^2 and is made up of: • removal of vegetation to the north and east of the existing bus stop • removal of vegetation at the top of the existing rock cutting. This option requires more vegetation removal than Option C (full closure) but less than Options A or E.

	Option B: Indented bus stop north of Heaton Avenue (permanent half closure)
Criterion	**Response**
Visual impact	When viewed from Manly Road this option would: • expose a substantial area of new rock face in contrast to the existing weathered rock • substantially open up the visual scenario through the removal of vegetation When viewed from Heaton Avenue this option would: • require a moderate degree of vegetation removal • require a substantial retaining wall structure facing Heaton Avenue. This option would rank as the third greatest visual impact of all options.
Construction noise	Activities associated with construction of this option would include, but not be limited to: • rock hammering • rock drilling • heavy machine operation • excavation The majority of construction throughout this location would have to be undertaken at night to prevent peak period traffic impacts. Based on the activities required the noise impact generated by this option would be the second highest of all options. The duration of this noise impact would also be the second longest of all options.
Constructability	This option would involve substantial challenges during planning and construction in order to: • undertake works only at night • minimise noise impacts during the early hours of the morning from activities such as rock breaking and truck movements • Manage construction to ensure all work material and machinery is either removed or in place to allow full traffic movement the following day • minimise the impact of construction traffic within the area • minimise safety risks to the public and workers. This option would be the equal second most difficult to construct of all the options.
Operational traffic	For users of the Manly Road kerbside T3 transit Lane, including B-Line and local buses, this option: • does not resolve the delays to traffic in the T3 transit lane resulting from the merging of Heaton Avenue traffic across the T3 transit lane into the general traffic lanes • resolves the delays to traffic in the T3 transit lane resulting from buses holding up T3 transit traffic when they stop at the existing in-lane bus stop For Heaton Avenue users this option would: • retain the left-out movement from Heaton Avenue • removes the left-in movement into Heaton Avenue • avoid increases in travel time for some local traffic as a result of the need to divert onto Sydney Road in order to travel south on Manly Road.

	Option B: Indented bus stop north of Heaton Avenue (permanent half closure)
Criterion	**Response**
Road safety	This option: • takes stopping buses out of the kerbside T3 transit lane, reducing the risk of rear-end and lane-changing crashes • introduces the risk of merge crashes for buses leaving the indented bus stop • addresses the potential for rear-end crashes as a result of traffic slowing to turn into Heaton Avenue • does not address the safety issues arising from Heaton Avenue traffic entering and merging from T3 transit lane into general traffic lane on Manly Road. The opening at Heaton Avenue will be one way out, but could lead to driver confusion with vehicles turning left into Heaton Avenue and entering a one-way section in the wrong direction, potentially resulting in head-on crashes.
Option B: Outcome of assessment	This option was not selected as it would involve substantial amenity impacts, including likely major night time disturbance from excavation noise, and the substantial cost of excavation. This option would also increase existing road safety risks currently associated with traffic exiting Heaton Avenue once the indented bus stop is constructed (faster kerbside traffic, reduced visibility for both Manly Road and Heaton Avenue traffic). This option meets all objectives for the Proposal except the last i.e. to improve road safety along the A8 corridor between Brookvale and Seaforth. **Considering the above factors this option has been ranked as third preference overall.**

Table 5 Assessment of Option C: Indented bus stop north of Heaton Avenue (permanent half closure/peak period full closure (6am to 10am Monday to Friday))

	Option C: Indented bus stop north of Heaton Avenue (permanent half closure/peak period full closure)
Criterion	**Response**
Cost	The costs associated with this option would be the same as Option B with the exception of the additional cost of the traffic management system required to regulate the full closure during peak periods. This is likely to be in the form of a gate that would require opening and closing at the start and end of the morning peak period each weekday.
Loss of vegetation	The degree of vegetation removal for this option would be as per Option B.
Visual impact	The visual impacts associated with this option would be as per Option B with the exception of the presence of peak period traffic management system. This additional infrastructure would result in a negligible change to the visual scenario over that outlined for Option B.
Construction noise	Construction noise for this option would be as per Option B.
Constructability	The constructability of this option would be effectively identical to that of Option B.

	Option C: Indented bus stop north of Heaton Avenue (permanent half closure/peak period full closure)
Criterion	**Response**
Operational traffic	For users of the Manly Road kerbside T3 Lane, including B-Line and local buses, this option: • avoids delays to traffic in the T3 lane resulting from buses holding up T3 traffic when they stop at the existing in-lane bus stop • avoids delays to traffic in the T3 lane resulting from the merging of Heaton Avenue traffic across the T3 lane into the general traffic lanes during the AM peak period only • provides the greatest reduction in travel time for B-Line and local bus services and T3 lane users during the AM peak period. For Heaton Avenue users this option would: • prevent both left-in and left out movements between Manly Road and Heaton Avenue during the AM peak period • prevent left-in movements from Manly Road to Heaton Avenue at all times. This would increase travel time for some local traffic as a result of the need to divert onto Sydney Road in order to travel south on Manly Road.
Road safety	This option: • takes stopping buses out of the kerbside T3 transit lane, reducing the risk of rear end and lane-changing crashes • introduces a risk of merge crashes for buses leaving the indented bus stop • addresses the potential for rear-end crashes as a result of traffic slowing to turn into Heaton Avenue • resolves safety issues arising from Heaton Avenue traffic seeking to merge across the Manly Road T3 transit lane during peak periods • does not address the safety issues arising from Heaton Avenue traffic entering and merging from T3 transit lane into general traffic lane during off-peak periods The opening at Heaton Avenue will be one way outside of peak periods, but could lead to driver confusion with vehicles turning left into Heaton Avenue and entering a one-way section in the wrong direction, potentially resulting in rear-end or head-on crashes.
Option C: Outcome of assessment	This option was not selected as it would involve substantial amenity impacts, including likely major night time disturbance from excavation noise, and the substantial cost of excavation. This option would also increase existing road safety risks currently associated with traffic exiting Heaton Avenue outside of peak periods once the indented bus stop is constructed (faster kerbside traffic, reduced visibility for both Manly Road and Heaton Avenue traffic). This option meets all objectives for the Proposal except the last i.e. to improve road safety along the A8 corridor between Brookvale and Seaforth. Considering the above factors this option has been ranked as second preference overall.

Table 6 Assessment of Option D: Indented bus stop across Heaton Avenue (full closure)

<table>
<tr><th></th><th>Option D: Indented bus stop across Heaton Avenue (full closure)</th></tr>
<tr><th>Criterion</th><th>Response</th></tr>
<tr><td>Cost</td><td>This option:
• requires no rock cutting
• has the shortest overall construction duration
• requires the least structural elements for the construction, (retaining wall, stairs, footpaths, stormwater, etc)
• eliminates safety risks associated with rock cutting during construction.
This option is the least expensive after ‘do nothing’.</td></tr>
<tr><td>Loss of vegetation</td><td>Vegetation removal associated with this option would be limited to minor removal around the top of Heaton Avenue.
This option requires the least amount of vegetation removal after ‘do nothing’.</td></tr>
<tr><td>Visual impact</td><td>When viewed from Manly Road this option would:
• result in no change to the existing rock face
• generally maintain the visual scenario in terms of vegetation
When viewed from Heaton Avenue this option would:
• require a modest retaining wall which would expose the least hard surface to the observer (with the exception of the ‘do nothing’ option’)
This option would rank as the second lowest visual impact after the ‘do nothing’ option.</td></tr>
<tr><td>Construction noise</td><td>Activities associated with construction of this option would include, but not be limited to:
• heavy machine operation
• minor excavation and filling
The majority of construction throughout this location would have to be undertaken at night to prevent peak period traffic impacts. The duration of work would be substantially less than all other options, with the exception of the ‘do nothing’ option.
The construction noise disruption associated with this option would be the second lowest after the ‘do nothing’ option.</td></tr>
<tr><td>Constructability</td><td>This option would require only minor excavation and general construction activity. The nature of the proposed works mean that this option could be constructed with minimal impact upon the use of Manly Road during the day.
This option would also have the benefit of temporarily utilising the closed end of Heaton Avenue for construction laydown and storage.
This option is considered to be the simplest option from a constructability point of view, with the exception of ‘do nothing’.</td></tr>
</table>

	Option D: Indented bus stop across Heaton Avenue (full closure)
Criterion	**Response**
Operational traffic	For users of the Manly Road kerbside T3 transit Lane, including B-Line and local buses, this option: • avoids delays to traffic in the T3 transit lane resulting from buses holding up T3 transit traffic when they stop at the existing in-lane bus stop • avoids delays to traffic in the T3 transit lane resulting from the merging of Heaton Avenue traffic across the T3 transit lane into the general traffic lanes • provides the greatest reduction in travel time for B-Line and local bus services and T3 transit lane users. For Heaton Avenue users this option would: • prevent both left-in and left out movements between Manly Road and Heaton Avenue • increase travel time for some local traffic as a result of the need to divert onto Sydney Road in order to travel south on Manly Road.
Road safety	This option: • takes stopping buses out of the kerbside T3 transit lane, reducing the risk of rear end and lane-changing crashes • introduces a risk of merge crashes for buses leaving the indented bus stop • addresses the potential for rear-end crashes as a result of traffic slowing to turn into Heaton Avenue Safety issues arising from Heaton Avenue traffic entering Manly Road and merging from T3 transit lane into the general traffic lanes are addressed by this option.
Option D: Outcome of assessment	With the exception of the 'do nothing' option this option would result in the lowest degree of impact in terms of noise, vegetation and visual impact. It would result in the greatest benefit for operational traffic, is the safest, the easiest to construct and cheapest of all build options. This option meets all objectives for the Proposal. Considering the above factors this option has been ranked as first preference overall and is therefore the preferred option (see discussion below for further justification).

Table 7 Assessment of Option E: Indented bus stop south of Heaton Avenue (no closure)

	Option E: Indented bus stop south of Heaton Avenue (no closure)
Criterion	**Response**
Cost	Construction of the indented bus stop to the south of Heaton Avenue would: • provide major constructability challenges that would substantially increase construction costs • require substantial structural elements for construction, (foundations, batters, extensive retaining wall, footpaths, drainage etc) • require substantial vegetation removal through direct displacement and the creation of access tracks • require an extended construction period. This option would be the most expensive of all options.

	Option E: Indented bus stop south of Heaton Avenue (no closure)
Criterion	**Response**
Loss of vegetation	This option would require the greatest degree of vegetation removal of all options as a result of direct displacement and the creation of access tracks.
Visual impact	When viewed from Manly Road this option would: • replace the existing guard rail, pedestrian fencing and vegetation with a concrete wall, bus ident and new fencing • substantially open up the visual scenario through the removal of vegetation • open up views across Middle Harbour. When viewed from the east and south of Manly Road (Clontarf and The Spit) this option would: • open up views to Manly Road currently screened by mature vegetation • replace part of the existing vegetated embankment with an extensive concrete structure (columns, slab, retaining walls) to support the bus indent. This option would have the greatest visual impact of all the options.
Construction noise	Activities associated with construction of this option would include, but not be limited to: • drilling and pile driving • the operation of heavy earthworks machinery • excavation and potential rock breaking. The majority of construction throughout this location would have to be undertaken at night to prevent peak period traffic impacts. It is anticipated that this option would result in noise impacts both across Manly Road to the west and into Clontarf to the east. This option would the noisiest of all options under consideration.
Constructability	This option would involve substantial challenges during planning and construction in order to: • undertake works only at night • minimise noise impacts during the early hours of the morning from rock breaking and construction traffic movements • access the base of the existing embankment with materials and construction plant such as truck-mounted drills or pile drivers • removal all existing vegetation • construct a substantial retaining wall structure in currently unknown ground conditions • safely place fill behind the retaining wall • minimise the impact of construction traffic within the area • minimise safety risks to the public and workers. This option would be the equal second most difficult to construct of all the options.

	Option E: Indented bus stop south of Heaton Avenue (no closure)
Criterion	**Response**
Operational traffic	For users of the Manly Road kerbside T3 transit Lane, including B-Line and local buses, this option: • does not resolve the delays to traffic in the T3 transit lane resulting from the merging of Heaton Avenue traffic across the T3 transit lane into the general traffic lanes • resolves the delays to traffic in the T3 transit lane resulting from buses holding up T3 transit traffic when they stop at the existing in-lane bus stop. For Heaton Avenue users this option would : • retain both left-in and left out movements between Manly Road and Heaton Avenue • avoid increases in travel time for some local traffic as a result of the need to divert onto Sydney Road in order to travel south on Manly Road.
Road safety	This option: • takes stopping buses out of the kerbside T3 transit lane, reducing the risk of rear end and lane-changing crashes • introduces a risk of merge crashes for buses leaving the indented bus stop • introduces a risk of merge and lane-change crashes south of Heaton Avenue as kerbside T3 traffic that has exited Heaton Avenue would be focused on merging out of the T3 transit lane and would therefore be paying less attention to bus attempting to exit the indented bus stop • does not address the safety issues arising from Heaton Avenue traffic entering Manly Road and merging from the T3 transit lane into the general traffic lanes.
Option E: Outcome of assessment	This option was not selected as it is the most expensive, would require significant construction activity and result in substantial noise impacts and vegetation removal. The costs and impacts associated with these works are not currently justified by the number of passengers boarding buses at this stop (an average of approximately 49 between 7am and 9am weekdays). This option would also increase existing road safety risks currently associated with traffic exiting Heaton Avenue once the indented bus stop is constructed (faster kerbside traffic, potential conflicts with traffic seeking to merge). This option meets all objectives for the Proposal except the last i.e. to improve road safety along the A8 corridor between Brookvale and Seaforth. Considering the above factors this option has been ranked as sixth preference overall.

Table 8 Assessment of Option F: Do nothing

	Option F: Do nothing
Criterion	**Response**
Cost	The cost for this option would be zero.
Loss of vegetation	There would be no vegetation removal required for this option.
Visual impact	This option would maintain the existing visual scenario.

Option F: Do nothing	
Criterion	**Response**
Construction noise	There would be no construction associated with this option.
Constructability	There would be no construction associated with this option.
Operational traffic	For users of the Manly Road kerbside T3 transit Lane, including B-Line and local buses, this option: • does not resolve the delays to traffic in the T3 transit lane resulting from the merging of Heaton Avenue traffic across the T3 transit lane into the general traffic lanes • does not resolve the delays to traffic in the T3 transit lane resulting from buses holding up T3 transit traffic when they stop at the existing in-lane bus stop. For Heaton Avenue users this option would : • retain both left-in and left out movements between Manly Road and Heaton Avenue. • avoid increases in travel time for some local traffic as a result of the need to divert onto Sydney Road in order to travel south on Manly Road.
Road safety	This option would retain the existing in-lane bus stop in the T3 transit lane along Manly Road, maintaining the risk of rear end and merging crashes. This option would maintain the existing safety risk associated with traffic exiting Heaton Avenue into the T3 transit/bus lane of Manly Road and then seeking to merge into the general traffic lanes prior to the 100 metre limit of travel in this lane.
Option F: Outcome of assessment	This option was not selected as it would not meet the overall objectives of the Proposal (Section 2.1.4), those being: • reduce the peak and off-peak bus journey times in both directions along Pittwater Road, Burnt Bridge Creek Deviation and Manly Road (the A8 corridor) between Brookvale and Seaforth • improve customer experience with improved frequency, capacity and reliability of bus services • improve road safety along the A8 corridor between Brookvale and Seaforth This option also retains several operational traffic and road safety issues currently present at the intersection. Considering the above factors this option has been ranked as fifth preference overall.

Preferred option for Heaton Avenue

The full closure of Heaton Avenue was selected as the preferred option in this location. This option was deemed to most efficiently meet the objectives of the Proposal whilst avoiding the majority of substantial local amenity impacts such as noise and disruption to traffic.

This option would facilitate the improved movement of B-Line and local buses through this area, improve customer experience and reduce existing road safety risks, meeting all of the Proposal's objectives. The cost and constructability of this option were also the most favourable of all options with the exception of 'do nothing'.

It is recognised that this option would result in additional travel time for some local traffic (see Section 6.1). Whilst this impact is regrettable locally it is considered acceptable in the broader context of the benefits provided to the Northern Beaches community and the large number of users of public transport in particular.

Community feedback

Following initial notification of the proposal, the project team received over 400 comments, primarily relating to the closure of Heaton Avenue.

The alternatives raised in these early submissions were considered by the project team in discussions and internal reviews. Alternatives suggested included:

- Doing nothing
- Installing the new bus indent but leaving Heaton Avenue partially or fully open
- Moving the bus bay to another location and leaving Heaton Avenue partially or fully open
- Placing restrictions on use of Heaton Avenue during the AM peak period.

The preferred option and potential alternatives will be further reviewed as part of the formal consultation for the Proposal. Outcomes of additional review will be documented within the Submissions Report prepared on behalf of the project (see Section 5.4.1).

2.2.5. Justification for the preferred option

The preferred option to upgrade on-road infrastructure along Pittwater Road, Burnt Bridge Creek Deviation, Manly Road and Sydney Road through Brookvale, Manly Vale, Balgowlah, Seaforth and Clontarf was selected to meet the objectives of the Proposal (refer to Section 2.1.4). The option was selected as part of a design refinement process developed through a series of meetings, field inspections, workshops, and technical specialist input (such as traffic and noise), in consultation with internal and external stakeholders. The preferred option would allow the objectives of the B-Line Program to be met, in particular the preferred option would:

- reduce the peak and off-peak bus journey times in both directions along Pittwater Road, Burnt Bridge Creek Deviation and Manly Road (the A8 corridor) between Brookvale and Seaforth
- improve customer experience with improved frequency, capacity and reliability of bus services
- improve road safety along the A8 corridor between Brookvale and Seaforth.

3. Description of the Proposal

This chapter describes the Proposal and summarises key design parameters, construction methods, and associated infrastructure and activities. The description of the Proposal is based on the concept design and is subject to further refinement during detailed design.

3.1. The Proposal

As described in Section 1.2, the Proposal includes on-road infrastructure improvements along Pittwater Road, Burnt Bridge Creek Deviation, Manly Road and Sydney Road to support faster and more reliable bus journeys on the north-south corridor. Activities as part of the Proposal would include new turn lanes, new median strip, lane extension and widening, indented bus bay and traffic efficiencies (including improvements to existing and installation of new traffic signage and signalling) to improve the travel time for buses along Pittwater Road, Burnt Bridge Creek Deviation, Manly Road and Sydney Road between Brookvale and Seaforth.

The Proposal includes the following key elements:

- construction of a new left turn lane from Pittwater Road (northbound) into Cross Street
- closure of the median strip within Pittwater Road at the Orchard Road intersection to prevent vehicles from turning right from Pittwater Road into Orchard Road (eastbound) and vehicles turning right from Orchard Road into Pittwater Road (northbound)
- extension of the existing right turn lane from Burnt Bridge Creek Deviation into Sydney Road (westbound)
- construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound)
- extension of the existing through traffic lane from Sydney Road (east) into Sydney Road (west)
- extension of the existing right turn lane from Manly Road into Sydney Road (eastbound) and widening of the left turn slip lane into Sydney Road (eastbound)
- full closure of Heaton Avenue at Manly Road to form a cul-de-sac
- construction of a new indented bus bay on Manly Road (southbound) at the Heaton Avenue intersection
- ancillary works associated with the above elements including road regrading, services diversion and/or relocation, minor drainage works, adjustments to lighting, retaining wall (at Heaton Avenue), upgrades to fencing and landscaping, new line marking and improved/new traffic signal infrastructure.

3.1.1. Scope of works

The Proposed construction and operational activities would be required at strategic locations within the Proposal area. These activities have been categorised into the following Zones and are described below:

Zone A: Pittwater Road from Orchard Road to Cross Street

Construction of a new left turn lane from Pittwater Road into Cross Street (westbound)

- removal of vegetation, including one small palm tree
- relocation of existing below and above ground electrical, gas and water services and utilities located in the road and road reserve south of Cross Street and west of Pittwater Road, where affected by the works
- demolition of existing kerbs, footpath and road concrete
- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- relocation of existing traffic signals and installation of new traffic signals required for the works
- construction of new road pavement, kerbs, road verge and footpath for the new left turn lane
- removal of sections of existing concrete pavement to allow for tie in of the new pavement
- installation of new concrete pavement sub-base at tie in locations
- installation of bitumen overlay
- adjustments to the existing pedestrian crossing across Cross Street
- landscaping at the southern corner of Pittwater Road and Cross Street
- new line marking and adjustments to existing traffic signal infrastructure
- partial acquisition of the adjacent parcel of land to accommodate the wider footprint required for the new left turn lane and footpath area
- *Reason for scope item:* to reduce delays to B-Line and local buses and general traffic travelling north on Pittwater Road by allowing all three through traffic lanes to pass traffic waiting to turn left into Cross Street.

Construction of continued median strip within Pittwater Road at the Orchard Road intersection to prevent vehicles from turning right from Pittwater Road into Orchard Road (northbound) and vehicles turning right from Orchard Road into Pittwater Road (northbound)

- demolition of existing concrete road pavement
- removal of existing statutory signage not required because of the new median strip
- installation of fittings and foundation for new median strip
- construction of new median (around 28 metres long)
- new line marking to designate the existing right turn lane from Pittwater Road into Orchard Road (northbound) as an extension of the right turn lane from Pittwater Road into Sydenham Road (northbound)
- *Reason for scope item:* to mitigate current safety concerns associated with slow right-turning vehicles potentially conflicting with relatively free flowing southbound buses in the Pittwater Road bus lane in the AM peak.

An overview of the proposed works within Zone A is provided in.

Zone B: Sydney Road/Manly Road/Burnt Bridge Creek Deviation

Extension of the existing right turn lane from Burnt Bridge Creek Deviation into Sydney Road (westbound)

- removal of vegetation within the existing median strip
- demolition and excavation existing kerbs and median strip
- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- construction of new road pavement, median and kerbs for the extended right turn lane
- new line marking
- *Reason for scope item:* to allow greater storage for vehicles waiting to turn right, reducing the potential for queuing traffic to impede the through lanes of Burnt Bridge Creek Deviation/Manly Road.

Construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)

- removal of vegetation within the road verge on the corner of Sydney Road
- demolition and excavation of existing road pavement, kerbs, pedestrian pathway and road verge
- relocation of existing below and above ground electrical, communication and water services and utilities located in the road and road reserve north of Sydney Road, where affected by the works
- construction of new road pavement, kerbs, pedestrian pathway and road verge for the new left turn lane
- relocation of existing safety barrier
- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- relocation of existing traffic signals and installation of new traffic signals required for the works
- installation of a low retaining wall between the new left turn lane and pedestrian pathway to account for differing grade heights, including pedestrian safety fencing along retaining wall
- new line marking and adjustments to existing traffic signal infrastructure
- narrow partial acquisition of embankment alongside pedestrian pathway in Council park
- *Reason for scope item:* to allow greater storage for vehicles waiting to turn left, reducing the potential for queuing traffic to impede the through lanes of Sydney Road.

Upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound)

- removal of vegetation within the eastern road verge of Burnt Bridge Creek Deviation

- demolition and excavation of existing road pavement, kerbs and road verge
- relocation of existing below and above ground electrical, communication and water services and utilities located in the road and road reserve north of Sydney Road, where affected by the works
- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- construction of new road pavement, kerbs, pedestrian pathway and road verge for the upgrade of the left turn slip lane
- widen the existing traffic island at the north-eastern corner of Burnt Bridge Creek Deviation and Sydney Road
- new line marking including re-alignment of the existing pedestrian crossing (non-signalised) across the upgraded slip lane
- *Reason for scope item:* to provide more road space to be dedicated to through traffic lanes heading east on Sydney Road and to provide a more acute angle within the slip lane to increase driver vision of traffic when merging onto Sydney Road.

Extension of the Sydney Road (westbound) through traffic lane on the eastern side of the Burnt Bridge Creek Deviation/Manly Road intersection

- demolition and excavation of the existing road pavement, kerbs and median strip within Sydney Road from Manly Road to around Maretimo Street
- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- Sydney Road to be narrowed from three to two lanes eastbound from Burnt Bridge Creek Deviation intersection
- reconfiguration of one existing eastbound traffic lane along Sydney Road into an extension of the westbound through traffic lane along Sydney Road across the Burnt Bridge Creek Deviation/Manly Road intersection
- construction of new road pavement, kerbs, and median within Sydney Road
- new line marking
- removal of two on-street parking spaces on Sydney Road (eastbound) to the east of Dudley Street
- relocation of bus stop (Sydney Road, near Dudley St) on Sydney Road (eastbound) to eastwards by approximately 40 m, including new bus shelter
- *Reason for scope item:* to allow greater storage for vehicles waiting to pass through the intersection towards Sydney Road west, reducing the potential for queuing traffic to impede the left turn lanes.

Extension of the existing right turn lane from Manly Road into Sydney Road (eastbound) and widening of the left turn slip lane into Sydney Road (westbound)

- demolition and excavation of existing road pavement, kerbs and the southern part of the median
- construction of new road pavement and kerbs for the extended right turn lane

- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- new line marking, including the widening of the existing left turn lane into Sydney Road (westbound)
- *Reason for scope item:* to allow greater storage for vehicles waiting to turn right, reducing the potential for queuing traffic to impede the through lanes of Manly Road/Burnt Bridge Creek Deviation.

An overview of the proposed works within Zone A is provided in

Zone C: Manly Road/Heaton Avenue intersection

Full closure of Heaton Avenue at Manly Road to form a cul-de-sac

- removal of vegetation within the northern road verge of Heaton Avenue
- relocation of existing below ground electrical and water service utilities and installation of new services in the road and road reserve around the junction of Heaton Avenue with Manly Road
- demolition and excavation of existing road pavement, kerbs and pedestrian pathway
- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- construction of new pedestrian pathway and retaining wall
- landscaping for new cul-de-sac
- new line marking
- *Reason for scope item:* to facilitate the construction of an indented bus bay to allow B-Line and local buses (and other bus lane traffic) to pass buses stopped to pick up or set down passengers at this location and to eliminate road safety issues associated with traffic merging out of Heaton Avenue into Manly Road.

Construction of a new indented bus bay on Manly Road (southbound) at the Heaton Avenue intersection

- removal of vegetation within the eastern road verge of Manly Road
- relocation of existing below ground and above ground electrical and water service utilities and installation of new services in the road and road reserve around the junction of Heaton Avenue with Manly Road
- demolition and excavation of existing road pavement, kerbs, pedestrian pathway and bus shelter
- construction of new road pavement and kerbs for the new indented bus bay (about 3 metres wide and 28 metres long, including a 15 metre taper at each end)
- construction of new bus shelter
- relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
- construction of new footpath and retaining wall

- replacement of existing guard rails
- new line marking
- *Reason for scope item:* to allow B-Line and local buses (and other bus lane traffic) to pass buses stopped to pick up or set down passengers at this location.

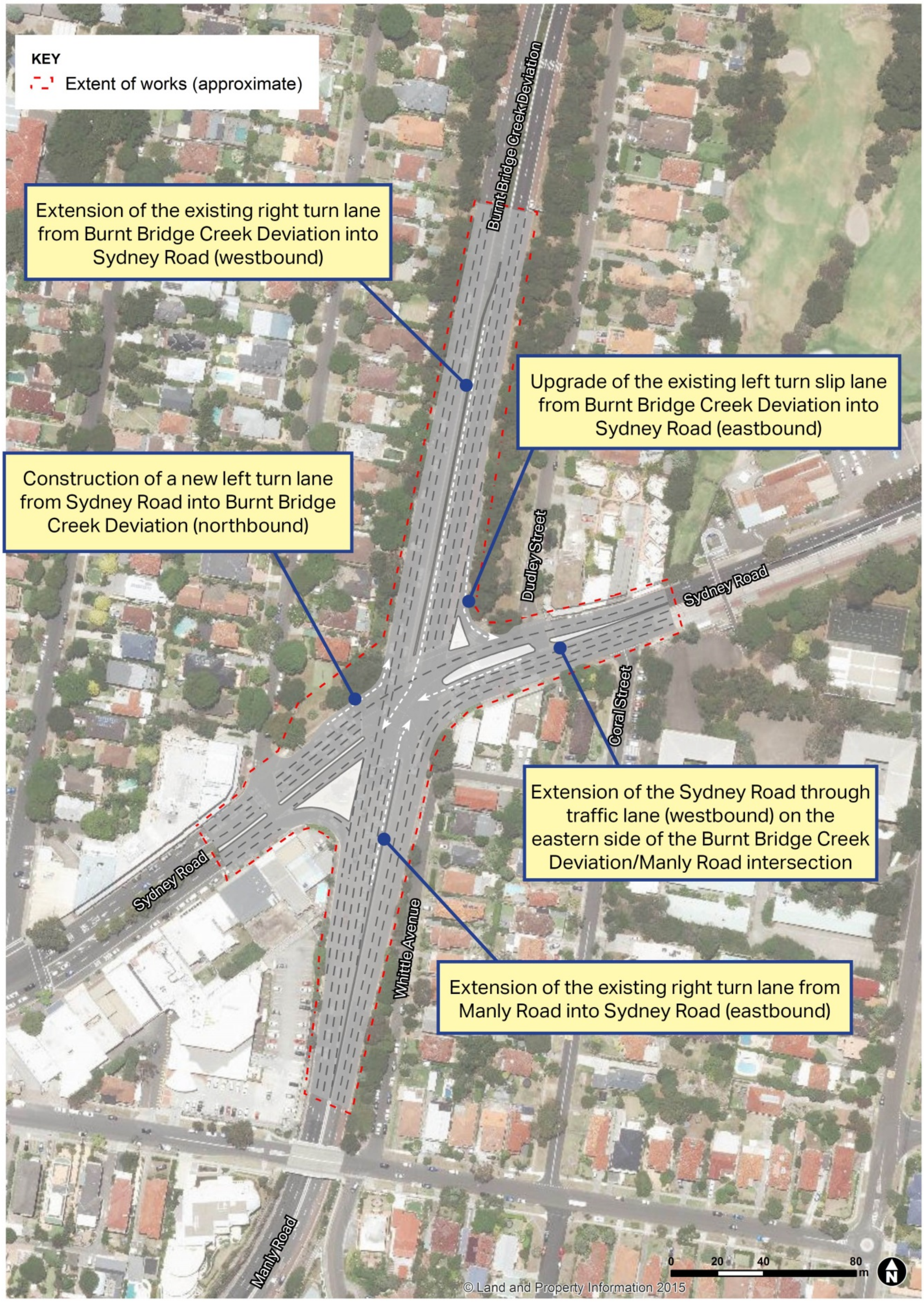
An overview of the proposed works within Zone A is provided in

Manly Vale Commuter Car Park construction compound

- continued use of the temporary construction compound for the Manly Vale Commuter Car Park beyond the initial construction period
- *Reason for scope item*: to provide a base from which construction activities may be coordinated and managed.

Figure 16, Figure 17 and Figure 18 show the general layout of key elements for the Proposal. Figure 19 shows the location of the proposed construction compound.

Figure 16 Key elements of the Proposal – Zone A



Key features of proposed works

Figure 17 Key elements of the Proposal – Zone B

Figure 18 Key elements of the Proposal – Zone C

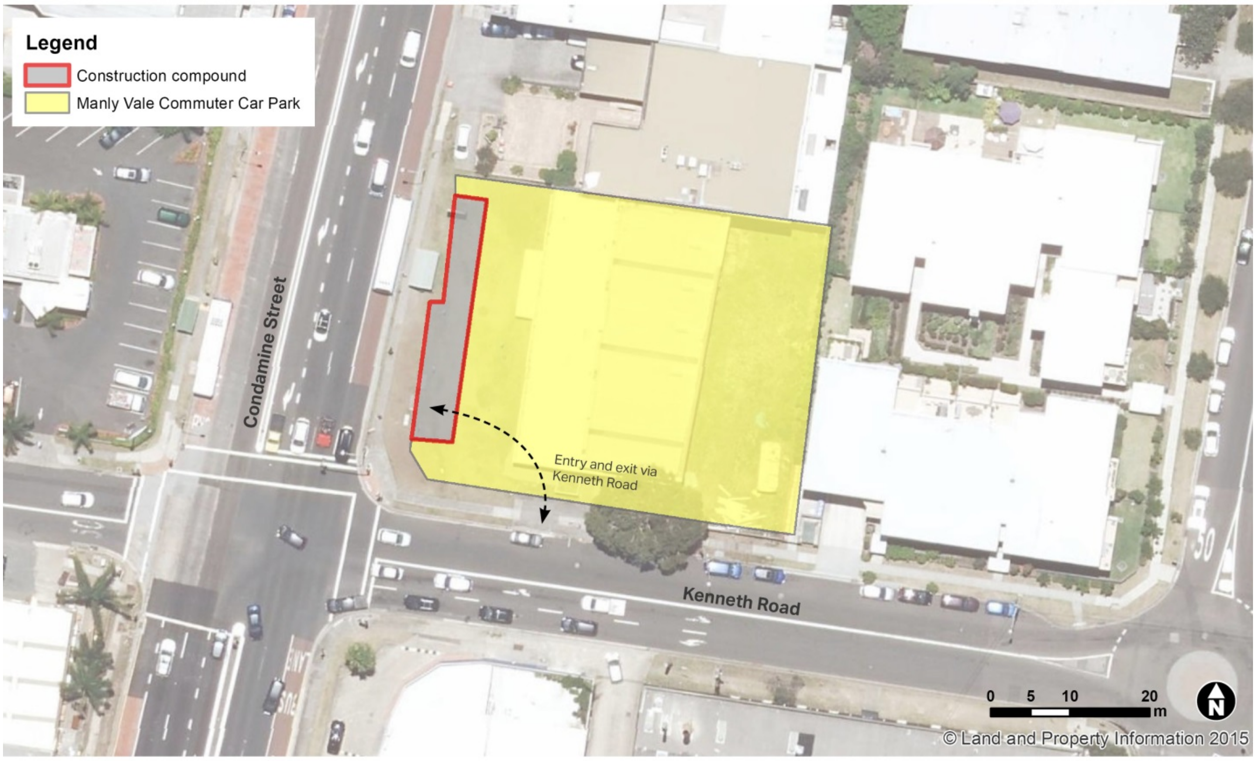


Figure 19 Manly Vale Commuter Car Park Construction compound

3.1.2. Engineering constraints

There are a number of constraints which have influenced the development of the concept design. These include:

- existing road widths
- minimum travel lane widths
- existing above ground and below ground services
- existing trees
- existing rock cuttings.

3.1.3. Design standards

The Proposal has been designed having regard to the following:

- *Disability Standards for Accessible Public Transport* 2002 (issued under the Commonwealth *Disability Discrimination Act 1992*)
- Building Code of Australia
- relevant Australian Standards
- Roads and Maritime Road Design Guidelines
- TfNSW Asset Standards Authority standards
- TfNSW *Wayfinding Design Guide*
- *NSW Sustainable Design Guidelines – Version 3.0* (TfNSW, 2013a)

- *Guidelines for the Development of Public Transport Interchange Facilities* (Ministry of Transport, 2008)
- Warringah Local Environmental Plan 2011
- Warringah Development Control Plan 2011
- Manly Local Environmental Plan 2013
- Manly Development Control Plan 2013
- *AustRoads Guide to Road Design* (AustRoads 2015).

3.1.4. Sustainability in design

An overarching sustainability strategy has been prepared for the Northern Beaches B-Line Program. This strategy describes how the program will address sustainability generally throughout construction and operation.

The design of the Proposal has been undertaken in accordance with the project targets identified in TfNSW's *NSW Sustainable Design Guidelines - Version 3.0* (TfNSW, 2013a) which groups sustainability into seven themes:

- energy and greenhouse gases
- climate resilience
- materials and waste
- biodiversity and heritage
- water
- pollution control
- community benefit.

Within each theme, potential initiatives are prioritised into two categories of requirements:

- **compulsory** – the initiative is required to be implemented when applicable to the project as they refer to a corporate target, or are fundamental to the delivery of sustainable assets
- **discretionary** – the initiative has benefits when implemented, however may not be the most appropriate.

The Sustainable Design Guidelines also specify a minimum level of compliance within each category: 100 per cent of applicable compulsory initiatives and 50 per cent of the applicable discretionary points are to be applied through each stage of design.

It is currently anticipated that the Proposal would achieve a 'gold' sustainability in design rating. This corresponds with approximately 80 per cent of applicable discretionary points being achieved.

Further assessment of the Proposal against the Guidelines would be undertaken during the detailed design phase. Notably, during detailed design some discretionary initiatives may prove unfeasible, in which case they would be excluded. Refer to Section 6.11 for further detail.

3.2. Construction activities

3.2.1. Work methodology

Subject to approval, construction of the Proposal is expected to commence in early 2017 and take approximately 9 nine months to complete. The B-Line service is expected to be operational by October late 2017. The construction methodology would be further developed during detailed design of the Proposal by the nominated construction contractor in consultation with Roads and Maritime.

The key construction activities and their staging for the Proposal are identified in Table 9. The staging is indicative and is based on the current concept design, which may be subject to change once the detailed design methodology is finalised. The staging is also dependent on the construction contractor's preferred methodology, program and sequencing of work. In the event that construction staging results in environmental impacts above those assessed in this REF, further environmental assessment would be required to be undertaken and approved by Roads and Maritime.

Table 9 Indicative construction staging for key activities

Stage	Activities
Site mobilisation and establishment	• establishment of site compound (i.e. erect fencing, tree protection zones, site offices, amenities and plant/material storage areas) • establishment of temporary facilities as required (i.e. traffic controls).
Enabling works	• survey and potholing • removal of identified vegetation • investigation and relocation of services (where required).
Road works	• demolition of the existing concrete road, road verge, kerbs and pedestrian pathways • resurfacing • construction of new road pavement for slip lanes, bus bays, right / left hand turns etc.
Drainage, line marking and signalling	• upgrades to kerbs, gutters and footpaths • line marking and new signalling

3.2.2. Working hours

The majority of works would need to occur outside standard NSW Environment Protection Authority (EPA) standard construction hours in order to minimise disruption to traffic and access and would include night works. Approval from Roads and Maritime would be required for the majority of works which would be out of hours and the affected community would be notified as outlined in the *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016) (refer to Section 6.3 for further details).

Where possible, and where works would not significantly obstruct traffic, works would be undertaken during standard construction hours, which are as follows:

- 7.00am to 6.00pm Monday to Friday

- 8.00am to 1.00pm Saturdays
- no work on Sundays or public holidays.

3.2.3. Earthworks

The Proposal would require excavation and earthworks for the following:

- trenching excavation for the relocation of existing and installation of new services around the proposed left turn lane in Zone A, intersection improvements in Zone B and the new bus indent in Zone C
- demolition of existing and construction of new road pavement, medians, road verges and kerbs, footpaths etc.
- other minor civil works including longitudinal regrading
- removal of non-contaminated soil from the works area (quantities to be determined during detailed design)
- use of imported clean fill where required (quantities to be determined during detailed design).

All excavated material would be disposed of in accordance with relevant legislative requirements (Section 3.2.4). Works would be undertaken in accordance with a Construction Environmental Management Plan (CEMP) and appropriate erosion and sediment controls would be installed and maintained in accordance with the requirements of the 'Blue Book' *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004), (hereafter referred to as the Blue Book).

3.2.4. Source and quantity of materials

The source and quantity of materials would be determined during the detailed design phase of the Proposal, and would consider the requirements of the *NSW Sustainable Design Guidelines – Version 3.0* (TfNSW, 2013a). Materials would be sourced from local suppliers where practicable. Reuse of existing and recycled materials would be undertaken where practicable.

3.2.5. Traffic access and vehicle movements

Traffic and transport impacts associated with the Proposal are assessed in Section 6.1 of this REF. The potential traffic and access impacts expected during the construction of the Proposal for each zone include:

Zone A: Pittwater Road from Orchard Road to Cross Street

- temporary impacts to pedestrians and cyclists through changes in access during construction (e.g. demolition of road verges and pedestrian pathways)
- higher road safety risk levels associated with construction vehicle-pedestrian interactions
- delivery and removal of materials to and from the Proposal area during construction including concrete and general waste
- temporary loss of up to 15 parking spaces within Warringah Mall car park during construction

- interruptions to traffic flow along Pittwater Road and Cross Street, particularly during road works.

Zone B: Sydney Road/Manly Road/Burnt Bridge Creek Deviation

- temporary impacts to pedestrians, cyclists and bus customers through changes in access during construction (e.g. demolition of road verges and pedestrian pathways)
- higher road safety risk levels associated with construction vehicle-pedestrian interactions
- permanent loss of two parking spaces on Sydney Road, east of Dudley Street
- delivery and removal of materials to and from the Proposal area during construction including waste and concrete
- interruptions to traffic flow along Sydney Road, Manly Road and Burnt Bridge Creek Deviation, particularly during road works.

Zone C: Manly Road/Heaton Avenue intersection

- temporary impacts to pedestrians, cyclists and bus customers through changes in access during construction (e.g. demolition of road verges and pedestrian pathways)
- higher road safety risk levels associated with construction vehicle-pedestrian interactions
- delivery and removal of materials to and from the Proposal area during construction including waste and concrete
- interruptions to traffic flow along Manly Road, particularly during road works
- prevention of traffic flow from Heaton Avenue to Manly Road following closure of Heaton Avenue.

A detailed construction methodology and associated management plans (including a CEMP) would be developed during the detailed design phase of the Proposal to manage impacts.

3.2.6. Ancillary facilities

A temporary construction compound would be required to accommodate a site office, amenities, machinery, and laydown and storage area for materials. A construction compound site has been proposed within the same location as the construction site for the new Manly Vale B-Line commuter car park, on the corner of Condamine Street and Kenneth Road.

The Proposal would utilise the same construction compound footprint though would extend the length of time that it would be in use by around six months. The environmental assessment of the Manly Vale Commuter Car Park was undertaken as part of the *Manly Vale Commuter Car Park and B-Line Stops Review of Environmental Factors* (TfNSW, March 2016). Construction for this facility has not yet commenced.

During detailed design an alternative location for the construction compound may be deemed to be required. Should this occur the alternative compound location would be the subject of a separate and additional environmental assessment and approval.

An overview of the proposed Manly Vale Commuter Car Park construction compound is provided in Figure 19.

3.2.7. Public utility adjustments

Temporary connections to utilities would be required for the construction compound and site facilities including but not limited to potable water, electricity, sewer and communication services. Based on investigations to date utility adjustments are considered necessary at Cross Street, Sydney Road and Heaton Avenue.

The Proposal has been designed to avoid the relocation of services; however utility adjustments would be required for the construction of left turn lanes at Cross Street and Sydney Road and for the bus indent at Heaton Avenue. This would require the relocation of existing below ground service utilities in the road verge of Pittwater Road at Cross Street and Sydney Road at Burnt Bridge Creek Deviation. In both cases utilities would be away from the current road moved, closer to existing property boundaries. The existing location of utilities at Heaton Avenue is still being investigated however it is likely that existing utilities running along the footpath down Manly Road would be required to be moved eastwards towards the property boundaries.

The utility design will be further investigated during detailed design

3.3. Property acquisition

The Proposal area is located on land owned by Northern Beaches Council, Roads and Maritime, and a private landowner.

Two partial property acquisitions would be required on the corner of Pittwater Road and Cross Street in Zone A, and on the corner of Sydney Road and Burnt Bridge Creek Deviation in Zone B.

The partial acquisition in Zone A would include the acquisition of an approximately 75 metre strip of land along the Pittwater Road boundary of the property (Warringah Mall) and approximately 20 metres along Cross Street. The strip to be acquired would be approximately 6-8 metres in depth in order to accommodate the new left turn bay in this location.

The B-line project team would engage the private landowner of the Warringah Mall complex to identify potential business impacts and to identify mitigation measures that may be applied during construction. This would be undertaken in parallel with the preparation and assessment of the Proposal’s design.

The B-Line project team would also consult with Northern Beaches Council regarding the partial acquisition of the verge of Cross Street adjacent to its junction with Pittwater Road. The B-line project team would engage with Council to identify potential impacts and mitigation measures.

The partial acquisition in Zone B would include the acquisition of an approximately 35 metre strip of land along the Sydney Road boundary of the property at the Corner of Sydney Road and Burnt Bridge Creek Deviation. This property is currently a public park. The B-line project team would engage the property owner, Northern Beaches Council, to identify potential impacts and mitigation measures. This will be undertaken in parallel with the preparation and assessment of the Proposal’s design.

4. Statutory considerations

This chapter provides a summary of the statutory considerations relating to the Proposal including a consideration of NSW Government polices/strategies, NSW legislation (particularly the EP&A Act), environmental planning instruments, and Commonwealth legislation.

4.1. Commonwealth legislation

4.1.1. Environment Protection and Biodiversity Conservation Act 1999

The (Commonwealth) EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places - defined in the EPBC Act as 'matters of National Environmental Significance (NES)'. The EPBC Act requires the assessment of whether the Proposal is likely to result in a significantly impact upon matters of NES or Commonwealth land. These matters are considered in full in Appendix A.

The Proposal would not impact on any matters of NES or on Commonwealth land. Therefore a referral to the Commonwealth Minister for the Environment is not required.

4.2. NSW legislation and regulations

4.2.1. Environmental Planning and Assessment Act 1979

The EP&A Act establishes the system of environmental planning and assessment in NSW. This Proposal is subject to the environmental impact assessment and planning approval requirements of Part 5 of the EP&A Act. Part 5 of the EP&A Act specifies the environmental impact assessment requirements for activities undertaken by public authorities, such as TfNSW, which do not require development consent under Part 4 of the EP&A Act.

In accordance with Section 111 of the EP&A Act, TfNSW, as the proponent and determining authority, must examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the Proposal.

Clause 228 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) defines the factors which must be considered when determining if an activity assessed under Part 5 of the EP&A Act would have a significant impact on the environment.

Chapter 5.1.2 of the REF provides an environmental impact assessment of the Proposal in accordance with clause 229 and Appendix B specifically responds to the factors for consideration under clause 228.

4.2.2. Other NSW legislation and regulations

Table 10 provides a review of other relevant legislation applicable to the Proposal.

Table 10 Other legislation applicable to the Proposal State Environmental Planning Policies

Applicable legislation	Considerations
Crown Lands Act 1987 (NSW)	The Proposal does not involve works on any Crown Land.
Disability Discrimination Act 1992 (DDA) (Commonwealth)	The Proposal would be designed having regard to the requirements of the DDA.
Fisheries Management Act 1994 (NSW)	Adequate stormwater quality measures would be implemented to seek to prevent adverse impacts on nearby natural watercourses. The Proposal would not affect any listed threatened species, populations, ecological communities, or marine vegetation or involve dredging or dam works.
Heritage Act 1977 (Heritage Act) (NSW)	The Heritage Act provides for the conservation of environmental heritage in NSW. Development affecting State-listed heritage items or activities cannot be carried out without the following: • Sections 57 and 60 (approval) where items listed on the State Heritage Register would be affected • Sections 139 and 140 (permit) where relics are likely to be exposed • Section 170 (consultation) where items listed on a government agency Heritage and Conservation Register would be affected. A search of NSW State Heritage Register (SHR) and State Heritage Inventory, the Australian Heritage Database (including Commonwealth and National Heritage lists and the Register of the National Estate (RNE)), and local planning instruments (Warringah LEP 2011 and Manly LEP 2013) revealed no listed State heritage items within the immediate vicinity of the Proposal. Refer to Section 6.5.
National Parks and Wildlife Act 1974 (NPW Act) (NSW)	Sections 86, 87 and 90 of the NPW Act require consent from OEH for the destruction or damage of Indigenous objects. It is considered unlikely that the Proposal would disturb any Indigenous objects of Aboriginal heritage significance (refer Section 6.4). However, if unexpected archaeological items or items of Aboriginal heritage significance Indigenous heritage significance are discovered during the construction of the Proposal, all works would cease and appropriate advice sought.
Noxious Weeds Act 1993 (NSW)	The *Noxious Weeds Act 1993* (NW Act) establishes a system for the identification and control of noxious weeds in NSW. Under section 13 of the NW Act, public authorities are required to control weeds that are likely to spread to adjoining land. The majority of the Proposal would be undertaken in previously cleared and disturbed areas, and noxious weeds are not expected to be encountered or disturbed. However, if noxious weeds are encountered, they would be managed and disposed of in accordance with the NW Act to an appropriate waste facility.
Protection of the Environment Operations Act 1997 (POEO Act) (NSW)	The Proposal does not involve a 'scheduled activity' under Schedule 1 of the POEO Act. Accordingly, an Environment Protection Licence (EPL) is not required for the Proposal. However, in accordance with Part 5.7 of the POEO Act, TfNSW would notify the EPA if any pollution incidents occur on site during construction. This would be managed within the CEMP to be prepared and implemented by the Contractor.

Applicable legislation	Considerations
Roads Act 1993 (Roads Act) (NSW)	Section 138 of the Roads Act requires consent from the relevant road authority for the carrying out of work in, on or over a public road. Clause 5(1) in Schedule 2 of the Roads Act states that public authorities do not require consent for works on unclassified roads. The Proposal would involve works on Pittwater Road, Burnt Bridge Creek Deviation, Manly Road and Sydney Road, all are classified roads maintained by Roads and Maritime. Cross Street, Orchard Road and Heaton Avenue are local roads and consent is not required for those works. Regardless, consultation with the Northern Beaches Council has commenced and is ongoing. Consent under the Roads Act is not required; however Road Occupancy Licence/s would be obtained from the relevant roads authority by the Contractor for road works and any temporary road closures.
Sydney Water Act 1994 (NSW)	The Proposal would not involve discharge of wastewater to the sewer.
Threatened Species Conservation Act 1995 (TSC Act) (NSW)	The Proposal area does not contain suitable habitat for any listed threatened species, population or community listed under the TSC Act and as such, the Proposal is unlikely to result in a significant impacts upon any threatened species or community same listed under the TSC Act (refer Section 6.7.
Waste Avoidance and Resource Recovery Act 2001 (WARR Act) (NSW)	TfNSW would carry out the Proposal having regard to the requirements of the WARR Act. A site specific Waste Management Plan would be prepared and implemented during construction as part of the CEMP.
Water Management Act 2000 (NSW)	The Proposal would not involve any water use, water management works, drainage or flood works, controlled activities or aquifer interference.

4.3. State Environmental Planning Policies

4.3.1. State Environmental Planning Policy (Infrastructure) 2007

Permissibility

State Environmental Planning Policy (Infrastructure) 2007 (the Infrastructure SEPP) is the key environmental planning instrument which determines the permissibility of a Proposal and under which part of the EP&A Act an activity or development may be determined.

Clause 94(1) of the Infrastructure SEPP allows for the development of "*a road or road infrastructure facilities*" by or on behalf of a public authority without consent on any land. Clause 93 defines "*road infrastructure facilities*" as including elements such as *"bus lanes, transit lanes, associated public transport facilities for roads used to convey passengers by means of regular bus services, bus layovers that are integrated or associated with roads, traffic control facilities and safety works".*

Clause 5 defines *"associated public transport facilities"* as including "*bus bays and bus layovers".* In addition, Clause 94(2) allows development that is in connection with a "*road or road infrastructure facility"* and includes "*alterations or additions to an existing road (such as widening, duplication or reconstruction of lanes, changing the alignment or strengthening of the road".*

The Proposal falls within the definition of "*road or road infrastructure facilities*" and "*associated public transport facilities*" and is therefore permissible without development consent and can be assessed and determined under Part 5 of the EP&A Act.

Part 2 of the Infrastructure SEPP contains provisions for public authorities to consult with local councils and other agencies prior to the commencement of certain types of development. Section 5 of this REF outlines the consultation undertaken in accordance with the requirements of the Infrastructure SEPP.

The Infrastructure SEPP prevails over all other environmental planning instruments except where *State Environmental Planning Policy (Major Development) 2005*, *State Environmental Planning Policy No 14 – Coastal Wetlands* or *State Environmental Planning Policy No 26 – Littoral Rainforest* applies. The Proposal is not of a type or located on land to which these SEPPs apply and therefore these SEPPs are not considered further within this REF.

4.3.2. State Environmental Planning Policy (State and Regional Development) 2011

State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP) provides that development by or on behalf a public authority for the purposes listed in the schedules of the SRD SEPP be designated as State Significant Infrastructure. State significant infrastructure requires approval from the Minister of Planning under Part 5.1 of the EP&A Act.

The Proposal does not trigger the State Significant Infrastructure provisions of the SRD SEPP. In addition the Proposal is not listed as State Significant Development under the SRD SEPP.

4.3.3. State Environmental Planning Policy 55 – Remediation of Land

SEPP 55 provides a State-wide approach to the remediation of contaminated land for the purpose of minimising the risk of harm to the health of humans and the environment. While development consent for the Proposal is not required, the provisions of SEPP 55 have still been considered in the preparation of this REF.

Due to the nature of the Proposal, it is unlikely that any large-scale remediation (Category 1) work would be required as part of the Proposal.

4.3.4. State Environmental Planning Policy No. 19 - Bushland in Urban Areas

SEPP 19 protects and preserves bushland within certain urban areas, as part of the natural heritage or for recreational, educational and scientific purposes. SEPP 19 is designed to protect bushland in public open space zones and reservations, and to ensure that bush preservation is given a high priority when local environmental plans for urban development are prepared.

Schedule 1 of the SEPP lists areas/part areas to which the Policy applies. Warringah and Manly LGA (now Northern Beaches LGA) are listed within Schedule 1. The SEPP states that public authorities cannot disturb bushland zoned or reserved for open space without consideration of the aims of the SEPP.

The Proposal involves the removal of vegetation; however this is not on land zoned for open space and therefore the SEPP does not apply.

4.4. Local environmental planning instruments and development controls

The Proposal is located within the Northern Beaches LGA. The provisions of the Infrastructure SEPP mean that Local Environmental Plans (LEPs), prepared by councils for an LGA, do not apply to Infrastructure SEPP activities. However, during the preparation of this REF, the provisions of the Warringah LEP 2011 and Manly LEP 2013 and associated strategic plans were considered in the following sections.

4.4.1. Warringah Local Environmental Plan 2011

The Warringah LEP is the governing plan for the part of the Northern Beaches LGA (formerly the Warringah LGA) relevant to Zone A. Under the Warringah LEP 2011, Pittwater Road and Burnt Bridge Creek Deviation are zoned as infrastructure (classified road). The area surrounding Zone A, B and E is zoned as business development, general industrial, commercial core, local centre, general residential and low density residential.

Table 11 summarises the relevant aspects of the Warringah LEP provisions applicable to the Proposal.

Table 11 Relevant provisions of the Warringah LEP

Provision	Relevance to the Proposal
Clause 2.3 – Zone objectives and Land Use Table	Under the Warringah LEP 2011: • Pittwater Road and Burnt Bridge Creek Deviation are zoned as SP2 Infrastructure – classified road • shops and businesses along Pittwater Road are zoned B5 Business Development, IN1 General Industrial, B3 Commercial Core and B2 Local Centre The Proposal is consistent with the objectives of each zone.
Clause 5.9 - Preservation of trees or vegetation	Clause 5.9 of the Warringah LEP 2011 is aimed at the preservation of trees and development consent is required for tree removal in most instances. However by virtue of clause 5(3) and 79 of the Infrastructure SEPP, the clearing of vegetation for the Proposal is permissible without development consent and would be approved by Part 5 of the EP&A Act. A discussion of potential impacts to vegetation is discussed in Section 6.7.
Clause 5.10 – Heritage conservation	Clause 5.10 of the Warringah LEP 2011 aims to conserve the heritage significance of heritage items within the Northern Beaches LGA. There are no known Aboriginal or non-Aboriginal heritage items located within the Proposal area. A discussion of potential impacts to non- Aboriginal Indigenous heritage is discussed in Section 6.5.
Clause 6.2 – Earthworks	Clause 6.1 of the Warringah LEP 2011 aims to ensure that earthworks for which development consent is required would not have a detrimental impact on environmental functions and processes, waterways and riparian land, neighbouring uses, cultural or heritage items or features of the surrounding land. By virtue of clause 5(3) and 79 of the Infrastructure SEPP, the Proposal is permissible without development consent and would be approved under Part 5 of the EP&A Act. Consideration of earthworks for the Proposal is outlined in Section 3.2.3.

4.4.2. Manly Local Environmental Plan 2013

The Manly LEP is the governing plan for the part of the Northern Beaches LGA (formerly Manly LGA) relevant to Zone C and Zone C of the Proposal area. Under the Manly LEP 2013, Burnt Bridge Creek Deviation, Manly Road and Sydney Road are zoned as infrastructure (classified road). Surrounding Zone B and C, the area is zoned as general residential, low density residential, local centre, neighbourhood centre and public recreation.

Table 12 summarises the relevant aspects of the Warringah LEP provisions applicable to the Proposal.

Table 12 Relevant provisions of the Manly LEP

Provision	Relevance to the Proposal
Clause 2.3 – Zone objectives and Land Use Table	Under the Manly LEP 2013: • Burnt Bridge Creek Deviation, Manly Road and Sydney Road are zoned as SP2 Infrastructure – classified road • surrounding Zone B, the area is zoned as R1 General Residential, B2 Local Centre, B1 Neighbourhood Centre and RE1 Public Recreation • the area surrounding Zone C is predominately zoned R2 Low Density Residential and RE1 Public Recreation. The Proposal is consistent with the objectives of each zone.
Clause 5.9 - Preservation of trees or vegetation	Clause 5.9 of the Manly LEP 2013 is aimed at the preservation of trees and development consent is required for tree removal in most instances. However by virtue of clause 5(3) and 79 of the Infrastructure SEPP, the clearing of vegetation for the Proposal is permissible without development consent and would be approved by Part 5 of the EP&A Act. A discussion of potential impacts to vegetation is discussed in Section 6.7.
Clause 5.10 – Heritage conservation	Clause 5.10 of the Manly LEP 2013 aims to conserve the heritage significance of heritage items within the Northern Beaches LGA. There are no known Aboriginal or non-Aboriginal heritage items located within the Proposal area. A discussion of potential impacts to non-Aboriginal heritage is discussed in Section 6.5.
Clause 6.2 – Earthworks	Clause 6.1 of the Manly LEP 2013 aims to ensure that earthworks for which development consent is required would not have a detrimental impact on environmental functions and processes, waterways and riparian land, neighbouring uses, cultural or heritage items or features of the surrounding land. By virtue of clause 5(3) and 79 of the Infrastructure SEPP, the Proposal is permissible without development consent and would be approved under Part 5 of the EP&A Act. Consideration of earthworks for the Proposal is outlined in Section 3.2.3.

Local strategies and plans

A number of local plans and studies within the Northern Beaches LGA are relevant to the Proposal. These are briefly outlined in Table 13.

Table 13 Additional local plans/strategies

Plan/Strategy	Comment
Warringah Creek Management Study (Warringah Council, 2004)	
The management study aims to develop an understanding of the water quality and ecological processes of creeks and associated habitats. The study identifies existing and future development pressures confronting creeks, and provides Council with the necessary information and recommendations to implement effective short and long-term creek management strategies and action policies. The study splits Warringah into separate catchment boundaries.	The Proposal is located within the Brookvale Creek and Burnt Bridge Creek catchment boundaries. These catchments include riparian zones and buffer zones. The Proposal would be confined to existing road infrastructure and would not traverse any riparian and/or buffer zones. Mitigation measures would be implemented to ensure construction does not impact on water quality.
Manly Lagoon Estuary Management Plan (Warringah Council, 1998)	
Estuary management plan aims to: • protect and conserve estuarine habitats and ecosystems at Manly lagoon • prevent future degradation and undertake repair of past damage • achieve ecologically sustainable use of local estuarine resources • conserve aesthetic values of the estuaries and wetlands.	The Proposal is located within the Manly Lagoon catchment area. The Proposal aims to minimise any impact on the lagoon catchment through the implementation of mitigation measures outlined in Table 43.
Manly Lagoon and Catchment Integrated Catchment Management Strategy and Evaluation (Warringah Council, 2004)	
The Plan recommends the development and adaptive implementation of a Five Year Action Plan for the Manly Lagoon catchment. The Five Year Action Plan aims to: • enhance investment in the catchment to address priority issues of diffuse pollution, high velocity stormwater flows and sewage exfiltration, infiltration and overflows • advance understanding of the causes of pollution and the decline in catchment values • improve appreciation and the development of better means to engage and galvanise community involvement and support.	The Manly Lagoon catchment has been divided into sub-catchment areas. The Proposal is located within the Manly Vale and Burnt Bridge sub catchment area. The Proposal aims to minimise any impact on the lagoon catchment through the implementation of mitigation measures outlined in Table 43.

4.5. NSW Government policies and strategies

Table 14 provides an overview of other NSW Government policies and strategies relevant to the Proposal.

Table 14 NSW Government policies and strategies applicable to the Proposal

Policy/Strategy	Commitment	Relevance to Proposal
The State Infrastructure Strategy 2012 – 2032 (Infrastructure NSW, 2012)	This strategy: • recognises that bus rapid transit projects can facilitate high quality connections on some of Sydney's existing corridors at relatively low cost • recommends investigating a range of potential enhancements to bus priority on the Northern Beaches corridor to develop a value for money improvement plan for the coming decade.	The Proposal supports investment in transport (bus) infrastructure, and aligns with the reservation of additional funds for urban public transport to support Sydney's population, that is expected to reach almost six million by 2031.
A Plan for Growing Sydney (Department of Planning and Environment, 2014)	This plan: • sets a vision for Sydney to be a more compact, networked city with improved accessibility to support jobs, homes and lifestyle opportunities • commits to managing demand on the road network through measures such as investment in strategic road upgrades • identifies improving local opportunities for walking, cycling and using public transport as a key policy • recognises that A8 corridor is a key corridor in the strategy and is critical over the longer term to ensure a connected city with efficient travel options.	The Proposal is consistent with the objectives of this Plan and would deliver improved public transport, encourage greater public transport use and better integrate interchanges with the role and function of town centres. The Proposal would also assist in responding to forecasted growth in the region and as such would support growth in residential development and the local economy.

Policy/Strategy	Commitment	Relevance to Proposal
NSW Long Term Transport Master Plan (TfNSW, 2012a)	This master plan: • sets out the framework for the NSW Government to deliver an integrated, modern transport system that puts the customer first • identifies the transport challenges that need to be addressed and identifies a planned and coordinated set of actions • identifies the Northern Beaches corridor (from Mona Vale to the Sydney CBD) as a highly constrained corridor. Bus transport is the only public transport in this region and there is high variability in bus travel times. This unreliability has effects across the bus network, with delays moving along the service chain and holding up the next services • identifies that the level of public transport demand and current operating conditions on the Northern Beaches may support a bus rapid transit system, which would provide congestion relief through provision of better services for customers • lists the Northern Beaches bus rapid transit system, subject to feasibility assessments, as a medium term (5-10 years) action of the master plan.	The Proposal implements the following key themes in the master plan: • improving customers' journey experience • making better use of existing assets • providing improved public transport within the Northern Beaches corridor (from Mona Vale to the Sydney CBD) • providing a bus rapid transit system, which would provide congestion relief through the provision of better services for customers.
Sydney's Bus Future (TfNSW, 2013b)	This plan: • aims to deliver a modern and customer focused bus system • identifies a three-tiered network for bus operation. Each tier would deliver a defined level of service consistency and reliability: - rapid service routes - suburban service routes, consisting of a mix of timetabled and frequent, 'turn up and go' type services that do not require timetables - local service routes comprising timetabled services with stops approximately every 400 metres. • identifies Mona Vale to the CBD as a rapid bus route.	The Proposal supports the plan by • providing improved public transport within the Northern Beaches corridor (from Mona Vale to the Sydney CBD) • improving customers' journey experience • making better use of existing assets.

Policy/Strategy	Commitment	Relevance to Proposal
Northern Beaches Regional Action Plan (Department of Premier and Cabinet, 2012)	This plan: • identifies that residents on the Northern Beaches rely heavily on private vehicles and public buses for travel • recommends that a bus rapid transit for the Northern Beaches be investigated.	The Proposal supports the plan by providing improved public transport within the Northern Beaches corridor which could potentially result in a reduction of private vehicle use and reliance.
Northern Beaches Transport Action Plan (NSW Government, 2014)	This plan: • identifies transport improvements to be delivered to the Northern Beaches, as well as planning for future growth • outlines that additional funds are being invested to deliver kerbside bus rapid transit on the Northern Beaches.	The Proposal supports the plan by providing improved public transport within the Northern Beaches corridor and would also assist in responding to forecasted growth in the region.

4.6. Ecologically sustainable development

Roads and Maritime is committed to ensuring that its projects are implemented in a manner that is consistent with the principles of ecologically sustainable development (ESD). The principles of ESD are generally defined under the provisions of clause 7(4) of Schedule 2 of the EP&A Regulation as:

- **the precautionary principle** – if there are threats of serious or irreversible damage, a lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- **intergenerational equity** – the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations
- **conservation of biological diversity and ecological integrity** – the diversity of genes, species, populations and their communities, as well as the ecosystems and habitats they belong to, should be maintained or improved to ensure their survival
- **improved valuation, pricing and incentive mechanisms** – environmental factors should be included in the valuation of assets and services.

The principles of ESD have been adopted by Roads and Maritime throughout the development and assessment of the Proposal. Section 6.11 includes an assessment of the Proposal with regards to climate change and sustainability, and lists mitigation measures to ensure ESD principles are incorporated during the construction phase of the Proposal.

5. Community and stakeholder consultation

This chapter discusses the consultation undertaken to date for the Proposal and the consultation proposed for the future, including the consultation strategy adopted for the Proposal.

5.1. B-Line Program Consultation

5.1.1. Consultation strategy

The consultation strategy for the B-Line Program was developed to encourage stakeholder and community involvement and foster interaction between stakeholders, the community and the project team. The consultation strategy that was developed, having regard to the requirements of the planning process, ensures that stakeholders, customers and the community are informed of the Proposal and have the opportunity to provide input.

The objectives of the consultation strategy are to:

- provide accurate and timely information about the B-Line Program and environmental assessment process to relevant stakeholders
- raise awareness of the various components of the B-Line Program and the specialist environmental investigations
- ensure that the directly affected community stakeholders are aware of the environmental assessment and consulted where appropriate
- provide opportunities for stakeholders and the community to express their view about the B-Line Program
- understand and access local knowledge from the community and stakeholders
- record the details and input from community engagement activities
- build positive relations with identified community stakeholders
- ensure a comprehensive and transparent approach.

5.1.2. Consultation to date

A range of community engagement activities and tools have been used to raise awareness of the B-Line Program and provide opportunities for stakeholders and the community to express their views.

The community engagement program will continue during the public display of this REF and, if the Proposal proceeds, during the construction phase. Community engagement undertaken to date includes:

- Establishment of a Project Infoline number (1800 048 751) and email address (projects@transport.nsw.gov.au)
- Establishment and interaction on a specific B-Line Program website (www.b-line.transport.nsw.gov.au)
- Area specific newsletters distributed to the Brookvale and Seaforth/Balgowlah communities
- Stakeholder meetings/briefings

- Newspaper advertisements

Following an initial notification of the proposal over 400 responses were received by the project team. See section 5.2.2 for detail of the issues raised and how these have been addressed within this environmental assessment.

5.2. Consultation under the Infrastructure SEPP

5.2.1. Consultation requirements

Part 2, Division 1 of the Infrastructure SEPP contains provisions for public authorities to consult with local councils and other public authorities prior to the commencement of certain types of development. Clauses 13, 14, 15 and 16 of the Infrastructure SEPP require that public authorities undertake consultation with councils and other agencies, when proposing to carry out development that does not require development consent under the SEPP.

Table 15 provides details of consultation requirements under the Infrastructure SEPP for the Proposal.

Table 15 Infrastructure SEPP consultation requirements

Clause	Requirements	Relevance to the Proposal
Clause 13 Consultation with Councils – development with impacts on council related infrastructure and services	Consultation is required where the Proposal would result in: • substantial impact on stormwater management services • generating traffic that would place a local road system under strain • involve connection to or impact on a council owned sewerage system • involve connection to and substantial use of council owned water supply • significantly disrupt pedestrian or vehicle movement • involve significant excavation to a road surface or footpath for which a council has responsibility.	The Proposal includes works that would: • temporarily disrupt pedestrian and vehicle movements • permanent impacts to traffic flows from Heaton Avenue • impact on road pavements under Council's care and control • affect council-operated footpaths. Consultation with the Northern Beaches Council has commenced in accordance with clause 13 of the Infrastructure SEPP and will continue throughout the detailed design and construction phases.
Clause 14 Consultation with Councils – development with impacts on local heritage	Consultation with Council is required where the Proposal would: • substantially impact on local heritage item (if not also a State heritage item) • substantially impact on a heritage conservation area.	There are several heritage items listed under the Warringah LEP 2011 and Manly LEP 2013 located near the Proposal including the following: • Tramway Staff War Memorial • Palm Tree and Plaque The Proposal is not expected to result in an impact upon these heritage items and accordingly, consultation is not required. Refer to Section 6.5.

Clause	Requirements	Relevance to the Proposal
Clause 15 Consultation with Councils – development with impacts on flood liable land	Consultation is required where the Proposal would: • impact on land that is susceptible to flooding – reference would be made to *Floodplain Development Manual: the management of flood liable land.* • change flood patterns other than to a minor extent	Consultation with the Northern Beaches Council has commenced and would continue throughout the detailed design and construction phases.
Clause 16 Consultation with public authorities other than Councils	Consultation is required for specified development. 'Specified development' is defined as the following with the relevant authority: • development adjacent to land reserved under the NPW Act – the Office of Environment and Heritage • development adjacent to a marine park declared under the *Marine Parks Act 1997* – the Office of Environment and Heritage and Department of Primary Industries • development adjacent to an aquatic reserve declared under the *Fisheries Management Act 1994* – the Department of Primary Industries • development in the foreshore area within the meaning of the *Sydney Harbour Foreshore Act 1998* – the Sydney Harbour Foreshore Authority • development comprising a fixed or floating structure in or over navigable waters – Roads and Maritime Services	The Proposal is not: • adjacent to land reserved under the NPW Act • adjacent to a marine park declared under the *Marine Parks Act 1997* • adjacent to an aquatic reserve declared under the *Fisheries Management Act 1994* • development in the foreshore area within the meaning of the *Sydney Harbour Foreshore Act 1998* • development comprising a fixed or floating structure in or over navigable waters.

The Northern Beaches Council has been consulted in accordance with the provisions of the ISEPP. A response from Council was received on 26 August 2016. The response included the following requests:

- Zone A:
  - footpath widths to meet Council widths and specifications
  - further discussions with Council required
- Zone B:
  - footpath widths to meet Council widths and specifications
  - scope of work in Dudley Street to be clarified
  - there should be no net loss of parking.
- Zone C:

- Council requested Heaton Avenue to remain open to traffic and the proposed indented bus bay be relocated

These responses have been considered by Roads and Maritime, who will continue to consult with Council as the detailed design for the Proposal develops.

Emergency services (State Emergency Service, NSW Fire Brigade Manly, Manly Police and St John's Ambulance service) were consulted regarding the proposed closure of Heaton Avenue. The emergency services had no objection with the proposed closure provided they were kept informed as the closure took effect.

5.2.2. Summary of issues raised by stakeholders

A summary of key issues identified to date are provided in Table 16 below. Some of these issues are limited to the construction phase and therefore would be temporary in nature while others are related to permanent changes which would occur as a result of the Proposal.

Table 16 also highlights the relevant section in the REF where the relevant potential impacts are assessed and the mitigation measures are described in more detail. These issues will be expanded upon during upcoming phases of consultation.

Table 16 Summary of issues raised by stakeholders

Issue	Response and where addressed
Traffic impacts • Closure of Heaton Avenue at Manly Road • Loss of right turn into Orchard Road from Pittwater Road, Brookvale • Increased traffic congestion and travel distance during construction	• the closure of Heaton Avenue is required to allow for the provision of an indented bus bay in this location and to reduce road safety concerns of traffic merging onto Manly Road • the closure of the right turn into Orchard Road would improve road safety by preventing traffic turning across the busy southbound carriageway of Pittwater Road. It would also allow extended storage for the right turn lane into Sydenham Road • traffic impacts during construction would not have a major impact on the performance or capacity of the surrounding road network. See Section 6.1 Traffic and Transport for more detail.
Parking impacts • Temporary loss of parking during construction • Permanent loss of street parking • Impact on deliveries to businesses	• a marginal increase in demand for parking within local streets would be expected during construction. A TMP would be prepared to manage this impact • there would be a temporary loss of up to 15 spaces in the Warringah Mall car park during construction • there would be a permanent loss of two parking spaces along Sydney Road during operation • deliveries to some businesses on Sydney Road would be affected by the loss of on-street parking in this location See Section 6.1 Traffic and Transport for more detail.

Issue	Response and where addressed
Noise and vibration impacts • Night works • Respite periods • Cumulative impacts caused by multiple construction projects in the area	• night works would be required for the majority of construction to avoid traffic disruption during peak periods • respite has been factored into the proposal through the avoidance of noisy works after midnight • cumulative road construction impacts would be managed through the Traffic Management Centre (TMC). The cumulative impact alongside other nearby developments is no considered to be significant See Section 6.3 Noise and Vibration for more detail.
Visual amenity • Loss of vegetation in small park on the corner of Sydney Road and Hope Avenue, Seaforth • Visual amenity during construction and operation	• the loss of vegetation in this location would be limited to landscaping plantings, all of which are non-native species e.g. oleander • temporary visual amenity impacts during construction would be minimised through the application of relevant mitigation measures such as construction site hoarding See section 6.2 Urban design, landscape and visual amenity for more detail.
Pedestrian access • Safe access around construction sites • Access to bus stops during construction	• alternative pedestrian routes around all construction sites would be made available, including proper signposting • access to all bus stops would be maintained during construction See Section 6.1 (Traffic and transport) for more detail. This would also be addressed in the CEMP.
Proposal need and alternatives • Justification for the proposed works • Cost versus benefits	• justification for the Proposal has been provided in the context of improving bus journey times through the Northern Beaches • cost versus benefits have been addressed in the Strategic and Final Business Cases for the B-Line Program See Section 2 Need for Proposal for more detail.
Heaton Avenue closure	See Table 17 for further detail of issues raised around this proposed closure.

As part of the early consultation for the Proposal a community update was distributed to approximately 4,300 households throughout Seaforth and Balgowlah. This update included early detail on the Proposal and an outline of changes being proposed. Of these, the closure of Heaton Avenue at Manly Road generated substantial interest from the community. This elicited over 400 responses by letter, email and through the B-Line website's 'have your say' section.

A summary of the main objections raised within these submissions and how these have been addressed is included in Table 17 below.

Many of the responses received included suggestions for alternatives to the full closure of Heaton Avenue. These suggestions and a response to each is included in Table 18 below.

Table 17 Summary of issues relating to closure of Heaton Avenue

Issue	Response and where addressed
Emergency services access	The State Emergency Service, Fire Department Manly, Manly Police and Ambulance service were consulted. All stated they have no issues with the closure providing they are kept informed of any temporary or permanent changes to access.
Increased travel time to CBD for diverted residents	The closure of Heaton Avenue will inevitably result in increases in travel time for local traffic utilising this route to join Manly Road. This increase and its implications area discussed in more detail in Section 6.1.2.
Additional congestion on local streets near local schools	The closure of Heaton Avenue will necessitate alternative travel patterns for local traffic previously utilising this route to join Manly Road. This will include the diversion of traffic onto Maretimo Street and Sydney Road, adjacent to Northern Beaches Secondary College - Balgowlah Boys Campus. The traffic diverted onto Maretimo Street is estimated to comprise approximately 62 additional vehicles during the two hour AM peak period (7am to 9am). As such the total increase in congestion is considered to be negligible.
Impacts of increased traffic at intersection of Manly Road and Sydney Road	The changes in traffic volumes and intersection performance have been assessed in detail in Section 6.1.2 of this report. This assessment indicates that the Sydney Road/Manly Road/Burnt Bridge Creek Deviation intersection would continue to provide the same level of service upon implementation of the Proposal.
Impacts of increased traffic at Seaforth roundabout	The impact of traffic entering the roundabout at the western end of Sydney Road has been addressed within Section 6.1.2 of this report. This assessment indicates that the additional traffic through this intersection would be in the order of 35 to 50 vehicles per hour during the AM peak period. Such an increase in traffic demands are likely to be manageable, with careful planning of local area traffic management measures (e.g. local signage to encourage use of Sydney Road east) and support from the Council.
Distribution of original notification	The community update was delivered on behalf of the B-Line project team to households within 500 metres of the Proposal area. This included approximately 4,300 households in the Seaforth/Balgowlah area.

Issue	Response and where addressed
Responses to questions and comments	The consultation period for the Proposal is set to commence in late November 2016. Comments received prior to the consultation period, as well as those received during the consultation period, will be assessed and collated, with responses sent to all those providing comment. Additional responses have been, and would continue to be, included on the B-Line website. All issues raised before and during the consultation would be collated and presented within a submissions report prepared on behalf of the Proposal prior to determination.
Modelling information	Details of traffic and noise modelling undertaken as part of this assessment are included within this REF and are included within the appendices.
Additional congestion pinchpoints along the B-Line corridor	This REF forms one of several that have been prepared to support the B-Line proposal in general. This includes other REFs for on-road pinch-point improvements at Dee Why, Mosman, Cremorne and Neutral Bay, as well as assessment of parking and clearways throughout the entire corridor. All Proposals have been prepared so as to minimise impacts upon general traffic while providing decreased travel times for local buses and B-Line services.
Objection to closure – loss of access/increased travel time	Please see above for detail on additional travel time. Access from Heaton Avenue for vehicles will be inevitably lost as part of the Proposal. There remain however several alternative routes to Manly Road, all via Sydney Road to the north. An assessment of these routes is provided in Section 6.1.2 of this report.
Increased congestion at Maretimo St	The closure of Heaton Avenue will necessitate alternative travel patterns for local traffic previously utilising this route to join Manly Road (see Section 6.1.2). This will include the diversion of traffic onto Maretimo Street. The traffic diverted onto Maretimo Street is estimated to comprise approximately 62 additional vehicles during the two hour AM peak period (7am to 9am). As such the total increase in congestion is considered to be negligible.
Congestion at Sydney Road/criticism of improvements to Sydney Road intersection	The changes in traffic volumes and intersection performance have been assessed in detail in Section 6.1.2 of this report. This assessment indicates that the Sydney Road/Manly Road/Burnt Bridge Creek Deviation intersection would continue to provide a satisfactory level of service upon implementation of the Proposal (level of service ‘C’).

Issue	Response and where addressed
Bus bay isn't required/can be in alternate location	Data derived from Opal card journeys commencing at Heaton Avenue indicate that the bus stop is currently used by approximately 116 people on an average weekday, with 49 of these occurring within the AM peak period. Buses stopping to allow these passengers to board must stop within the kerbside lane, which results in delays to other traffic within the T3 transit lane, including other buses that are not scheduled to stop at this location and other T3 transit lane vehicles. The overall result is that the journeys of a significant number of motorists and passengers are adversely affected by a small number of boarding passengers. This situation would become worse upon implementation of the new timetable delivered around the new B-Line service as more buses would stop at this location throughout the day, including the AM peak period. Alternative locations for the indented bus bay have been discussed in Section 2.2.4 of this report. These alternatives indicate that the topography of the local area would require more substantial engineering work than the preferred approach.
Insufficient modelling/not enough data to justify proposal	Heaton Avenue has been the subject of a number of studies undertaken to understand current traffic movements and the times at which they are undertaken. These studies have provided input into comprehensive modelling of the proposed closure. The results of this modelling and the assessment arising from it are provided in Section 6.1.2 of this report.
Congestion on Kanangra Crescent & Beatrice Street	The closure of Heaton Avenue will necessitate alternative travel patterns for local traffic previously utilising this route to join Manly Road (see Section 6.1.2). Traffic diverted onto Kanangra Crescent is estimated to comprise approximately 78 vehicles per hour during the AM peak period (7am to 9am). Traffic diverted onto Beatrice Street is estimated to comprise approximately 30 vehicles per hour during the AM peak period (7am to 9am). These additional movements are relatively minor and are not expected to result in substantial congestion on these local streets.
Make B-Line more accessible to residents of Seaforth, Balgowlah & Clontarf	The B-Line service has been designed as an express service between Mona Vale and the Sydney CBD. At present this includes nine stops between Mona Vale and Neutral Bay, the closest of which to Seaforth and Balgowlah is either Manly Vale or Spit Junction. The location of the proposed B-Line stops have been developed in responses to demand modelling, taking into account the existing movement patterns of bus passengers as observed through Opal card data. At present passenger demand within the Seaforth and Balgowlah area do not justify the inclusion of additional B-Line stops.

Table 18 Potential alternatives to the closure of Heaton Avenue raised during early consultation

Potential alternative	Response
Move bus bay (generally south)	Alternative locations and designs for the indented bus bay have been discussed in Section 2.2.4 of this report. These alternatives indicate that the topography of the local area would require more substantial engineering work than the preferred approach.
Facilitate a bus pullover bay with a single left turn lane out of Heaton Avenue	Alternative locations and designs for the indented bus bay have been discussed in Section 2.2.4 of this report. The implementation of a half closure of Heaton Avenue (restrict left-in movement from Manly Road) would affect road safety at this intersection being, particularly when traffic on Manly Road is travelling at or near the speed limit outside of the AM peak.
Allow motorists exiting Heaton Avenue onto Manly Road more time to merge	The NSW Road Rules require that vehicles exiting Heaton Avenue with one or two occupants merge out of the kerbside T3 transit lane within 100 metres. The amendment of this rule is beyond the scope of this Proposal.
Limit access to Heaton Avenue onto Manly Road to local residents only	In order to allow continued access from Heaton Avenue onto Manly Road it would be necessary to maintain at least a single exit lane. This would result in road safety issues at this intersection for vehicles exiting Heaton Avenue as well as those travelling along Manly Road, particularly cyclists and motorcyclists. In addition to this the limiting of traffic exiting Heaton Avenue to local traffic only would be extremely difficult to enforce. In the event that this was possible the reduction in traffic exiting Heaton Avenue would only reduce by approximately 33% (see Section 6.1.2).
No left turn at Heaton Avenue (into Manly Road) between 0630-0930, taxis & buses excepted	In order to allow continued access from Heaton Avenue onto Manly Road it would be necessary to maintain at least a single exit lane. This would result in road safety issues at this intersection for vehicles exiting Heaton Avenue as well as those travelling along Manly Road, particularly cyclists and motorcyclists. There are no existing bus routes that exit Heaton Avenue onto Manly Road. The restriction of traffic exiting Heaton Avenue to taxis only would be extremely difficult to enforce unless a physical barrier were installed, and is unlikely to be practical.
Install a dynamic traffic light that turns red when there is not a bus at the bus stop (hence free flow from Heaton St when a bus is stationery)	This proposal would allow traffic to exit Heaton Avenue while buses are stopped. This scenario would result in road safety issues at this intersection for vehicles exiting Heaton Avenue as well as those travelling along Manly Road, particularly cyclists and motorcyclists.

Potential alternative	Response
Remove Heaton Avenue bus stop entirely	The removal of the Heaton Avenue bus stop on Manly Road would substantially inconvenience current bus passengers boarding and alighting at this stop. This includes approximately 96 passengers known to board at this location each weekday.

5.3. Consultation during public display

The REF will be placed on public display for four weeks from Thursday 24 November 2016 to Thursday 22 December and written submissions will be invited during this period. Further community consultation will be undertaken during the public display period to enable the community to comment and ask questions about the Proposal.

Planned consultation activities associated with the public display include:

- three community information sessions to give local residents and businesses an opportunity to view the plans and discuss the Proposal with members of the project team at the following times:
  - Balgowlah Golf Club, Wednesday 30 November between 4.00pm and 6.30pm
  - Balgowlah Golf Club, Wednesday 7 December between 4.00pm and 6.30pm
  - Balgowlah Golf Club, Wednesday 14 December between 4.00pm and 6.30pm
- shopping centre displays will be held from at Balgowlah Stockland Shopping Centre (197-215 Condamine Street, Balgowlah) at the following times:
  - Monday 12 December, 12:00-2:00pm
  - Tuesday 13 December, 12:00-2:00pm
  - Wednesday 14 December, 12:00-2:00pm
  - Thursday 15 December, 6:00pm – 8:00pm
- advertisements in the Manly Daily to publicise the REF display and community information sessions
- a letterbox drop to properties within 500 metres of the study area in Brookvale and within 1 km radius in Seaforth, publicising the REF display and community information sessions and inviting feedback
- public display of the REF documents at the following locations:
  - Northern Beaches Council office - 1 Belgrave St, Manly
  - Northern Beaches Council office - 725 Pittwater Road, Dee Why
  - Dee Why Library - 725 Pittwater Road, Dee Why
  - Manly Library - Market Place, Manly
  - Balgowlah Seaforth Community Library, Corner of Frenchs Forest Road and Sydney Road, Seaforth
- all documents available on the B-Line website at www.b-line.transport.nsw.gov.au
- targeted meetings and briefings for key stakeholders to provide an overview of the REF findings and identify potential issues
- project Infoline: 1800 048 751 and projects@transport.nsw.gov.au

5.4. Post-public display consultation

5.4.1. Submissions report

At the conclusion of the public display period for the REF, Roads and Maritime Services will acknowledge receipt of feedback from each respondent. The issues raised by respondents will be consolidated and considered by Roads and Maritime Services.

A Submissions Report will be prepared summarising the key impacts identified in this REF, demonstrating how Roads and Maritime Services considered issues raised during the public display period, and include a summary of mitigation measures proposed to minimise the impacts of the Proposal. The Submissions Report will be made available on the B-Line website and everyone who made a submission will be individually notified of the outcome.

5.4.2. Construction phase

Should Roads and Maritime Services proceed with the Proposal, consultation activities would continue up to and during construction. These consultation activities would ensure that:

- the community and stakeholders have a high level of awareness of all processes and activities associated with the Proposal
- accurate, up to date and accessible information is made available
- a timely response is given to issues and concerns raised by the community.

The project team would keep the community, Northern Beaches Council and other key stakeholders informed of progress, identify further issues as they arise, and develop additional mitigation measures to minimise potential impacts of the Proposal. Targeted consultation activities such as door knocks, meetings, newsletters, notifications, advertising, signage and verbal communications would continue during the construction phase. The B-Line website would include frequent updates and the project infoline and email address would continue to operate during the construction phase.

6. Environmental impact assessment

This chapter of the REF provides a detailed description of the potential environmental impacts associated with the construction and operation of the Proposal. For each potential impact, the existing environment is characterised and an assessment is undertaken as to how it would be affected by the Proposal.

This environmental assessment has been undertaken in accordance with clause 228 of the EP&A Regulation. A checklist of clause 228 factors and how they have been specifically addressed in this REF is included at Appendix B.

6.1. Traffic and transport

A Traffic and Transport Assessment was undertaken for the Proposal (AECOMa 2016). The assessment included an analysis of the existing bus and general traffic movements along the corridor and assessment of the future bus and general traffic scenarios with and without the Proposal.

A key focus of the traffic impact assessment has been the operation of the study area road network for buses and general traffic. The network operational assessment for the current situation (Base Year) and in the future (2021) was undertaken using VISSIM traffic modelling. In addition to this an isolated SIDRA model of the Sydney Road/Manly Road intersection was developed. The Manly Road/Heaton Avenue closure was also assessed using a Commuter microsimulation model, which took into account the southern section of the study area.

SIDRA, VISSIM and Commuter modelling are different methods of assessing traffic flow and/or intersection performance. SIDRA modelling focuses upon intersection performance and is generally used to compare alternative treatments of individual intersections. For this Proposal it has been employed to analyse the following intersections:

- Pittwater Road/Winbourne Road
- Pittwater Road/Sydenham Road
- Pittwater Road/Orchard Road
- Pittwater Road/Cross Street
- Sydney Road/Manly Road

VISSIM modelling assesses traffic flow and intersection performance on the basis of a ‘microscopic simulation’. That is, it models the movement of each entity (car, bus, truck) individually, allowing interaction between these entities to be demonstrated and analysed.

Commuter modelling is a further refinement on VISSIM that analyses traffic on a broader network scale and allows for dynamic route and mode choice by agents during simulation. This allows a broader view of traffic in the local area.

Both VISSIM and Commuter models were employed for analysis of the proposed Heaton Avenue closure in order to provide a broader view of the implications of this change. Further detail of the findings of this assessment are summarised within this section.

6.1.1. Existing environment

Traffic and road network

The A8 road corridor serves as the primary arterial route between the Sydney CBD in the south (via the M1 Motorway) and the Northern Beaches in the north (terminating at Mona

Vale). This route connects with Warringah Road at the boundary of Dee Why and Brookvale, providing a further east-west arterial connection between the Northern Beaches suburbs and Chatswood in the west.

The northern section of the A8 Corridor consists of Pittwater Road, Condamine Street, Burnt Bridge Creek Deviation and Manly Road and is the main north-south corridor through the Northern Beaches LGA. This road accommodates around 40,000 vehicles per day and provides access to various urban centres including Mona Vale, Warriewood, Narrabeen, Collaroy, Dee Why, Brookvale, Manly Vale and Balgowlah. The corridor intersects with a number of local and sub-regional roads within Zones A, B, C and D of the Proposal.

On-street parking is permitted along the sealed shoulders at various points on either side of the corridor (see Parking section below). Kerbside bus lanes are operational in the southbound direction in the AM peak period between 6am and 10am; and in the northbound direction in the PM peak between 3pm and 7pm. The posted speed limit along the corridor is 60 kilometres per hour with the exception of Burnt Bridge Creek Deviation which is 80 kilometres per hour.

Travel mode

A review of the 2011 ABS Journey to Work data indicated that around 60% of travel in and out of the (former) Warringah and Manly LGAs is made by private car (as either a driver or passenger) and around 20 per cent is made by public transport (predominantly by bus). This trend is broadly consistent with that of metropolitan Sydney, which has a slightly higher rate of private car journeys. The remainder of journeys are undertaken on foot or bicycle.

Intersection performance

Intersection performance within the Proposal area was assessed by modelling vehicle delay at relevant intersections. Intersection performance modelling determines the average delay that vehicles encounter at a particular intersection and provides a measure of the level of service (LoS). This is a qualitative measure of vehicle delay. There are six levels of performance, which are expressed in terms of LoS which range from ‘A’ (best level with good intersection performance) to ‘F’ (worst level with saturated conditions, long queues and delays).

Table 19 provides the overall LOA for each intersection within the Proposal area for AM and PM weekday peak periods for the base year (2016).

Table 19 Level of Service (LoS) at key intersections (AM and PM weekday peaks). Worst case of each of the two hours of the peak presented.

Zone	Intersection	AM 7am to 9am	PM 4:30pm to 6:30pm
A	Pittwater Rd/Winbourne Rd	**C**	**E**
A	Pittwater Rd/Sydenham Rd	**A**	**C**
A	Pittwater Rd/Orchard Rd	**A**	**A**
A	Pittwater Rd/Cross St	**B**	**C**
B	Manly Rd/Sydney Rd	**F**	**F**

Most intersections along the A8 corridor within the Proposal area operate at a satisfactory LoS (LoS C or better), with the following exceptions:

- The Manly Rd/Sydney Rd intersection operates at a poor LoS, attributable to the downstream congestion and capacity constraints experienced by traffic south of Spit Bridge, which induces traffic to queue back and reduce the operation of the Manly Road/Sydney Road intersection. This intersection continues to operate unsatisfactorily in the PM peak with competing traffic demands from most approaches. The tidal flow arrangement at Spit Bridge with a single traffic lane for southbound traffic also induces downstream delays, affecting the performance of this intersection.
- The Old Pittwater Road/Winbourne Road intersection experiences periods of poor LoS due to the prioritisation of green light time along the mainline A8 corridor in peak times, which results in limited allocation of green time for these side roads.

The following trends were identified from site observations within the Proposal area:

- In the morning peak, moderate delays were observed for southbound traffic on approach to the Pittwater Road/Old Pittwater Road/Winbourne Road intersection from near Brookvale Oval, west of Mitchell Road. This is due to a combination of delays from the traffic signals and the speed reduction of the school zone, effective between 8.00-9.30am
- In the evening peak, intermittent northbound traffic queues were observed along Pittwater Road on approach to the Cross Street, Old Pittwater Road and Warringah Road intersections. The northbound queues on approach to Warringah Road propagate south to Mitchell Road. Queues of approximately 50 metres were observed at the approach to Cross Street. These queues were comprised of buses using the kerbside bus lane as well as vehicles turning left into Cross Street
- Frequent bus and passenger activities were observed along Pittwater Road adjacent to Warringah Mall, where the existing ‘bus only’ lanes are located, in both directions during the peak periods.

Heaton Avenue

Heaton Avenue currently forms a left-in/left-out connection with Manly Road, approximately 350 metres south of the major signalised intersection with Sydney Road. The kerbside lane of Manly Road through this area is a T3 transit lane between 6am and 10am Monday to Friday and bus lane between 3pm and 7pm Monday to Friday.

Traffic turning out of Heaton Avenue typically uses the existing kerbside T3 transit/bus lane along Manly Road as an acceleration lane before merging into the first general traffic lane (lane 2). It should be noted that the legal limit of travelling in a bus or transit lane without the required number of passengers when entering or leaving an intersection is 100 metres. As such single or dual occupant vehicles typically seek to merge out of the T3 transit/bus lane in the first 100 metres, leading to sub-optimal merging behaviour in this location during peak periods. This has flow on effects for road safety at this location.

In periods of heavy traffic the opportunities for single or dual occupant vehicles to merge out of the T3 transit/bus lane into the general traffic lanes are limited by the extremely slow or stopped traffic. In such a scenario the T3 transit/bus lane becomes more highly occupied than under optimal conditions, leading to decreases in travel time for buses, taxis, hire cars, bicycles, motorcycles and three-occupant vehicles, all of which are legally entitled to use this lane the AM peak. Buses, taxis, hire cars, bicycles and motorcycles are also permitted to use this lane in the PM peak and would be similarly affected at this time when traffic is restricted downstream by the single tidal flow lane crossing The Spit Bridge.

Investigations undertaken as part of the Proposal’s traffic and transport assessment (AECOM 2016a) observed that around 550 vehicles turned left out of Heaton Avenue between 7.30am and 9.30am on a weekday, with around 15-20 vehicles per hour turning into Heaton Avenue from Manly Road.

An origin-destination traffic survey was undertaken on Tuesday 13 September 2016 between 7.30-9.30am to further understand the pattern of traffic movements out of Heaton Avenue onto Manly Road. This survey found that 12% of the vehicles exiting Heaton Avenue originate from areas west of Manly Road (arriving via Ethel Street). A further 21% of traffic exiting Heaton Avenue originates from Sydney Road to the east of Condamine Street. These vehicles, 33% cumulatively, appear to be seeking to bypass the Sydney Road/Manly Road traffic signals by diverting along the local road network and Heaton Avenue (commonly referred to as ‘rat running’). This travel pattern is generally not encouraged given that the primary purpose of the local road network is to serve local traffic only.

Further results from this study indicated that 31% of the traffic exiting Heaton Avenue is likely to originate from local catchments east of Manly Road, with the remaining 36% accessing Heaton Avenue via Peronne Avenue. This traffic is considered to be local. On this basis it is assumed that approximately 369 local vehicles (67% of 550 vehicles) legitimately utilise the Heaton Avenue intersection to access Manly Road during the weekday AM peak period.

The existing bus stop on Manly Road at the intersection of Heaton Avenue is an ‘in lane’ stop. This means that buses stop within the kerbside lane when picking up or setting down passengers, hence affecting the travel time of other users of this lane including other buses, taxis, hire cars, bicycles, motorcycles and three-occupant vehicles (during the AM peak). The stopping of traffic in this lane whilst buses are stopped creates an ‘opening’ for vehicles exiting Heaton Avenue, which subsequently results in sub-optimal merging behaviour and T3 transit/bus lane delays, as outlined above.

Crash statistics for vehicles travelling south through this location indicates at least five incidents over the past seven years. This includes one serious and one moderate injury arising from vehicles exiting Heaton Avenue onto Manly Road. The remaining three incidents relate to rear-end and lane change incidents that resulted in minor or no injury.

Further detail regarding the permanent impact of the closure of Heaton Avenue is provided within the operational impacts section of this chapter.

Pedestrian and bicycle facilities

Pedestrian footpaths within Zone A provide access to existing bus stops and businesses along Pittwater Road. A signalised intersection with pedestrian crossing facilities is located at Cross Street. No formal pedestrian crossing facilities are available at Orchard Street.

There are no pedestrian footpaths alongside Burnt Bridge Creek Deviation or the northern section of Manly Road within Zone B. A pedestrian footpath is present along Manly Road to the south of Heaton Avenue.

The signalised intersection at Burnt Bridge Creek Deviation/Sydney Road/Manly Road provides a crossing facility for pedestrians across the Burnt Bridge Creek Deviation approach only. This includes a pedestrian crossing across the existing slip lane onto Sydney Road.

There is a dedicated cycleway along Burnt Bridge Creek Deviation north of Zone B. A number of other cycleways connect surrounding areas with the A8 corridor. These are shown in Figure 10 and Figure 11. Bus lanes located along the A8 corridor are often used by cyclists as they provide some segregation from general traffic. The bus lane between Sydney Road and the Spit Bridge is particularly favoured by cyclists due to the lack of a feasible alternative route across Middle Harbour in this location.

Bus services

Various local buses travel through and service routes along the A8 Corridor within the Proposal area. A map of the existing bus services operating within the Proposal area is shown in Figure 20.

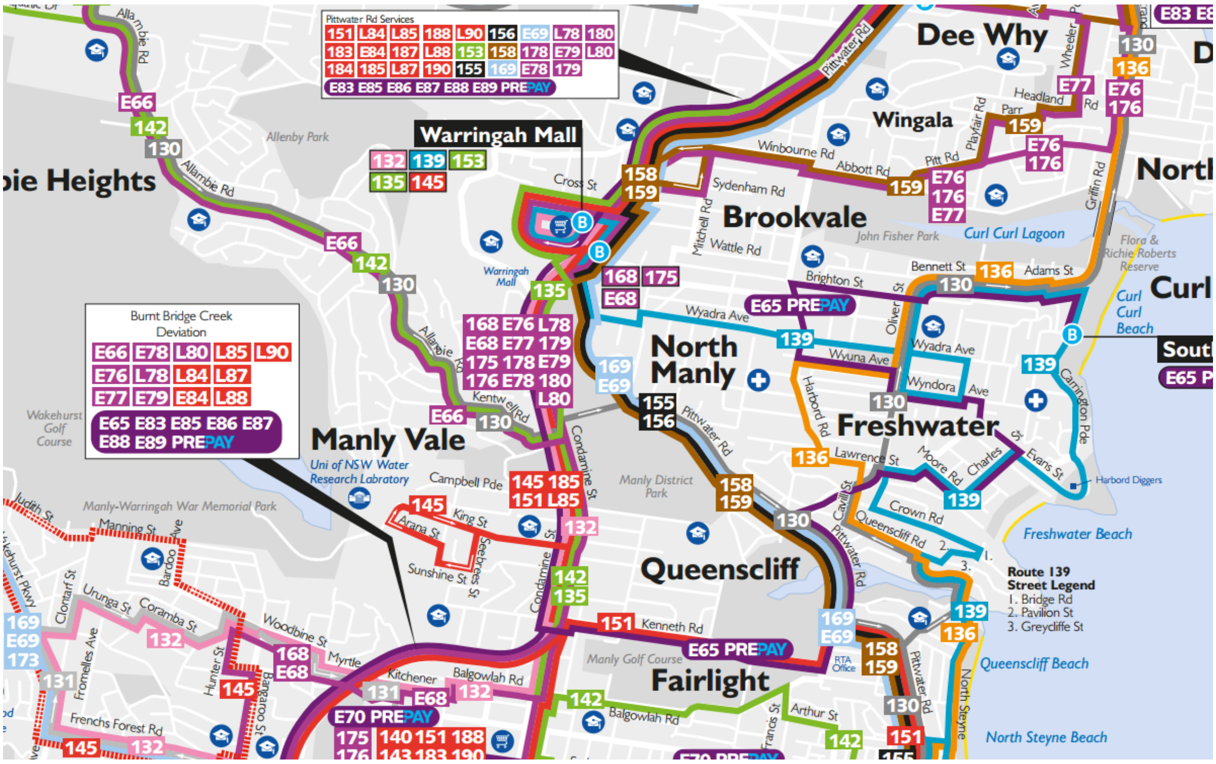


Figure 20 Existing bus services operating within the Proposal Area (north)

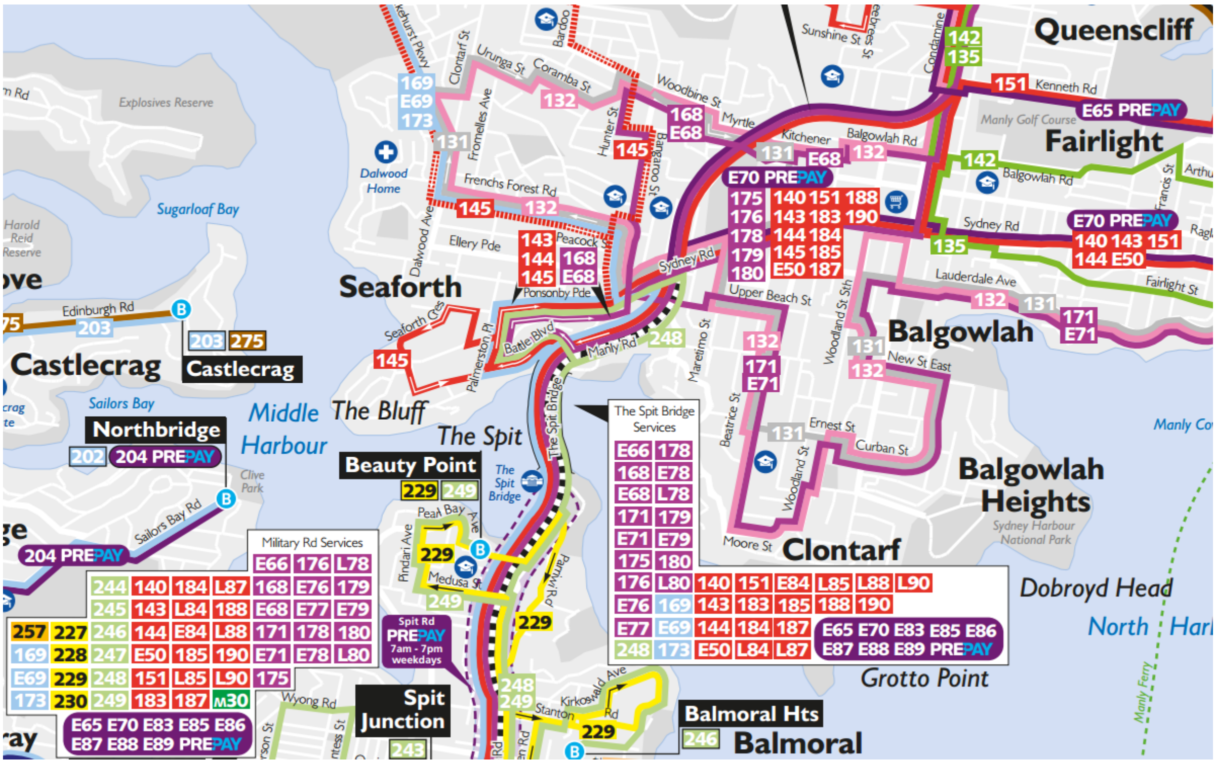


Figure 21 Existing bus services operating within the Proposal Area (south)

Bus lanes are present on the A8 Corridor through the Proposal area in both northbound and southbound directions. These lanes are operational in the AM and PM weekday peaks (6am to 10am southbound and 3pm to 7pm northbound). In some areas, outside peak hours, the bus lane provides short term parking. There is a short interruption in the bus lane on the northbound kerb lane of Pittwater Road as it approaches Cross Street, however the bus lane commences again north of Roger Street.

Parking

Within Zone A there are ‘no parking’ and ‘no stopping’ zones present on the northbound carriageway of Pittwater Road as it approaches Cross Street. North of Cross Street the kerb lane becomes a bus lane between 3pm and 7pm on weekdays. One hour restricted parking is available in this location between 8:30am and 3pm Monday to Friday and 8:30 to 12:30 Saturday, with unrestricted parking available outside of these times.

There is no parking along the full length of Burnt Bridge Creek Deviation or Manly Road in Zones B and C. Parking is however currently available along the northern side of Sydney Road to the east of the Burnt Bridge Creek Deviation/Manly Road intersection. There are two one hour parking spaces available outside of peak hours in this location.

6.1.2. Potential impacts

Construction phase

Traffic

During construction of the Cross Street left turn lane (Zone A) it is likely that there would be temporary impacts upon the flow of traffic through this intersection. It is probable that at least the kerbside lane would be temporarily closed during active work periods, which are likely to be undertaken at night in order to avoid disruption to peak period traffic. This lane would be kept open during the day as far as feasible There is the potential that left turning traffic at this location may need to be diverted during active work periods (i.e. at night). The impact of these changes is expected to be minor given that the majority of the works would be undertaken within the existing verge and would be timed to be undertaken outside of the peak period.

Within Zone B temporary road and lane closures would be required along Burnt Bridge Creek Deviation and Sydney Road for the construction of new and extended turning/through traffic lanes. This would slow traffic through this intersection for the duration of the works. During this period it may be necessary to temporarily suspend existing parking on Sydney Road to the east of Dudley Street. This suspension is likely to only be required at night during active work periods.

Minor traffic disruptions may also arise as a result of construction vehicles entering and departing the construction compound at Manly Vale on Condamine Street. This would be mitigated by the fact that majority of movements into and out of this compound would occur during night working periods.

Access to all residential property driveways within the Proposal area would generally be maintained throughout the construction period. Should any closures of property accesses be required the relevant owners/tenants/occupiers would be notified in advance.

Any necessary temporary diversions would be determined during detailed design and would be implemented with appropriate signage and traffic control, to direct vehicles appropriately. After hours deliveries to businesses throughout the corridor may be affected by the presence of construction activities. Based on the general type of businesses present in this location and the availability of loading docks (e.g. Warringah Mall) or parking in nearby side streets (e.g. Sydney Road/Dudley Street) this impact is not expected to be significant. Consultation would be undertaken with all affected businesses to establish those that may be affected and to organise construction so as to minimise overall impacts upon their operation.

It is likely that the majority of construction activities, such as concrete pours and delivery of oversized materials, would occur outside of standard construction hours. This would minimise traffic disruptions given there would be less traffic on Pittwater Road, Condamine Street, Burnt Bridge Creek Deviation, Manly Road and Sydney Road during the night.

Access for emergency vehicles along the A8 corridor and on relevant side roads would be maintained in accordance with emergency vehicle requirements. Emergency services would be advised of all planned changes to traffic arrangements prior to their implementation.

Overall, provided the proposed traffic management measures are implemented, the likely impact upon local traffic during construction is expected to be manageable and would not have a major impact on the performance or capacity of the surrounding road network.

Road network

During construction, additional vehicle movements would be generated along Pittwater Road, Condamine Street, Burnt Bridge Creek Deviation, Manly Road and Sydney Road within the Proposal Area. These movements would generally be between Zone A, Zone B and Zone C and the Manly Vale Commuter Car Park construction compound.

Heavy vehicle traffic would mainly be generated by activities associated with the following:

- delivery of construction materials
- spoil removal
- delivery and removal of construction equipment and machinery
- movement of construction personnel, including contractors, site labour force and specialist supervisory personnel.

Up to five heavy vehicles would be required at each zone per day, resulting in approximately 20 heavy vehicle movements in and out of each zone per work period. These heavy vehicle movements are likely to be spread through the day, however in adopting a worst case assessment of the traffic impacts it has been assumed that 10 per cent, or two vehicle movements, would occur during the peak hour.

Construction vehicles would access the site via arterial roads wherever possible. Given that these roads already carry high volumes of traffic it is not anticipated that the Proposal would result in a high degree of impact above what is currently experienced. Additional construction traffic would be well within the range of daily variation in traffic on these routes.

To minimise impacts upon the local road network, heavy vehicle traffic would use the regional road network for access routes to and from construction areas. Any disruption to existing traffic conditions or property access would be minimised and would only be undertaken following consultation with the community and individual property owners/occupiers affected by the works.

The movement of materials would be managed through the scheduling of deliveries and availability of fleet, and would aim to minimise the number of haulage and delivery vehicles required during peak periods and weekends. Modelling undertaken for the Proposal (AECOM 2016a) concluded that this slight increase in vehicular traffic would result in a negligible impact on the local road network operation.

Light vehicle traffic generation would be associated with staff movements to and from each zone. Staff would comprise of project managers, various trades, and general construction personnel. Light vehicles used to transport staff to and from each zone would be parked on nearby local streets or in public car parks during active work periods.

The workforce arrival and departure periods represent the peak construction traffic generation periods for the Proposal. It is possible that these periods may coincide within the existing road network AM and PM peak periods.

The traffic generated from construction light vehicles is likely to result in increases of up to 18 vehicles per hour in the AM and PM peak periods, which is well within the daily variation traffic on the road network.

Pedestrian and bicycle facilities

During construction, there is the potential for temporary disruptions to the existing pedestrian facilities (including paths and signalised road crossings) along the A8 corridor between Brookvale and Seaforth, as well as on surrounding local roads. This has the potential to increase safety risks for pedestrians due to possible interactions with construction plant and vehicles.

There would be temporary disruptions to pedestrian access at the location of the proposed left turn lane into Cross Street from Pittwater Road. In this location it may be necessary to divert pedestrian access temporarily to the opposite footpath, adjacent to the southbound carriageway.

Pedestrian access at the intersection of Manly Road, Sydney Road and Burnt Bridge Creek Deviation would be temporarily disrupted at the location of the proposed left turn lane into Burnt Bridge Creek Deviation from Sydney Road. It is noted that this pedestrian crossing is the only available crossing at this intersection. As such pedestrian access would be maintained through this crossing during construction.

Pedestrian access at the intersection of Heaton Avenue and Manly Road would be temporarily disrupted by the closure of Heaton Avenue and the construction of the bus indent at this location. This would affect pedestrians travelling south along Manly Road and east along Heaton Avenue. Whilst the volume of such pedestrian movements is considered to be low, temporary access arrangements would be put in place during construction to maintain connectivity throughout this period.

Potential impacts to pedestrians during construction would be managed through the development of a construction TMP. Appropriate signs and/or traffic controllers would be positioned to notify pedestrians of temporary arrangements and to manage their interaction with construction vehicles.

Bicycle users may also be temporarily affected during construction. Impacts upon cyclists in these locations are expected to be limited to temporary diversions in some locations whilst works are undertaken, which would be mainly at night and hence less likely to affect cyclists. Temporary bicycle diversions would be minimised where possible and adequately sign-posted, with notification provided to the community. All bicycle diversions would be made via the safest possible alternative routes.

Bus services

During construction there is the potential for existing local bus services to be disrupted. Impacts may occur during road works as a result of temporary lane and road closures, the majority of which would be carried out as night works and hence would result in minimal impact upon bus services. During these times there may be reduced speeds and diversions put in place, however buses would continue to service the bus stops at Sydney Road and Heaton Avenue. Temporary traffic diversions and changes to bus services (including zones and stops) would be minimised where possible and adequately sign-posted, with notification provided to the community.

Parking

During construction it would be necessary to temporarily suspend parking along certain parts of Sydney Road whilst construction is undertaken. Specifically this would affect parking at and adjacent to the proposed lane reconfiguration on Sydney Road, east of Dudley Street. The parking suspension in this location may be active during night works times only or may extend 24 hours, as determined by the specific construction activities.

Access to all residential property driveways within the Proposal area would generally be maintained throughout the construction period. After hours deliveries to businesses that depend upon on-street parking (such as Sydney Road) may be affected by the presence of construction activities. Based on the general type of businesses present in this location and the availability of parking in nearby side streets this impact is expected to be minor. Consultation would be undertaken with all affected businesses to establish those that may be affected and to organise construction so as to minimise overall impacts upon their operation.

Parking provisions are not proposed for construction staff vehicles within or adjacent to the construction sites; instead construction workers would be encouraged to car-pool or utilise public transport services. However it is expected a portion of workers would travel via private vehicles which may also marginally increase the demand for on-street parking within the surrounding local streets. Generally, light vehicles used to transport staff to and from each zone would be parked on nearby local streets or public car parks.

Operational phase

Intersection performance

Operational traffic modelling was undertaken to assess intersection LoS and bus and general traffic travel times for the year 2021 with (‘Proposal’ scenario) and without (‘do nothing’ scenario) the Proposal. The ‘Proposal’ scenario assumes that the entire B-Line program is in place.

Generally the LoS at the key intersections across the network is not forecast to change significantly between the 2021 ‘do-nothing’ and ‘Proposal’ scenarios. Five key intersections within the Proposal area were assessed for their LoS, of these intersections, three involve upgrades as described in Section 3.1.1:

- Pittwater Rd/Winbourne Rd
- Pittwater Rd/Sydenham Rd
- Pittwater Road/Orchard Road intersection
- Pittwater Road/Cross Street intersection
- Sydney Road/Manly Road/Burnt Bridge Creek Deviation

The remaining intersections (i.e. those without upgrades proposed) were included in the assessment in order to further understand the impacts of the upgrades on the wider network.

Table 20 provides the LoS for 2021 under for AM peak times (7:00am-9:00am) under the ‘do nothing’ scenario and ‘Proposal’ scenario. Table 21 provides the LoS for 2021 for PM peak times (4:30pm-6:30pm) under both scenarios.

Table 20 Level of Service (LoS) 2021 - AM (7:00am-9:00am). Worst case of each of the two hours of the peak presented.

Zone	Intersection	‘Do nothing’ AM	‘Proposal’ AM
A	Pittwater Rd/Winbourne Rd	**C**	**C**
A	Pittwater Rd/Sydenham Rd	**A**	**B**
A	Pittwater Rd/Orchard Rd	**D**	**B**
A	Pittwater Rd/Cross St	**B**	**B**
B	Sydney Road/Manly Road/Burnt Bridge Creek Deviation	**C**	**C**

Table 21 Level of Service (LoS) 2021 – PM (4:30pm-6:30pm). Worst case of each of the two hours of the peak presented.

Zone	Intersection	'Do nothing' PM	'Proposal' PM
A	Pittwater Rd/Winbourne Rd	**E**	**F**
A	Pittwater Rd/Sydenham Rd	**D**	**C**
A	Pittwater Rd/Orchard Rd	**B**	**A**
A	Pittwater Rd/Cross St	**D**	**D**
B	Sydney Road/Manly Road/Burnt Bridge Creek Deviation	**C**	**D**

The network currently operates at a poorer LoS during the PM peak in comparison to the AM peak period. This scenario is forecast to remain during the modelled 2021 scenarios.

There is marginal change in forecast LoS at the intersections between the 2021 do-nothing and Proposal scenarios, with the exception of the intersection at Winbourne Road, which deteriorates from E to F in the Proposal scenario. A review of the corridor volumes indicates that in the Proposal scenario, there is an increase in northbound throughput at the Cross Street intersection of around 100 vehicles per hour (likely due to the implementation of the dedicated left turn lane). This additional throughput provides additional input vehicles to the Winbourne Road intersection, which is sensitive to additional demands, hence resulting in the deterioration in LoS in this location.

The existing right turn movement from Pittwater Road into Orchard Road is proposed to be closed as part of the proposal. This traffic would be diverted to the Pittwater Road/Sydenham Road signalised intersection. Traffic modelling shows that under the Proposal scenario the additional right turn demand generates a maximum queue length of up to 150 metres from Pittwater Road to Sydenham Road during the PM peak. This queue would be contained within the right turn bay which is approximately 175 meters in length.

Generally, the Proposal is anticipated to result in a comparable level of intersection performance throughout the Proposal area, and in some cases an improvement, when compared to the 2021 'do nothing' scenario.

Road network

Average operational travel times for general traffic along Pittwater Road, Condamine Street, Burnt Bridge Creek Deviation, Manly Road and Sydney Road through the Proposal area were modelled (AECOM 2016a). The results of this modelling indicated that during the AM weekday peak:

- operational travel times for general traffic in both directions are largely consistent between the 2021 Do-nothing and Option scenarios, though both scenarios indicate an increase in travel time compared to the 2016 baseline
- travel time variations in both directions along the corridor between the 2021 option and do nothing scenario are within five seconds of each other. This suggests that the Proposal is not expected to significantly affect general traffic travel times in the AM peak when considered alongside the forecasted traffic growth.

During the PM weekday peak:

- the Proposal would improve general traffic travel time through the Proposal area in the southbound direction by around one minute compared to the do nothing scenario. This is likely due to the proposed implementation of additional clearways and no-stopping zones in the counter-peak direction and associated increase in capacity that this would allow
- travel times for general traffic in the northbound direction are forecast to be relatively consistent between the 2021 do nothing and option scenarios.

On this basis it is expected that the overall impact upon general traffic travelling through the Proposal area would be neutral during operation.

See 'Bus Services' below for detail of travel time impacts upon bus movements.

Heaton Avenue

As discussed in Section 3.1.1, it is proposed that Heaton Avenue be closed to form a cul-de-sac and for an indented bus bay to be constructed along Manly Road in this location. The closure of this street would also mitigate road safety issues described under the Heaton Avenue section of Section 6.1.1. This includes issues relating to general traffic merging into and out of the T3 transit/bus lane from Heaton Avenue and buses stopping within the active T3 transit/bus lane, as well as delays caused to travel times for buses, taxis, hire cars, bicycles, motorcycles and three-occupant vehicles (in the AM peak). This closure would also directly address the crash history of the site, removing the potential for vehicles exiting Heaton Avenue to adversely interact with Manly Road traffic.

Upon closure traffic vehicles currently exiting Heaton Avenue into Manly Road would be required to use the Sydney Road/Manly Road intersection in order to complete this journey. This would result in a permanent impact upon local and non-local (rat-running) traffic, including traffic making left-in movements from Manly Road and left-out from Heaton Avenue. As outlined in Section 6.1.1, approximately 33% of the traffic exiting Heaton Avenue during the weekday AM peak is considered to be comprised of rat-runners. The impact on these motorists is expected to be minor given the availability of alternative routes.

Of the 550 vehicles observed to be using Heaton Avenue to access Manly Road in the AM peak approximately 369 were considered to be local traffic i.e. not rat-runners. Upon closure of Heaton Avenue it would be necessary for this traffic to take an alternative route in order to travel south on Manly Road. Potential diversions for traffic originating from catchments to both the east and west of Manly Road are shown in Figure 22 and Figure 23 respectively.

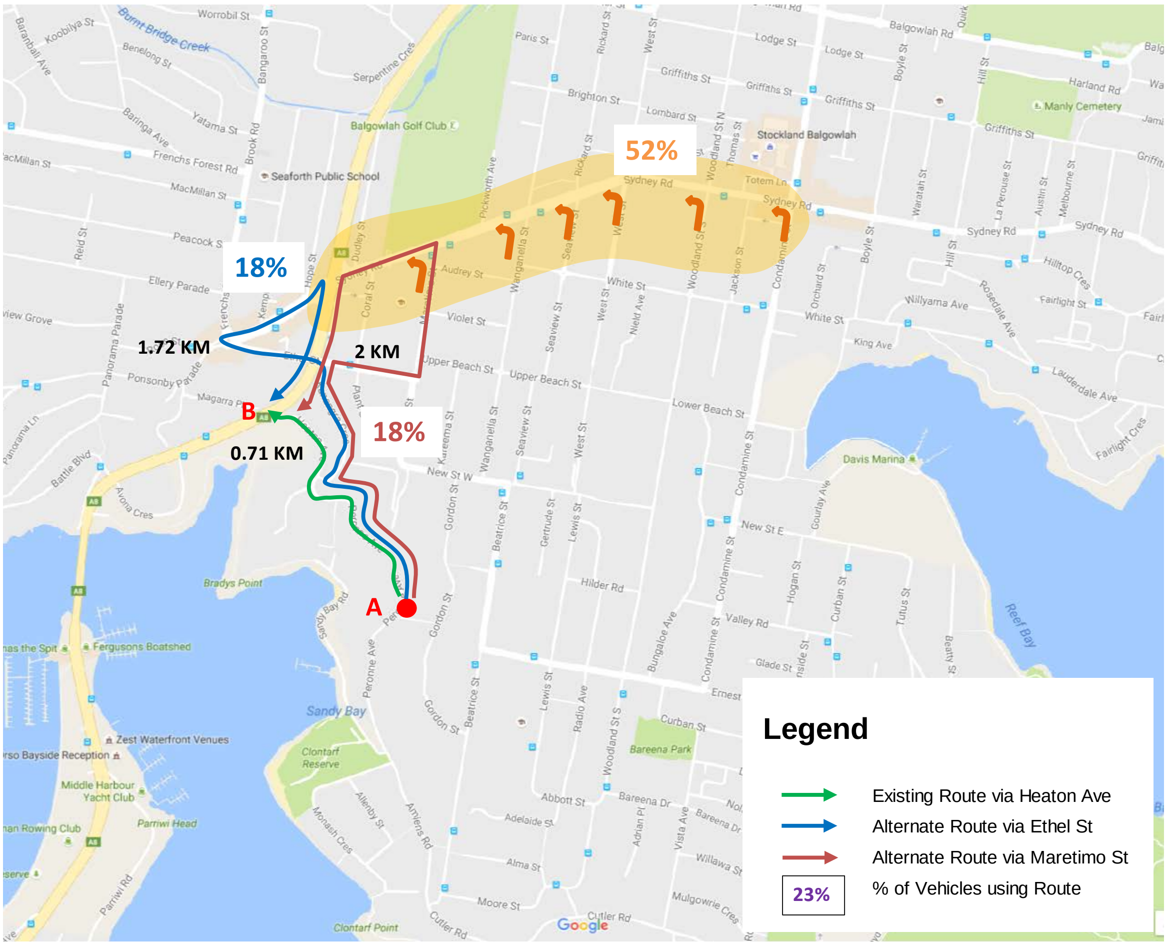


Figure 22 Proposed diversion of Heaton Avenue traffic east of Manly Road. Note the remaining 12% of Heaton Avenue traffic originating from the catchment west of Manly Road is shown in Figure 22.

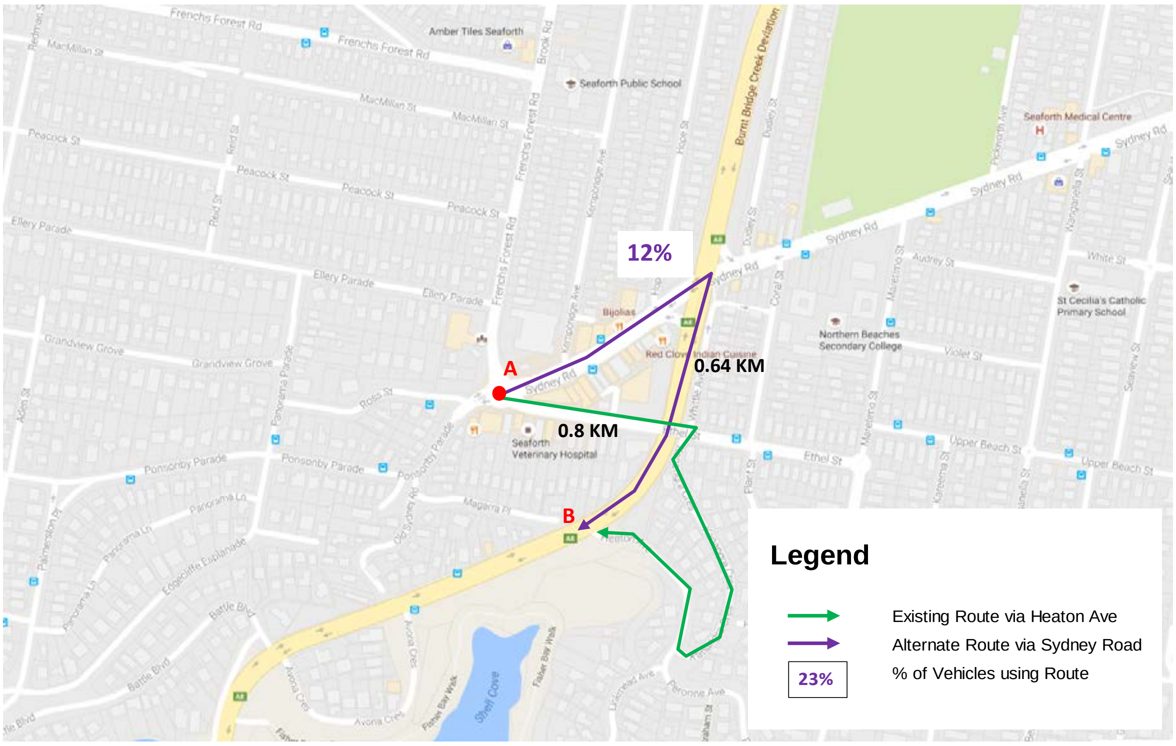


Figure 23 Diversion of affected Heaton Avenue traffic west of Manly Road

Traffic modelling undertaken on behalf of the Proposal (AECOM 2016a) showed that during the AM peak these diversions would typically add between five and ten minutes to journeys originating in the Clontarf/Balgowlah Heights area. The worst case additional travel time would be for vehicles originating from Vista Avenue (point D), affecting approximately 25 vehicles per hour during the AM peak period. See Figure 24 and Table 22 for further detail.

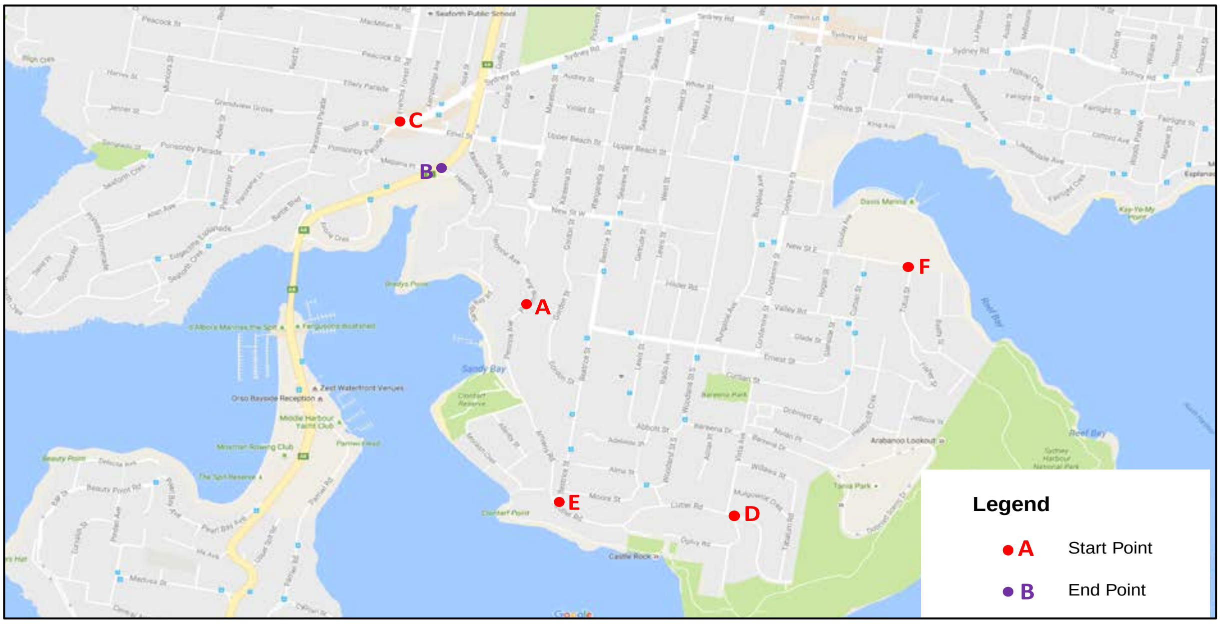


Figure 24 Origin and Destination Points for travel time analysis (AM Peak)

Table 22 Summary of AM Peak travel time estimates for existing and alternate routes

Starting point	Existing route (mm:ss)	Alternate route (mm:ss)	Difference (mm:ss)	Estimate of traffic (vph)
A (Route R1)	6:05	13:30	+7:25	54
A (Route R2)	6:05	9:36	+3:31	54
C	5:12	6:11	+0:59	36
D	8:00	19:14	+11:14	23
E	6:41	12:45	+6:04	23
F	6:00	15:40	+9:40	47

Note that approximately 65 vehicles per hour of westbound 'rat-running' traffic from Sydney Road east is not included in the above table. It is however estimated that any increase in travel time for these 'rat-running' traffic will likely fall within the above range of travel time differences.

Upon closure of Heaton Avenue it is conservatively estimated that approximately 50 vehicles per hour would re-route though the moderately congested Sydney Road/Ethel Street roundabout. Such an increase in traffic demand is likely to be manageable with careful planning of local area traffic management measures (e.g. local signage to encourage use of Sydney Road east) and support from Northern Beaches Council.

Specialist traffic modelling undertaken on behalf of the Proposal assessed the impact of additional traffic diverted through the Sydney Road/Manly Road/Burnt Bridge Creek Deviation intersection as a result of the closure of Heaton Avenue. This assessment was undertaken using both the SIDRA and Commuter microsimulation modelling packages (AECOM 2016a). The assessment showed that the proposed upgrades at the Sydney Road intersection (e.g. extended through traffic lane on Sydney Road) would satisfactorily cater for the displaced Heaton Avenue traffic under both the existing (2016) and future (2021) forecast conditions.

The above traffic modelling also assessed impacts to travel times for buses using the existing T3 transit/bus lane southbound along Manly Road. This model assumed that the proposed indent at Heaton Avenue was operational. This assessment indicated that during the AM peak buses would have a travel time saving of approximately one and half minutes (20% time saving as per Commuter model Scenario 1) between Sydney Road and Parriwi Road north based on existing traffic demands. This improvement in travel time is considered to be a moderate beneficial impact to bus users.

Given the availability of alternative routes, the proposed upgrade of the Sydney Road/Manly Road/Burnt Bridge Creek Deviation intersection and the degree of additional travel time for some local traffic, the proposed closure of Heaton Avenue would provide an overall benefit to the travelling public through increased public transport efficiency and improvements in road safety. The benefits arising from the proposed closure (improvements in local and B-Line bus travel times) are expected to be appreciable and important to the overall efficiency of both B-Line and local bus services through this location.

It is recognised that the closure of Heaton Avenue would result in additional travel time for some local traffic. Whilst this impact is regrettable locally it would provide broader benefits to the Northern Beaches community and the large number of users of the public transport system in particular.

Pedestrian and bicycle facilities

The Proposal includes a range of proposed upgrades for active transport facilities for pedestrians and cyclists. These include:

- new kerbside ramps and kerb extensions
- signalised pedestrian crossings

Ongoing impacts upon pedestrian movements during operation of the Proposal would be limited to the minor diversion of pedestrians at various locations throughout the Proposal area.

Pedestrian access at the intersection of Pittwater Road and Cross Street would be diverted around the newly constructed left turn lane, closer to the current Warringah Mall parking area. The existing pedestrian crossing over Cross Street in this location would also be moved westwards to allow space for the left turn lane. Traffic signalling would be implemented so as to allow for protection of pedestrians whilst crossing.

Pedestrian access the Sydney Road/Burnt Bridge Creek Deviation intersection would be diverted around the proposed left turn lane. This would move the footpath and subsequent pedestrian crossing of Burnt Bridge Creek Deviation slightly north. Traffic signalling would be implemented so as to allow for protection of pedestrians whilst crossing.

Pedestrian access from Heaton Avenue into Manly Road would be maintained via a pedestrian ramp which would be designed according to disability access standards. Access for pedestrians travelling south along Manly Road would be made safer through the removal of the need to cross Heaton Avenue as it intersects with Manly Road.

In all of the above locations changes to pedestrian access would result in minimal change to the existing ease of access or travel times. As such the overall impact is upon pedestrians is considered to be negligible.

Changes to the movement of bicycles through the proposal area would be minimal. At Cross Street and Sydney Road/Burnt Bridge Creek Deviation the movement of bicycles in all existing travel paths would be maintained as per the existing scenario. The inclusion of left turn slip lanes would slightly increase safety for cyclists in these locations waiting at the traffic lights to turn left.

The removal of parking to the east of the Dudley Street/Sydney Road intersection would eliminate the potential for interaction between parked vehicles and cyclists, including the opening of car doors into the path of cyclists and interactions whilst vehicles enter and depart. On this basis the proposal would have a minor positive impact for cyclists during operation.

At Heaton Avenue direct cycling access to Manly Road would be prevented by the proposed road closure. However cyclists may dismount in this location and utilise the footpath for a short distance (less than 30 m) prior to re-joining the carriageway of Manly Road. This change to bicycle access is considered to be minor.

Bus services

Average operational travel times for buses along Pittwater Road, Condamine Street, Burnt Bridge Creek Deviation, Manly Road and Sydney Road through the Proposal area were modelled (AECOM 2016a). The results of this modelling indicated that during the AM weekday peak:

- travel times southbound for B-Line services are forecast to be around 100 seconds (15%) better than under the 'do nothing' scenario
- travel times southbound for local bused are forecast to reduce by around one minute (9%) compared to the 'do nothing' scenario
- travel times for all buses (including B-Line) in the AM peak are forecast to improve by around 20 seconds (3%) northbound
- the outputs suggest that the B-Line proposal would have a positive impact on bus flow and operation along the corridor and would provide moderate benefits in terms of bus travel times, especially in the morning peak southbound direction in comparison to the 'do nothing' scenario.

During the PM weekday peak:

- Local bus times and B-Line service times in the northbound direction would increase by around 20 seconds. This increase in travel time may due to additional northbound throughput in the traffic model at the Cross Street intersection (approximately 100 vehicles per hour), which exacerbates existing congestion along this stretch of already congested corridor
- B-Line and local bus travel times in the southbound direction would reduce by around one minute (9%) between the 2021 'do nothing' and Proposal scenario. This benefit is likely due to the proposed addition of clearways and no stopping zones in the counter-peak direction.

During operation bus users would experience a beneficial impact through the provision of safer bus stops and overall improvements to travel times. These improvements would be experienced by both existing local bus passengers and those of the new B-Line service. Increases in safety would arise from the provision of the new bus indent at Heaton Avenue. This facility would allow buses to stop clear of the T3 transit/bus lane, reducing the potential for lane change and rear end crashes. This would also reduce the need for other traffic in the T3 transit/bus lane (other buses, taxis, hire cars, bicycles, motorcycles and three-occupant vehicles in the AM peak) to queue behind buses stopped to pick up or set down passengers, hence improving travel times through this location. Further benefits would arise from the avoidance of conflict between buses and traffic exiting Heaton Avenue, particularly during the AM peak.

The provision of new left turn lanes at Cross Street and Sydney Road/Burnt Bridge Creek Deviation would reduce the incidence of buses queuing behind general traffic waiting to turn left from the kerbside lane, hence reducing the time for buses to pass through these intersections. This would result in travel time benefits for both local and B-Line bus services.

The existing bus stop on Sydney Road to the east of Dudley Street would be permanently relocated approximately 40 metres to the east. This would be undertaken in order to reallocate road space adjacent to the Dudley Street from bus stop to active traffic lanes. The relocated bus stop would include the installation of new signage and a bus shelter. The bus shelter structure would not include any capability for the display of advertising. The relocated bus stop would remain an ‘in lane’ stop though being further along Sydney Road there would be greater opportunity for general traffic to merge and divert around any stopped buses.

Parking

The operation of the proposal would result in the permanent loss of two parking spaces on the northern side of Sydney Road, east of Dudley Street, to accommodate the new lane configuration. Parking within this location is restricted a one hour stay during the day on Monday to Friday and on Saturday mornings. Parking in this location is unrestricted at other times. Given the availability of nearby alternative and unrestricted parking along Dudley Street, immediately to the west, the impact of the loss of these spaces is considered to be minor.

6.1.3. Mitigation measures

A construction Traffic Management Plan (TMP) would be prepared and implemented by the Construction Contractor, included in the Construction Environmental Management Pan (CEMP) and provided to Northern Beaches Council. The construction TMP would be the primary management tool to manage potential traffic and pedestrian impacts associated with construction. The construction TMP, at a minimum, would include:

- Outline of the road closures and alternatives
- Pedestrian and cycle provisions throughout the construction period
- Outline of the consultation process to inform the community of any road, pedestrian or cycle changes

Property accesses are to be maintained during the works. Any unexpected disturbances to property access would be discussed with the affected resident(s)

To manage the potential for cumulative traffic impacts during construction, the Traffic Management Centre (TMC) would coordinate road occupancy licences throughout the corridor.

6.2. Urban design, landscape and visual amenity

A visual impact assessment was undertaken for the Proposal in line with Roads and Maritime’s *EIA-N04 Guideline for Landscape Character and Visual Impact Assessment* (Roads and Maritime, 2013). The findings of the assessment are summarised in this section.

6.2.1. Existing environment

The visual character of the Proposal area is typical of a main arterial road within an established urban environment. This includes residential and commercial land uses located in close proximity to the road corridor. Visual features dominating the Proposal area comprise road (and related) infrastructure, traffic, pedestrian and cycle paths, and commercial buildings. In some locations, landscaped street trees provide visual screening from the road corridor for adjacent residential and commercial receivers. Visual receivers include community facility users, local businesses, residents, vehicle-based receptors, pedestrians and cyclists.

Six visual receiver locations (two for each zone) have been identified to represent key viewpoints to and from the Proposal. An assessment was undertaken to determine the potential impacts upon views as a result of the Proposal at these locations. These locations are described in Table 23 and shown in Figure 25, Figure 26 and Figure 27.

Table 23 Visual receivers within the vicinity of the Proposal Area

Zone	No.	Visual receiver	Existing Environment	Purpose
A	**A1**	2-4 Roger St, Brookvale	Commercial property with frontage to Rogers St and Pittwater Rd. Small pocket park present with small trees and groundcovers	To assess the visual impact on staff and customers at a commercial property
A	**A2**	Bus stop (Pittwater Rd Near Roger St)	Commercial precinct dominated by Pittwater Road and views to Brookvale bus depot on eastern side of the road	To assess the visual impact on pedestrians and bus users
B	**B1**	10 Whittle Avenue, Balgowlah	Residential area on a local road elevated above Manly Road with views to the Sydney Road intersection. View dominated by the intersections and roads, with minor screening vegetation present	To assess the visual impact on a nearby residential property
B	**B2**	510-514 Sydney Rd, Seaforth	Small commercial precinct with views dominated by Sydney Road and medium density residential and commercial development opposite	To assess the visual impact on a nearby small businesses
C	**C1**	31 Magarra Place, Seaforth	Residential area with views dominated by Manly Road in the foreground and Middle Harbour in the distance	To assess the visual impact on a nearby residential property
C	**C2**	14 Heaton Avenue, Clontarf	Residential area with views dominated by vegetation along the southern side of Heaton Avenue and Middle Harbour in the distance	To assess the visual impact on a nearby residential property

Figure 25 Visual receivers within Zone A

Figure 26 Visual receivers within Zone B

Figure 27 Visual receivers within Zone C

6.2.2. Potential impacts

Construction phase

Construction of the Proposal would result in temporary visual amenity impacts for surrounding receivers within or adjacent to the Proposal area. Construction features that may affect visual amenity include:

- the presence of construction vehicles, machinery, equipment and personnel
- open excavations within works area
- vegetation clearance
- temporary construction compounds including demountable buildings, storage containers, stockpiling areas, amenities and a perimeter fence with gates
- safety barriers/fencing
- stockpiled materials.

It should be noted that the majority of works within the Proposal area would be carried out at night in order to minimise impacts to traffic and access. As such construction would include temporary lighting for operational, safety and security purposes. Lighting installations would be placed to minimise light spill to adjoining road corridors and occupied residential or commercial areas.

Visual impacts within during construction within Zone A at Cross Street would include the presence of several of the above elements including construction plant and materials, open excavations, and safety barriers. It may be necessary to stockpile materials at this location though these would generally be temporary and would be utilised or removed within the period of each construction shift i.e. these would not be left at the site outside of active construction.

Visual impacts within Zone B would include the same construction related impacts as Zone A, with the added impact associated with the removal of vegetation adjacent to Sydney Road and within the median of Burnt Bridge Creek Deviation.

Within Zone C (Heaton Avenue) construction related visual impacts would be associated with the minor removal of vegetation around the intersection to facilitate the construction of the proposed indented bus bay and for works to support the closure of Heaton Avenue. Such impacts would be temporary and are not considered to be significant.

The overall construction duration for the Proposal would be around nine months. Construction activities would not occupy the entire Proposal area (Brookvale to Seaforth) for this entire period but would move progressively as certain sections are completed.

The overall visual impact of the construction of the Proposal is considered to be moderate, given the scale and length of construction activities in the context to the existing urban environment and the temporary nature of the proposed works.

Mitigation measures to manage impacts to visual amenity and urban design during construction of the Proposal are outlined in Section 7.2. With the implementation of these measures, construction of the Proposal is not expected to result in a significant impact on the urban design, landscape and visual amenity of the Proposal area.

Manly Vale Commuter Car Park construction compound

The Manly Vale Commuter Car Park construction compound would include a site office, construction vehicles, equipment, fencing, signage material stockpiling and storage. Impacts upon the local visual scenario would be mitigated through the use of opaque or semi-opaque shade coth to cover all temporary fencing. At night, the site compound would be lit for passive security and surveillance. Such lighting would be located so at minimise light spill off site, particularly into nearby residential areas.

The presence of a site office, construction vehicles, equipment, fencing, signage material stockpiling and storage areas and night time lighting for security would have a temporary visual impact. Generally, the character of the site compound at night would be visually absorbed into the surrounding brightly lit environment.

The visual impacts created by the Manly Vale Commuter Car Park construction compound would be temporary and have a minor to negligible impact.

During operation there would be no additional visual or urban amenity impact in addition to that previously identified in the *Manly Vale Commuter Car Park and B-Line Stops Review of Environmental Factors* (TfNSW, March 2016).

Operational phase

The relationship between each visual receiver and the relevant works for the Proposal is provided in Table 24.

Table 24 Works with the potential to impact on sensitive receivers

No.	Visual receiver	Relevant proposed works
A1	2-4 Roger St, Brookvale	Construction of a new left turn lane from Pittwater Road into Cross Street (westbound)
A2	Bus stop (Pittwater Rd Near Roger St)	Construction of continued median strip within Pittwater Road at the Orchard Road intersection

No.	Visual receiver	Relevant proposed works
B1	10 Whittle Avenue, Balgowlah	Extension of the existing right turn lane from Manly Road into Sydney Road (eastbound)
B2	510-514 Sydney Rd, Seaforth	Upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound) Extension of the Sydney Road (westbound) through traffic lane on the eastern side of the Burnt Bridge Creek/Manly Road intersection
C1	31 Magarra Place, Seaforth	Construction of a new indented bus bay on Manly Road (southbound) at the at the Heaton Avenue intersection including full closure of Heaton Avenue at Manly Road to form a cul-de-sac
C2	14 Heaton Avenue, Clontarf	Construction of a new indented bus bay on Manly Road (southbound) at the at the Heaton Avenue intersection including full closure of Heaton Avenue at Manly Road to form a cul-de-sac

An assessment of the visual sensitivity and magnitude of each visual receiver location was undertaken for the operational phase of the Proposal. The sensitivity of the receiver is assessed based upon the extent to which it can accept change of a particular type and scale without adverse impacts on its character. The magnitude of change affecting a visual receiver depends on factors such as extent of visibility, degree of obstruction of existing features, degree of contrast with the existing view, angle of view, duration of view and distance from the Proposal. The visual impact grading matrix was used to assign a rating to each visual receiver (refer to Table 25).

The results of the visual impact assessment are provided in Table 26.

Table 25 **Visual impact grading matrix**

Sensitivity \ Magnitude	High change	Moderate change	Low change	Negligible change
High	High	High-moderate	Moderate	Negligible
Moderate	High-moderate	Moderate	Moderate-low	Negligible
Low	Moderate	Moderate-low	Low	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Table 26 Operational visual impact assessment

No.	Visual receiver	Sensitivity	Magnitude	Rating
A1	2-4 Roger St, Brookvale	The receiver is a large automotive sales store with existing views to Cross St and Pittwater Rd. The sensitivity of the receiver is low.	The receiver is over 20 metres from the Proposal and views towards the Proposal would be similar to the existing view. The magnitude of change would be low.	Low
A2	Bus stop (Pittwater Rd Near Roger St)	The receiver is located on Pittwater Rd and bus users are likely to be accustomed to the urbanised and traffic-laden outlook. The sensitivity of the receiver is low.	Views from the bus stop to Pittwater Road often consist of high traffic flows. The Proposal would result in a similar view from the bus stop. The magnitude of change would be low.	Low
B1	10 Whittle Avenue, Balgowlah	The residence is a multi-unit dwelling located adjacent to Sydney Road. As such, residents are likely to be accustomed to heavy traffic flow through the intersection. The sensitivity of the receiver would be low.	A change in view from this location would be minor considering the majority of the Proposal in view involves reconfiguration of existing lanes. The magnitude of change would be low.	Low
B2	510-514 Sydney Rd, Seaforth	Small businesses are likely to be accustomed to parked vehicles within view. The works proposed involves removing these parking spaces. The sensitivity would be moderate.	The Proposal would remove parking in front of the receiver. This would result in continuous traffic flow as the dominant view from the receiver. The magnitude of change would be moderate.	Moderate
C1	31 Magarra Place, Seaforth	The residence is elevated above the Proposal and views from the receiver would overlook the Proposal. The sensitivity would be low.	The proposal would include the removal of a small amount of mature and juvenile vegetation, resulting in a low change in overall magnitude when considered in the context of the area's general visual scenario.	Low
C2	14 Heaton Avenue, Clontarf	The residence is located near the Proposal, however, the view from the property is predominately southwards towards Middle Harbour. The sensitivity would be low.	The magnitude of change for this receiver would be moderate based upon the minimal nature of the physical works proposed and limited vegetation removal. The reduction in traffic through Heaton Avenue would result in a minor positive change for the receiver.	Moderate - Low

Based on the above assessment it is likely that receivers in Zone B2 and D2 would experience a moderate degree of visual impact. Overall however, the Proposal is considered to have a low visual impact on the majority of people living, working or travelling through the Proposal area during operation.

6.2.3. Mitigation measures

The overall visual impacts of the Proposal have been determined to range from low to moderate for the surrounding visual receiver locations. Mitigation measures would be considered during design development and construction planning to minimise the level of visual impact of the construction and operation phases of the Proposal.

The following mitigation measures are proposed to manage visual impacts:

- the site would be kept tidy and well maintained during construction, including removal of all rubbish at regular intervals. There should be no storage of materials beyond the construction boundaries
- light spill from the road corridor into adjacent visually sensitive properties is to be minimised by the use of cut-off lighting, directing construction lighting into the construction areas and ensuring the site is not over-lit. This includes the sensitive placement and specification of lighting to minimise any potential increase in light pollution
- temporary hoardings, barriers, traffic management and signage would be removed when no longer required
- work/site compounds would be screened where practical, with shade cloth or similar material to minimise visual impacts
- the construction contractor would restore any areas that are affected by construction with appropriate landscape treatments
- an urban design and landscape plan would be prepared in consultation with relevant stakeholders
- Vegetation offsets and/or landscaping would be undertaken in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment* (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b). All planting would be undertaken in consultation with the Northern Beaches Council, and/or the owner of the land upon which the vegetation would be planted.

Refer to Table 43 in Section 7.2 for a full list of mitigation measures.

6.3. Noise and vibration

A Noise and Vibration Impact Assessment was undertaken by AECOM for the Proposal (AECOM, 2016b). The assessment applied the Roads and Maritime Construction Noise Estimator tool to prepare the construction noise assessment and to determine construction noise levels, noise impacts at the most affected sensitive receivers and, where necessary, recommend appropriate mitigation measures to reduce and manage noise and vibration impacts from the Proposal.

As operational noise levels are expected to remain largely unchanged, no quantitative modelling of operational noise impacts was undertaken. The findings of the assessment are summarised in this section.

6.3.1. Existing environment

Sensitive noise receivers

Attended and unattended noise monitoring was undertaken in August and September 2016 at the following representative receiver locations within the Proposal area:

- P8_1: 727 Pittwater Road, Dee Why – commercial precinct
- P9_1: 14 Heaton Avenue, Clontarf – residential precinct
- P9_2: 10 Magarra Place, Seaforth – residential precinct
- P9_3: 10 Whittle Avenue, Balgowlah – residential precinct
- P9_4: 2 Hope Street, Seaforth – residential precinct
- Construction compound: 82 Kenneth Road, Manly Vale

Monitoring locations are shown in Figure 28 and reflect Zone B and C.

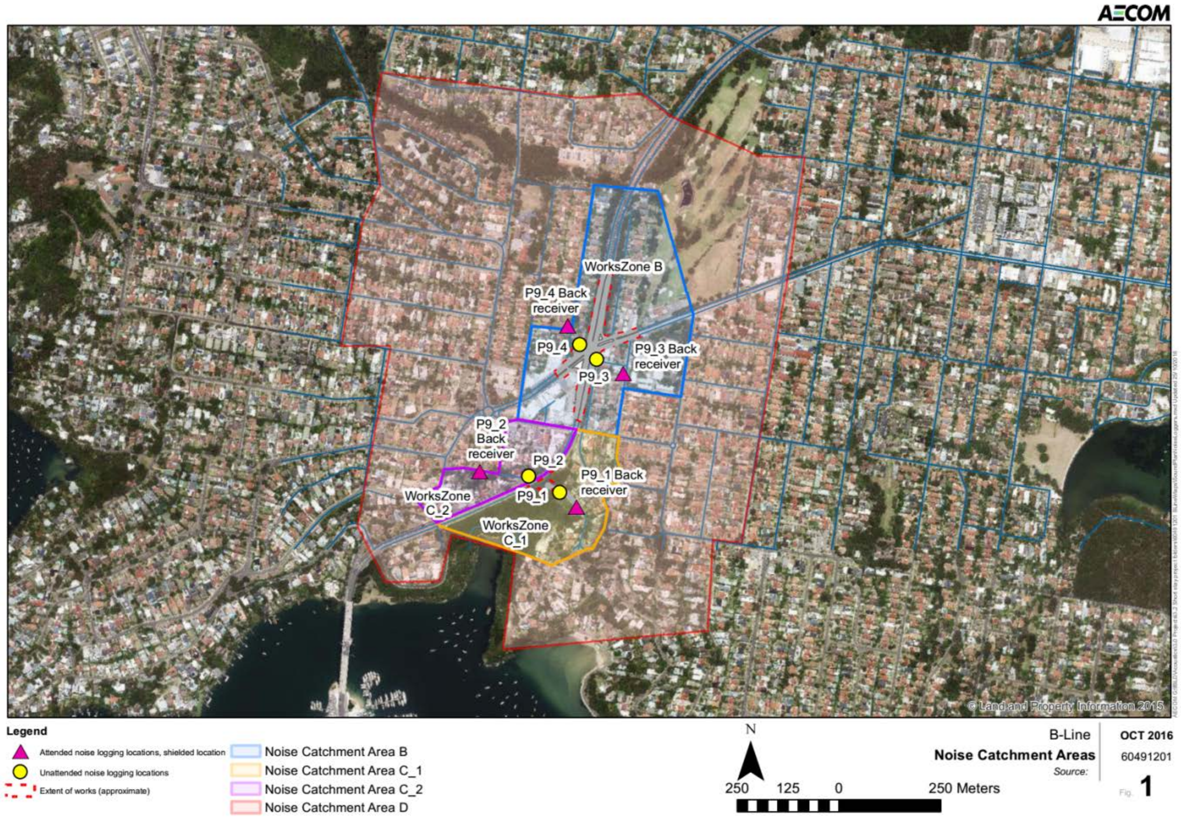


Figure 28 Noise logger locations

To assist in determining noise criteria for the receivers surrounding the Proposal, six noise catchment areas (NCA) have been identified:

- NCA_A (Logger P8_1) is analogous to the noise environment of Zone A
- NCA_B (Logger P9_3) comprises the area of Zone B
- NCA_C_1 (Logger P9_1) comprises the area of Zone C
- NCA_C_2 (Logger P9_2) also comprises the area of Zone C
- NCA_D (no logger) covers non-facing properties away from the immediate construction area around Zone B and Zone C
- Construction compound (data from previous REF) covers the Manly Vale Commuter Car Park construction compound area.

Refer to Figure 2 for an overview of each zone. All NCAs have a similar existing noise environment.

Background noise levels

Monitoring determined that the existing noise environment at all locations is typical of suburban/urban noise environments alongside major transport corridors, where day time and evening background levels are high due to heavy and continuous traffic flows. The night time background noise level tends to decrease substantially as a result of reduced traffic flows.

A summary of the existing background noise during the day, evening and night for both monitoring locations is provided in Table 27.

Table 27 Existing background and ambient noise levels (dB(A))

NCA	Logger number	Period[1]	Rating Background Level (RBL) (L_{90})[2]	Ambient noise levels (L_{Aeq})[3]
NCA_A	P8_1	Day	58 dB(A)	71 dB(A)
		Evening	55 dB(A)	70 dB(A)
		Night	42 dB(A)	66 dB(A)
NCA_B	P9_3	Day	62 dB(A)	74 dB(A)
		Evening	57 dB(A)	71 dB(A)
		Night	36 dB(A)	68 dB(A)
NCA_C_1	P9_1	Day	51 dB(A)	61 dB(A)
		Evening	48 dB(A)	58 dB(A)
		Night	33 dB(A)	55 dB(A)
NCA_C_2	P9_2	Day	61 dB(A)	74 dB(A)
		Evening	58 dB(A)	72 dB(A)
		Night	38 dB(A)	69 dB(A)
NCA_D	AS1055.3 – R3	Day	50 dB(A)	- dB(A)
		Evening	45 dB(A)	- dB(A)
		Night	40 dB(A)	- dB(A)
Construction compound	Previous REF[4]	Day	54 dB(A)	- dB(A)
		Evening	48 dB(A)	- dB(A)
		Night	38 dB(A)	- dB(A)

Notes:

1. *day is defined as 7am to 6pm, Monday to Saturday and 8am to 6pm Sundays and public holidays*
   evening is defined as 6pm to 10pm, Monday to Sunday and public holidays
   night is defined as 10pm to 7am, Monday to Saturday and 10pm to 8am Sundays and public holidays.
2. *the rating background level (RBL) (L_{A90}) represents the noise level exceeded for 90 per cent of the monitoring period.*
3. *the ambient noise level represents the average noise level over the monitoring period.*
4. *Logger data obtained from the Manly Vale Commuter Car Park REF. Ambient noise levels not available.*

Construction noise criteria

The EPA's *Interim Construction Noise Guideline* (ICNG) (Department of Environment and Climate Change, 2009) is the principal guideline for the assessment and management of construction noise in NSW. The ICNG recommends standard hours of construction as:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm

- Sundays and public holidays: no works.

Noise management levels (NMLs) have been determined for receivers in accordance with the ICNG. The ICNG outlines NMLs for non-residential receivers such as commercial properties, schools and places of worship. NMLs for residential receivers are calculated based on the rating background level (RBL) + 10 dB(A) (for daytime periods) or the RBL + 5 dB(A) (for evening and night time periods). Evening is defined by the ICNG as between 6pm and 10pm and night as between 10pm and 7am. A 'highly noise affected' level of 75 dB(A) for residential receivers represents the point above which there may be strong community reaction to noise.

Where works exceed the NMLs, all reasonable and feasible measures (such as equipment selection and location, construction scheduling and respite periods) should be implemented to reduce noise levels as far as practicable.

The construction NMLs developed for the Proposal for sensitive receivers are listed in Table 28 and Table 29

Table 28 Construction NMLs for residential receivers

NCA	Period[1]	Rating Background Level (RBL) (L_{90})[2]	Standard hours NMLs ($L_{Aeq,15min}$)	Out of hours NMLs ($L_{Aeq,15min}$)
NCA_A	Day	58 dB(A)	68 dB(A)	63 dB(A)
	Evening	55 dB(A)	N/A	60 dB(A
	Night	42 dB(A)	N/A	47 dB(A
NCA_B	Day	62 dB(A)	72 dB(A)	67 dB(A)
	Evening	57 dB(A)	N/A	63 dB(A
	Night	36 dB(A)	N/A	41 dB(A
NCA_C_1	Day	51 dB(A)	61 dB(A)	56 dB(A)
	Evening	48 dB(A)	N/A	53 dB(A
	Night	33 dB(A)	N/A	38 dB(A
NCA_C_2	Day	61 dB(A)	71 dB(A)	66 dB(A)
	Evening	58 dB(A)	N/A	63 dB(A
	Night	34 dB(A)	N/A	39 dB(A
NCA_D	Day	50 dB(A)	60 dB(A)	55 dB(A)
	Evening	45 dB(A)	N/A	50 dB(A
	Night	40 dB(A)	N/A	45 dB(A
Construction compound	Day	54 dB(A)	64 dB(A)	59 dB(A)
	Evening	48 dB(A)	N/A	54 dB(A

NCA	Period[1]	Rating Background Level (RBL) (L_{90})[2]	Standard hours NMLs ($L_{Aeq,15min}$)	Out of hours NMLs ($L_{Aeq,15min}$)
	Night	38 dB(A)	N/A	43 dB(A

Table 29 Construction noise management levels for non-residential receivers

Land use	NMLs, $L_{Aeq,15min}$ (applies when properties are in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas	External noise level 65 dB(A)
Passive recreation areas	External noise level 60 dB(A)
Community centres	Depends on the intended use of the centre. Refer to the recommended “maximum” internal levels in AS2107 for specific uses.

Notes:

1. *these external NMLs are based upon a 45 dB(A) internal NML and a 10 dB reduction from outside to inside through an open window.*

Sleep disturbance noise goals have also been established for residential receivers which are based on the *NSW Road Noise Policy* (Department of Environment, Climate Change and Water, 2011). The sleep disturbance criteria derived from this Policy arte presented for all NCAs in Table 30 below.

Table 30 Construction noise management levels for non-residential receivers

NCA	Rating Background Level (RBL) (L_{90})	Sleep disturbance screening ($L_{A1,1min}$) criteria	Sleep disturbance awakening reaction ($L_{A1,1min}$) criteria
NCA_A	42 dB(A)	57 dB(A)	65 dB(A)
NCA_B	36 dB(A)	51 dB(A)	65 dB(A)
NCA_C_1	33 dB(A)	48 dB(A)	65 dB(A)
NCA_C_2	34 dB(A)	49 dB(A)	65 dB(A)
NCA_D	40 dB(A)	55 dB(A)	65 dB(A)
Construction compound	38 dB(A)	53 dB(A)	65 dB(A)

Construction vibration criteria

When assessing vibration there are two categories to consider: one related to the impact of vibration to human comfort and one relating to the impact on building structures (cosmetic damage).

Human comfort

The assessment of intermittent vibration outlined in the NSW EPA guideline *Assessing Vibration: A Technical Guideline* (AVTG) is based on Vibration Dose Values (VDVs). Maximum and preferred VDVs for intermittent vibration arising from construction activities are listed in Table 31. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

Table 31 Preferred and maximum vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Period	Preferred	Max
Critical areas[1]	Day or night time	0.1	0.2
Residences	Daytime[3]	0.2	0.4
	Night time[4]	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night time	0.4	0.8
Workshops[2]	Day or night time	0.8	1.6

Notes:

1. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. Places where sensitive equipment is stored or delicate tasks are undertaken require more stringent criteria than the residential criteria specified above.*
2. *Examples include automotive repair shops, manufacturing or recycling facilities. This includes places where manufacturing, recycling or repair activities are undertaken but do not require sensitive or delicate tasks.*
3. *Daytime period is defined as 7am – 10pm under BS 6472-1992 Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz).*
4. *Night period is defined as 10pm – 7am under BS 6472-1992.*

Structural damage to buildings

There is currently no Australian Standard that provides guidance for assessing cosmetic building damage caused by vibration. However, the German standard (DIN 4150) provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in Table 32. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage. The vibration criteria provided below in Table 32 would be adopted for the management of vibration impacts on structures, and include more conservative values for heritage structures.

Table 32 DIN 4150: Structural damage safe limits for building vibration velocity

Group	Type of Structure	At foundation - less than 10 Hz	At foundation - 10 to 50 Hz	At foundation - more than 50 Hz	At the horizontal plane of the highest floor – all frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20 mm/s	20 to 40 mm/s	40 to 50 mm/s	40 mm/s
2	Dwellings and buildings of similar design and/or use	5 mm/s	5 to 15 mm/s	15 to 20 mm/s	15 mm/s
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. heritage listed buildings)	3 mm/s	3 to 8 mm/s	8 to 10 mm/s	8 mm/s

Notes:

1. At frequencies above 100 Hz, the values given in this column may be used as minimum values.

6.3.2. Potential impacts

Construction phase

To assess the potential noise impacts from the proposed construction works, the construction stages described in Chapter 3 were further divided into indicative scenarios. Scenarios for each construction stage were modelled based on the likely construction equipment that would be used to understand the potential noise impact for each stage. Scenarios are outlined in Table 33.

Table 33 Construction assessment scenarios

Scenario	Activity	Stage	Equipment	Timing
Site mobilisation and establishment	Establishment of site compound (erect fencing, tree protection zones, site offices, amenities and plant/material storage areas), establish temporary facilities as required (e.g. traffic control)	1	• trucks • scissor lift • franna crane	Standard hours

Scenario	Activity	Stage	Equipment	Timing
Enabling works	survey and potholing, removal of identified vegetation and investigation and relocation of services (where required)	2	• excavator • dump truck • franna crane • pneumatic hammer • concrete saw • vacuum truck • backhoe • generator	Outside standard hours
Road works	Demolition of the existing concrete road, road verge, kerbs and pedestrian pathways, resurfacing and construction of new road pavement for slip lanes, bus bays, right/left hand turns etc.	3	• pavement laying machine • dump truck • asphalt truck and sprayer • concrete truck • smooth drum roller • concrete saw	Outside standard hours
Drainage, line marking and signalling	Upgrades to kerbs, gutters and footpaths and line marking and new signalling	4	• backhoe • franna crane • excavator • concrete truck • truck compressor • vibratory roller • truck	Standard hours

A summary of the predicted construction noise levels for each scenario during standard working hours for sensitive receivers is shown in Table 34.

Table 34 Predicted construction noise levels for each scenario during standard hours (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	225 metres	68	55	56	-	58
NCA_B	20 metres	72	**77**	**78**	**77**	**80**
NCA_C_1	85 metres	61	65	66	65	68
NCA_C_2	50 metres	71	69	70	69	72
NCA_D	50 metres	60	59	60	59	62

Note: *Items in* ***BOLD*** *indicate a predicted noise impact above the* ***NML*** *and a '****highly affected'*** *residential receiver with a noise level of 75 dB(A) or greater.*

The predicted noise levels indicate that there would be exceedances of the residential and non-residential noise management levels during standard hours during all assessed stages of construction.

Within Zone A noise would be associated with the construction of a new left turn lane from Pittwater Road (northbound) into Cross Street and the closure of the median strip within Pittwater Road at the Orchard Road intersection. The most affected receptors in this location would be commercial properties adjacent to the Pittwater Road/Cross Street intersection. There would be no exceedances of the noise management level in this location.

For Zone B, noise would be associated with various works on the Burnt Bridge Creek Deviation/Sydney Road/Manly Road intersection. This includes the construction of a dedicated left turn lane and changes to medians, line marking and signage. The most affected receivers in this location would be residences and small businesses within the vicinity of the intersection. There would be exceedances of both the noise management level and highly affected noise levels at all stages of construction in this location.

For Zone C, noise would be associated with the closure of Heaton Avenue and construction of a new indented bus bay on Manly Road (southbound). The most affected receivers at this location would be residences along Heaton Avenue and on the western side of Manly Road. There would be exceedances of the noise management level at all stages of construction in NCA_C_1, though only exceedances for scenario 4 for NCA_C_2. There would be no exceedances of the highly affected noise levels at this location.

During construction, not all equipment would be operating simultaneously at all times in any one location (which is the worst case scenario assumed in the assessment). This would result in a slight reduction in predicted noise levels. The level of impact may change depending on the final construction methodology and further assessment would be undertaken if required. Further to this no noisy works would be undertaken after midnight.

The exceedances shown above in Table 34 would be mitigated by implementing standard Roads and Maritime noise mitigation measures where feasible and reasonable (refer to Section 6.3.3). The exceedances would be short-term and limited to the duration of the construction period.

Out of hours works

Out of hours works would be required to undertake the road works throughout the Proposal area in order to minimise traffic impacts during peak periods.

The predicted construction noise levels for each scenario (refer to Table 33 for scenarios) during out of hours works during the day, evening and night for sensitive receivers is shown in Table 35, Table 36 and Table 37.

Table 35 Predicted construction noise levels for each scenario during out of hours (day) works (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	225 metres	63	55	56	-	58
NCA_B	20 metres	67	**77**	**78**	**77**	**80**
NCA_C_1	85 metres	56	65	66	65	58
NCA_C_2	50 metres	66	69	70	69	72
NCA_D	50 metres	55	59	60	59	62

Note: *Items in **BOLD** indicate a predicted noise impact above the **NML** and a '**highly affected'** residential receiver with a noise level of 75 dB(A) or greater.*

Table 36 Predicted construction noise levels for each scenario during out of hours (evening) works (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	225 metres	60	55	56	-	58
NCA_B	20 metres	62	**77**	**78**	**77**	**80**
NCA_C_1	85 metres	53	69	66	65	68
NCA_C_2	50 metres	63	77	70	69	72
NCA_D	50 metres	50	59	80	59	62

Note: *Items in* ***BOLD*** *indicate a predicted noise impact above the* ***NML*** *and a '****highly affected'*** *residential receiver with a noise level of 75 dB(A) or greater.*

Table 37 Predicted construction noise levels for each scenario during out of hours (night) works (dB(A)) for receivers

NCA	Distance to closest receiver	NML	1	2	3	4
NCA_A	225 metres	47	55	56	-	58
NCA_B	20 metres	41	**77**	**78**	**77**	**80**
NCA_C_1	85 metres	38	**65**	**66**	**65**	**68**
NCA_C_2	50 metres	39	**69**	70	**69**	**72**
NCA_D	50 metres	45	59	60	59	62

Note: *Items in* ***BOLD*** *indicate a predicted noise impact above the NML and* ***sleep awakening criteria*** *for a residential receiver with a noise level of* ***65 dB(A)*** *or greater.*

The above results indicate that:

- For both daytime and evening out of hours works there would be exceedances of noise management levels in all areas except Zone A. Noise levels would exceed the highly affected level for residential properties in Zone B during both daytime and evening periods
- For night time out of hours works there would be exceedances of noise management levels within all Zones. Noise levels would exceed the highly affected level for residential properties in Zone B. Noise would exceed sleep awakening criteria for residences in Zone B and Zone C.

The most affected receivers would be consistent with those affected during standard working hours as outlined above.

Where feasible, construction activities would be scheduled to be undertaken during standard hours, however for a number of reasons (including safety of workers/general public and traffic impacts) some construction activities would be required to be undertaken outside of standard working hours. If extended out of hours works are required, additional mitigation measures such as respite periods would be applied (refer to Section 6.3.3).

Out of hours works would be assessed in more detail following confirmation of the construction methodology by the Contractor and may be subject to further approval by Roads and Maritime. This would include appropriate community notification and mitigation measures in accordance with appropriate Roads and Maritime policies.

Sleep disturbance

Noise from loud construction activities has the potential to cause sleep disturbance at the nearby residential receivers.

The predicted results for the Proposal indicate that the sleep awakening reaction criterion of 60 to 65 dB(A) is predicted to be matched or exceeded within Zone B and Zone C during all construction stages. Where feasible, noisy works would be undertaken during the daytime and would not occur after midnight.

The predicted construction noise levels are typically the worst case noise levels and, the majority of actual noise levels are likely to be less than those predicted. The potential for sleep disturbance would be considered further following confirmation of the construction methodology by the Contractor and would be subject to additional mitigation measures, if required.

Construction traffic

The Traffic and Transport Assessment (AECOM 2016a) identified that approximately five heavy vehicles would be required on site per day. It is estimated that a maximum of two vehicles per hour would access the site. Additionally, 18 light vehicles would make two-way trips. Light vehicles would generally arrive between 6.30 am and 7 am and depart between 5 pm and 5.30 pm. Existing hourly movements (both heavy and light vehicles combined) along the A8 Corridor are between approximately 500 movements per hour at 5am with an afternoon peak of 3,500 movements at 5 pm. The movements associated with the construction traffic are relatively insignificant and may increase noise levels by up to 0.2 dB(A). This increase in noise would not have a perceptible change on existing road traffic throughout the Proposal area.

Construction vibration

During construction, vibration generating machinery would be required including jackhammers, wacker packers and bored piling rigs. Construction activities that require the use of this machinery have the potential to create vibration which can disturb nearby sensitive receivers.

The Noise and Vibration Impact Assessment (AECOM 2016b) concluded that the distances from the nearest receivers to the operation of vibration intensive machinery and/or plant would be sufficient to mitigate potential building impacts, including cosmetic damage, and would not result in exceedances of human comfort criteria at nearby receivers.

In order to avoid structural impacts, the proposed works would need to be undertaken in accordance with the safe working distances outlined in Table 38. Where work is required within the safe working distances of structures, site-specific safe working distances would be established on-site prior to the vibration generating works commencing. In addition, building surveys of sensitive structures would be undertaken in order to assess potential for increased susceptibility to building damage from vibration.

Vibration intensive work would not proceed within the safe working distances unless a permanent vibration monitoring system is installed approximately one metre from the building footprint, to warn operators in real time (e.g. flashing lights, SMS, or alarm system) when vibration levels are approaching the maximum vibration criteria.

Table 38 Safe working distances of vibration intensive equipment (in metres)

Machinery/plant	Rating/ Description	Safe work distance: Cosmetic damage – residential/commercial	Safe work distance: Cosmetic damage - heritage
Vibratory roller	1 - 2 Tonnes	5	15 - 20
	2 - 4 Tonnes	6	20
	4 - 6 Tonnes	12	40
	7 - 13 Tonnes	15	100
	Typically 13 - 18 Tonnes	20	100
	Less than 18 Tonnes	25	100
Small hydraulic hammer	5 - 12 Tonnes	2	7
Small hydraulic hammer	5 - 12 Tonnes	7	23
Medium hydraulic hammer	12 - 18 Tonnes	22	73
Large hydraulic hammer	18 - 34 Tonnes	2 - 20	20
Vibratory pile driver	Sheet piles	2	N/A
Pile boring	≤ 800 mm	Avoid contact with structure	Avoid contact with structure
Jack hammer	Handheld	5	15 - 20

Operational phase

No substantial noise or vibration impacts associated with the operation of the Proposal are anticipated.

6.3.3. Mitigation measures

Table 39 Mitigation measures to be considered within each works Zone as per Roads and Maritime *Construction Noise and Vibration Guideline*

NCA	Standard hours	Day out of hours	Evening out of hours	Night out of hours
NCA_A	No specific measures required	No specific measures required	No specific measures required	Verification, notifications, respite period 2, duration respite

NCA	Standard hours	Day out of hours	Evening out of hours	Night out of hours
NCA_B	No specific measures required	Notifications, respite period 1, duration respite	Verification, notifications, respite period 1, duration respite	Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite
NCA_C_1	No specific measures required	Notifications, respite period 1, duration respite	Verification, notifications, respite period 1, duration respite	Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite
NCA_C_2	No specific measures required	Notifications, respite period 1, duration respite	Notifications, respite period 1, duration respite	Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite
NCA_D	No specific measures required	No specific measures required	Notifications, respite period 1, duration respite	Verification, notifications, respite period 1, duration respite
Construction compound	No specific measures required	Notifications, respite period 1, duration respite	Notifications, respite period 1, duration respite	Verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite

- A Construction Noise and Vibration Management Plan (CNVMP) would be prepared and implemented. The CNVMP would include the following:
  - identification of nearby residences and other sensitive land uses
  - description of all approved hours of work
  - description and identification of all construction activities, including work areas, equipment and duration
  - description of what work practices (generic and specific) would be applied to minimise noise and vibration
  - a complaints handling process
  - noise and vibration monitoring procedures
  - overview of community consultation required for identified high impact works.

- all residents impacted by noise from the proposed works which are expected to exceed the construction noise management levels should be consulted prior to the commencement of construction. The highest consideration should be given to those that are predicted to be most affected as a result of the works. Information provided to residents should include:
  - programmed times and locations of construction work
  - the hours of proposed works
  - construction noise and vibration impact predictions
  - construction noise and vibration mitigation measures to be implemented on site
- community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process.
- for out-of-hours works, consultation would take place with consideration to measures outlined in Roads and Maritime's *Construction Noise and Vibration Guideline* and Strategy 2 of the ICNG
- induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration
- deliveries would be carried out during standard construction hours where feasible and reasonable
- a protocol would be developed to identify the need for, and provision of, respite measures for residential receivers in accordance with the ICNG. Respite measures may include appropriate timetabling of noisy works or the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as temporary alternative accommodation
- the following measures would be implemented to reduce and manage noise and vibration impacts associated with construction traffic:
  - truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising/restricting the use of engine compression brakes, and no extended periods of engine idling)
  - site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable
  - deliveries and spoil removal would be planned to avoid queuing of trucks on or around the compounds
  - construction sites would be arranged to limit the need for reversing associated with regular/repeatable movements (e.g. trucks transporting spoil) to minimise the use of reversing alarms
  - where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation
  - spoil would be moved during the day where practical, and feasible and reasonable management strategies would be investigated in consultation with the NSW Environment Protection Authority to minimise the volume of heavy vehicle movements at night
- appropriate plant would be selected for each task to minimise the noise contributions

- alternative works methods such as the use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function, such as rubber wheeled plant, would be considered in place of steel tracked plant
- all equipment would be regularly inspected and maintained to ensure it is in good working order
- plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable
- a noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during construction. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures.
- if regenerated noise is reported to be a problem during vibration intensive works, attended and/or unattended noise measurements would be undertaken within the relevant building spaces to determine the level of regenerated noise
- equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the most affected sensitive receiver. The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures.
- wherever reasonable and reasonable, vibration intensive works should be limited to less sensitive times of the day
- if the use of vibration intensive plant cannot be avoided within the safe working distance for cosmetic damage to existing structures the following procedure would occur as a minimum:
  - notification of the works to the affected residents and community
  - works would not proceed until attended vibration measurements are undertaken
- if ongoing works are required a temporary relocatable vibration monitoring system would be installed to warn operators (via flashing light, audible alarm, short message service (SMS) etc.) when vibration levels are approaching the cosmetic damage objective
- no noisy works (including concrete sawing) are to be undertaken after midnight.

6.4. Aboriginal heritage

6.4.1. Existing environment

The Proposal area forms part of a landscape that was used by the traditional Aboriginal owners, the Guringai, for many thousands of years prior to European settlement.

There are more than 300 known Aboriginal heritage sites in the Manly/Warringah LGAs. The potential for discovering new sites in undisturbed areas is relatively high, due to the area's unique geographical landscape features with sandstone, beaches, lagoons and creek lines (Warringah Council, 2016).

Certain landscape features can often indicate the likely presence of Aboriginal objects, such as nearby waterways, sand dune systems, ridge tops, ridge lines, headlands, cliff faces and rock caves/shelters. Given its proximity of the Proposal to the coast line, the Proposal is considered to be located within a traditionally high risk Aboriginal landscape. However, the extensive landscape modification and high level of disturbance that has occurred within the Proposal area from road and other urban development suggests that the presence of previously unidentified culturally sensitive buried items is unlikely within the boundaries of the Proposal area.

A due diligence assessment was undertaken for the Proposal in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW, 2010). An Aboriginal Heritage Information Management System (AHIMS) search was undertaken for the Proposal area with a 200 metre radial buffer for the entire Proposal area (Zones A, B, and C) on 4 August 2016. Two registered AHIMS sites were identified outside but within 200 metres of the Proposal area, these are:

- 45-6-1024 – located about 180 metres south of the Heaton Avenue/Manly Road intersection (Zone C)
- 45-6-1025 – located about 200 metres south of the Heaton Avenue/Manly Road intersection (Zone C)

6.4.2. Potential impacts

Construction phase

Construction of the Proposal would involve excavation and other ground disturbing activities associated with the demolition and construction of new road (and related) infrastructure, and trenching for the relocation of services. Such activities have the potential to affect Aboriginal heritage sites, if present.

Despite the fact that the Proposal is located within a high risk Aboriginal landscape being within proximity of the coast and Middle Harbour no previously identified Aboriginal heritage items are known to have been located in the Proposal area and the land subject to proposed works has been the subject of extensive historical disturbance. As such the potential for unknown Aboriginal items to be present is considered to be low.

The *Standard Management Procedure: Unexpected Heritage Procedure* (Roads and Maritime, 2015) would be implemented in the unlikely event that any unknown Aboriginal items are found.

Operational phase

A Stage 1 assessment was undertaken by Roads and Maritime in accordance with the *Procedure for Aboriginal cultural heritage consultation and investigation* (Roads and Maritime 2011). The assessment determined that the Proposal is unlikely to have an impact on

Aboriginal cultural heritage. The assessment was based on the following due diligence considerations:

- the Proposal is unlikely to harm known Aboriginal objects or places
- the AHIMS search did not indicate any known Aboriginal objects or places in the immediate study area
- plotting of identified Aboriginal heritage items places all items outside the Proposal footprint
- the study area does not contain landscape features that indicate the presence of Aboriginal objects, based on the Office of Environment and Heritage's Due diligence Code of Practice for the Protection of Aboriginal objects in NSW and the Roads and Maritime Services' procedure.

A Stage 1 Clearance Letter has been issued by the Roads and Maritime Cultural Heritage Officer for the Proposal.

6.4.3. Mitigation measures

The following mitigation measures are proposed to minimise impacts on Aboriginal heritage:

- If Aboriginal heritage items are uncovered during the works, all works in the vicinity of the find must cease and Roads and Maritime Environment staff contacted immediately. Steps in the Roads and Maritime Services *Standard Management Procedure: Unexpected Heritage Items* must be followed.

Refer to Table 43 in Section 7.2 for a full list of mitigation measures.

6.5. Non-Aboriginal heritage

6.5.1. Existing environment

A search of NSW State Heritage Register (SHR) and State Heritage Inventory, the Australian Heritage Database (including Commonwealth and National Heritage lists and the Register of the National Estate (RNE)), and local planning instruments (Warringah LEP 2011 and Manly LEP 2013) was undertaken for the Proposal. Non-Aboriginal heritage listed items within 200 metres of the Proposal area are listed in Table 40.

Table 40 Listed items within the vicinity of the Proposal area

Name	Heritage listing	Heritage significance	Location in relation to the Proposal area
Zone A			
Tramway Staff War Memorial	Warringah LEP 2011 (item 1)	Local	Adjacent to Pittwater Road, east of the Proposal area.
Palm Tree & Plaque	Warringah LEP 2011 (item 6)	Local	Adjacent to Pittwater Road, west of the Proposal area.
Zone B			
Reserved track for trams	Manly LEP 2013 (item 280)	Local	Adjacent to Manly Road, south east of the Proposal area
House	Manly LEP 2013 (item 285)	Local	100 metres south of the Proposal area
Zone C			
Reserved track for trams	Manly LEP 2013 (item 280)	Local	150 metres south of the Proposal area
Fisher Bay Reserve	Manly LEP 2013 (item 272)	Local	150 metres south of the Proposal area

Figure 29**,** Figure 30 and Figure 31 provides the location of heritage items located within each zone.

No non-Aboriginal heritage items were identified within 200 metres of the Manly Vale Commuter Car Park construction compound.

Figure 29 Non-Aboriginal heritage items within the vicinity of Zone A

Figure 30 Non-Aboriginal heritage items within the vicinity of Zone B

Figure 31 Non-Aboriginal heritage items within the vicinity of Zone C

6.5.2. Potential impacts

Construction phase

There are no non-Aboriginal heritage items located within the extent of the Proposal area. While there are several heritage items located adjacent to the Proposal area, such as The Tramway Staff War Memorial, generally the structures within these listings are located at an adequate buffer distance from the Proposal to not be affected. The closest heritage structure is the Palm Tree and Plaque which are located about 10 metres from the Cross Street/Pittwater Road intersection.

Although proposed works would not extend into the curtilage of heritage items identified in Table 40, there is potential for structural impacts from vibration generating activities associated with construction (such as compaction and or excavation). It is highly unlikely the Proposal would result in substantial visual impacts on the heritage items.

Operational phase

The operation of the Proposal would not result in any additional impact upon non-Aboriginal or archaeological heritage.

6.5.3. Mitigation measures

The following mitigation measures would be implemented to minimise impact upon non-Aboriginal heritage items:

- If unexpected archaeological remains are uncovered during the works, all works must cease in the vicinity of the material/find and the steps in the Roads and Maritime

Services *Standard Management Procedure: Unexpected Heritage Items* must be followed. Roads and Maritime Environment staff must be contacted immediately

- If any items defined as relics under the NSW *Heritage Act 1977* are uncovered during the works, all works must cease in the vicinity of the find and the Roads and Maritime Environment staff must be contacted immediately
- If an existing heritage item or item identified on the Roads and Maritime Services s.170 register is on site or in the near vicinity of the works, the item is to be protected to prevent any damage or disturbance.

Refer to Table 43 in Section 7.2 for a full list of mitigation measures.

6.6. Socio-economic impacts

6.6.1. Existing environment

The proposed works would be within the suburbs of Brookvale (Zone A); Manly Vale, Balgowlah and Seaforth (Zone B); and Clontarf (Zone C) along Pittwater Road, Burnt Bridge Creek Deviation, Manly Road and Sydney Road. Figure 2 shows the extent of each Zone. A review of the Australian Bureau of Statistics (ABS) 2011 Census data was undertaken for each suburb. Table 41 provides the key statistics for each suburb.

Table 41 Key statistics for the Proposal area (ABS, 2011)

Suburb	Population	Largest population group	Population density	People per household	Mode of transport to work
Brookvale	2,589	30-34 years	11.77 per hectare	2.4	Car (57%) Public Transport (14%)
Manly Vale	5,702	30-34 years	35.64 per hectare	2.4	Car (53%) Public Transport (20%)
Balgowlah	7,495	35-39 years	37.86 per hectare	2.5	Car (50%) Public Transport (25%)
Seaforth	6,726	40-49 years	21.80 per hectare	3.1	Car (55%) Public Transport (21%)
Clontarf	1,693	45-49 years	19.50 per hectare	3.1	Car (56%) Public Transport (14%)

Within each zone there are a number of parks, community facilities, local business and residences. The key points of interest and land uses surrounding each Zone are provided in Table 42.

Table 42 Key points of interest within the Proposal area

Zone	Key points of interest
Zone A	• Westfield Warringah Mall • multiple automotive businesses • several retail stores and small to medium sized businesses • cafes and restaurants • Northern Beaches Community College
Zone B	• Balgowlah Golf Club • Balgowlah RSL Memorial Club • Northern Beaches Secondary College • cafes and restaurants • low and medium density residential dwellings • small businesses and retail stores
Zone C	• low density residential housing

Figure 4, Figure 5 and Figure 6 show relevant points of interest surrounding the Proposal area for each zone.

6.6.2. Potential impacts

Construction phase

During construction of the Proposal, there is potential for temporary impacts on customers, pedestrians, residents, local businesses, motorists, and other receivers as a result of:

- temporary changes to vehicular and pedestrian access around the Proposal from partial road closures and diversions
- temporary impacts to local traffic movements
- temporary loss of parking along some streets and within car parks
- small increase in truck movements delivering materials and equipment, and transporting waste
- construction noise, vibration, dust and visual impacts.

To facilitate the works in Zone A, the Proposal would require partial property acquisition. This would involve the acquisition of an approximate 75 metre strip of land along the Pittwater Road boundary of Warringah Mall including a further approximately 20 metre strip along Cross Street. The B-Line project team would engage Warringah Mall and Northern Beaches Council in consultation in order to identify potential business impacts and to identify mitigation measures. This will be undertaken in parallel with the preparation and assessment of the Proposal's design.

In Zone A, the Proposal would require the occupation of up to 15 parking spaces within the Warringah Mall open-air car park. This area would be occupied by construction hoarding and or equipment during the construction of the left turn lane into Cross Street from Pittwater Road, and potentially during service relocation activities. The impact of this would be negligible considering the number of alternative parking spaces available within Warringah Mall car park (listed as 4,463 on their website).

The Proposal would also require the removal and permanent relocation of the Warringah Mall advertising sign and road directional signage. These signs are currently located on the corner of Pittwater Road and Cross Street. The impact on the businesses within Warringah Mall is considered to be negligible given the removal of the signs would be temporary and that both signs would be relocated to the same or a nearby location upon completion of the proposed works.

Local businesses and services within Zone A that rely on access via Pittwater Road for delivery of inventory and goods may be affected by construction. It is noted that Cross Street is signposted as a recommended route for deliveries to Warringah Mall, disruption to which may affect a large number of business. Construction activity in this location also has the potential to decrease access for customers, though it is noted that there are no access driveways to Warringah Mall general car parking directly off Cross Street. Such impacts upon customer and delivery access have the potential to result in a decrease in revenue for businesses located within the mall or in the general vicinity.

The presence of construction activity in Zone A may also result in beneficial impacts for businesses through the increased custom, and hence revenue, arising from the presence of the workforce. This is likely to be particularly relevant to businesses such as such as food and beverage retailers.

Construction of the proposal in Zone A would require the temporary closure, diversion and eventual permanent relocation of the existing pedestrian footpath. Any closures would be notified to pedestrians further along the block to allow for the safe crossing of the road at an alternative location. The relocated pathway would eventually provide the same connectivity through the intersection as existing. The overall socio-economic impact of these changes is considered to be very minor.

The presence of construction activity at the corner of Pittwater Road and Cross Street is likely to result in temporary increases in noise, dust and other emissions. These, as well as the removal of landscaping vegetation, have the potential to affect the general amenity of the area. These impacts have been assessed in more detail in Section 6.2, Section 6.3, Section 6.9, Section 6.7 and Section 6.10. Such impacts are considered to be minor in the context of the existing busy road corridor in this location and commitments to reinstate vegetation upon completion.

Figure 32 Existing signage at Warringah Mall

At the intersection of Sydney Road (west) and Burnt Bridge Creek Deviation (Zone B) acquisition of approximately 35 metres of land along the Sydney Road boundary would be required. The B-Line project team would engage the property owner, Northern Beaches Council, in consultation in order to identify potential property impacts and to identify ameliorative measures. This would be undertaken in parallel with the preparation and assessment of the Proposal's design.

Construction of the proposal in this location would require temporary diversions and an eventual permanent relocation of the existing pedestrian footpath along Sydney Road where it joins Burnt Bridge Creek Deviation. Any disruptions to access during construction would be notified to pedestrians further along the block to allow for a safe crossing at an alternative location. The relocated pathway would eventually provide the same connectivity through the intersection as existing. This would include the relocation of the pedestrian crossing over Burnt Bridge Creek Deviation slightly to the north to account for the new left turn lane. The existing pedestrian crossing over the southbound slip lane off Burnt Bridge Creek Deviation into Sydney Road east would be maintained though there may be temporary disruptions during active construction. The overall socio-economic impact of these changes is considered to be minor.

Construction activities may also result in changed traffic conditions and temporary road closures within this area. Local businesses and services that rely on the A8 road corridor for delivery of inventory and goods may be affected by changes to access, which could result in delays. Further, potential impacts on businesses could include a decrease in revenue for local businesses if changes in traffic conditions result in decreased customer access (such as parking availability).

The presence of construction activity in this Zone may also result in beneficial impacts for businesses through the increased custom, and hence revenue, arising from the presence of the workforce. This is likely to be particularly relevant to businesses such as such as food and beverage retailers further west along Sydney Road.

The presence of construction activity at this intersection is likely to result in temporary increases in noise, dust and other emissions. These, as well as the removal of landscaping vegetation, have the potential to affect the general amenity of the area. This includes the reduction in the overall size of the small park at the corner of Hope Street and Sydney Road. These impacts have been assessed in more detail in Section 6.2, Section 6.3, Section 6.9, Section 6.7 and Section 6.10. Such impacts are considered to be minor in the context of the existing busy road corridor in this location and commitments to reinstate vegetation upon completion.

Construction at the intersection of Manly Road and Heaton Avenue (Zone C) would require the acquisition of a portion of land within the Heaton Avenue road verge. The B-Line project team would engage the property owner, Northern Beaches Council, in order to identify potential property impacts and to identify ameliorative measures. This would be undertaken in parallel with the preparation and assessment of the Proposal's design.

Construction of the proposal in this location would require the temporary closure, diversion and eventual permanent relocation of the existing pedestrian footpath along Manly Road where it passes the existing bus stop. Disruption to the footpath along the southern verge of Heaton Avenue would also be likely. Pedestrian access and connectivity from all directions to the existing bus stop would however be retained during construction. The relocated footpath along Manly Road would eventually provide the same connectivity through the site as existing, with the added connection across the closed frontage of Heaton Avenue, allowing direct access southwards towards The Spit. The existing non-compliant footpath at the western end of Heaton Avenue would be formalised as part of the proposal. The overall socio-economic impact of these changes is considered to be minor.

The presence of construction in this Zone is considered unlikely to affect any known nearby businesses by virtue of the site's relative isolation. There may however be minor beneficial impacts to other businesses in the general vicinity should workers be willing to travel to make purchases e.g. food and beverage retailers on Sydney Road west.

The presence of construction activity at this intersection is likely to result in temporary increases in noise, dust and other emissions. These, as well as the removal of landscaping vegetation, have the potential to affect the general amenity of the area, including the public open space to the northeast. These impacts have been assessed in more detail in Section 6.2, Section 6.3, Section 6.9, Section 6.7 and Section 6.10. Such impacts are considered to be minor in the context of the existing busy road corridor in this location and commitments to reinstate vegetation upon completion.

It should be noted that the majority of construction activity throughout all Zones would occur outside the standard work hours to minimise potential traffic impacts. All relevant working arrangements would be notified to the community prior to works commencing.

Operational phase

The Proposal forms part of the overall improvements to infrastructure along the A8 corridor in support of the delivery of the new B-Line service, which is a major part of the NSW Government's Northern Beaches Transport Action Plan. The Transport Action Plan, along with other government initiatives and strategies, aims to support forecasted growth in the Northern Beaches region by improving the transport network across the region.

The Pittwater Road/Burnt Bridge Creek Deviation/Manly Road corridor plays a critical role in the economic and social functioning of the Northern Beaches LGA and the wider region. Its improved efficiency as a transit route and transport corridor generally would have a number of important social and economic impacts through improved bus travel times and performance, and continued growth of the local economy. The improved public transport reliability and efficiency arising from the operation of the B-Line is expected to improve travel to work options for Northern Beaches LGA residents and increase the attractiveness of public transport, potentially at the expense of private vehicle travel.

The operational nature of the Proposal within Zone A at Cross Street would be very similar to that of the existing socio-economic scenario, with the exception of improvements to traffic efficiency arising from the presence of the new left turn lane. On this basis the overall impact of Proposal in this location is considered to be minor beneficial.

The closure of the median at Orchard Road would prevent right-in, right-out movements between this road and Pittwater Road. Whilst this has the potential to reduce overall access to the industrial (and residential) area to the east of Pittwater Road, the improvements in road safety and general traffic flow (including buses) would result in an overall positive socio-economic impact to the local area and wider region.

Permanent changes proposed within Zone B include the new left turn lane out of Sydney Road into Burnt Bridge Creek Deviation and the removal of two parking spaces on Sydney Road to the east of Dudley Street. Whilst the new left turn lane would require partial acquisition of the adjacent public open space, such a reduction is relatively minor in the context of the park's size and given that much of this space is currently occupied by large Oleander bushes, making it effective unavailable for park users. Given the relative number of users of the park and Sydney Road it is considered that the improvement in traffic flow through this intersection would result in a minor overall socio-economic benefit.

The removal of two one-hour parking spaces on Sydney Road to the east of Dudley Street may result in the loss of some trade to businesses in this location. However, given the presence of unrestricted parking along Dudley Street, immediately to the west, the loss of these spaces and subsequent business impacts are considered to be minor.

The Proposal has been designed to minimise potential traffic and amenity impacts and therefore impacts on property values are not anticipated.

The changes in traffic conditions along the corridor, including the closure of Heaton Avenue, would result in permanent impacts upon local residents, both positive (new and extended turning lanes) and negative (prevention of right turns, road closure). It should be noted however that impacts would differ according to individual receptors, such that an adverse impact for one individual or group may be a positive for others. For example the closure of Heaton Avenue is likely to result in increased travel times for local traffic however nearby residents are likely to experience a beneficial impact through a reduction in road noise and improvements to public transport efficiency, road safety and local air quality.

6.6.3. Mitigation Measures

The following safeguards would be implemented to minimise potential socio-economic impacts upon the local community:

- Access for emergency services would be maintained at all times
- Community consultation is to be undertaken in accordance with the *Community Involvement Practice Notes and Resource Manual*
- Complaints received are to be recorded and attended to promptly in accordance with the *Community Involvement Practice Notes and Resource Manual*

- Existing access for nearby and adjoining properties is to be maintained at all times during the works unless otherwise agreed to by the affected property owner.

Refer to Sections 6.1, 6.2 and 6.3 for discussion on the potential traffic/access, visual and acoustic amenity impacts associated with the Proposal.

Refer to Table 43 in Section 7.2 for a full list of mitigation measures.

6.7. Biodiversity

6.7.1. Existing environment

The Proposal is within an area with a long history of disturbance for urban development purposes. This has resulted in near complete clearance of native vegetation and replacement by planted and regenerated native and exotic vegetation/trees, including specific landscaping. Generally, the vegetation within the Proposal area is mapped as 'Urban Native' and 'Exotic' (OEH, 2013).

Areas of potential biodiversity value in proximity of the Proposal area include:

- Warringah Golf Course
- Brookvale Creek, Manly Creek, Burnt Bridge Creek and their associated riparian areas
- Balgowlah Golf Course
- Fisher Bay Reserve and Shell Cove.

The A8 corridor is primarily devoid of vegetation aside from some scattered and isolated trees located along road verges and some low vegetation in the centre median in Zone B. Despite this, vegetation within road verges along the corridor provide landscape features, screening for businesses, residents and motorists, shading for pedestrians and some degree of habitat value for urban fauna.

Figure 33**,** Figure 34**,** Figure 35 and Figure 36 show the existing vegetation for each zone.

Figure 33 Existing vegetation in Zone A, on the corner of Pittwater Road and Cross Street

Figure 34 Existing vegetation in Zone B, along Burnt Bridge Creek Deviation

Figure 35 Existing vegetation in Zone B, corner of Sydney Road and Burnt Bridge Creek Deviation

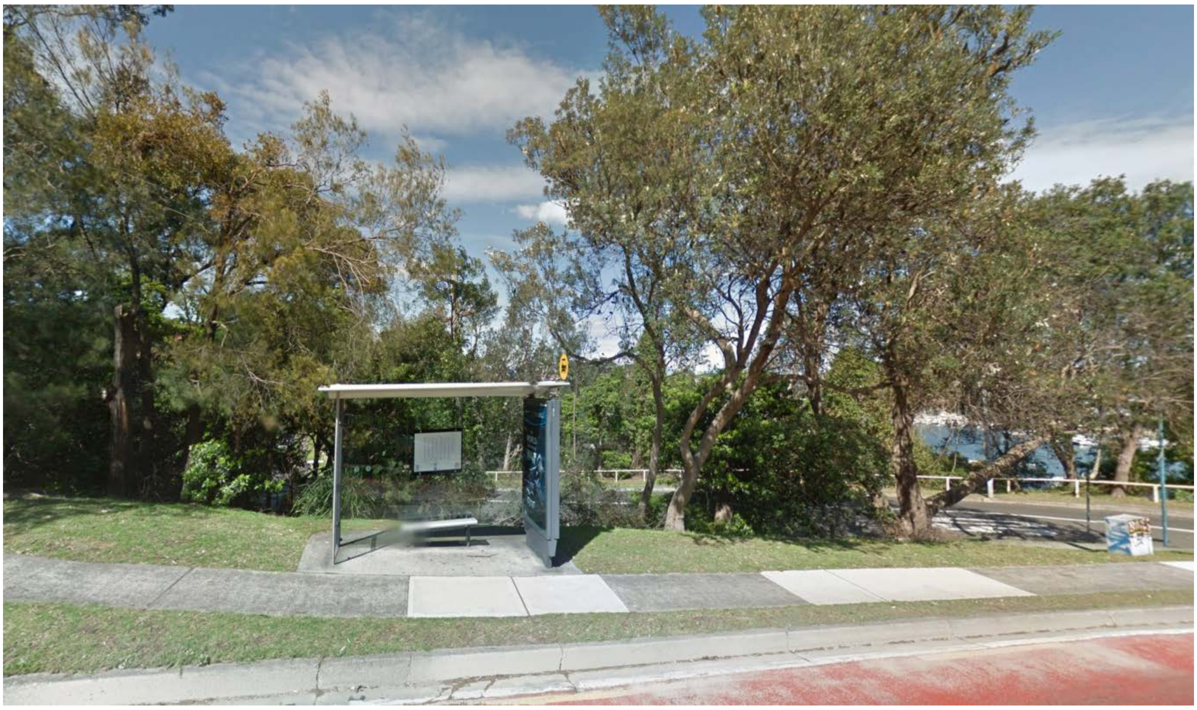


Figure 36 Existing vegetation in Zone C, corner of Manly Road and Heaton Avenue

Flora and fauna

Vegetation communities

An EPBC Protected Matters Search was undertaken on 2 August 2016. This returned one endangered ecological community (EEC) as potentially occurring within 200 metres of the Proposal area: Coastal Upland Swamps in the Sydney Basin Bioregion. This community is listed under the *NSW Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Based on a site inspection by a qualified ecologist and given the disturbed nature of the Proposal area this vegetation community was deemed to not be present within the vicinity of proposed works.

Flora, fauna and habitat

A search of the NSW Environment and Heritage BioNet Atlas was undertaken on 20 August 2016. This identified the following threatened species listed under the TSC Act or EPBC Act as having the potential to occur within a five kilometre radius of the Proposal:

- 23 threatened species of flora
- 52 threatened species of fauna

Generally, vegetation within the Proposal area is comprised of exotic or planted native species. While the habitat value of such vegetation for native species is considered to be generally limited it is recognised that such vegetation may provide functional structure for occasional roosting or foraging of wide-ranging, mobile species. Such value is likely to be low, however, based on the general lack of broad scale and/or contiguous vegetation cover in the area.

The vegetation present provides some connectivity within the area for mobile fauna species. This is however compromised by the presence of large areas of urban development and the high-traffic road corridor. In addition, higher quality and better connected remnant vegetation exists within other areas such as the riparian areas of Brookvale Creek, Manly Creek and Burnt Bridge Creek, and the coastal areas of Fisher Bay Reserve and Shell Cove.

There is the potential that landscaped areas within the Proposal area may harbour weeds listed as noxious under the NW Act. Given the highly urbanised nature of the Proposal area and the maintenance regime implemented by the Council it is considered highly unlikely that such species are present.

6.7.2. Potential impacts

Construction phase

The Proposal would not require the removal of any remnant native vegetation, however the removal of some exotic or planted native vegetation removal would be required in the following zones:

Zone A: Pittwater Road from Orchard Road to Cross Street

- removal of 0.3 hectares of vegetation, including one small palm tree and various other exotic species within the road verge on the corner of Pittwater Road and Cross Street (refer to Figure 33 and Figure 37)

Zone B: Sydney Road/Manly Road/Burnt Bridge Creek Deviation

- removal of 0.7 hectares of vegetation, including planted native species within the central median along Burnt Bridge Creek Deviation at the Sydney Road intersection (refer to Figure 34 and Figure 38)
- removal of 0.4 hectares of vegetation, including several exotic species within the road verge on the corner of Sydney Road and Burnt Bridge Creek Deviation (refer to Figure 35 and Figure 38)

Zone C: Manly Road/Heaton Avenue intersection

- removal of 0.5 hectares of vegetation, including several planted natives species adjacent to the northern road verge of Heaton Avenue (refer to Figure 36 and Figure 39).

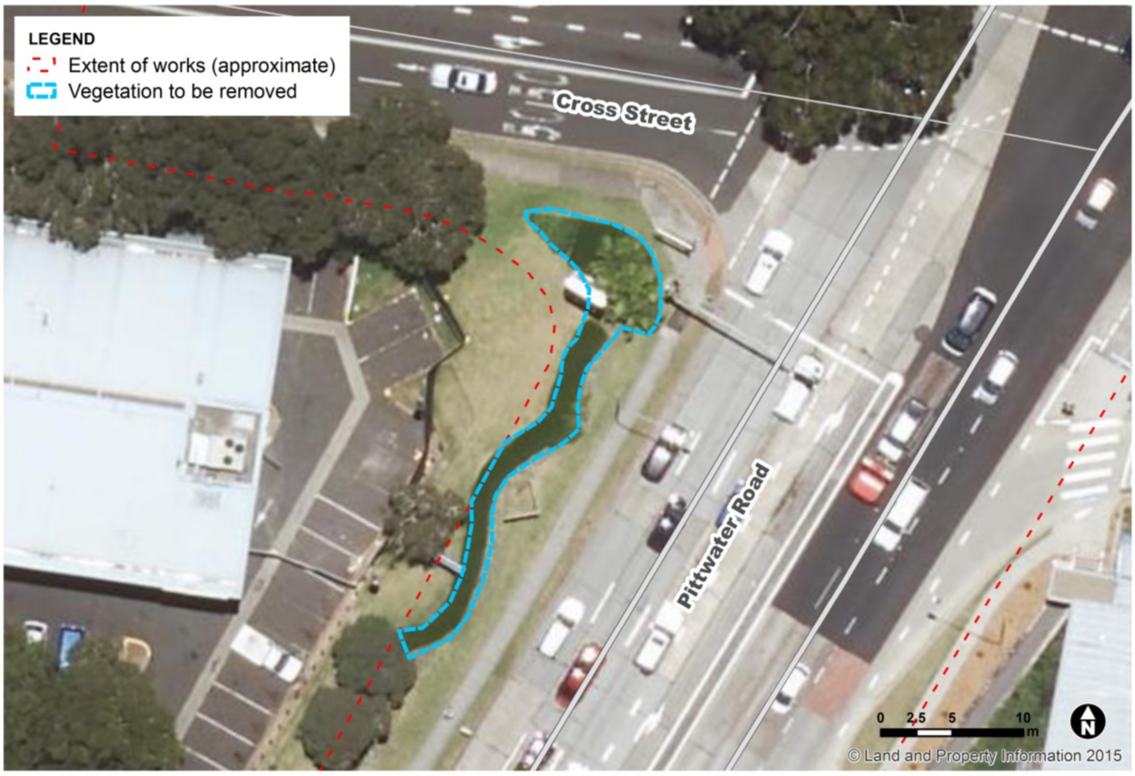


Figure 37 Vegetation to be removed within Zone A

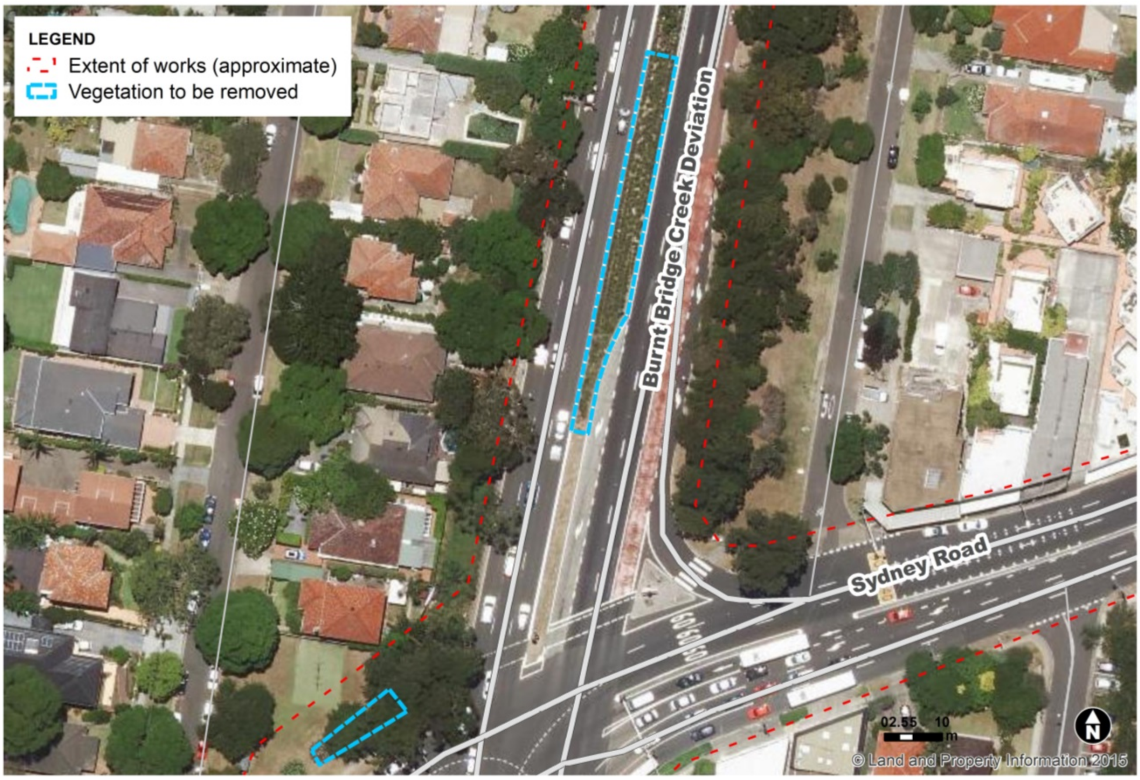


Figure 38 Vegetation to be removed within Zone B

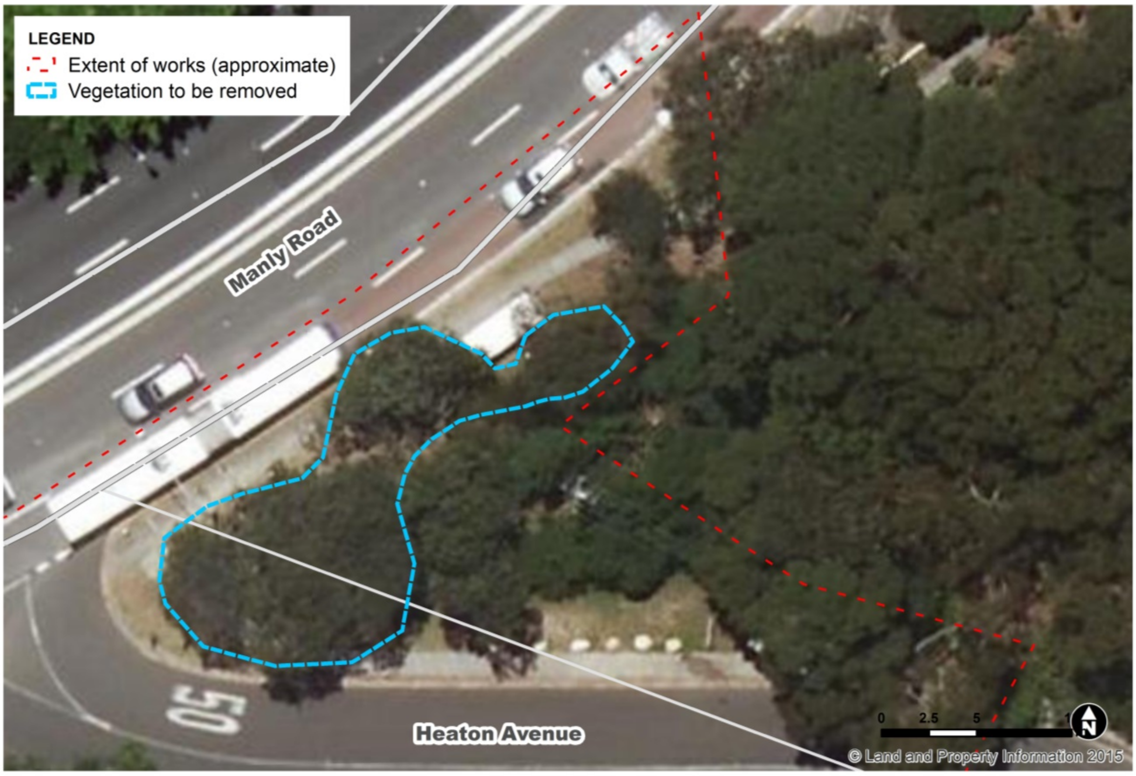


Figure 39 Vegetation to be removed within Zone C

None of the vegetation requiring removal forms part of any threatened ecological community under either the TSC Act or EPBC Act and is only considered to provide marginal foraging or roosting habitat to some highly mobile species. As such, it is expected that overall habitat impacts would be limited.

The implementation of mitigation measures identified in this REF would mitigate overall impacts upon vegetation. On this basis, the Proposal area is considered unlikely to provide important habitat for threatened species. The Proposal is also considered unlikely to result in off-site impacts such that existing habitat within the region is adversely affected.

There is a potential for the proliferation of weed species a result of construction activities without the implementation of appropriate management strategies. Construction activities also have the potential to import new weed species into the Proposal area.

It is recognised that vegetation within and adjacent to the road corridor currently provide screening to road users, bus customers and adjacent local business and other receivers. Landscape amenity and visual impacts associated with the removal of this vegetation have been assessed in Section 6.2.

The mitigation measures outlined in Section 7.2 would ensure that these indirect impacts are minimised.

Operational phase

There would be no ongoing operational risks to biodiversity as a result of the operation of the Proposal.

6.7.3. Mitigation measures

Vegetation that is to be removed will be offset in accordance with the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b) during detailed design. This guide provides a framework for a consistent approach to offset impacts to vegetation on applicable TfNSW projects and allows for appropriate offsets to be applied for single trees or a group of trees that do not form part of a vegetation community, regardless of whether they are native or not. The exact number of offset trees required would be determined at detailed design stage.

The following mitigation measures are proposed to manage impacts to biodiversity:

- If unexpected threatened fauna or flora species are discovered, stop works immediately and follow the Roads and Maritime Services *Unexpected Threatened Species Find Procedure* in the *Roads and Maritime Services Biodiversity Guidelines 2011 – Guide 1 (Pre-clearing process)*.
- All pathogens (e.g. Chytrid, Myrtle Rust and *Phytophthora*) are to be managed in accordance with the *Roads and Maritime Services Biodiversity Guidelines - Guide 7 (Pathogen Management)* and *DECC Statement of Intent 1: Infection of native plants by Phytophthora cinnamomi* (for *Phytophthora)*.
- Declared noxious weeds are to be managed according to requirements under the *Noxious Weeds Act 1993* and *Guide 6 (Weed Management)* of the *Roads and Maritime Services Biodiversity Guidelines 2011.*
- All pruning and trimming of trees is to be in accordance with the *Australian Standard 4373-2007 Pruning of amenity trees.* Pruning of mature trees is to be undertaken by a qualified arborist.
- Vegetation offsets and/or landscaping would be undertaken in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment* (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b). All planting would be undertaken in consultation with the Northern Beaches Council, and/or the owner of the land upon which the vegetation would be planted.

Refer to Table 43 in Section 7.2 for a full list of mitigation measures.

6.8. Soils and water

6.8.1. Existing environment

Soils

The Proposal area is located predominately within the Warriewood soil landscape (OEH, 2016), featuring level to gently undulating swales, depressions and infilled lagoons on Quaternary sands. The Proposal area is underlain by holocene silty to peaty quartz sand, and medium to fine marine sand with podzols. The Warriewood landscape typically includes limitations of localised flooding, high water tables, and highly permeable soil.

The Warringah and Manly LEPs confirm the following zones have the potential to contain acid sulphate soils:

- Zone B – Class 5
- Zone C – Class 5

The Proposal area is not listed on the EPA's contaminated lands register.

Hydrology and Flooding

The Northern Beaches catchment comprises areas draining to the Pacific Ocean north of Sydney Harbour and south of the Narrabeen Lagoon Catchment Boundary. The Proposal is predominately located within the Manly Lagoon Catchment. Manly Lagoon is fed primarily by Burnt Bridge Creek, Brookvale Creek and Manly Creek. These three waterways each form a distinct sub-catchment, with the Manly Creek sub-catchment incorporating inflows from Manly Dam and Curl Curl Creek in the upper catchment. Most of the original creek lines in this area have been disturbed by urban development and are now contained within enclosed culverts.

The catchment of Manly Lagoon is predominantly urbanised, with industrial, commercial and residential development. The Manly Lagoon floodplain is primarily open space, with a combination of golf courses, parks and reserves dominating the lower catchment. There are a number of areas within the Manly Lagoon catchment which represent the most significant flood risk exposure to existing property. The worst affected areas are typically in the lower parts of the catchment and most severely affected by major flooding in Manly Lagoon (Manly Warringah Councils, 2013). Figure 40 shows the catchments within the Proposal area.

Zone A is located 300 metres north of Brookvale Creek. It is considered unlikely that flooding would be a significant concern in this location.

Figure 40 Catchments within the Northern Beaches LGA

6.8.2. Potential impacts

Construction phase

Activities which would disturb soil during construction work have the potential to affect local water quality through the release of sediment as a result of erosion. Without appropriate safeguards, such pollutants (as well as fuel, chemicals or wastewater from accidental spills, and sediment from excavations and stockpiles) could potentially reach nearby stormwater drains and flow into waterways in Zone A, B and C.

Direct impacts to the underground stormwater network may arise during demolition and construction activities. Any such impacts would be identified during the detailed design phase of the Proposal and controls would be detailed in the CEMP and established to ensure that drainage points are adequately protected during construction activities so as to minimise the potential for damage. Where stormwater drains are affected by the design of the Proposal, these would be relocated during construction in consultation with the Northern Beaches Council so as to avoid any adverse impact upon the stormwater system as a whole.

Operational phase

There would be no operational risks to geology or soils as a result of the Proposal.

The Proposal would result in a minor increase in local hardstand area, which would reduce the overall permeability of the Proposal area. Specifically this would include the provision of additional hardstand at the new Cross Street left turn lane and the new Sydney Road left turn lane. Hardstand would be reduced at Heaton Avenue where part of the existing road pavement would be taken up and replaced with grass or other soft landscaping at the point where the road is closed. Although an overall increase would be minor, this could potentially contribute to marginally larger peak flows entering the stormwater network. The potential for these flows to cause any noticeable changes to local flooding or to overload the local drainage network is considered to be negligible. The final drainage arrangements would be subject to detailed design in consultation with the Northern Beaches Council to avoid or minimise any other operational changes to local drainage.

The Proposal is unlikely to result in a significant impact on the soil and water quality, and hydrology of the area surrounding the Proposal.

6.8.3. Mitigation measures

The following measures are proposed to manage the impact of the Proposal on soils and water:

- erosion and sediment control measures are to be implemented and maintained in accordance with the Landcom/Department of Housing Managing Urban Stormwater, Soils and Construction Guidelines (the Blue Book) to:
    - Minimise sediment moving off-site and sediment laden water entering any water course, drainage line, or drain inlet
    - Reduce water velocity and capture sediment on site
    - Minimise the amount of material transported from site to surrounding pavement surfaces
    - Divert clean water around the site
- erosion and sedimentation controls are to be checked and maintained on a regular basis (including clearing of sediment from behind barriers) and records kept and provided on request
- erosion and sediment control measures are not to be removed until the works are complete and areas are stabilised
- work areas are to be stabilised progressively during the works
- a progressive erosion and sediment control plan is to be prepared for the works
- the maintenance of established stockpile sites is to be in accordance with the Roads and Maritime Services *Stockpile Site Management Guideline (EMS-TG-10)*
- adequate water quality and hazardous materials procedures (including spill management procedures, use of spill kits and procedures for refuelling and maintaining construction vehicles/equipment) would be implemented during the construction phase in accordance with relevant EPA and Roads and Maritime guidelines. All staff would be made aware of the location of spill kits and be trained in their use
- vehicles and machinery would be properly maintained and routinely inspected to minimise the risk of fuel/oil leaks
- the existing Sydney Water and Council drainage systems would remain operational and be protected throughout construction
- should groundwater be encountered during excavation works, this would be managed in accordance with the requirements of the Waste Classification Guidelines (EPA, 2014) and Water Discharge and Reuse Guidelines (TfNSW, 2015e).
- potential or actual acid sulphate soils are to be managed in accordance with the Roads and Maritime Services *Guidelines for the Management of Acid Sulphate*

Materials 2005. The contractor is to prepare an Acid Sulphate Materials management plan.

Refer to Table 43 in Section 7.2 for a full list of mitigation measures.

6.9. Air quality

6.9.1. Existing environment

Air quality in the vicinity of the Proposal is representative of an urban area, being mainly dominated by vehicle emissions (cars, buses and trucks). The Proposal area is generally surrounded by local business, retail and residential development. There are no significant air-polluting industries located in the vicinity of the Proposal area.

A review of the National Pollutant Inventory (NPI) was undertaken on 19 August 2016. The closest registered source of air pollution is a petroleum and coal product manufacturer located about 400 metres west of Zone A.

Sensitive receivers in the vicinity of the Proposal include waiting bus passenger and pedestrians along the road corridor, users of community facilities and nearby residential and commercial receivers.

6.9.2. Potential impacts

Construction phase

During construction there is the potential for temporary local air quality impacts arising from plant, equipment and ground disturbance. This includes the release of dust particles and exhaust emissions associated with the combustion of diesel fuel and petrol from construction plant and equipment.

Anticipated sources of dust and dust-generating activities include:

- demolition of existing concrete road verges, medians, kerbs and pedestrian pathways
- excavations for construction of new road concrete and relocation of existing and installation of new services
- stockpiling activities
- loading and transfer of material from trucks
- other general construction activities.

The Proposal would not involve extensive excavation or other ground disturbance likely to generate significant quantities of dust. Appropriate measures would be established to manage dust emissions from demolition works.

The operation of plant, machinery and trucks may also lead to increases in exhaust emissions. Changes to air quality in the vicinity of the Proposal area during construction are anticipated to be temporary in nature and would be limited by implementation of the measures outlined below. Overall the impact of construction of the Proposal on local air quality is expected to be minimal.

Operational phase

The Proposal intends to improve traffic flow, particularly relating to bus movements. As a result of this air emissions from operational traffic are expected to remain broadly similar to the existing scenario, if not slightly decrease through reduce need for buses to stop and start. Also, as the Proposal would increase the reliability and quality of public transport, the use of this service would be expected to increase, potentially leading to a relative reduction in the amount of private vehicle related emissions in the long-term.

6.9.3. Mitigation measures

The following mitigation measures are proposed to manage impacts on air quality:

- Measures (such as watering or covering exposed areas) are to be used to minimise or prevent air pollution and dust.
- Vegetation or other materials are not to be burnt on site.
- Vehicles transporting waste or other materials that may produce odours or dust are to be covered during transportation.
- Stockpiles or areas that may generate dust are to be managed to suppress dust emissions in accordance with the Roads and Maritime Services *Stockpile Site Management Guideline (EMS-TG-10).*

Refer to Table 43 in Section 7.2 for a full list of mitigation measures.

6.10. Cumulative impacts

Cumulative impacts may occur when two or more projects are carried out concurrently and in close proximity to one another and where similar impact types overlap (e.g. air quality or noise impacts). The impacts may be caused by construction and/or operational activities and may result in a greater impact to the surrounding area than would be expected if each project was undertaken in isolation.

A search of the Department of Planning and Environment's Major Projects Register, Sydney East Joint Regional Planning Panel Development and Planning Register, and Northern Beaches Council Development Application Registers in August 2016 identified the following development applications in the vicinity of the Proposal:

- Sydney Road, Manly (DA116/2016): Underground Council car park. Currently being assessed by Council
- Lot 1768 Sunshine Street, Manly Vale (DA2015-0597): Manly Vale Public School. Currently being assessed by Council.

Other developments currently under construction in the vicinity of the Proposal area include:

- Warringah Mall redevelopment: Due for completion late 2016
- Brookvale Community Health Centre: Due for completion early 2018

Further consultation would be undertaken with Northern Beaches Council to determine whether or to what degree construction of the Proposal would overlap with the construction of the above projects and subsequently the potential for cumulative impacts to arise.

Generally, the above developments would involve demolition and construction of buildings and facilities. These activities are relatively small scale and are anticipated to involve only small numbers of construction vehicles. As such these developments are unlikely to result in a substantial impact upon the surrounding road network such that a significant cumulative impact may arise alongside the Proposal. The potential for cumulative interaction in this regard is further reduced by the likelihood that these developments would be constructed during standard working hours and the majority of works associated with the Proposal would be at night.

Other potential cumulative impacts upon factors such as noise and air emissions, heritage, biodiversity, visual amenity and soils and water are expected to be negligible given the highly urbanised nature of the area and the relative separation of these works from the Proposal.

In addition to these developments, the delivery of the overall Northern Beaches B-Line Program would also involve construction of a number of simultaneous projects along the A8 corridor. These projects are:

- Mona Vale road works
- Mona Vale commuter car park
- Warriewood road works
- Warriewood commuter carpark
- Narrabeen road works
- Narrabeen commuter carpark
- Dee Why and Collaroy road works
- Dee Why commuter carpark

- Spit Bridge to Neutral Bay road works
- Manly Vale commuter car park
- Installation of B-Line branded shelters from Mona Vale to Neutral Bay

To manage the potential cumulative impacts of multiple projects being undertaken simultaneously, the B-Line project team would establish a coordination group. This group would seek to coordinate all B-Line related works both spatially and temporally in order to reduce the likelihood of any significant physical overlap of similar impacts. For example, this would include avoiding simultaneous work on elements of separate B-Line projects that are only separated by short distances. To mitigate any cumulative traffic impacts, within and outside of the B-Line Program, the Traffic Management Centre (TMC) would coordinate all Road Occupancy Licences (ROLs).

On this basis, it is anticipated that the cumulative impacts associated with the Proposal would be minor, provided that consultation with relevant stakeholders and mitigation measures in Section 7.2 are implemented.

The potential cumulative impacts associated with the Proposal would be further considered as the design develops and as further information regarding the location and timing of any additional developments is released. Environmental management measures would be developed and implemented as appropriate in order to minimise cumulative impacts upon local residents, the community and road users.

6.11. Climate change and sustainability

6.11.1. Greenhouse gas emissions

A slight increase in greenhouse gas emissions, primarily carbon dioxide, would be expected during construction of the Proposal due to exhaust emissions from construction machinery and vehicles transporting materials and personnel to and from site.

Due to the small scale of the Proposal and the short term nature of the construction works, it is considered that greenhouse gas emissions resulting from the construction of the Proposal would be minimal. Furthermore, greenhouse gas emissions generated during construction would be kept to a minimum through the implementation of the mitigation measures managed through the CEMP.

Once operational, the Proposal would assist in facilitating an increase in the use of public transport. There is the potential that this may reduce the use of private vehicles through the corridor, with an associated reduction in greenhouse gas emissions.

6.11.2. Climate change

The dynamic nature of our climate system indicates a need to focus attention on how to adapt to the changes in climate, while understanding the limitations of adaptation. The effects of climate on the Sydney region can be assessed in terms of weather changes, storm intensity, flooding and increased risk of fire.

Climate change could lead to an increase in the intensity and frequency of rainfall events, whereby major flood events would be expected to occur more frequently.

Climate change could also lead to an increase in frequency and severity in bushfires. The Proposal is not situated on land mapped as bush fire prone.

The increased potential for such events will be further considered in the design of the proposal. This will include the design of infrastructure to account for greater stormwater flows, where appropriate.

6.11.3. Sustainability

The design of the Proposal would be based on the principles of sustainability, including the incorporation of the *Sustainable Design Guidelines – Version 3.0* (TfNSW, 2013a).

These guidelines require a number of mandatory and discretionary initiatives to be applied. Refer to Section 4 for more information regarding the application of these guidelines. The following key sustainability initiatives are being considered for the design and construction of the Proposal:

- **Materials and waste:** ensure at least 95 per cent of construction and demolition waste (by weight) is diverted from landfill, and either recycled or reused
- **Materials and waste**: for all projects generating >300m^3 of spoil, ensure that 100 per cent of usable spoil (by weight) is beneficially reused, on-site or nearby off-site. Usable spoil is not to be sent to landfill
- **Biodiversity and heritage:** for non-significant biodiversity impacts, offsetting is to be in accordance with the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b) during detailed design, as applicable
- **Biodiversity and heritage:** 100 per cent of significant heritage items are identified during project development and design and are protected or beneficially reused where practical
- **Pollution control:** the Proposal could comply with the TfNSW Construction Noise Strategy and related conditions of approval
- **Community benefit:** incorporate Crime Prevention Through Environmental Design (CPTED) principles during design (including lighting).

It is currently anticipated that the Proposal would achieve a ‘gold’ sustainability in design rating. This corresponds with approximately 80% of applicable discretionary points being achieved.

7. Environmental management

This chapter identifies how the environmental impacts of the Proposal would be managed through environmental management plans and mitigation measures. Section 7.2 collates the proposed mitigation measures for the Proposal as identified in Chapter 5.1.2.

7.1. Environmental management plans

A CEMP for the construction phase of the Proposal would be prepared in accordance with the requirements of TfNSW's Environmental Management System (EMS). The CEMP would provide a centralised mechanism through which all potential environmental impacts relevant to construction of the Proposal would be managed, and outline a framework of procedures and controls for managing environmental impacts during construction.

The CEMP would incorporate as a minimum all environmental mitigation measures identified in Section 7.2, any conditions from licences or approvals required by legislation, and a process for demonstrating compliance with such mitigation measures and conditions. The following plans would be included in the CEMP:

- Construction Traffic and Access Management Plan
- Construction Noise and Vibration Management Plan
- Erosion and Sediment Control Plan
- Waste Management Plan.

7.2. Mitigation measures

Mitigation measures for the Proposal are listed in Table 43. These proposed measures would minimise the potential adverse impacts of the Proposal identified in Chapter 5.1.2, should the Proposal proceed.

Table 43 Proposed mitigation measures

No.	Mitigation measure
	General
G1	If the scope of the works changes at any time, review under the Roads and Maritime Services *Environmental assessment procedure for routine and minor works* (EIA-PO5-1) to determine any new measures to take.
G2	An environmental management plan is prepared and implemented prior to the commencement of works.
G3	No new access tracks to be created for the works.
G4	Parking of vehicles and storage of plant/equipment is to occur on existing paved areas. Where this is not possible, vehicles and plant/equipment are to be kept away from environmentally sensitive areas and outside the dripline of trees.

No.	Mitigation measure
	Traffic and site access
T1	A Traffic Management Plan would be prepared and implemented for the construction phase of the Proposal and would outline: - road closures and alternatives - pedestrian and cycle provisions throughout the construction period - the consultation process to inform the community of any road, pedestrian or cycle changes
T2	Property accesses are to be maintained during the works. Any unexpected disturbances to property access would be discussed with the affected resident(s).
T3	To manage the potential for cumulative traffic impacts during construction, the Traffic Management Centre would coordinate road occupancy licences throughout the corridor.
	Urban design, landscape and visual amenity
V1	The site would be kept tidy and well maintained during construction, including removal of all rubbish at regular intervals. There should be no storage of materials beyond the construction boundaries
V2	Light spill from the road corridor into adjacent visually sensitive properties is to be minimised by the use of cut-off lighting, directing construction lighting into the construction areas and ensuring the site is not over-lit. This includes the sensitive placement and specification of lighting to minimise any potential increase in light pollution
V3	Temporary hoardings, barriers, traffic management and signage would be removed when no longer required
V4	Work/site compounds would be screened where practical, with shade cloth or similar material to minimise visual impacts
V5	The construction contractor would restore any areas that are affected by construction with appropriate landscape treatments
V6	An urban design and landscape plan would be prepared in consultation with relevant stakeholders
V7	Vegetation offsets and/or landscaping would be undertaken in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment* (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b). All planting would be undertaken in consultation with the Northern Beaches Council, and/or the owner of the land upon which the vegetation would be planted.

No.	Mitigation measure
	Noise and vibration
N1	A Construction Noise and Vibration Management Plan (CNVMP) would be prepared and implemented. The CNVMP would include the following: - identification of nearby residences and other sensitive land uses - description of all approved hours of work - description and identification of all construction activities, including work areas, equipment and duration - description of what work practices (generic and specific) would be applied to minimise noise and vibration - a complaints handling process - noise and vibration monitoring procedures - overview of community consultation required for identified high impact works.
N2	All residents impacted by noise from the proposed works which are expected to exceed the construction noise management levels should be consulted prior to the commencement of construction. The highest consideration should be given to those that are predicted to be most affected as a result of the works. Information provided to residents should include: - programmed times and locations of construction work - the hours of proposed works - construction noise and vibration impact predictions - construction noise and vibration mitigation measures to be implemented on site.
N3	Community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process
N4	For out-of-hours works, consultation would take place with consideration to measures outlined in Roads and Maritime's *Construction Noise and Vibration Guideline* and Strategy 2 of the ICNG
N5	Induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration
N6	Deliveries would be carried out during standard construction hours where feasible and reasonable
N7	A protocol would be developed to identify the need for, and provision of, respite measures for residential receivers in accordance with the ICNG. Respite measures may include appropriate timetabling of noisy works or the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as temporary alternative accommodation

No.	Mitigation measure
N8	The following measures would be implemented to reduce and manage noise and vibration impacts associated with construction traffic: - truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (i.e. minimising/restricting the use of engine compression brakes, and no extended periods of engine idling) - site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable - deliveries and spoil removal would be planned to avoid queuing of trucks on or around the compounds - construction sites would be arranged to limit the need for reversing associated with regular/repeatable movements (e.g. trucks transporting spoil) to minimise the use of reversing alarms - where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation - Spoil would be moved during the day where practical, and feasible and reasonable management strategies would be investigated in consultation with the NSW Environment Protection Authority to minimise the volume of heavy vehicle movements at night
N9	Appropriate plant would be selected for each task to minimise the noise contributions
N10	Alternative works methods such as the use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function, such as rubber wheeled plant, would be considered in place of steel tracked plant
N11	All equipment would be regularly inspected and maintained to ensure it is in good working order
N12	Plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable
N13	A noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during construction. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with Australian Standard 1055.1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures
N14	If regenerated noise is reported to be a problem during vibration intensive works, attended and/or unattended noise measurements would be undertaken within the relevant building spaces to determine the level of regenerated noise
N15	Equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the most affected sensitive receiver. The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures
N16	Wherever reasonable and reasonable, vibration intensive works should be limited to less sensitive times of the day

No.	Mitigation measure
N17	If the use of vibration intensive plant cannot be avoided within the safe working distance for cosmetic damage to existing structures the following procedure would occur as a minimum: - notification of the works to the affected residents and community - works would not proceed until attended vibration measurements are undertaken.
N18	If ongoing works are required a temporary relocatable vibration monitoring system would be installed to warn operators (via flashing light, audible alarm, short message service (SMS) etc.) when vibration levels are approaching the cosmetic damage objective
N19	no noisy works (including concrete sawing) are to be undertaken after midnight.
	Aboriginal heritage
B1	If Aboriginal heritage items are uncovered during the works, all works in the vicinity of the find must cease and Roads and Maritime Environment staff contacted immediately. Steps in the Roads and Maritime Services *Standard Management Procedure: Unexpected Heritage Items* must be followed.
	Non-Aboriginal heritage
H1	If unexpected archaeological remains are uncovered during the works, all works must cease in the vicinity of the material/find and the steps in the Roads and Maritime Services *Standard Management Procedure: Unexpected Heritage Items* must be followed. Roads and Maritime Services Environment staff must be contacted immediately.
H2	If any items defined as relics under the NSW *Heritage Act 1977* are uncovered during the works, all works must cease in the vicinity of the find and the Roads and Maritime Services Environment staff must be contacted immediately.
H3	If an existing heritage item or item identified on the Roads and Maritime Services s.170 register is on site or in the near vicinity of the works, the item is to be protected to prevent any damage or disturbance.
	Socio-economic
C1	Access for emergency services would be maintained at all times.
C2	Community consultation is to be undertaken in accordance with the *Community Involvement Practice Notes and Resource Manual*.
C3	Complaints received are to be recorded and attended to promptly in accordance with the *Community Involvement Practice Notes and Resource Manual*.
C4	Existing access for nearby and adjoining properties is to be maintained at all times during the works unless otherwise agreed to by the affected property owner.
	Biodiversity
F1	If unexpected threatened fauna or flora species are discovered, stop works immediately and follow the Roads and Maritime Services *Unexpected Threatened Species Find Procedure* in the *Roads and Maritime Services Biodiversity Guidelines 2011 – Guide 1 (Pre-clearing process)*.

No.	Mitigation measure
F2	All pathogens (e.g. Chytrid, Myrtle Rust and *Phytophthora*) are to be managed in accordance with the *Roads and Maritime Services Biodiversity Guidelines - Guide 7 (Pathogen Management)* and *DECC Statement of Intent 1: Infection of native plants by Phytophthora cinnamomi* (for *Phytophthora)*.
F3	Declared noxious weeds are to be managed according to requirements under the *Noxious Weeds Act 1993* and *Guide 6 (Weed Management)* of the *Roads and Maritime Services Biodiversity Guidelines 2011.*
F4	All pruning and trimming of trees is to be in accordance with the *Australian Standard 4373-2007 Pruning of amenity trees.* Pruning of mature trees is to be undertaken by a qualified arborist.
F5	Vegetation offsets and/or landscaping would be undertaken in accordance with the Roads and Maritime *Environmental Impact Assessment Practice Note – Guidelines for Landscape Character and Visual Impact Assessment* (2013), the Roads and Traffic Authority *Biodiversity Guidelines* (2011) and the TfNSW *Vegetation Offset Guide* (TfNSW, 2013b). All planting would be undertaken in consultation with the Northern Beaches Council, and/or the owner of the land upon which the vegetation would be planted.
	Soils and water
E1	Erosion and sediment control measures are to be implemented and maintained to: - Minimise sediment moving off-site and sediment laden water entering any water course, drainage lines, or drain inlets - Reduce water velocity and capture sediment on site - Minimise the amount of material transported from site to surrounding pavement surfaces - Divert off site water around the site
E2	Erosion and sedimentation controls are to be checked and maintained on a regular basis (including clearing of sediment from behind barriers) and records kept and provided on request.
E3	Erosion and sediment control measures are not to be removed until the works are complete and areas are stabilised.
E4	Work areas are to be stabilised progressively during the works.
E5	A progressive erosion and sediment control plan is to be prepared for the works.
E6	The maintenance of established stockpile sites during is to be in accordance with the Roads and Maritime Services Stockpile *Site Management Guideline* (EMS-TG-10).
E7	adequate water quality and hazardous materials procedures (including spill management procedures, use of spill kits and procedures for refuelling and maintaining construction vehicles/equipment) would be implemented during the construction phase in accordance with relevant EPA and Roads and Maritime guidelines. All staff would be made aware of the location of spill kits and be trained in their use.
E8	vehicles and machinery would be properly maintained and routinely inspected to minimise the risk of fuel/oil leaks.

No.	Mitigation measure
E9	the existing Sydney Water and Council drainage systems would remain operational and be protected throughout construction.
E10	should groundwater be encountered during excavation works, this would be managed in accordance with the requirements of the Waste Classification Guidelines (EPA, 2014) and Water Discharge and Reuse Guidelines (TfNSW, 2015e).
E11	potential or actual acid sulphate soils are to be managed in accordance with the Roads and Maritime Services *Guidelines for the Management of Acid Sulphate Materials 2005*. The contractor is to prepare an Acid Sulphate Materials management plan.
	Air quality
A1	Measures (including watering or covering exposed areas) are to be used to minimise or prevent air pollution and dust.
A2	Vegetation or other materials are not to be burnt on site.
A3	Vehicles transporting waste or other materials that may produce odours or dust are to be covered during transportation.
A4	Stockpiles or areas that may generate dust are to be managed to suppress dust emissions in accordance with the Roads and Maritime Services *Stockpile Site Management Guideline (EMS-TG-10).*

8. Conclusion

This REF has been prepared in accordance with the provisions of Section 111 of the EP&A Act, taking into account to the fullest extent possible all matters affecting or likely to affect the environment as a result of the Proposal.

The Proposal would support the delivery the B-Line Program by providing the following benefits:

- reducing peak and off-peak bus journey times between Brookvale and Seaforth
- improving customer experience with improved frequency, capacity and reliability of bus services
- improving road safety along the corridor

The following key impacts have the potential to occur, should the Proposal proceed:

- temporary changes to vehicle, pedestrian and cycle movements to, from and around the affected areas during construction
- temporary noise and vibration impacts during construction
- removal of trees and vegetation that would require planting offsets
- changes to traffic movements and accessibility along and surrounding Pittwater Road, Burnt Bridge Creek Deviation, Manly Road, Sydney Road and Heaton Avenue.

The Proposal has been designed to minimise traffic impacts and is considered to have a minor overall impact during operation.

This REF has considered and assessed the above impacts in accordance with clause 228 of the EP&A Regulation and the requirements of the EPBC Act (refer to Chapter 5.1.2, Appendix A and Appendix B). Based on the assessment within this REF, it is considered that the Proposal is not likely to have a significant impact upon the environment or any threatened species, populations or ecological communities. Accordingly an EIS is not required, nor is approval by the Minister for Planning.

The Proposal has taken into account the principles of ESD (refer to Section 4.6 and Section 6.11). These would be considered further during the detailed design, construction and operational phases of the Proposal. This would ensure the Proposal is delivered to maximum benefit to the community, is cost effective and minimises any further adverse impacts on the environment.

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Appendix A Consideration of matters of National Environmental Significance

The table below demonstrates TfNSW's consideration of the matters of NES under the EPBC Act to be considered in order to determine whether the Proposal should be referred to Commonwealth Department of the Environment.

Matters of NES	Impacts
Any impact on a World Heritage property? The Proposal would not have any impact on a World Heritage property.	Nil
Any impact on a National Heritage place? The Proposal would not have any impact on a National Heritage place.	Nil
Any impact on a wetland of international importance? The Proposal would not have any impact on a wetland of international importance.	Nil
Any impact on a listed threatened species or communities? The Proposal would not have an impact on a listed threatened species, population or communities.	Nil
Any impacts on listed migratory species? The Proposal would not have any impacts on listed migratory species.	Nil
Does the Proposal involve a nuclear action (including uranium mining)? The Proposal does not involve a nuclear action.	Nil
Any impact on a Commonwealth marine area? The Proposal would not have any impact on a Commonwealth marine area.	Nil
Does the Proposal involve development of coal seam gas and/or large coal mine that has the potential to impact on water resources? The Proposal is for a transport facility and is not related to coal seam gas or mining.	Nil
Additionally, any impact (direct or indirect) on Commonwealth land? The Proposal would not have a direct or indirect impact on Commonwealth land.	Nil

Appendix B Consideration of clause 228

The table below demonstrates TfNSW's consideration of the specific factors of clause 228 of the EP&A Regulation in determining whether the Proposal would have a significant impact on the environment.

Factor	Impacts
(a) Any environmental impact on a community? There would be some temporary impacts to the community during construction, particularly in relation to noise, traffic, access and visual amenity. The Proposal would have a positive benefit on the community by improving public transport services.	Minor
(b) Any transformation of a locality? The Proposal would result in minor visual changes of the surrounding locality, however these changes would be consistent with the existing infrastructure and would not change the land use.	Minor
(c) Any environmental impact on the ecosystem of the locality? The Proposal would require removal of several trees. Given the Proposal's location with an urbanised environment, the low habitat value of the trees to be removed and the proposed offsets, impacts to biodiversity and ecosystems are expected to be negligible.	Minor
(d) Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality? There would be some temporary impacts during construction particularly in relation to noise, traffic and access and visual amenity. During operation the Proposal would have positive impacts to the community through improving public transport services. The visual impact of the Proposal is anticipated to be negligible.	Minor
(e) Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations? The Proposal would have a positive effect on public transport access and would be sympathetic to the existing surroundings.	Nil
(f) Any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)? The Proposal is unlikely to have any impact on the habitat of protected fauna.	Nil
(g) Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air? The Proposal is unlikely to result in the endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air.	Nil
(h) Any long-term effects on the environment? The Proposal is unlikely to have any long term effects on the environment.	Nil

Factor	Impacts
(i) Any degradation of the quality of the environment? During construction there is potential for noise, visual and traffic and access impacts. During operation, the Proposal is unlikely to have any degradation of the quality of the environment.	Minor
(j) Any risk to the safety of the environment? The Proposal is unlikely to cause any pollution or safety risks to the environment provided the recommended mitigation measures are implemented.	Nil
(k) Any reduction in the range of beneficial uses of the environment? The Proposal is unlikely to have any reduction in the range of beneficial uses of the environment.	Nil
(l) Any pollution of the environment? The Proposal is unlikely to cause any pollution of the environment provided the recommended mitigation measures are implemented.	Nil
(m) Any environmental problems associated with the disposal of waste? The Proposal is unlikely to cause any environmental problems associated with the disposal of waste. All waste would be managed and disposed of with a site-specific Waste Management Plan. Mitigation measures would be implemented to ensure waste is reduced, reused or recycled where practicable.	Nil
(n) Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply? The Proposal is unlikely increase demands on resources that are or are likely to become in short supply.	Nil
(o) Any cumulative environmental effect with other existing or likely future activities? Cumulative effects of the Proposal are described in Chapter 5.1.2. Where feasible, environmental management measures would be coordinated to reduce cumulative construction impacts. The Proposal is unlikely to have any significant long term impacts.	Nil
(p) Any impact on coastal processes and coastal hazards, including those under projected climate change conditions? The Proposal would not affect or be affected by any coastal processes or hazards.	Nil

Appendix C Brookvale-Dee Why B-Line On-Road Infrastructure – Traffic and Transport Assessment

Northern Beaches B-LineNorthern Beaches B-Line

15-Nov-2016

Brookvale-Dee Why B-Line On-Road Infrastructure

Traffic and Transport Assessment (Nov 2016)

Brookvale-Dee Why B-Line On-Road Infrastructure

Traffic and Transport Assessment (Nov 2016)

Client: Roads and Maritime Services NSW

ABN: 76 236 371 088

Prepared by

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15-Nov-2016

Quality Information

Document Brookvale-Dee Why B-Line On-Road Infrastructure

Ref

Date 15-Nov-2016

Prepared by John Bennett / Fariza Hoque / Muneem Anwar

Reviewed by Andersen Hui

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
1	13-Sep-2016	DRAFT	Andersen Hui	
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5	15-Nov-2016	FINAL_v4	Andersen Hui	

Table of Contents

Glossary of Terms

Term	Meaning
A	
Active Travel / Active Transport	Walking and cycling.
VPD	Vehicles Per Day
Arterial Road	Inter-regional roads, urban freeways / motorways, the main function of which is to provide for the safe and efficient movement of people and freight.
B	
BBCD	Burnt Bridge Creek Deviation
Bottleneck	The location on the road network where traffic is held up.
BRT	Bus Rapid Transit
BTS	NSW Bureau of Transport Statistics
Bus priority	Measures to enable buses to have priority over other modes of transport, such as a bus jump at an intersection.
C	
Carriageway	The portion of a roadway used by vehicles including shoulders and ancillary lanes.
Casualty	A person killed or injured as a result of a crash.
CBD	Central Business District
D	
Do Nothing	A scenario in which the upgrades in the B-line proposal do not occur.
DOS	Degree of Saturation
G	
GEH Value	A non-linear statistic used to compare two sets of traffic volumes (i.e. those obtained from the traffic survey and those generated by the VISSIM microsimulation traffic model).
H	
HGVs	Heavy Goods Vehicles are vehicles classified as a Class 3 vehicle (a two axle truck) or larger, in accordance with the Austroads Vehicle Classification System. (i.e. trucks, tankers, B-Doubles)
I	
Interchange	A place where people can change between different modes of transport, or from one service to another.
IDM	Intersection Diagnostic Monitor
J	
JTW	Journey To Work

Term	Meaning
L	
Left-in / left-out	Restricted turning movements for vehicles entering and leaving the road. Only left hand turns would be permitted due to the central median barrier to prevent conflicting traffic movements.
LEP	Local Environmental Plan
Level of Service (LoS)	The measure for determining the performance of an intersection.
LGA	Local Government Area
M	
Median	A line, barrier or area running down the centre of a road that separates opposing traffic lanes.
Microsimulation	A detailed form of traffic modelling analysis used to simulate traffic flows.
Mid-block	Refers to traffic volumes on sections of road located between intersections.
Mode share	The proportion of people using a particular mode of transport.
O	
OD	The Origin and Destination (of a trip).
P	
Peak hours	The AM and PM traffic peak periods in the Study Area.
R	
REF	Review of Environmental Factors
RMS	Roads and Maritime Services of New South Wales.
Roads and Maritime	Roads and Maritime Services of New South Wales.
RTA	The former Roads and Traffic Authority of New South Wales.
S	
SCATS	Sydney Coordinated Adaptive Travel System
Seed	Term to describe values selected at random by the microsimulation traffic model that provide for different variables to occur within the traffic flow.
Shoulder	The portion of the carriageway beyond the traffic lanes adjacent to and flush with the surface of the pavement.
SIDRA	A modelling software used for intersection and network analysis
Signalising	Upgrading an intersection to include traffic signals.
STFM	Sydney Strategic Forecasting Model
State Road	Road managed by Roads and Maritime Services.
T	
TfNSW	Transport for New South Wales
TMAS	Transport Management and Accessibility Study
Travel time surveys	Data obtained from GPS recorders located within vehicles travelling along the B-line corridor
TZ	Travel Zone (statistical area)

Term	Meaning
V	
V/C Ratio / Volume Capacity Ratio	A method of assessing the level of traffic congestion on a road by relating the theoretical capacity of the road to expected traffic volumes. A factor of 1.0 is used to represent the capacity of an intersection or approach/movement.
Veh/hr	Vehicles per hour
VISSIM	A microsimulation traffic model used to simulate traffic

1.0 Introduction

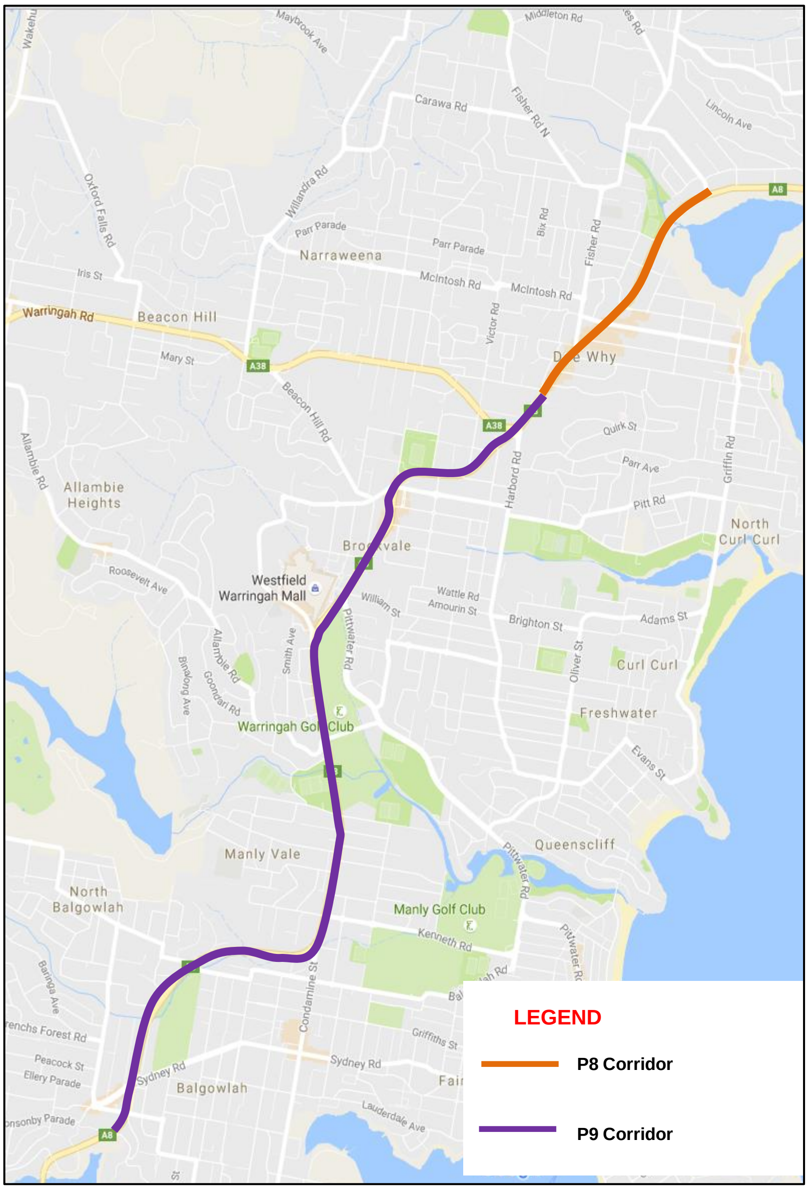
1.1 Background

NSW Roads and Maritime Services (Roads and Maritime) is proposing a series of road infrastructure improvements along Pittwater Road at Brookvale and Dee Why in Sydney, as part of the overarching Northern Beaches B-Line Program (otherwise referred to as ‘the B-Line Program’). A traffic and transport assessment is being prepared by AECOM as part of the project's Review of Environmental Factors (REF).

The entire B-Line program is divided into different work packages which will be assessed as separate bodies of works by RMS and TfNSW. Specifically, the following two sections of the Pittwater Road B-Line corridor in Sydney’s Northern Beaches as shown in **Figure 1**, are the focus of this report:

- B-line Package (P8) - between Pittwater Road / South Creek Road and Pittwater Road / Warringah Road.
- B-line Package (P9) - between Pittwater Road / Warringah Road and Manly Road / Avona Crescent.

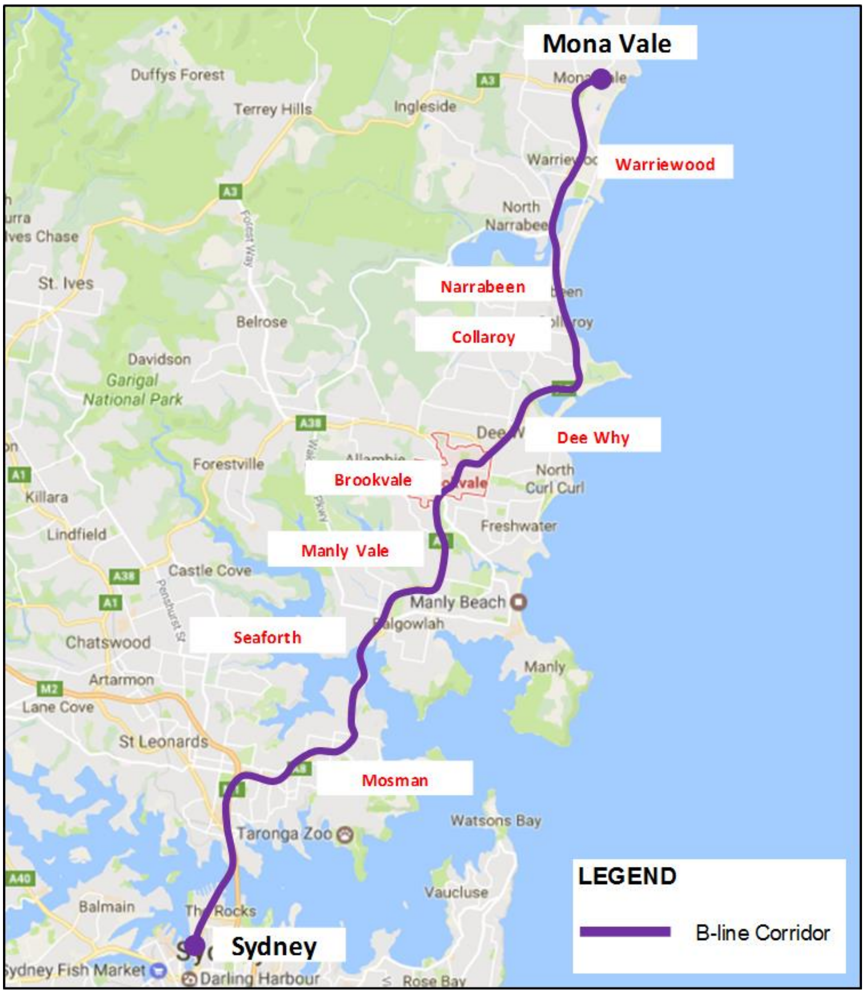
Figure 1 B-Line bus corridor locations (P8 and P9)



Background source: Google Maps

The overarching Northern Beaches B-Line program is an integrated program of bus service and infrastructure improvements that aims to deliver more frequent and reliable services for customers travelling between the Northern Beaches and Sydney CBD. The program includes on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network, with a focus on improvements in bus travel times. The extents of the entire B-Line corridor are illustrated in **Figure 2.**

Figure 2 B-Line corridor (Mona Vale to CBD)



The overall aim of the program is to improve the efficiency of the bus transport network within the Northern Beaches by addressing the following key existing issues:

- Unreliable and inconsistent bus journey times on the main north-south corridor.
- Long wait times for bus services in off-peak periods when frequency is reduced.
- A lack of network legibility due to the complexity of the bus network, which leads to bus congestion.
- Low peak-period average bus speeds, combined with long travel times and delays along the north-south corridor.
- Uneven passenger loadings across similar services on the north-south corridor.
- Passenger crowding and poor pedestrian levels of service at major bus stops along the corridor.
- User dissatisfaction with current level of bus stop amenity.

1.2 Proposal outline

The B-Line program proposes the following key improvements and traffic management measures along the P8 and P9 sections of the corridor as part of the overall B-Line work packages.

- Extension of the existing bus lane operation periods in the PM Peak to five hours between 3pm and 8pm.
- Implementation of new clearways and extension of existing clearways.
- Consolidation of existing local bus stops to reduce dwell times and improve bus travel times.
- Construction of indented bus bays to remove in lane bus stops.
- Provision of a new double decker bus fleet.
- Targeted intersection upgrades to provide additional capacity and improve bus priority / traffic flow / safety.

Further details of the proposed upgrades are provided in **Section 1.3**.

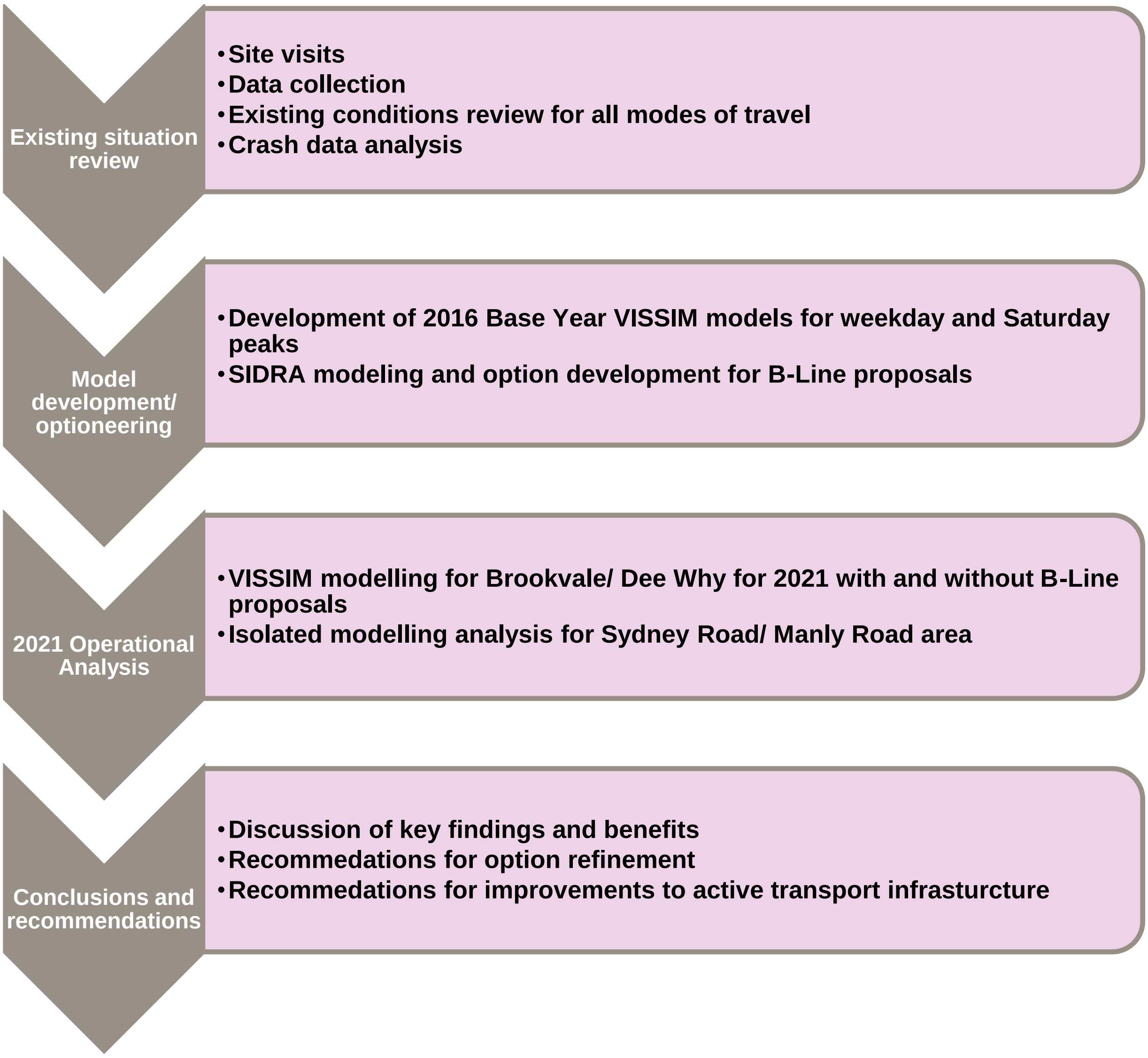
1.3 Study objectives

This report provides details of the traffic and transport assessment methodology, assumptions, findings and recommendations. The key objectives for this study relate to the assessment and analysis of on-road upgrades proposed along the P8 and P9 sections of B-Line, including:

- Analysis of the current operation of the corridor for buses and general traffic to determine existing issues.
- Assessment of the future operation of the corridor for buses and general traffic with and without the proposed B-Line upgrades.
- Optioneering of the proposed on-road infrastructure upgrades to identify preferred options.
- Assessment of current active transport provision along the P8 and P9 sections of the B-Line corridor.

A key focus of the assessment has been the operation of the study area road network for buses and general traffic. The network operational assessment for the current situation (Base Year) and in the future was undertaken using SIDRA and VISSIM traffic modelling. The overall study approach is illustrated in **Figure 3**. Details of the modelling assessment methodology, assumptions and findings are presented in the later sections of this report.

Figure 3 Overall study approach



1.4 Report structure

The remainder of this report takes the following structure:

Section 2 – B-Line proposal

Section 3 – Existing conditions

Section 4 – Future traffic growth

Section 5 – Traffic operational assessment

Section 6 – Future transport provision

Section 7 – Summary and conclusion

2.0 B-Line proposal

The B-Line proposal will include a number of physical upgrades to the road network to accommodate the high frequency bus service. In addition, a range of other traffic management measures such as indented bus bay, clearways and local road closure are proposed to improve traffic flow and reduce delay for the B-Line and local bus services. The B-Line proposal is described in detail in the following sections.

2.1 Network upgrades

Details of the road network upgrades proposed as part of the P8 and P9 work packages are provided in **Table 1**.

Table 1 Upgrades proposed in the P8 and P9 work packages

Location	Proposed upgrade	Corridor section
Pittwater Rd south of Hawkesbury Ave	Provision of indented bus bay on Pittwater Road, south of Hawkesbury Avenue to accommodate two local buses.	P8
Pittwater Rd near Howard Ave	Provision of local bus stop on Pittwater Road south of Howard Avenue to accommodate two local buses. Provision of an additional southbound lane on Pittwater Road between Oaks Avenue and Howard Avenue.	P8
Pittwater Rd / Oaks Ave	Extension of northbound right turn pocket for vehicles turning right from Pittwater Road into Oaks Road.	P8
Pittwater Rd / Cross St	Provision of an additional northbound left turn lane into Cross Street. Modification of signals to provide protection for pedestrian crossing the Cross Street west approach.	P9
Pittwater Rd / Orchard Rd	Banning of the northbound right turn into Orchard Road from Pittwater Road by closing the existing median opening.	P9
Manly Rd / Heaton Ave	Provision of an indented bus bay at Heaton Avenue, south of the Manly Road / Sydney Road intersection, facilitated by the closure of access to and from Manly Road.	P9
Sydney Rd / Manly Rd	Extension of the southbound right turn lane from Burnt Bridge Creek Deviation to Sydney Road. Extension of the westbound through lane from Sydney Road east to Sydney Road west. Extension of the northbound right turn lane from Manly Road to Sydney Road. Extension of the northbound left turn slip lane from Manly Road to Sydney Road. Provision of an additional eastbound left turn lane from Sydney Road west approach to Burnt Bridge Creek Deviation. Provision of two exit lanes on Sydney Road east approach.	P9

Additional upgrades are proposed along the corridor as part of the C3 Clearway program and Health Infrastructure packages of works. Whilst these upgrades are not directly associated with the subject REF, they will work in tandem with the B-Line proposal to improve bus operation along the corridor. Therefore, a majority of these proposed improvements have been included in the modelling to provide a holistic understand of the future traffic conditions.

Work package C3 proposes the removal/ relocation of existing bus stops, whilst Health Infrastructure proposes the construction of a commuter carpark and intersection upgrades. Detailed inputs of the Health Infrastructure works were not confirmed at the time of model development and therefore not included as part of the modelling assessment. The C3 and Health Infrastructure works are detailed in **Table 2**.

Table 2 Upgrades proposed in the C3 and other package of works

Location	Proposed upgrades	Section	Package of works	Included / excluded from modelling
Pittwater Rd near Howard Ave	Provision of two new B-Line bus stops (northbound and southbound) to accommodate two B-Line buses on Pittwater Road south of Howard Avenue.	P8	C3	Included
Pittwater Rd near May Rd	Removal of outbound bus stop on Pittwater Rd near May Road (bus stop 209911).	P8	C3	Included
Dee Why adjacent to Kingsway and Fisher Rd	TFNSW is proposing to acquire the bottom level of the existing PCYC carpark in Dee-Why. This is expected to generate 120 additional trips.	P8	Warringah Council	Included
North of Brookvale Interchange (Pittwater Rd / Condamine St / William St)	Provision of two new B-Line bus stops (northbound and southbound) north of Condamine Street to accommodate three B-line buses	P9	C3	Included
Brookvale (adjacent to Pittwater Road / Condamine Street / William Street)	Construction of a new commuter carpark in Brookvale.	P9	Health Infrastructure	Excluded
Pittwater Rd / Condamine St / William St	Removal of existing at-grade pedestrian crossing. Modification of traffic signals at Pittwater Road/ Condamine Street/ William Street to facilitate the right turn out of William Street into Pittwater Road.	P9	Health Infrastructure	Excluded
Pittwater Rd / Condamine St / William St	Construction of pedestrian bridge to provide a pedestrian walk-way between the southbound bus stand and Warringah Mall precinct.	P9	Health Infrastructure	Excluded
Pittwater Rd near Roger St	Removal of outbound bus stop near Roger Street (bus stop 210015).	P9	C3	Included
Pittwater Rd near Orchard Rd	Removal of inbound bus stop near Orchard Road (bus stop 210026).	P9	C3	Included
Condamine Street near Fishbourne Road	Remove outbound bus stop on Condamine Street near Fishbourne Road (bus stop 2100109)	P9	C3	Included
Condamine Street near James Street	Relocate bus stop 210011 to opposite 210028.	P9	C3	Included

2.2 B-Line bus services

Details of the proposed B-Line bus service frequencies and operation are outlined in the *Northern Beaches B-Line Program Final Business Case* report. It is proposed that the B-Line service will run at 3-4 minute intervals on the AM peak; at five minute intervals in the PM peak; and at 10 minute intervals on weekends.

The B-Line services are intended to provide a high frequency express service that will be similar in operation to a bus rapid transit or light rail service. For this reason the B-Line will operate at limited stops along the corridor to keep dwell time delay to a minimum, with local bus services catering for the shorter localised journeys.

2.3 Clearways

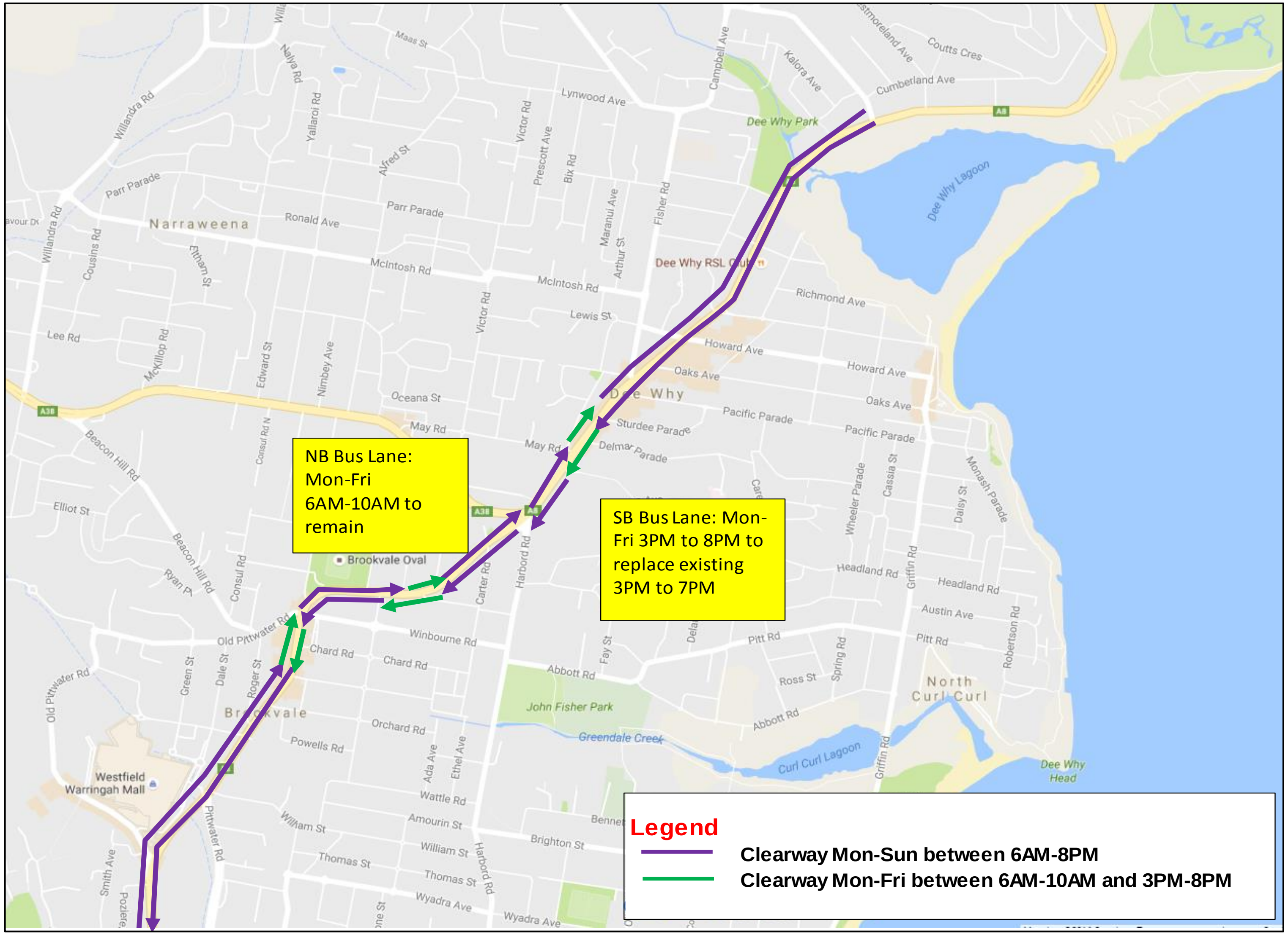
The Northern Beaches B-line Program Final Business Case, February 2016 proposes a number of clearways along the corridor to improve flow progression and reduce delays for buses. The Clearways proposed in Brookvale and Dee Why are summarised in **Table 3** and graphically represented in **Figure 4**.

In brief, the proposed clearways will be operational either five days a week between 6AM-10AM and 3PM-8PM or seven days a week between 6AM and 8PM.

Table 3 Clearways proposed in the study area

Clearways (7-days between 6AM and 8PM)		Clearways (5-days between 6AM-10AM and 3PM-PM	
Pittwater Road (NB)	**Pittwater Road (SB)**	**Pittwater Road (NB)**	**Pittwater Road (SB)**
• Warringah Road to May Road, Dee Why • Sturdee Parade to South Creek Road, Dee Why • King Street, Manly Vale, to Sydenham Road, Brookvale • Winbourne Road to between Pine Avenue and Victor Road • Victor Road to Warringah Road	• South Creek Road to Sturdee Parade • Stony Range Regional Botanic Garden carpark access to Warringah Road, Dee Why • Warringah Road to Victor Road • North of Mitchell Road to Winbourne Road, Manly Vale • Sydenham Road to King Street, Manly Vale	• May Road to Sturdee Parade, Dee Why • Sydenham Road to Winbourne Road • North of Pine Avenue to Victor Road	• Sturdee Parade to Stony Range Regional Botanic Garden, Dee Why, carpark access • Victor Road to north of Mitchell Road • Winbourne Road to Sydenham Road

Figure 4 Clearways proposal in the study area



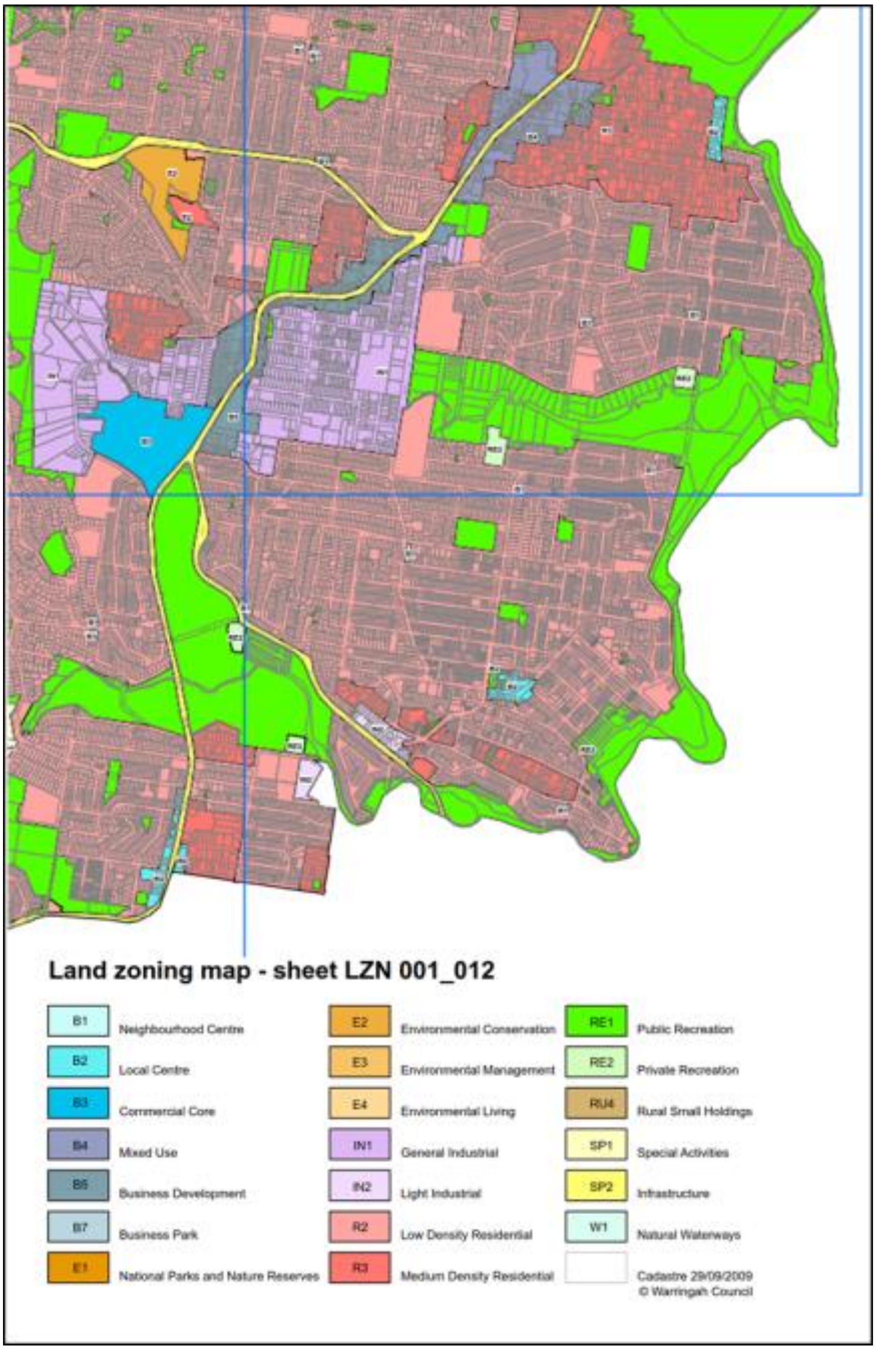
3.0 Existing conditions

This section of the report provides details of the existing conditions along the corridor for all modes of travel. This includes a review of existing infrastructure for vehicles and active transport; details of existing land uses and key developments; existing travel patterns; and current performance of intersections along the corridor.

3.1 Existing land uses

Existing land uses in the study area consist of a mix of retail, commercial and residential development. The current land use plan for the study area is shown in **Figure 5**.

Figure 5 Study area land zoning map



Source: Warringah Council

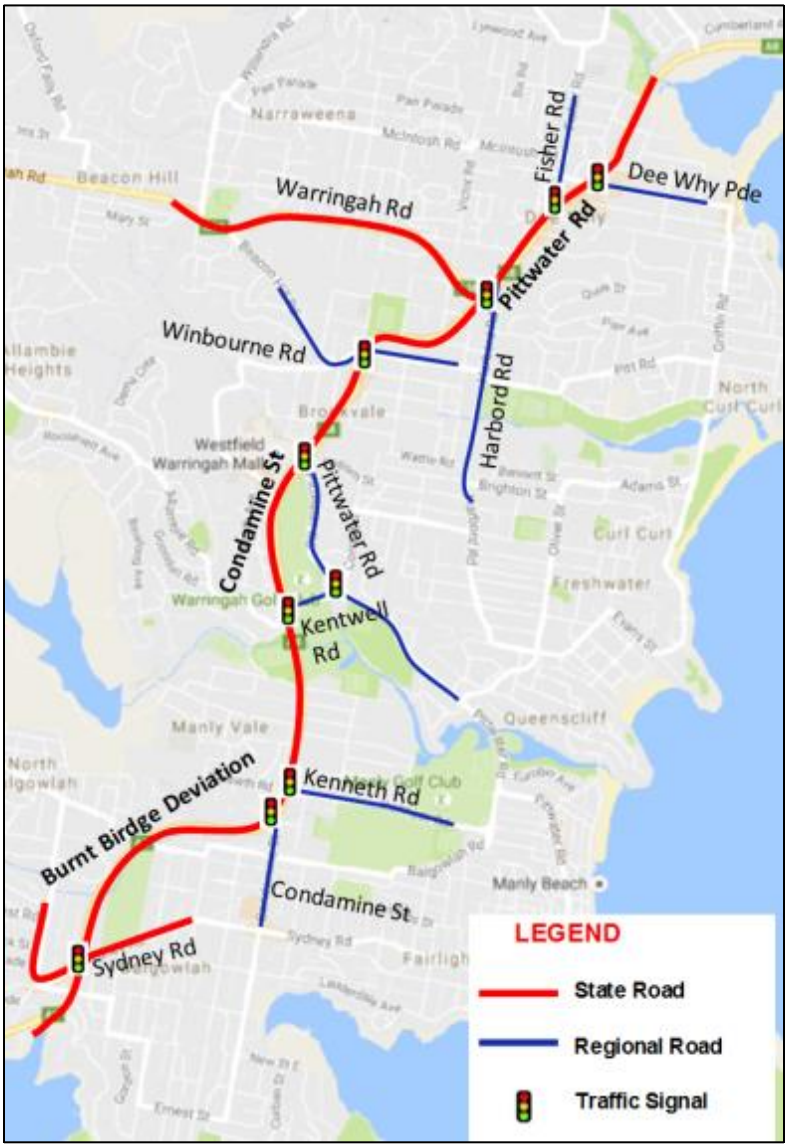
The study area generally consists of low density residential development, with sections of the northern and southern end of the corridor zoned as medium density residential. The central section of the corridor is zoned as B4 Mixed Use, B5 Business Development and IN1 General Industrial. Land adjacent to Pittwater Road / Condamine Street intersection is zoned as B3 Commercial Core, which includes Warringah Mall. Land to the south of Pittwater Road / Condamine Street intersection is zoned as RE1 Public Recreation.

3.2 Road network

The Pittwater Road / Condamine Street / Burnt Bridge Creek Deviation corridor is a state road that serves as a primary arterial route and provides connections between the Sydney CBD in the south (via the M1 Motorway) and the Northern Beaches in the north (terminating at Mona Vale). Warringah Road is also a state road and connects with Pittwater Road in the central section of the study area. It provides a primary arterial east-west route between the Northern Beaches suburbs and Chatswood in the west.

Within the study area, numerous lower-order side roads connect with Pittwater Road and Warringah Road that provide access into the residential areas and retail / commercial areas in the area surrounding Warringah Mall, Brookvale and Manly Vale commercial centres. An overview of the road hierarchy and signalised intersections along the corridor at the connections with the regional roads are illustrated in **Figure 6.**

Figure 6 Existing intersection control types along the corridor



Background source: Google Maps

Pittwater Road / Condamine Street / Burnt Bridge Creek Deviation / Manly Road

The main north-south corridor through the study area accommodates between 40,000 to 60,000 vehicles per day (vpd) and functions as an arterial road providing access to various urban centres; including Mona Vale, Warriewood, Narrabeen, Collaroy, Dee-Why, Brookvale, Manly Vale and Balgowlah. The corridor intersects with a number of local and sub-regional roads along the P8 and P9 corridor sections.

On-street parking is permitted along the sealed shoulders at various points on either side of the corridor. Kerbside bus lanes are operational in the southbound direction in the AM peak period between 6AM and 10AM; and in the northbound direction in the PM peak between 3PM and 7PM.

The posted speed limit along the corridor varies between 60 kilometres per hour (kph) along Pittwater Road / Condamine Street to 80 kph along Burnt Bridge Creek Deviation.

Warringah Road

Warringah Road is a state road which connects with Pittwater Road at the intersection with Harbord Road. It carries about 41,000 vpd. Warringah Road functions as an arterial road and provides a key east-west route between the Northern Beaches and Sydney's central suburbs.

Harbord Road

Harbord Road is a regional road forming the eastern leg of Pittwater Road/ Warringah Road intersection. Harbord Road functions as a sub-arterial road and provides access to a number of residential developments to the east and commercial developments to the west. Harbord Road provides access to Curl Curl and Freshwater town centres. The posted speed limit is 60 kilometres per hour.

Winbourne Road

Winbourne Road is a sub-arterial road and provides access to number of residential and commercial areas. Winbourne Road forms a four-way intersection with Pittwater Road. The posted speed limit along the road is 50 kilometres per hour.

Fisher Road

Fisher Road is a sub-arterial road and provides access to shopping complex and residential areas. Fisher Road forms a signalised T-intersection with Pittwater Road. It has a posted speed limit of 50 kilometres per hour.

Dee-Why Parade

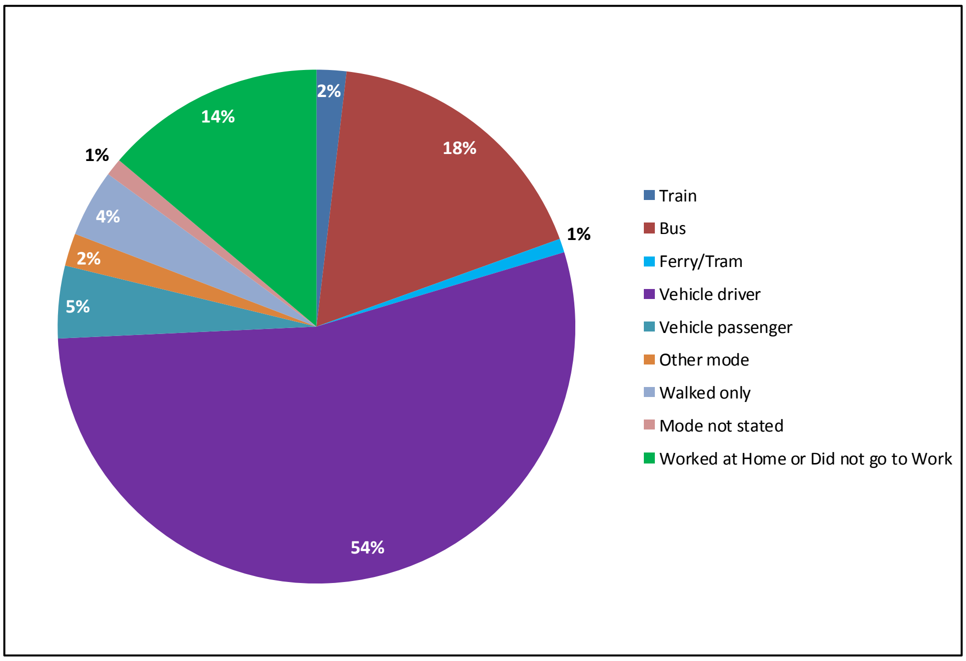
Dee-Why Parade is a sub-arterial road and provides access to commercial and residential areas. Dee-Why Parade forms a signalised T-intersection with Pittwater Road. It has a posted speed limit of 50 kilometres per hour.

3.3 Travel mode shares

A review of 2011 journey-to-work data was undertaken to determine the current travel patterns for the study area.

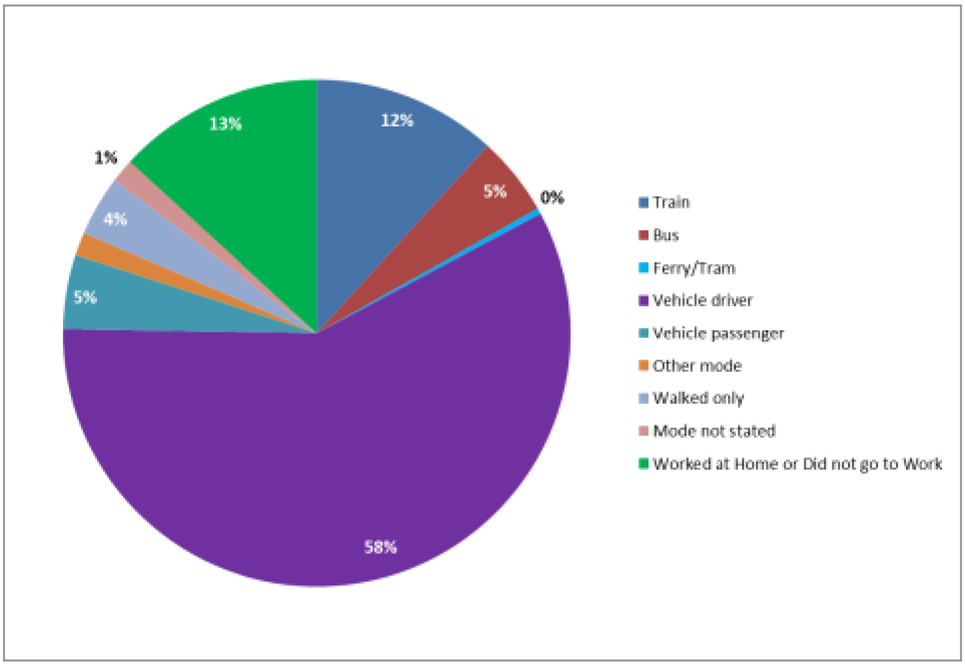
Figure 7 shows the mode shares for journey-to-work trips in the Warringah LEP, which aligns with the extent of subject study area. The data shows that around 60% of travel from the area is made by private car or car passenger travel; with around 20% of journeys undertaken by public transport (predominantly by bus). The mode share data for Warringah is broadly consistent with that of metropolitan Sydney, which has a slightly higher mode share of car driver / car passenger and slightly lower mode share of public transport journeys (refer **Figure 8).**

Figure 7 Journey to work mode share data for the study area



Source: Journey to Work (2011), NSW Bureau of Transport Statistics

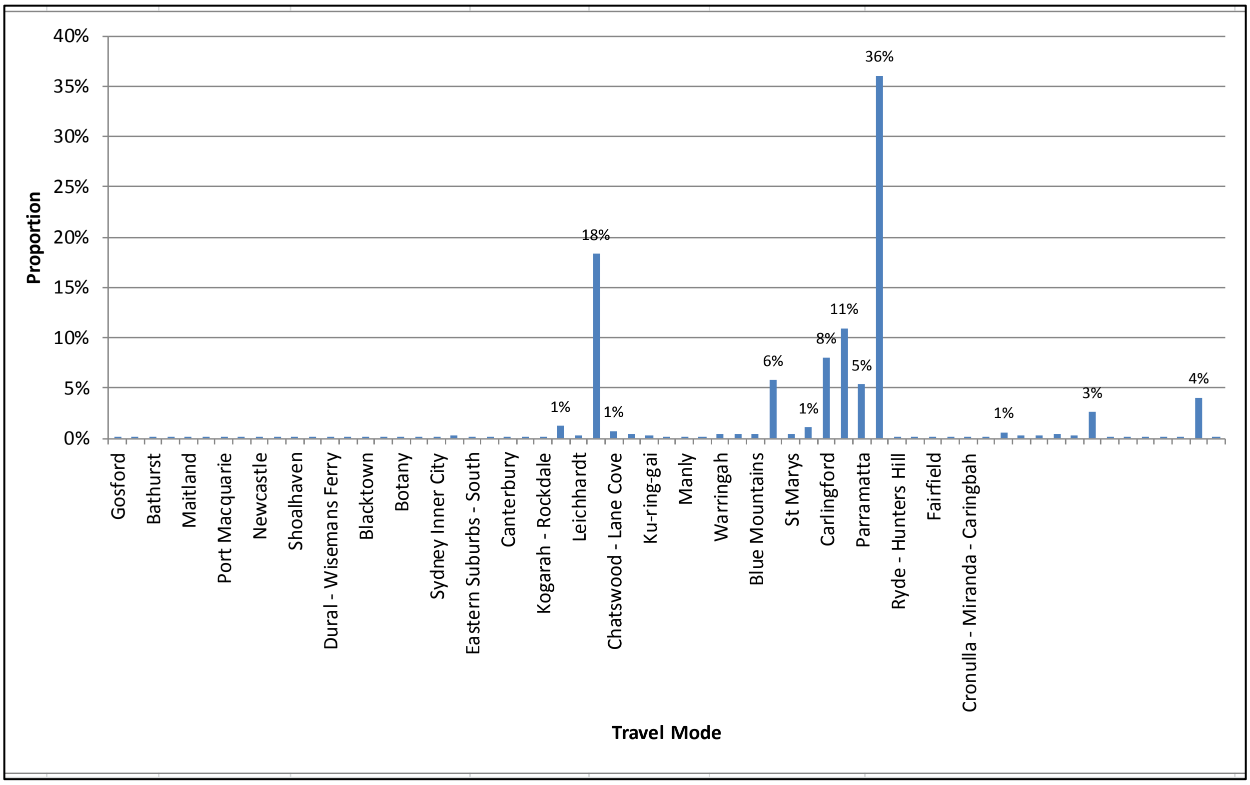
Figure 8 Journey to work mode share data for metropolitan Sydney



Source: Journey to Work (2011), NSW Bureau of Transport Statistics

Figure 9 shows that 36% of journey to work trips in the Warringah Council LGA are generated within the LGA itself, with the remaining be generated from outside the LGA. Approximately 18% are generated from Sydney Inner City and 11% are generated from Manly. These trends seem sensible given that Pittwater Road and Condamine Street provide a major arterial route between the Northern Beaches and the Sydney CBD; and therefore accommodate a large amount of longer journeys and through traffic.

Figure 9 BTS Journey to work – Modes of Transport



Source: Journey to Work (2011), NSW Bureau of Transport Statistics

3.4 Traffic flow profiles

Midblock tube counts were extracted for a seven day period between 25 October 2011 and 31 October 2011. The midblock counts were located on Pittwater Road, north of South Creek Road; and Condamine Street, south of Old Pittwater Road.

The daily traffic flow profile of the two-way traffic along Pittwater Road, north of South Creek Road and Condamine Street, south of Old Pittwater Road are illustrated in **Figure 10** and **Figure 11**. The flow profiles indicate that the average weekday peak occurs between 7-9am in the morning and between 4-6pm in the evening.

Figure 10 Daily traffic flow profile at Pittwater Road, north of South Creek Road

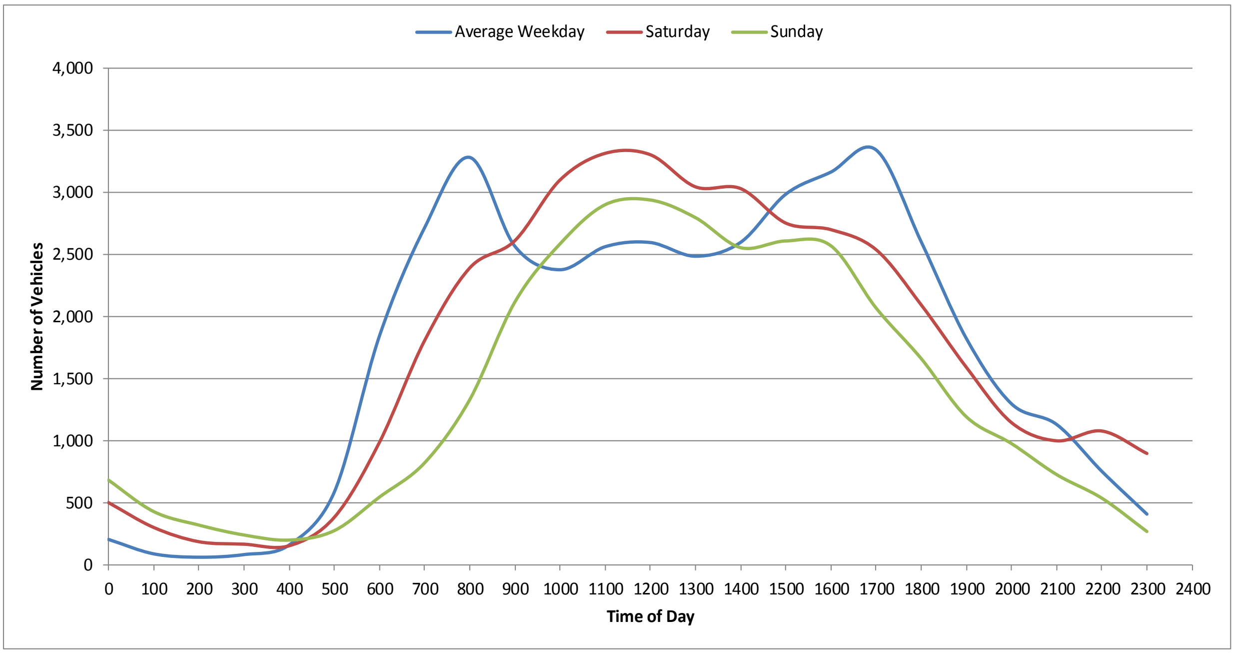
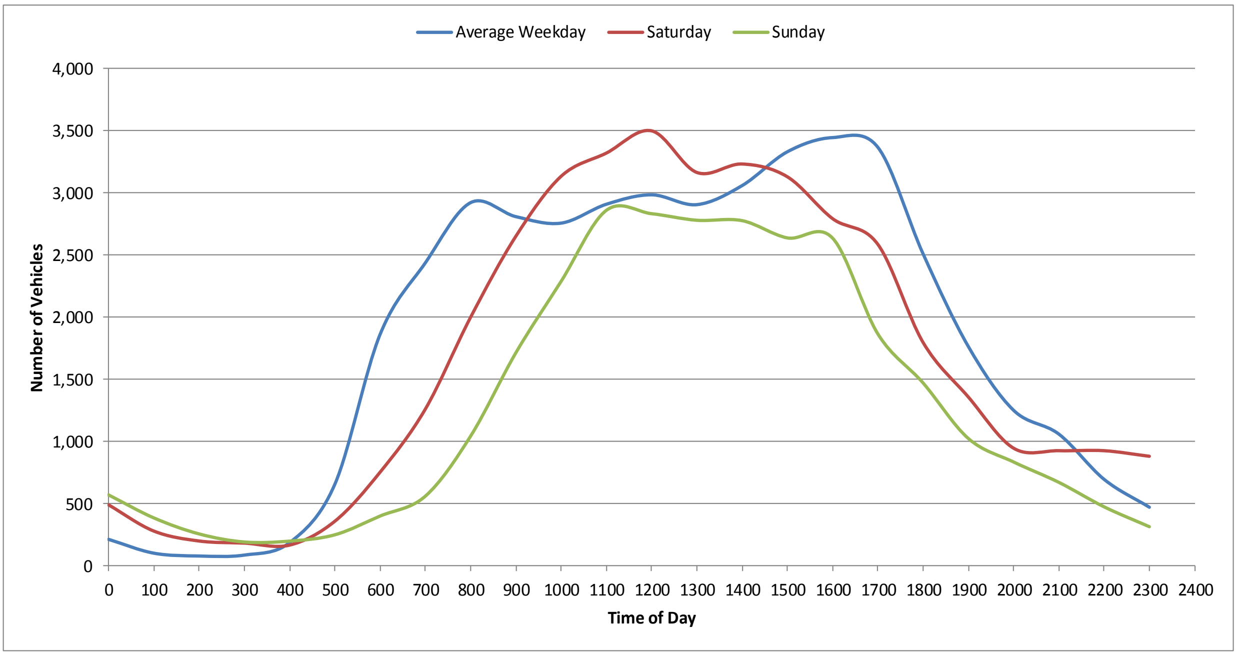


Figure 11 Daily traffic flow profile at Condamine Street, south of Old Pittwater Road



3.5 Existing network operation

As discussed in **section 1.3**, the operation of the study area road network was assessed using a VISSIM microsimulation model. The model was developed for the 2016 Base Year and for 2021 with and without the B-Line proposed upgrades. Details of the 2016 Base Year VISSIM model development are provided in the AECOM report '*Northern Beaches B-Line Program On-Road Infrastructure – VISSIM Base Model Calibration and Validation Report'*, which is contained within **Appendix B** of this report.

As well as the VISSIM model, an isolated SIDRA model of the Sydney Road / Manly Road intersection was developed and the associated Manly Road / Heaton Avenue closure was assessed using a Commuter microsimulation model of the southern section of the study area.

(Note that the Commuter model is being developed with the intent for a separate package of works (i.e. P12) of the B-Line program, but adopted to supplement this assessment to provide vital information such as travel time forecast.)

The following sections provide details of the 2016 Base Year network operation as forecast by the traffic modelling.

3.5.1 Intersection LOS

Intersection Level of Service (LOS) is a measure of average intersection delay across all movements. The different categories of LOS are defined in **Table 4.**

Table 4 Summary of LOS performance levels

Level of Service (LOS)	Average delay per vehicle (s)	Description
A	≤ 14.5	Best operation
B	14.5 seconds ≤ Delay ≤ 28.5	Operating well
C	28.5 seconds ≤ Delay ≤ 42.5	Desirable minimum level of operation
D	42.5 seconds ≤ Delay ≤ 56.5	Operating near capacity
E	56.5 seconds ≤ Delay ≤ 70.5	Significant congestion expected
F	70.5 ≤ Delay	Worst operation

The overall LOS for each of the key signalised intersections reported in the VISSIM model and the SIDRA model for the Sydney Road / Manly Road intersection only are summarised in **Table 5.** Summaries of the LOS by approach are provided in **Appendix A**.

Table 5 2016 Base Year LOS at key intersections

Intersection	AM peak		PM peak		Saturday	
	0700-0800	0800-0900	1630-1730	1730-1830	1130-1230	1230-1330
Pittwater Rd / Hawkesbury Ave	B	C	B	B	B	C
Pittwater Rd / Kingsway	B	B	A	B	B	B
Pittwater Rd / Howard Ave	B	C	B	B	C	C
Pittwater Rd / Oakes Ave	A	B	A	A	C	C
Pittwater Rd / Fisher Rd	B	C	B	A	B	B
Pittwater Rd / Pacific Pde	B	B	B	C	B	B
Pittwater Rd / Sturdee Pde	A	B	A	B	B	B
Pittwater Rd / Delmar Pde	B	C	B	C	C	D
Pittwater Rd / Warringah Rd	D	D	E	E	F	F
Pittwater Rd / Victor Rd	B	A	D	B	B	B
Pittwater Rd / Pine Ave	B	B	C	C	B	B
Pittwater Rd / Winbourne Rd	B	C	E	C	C	C
Pittwater Rd / Sydenham Rd	A	A	C	B	A	A
Pittwater Rd / Orchard Rd	B	C	B	B	C	B
Pittwater Rd / Cross St	B	B	C	C	C	C

Intersection	AM peak		PM peak		Saturday	
	0700-0800	0800-0900	1630-1730	1730-1830	1130-1230	1230-1330
Pittwater Rd / Condamine St	C	C	D	E	C	C
Sydney Rd / Manly Rd	F		F		n/a	

In the AM peak period the outputs show that:

- Most intersections along the corridor operate at a satisfactory LOS (LOS D or better). The only exception being the Sydney Road / Manly Road intersection, primarily due to the downstream congestion and capacity constraints experienced by road traffic south of the Spit Bridge.
- Most intersections operate at the same LOS during both AM peak hours, with the exceptions of the Hawkesbury Avenue, Howard Avenue, Fisher Road, Sturdee Parade and Winbourne Road intersections; where the LOS deteriorates slightly in the second hour as the congestion worsens due to the sustained increase of traffic demands.
- Some side road movements operate at high levels of service (E or F) even though the overall intersection LOS remains satisfactory. This is primarily due to the prioritisation of green time along the corridor for the mainline movements, which results in limited allocation of green time for the side roads.

In the PM peak period the outputs show that:

- Generally the corridor operates at a poorer LOS with increased congestion compared to the AM peak.
- The Warringah Road intersection operates at capacity (LOS E) with average delays approaching 60 seconds during both PM peak hours.
- There are a number of other intersections which approach the limits of acceptable operation (LOS D), including the Condamine Street and Victor Road intersections. The Condamine Street intersection also deteriorates to LOS E in the second hour of the PM peak.
- The Sydney Road / Manly Road intersection continues to operate unsatisfactorily in the PM peak with competing traffic demands from most approaches. The tidal flow arrangement at Spit Bridge with a single traffic lane for southbound traffic also induces downstream delays, affecting the performance of the Sydney Road intersection. This is in line with the general observation collected on site.

In the Saturday peak period the outputs show that:

- Overall corridor operates at LOS C or better with the sole exception of the Warringah Road intersection.
- The Warringah Road intersection operates at LOS F during both peak hours due to high traffic volumes on the east approach, where delays approach over 100 seconds. Despite the high side-road delays driving up the overall intersection LOS, the mainline Pittwater Road approaches still operate at LOS C and LOS D.

3.5.2 Site observations and network performance

Observation of traffic conditions was undertaken during site visits for validation against the available inputs used for the traffic modelling. In addition, operational characteristics of the road network were observed to develop an understanding of any issues and opportunities within the existing road network.

Site observations generally indicated that areas within the study area with a higher level of congestion and delays are most predominant along the Pittwater Road on approach to the Brookvale and Dee Why town centres. This is primarily due to the higher concentration and mix of various land use functions such as commercial, retail and employment activities that are typically associated with the town centres.

3.5.2.1 Dee Why

- In the morning peak, southbound traffic along Pittwater Road was observed to experience moderate delays and congestion along the section between Dee Why Parade and Sturdee Parade, partly due to the closely spaced signals and the competing traffic demands from side roads connecting to the commercial centre. Transient traffic queues were frequently observed along this section of Pittwater Road in the morning peak.
- The right turn bay on Pittwater Road on approach to Oaks Avenue was observed with traffic queuing towards Fisher Road in both the morning and evening peak periods.

- Frequent bus activities were observed at the bus stop on the eastern side of the Pittwater Road between Howard Avenue and Oaks Avenue. In both peak periods during the site visit, up to three buses were observed at the kerbside lane with passengers boarding and alighting. The relatively narrow footpath adjacent to the bus stop is also observed to have a moderate number of bus passengers queuing for bus services.
- In the evening peak, slow moving traffic was observed in both the peak (northbound) and counter-peak (southbound) directions for the section of Pittwater Road between Oaks Avenue and Sturdee Parade.

3.5.2.2 Brookvale

- In the morning peak, moderate level of delays were observed for southbound traffic on approach to the Pittwater Road / Old Pittwater Road / Winbourne Road intersection from near Brookvale Oval, west of Mitchell Road. This is due to a combination of delays from the signals and the speed reduction of the school zone effective between 8.00-9.30am.
- In the evening peak, intermittent northbound traffic queues were observed along Pittwater Road on approach to the Cross Street, Old Pittwater Road and Warringah Road intersections. The northbound queues on approach to Warringah Road could propagate south to Mitchell Road. A mix of left-turn traffic with buses using the kerbside bus lane with queues close to approximately 50 metres were also observed at approach to Cross Street.
- Frequent bus and passenger activities were observed along Pittwater Road adjacent to Warringah Mall, where the existing 'Bus-Only' lanes are located, in both directions during the peak periods.

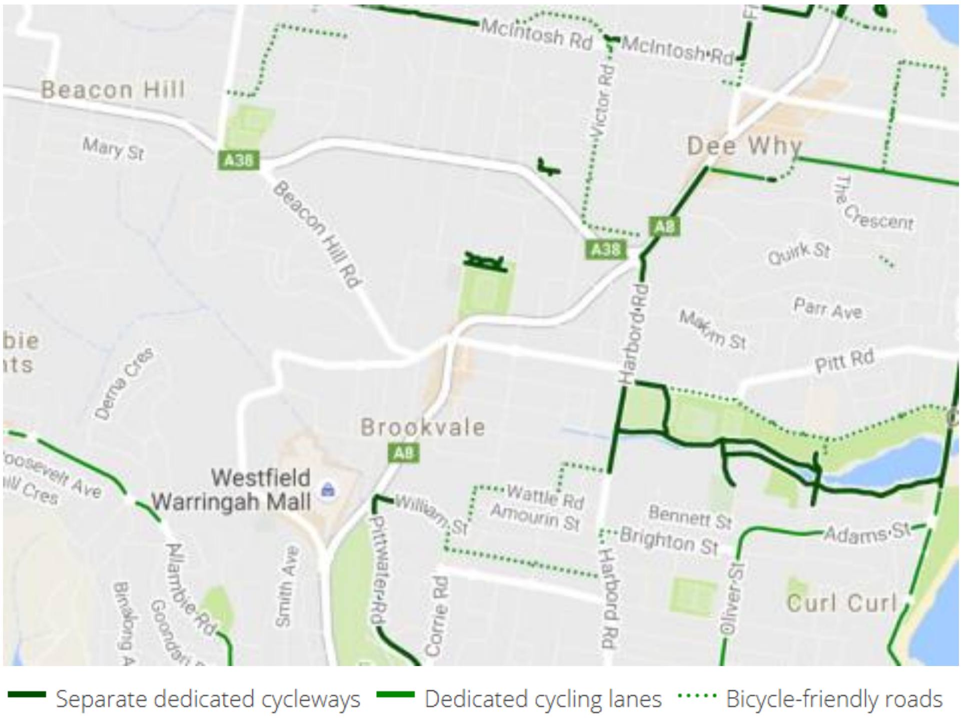
3.6 Walking and cycling

Pedestrian footpaths exist along both sides of Condamine Street, Pittwater Road and the key side roads connecting to the corridor. These paths broadly connect to provide adequate facilities to / from key transport nodes and other local area facilities and destinations.

Connected bicycle routes are not currently provided along the entire length of the Condamine Street and Pittwater Road corridor. Segregated and on-road bicycle lanes are provided along relatively short sections of the corridor in Dee Why (between Warringah Road and Sturdee Parade) and in Manly Vale (between the Condamine Street / Pittwater Road intersection and Sydney Street). Connections do exist, however, between the corridor and residential areas to the west in Brookvale and Dee Why; and Manly Vale/ North Balgowlah to the east of the corridor.

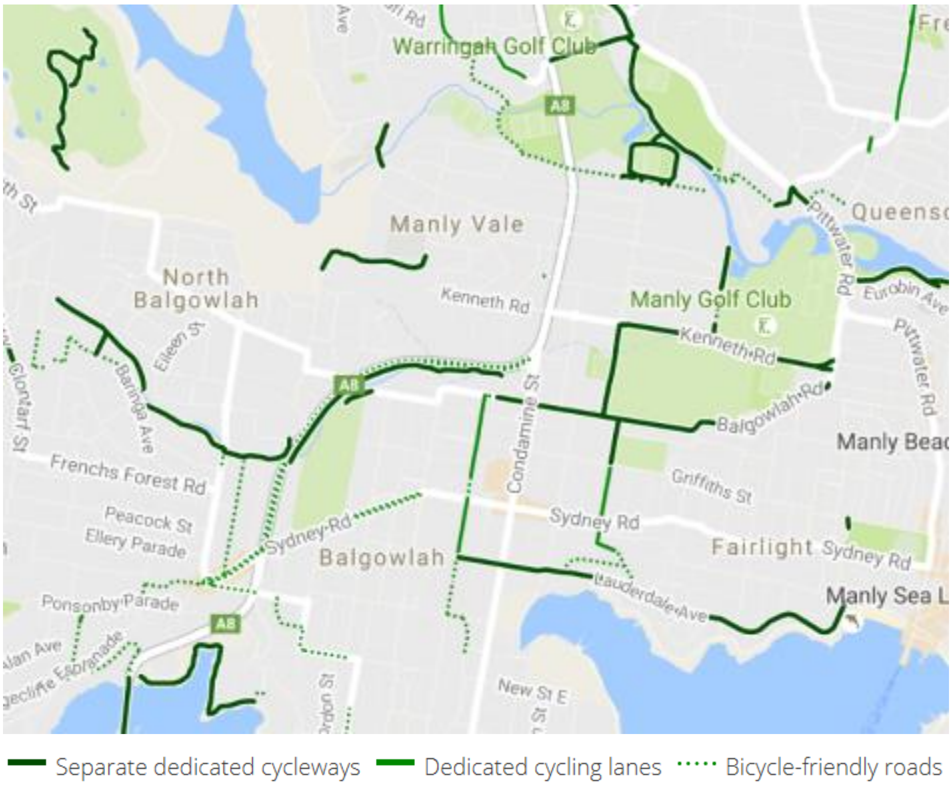
The locations of existing bicycle routes and infrastructure in the study area are illustrated in **Figure 12** and **Figure 13.**

Figure 12 **Existing bicycle infrastructure in Brookvale and Dee Why (P8 and northern P9 corridor)**



Source: www.sydneycycleways.net

Figure 13 **Existing bicycle infrastructure in Manly Vale (southern P9 corridor)**



Source: www.sydneycycleways.net

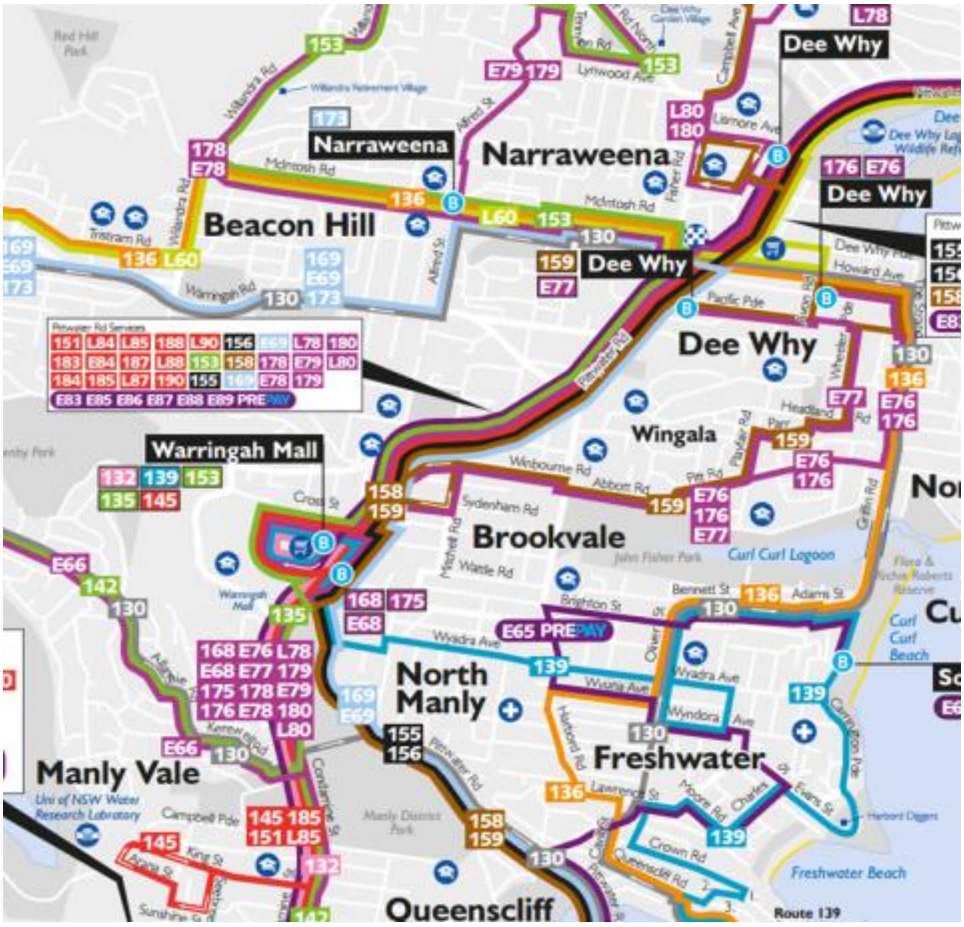
3.7 Public transport

The study area is currently served by a range of local buses that service routes along Pittwater Road / Condamine Street and the surrounding local areas. A summary of the existing bus services is provided in **Table 6.** A map of the existing bus services operating in the study area is shown in **Figure 14.**

Table 6 **Existing bus services operating in the study area**

Route type	Service pattern	Routes
Sydney CBD radial services along the key North-South trunk corridor between Mona Vale and Sydney CBD or Milsons Point	Peak hour express	E65, E66, E68, E69, E76, E77, E78, E79, E83, E84, E85, E86, E87, E88, E89
	Limited stops	L78, L80, L84, L85, L87, L88, L90
	All stops	151, 168, 169, 175, 176, 178, 179, 180, 183, 184, 185, 188, 190
Cross regional routes linking the Northern Beaches to Gordon, Frenchs Forest and Chatswood	Limited stops	L60
	All stops	196, 197, 280 (Forest Coaches)
Local routes which provide feeder services to the trunk corridor and provide access to key local destinations	All stops	130, 131, 132, 135, 136, 137, 139, 142, 143, 144, 145, 153, 155, 156, 158, 159, 182, 187, 189

Figure 14 **Existing bus services operating in the study area**



Source: Transport for NSW

Peak direction bus priority and traffic measures along the corridor and are shown in **Figure 15** to **Figure 18.**

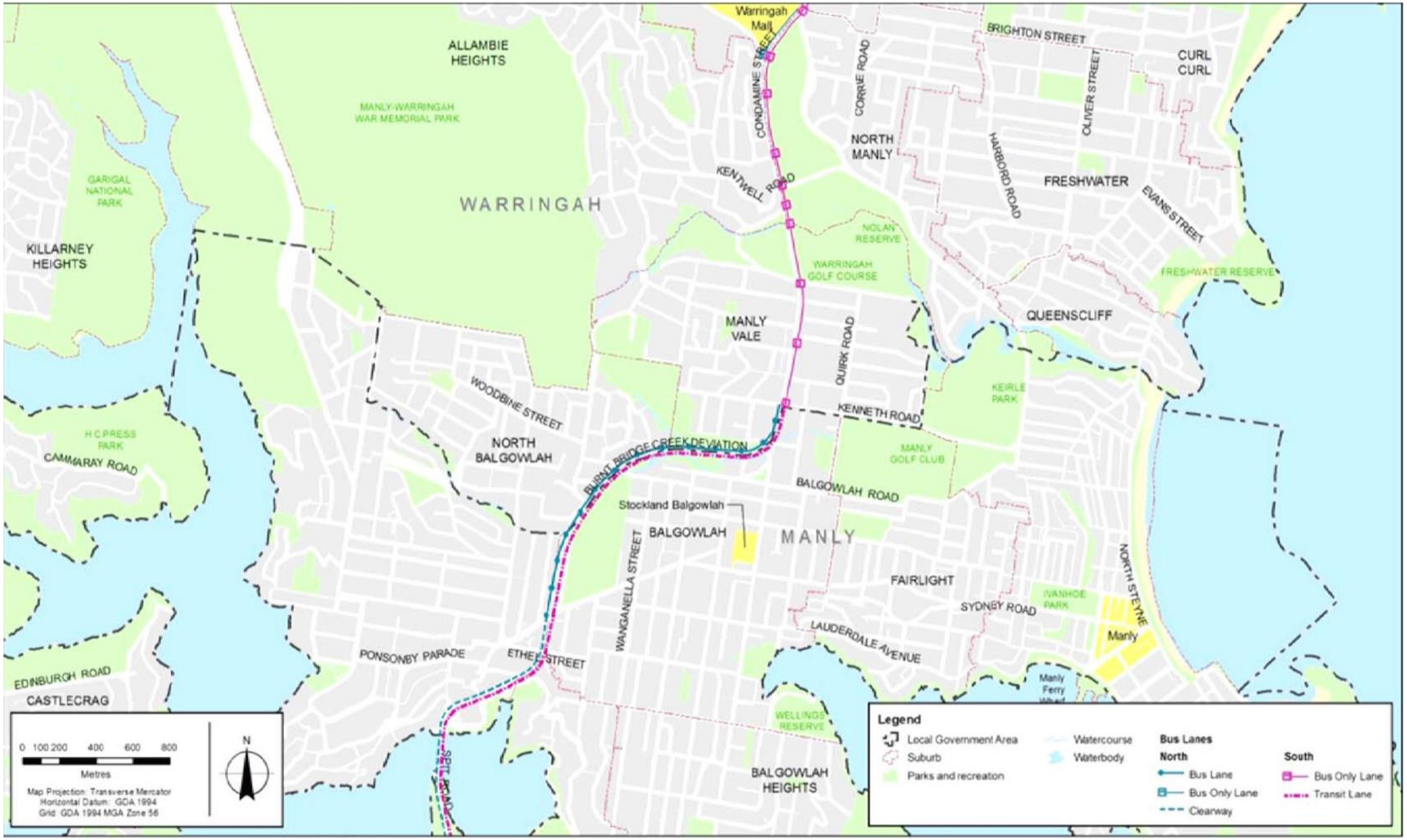
Figure 15 AM peak bus lanes and T3 lanes in Brookvale and Dee Why

Source: TfNSW 2014

Figure 16 PM peak bus lanes and T3 lanes in Brookvale and Dee Why

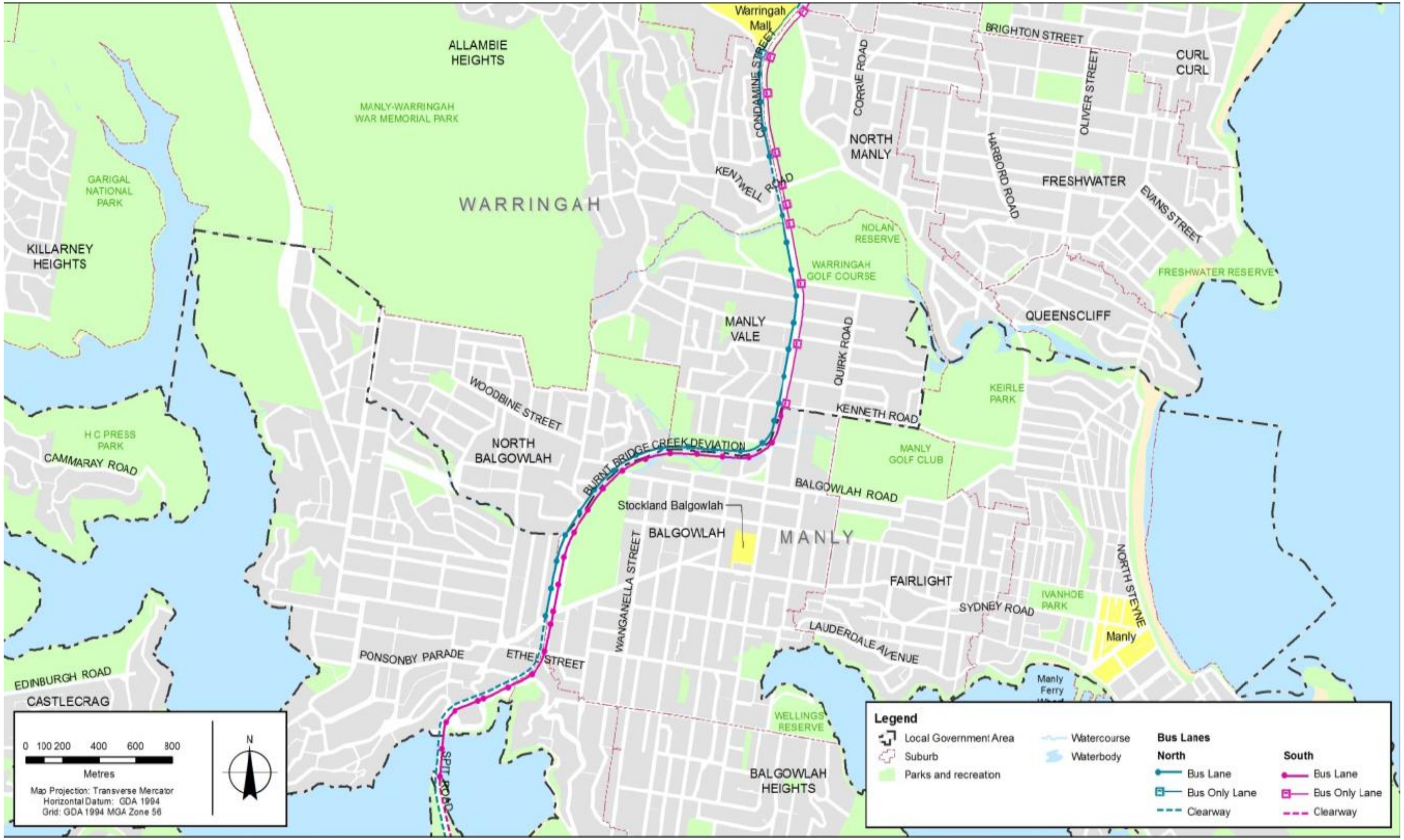
Source: TfNSW 2014

Figure 17 AM peak bus lanes and T3 lanes in Warringah and Manly Vale



Source: TfNSW 2014

Figure 18 PM peak bus lanes and T3 lanes in Warringah and Manly Vale



Source: TfNSW 2014

3.8 Parking

Dee Why

The P8 B-Line corridor consists of approximately 2 km of the Pittwater Road section between South Creek Road to the north, and Warringah Road to the south. Currently, there are existing kerbside bus lanes for the southbound and northbound peak directions respectively for the weekday morning (6-10am) and evening peaks (3-7pm). On-street parking is allowed in the kerbside lane in the morning and evening contra-peak directions and during off-peak periods. Parking restrictions vary from half hour to one hour, with a certain amount of unrestricted parking.

This section has a total supply of 253 parking spaces according to the *Northern Beaches B-Line Offset Parking Assessment* commissioned by Transport for NSW (TfNSW) in November 2015 for the B-Line program. A total of 138 and 115 parking spaces are provided respectively on the eastern and western sides of the Pittwater Road corridor.

The study also identifies the parking utilisation at 49% and 63% occupancy respectively in the southbound and northbound directions. This section of Pittwater Road has mixed land usage together with medium density housing, business and recreational areas. The Dee Why commercial centre accounts for a significant proportion of the overall parking demand in the area.

Brookvale

The P9 B-Line corridor consists of approximately 6 km of the B-line corridor between Warringah Road to the north, and Avona Crescent to the south. Currently, there are existing kerbside bus lanes between Warringah Road and Kenneth Road for the southbound and northbound peak directions respectively for the weekday morning (6-10am) and evening peaks (3-7pm). On-street parking is allowed in the kerbside lane in the morning and evening contra-peak directions and during off-peak periods. Parking restrictions vary from one to two hours, with a certain amount of unrestricted parking.

This section has a total supply of 206 parking spaces according to the *Northern Beaches B-Line Offset Parking Assessment* commissioned by Transport for NSW (TfNSW) in November 2015 for the B-Line program. A total of 48 and 158 parking spaces are provided respectively on the eastern and western sides of the Pittwater Road corridor.

The study also identifies the parking utilisation at 74% and 54% occupancy in the southbound and northbound directions respectively. This section of the corridor comprises residential, business and recreational facilities. The Brookvale commercial centre, north of Orchard Road also accounts for a significant proportion of the overall parking demand in the area.

Note that for the section of the corridor south of Kenneth Road, there is a 24-hour bus lane in the northbound direction and in the southbound direction there is a T3 Transit Lane in the morning (6-10am) and a bus lane in the evening (3-7pm) weekdays. Existing parking restrictions do not allow any parking throughout the week and there is no proposal as part of the B-Line program to change this situation.

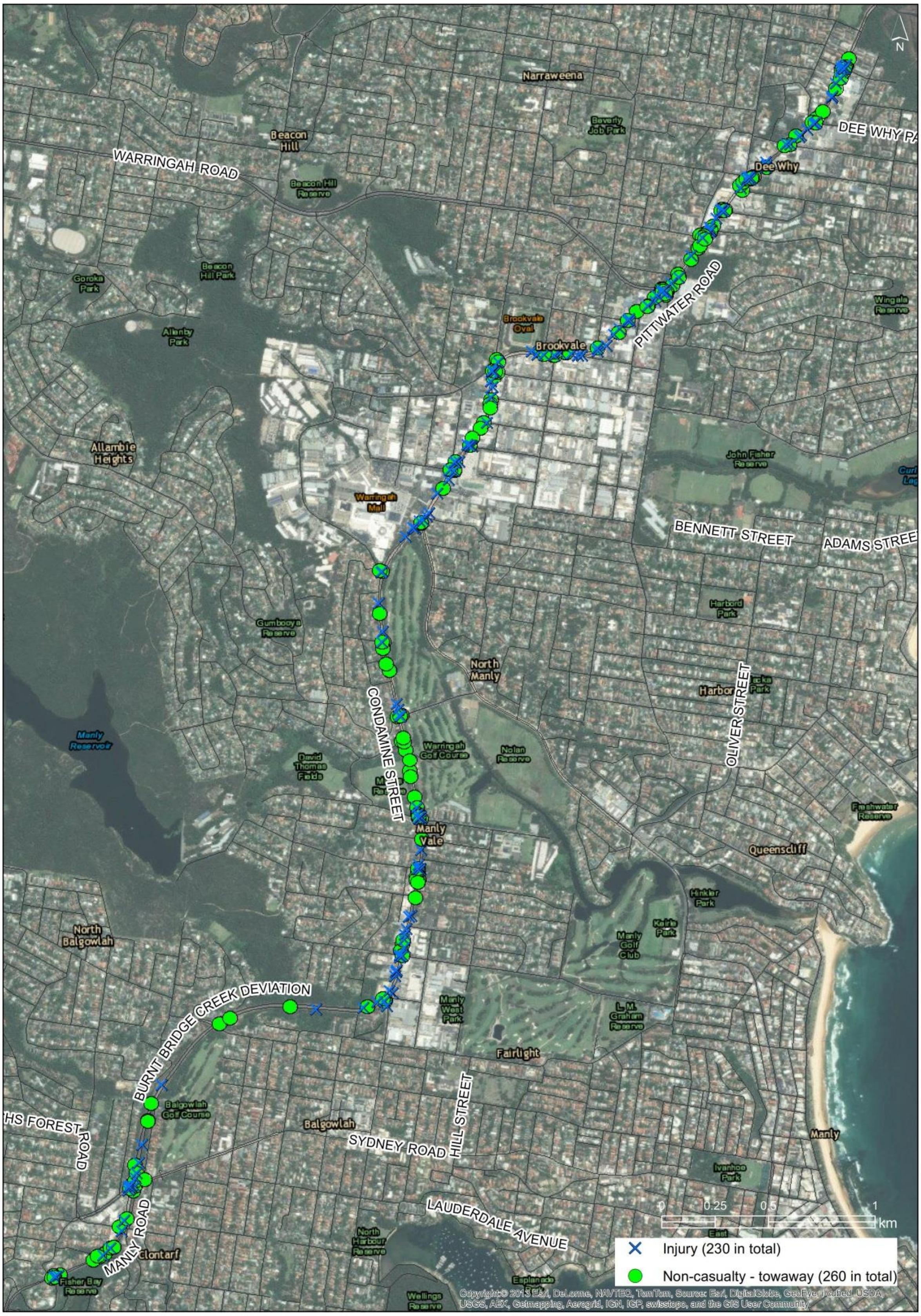
3.9 Existing road safety trends

Roads and Maritime supplied crash statistics for key roads within the study area between South Creek Road and Avona Crescent over a five year period from January 2010 to December 2015. A summary of the crash trends by accident types along the main north-south corridor in the study area is presented in **Table 7** below. The crash statistics are also graphically represented in **Figure 19** to aid the visualization of the spread of crashes along the corridor.

Table 7 Crash statistics summary by crash types for the study area (January 2011 – December 2015)

Type of crash	Number of crashes
Pedestrian	30
Intersection	31
Head on	5
Head on (Right Through)	96
Head on (Left Through)	2
Rear end	180
Side swipe / lane change	91
Entering road way / off-carriageway	14
On path	8
Off path on straight	21
Off path on curve / turning	11
Miscellaneous	1
Total Crashes	**490**

Figure 19 Reported crash locations along the B-Line route (January 2011 – December 2015)



A review of the crash summary indicates a total of 490 reported crashes that have occurred along the proposed B-Line route during the 5-year period between 2010 and 2015. 230 of these crashes resulted in injuries. Of all the crashes, 37% were rear end type crashes and 18% occurred between vehicles traveling in the same direction (e.g. side swipe and lane changing). The other predominant type of crashes is head on crashes with vehicles turning right. This makes up 20% of the total crash data.

Rear-end crashes are common on roads that experience reasonable queuing and congestion and tend to be low in severity. Head on right-turning type of crashes are also common however can be high in severity as this involves crashes with vehicles traveling from opposing directions.

In addition, summary of crash statistics are provided in **Table 8** for areas where the proposed on-road infrastructure improvements may provide benefits from a road safety perspective. A review of the summary suggests the following:

Table 8 Crash statistics at key areas

Type of crash	Manly Rd / Heaton Ave	Pittwater Rd / Cross St	Pittwater Rd / Orchard Rd
Pedestrian	0	2	1
Intersection	2	0	0
Head on	1	0	0
Head on (Right Through)	0	2	3
Rear end	5	4	1
Side swipe / lane change	2	6	1
Entering road way / off-carriageway	1	2	2
On path		1	
Off path on straight	0	2	0
Off path on curve / turning	0	0	0
Total Crashes	**11**	**19**	**8**

Crash Mitigation

- **Manly Road / Heaton Avenue:** the proposed closure of Heaton Avenue will eliminate intersection and entering crashes. The indented bus bay and closure of Heaton Avenue will reduce the potential for rear end and side swipe crashes. This is achieved through elimination of the conflicting traffic movement exiting Heaton Avenue with descending southbound buses, cyclist and taxi traversing on the kerbside T3/bus lane. Site observations had also identified a high risk for cyclists with relatively fast travel speeds and vehicles entering from Heaton Avenue. The closure of Heaton Avenue will mitigate such risk.
- **Pittwater Road / Cross Street:** reduction of rear end crash rates through segregation of different traffic movements into dedicated traffic lanes as a result of the proposed left-turn bay for northbound traffic at approach to Cross Street.
- **Pittwater Road / Orchard Street:** the proposed restriction of traffic movements at Orchard Road with Left-in and Left-out arrangement at the priority control intersection will potentially reduce crash rates for potential collision (i.e. right-through collision) between southbound mainline traffic with right-turning vehicles accessing Orchard Road from Pittwater Road.

4.0 Future traffic growth

A key component of the future year traffic modelling assessments was the forecast level of future background traffic growth in the study area. The Base Year traffic models were developed to represent the operation of the road network in 2016; however it was important for the 2021 modelling scenarios to provide an adequate forecast of how the network may operate in 2021, with and without B-Line proposal.

The forecast level of background traffic growth between 2016 and 2021 was calculated using a range of data and information sources. These sources are described in the following sections.

4.1 Historical traffic growth

A review of available traffic count data along the Pittwater Road corridor was undertaken to determine historical levels of traffic growth within the study area. The traffic counts were obtained from the RMS traffic count database for the period between 2011 and 2015 in the following locations:

- Site 34016: Pittwater Road 90m south of Sloane Crescent
- Site 55022: Pittwater Road 120m north of William Street
- Site 55138: Pittwater Road 70m south of May Road
- Site 55030: Pittwater Road 50m north of Lismore Avenue

The availability of traffic count data for the above sites during the defined time period was sporadic; however comparisons of daily and peak hour volumes at the different sites indicated a clear pattern of either very minor positive or negative traffic growth.

The most complete sample of data was available for site 34016. Comparisons of the two-way daily and peak hour traffic volumes recorded at this site between 2011 and 2014 for weekdays and on Saturdays are illustrated in **Figure 20** and **Figure 21.**

Figure 20 **Weekday volume comparisons along Pittwater Road 2011-2014**

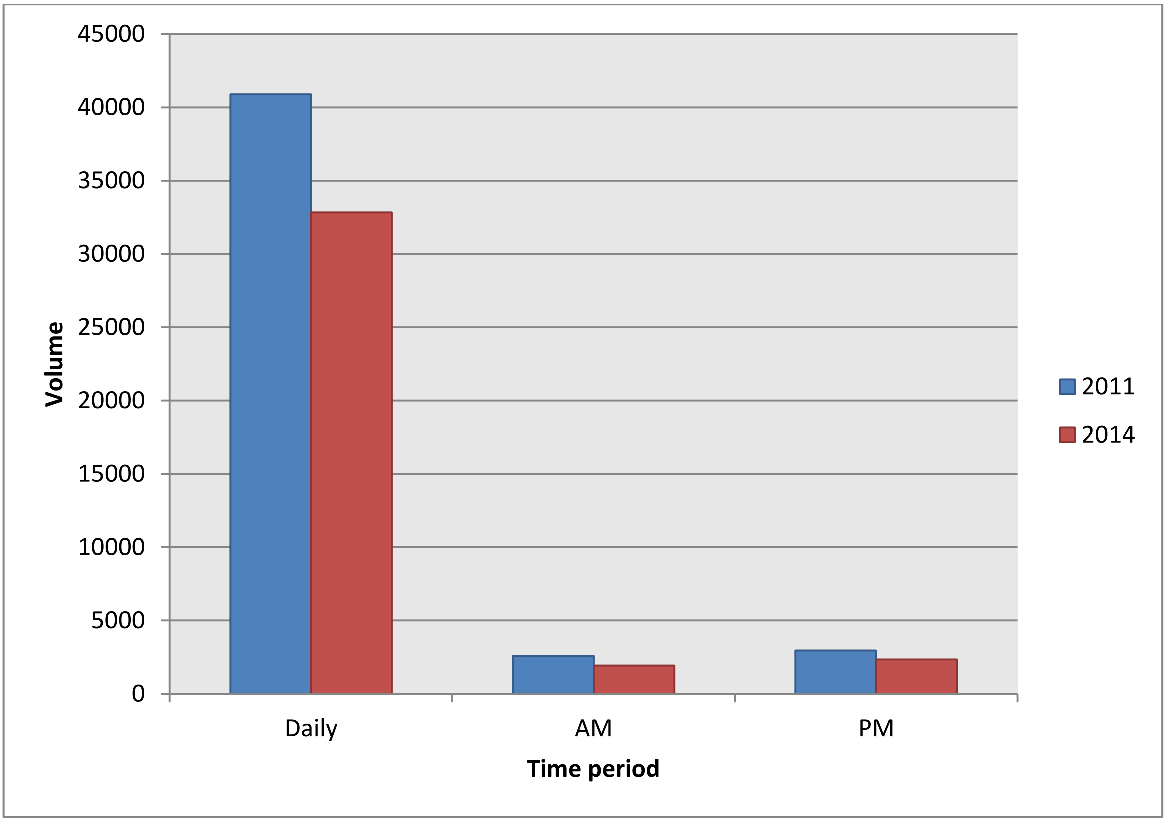
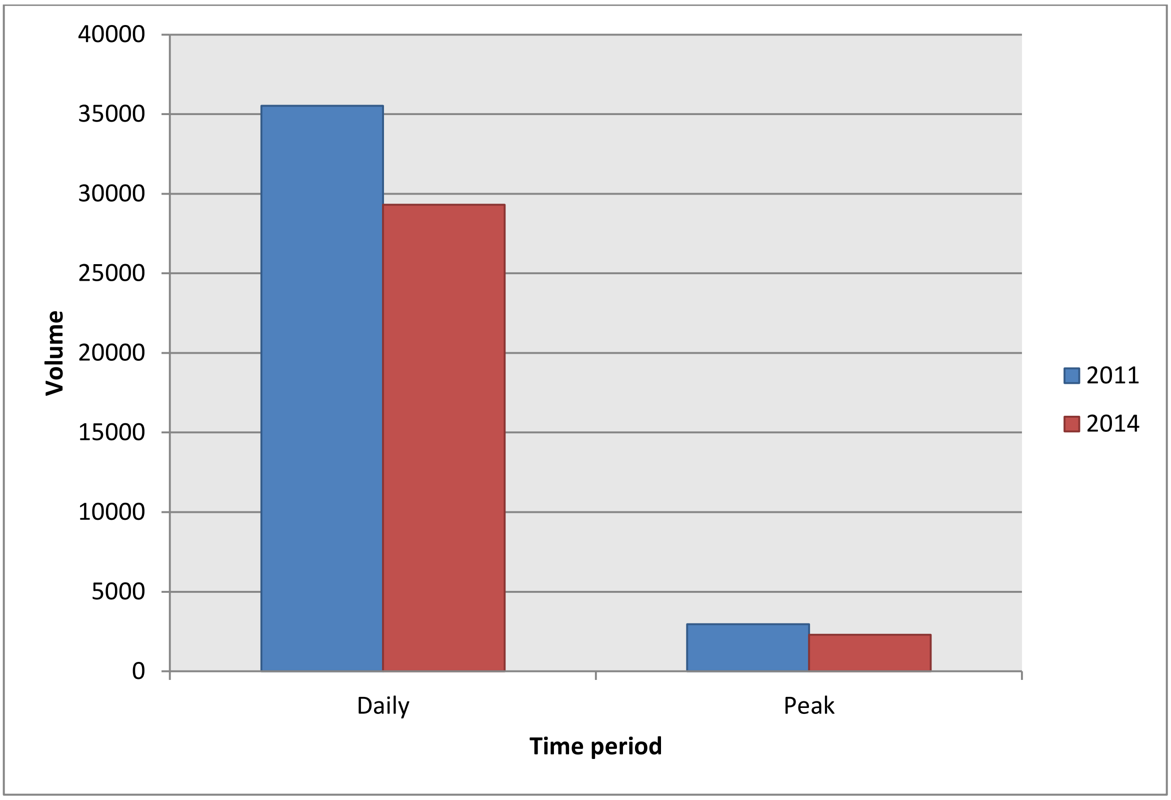


Figure 21 Saturday volume comparisons along Pittwater Road 2011-2014



4.2 Population forecasts for Sydney and the Northern Beaches

Population forecasts are commonly used to inform decision making in planning for transport and infrastructure and are a key input into strategic travel demand models. The forecasts are generally based on transport and planning policies (at a local, regional and national level); and committed / aspirational developments.

To inform the calculation of future background traffic growth along the Pittwater Road corridor, population forecasts for the Northern Beaches were sourced from the TfNSW report '*Northern Beaches BRT Demand Report Addendum 2*'. The forecasts are summarised in **Table 9.**

Table 9 Population forecasts for the Northern Beaches

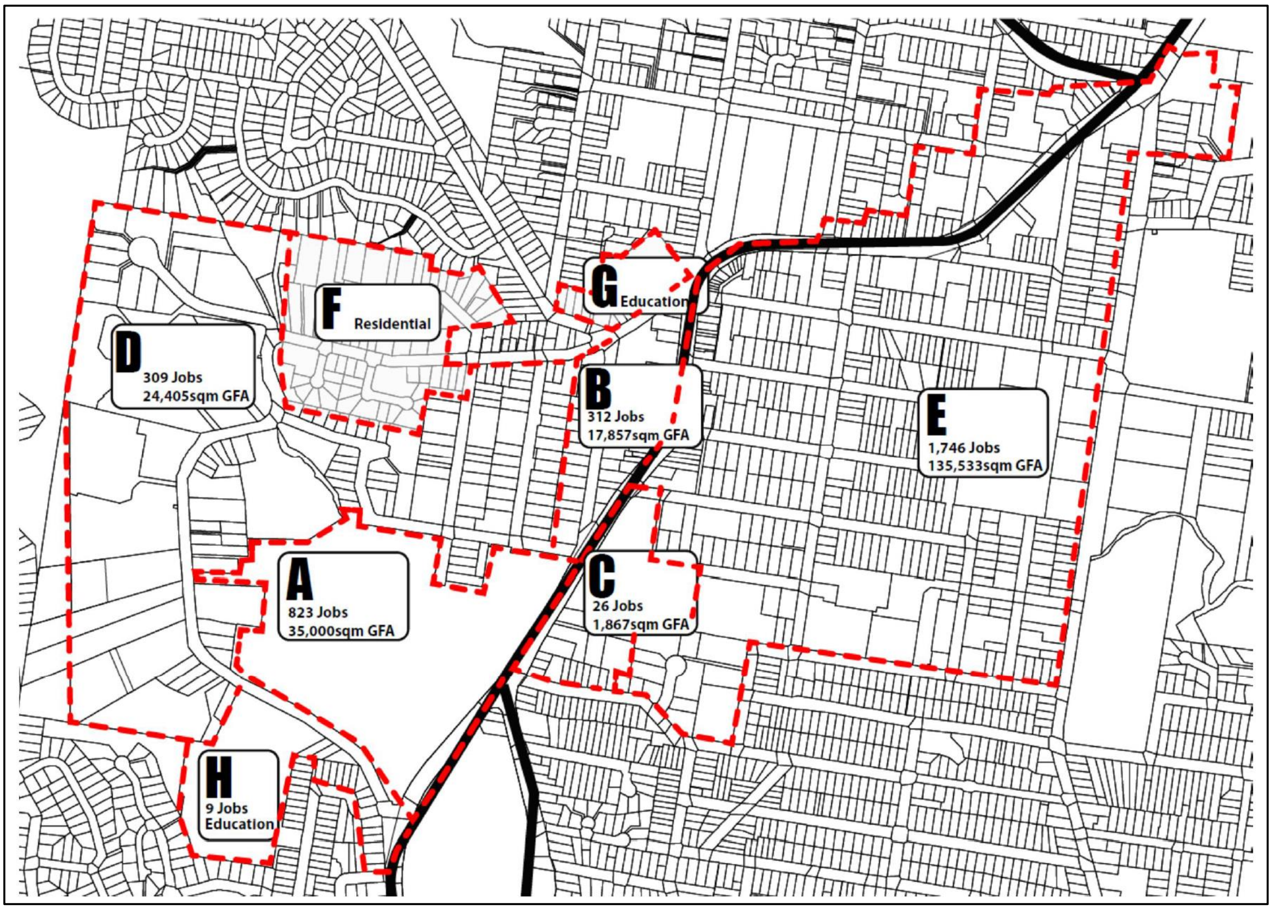
Area	People			Growth 2011 – 2031	
	2011	2021	2031	No.	%
Pittwater	60,460	68,570	77,590	17,130	28%
Warringah East	102,520	115,350	124,070	21,550	21%
Warringah West	45,900	49,360	55,520	9,620	21%
Manly	42,820	47,680	53,600	10,780	25%
Total	**251,700**	**280,970**	**310,770**	**59,070**	**23%**

It is forecast that the population of the Northern Beaches will increase by 23% between 2011 and 2031. Assuming linear growth across this period this would equate to approximately 1% population growth per annum.

4.3 Future developments within the study area

Information on potential future development within the study and associated forecasts on development traffic was sourced from the *Brookvale Dee Why Transport Management and Accessibility Study* (TMAS) produced by GHD on behalf of Warringah Council in 2012. The information contained within the study suggests that the majority of development planned for the study area is likely to take place at Warringah Mall and surrounding areas. Development yield forecasts to 2036 from the TMAS study report are illustrated in **Figure 22.**

Figure 22 2012 TMAS development yield forecasts for Brookvale Dee Why 2011 - 2036



Source: Brookvale Dee Why TMAS, GHD 2012

4.4 STFM forecasts

Peak hour traffic forecasts for the Pittwater Road corridor and major side roads were obtained from the Sydney Strategic Forecasting Model (STFM) for 2015 and 2021 to determine the forecast level of traffic growth in the model. Strategic traffic models such as the STFM provide a good source of information for calculating future background traffic growth as the models generally contain up-to-date inputs on population, employment and infrastructure changes.

To inform the calculation of future background traffic growth for the study area, 2015 volumes from the STFM were extracted for the following locations:

- Condamine Street south of Pittwater Road.
- Pittwater Road east of Condamine Street.
- Old Pittwater Road at intersection with Condamine Street and Pittwater Road.
- Cross Street west of Pittwater Road.
- Old Pittwater Road at intersection with Pittwater Road and Winbourne Road.
- Warringah Road west of Pittwater Road.
- Harbord Road south of Pittwater Road.

The volume forecasts for Old Pittwater Road and Cross Street were combined to calculate overall forecasts the area including Warringah Mall and the surrounding land uses. The forecasts were combined as the zoning in the

STFM in this location is relatively coarse and does not accurately reflect the vehicle access arrangements for the mall and adjacent land uses. So by combining the volumes an overall forecast for this area was calculated.

Comparisons of the STFM volume forecasts between 2015 and 2021 for the key roads in the study area are provided in **Table 10** and **Table 11.**

Table 10 STFM AM peak hour volume forecasts for 2015 and 2021

Location	2015	2021	Growth per annum	2016-2021
Condamine St south of Pittwater Rd NB	1,489	1,579	0.98%	5%
Condamine St south of Pittwater Rd SB	1,587	1,689	1.04%	5%
Warringah Mall area inbound	724	832	2.34%	12%
Warringah Mall area outbound	900	925	0.46%	2%
Warringah Rd west of Pittwater Rd EB	1,201	1,304	1.39%	7%
Warringah Rd west of Pittwater Rd WB	973	1,071	1.61%	8%
Harbord Rd NB	624	657	0.86%	4%
Harbord Rd SB	883	931	0.89%	5%

Table 11 STFM PM peak hour volume forecasts for 2015 and 2021

Location	2015	2021	Growth per annum	2016-2021
Condamine St south of Pittwater Rd NB	1,557	1,613	0.59%	3%
Condamine St south of Pittwater Rd SB	1,423	1,489	0.76%	4%
Warringah Mall area inbound	736	843	2.29%	12%
Warringah Mall area outbound	1,110	1,188	1.14%	6%
Warringah Rd west of Pittwater Rd EB	1,038	1.131	1.44%	7%
Warringah Rd west of Pittwater Rd WB	1,234	1,367	1.72%	9%
Harbord Rd NB	869	935	1.23%	6%
Harbord Rd SB	689	734	1.06%	5%

The forecast show that Pittwater Road and the major connecting roads are estimated to increase by between 0.8% and 1.8% per annum between 2015 and 2021; equating to an overall increase of between 3% and 9% between 2016 and 2021. These forecasts align reasonably well to the population forecasts for the Northern Beaches presented in **Section 4.2**.

Traffic using the roads that provide access into the Warringah Mall area is forecast to increase by between 1 and 2.5% per annum between 2015 and 2021; equating to an overall increase of between 2% and 12% between 2016 and 2021. This aligns reasonably well to the development yield forecasts outlined in the Brookvale Dee Why TMAS report and suggests that the STFM model includes the forecast increase in population and employment for the Warringah Mall area.

The link volume plots used to determine the above analysis are provided in **Appendix C**.

4.5 Background traffic growth for traffic modelling

The above sections have presented forecasts from a variety of sources relating to population growth, future development and future volumes within the study area; as well as a comparison of historical traffic growth through the comparison of traffic count data along Pittwater Road between 2008 and 2015. The analysis has shown that:

- There has been very little traffic growth along the corridor in the last 10 years. This may be due to low population growth, limited development and a shift in travel mode from car to public transport.
- The population within the study area is forecast to increase by 1% per annum between 2016 and 2021.

- The majority of future development within the study area is expected to take place at and around Warringah Mall.
- 2021 traffic volume forecasts for the study area in the STFM are generally well aligned to the population forecasts and indicate an increase in traffic around the Warringah Mall area in line with the forecasts provided in the Brookvale Dee Why TMAS report.

In light of the above analysis it was decided to base the future background traffic growth between 2016 and 2021 in the VISSIM modelling on the STFM volume forecasts as they are generally consistent with the other key sources of information available (population forecasts and the Brookvale Dee Why TMAS).

The STFM forecasts were applied to the VISSIM model demand matrices by factoring the trips originating from the zones at Condamine Street, Pittwater Road, Warringah Road and Harbord Street by the growth percentages shown in **Table 10** and **Table 11.** For the Warringah Mall zone, trips were factored by the inbound and outbound growth forecasts to make sure that the model provided a good representation of the expected future increase in development traffic in this area.

For all other zones in the model (which predominantly represent local access streets) the 2016 trip origins were factored by 1% per annum in line with the future population growth forecasts for the Northern Beaches. A review of the assigned volumes for 2021 revealed that volumes increase by between 3% and 7% in mid-block locations. This is in line with the forecast increases shown in the STFM.

It is important to note that the STFM forecasts do not take into consideration of potential travel mode shift as a result of the proposal (i.e. reduction of vehicle demands due to a higher usage of public transport such as the proposed B-Line services). Therefore, the forecast adopted for the modelling depicts a conservative representation of the future traffic conditions with the proposal.

5.0 Traffic operational assessment

This section of the report presents the analysis and findings of the traffic modelling that was undertaken to assess the operation of the study area road network in the 2016 Base Year and in 2021 without and with the B-Line proposal.

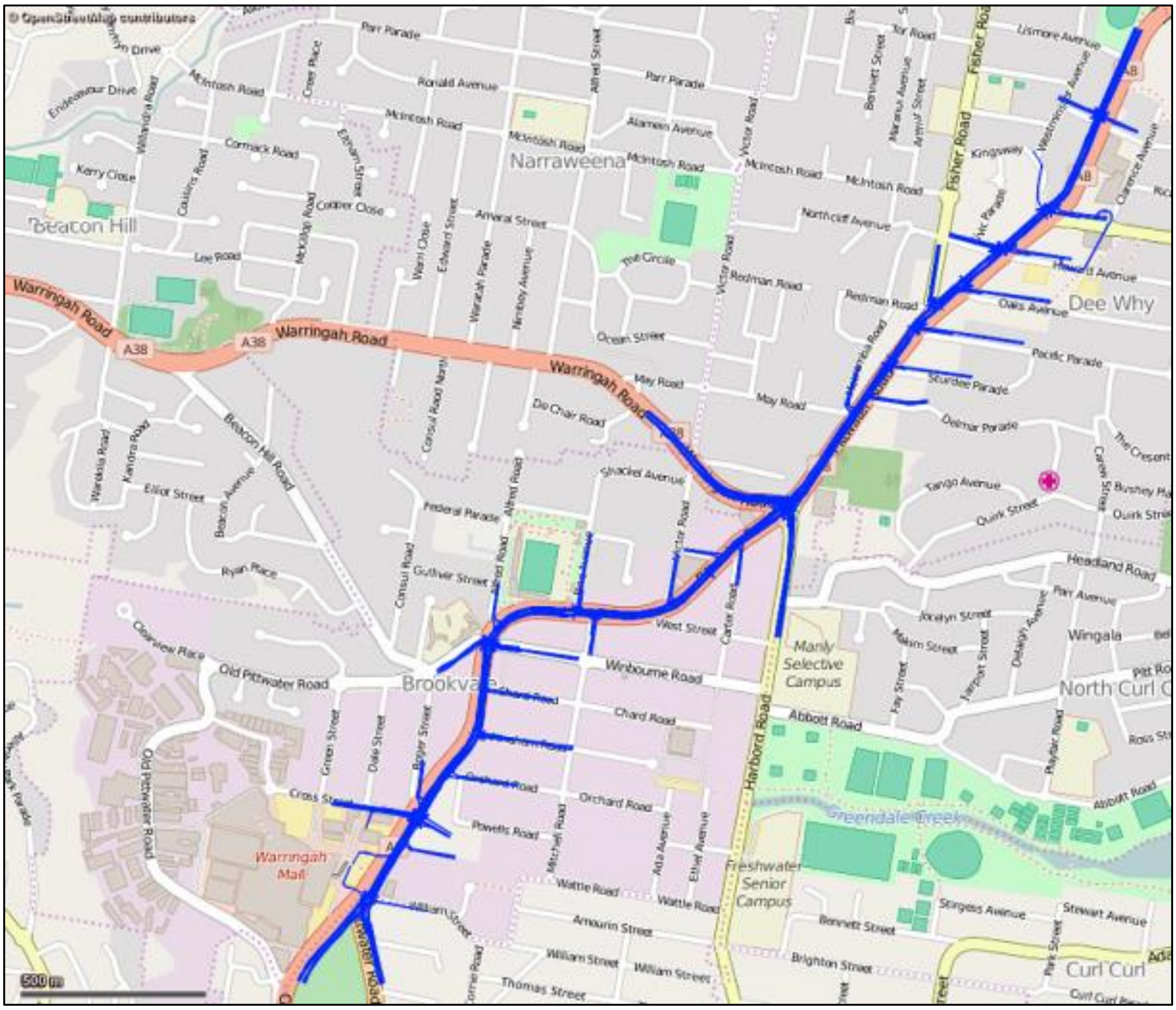
5.1 Modelling approach and assumptions

5.1.1 Assessments

The modelling approach adopted for the network operational assessment consisted of the following assessment elements:

- Individual intersection assessments (using SIDRA 6) to undertake optioneering of the B-Line proposal in Brookvale and Dee Why prior to a network assessment using VISSIM.
- Microsimulation modelling (using VISSIM V7) of the northern section of the study area (indicated by the blue shading in **Figure 23**), to assess the operation of the network in Brookvale and Dee Why, where the majority of the upgrades are proposed.

Figure 23 Dee Why and Brookvale model coverage



Background source: OpenStreetMap

- SIDRA and Commuter modelling of the Sydney Road / Manly Road and Manly Road / Heaton Avenue intersections to assess the impacts of closing Heaton Avenue with traffic displacement and its interaction with downstream pinch-points at the Spit Bridge. (Note that the Commuter model is being developed with the intent for a separate package of works (i.e. P12) of the B-Line program, but adopted to supplement this assessment to provide vital information such as travel time comparison.)

All of the above modelling elements assessed the 2016 Base Year and 2021 with and without the B-Line proposals (Do-nothing and Option scenarios), with the exception of the Commuter modelling which focuses based on 2016 demands only. Details of the 2016 Base Year VISSIM model development and calibration are provided in **Appendix B**.

The SIDRA modelling undertaken for intersections within the VISSIM model extents were based on 2021 volumes which aligns with the forecast in the VISSIM modelling (refer to **Section 4.0**). The SIDRA model developed for Sydney Road / Manly Road used observed survey volumes for the Base Year and factored observed volumes for the 2021 assessments. Further details of the modelling assessments are provided in the following sections.

5.1.2 Dee Why Park n' Ride expansion

To provide additional Park n' Ride capacity in Dee Why for the B-Line, TfNSW is proposing to acquire the bottom level of the existing PCYC carpark located off Fisher Road in Dee Why. The parking is anticipated to generate an additional 120 trips commuter trips.

The *Manly Vale Traffic and Transport Assessment, February* 2016 indicates that the commuter carpark peak is generally between 6:30-7:30AM (61% vehicles arrive) and 5:30-6:30PM (45% vehicles depart). As such, impacts of additional car park traffic are likely to be negligible during the modelled peak hours. This is especially the case since the carpark has multiple access routes (via Kingsway, Civic Parade and Fisher Road) where carpark traffic is unlikely to converge at one particular intersection. The traffic generation for the additional parking was therefore not explicitly included in the traffic modelling.

5.1.3 Diversion of Orchard Street traffic

As discussed previously in **Section 2.0**, it is proposed that the existing un-signalised right turn movement from Pittwater Road into Orchard Street is prohibited to mitigate current safety concerns associated with slow right-turning vehicles potentially conflicting with relatively free flowing southbound buses in the bus lane in the AM peak. The displaced right turn traffic was diverted to the Sydenham Road signal in the VISSIM model for the Option scenario assessment.

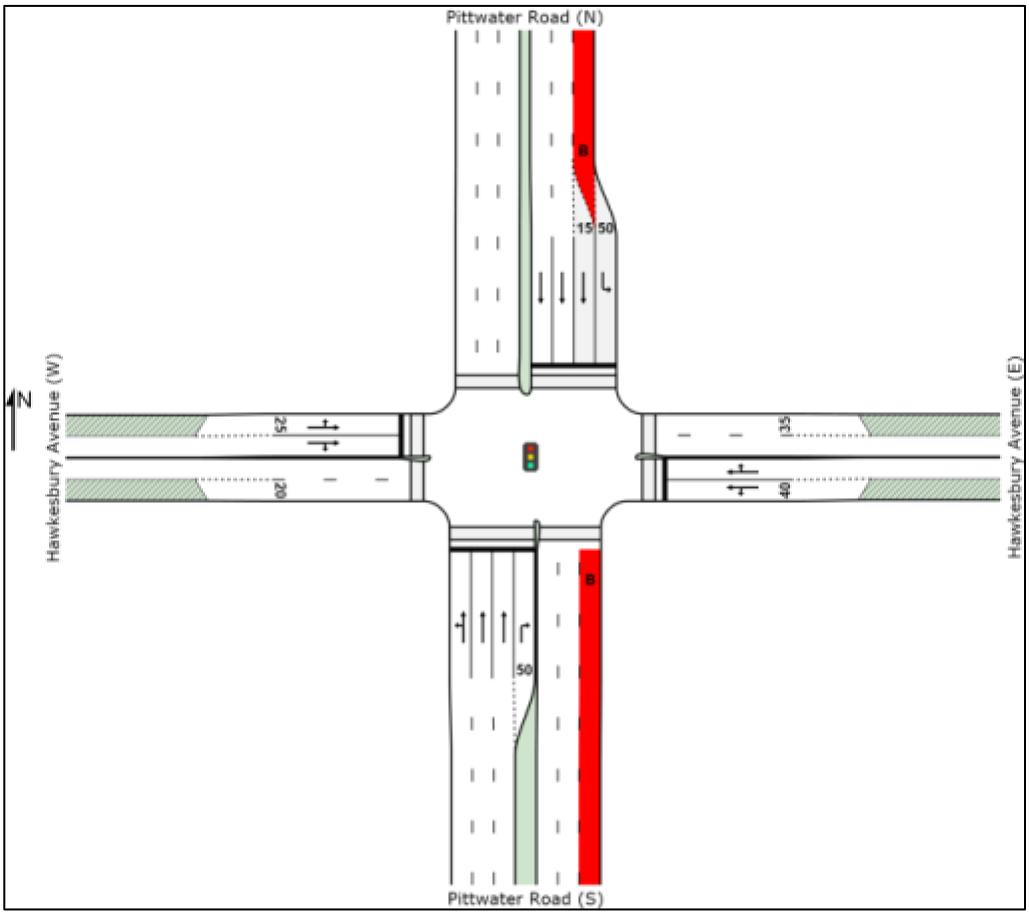
5.2 Brookvale / Dee Why SIDRA optioneering

As part of the preliminary option development process, isolated SIDRA intersection modelling was undertaken for the key intersection upgrades to determine preferred configurations, prior to assessment in the VISSIM modelling. The SIDRA modelling approach and findings are summarised in the following sections.

5.2.1 Pittwater Road / Hawkesbury Avenue

The initial proposed option for this intersection involved the implementation of a dedicated left turn pocket for the movement from Pittwater Road north to Hawkesbury Avenue east. There is currently a high demand for this movement in the AM peak (over 450 vehicles per hour). The proposed segregation of the currently shared movements on the kerbside lane could also benefit bus prioritisation measures at approach to the signal in the future. The configuration assessed is illustrated in **Figure 24.**

Figure 24 Upgrade option for Pittwater Road / Hawkesbury Avenue



It is important to note that the existing signal phasing arrangement at the intersection does not allow for pedestrian protection from turning traffic. During the assessment process, Roads and Maritime advised that any modification proposed to an existing intersection would require consideration of pedestrian protection to align with the latest principles for safety. As such potential implications on stop line / turning capacities were included in the modelling.

Results from the SIDRA modelling suggest that the option may result in minor benefits during the AM peak, but the performance of the intersection may reduce in the PM peak, due to the requirement for pedestrian protection.

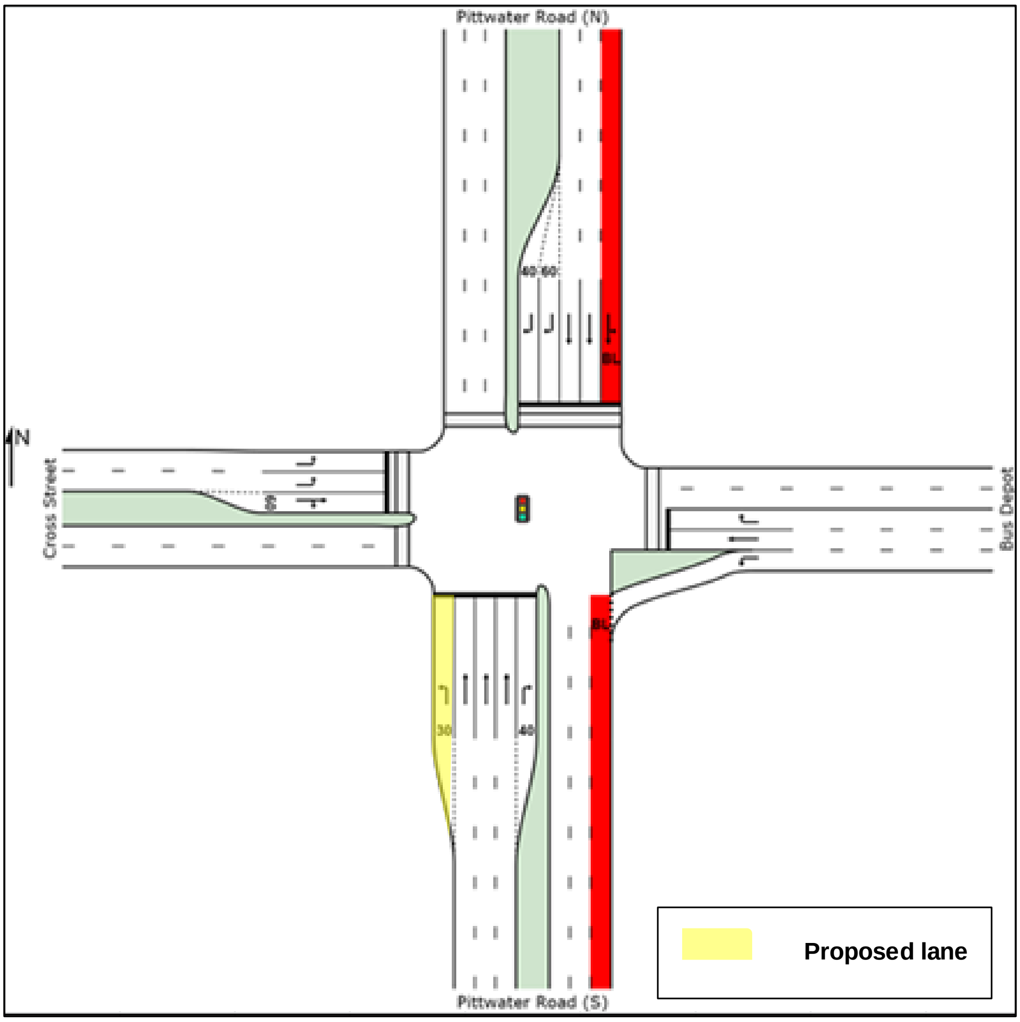
Therefore, the option was not considered to be significantly beneficial and was excluded in the subsequent VISSIM modelling assessment.

An eastern side indented bus bay for local buses south of Hawkesbury Avenue was considered to be feasible from a road design perspective, which minimises the potential requirement of bus priority measures at the intersection.

5.2.2 Pittwater Road / Cross Street

The proposed option for this intersection involves the implementation of an additional left turn lane for the left turn movement from Pittwater Road south into Cross Street. The intent of this option is to separate the left turn traffic from the existing kerbside lane to reduce the delay of turning traffic on northbound buses, particularly in the PM peak due to the higher traffic flows. The assessed option is illustrated in **Figure 25.**

Figure 25 Upgrade option for Pittwater Road / Cross Street



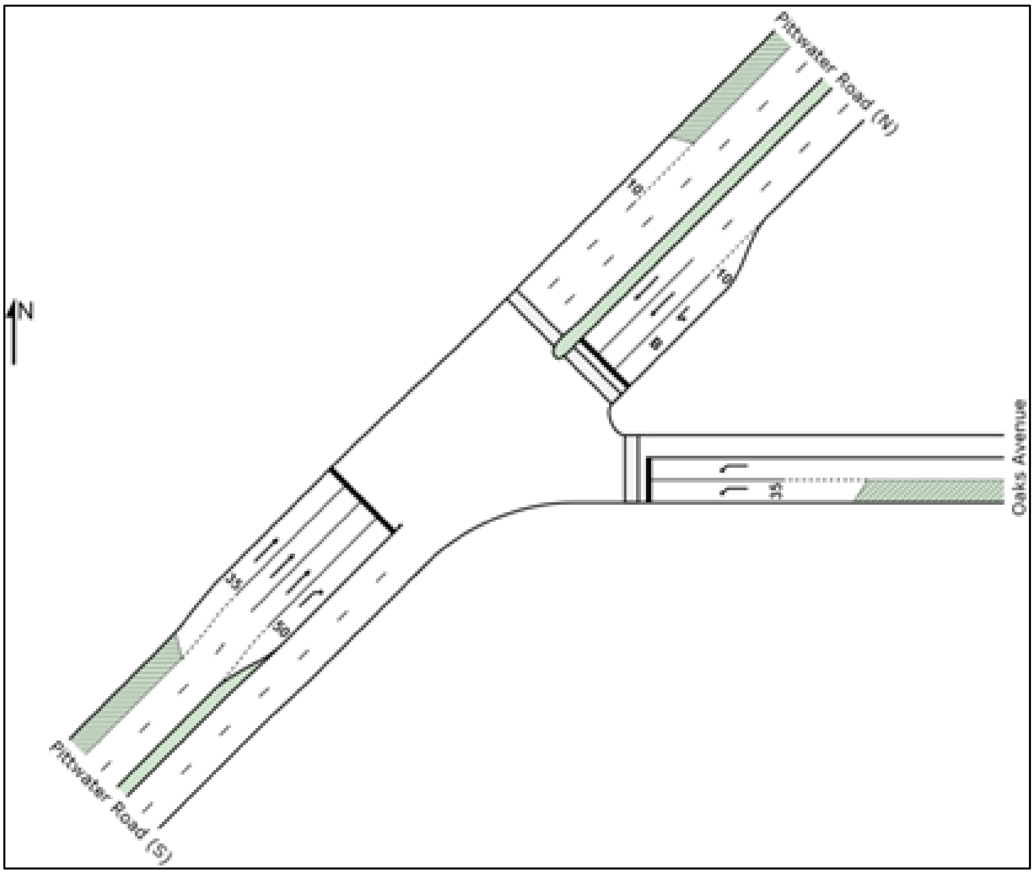
Similar to the earlier intersection analysis, pedestrian protections are taken into consideration as part of the modelling to provide a plausible assessment of the proposed intersection improvement.

In brief, the preliminary SIDRA modelling indicated that the option could improve the intersection performance, and the flow progression for buses, which is in line with the B-Line objectives. The minimum required left turn pocket length was estimated to be 45 metres, upon consideration and consultation with respect to minimising potential property acquisition. This option has also been taken forward and included in the VISSIM modelling assessment for further validation.

5.2.3 Pittwater Road / Oaks Avenue

The proposed option for this intersection involves the extension of the right turn bay for vehicles turning right into Oaks Avenue to accommodate increases in future traffic volumes into the Dee Why town centre and to minimise any impedance on through traffic along the mainline. The existing layout of the intersection is illustrated in **Figure 26.**

Figure 26 Pittwater Road / Oaks Avenue existing layout



Options for the upgrade included extension of the turn pocket to either the intersection of Pacific Parade or to Sturdee Parade, if required. The SIDRA modelling forecast that a turn pocket length for a minimum of 135 metres will be required to accommodate the right turn volumes in 2021. This upgrade has been included in the VISSIM modelling for further analysis.

5.3 Brookvale / Dee Why VISSIM modelling

For the Brookvale and Dee Why microsimulation modelling, three key performance measures are provided to analyse the operation of the proposed options in comparison to the ‘Do-nothing’ scenario in 2021. The performance criteria are defined as follows:

- Overall intersection Level of Service (LOS) – for each key intersection based on the average delay thresholds shown in **Table 4.**
- Average travel times – compared between options with a focus on identifying the level of improvement in local bus and B-Line bus travel times.
- Overall network performance statistics – including average vehicle delay and average network speed to determine the network-wide performance of the model.

5.3.1 Intersection LOS

5.3.1.1 AM peak period

A summary of the AM peak period LOS outputs for the 2016 Base Year and 2021 scenarios is provided in **Table 12**.

Table 12 AM peak period LOS outputs

Intersection	2016 Base Case		2021 Do Nothing		2021 Option	
	07:00 to 08:00	08:00 to 09:00	07:00 to 08:00	08:00 to 09:00	07:00 to 08:00	08:00 to 09:00
Pittwater R / Hawkesbury Ave	B	C	B	C	B	C
Pittwater Rd / Kingsway / Dee-Why Pde	B	B	B	C	B	B
Pittwater Rd / Howard Ave / St David Ave	B	C	B	C	B	C
Pittwater Rd / Oakes Ave	A	B	A	B	A	B
Pittwater Rd / Fisher Rd	B	C	B	C	B	C
Pittwater Rd / Pacific Pde	B	B	B	B	B	C
Pittwater Rd / Sturdee Pde	A	B	A	B	B	B
Pittwater Rd / Delmar Pde	B	C	B	C	B	B
Pittwater Rd / Warringah Rd / Harbord Rd	D	D	D	D	D	D
Pittwater Rd / Victor Rd	B	A	B	B	B	B
Pittwater Rd / Pine Ave / Mitchell Rd	B	B	B	B	B	B
Pittwater Rd / Winbourne Rd	B	C	B	C	B	C
Pittwater Rd / Sydenham Rd	A	A	A	A	A	B
Pittwater Rd / Orchard Rd	B	C	B	D	A	B
Pittwater Rd / Cross St	B	B	B	B	B	B
Pittwater Rd / Condamine St	C	C	C	C	C	C

The key findings from the AM peak period LOS outputs are as follows:

- Overall, the network is forecast to operate relatively well with no intersections expected to operate at worse than LOS D.
- The LOS at intersections across the network does not significantly deteriorate between 2016 and 2021, indicating that there is capacity at most intersections in the AM peak to cater for the expected growth in traffic volumes.
- For a minimum, the proposal is anticipated to have a comparable level of intersection performances, and in some cases marginal improvement, when compared to the 2021 Do-Nothing scenario.

5.3.1.2 PM peak period

A summary of the AM peak period LOS outputs for the 2016 Base Year and 2021 scenarios is provided in **Table 13**.

Table 13 PM peak period LOS outputs

Intersection	2016 Base Case		2021 Do Nothing		2021 Option	
	16:30 to 17:30	17:30 to 18:30	16:30 to 17:30	17:30 to 18:30	16:30 to 17:30	17:30 to 18:30
Pittwater R / Hawkesbury Ave	B	B	B	B	B	B
Pittwater Rd / Kingsway / Dee-Why Pde	A	B	A	B	A	B
Pittwater Rd / Howard Ave / St David Ave	B	B	B	B	A	B
Pittwater Rd / Oakes Ave	A	A	A	A	A	A
Pittwater Rd / Fisher Rd	B	A	B	A	B	A
Pittwater Rd / Pacific Pde	B	C	B	C	B	C
Pittwater Rd / Sturdee Pde	A	B	A	B	A	B
Pittwater Rd / Delmar Pde	B	C	C	B	B	B
Pittwater Rd / Warringah Rd / Harbord Rd	E	E	E	E	E	E
Pittwater Rd / Victor Rd	D	B	D	C	D	D
Pittwater Rd / Pine Ave / Mitchell Rd	C	C	C	C	C	D
Pittwater Rd / Winbourne Rd	E	C	E	C	F	F
Pittwater Rd / Sydenham Rd	C	B	D	B	C	B
Pittwater Rd / Orchard Rd	B	B	C	B	A	A
Pittwater Rd / Cross St	C	C	D	C	D	C
Pittwater Rd / Condamine St	D	E	E	F	E	D

The key findings from the PM peak period LOS outputs are as follows:

- At an overall level, the network operates at a poorer LOS during the PM peak in comparison to the AM peak period. This supports the observations made during site visits in relation to congestion along the corridor on approach Warringah Road, Winbourne Road and Condamine Street intersections.
- There is marginal change in forecast LOS at the intersections between the 2021 Do-nothing and Option scenarios, with the exception of the intersection at Winbourne Road, which deteriorates from LOS E to LOS F in the Option scenario.

  A review of the corridor volumes indicates that in the Option scenario, there is an increase in northbound throughput at the Cross Street intersection of around 100 vehicles per hour (likely due to the implementation of the dedicated left turn pocket). The additional throughput increases delay along the already congested section of the corridor between Cross Street and Winbourne Road, which is sensitive to additional demands, likely leading to the deterioration in LOS at the Winbourne Road intersection.
- It is worthwhile noting that the existing right turn movement from Pittwater Road to Orchard Road is proposed to be banned as part of the proposal. The banned right turn traffic will be diverted to the Pittwater Road / Sydenham Road signalised intersection. In the 2021 option scenario model, the additional right turn demand is observed to generate a maximum queue length of up to 150m for the right turning movement from Pittwater Road to Sydenham Road. These traffic queues are contained within the right turn bay which is approximately 175 meters in length. The aforementioned traffic queues are most pronounced in the PM peak that has the highest right turn traffic demand forecast of all modelled peak periods.
- The congested Warringah Road intersection operates at LOS E in all scenarios. This suggests that the proposal (at a minimum) results in comparable operational performance as per the Do-nothing scenario.

5.3.1.3 Saturday peak period

A summary of the Saturday peak period LOS outputs for the 2016 Base Year and 2021 scenarios is provided in Table 14.

Table 14 Saturday peak period LOS outputs

Intersection	2016 Base Case		2021 Do Nothing		2021 Option	
	11:30 to 12:30	12:30 to 13:30	11:30 to 12:30	12:30 to 13:30	11:30 to 12:30	12:30 to 13:30
Pittwater R / Hawkesbury Ave	B	C	C	C	B	C
Pittwater Rd / Kingsway / Dee-Why Pde	B	B	B	C	A	A
Pittwater Rd / Howard Ave / St David Ave	C	C	C	D	B	B
Pittwater Rd / Oakes Ave	C	C	C	C	B	B
Pittwater Rd / Fisher Rd	B	B	B	C	B	B
Pittwater Rd / Pacific Pde	B	B	B	B	B	B
Pittwater Rd / Sturdee Pde	B	B	B	B	B	B
Pittwater Rd / Delmar Pde	C	D	C	E	B	C
Pittwater Rd / Warringah Rd / Harbord Rd	F	F	F	F	F	F
Pittwater Rd / Victor Rd	B	B	B	B	B	B
Pittwater Rd / Pine Ave / Mitchell Rd	B	B	B	B	B	B
Pittwater Rd / Winbourne Rd	C	C	D	D	D	D
Pittwater Rd / Sydenham Rd	A	A	A	A	A	A
Pittwater Rd / Orchard Rd	C	B	C	B	A	A
Pittwater Rd / Cross St	C	C	C	C	C	C
Pittwater Rd / Condamine St	C	C	C	C	B	C

The key findings from the Saturday peak period LOS outputs are as follows:

- The majority of intersections do not experience a significant increase in overall delay between 2016 and 2021; and the LOS outputs are relatively comparable between all scenarios. This suggests that the forecast traffic growth along the corridor is not anticipated to have a significant impact and that the proposed upgrades also demonstrate a marginal performance improvement in the Saturday peak.
- Most intersections operate at an acceptable LOS (LOS D or better) with the exception of the Warringah Road intersection, which is observed to be operating at capacity in the base year. The overall delay for this intersection reduces slightly between the 2021 Do-Nothing and Option scenario (from 85 seconds to 77 seconds). This is likely due in part to the increase in capacity as a result of the proposed parking restrictions on Pittwater Road.

5.3.2 Travel times

Average travel times for general traffic, local buses and B-Line buses were extracted from the VISSIM models for the sections of P9 (Section 1) and P8 (Section 2) routes included within the VISSIM model extents. The travel time routes are illustrated in **Figure 27**. Travel time comparisons for each time period are presented graphically in the following sections. Detailed travel time output tables are provided in **Appendix D**.

Figure 27 Travel time analysis routes

Background source: Google Maps

5.3.2.1 AM peak period

Average travel time outputs for the AM peak period are illustrated in **Figure 28** to **Figure 31.**

Figure 28 AM peak period Section 1 general traffic travel time comparisons

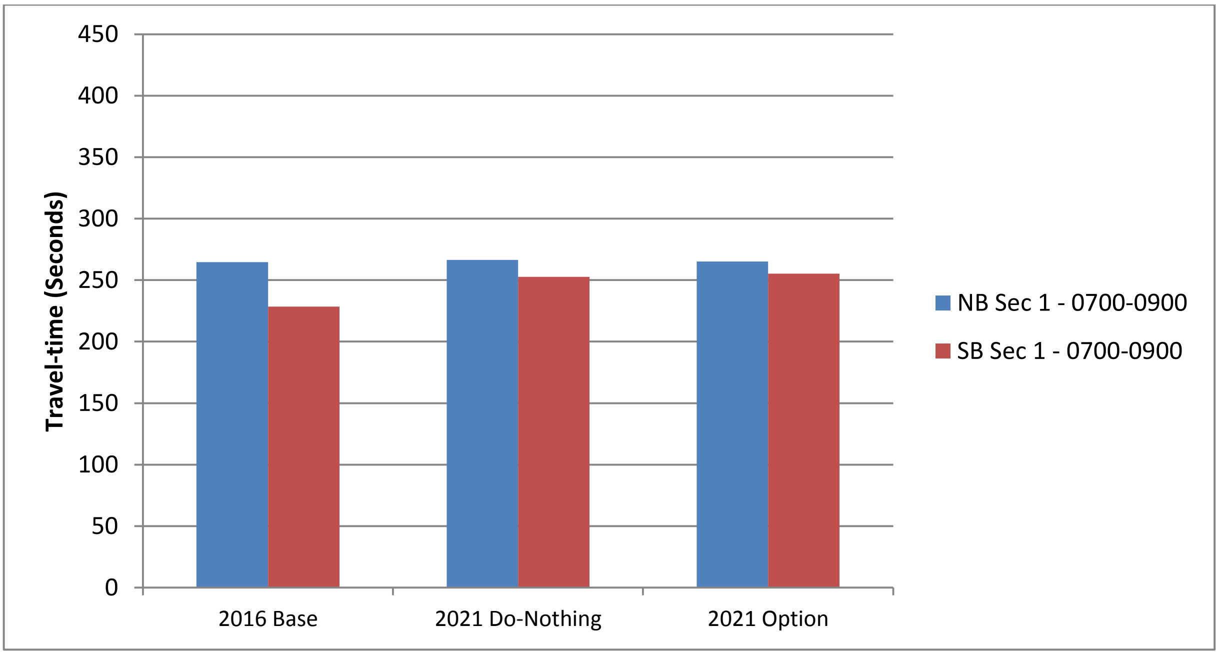
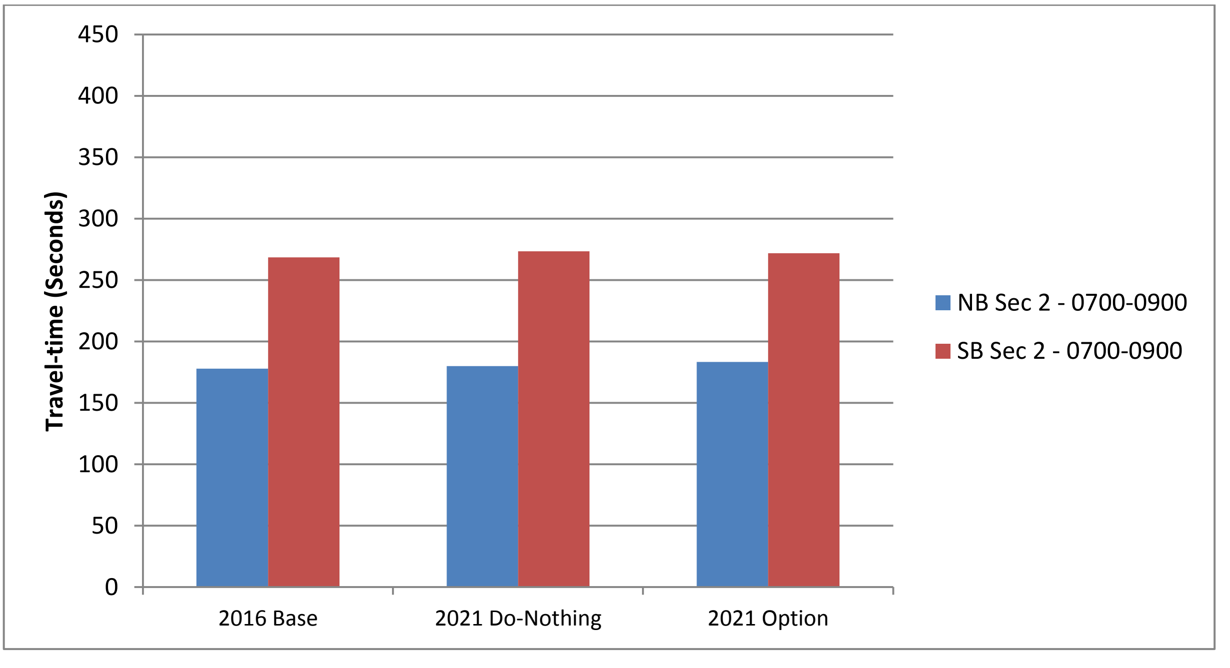


Figure 29 AM peak period Section 2 general traffic travel time comparisons



The general traffic travel time outputs for the AM peak period show that:

- Travel times in both directions are largely consistent between the 2021 Do-nothing and Option scenarios.
- Travel time variations in both directions along the corridor between each scenario are within five seconds. This suggests that the forecast traffic growth and the B-Line proposal is not expected to significantly impact on general traffic travel times in the AM peak.

Figure 30 AM peak period Section 1 bus travel time comparisons

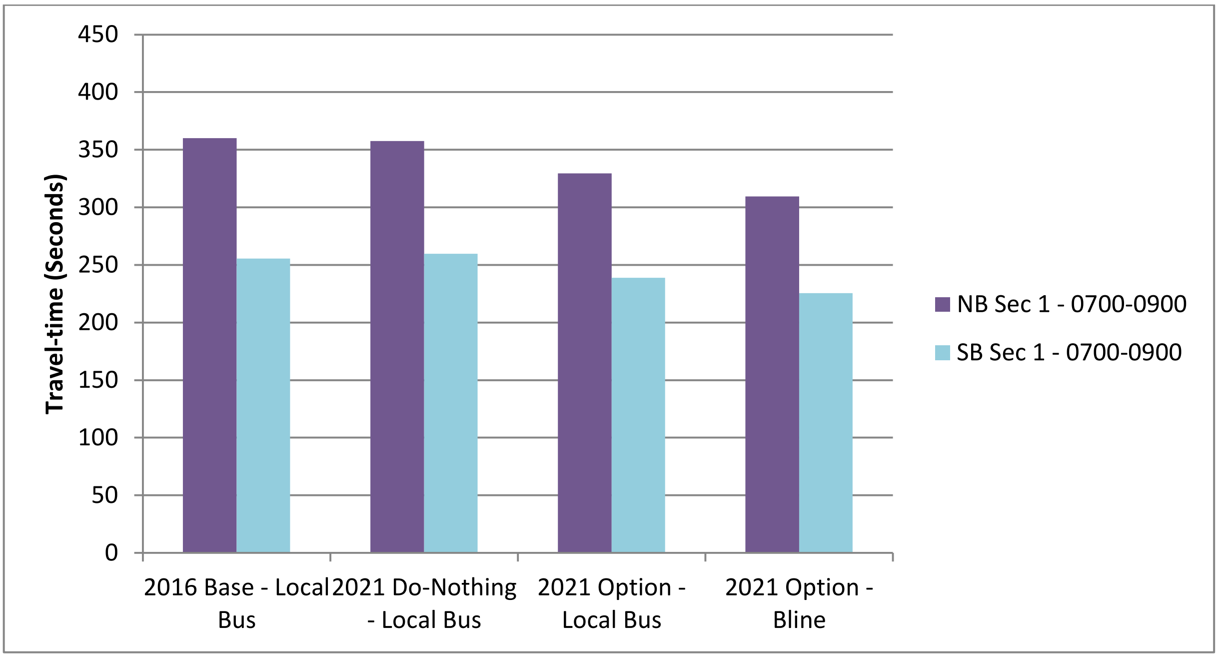
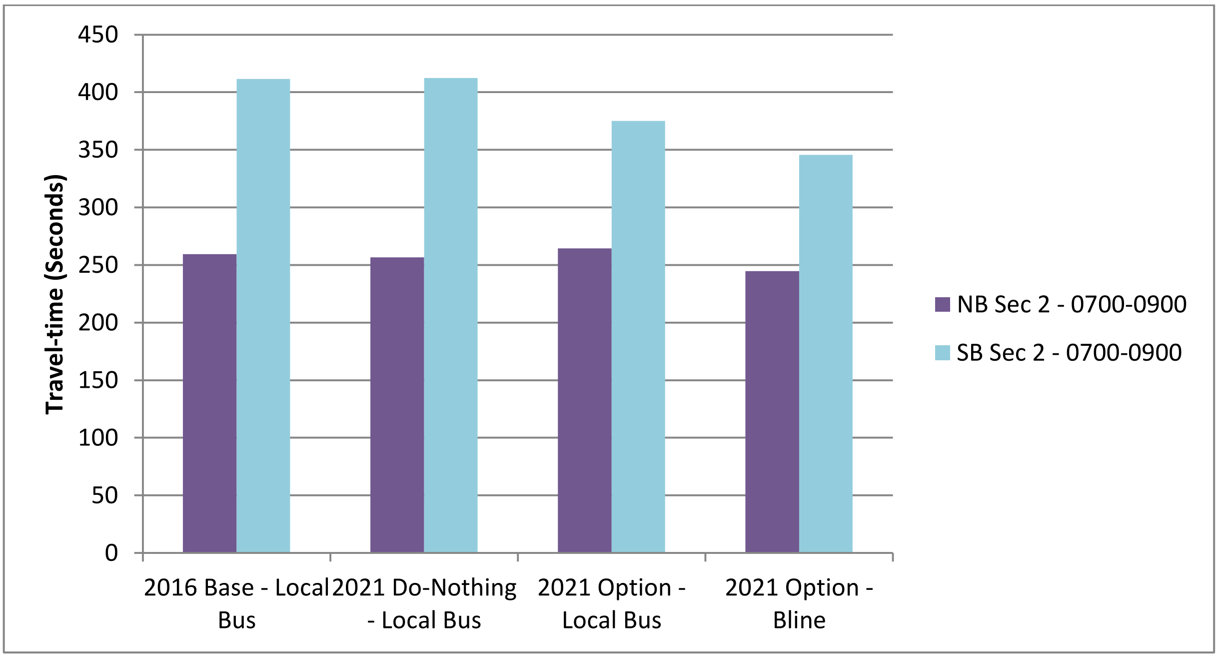


Figure 31 AM peak period Section 2 bus travel time comparisons



The bus travel time outputs for the AM peak period show that:

- In the northbound direction, local bus times are forecast to improve by approximately 20 seconds (3%) between the 2021 Do-nothing and Option scenarios. This improvement is forecast for Section 1.
- In the southbound direction, the modelling shows a consistent benefit for buses in 2021 in the Option scenario in comparison to the Do-Nothing scenario. Local bus times are forecast to reduce by around one minute (9%); B-Line bus times are forecast to be approximately 100 seconds (15%) faster than Do-Nothing.
- The outputs suggest that the B-line proposal should have a positive impact on bus flow and operation along the corridor and should provide moderate benefits in terms of bus travel times, especially in the morning peak southbound direction in comparison to the Do-nothing scenario.

5.3.2.2 PM peak period

Average travel time outputs for the PM peak period are illustrated in **Figure 32** to **Figure 35.**

Figure 32 PM peak period Section 1 general traffic travel time comparisons

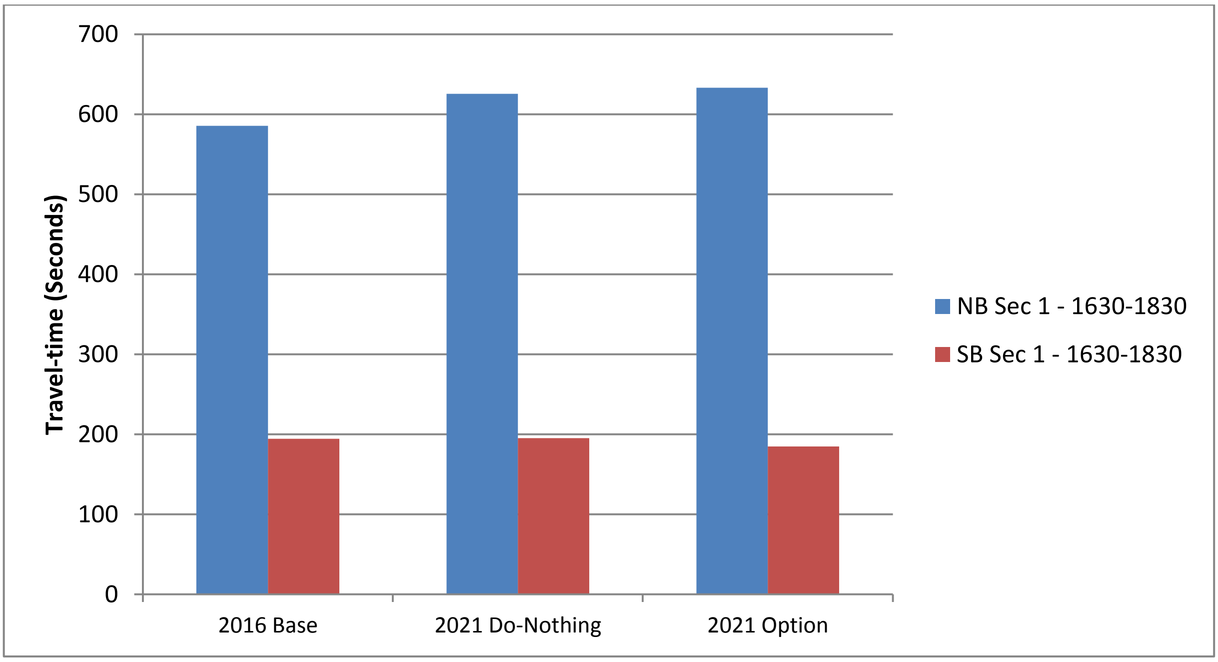
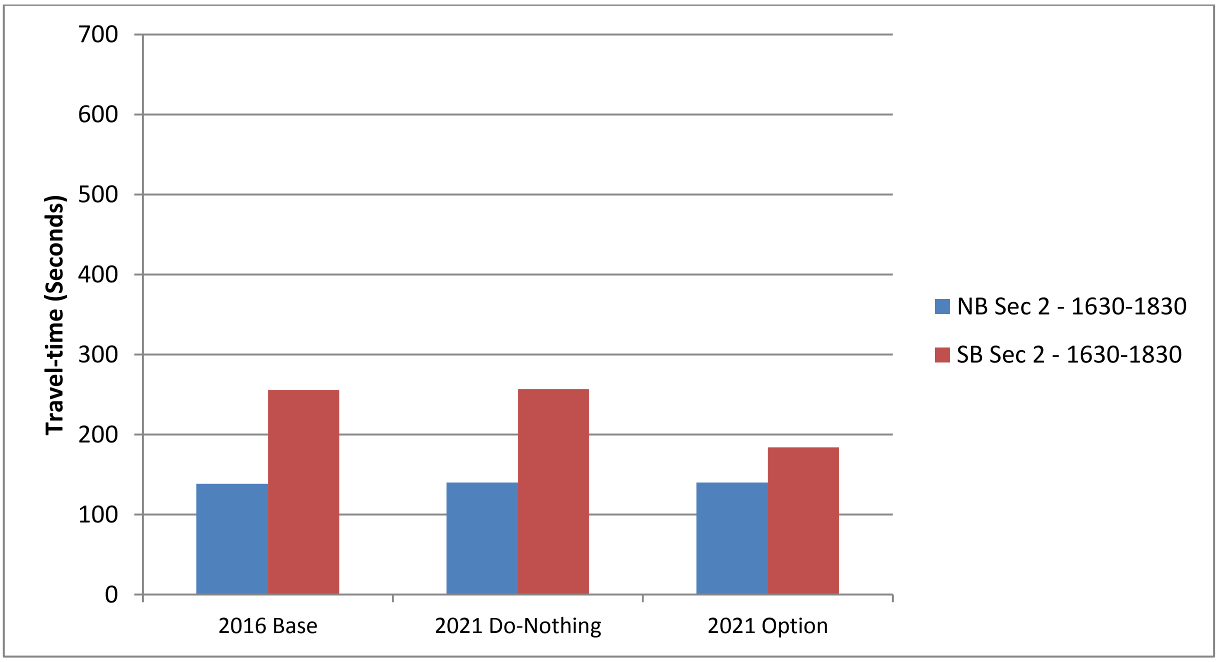


Figure 33 PM peak period Section 2 general traffic travel time comparisons



The general traffic travel time outputs for the PM peak period show that:

- Travel times in the southbound direction are forecast to reduce by around one minute between the 2021 Do-nothing and Option scenarios. This is likely due to the proposed implementation of additional clearways and no-stopping zones in the counter-peak direction and associated increase in capacity. The southbound improvement is forecast to be achieved along Section 2.
- Travel times in the northbound direction are forecast to be relatively consistent between the 2021 Do-Nothing and Option scenarios.

Figure 34 PM peak period Section 1 bus travel time comparisons

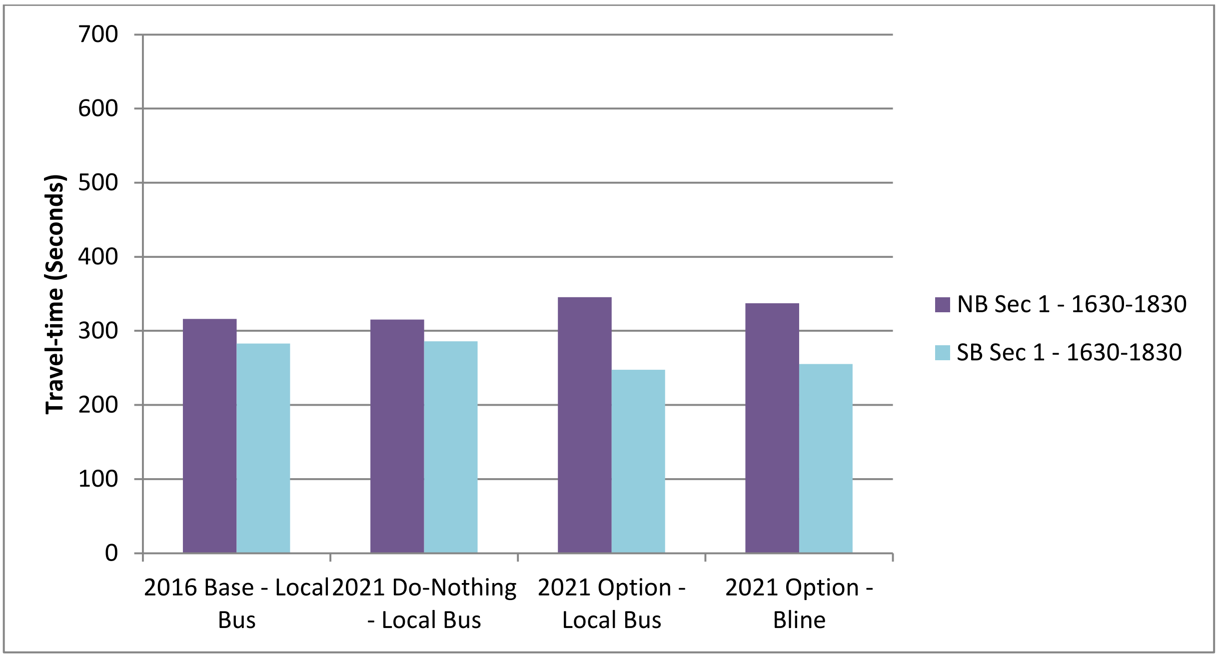
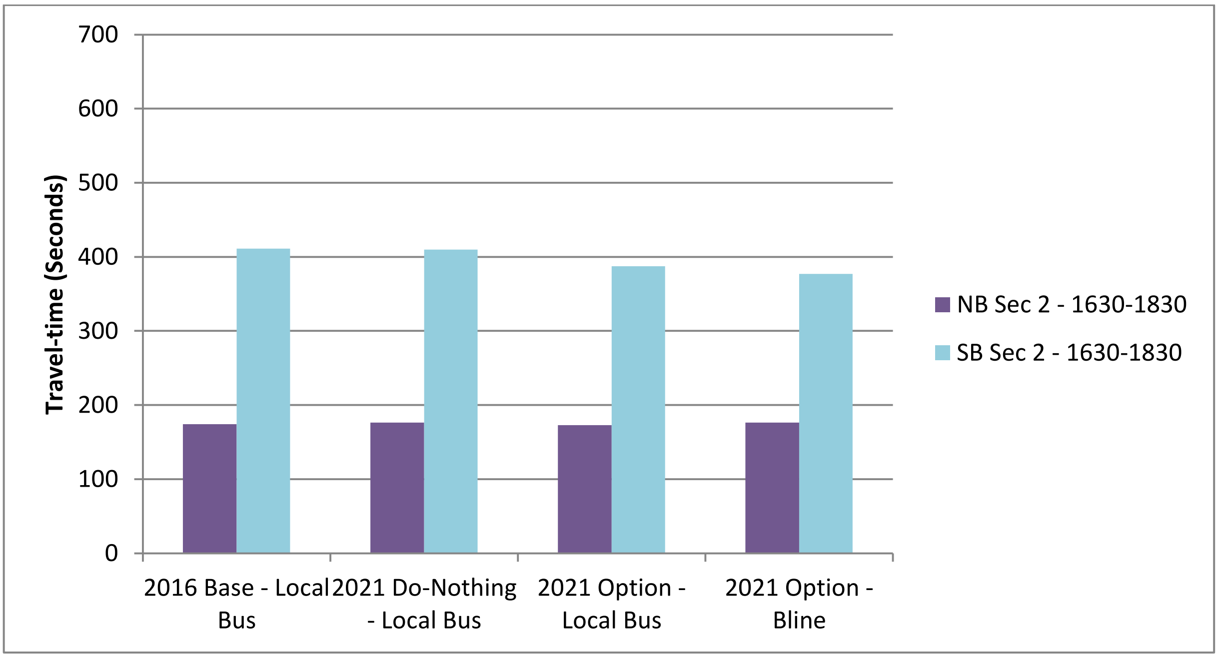


Figure 35 PM peak period Section 2 bus travel time comparisons



The bus travel time outputs for the PM peak period show that:

- Local bus times in the southbound direction reduce by around one minute (9%) between the 2021 Do-nothing and Option scenario. This benefit is likely due to the proposed addition of clearways and no-stopping zones in the counter-peak direction. The outputs show that the majority of the travel time benefit is forecast along Section 1.
- Local bus times and B-Line service times in the northbound direction increase by around 20 seconds. This increase in travel time may due to additional northbound throughput in the Option model at the Cross Street intersection (approximately 100 vehicles per hour), which exacerbates existing congestion along this stretch of already congested corridor. The increase is however so minor that it is well within the stochasticity of the model along this congested section of corridor and is considered to be insignificant.

5.3.2.3 Saturday peak period

Average travel time outputs for the Saturday peak period are illustrated in **Figure 36** to **Figure 39**.

Figure 36 Saturday peak period Section 1 general traffic travel time comparisons

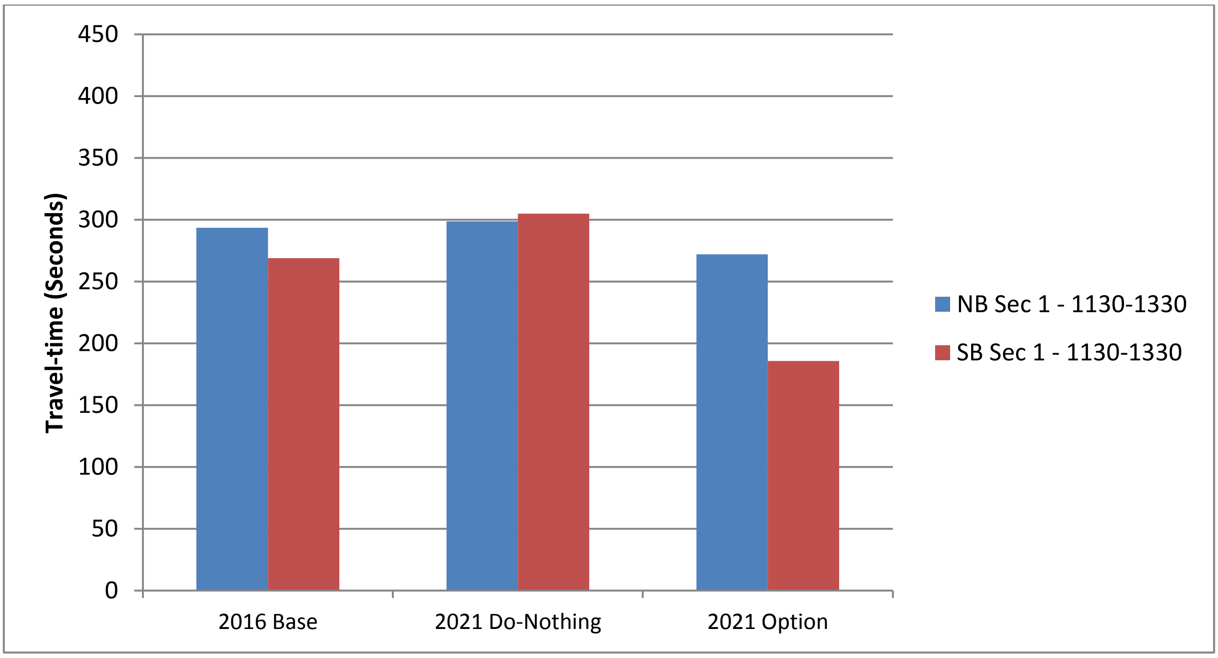
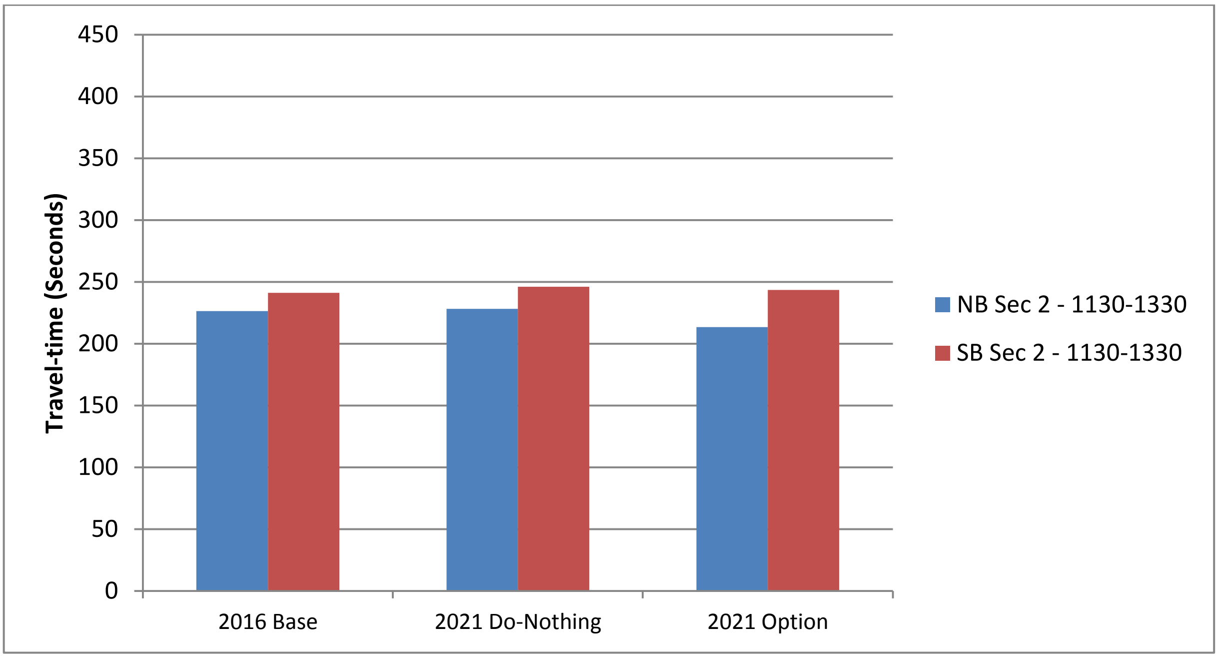


Figure 37 Saturday peak period Section 2 general traffic travel time comparisons



The general traffic travel time outputs for the Saturday peak period show that:

- The 2021 Option scenario is forecast to result in significant improvements in travel times compared to the Do-nothing scenario (around 40 seconds northbound and two minutes southbound). This improvement is likely due to the implementation of additional clearways in the Saturday peak.
- The majority of the travel time improvement is forecast to occur along Section 1, particularly in the southbound direction.

Figure 38 Saturday peak period Section 1 bus travel time comparisons

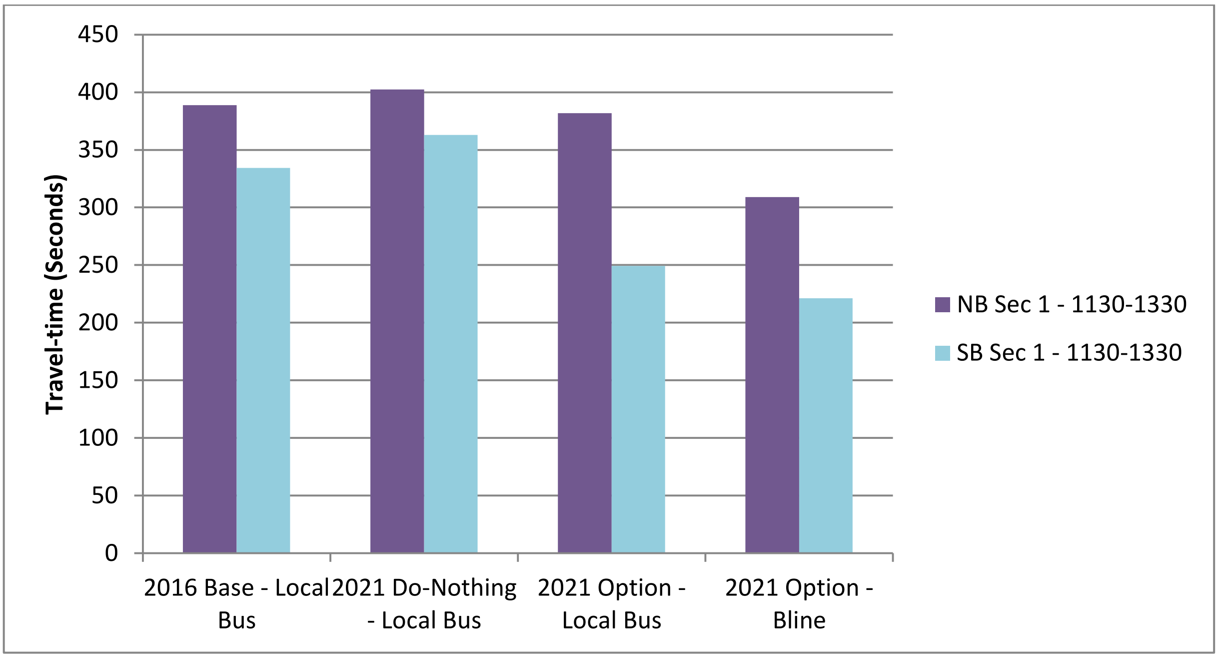
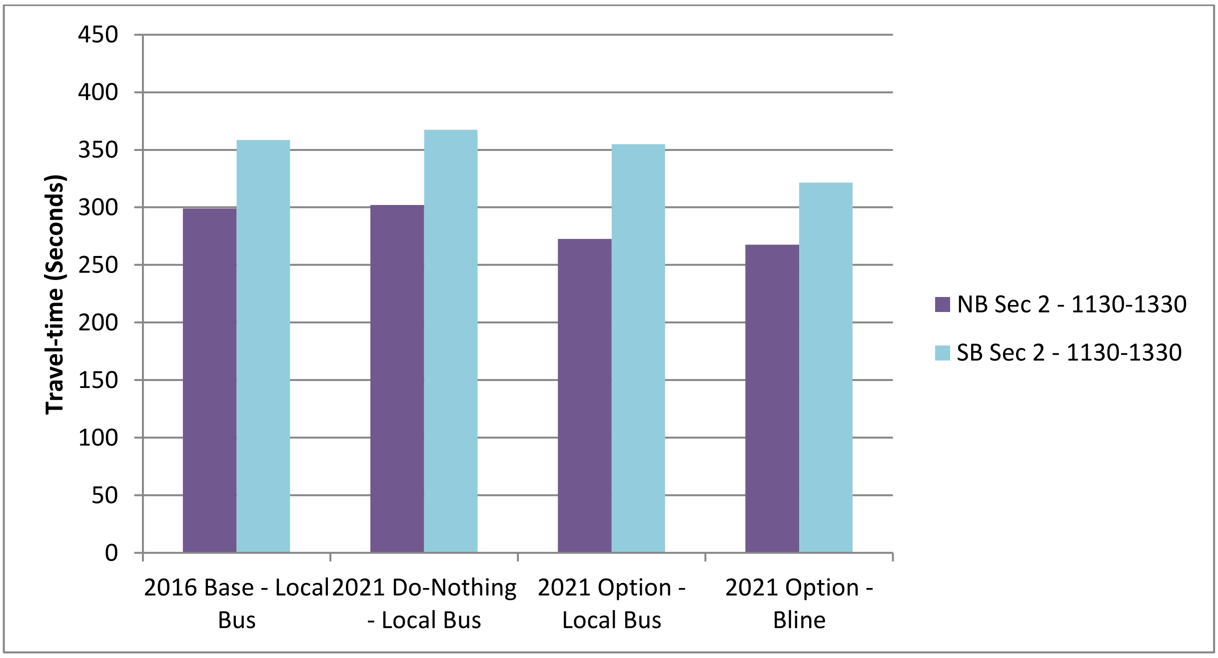


Figure 39 Saturday peak period Section 2 bus travel time comparisons



The bus travel time outputs for the Saturday peak period show that:

- Local bus travel times are forecast to reduce by around 50 seconds (7%) in the northbound direction and by two minutes (16%) in the southbound direction between the 2021 Do-nothing and Option scenarios. Again, this forecast benefit is likely due to the implementation of additional clearways in the Saturday peak.
- Further travel time benefits are forecast for B-Line buses in the Option scenario, with time savings of approximately two minutes (17%) forecast northbound and three minutes (25%) southbound in comparison to the Do-nothing scenario.
- The majority of the travel time savings are forecast to occur along Section 1.

5.3.3 Network performance outputs

The overall performance of the network was analysed for the following parameters for the two-hour peak periods:

- Average vehicle delay – the average delay per vehicle across the network in seconds.
- Average network speed – The average speed of vehicles across the network.
- Latent demand – The number of vehicles blocked outside the network at the end of the model period.

The overall network performance outputs for the 2016 Base Year and 2021 scenarios are presented in the following sections.

5.3.3.1 AM peak period

The overall network performance outputs for the AM peak period are summarised in **Table 15** and **Table 16**.

Table 15 AM peak period network performance outputs 0700 – 0800

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	93	21.6	2
2021 Do-nothing	95	21.4	2
2021 Option	97	21.3	2

Table 16 AM peak period network performance outputs 0800 – 0900

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	110	18.8	83
2021 Do-nothing	120	17.6	121
2021 Option	123	17.5	88

- The outputs appear to show a slight deterioration of network speed and increase of delays in the 2021 Option. However, it is important to note that network performance statistics should be considered in conjunction with latent demands between scenarios. The 2021 Option demonstrates a reduction of latent demands indicating an improvement of efficiency in moving traffic across the network. Such improvement is considered be beneficial and outweighed the slight increase of network delays which is normal given more traffic traversing into the network.

- As such, the average network speed and delays are at a minimum considered to be comparable between the Do-Nothing and Option scenarios indicating that the proposal will not induce any adverse impact to the overall performance of the study road network.

5.3.3.2 PM peak period

The overall network performance outputs for the PM peak period are summarised in **Table 17** and **Table 18**.

Table 17 PM peak period network performance outputs 1630 – 1730

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	132	16.2	272
2021 Do-nothing	140	14.9	390
2021 Option	133	16.1	310

Table 18 PM peak period network performance outputs 1730 – 1830

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	122	14.7	136
2021 Do-nothing	130	12.6	285
2021 Option	136	12.8	112

- Similar to the AM peak, there appears to be a slight deterioration of overall network performance in the PM peak 2021 Option. However, there is a considerable reduction of latent demands which suggests an improvement of network efficiency in moving traffic across the road network as a result of the B-Line proposal. Therefore, it is considered that the overall network performance is at a minimum comparable between the 2021 Do-Nothing and Option scenarios.

5.3.3.3 Saturday peak period

The overall network performance outputs for the Saturday peak period are summarised in **Table 19** and **Table 20**.

Table 19 Saturday peak period network performance outputs 1130 – 1230

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	122	18.2	46
2021 Do-nothing	130	17.2	82
2021 Option	116	18.7	51

Table 20 Saturday peak period network performance outputs 1230 – 1330

Scenario	Ave delay (s)	Ave network speed (kph)	Latent demand
2016 Base	126	17.7	1
2021 Do-nothing	140	15.9	22
2021 Option	114	19.2	1

- The outputs show that under the existing and 2021 Do-Nothing scenarios, the second hour of the Saturday peak period experiences more congestion that the first hour.

- Average network speeds reduce by approximately 1kph in the second hour between 2016 and 2021 Do-nothing scenarios.

- Average speeds in the 2021 Option scenario are approximately 3kph higher than in the Do-nothing scenario in the second hour. Average network delay and latent demand are also reduced. This indicates that the

B-Line proposal will provide a moderate improvement in overall network operation in the Saturday peak period.

5.3.4 VISSIM modelling summary and conclusion

The improvement of bus travel times and efficiency is the primary objective of the B-Line program. Based on the VISSIM modelling analysis, the following conclusions can be made in relation to the future performance of buses in Brookvale and Dee Why with and without the B-Line proposals:

- In the AM peak, travel times for local buses are forecast to improve by approximately 9% southbound and 3% northbound with the B-Line proposals. Travel times southbound for B-Line services are forecast to be around 15% faster than Do-nothing. These improvements are partly attributed to the implementation of the southbound indented bay near Hawkesbury Avenue and the provision of an additional southbound traffic lane near Howard Avenue and Oak Avenue.
- In the PM peak, travel times for local buses are forecast to reduce by around 9% in the southbound direction between the 2021 Do-nothing and Option scenarios. Local bus and B-Line northbound travel times are forecast to remain relatively consistent between the Do-nothing and Option scenarios.
- In Saturday peak, travel times for local buses are forecast to improve by approximately 7% northbound and 16% southbound between the 2021 Do-Nothing and Option scenarios. Travel times for B-Line buses are forecast to improve by around 17% northbound and 25% southbound. These significant benefits can be partly attributed to the indented bus bay and implementation of clearways in both directions.

In relation to general traffic and overall intersection operation, the VISSIM modelling has forecast that:

- The LOS at the key intersections across the network is not forecast to change significantly between the 2021 Do-nothing and the Option scenarios.
- In the AM peak, general traffic travel times in both directions along the corridor are forecast to remain largely consistent between the 2021 Do-nothing and Option scenarios.
- In the PM peak, general traffic travel times in the southbound direction are forecast to reduce by around one minute. Northbound times are forecast to remain relatively consistent between the 2021 Do-Nothing and Option scenarios.
- In the Saturday peak period, the B-Line proposal is forecast to reduce general traffic travel times by between 40 seconds and two minutes in comparison to Do-nothing. This significant improvement is likely due to the implementation of clearways and the associated increase in road capacity.

From an overall network operation perspective, the modelling has shown that:

- The global network performances for a minimum are comparable between the 2021 Do-Nothing and Option scenarios in the weekday peak periods. Indeed, there is a consistent reduction of latent traffic demands with the B-Line proposal indicating an improved efficiency of the network in moving traffic to their destinations.
- On the Saturday peak, there network performance metrics shows moderate improvements with an increase in average network speed as well as a reduction of average delays with the B-Line proposal.
- The above suggests that the B-Line proposal could provide travel time benefits to buses while maintaining a similar level of network performance. In other words, the proposal’s focus on bus related improvement measures is not anticipated to have any adverse impact to other traffic and road users.

5.4 Sydney Road / Manly Road and Heaton Avenue assessment

5.4.1 Existing issues

Towards the southern end of the study area corridor it was identified that there is currently a significant amount of traffic turning left out of Heaton Avenue onto Manly Road during the peak periods. Heaton Avenue forms a left-in / left-out (LILO) connection with Manly Road and is located approximately 350 metres south of the major signalised intersection with Sydney Road.

The traffic turning out of Heaton Avenue uses the existing kerbside T3 lane along Manly Road as an acceleration lane. This interferes with the smooth running and operation of buses at an existing bus stop located approximately 20 metres north of the intersection. There are also safety concerns for traffic exiting Heaton Avenue merges onto the mainline with a steep downward gradient.

In addition, buses stopping at the existing bus stop north of Heaton Avenue are observed to cause delays to other southbound buses and T3 traffic along the corridor. These issues are most prominent in the AM peak period, when the southbound direction along Manly Road is the peak direction for buses and general traffic.

The traffic exiting from Heaton Avenue is surveyed to be at most 300 vehicles per hour in the morning peak period between 7:30-8.30am (or up to 550 vehicles between 7.30-9.30am), with another 30 to 40 vehicles per hour entering Heaton Avenue from Manly Road.

5.4.2 Proposed upgrade

To mitigate the existing issues detailed in the section above, it is proposed to close the Heaton Avenue access at Manly Road and to construct an indented bus bay for replacing the existing bus stop currently located north of Heaton Avenue. This would require that the traffic currently using Heaton Avenue to divert to the signalised intersection upstream at Sydney Road which is also proposed to be upgraded as part of this proposal. The proposed diversion routes for Heaton Avenue traffic will be discussed in the forthcoming sections in conjunction with supplementary Origin-Destination survey data for validation of traffic modelling and assessment assumptions.

5.4.3 Assessment approach

To assess the potential impacts of closing the Heaton Avenue access on the operation of the surrounding network, the following two-tiered modelling assessment was undertaken:

- SIDRA assessment of the Sydney Road / Manly Road intersection to ascertain the proposed intersection upgrades able to satisfactorily cater for the displacement of Heaton Avenue traffic. The traffic volumes used in the SIDRA assessment assumed 6% background traffic growth between 2016 and 2021, in line with the STFM forecasts and population growth forecasts for the Northern Beaches. Two scenarios were tested:
    - **Scenario 1 – all traffic currently using Heaton Avenue is diverted to the eastern approach of the Sydney Road / Manly Road intersection.**
    - **Scenario 2 – 50% of the diverted traffic originates from the eastern side of Manly Road and 50% from the west.**
- Preliminary assessment of the Heaton Avenue / Sydney Road locality is facilitated by a microsimulation model of the corridor, which was developed as part of the P12 work package of the B-Line program. The proprietary modelling tool is called ‘Commuter’ (referred to as ‘Commuter modelling’). This assessment was undertaken for the 2016 Base Year only and tested the same scenarios considered in the SIDRA assessment in terms of traffic diversions. The benefits of the Commuter modelling assessment allow consideration of the proposed upgrade in a connected network to holistically understand traffic issues in conjunction with other network constraints such as the downstream bottleneck at Spit Bridge.

Both modelling assessments were undertaken for the AM and PM peak periods. Assumed upgrades at Sydney Road / Manly Road intersection includes:

- Extension of the existing right turn lane from Burnt Bridge Creek Deviation into Sydney Road (westbound).
- Construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound)
- Upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound).
- Extension of the Sydney Road through traffic lane on the eastern side of the Burnt Bridge Creek Deviation/ Manly Road intersection.

- Extension of the existing right turn lane from Manly Road into Sydney Road (eastbound).

5.4.4 SIDRA assessment

Outputs from the SIDRA analysis are summarised in **Table 21.** Detailed outputs from the SIDRA modelling are also provided in **Appendix E**.

Table 21 Sydney Road / Manly Road SIDRA outputs

Scenario	Total veh	Delay (s)	LOS	DOS
2016 AM	4,757	37.3	LOS C	1.107
2016 PM	5,722	32.5	LOS C	1.052
2021 Do-nothing AM	5,048	41.6	LOS C	1.169
2021 Do-nothing PM	6,076	38.4	LOS C	1.126
2021 Scenario 1 AM	5,322	41.1	LOS C	1.169
2021 Scenario 1 PM	6,223	43	LOS D	1.009
2021 Scenario 2 AM	5,322	33.3	LOS C	0.927
2021 Scenario 2 PM	6,223	45.2	LOS D	1.126

The key findings of the SIDRA analysis are as follows:

- Review of the SIDRA analysis outputs indicates that the displaced traffic resulting from the closure of Heaton Avenue, being re-routed via the Sydney Road intersection can be satisfactorily mitigated with the proposed intersection improvements.
- Comparison of the 2021 'Do Nothing' scenario with the upgrade scenarios suggests that the overall intersection performance could be maintained. It is however noted that the reported intersection performances should only be used for comparative analysis only.
- It is anticipated based on recent site investigation that the rerouted traffic on Sydney Road (east) will likely exhibit similar merging behaviours (i.e. first merging on to the kerbside T3 lane, prior to moving into the general traffic lanes). Notwithstanding the above, this is considered to be a better alternative from a safety perspective given the relatively better visibility and level gradient.

5.4.5 SIDRA modelling limitation

The subject intersection was modelled in SIDRA in isolation. The complex downstream delays from Spit Bridge and beyond are not necessarily replicated. As a result the reported intersection LOS is likely to be under estimated.

Notwithstanding the above, the SIDRA analysis is intended to provide a comparative analysis to demonstrate that the displaced traffic from Heaton Avenue would not significantly worsen the operational performance of the intersection, when compared to the 2021 'Do Nothing' scenario (i.e. without the Heaton Avenue Closure and intersection upgrades).

5.4.6 Commuter microsimulation modelling assessment

The objective of the Commuter modelling is to supplement the SIDRA analysis undertaken for the Sydney Road / Manly Road intersection, and to assess the proposed Heaton Avenue closure. The Commuter simulation model covers approximately 8.3 km of the Spit Road / Military Road corridor, including the intersections of Sydney Road and Heaton Avenue.

In the model simulation, the congestion at Parriwi Road / Spit Road in the AM peak and at the Spit Bridge in PM peak spills back to impede exit flows from the Sydney Road / Manly Road intersection. The model also captures delay caused by buses stopping to pick up passengers on the southern exit from the Sydney Road intersection.

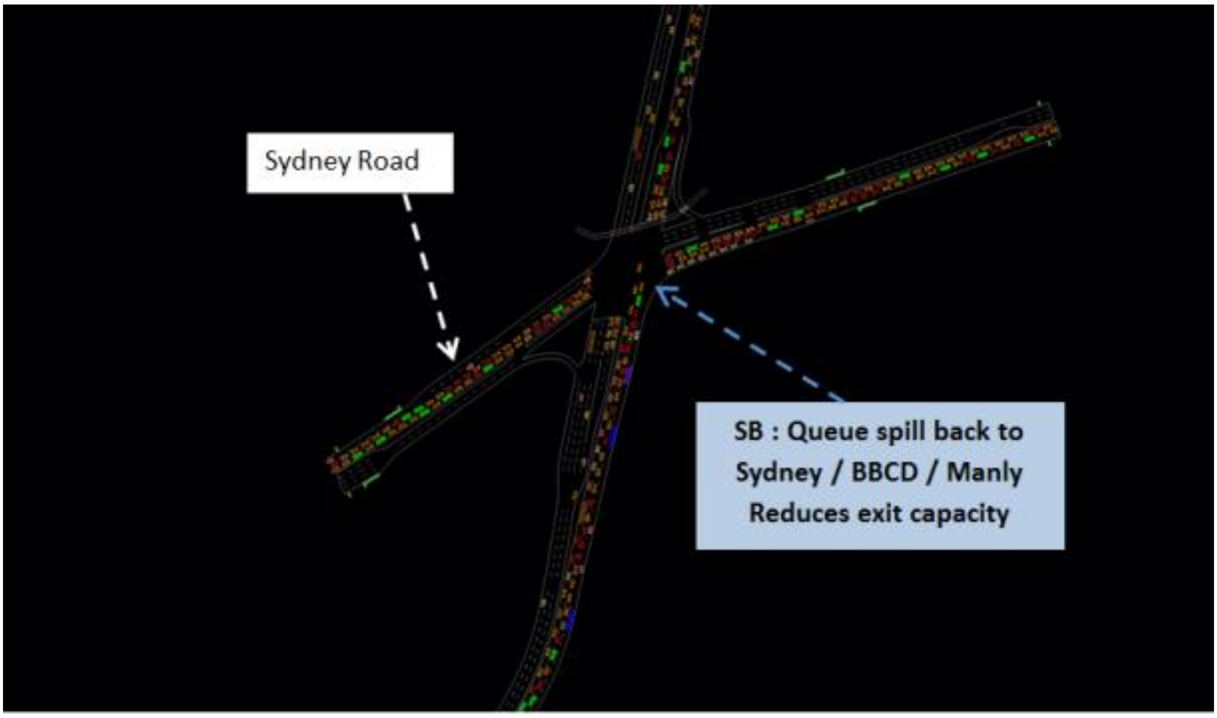
These exit delays are a close representation to actual traffic operation and provided a good basis to test for assumed traffic re-routing resulting from the proposed closure of Heaton Avenue.

The modelled periods are 6.00am to 10.00am and 3.00pm to 7.00pm. The models include road gradients and use fixed time signal control as a proxy to SCATS adaptive control.

5.4.6.1 Existing network operational issues

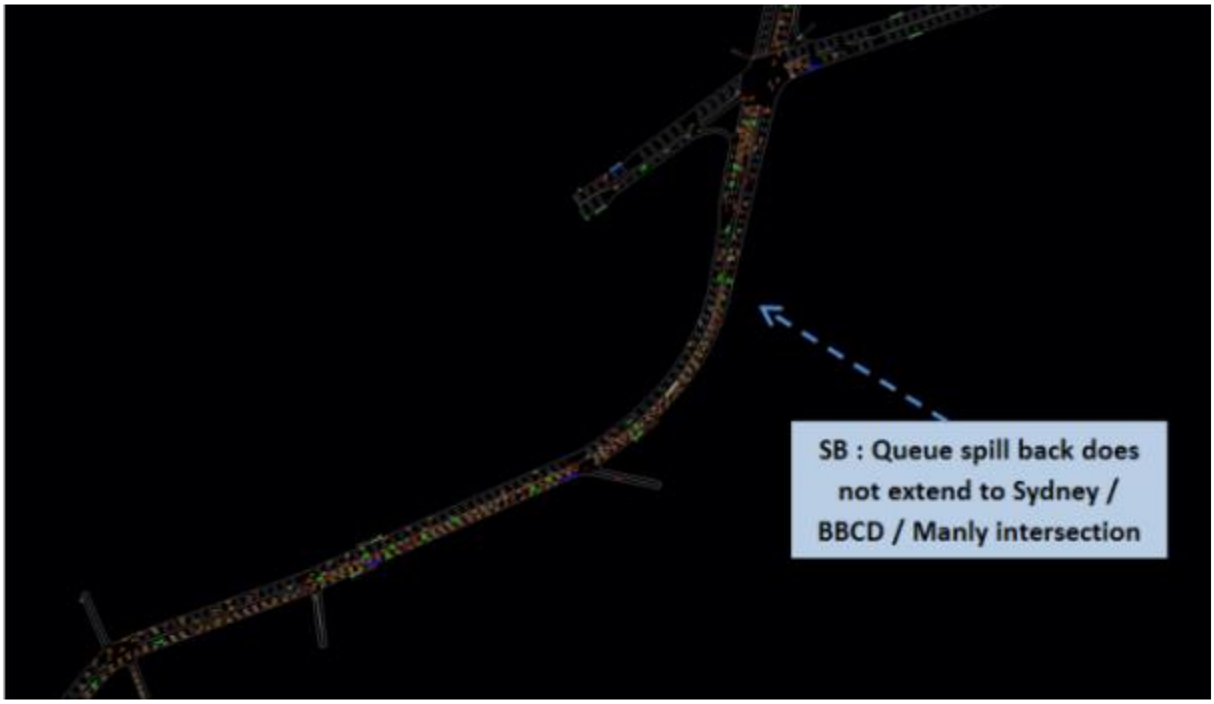
In the AM peak congestion builds for southbound traffic causing queues to spill back from Parriwi Road / Spit Road. These queues eventually reach the Sydney Road / Manly Road intersection and reduce the exit capacity at this intersection (refer to **Figure 40** for typical AM traffic queue pattern). This is in line with the traffic conditions observed on site.

Figure 40 2016 AM Commuter model operation at Sydney Road / Manly Road



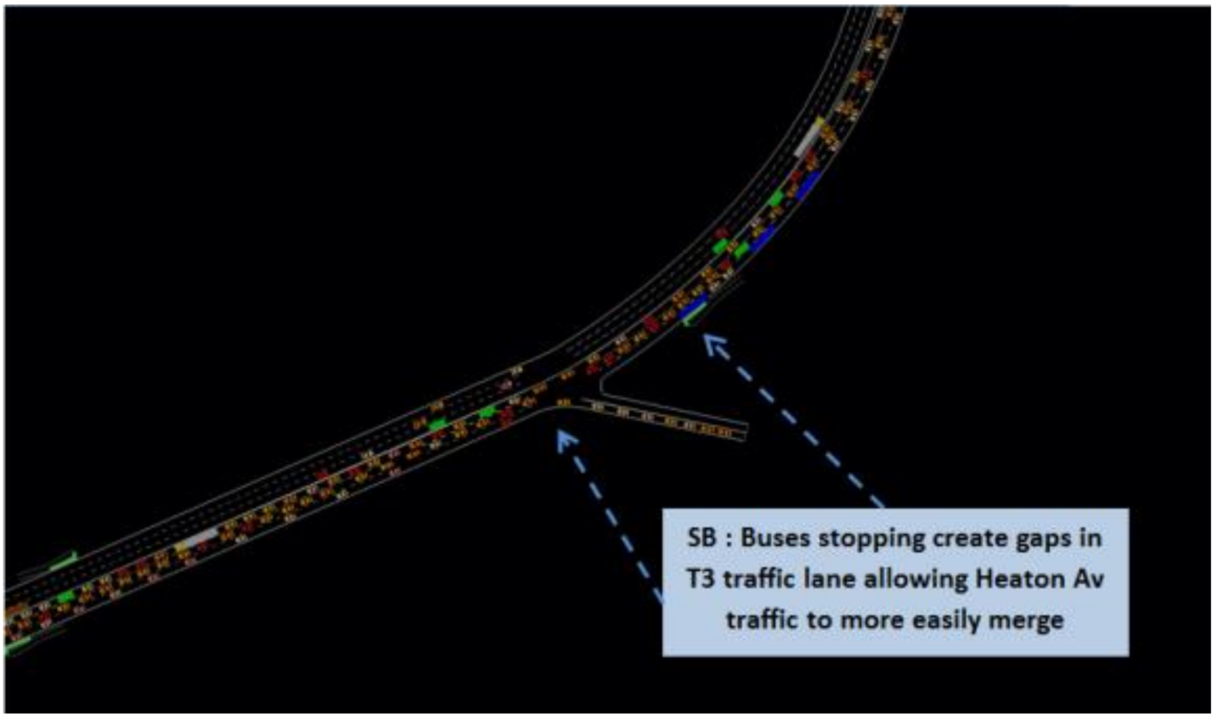
During the PM peak southbound traffic queues form where the tidal flow arrangement on Spit Bridge forces 3 lanes to merge to 1 lane (refer to **Figure 41** for typical southbound PM queuing pattern). Queues for southbound traffic extend to the north, but do not normally reach the Sydney Road / BBCD / Manly Road intersection.

Figure 41 2016 PM Commuter model operation at Sydney Road and Heaton Avenue



Southbound buses stopping at the bus stop on Manly Road between Sydney Road and Heaton Avenue create gaps in traffic in the T3 kerbside lane. These gaps make it easier for traffic from Heaton Avenue to join the T3 lane and then merge into the general traffic in lanes 2 and 3. This behaviour was observed on site and is replicated in the simulation models, as shown in **Figure 42**.

Figure 42 Existing issues at Heaton Avenue



The existing conditions shown in the Commuter model are consistent with observations made during peak hour site visits.

5.4.6.2 Upgrade options assessment

The upgrade options in the Commuter modelling take into consideration the following upgrades of the proposal:

- Provision of an indented bus bay at Heaton Avenue, south of the Manly Road / Sydney Road intersection, facilitated by the closure of access to and from Manly Road.
- Upgrade at Sydney Road / Manly Road intersection to accommodate for the traffic diversion from Heaton Avenue closure.

Other upgrades proposed south of the Manly Road / Heaton Avenue intersection as part of the overarching B-Line proposal have not been included in this phase of the commuter modelling assessment.

The screenshots in **Figure 43** and **Figure 44** show typical queuing patterns for the upgrade scenarios for AM and PM periods. **Figure 45** and **Figure 46** illustrate the typical peak hour performance of the Sydney Road / Manly Road intersection with the proposed upgrades in place.

Figure 43 AM peak corridor queuing in upgrade scenarios

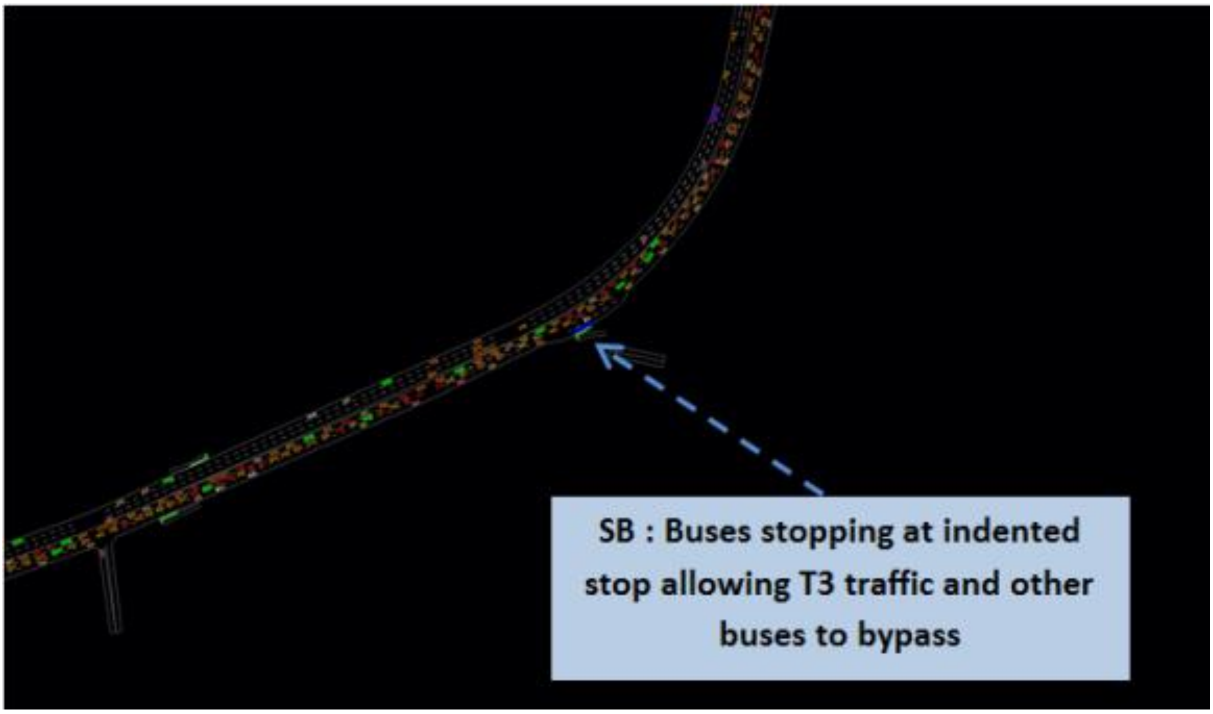


Figure 44 PM peak corridor queuing in upgrade scenarios

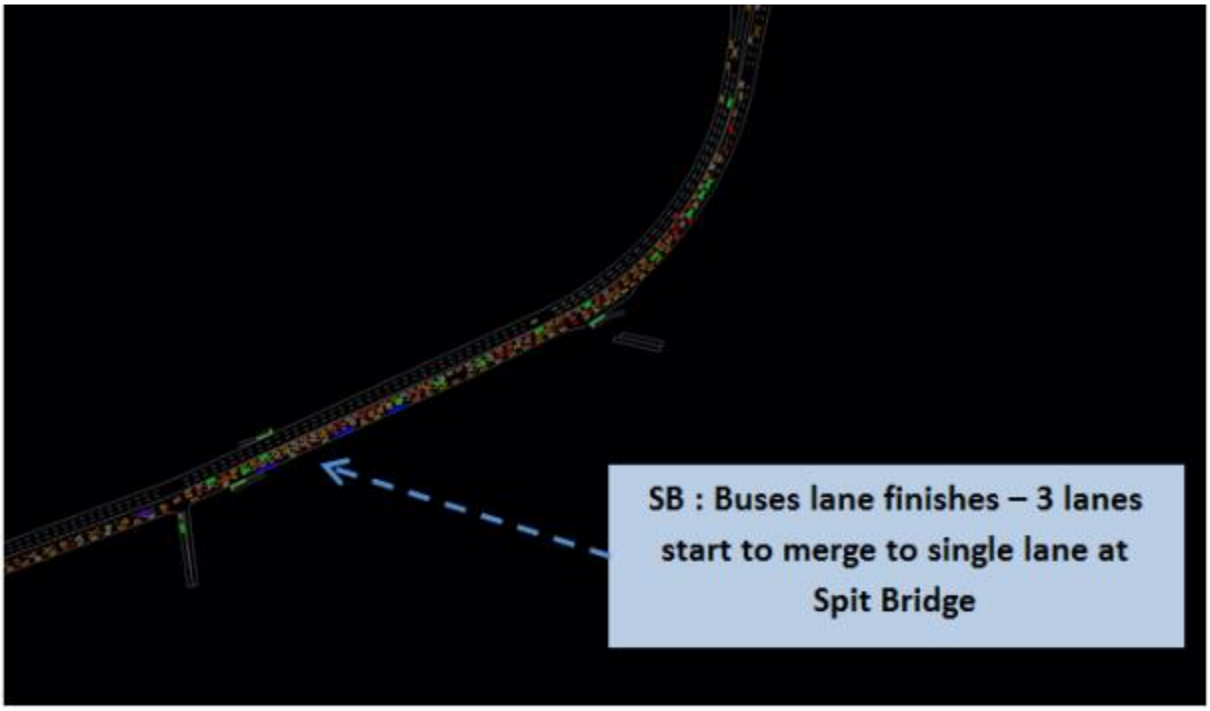


Figure 45 AM peak Sydney Road / Manly Road operation in upgrade scenarios

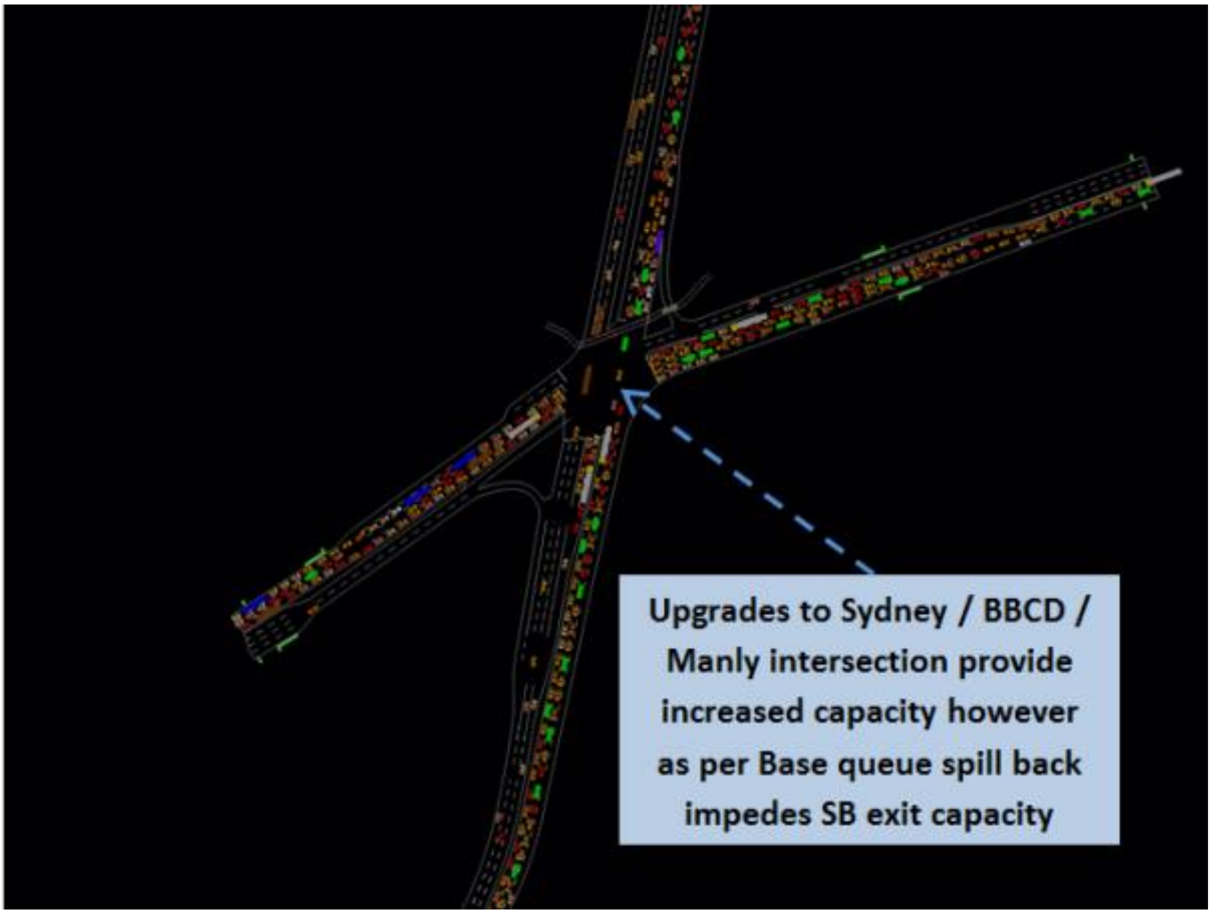


Figure 46 PM peak Sydney Road / Manly Road operation in upgrade scenarios

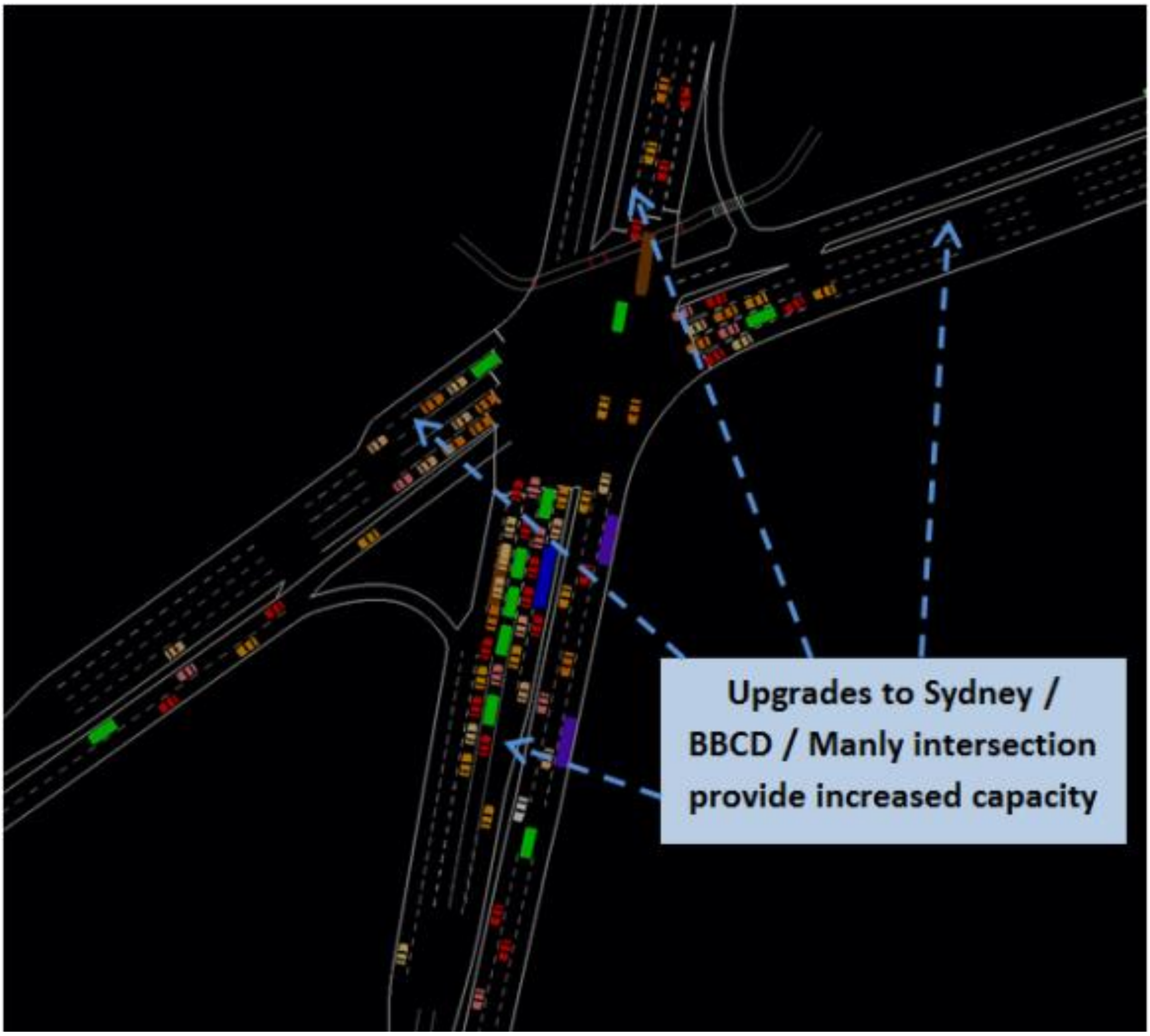


Table 22 summaries travel time outputs from the Commuter modelling for southbound buses between Sydney Road and Parriwi Road for discussion. **Table 23** summaries travel time outputs from the Commuter modelling for southbound general traffic and T3 vehicles between Sydney Road and Parriwi Road for discussion. Other detailed Commuter modelling outputs are also provided in **Appendix F**.

Table 22 Summary of SB Bus travel times

Time period	Modelled Travel Time (Sydney Road to Parriwi Road)		
	Existing Base (mm:ss)	Scenario 1 (mm:ss)	Scenario 2 (mm:ss)
AM peak	4:47	3:23	3:06
PM peak	6:15	6:11	6:35

Table 23 Summary of SB General Traffic and T3 vehicles travel times

Time period	Modelled Travel Time (Sydney Road to Parriwi Road)					
	Existing Base (mm:ss)		Scenario 1 (mm:ss)		Scenario 2 (mm:ss)	
	General Traffic	T3 Vehicles	General Traffic	T3 Vehicles	General Traffic	T3 Vehicles
AM Peak	8:34	4:59	8:24	4:36	8:04	4:34
PM peak	8:38	8:28	8:16	8:03	8:54	8:45

- The travel time for buses is shown to improve in both scenarios in the AM period. This is in part due to the removal of traffic entering from Heaton Avenue. However, the main advantage is resulted from the indented bus bay which allows non-stopping buses to bypass stopping buses.
- The Commuter modelling forecasts poorer levels of services than the SIDRA analysis for the Sydney Road / Manly Road intersection (LOS F compared to LOS C). This is expected as the simulation model accounts for downstream capacity constraints which is a more accurate reflection of forecast traffic conditions. In the AM period, the predominant constraint is identified due to traffic blocking back from the Parriwi Road / Spit Road intersection. For the PM period, the major constraint is for southbound traffic as vehicles merge into a single lane on Spit Bridge as a result of the tidal flow arrangement.
- The Sydney Rd / Manly Rd intersection is already very congested in the base year during the peak periods (LOS F). The design scenarios operate at the same levels of services as the base during both peak periods. This indicates that the re-routed traffic from the Heaton Avenue closure should have a minimal effect on the Sydney Road / Manly Road intersection when the intersection upgrades are in place.
- In Scenario 2 during the AM peak, although very congested, has shown better performance when compared to the existing and Scenario 1. In Scenario 2, the distribution of the re-routed Heaton Avenue traffic (i.e. 50/50 to the Sydney Road east and west approaches) means that the side street traffic is less likely to run into the back of southbound queues on Manly Road. This operation is not shown in the PM period largely because the southbound queue in the PM is less of a constraint than the southbound AM queuing.
- In the proposed designs with the indented bus bay, the southbound T3 traffic benefits from being able to bypass the indented bus bay at Heaton Avenue. Thus in the AM peak, the T3 traffic is observed to travel faster than general traffic.
- The travel times in the PM period are similar between existing and the scenarios. This southbound section of road has three traffic lanes which merge to a single lane at Spit Bridge (tidal flow arrangement). The travel times for general traffic and T3 are similar as these vehicles share the same traffic lane over the bridge. The bus travel times are faster than general / T3 because of the kerbside bus lane on the southern exit from the Sydney Rd / BBCD / Manly Rd intersection. This PM peak bus lane extends to Avona Crescent where the buses are required to merge with general traffic.

5.4.7 Qualitative assessment of local network

An Origin-Destination (O-D) survey was undertaken on 13 September 2016 between 7.30-9.30am to understand the travel pattern of Heaton Avenue traffic at Manly Road. The findings of the O-D survey allow further validation of traffic diversion assumptions adopted in the SIDRA and Commuter modellings. Feasible traffic diversion routes in the local road network can also be instigated given the better understanding on the likely origins of traffic currently exiting Heaton Avenue onto Manly Road.

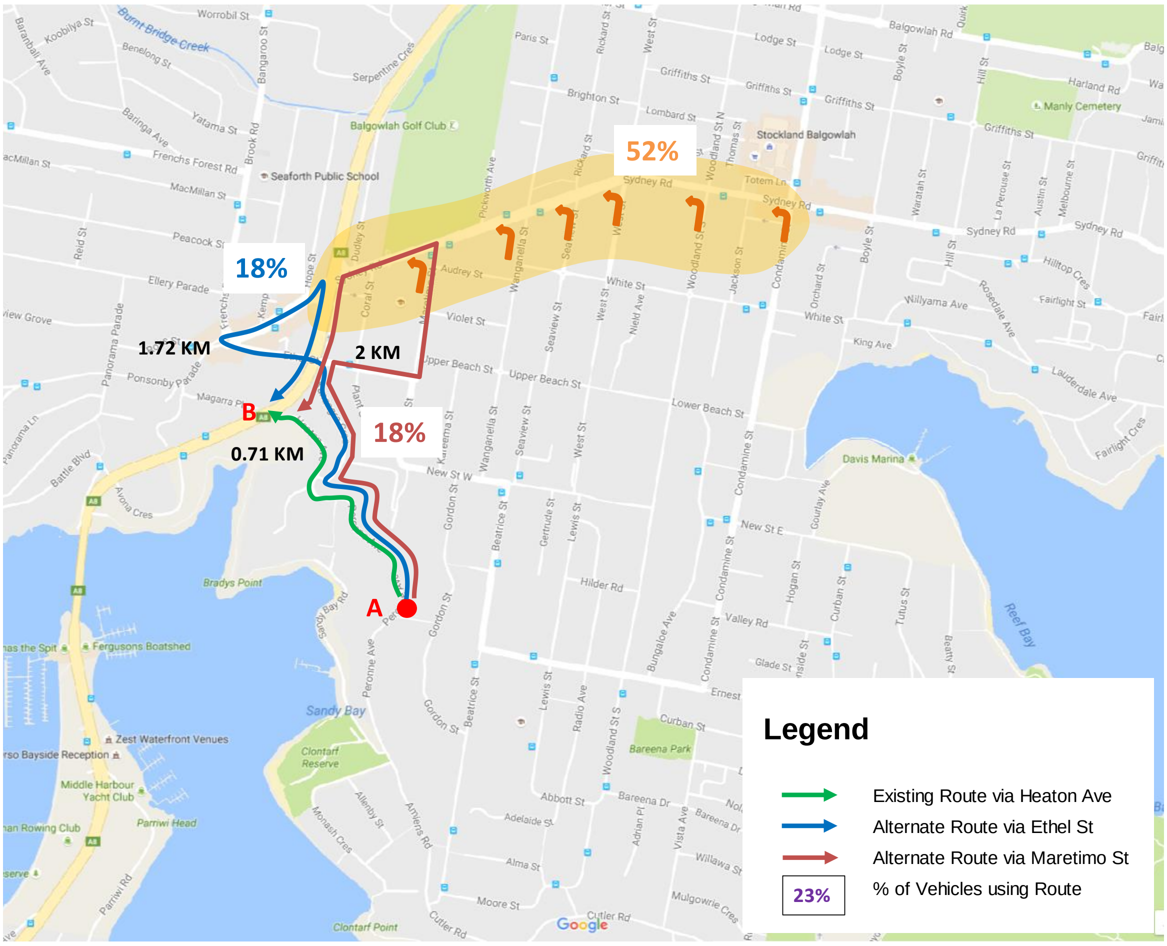
Key findings of the O-D survey is summarised as follows:

- The traffic existing from Heaton Avenue is surveyed to be at most 300 vehicles per hour in the morning peak period between 7:30-8.30am (or up to 550 vehicles between 7.30-9.30am).
- 12% access Heaton Avenue from areas west of Manly Road via Ethel Street eastbound.
- 21% of the Heaton Avenue traffic originates from Sydney Road east of Condamine Street.

- The aforementioned traffic (33%) are considered to be 'rat-runners' bypassing the traffic signal through the local road network and Heaton Avenue. These through traffic are generally not encouraged given the intended purpose of local road network are primarily designed to serve local traffic only.
- 31% of the Heaton Avenue traffic is likely originating from the local catchments east of manly Road (i.e. a combined total of 52% including 'rat-running' traffic from the east).
- The remaining 36% are observed to access Heaton Avenue via Peronne Avenue.

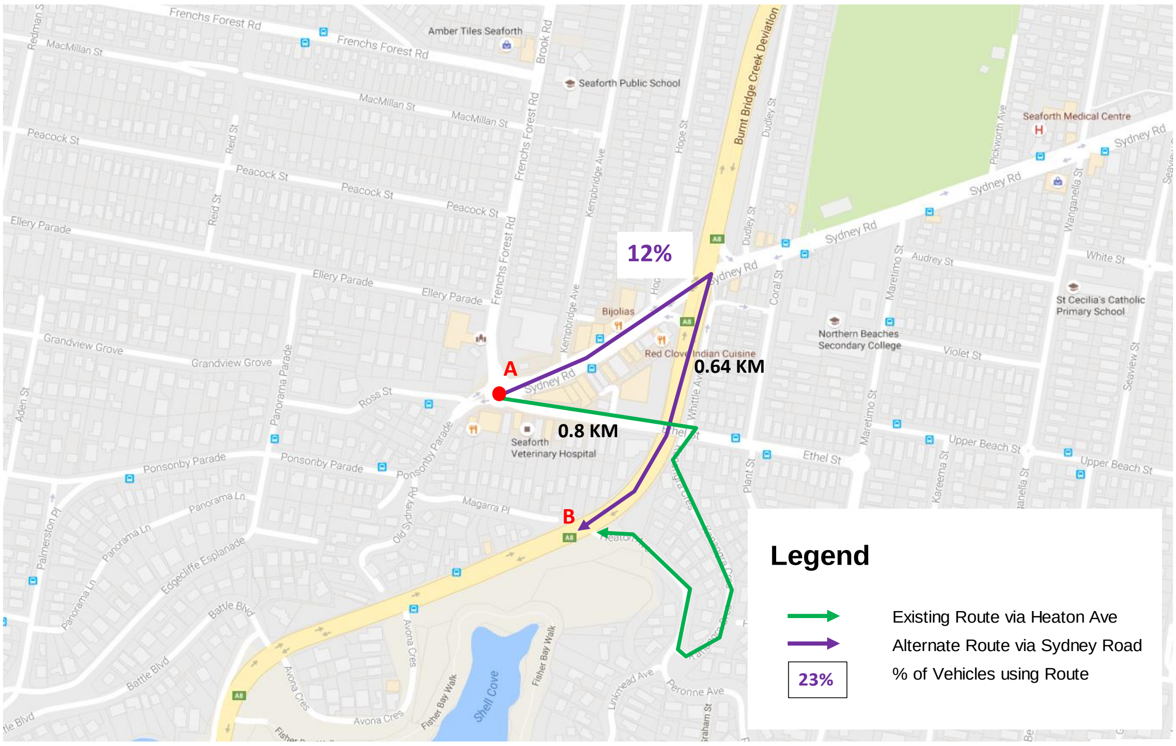
Based on the above, the proposed distribution of Heaton Avenue traffic including the proposed diversion routes is shown in **Figure 47** and **Figure 48,** followed by a high level qualitative assessment:

Figure 47 Diversion of affected Heaton Avenue traffic east of Manly Road



**- Note the remaining 12% of Heaton Avenue traffic originating from the catchment west of Manly Road is shown in Figure 48.*

Figure 48 Diversion of affected Heaton Avenue traffic west of Manly Road



Background source: Google Maps

- 12% of affected Heaton Avenue traffic as shown in **Figure 48** are considered to be 'rat-runners' originating from areas west of Manly Road and will divert via Sydney Road west to access Manly Road southbound.
- A total of 52% of affected Heaton Avenue traffic (21% are 'rat-runners') as shown in **Figure 47** are presented with multiple alternative north-south routes along Sydney Road east between Maretimo Street and Condamine Street, to access Manly Road southbound.
- The remaining 36% (or 100 vehicles per hour) of traffic are considered to be most affected by the proposed closure of Heaton Avenue at Manly Road. These vehicles could travel along Ethel Street to Manly Road via either Sydney Road east or west.

Under the above assumptions, additional traffic volumes re-routing through the moderately congested Sydney Road / Ethel Street roundabout from the eastern catchment are conservatively estimated to be approximately 50 vehicles per hour. Such increase in traffic demands are likely manageable, with careful planning of local area traffic management measures (e.g. local signage to encourage use of Sydney Road east) and support from the Council. Based on the above assessment significant traffic issues associated with the diversion of traffic on local roads are not anticipated at this stage. However, an increase of journey time due to the proposed diversion is expected.

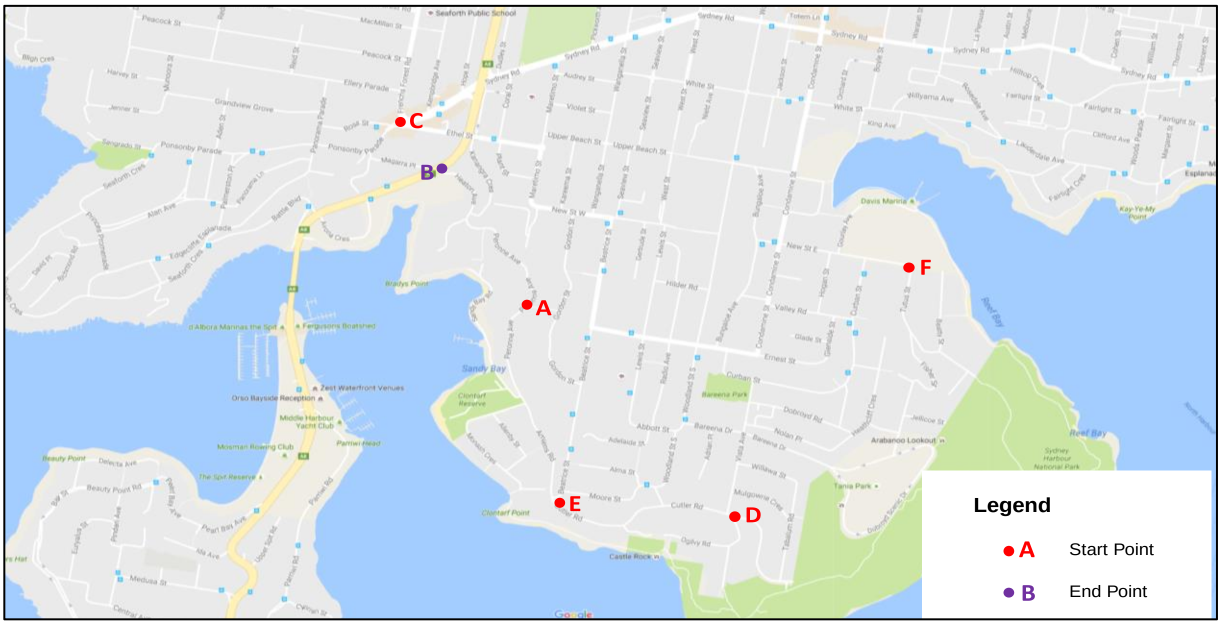
It is also concluded that Scenario 1 adopted in both the SIDRA and Commuter microsimulation modellings provides a conservative and adequate estimation of the potential traffic impact in line with the O-D survey (i.e. the vast majority of displaced Heaton Avenue traffic originates east of Manly Road).

Travel Time Analysis

To further understand the impacts of the proposed Heaton Avenue closure, travel time data was collected for the existing route (via the Heaton Avenue access) and other potential diversion routes. Travel time data was sourced from Google maps data and on-site floating car survey conducted on Wednesday 19th October, Friday 21st October and Tuesday 25th October 2016 in the AM peak.

Figure 49 shows the origin locations and the destination point (i.e. Point B) considered for travel time analysis. The origins are selected at various locations, mostly across the south eastern catchment at Balgowlah and Clontarf, whilst the common destination point is chosen at the Manly Road / Heaton Avenue intersection. Additional details of the travel time routes are also provided in **Appendix G**.

Figure 49 Origin and Destination Points for travel time analysis (AM Peak)



Background source: Google Maps

Table 24 compares the travel times on the existing and alternate routes, and summarises the number of vehicles that are expected to be diverted to the alternate routes. The maximum travel time recorded from either the site visits or Google maps has been reported to provide a conservative assessment.

Table 24 Summary of AM Peak travel time estimates for existing and alternate routes

Starting Point		Existing Route via Heaton Ave (mm:ss)	Alternate Route (mm:ss)	Difference (mm:ss)	Estimates of Traffic (vph)
A	Alternate R1	6:05	13:30	+7:25	54
	Alternate R2		9:36	+3:31	54
C		5:12	6:11	+0:59	36
D		8:00	19:14	+11:14	23
E		6:41	12:45	+6:04	23
F		6:00	15:40	+9:40	47

**- Note that approximately 65 vph of westbound 'rat-running' traffic from Sydney Road east is not included in the above table. It is however estimated that any increase in travel time for these 'rat-running' traffic will likely fall within the above range of travel time differences.*

Key findings of the travel time analysis are as follows:

- The alternate route via Vista Avenue and Condamine Street (R4 from Point D to Point B) would experience the greatest increase in travel time compared to the existing route via the Heaton Avenue access. The travel time for this route is estimated to be approximately 19 minutes compared to eight minutes on the existing route. This represents an increase in travel time of more than 10 minutes. Approximately 25 vehicles per hour are expected to be diverted to this route as a result of the Heaton Avenue closure.
- The alternate route via Peronne Avenue and Kanangra Crescent (R2 from Point A to Point B) to Sydney Road west would experience the lowest increase in travel time amongst the traffic originating from the eastern catchments. The travel time for this route is estimated to be approximately nine minutes compared to six minutes on the existing route. This represents an increase in travel time of approximately three minutes. Approximately 55 vehicles per hour are expected to use this route.
- The alternate route for traffic coming from the western side of the Sydney Road / Manly Road intersection (from Point C to Point B) would experience a marginal increase in travel time by about one minute. Approximately 35 vehicles per hour are expected to use this route.

5.4.8 Summary of Sydney Road and Heaton Avenue assessment

Summary of key findings for the Heaton Avenue Assessment is highlighted as follows:

- Bus travel times in the AM peak are forecast to reduce by approximately one and a half minutes (29% as per Commuter modelling Scenario 1) in the southbound direction for the section between Sydney Road and Parriwi Road, which is a significant improvement. This is primarily resulted from the closure of Heaton Avenue that enables the provision of an indented bus bay for southbound buses. In addition, the closure also eliminates the conflicting Heaton Avenue traffic movement from merging with mainline traffic, which currently impedes the operational efficiency of the kerbside traffic lane.
- In the PM peak hour, bus travel times are fairly consistent between the base and option scenarios, primarily due to the downstream constraint at the Spit Bridge allowing only one southbound traffic lane in this time period.
- Overall, the traffic assessment based on both the SIDRA and Commuter microsimulation modellings indicate that the proposed B-Line upgrades at the Sydney Road intersection would satisfactorily mitigate the traffic impacts arising from the proposed closure of Heaton Avenue under both the existing and future forecast conditions.
- The proposed diversion of Heaton Avenue traffic is not anticipated to cause significant traffic congestion in the local road network provided careful planning of traffic management measures are in place. However, an increase of journey time broadly between 5 to 10 minutes is estimated for the affected local traffic originating from the Clontarf and Balgowlah areas.
- There are also potential benefits in reducing crash rates by eliminating the conflicting movement of traffic exiting Heaton Avenue from mainline buses or other road users including cyclists.

Details of intersection LOS and travel time outputs from the Commuter modelling are provided in **Appendix F**.

6.0 Future transport provision

This section of the report provides a qualitative assessment on potential impacts of the proposal with respect to active and public transport amenities, parking provision and construction traffic conditions.

6.1 Walking and cycling

As part of the business case for the B-Line program[1] a significant amount of analysis and option planning was undertaken to identify ways in which the access to the B-Line service could be improved for pedestrians and cyclists. The geographic scope for improvement was defined for areas within an 800 metres walking and 2.5 kilometre cycling catchment; with a focus on the key urban centres of Brookvale, Dee Why, Neutral Bay and Spit Junction. A summary of the proposed upgrades for active transport (as outlined in the business case) is provided in **Figure 50**.

Figure 50 Proposed upgrades for active transport as part of the B-Line program

Scope element	Description
Pedestrian	
Upgrade or installation of new kerbside ramp	Inclined section of an access way, generally at road crossing to assist safe and accessible crossing. It has a gradient ramp and flare on both sides to transition the footpath/ sidewalk level. It may also include tactile indicators.
Kerb extension	Used for traffic calming measure, primarily to extend the sidewalk, reducing the crossing distance and allowing pedestrians and allowing pedestrians and drivers to see each other.
Personal security	Defined as areas with lack of passive or active surveillance and adequate lighting. It also considers graffiti, presence of rubbish that creates perceptions of a lack of security in a public area. The recommendations include removal of graffiti, provision of additional bins, CCTV and signage, additional lighting facilities and/or improvements to lighting quality.
Pedestrian refuse	Defined as a small area of a pavement / sidewalk completely surrounded by asphalt or other road materials where pedestrians can stop before crossing a road. Locations have been identified where the kerb width was too narrow or length was too short
Zebra crossing	Defined as a crossing location on a road that gives priority to pedestrians or cyclists to cross the road. The recommendations for improvement include measures such as providing new line marking, new or upgraded zebra crossings, kerb extensions or installation/removal of signage.
Signalised pedestrian crossing	Defined as providing signalised crossings for pedestrian with green light signal priority to cross the street at both intersections and mid-blocks. Recommendations include providing audio indicators, installing / moving signage, investigating provision of pedestrian crossing facilities on missing legs and widening the crossing line marking to 3.3m (where applicable).
Addressing path obstruction or bike / ped conflict	The obstructions can be street furniture, vegetation, bins and others. The bike / ped conflicts are pinch points where shared path facility is not wide enough for both to move and overtake.
Addressing difficulties in crossing roads	These are defined as dangerous crossing points for pedestrians because they lack facilities and impede their ability to cross safely. This includes driveway and other pedestrian and vehicle conflict locations. Recommendations include warning equipment and mirrors.
Cycling	
Addressing difficulties in crossing roads	Defined as existing infrastructures where defects, in terms of cyclist safety and lack of amenity, have been identified. These defects include lack of clear signage, conflict potential, missing bike lane, road / street approach angle, pedestrian refuge not compliant and lack of separation from vehicles at intersections. The recommendations to rectify these defects include signage, bike lanterns at intersections, wider staging points and vehicle warning signage, separate facility at

[1] Details provided in the February 2016 TfNSW report '*Northern Beaches B-Line Program Final Business Case*'.

	intersection and new pedestrian refuges.
Improving merge and/ or termination points	Defined as merging facilities for cyclists where a shared path ends and bicycle riders are required to move onto the road to continue their journey. The specific defects identified include lack of warning signs, lack of clear path connections, lack of bicycle priority for merging and lack of guiding road markings. The recommendations include new signage / markings.
Addressing conflict and obstructions	Defined as areas where there are pinch points along the bicycle routes that impact rider safety and convenience. These potential hazards include lack of sight distance to / from driveway, parked car conflict, on road bicycle lane in car door zones, pedestrian and bicycle conflict points and lack of signage. The recommendations to rectify these defects include convex mirrors, buffers between parked car and bike lanes, removal or reconfiguration of parking and new bike lanes.
Improving cyclist comfort	Improving cyclist rider comfort is defined as providing a better environment for cyclists. This includes better separating car and bike movements and implementing parking facilities for riders.
New or upgraded kerb ramps	Inclined section of an access way, generally at road crossings, to assist with safe and accessible crossings. It has a gradient ramp and flare on both sides to transition to the footpath/ sidewalk level. It may also include tactile indicators. Identified location includes kerb ramps that need to be upgraded or where ramps are required.

Source: TfNSW 2016

The measures outlined in **Figure 50** will address the objectives of the B-Line program by improving access to B-Line stops with associated commuter car parks; and by improving active transport connections at selected stops not associated with commuter car parks. It is anticipated that the proposals for active transport will achieve the following key benefits:

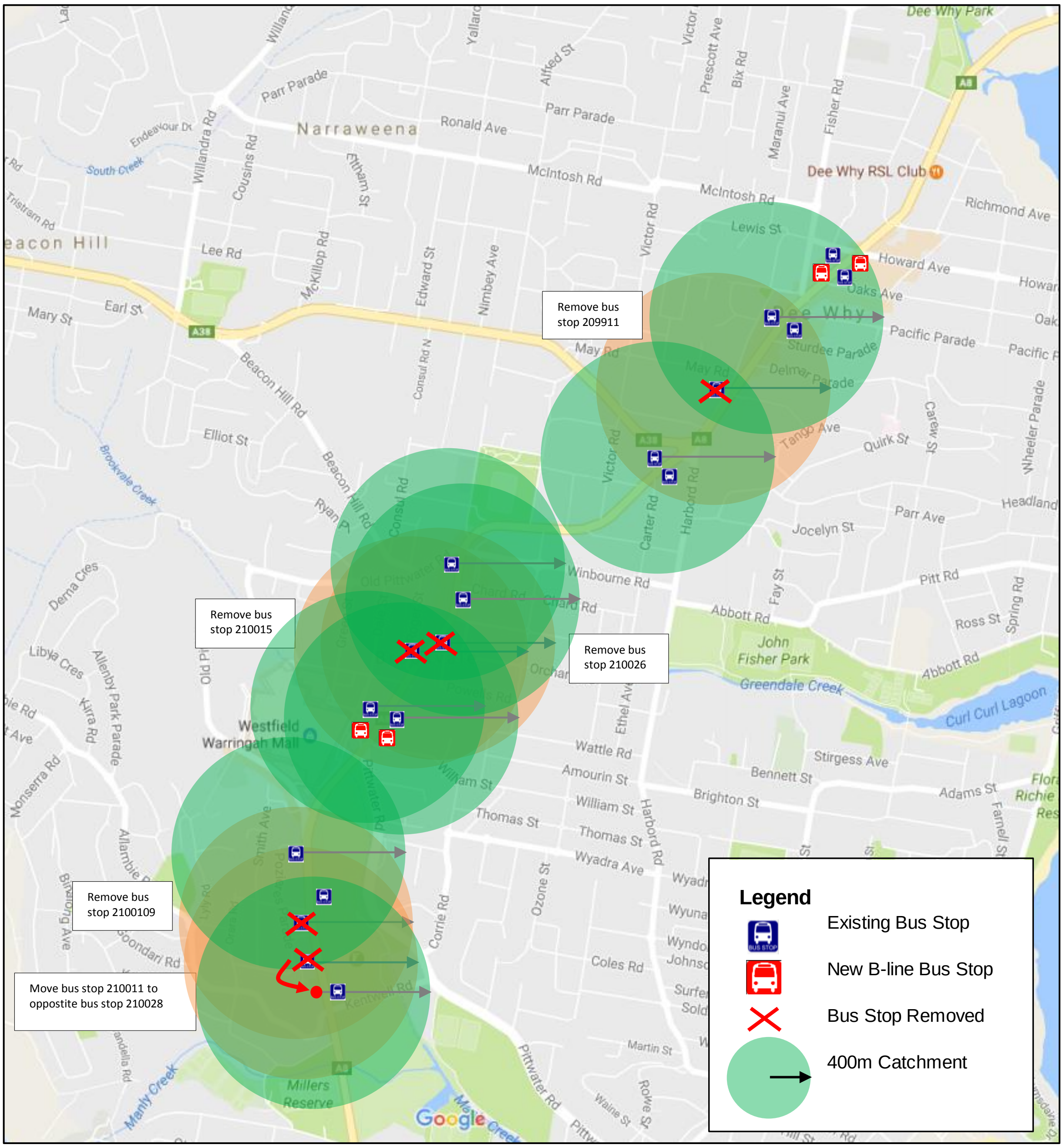
- B-Line bus stops will have improved walking and cycling connections.
- More passengers will use commuter parking, active transport links and local bus services to access the B-Line.
- All B-Line interchanges will be located at or near key customer activity centres and major road intersections to maximise access and network utility.

6.2 Public transport

The B-Line program proposes the removal and consolidation of up to five existing bus stops within the study extent of the P8 and P9 work packages (refer to **Table 2** for details). It is anticipated that a separate body of work in conjunction with work package C3 will provide further details once the proposed future bus network is finalised. Notwithstanding the above, **Figure 51** shows the locations of the proposed removal and remaining existing bus stops within a 400 metre walking catchment to provide an understanding on the adequacy of the bus stop provision. The figure also shows the proposed locations of new B-Line stops.

A review of the walking catchment indicates that there are existing bus stops within the vicinity of the proposed bus stop removals to provide an adequate coverage within the desirable walking distance of 400 metres. In addition, the likely benefits of the new B-Line stops with 'turn-up-and-go' services and the associated off-road improvements are anticipated to outweigh the inconvenience of the existing bus stop removals.

Figure 51 Bus stop catchment of B-Line proposal



6.3 Parking provision

The B-Line proposal of the implementation of clearway restrictions are currently included as part of the C2 work package of the B-Line program. A separate body of works, including the *Northern Beaches B-Line Offset Parking Assessment* commissioned by Transport for NSW, is anticipated to provide a detailed assessment of the associated impacts. As such, detailed analysis is not considered to be part of the scope of this traffic and transport assessment. Nevertheless, a brief overview of the key findings of the forgoing study is discussed in the following sections to provide a holistic understanding of the proposal.

Dee Why

At a strategic level, the B-Line program proposes clearways from 6am-8pm, Monday to Sunday for majority of the P8 corridor between South Creek Road to the north, and Warringah Road to the south. With the exception of a length of weekday clearway (6-10am and 3-8pm) on both sides of Pittwater Road, near May Road to the north of the Warringah Road intersection (refer to **Figure 4** for details).

The detailed analysis of the *Northern Beaches B-Line Offset Parking Assessment* assessed the availability of parking spaces at nearby side streets within reasonable walking distances as offsets for the loss of parking due to the proposal. It has been inferred from the study that the majority of the sections within the P8 corridor will have sufficient vacancies where impacts of the proposal are not considered to be significant, with the exception of the following:

- Eastern side of Pittwater Road from Fisher Road to the Botanic Garden south of Delmar Parade.
- Western side of Pittwater Road from Kingsway to Hawkesbury Avenue.

A part of the recommendations, the study suggests signage changes to convert some unrestricted parking spaces on side streets, such as Kingsway Avenue and Westminster Avenue, to short term parking. Additional off-street parking is also recommended to offset the losses on the eastern side of Pittwater Road.

Brookvale

Similar to the above, the B-Line program proposes a combination of clearway policies for the P9 corridor (refer to **Figure 4** for details). A maximum of 104 (19 inbound and 85 outbound) parking spaces are likely to be impacted by the 6am-8pm, Monday to Sunday clearway proposal; and 73 outbound parking spaces to be impacted by the 3-8pm (extension of one hour from the existing clearway), Monday to Friday clearway proposal.

The study suggests that the overall parking impacts associated with the loss of parking are significantly reduced due to the 'peak hour' only proposal in high demand areas such as the Brookvale and Manly Vale commercial centres.

It is also important to note that offset parking facilities along the corridor at critical locations are being investigated and will be assessed in the relevant work package and subject to community consultation to arrive at an optimum solution as part of the B-Line program. Therefore, it is anticipated that the effects of the proposal on parking will be managed to an acceptable level of impacts.

6.4 Construction traffic impacts

6.4.1 Overview

A construction traffic impact assessment has been undertaken to obtain an understanding of the likely impacts from construction scheduling and sequencing. The construction period of the proposed B-Line road infrastructure works for P8 and P9 work packages is expected to be completed by October 2017.

6.4.2 Proposed working hours

The construction workforce would vary depending on the phase of construction and associated activities and includes both construction and design personnel. An on-site workforce of around 10 to 20 people is expected to be engaged at any given time during the construction period, with a maximum of 50 workers per day during peak construction periods.

Night works are proposed for majority of the construction to minimise disruption to traffic. Night work and normal working hours are assumed to be as follows:

- Night works Monday to Friday: between 10pm-7am.
- Monday to Friday: between 7am-6pm.
- Saturday: between 8am-1pm.
- Sunday and public holidays: no work.

It is considered necessary to undertake night works to minimise disruption to traffic. Further appraisals would be undertaken once the detailed design stage is undertaken and the requirements are known. All night work would be undertaken in accordance with the *Office of Environment and Heritage (formerly DECCW) Interim Construction Noise Guideline (DECC 2009)* and the *Roads and Maritime Services Environmental Noise Management Manual (RTA 2001): Practice Note vii – Road works outside normal working hours*.

Prior notice would be given to the community for any night works planned to be undertaken outside normal construction hours.

6.4.3 Construction vehicles

Heavy vehicles generation

Heavy vehicle traffic would mainly be generated by activities associated with the following:

- Delivery of construction materials.
- Spoil removal.
- Delivery and removal of construction equipment and machinery.
- Movement of construction personnel, including contractors, site labour force and specialist supervisory personnel.

Approximately 5 heavy vehicles would be required on-site per day, resulting in approximately 20 heavy vehicles movements in and out of the site per day. These heavy vehicle movements are likely to be spread through the night work time period. However for a worst case assessment of the traffic impacts, it has been assumed that 10 per cent, or 2 vehicle movements would occur during the peak hour.

Construction vehicles would access the site via arterial roads wherever possible. However, given that these roads already carry high volumes of traffic it is not anticipated that the project would have a high degree of impact above what is currently experienced, as this additional construction traffic would be well within the range of daily variation in traffic on these routes.

As a part of the construction management plan it is expected that heavy vehicle traffic would be constrained, as much as possible, to the regional road network and that the impact on local roads would be minimised. Any disruption to access side streets and properties would be minimised and would only be undertaken following consultation with the community and with individual property owners affected by the works.

The movement of materials would be managed through the scheduling of deliveries and availability of fleet, and would aim to minimise the number of haulage and delivery vehicles required during peak periods and weekends.

Light vehicles generation

Light vehicle traffic generation would be associated with staff movements to the site. Staff would comprise of project managers, various trades, and general construction staff. Light vehicles used to transport staff to and from the site would be parked at the main site compound facility or nearby local streets.

Over the construction period, the peak construction workforce is estimated to be around 20 people. Similarly, the worst case scenario in terms of vehicle movement impact during the morning or evening road network peaks is assessed to provide a conservative assessment. It is assumed that the majority of the workforce would arrive between 6.30-7.00am and depart generally between 5.00-5.30pm. The workforce arrival and departure periods represent the worst case scenario with peak construction traffic generation occurring within the existing road network peak periods.

Allowing for some vehicle sharing, it is expected that up to 18 daily two-way trips (assuming 1.1 people per vehicle) would be generated by light vehicles during the peak period. Taking a conservative approach, it is expected that up to 18 vehicle movements would be generated during each of the morning and afternoon construction peak arrival and departure periods. During the construction traffic peak periods, the workforce traffic movements are likely to be distributed based on a 100/0 arrival and departure split in the morning peak period, and the reverse during the afternoon peak period.

Based on the above traffic generation assumptions, construction traffic is likely to result in increases of up to 18 vehicles per hour in the morning and evening peak periods under the worst case scenario, which is still well within the daily variation traffic on the road network within the study area.

It is also important to note that majority of the construction is proposed to be night works, where the impacts will be even less significant given the ample amount of road capacity during the night working hours between 10pm-7am.

6.4.4 Cumulative construction impacts

Cumulative impacts for the construction of other planned infrastructure in the area may also result in traffic impacts to the B-Line corridor. Construction of these infrastructure may also occur at the same time as the construction of the proposed Pittwater Road upgrade. These potentially include the following developments:

- B-Line infrastructure road program south of Spit Bridge (P12 work package)
- Bus stop removal and construction of B-Line shelter and stops (C3 work package)
- Pittwater Road / Condamine Street / William Street pedestrian footbridge (Health Infrastructure).
- Northern Beaches Hospital Road Upgrade.

The majority of the above work packages involve off-road developments, with the exception of the P12 work package and the Northern Beaches Hospital Road Upgrade. These proposed works are spread across the entire Northern Beaches area with separate assessments being developed. Notwithstanding the above, it is recommended to adopt a coordinated and collaborative approach for all B-line packages and the nearby Northern Beaches Hospital Upgrade works within an integrated construction control group to assess and manage the overall impacts through the implementation of a detailed construction traffic management plan.

6.4.5 Construction mitigation measures

The following proposed traffic management principles would be adopted during the construction period:

- Traffic control would need to be provided to manage and regulate traffic movements during construction.
- Disruption to all road users during the construction period would be kept to a minimum.
- In most cases property access would be maintained throughout the construction period with suitable alternative access arrangements provided otherwise.
- Construction and delivery vehicles entering or leaving the site compound and/or stockpile sites would use arterial roads. These movements would be restricted to non-peak traffic periods.
- Development of a detailed construction traffic management plan is recommended as part of the detailed design stage.

6.4.6 Summary of construction traffic generation

The majority of the construction works are proposed to be undertaken as night works. Nevertheless, construction traffic impacts are developed in the forgoing sections for normal work hours as a worst case assessment.

Under the worst case scenario, up to 20 truck movements per day is estimated during the earth moving phase. The majority of these truck movements would take place outside the road network peak periods, with approximately 2 trucks per hour occurring in the peak hours as a conservative assumption.

Worker traffic is assumed to generate 18 inbound and outbound light vehicle trips during each peak period. The majority of these trips are assumed to occur at the start (6.30-7.00am) or end of the day (5.00-5.30pm). The overall construction generation of traffic is considered to be well within the daily variation of road network demands. In addition, given the majority of construction is proposed to be night works, the actual impacts will be even less significant given the ample amount of road capacity available during the night working hours between 10pm-7am.

Based on this assessment, it is concluded that construction of the Proposal in not likely to have a significant impact on the road network in the study area.

7.0 Summary and conclusion

7.1 Overview

The purpose of this study is to assess the traffic and transport impacts on the operation and construction of the Northern Beaches B-Line On-Road Infrastructure Program for the Dee Why (P8) and Brookvale (P9) areas of the B-Line corridor. It is acknowledged that the need for the proposal along the corridor is focused around providing improvements to the existing and proposed B-Line bus services in terms of efficiency and reliability.

7.2 Key findings

The key findings based on evidenced-based analysis, traffic modelling and qualitative assessments are summarised as follows for the B-line proposal:

- Intersection performance measures (LOS) with the proposal indicate that majority of the key intersections along the Pittwater Road corridor are not expected to deteriorate, when compared with the Do-nothing 2021 scenario in all modelled peak periods. Most intersections are expected to operate at LoS D or better, except the Pittwater Road / Warringah Road / Harbord and Pittwater Road / Winbourne Road / Old Pittwater Road intersections. These two intersections are currently operating at close to capacity during the existing PM and Saturday peaks.
- The Pittwater Road / Winbourne Road / Old Pittwater intersection in 2021 PM peak with the proposed B-Line upgrades implemented is the only intersection with worsening performance when compared to the 2021 Do-nothing scenario (from LOS E to LOS F). A review of the corridor volumes indicates that in the Option scenario, there is an increase in northbound throughput (peak direction) at the Cross Street intersection of around 100 vehicles per hour (likely due to the implementation of the dedicated left turn pocket). The additional throughput increases delay along the already congested section of the corridor between Cross Street and Winbourne Road, which is sensitive to additional demands, leading to the deterioration in LOS at the Winbourne Road intersection.
- In the Brookvale and Dee Why areas, travel time savings for buses are most pronounced in the southbound direction in the AM peak period, and for both directions during the Saturday peak. For local and B-Line buses, between one and three minutes of travel time savings are expected respectively for the weekday morning and Saturday peaks. B-Line buses are generally operating with lower journey time when compared with local buses ranging from 30 seconds to one minute in those two peak periods.
- There are no significant travel time savings observed for buses in the northbound peak direction in the PM peak. This is generally as expected given that there is no targeted bus improvement measures on the western side of the carriageway instigated in the PM peak.
- Global network statistics also indicates that the average network speed for a minimum could be maintained for all three peak study periods in 2021 with the B-Line proposal. This suggests that the B-Line proposal not only provides travel time benefits to buses, but also maintaining a similar level of overall network performance. In other words, the proposal’s focus on bus related improvement measures is not anticipated to have any adverse impact to other traffic and road users.
- The above travel time and network performance improvements are partly due to the increased capacity resulting from the proposed clearways. This is further enhanced by targeted bus improvement measures such as the provision of indented bus bay south of Hawkesbury Avenue, and the local widening of the southbound carriageway at approach near Howard and Oaks Avenues.
- The proposed closure of Heaton Avenue and implementation of the southbound indented bay are shown to provide bus travel time savings in the AM peak by approximately one and a half minutes in the southbound direction for the section between Sydney Road and Parriwi Road.
- The displaced Heaton Avenue traffic is not anticipated to cause significant traffic congestion in the local road network provided careful planning of traffic management measures are in place. However, an increase of journey time broadly between 5 to 10 minutes is estimated for the affected local traffic originating from the Clontarf and Balgowlah areas.

- The SIDRA and Commuter microsimulation modellings for Heaton Avenue also suggest that the proposed intersection upgrades at the Sydney Road / Burnt Bridge Creek Deviation / Manly Road intersection could mitigate the impacts of the diverted traffic in both the AM and PM peak periods.

Appendix A

Intersection Levels of Service (Vissim)

Appendix A

2016 Base Year Intersection Levels of Service

2016 – AM Peak Period		07:00 to 08:00			08:00 to 09:00		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1796	18.2	B	2191	20.6	B
	East - Hawkesbury Avenue	141	50.2	D	137	198.3	F
	South - Pittwater Road	932	9.3	A	1061	6.1	A
	West - Hawkesbury Avenue	106	42.6	D	222	104.2	F
	Intersection	**2975**	**17.8**	**B**	**3611**	**28.2**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1524	25.9	B	1749	21.8	B
	East - Dee-Why Parade	304	49.1	D	369	59.3	E
	South - Pittwater Road	744	12.1	A	836	2.0	A
	Intersection	**2572**	**24.7**	**B**	**2954**	**20.9**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1390	14.1	B	1607	21.4	B
	East - Howard Avenue	220	43.2	D	234	50.9	D
	South - Pittwater Road	733	9.1	A	821	29.7	C
	West - St David Avenue	161	43.6	D	229	51.6	D
	Intersection	**2504**	**17.1**	**B**	**2891**	**28.5**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1386	13.6	A	1627	23.4	B
	East - Oakes Avenue	105	60.8	E	96	109.6	F
	South - Pittwater Road	867	3.0	A	948	4.9	A
	Intersection	**2358**	**11.8**	**A**	**2671**	**19.9**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1415	9.9	A	1661	22.4	B
	South - Pittwater Road	1107	8.8	A	1326	8.6	A
	West - Fisher Road	477	51.8	D	435	139.3	F
	Intersection	**2999**	**16.2**	**B**	**3422**	**31.9**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1842	4.6	A	2052	9.8	A
	East - Pacific Parade	244	111.9	F	317	83.7	F
	South - Pittwater Road	1043	20.8	B	1202	37.6	C
	Intersection	**3129**	**18.4**	**B**	**3571**	**25.7**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1925	9.4	A	2110	10.8	A
	East - Sturdee Parade	308	57.3	E	314	79.7	F
	South - Pittwater Road	1030	4.4	A	1223	9.8	A
	Intersection	**3263**	**12.3**	**A**	**3647**	**16.4**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2124	0.5	A	2282	1.4	A
	East - Delmar Parade	12	18.5	B	12	26.1	B
	South - Pittwater Road	1059	4.0	A	1283	3.9	A
	Intersection	**3195**	**26.5**	**B**	**3577**	**33.9**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2048	44.6	D	2306	44.7	D
	East - Harbord Road	634	55.7	D	656	77.7	F
	South - Pittwater Road	1047	30.8	C	1300	29.2	C
	West - Warringah Road	797	51.5	D	942	65.1	E
	Intersection	**4526**	**44.2**	**D**	**5204**	**48.7**	**D**
Pittwater Road / Victor Road	North - Victor Road	6	3.4	A	16	3.4	A
	East - Pittwater Road	1672	11.0	A	1880	11.6	A
	West - Pittwater Road	1118	2.3	A	1340	2.3	A
	Intersection	**2796**	**16.9**	**B**	**3236**	**13.1**	**A**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	147	52.1	D	168	53.7	D
	East - Pittwater Road	1612	23.0	B	1764	24.4	B
	South - Mitchell Road	150	47.2	D	266	51.4	D
	West - Pittwater Road	1009	4.9	A	1123	5.5	A
	Intersection	**2918**	**19.5**	**B**	**3321**	**21.6**	**B**
Pittwater	North - Pittwater Road	1553	13.0	A	1731	22.6	B

Road / Winbourne Road	East - Winbourne Road	207	41.9	C	345	38.1	C
	South - Pittwater Road	829	32.8	C	934	35.1	C
	West - Winbourne Road	319	40.4	C	332	38.5	C
	Intersection	**2908**	**23.7**	**B**	**3342**	**29.3**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1508	7.1	A	1667	6.6	A
	East - Sydenham Road	91	42.2	D	130	48.2	D
	South - Pittwater Road	1046	6.4	A	1267	8.6	A
	Intersection	**2645**	**8.0**	**A**	**3064**	**9.2**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1570	2.7	A	1784	2.6	A
	East - Orchard Road	107	7.0	A	179	13.4	A
	South - Pittwater Road	1186	5.0	A	1440	8.5	A
	Intersection	**2863**	**21.5**	**B**	**3403**	**38.4**	**C**
Pittwater Road / Cross Street	North - Pittwater Road	1583	18.1	B	1859	22.6	B
	South - Pittwater Road	1150	23.9	B	1434	20.6	B
	West - Cross Street	228	44.4	D	346	52.8	D
	Intersection	**2961**	**22.4**	**B**	**3639**	**24.7**	**B**
Pittwater Road / Condamine Road	North - Pittwater Road	1555	33.1	C	1705	41.9	C
	East - Condamine Road	446	43.0	D	592	44.1	D
	South - Pittwater Road	927	21.6	B	1169	26.1	B
	Intersection	**2928**	**30.9**	**C**	**3466**	**37.0**	**C**

2016 - PM Peak Period		16:30 to 17:30			17:30 to 18:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1421	18.8	B	1324	19.1	B
	East - Hawkesbury Avenue	311	99.7	F	263	101.6	F
	South - Pittwater Road	1783	4.5	A	1724	10.1	A
	West - Hawkesbury Avenue	200	46.1	D	205	51.8	D
	Intersection	**3715**	**20.2**	**B**	**3516**	**22.8**	**B**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1207	4.2	A	1131	5.5	A
	East - Dee-Why Parade	373	47.7	D	389	52.5	D
	South - Pittwater Road	1639	7.1	A	1566	20.9	B
	Intersection	**3219**	**10.7**	**A**	**3086**	**19.2**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1127	14.1	B	1040	22.8	B
	East - Howard Avenue	307	41.5	C	297	46.5	D
	South - Pittwater Road	1559	4.5	A	1485	8.7	A
	West - St David Avenue	298	43.2	D	292	47.7	D
	Intersection	**3291**	**14.8**	**B**	**3114**	**20.7**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1124	10.2	A	1040	3.7	A
	East - Oakes Avenue	181	55.5	D	147	55.6	D
	South - Pittwater Road	1745	1.8	A	1679	3.4	A
	Intersection	**3050**	**8.1**	**A**	**2866**	**6.2**	**A**
Pittwater Road / Fisher Road	North - Pittwater Road	1275	16.6	B	1139	10.2	A
	South - Pittwater Road	2224	1.5	A	2119	2.7	A
	West - Fisher Road	515	66.9	E	515	56.1	E
	Intersection	**4014**	**14.7**	**B**	**3773**	**12.2**	**A**
Pittwater Road / Pacific Parade	North - Pittwater Road	1728	6.7	A	1569	7.0	A
	East - Pacific Parade	407	97.4	F	382	225.7	F
	South - Pittwater Road	1868	11.0	A	1783	13.8	A
	Intersection	**4003**	**17.9**	**B**	**3734**	**32.6**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1598	10.2	A	1434	18.4	B
	East - Sturdee Parade	221	50.9	D	213	59.1	E
	South - Pittwater Road	1983	5.3	A	1925	9.4	A
	Intersection	**3802**	**10.0**	**A**	**3572**	**16.0**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1683	0.3	A	1504	0.5	A
	East - Delmar Parade	16	11.0	A	20	13.3	A
	South - Pittwater Road	2010	2.4	A	1964	5.2	A
	Intersection	**3709**	**19.9**	**B**	**3488**	**28.4**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1651	44.3	D	1545	41.5	C
	East - Harbord Road	820	79.7	F	813	70.4	F
	South - Pittwater Road	1825	66.6	E	1729	66.3	E
	West - Warringah Road	905	50.8	D	923	54.9	D
	Intersection	**5201**	**58.8**	**E**	**5010**	**57.2**	**E**
Pittwater Road / Victor Road	North - Victor Road	19	55.6	D	12	16.1	B
	East - Pittwater Road	1340	5.1	A	1173	4.8	A
	West - Pittwater Road	2154	31.5	C	1979	15.9	B
	Intersection	**3513**	**55.6**	**D**	**3164**	**21.5**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	177	66.1	E	118	59.4	E
	East - Pittwater Road	1326	17.0	B	1155	16.2	B
	South - Mitchell Road	398	130.2	F	337	90.7	F
	West - Pittwater Road	1872	26.2	B	1720	9.4	A
	Intersection	**3773**	**35.8**	**C**	**3330**	**21.8**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1270	17.8	B	1058	14.6	B
	East - Winbourne Road	360	36.6	C	241	31.4	C
	South - Pittwater Road	1468	111.3	F	1383	33.9	C
	West - Winbourne Road	539	59.5	E	501	35.4	C
	Intersection	**3637**	**63.6**	**E**	**3183**	**27.5**	**B**

Pittwater Road / Sydenham Road	North - Pittwater Road	1324	8.0	A	1066	8.2	A
	East - Sydenham Road	257	161.9	F	183	151.5	F
	South - Pittwater Road	1749	34.7	C	1612	5.2	A
	Intersection	**3330**	**33.9**	**C**	**2861**	**15.7**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1556	3.0	A	1233	2.1	A
	East - Orchard Road	49	7.4	A	31	5.3	A
	South - Pittwater Road	1992	11.8	A	1862	6.5	A
	Intersection	**3597**	**25.0**	**B**	**3126**	**21.2**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1483	26.7	B	1140	33.7	C
	South - Pittwater Road	1604	41.1	C	1629	42.7	D
	West - Cross Street	690	85.4	F	283	46.1	D
	Intersection	**3777**	**43.5**	**D**	**3052**	**39.7**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1610	24.5	B	1184	28.0	C
	East - Condamine Road	451	83.9	F	434	74.0	F
	South - Pittwater Road	1199	109.7	F	1279	152.9	F
	Intersection	**3260**	**64.1**	**E**	**2897**	**90.0**	**F**

2016 – Saturday Peak Period		11:30 to 12:30			12:30 to 13:30		
		Volume	**Delay**	**LOS**	**Volume**	**Delay**	**LOS**
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1747	25.8	B	1621	23.8	B
	East - Hawkesbury Avenue	334	76.8	F	297	71.6	F
	South - Pittwater Road	1303	12.0	A	1291	33.7	C
	West - Hawkesbury Avenue	193	48.1	D	124	46.0	D
	Intersection	**3577**	**26.8**	**B**	**3333**	**32.7**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1401	12.1	A	1325	24.5	B
	East - Dee-Why Parade	356	49.8	D	338	54.6	D
	South - Pittwater Road	1104	11.9	A	1077	2.2	A
	Intersection	**2861**	**16.7**	**B**	**2740**	**19.4**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1247	40.3	C	1192	45.4	D
	East - Howard Avenue	248	48.9	D	201	46.4	D
	South - Pittwater Road	1078	10.7	A	1084	14.2	B
	West - St David Avenue	237	48.1	D	248	50.3	D
	Intersection	**2810**	**30.3**	**C**	**2725**	**33.5**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1244	38.7	C	1203	37.8	C
	East - Oakes Avenue	150	52.4	D	146	54.7	D
	South - Pittwater Road	1267	17.6	B	1274	16.4	B
	Intersection	**2661**	**29.4**	**C**	**2623**	**28.4**	**C**
Pittwater Road / Fisher Road	North - Pittwater Road	1332	16.5	B	1298	19.6	B
	South - Pittwater Road	1729	15.0	B	1751	16.8	B
	West - Fisher Road	377	66.5	E	392	97.0	F
	Intersection	**3438**	**21.2**	**B**	**3441**	**27.0**	**B**
Pittwater Road / Pacific Parade	North - Pittwater Road	1661	8.1	A	1650	9.4	A
	East - Pacific Parade	314	64.4	E	277	66.4	E
	South - Pittwater Road	1512	31.8	C	1575	37.7	C
	Intersection	**3487**	**23.4**	**B**	**3502**	**26.6**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1669	14.0	B	1650	13.7	A
	East - Sturdee Parade	316	59.2	E	312	64.4	E
	South - Pittwater Road	1713	11.2	A	1740	16.0	B
	Intersection	**3698**	**16.6**	**B**	**3702**	**19.1**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1898	0.5	A	1875	0.5	A
	East - Delmar Parade	40	16.3	B	40	25.2	B
	South - Pittwater Road	1731	4.0	A	1756	5.8	A
	Intersection	**3669**	**31.2**	**C**	**3671**	**55.9**	**D**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1904	43.1	D	1888	36.1	C
	East - Harbord Road	752	250.4	F	779	283.1	F
	South - Pittwater Road	1642	49.3	D	1645	47.3	D
	West - Warringah Road	959	67.0	E	998	65.2	E
	Intersection	**5257**	**79.0**	**F**	**5310**	**81.3**	**F**
Pittwater Road / Victor Road	North - Victor Road	20	8.4	A	20	5.9	A
	East - Pittwater Road	1467	6.1	A	1453	5.7	A
	West - Pittwater Road	1756	5.2	A	1712	2.9	A
	Intersection	**3243**	**16.0**	**B**	**3185**	**16.0**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	136	56.0	E	140	55.3	D
	East - Pittwater Road	1426	15.3	B	1450	11.0	A
	South - Mitchell Road	338	61.8	E	363	63.2	E
	West - Pittwater Road	1570	4.1	A	1534	4.0	A
	Intersection	**3470**	**16.4**	**B**	**3487**	**15.1**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1514	19.7	B	1508	17.6	B
	East - Winbourne Road	340	47.1	D	351	45.8	D
	South - Pittwater Road	1379	43.7	D	1340	54.0	D
	West - Winbourne Road	469	84.7	F	438	74.9	F
	Intersection	**3702**	**39.4**	**C**	**3637**	**40.6**	**C**

Pittwater Road / Sydenham Road	North - Pittwater Road	1692	5.1	A	1652	7.3	A
	East - Sydenham Road	119	59.4	E	123	57.6	E
	South - Pittwater Road	1637	9.9	A	1536	6.3	A
	Intersection	**3448**	**9.3**	**A**	**3311**	**8.7**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1756	4.4	A	1709	2.9	A
	East - Orchard Road	17	14.4	B	16	15.7	B
	South - Pittwater Road	1689	4.2	A	1592	2.3	A
	Intersection	**3462**	**29.9**	**C**	**3317**	**17.8**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1750	29.0	C	1689	23.6	B
	South - Pittwater Road	1631	20.8	B	1511	20.1	B
	West - Cross Street	535	107.1	F	550	86.5	F
	Intersection	**3916**	**36.3**	**C**	**3750**	**31.4**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1626	24.7	B	1678	35.3	C
	East - Condamine Road	516	45.6	D	394	40.8	C
	South - Pittwater Road	1152	25.7	B	1156	25.0	B
	Intersection	**3294**	**28.3**	**C**	**3228**	**32.3**	**C**

2021 Do-nothing Intersection Levels of Service

2021 – AM Peak Period		07:00 to 08:00			08:00 to 09:00		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1903	19.1	B	2345	30.6	C
	East - Hawkesbury Avenue	148	49.5	D	137	187.7	F
	South - Pittwater Road	971	9.5	A	1094	6.6	A
	West - Hawkesbury Avenue	109	42.2	D	232	99.9	F
	Intersection	**3131**	**18.4**	**B**	**3808**	**33.6**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1611	27.8	B	1859	38.4	C
	East - Dee-Why Parade	319	49.1	D	386	58.8	E
	South - Pittwater Road	772	12.1	A	859	2.1	A
	Intersection	**2702**	**25.8**	**B**	**3104**	**30.9**	**C**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1468	14.1	B	1706	22.8	B
	East - Howard Avenue	226	42.1	D	242	53.1	D
	South - Pittwater Road	760	9.1	A	845	29.2	C
	West - St David Avenue	165	43.9	D	239	51.6	D
	Intersection	**2619**	**16.9**	**B**	**3032**	**29.3**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1457	14.5	B	1720	28.1	C
	East - Oakes Avenue	107	60.1	E	93	113.6	F
	South - Pittwater Road	897	3.5	A	972	5.2	A
	Intersection	**2461**	**12.5**	**A**	**2785**	**22.9**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1487	10.9	A	1746	24.0	B
	South - Pittwater Road	1150	8.6	A	1368	8.4	A
	West - Fisher Road	494	55.7	D	425	208.1	F
	Intersection	**3131**	**17.1**	**B**	**3539**	**40.1**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1930	6.0	A	2132	10.6	A
	East - Pacific Parade	248	124.8	F	334	92.6	F
	South - Pittwater Road	1082	22.0	B	1238	37.4	C
	Intersection	**3260**	**20.3**	**B**	**3704**	**26.9**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	2010	9.6	A	2195	11.9	A
	East - Sturdee Parade	318	61.9	E	335	96.0	F
	South - Pittwater Road	1070	4.9	A	1251	11.7	A
	Intersection	**3398**	**13.0**	**A**	**3781**	**19.3**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2214	0.8	A	2378	2.7	A
	East - Delmar Parade	12	16.7	B	12	25.3	B
	South - Pittwater Road	1101	4.1	A	1311	4.6	A
	Intersection	**3327**	**27.8**	**B**	**3701**	**31.9**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2138	45.1	D	2402	49.6	D
	East - Harbord Road	654	56.9	E	684	82.9	F
	South - Pittwater Road	1073	32.0	C	1319	29.3	C
	West - Warringah Road	853	52.4	D	1007	67.9	E
	Intersection	**4718**	**45.1**	**D**	**5412**	**52.3**	**D**
Pittwater Road / Victor Road	North - Victor Road	6	1.9	A	16	4.6	A
	East - Pittwater Road	1745	11.1	A	1980	13.3	A
	West - Pittwater Road	1145	2.1	A	1359	2.7	A
	Intersection	**2896**	**15.8**	**B**	**3355**	**14.8**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	150	50.2	D	167	51.4	D
	East - Pittwater Road	1679	24.5	B	1862	25.5	B
	South - Mitchell Road	151	47.5	D	274	52.0	D
	West - Pittwater Road	1033	5.1	A	1137	5.5	A
	Intersection	**3013**	**20.3**	**B**	**3440**	**22.3**	**B**
Pittwater	North - Pittwater Road	1616	14.0	A	1819	23.2	B

Road / Winbourne Road	East - Winbourne Road	227	41.4	C	374	39.2	C
	South - Pittwater Road	857	32.9	C	949	35.9	C
	West - Winbourne Road	320	41.9	C	336	39.9	C
	Intersection	**3020**	**24.4**	**B**	**3478**	**30.0**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1555	6.9	A	1730	6.9	A
	East - Sydenham Road	93	45.4	D	141	45.3	D
	South - Pittwater Road	1087	6.2	A	1303	9.0	A
	Intersection	**2735**	**7.9**	**A**	**3174**	**9.4**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1626	3.0	A	1852	2.9	A
	East - Orchard Road	12	13.6	A	24	20.7	B
	South - Pittwater Road	1237	5.4	A	1490	9.7	A
	Intersection	**2875**	**24.9**	**B**	**3366**	**44.9**	**D**
Pittwater Road / Cross Street	North - Pittwater Road	1647	18.8	B	1929	23.2	B
	South - Pittwater Road	1205	23.7	B	1505	21.5	B
	West - Cross Street	232	44.9	D	350	54.1	D
	Intersection	**3084**	**22.7**	**B**	**3784**	**25.4**	**B**
Pittwater Road / Condamine Road	North - Pittwater Road	1615	33.0	C	1752	41.8	C
	East - Condamine Road	472	43.6	D	625	45.9	D
	South - Pittwater Road	978	21.7	B	1237	26.8	B
	Intersection	**3065**	**31.0**	**C**	**3614**	**37.4**	**C**

2021 – PM Peak Period		16:30 to 17:30			17:30 to 18:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1446	19.0	B	1352	19.1	B
	East - Hawkesbury Avenue	314	126.0	F	282	130.5	F
	South - Pittwater Road	1847	4.5	A	1774	9.8	A
	West - Hawkesbury Avenue	207	45.7	D	212	53.6	D
	Intersection	**3814**	**22.2**	**B**	**3620**	**25.2**	**B**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1226	4.0	A	1161	5.8	A
	East - Dee-Why Parade	390	48.3	D	409	52.7	D
	South - Pittwater Road	1687	6.8	A	1612	20.4	B
	Intersection	**3303**	**10.7**	**A**	**3182**	**19.2**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1148	14.1	B	1071	21.9	B
	East - Howard Avenue	321	42.5	D	311	47.5	D
	South - Pittwater Road	1603	4.7	A	1521	9.1	A
	West - St David Avenue	312	43.8	D	303	48.6	D
	Intersection	**3384**	**15.1**	**B**	**3206**	**20.9**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1148	10.8	A	1072	3.8	A
	East - Oakes Avenue	182	55.9	D	147	58.6	E
	South - Pittwater Road	1793	1.9	A	1715	3.4	A
	Intersection	**3123**	**8.3**	**A**	**2934**	**6.3**	**A**
Pittwater Road / Fisher Road	North - Pittwater Road	1301	17.0	B	1171	10.9	A
	South - Pittwater Road	2289	1.6	A	2168	2.7	A
	West - Fisher Road	544	82.6	F	541	63.3	E
	Intersection	**4134**	**17.1**	**B**	**3880**	**13.6**	**A**
Pittwater Road / Pacific Parade	North - Pittwater Road	1778	6.7	A	1626	7.1	A
	East - Pacific Parade	420	162.9	F	382	283.8	F
	South - Pittwater Road	1923	11.5	A	1834	14.0	A
	Intersection	**4121**	**24.9**	**B**	**3842**	**37.9**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1646	10.4	A	1489	18.0	B
	East - Sturdee Parade	230	49.9	D	216	56.3	E
	South - Pittwater Road	2029	5.6	A	1972	9.9	A
	Intersection	**3905**	**10.2**	**A**	**3677**	**15.9**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1730	0.3	A	1560	0.5	A
	East - Delmar Parade	16	16.1	B	20	10.1	A
	South - Pittwater Road	2051	2.3	A	2013	5.6	A
	Intersection	**3797**	**28.5**	**C**	**3593**	**22.8**	**B**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1694	44.5	D	1604	42.3	D
	East - Harbord Road	856	99.3	F	855	79.4	F
	South - Pittwater Road	1838	65.9	E	1754	72.1	F
	West - Warringah Road	966	52.8	D	989	57.1	E
	Intersection	**5354**	**62.1**	**E**	**5202**	**61.3**	**E**
Pittwater Road / Victor Road	North - Victor Road	19	51.7	D	12	28.4	C
	East - Pittwater Road	1392	5.3	A	1222	4.7	A
	West - Pittwater Road	2171	30.6	C	2016	22.0	B
	Intersection	**3582**	**51.7**	**D**	**3250**	**28.4**	**C**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	179	64.4	E	118	61.2	E
	East - Pittwater Road	1380	17.1	B	1207	16.4	B
	South - Mitchell Road	408	127.8	F	358	113.9	F
	West - Pittwater Road	1881	25.3	B	1749	12.8	A
	Intersection	**3848**	**35.0**	**C**	**3432**	**26.3**	**B**
Pittwater Road / Winbourne	North - Pittwater Road	1318	18.2	B	1109	15.1	B
	East - Winbourne Road	397	36.9	C	260	32.1	C
	South - Pittwater Road	1455	112.9	F	1400	37.3	C

Road	West - Winbourne Road	567	61.5	E	524	36.9	C
	Intersection	**3737**	**63.6**	**E**	**3293**	**29.3**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1373	7.9	A	1105	8.8	A
	East - Sydenham Road	263	173.8	F	199	182.7	F
	South - Pittwater Road	1750	39.6	C	1624	5.4	A
	Intersection	**3386**	**37.2**	**C**	**2928**	**18.8**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1610	3.1	A	1289	2.1	A
	East - Orchard Road	49	10.8	A	31	5.4	A
	South - Pittwater Road	1984	15.4	B	1873	7.1	A
	Intersection	**3643**	**31.0**	**C**	**3193**	**24.5**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1539	27.2	B	1190	34.6	C
	South - Pittwater Road	1583	46.6	D	1639	42.1	D
	West - Cross Street	716	98.8	F	296	44.3	D
	Intersection	**3838**	**48.5**	**D**	**3125**	**39.4**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1667	24.8	B	1229	29.3	C
	East - Condamine Road	452	88.0	F	435	76.8	F
	South - Pittwater Road	1178	139.4	F	1290	150.6	F
	Intersection	**3297**	**74.4**	**F**	**2954**	**89.3**	**F**

2021 – Saturday Peak Period		11:30 to 12:30			12:30 to 13:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1803	28.0	C	1648	26.0	B
	East - Hawkesbury Avenue	349	93.1	F	311	77.7	F
	South - Pittwater Road	1349	12.2	A	1334	34.0	C
	West - Hawkesbury Avenue	200	47.3	D	129	45.8	D
	Intersection	**3701**	**29.4**	**C**	**3422**	**34.5**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1432	20.5	B	1369	54.5	D
	East - Dee-Why Parade	374	56.2	E	357	55.1	D
	South - Pittwater Road	1137	11.7	A	1111	2.3	A
	Intersection	**2943**	**21.7**	**B**	**2837**	**34.1**	**C**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1282	44.3	D	1236	65.6	E
	East - Howard Avenue	257	48.3	D	210	50.6	D
	South - Pittwater Road	1109	10.3	A	1116	14.0	B
	West - St David Avenue	246	47.8	D	260	52.8	D
	Intersection	**2894**	**31.9**	**C**	**2822**	**42.9**	**D**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1280	40.4	C	1247	46.7	D
	East - Oakes Avenue	154	53.0	D	150	55.9	D
	South - Pittwater Road	1293	17.6	B	1309	16.6	B
	Intersection	**2727**	**30.3**	**C**	**2706**	**32.7**	**C**
Pittwater Road / Fisher Road	North - Pittwater Road	1372	16.8	B	1345	20.0	B
	South - Pittwater Road	1763	15.8	B	1813	16.8	B
	West - Fisher Road	391	74.8	F	401	136.3	F
	Intersection	**3526**	**22.7**	**B**	**3559**	**31.5**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1712	8.4	A	1705	9.2	A
	East - Pacific Parade	329	67.7	E	289	66.4	E
	South - Pittwater Road	1538	34.5	C	1628	38.3	C
	Intersection	**3579**	**25.1**	**B**	**3622**	**26.9**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1725	14.5	B	1709	13.3	A
	East - Sturdee Parade	333	63.3	E	328	76.9	F
	South - Pittwater Road	1740	12.4	A	1798	16.4	B
	Intersection	**3798**	**17.8**	**B**	**3835**	**20.2**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1968	0.4	A	1947	0.4	A
	East - Delmar Parade	41	18.2	B	40	27.1	B
	South - Pittwater Road	1756	4.1	A	1814	6.1	A
	Intersection	**3765**	**37.4**	**C**	**3801**	**59.4**	**E**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1971	39.5	C	1960	35.1	C
	East - Harbord Road	750	264.5	F	799	305.7	F
	South - Pittwater Road	1663	50.2	D	1683	48.2	D
	West - Warringah Road	1028	72.5	F	1068	76.6	F
	Intersection	**5412**	**80.2**	**F**	**5510**	**86.4**	**F**
Pittwater Road / Victor Road	North - Victor Road	20	9.0	A	20	5.8	A
	East - Pittwater Road	1533	6.6	A	1531	5.6	A
	West - Pittwater Road	1792	5.4	A	1748	3.5	A
	Intersection	**3345**	**19.7**	**B**	**3299**	**21.2**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	136	56.7	E	140	57.5	E
	East - Pittwater Road	1493	15.4	B	1526	11.4	A
	South - Mitchell Road	349	60.9	E	378	75.2	F
	West - Pittwater Road	1612	4.1	A	1562	4.3	A
	Intersection	**3590**	**16.3**	**B**	**3606**	**16.8**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1589	20.2	B	1585	18.5	B
	East - Winbourne Road	375	47.2	D	382	48.5	D
	South - Pittwater Road	1418	44.8	D	1366	54.9	D
	West - Winbourne Road	508	136.3	F	461	104.6	F
	Intersection	**3890**	**46.9**	**D**	**3794**	**45.1**	**D**

Pittwater Road / Sydenham Road	North - Pittwater Road	1780	5.2	A	1734	7.6	A
	East - Sydenham Road	124	56.3	E	129	54.8	D
	South - Pittwater Road	1662	10.3	A	1571	6.7	A
	Intersection	**3566**	**9.3**	**A**	**3434**	**9.0**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1852	6.3	A	1791	4.4	A
	East - Orchard Road	29	17.7	B	29	11.2	A
	South - Pittwater Road	1718	4.5	A	1623	2.6	A
	Intersection	**3599**	**35.0**	**C**	**3443**	**21.4**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1842	31.3	C	1774	25.3	B
	South - Pittwater Road	1681	21.7	B	1553	20.3	B
	West - Cross Street	544	132.9	F	572	135.7	F
	Intersection	**4067**	**40.9**	**C**	**3899**	**39.5**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1684	26.0	B	1736	35.7	C
	East - Condamine Road	527	46.1	D	403	41.2	C
	South - Pittwater Road	1198	25.0	B	1201	26.0	B
	Intersection	**3409**	**28.8**	**C**	**3340**	**32.9**	**C**

2021 Option Intersection Levels of Service

2021 – Option AM Peak		07:00-08:00			08:00-09:00		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1924	19.4	B	2358	28.6	C
	East - Hawkesbury Avenue	149	44.9	D	184	139.0	F
	South - Pittwater Road	971	15.4	B	1087	7.8	A
	West - Hawkesbury Avenue	109	39.2	C	239	55.0	D
	Intersection	**3153**	**20.1**	**B**	**3868**	**29.6**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1628	25.6	B	1878	32.7	C
	East - Dee-Why Parade	320	49.5	D	386	59.3	E
	South - Pittwater Road	774	11.6	A	851	2.1	A
	Intersection	**2722**	**24.4**	**B**	**3115**	**27.6**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1486	15.6	B	1725	23.9	B
	East - Howard Avenue	226	42.4	D	243	54.1	D
	South - Pittwater Road	764	9.2	A	837	29.7	C
	West - St David Avenue	165	45.6	D	238	60.0	E
	Intersection	**2641**	**17.9**	**B**	**3043**	**30.7**	**C**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1464	16.9	B	1742	29.4	C
	East - Oakes Avenue	105	62.2	E	94	114.1	F
	South - Pittwater Road	900	3.4	A	964	5.1	A
	Intersection	**2469**	**13.9**	**A**	**2800**	**23.9**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1493	11.1	A	1769	15.7	B
	South - Pittwater Road	1151	10.5	A	1345	13.4	A
	West - Fisher Road	490	57.9	E	419	239.6	F
	Intersection	**3134**	**18.2**	**B**	**3533**	**41.4**	**C**
Pittwater Road / Pacific Parade	North - Pittwater Road	1931	6.5	A	2154	6.7	A
	East - Pacific Parade	253	114.7	F	326	132.3	F
	South - Pittwater Road	1087	20.3	B	1217	48.8	D
	Intersection	**3271**	**19.4**	**B**	**3697**	**31.7**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	2016	9.6	A	2228	11.9	A
	East - Sturdee Parade	313	78.5	F	320	162.3	F
	South - Pittwater Road	1070	4.7	A	1252	14.0	A
	Intersection	**3399**	**14.4**	**B**	**3800**	**25.2**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2214	0.5	A	2393	2.5	A
	East - Delmar Parade	12	16.8	B	12	19.6	B
	South - Pittwater Road	1100	2.7	A	1309	3.6	A
	Intersection	**3326**	**27.0**	**B**	**3714**	**26.2**	**B**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2143	45.4	D	2401	52.1	D
	East - Harbord Road	653	56.0	D	677	85.8	F
	South - Pittwater Road	1075	31.2	C	1318	29.9	C
	West - Warringah Road	854	52.8	D	1007	67.7	E
	Intersection	**4725**	**45.0**	**D**	**5403**	**53.8**	**D**
Pittwater Road / Victor Road	North - Victor Road	6	0.9	A	16	0.6	A
	East - Pittwater Road	1762	12.0	A	1978	13.2	A
	West - Pittwater Road	1146	0.9	A	1362	1.0	A
	Intersection	**2914**	**14.1**	**B**	**3356**	**16.8**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	149	50.0	D	167	51.5	D
	East - Pittwater Road	1692	26.2	B	1867	25.8	B
	South - Mitchell Road	151	46.9	D	272	51.9	D
	West - Pittwater Road	1031	5.2	A	1141	5.5	A
	Intersection	**3023**	**21.2**	**B**	**3447**	**22.4**	**B**
Pittwater Road /	North - Pittwater Road	1631	13.9	A	1823	22.0	B
	East - Winbourne Road	227	42.1	D	375	39.1	C

Winbourne Road	South - Pittwater Road	855	35.0	C	952	36.2	C
	West - Winbourne Road	323	44.5	D	336	42.0	D
	Intersection	**3036**	**25.2**	**B**	**3486**	**29.7**	**C**
Pittwater Road / Sydenham Road	North - Pittwater Road	1573	10.1	A	1736	8.9	A
	East - Sydenham Road	106	38.1	C	166	39.6	C
	South - Pittwater Road	1230	8.2	A	1493	22.7	B
	Intersection	**2909**	**10.3**	**A**	**3395**	**16.5**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1642	3.1	A	1856	4.4	A
	East - Orchard Road	99	7.2	A	164	14.4	B
	South - Pittwater Road	1243	0.5	A	1493	5.4	A
	Intersection	**2984**	**7.2**	**A**	**3513**	**14.4**	**B**
Pittwater Road / Cross Street	North - Pittwater Road	1662	17.4	B	1936	23.3	B
	South - Pittwater Road	1205	22.0	B	1504	17.8	B
	West - Cross Street	232	44.2	D	350	54.5	D
	Intersection	**3099**	**21.2**	**B**	**3790**	**24.0**	**B**
Pittwater Road / Condamine Road	North - Pittwater Road	1625	30.2	C	1767	39.9	C
	East - Condamine Road	471	42.5	D	624	45.4	D
	South - Pittwater Road	979	21.7	B	1238	26.7	B
	Intersection	**3075**	**29.4**	**C**	**3629**	**36.3**	**C**

2021 – Option PM Peak		16:30-17:30			17:30-18:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1450	16.4	B	1356	16.7	B
	East - Hawkesbury Avenue	328	76.6	F	272	72.8	F
	South - Pittwater Road	1855	4.4	A	1799	9.8	A
	West - Hawkesbury Avenue	207	45.2	D	213	51.6	D
	Intersection	**3840**	**17.3**	**B**	**3640**	**19.5**	**B**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1231	3.3	A	1156	3.9	A
	East - Dee-Why Parade	392	48.0	D	409	52.1	D
	South - Pittwater Road	1702	7.0	A	1633	20.7	B
	Intersection	**3325**	**10.5**	**A**	**3198**	**18.7**	**B**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1151	10.4	A	1071	20.5	B
	East - Howard Avenue	321	42.4	D	311	47.0	D
	South - Pittwater Road	1615	5.1	A	1555	9.5	A
	West - St David Avenue	313	43.7	D	302	49.0	D
	Intersection	**3400**	**14.0**	**A**	**3239**	**20.4**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1146	8.2	A	1072	3.5	A
	East - Oakes Avenue	183	49.2	D	147	56.5	E
	South - Pittwater Road	1802	1.9	A	1751	3.3	A
	Intersection	**3131**	**7.0**	**A**	**2970**	**6.0**	**A**
Pittwater Road / Fisher Road	North - Pittwater Road	1296	16.8	B	1171	8.5	A
	South - Pittwater Road	2303	1.5	A	2184	3.0	A
	West - Fisher Road	542	62.8	E	543	54.2	D
	Intersection	**4141**	**14.3**	**B**	**3898**	**11.8**	**A**
Pittwater Road / Pacific Parade	North - Pittwater Road	1772	7.6	A	1627	6.9	A
	East - Pacific Parade	425	126.0	F	389	259.2	F
	South - Pittwater Road	1933	10.7	A	1845	14.6	B
	Intersection	**4130**	**21.2**	**B**	**3861**	**36.0**	**C**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1648	6.6	A	1484	17.7	B
	East - Sturdee Parade	229	47.5	D	217	53.0	D
	South - Pittwater Road	2042	4.4	A	1993	7.6	A
	Intersection	**3919**	**7.8**	**A**	**3694**	**14.4**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	1733	0.2	A	1556	0.2	A
	East - Delmar Parade	16	15.4	B	20	8.0	A
	South - Pittwater Road	2065	1.8	A	2035	4.8	A
	Intersection	**3814**	**24.5**	**B**	**3611**	**16.8**	**B**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	1698	45.8	D	1600	42.1	D
	East - Harbord Road	854	99.5	F	854	78.6	F
	South - Pittwater Road	1846	66.0	E	1778	72.8	F
	West - Warringah Road	970	52.6	D	987	56.8	E
	Intersection	**5368**	**62.5**	**E**	**5219**	**61.3**	**E**
Pittwater Road / Victor Road	North - Victor Road	19	43.7	D	12	44.2	D
	East - Pittwater Road	1396	5.0	A	1219	4.5	A
	West - Pittwater Road	2179	30.5	C	2082	35.4	C
	Intersection	**3594**	**43.7**	**D**	**3313**	**44.2**	**D**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	179	64.0	E	119	70.2	F
	East - Pittwater Road	1383	17.8	B	1203	17.6	B
	South - Mitchell Road	410	143.7	F	270	236.3	F
	West - Pittwater Road	1896	25.5	B	1912	29.3	C
	Intersection	**3868**	**37.1**	**C**	**3504**	**42.6**	**D**
Pittwater Road / Winbourne Road	North - Pittwater Road	1325	19.3	B	1100	17.7	B
	East - Winbourne Road	397	36.0	C	262	31.8	C
	South - Pittwater Road	1472	130.3	F	1588	117.4	F
	West - Winbourne Road	568	70.1	F	522	67.5	E

	Intersection	**3762**	**72.2**	**F**	**3472**	**71.8**	**F**
Pittwater Road / Sydenham Road	North - Pittwater Road	1390	10.0	A	1090	12.0	A
	East - Sydenham Road	304	63.1	E	196	55.6	D
	South - Pittwater Road	2005	38.1	C	2108	21.5	B
	Intersection	**3699**	**29.6**	**C**	**3394**	**20.4**	**B**
Pittwater Road / Orchard Road	North - Pittwater Road	1655	1.7	A	1265	0.9	A
	East - Orchard Road	40	1.8	A	25	1.0	A
	South - Pittwater Road	2017	10.4	A	2091	3.6	A
	Intersection	**3712**	**10.4**	**A**	**3381**	**3.6**	**A**
Pittwater Road / Cross Street	North - Pittwater Road	1591	26.7	B	1163	29.0	C
	South - Pittwater Road	1613	48.1	D	1865	31.0	C
	West - Cross Street	716	95.4	F	296	44.3	D
	Intersection	**3920**	**48.1**	**D**	**3324**	**31.5**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1704	23.4	B	1213	27.5	B
	East - Condamine Road	449	73.4	F	434	53.7	D
	South - Pittwater Road	1217	85.6	F	1504	67.1	E
	Intersection	**3370**	**52.5**	**D**	**3151**	**50.0**	**D**

2021 – Option Saturday Peak		11:30 to 12:30			12:30 to 13:30		
		Volume	Delay	LOS	Volume	Delay	LOS
Pittwater Road / Hawkesbury Avenue	North - Pittwater Road	1809	18.7	B	1680	18.4	B
	East - Hawkesbury Avenue	346	101.6	F	313	83.7	F
	South - Pittwater Road	1360	12.2	A	1345	29.3	C
	West - Hawkesbury Avenue	198	46.9	D	128	45.9	D
	Intersection	**3713**	**25.6**	**B**	**3466**	**29.5**	**C**
Pittwater Road / Kingsway / Dee-Why Parade	North - Pittwater Road	1474	2.8	A	1425	4.2	A
	East - Dee-Why Parade	375	47.1	D	355	51.1	D
	South - Pittwater Road	1156	10.4	A	1116	1.7	A
	Intersection	**3005**	**11.3**	**A**	**2896**	**9.0**	**A**
Pittwater Road / Howard Avenue / St David Avenue	North - Pittwater Road	1332	18.9	B	1270	10.8	A
	East - Howard Avenue	258	45.2	D	210	47.0	D
	South - Pittwater Road	1125	12.0	A	1127	14.4	B
	West - St David Avenue	246	49.7	D	258	56.5	E
	Intersection	**2961**	**21.2**	**B**	**2865**	**19.0**	**B**
Pittwater Road / Oakes Avenue	North - Pittwater Road	1342	14.9	B	1264	10.0	A
	East - Oakes Avenue	154	51.9	D	149	52.5	D
	South - Pittwater Road	1306	16.1	B	1320	14.7	B
	Intersection	**2802**	**17.5**	**B**	**2733**	**14.6**	**B**
Pittwater Road / Fisher Road	North - Pittwater Road	1434	15.5	B	1361	9.3	A
	South - Pittwater Road	1789	10.0	A	1820	12.7	A
	West - Fisher Road	391	76.6	F	418	66.8	E
	Intersection	**3614**	**19.4**	**B**	**3599**	**17.7**	**B**
Pittwater Road / Pacific Parade	North - Pittwater Road	1780	7.0	A	1743	6.3	A
	East - Pacific Parade	327	61.5	E	289	64.7	E
	South - Pittwater Road	1563	26.4	B	1640	31.1	C
	Intersection	**3670**	**20.1**	**B**	**3672**	**22.0**	**B**
Pittwater Road / Sturdee Parade	North - Pittwater Road	1791	8.6	A	1742	12.5	A
	East - Sturdee Parade	338	70.8	F	327	97.6	F
	South - Pittwater Road	1772	11.5	A	1801	13.5	A
	Intersection	**3901**	**15.3**	**B**	**3870**	**20.2**	**B**
Pittwater Road / Delmar Parade	North - Pittwater Road	2043	0.8	A	1981	0.6	A
	East - Delmar Parade	40	13.0	A	40	16.9	B
	South - Pittwater Road	1794	5.7	A	1812	5.6	A
	Intersection	**3877**	**24.0**	**B**	**3833**	**31.3**	**C**
Pittwater Road / Warringah Road / Harbord Road	North - Pittwater Road	2041	44.5	D	1995	38.0	C
	East - Harbord Road	783	255.6	F	836	249.6	F
	South - Pittwater Road	1686	38.3	C	1667	37.5	C
	West - Warringah Road	1028	72.8	F	1068	61.2	E
	Intersection	**5538**	**77.7**	**F**	**5566**	**74.1**	**F**
Pittwater Road / Victor Road	North - Victor Road	20	0.5	A	20	0.6	A
	East - Pittwater Road	1580	7.0	A	1553	6.8	A
	West - Pittwater Road	1797	1.6	A	1765	1.4	A
	Intersection	**3397**	**15.8**	**B**	**3338**	**18.4**	**B**
Pittwater Road / Pine Avenue / Mitchell Road	North - Pine Avenue	135	59.5	E	140	57.4	E
	East - Pittwater Road	1540	15.7	B	1546	12.0	A
	South - Mitchell Road	347	60.9	E	379	72.6	F
	West - Pittwater Road	1615	4.0	A	1572	4.1	A
	Intersection	**3637**	**16.4**	**B**	**3637**	**16.6**	**B**
Pittwater Road / Winbourne Road	North - Pittwater Road	1633	20.1	B	1606	17.3	B
	East - Winbourne Road	376	47.1	D	383	48.7	D
	South - Pittwater Road	1426	42.2	D	1370	50.0	D
	West - Winbourne Road	513	131.9	F	461	122.1	F

	Intersection	**3948**	**45.2**	**D**	**3820**	**44.8**	**D**
Pittwater Road / Sydenham Road	North - Pittwater Road	1821	4.9	A	1756	7.1	A
	East - Sydenham Road	140	55.9	D	146	55.1	D
	South - Pittwater Road	1725	15.1	B	1628	6.7	A
	Intersection	**3686**	**11.6**	**A**	**3530**	**8.9**	**A**
Pittwater Road / Orchard Road	North - Pittwater Road	1888	3.0	A	1817	2.2	A
	East - Orchard Road	12	3.4	A	12	3.1	A
	South - Pittwater Road	1729	1.3	A	1626	0.3	A
	Intersection	**3629**	**3.4**	**A**	**3455**	**3.1**	**A**
Pittwater Road / Cross Street	North - Pittwater Road	1877	30.3	C	1806	24.9	B
	South - Pittwater Road	1684	21.5	B	1560	19.9	B
	West - Cross Street	566	93.4	F	583	84.2	F
	Intersection	**4127**	**35.4**	**C**	**3949**	**31.7**	**C**
Pittwater Road / Condamine Road	North - Pittwater Road	1726	23.7	B	1781	33.0	C
	East - Condamine Road	526	45.7	D	403	40.0	C
	South - Pittwater Road	1206	25.2	B	1206	26.0	B
	Intersection	**3458**	**27.6**	**B**	**3390**	**31.3**	**C**

Appendix B

Base Model Calibration and Validation Report (Vissim)

Appendix B

Northern Beaches B-Line Program On-Road Infrastructure

VISSIM Base Model - Calibration and Validation Report

Northern Beaches B-Line Program On-Road Infrastructure

VISSIM Base Model - Calibration and Validation Report

Client: Roads and Maritime Services

ABN: 89 600 377 397

Prepared by

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Quality Information

Document Northern Beaches B-Line Program On-Road Infrastructure

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Prepared by John Bennett and Muneem Anwar

Reviewed by Andersen Hui

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
1	04-Jun-2016	Draft report	Andersen Hui Principal Transport Planner	
2	20-Oct-2016	FINAL	Andersen Hui Principal Transport Planner	

Table of Contents

1.0 Introduction

1.1 Preamble

AECOM was commissioned by Roads and Maritime Services (Roads and Maritime) to develop VISSIM microsimulation traffic models for the Narrabeen and Brookvale areas of Sydney to assist in the planning and development of the Northern Beaches B-Line program. This technical report provides details of the development of the VISSIM models; including data inputs, modelling assumptions, approach and, calibration and validation processes.

The base year models were developed for the mid-week AM and PM and Saturday peak periods; and were calibrated and validated to 2016 existing traffic conditions. The models will be used to analyse the operational performance of the proposed B-line Program on-road infrastructure works along the Pittwater Road which aims to improve the efficiency and reliability of bus services (including the proposed new B-Line Bus service).

1.2 Project Background

The Northern Beaches B-Line program (otherwise referred to as 'the B-Line Program') is an integrated program of service and infrastructure improvements that will deliver a high quality, high frequency bus service for passengers within Sydney's Northern Beaches area. The program will improve the frequency and reliability of bus services between the Northern Beaches and the Sydney CBD. The improved, high-frequency bus services will be supported by additional on-road and off-road infrastructure improvements and enhancements to the broader Northern Beaches bus network.

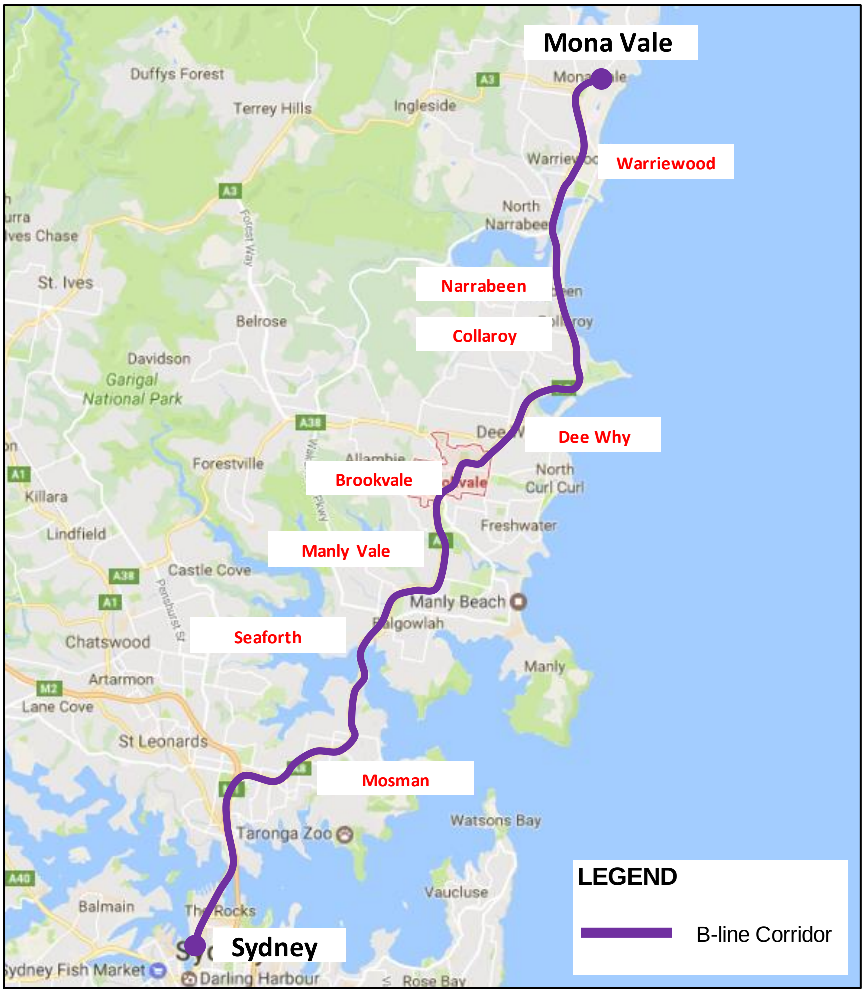
The overall aim of the program is to improve the effectiveness and attractiveness of the bus transport network within the Northern Beaches by addressing the following key existing issues:

- A lack of network legibility due to the complexity of the bus network, which leads to bus congestion;
- Low peak period average bus speeds, combined with long travel-times and delays along the north-south corridor;
- Unreliable and inconsistent bus journey times on the main north-south corridor;
- Uneven passenger loadings across similar services on the north-south corridor;
- Passenger crowding and poor pedestrian levels of service at major bus stops along the corridor;
- Long wait times for bus services in off-peak periods when frequency is reduced; and
- Customer dissatisfaction with current level of bus stop amenity.

At the core of the program is the introduction of a new high-frequency bus service called the B-Line service, which will run between Mona Vale and the Sydney CBD along the Northern Beaches north-sound corridor as shown in **Figure 1-1**.

The B-Line service is intended to be introduced as a higher frequency, more reliable, limited stops service which will benefit commuters and off-peak customers alike. While the existing express buses will continue to provide a fast service for commuters and local connections (especially those from the northern most suburbs), the B-Line service will still provide substantial benefits to passengers travelling along the Mona Vale to CBD corridor.

Figure 1-1 Map of Northern Beaches arterial, north-south (Mona Vale to CBD) corridor and east-west corridor



Source: Transport for NSW 2012, Long Term Transport Master Plan

1.3 Modelling Objectives

The key objectives of the VISSIM modelling are:

- To forecast the performance of the corridor for general traffic and buses in 2021 without and with the B-Line services, associated network upgrades and committed works from other REF programs.
- To identify preferred options for upgrade of the corridor to facilitate the B-Line service for input into the strategic design process.

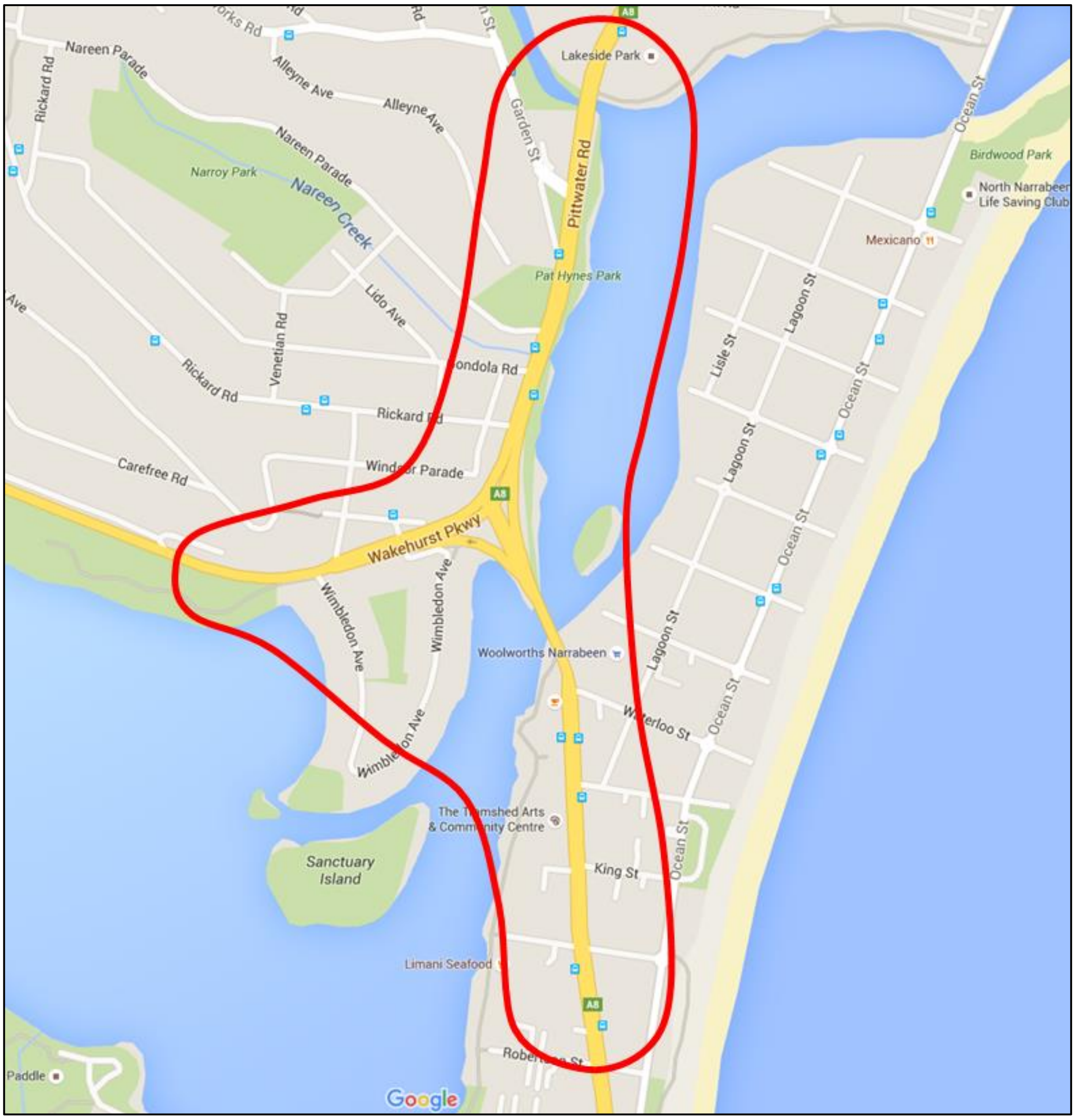
The base year traffic models are required to meet the calibration and validation criteria set out in the *RMS Traffic Modelling Guidelines* (2013) and will form the basis for the assessment of the network in 2021.

1.4 Study Area and VISSIM Model Extents

The VISSIM models were developed to cover the key areas of the Pittwater Road corridor in Narrabeen (between north of Pittwater Road/ Garden Street and south of Pittwater Road/ Albert Street) and in Brookvale / Dee Why (between Hawkesbury Avenue and Condamine Street).

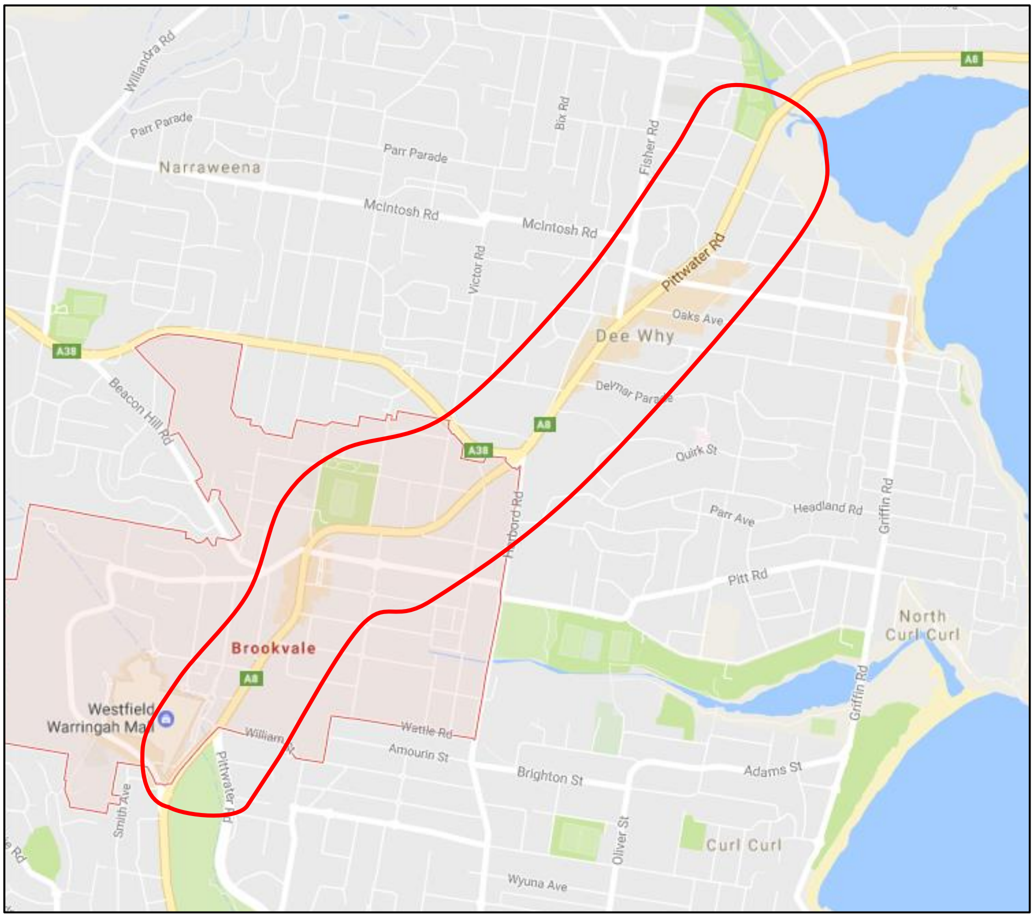
Figure 1-2 and **Figure 1-3** illustrate the extents of the modelled road network for Narrabeen and Brookvale / Dee Why respectively (within the red boundaries). The areas in Narrabeen and Brookvale / Dee Why have been modelled separately and have not been linked within a single model. However, as the demand matrices have been developed based on observed traffic counts any traffic impacts due to upstream congestion towards Narrabeen will also be reflected in the Brookvale demand matrices.

Figure 1-2 Narrabeen VISSIM Model Coverage



Source: Google Maps, 2016

Figure 1-3 Brookvale / Dee Why VISSIM Model Coverage



Source: Google Maps, 2016

1.5 Report Structure

The following sections of the report outline the main processes involved in developing and calibrating the VISSIM models:

Section 2.0: Data Inputs

Section 3.0: Model Development

Section 4.0: Model Calibration

Section 5.0: Model Validation

Section 6.0: Summary and Conclusion

2.0 Data Inputs

This section of the report provides details of the data used in the development, calibration and validation of the Narrabeen and Brookvale/ Dee Why VISSIM models.

2.1 Site Observations

Site visit was undertaken in the morning and evening peak periods on Tuesday, 31 May 2016 for the study area. Information collected such as sign posted speed limits, lane arrangement at intersections, traffic queues on Pittwater Road, parking restrictions and bus movements were used to validate the inputs for the modelling. In addition to this, travel time samples were collected and videos of the corridor drive through were recorded. A site visit during the Saturday peak period was also undertaken.

Observation in relation to the overall network operation generally indicates that areas within the study area with a relatively higher level of congestion and delays are most pronounced along the Pittwater Road approaching the Brookvale and Dee Why town centres. This is primarily due to the higher concentration and mix of various land use functions such as commercial, retail and employment activities typically associated with the town centres. There is no significant traffic issues observed in Narrabeen during the site visits.

2.1.1 Dee Why

- In the morning peak, the southbound peak traffic along the Pittwater Road is expected to experience moderate delays and congestion for the section between Dee Why Parade and Sturdee Parade, partly due to the closely spaced signals and the competing traffic demands from the side roads connecting to the town centre. Transient traffic queues are frequently observed along this section of Pittwater Road in the morning peak.

- The right-turn bay on Pittwater Road at approach to Oaks Avenue is occasionally observed with traffic queuing towards Fisher Road in both the morning and evening peak periods.
- Frequent bus activities at the bus stop on the eastern side of the Pittwater Road section between Howard Avenue and Oaks Avenue are observed. In both peak periods during the site visit, up to three (3) buses are observed at the kerbside lane with passenger boarding and alighting. The relatively narrow footpath adjacent to the bus stop is also observed to have a moderate number of bus passengers queuing for bus services.
- In the evening peak, slow moving traffic is observed in both the peak (northbound) and counter-peak (southbound) directions for the section of Pittwater Road between Oaks Avenue and Sturdee Parade.

2.1.2 Brookvale

- In the morning peak, moderate level of delays are expected for southbound traffic at approach to the Pittwater Road / Old Pittwater Road / Winbourne Road intersection from near the Brookvale Oval, west of Mitchell Road. This is due to a combination of delays from the traffic signal and the speed reduction of school zone effective between 8.00-9.30am.
- In the evening peak, intermittent northbound traffic queues are observed along Pittwater Road at approach to Cross Street, Old Pittwater Road and Warringah Road intersections. The northbound queues at approach to Warringah Road could propagate back south close to Mitchell Road. A mix of left-turn traffic with buses using the kerbside bus lane with queues close to approximately 50 metres is also observed at approach to Cross Street.
- Frequent bus and passenger activities are observed along Pittwater Road adjacent to Warringah Mall, where the existing 'Bus-Only' lanes are located, in both the southbound and northbound directions during the peak periods.

2.2 Traffic Data

An extensive traffic data collection and collation exercise was undertaken to inform the calibration and validation of the VISSIM models. The data was provided by RMS and consisted of the following:

- Manual classified turn count surveys in 15 minute intervals;
- Sydney Coordinated Adaptive Traffic System (SCATS) detector counts for signalised intersections in 15 minute intervals (collected for some locations where manual turn counts were not available);
- Travel time surveys for buses (including express buses and limited stops buses); and
- Travel time surveys for general traffic (all vehicle classes).

Further details of the traffic data inputs used in the traffic modelling are provided in the following sections.

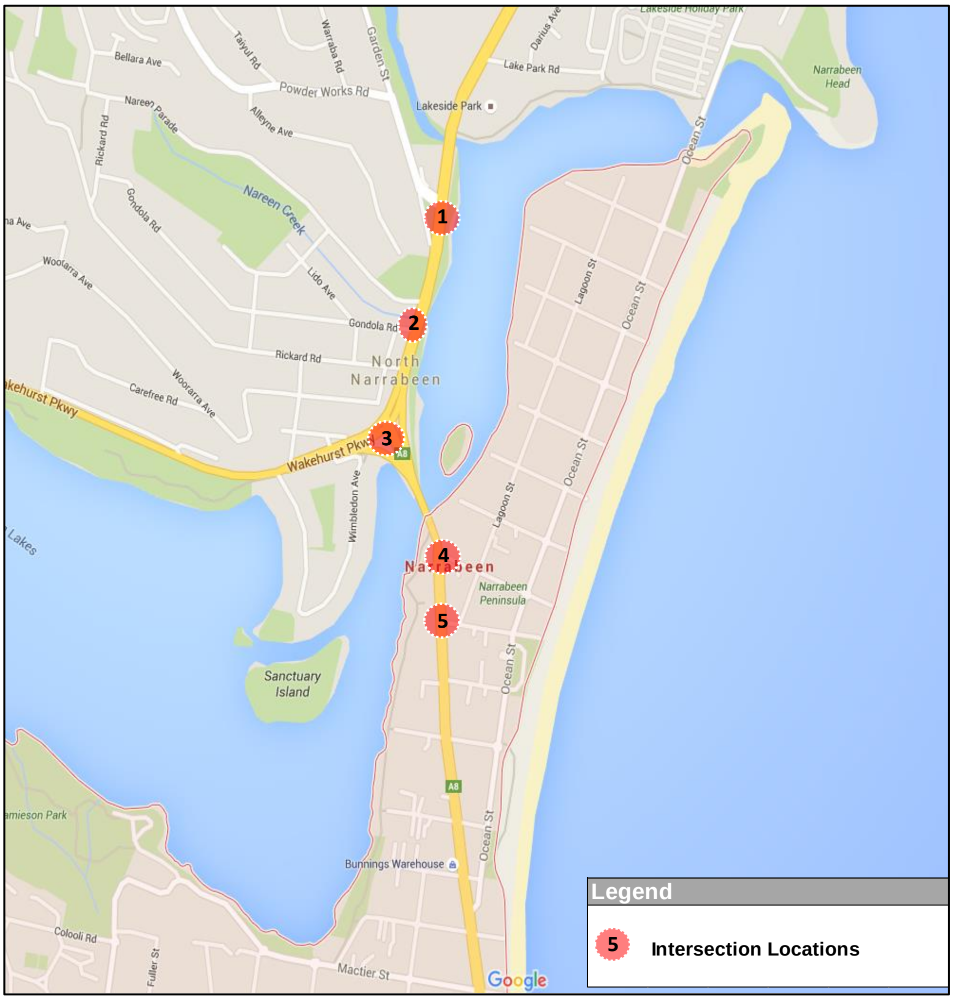
2.2.1 Manual Classified Turn Count Surveys

Manual classified turn count surveys were undertaken between 06.00 – 10.00 in the morning and 15.00 – 19.00 in the evening on a weekday; and between 11.00 and 14.00 on a Saturday. In some locations, where turning counts were not available, SCATS detector counts for the same time periods were collated in 15 minute intervals.

Figure 2-1 shows the traffic survey locations for the Brookvale / Dee Why traffic model, as summarised in **Table 2-1. Figure 2-2** shows the traffic survey locations for the Narrabeen model, as summarised in **Table 2-2**.

The observed volumes for each movement at each of the surveyed intersections are summarised in **Appendix A**.

Figure 2-1 Traffic Survey Locations (Intersection Counts and SCATS Counts) in Narrabeen

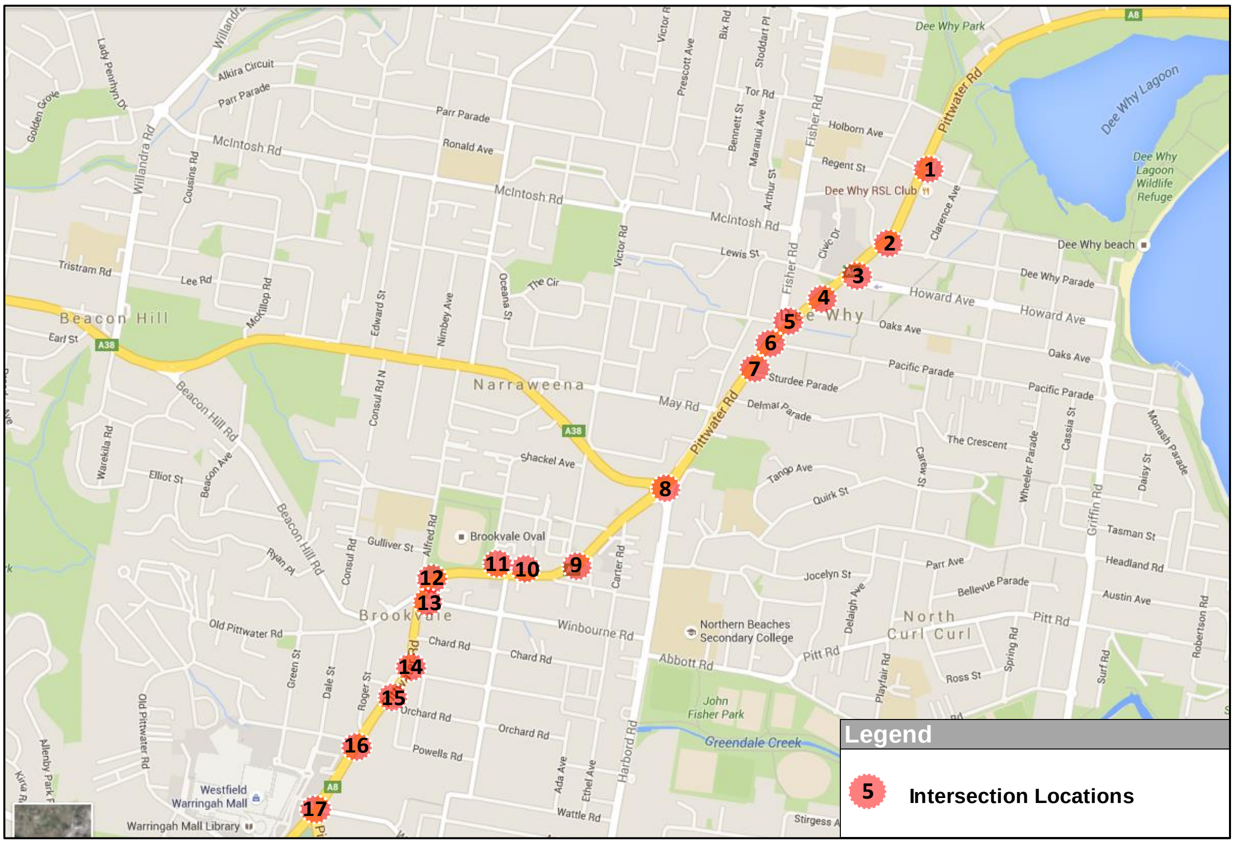


Source: Google Maps, 2016

Table 2-1 Traffic Survey s in Narrabeen

Site Number	Intersection	Intersection Control	Weekday Data Used	Weekend Data Used
1	Pittwater Road / Garden Street	Signal	**SCATS Counts -** Thursday 5 November 2015 and Wednesday 2 March 2016 (24 hours)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
2	Pittwater Road / Gondola Road	Signal	**Turning Movement Counts -** Wednesday 22 October, 2014 (from 7AM to 9AM, and 4PM to 6PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
3	Pittwater Road / Wakehurst Parkway	Signal	**Turning Movement Counts -** Tuesday 24 March 2015 (from 6AM to 10AM and 3PM to 7PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
4	Pittwater Road / Waterloo Street	Signal	**Turning Movement Counts -** Wednesday 11 November 2015 (from 6AM to 9AM and 4PM to 7PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
5	Pittwater Road / Albert Street	Signal	**Turning Movement Counts -** Monday 12 October 2015 (from 6AM to 9AM and 3PM to 6PM)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)

Figure 2-2 Traffic Survey Locations (Intersection Counts and SCATS Counts) in Brookvale / Dee Why



Source: Google Maps, 2016

Table 2-2 Traffic Surveys in Brookvale

Site Number	Intersection	Control	Weekday Data Used	Weekend Data Used
1	Pittwater Road / Hawkesbury Avenue	Signal	**SCATS Count** – Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
2	Pittwater Road / Kingsway / Dee-Why Parade	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
3	Pittwater Road / St David Avenue	Signal	**SCATS Count** – Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
4	Pittwater Road / Oaks Avenue	Signal	**SCATS Count** – Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
5	Pittwater Road / Fisher Road	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
6	Pittwater Road / Pacific Parade	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
7	Pittwater Road / Sturdee Parade	Signal	**Turning Movement Counts –** Thursday 10 October 2013 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
8	Pittwater Road / Warringah Road / Harbord Road	Signal	**SCATS Count –**Wednesday 2 March 2016 (24 hours)	**Turning Movement Counts –** Saturday 5 March 2016 (from 11AM to 2PM)
9	Pittwater Road / Victor Road	Priority	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	Nominal volumes were assumed due to a lack of data
10	Pittwater Road / Mitchell Road	Signal	**SCATS Count –**Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
11	Pittwater Road / Pine Avenue	Signal	**SCATS Count –**Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
12	Pittwater Road / Alfred Road	Priority	**Turning Movement Counts – ** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	Nominal volumes were assumed due to a lack of data
13	Pittwater Road / Old Pittwater Road / Winbourne Road	Signal	**SCATS Count –**Thursday 5 November 2015 (24 hours)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)

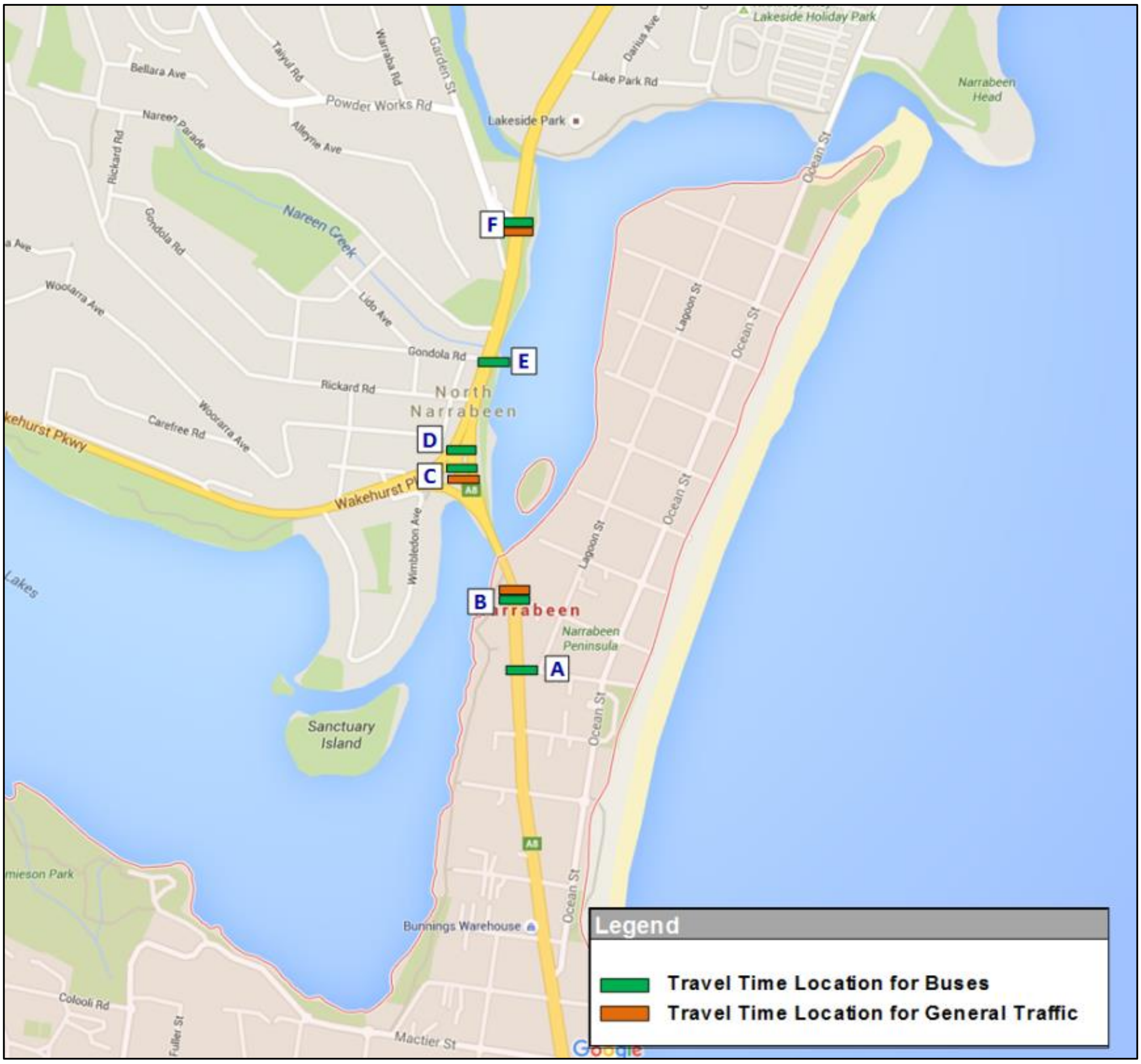
Site Number	Intersection	Control	Weekday Data Used	Weekend Data Used
14	Pittwater Road / Sydenham Road	Signal	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
15	Pittwater Road / Orchard Road	Priority	**Turning Movement Counts –** Wednesday 12 October 2011 (from 7AM to 9AM and 4PM to 6PM)	Nominal volumes were assumed due to a lack of data
16	Pittwater Road / Cross Street / Bus Depot	Signal	**Turning Movement Counts –** Tuesday 13 October 2015 (from 6AM to 9AM and 3PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)
17	Pittwater Road / Condamine Road	Signal	**Turning Movement Counts –** Tuesday 13 October 2015 (from 6AM to 9AM and 3PM to 6PM)	**SCATS Count** – Saturday 5 March November 2016 (24 hours)

2.2.2 Travel Time Data

Travel time data for general traffic was derived from Roads and Maritime's database of GPS travel times; and bus travel time data was derived from PTIPS data provided by Roads and Maritime. Although the available GPS travel data for general traffic on weekdays provided a relatively large sample size, it should be noted that the sample size of data for the Saturday period was small in comparison (between 2-5 surveys in most locations) and was not available for some sections of the corridor in the study area.

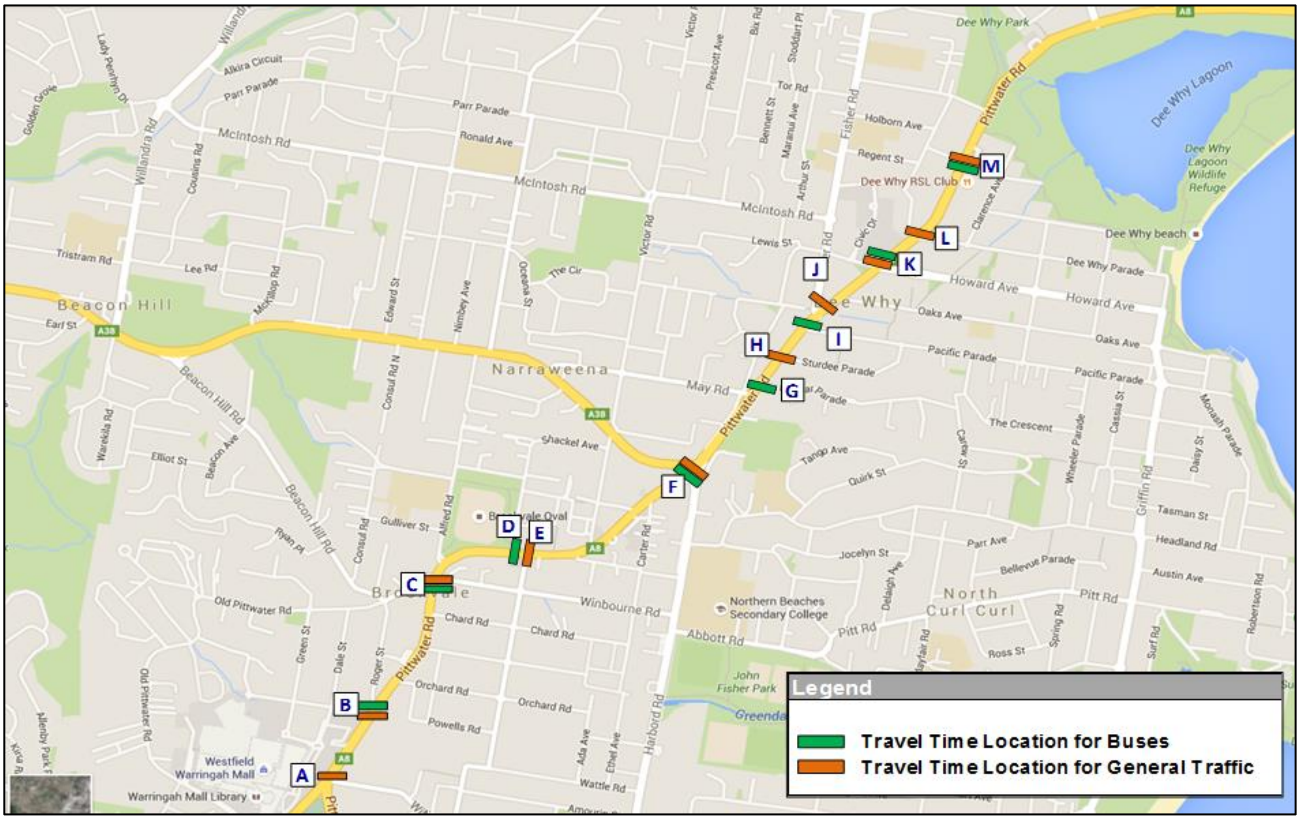
Figure 2-3 and **Figure 2-4** show the travel time sections analysed for general traffic and buses for the Narrabeen and Brookvale/ Dee Why study areas. A summary of the observed travel-time data used in the model validation process is provided in **Appendix B**.

Figure 2-3 Travel Time sections in Narrabeen



Source: Roads and Maritime, 2016

Figure 2-4 Travel Time sections in Brookvale / Dee Why



Source: Roads and Maritime, 2016

3.0 Model Development

This section of the report provides details of the VISSIM models development and network calibration.

3.1 Time Periods

The VISSIM models were developed and calibrated for two-hour peak periods for the mid-week AM/ PM and Saturday periods. The following peak periods were identified from the available traffic count data for the study areas:

- AM Peak: 07:00 to 09:00
- PM Peak: 16:30 to 18:30
- Saturday Peak: 11:30 to 13:30

The models include a 30 minute warm-up period and a 30 minute cool-down period, prior to/ following the peak periods listed above. The purpose of the warm-up period is to make sure that there is a representative level of traffic and congestion within the network at the start of the peak period. The purpose of the cool-down period is to allow all vehicles released during the evaluation period to complete their trips and to allow congestion to dissipate.

The warm-up and cool-down period demand matrices were calculated as a percentage of the peak period demand matrices, based on the available traffic count data for the study area.

3.2 Network Coding

3.2.1 Network Geometry and Intersection Coding

The VISSIM models road networks and intersection geometries were coded according to spatial data (which includes Google Maps and Street View) and aerial imagery. Observations and notes collected from the site visits were also used to further verify and confirm the details for the following key network attributes:

- Number of lanes;
- Turn restrictions;
- Intersection layouts, control mechanisms and lane arrangements;
- Posted speed limits;
- Bus stop locations;
- Stop lines at intersections; and
- Pedestrian crossings.

Non-signalised priority control movements were coded into the model using conflict areas and priority rules where appropriate. This included conflict areas for controlled pedestrian crossing where vehicles are required to give way to pedestrians.

VISSIM does not automatically calculate speed decreases associated with geometry or curved movements; therefore reduced speed areas were implemented on turn movements and curves where required. To make sure that vehicles merge into the correct lane early enough as they approach a turn, lane change parameters were adjusted from the default value as required.

3.2.2 Zone System

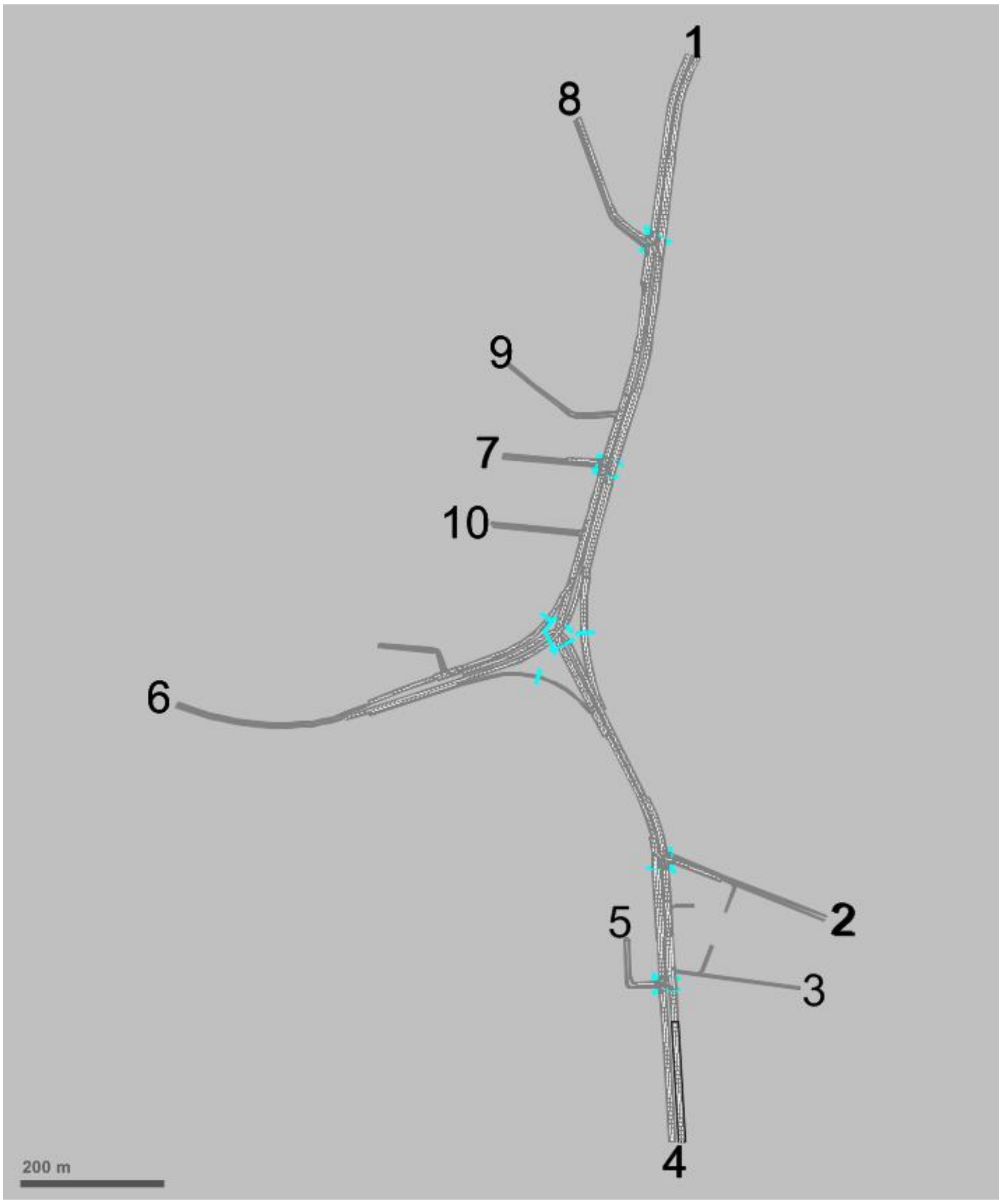
A total of 10 demand zones were defined within the Narrabeen model to cover the main traffic entry/ exit points in the network. The zones are summarised in **Table 3-1** and illustrated in **Figure 3-1**.

Table 3-1 Zone Structure for Narrabeen

Zone Number	Description
Zone 1	Pittwater Road, north of Pittwater Road / Garden Street intersection
Zone 2	Waterloo Street, east of Pittwater Road / Waterloo Street intersection
Zone 3	Albert Street, east of Pittwater Road / Albert Street intersection

Zone Number	Description
Zone 4	Pittwater Road, south of Pittwater Road / Albert Street intersection
Zone 5	Berry Carpark, west of Pittwater Road / Albert Street intersection
Zone 6	Wakehurst Parkway, west of Pittwater Road / Wakehurst Parkway intersection
Zone 7	Gondola Road, west of Pittwater Road / Gondola Road intersection
Zone 8	Garden Street, west of Pittwater Road / Garden Street intersection
Zone 9	Nareen Parade, west of Pittwater Road / Nareen Parade intersection
Zone 10	Rikard Road, west of Pittwater Road / Rikard Road intersection

Figure 3-1 Zone System for Narrabeen



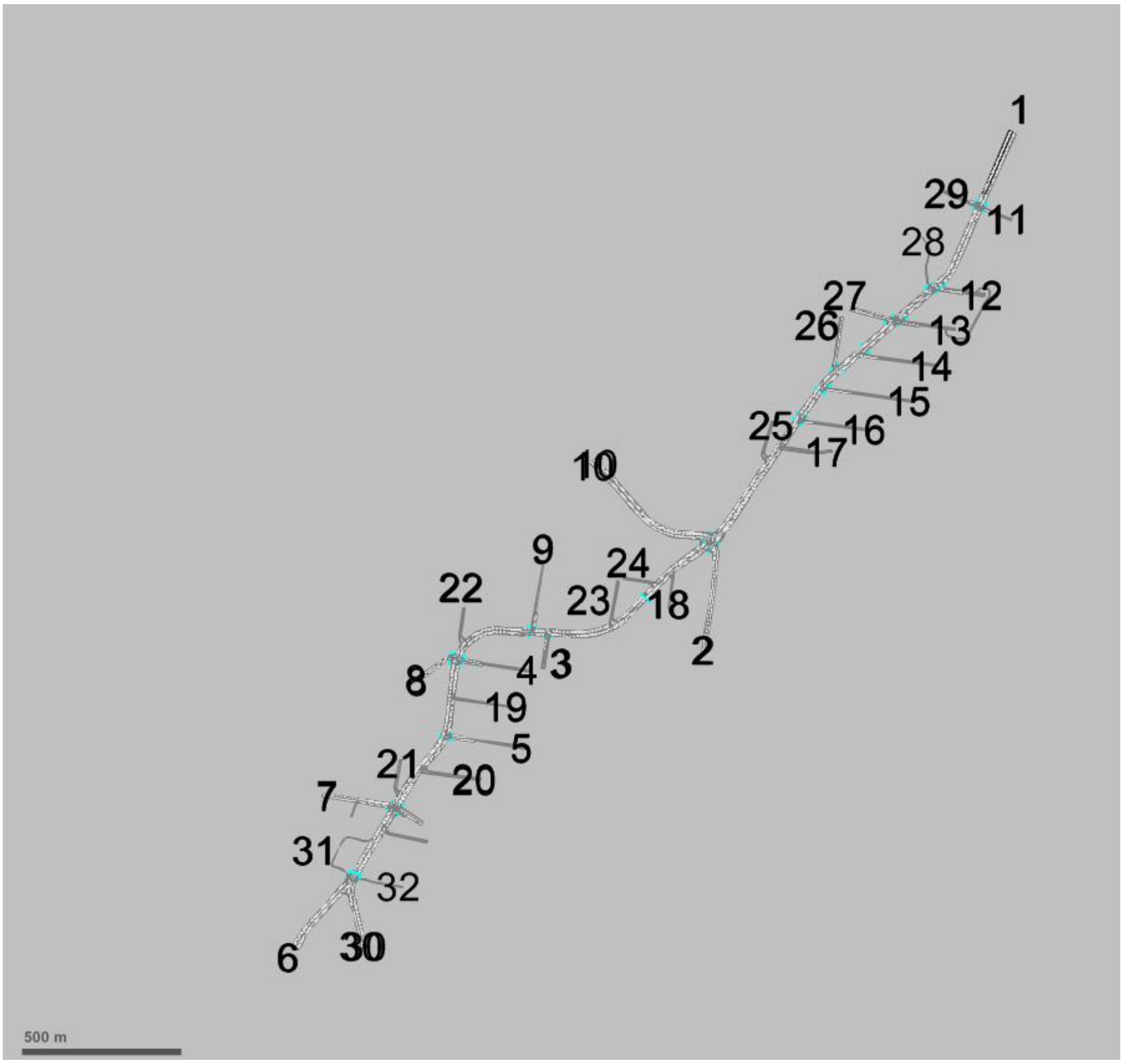
A total of 32 demand zones were defined for the Brookvale model. The zones are summarised in **Table 3-2** and illustrated in **Figure 3-2**.

Table 3-2 Zone Structure for Brookvale

Zone Number	Description
Zone 1	Pittwater Road, north of Pittwater Road / Hawkesbury Road intersection
Zone 2	Harbord Road, east of Pittwater Road / Harbord Road / Warringah Road intersection
Zone 3	Mitchell Road, east of Pittwater Road / Mitchell Road intersection
Zone 4	Winbourne Road, east of Pittwater Road / Winbourne Road / Old Pittwater Road intersection
Zone 5	Sydenham Road, east of Pittwater Road / Sydenham Road intersection
Zone 6	Condamine Road, south of Pittwater Road / Condamine Road intersection
Zone 7	Cross Street, west of Pittwater Road / Cross Street intersection
Zone 8	Old Pittwater Road, west of Pittwater Road / Winbourne Road intersection
Zone 9	Pine Avenue, west of Pittwater Road / Pine Avenue intersection
Zone 10	Warringah Road, west of Pittwater Road / Harbord Road / Warringah Road intersection
Zone 11	Hawkesbury Avenue, east of Pittwater Road / Hawkesbury Road intersection
Zone 12	Dee-Why Parade, east of Pittwater Road / Kingsway / Dee-Why Parade intersection
Zone 13	Howard Avenue, east of Pittwater Road / St David Avenue / Howard Avenue intersection
Zone 14	Oaks Avenue, east of Pittwater Road / Oaks Avenue intersection
Zone 15	Pacific Parade, east of Pittwater Road / Pacific Parade intersection
Zone 16	Sturdee Parade, east of Pittwater Road / Sturdee Parade intersection
Zone 17	Delmar Parade, east of Pittwater Road / Delmar Parade intersection
Zone 18	Carter Road, east of Pittwater Road / Carter Road intersection
Zone 19	Chard Road, east of Pittwater Road / Chard Road intersection
Zone 20	Orchard Road, east of Pittwater Road / Orchard Road intersection
Zone 21	Roger Street, west of Pittwater Road / Roger Street intersection
Zone 22	Alfred Road, west of Pittwater Road / Alfred Road intersection
Zone 23	Victor Road, west of Pittwater Road / Victor Road intersection
Zone 24	Federal Parade, west of Pittwater Road / Federal Parade intersection
Zone 25	Mooramba Road, west of Pittwater Road / Mooramba Road intersection
Zone 26	Fisher Road, west of Pittwater Road / Fisher Road intersection
Zone 27	St David Avenue, west of Pittwater Road / St David Avenue / Howard Avenue intersection
Zone 28	Kingsway
Zone 29	Hawkesbury Avenue, west of Pittwater Road / Hawkesbury Road intersection

Zone Number	Description
Zone 30	Pittwater Road, south of Pittwater Road / Condamine Road intersection
Zone 31	Warringah Mall
Zone 32	William Street, east of Pittwater Road / William Street

Figure 3-2 Zone System for Brookvale/Dee Why



3.2.3 Traffic Signal Operation

The Narrabeen and Brookvale / Dee Why models consist of a number of signalised intersections, which operate under SCATS control. All of the signal plans in the models were coded with fixed phase times. The phase times were based on average phase time data calculated from IDM data provided by RMS. The phase times were broken down into 30 minute intervals to reflect the changes in signal plans and average timings across the peak periods.

Details of link plans and offsets between groups of intersections were obtained from SCATS and coded into the models to provide a representation of the corridor operation as a network of connected signals. Co-ordination between networks of signals was achieved by maintaining common cycle times.

Coding of the link plans and offsets was important to achieve a good representation of observed traffic flow progression along the corridor. Adjustments were made to the signal offsets and timings where necessary to maintain the observed flow progression across the 30 minute intervals within the peak periods and to assist in the model validation process.

Within the VISSIM models, the signalised intersections were coded in VisVAP so that the cycle times and phase times could be varied by 30 minute intervals according to the IDM data. The signal coding in VisVAP will also allow easier implementation of bus priority signal actuation if required for future scenario testing.

3.3 Traffic Demands

3.3.1 Matrix Development

Traffic demand matrices were developed using a matrix furnessing technique to calibrate the modelled demands to the observed count data. Manual adjustments were made to the demand matrices for a small number of O-D pairs in order to achieve a good level of calibration to the observed counts. High-level trip length distribution checks were undertaken to make sure the model was not producing an excessive number of short trips between adjacent zones and illogical zone pairs.

The demand matrices were developed for light and heavy vehicles separately for individual 15-minute periods to reflect the variability and inter-hour peaking effects of the traffic entering the network.

There are a number of minor intersections within the models' areas for which traffic counts were unavailable. These intersections are all relatively minor priority controlled intersections and a large proportion of them are Left-In / Left-Out (LILO) and are not considered to have a significant impact on the operation of the corridor. As such, a nominal demand was added to these intersections for visualisation purposes. These locations include:

- Narrabeen:
  - Pittwater Road / Nareen Parade (LILO)
  - Pittwater Road / Rickard Road (LILO)
- Brookvale / Dee Why:
  - Pittwater Road / Delmar Parade (Three-way, priority controlled)
  - Pittwater Road / Mooramba Road (LILO)
  - Pittwater Road / Carter Road (LILO)
  - Pittwater Road / Federal Parade (Three-way, priority controlled)
  - Pittwater Road / Chard Road (LILO)
  - Pittwater Road / Roger Street (LILO

3.3.2 Demand Release Profiles

Demand release profiles control the rate of release of vehicles from the demand matrix into the model network over the course of the model period. The demand release profiles were developed for 15 minute intervals for each zone in the model using traffic count data for the study area. The profiles were then applied to the overall 3-hour demand matrices to produce demand matrices in 15 minute time slices.

3.3.3 Public Transport

All existing bus services along the corridor were included in the models. The frequencies and headways were coded according to timetable information published by Transport for NSW. The Pittwater Road corridor is utilised by three types of bus service including:

- All stops;
- Limited stops; and
- Express services.

A number of bus services are directional services or peak hour express type services, which only operate during specific times of day i.e. AM or PM, peak only. In such cases, the corresponding public transport lines were included in the model for completeness, but do not generate any bus trips (i.e. the corresponding PT line for an AM peak service is present in the PM peak model however it does not produce any buses). The Pittwater Road Corridor has bus lanes that are active depending upon the time of the day, i.e. bus lane is active in peak direction. When a bus lane is not active, it may be used for parking.

Comprehensive bus stop dwell time data was not available at the time of model development. As an initial starting point, the dwell time assumptions from the Northern Beaches B-Line AIMSUN base model (developed by Jacobs as part of the Business Case) was adopted. During the travel time validation process, the bus dwell times were further manipulated to closely match bus travel times calculated from PTIPS data.

3.3.4 Pedestrians

Count data for pedestrian movements was not available for input into the model development process. It was however possible to determine pedestrian activity across the study area by interrogating the SCATS IDM data for the signalised intersections to see how often pedestrian phases are called during the peak periods.

Analysis of the IDM data revealed that pedestrian phases are generally called over 70% of the time at most signalised intersections, which indicates that there is currently a reasonable level of pedestrian demand for the controlled crossing facilities.

In the absence of pedestrian count data, a nominal demand of 50 pedestrians per hour was coded for each crossing location. This is to ascertain that there is some level of interaction in the model between vehicles and pedestrians; and will allow for the analysis of pedestrian movements in the future year scenarios.

In locations in the model where pedestrian movements caused significant delay to turning vehicles, reviews against site observations were made and the pedestrian demands adjusted accordingly.

4.0 Model Calibration

This section of the report provides details of the model demand calibration process and outcomes.

4.1 Calibration Criteria

The model calibration exercise involved comparisons between modelled and observed traffic count data. The GEH statistic was used during the calibration of the models to compare the difference between observed flow and assigned flow on each turn movement.

The GEH statistic is calculated using the following equation:

$$GEH = \sqrt{\frac{(E-V)^2}{\frac{E+V}{2}}}$$

Where:

E = modelled flow

V = observed flow

Comparisons between the modelled and observed flow are made using the GEH statistic as it is able to cope with a wide range of traffic flows. For example, a difference of 100 vehicles per hour is significant in a flow of 200 vehicles per hour but it is insignificant in a flow of thousands of vehicles per hour.

The model was calibrated against the criteria outlined in the *RMS Traffic Modelling Guidelines 2013.* The guidelines recommend that 85% of counts across the model networks should be within 5 GEH of the observed counts.

To reflect the impact of daily traffic variation, VISSIM randomises the release of vehicles into the network using different seed values. A run of the model using a single seed value may produce a random event that increases delays in a certain area of the model, leading to unrepresentative results. An example would be the simultaneous arrival of HGVs at a certain intersection. It is therefore a good practice to run the model using a range of seed values to compare an average of the model results to the observed data.

The base models were calibrated and validated over an average of 5 model seeds values, in line with the criteria recommended in the *RMS Traffic Modelling Guidelines 2013*. The RMS recommended seed values used are 560, 28, 7771, 86524 and 2849.

4.2 Flow Comparisons

4.2.1 Narrabeen Model

Table 4-1 to **Table 4-3** provide summaries of the model calibration outputs for the Narrabeen base model for each time period.

Table 4-1 AM Period Calibration Results Summary Narrabeen

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
7:00 AM-8:00AM	GEH < 5	>85%	33	32	97%
8:00 AM-9:00AM	GEH < 5	>85%	33	30	91%

Table 4-2 PM Period Calibration Results Summary Narrabeen

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
4:30PM-5:30PM	GEH < 5	>85%	33	33	100%
5:30PM-6:30PM	GEH < 5	>85%	33	32	97%

Table 4-3 Saturday Period Calibration Results Summary Narrabeen

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
11:30AM-12:30PM	GEH < 5	>85%	33	32	97%
12:30PM-1:30PM	GEH < 5	>85%	33	29	88%

The outputs indicate that over 90% of the observed flows are within 5 GEH of the observed flows for majority of the calibrated hourly time periods. In addition, no movement was found to have a GEH of greater than 10. It was therefore considered that the Narrabeen base year model is sufficiently calibrated to the observed traffic count data.

4.2.2 Brookvale / Dee Why Model

Table 4-4 to **Table 4-6** provide summaries of the model calibration outputs for the Brookvale base model for each time period.

Table 4-4 AM Period Calibration Results Summary Brookvale / Dee Why

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
7:00 AM-8:00AM	GEH < 5	>85%	110	107	97%
8:00 AM-9:00AM	GEH < 5	>85%	110	100	91%

Table 4-5 PM Period Calibration Results Summary Brookvale / Dee Why

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
4:30PM-5:30PM	GEH < 5	>85%	110	104	95%
5:30PM-6:30PM	GEH < 5	>85%	110	100	91%

Table 4-6 Saturday Period Calibration Results Summary Brookvale / Dee Why

Time	Measurements	Target	Total Counts Considered	No. of Counts GEH < 5	% of Counts GEH < 5
11:30-12:30	GEH < 5	>85%	101	96	95%
12:30-13:30	GEH < 5	>85%	101	99	98%

It should be noted that for the Saturday model, there were several turning movements where observed traffic volumes were not available and as such the observed traffic volumes for these movements could not be compared to the modelled volume. For this reason the ‘Total Counts Considered’ value is slightly lower for Saturday than during the weekday peak periods.

The outputs indicate that over 90% of the observed flows are within 5 GEH of the observed flows for each hour in each time period. In addition, no movement was found to have a GEH of greater than 10. It was therefore considered that the Brookvale/Dee Why base year model is sufficiently calibrated to the observed traffic count data.

Flow comparisons for each of the modelled vs. observed turn movements in the models are provided in **Appendix A**.

5.0 Model Validation

Model validation is a term used to describe the independent process undertaken to demonstrate that a model has been calibrated to a sufficient extent to accurately reproduce on-the-ground traffic conditions. This process involves a comparison of model outputs to an independent set of data that has not been used in the model calibration.

For this assessment traffic count data was used to calibrate the model demands, with the model subsequently validated against travel time data for general traffic and buses. The model travel times have been validated against the RMS modelling criteria:

- *Average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times.*

This section of the report provides details of the validation processes undertaken and summarises the validation results for the Narrabeen and Brookvale / Dee Why base models. Detailed outputs for the model validation process, including graphical comparisons, are provided in **Appendix B**.

5.1 Narrabeen Model

A summary of the travel time validation comparisons for the Narrabeen base year model are presented in **Table 5-1** and **Table 5-2**.

Table 5-1 Narrabeen Base Year Model Travel Time Comparisons Hour 1 (mm:ss)

Vehicle Type/ Route	AM Peak 0700-0800			PM Peak 1630-1730			Saturday 1130-1230		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	1:57	2:02	5	2:05	2:33	28	1:56	2:40	43
General traffic SB	0:57	1:21	24	1:19	1:22	2	1:45	1:30	-15
Buses NB	3:44	3:16	-27	3:19	2:50	-29	4:16	4:25	9
Buses SB	3:48	2:58	-50	3:28	3:15	-4	3:51	3:18	-33

Table 5-2 Narrabeen Base Year Model Travel Time Comparisons Hour 2 (mm:ss)

Vehicle Type/ Route	AM Peak 0800-0900			PM Peak 1730-1830			Saturday 1230-1330		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	2:06	1:37	-29	2:11	2:52	40	2:50	1:57	-52
General traffic SB	0:56	1:21	25	1:16	1:22	7	2:00	1:01	-59
Buses NB	3:19	3:43	24	3:17	3:29	13	3:45	4:26	42
Buses SB	3:20	3:25	5	2:57	2:53	-4	3:12	2:39	-33

The comparisons show that the modelled travel times for general traffic and buses are within one minute of the observed times for all routes and in all time periods. This indicates that the model achieves a good level of validation to observed conditions in terms of general traffic and bus travel times and flow progression along the corridor in both directions.

In the PM period it was found that the signal link plans and offsets obtained from SCATS produced significant congestion in the northbound direction along Pittwater Road that did not align with the observed travel time data. The signal offsets were therefore adjusted in line with site video observations to validate the model to the observed northbound flow progression and travel times.

5.2 Brookvale / Dee Why Model

A summary of the travel time validation comparisons for the Brookvale / Dee Why base year model are presented in **Table 5-3** and **Table 5-4**.

Table 5-3 Brookvale / Dee Why Base Year Model Travel Time Comparisons Hour 1 (mm:ss)

Vehicle Type/ Route	AM Peak 0700-0800			PM Peak 1630-1730			Saturday 1130-1230		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	05:56	06:06	3%	08:31	09:45	14%	05:41	06:09	8%
General traffic SB	07:14	07:02	-3%	07:16	06:31	-10%	06:52	06:07	-11%
Buses NB	09:16	09:31	3%	07:59	07:17	-9%	10:07	10:01	-1%
Buses SB	10:12	10:09	-1%	10:02	10:10	1%	12:34	10:30	-16%

Table 5-4 Brookvale / Dee Why Base Year Model Travel Time Comparisons Hour 2 (mm:ss)

Vehicle Type/ Route	AM Peak 0800-0900			PM Peak 1730-1830			Saturday 1230-1330		
	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)	Observed	Modelled	Diff (s)
General traffic NB	05:59	06:36	10%	08:23	09:09	9%	06:01	06:54	15%
General traffic SB	09:07	07:58	-13%	07:22	06:54	-6%	06:31	06:14	-4%
Buses NB	08:45	09:50	12%	07:06	07:18	3%	09:05	10:30	16%
Buses SB	10:13	10:47	6%	09:04	10:46	19%	09:34	11:01	15%

The comparisons show that the modelled general traffic travel times are within 15% of the observed times for all routes and in all time periods. This indicates that the model achieves a good level of validation to observed conditions in terms of general traffic travel times and flow progression along the corridor in both directions.

For the bus travel time comparisons, the modelled times are within 15% of the observed for nine of the 12 routes. For the remaining three routes the average modelled travel time falls slightly outside the recommended criteria, but within 20% of the observed times in all cases. The travel time differences on these routes may be due to minor differences in bus dwell times on the survey days and are not considered to be a significant issue in terms of the model's ability to replicate existing conditions. This is supported by the good level of validation achieved for general traffic travel times.

During the development and validation of the Saturday model for Brookvale/ Dee Why it was determined that the observed travel times southbound along the corridor could not be achieved in the model when adopting the signal link plans and offsets extracted from SCATS (i.e. the modelled times were consistently higher than the observed in the southbound directions).

To validate the Saturday model, a number of changes were made to the signal offsets that adjusted the co-ordination of intersections north of Warringah Road. These changes resulted in more delay along the corridor north of Fisher Road, but resulted in a reasonable match between the observed and modelled travel times.

The most likely reason for the difficulty in validating the Saturday model is that the observed travel time survey sample size was very small. The signal coordination implemented in the 2016 Saturday model should be carried forward for the 2021 scenarios for a like-to-like comparison amongst the models.

6.0 Summary and Conclusion

This report has provided details of the development of VISSIM microsimulation models for the Pittwater Road corridor in Narrabeen and Brookvale / Dee Why in Sydney's Northern Beaches. The models were developed as part of the B-Line REF assessment and will be used to inform option development for bus priority improvement and the implementation of the B-Line service along the corridor.

An extensive data collection and collation exercise was undertaken to develop an understanding of the existing network conditions and to provide a comprehensive set of data for use in the model development process. The key data inputs included:

- On-site observations during the peak periods.
- Manual classified turn counts and SCATS counts at the key intersections and mid-block locations.
- Existing public transport service routes and frequencies.
- Signal data in the form of IDM recordings, link plans and offsets.
- Bus and general traffic travel time data for the corridor during the peak periods

The models were developed in line with best practice the midweek AM / PM and Saturday peak periods and were calibrated and validated to a satisfactory level in line with criteria recommended in the *RMS Traffic Modelling Guidelines 2013*.

The outputs presented in this report show that for each model:

- Over 90% of modelled flows are within 5 GEH of the observed flows for majority of the modelled time periods.
- 100% of the modelled flows are within 10 GEH of the observed flows in each time period.
- 100% of the modelled general traffic travel time routes are within 15% / one minute (whichever is greater) of the observed in each time period.
- The vast majority of the modelled bus travel time routes are within 15% / one minute (whichever is greater) of the observed in each time period. A small number of routes have modelled bus travel times that are slightly more than 15% different to the observed, potentially due to differences in bus dwell times on the observed survey days.

On the basis of the above analysis, it has been concluded that the base year VISSIM models are satisfactorily calibrated and validated to existing traffic conditions and that the models are suitable for use in future year scenario testing.

Appendix A

Detailed Model Calibration Outputs

Narrabeen Turning Movement Flows – AM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				7 to 8	8 to 9	7 to 8	8 to 9	7 to 8	8 to 9
Pittwater / Garden	Pittwater Road	South	L	539	598	570	660	1.3	2.5
			T	1210	1525	1184	1520	0.8	0.1
	Pittwater Road	North	T	1791	1868	1744	1828	1.1	0.9
			R	69	64	68	67	0.2	0.3
	Garden Street	West	L	152	180	152	180	0.0	0.0
			R	360	425	390	462	1.5	1.8
Pittwater / Gondola	Pittwater Road	South	L	47	80	30	31	2.7	6.6
			T	1679	2014	1714	2002	0.8	0.3
	Pittwater Road	North	T	2103	2218	2120	2222	0.4	0.1
			R	45	80	63	139	2.4	5.6
	Gondola Street	West	L	67	99	38	82	4.0	1.8
			R	79	109	99	112	2.1	0.3
Pittwater / Wakehurst	Pittwater Road	South	L	315	319	247	261	4.1	3.4
			T	1331	1570	1389	1635	1.6	1.6
	Pittwater Road	North	T	1523	1653	1567	1599	1.1	1.3
			R	673	664	723	742	1.9	2.9
	Wakehurst Parkway	West	L	385	517	407	489	1.1	1.2
			R	248	302	218	328	2.0	1.5
Pittwater / Waterloo	Pittwater Road	South	T	1410	1597	1419	1596	0.2	0.0
			R	67	87	39	41	3.8	5.8
	Waterloo Street	East	L	120	125	63	76	6.0	4.9
			R	255	302	265	287	0.6	0.9
	Pittwater Road	North	L	116	175	136	210	1.8	2.5
			T	1663	1782	1583	1783	2.0	0.0
Pittwater / Albert / Berry Car Park	Pittwater Road	South	L	22	20	22	22	0.0	0.4
			T	1474	1686	1413	1589	1.6	2.4
	Pittwater Road	North	L	47	26	50	25	0.4	0.2
			T	1727	1863	1673	1848	1.3	0.3
			R	20	18	21	23	0.2	1.1
	Berry Car Park	West	L	0	0	0	1	0.0	1.4
			R	14	14	13	14	0.3	0.0
Pittwater / Wakehurst	Pittwater Road	South	T	6	7	10	21	1.4	3.7
	Pittwater Road	North	T	38	12	48	25	1.5	3.0

Narrabeen Turning Movement Flows – PM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				16.30 to 17.30	17.30 to 18.30	16.30 to 17.30	17.30 to 18.30	16.30 to 17.30	17.30 to 18.30
Pittwater / Garden	Pittwater Road	South	L	569	504	653	587	3.4	3.6
			T	1888	1937	1956	2028	1.6	2.0
	Pittwater Road	North	T	1758	1624	1791	1590	0.8	0.9
			R	86	83	85	87	0.1	0.4
	Garden Street	West	L	302	247	296	245	0.3	0.1
			R	496	396	548	454	2.3	2.8
Pittwater / Gondola	Pittwater Road	South	L	102	97	88	75	1.4	2.4
			T	2354	2330	2497	2122	2.9	4.4
	Pittwater Road	North	T	2077	1872	2190	1862	2.4	0.2
			R	167	152	218	185	3.7	2.6
	Gondola Street	West	L	103	94	82	70	2.2	2.7
			R	82	66	94	80	1.3	1.6
Pittwater / Wakehurst	Pittwater Road	South	L	187	147	176	146	0.8	0.1
			T	1549	1467	1704	1590	3.8	3.1
	Pittwater Road	North	T	1552	1389	1496	1427	1.4	1.0
			R	609	543	571	494	1.6	2.2
	Wakehurst Parkway	West	L	915	948	963	941	1.6	0.2
			R	376	353	366	367	0.5	0.7
Pittwater / Waterloo	Pittwater Road	South	T	1571	1352	1543	1448	0.7	2.6
			R	89	99	72	70	1.9	3.2
	Waterloo Street	East	L	55	48	82	83	3.3	4.3
			R	203	224	193	193	0.7	2.1
	Pittwater Road	North	L	247	310	236	312	0.7	0.1
			T	1685	1414	1839	1684	3.7	6.9
Pittwater / Albert / Berry Car Park	Pittwater Road	South	L	14	10	13	11	0.3	0.3
			T	1649	1449	1505	1279	3.6	4.6
	Pittwater Road	North	L	16	15	18	15	0.5	0.1
			T	1692	1416	1521	1293	4.3	3.3
			R	39	33	38	32	0.2	0.1
	Berry Car Park	West	L	2	2	3	3	0.6	0.4
			R	25	19	25	21	0.0	0.5

Narrabeen Turning Movement Flows – Sat Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled 1130 to 1230	Modelled 1230 to 1330	Observed 1130 to 1230	Observed 1230 to 1330	GEH 1130 to 1230	GEH 1230 to 1330
Pittwater / Garden	Pittwater Road	South	L	29	34	29	39	0.0	0.8
			T	2234	2096	2153	2073	1.7	0.5
	Pittwater Road	North	T	2136	1826	2320	2017	3.9	4.4
			R	240	198	233	200	0.5	0.1
	Garden Street	West	L	54	19	49	20	0.7	0.2
			R	87	62	98	80	1.1	2.1
Pittwater / Gondola	Pittwater Road	South	L	77	80	48	59	3.7	2.5
			T	2164	2061	2113	2023	1.1	0.8
	Pittwater Road	North	T	2101	1763	2196	2059	2.0	6.8
			R	129	116	174	177	3.7	5.0
	Gondola Street	West	L	93	65	77	59	1.7	0.8
			R	94	65	105	87	1.1	2.5
Pittwater / Wakehurst	Pittwater Road	South	L	336	324	216	240	7.2	5.0
			T	1437	1388	1364	1322	2.0	1.8
	Pittwater Road	North	T	1604	1366	1750	1640	3.6	7.1
			R	602	460	592	498	0.4	1.7
	Wakehurst Parkway	West	L	794	762	812	798	0.6	1.3
			R	414	402	357	349	2.9	2.7
Pittwater / Waterloo	Pittwater Road	South	T	1544	1472	1579	1522	0.9	1.3
			R	86	93	87	99	0.1	0.6
	Waterloo Street	East	L	117	116	100	75	1.6	4.2
			R	220	224	249	254	1.9	1.9
	Pittwater Road	North	L	200	188	167	167	2.4	1.6
			T	1816	1575	1661	1568	3.7	0.2
Pittwater / Albert / Berry Car Park	Pittwater Road	South	L	26	23	26	22	0.0	0.2
			T	1627	1562	1656	1608	0.7	1.2
	Pittwater Road	North	L	46	21	41	22	0.8	0.2
			T	1855	1647	1749	1601	2.5	1.1
			R	25	35	27	34	0.4	0.2
	Berry Car Park	West	L	6	0	5	2	0.4	2.0
			R	27	19	20	18	1.4	0.2

Brookvale Turning Movement Flows – AM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled		Observed		GEH	
				7 to 8	8 to 9	7 to 8	8 to 9	7 to 8	8 to 9
Pittwater / Hawkesbury	Pittwater Road	South	L	11	14	16	19	1.3	1.3
			T	892	996	921	1120	1.0	3.8
			R	29	52	37	60	1.4	1.1
	Hawkesbury Avenue	East	L	7	11	14	21	2.2	2.5
			T	33	32	33	50	0.1	2.8
			R	101	94	101	152	0.0	5.2
	Pittwater Road	North	L	315	498	323	497	0.4	0.0
			T	1480	1692	1359	1613	3.2	1.9
	Hawkesbury Avenue	West	L	13	24	12	26	0.3	0.3
			T	68	137	68	147	0.0	0.9
			R	25	60	29	63	0.8	0.4
Pittwater / Dee Why / Kingsway	Pittwater Road	South	L	18	33	24	40	1.3	1.2
			T	727	803	760	935	1.2	4.5
	Dee Why Parade	East	L	19	34	65	61	7.1	3.9
			T	72	84	75	84	0.3	0.0
			R	213	251	230	292	1.1	2.5
	Pittwater Road	North	L	141	188	157	199	1.3	0.8
			T	1382	1562	1408	1512	0.7	1.3
Pittwater / Howard / St David	Pittwater Road	South	L	25	29	33	38	1.5	1.5
			T	708	793	682	780	1.0	0.5
	Howard Avenue	East	L	43	41	32	35	1.7	1.0
			T	151	163	147	160	0.3	0.3
			R	26	30	55	60	4.6	4.5
	Pittwater Road	North	L	55	54	61	58	0.8	0.5
			T	1336	1552	1315	1239	0.6	8.4
	St David Avenue	West	L	10	14	25	37	3.6	4.5
			T	126	183	127	185	0.0	0.2
			R	25	32	10	15	3.5	3.4
Pittwater / Oaks	Pittwater Road	South	T	733	821	713	815	0.7	0.2
			R	134	127	140	143	0.5	1.4
	Oaks Avenue	East	L	105	96	103	92	0.2	0.4
	Pittwater Road	North	L	58	60	61	56	0.4	0.6
			T	1327	1567	1331	1215	0.1	9.4
Pittwater / Fisher	Pittwater Road	South	L	283	422	316	472	1.9	2.4
			T	824	905	825	1007	0.0	3.3
	Pittwater Road	North	T	1415	1661	1507	1560	2.4	2.5
	Fisher Road	West	L	43	43	37	49	0.9	0.9
			R	434	386	481	461	2.2	3.6
Pittwater / Pacific	Pittwater Road	South	T	1043	1203	991	1242	1.6	1.1
	Pacific Parade	East	L	165	194	123	90	3.5	8.7
			R	78	123	153	244	7.0	8.9

	Pittwater Road	North	L	68	130	79	138	1.3	0.7
			T	1774	1917	1913	1959	3.2	1.0
Pittwater / Sturdee	Pittwater Road	South	T	958	1110	1098	1182	4.4	2.1
			R	71	114	115	163	4.6	4.2
	Sturdee Parade	East	L	220	214	259	278	2.5	4.1
			R	88	100	50	39	4.6	7.3
	Pittwater Road	North	L	22	41	15	40	1.6	0.2
			T	1905	2064	2036	2082	3.0	0.4
Pittwater / Warringah / Harbord	Pittwater Road	South	L	119	143	82	102	3.7	3.7
			T	819	1030	846	950	0.9	2.5
			R	107	129	105	123	0.2	0.5
	Harbord Road	East	L	25	27	26	34	0.2	1.3
			T	350	363	344	387	0.3	1.2
			R	259	266	263	269	0.2	0.2
	Pittwater Road	North	L	364	413	453	447	4.4	1.6
			T	1414	1607	1596	1586	4.7	0.5
			R	270	283	298	308	1.7	1.5
	Warringah Road	West	L	67	86	108	128	4.4	4.1
			T	418	469	419	485	0.0	0.7
			R	312	386	336	448	1.3	3.0
Pittwater / Mitchell	Mitchell Road	South	L	25	44	28	48	0.6	0.6
			R	125	222	134	225	0.8	0.2
	Pittwater Road	East	L	38	45	15	15	4.6	5.5
			T	1573	1721	1744	1807	4.2	2.0
	Pittwater Road	West	T	1003	1113	860	1163	4.7	1.5
			R	36	41	86	89	6.4	5.9
Pittwater / Pine	Pittwater Road	East	T	1495	1653	1675	1718	4.5	1.6
			R	103	112	84	104	2.0	0.8
	Pine Avenue	North	L	82	93	44	74	4.8	2.1
			R	65	75	104	97	4.2	2.4
	Pittwater Road	West	L	51	61	23	29	4.7	4.7
			T	957	1061	882	1146	2.5	2.6
Pittwater / Old Pittwater / Winbourne	Pittwater Road	South	L	30	37	30	39	0.1	0.4
			T	799	896	772	999	1.0	3.3
	Winbourne Road	East	L	59	98	59	97	0.0	0.1
			T	148	247	152	249	0.3	0.1
	Pittwater Road	North	L	10	12	10	11	0.1	0.3
			T	1365	1475	1213	1268	4.2	5.6
			R	177	244	204	247	2.0	0.2
	Old Pittwater Road	West	L	97	96	85	89	1.2	0.8
			T	134	140	136	142	0.2	0.1
			R	88	96	132	138	4.2	3.9
Pittwater / Sydenham	Pittwater Road	South	T	871	1035	885	1113	0.5	2.4
			R	176	232	190	255	1.0	1.5
	Sydenham	East	L	91	130	96	143	0.5	1.1

	Road		R	0	0	2	0	2.0	0.0
	Pittwater Road	North	L	18	22	21	29	0.7	1.4
			T	1490	1644	1385	1519	2.8	3.1
Pittwater / Cross / Bus Station	Pittwater Road	South	L	80	161	129	234	4.8	5.2
			T	1072	1272	1106	1403	1.0	3.6
	Pittwater Road	North	T	1445	1509	1506	1451	1.6	1.5
			R	140	347	135	311	0.4	2.0
	Cross Road	West	L	93	148	75	148	2.0	0.0
			R	135	198	126	185	0.8	0.9
Pittwater / Condamine / William	Condamine Street	South	L	25	76	26	78	0.2	0.2
			T	927	1169	851	1160	2.5	0.3
	Pittwater Road	East	L	78	137	79	132	0.1	0.4
			T	23	70	23	70	0.0	0.0
			R	368	455	309	409	3.2	2.2
	Pittwater Road	North	L	330	479	338	411	0.4	3.2
			T	1228	1225	1323	1215	2.7	0.3

Brookvale Turning Movement Flows – AM Peak (Buses)

Pittwater / Hawkesbury	Pittwater Road	South	T	13	16	27	23	3.1	1.6
	Pittwater Road	North	T	68	37	51	39	2.2	0.3
Pittwater / Condamine / William	Condamine Street	South	T	10	15	11	31	0.3	3.3
	Condamine Street	North	T	64	40	96	57	3.6	2.4

Brookvale Turning Movement Flows – PM Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled 16.30 to 17.30	Modelled 17.30 to 18.30	Observed 16.30 to 17.30	Observed 17.30 to 18.30	GEH 16.30 to 17.30	GEH 17.30 to 18.30
Pittwater / Hawkesbury	Pittwater Road	South	L	24	24	31	28	1.3	0.8
			T	1702	1644	1709	1556	0.2	2.2
			R	64	66	74	77	1.2	1.3
	Hawkesbury Avenue	East	L	30	23	23	19	1.3	0.8
			T	104	90	105	87	0.1	0.3
			R	177	150	176	147	0.1	0.3
	Pittwater Road	North	L	275	258	274	258	0.1	0.0
			T	1146	1066	1142	1047	0.1	0.6
	Hawkesbury Avenue	West	L	28	28	25	29	0.5	0.2
			T	132	133	121	137	1.0	0.4
			R	40	44	34	39	0.9	0.8
Pittwater / Dee Why / Kingsway	Pittwater Road	South	L	70	76	64	60	0.7	1.9
			T	1572	1508	1614	1624	1.1	2.9
	Dee Why Parade	East	L	50	49	79	62	3.6	1.7
			T	91	105	91	104	0.0	0.1
			R	232	235	318	340	5.2	6.2
	Pittwater Road	North	L	125	146	116	150	0.8	0.3
			T	1082	985	1037	1024	1.4	1.2
Pittwater / Howard / St David	Pittwater Road	South	L	37	41	35	35	0.3	1.0
			T	1523	1467	1346	1320	4.7	3.9
	Howard Avenue	East	L	54	51	63	60	1.1	1.1
			T	170	165	165	157	0.4	0.7
			R	83	81	107	102	2.5	2.2
	Pittwater Road	North	L	66	55	64	58	0.3	0.5
			T	1061	985	1097	1006	1.1	0.7
	St David Avenue	West	L	40	41	59	58	2.7	2.4
			T	251	243	247	240	0.3	0.2
			R	7	8	4	4	1.1	1.5
Pittwater / Oaks	Pittwater Road	South	T	1562	1505	1397	1357	4.3	3.9
			R	186	199	242	262	3.8	4.1
	Oaks Avenue	East	L	181	147	154	137	2.1	0.8
	Pittwater Road	North	L	40	44	51	48	1.7	0.6
			T	1084	996	1117	1044	1.0	1.5
Pittwater / Fisher	Pittwater Road	South	L	548	515	592	548	1.8	1.4
			T	1680	1628	1728	1694	1.2	1.6
	Pittwater Road	North	T	1275	1139	1177	1036	2.8	3.1
	Fisher Road	West	L	68	78	43	62	3.4	1.9
			R	448	437	470	436	1.0	0.0
Pittwater / Pacific	Pittwater Road	South	T	1872	1809	1999	1970	2.9	3.7
	Pacific Parade	East	L	51	47	75	78	3.0	3.9

			R	356	334	328	324	1.5	0.6
	Pittwater Road	North	L	185	168	172	168	1.0	0.0
			T	1544	1401	1465	1366	2.0	0.9
Pittwater / Sturdee	Pittwater Road	South	T	1778	1722	1820	1800	1.0	1.9
			R	213	236	313	350	6.2	6.7
	Sturdee Parade	East	L	138	126	196	192	4.5	5.2
			R	83	87	56	50	3.2	4.5
	Pittwater Road	North	L	54	56	86	56	3.8	0.0
			T	1546	1377	1508	1434	1.0	1.5
Pittwater / Warringah / Harbord	Pittwater Road	South	L	156	133	134	101	1.8	3.0
			T	1526	1510	1579	1457	1.3	1.4
			R	153	124	124	114	2.5	0.9
	Harbord Road	East	L	15	13	29	26	3.0	2.9
			T	440	406	439	409	0.0	0.1
			R	365	394	353	380	0.6	0.7
	Pittwater Road	North	L	314	359	397	449	4.4	4.5
			T	1051	930	997	886	1.7	1.5
			R	286	256	350	299	3.6	2.6
	Warringah Road	West	L	196	198	243	249	3.2	3.4
			T	441	483	439	492	0.1	0.4
			R	268	242	198	164	4.6	5.5
Pittwater / Mitchell	Mitchell Road	South	L	53	35	43	29	1.5	1.0
			R	348	300	345	239	0.1	3.7
	Pittwater Road	East	L	128	139	187	165	4.7	2.1
			T	1199	1015	1095	962	3.1	1.7
	Pittwater Road	West	T	1827	1752	1770	1642	1.3	2.7
			R	125	93	129	135	0.4	3.9
Pittwater / Pine	Pittwater Road	East	T	1198	1011	1221	1091	0.7	2.5
			R	54	39	60	37	0.8	0.4
	Pine Avenue	North	L	111	78	64	35	5.0	5.7
			R	66	39	90	91	2.7	6.4
	Pittwater Road	West	L	50	48	79	75	3.6	3.4
			T	1841	1767	1756	1667	2.0	2.4
Pittwater / Old Pittwater / Winbourne	Pittwater Road	South	L	59	66	81	77	2.6	1.3
			T	1428	1416	1589	1507	4.1	2.4
	Winbourne Road	East	L	96	64	93	64	0.3	0.0
			T	264	177	255	177	0.5	0.0
	Pittwater Road	North	L	27	24	26	24	0.2	0.1
			T	1140	931	1081	988	1.8	1.9
			R	102	106	113	132	1.1	2.4
	Old Pittwater Road	West	L	270	269	259	229	0.7	2.5
			T	187	166	173	153	1.0	1.0
			R	83	66	96	85	1.4	2.2
Pittwater / Sydenham	Pittwater Road	South	T	1573	1526	1579	1565	0.2	1.0
			R	214	182	302	218	5.5	2.5

	Sydenham Road	East	L	257	183	255	173	0.1	0.7
			R	0	0	1	3	1.4	2.4
	Pittwater Road	North	L	28	18	32	10	0.7	2.1
			T	1295	1049	1353	1202	1.6	4.6
Pittwater / Cross / Bus Station	Pittwater Road	South	L	78	57	120	70	4.2	1.6
			T	1577	1679	1619	1324	1.1	9.2
	Pittwater Road	North	T	1262	1007	1039	742	6.6	9.0
			R	223	131	164	100	4.2	2.9
	Cross Road	West	L	323	112	275	112	2.8	0.0
			R	366	171	317	176	2.7	0.4
Pittwater / Condamine / William	Condamine Street	South	L	47	48	51	42	0.6	0.9
			T	1250	1371	1314	1066	1.8	8.7
	Pittwater Road	East	L	50	51	49	52	0.1	0.1
			T	39	24	38	22	0.2	0.4
			R	398	384	299	284	5.3	5.5
	Pittwater Road	North	L	566	384	491	304	3.3	4.3
			T	1047	796	907	728	4.5	2.5

Brookvale Turning Movement Flows – PM Peak (Buses)

Pittwater / Hawkesbury	Pittwater Road	South	T	32	47	31	46	0.2	0.1
	Pittwater Road	North	T	19	20	25	21	1.3	0.2
Pittwater / Condamine / William	Condamine Street	South	T	37	45	60	59	3.3	1.9
	Condamine Street	North	T	17	16	28	21	2.3	1.2

Brookvale Turning Movement Flows – Sat Peak (All Vehicles)

Intersection name	Road name	Approach	Turn	Modelled 1130 to 1230	Modelled 1230 to 1330	Observed 1130 to 1230	Observed 1230 to 1330	GEH 1130 to 1230	GEH 1230 to 1330
Pittwater / Hawkesbury	Pittwater Road	South	L	16	15	23	24	1.7	2.1
			T	1240	1222	1365	1412	3.5	5.2
			R	46	56	55	67	1.3	1.4
	Hawkesbury Avenue	East	L	26	26	32	28	1.1	0.5
			T	75	67	76	67	0.1	0.0
			R	233	204	230	204	0.2	0.0
	Pittwater Road	North	L	396	307	393	306	0.2	0.1
			T	1351	1313	1352	1293	0.0	0.6
	Hawkesbury Avenue	West	L	22	14	22	14	0.0	0.1
			T	123	83	126	82	0.3	0.1
			R	48	27	54	35	0.8	1.4
Pittwater / Dee Why / Kingsway	Pittwater Road	South	L	0	0	0	0		
			T	1102	1079	0	0		
	Dee Why Parade	East	L	60	53	64	60	0.5	1.0
			T	80	76	81	76	0.1	0.0
			R	216	210	266	251	3.2	2.7
	Pittwater Road	North	L	201	191	0	0		
			T	1202	1129	0	0		
Pittwater / Howard / St David	Pittwater Road	South	L	40	49	47	55	1.0	0.9
			T	1036	1035	1067	1151	0.9	3.5
	Howard Avenue	East	L	39	30	36	28	0.5	0.3
			T	165	135	164	130	0.1	0.5
			R	44	36	62	49	2.4	2.0
	Pittwater Road	North	L	50	53	52	56	0.2	0.4
			T	1197	1137	1110	1204	2.6	2.0
	St David Avenue	West	L	17	18	38	39	4.0	4.0
			T	193	201	191	199	0.1	0.1
			R	27	29	16	16	2.4	2.6
Pittwater / Oaks	Pittwater Road	South	T	1063	1090	1151	1229	2.6	4.1
			R	200	186	262	241	4.1	3.8
	Oaks Avenue	East	L	150	146	140	130	0.8	1.4
	Pittwater Road	North	L	55	51	51	53	0.6	0.3
			T	1190	1150	1103	1163	2.6	0.4
Pittwater / Fisher	Pittwater Road	South	L	517	519	543	554	1.1	1.5
			T	1208	1233	1259	1284	1.5	1.4
	Pittwater Road	North	T	1333	1296	1264	1258	1.9	1.1
	Fisher Road	West	L	44	44	34	34	1.7	1.5
			R	333	349	365	376	1.7	1.4
Pittwater / Pacific	Pittwater Road	South	T	1509	1577	1586	1632	2.0	1.4
	Pacific Parade	East	L	105	92	88	65	1.7	3.0

			R	209	185	240	220	2.1	2.5
	Pittwater Road	North	L	88	86	91	94	0.4	0.9
			T	1573	1561	1619	1669	1.1	2.7
Pittwater / Sturdee	Pittwater Road	South	T	1467	1507	1498	1497	0.8	0.3
			R	241	237	270	263	1.8	1.6
	Sturdee Parade	East	L	250	243	247	244	0.2	0.1
			R	66	68	66	59	0.0	1.1
	Pittwater Road	North	L	20	19	23	23	0.6	0.8
			T	1649	1628	1695	1665	1.1	0.9
Pittwater / Warringah / Harbord	Pittwater Road	South	L	136	141	83	92	5.1	4.5
			T	1381	1386	1176	1248	5.7	3.8
			R	122	120	149	122	2.3	0.2
	Harbord Road	East	L	66	66	48	48	2.4	2.4
			T	432	451	495	398	2.9	2.6
			R	252	266	343	289	5.3	1.4
	Pittwater Road	North	L	412	401	397	417	0.7	0.8
			T	1147	1136	1151	1152	0.1	0.5
			R	347	346	392	404	2.3	3.0
	Warringah Road	West	L	234	239	274	281	2.5	2.6
			T	492	526	490	526	0.1	0.0
			R	233	233	243	227	0.6	0.4
Pittwater / Mitchell	Mitchell Road	South	L	75	85	56	61	2.4	2.8
			R	263	278	262	290	0.0	0.7
	Pittwater Road	East	L	25	27	14	13	2.6	3.1
			T	1402	1421	1646	1578	6.3	4.1
	Pittwater Road	West	T	1481	1446	1428	1268	1.4	4.8
			R	91	109	92	116	0.1	0.7
Pittwater / Pine	Pittwater Road	East	T	1438	1469	1589	1526	3.9	1.5
			R	39	37	71	65	4.3	3.9
	Pine Avenue	North	L	73	78	50	42	2.9	4.6
			R	63	62	79	89	1.9	3.1
	Pittwater Road	West	L	68	58	37	33	4.3	3.6
			T	1499	1477	1433	1309	1.7	4.5
Pittwater / Old Pittwater / Winbourne	Pittwater Road	South	L	64	64	54	48	1.3	2.1
			T	1314	1279	1377	1228	1.7	1.4
	Winbourne Road	East	L	99	102	97	95	0.3	0.7
			T	241	249	246	244	0.4	0.3
	Pittwater Road	North	L	9	8	11	10	0.6	0.6
			T	1425	1417	1259	1215	4.5	5.6
			R	79	81	110	117	3.2	3.6
	Old Pittwater Road	West	L	119	117	116	107	0.3	1.0
			T	185	172	185	170	0.0	0.1
			R	165	149	180	165	1.1	1.3
Pittwater / Sydenham	Pittwater Road	South	T	1426	1350	0	0		
			R	209	186	171	158	2.8	2.1

	Sydenham Road	East	L	68	69	70	46	0.2	3.0
			R	51	54	74	88	2.9	4.0
	Pittwater Road	North	L	14	11	0	0		
			T	1678	1640	0	0		
Pittwater / Cross / Bus Station	Pittwater Road	South	L	219	183	242	216	1.5	2.4
			T	1412	1329	1628	1456	5.5	3.4
	Pittwater Road	North	T	1350	1327	1261	1178	2.5	4.2
			R	395	365	402	346	0.4	1.0
	Cross Road	West	L	236	220	287	260	3.2	2.6
			R	299	329	282	286	1.0	2.4
Pittwater / Condamine / William	Condamine Street	South	L	61	59	63	61	0.3	0.2
			T	1152	1156	1219	1165	1.9	0.3
	Pittwater Road	East	L	73	64	74	64	0.1	0.0
			T	31	27	32	28	0.2	0.2
			R	443	331	427	312	0.8	1.1
	Pittwater Road	North	L	629	680	595	661	1.4	0.7
			T	994	1000	1028	997	1.1	0.1

Brookvale Turning Movement Flows – Sat Peak (Buses)

Pittwater / Hawkesbury	Pittwater Road	South	T	13	13	12	11	0.3	0.6
	Pittwater Road	North	T	14	14	11	10	0.8	1.2
Pittwater / Condamine / William	Condamine Street	South	T	12	13				
	Condamine Street	North	T	11	13				

Appendix B

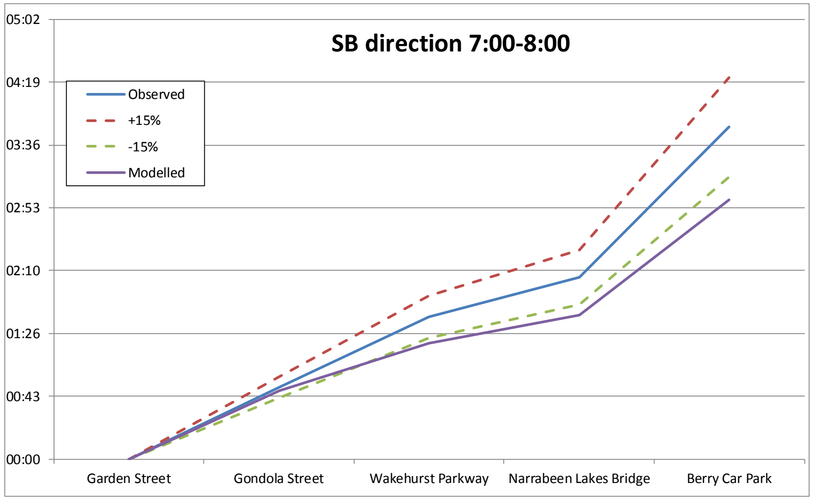
Travel Time Validation Outputs

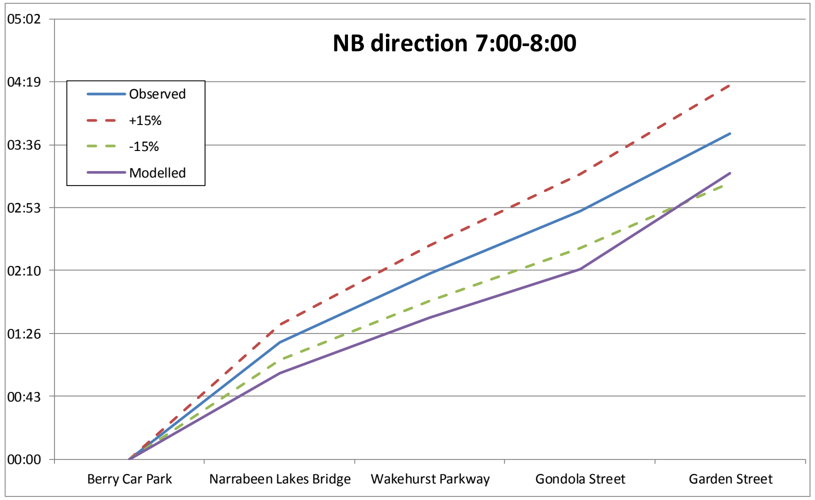
Appendix B-1 Bus Travel Time Comparisons for Narrabeen

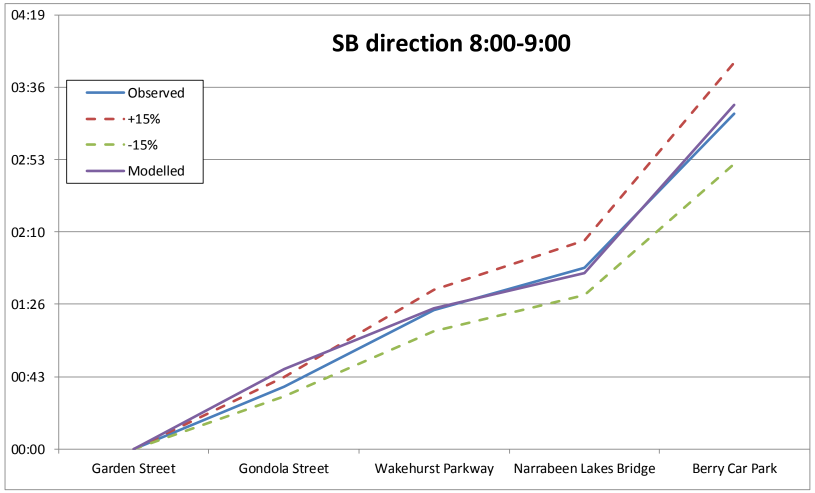
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
Berry Car Park	Narrabeen Lakes Bridge	01:43	01:32	01:19	01:40	-24	8	01:21	01:06	00:59	01:09	-21	3
Narrabeen Lakes Bridge	Wakehurst Parkway	00:27	00:26	00:19	00:21	-8	-4	00:47	00:47	00:38	00:44	-9	-3
Wakehurst Parkway	Gondola Street	00:48	00:46	00:32	00:36	-16	-9	00:43	00:43	00:33	00:27	-9	-16
Gondola Street	Garden Street	00:49	00:37	00:47	00:48	-2	11	00:53	00:44	01:06	01:23	13	39
Total		**03:48**	**03:20**	**02:58**	**03:25**	**-50**	**5**	**03:44**	**03:19**	**03:16**	**03:43**	**-27**	**24**

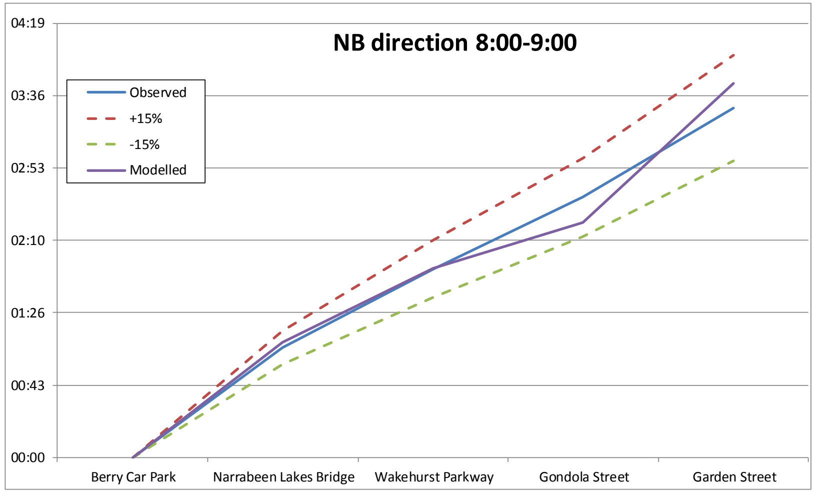
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
Berry Car Park	Narrabeen Lakes Bridge	01:27	01:17	00:58	00:54	-29	-23	00:57	00:53	00:46	01:08	-11	15
Narrabeen Lakes Bridge	Wakehurst Parkway	00:42	00:29	00:29	00:29	-13	1	00:49	00:51	00:44	00:49	-5	-3
Wakehurst Parkway	Gondola Street	00:41	00:38	00:34	00:36	-7	-3	00:40	00:47	00:34	00:39	-7	-8
Gondola Street	Garden Street	00:38	00:33	01:14	00:54	35	20	00:52	00:46	00:46	00:54	-6	8
Total		**03:28**	**02:57**	**03:15**	**02:53**	**-14**	**-4**	**03:19**	**03:17**	**02:50**	**03:29**	**-29**	**13**

Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
Berry Car Park	Narrabeen Lakes Bridge	01:29	01:25	01:41	01:07	11	-17	01:42	01:20	01:31	01:53	-11	33
Narrabeen Lakes Bridge	Wakehurst Parkway	00:53	00:32	00:17	00:14	-36	-17	00:53	00:43	01:01	00:21	7	-22
Wakehurst Parkway	Gondola Street	00:46	00:37	00:40	00:32	-5	-5	00:56	00:58	00:43	01:16	-13	19
Gondola Street	Garden Street	00:43	00:39	00:39	00:46	-3	7	00:45	00:43	01:10	00:55	25	12
Total		**03:51**	**03:12**	**03:18**	**02:39**	**-33**	**-33**	**04:16**	**03:45**	**04:25**	**04:26**	**9**	**42**

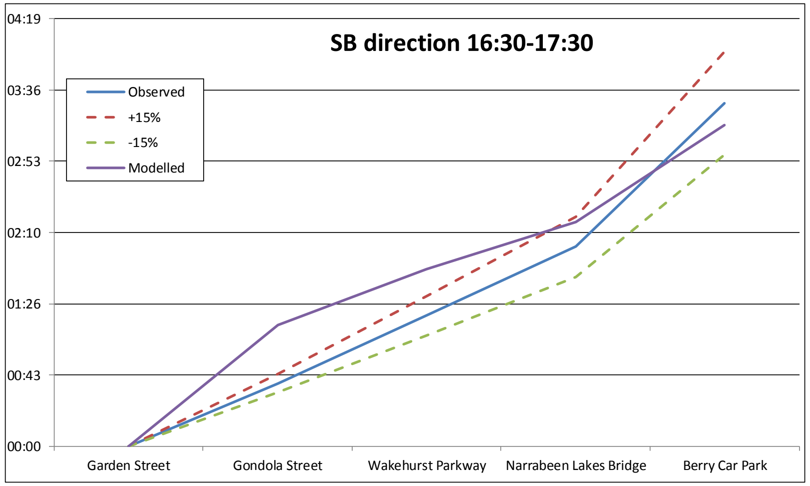


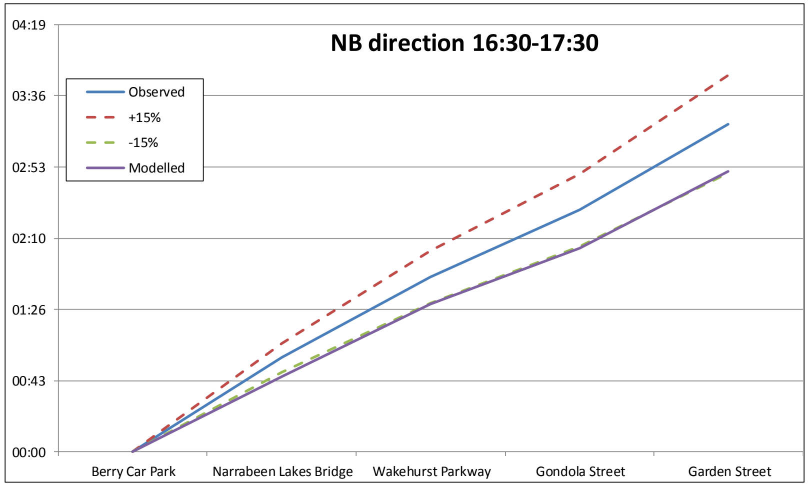


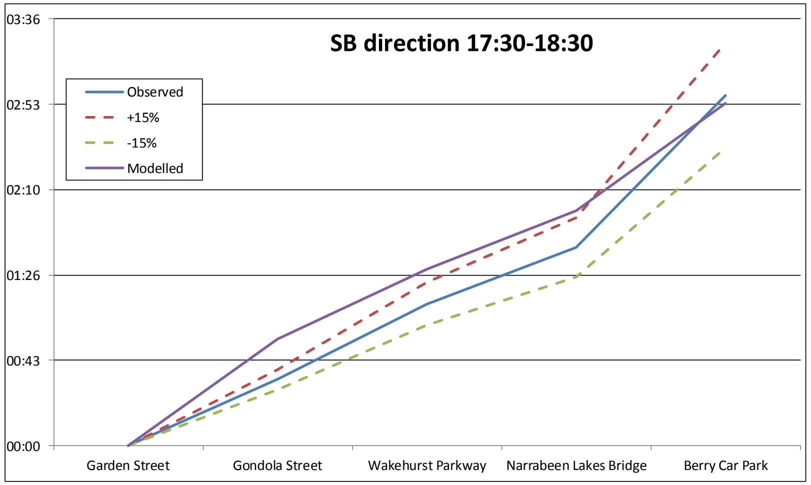


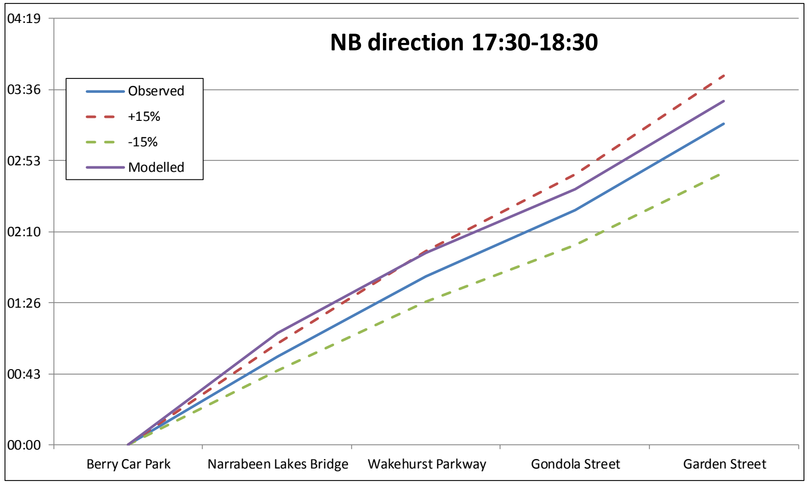


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

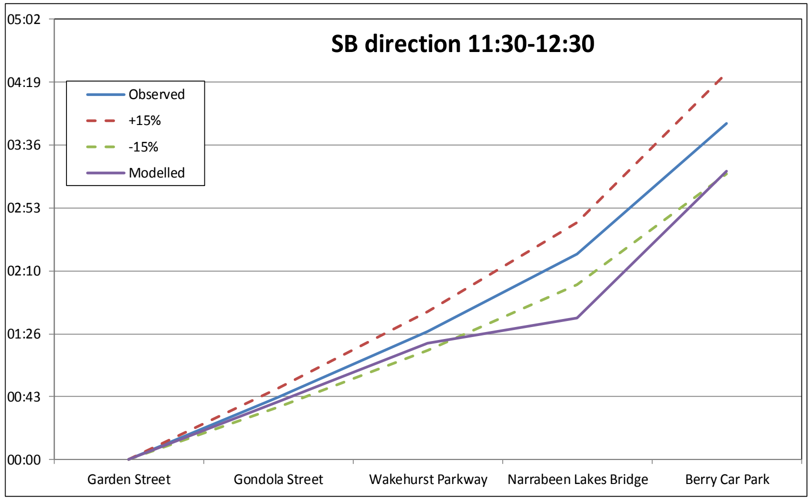


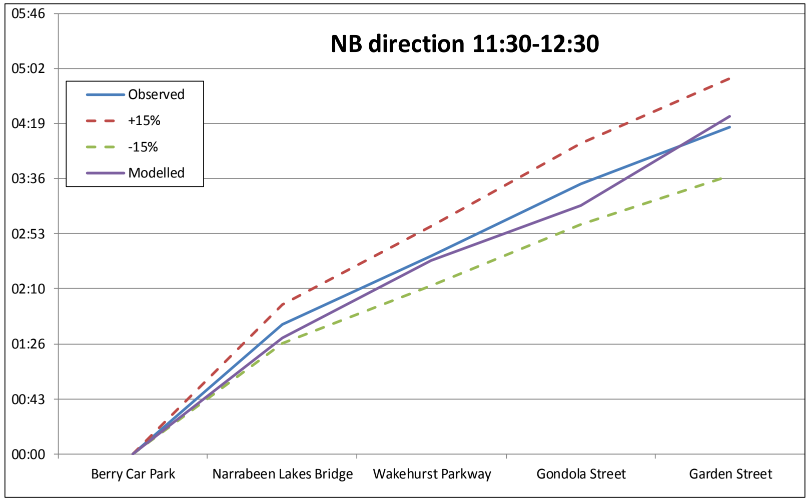


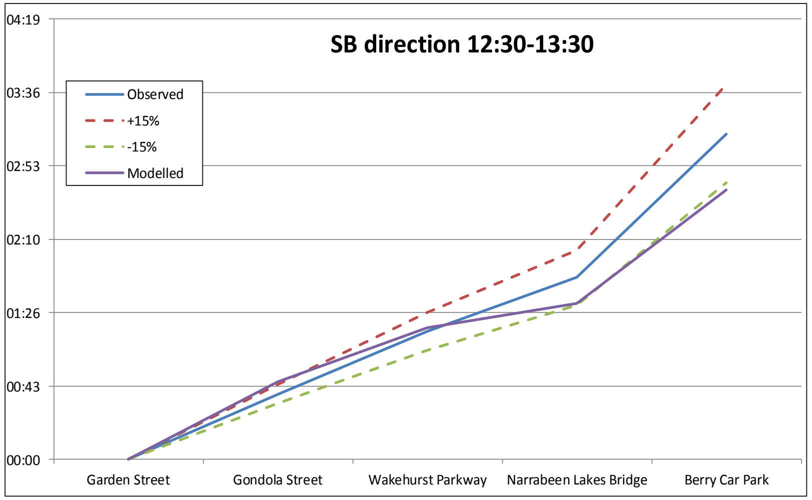


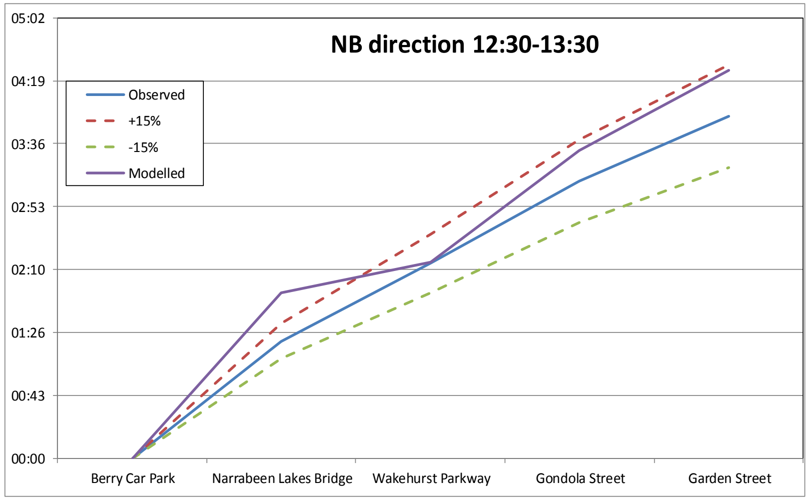


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.









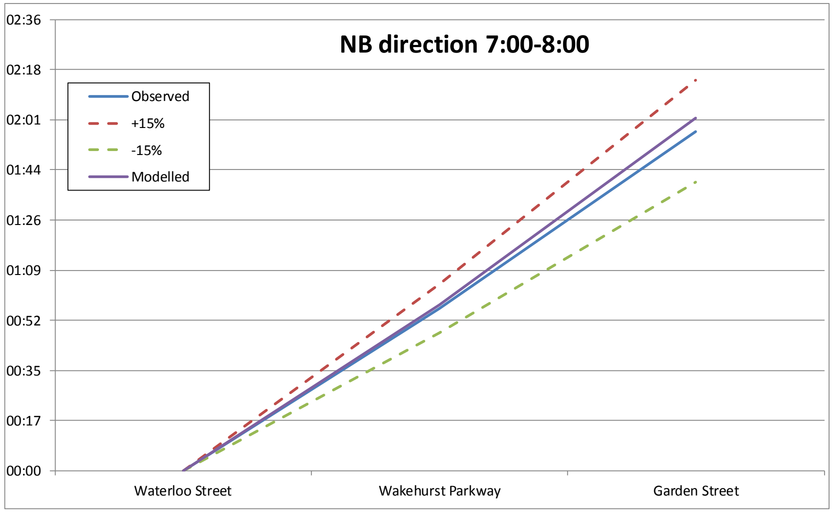
Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

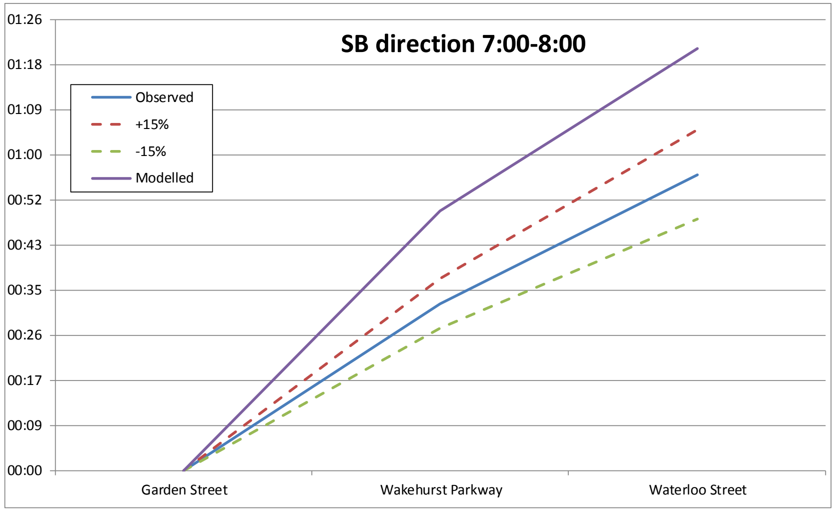
Appendix B-2 General Traffic Travel Time Comparisons for Narrabeen

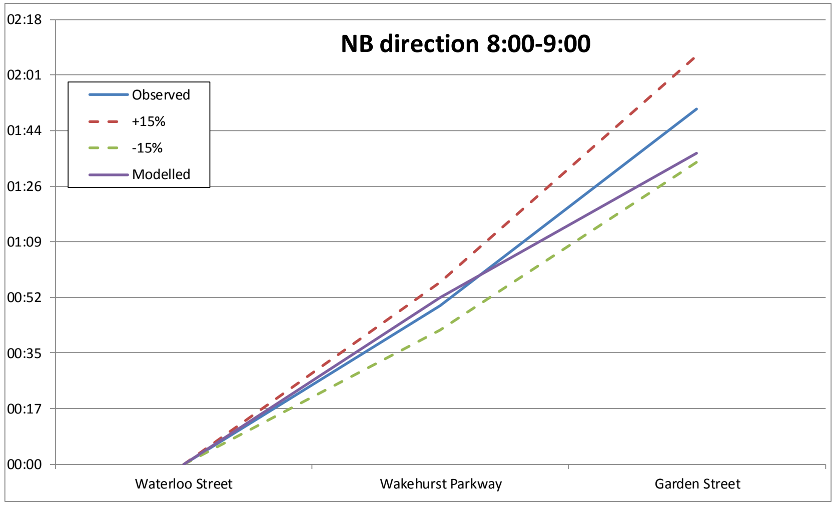
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
Waterloo Street	Wakehurst Parkway	00:25	00:24	00:31	00:36	6	11	00:56	00:49	00:57	00:52	1	3
Wakehurst Parkway	Garden Street	00:32	00:32	00:50	00:45	18	13	01:01	01:17	01:05	00:45	3	-32
Total		**00:57**	**00:56**	**01:21**	**01:21**	**24**	**25**	**01:57**	**02:06**	**02:02**	**01:37**	**5**	**-29**

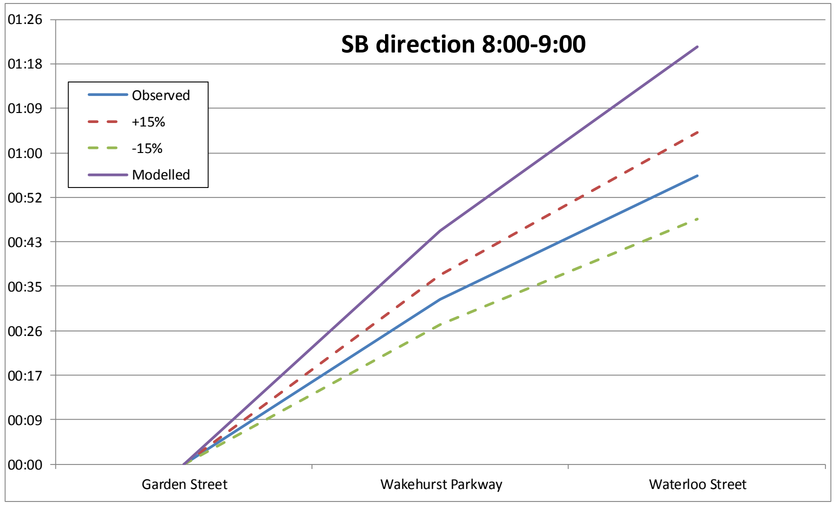
Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
Waterloo Street	Wakehurst Parkway	00:48	00:44	00:42	00:38	-5	-6	00:56	01:11	01:16	01:21	19	10
Wakehurst Parkway	Garden Street	00:32	00:32	00:39	00:44	7	13	01:08	01:00	01:17	01:31	8	31
Total		**01:19**	**01:16**	**01:22**	**01:22**	**2**	**7**	**02:05**	**02:11**	**02:33**	**02:52**	**28**	**40**

Section between		Southbound						Northbound					
		Observed		Modelled		Difference (s)		Observed		Modelled		Difference (s)	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
Waterloo Street	Wakehurst Parkway	00:40	00:40	00:36	00:25	-5	-15	00:47	01:22	01:11	00:49	25	-33
Wakehurst Parkway	Garden Street	01:04	01:20	00:54	00:36	-10	-44	01:10	01:28	01:28	01:08	19	-20
Total		**01:45**	**02:00**	**01:30**	**01:01**	**-15**	**-59**	**01:56**	**02:50**	**02:40**	**01:57**	**43**	**-52**

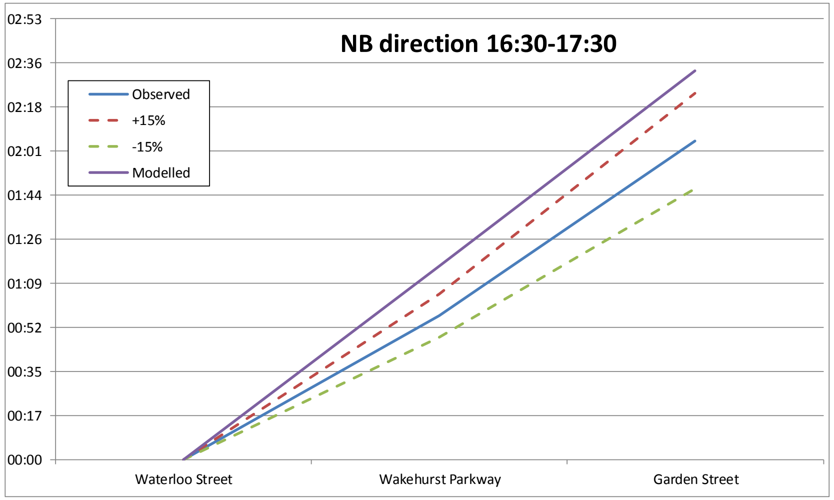


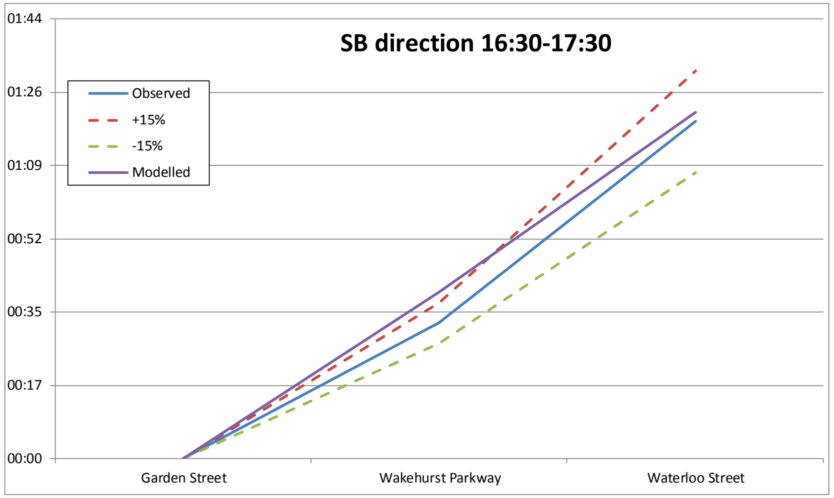


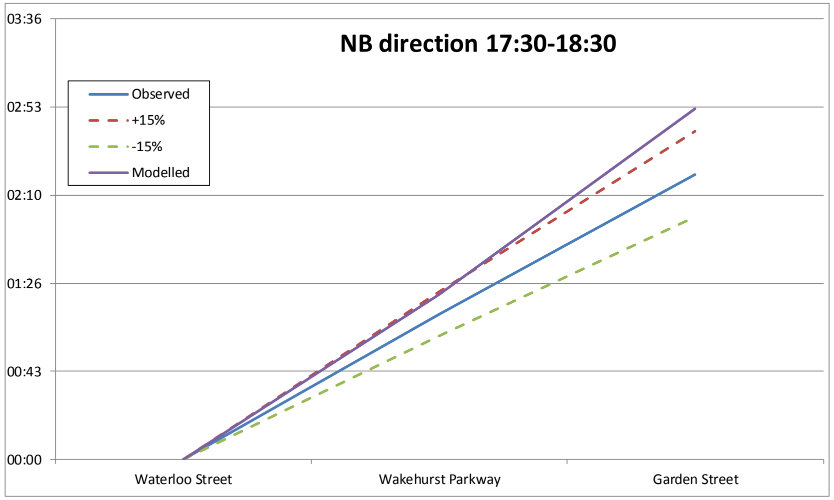


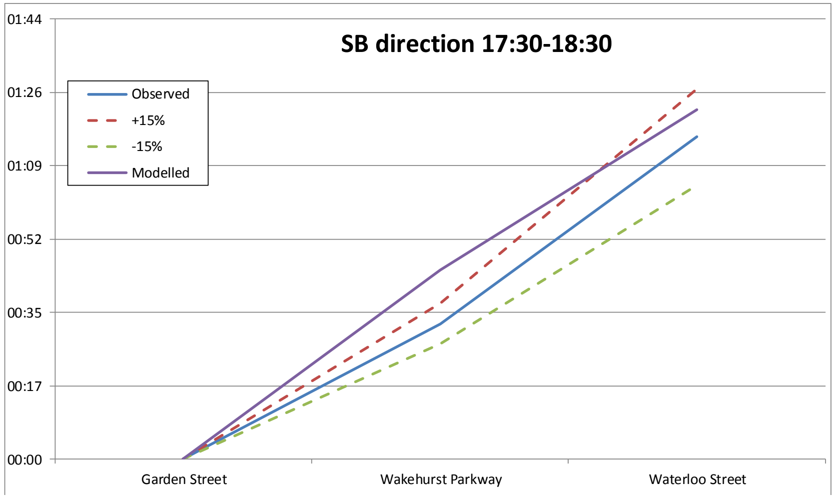


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

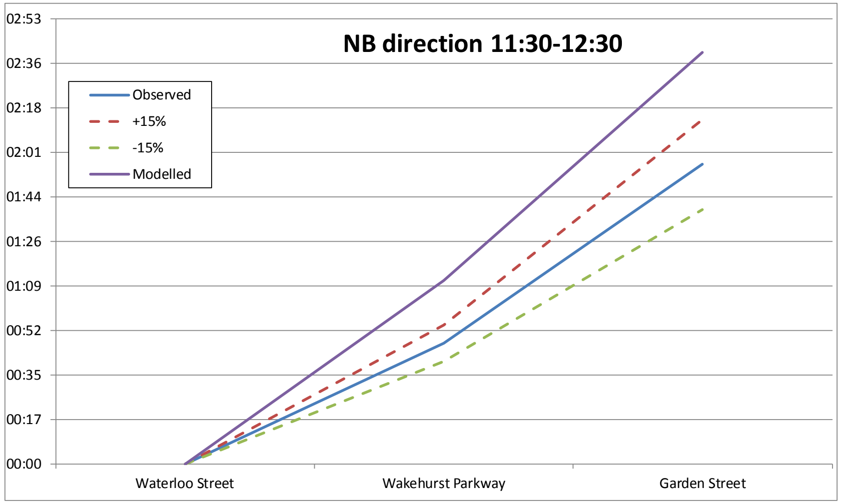


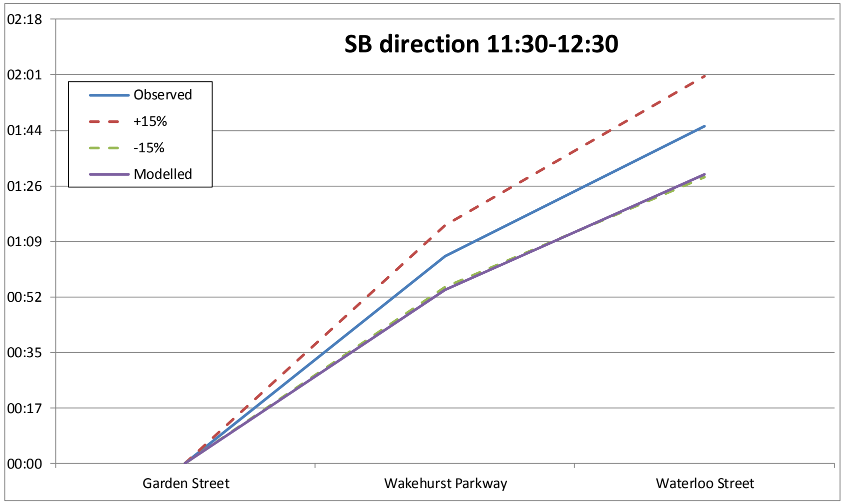


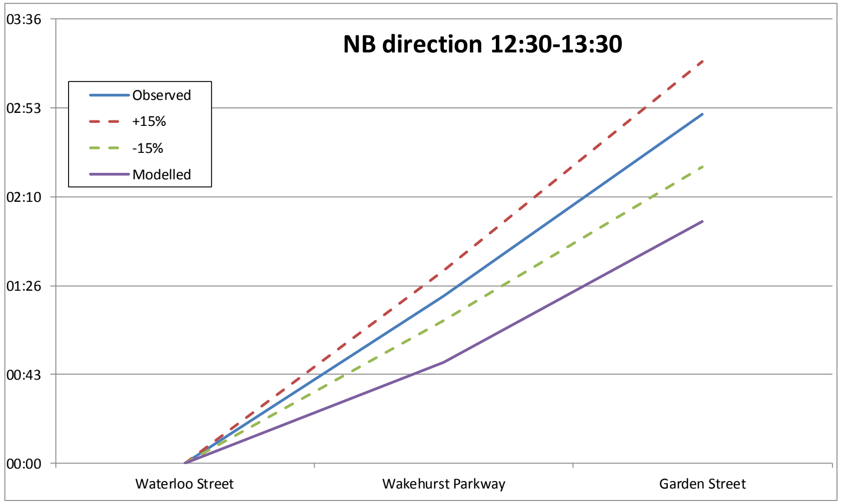


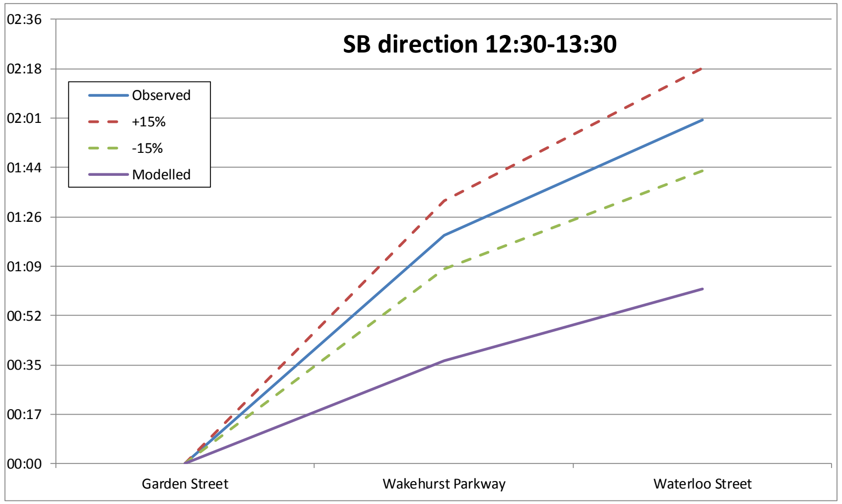


Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.









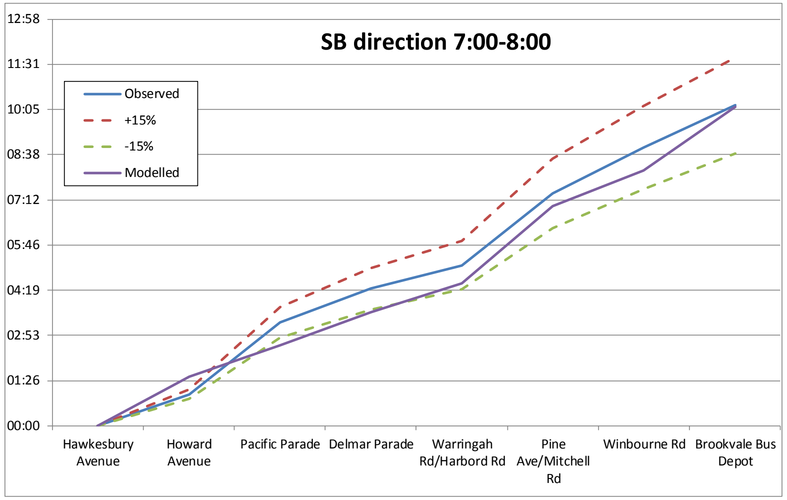
Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

Appendix B-3 Bus Travel Time Comparisons for Brookvale/Dee Why

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
Brookvale Bus Depot	Winbourne Rd	01:20	01:45	02:00	02:09	50%	23%	01:53	01:53	01:48	01:50	-5%	-3%
Winbourne Rd	Pine Ave/Mitchell Rd	01:28	01:16	01:10	01:24	-21%	10%	00:45	00:36	01:01	01:06	36%	85%
Pine Ave/Mitchell Rd	Warringah Rd/Harbord Rd	02:18	02:02	02:26	02:14	6%	9%	02:09	01:58	02:06	02:11	-2%	11%
Warringah Rd/Harbord Rd	Delmar Parade	00:45	00:42	00:56	00:53	26%	27%	00:31	00:32	00:50	00:51	62%	59%
Delmar Parade	Pacific Parade	01:04	01:07	01:02	01:02	-3%	-8%	01:19	01:13	00:31	00:45	-61%	-38%
Pacific Parade	Howard Avenue	02:18	02:21	01:00	01:21	-56%	-43%	01:35	01:31	02:15	01:52	43%	24%
Howard Avenue	Hawkesbury Avenue	01:00	01:00	01:35	01:46	58%	75%	01:03	01:03	01:00	01:15	-5%	18%
Total		**10:12**	**10:13**	**10:09**	**10:47**	**-1%**	**6%**	**09:16**	**08:45**	**09:31**	**09:50**	**3%**	**12%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
Brookvale Bus Depot	Winbourne Rd	01:45	01:24	02:02	02:07	16%	50%	01:18	01:05	01:33	01:22	19%	26%
Winbourne Rd	Pine Ave/Mitchell Rd	01:19	01:04	01:05	00:58	-17%	-9%	00:49	00:35	00:51	00:46	3%	30%
Pine Ave/Mitchell Rd	Warringah Rd/Harbord Rd	02:00	01:47	01:50	01:53	-8%	6%	02:06	01:52	01:55	02:00	-9%	
Warringah Rd/Harbord Rd	Delmar Parade	00:54	00:48	01:12	01:15	34%	55%	00:37	00:38	00:43	00:42	15%	8%
Delmar Parade	Pacific Parade	01:01	01:01	01:16	01:34	24%	55%	00:57	00:56	00:21	00:31	-63%	-44%
Pacific Parade	Howard Avenue	02:00	01:56	01:05	01:26	-45%	-26%	01:18	01:10	01:00	00:58	-23%	-18%
Howard Avenue	Hawkesbury Avenue	01:04	01:03	01:39	01:33	55%	48%	00:54	00:49	00:55	01:01	1%	24%
Total		**10:02**	**09:04**	**10:10**	**10:46**	**1%**	**19%**	**07:59**	**07:06**	**07:17**	**07:18**	**-9%**	**3%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
Brookvale Bus Depot	Winbourne Rd	02:08	01:34	01:49	01:58	-15%	26%	01:53	01:38	02:07	02:02	13%	25%
Winbourne Rd	Pine Ave/Mitchell Rd	01:09	00:55	01:07	01:04	-3%	17%	00:34	00:35	00:40	00:48	17%	37%
Pine Ave/Mitchell Rd	Warringah Rd/Harbord Rd	02:12	01:39	01:55	01:58	-13%	19%	02:35	02:23	02:01	02:13	-22%	-7%
Warringah Rd/Harbord Rd	Delmar Parade	00:55	00:43	00:34	00:46	-38%	5%	00:38	00:34	00:51	00:49	32%	46%
Delmar Parade	Pacific Parade	01:08	01:10	01:18	01:05	15%	-7%	01:26	01:15	00:51	00:55	-40%	-26%
Pacific Parade	Howard Avenue	02:49	02:16	01:42	01:50	-40%	-19%	01:47	01:36	02:11	02:29	22%	54%
Howard Avenue	Hawkesbury Avenue	02:13	01:17	02:06	02:19	-5%	81%	01:13	01:04	01:21	01:14	11%	16%
Total		**12:34**	**09:34**	**10:30**	**11:01**	**-16%**	**15%**	**10:07**	**09:05**	**10:01**	**10:30**	**-1%**	**16%**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11:31
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Observed
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Modelled
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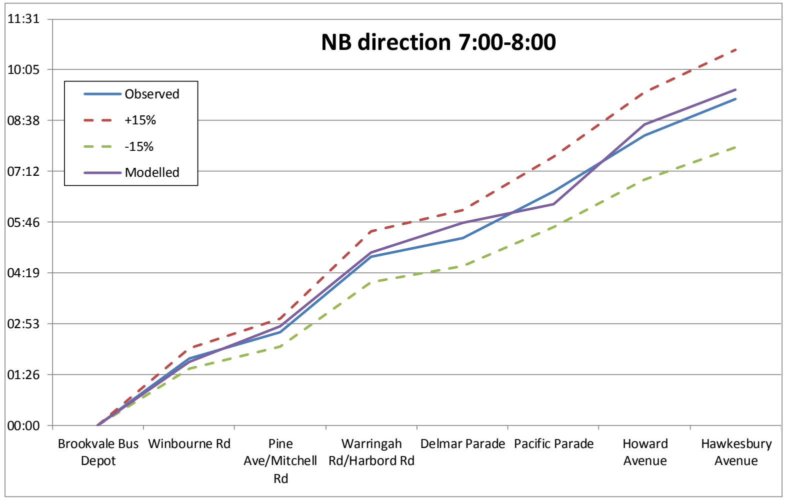
Howard Avenue
Pacific Parade
Delmar Parade
Warringah Rd/Harbord Rd
Pine Ave/Mitchell Rd
Winbourne Rd
Brookvale Bus Depot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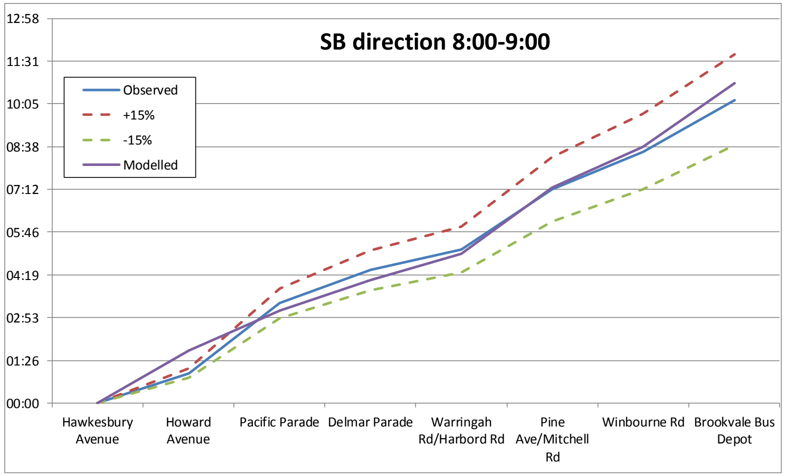
Delmar Parade
Pacific Parade
Howard Avenue
Hawkesbury Avenue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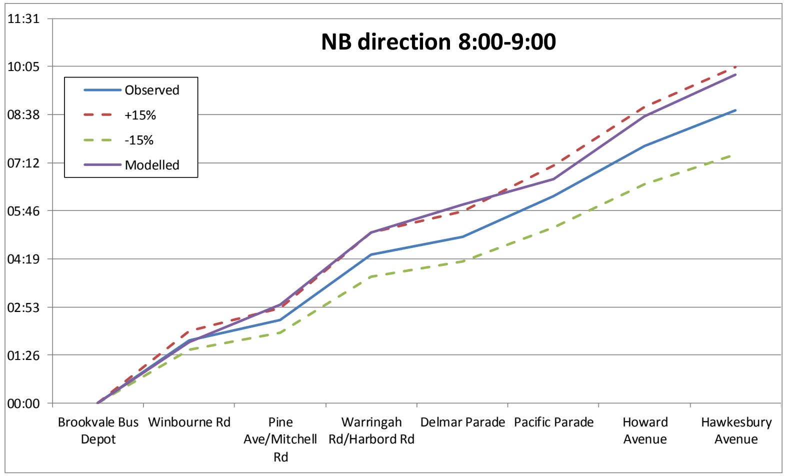
Warringah Rd/Harbord Rd
Pine Ave/Mitchell Rd
Winbourne Rd
Brookvale Bus Depot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Pacific Parade
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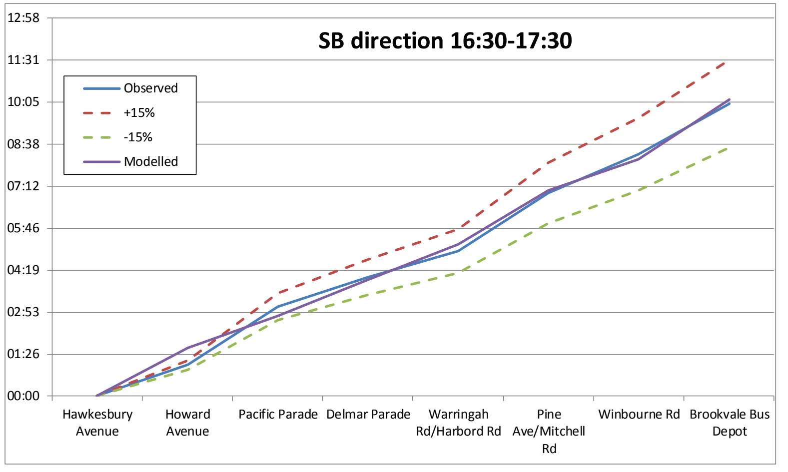
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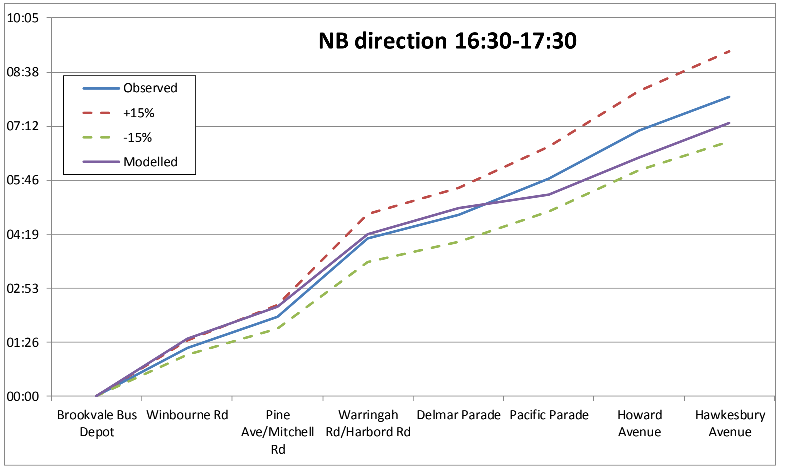
Pacific Parade
Delmar Parade
Warringah Rd/Harbord Rd
Pine Ave/Mitchell Rd
Winbourne Rd
Brookvale Bus Depot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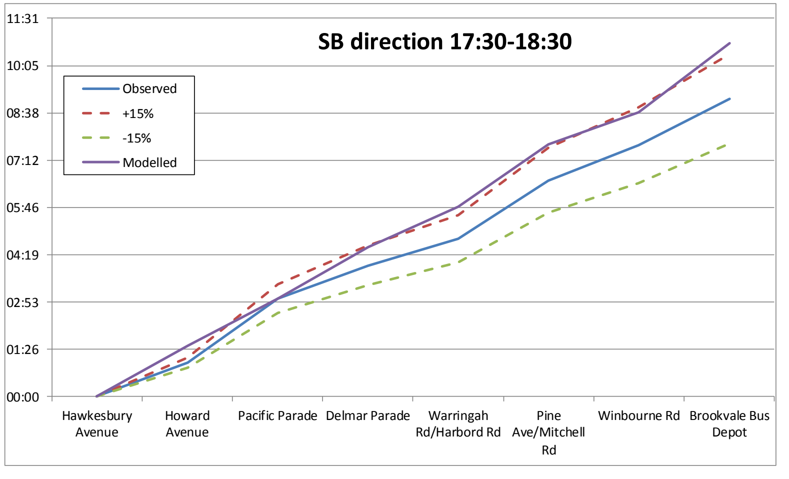
Delmar Parade
Pacific Parade
Howard Avenue
Hawkesbury Avenue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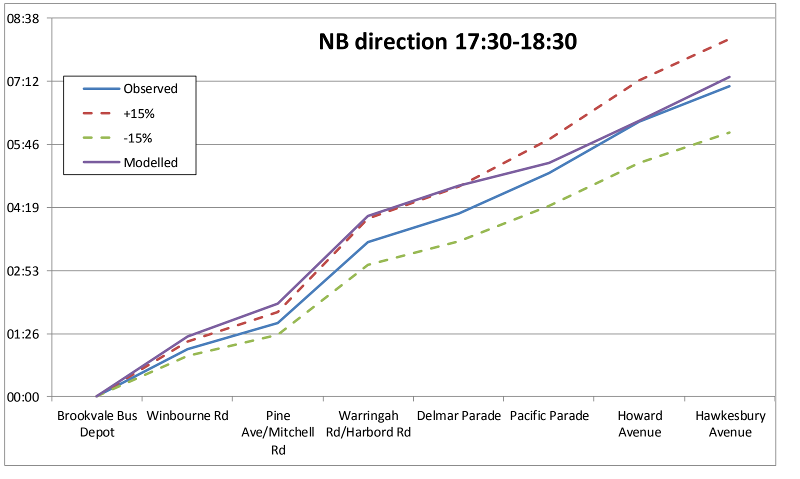
Winbourne Rd
Brookvale Bus Depot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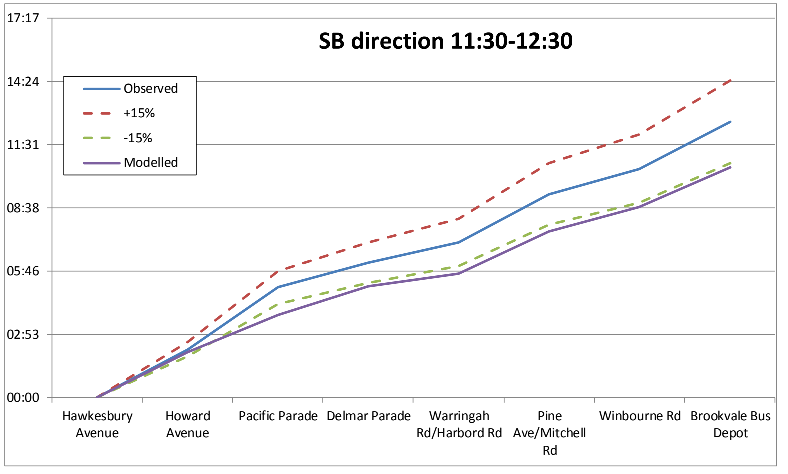
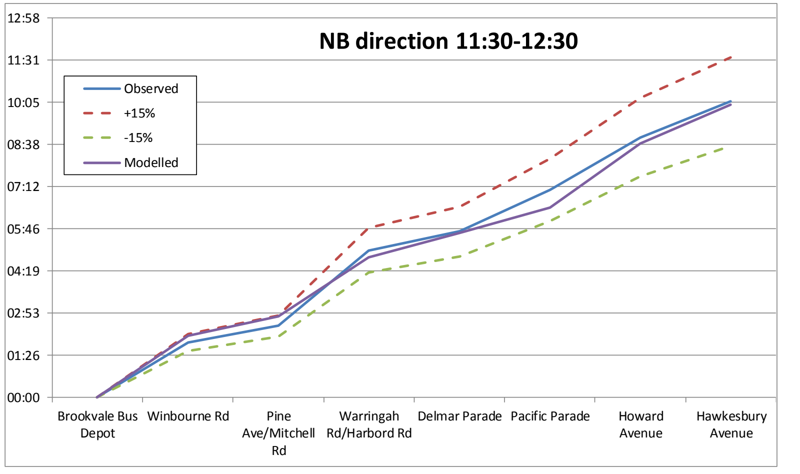
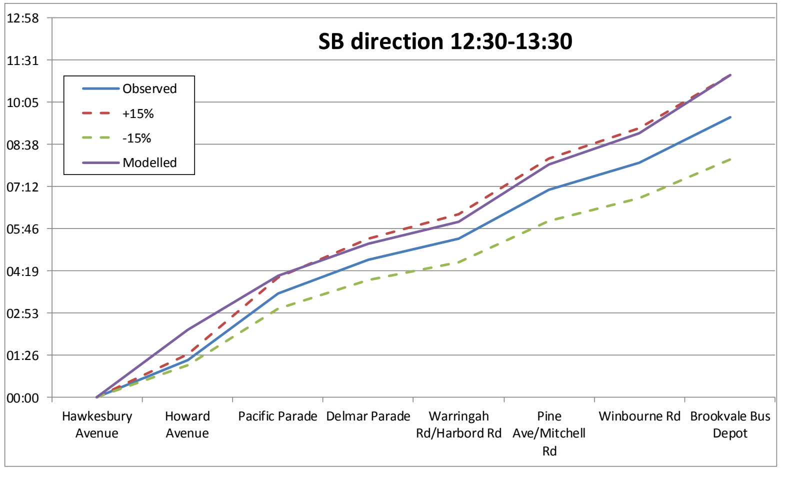
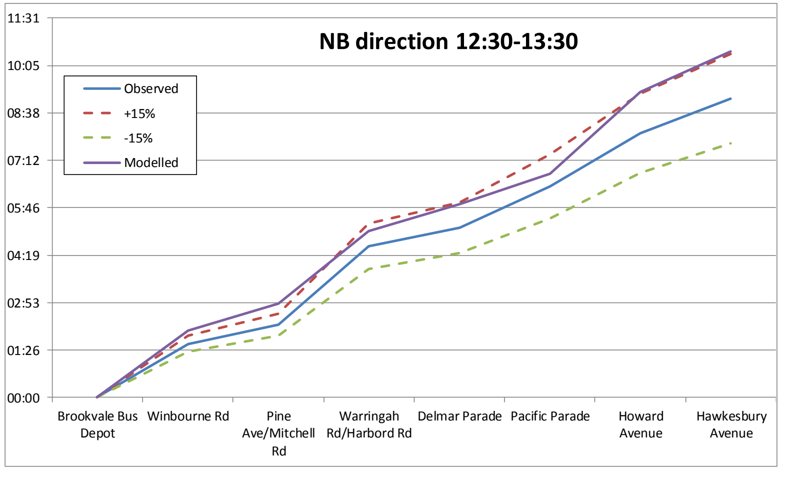
Howard Avenue
Hawkesbury Avenue









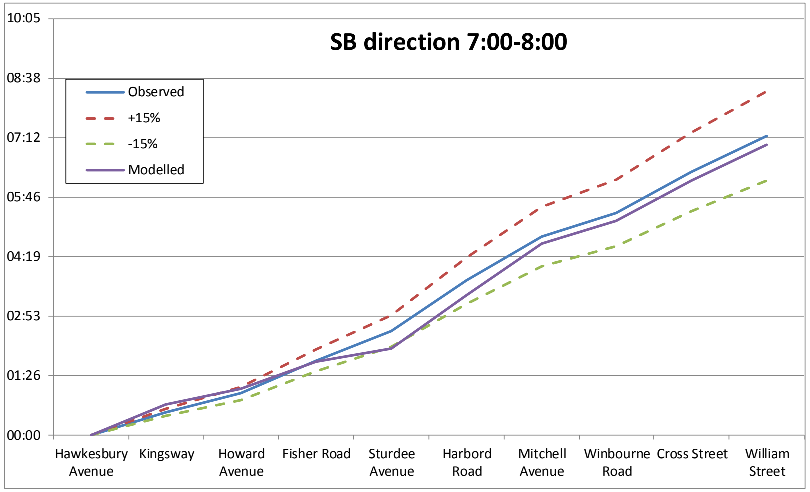
Note: The graph compares the modelled travel time to +/- 15% of the observed counts. RMS criteria for validation requires the average modelled travel times to be within 15% or one minute (whichever is greater) of the average observed travel times. Travel time sections on the graph which are not within 15% of observed travel times still validates by meeting the second criteria.

Appendix B-3 General Traffic Travel Time Comparisons for Brookvale/Dee Why

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00	7:00 - 8:00	8:00 - 9:00
William Street	Cross Street	00:52	01:02	00:52	01:03	0%	1%	00:38	00:35	00:40	00:38	7%	10%
Cross Street	Winbourne Road	01:00	00:59	00:58	01:02	-3%	6%	01:02	01:19	00:58	00:59	-7%	-26%
Winbourne Road	Mitchell Avenue	00:34	00:54	00:33	00:43	-3%	-20%	00:28	00:32	00:37	00:47	32%	45%
Mitchell Avenue	Harbord Road	01:04	01:40	01:14	01:20	17%	-20%	01:13	01:09	01:17	01:13	6%	5%
Harbord Road	Sturdee Avenue	01:13	01:27	01:18	01:11	6%	-19%	00:47	00:40	00:34	00:36	-28%	-10%
Sturdee Avenue	Fisher Road	00:43	00:38	00:19	00:27	-56%	-30%	00:28	00:43	00:43	01:01	55%	44%
Fisher Road	Howard Avenue	00:48	00:52	00:40	01:04	-16%	23%	00:26	00:20	00:24	00:47	-8%	132%
Howard Avenue	Kingsway	00:27	00:52	00:23	00:32	-15%	-39%	00:16	00:14	00:22	00:13	38%	-8%
Kingsway	Hawkesbury Avenue	00:34	00:44	00:44	00:38	31%	-14%	00:38	00:28	00:29	00:22	-23%	-19%
Total		**07:14**	**09:07**	**07:02**	**07:58**	**-3%**	**-13%**	**05:56**	**05:59**	**06:06**	**06:36**	**3%**	**10%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30	16:30 - 17:30	17:30 - 18:30
William Street	Cross Street	00:31	00:40	00:39	00:46	25%	16%	00:43	00:49	01:14	01:06	70%	35%
Cross Street	Winbourne Road	01:25	01:27	01:04	01:16	-25%	-12%	01:16	01:27	02:15	01:10	78%	-19%
Winbourne Road	Mitchell Avenue	00:43	00:55	00:36	00:33	-15%	-40%	00:50	00:49	01:11	00:54	42%	9%
Mitchell Avenue	Harbord Road	01:01	01:03	01:00	01:00	-1%	-4%	02:55	02:40	03:16	03:26	12%	29%
Harbord Road	Sturdee Avenue	01:29	01:04	01:22	01:17	-8%	20%	00:52	00:53	00:32	00:41	-39%	-23%
Sturdee Avenue	Fisher Road	00:33	00:25	00:26	00:39	-21%	55%	00:43	00:26	00:22	00:28	-47%	10%
Fisher Road	Howard Avenue	00:49	00:56	00:39	00:26	-20%	-53%	00:28	00:21	00:18	00:20	-36%	-6%
Howard Avenue	Kingsway	00:21	00:14	00:23	00:33	11%	133%	00:18	00:24	00:17	00:37	-4%	56%
Kingsway	Hawkesbury Avenue	00:25	00:38	00:22	00:23	-9%	-38%	00:26	00:34	00:20	00:25	-23%	-25%
Total		**07:16**	**07:22**	**06:31**	**06:54**	**-10%**	**-6%**	**08:31**	**08:23**	**09:45**	**09:09**	**14%**	**9%**

Section between		Southbound						Northbound					
		Observed		Modelled		% Difference		Observed		Modelled		% Difference	
		11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30	11:30-12:30	12:30-13:30
William Street	Cross Street	00:00	00:00	00:00	00:00	0%	0%	00:37	00:37	00:37	00:38	1%	3%
Cross Street	Winbourne Road	00:43	00:43	01:04	01:00	49%	39%	01:09	01:09	01:01	01:18	-12%	13%
Winbourne Road	Mitchell Avenue	01:29	01:29	00:38	00:34	-57%	-62%	00:26	00:26	00:45	00:44	74%	70%
Mitchell Avenue	Harbord Road	00:58	00:55	00:59	00:55	3%	2%	01:46	02:06	01:45	01:36	-1%	-24%
Harbord Road	Sturdee Avenue	00:39	00:39	00:52	00:54	34%	37%	00:39	00:39	00:35	00:41	-11%	5%
Sturdee Avenue	Fisher Road	00:00	00:00	00:00	00:00	0%	0%	00:31	00:31	00:57	01:05	86%	112%
Fisher Road	Howard Avenue	01:39	01:44	01:22	01:25	-17%	-18%	00:00	00:00	00:00	00:00	0%	0%
Howard Avenue	Kingsway	00:27	00:27	00:46	00:47	70%	76%	00:00	00:00	00:00	00:00	0%	0%
Kingsway	Hawkesbury Avenue	00:58	00:34	00:26	00:39	-55%	13%	00:34	00:34	00:30	00:53	-13%	55%
Total		**06:52**	**06:31**	**06:07**	**06:14**	**-11%**	**-4%**	**05:41**	**06:01**	**06:09**	**06:54**	**8%**	**15%**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Modelled
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Hawkesbury Avenue
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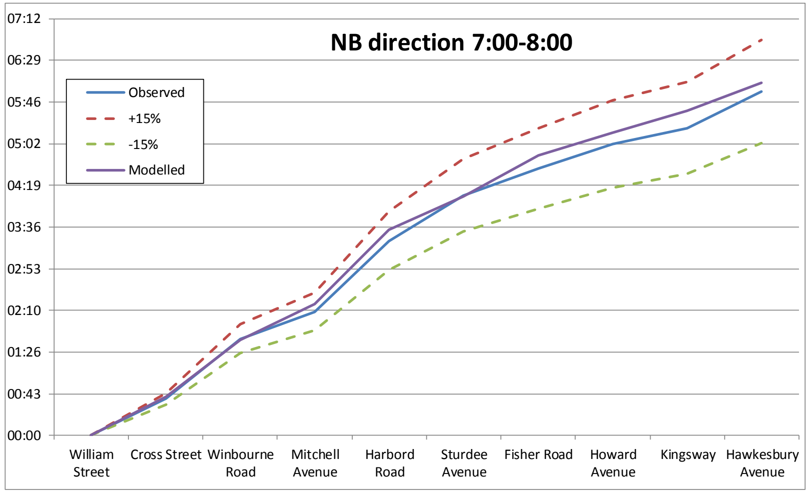
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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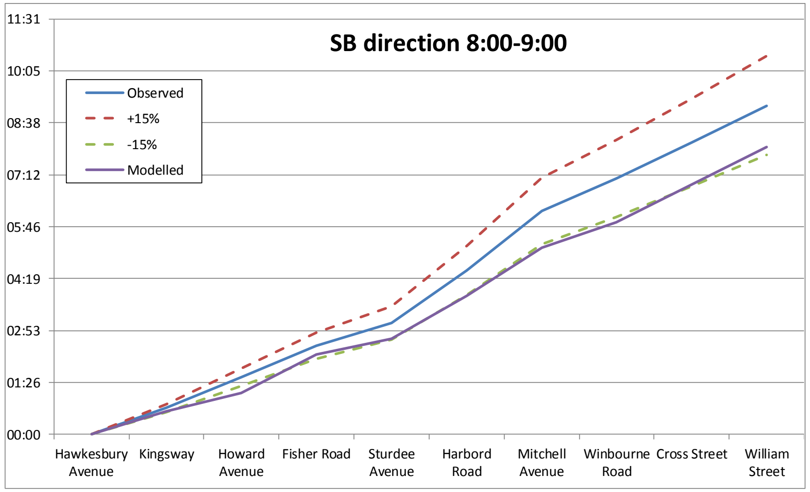
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue


SB direction 8:00-9:00
Observed
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Modelled
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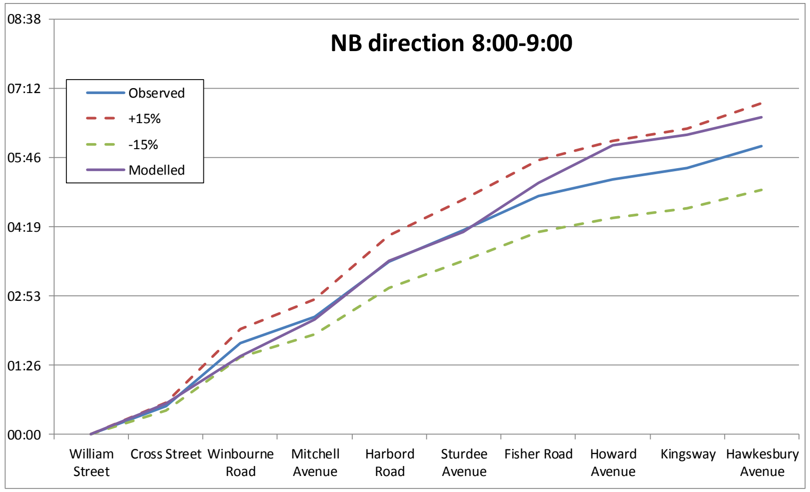
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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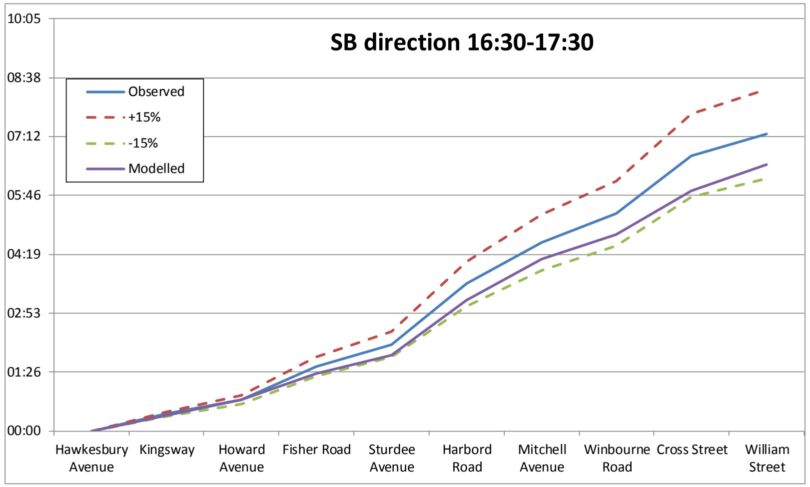
Hawkesbury Avenue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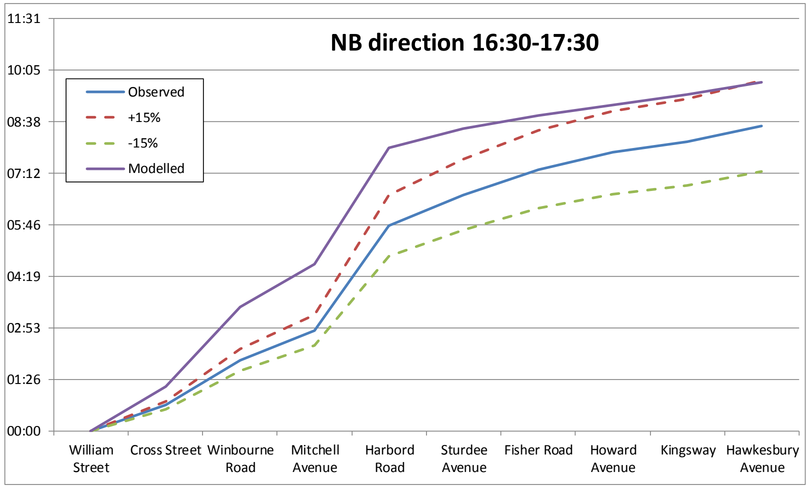
Mitchell Avenue
Winbourne Road
Cross Street
William Street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Sturdee Avenue
Fisher Road
Howard Avenue
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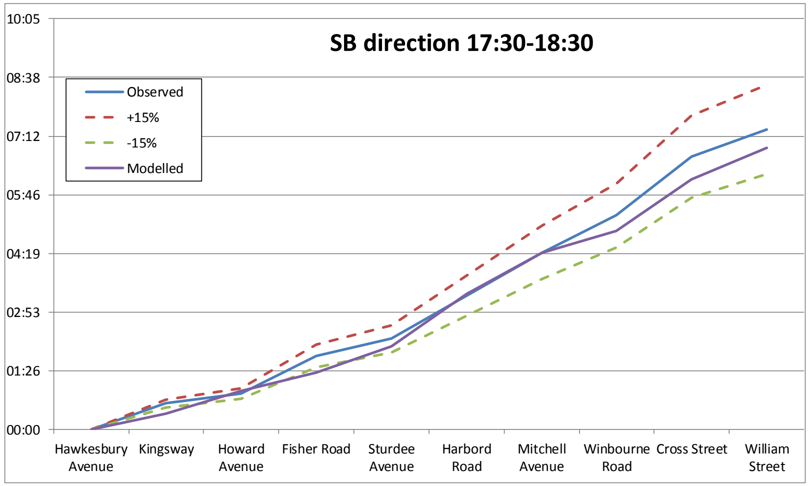
Hawkesbury Avenue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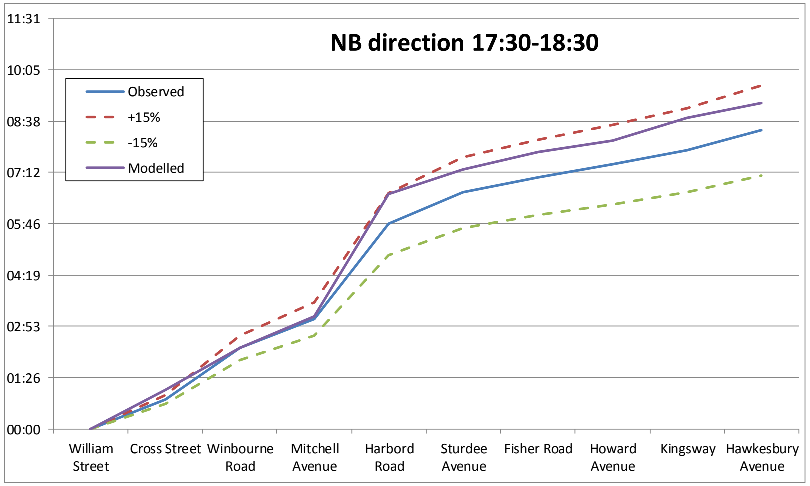
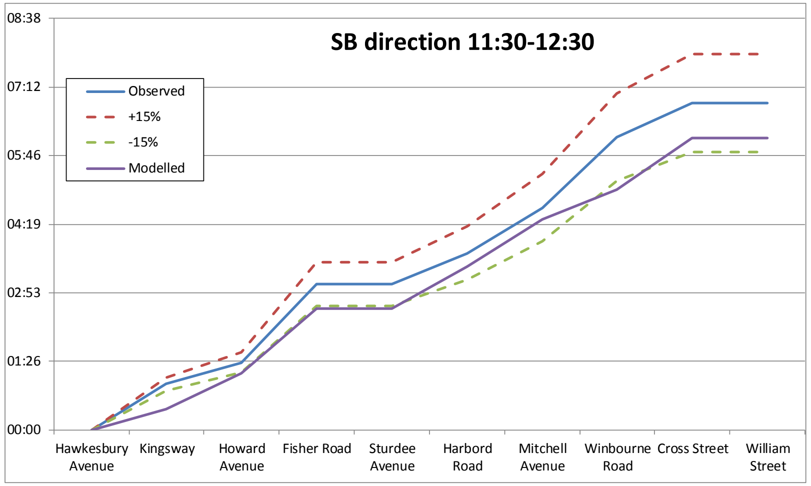
02:53
01:26
00:00
Observed
+15%
-15%
Modelled
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street


NB direction 17:30-18:30
11:31
10:05
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Observed
+15%
-15%
Modelled
William Street
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue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Observed
+15%
-15%
Modelled
08:38
07:12
05:46
04:19
02:53
01:26
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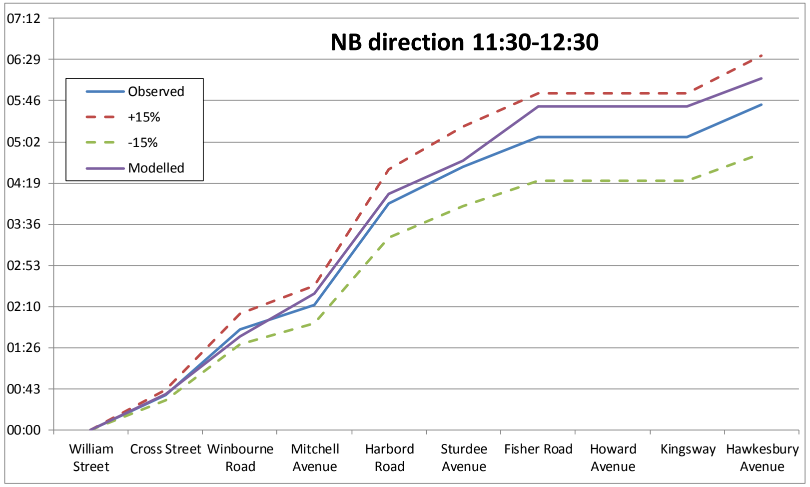
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street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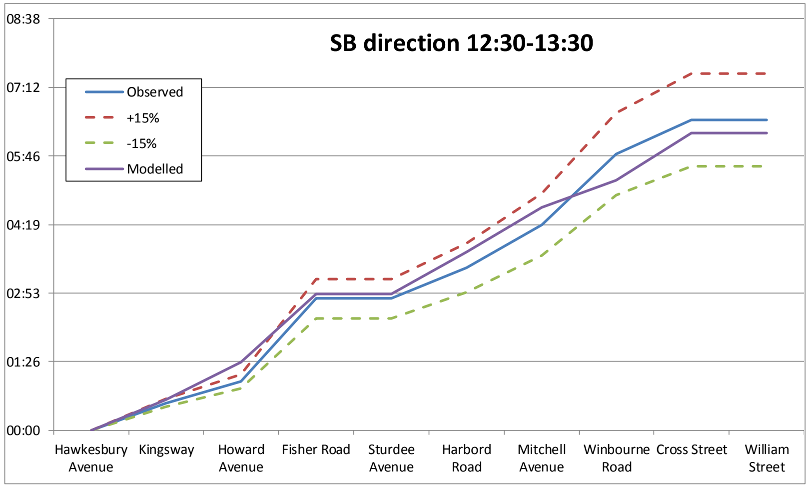
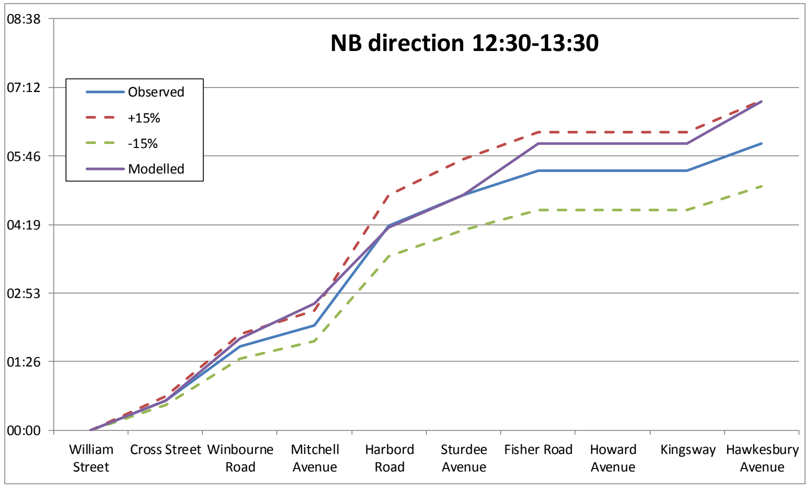
Observed
+15%
-15%
Modelled
07:12
06:29
05:46
05:02
04:19
03:36
02:53
02:10
01:26
00:43
00:00
William Street
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue


SB direction 12:30-13:30
Observed
+15%
-15%
Modelled
08:38
07:12
05:46
04:19
02:53
01:26
00:00
Hawkesbury Avenue
Kingsway
Howard Avenue
Fisher Road
Sturdee Avenue
Harbord Road
Mitchell Avenue
Winbourne Road
Cross Street
William Street

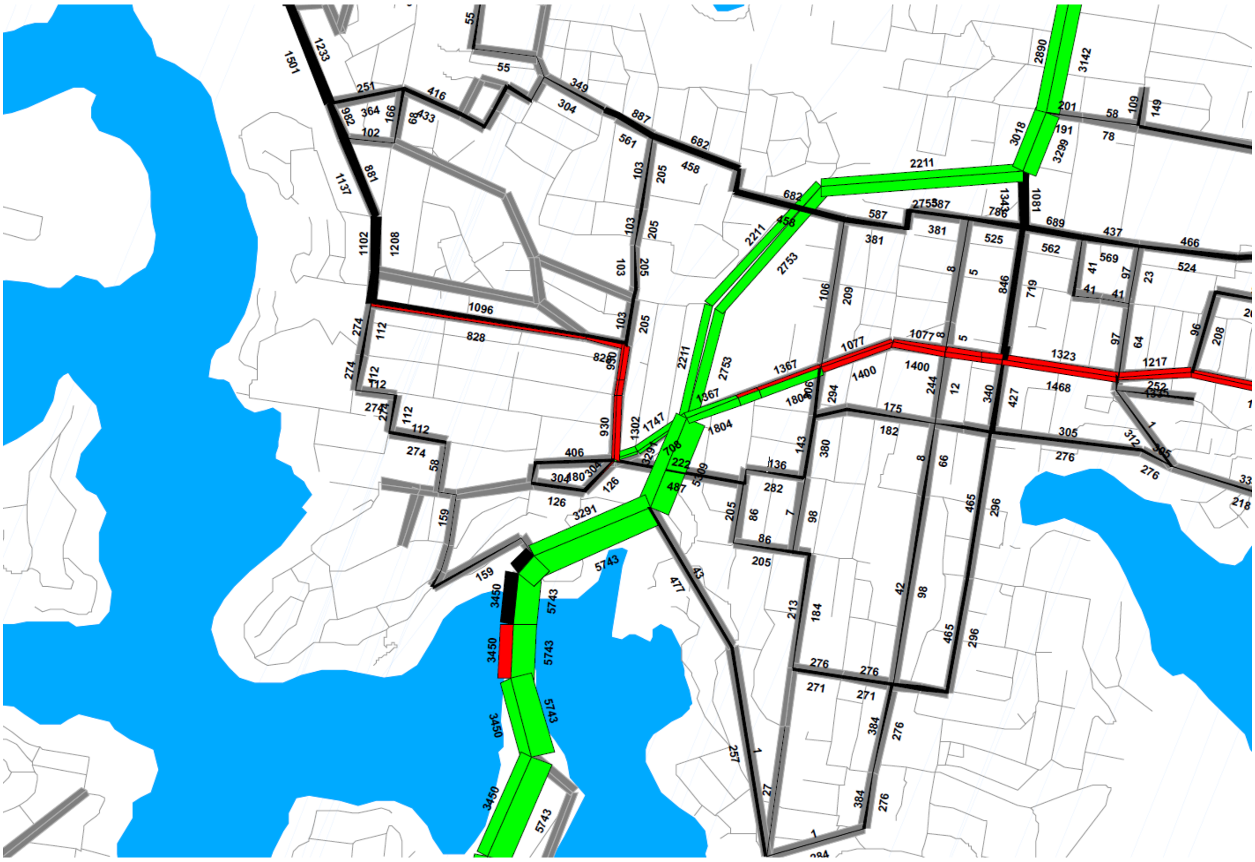

NB direction 12:30-13:30
Observed
+15%
-15%
Modelled
08:38
07:12
05:46
04:19
02:53
01:26
00:00
William Street
Cross Street
Winbourne Road
Mitchell Avenue
Harbord Road
Sturdee Avenue
Fisher Road
Howard Avenue
Kingsway
Hawkesbury Avenue

Appendix C

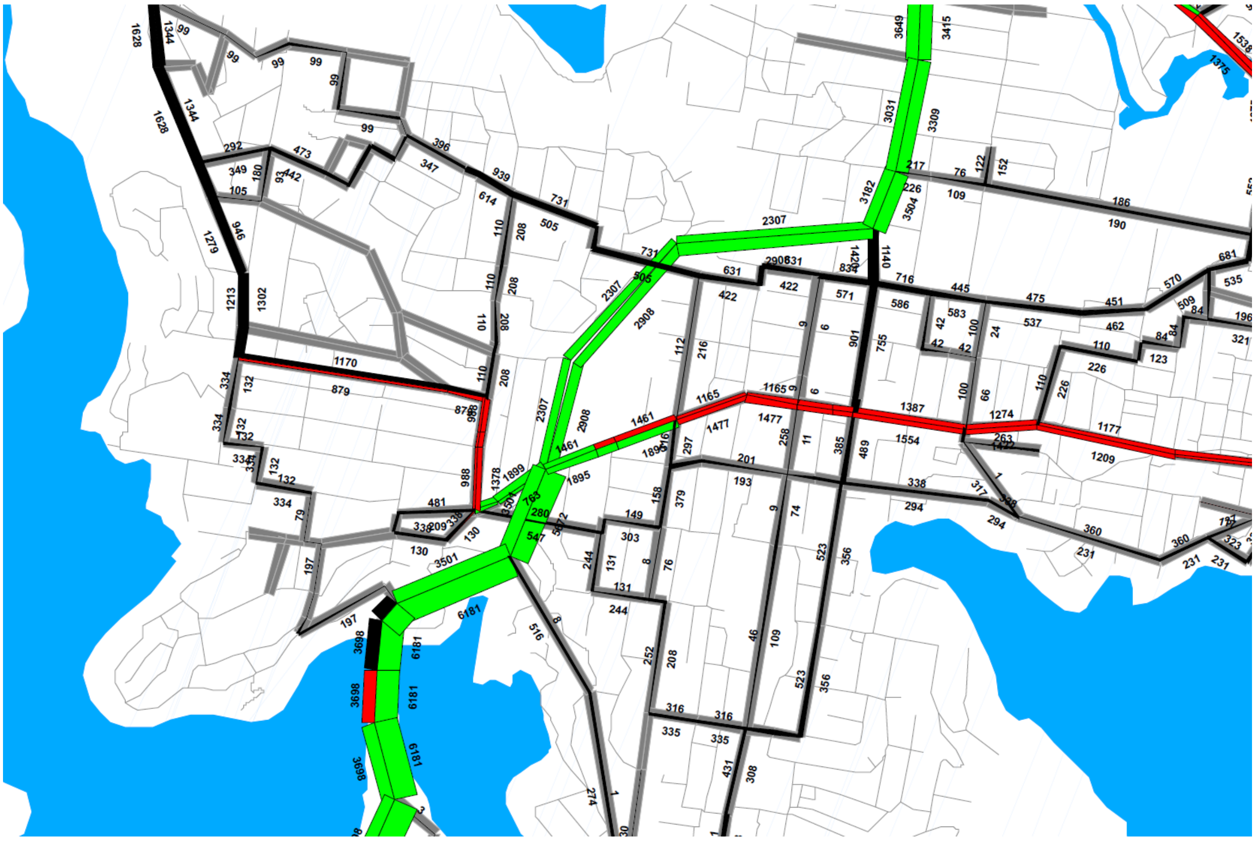
Forecast Link Volumes (STFM)

Appendix C

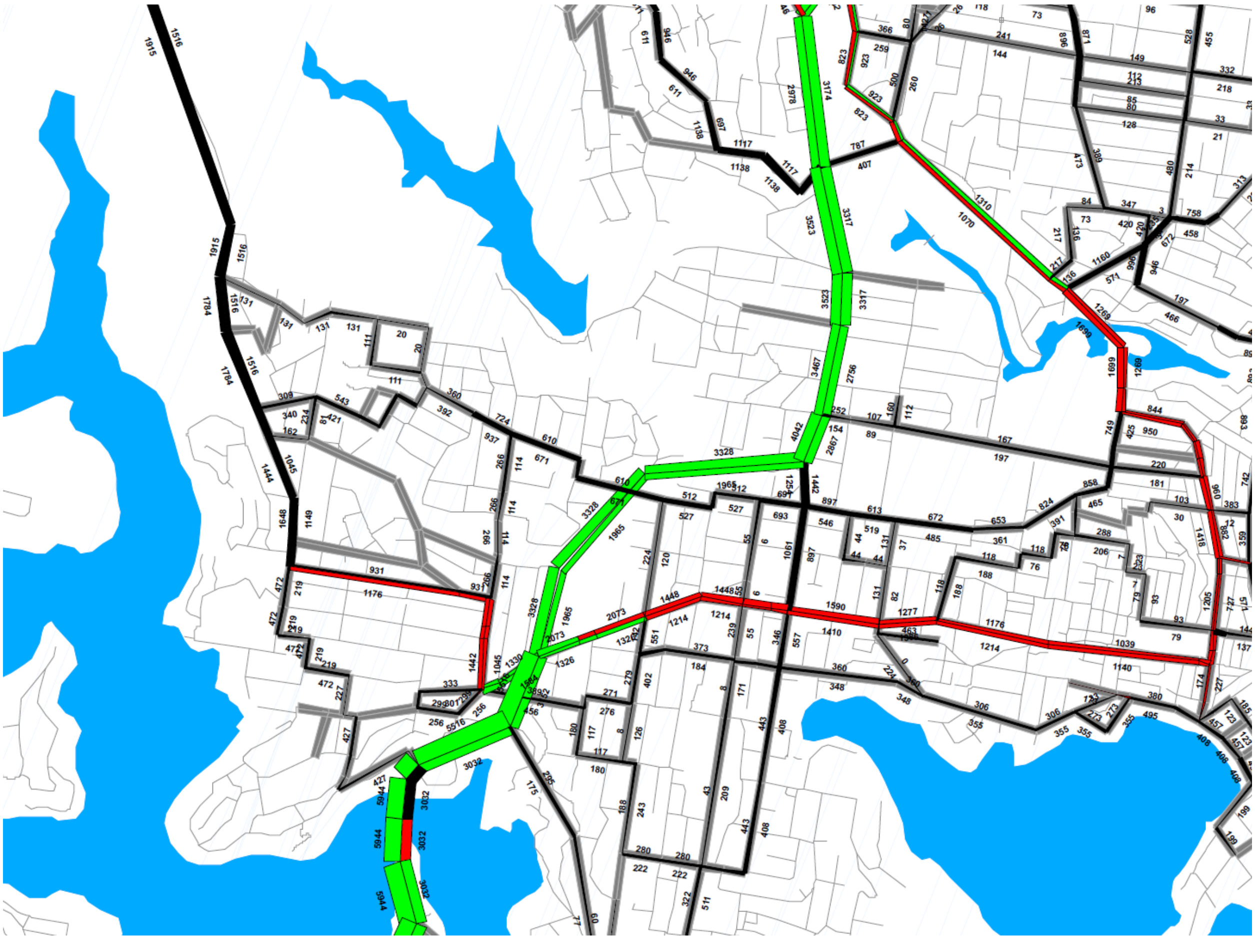
2015 7-9AM STFM Volumes – Spit Bridge



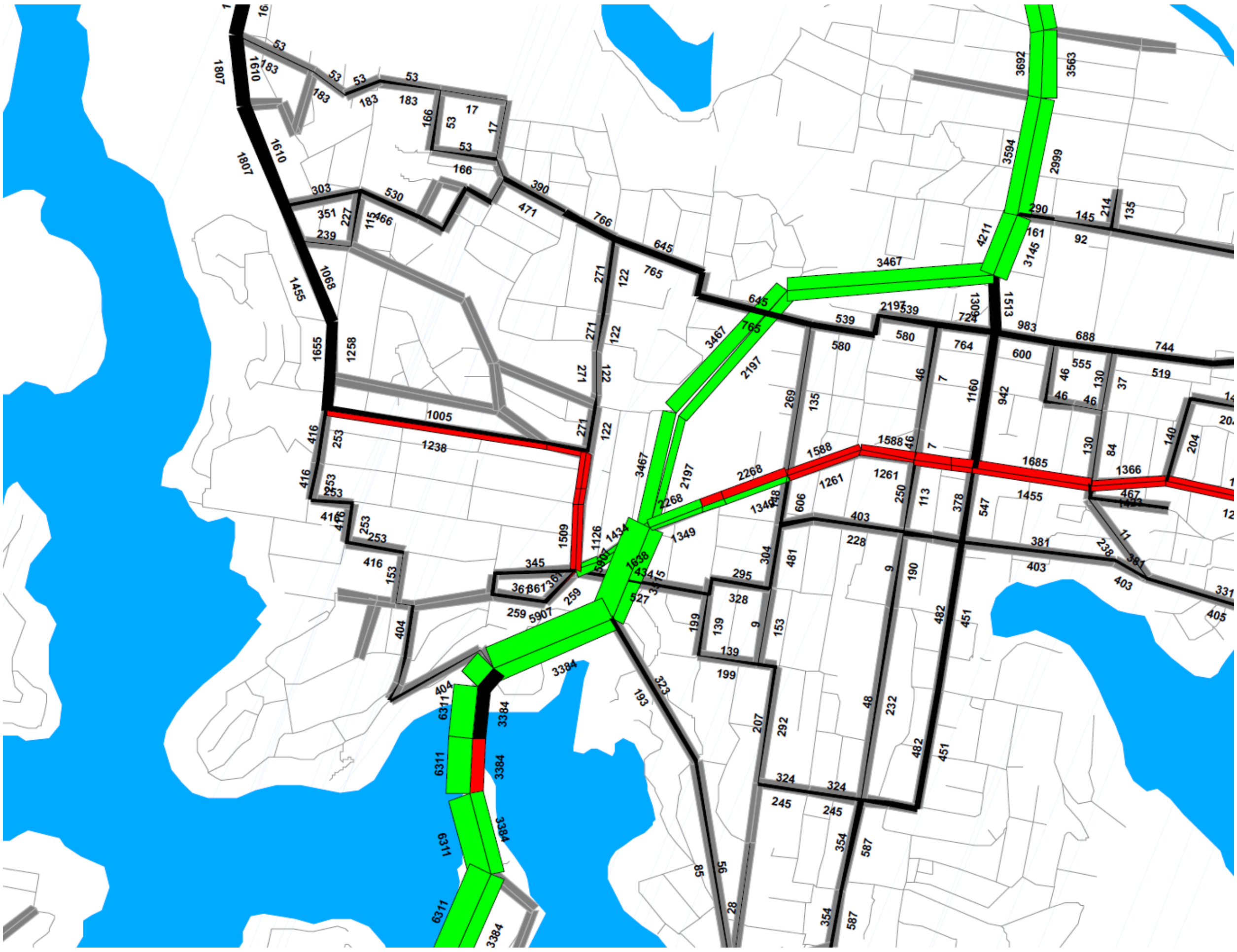
2021 7-9AM STFM Volumes – Spit Bridge



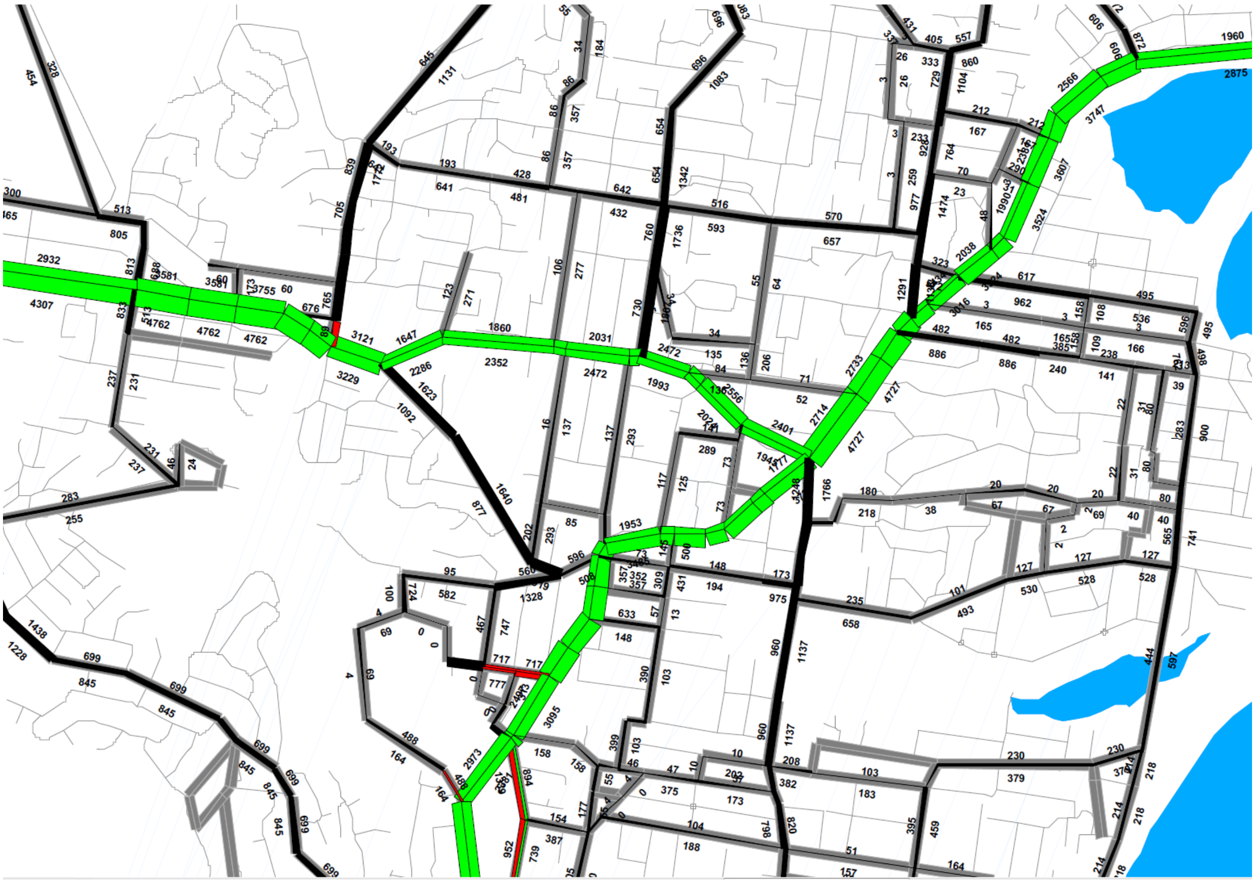
2015 4-6PM STFM Volumes – Spit Bridge



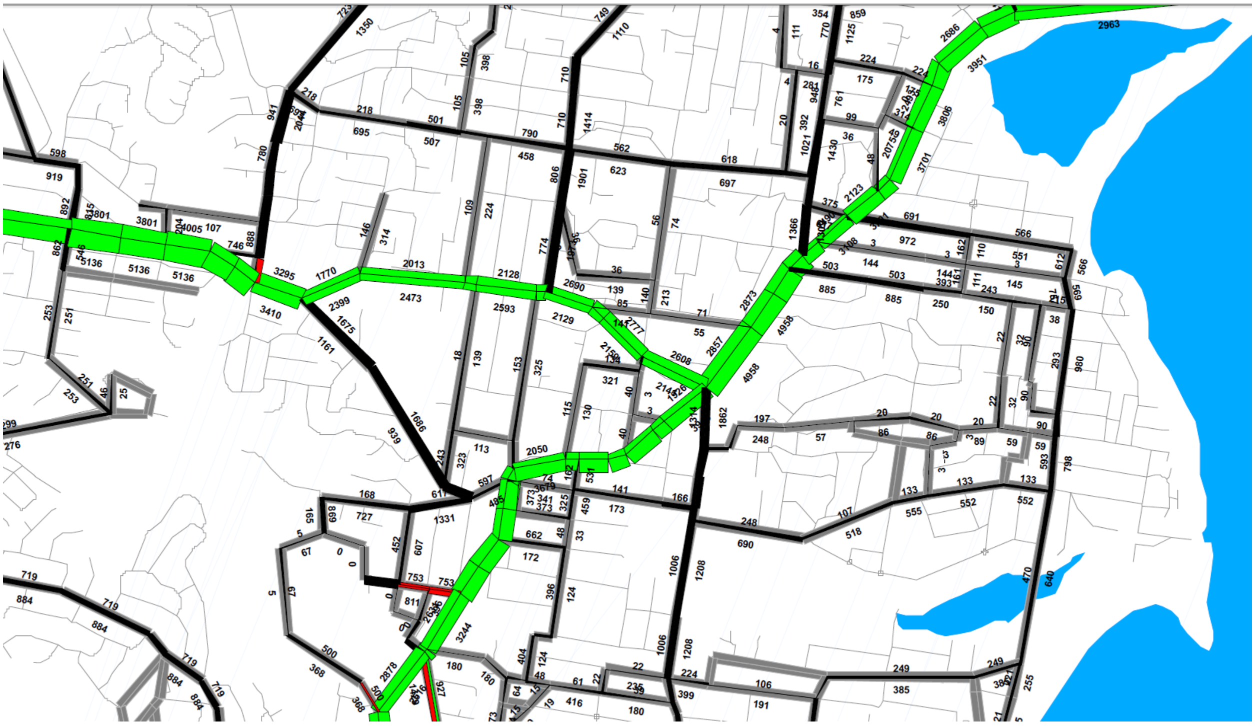
2021 4-6PM STFM Volumes – Spit Bridge



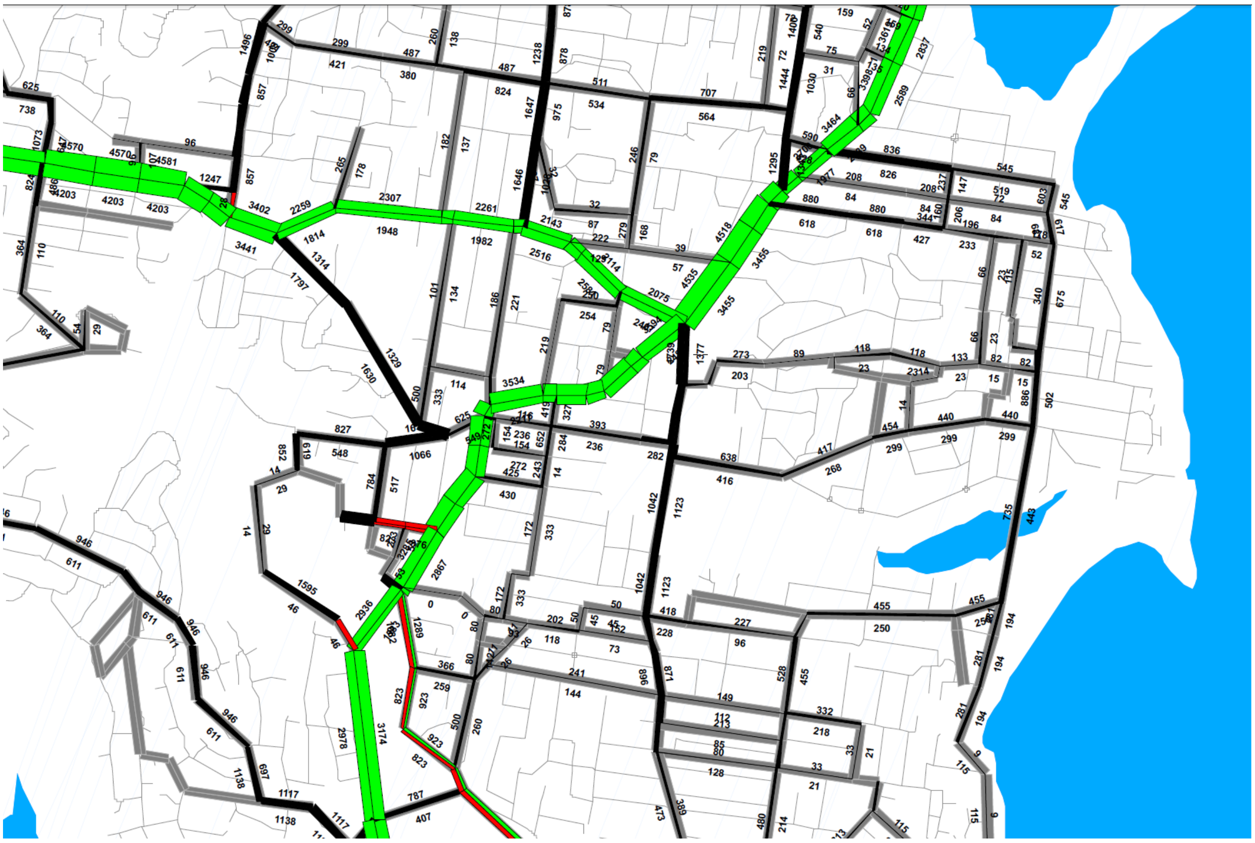
2015 7-9AM STFM Volumes – Brookvale / Dee Why



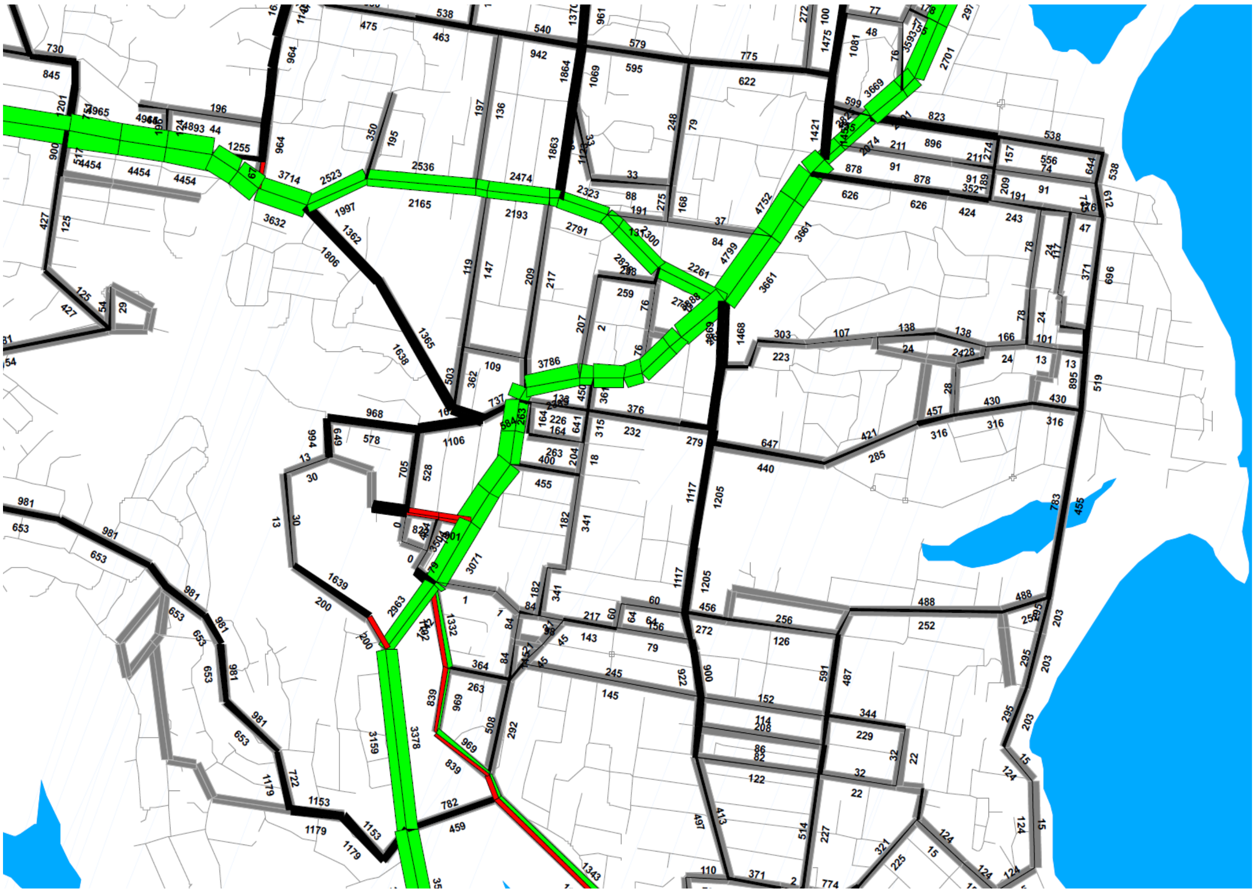
2021 7-9AM STFM Volumes – Brookvale / Dee Why



2015 4-6PM STFM Volumes – Brookvale / Dee Why

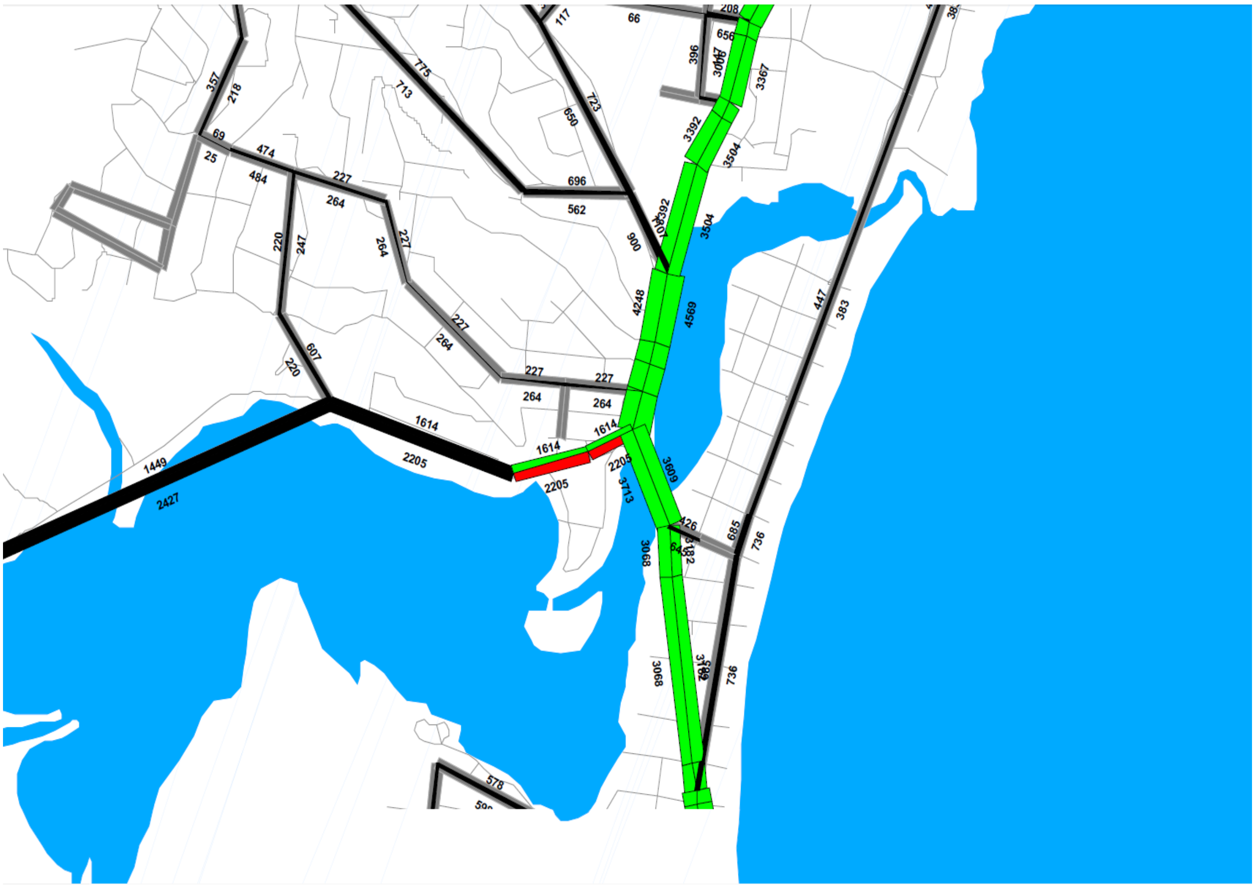


2021 4-6PM STFM Volumes – Brookvale / Dee Why

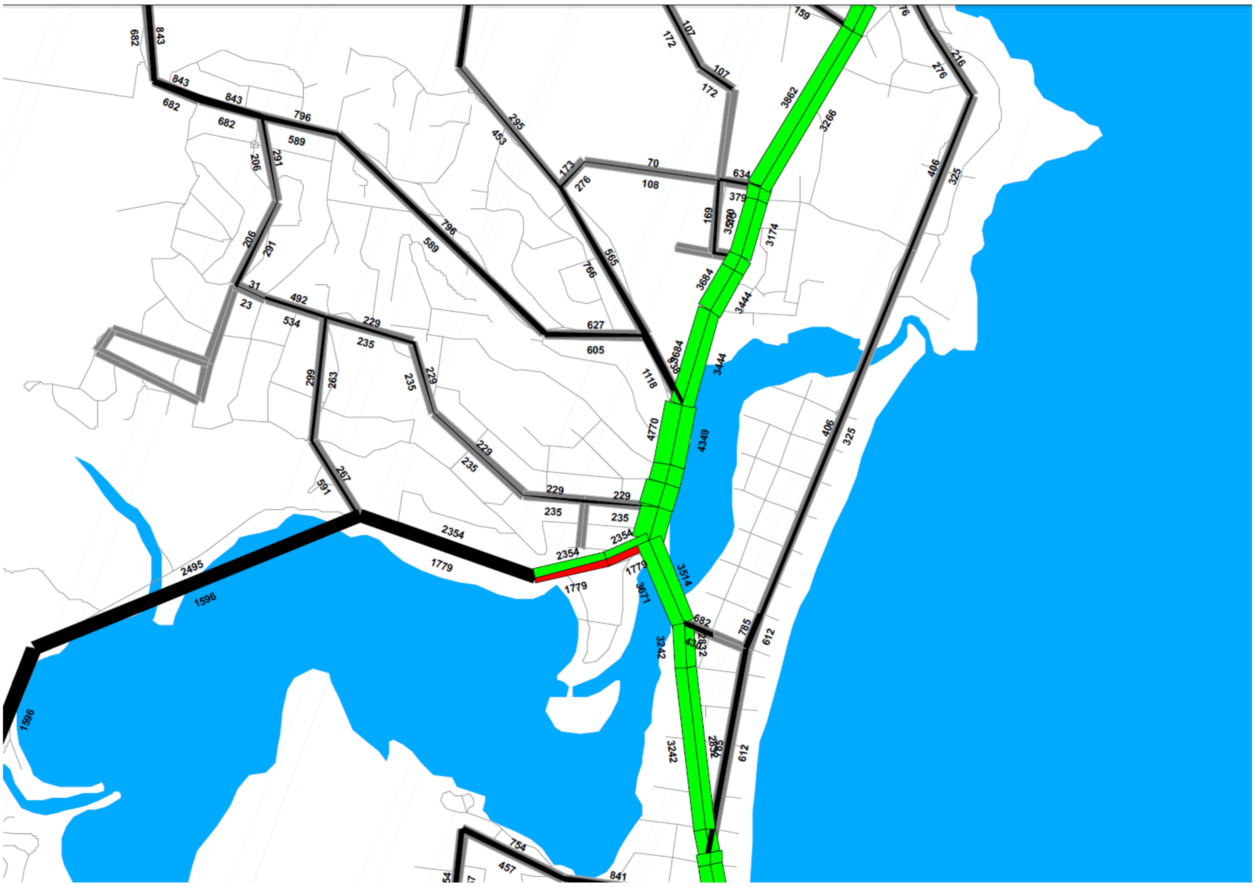


2015 7-9 AM STFM Volumes – Narrabeen

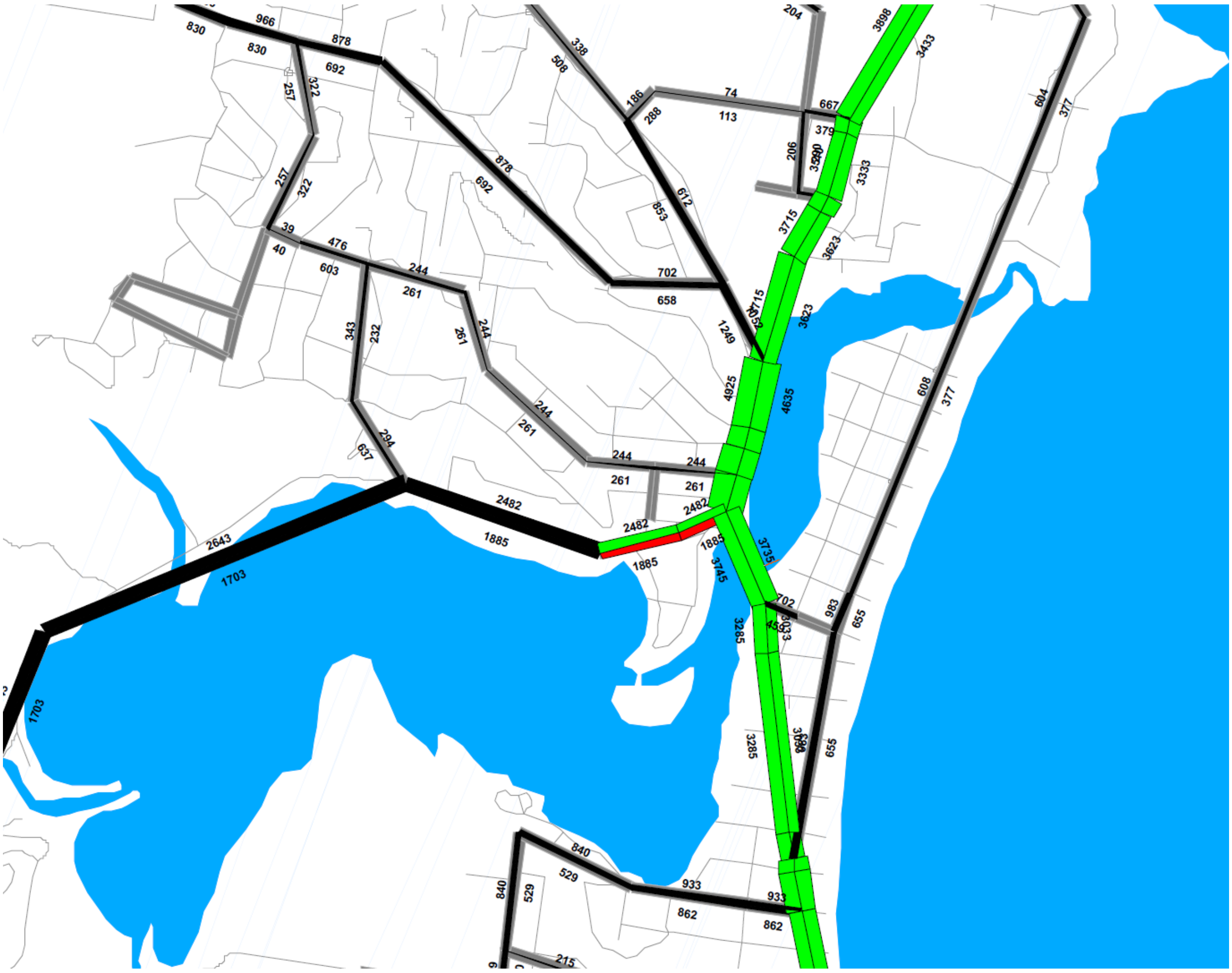
2021 7-9 AM STFM Volumes – Narrabeen



2015 4-6 PM STFM Volumes – Narrabeen



2021 4-6 PM STFM Volumes – Narrabeen



Appendix D

Travel Time Outputs (Vissim)

Appendix D

2016 vs 2021 Travel Time Comparison AM Peak (07:00-09:00) – General Traffic

Route	2016 Base Year		2021 Do-nothing		2021 Option	
	0700-0800	0800-0900	0700-0800	0800-0900	0700-0800	0800-0900
NB Section 1	266	263	266	266	266	264
NB Section 2	167	189	169	191	171	195
NB Total	**433**	**452**	**435**	**458**	**437**	**460**
SB Section 1	209	248	216	289	223	288
SB Section 2	253	283	256	291	255	289
SB Total	**462**	**531**	**472**	**581**	**478**	**577**

2016 vs 2021 Travel Time Comparison AM Peak (07:00-09:00) – Buses

Route	Local Buses						B-Line Buses	
	2016 Base Year		2021 Do-nothing		2021 Option		2021 Option	
	0700-0800	0800-0900	0700-0800	0800-0900	0700-0800	0800-0900	0700-0800	0800-0900
NB Section 1	349	371	347	368	317	342	273	326
NB Section 2	246	273	241	272	245	284	189	240
NB Total	**595**	**644**	**589**	**640**	**562**	**626**	**462**	**566**
SB Section 1	248	263	249	270	232	246	227	224
SB Section 2	410	413	411	414	374	376	352	339
SB Total	**658**	**676**	**660**	**684**	**606**	**622**	**579**	**563**

2016 vs 2021 Travel Time Comparison PM Peak (16:30-18:30) – General Traffic

Route	2016 Base Year		2021 Do-nothing		2021 Option	
	1630-1730	1730-1830	1630-1730	1730-1830	1630-1730	1730-1830
NB Section 1	613	558	657	594	593	673
NB Section 2	121	156	122	159	120	160
NB Total	**733**	**714**	**779**	**753**	**713**	**833**
SB Section 1	190	200	190	200	176	193
SB Section 2	249	262	249	264	237	131
SB Total	**439**	**462**	**439**	**464**	**414**	**324**

2016 vs 2021 Travel Time Comparison PM Peak (16:30-18:30) – Buses

Route	Local Buses						B-Line Buses	
	2016 Base Year		2021 Do-nothing		2021 Option		2021 Option	
	1630-1730	1730-1830	1630-1730	1730-1830	1630-1730	1730-1830	1630-1730	1730-1830
NB Section 1	323	309	321	309	343	348	334	341
NB Section 2	156	192	161	191	150	195	155	198
NB Total	**479**	**501**	**482**	**501**	**493**	**544**	**489**	**538**
SB Section 1	273	292	276	296	256	240	217	233
SB Section 2	412	410	410	409	400	375	373	360
SB Total	**685**	**702**	**686**	**705**	**655**	**615**	**591**	**593**

2016 vs 2021 Travel Time Comparison Sat Peak (11:30-13:30) – General Traffic

Route	2016 Base Year		2021 Do-nothing		2021 Option	
	1130-1230	1230-1330	1130-1230	1230-1330	1130-1230	1230-1330
NB Section 1	295	292	297	300	271	273
NB Section 2	208	244	212	244	197	229
NB Total	**503**	**536**	**509**	**545**	**468**	**502**
SB Section 1	257	281	270	339	199	172
SB Section 2	238	244	244	248	240	247
SB Total	**495**	**525**	**514**	**588**	**439**	**419**

2016 vs 2021 Travel Time Comparison Sat Peak (11:30-13:30) – Buses

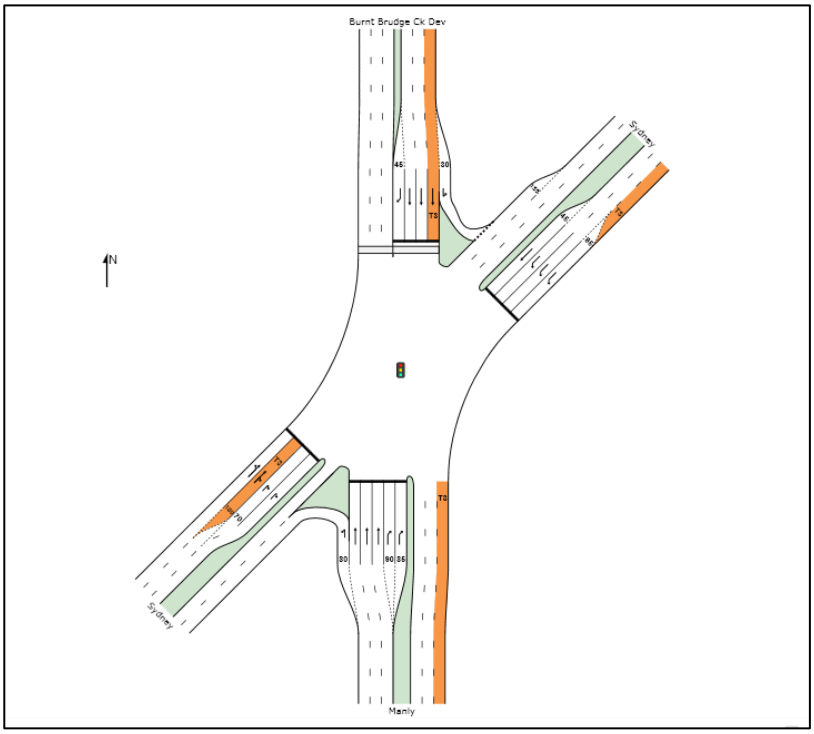
Route	Local Buses						B-Line Buses	
	2016 Base Year		2021 Do-nothing		2021 Option		2021 Option	
	1130-1230	1230-1330	1130-1230	1230-1330	1130-1230	1230-1330	1130-1230	1230-1330
NB Section 1	391	386	405	400	384	379	319	299
NB Section 2	290	309	298	307	273	272	248	288
NB Total	**681**	**695**	**703**	**706**	**657**	**652**	**566**	**587**
SB Section 1	334	335	329	396	254	245	203	239
SB Section 2	345	372	354	381	361	349	330	313
SB Total	**679**	**707**	**683**	**778**	**614**	**594**	**533**	**553**

Appendix E

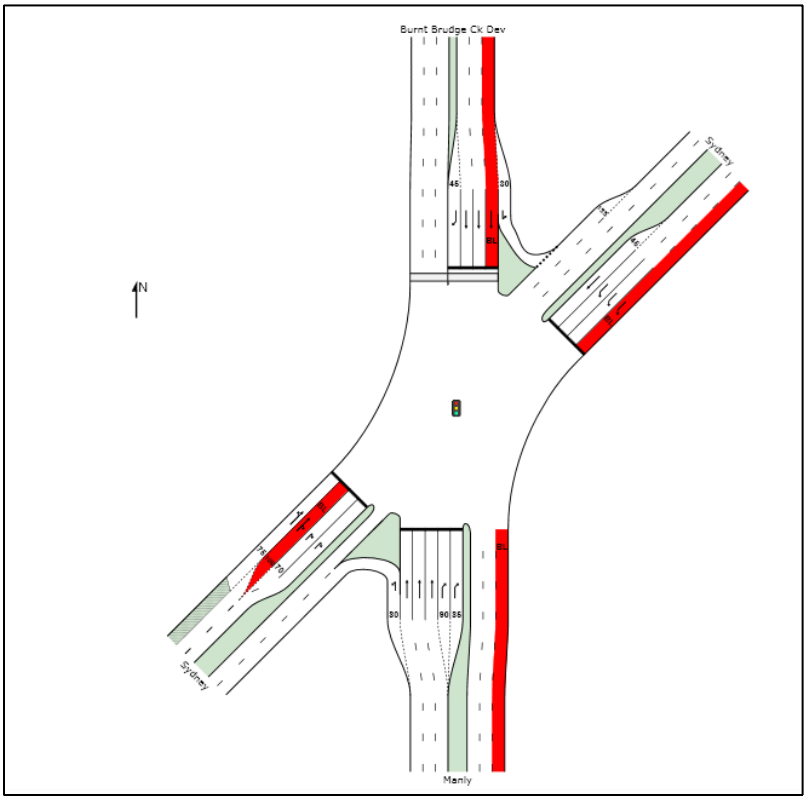
SIDRA Model Outputs

Appendix E

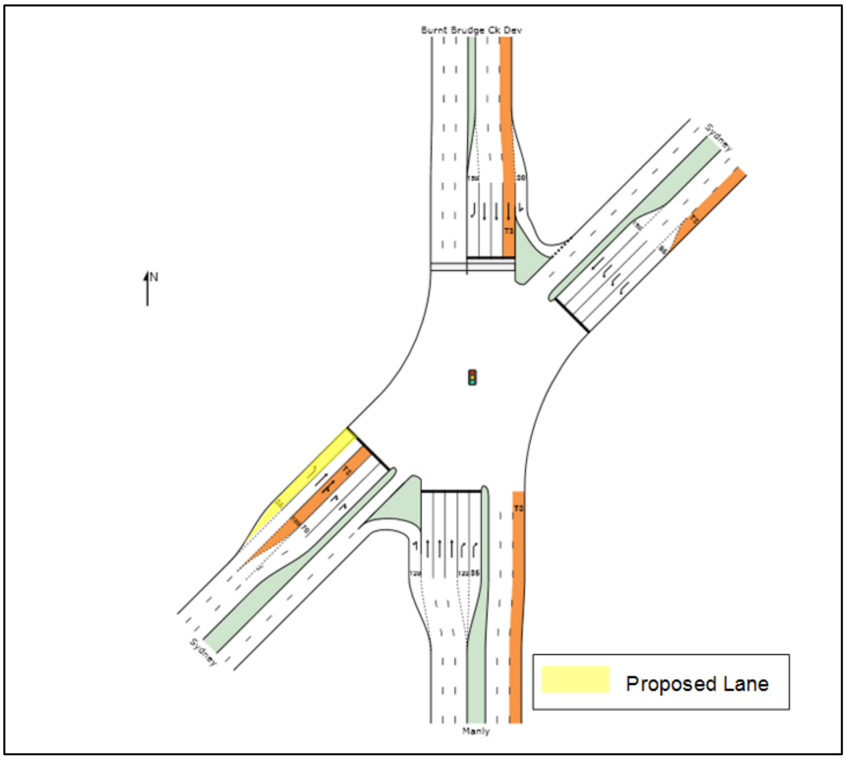
2016 AM Peak – Existing Layout



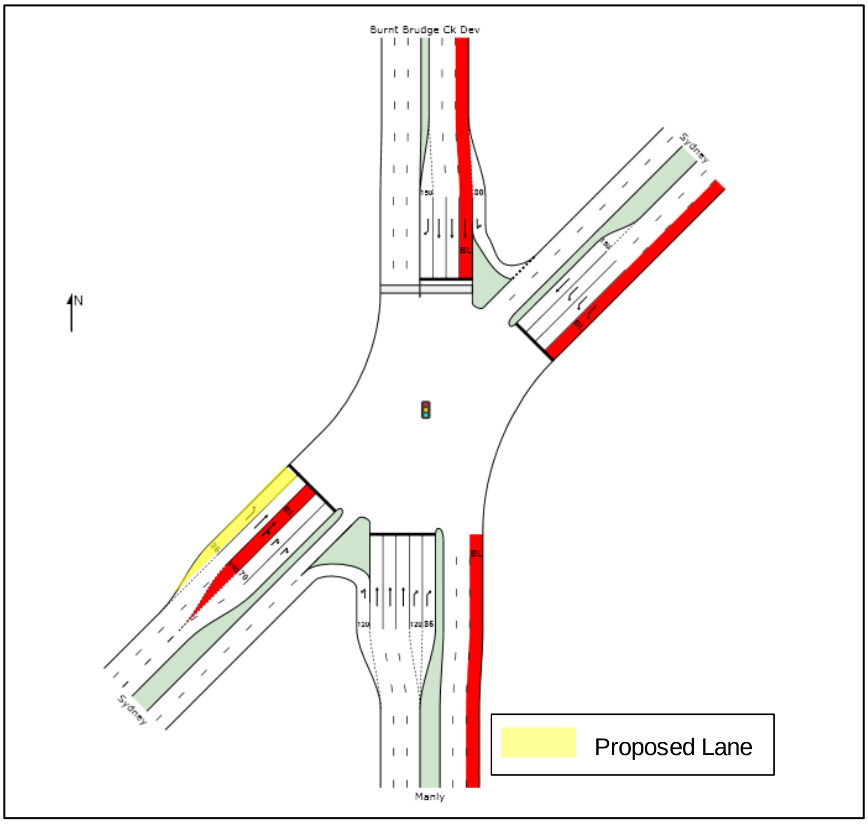
2016 PM Peak – Existing Layout



2021 AM Peak – Upgrade



2021 PM Peak – Upgrade



MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_Existing_2016

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMo v	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	345	5.2	0.220	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	972	6.7	0.392	20.9	LOS B	11.0	81.5	0.72	0.62	44.7
3a	R1	463	5.9	0.875	58.6	LOS E	13.3	98.2	1.00	1.09	24.7
Approach		1780	6.2	0.875	27.7	LOS B	13.3	98.2	0.65	0.72	36.8
NorthEast: Sydney											
24a	L1	912	3.7	0.661	37.0	LOS C	15.7	112.2	0.92	0.80	31.9
25	T1	86	9.8	0.612	53.7	LOS D	4.5	34.5	1.00	0.81	22.1
Approach		998	4.2	0.661	38.4	LOS C	15.7	112.2	0.93	0.80	31.1
North: Burnt Brudge Ck Dev											
7b	L3	37	2.9	0.037	12.4	LOS A	0.6	4.3	0.39	0.65	42.8
8	T1	993	9.4	0.473	24.2	LOS B	13.3	98.4	0.78	0.67	43.0
9a	R1	73	5.8	0.374	52.5	LOS D	3.6	26.3	0.97	0.76	26.9
Approach		1102	9.0	0.473	25.7	LOS B	13.3	98.4	0.78	0.68	41.8
SouthWest: Sydney											
30a	L1	175	6.6	0.642	25.8	LOS B	11.1	82.3	0.75	0.71	35.2
31	T1	222	10.0	1.107	73.1	LOS F	12.4	94.6	0.85	1.02	22.1
32b	R3	480	5.7	1.107	85.1	LOS F	12.4	94.6	0.95	1.06	22.4
Approach		877	7.0	1.107	70.2	LOS E	12.4	94.6	0.89	0.98	21.1
All Vehicles		4757	6.6	1.107	37.3	LOS C	15.7	112.2	0.78	0.78	33.0

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_Existing_2016

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMo v	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	757	2.4	0.473	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1612	3.7	0.608	20.8	LOS B	18.9	136.6	0.80	0.71	44.8
3a	R1	846	2.0	0.837	46.6	LOS D	21.2	150.9	1.00	0.98	34.0
Approach		3215	2.9	0.837	24.0	LOS B	21.2	150.9	0.67	0.74	41.5
NorthEast: Sydney											
24a	L1	557	3.0	0.339	24.4	LOS B	8.6	60.8	0.71	0.74	42.3
25	T1	184	5.1	1.052	120.4	LOS F	15.2	110.9	1.00	1.43	14.4
Approach		741	3.6	1.052	48.3	LOS D	15.2	110.9	0.79	0.91	31.2
North: Burnt Brudge Ck Dev											
7b	L3	37	2.9	0.044	15.2	LOS B	0.7	5.1	0.48	0.67	47.7
8	T1	848	5.0	0.821	39.1	LOS C	22.0	157.8	0.97	0.93	36.6
9a	R1	155	4.1	0.897	63.1	LOS E	8.6	62.4	1.00	1.03	24.2
Approach		1040	4.8	0.897	41.9	LOS C	22.0	157.8	0.96	0.94	34.9
SouthWest: Sydney											
30a	L1	164	3.8	0.926	35.1	LOS C	20.1	143.0	0.99	0.96	32.2
31	T1	256	4.5	0.926	31.9	LOS C	20.1	143.0	0.99	0.95	32.3
32b	R3	306	3.1	0.896	51.7	LOS D	7.6	53.6	0.99	0.88	26.4
Approach		726	3.8	0.926	41.0	LOS C	20.1	143.0	0.99	0.92	29.4
All Vehicles		5722	3.5	1.052	32.5	LOS C	22.0	157.8	0.78	0.82	37.1

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_Existing_2021

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	366	5.2	0.233	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1031	6.6	0.415	21.2	LOS B	11.8	87.5	0.73	0.63	44.6
3a	R1	492	5.8	0.927	66.8	LOS E	15.3	112.8	1.00	1.21	23.4
Approach		1888	6.1	0.927	30.0	LOS C	15.3	112.8	0.66	0.76	36.0
NorthEast: Sydney											
24a	L1	966	3.6	0.701	37.7	LOS C	16.9	121.2	0.93	0.82	31.7
25	T1	93	10.2	0.659	54.3	LOS D	4.9	37.6	1.00	0.84	22.0
Approach		1059	4.2	0.701	39.2	LOS C	16.9	121.2	0.94	0.82	30.9
North: Burnt Brudge Ck Dev											
7b	L3	41	5.1	0.042	12.8	LOS A	0.7	5.0	0.40	0.66	42.6
8	T1	1051	9.2	0.510	24.5	LOS B	14.6	108.2	0.79	0.68	42.8
9a	R1	78	6.8	0.403	52.7	LOS D	3.9	28.5	0.98	0.76	26.8
Approach		1169	8.9	0.510	26.0	LOS B	14.6	108.2	0.79	0.69	41.6
SouthWest: Sydney											
30a	L1	186	6.8	0.685	26.2	LOS B	12.3	91.2	0.78	0.73	35.0
31	T1	237	9.8	1.169	95.7	LOS F	12.4	94.6	0.87	1.13	20.9
32b	R3	508	5.6	1.169	106.3	LOS F	12.4	94.6	0.96	1.16	21.2
Approach		932	6.9	1.169	87.6	LOS F	12.4	94.6	0.90	1.07	18.4
All Vehicles		5048	6.5	1.169	41.6	LOS C	16.9	121.2	0.79	0.81	31.7

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_Existing_2021

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	803	2.4	0.502	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1707	3.6	0.723	21.9	LOS B	24.3	175.5	0.84	0.75	44.2
3a	R1	898	2.0	0.888	52.6	LOS D	24.4	174.0	1.00	1.04	32.2
Approach		3408	2.9	0.888	26.1	LOS B	24.4	175.5	0.68	0.77	40.4
NorthEast: Sydney											
24a	L1	591	3.0	0.360	24.6	LOS B	9.3	65.4	0.72	0.74	42.2
25	T1	197	5.3	1.126	179.0	LOS F	20.4	149.2	1.00	1.64	10.7
Approach		787	3.6	1.126	63.2	LOS E	20.4	149.2	0.79	0.97	27.3
North: Burnt Brudge Ck Dev											
7b	L3	40	2.6	0.050	17.1	LOS B	0.9	6.1	0.53	0.68	46.5
8	T1	900	4.9	0.873	44.6	LOS D	25.4	182.1	0.98	1.01	34.7
9a	R1	166	4.4	0.967	77.4	LOS F	10.5	76.1	1.00	1.15	21.3
Approach		1106	4.8	0.967	48.5	LOS D	25.4	182.1	0.96	1.02	32.7
SouthWest: Sydney											
30a	L1	175	4.2	0.997	52.0	LOS D	26.3	187.8	1.00	1.12	26.5
31	T1	273	4.6	0.997	48.3	LOS D	26.3	187.8	0.99	1.11	26.6
32b	R3	326	3.2	0.958	56.6	LOS E	8.7	61.2	0.99	0.95	25.1
Approach		774	3.9	0.997	52.7	LOS D	26.3	187.8	0.99	1.05	25.9
All Vehicles		6076	3.5	1.126	38.4	LOS C	26.3	187.8	0.79	0.88	34.8

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_2021- Upgrade_SC1

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMo v	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	366	5.2	0.233	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1031	6.6	0.466	25.1	LOS B	12.9	95.4	0.79	0.68	42.5
3a	R1	492	5.8	0.927	66.8	LOS E	15.3	112.8	1.00	1.21	23.4
Approach		1888	6.1	0.927	32.1	LOS C	15.3	112.8	0.69	0.79	35.2
NorthEast: Sydney											
24a	L1	1240	2.8	0.695	31.2	LOS C	20.7	147.2	0.89	0.81	33.7
25	T1	93	10.2	0.310	42.2	LOS C	4.2	32.3	0.92	0.73	24.7
Approach		1333	3.3	0.695	32.0	LOS C	20.7	147.2	0.89	0.80	33.1
North: Burnt Brudge Ck Dev											
7b	L3	41	5.1	0.052	18.4	LOS B	1.0	7.1	0.54	0.68	40.0
8	T1	1051	9.2	0.633	32.4	LOS C	15.6	115.0	0.90	0.78	39.2
9a	R1	78	6.8	0.634	59.0	LOS E	4.2	30.9	1.00	0.80	25.3
Approach		1169	8.9	0.634	33.7	LOS C	15.6	115.0	0.89	0.77	38.2
SouthWest: Sydney											
30a	L1	186	6.8	0.236	8.0	LOS A	1.6	11.7	0.18	0.48	47.3
31	T1	237	9.8	1.169	87.4	LOS F	12.4	94.6	0.61	0.86	24.1
32b	R3	508	5.6	1.169	106.3	LOS F	12.4	94.6	0.96	1.16	21.2
Approach		932	6.9	1.169	81.8	LOS F	12.4	94.6	0.71	0.95	19.2
All Vehicles		5322	6.2	1.169	41.1	LOS C	20.7	147.2	0.79	0.82	31.7

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_2021 - Upgrade_SC1

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMo v	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	803	2.4	0.502	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1707	3.6	0.783	30.6	LOS C	24.9	179.5	0.95	0.88	40.0
3a	R1	898	2.0	1.009	95.5	LOS F	33.8	240.9	1.00	1.35	23.2
Approach		3408	2.9	1.009	41.8	LOS C	33.8	240.9	0.74	0.92	34.1
NorthEast: Sydney											
24a	L1	738	2.4	0.402	21.9	LOS B	11.1	78.0	0.69	0.74	43.6
25	T1	197	5.3	0.596	40.8	LOS C	8.8	64.6	0.97	0.80	27.2
Approach		935	3.0	0.596	25.9	LOS B	11.1	78.0	0.75	0.75	39.9
North: Burnt Brudge Ck Dev											
7b	L3	40	2.6	0.067	20.7	LOS B	1.0	7.2	0.60	0.70	44.5
8	T1	900	4.9	0.971	71.0	LOS F	29.3	210.4	1.00	1.24	27.8
9a	R1	166	4.4	0.967	77.3	LOS F	10.5	76.1	1.00	1.15	21.4
Approach		1106	4.8	0.971	70.1	LOS E	29.3	210.4	0.98	1.21	27.2
SouthWest: Sydney											
30a	L1	175	4.2	0.217	7.6	LOS A	1.4	9.8	0.17	0.48	47.7
31	T1	273	4.6	0.400	13.5	LOS A	5.5	38.7	0.48	0.40	44.0
32b	R3	326	3.2	0.958	56.6	LOS E	8.7	61.2	0.99	0.95	25.1
Approach		774	3.9	0.958	30.4	LOS C	8.7	61.2	0.63	0.65	33.6
All Vehicles		6223	3.4	1.009	43.0	LOS D	33.8	240.9	0.77	0.91	33.2

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_AM Peak_2021-Upgrade_SC2

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 104 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	366	5.2	0.233	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1031	6.6	0.478	25.9	LOS B	13.1	97.0	0.80	0.70	42.1
3a	R1	492	5.8	0.927	66.8	LOS E	15.3	112.8	1.00	1.21	23.4
Approach		1888	6.1	0.927	32.6	LOS C	15.3	112.8	0.70	0.80	35.0
NorthEast: Sydney											
24a	L1	1103	3.1	0.782	40.7	LOS C	20.4	145.2	0.96	0.89	30.9
25	T1	93	10.2	0.659	54.3	LOS D	4.9	37.6	1.00	0.84	22.0
Approach		1196	3.7	0.782	41.7	LOS C	20.4	145.2	0.97	0.88	30.3
North: Burnt Brudge Ck Dev											
7b	L3	41	5.1	0.046	14.3	LOS A	0.8	5.6	0.44	0.67	41.9
8	T1	1051	9.2	0.652	33.4	LOS C	15.8	116.8	0.91	0.79	38.8
9a	R1	78	6.8	0.634	59.0	LOS E	4.2	30.9	1.00	0.80	25.3
Approach		1169	8.9	0.652	34.4	LOS C	15.8	116.8	0.90	0.78	37.9
SouthWest: Sydney											
30a	L1	186	6.8	0.231	7.2	LOS A	1.4	10.1	0.15	0.47	48.0
31	T1	237	9.8	0.721	16.8	LOS B	12.0	91.3	0.52	0.47	31.8
32b	R3	645	4.4	0.721	31.6	LOS C	12.0	91.3	0.79	0.78	33.1
Approach		1068	6.0	0.721	24.1	LOS B	12.0	91.3	0.62	0.66	34.6
All Vehicles		5322	6.2	0.927	33.3	LOS C	20.4	145.2	0.79	0.78	34.3

MOVEMENT SUMMARY

Site: TCS 323_Sydney Road_Manly Road_PM Peak_2021_ Upgrade_SC2

Manly Rd and Sydney Rd Intersection, Seaforth
Signals - Fixed Time Coordinated   Cycle Time = 97 seconds (User-Given Phase Times)

Movement Performance - Vehicles

Mov ID	ODMov	Demand Flows Total	Demand Flows HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Manly											
1b	L3	803	2.4	0.502	5.5	LOS A	0.0	0.0	0.00	0.52	47.0
2	T1	1707	3.6	0.690	23.9	LOS B	21.8	157.0	0.87	0.77	43.1
3a	R1	898	2.0	1.050	122.2	LOS F	38.4	273.7	1.00	1.50	19.8
Approach		3408	2.9	1.050	45.5	LOS D	38.4	273.7	0.70	0.90	32.9
NorthEast: Sydney											
24a	L1	664	2.7	0.449	28.3	LOS B	11.5	81.1	0.79	0.78	40.5
25	T1	197	5.3	1.126	179.0	LOS F	20.4	149.2	1.00	1.64	10.7
Approach		861	3.3	1.126	62.7	LOS E	20.4	149.2	0.84	0.97	27.5
North: Burnt Brudge Ck Dev											
7b	L3	40	2.6	0.056	16.0	LOS B	0.8	5.9	0.50	0.68	47.2
8	T1	900	4.9	0.770	35.6	LOS C	20.0	143.5	0.97	0.89	37.9
9a	R1	166	4.4	0.967	77.3	LOS F	10.5	76.1	1.00	1.15	21.4
Approach		1106	4.8	0.967	41.1	LOS C	20.0	143.5	0.96	0.92	35.2
SouthWest: Sydney											
30a	L1	175	4.2	0.247	11.7	LOS A	2.4	17.5	0.31	0.54	44.3
31	T1	273	4.6	0.471	18.7	LOS B	7.3	51.5	0.62	0.52	40.1
32b	R3	400	2.6	0.906	48.5	LOS D	9.9	69.9	0.99	0.90	27.2
Approach		847	3.6	0.906	31.3	LOS C	9.9	69.9	0.73	0.70	33.2
All Vehicles		6223	3.4	1.126	45.2	LOS D	38.4	273.7	0.77	0.89	32.4

Appendix F

Commuter Model Outputs

Appendix F

Level of Service: AM Peak

Scenarios	AM Peak Hour															
	Intersection Statistics			Approach Statistics												
	Total	Delay	Level of	Queue Size - number of vehicles				Queue Max - number of vehicles				Number of Stops				
	Vehicle	(sec)	Service	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd
2016 Existing AM Peak	4958	212	F	18	100	11	8	54	273	46	27	1095	3131	927	848
2016 Upgrade - Scenario 1 AM Peak	5303	210	F	24	85	20	8	72	243	65	28	1446	3197	1368	863
2016 Upgrade - Scenario 2 AM Peak	4759	177	F	45	44	9	8	80	166	34	27	1739	2294	851	854

Level of Service: PM Peak

Scenarios	PM Peak Hour															
	Intersection Statistics			Approach Statistics												
	Total	Delay	Level of	Queue Size - number of vehicles				Queue Max - number of vehicles				Number of Stops				
	Vehicle	(sec)	Service	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd	Sydney Rd W	BBCD	Sydney Rd E	Manly Rd
2016 Existing PM Peak	5044	92	F	6	25	4	23	22	62	16	87	581	1373	430	2333
2016 Upgrade - Scenario 1 PM Peak	5211	86	F	7	19	5	28	23	59	21	96	618	914	526	2535
2016 Upgrade - Scenario 2 PM Peak	5221	89	F	10	21	5	22	26	71	19	83	775	1009	487	2222

Travel Times southbound between Sydney Rd and Parriwi Rd

AM Peak

Average Travel Times (SB: Sydney Rd to Parriwi Rd)			
	BASE	Scenario 1	Scenario 2
GT	0:08:34	0:08:24	0:08:04
T3	0:04:59	0:04:36	0:04:34
PT	0:04:47	0:03:23	0:03:06

PM Peak

Average Travel Times (SB: Sydney Rd to Parriwi Rd)			
	BASE	Scenario 1	Scenario 2
GT	0:08:38	0:08:16	0:08:54
T3	0:08:28	0:08:03	0:08:45
PT	0:06:15	0:06:11	0:06:35

Note:

Scenario 1: 100% of Heaton Avenue traffic is diverted to the eastern approach of Sydney Road / Manly Road intersection.

Scenario 2: 50% of the diverted traffic originates from the eastern side of Manly Road and 50% from the west.

GT: General Traffic

T3: Vehicles that have three or more passengers

PT: Public Transport vehicles (i.e. buses in the Commuter model)

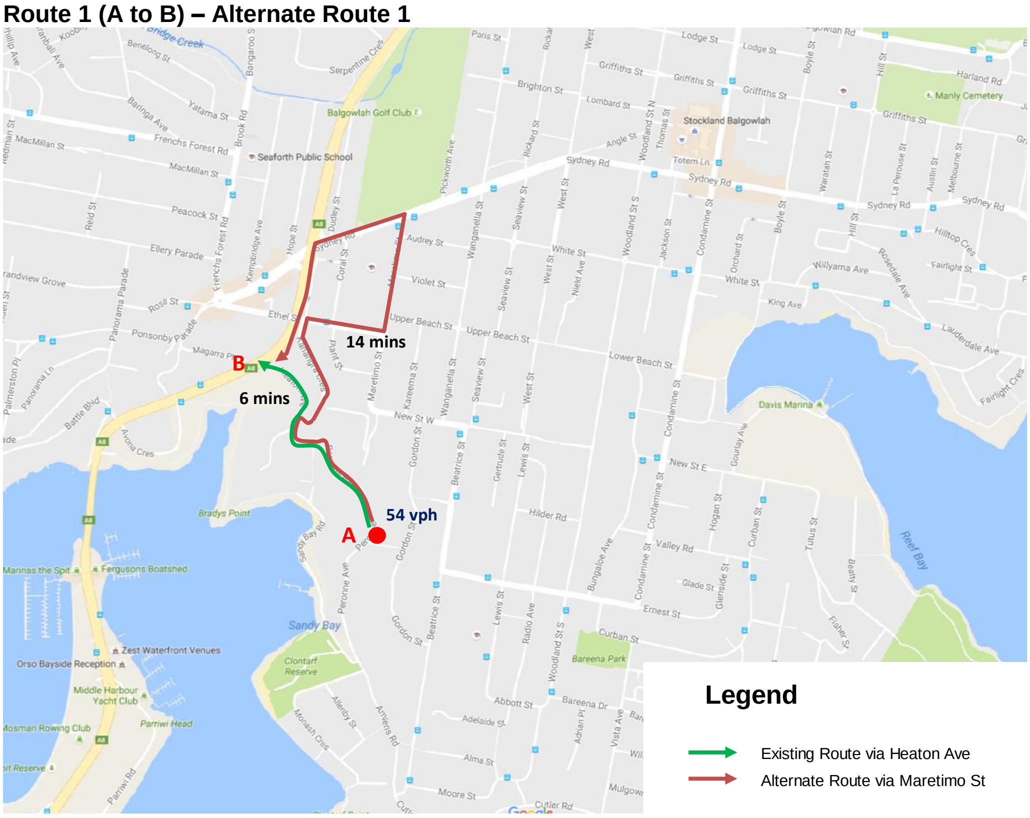
Appendix G

Heaton Avenue Travel Time Routes

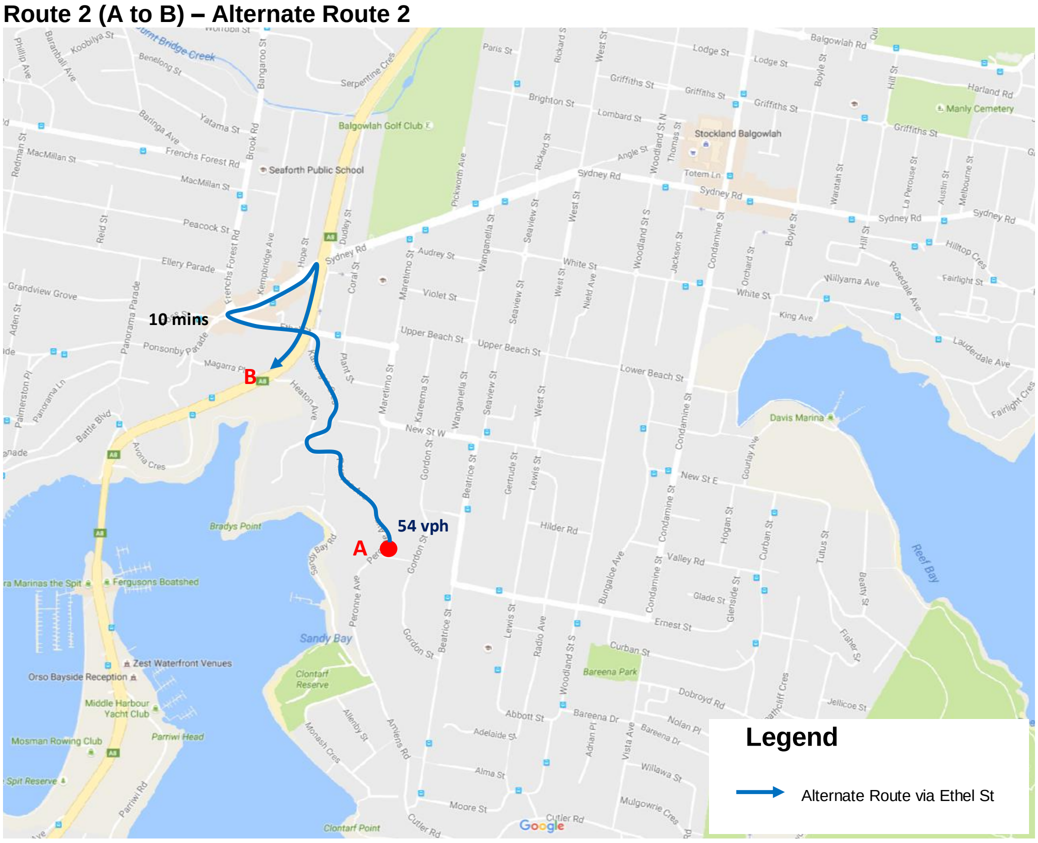
Appendix G

Travel time estimates in the AM peak based on Google data and floating car sampling on, Wednesday 19th October, Friday 21st October and Tuesday 25th October 2016 are presented in the following diagrams.

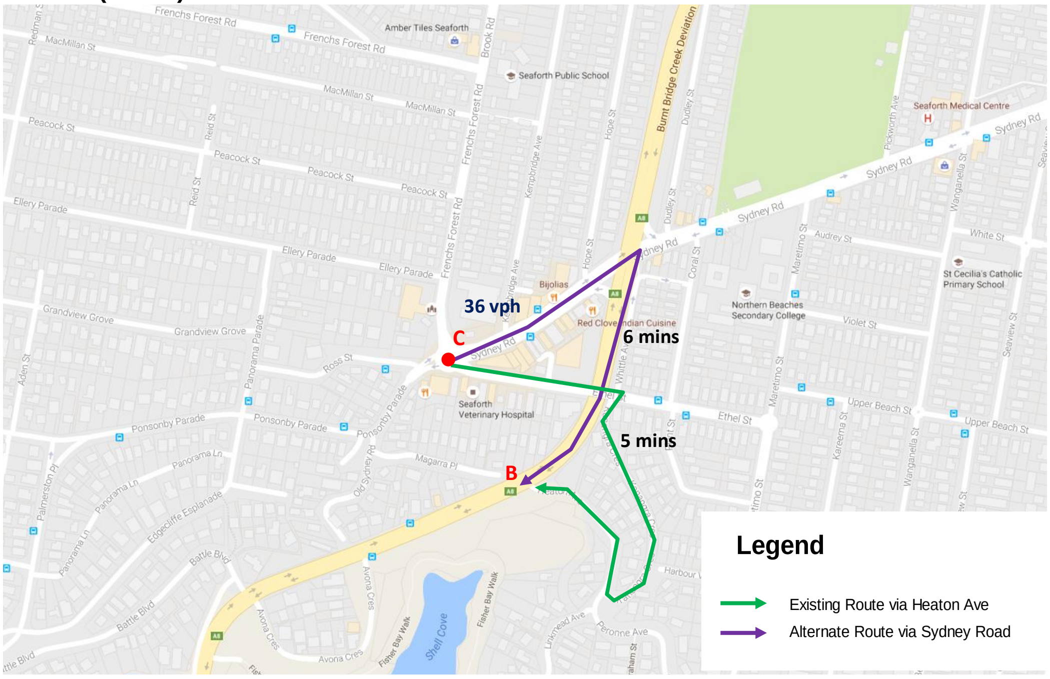
Route 1 (A to B) – Alternate Route 1



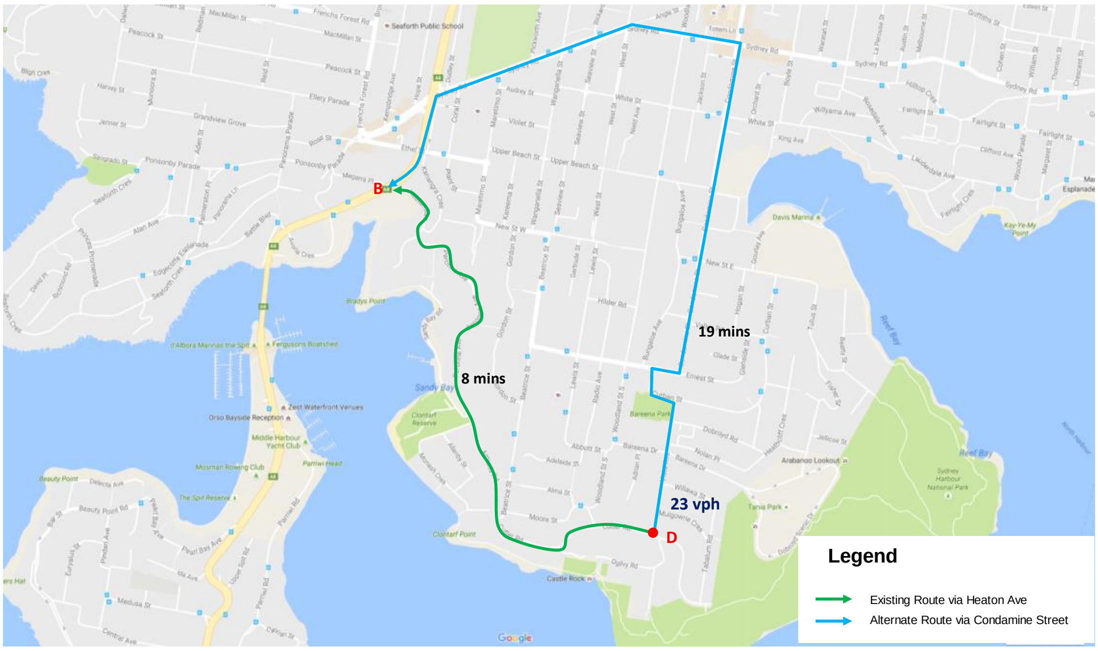
Route 2 (A to B) – Alternate Route 2



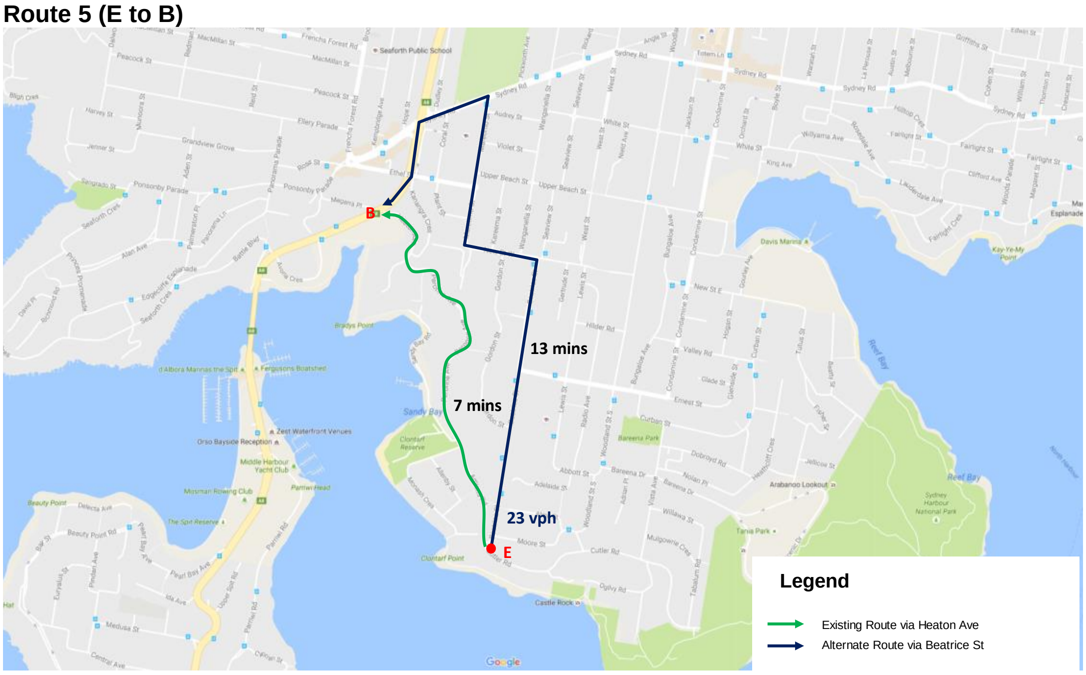
Route 3 (C to B)



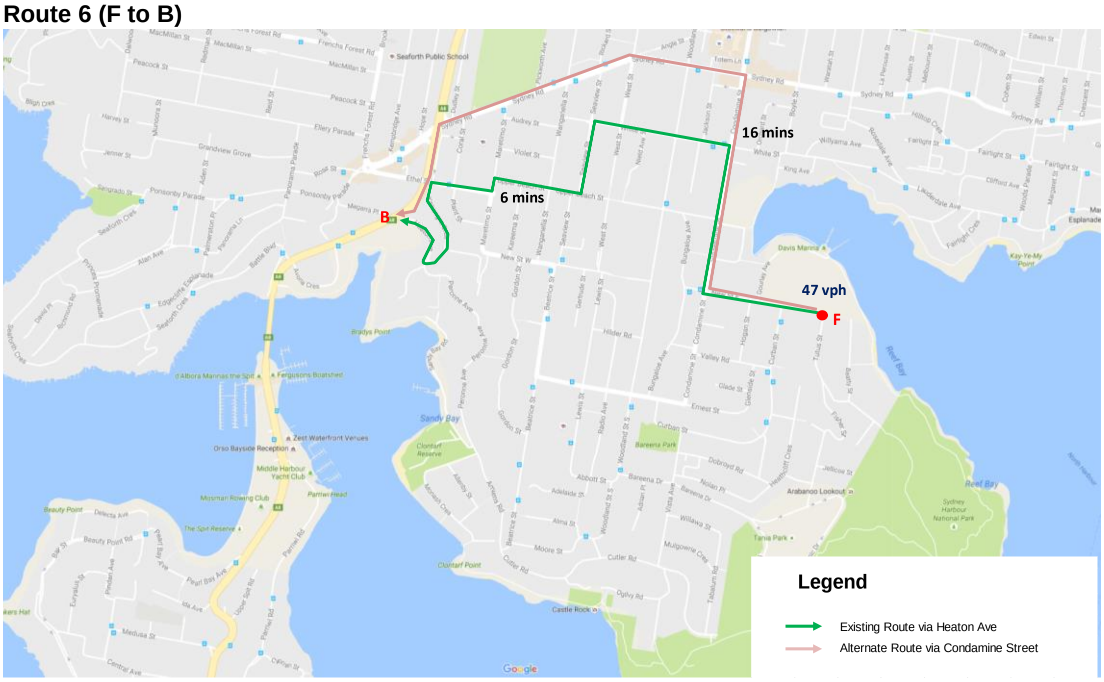
Route 4 (D to B)



Route 5 (E to B)



Route 6 (F to B)



Appendix D Construction Noise and Vibration Impact Assessment – Package 9

Easing Sydneys' Congestion
Roads and Maritime Services
25-Oct-2016
Doc No. 60491201-RPNV-01_A

Northern Beaches B-Line Package 9 - Brookvale to Seaforth

Construction Noise and Vibration Impact Assessment

Northern Beaches B-Line Package 9 - Brookvale to Seaforth

Construction Noise and Vibration Impact Assessment

Client: Roads and Maritime Services

ABN: 76 236 371 088

Prepared by

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25-Oct-2016

Job No.: 60491201

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

Quality Information

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Ref	60491201
Date	25-Oct-2016
Prepared by	Michael Allan
Reviewed by	Gayle Greer

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	10-Oct-2016	Draft for client review		
B	25-Oct-2016	Final		

Table of Contents

1.0 Introduction

1.1 Background

AECOM has been commissioned by Roads and Maritime Services (Roads and Maritime) to carry out an acoustic assessment of the proposed construction of part of the Northern Beaches B-Line Program (hereafter referred to as B-line). The overall B-line Program involves a series of road infrastructure and bus service improvements that will aim to deliver a more frequent and reliable bus service for customers travelling between the Northern Beaches and the Sydney CBD.

This report provides a construction noise and vibration assessment of the impact of construction of road infrastructure associated within one section of the B-Line Program. The subject section commences at the intersection of Orchard Road, Brookvale to the north and finishes at the intersection of Heaton Avenue Clontarf to the south. The assessment also includes activity associated with the proposed construction compound at the Manly Vale commuter car park. This subject section is referred to as Package 9 throughout this report and within the project Review of Environmental Factors (REF).

Roads and Maritime do not expect a change in traffic volumes as a result of the project. As such as an operational noise assessment is not warranted for this project.

1.2 Scope

Provided below is a summary of the construction activities associated with the Proposal, separated into the four relevant Zones.

Zone A: Pittwater Road from Orchard Road to Cross Street, Brookvale

- Construction of a new left turn lane from Pittwater Road (northbound) into Cross Street:
  - removal of vegetation
  - relocation of existing below and above ground electrical, gas and water services and utilities located in the road and road reserve south of Cross Street and west of Pittwater Road, where affected by the works
  - demolition of existing kerbs, footpath and road concrete
  - relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works
  - relocation of existing traffic signals and installation of new traffic signals required for the works
  - construction of new road pavement, kerbs, road verge and footpath for the new left turn lane
  - removal of sections of existing concrete pavement to allow for tie in of the new pavement
  - installation of new concrete pavement sub-base at tie in locations
  - installation of bitumen overlay
  - adjustments to the existing pedestrian crossing across Cross Street
  - landscaping at the southern corner of Pittwater Road and Cross Street
  - new line marking and adjustments to existing traffic signal infrastructure
  - partial acquisition of the adjacent parcel of land to accommodate the wider footprint required for the new left turn lane and footpath area.
- Closure of the median strip within Pittwater Road at the Orchard Road intersection to prevent vehicles from turning right from Pittwater Road (northbound) into Orchard Road and vehicles turning right from Orchard Road into Pittwater Road (northbound):
  - demolition of existing concrete road pavement

  - removal of existing statutory signage not required because of the new median strip
  - installation of fittings and foundation for new median strip
  - construction of new median (around 28 m long)
  - new line marking to designate the existing right turn lane from Pittwater Road into Orchard Road (northbound) as an extension of the right turn lane from Pittwater Road into Sydenham Road (northbound)

Zone B – Sydney Road/Manly Road/Burnt Bridge Creek Deviation, Balgowlah and Seaforth

- Extension of the existing through lane from Burnt Bridge Creek Deviation into Sydney Road (westbound):
  - removal of vegetation within the existing median strip including 19 immature trees.
  - demolition and excavation existing kerbs and median strip.
  - relocation of existing statutory and directional signage and installation of new statutory and directional signage required for the works.
  - construction of new road pavement, median and kerbs for the extended right turn lane.
  - new line marking.
- Construction of a new left turn lane from Sydney Road into Burnt Bridge Creek Deviation (northbound):
  - removal of vegetation within the road verge on the corner of Sydney Road.
  - demolition and excavation of existing road pavement, kerbs, pedestrian pathway and road verge.
  - construction of new road pavement, kerbs, pedestrian pathway and road verge for the new left turn lane.
  - installation of a low retaining wall between the new left turn lane and pedestrian pathway to account for differing grade heights, including pedestrian safety fencing along retaining wall.
  - new line marking and adjustments to existing traffic signal infrastructure.
- Upgrade of the existing left turn slip lane from Burnt Bridge Creek Deviation into Sydney Road (eastbound):
  - removal of vegetation within the eastern road verge of Burnt Bridge Creek Deviation.
  - demolition and excavation of existing road pavement, kerbs, pedestrian crossing and road verge.
  - construction of new road pavement, kerbs, pedestrian pathway and road verge for the new left turn slip lane.
  - widen the existing traffic island at the north-eastern corner of Burnt Bridge Creek Deviation and Sydney Road.
  - new line marking including a new pedestrian crossing (non-signalised) across the reconstructed slip lane.
- Extension of the existing right turn lane from Manly Road into Sydney Road (eastbound):
  - demolition and excavation of existing road pavement, kerbs and the southern part of the median.
  - construction of new road pavement and kerbs for the extended right turn lane.
  - new line marking.

Zone C – Manly Road/Heaton Avenue intersection, Clontarf

- Full closure of Heaton Avenue at Manly Road to form a cul-de-sac:

- relocation of existing service utilities and installation of new services where required.
- demolition and excavation of existing road pavement and kerbs.
- removal of vegetation within and adjacent to the northern road verge of Heaton Avenue.
- construction of new pavement, footpath, kerbs and landscaping for the new cul-de-sac.
- new line marking and signage.

- Construction of a new indented bus bay on Manly Road (southbound) at the Heaton Avenue intersection:
  - relocation of existing below ground and above ground service utilities and installation of new services where required.
  - demolition and excavation of existing road pavement, kerbs, footpath and bus stop.
  - construction of new road pavement and kerbs for the new indented bus bay (about 3 m wide and 46 m long including a 15 m taper at each end).
  - construction of new footpath and retaining wall.
  - replacement of existing guard rails.
  - new line marking.

Use of Manly Vale Commuter Car Park as construction compound

2.0 Existing ambient noise environment

2.1 Overview

Package 9 of the B-line program is situated on Pittwater road, Burnt Bridge Creek Deviation, Sydney Road, and Manly Road between Brookvale and Clontarf. The project road facilitates a large proportion north and south vehicle travel within the Northern Beaches. As such the existing noise environment consists primarily of traffic noise.

2.2 Ambient noise monitoring

Ambient noise monitoring was undertaken at four locations throughout the study area from 31 August 2016 to 11 September 2016. The locations for the noise logging were chosen through examination of aerial photography and site inspections. . However it is noted that the logging locations were ultimately directed by RMS.

Attended noise measurements were also undertaken to determine the nature of the local noise environment and confirm road traffic was the controlling noise source.

The background noise logging locations are illustrated in Appendix B. The noise logging results are provided graphically in Appendix C.

A noise logger measures the noise level over the sample period and then determines L_{A1}, L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} levels of the noise environment. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1 per cent, 10 per cent and 90 per cent of the sample period respectively. The L_{Amax} is indicative of maximum noise levels due to individual noise events. The L_{A90} is taken as the background noise level. The L_{Aeq} is the energy averaged noise level over a defined period.

The results of the noise monitoring have been processed in accordance with the procedures contained in the *NSW EPA Road Noise Policy* (RNP) (Department of Environment, Climate Change and Water NSW, 2011) and the *NSW EPA Industrial Noise Policy* (INP) (Environment Protection Authority). Weather data recorded during the noise monitoring survey periods was obtained from the Bureau of Meteorology weather station, located at Sydney Olympic Park. Periods which were affected by noise from extraneous wind and rain were omitted from the results.

Noise logging has previously been carried out for the construction compound site for a previous B-Line REF (Manly Vale Commuter Car Park and B-Line stops - Review of Environmental Factors, Transport for New South Wales, March 2016). The results from this assessment have been adopted in this report.

Details of each noise logging location and the noise monitoring equipment are provided in Table 1 below.

Table 1 Noise logging locations

No.	Address	Location on property	Logger	Serial number	Measurement period
P8_1	727 Pittwater Road	Reserve adjacent carpark and Pittwater Road	ARL 215	194803	31 Aug 2016 to 11 Sep 2016
P9_1	14 Heaton Avenue, Clontarf	Public bushland opposite the residential property	ARL 315	15-203-504	31 Aug 2016 to 10 Sep 2016
P9_2	10 Magarra Place, Seaforth	Reserve between property and Manly Road	ARL 316	16-203-502	31 Aug 2016 to 11 Sep 2016

No.	Address	Location on property	Logger	Serial number	Measure ment period
P9_3	10 Whittle Avenue, Balgowlah	Reserve/nature strip opposite property	ARL 316	16-302-485	31 Aug 2016 to 11 Sep 2016
P9_4	2 Hope Street, Seaforth	Neighbouring reserve			Logger stolen
Construction compound	82 Kenneth Road, Manly Vale	East of existing Casey's toys building	-	-	30 Nov 2016 to 14 Dec 2016

2.3 Unattended background noise monitoring results

The background noise monitoring results are provided in

Table 2. These noise levels were used to define the appropriate construction noise management levels, consistent with the *Interim Construction Noise Guideline* (Department of Environment and Climate Change NSW, 2009).

The assessment background levels (ABL) were established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each assessment period of interest. The background noise level or rating background levels (RBL) representing the day, evening and night-time assessment periods were based on the median of individual ABLs determined over the entire monitoring duration.

Table 2 also presents the ambient L_{Aeq} levels at each monitoring location. The L_{Aeq} level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels.

The noise levels presented in Table 2 indicate that the noise environment at the measurement locations are typical of suburban/urban noise environments located alongside major transport corridors, where day time and evening background levels are high due to heavy and continuous traffic flows. The night time background levels tend to decrease as a result of reduced traffic flows.

Table 2 Ambient noise measurements

Noise logging location	Rating background level, dB(A)			Ambient L_{Aeq} noise level, dB(A)		
	Day (7am to 6pm) $L_{A90,15\ minute}$	Evening (6pm to 10pm) $L_{A90,15\ minute}$	Night (10pm to 7am) $L_{A90,15\ minute}$	Day (7am to 6pm) $L_{Aeq,15\ hour}$	Evening (6pm to 10pm) $L_{Aeq,4\ hour}$	Night (10pm to 7am) $L_{Aeq,9\ hour}$
P8_1	58	55	42	71	70	66
P9_1	51	48	33	61	58	55
P9_2	61	58	38	74	72	69
P9_3	62	57	36	74	71	68
Construction Compound	54	48	38	-[1]	-[1]	-[1]

Note1: These figures were not available for this assessment.

2.4 Attended noise monitoring results

Attended monitoring was conducted at the five unattended noise monitoring locations and also at a receiver back from the road. Each measurement was conducted over a 15 minute period. The monitoring was carried out on 31 August 2016, and 12 September 2016. Skies were clear with scattered clouds and conditions were calm with a slight breeze on the days of monitoring. Measurement details are provided below in

Table 3 and Table 4.

Table 3 Attended noise monitoring results (logger location)

Monitoring location	Date	Time	Description	Attended measurement results, dB(A)			
				$L_{max, 15min}$	$L_{10, 15min}$	$L_{eq, 15min}$	$L_{90, 15min}$
Zone A	31 Aug 2016	11:38	• Located in public reserve next to council carpark • Traffic noise along Pittwater Road dominates • Non-stop traffic at time of measurement	89	75	71	60
Zone B	31 Aug 2016	13:36	• Located adjacent to intersection of two main roads in public reserve/nature strip. • Traffic noise dominates. • Non-stop traffic at time of measurement.	93	75	72	62
Zone B	31 Aug 2016	12:30	• Located in a public reserve. • Background noise controlled by traffic passing through the intersection of the two main roads. • Location is below the alignment of the main roads.	75	62	59	53
Zone C_1	31 Aug 2016	14:17	• Located in public vegetation opposite residential properties. • Ambient noise controlled by passing traffic and also traffic along Manly road. • Background noise controlled by nature.	79	63	60	54
Zone C_2	31 Aug 2016	14:48	• Located by near side of road. • Traffic noise dominates. • Constant flow of traffic at time of measurement.	90	76	74	67

Table 4 Attended noise monitoring results (back receiver location)

Monitoring location	Date	Time	Description	Attended measurement results, dB(A)			
				$L_{max, 15min}$	$L_{10, 15min}$	$L_{eq, 15min}$	$L_{90, 15min}$
P8_1	12 Sep 2016	09:57	• Located in front of 5 Kingsway • Ambient noise controlled by intermittent passing traffic along Kingsway • Background noise controlled by traffic along Pittwater Road	71	59	57	49
P9_3	12 Sep 2016	11:36	• Located in front of 15 Coral Street. • Ambient noise controlled by intermittent passing traffic along Coral Street and Sydney Road. • Background noise controlled by nature.	78	55	56	47
P9_3	12 Sep 2016	11:06	• Located in front of 9 Hope Street. • Ambient noise controlled by intermittent passing traffic along Hope Street. • Background noise controlled by traffic along Sydney and Manly Road.	69	56	53	46
P9_1	12 Sep 2016	12:09	• Located at front of 8 Heaton Avenue. • Ambient noise controlled by intermittent passing traffic along Heaton Avenue • Background noise controlled by passing traffic along Manly Road and nature.	69	59	56	48
P9_2	12 Sep 2016	12:51	• Located near 3 Magarra Place. • Background controlled by traffic along Manly Road.	86	54	54	47

3.0 Construction noise and vibration criteria

3.1 Construction noise

The risk of adverse impacts of construction noise on a community is determined by the extent of its emergence above the existing background noise level, the duration of the event and the characteristics of the noise.

The Interim Construction Noise Guideline (ICNG) is a NSW Government document that sets out ways to deal with the impacts of construction noise on residences and other sensitive land uses. It presents assessment approaches tailored to the scale of the construction project and identifies practices to minimise noise impacts. The Interim Construction Noise Guideline recommends that a quantitative assessment is carried out for all major construction proposals that are typically subject to the environmental impact assessment processes. A quantitative assessment, based on the likely construction scenarios, has been carried out for the project.

Predicted noise levels at nearby noise sensitive receivers are compared to the levels provided in the ICNG. Where an exceedance of the management levels is predicted the ICNG advises that receivers can be considered 'noise affected' and the proponent should apply all feasible and reasonable work practices to minimise the noise impact. The proponent should also inform all potentially impacted residents of the nature of the works to be carried out, the expected noise level and duration, as well as contact details.

Where construction noise levels reach 75 dB(A) residential receivers can be considered as 'highly noise affected' and the proponent should, in consultation with the community, consider restricting hours to provide respite periods.

The ICNG defines what is considered to be feasible and reasonable as follows:

> **Feasible** - A work practice or abatement measure is feasible if it 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.
>
> **Reasonable** - 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.

Work that is proposed outside of standard working hours, as defined in the ICNG, generally requires strong justification.

Noise management levels for residential receivers are derived using the information in Table 5.

Table 5 Construction noise management levels - Residential receivers from the Interim Construction Noise Guideline

Time of day	Management level LAeq (15 min)1	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. 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 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.
Outside recommended	Noise affected	A strong justification would typically be required for works

Time of day	Management level LAeq (15 min)1	How to apply
standard hours	RBL + 5 dB(A)	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.

Note 1: *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.*

3.2 Noise catchment areas

The study area has been divided into five distinct noise catchment areas (NCAs). The noise environment at each of the sensitive receivers within a noise catchment area is considered to have a similar noise environment to the unattended monitoring location within that NCA. As such each of these sensitive receivers is assigned the same background noise level and noise management level. The location of each NCA is provided graphically in Appendix D. NCA_A is analogous to Zone A, similarly NCA_B is analogous to zone B respectively and so on.

NCA_D described in Table 6 is the catchment area starting one row back from the main road and extending further into the suburbs. Attended noise logging was undertaken to characterise this area. Considering the size of the catchment area and the small logging period, a conservative approach has been used incorporating the background noise levels identified in AS1055.3-1997. Based on operator attended noise measurements in the area, the area has been conservatively has been classed as R3.

Table 6 Noise catchment areas and construction noise management levels

NCA	Representative logger	Period	Rating background level1 (RBL)	Construction noise management levels (NML) 2,3
NCA_A	P8_1	Day	58	68
		Evening	55	60
		Night	42	47
NCA_B	P9_3	Day	62	72
		Evening	57	62
		Night	36	41
NCA_C_1	P9_1	Day	51	61
		Evening	48	53
		Night	33	38
NCA_C_2	P9_2	Day	61	71
		Evening	58	63

NCA	Representative logger	Period	Rating background level1 (RBL)	Construction noise management levels (NML) 2,3
		Night	34	39
NCA_D	AS1055.3 – R3	Day	50	60
		Evening	45	50
		Night	40	45
Construction compound	Note 3	Day	54	64
		Evening	48	53
		Night	38	43

Note 1: *Day noise management levels = RBL + 10 dB(A)*
Note 2: *Evening/night noise management levels = RBL + 5 dB(A)*
Note 1*:* *Logger data obtained from a previous report*

3.2.1 Non-residential criteria

Noise management levels recommended by the ICNG for other sensitive land uses, such as schools, hospitals or places of worship are shown in Table 7. Noise management levels for commercial and industrial premises are provided in Table 8.

Table 7 Construction noise management levels – Sensitive land uses other than residential

Land use	Construction noise management level, LAeq (15 min) (applies when properties are in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Depends on the intended use of the centre. Refer to the recommended “maximum” internal levels in AS2107 for specific uses.

Table 8 Construction noise management levels – Commercial and industrial land uses

Land use	Construction noise management level, $L_{Aeq(15min)}$ (applies when properties are in use)

Land use	Construction noise management level, $L_{Aeq(15min)}$ (applies when properties are in use)
Industrial premises	External noise level 75 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

3.2.2 Sleep disturbance (construction)

The ICNG requires a sleep disturbance assessment to be undertaken where construction works are planned to extend over more than two consecutive nights. The ICNG makes reference to the NSW EPA's *Environmental Criteria for Road Traffic Noise* (ECRTN) (Environment Protection Authority, 1999), now superseded by the RNP), for assessment of sleep disturbance. The *NSW Road Noise Policy* references the recommendations in the ECRTN as providing the most appropriate assessment guidance.

The guidance provided in the *NSW Road Noise Policy* for assessing the potential for sleep disturbance recommends that to minimise the risk of sleep disturbance during the night-time period (10pm to 7am), the $L_{A1(1\ min)}$ noise level outside a bedroom window should not exceed the $L_{A90\ (15\ minute)}$ background noise level by more than 15 dB(A). The EPA considers it appropriate to use this metric as a screening criterion to assess the likelihood of sleep disturbance. If this screening criterion is found to be exceeded then a more detailed analysis must be undertaken and include the extent that the maximum noise level exceeds the background noise level and the number of times this is likely to happen during the night-time period.

The *NSW Road Noise Policy* contains a review of research into sleep disturbance which presents NSW EPA advice on the subject of sleep disturbance due to noise events. It concludes that having considered the results of research to date that, '*Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions*'. Therefore, given that an open window provides around 10 dB(A) in noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions.

Table 9 presents the sleep disturbance screening and sleep disturbance awakening reaction criteria.

Table 9 Construction noise sleep disturbance criteria

NCA	Rating background level (RBL), dB(A)	Sleep disturbance screening LA1(1min) criteria, dB(A)	Sleep disturbance awakening reaction LA1(1min) criteria, dB(A)
NCA_A	42	57	65
NCA_B	36	51	65
NCA_C_1	33	48	65
NCA_C_2	34	49	65
NCA_D	40	55	65
Construction compound	38	53	65

3.3 Construction vibration criteria

The relevant standards/guidelines for the assessment of construction vibration are summarised in Table 10.

Table 10 Standards/guidelines used for assessing construction vibration

Item	Standard/guideline
Structural damage	German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (DIN 4150)
Human comfort (tactile vibration) 1	Assessing Vibration: A Technical Guideline (AVATG) 1
Human comfort (regenerated noise)	Interim Construction Noise Guideline (ICNG)

***Note 1:** This document is based upon the guidelines contained in British Standard 6472:1992, "Evaluation of human exposure to vibration in buildings (1-80 Hz)". This British Standard was superseded in 2008 with BS 6472-1:2008 "Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting" and the 1992 version of the Standard was withdrawn. Although a new version of BS 6472 has been published, the Environment Protection Authority still requires vibration to be assessed in accordance with the 1992 version of the Standard at this point in time.*

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent as follows:

- Continuous vibration continues uninterrupted for a defined period and includes sources such as machinery and continuous construction activities for example, a tunnel boring machine
- Impulsive vibration is a rapid build up to a peak followed by a damped decay. It may consist of several cycles at around the same amplitude, with a duration of typically less than two seconds and no more than three occurrences in an assessment period. This may include occasional dropping of heavy equipment or loading activities
- Intermittent vibration occurs where there are interrupted periods of continuous vibration, repeated periods of impulsive vibration or continuous vibration that varies significantly in magnitude. This may include intermittent construction activity, impact pile driving, jack hammers.

3.3.1 Structural damage

At present, no Australian Standards exist for the assessment of building damage caused by vibration.

DIN 4150 provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are presented in Table 11. DIN 4150 states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage.

Table 11 DIN 4150: Structural damage safe limits for building vibration

Group	Type of structure	Vibration velocity in mm/s			
		At foundation at a frequency of:			Vibration at the horizontal plane of the highest floor
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and	3	3 to 8	8 to 10	8

	have intrinsic value (eg buildings that are under a preservation order)				

3.3.2 Human comfort

Humans are sensitive to vibration such that they can detect vibration levels well below those required to cause any risk of damage to a building or its contents. Criteria to avoid annoyance are therefore more stringent than those to prevent structural damage.

Intermittent vibration

The assessment of intermittent vibration outlined in Assessing Vibration: A Technical Guideline (DEC, 2006) is based on Vibration Dose Values (VDVs). The VDV accumulates the vibration energy received over the day time and night time periods.

Maximum and preferred VDVs for intermittent vibration arising from construction activities are listed in Table 12. The VDV criteria are based on the likelihood that a person would be annoyed by the level of vibration over the entire assessment period.

Table 12 Preferred and maximum vibration dose values for intermittent vibration (m/s 1.75)

Location	Day time		Night time	
	Preferred	Max	Preferred	Max
Critical areas	0.1	0.2	0.1	0.2
Residences	0.2	0.4	0.13	0.26
Offices, schools, educational institutions and places of worship	0.4	0.8	0.4	0.8
Workshops	0.8	1.6	0.8	1.6

Continuous and impulsive vibration

Acceptable levels of human exposure to continuous and impulsive vibration are dependent on the time of day and the activity taking place in the occupied space. *Assessing Vibration: A Technical Guideline* (Department of Environment and Conservation, 2006) provides the preferred values for continuous and impulsive vibration. These are presented in Table 13.

There is low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values in Table 13. Situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances and infrequent events of short duration. Vibration levels above those indicated in Table 13 may be dealt with through negotiation with the regulator of the affected community. The following axes are defined in relation to the human body:

- x – back to chest.
- y – right side to left side.
- z – foot to head.

Table 13 Preferred and maximum peak particle velocity for continuous and impulsive vibration acceleration (mm/s)

Location	Assessment period	Preferred	Maximum	
		z axis x and y axes	z axis	x and y axes
Continuous vibration				
Critical areas[1]	When in use	0.14	0.28	
Residences[2]	Day Night	0.28 0.20	0.56 0.40	
Offices, schools, educational institutions and places of worship	When in use	0.56	1.1	
Workshops	When in use	1.1	2.2	
Impulsive vibration				
Critical areas	When in use	0.14	0.28	
Residences[2]	Day Night	8.6 2.8	17.0 5.6	
Offices, schools, educational institutions and places of worship	When in use	18.0	36.0	
Workshops	When in use	18.0	36.0	

Note 1: *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria.*
Note 2: *Criteria for residences are lower than schools as people expect to be able to relax/sleep in their homes without annoyance and are generally more concerned about structural damage than would be the case within schools and offices.*

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4.0 Construction Noise Assessment

4.1 Construction Scenarios

The construction scenarios used in this assessment are based on the scope of works as outlined in Section 0. Specific elements relating to construction of the Proposal have been assigned a specific works activity with a corresponding L_{eq} sound power level. The construction scenarios have been assumed based on the Roads and Maritime construction noise estimator tool.

Table 14 Construction scenarios

Scenario	Equipment	SWL, dBA	No of units	Overall SWL
Mobilisation & Site Establishment	Truck (medium rigid)	103	4 per hour	115
	Road truck	108	4 per hour	
	Scissor Lift	98	1	
	Franna crane	98	1	
Utility, property, service adjustment	Excavator (tracked) 35t	110	1	116
	Dump truck	110	4 per hour	
	Franna crane 20t	98	1	
	Pneumatic hammer	113	-	
	Concrete saw	118	1	
	Vacuum truck	109	-	
	Backhoe	111	-	
	Power generator	103	1	
Drainage infrastructure	Backhoe	110	-	115
	Franna crane 20t	98	1	
	Excavator (tracked) 35t	110	1	
	Concrete truck	109	4 per hour	
	Truck compressor	75	1	
	Vibratory roller	109	1	
	Road truck	108	4 per hour	
Paving/ asphalting (inc concrete sawing)	Pavement laying machine	114	1	118
	Dump truck	110	4 per hour	
	Asphalt truck & sprayer	103	1	
	Concrete truck	109	1	
	Smooth drum roller	107	1	
	Concrete saw	118	1	
Construction compound operation	Front end loader	91	1	114
	Excavator (tracked) 35t	110	-	
	Road truck	108	4 per hour	
	Compressor	109	1	

Scenario	Equipment	SWL, dBA	No of units	Overall SWL
	Welding equipment	105	1	
	Light vehicles	88	12 per hour	
	Power generator	103	1	

4.2 Methodology

The construction noise assessment was carried out using the RMS Construction Noise Estimator tool. The tool was used to determine construction noise levels, noise impacts at the most affected sensitive receivers and appropriate specific noise mitigation.

4.3 Results

Provided below is a summary of noise levels at the most affected sensitive receiver location. The following information is provided:

- Daytime standard hours work (Table 15)
- Daytime out of house work (Table 16)
- Out of hours work, evening (Table 17)
- Out of hours work (Table 18)

Table 15 Predicted noise impacts – standard hours work

Work Zone	Noise management level	Most affected receiver		
		Offset (m)	Predicted $L_{Aeq(15min)}$ noise Level, dB(A)	Exceedance, dB(A)
Mobilisation & Site Establishment				
NCA_A	68	225	55	-
NCA_B	72	20	77	5
NCA_C_1	61	85	65	4
NCA_C_2	71	50	69	-
NCA_D	60	50	59	-
Utility, property, service adjustment				
NCA_A	68	225	56	-
NCA_B	72	20	78	6
NCA_C_1	61	85	66	5
NCA_C_2	71	50	70	-
NCA_D	60	50	60	-
Drainage infrastructure				
NCA_A	68	-	-	-
NCA_B	72	20	77	5
NCA_C_1	61	85	65	4
NCA_C_2	71	50	69	-

Work Zone	Noise management level	Most affected receiver		
		Offset (m)	Predicted $L_{Aeq(15min)}$ noise Level, dB(A)	Exceedance, dB(A)
NCAD	60	50	59	-
Paving/ asphalting (inc concrete sawing)				
NCA_A	68	225	58	-
NCA_B	72	20	80	8
NCA_C_1	61	85	68	7
NCA_C_2	71	50	72	1
NCA_D	60	50	62	2
Construction compound operation				
Construction compound	64	40	65	1

Table 16 Predicted noise impacts – day out of hours work

Work Zone	Noise management level	Most affected receiver		
		Offset (m)	Predicted $L_{Aeq(15min)}$ noise Level, dB(A)	Exceedance, dB(A)
Mobilisation & Site Establishment				
NCA_A	63	225	55	-
NCA_B	67	20	77	10
NCA_C_1	56	85	65	9
NCA_C_2	66	50	69	3
NCA_D	55	50	59	4
Utility, property, service adjustment				
NCA_A	63	225	56	-
NCA_B	67	20	78	11
NCA_C_1	56	85	66	10
NCA_C_2	66	50	70	4
NCA_D	55	50	60	5
Drainage infrastructure				
NCA_A	63	-	-	-
NCA_B	67	20	77	10
NCA_C_1	56	85	65	9
NCA_C_2	66	50	69	3
NCA_D	55	50	59	4
Paving/ asphalting (inc concrete sawing)				
NCA_A	63	225	58	-
NCA_B	67	20	80	13

Work Zone	Noise management level	Most affected receiver		
		Offset (m)	Predicted $L_{Aeq(15min)}$ noise Level, dB(A)	Exceedance, dB(A)
NCA_C_1	56	85	68	12
NCA_C_2	66	50	72	6
NCA_D	55	50	62	7
Construction compound operation				
Construction compound	59	40	65	6

Table 17 Predicted noise impacts –out of hours work, evening

Work Zone	Noise management level	Most affected receiver		
		Offset (m)	Predicted $L_{Aeq(15min)}$ noise Level, dB(A)	Exceedance, dB(A)
Mobilisation & Site Establishment				
NCA_A	60	225	55	-
NCA_B	62	85	77	15
NCA_C_1	53	50	69	16
NCA_C_2	63	20	77	14
NCA_D	50	50	59	9
Utility, property, service adjustment				
NCA_A	60	225	56	-
NCA_B	62	20	78	16
NCA_C_1	53	85	66	13
NCA_C_2	63	50	70	7
NCA_D	50	50	60	10
Drainage infrastructure				
NCA_A	60	-	-	-
NCA_B	62	20	77	15
NCA_C_1	53	85	65	12
NCA_C_2	63	50	69	6
NCA_D	50	50	59	9
Paving/ asphalting (inc concrete sawing)				
NCA_A	60	225	58	-
NCA_B	62	20	80	18
NCA_C_1	53	85	68	15
NCA_C_2	63	50	72	9
NCA_D	50	50	62	12
Construction compound operation				

Work Zone	Noise management level	Most affected receiver		
		Offset (m)	Predicted $L_{Aeq(15min)}$ noise Level, dB(A)	Exceedance, dB(A)
Construction compound	54	40	65	12

Table 18 Predicted noise impacts –out of hours work, night

Work Zone	Noise management level	Most affected receiver		
		Offset (m)	Predicted $L_{Aeq(15min)}$ noise Level, dB(A)	Exceedance, dB(A)
Mobilisation & Site Establishment				
NCA_A	47	225	55	8
NCA_B	41	20	77	36
NCA_C_1	38	85	65	27
NCA_C_2	39	50	69	30
NCA_D	45	50	59	14
Utility, property, service adjustment				
NCA_A	47	225	56	9
NCA_B	41	20	78	37
NCA_C_1	38	85	66	28
NCA_C_2	39	50	70	31
NCA_D	45	50	60	15
Drainage infrastructure				
NCA_A	47	-	-	-
NCA_B	41	20	77	36
NCA_C_1	38	85	65	27
NCA_C_2	39	50	69	30
NCA_D	45	50	59	14
Paving/ asphalting (inc concrete sawing)				
NCA_A	47	225	58	11
NCA_B	41	20	80	39
NCA_C_1	38	85	68	30
NCA_C_2	39	50	72	33
NCA_D	45	50	62	17
Construction compound operation				
Construction compound	43	40	65	22

Sleep disturbance

Due to the high noise levels, sleep disturbance can be expected for noise intensive works during the night-time period. Mitigation should be employed in accordance with the recommendations provided in Section 6.0 of this report.

4.4 Construction traffic noise impacts

The traffic report has identified that approximately 5 heavy vehicles would be required on site per day. It is estimated that a maximum of two vehicles per hour would access the site. Additionally 18 light vehicles would make two-way trips. Light vehicles would generally arrive between 6.30 am and 7.00 am and depart between 5.00 pm and 5.30 pm. Existing hourly movements (both heavy and light vehicles combined) on Pittwater road are between approximately 500 movements per hour at 5.00 am with an afternoon peak of 3500 movements at 5.00 pm. The movements associated with the construction traffic are relatively insignificant and may increase noise levels by up to 0.2 dB(A). This increase in noise would not have a perceptible change on existing road traffic throughout the project area.

5.0 Construction vibration assessment

In order to comply with the cosmetic/structural damage and human discomfort criteria presented in Section 3.3 the safe working distances presented in Table 19 should not be encroached.

Table 19 Recommended safe working distances for vibration intensive plant

Plant	Rating/description	Safe working distance	
		Cosmetic damage (metres)	Human response (metres)
Vibratory roller	< 50 kN (Typically 1-2 T)	5	15-20
	< 100 kN (Typically 2-4 T)	6	20
	< 200 kN (Typically 4-6 T)	12	40
	< 300 kN (Typically 7-13 T)	15	100
	> 300 kN (Typically 13-18 T)	20	100
	> 300 kN (> 18 T)	25	100
Small hydraulic hammer	(300 kg – 5-12 T excavator)	2	7
Medium hydraulic hammer	(900 kg – 12-18 T excavator)	7	23
Large hydraulic hammer	(1,600 kg – 18-34 T excavator)	22	73
Vibratory pile driver	Sheet piles	2-20	20
Pile boring	≤ 800 mm	2 nominal	N/A
Jack hammer	Handheld	Avoid contact with structure	Avoid contact with structure

Note: *More stringent conditions may apply to heritage or other sensitive structures. Any heritage property would need to be considered on a case by case basis*

Depending on the construction equipment that is used, the safe working distances outlined in Table 19 may be encroached. The primary form of mitigation of vibration would be ensuring vibration intensive works do not occur where safe working distances would be encroached by sensitive receivers. If vibration intensive works are required within the safe working distances identified, alternative equipment should be identified and vibration monitoring implemented. Further mitigation of vibration would not be required where the safe working distances do not coincide with sensitive receivers.

In some circumstances, construction activity within the safe working distance cannot be avoided due to the work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced, resulting in a potential change in operating equipment. Approaches to manage such circumstances are discussed in Chapter 6.9.

6.0 Recommended mitigation measures

The construction noise and vibration assessment presented in Chapter 4.0 of this report detailed a number of exceedances of the noise management levels within this project. These were predicted as a result of various construction activities. A number of exceedances of the 'highly noise affected' criteria have also been predicted within the study area. As a result of these exceedances, and potential exceedances of vibration criteria, generic and receiver specific mitigation measures have been identified.

Specific noise mitigation has been recommended in accordance with the RMS Construction Noise and Vibration Guideline. Provided below is a summary of the details of various types of noise mitigation.

Table 20 Specific noise mitigation measures

Measure	Description
Notification (letterbox drop or equivalent)	Advanced warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works. The approval conditions for projects may also specify requirements for notification to the community about works that may impact on them.
Specific notifications	Specific notifications are letterbox dropped (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification provides additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops. This form of communication is used to support periodic notifications, or to advertise unscheduled works.
Phone calls	Phone calls detailing relevant information made to identified/affected stakeholders within seven calendar days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs. Where the resident cannot be telephoned then an alternative form of engagement should be used.
Individual briefings	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Project representatives would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Where the resident cannot be met with individually then an alternative form of engagement should be used.
Respite offer	Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.
Respite Period 1 Mon-Fri 6pm-10pm Sat 7am-9am & 1pm-10pm, Sun/Pub Hol 8am-6pm	Out of hours construction noise in out of hours period 1 shall be limited to no more than three consecutive evenings per week except where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and no more than 6 evenings per month

Measure	Description
Respite Period 2 Mon-Fri 10pm-7am Sat 10pm-8am Sun/Pub Hol 6pm-7am	Night time construction noise in out of hours period 2 shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and 6 nights per month. Where possible, high noise generating works shall be completed before 11pm.
Duration respite	Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite. Support may be demonstrated from surveys, online feedback, contact phone numbers and community events.
Alternative accommodation	Alternative accommodation options may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels . The specifics of the offer will be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.
Verification	Verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

6.1 Specific noise mitigation - Noise Catchment Area A

In accordance with the *RMS Construction Noise and Vibration Guideline*, provided below is a summary of the required noise mitigation and management measures for the most affected sensitive receivers in Zone A:

- Standard work hours – No specific measures required
- Day out of hours work – No specific measures required
- Evening out of hours work - No specific measures required
- Night-time out of hours work – Verification, notifications, respite period 2, duration respite.

6.2 Specific noise mitigation - Noise Catchment Area B

In accordance with the *RMS Construction Noise and Vibration Guideline*, provided below is a summary of the required noise mitigation and management measures for the most affected sensitive receivers in Zone B:

- Standard work hours – No specific measures required
- Day out of hours work –Notifications, respite period 1, duration respite,
- Evening out of hours work - Verification, , notifications, respite period 1, duration respite
- Night-time out of hours work – Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite.

6.3 Specific noise mitigation - Noise Catchment Area C_1

In accordance with the *RMS Construction Noise and Vibration Guideline*, provided below is a summary of the required noise mitigation and management measures for the most affected sensitive receivers in Zone B:

- Standard work hours – No specific measures required
- Day out of hours work – Notifications, respite period 1, duration respite,
- Evening out of hours work - Verification, notifications, respite period 1, duration respite
- Night-time out of hours work – Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite.

6.4 Specific noise mitigation - Noise Catchment Area C_2

In accordance with the *RMS Construction Noise and Vibration Guideline*, provided below is a summary of the required noise mitigation and management measures for the most affected sensitive receivers in Zone B:

- Standard work hours – No specific measures required
- Day out of hours work – No specific measures required
- Evening out of hours work - Notifications, respite period 1, duration respite
- Night-time out of hours work – Alternative accommodation, verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite.

6.5 Specific noise mitigation - Construction compound

- Day out of hours work – Notification, respite period 1, duration respite
- Evening out of hours work - Notification, respite period 1, duration respite
- Night-time out of hours work – Verification, individual briefings, notifications, phone calls, specific notifications, respite period 2, duration respite.

6.6 Specific noise mitigation - Noise Catchment Area D

In accordance with the *RMS Construction Noise and Vibration Guideline*, provided below is a summary of the required noise mitigation and management measures for the most affected sensitive receivers in Zone D:

- Standard work hours – No specific measures required
- Day out of hours work – No specific measures required
- Evening out of hours work - Notifications, respite period 1, duration respite
- Night-time out of hours work –Verification, notifications, respite period 1, duration respite.

6.7 Standard noise mitigation

In addition to the specific noise mitigation, where reasonable and feasible the following noise mitigation should be employed.

6.7.1 Construction noise and vibration management plan

A Construction Noise and Vibration Management Plan (CNVMP) would be prepared. The CNVMP would include the following:

- Identification of nearby residences and other sensitive land uses
- Description of approved hours of work

- Description and identification of all construction activities, including work areas, equipment and duration
- Description of what work practices (generic and specific) would be applied to minimise noise and vibration
- A complaints handling process
- Noise and vibration monitoring procedures
- Overview of community consultation required for identified high impact works.

The CNVMP should include consideration of the following issues:

- Cumulative construction noise impacts
- Construction noise fatigue.

Feasible and reasonable mitigation measures would be detailed within the CNVMP to manage predicted noise levels at sensitive receivers and areas where construction fatigue could occur. Consultation with the affected community would also occur prior to and during construction.

6.7.2 Community consultation and complaints handling

All residents impacted by noise from the proposed works which are expected to exceed the construction noise management levels (NML) should be consulted prior to the commencement of construction. The highest consideration should be given to those that are predicted to be most affected as a result of the works.

The information provided to the residents should include:

- Programmed times and locations of construction work
- The hours of proposed works
- Construction noise and vibration impact predictions
- Construction noise and vibration mitigation measures to be implemented on site.

Community consultation regarding construction noise and vibration would be detailed in the Community Involvement Plan for the construction of the project and would include a 24 hour hotline and complaints management process.

For out-of-hours works, consultation would take place with consideration to Practice Note vii of Roads and Maritime's *Environmental Noise Management Manual* (ENMM) and Strategy 2 of the ICNG.

6.7.3 Work practices

Induction and training would be provided to relevant staff and sub-contractors outlining their responsibilities with regard to noise and vibration.

6.7.4 Construction hours and work scheduling

Details of all out of hours work required would form part of the CNVMP.

Noisy work would be scheduled to be undertaken during the standard hours as far as possible. Noisy activities that cannot be undertaken during standard construction hours are to be scheduled as early as possible during the evening and/or night-time periods.

Particularly noisy activities such as the use of impact piling rigs, road and concrete saws, rock hammers, should be scheduled where feasible and reasonable around times of high background noise to provide masking.

Deliveries would be carried out during standard construction hours where feasible and reasonable.

Consideration would be given to construction timetabling to minimise noise impacts, such as the use of respite periods.

6.7.5 Respite

A protocol would be developed to identify the need for, and provision of, respite measures for residential receivers in accordance with the *ICNG*. Respite measures may include the restriction to the hours of construction activities resulting in impulsive or tonal noise (such as rock hammering, pile driving), or other appropriate measures agreed between the contractor and residential receiver such as temporary alternative accommodation.

The protocol would form part of the CNVMP.

6.8 Construction noise

6.8.1 Construction traffic

The following measures would be implemented to reduce and manage noise and vibration impacts associated with construction traffic:

- Truck drivers would be advised of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (ie minimising/restricting the use of engine compression brakes, and no extended periods of engine idling)
- Site access and egress points would be located away from residences and other sensitive land uses, where feasible and reasonable
- Deliveries and spoil removal would be planned to avoid queuing of trucks on or around the compounds
- Construction sites would be arranged to limit the need for reversing associated with regular/repeatable movements (eg trucks transporting spoil) to minimise the use of reversing alarms
- Where feasible and reasonable, non-tonal reversing alarms would be used, taking into account the requirements of the Workplace Health and Safety legislation
- Spoil would be moved during the day where practical, and feasible and reasonable management strategies would be investigated in consultation with the NSW Environment Protection Authority to minimise the volume of heavy vehicle movements at night.

6.8.2 Plant and equipment selection and location

The selection of plant and equipment can have a significant impact on construction noise levels. Appropriate plant would be selected for each task to minimise the noise contributions.

Alternative works methods such as the use of hydraulic or electric-controlled units in place of diesel units would be considered and implemented where feasible and reasonable. The use of alternative machines that perform the same function, such as rubber wheeled plant, would be considered in place of steel tracked plant.

Equipment would be regularly inspected and maintained to ensure it is in good working order.

Plant should be located on site with as much distance as possible between the plant and noise sensitive receivers. Noisy equipment would be orientated away from residential receivers where feasible and reasonable.

6.8.3 Noise monitoring

A noise monitoring program would be implemented to assist in confirming and controlling the site specific potential for disturbance at particularly sensitive localities at the commencement of activities and periodically during construction. The results would be reviewed to determine if additional mitigation measures are required. All measurements would be undertaken in accordance with *Australian Standard 1055. 1-1997 – Acoustics – Description and measurement of environmental noise, Part 1: General procedures*.

A noise monitoring program would be presented in the CNVMP.

If regenerated noise is reported to be a problem during vibration intensive works, attended and/or unattended noise measurements would be undertaken within the relevant building spaces to determine the level of regenerated noise.

6.9 Construction vibration

In some circumstances, construction activity within the safe working distance cannot be avoided based on the type of work required and the prevalent geological site conditions. These conditions may not be fully understood until work has commenced. Provided below is a summary of management measures for vibration intensive activities that occur within safe working distances.

Equipment selection and maintenance

Equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the most affected sensitive receiver.

The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures.

Equipment would be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts.

Scheduling of construction activities

Wherever reasonable and reasonable, vibration intensive works should be limited to the least sensitive times of the day.

Supplementary vibration monitoring

If the use of vibration intensive plant cannot be avoided within the safe working distance for cosmetic damage to existing structures the following procedure would occur as a minimum:

- Notification of the works to the affected residents and community
- Works would not proceed until attended vibration measurements are undertaken.

If ongoing works are required a temporary relocatable vibration monitoring system would be installed to warn operators (via flashing light, audible alarm, short message service (SMS) etc) when vibration levels are approaching the cosmetic damage objective.

7.0 Conclusion

A construction noise and vibration assessment has been undertaken for the Proposal to determine likely impacts to nearby sensitive receivers. Roads and Maritime do not expect a change in traffic volumes as a result of the project. As such as operational noise assessment has not been undertaken for this Proposal.

The project is divided up into four work areas.

- Zone A is located on Pittwater Road between Orchard Road and Cross Street
- Zone B is located in the vicinity of the intersection of Sydney road, Manly Road and Burnt Bridge Creek Deviation
- Zone C is located at the intersection of Manly Road and Heaton Avenue intersection The project also incorporates a construction compound which is at the site of the Manly Vale Commuter Car Park.

Background noise logging was undertaken at each of the zones to quantify the existing noise levels in the area. Background noise logging was used to define the construction noise management levels in accordance with the EPA's Construction Noise Guideline.

The degree of potential construction noise has been assessed at the most affected noise sensitive receiver within each Zone of works. The results identify that the community has the potential to be adversely impacted by the proposed works, particularly if out of hours working hours are used. Provided in Section 6.0 are specific noise mitigation measures for each Zone of the proposed works. These recommendations have been made in accordance with the *Roads and Maritime Construction Noise and Vibration Guideline*. Due to small offset distances between the source and receivers, some works are expected to exceed the noise management levels at the most affected receiver. Both generic and project specific noise mitigation measures have been provided for inclusion where reasonable and feasible. These measures are detailed in Section 6.7.

Vibration criteria have been based on the EPA's *Assessing Vibration: A technical guideline*. Dependent on the specific equipment used in the construction process, the vibration generated by the proposed construction works has the potential to impact sensitive receivers. Measures to manage vibration impacts have been recommended primarily in the form of selecting equipment which will comply with the safe working distances identified in Section 5.0. If vibration intensive work is required that would where existing structures would fall within these safe working distances, additional mitigation measures should be implemented as outlined in 6.9.

Appendix A

Acoustic Glossary

Appendix A Acoustic Glossary

The following is a brief description of acoustic terminology used in this report.

<table>
<tr><th>Term</th><th colspan="2">Definition</th></tr>
<tr><td>Sound power level</td><td colspan="2">The total sound emitted by a source</td></tr>
<tr><td>Sound pressure level</td><td colspan="2">The amount of sound at a specified point</td></tr>
<tr><td>Decibel [dB]</td><td colspan="2">The measurement unit of sound</td></tr>
<tr><td>A Weighted decibels [dB(A])</td><td colspan="2">The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1 kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).</td></tr>
<tr><td rowspan="2">Decibel scale</td><td colspan="2">The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB(A) increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB(A) increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows:</td></tr>
<tr><td>0 dB(A)
30 dB(A)
40 dB(A)
50 dB(A)
70 dB(A)
80 dB(A)
90 dB(A)
100 dB(A)
110 dB(A)
115 dB(A)
120 dB(A)</td><td>Threshold of human hearing
A quiet country park
Whisper in a library
Open office space
Inside a car on a freeway
Outboard motor
Heavy truck pass-by
Jack hammer/subway train
Rock Concert
Limit of sound permitted in industry
747 take off at 250 metres</td></tr>
<tr><td>Frequency [f]</td><td colspan="2">The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.</td></tr>
<tr><td>Equivalent continuous sound level [L_{eq}]</td><td colspan="2">The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.</td></tr>
<tr><td>Insertion loss</td><td colspan="2">Reduction in noise by inserting a barrier between the source and receiver</td></tr>
<tr><td>L_{max}</td><td colspan="2">The maximum sound pressure level measured over the measurement period</td></tr>
<tr><td>L_{min}</td><td colspan="2">The minimum sound pressure level measured over the measurement period</td></tr>
<tr><td>L_{10}</td><td colspan="2">The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.</td></tr>
<tr><td>L_{90}</td><td colspan="2">The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.</td></tr>
</table>

Term	Definition
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.
Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L90 sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	Construction noise The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays. Road traffic noise The period from 0700 to 2200 h every day of the week.
Evening	Construction noise The period from 1800 to 2200 h Monday to Sunday and Public Holidays. Road traffic noise Not applicable.
Night	Construction noise The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays. Road traffic noise The period from 2200 to 0700 h every day of the week.
Assessment background level [ABL]	The overall background level for each day, evening and night period for each day of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the entire length of noise monitoring.

*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 “Acoustics – Glossary of terms and related symbols”, the EPA’s Industrial Noise Policy and Road Noise Policy.

Appendix B

Noise logging locations

AECOM G:\!BLD\Acoustics\3.0 Projects\3.2 Short stay project folders\60491201 BLine\Maps\SoundPlanNoiseLoggers.mxd Updated 21/10/2016

Legend

- Extent of works (approximate)
- Package 9 Zones
- Unattended noise logging locations
- Attended noise logging locations, shielded location

250 125 0 250 Meters

N

B-Line

Package 9 Noise Loggers

Source:

OCT 2016

60491201

Fig. **1**

Appendix C

Noise logging charts

P8_1 - 727 Pittwater Road - 31/08/16 - 11/09/16

Logger Setup

Logger Type: ARL 215

Serial No : 194803

Address: 727 Pittwater Road , Dee Why

Location: On nature strip adjacent carpark, under tree.

Facade / Free Field: Free Field

Environment: Traffic noise is dominant. Logger located elevated above the alignment of Pittwater Road.

Logger Setup Photo

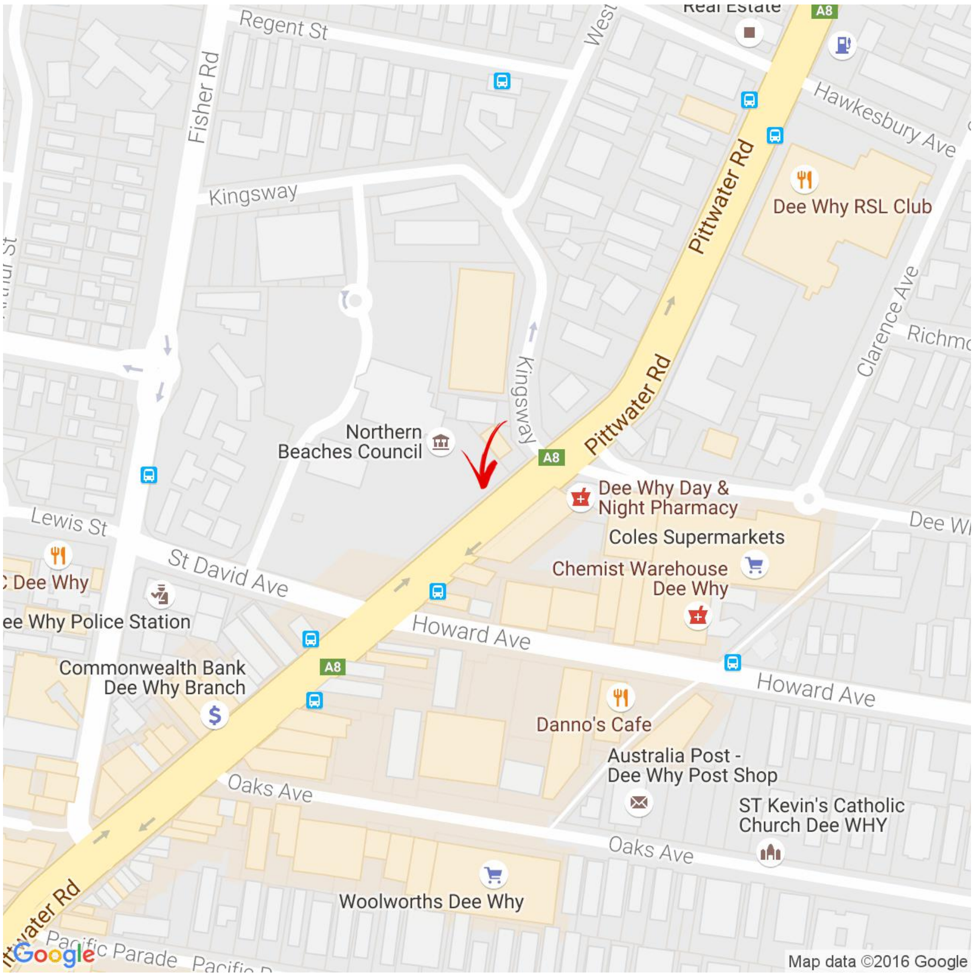
INP Noise Level, dB(A)

	Log Average	RBL
Day	71	58
Evening	70	55
Night	66	42

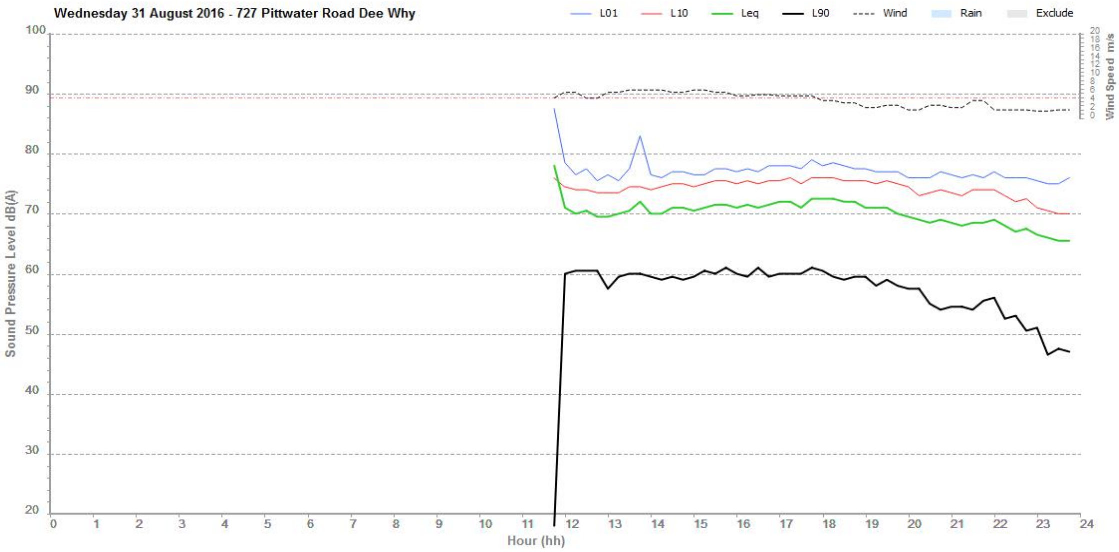
RNP Noise Level, dB(A)

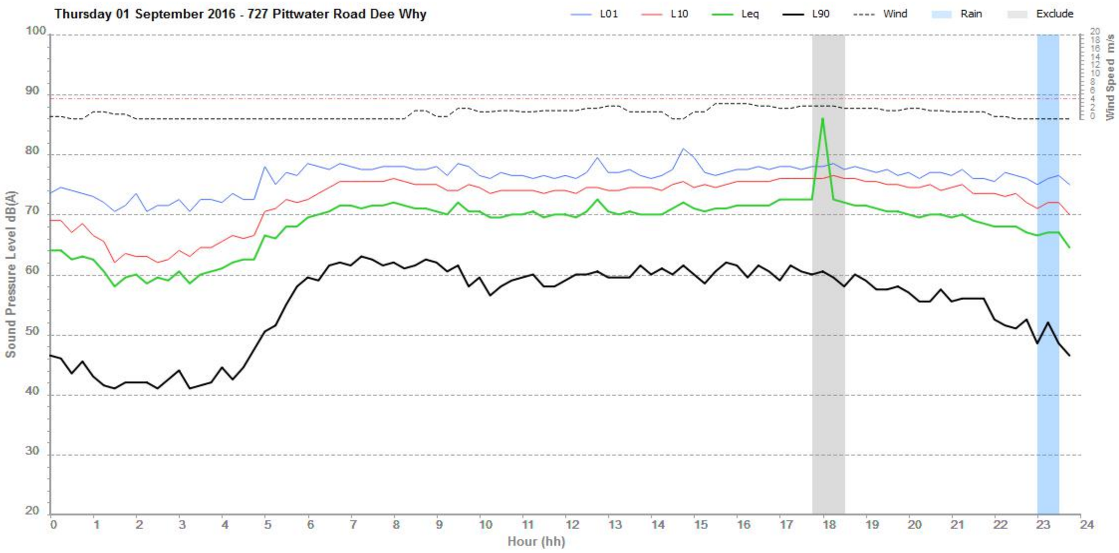
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

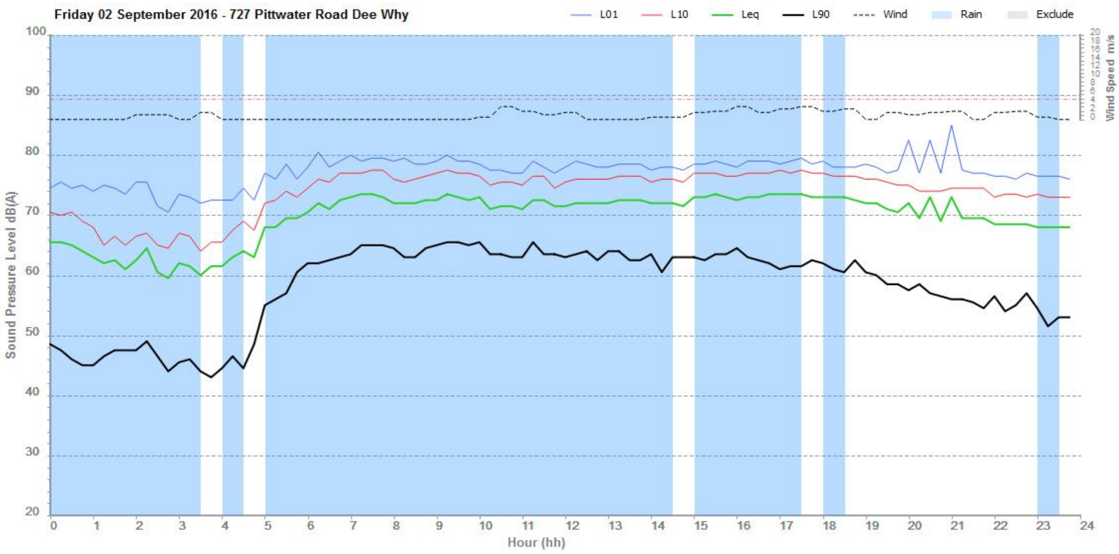
Logger Location Map



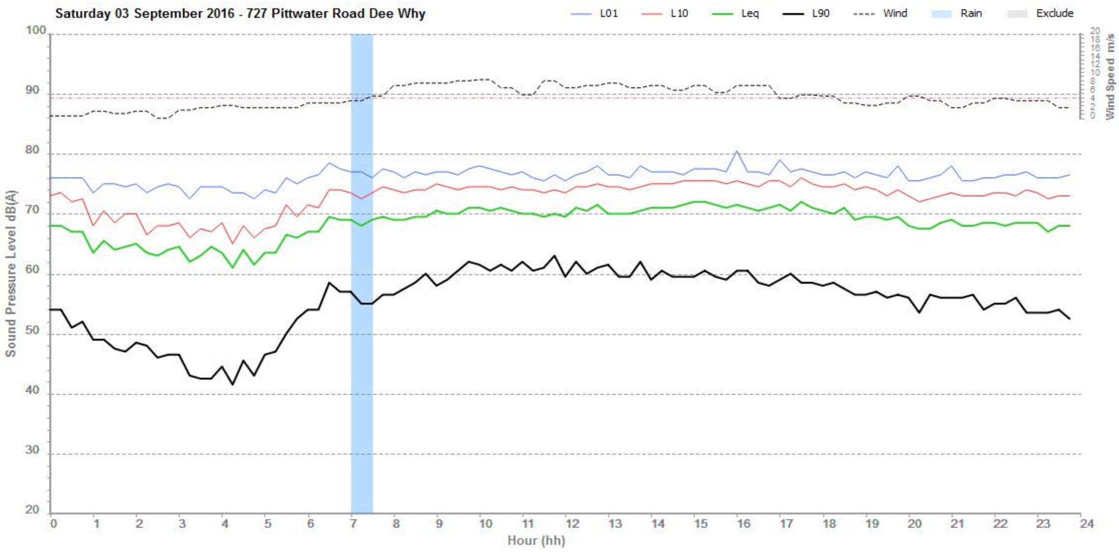
Logger Graphs

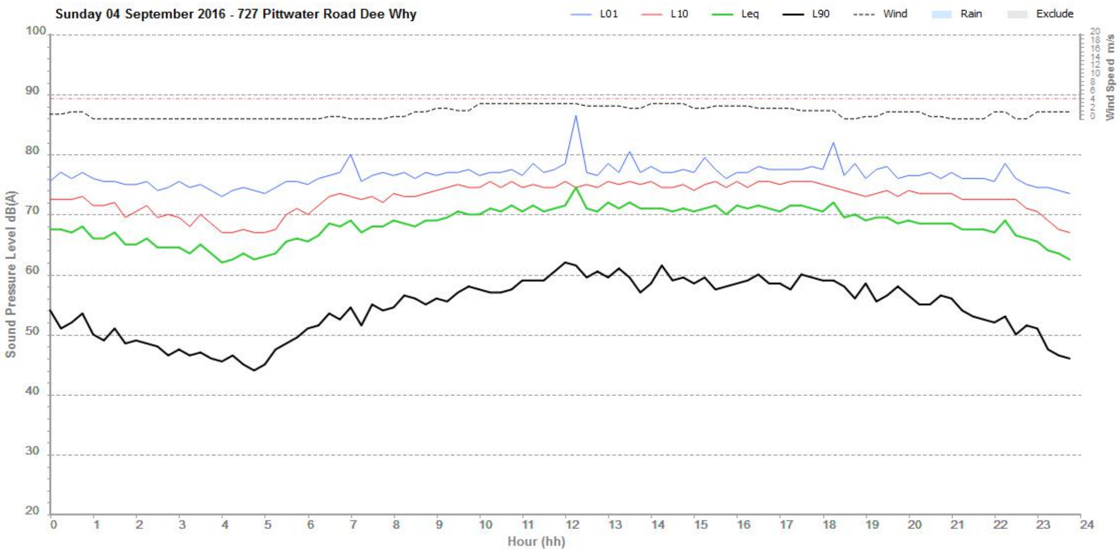


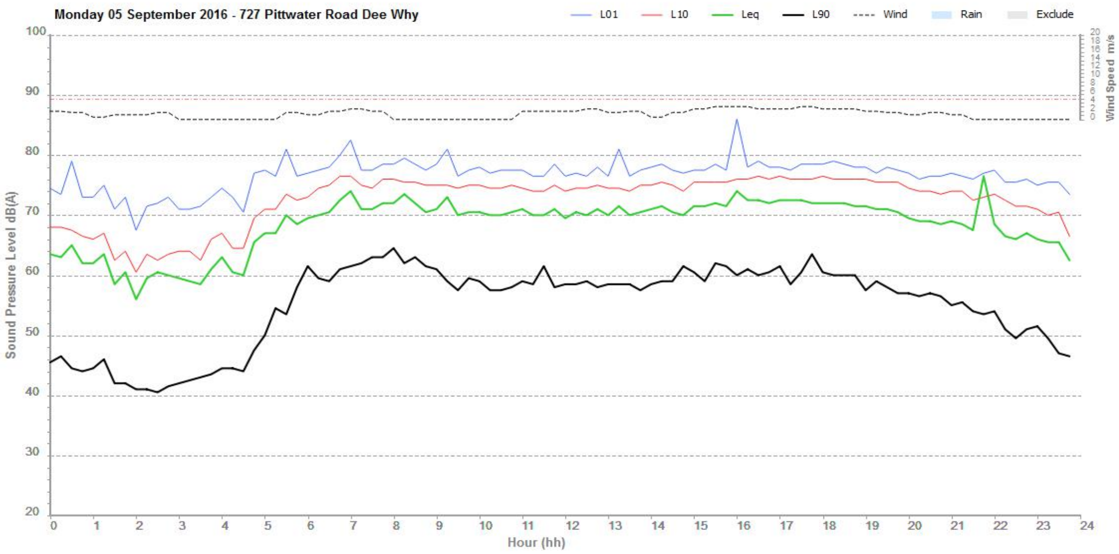




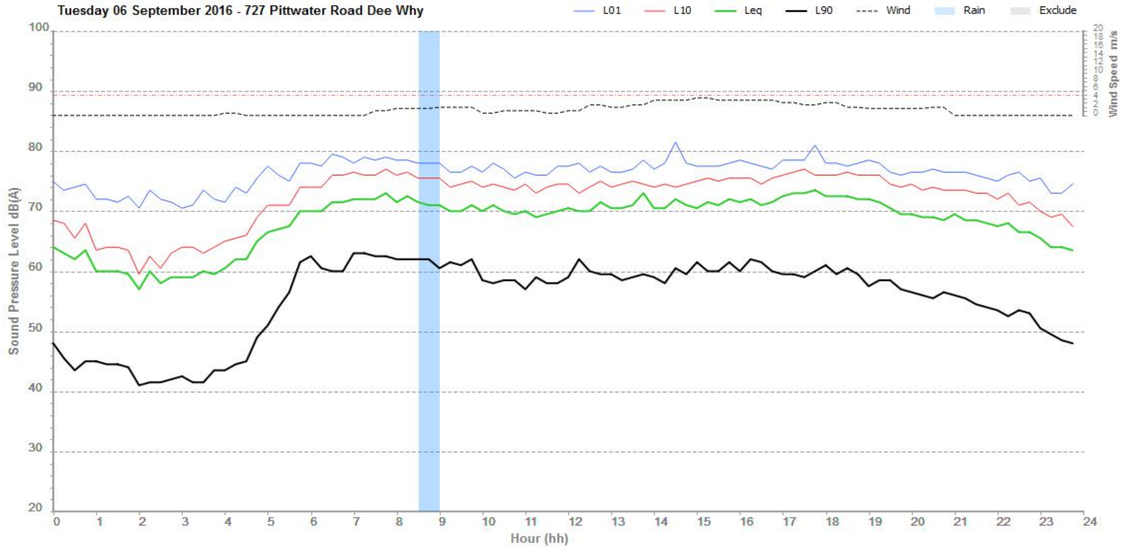
Logger Graphs

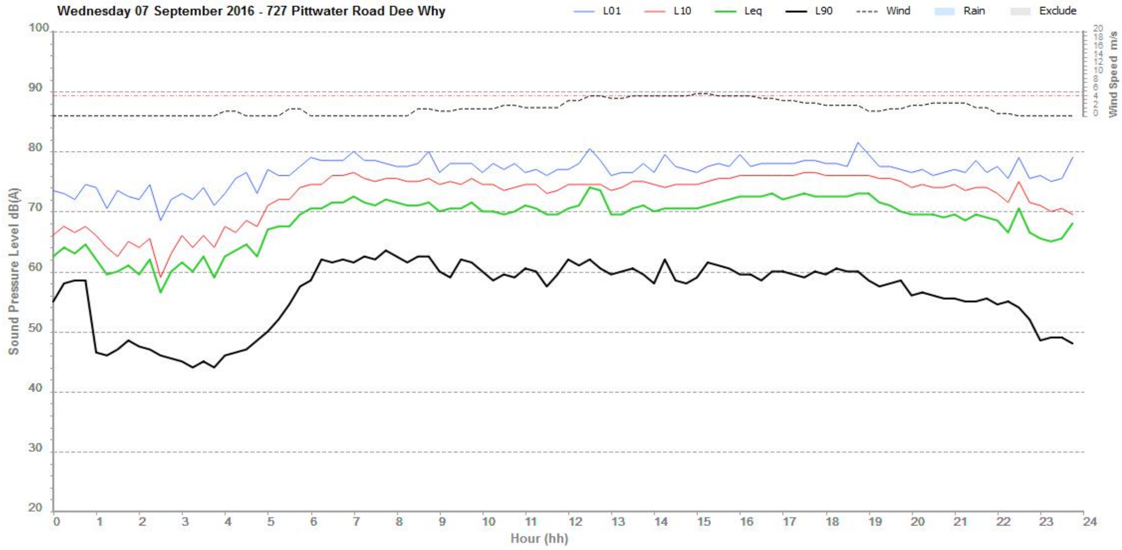


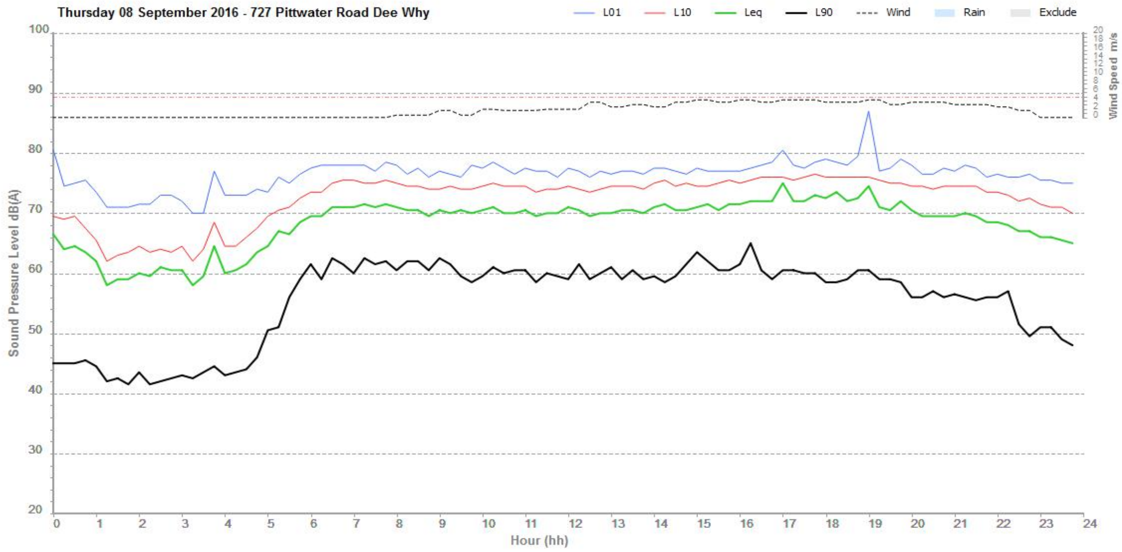




Logger Graphs







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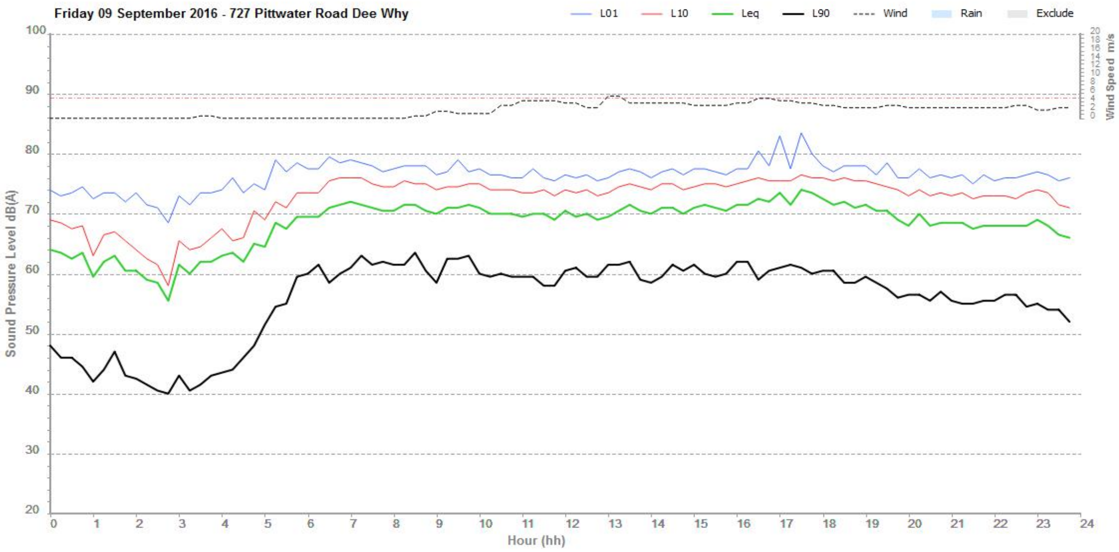
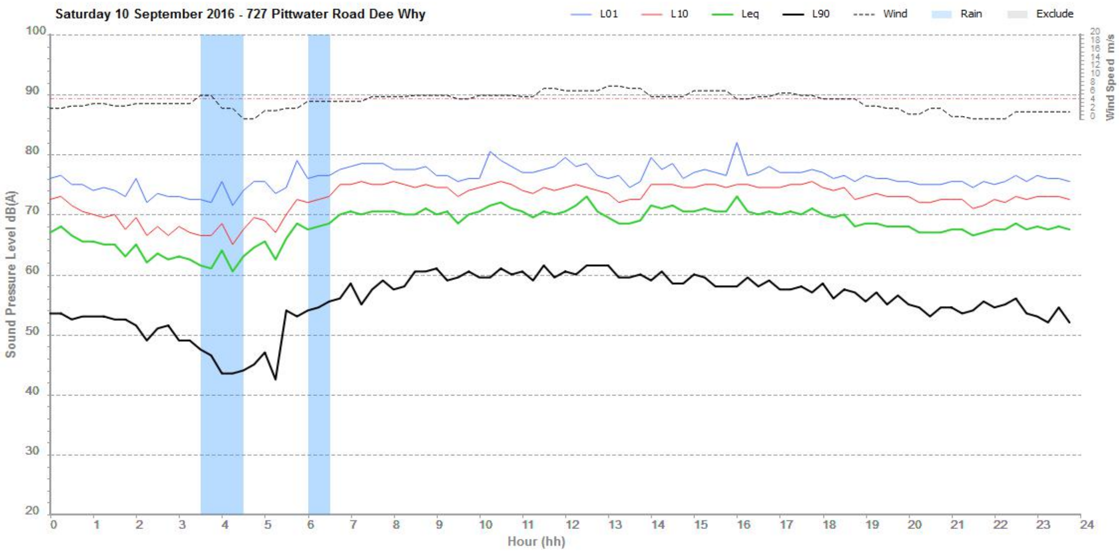
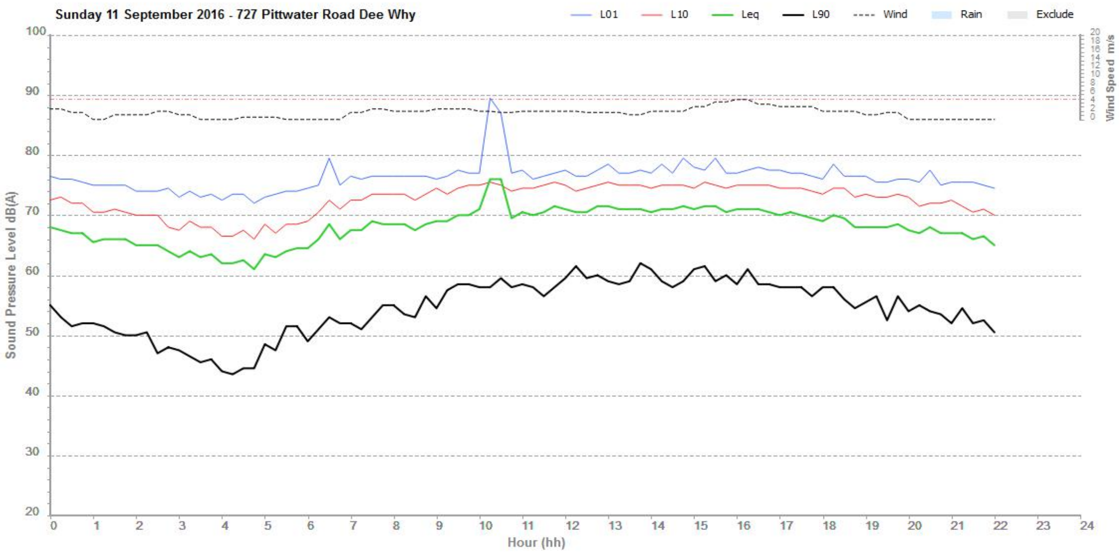






P9_1 - 14 Heaton Avenue - 31/08/16 - 09/09/16

Logger Setup

Logger Type: ARL 315

Serial No : 15-203-504

Address: 14 Heaton Avenue , Clontarf

Location: In vegetation in public space

Facade / Free Field: Free Field

Environment: Background noise controlled by nature. Ambient noise controlled by passing traffic and also traffic along Manly road.

Logger Setup Photo

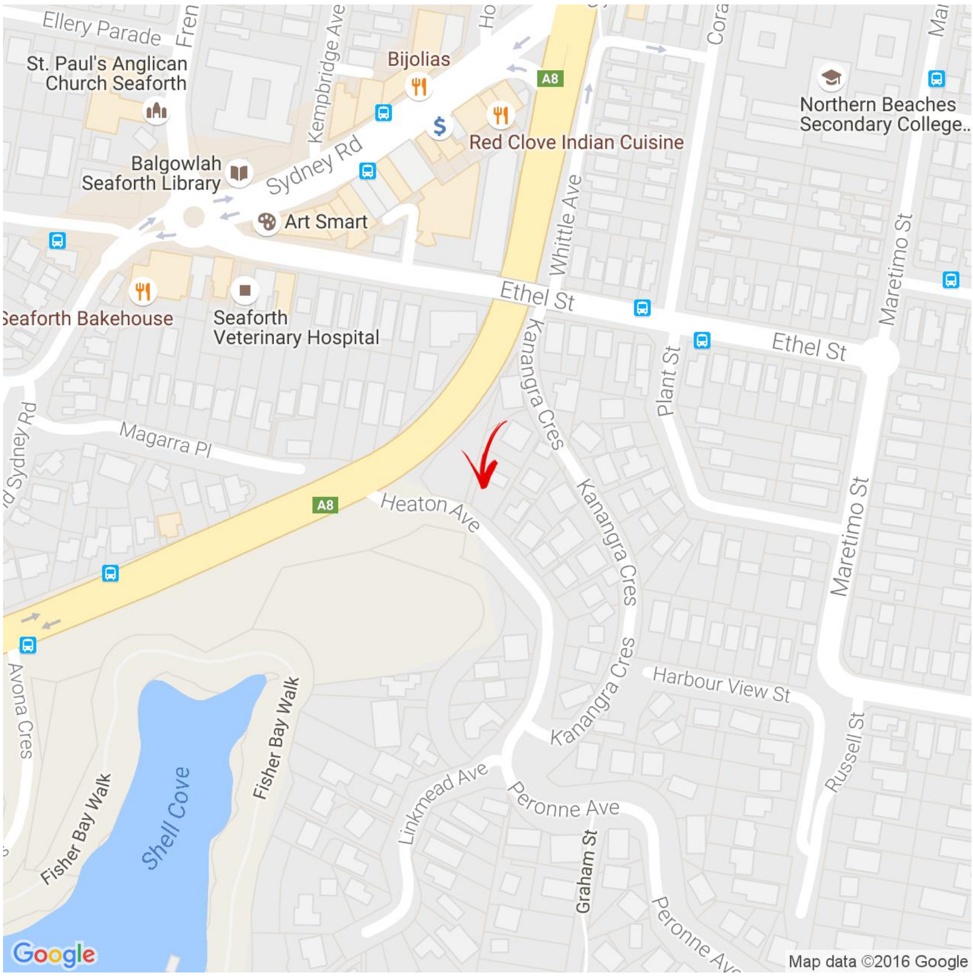
INP Noise Level, dB(A)

	Log Average	RBL
Day	61	51
Evening	58	48
Night	55	33

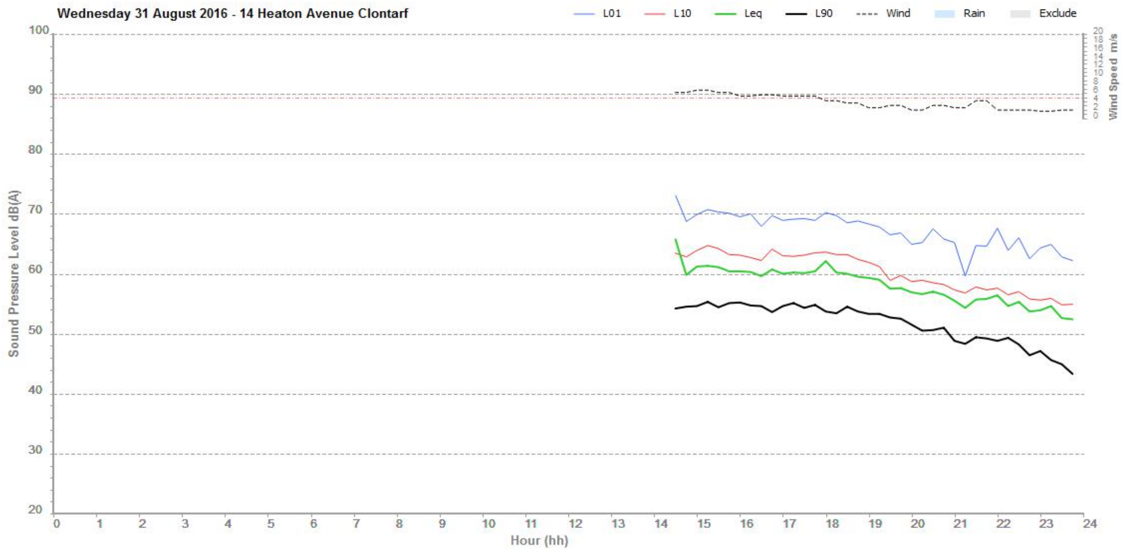
RNP Noise Level, dB(A)

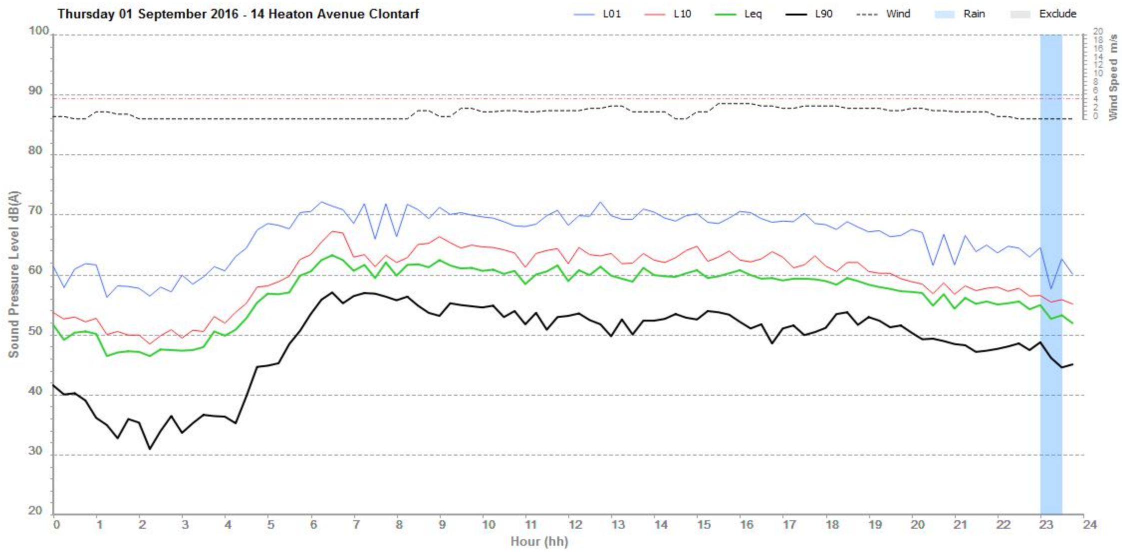
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

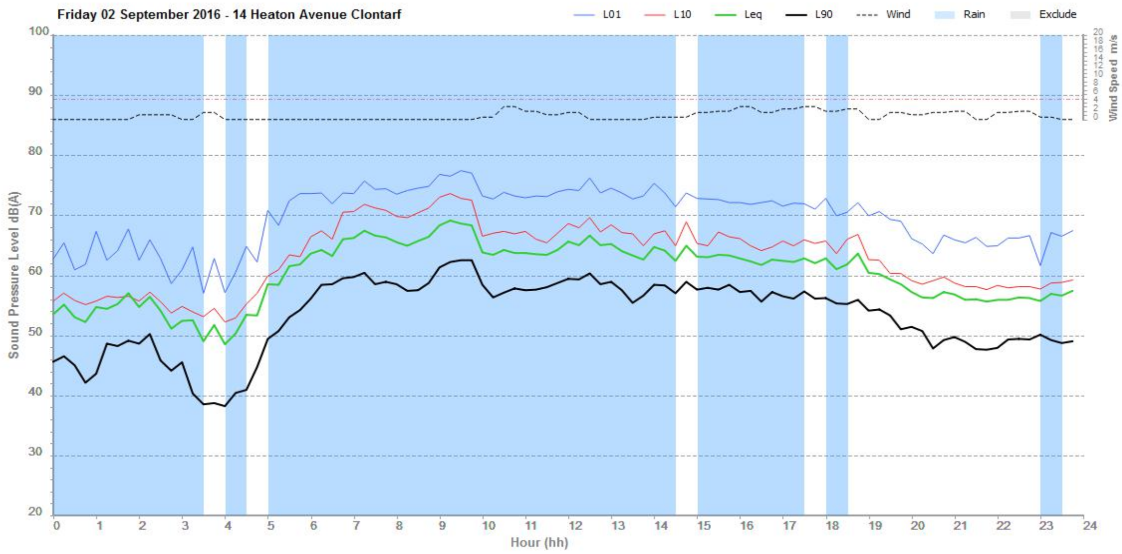
Logger Location Map



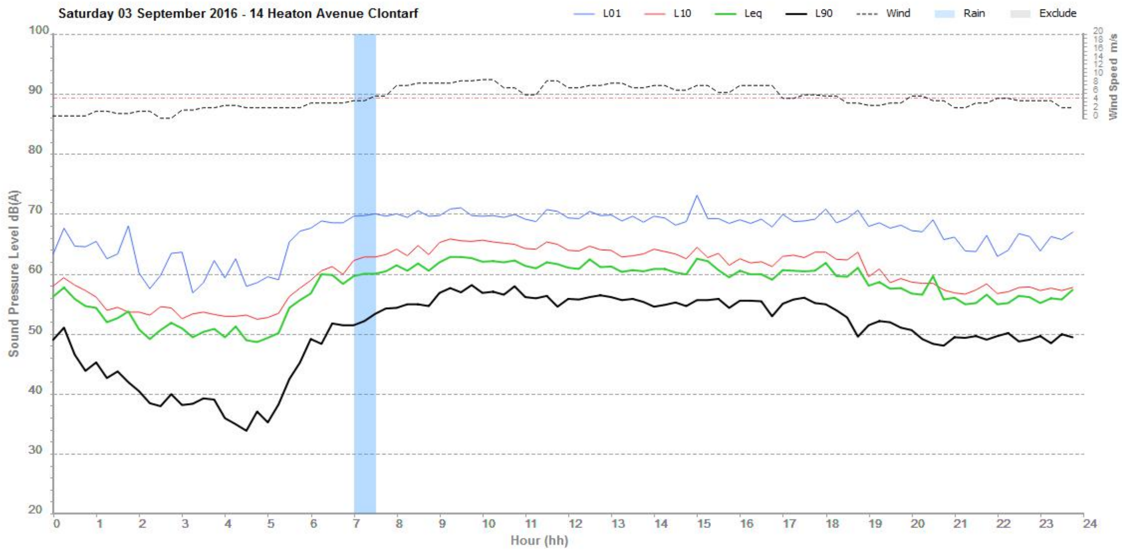
Logger Graphs

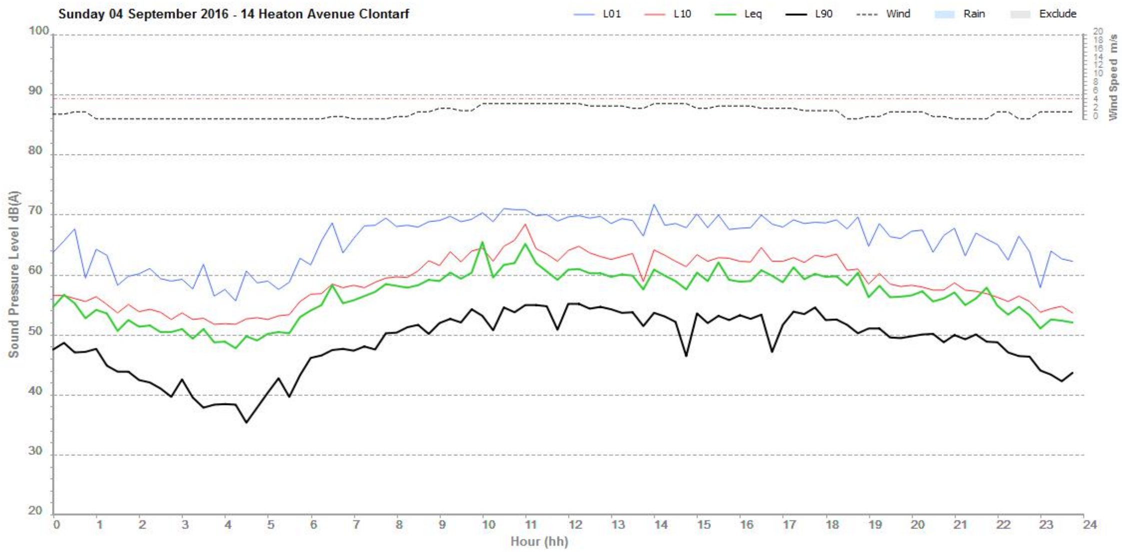


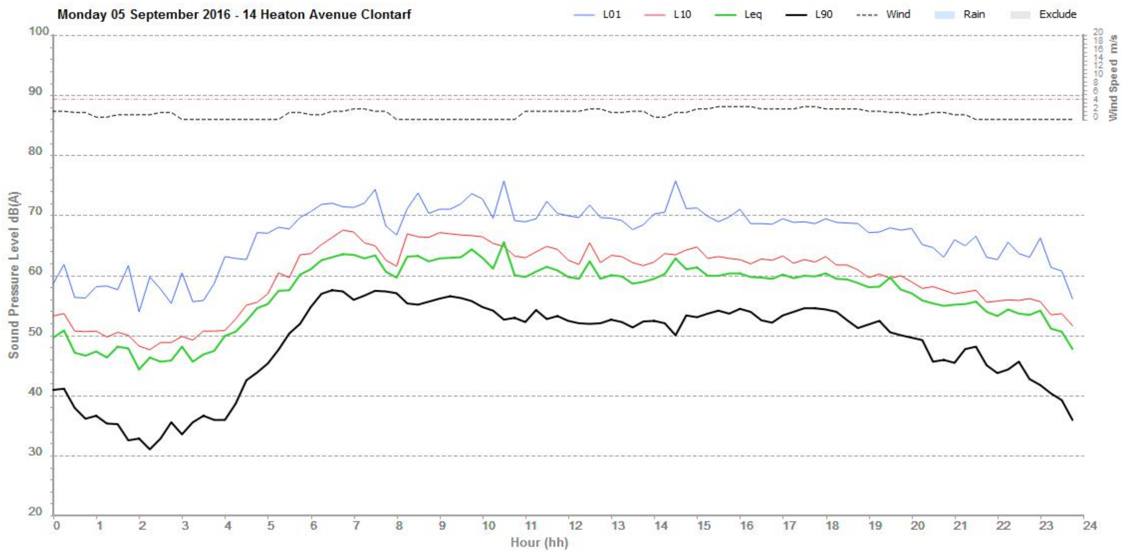




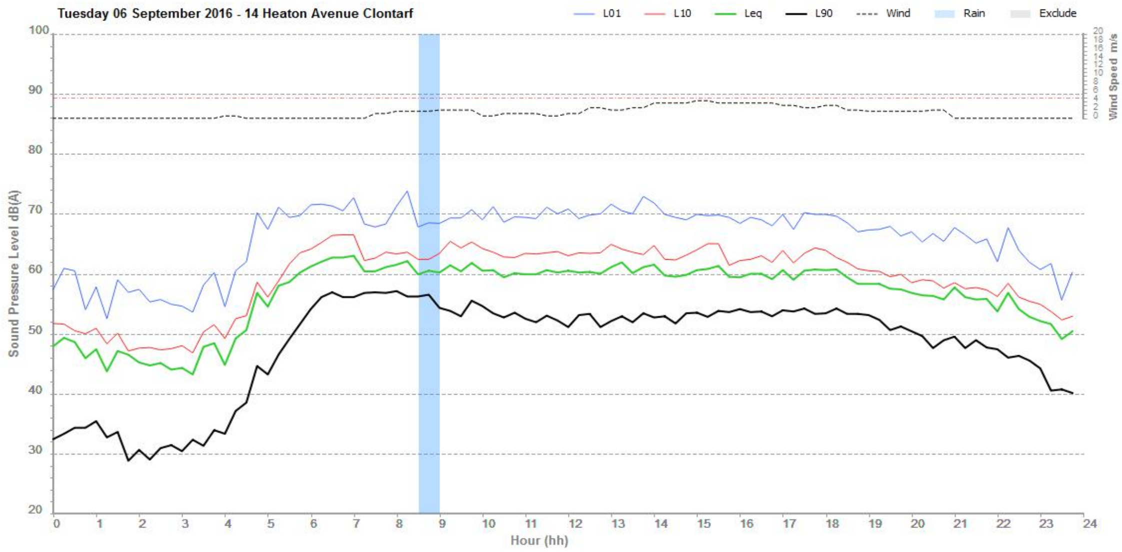
Logger Graphs

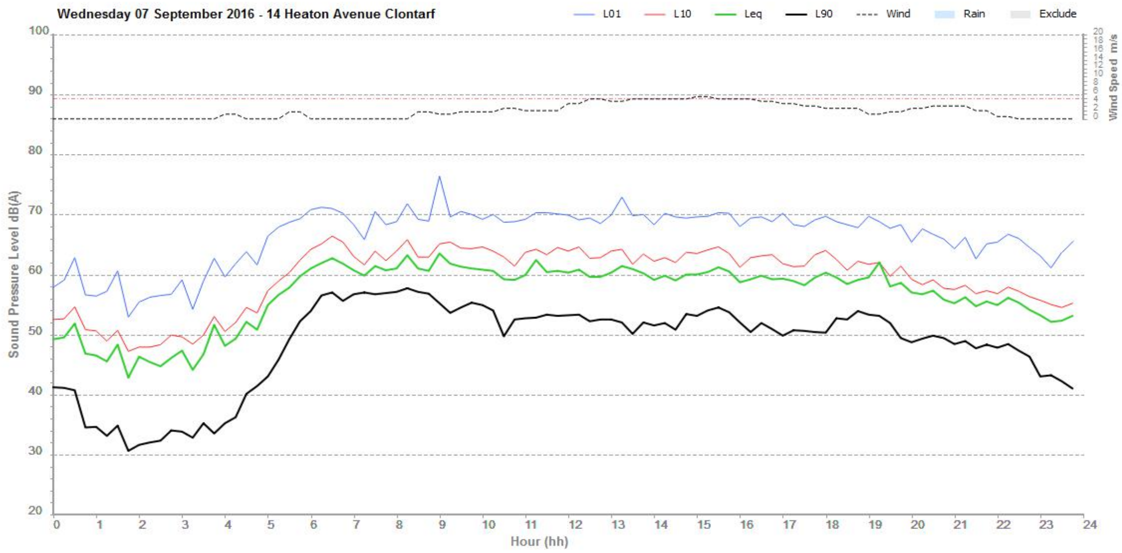


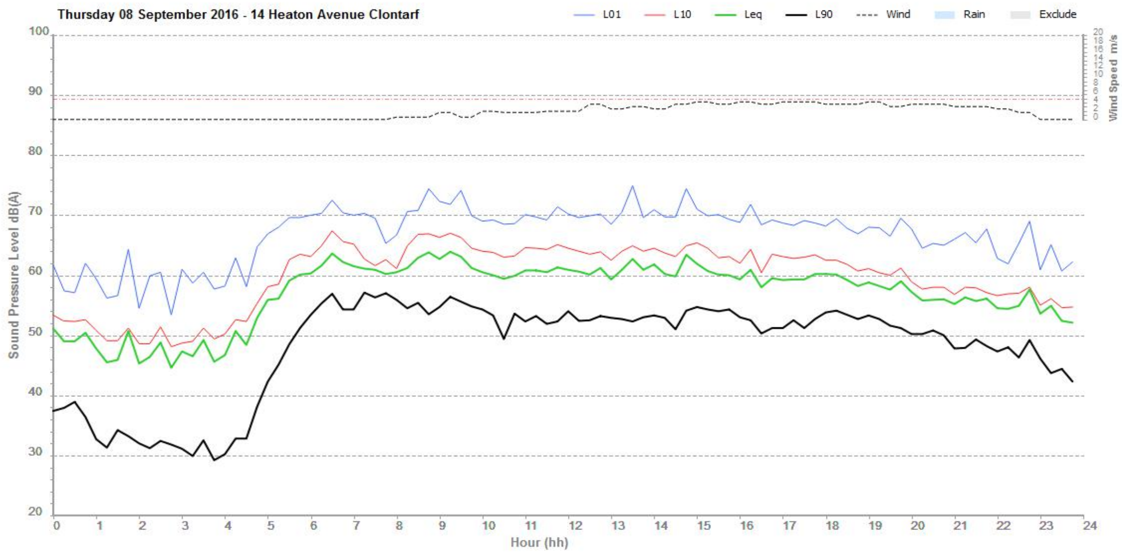




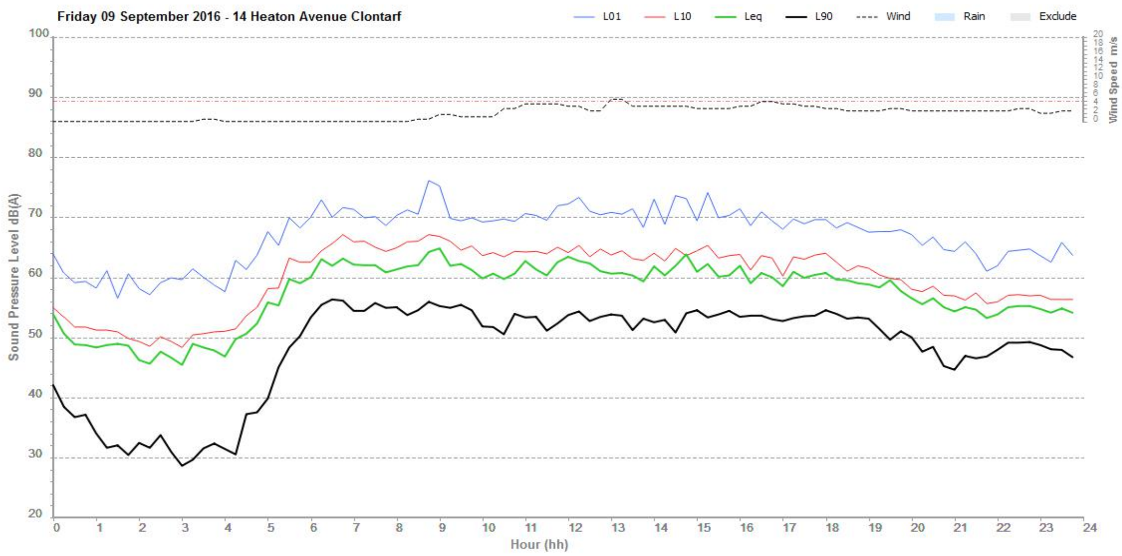
Logger Graphs







Logger Graphs



P9_2 - 10 Magarra Place - 31/08/16 - 12/09/16

Logger Setup

Logger Type: ARL 315

Serial No : 16-203-502

Address: 10 Magarra Place , Seaforth

Location: Front of property

Facade / Free Field: Free Field

Environment: Traffic noise is dominant. Logger located by the side of Manly Road.

Logger Setup Photo

INP Noise Level, dB(A)

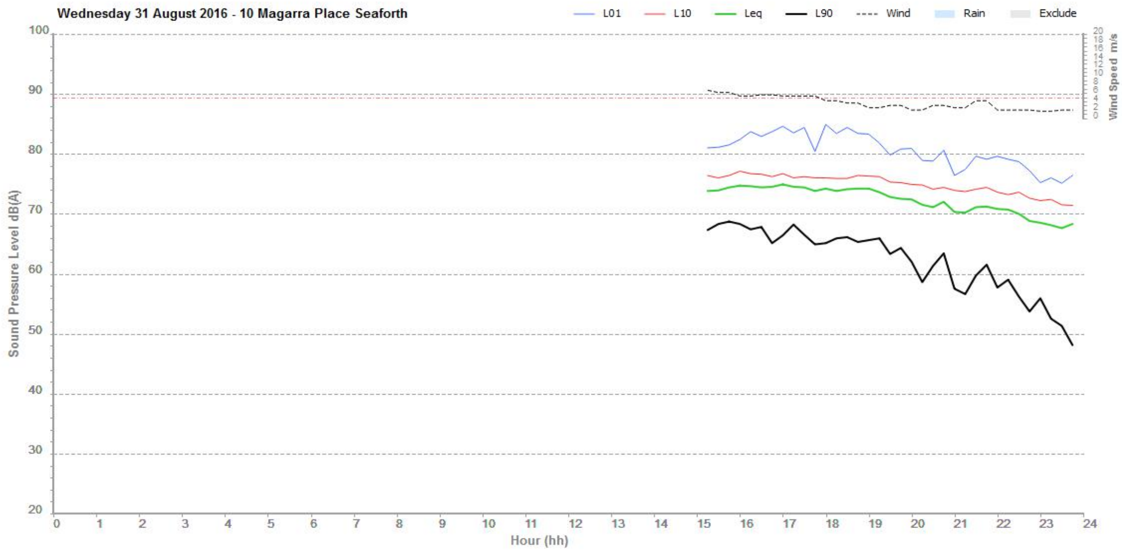
	Log Average	RBL
Day	74	61
Evening	72	58
Night	69	38

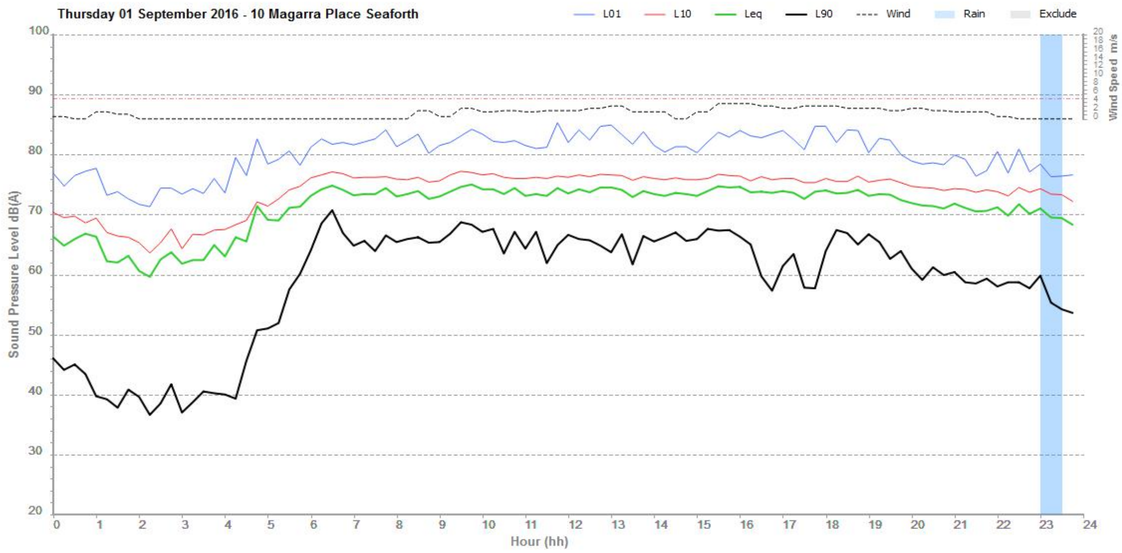
RNP Noise Level, dB(A)

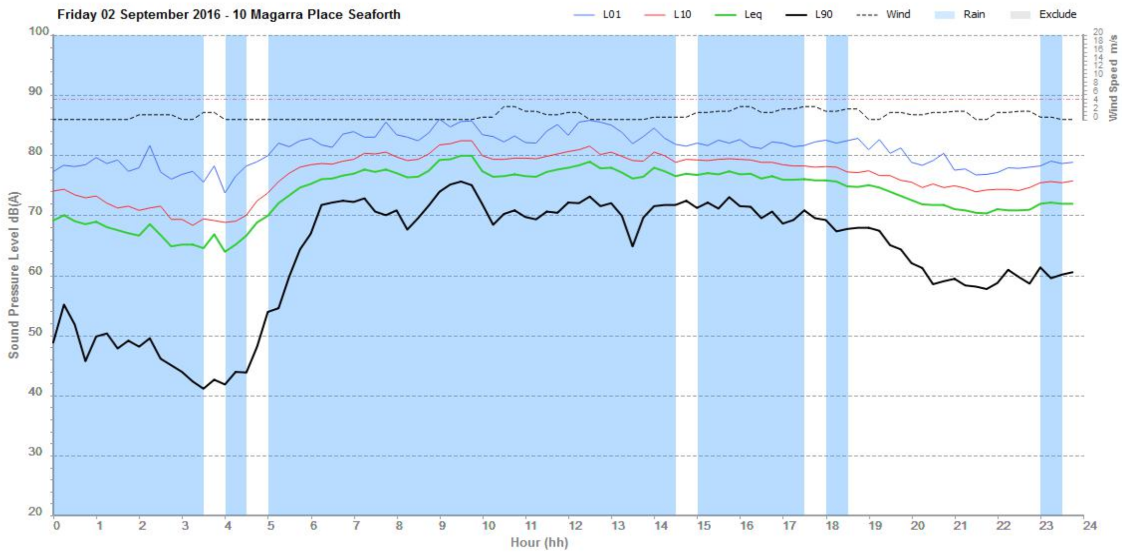
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

Logger Location Map

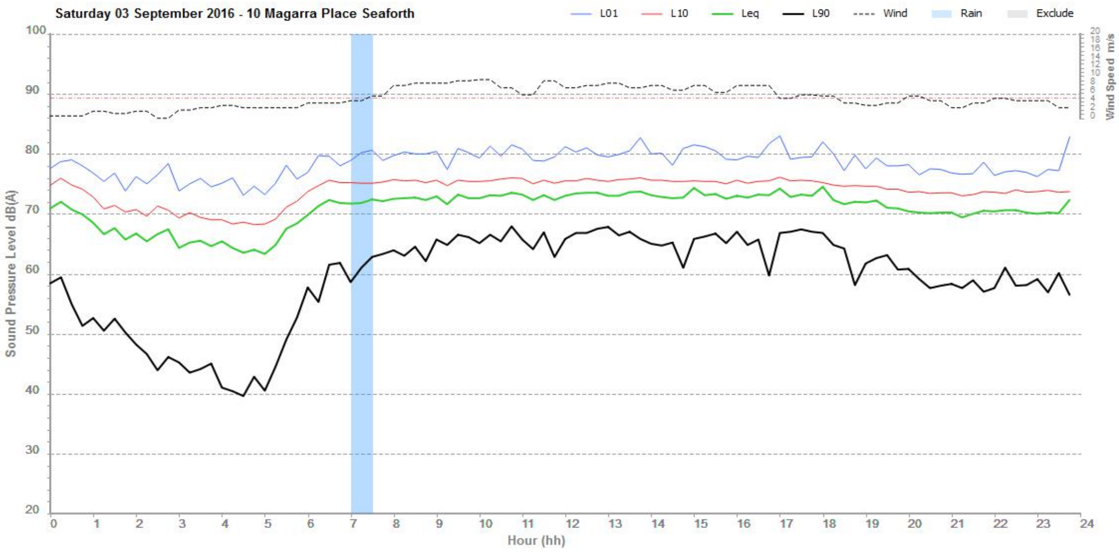
Logger Graphs

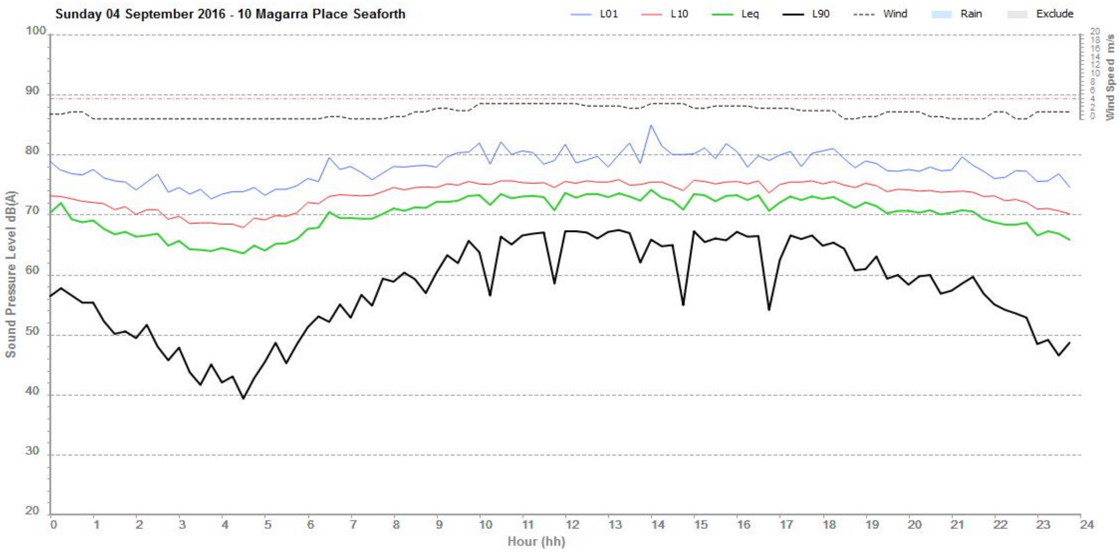


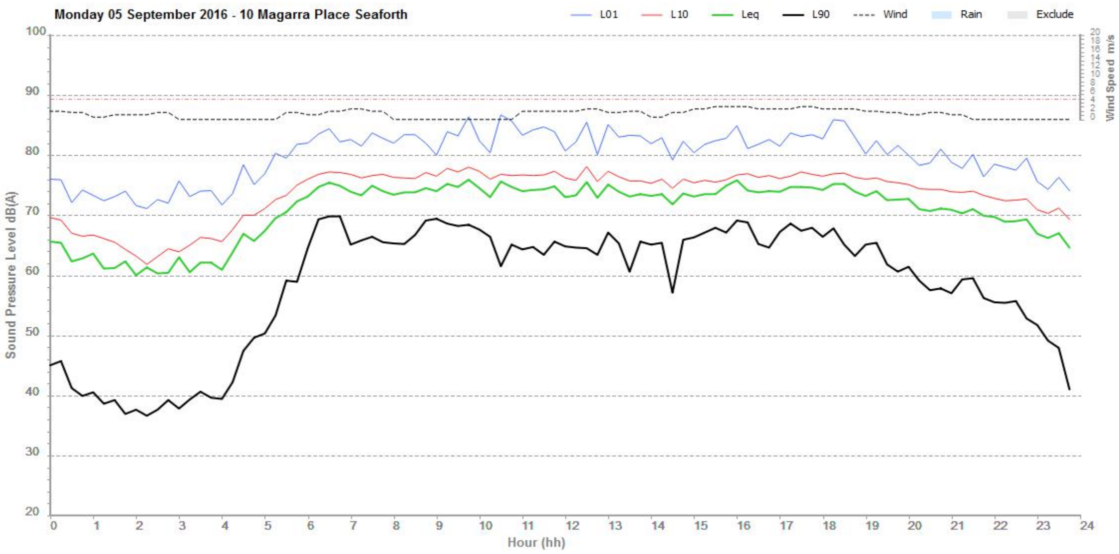




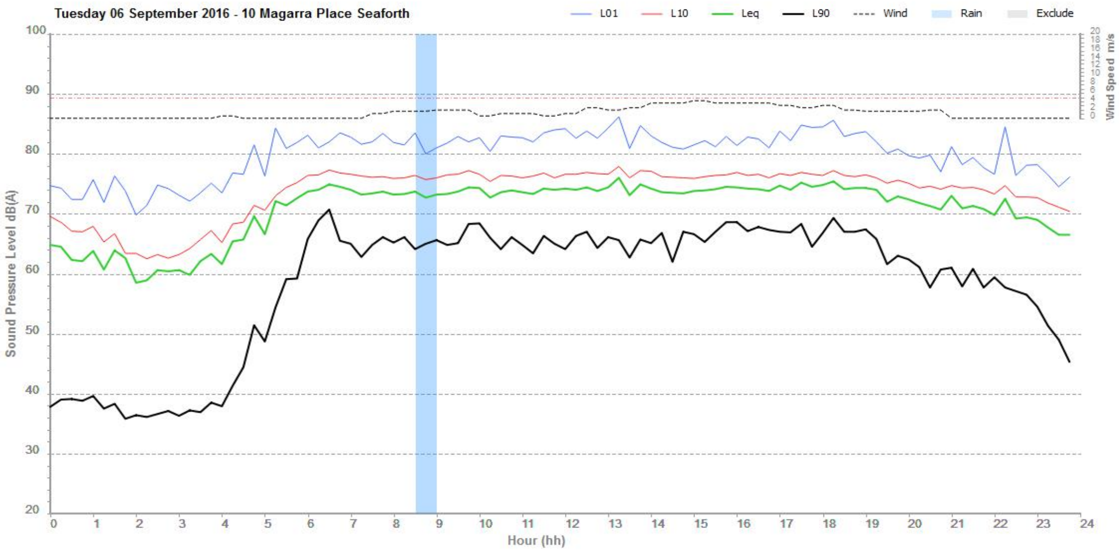
Logger Graphs

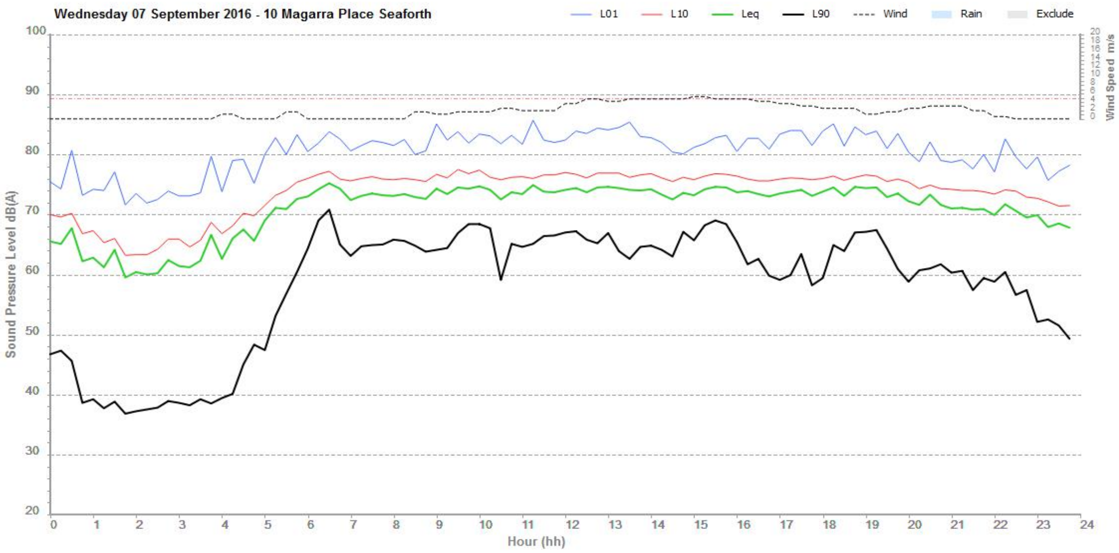


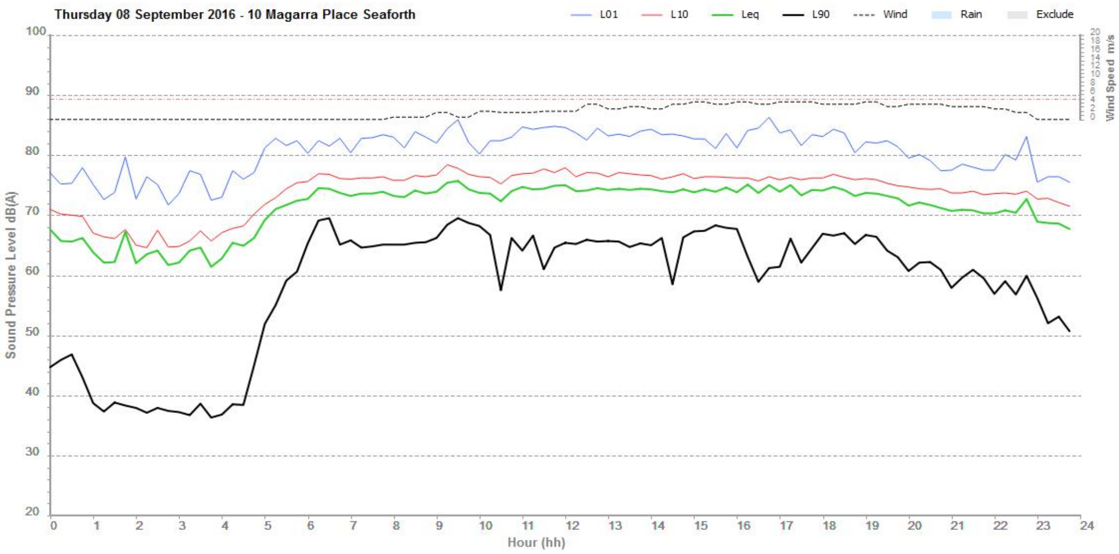




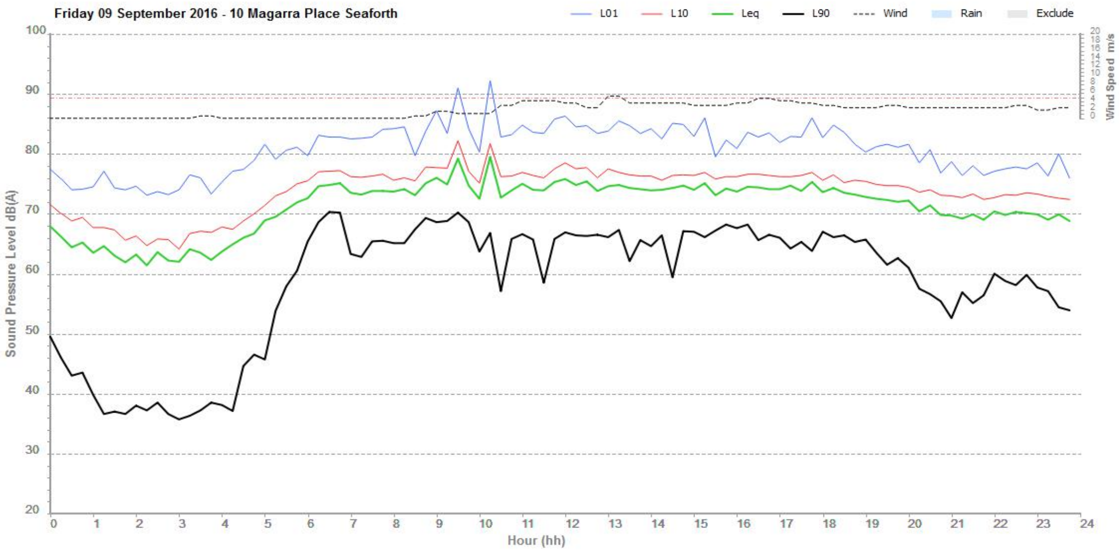
Logger Graphs

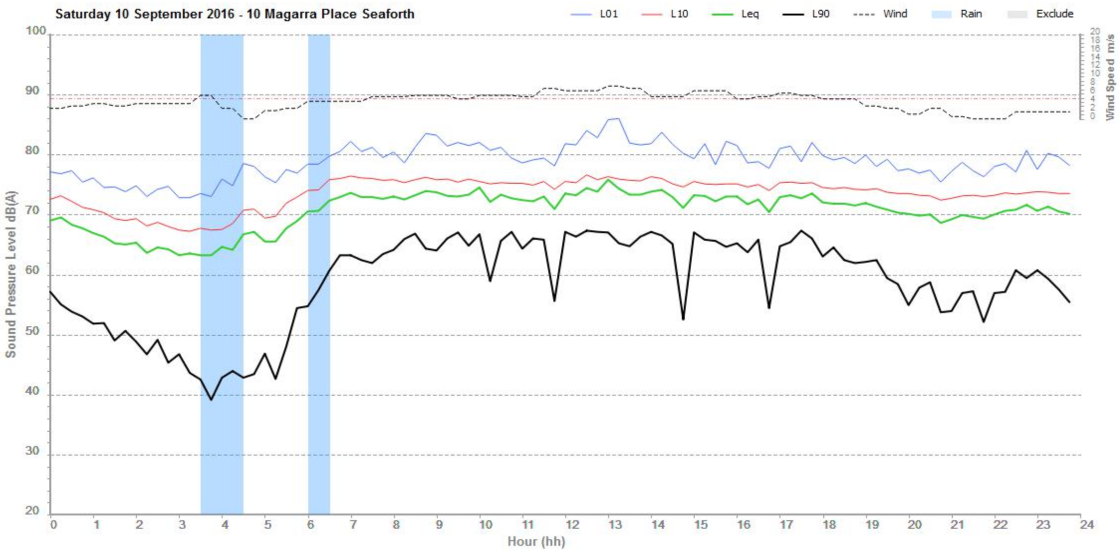


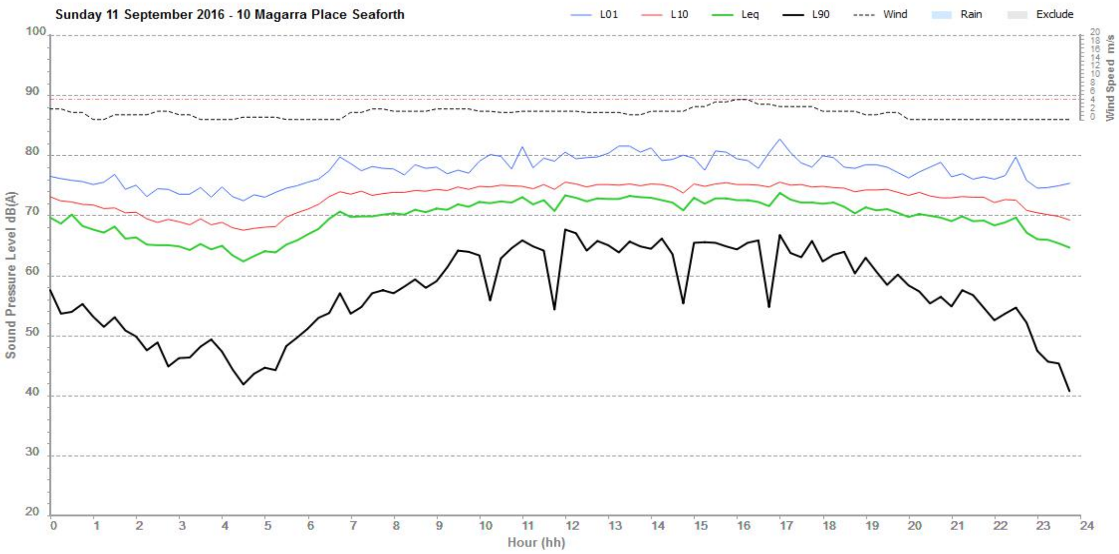




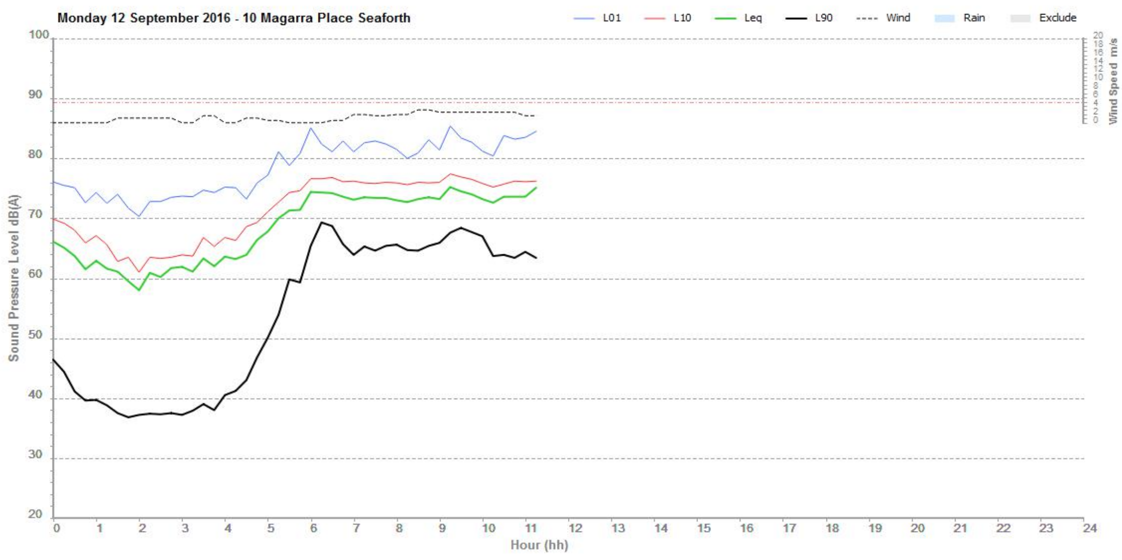
Logger Graphs







Logger Graphs



P9_3 - 10 Whittle Avenue - 31/08/16 - 12/09/16

Logger Setup

Logger Type: ARL 315

Serial No : 16-302-485

Address: 10 Whittle Avenue , Balgowlah

Location: Nature Strip

Facade / Free Field: Free Field

Environment: Traffic noise dominates. Logger location is adjacent to an intersection of two main roads in a public reserve/nature strip.

Logger Setup Photo

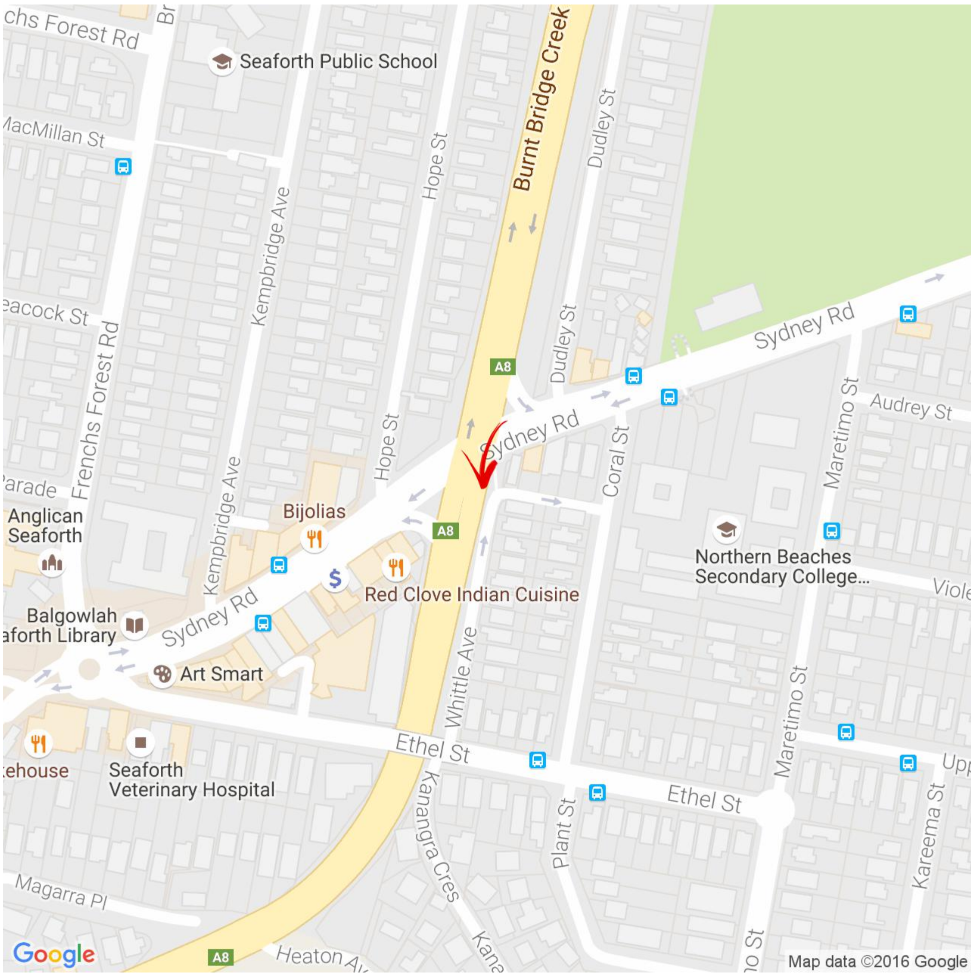
INP Noise Level, dB(A)

	Log Average	RBL
Day	74	62
Evening	71	57
Night	68	36

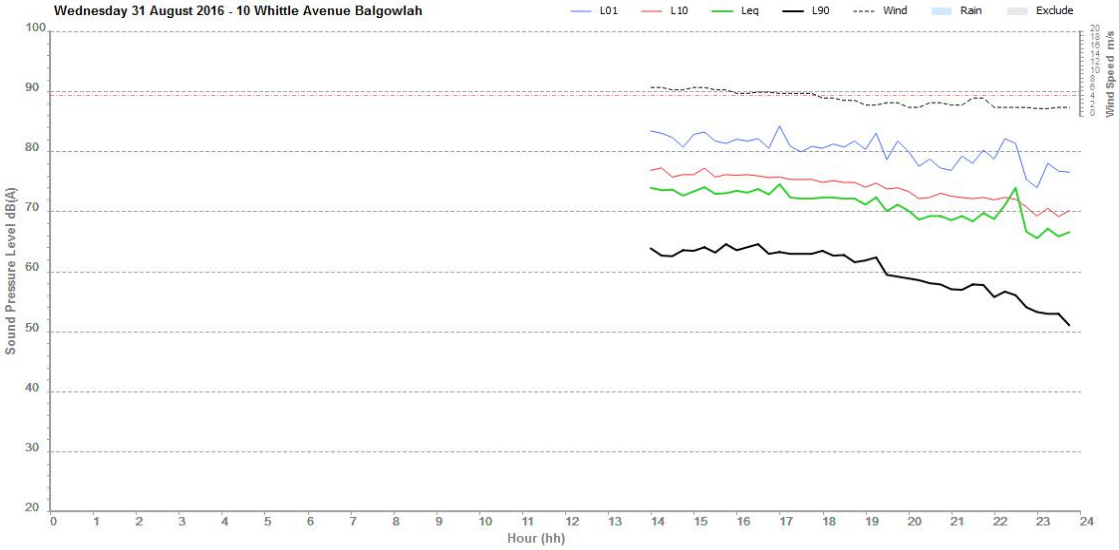
RNP Noise Level, dB(A)

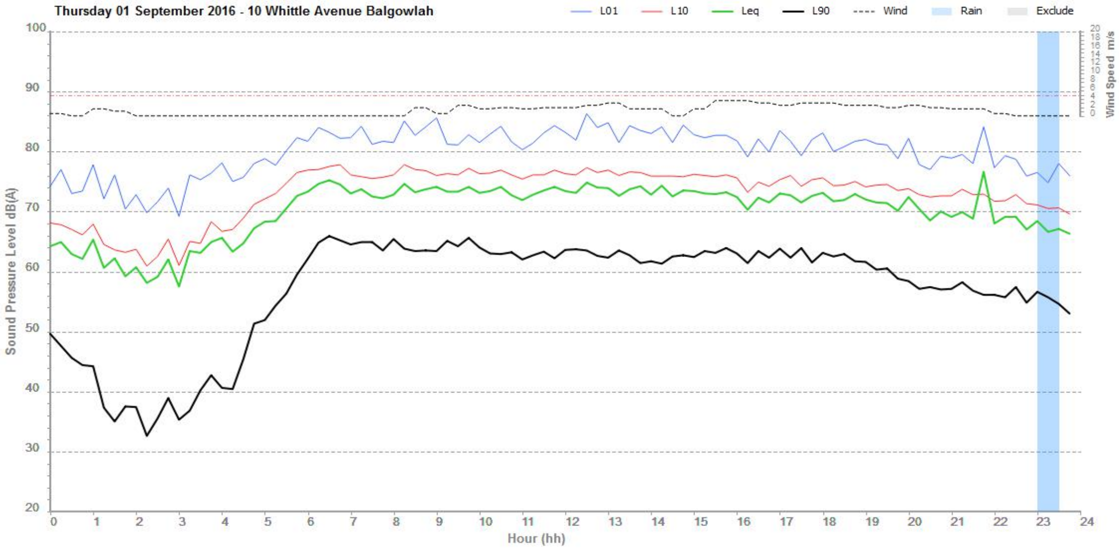
	$L_{Aeq(1hr)}$	$L_{Aeq(period)}$
Day (7am - 10 pm)	-	-
Night (10pm - 7am)	-	-

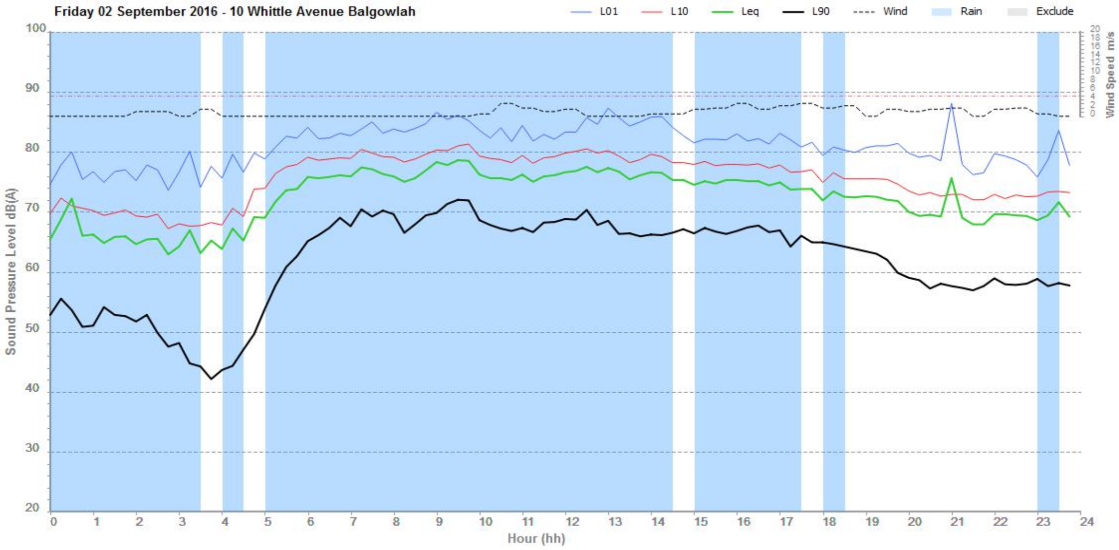
Logger Location Map



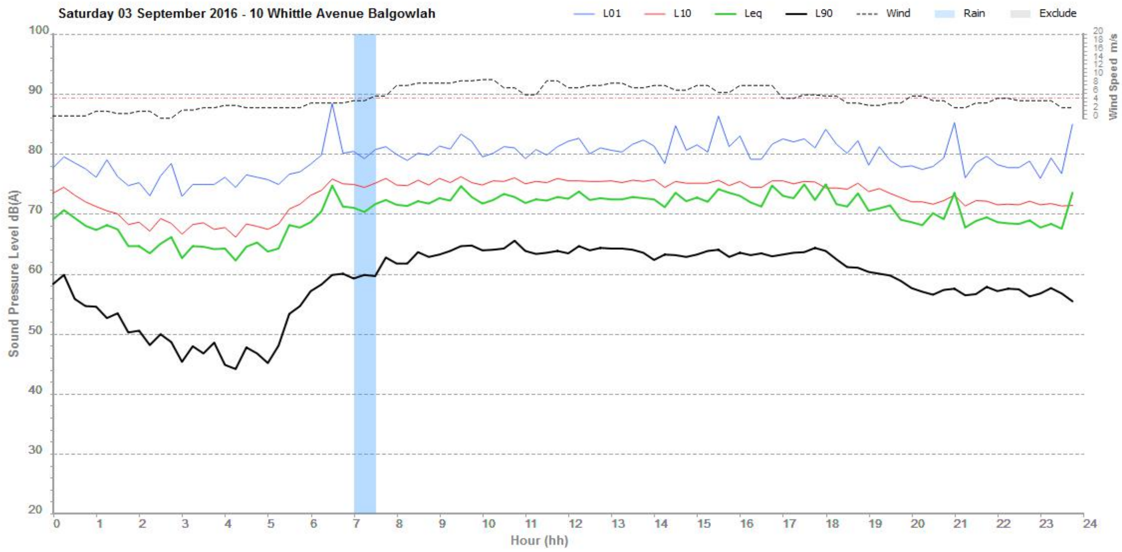
Logger Graphs

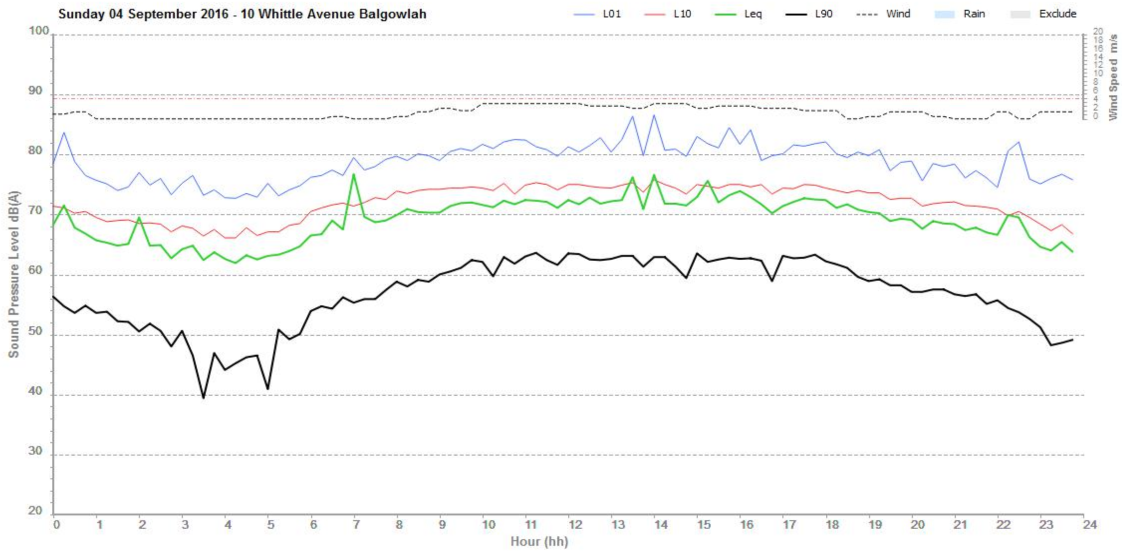


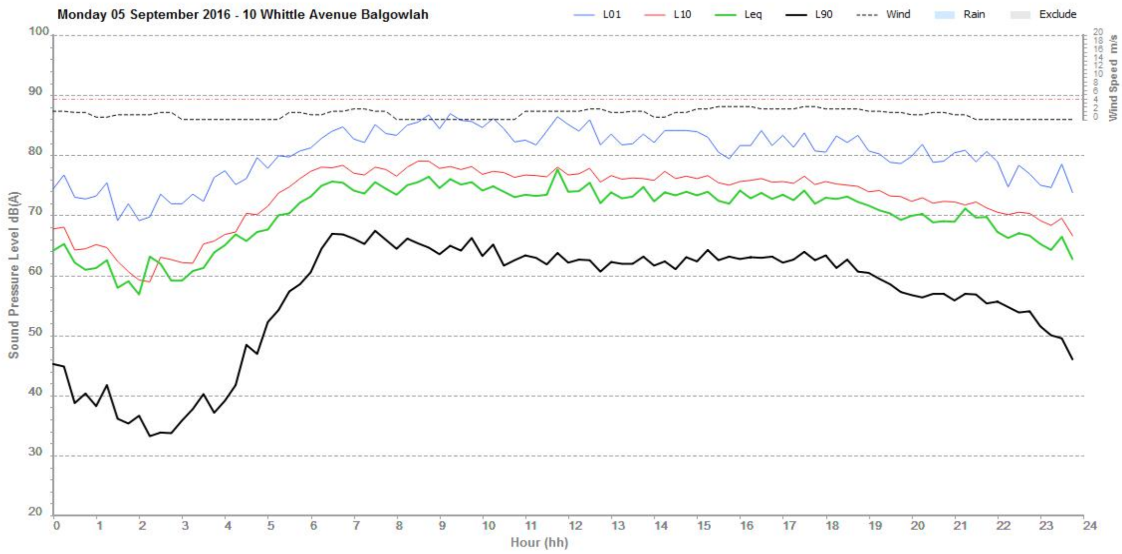




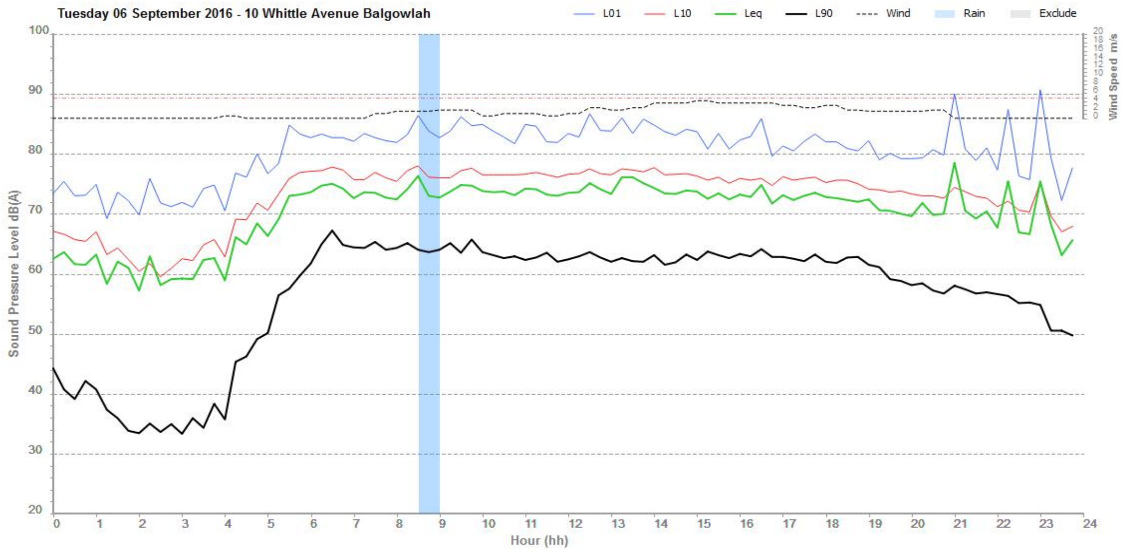
Logger Graphs

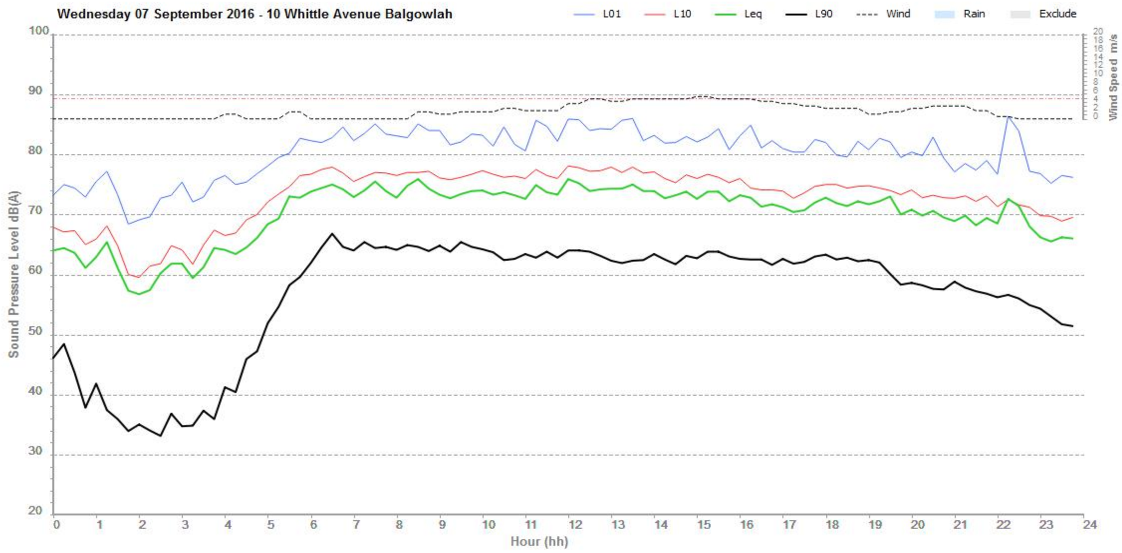


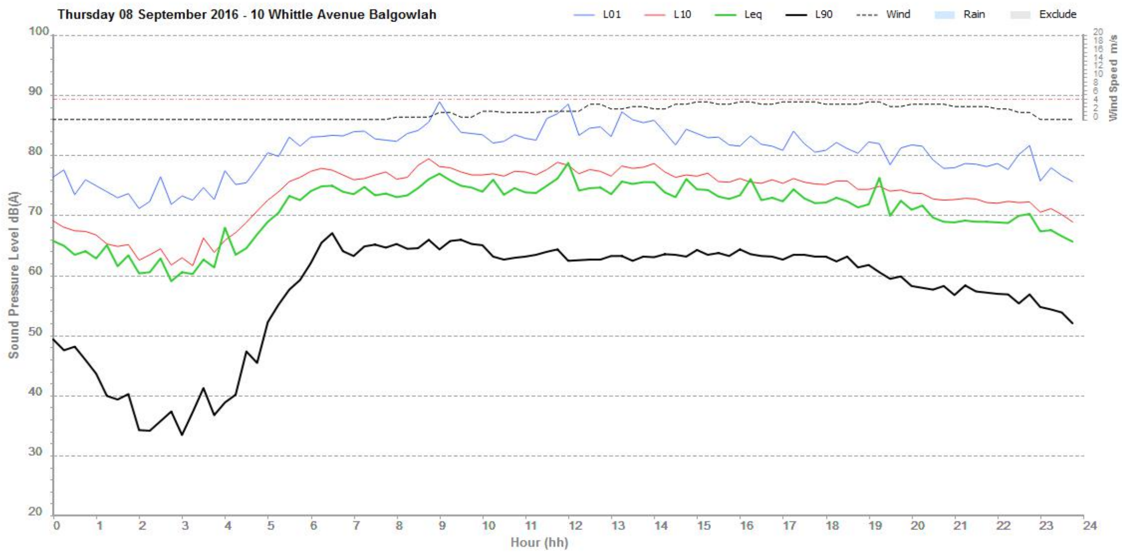




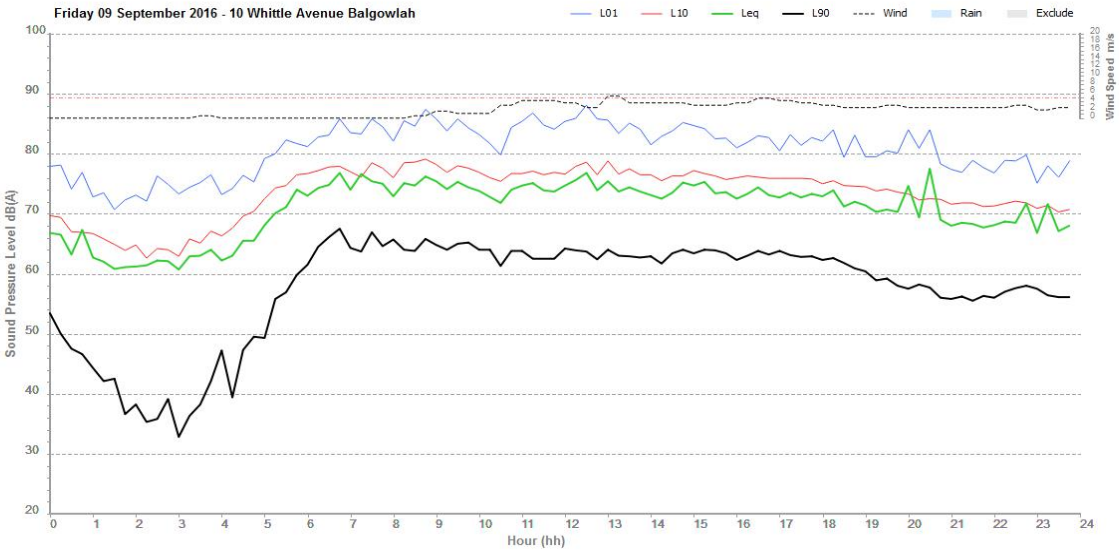
Logger Graphs

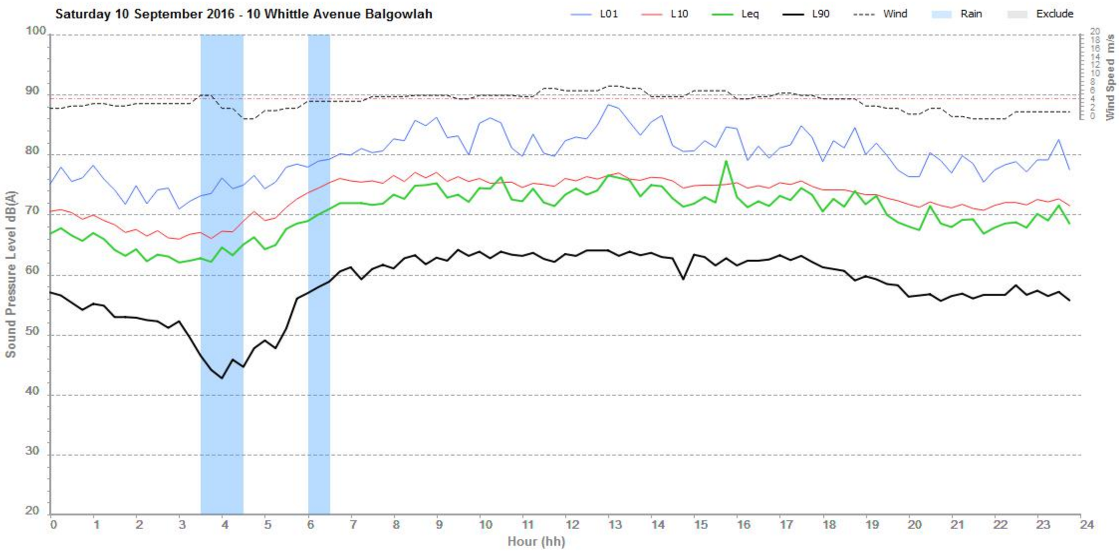


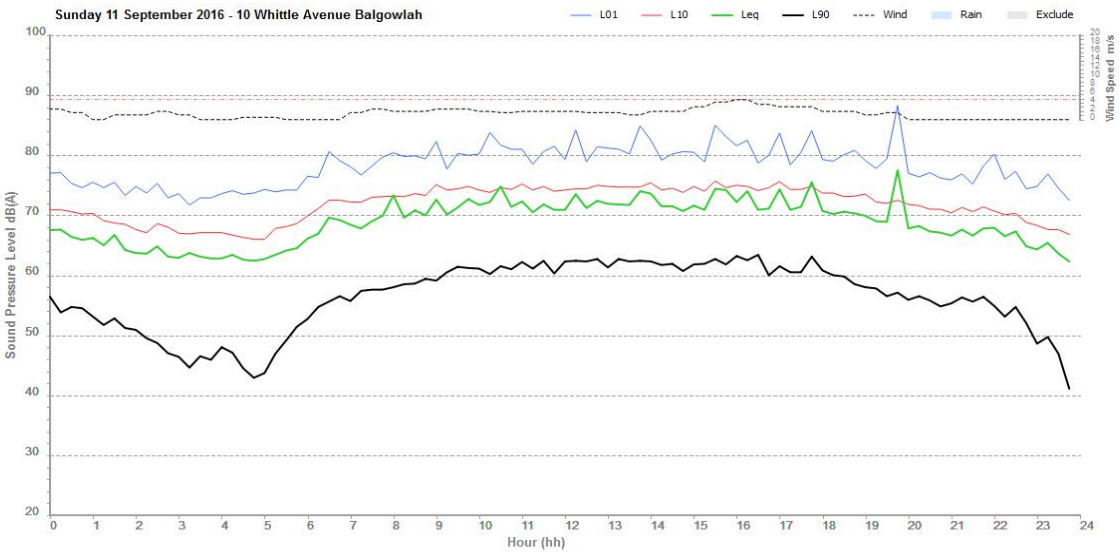




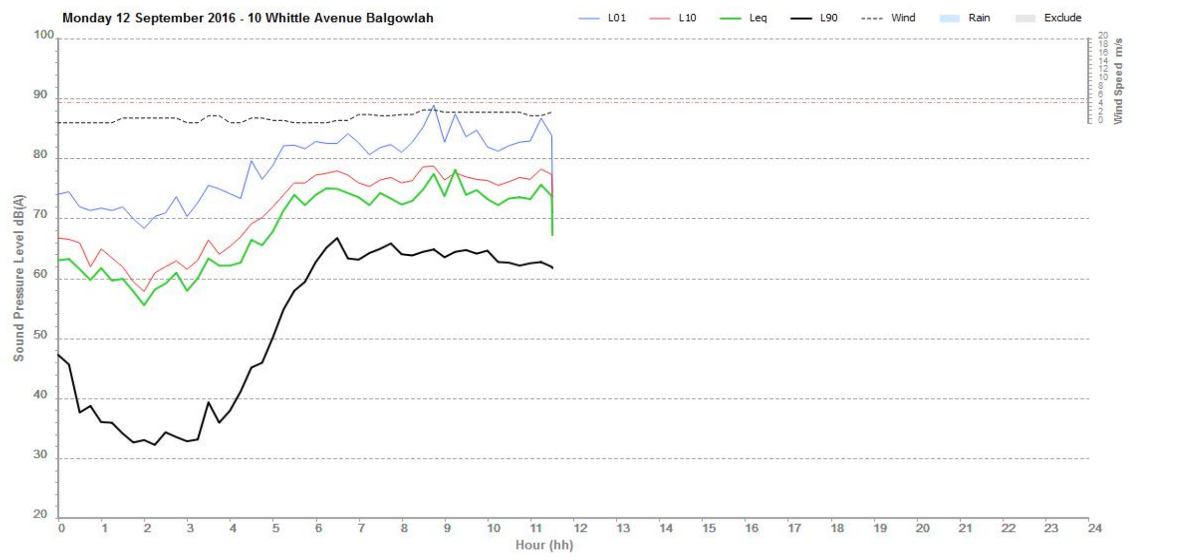
Logger Graphs







Logger Graphs



Appendix D

Noise catchment areas

AECOM

AECOM G:\!BLD\Acoustics\3.0 Projects\3.2 Short stay project folders\60491201 BLine\Maps\SoundPlanNoiseLoggers.mxd Updated 25/10/2016

Legend

- Noise Catchment Area A
- Noise Catchment Area D

N

250 125 0 250 Meters

B-Line

Noise Catchment Areas

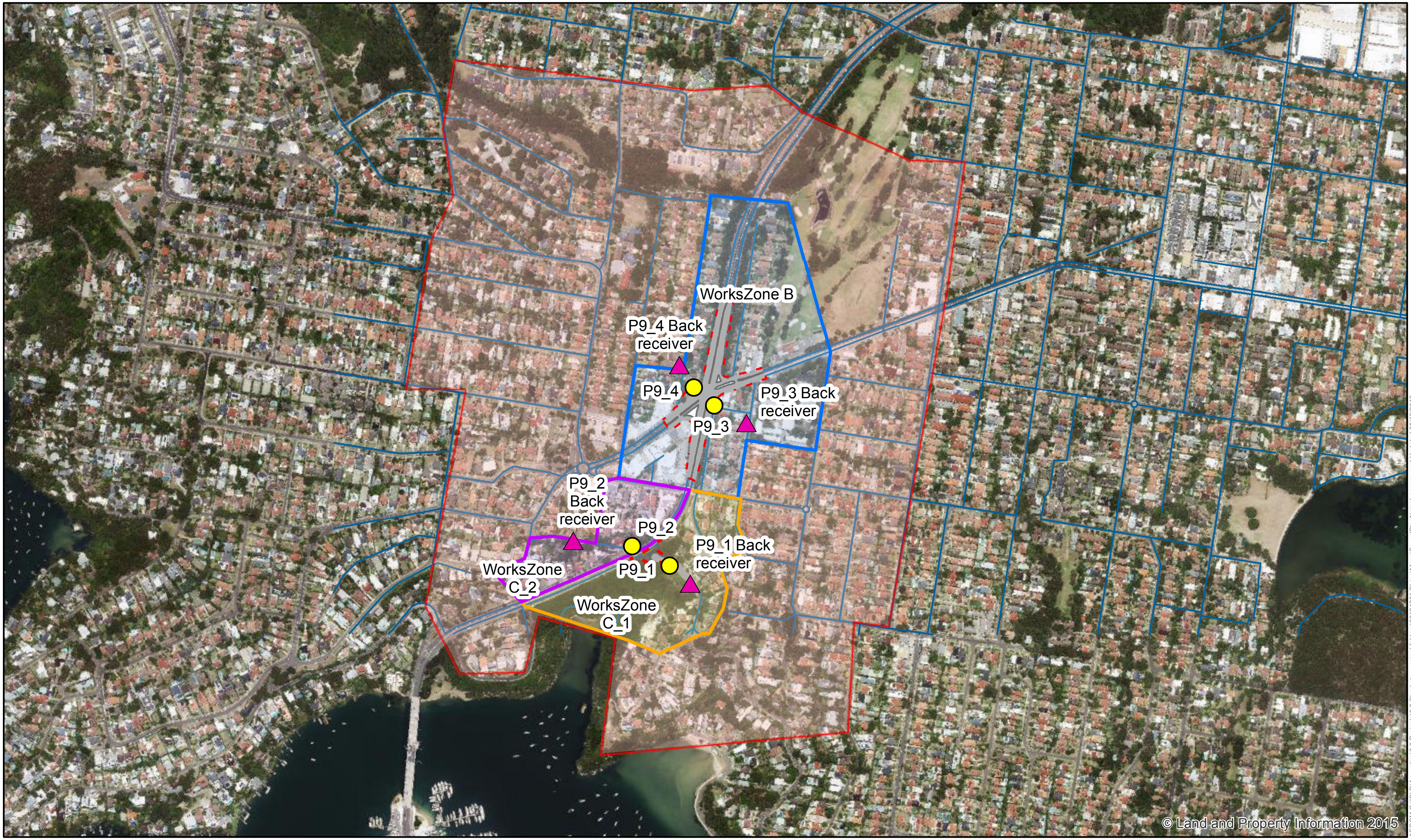
Source:

OCT 2016

60491201

Fig. **1**

AECOM



AECOM G:\BLD\Acoustics\3.0 Projects\3.2 Short stay project folders\60491201 BLine\Maps\SoundPlanNoiseLoggers.mxd Updated 25/10/2016

Legend

- Attended noise logging locations, shielded location
- Unattended noise logging locations
- Extent of works (approximate)
- Noise Catchment Area B
- Noise Catchment Area C_1
- Noise Catchment Area C_2
- Noise Catchment Area D

N

250 125 0 250 Meters

B-Line

Noise Catchment Areas

Source:

OCT 2016

60491201

Fig. **1**

Transport for NSW
projects@transport.nsw.gov.au
Tel 1800 048 751 Fax 02 9200 0290
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Locked Bag 6501,St Leonards NSW 2065