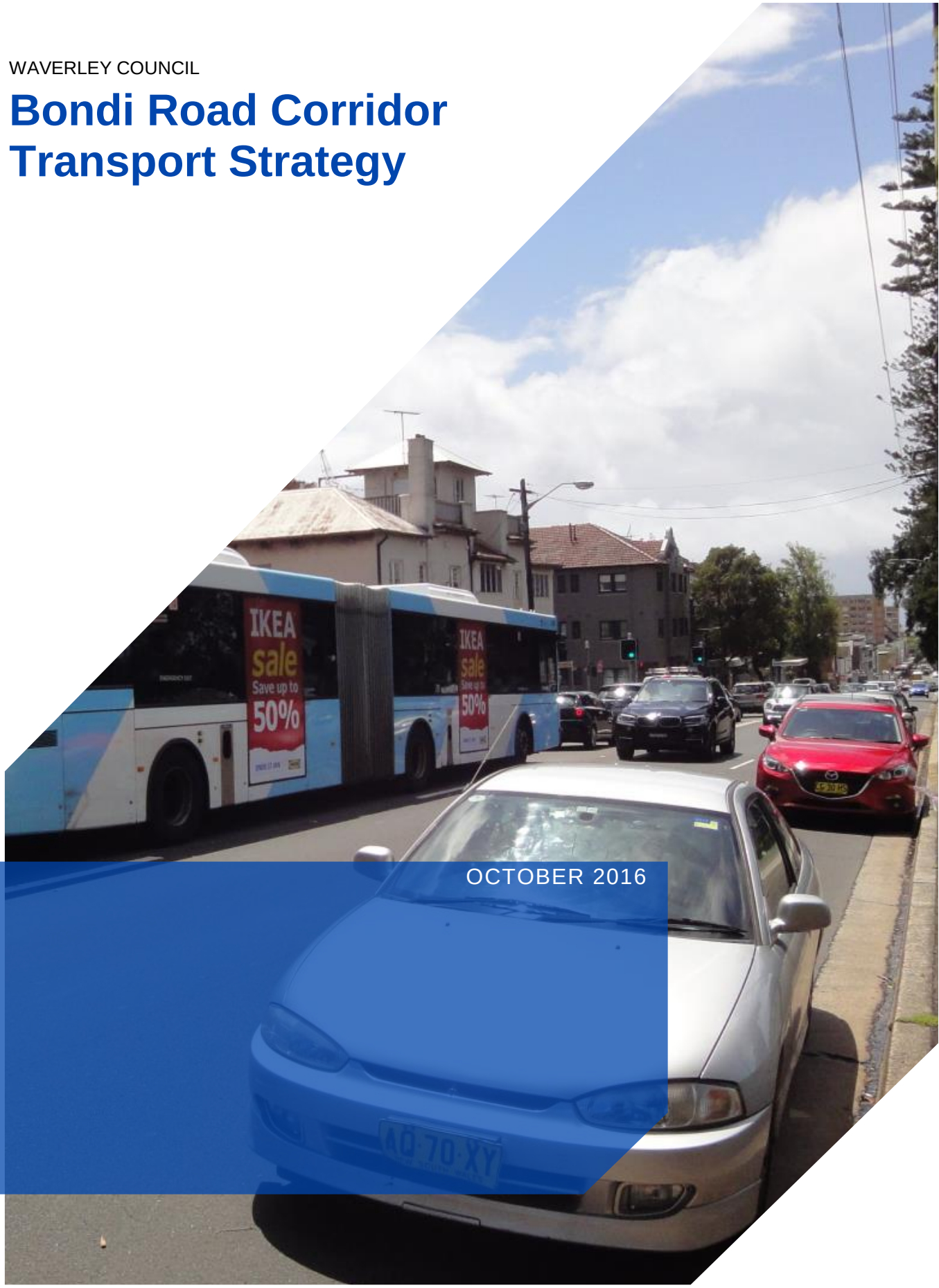
WAVERLEY COUNCIL

Bondi Road Corridor Transport Strategy



OCTOBER 2016

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Bondi Road Corridor Transport Strategy

Waverley Council

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF APPENDICES

GLOSSARY

Bus Rapid Transit (BRT)	A bus operation providing service similar to rail transit, at a lower cost. BRT systems are characterised by several of the following components: exclusive transitways, enhanced stops, easily identified vehicles, high-frequency all day service, simple route structures, simplified fare collection, and ITS technologies. Integrating these components is intended to improve bus speed, reliability, and identity and provide a higher level of bus service. Frequent 'turn up and go' services without the need for consulting a timetable. Stops every 800 metres to 1 kilometre. Investment in bus priority infrastructure for fast and reliable journeys. Also known as Rapid service routes in the Sydney bus context. Rapid service routes form the backbone of the new bus network, offering fast, reliable bus travel for customers between major centres. Rapid routes provide customers with mass transit level services between centres which are not linked by trains or light rail.
Bus	Suburban service routes are a mix of frequent 'turn up and go' and timetabled services. Stops are located every 400 metres. Bus priority targeted at key pinch points to speed up services. Local service routes are timetabled services. They complete the network, providing services such as local shopping services, CBD shuttles and peak express services. Stops are typically every 400 metres. Peak express services can have variable stop spacing. Services use local streets and roads, and bus priority for peak express connections.
Heavy rail	A transit system using trains of high performance, electrically powered rail cars operating in exclusive rights-of-way, usually without at-grade crossings with high platform stations. The tracks may be in underground tunnels, on elevated structures, in open cuts, at surface level or any combination thereof. For modern rail systems the distinction between 'heavy' and 'light' is determined by the type of service (service frequency and distance between stations) and train characteristics such as floor heights. Typically timetabled services utilising double deck trains with more seats per train. Also known as Tier 2 Suburban services in the Sydney rail context.
Light rail (LRT)	An electric railway system characterised by its ability to operate single cars or short trains along an exclusive rights-of-way at ground level, on aerial structures in subways or occasionally in traffic with low platform stops.
Light metro	A light rail system designed with provisions for easy conversion to metro rail.
Metro rail	Transit service which operates completely separate from all other modes of transportation.

	Frequent ‘turn up and go’ services without the need for consulting a timetable. Fast single deck trains, with plenty of seats, more doors, designed for easy boarding and alighting. Also known as Tier 1 Rapid Transit services in the Sydney rail context.
Monorail	A transit system consisting of vehicles supported and guided by a single guideway (rail or beam) either elevated or suspended.
Personalised rapid transit (PRT)	A theoretical concept for an automated guideway transit system that would operate small units (two to six passengers) under computer control over an elaborate system of guideways. Offline stations would provide demand-responsive service with very short headways with travel between origin and destination stations without stopping.

THE BONDI ROAD CORRIDOR TRANSPORT STRATEGY

This corridor transport strategy has been undertaken to support Waverley Council in identifying the most appropriate response to the existing congestion issues being experienced on the Bondi Road corridor and to identify the appropriate transport and land use measures required, in line with government policy, to allow the corridor to function efficiently into the future.

The Bondi Road corridor links the suburb of Bondi to Bondi Junction and the Central Business District of Sydney via Oxford Street. Alternatively, access to the CBD is facilitated through interchange with the Sydney Trains network at Bondi Junction. Bondi Road is currently a four lane road (two lanes in each direction) with the kerbside lane used for car parking outside of peak periods – during the peaks 'no standing' provisions are applied on the peak flow direction of the road to enhance capacity.

The level of peak hour travel demand is close to reaching the capacity of the road corridor despite the previous introduction of road and public transport capacity enhancement measures. Significant traffic congestion is also experienced at weekends and during the warmer months when there is demand for trips to the beach, and also when special events are held in Bondi. The ongoing efficient operation of bus services using the corridor is compromised under the business as usual scenario and this will continue to limit the attractiveness of public transport as a viable alternative to the private vehicle.

Clearly a step change in public transport provision is required to reflect the future of Waverley as a vibrant inner city (and beachside) area characterised by medium density housing and supported by viable sustainable travel options. Private vehicle usage on the Bondi Road corridor will have to reduce over time in line with the change in travel behaviour across Sydney as the population grows and sustainable transport modes begin to be given priority for road space on corridors supported by the desired levels of density. There is an opportunity for Council to envisage the Bondi Road corridor as a 'boulevard to the beach' with public transport at its core. This would be consistent with the outcomes of Council's Waverley People, Movement and Places study which identifies Bondi Road as the key public transport corridor in the local government area.

'A Plan for Growing Sydney' (Department of Environment and Planning, 2014), is the key planning policy direction for metropolitan Sydney. It identifies Bondi Junction as a key strategic centre for growth in this part of the city. Waverley sits within the Central District as defined by the Greater Sydney Commission (GSC) who is tasked with developing and implementing district plans in partnership with local government. The GSC are currently commencing their metropolitan planning at a district level which is timely as the planning process will identify the character and level of development that the community and local government want to see for their communities.

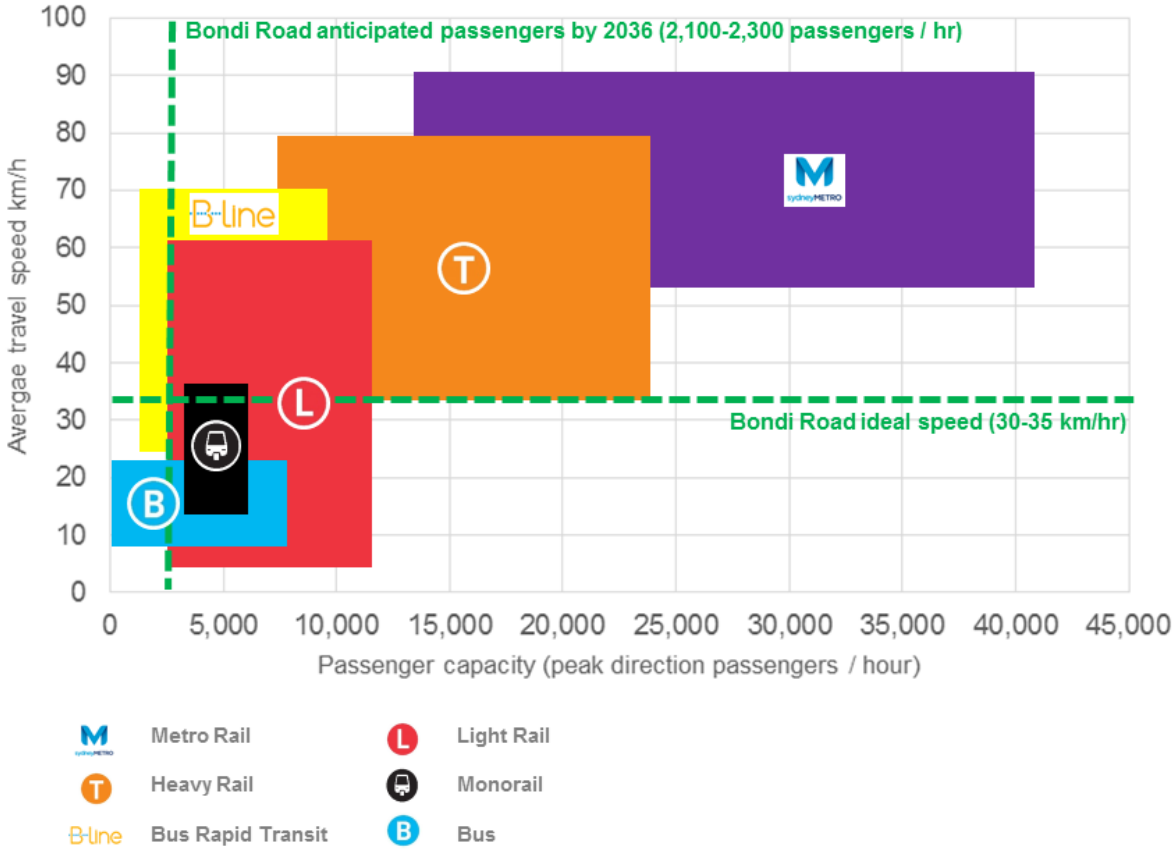
The state government has recognised the importance of the Bondi Road corridor through designating it as a rapid bus corridor in Sydney's Bus Future (TfNSW December 2013). Identified bus improvement measures for the corridor include:

- → extend bus operating hours and speed up services through wider stop spacing
- → implement bus priority infrastructure along the corridor
- → introduction of high capacity vehicles
- → high quality interchanges with consistent wayfinding and signage
- → address bus pinch points with bus priority treatments

It is acknowledged that the rapid bus route plans identified by state government are the first step in the evolution of this important public transport corridor. This study identified options to further enhance the provision of public transport in the corridor and to this affect, a number of modal options were considered. A long list of options was initially developed and then reduced to a short list of six concepts worthy of more detailed examination as identified below (shortlisted concepts identified in ***bold italic*** text):

- Street level options:
  - ***Bus priority in shared lane***
  - ***Bus Rapid Transit (BRT) in managed traffic lanes***
  - ***Bus Rapid Transit (BRT) in kerbside lane (e.g. B Line concept)***
  - Light Rail Transit (LRT) in shared traffic lane
  - ***Light Rail Transit (LRT) in dedicated central lanes***
- Elevated options:
  - Heavy rail
  - Light Metro
  - ***Monorail***
  - Personalised Rapid Transit (PRT)
- Underground options:
  - Heavy rail
  - ***Metro rail***
  - Light Metro.

Through a multi-criteria assessment of the six short-listed concepts, those that provided additional capacity by providing a new/additional corridor to complement the existing capacity of the Bondi Road corridor scored the highest (i.e. Metro rail and Monorail). The cost (both capital and operational) of providing these solutions is high and the passenger demand required to make metro rail feasible is not aligned with the current land use forecasts for the area. Monorail is a transport mode that is currently not part of the transport planning framework in NSW and has significant visual amenity and station access issues which are in conflict with the desired urban outcomes for the corridor. Figure E1.1 outlines the operating speed and passenger capacities of the public transport modes considered.



Source: adapted from Transit Capacity and Quality Service Manual (TRB 2003)

Figure E1.1 Typical travel speed and capacity ranges for proposed transit modes

The feasibility an underground heavy rail or metro rail link beneath the Bondi Road corridor may be achieved through the broader planning for metropolitan scale rail projects such as the Western Sydney Rail Needs Scoping Study and planning for the Sydney Metro. Several of the options identified that connect Western Sydney to other areas in Sydney could be extended through to Bondi Junction and Bondi Beach thus linking Sydney's key activity centres and tourist locations to the city's new airport.

The concepts that are most likely to be support future public transport demands and achieve the urban renewal outcomes for the Bondi Road corridor are bus rapid transit (BRT) and light rail transit (LRT). The introduction of BRT would be a result of direct growth in the patronage of the rapid routes currently proposed by state government. If increases in patronage occurs through the provision of high quality and frequent public transport (initially rapid routes) supported by a new land use scenario for the corridor of high density, mixed use and walkable neighbourhoods between the strong anchors of Bondi Junction and Bondi Beach, light rail could then be considered as a feasible mode in the medium term.

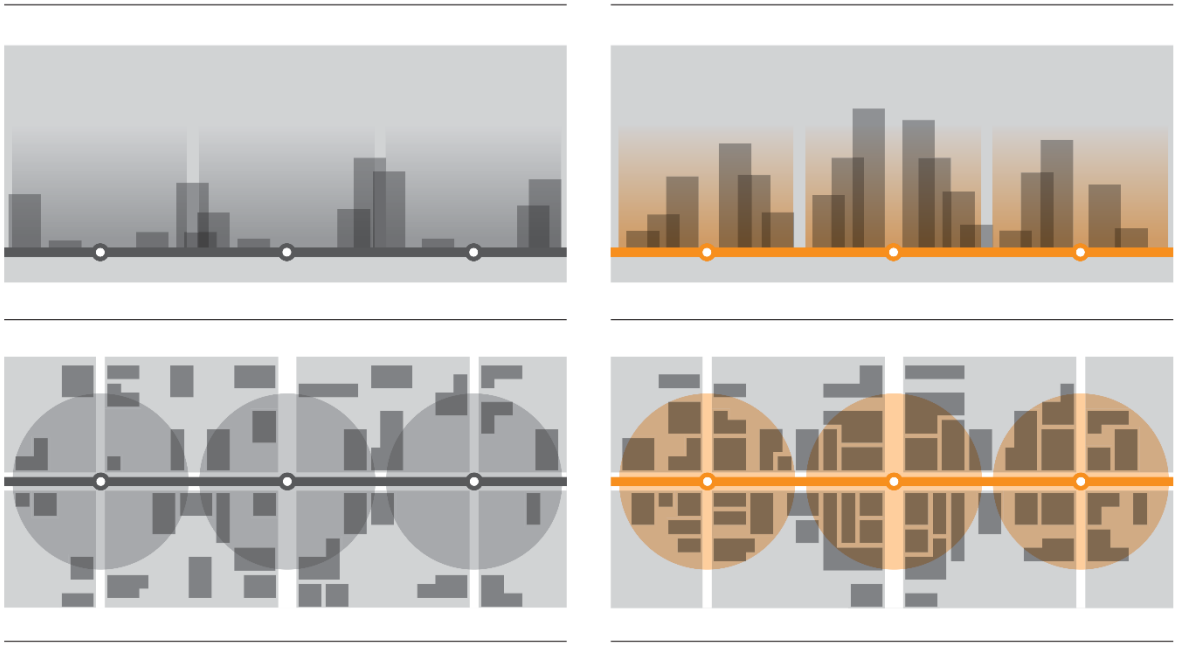
Both BRT and LRT are the two modes most likely to be connected into the existing Sydney public transport network in the short to medium term. The Bondi Road bus corridor currently meets the public transport network (heavy rail) at Bondi Junction interchange before continuing on via Oxford Street to the Sydney CBD as part of the network of rapid routes.

The Waverley Light Rail Report (AECOM, 2013) identified a light rail route via Bondi Road which incorporated:

- An alignment at the eastern end of Bondi Road between Denham Street and Campbell Parade which has a significant gradient (greater than 7%) that cannot be negotiated by conventional light rail vehicles
- 'Drive-over' light rail stops which require passengers to load and unload from the light rail vehicle across a self-managed traffic lane (i.e. no dedicated passenger platform)
- Absence of left and right turn lanes for general traffic along the alignment.

These three key light rail design considerations do not conform to TfNSW's design guidance for new light rail schemes and therefore have not been considered feasible in their current form.

A light rail network is also most likely to follow the existing bus corridor on Oxford Street however further detailed planning of the connections to the Sydney Light Rail network in the CBD would be required as there are currently limited access points available. Other key considerations such as the location of a depot would need to be considered.



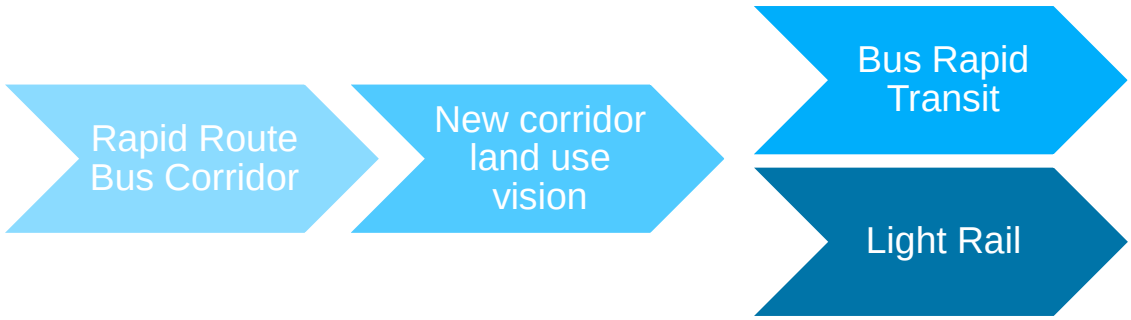
Source: Translink Canada (2011)

Figure E1.2 Car orientated (left) and transit orientated (right) density distribution

To successfully implement a segregated public transport operation within Bondi Road (BRT and LRT), there has to be an acknowledgement from the community that the corridor will need to be transformed. This is likely to involve the removal of on-street parking, restrictions to local access and limited property acquisitions to achieve the required road capacity, turning lanes and compliant stops at intersections. Currently the Bondi Road corridor is not wide enough to accommodate BRT and LRT when considering these constraints. The transformation of an enhanced public transport corridor is best achieved when the transport infrastructure is planned and delivered in close coordination with the desired urban renewal outcome. This has been the successful approach undertaken by state government for similar light rail projects in Central and South East Sydney, Newcastle and Parramatta.

The issue of new funding sources for large scale public transport infrastructure beyond the traditional constrained approach of government funding or Public Private Partnerships (PPPs) is currently under investigation by both federal and state governments. Waverley Council has also investigated sources at the local government level. As the initial rapid route bus plans are likely to be funded by the state government under Sydney's Bus Future, it is recommended that Council continue to closely monitor the outcomes of the federal and state government investigations. Any plans for development uplift in the corridor which would support the establishment of higher capacity public transport is likely to be in line with current approaches to funding mechanisms such as land value capture. Ultimately the choice of transport solution, and the funding and timing of the provision of the relevant infrastructure will need to be supported through coordinated transport and land use planning with the state government and the application of the business case process.

The strategy applicable to the Bondi Road corridor would best be represented by a transitional approach that responds to levels of demand supported by land use change through a staged implementation pathway as indicated below:



The key steps required to realise an improvement to public transport and associated urban renewal of the Bondi Road corridor include:

- Establish Transport for NSW's implementation timeline for the introduction of the rapid route bus corridor from North Bondi to the Sydney CBD as outlined in Sydney's Bus Future to ensure its current priority status reflects the current level of public transport congestion experienced. This short term measure will begin to address the existing public transport constraints within the corridor.
- Address chronic passenger congestion issues of the existing transport interchange at Bondi Junction. The transport interchange currently services around 80,000 bus and train passengers per day. Around 60,000 of passengers arrive or leave on foot (rather than transferring between bus/bus or bus/train). Bondi Junction currently contributes $1.1 million a year to the NSW State Parking Levy: since 2000 this has equated to around $20 million (indexed to CPI) which should be used to fund a major upgrade to the transport interchange.
- Coordination with state government for the implementation of Council's Waverley People, Movement and Places study which identifies the Bondi Road corridor as the primary public transport corridor in the local government area. This strategy will reinforce the local significance of the corridor into the local government planning framework.
- Collaborate with Transport for NSW to incorporate the requirement to upgrade public transport capacity on the Bondi Road corridor between Bondi Junction and Bondi Beach as part of the NSW Long Term Transport Master Plan 5 year Refresh in 2017.
- Coordinate with the state government regarding planning for the Western Sydney Rail Needs Scoping Study and planning for the Sydney Metro to explore the opportunities to extend rail links through the CBD from the west to Bondi Beach.

- Commence the formulation of a future urban design outcome and associated land use strategy for the Bondi Road corridor between Bondi Junction and Bondi Beach which would ultimately accommodate BRT or LRT in its street configuration. This strategy should also consider the mix of land uses and densities required to support these intermediate public transport modes.
- Coordinate and ultimately seek support from the Greater Sydney Commission (GSC) to improve the operation and urban form of this key public transport corridor within the Central District. The initial step in this key stakeholder engagement would be to raise awareness of the existing constraints to public transport operations in the corridor and incorporate the integrated transport and land use vision for the corridor into the initial District Plans being developed by GSC in coordination with local government and its community. This approach can also facilitate the required support from state government to pursue a City Deal with the Australian Government to assist in funding for the upgrade of this vital public transport corridor.

1 Introduction

1.1 Purpose of this report

Waverley Council has commissioned this study with the overall aim to demonstrate to State Government that there are growing capacity concerns associated with the movement of people along the Bondi Beach to Bondi Junction corridor via Bondi Road and develop key transport solutions.

Council is seeking answers to the following issues:

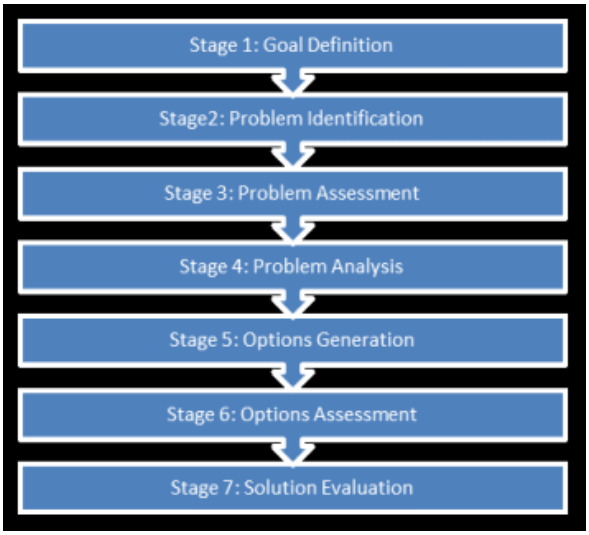
1. Identify the nature and extent of the transport problems
2. Compare a range of rapid mass transit options for the key transport corridor between Bondi Beach and Bondi Junction, which broadly takes into consideration the high level costs and benefits, i.e.:
   a) Preliminary pre-feasibility costs
   b) Key benefits such as improved liveability (which will be essential to garner community support); improved transport access and reliability; and better social, environmental and economic outcomes.
3. Demonstrate how the proposal connects to, and completes, the broader Sydney metropolitan transit network – including linking to the heavy rail network at Bondi Junction.
4. Broadly demonstrate how the capital works for the project would be funded, for example value capture along the transit corridor; sale or lease of assets; and what Council can do to ensure best outcomes.

1.2 Desired outcomes

Council is seeking to understand how it can reduce reliance on private car travel by increasing mode share of public transport (and walking and cycling). To achieve greater mode share of public transport there will need to be improved level of service through greater reliability, speed, convenience of access, and frequency of public transport.

1.3 Structure of the analysis

This report has been produced in a format that generally follows the guidelines for making submissions to Infrastructure Australia as set out in their document 'Better Infrastructure Decision-Making', August 2014. This will allow Council to consider the strength of its case for obtaining the funding and approvals required to support the transport outcomes identified in this strategy document.

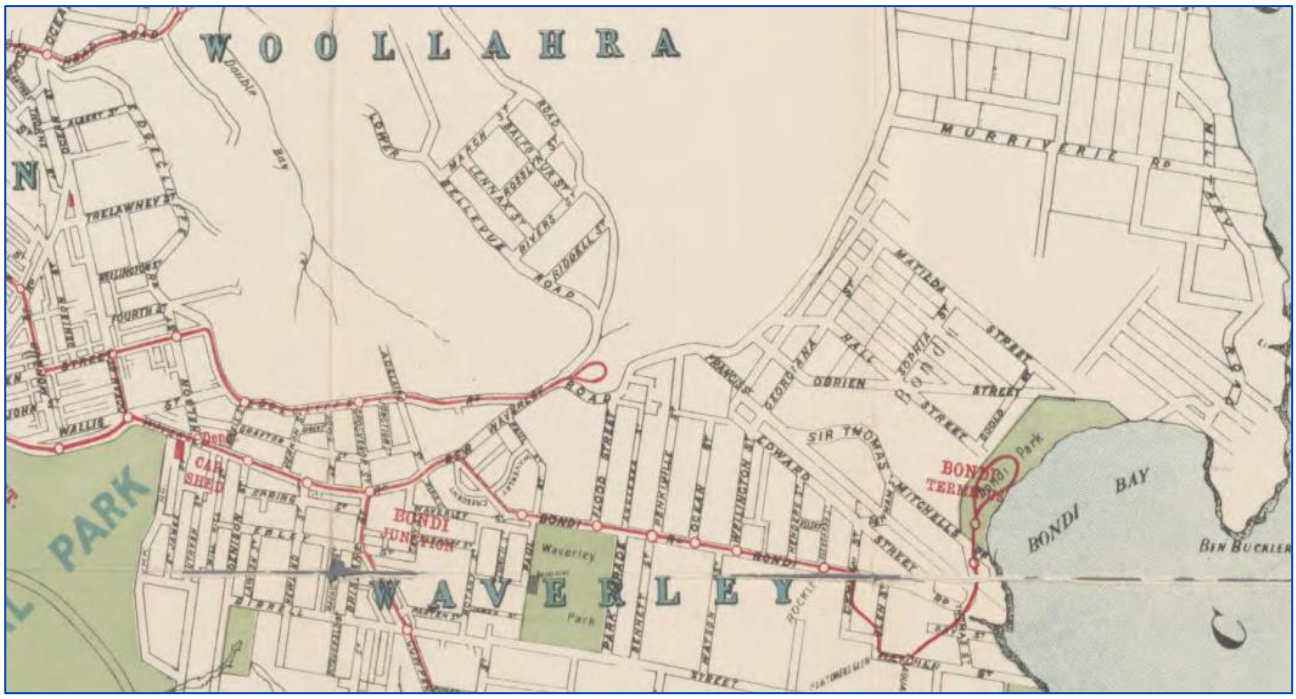


2 Background

2.1 History of the Bondi Road

Bondi Road began its life as a dirt track connecting the fledgling town of Sydney to the beach at Bondi. The road was affected by weather conditions and the first motor vehicles struggles with the resulting muddy conditions. The popularity of the seaside location and its proximity to Sydney made it a popular destination and holiday location which spurned a seaside village and amusement park.

Over one hundred years ago, a tram line was provided from the Bondi Aquarium terminus at Fletcher Street to a reversing loop at the southern end of Bondi Beach. The early rolling stock consisted of steam tram motors units hauling two passenger cars.



Source: National Library of Australia, Digital Collection, 2013

Figure 2.1 The former Waverley tram network 1907–1920

Electric tram services from the city to Bondi Beach began on October 19, 1902, and the access provided by the trams further fostered the development of the tourism orientated industry at Bondi Beach. The Bondi tram loop was removed as part of Waverley Council's Bondi Improvement Scheme in the 1920's and the trams rerouted along Campbell Parade to a new terminus at North Bondi. The terminus site is still used today as the bus terminus.

The tracks diverted off Bondi Road at Denham Street to avoid a steep gradient at the eastern end of Bondi Road, eventually passing under Bondi Road via Rowland Avenue and passing through a cutting to join Campbell Parade near Francis Street.

At Bondi Junction, the route followed Oxford Street, which was at that time a strip shopping centre, and then continued to the CBD, connecting to the CBD network at Elizabeth Street.

The tram depot and storage yard was located on the corner of Oxford Street and York Road, and the site is still used as a bus depot today. The trams were stored in a large building at the back along York Road which was serviced by 17 tracks. There was also a large substation at depot site to supply traction power to the network.

In 1914 another tram route was provided to the Bondi North terminus via Curlewis Street. This was an extension of the Bellevue Hill line which relieved congestion along Oxford Street.

The last Bondi tram to operate to Bondi Beach via Bondi Road occurred in 1960.

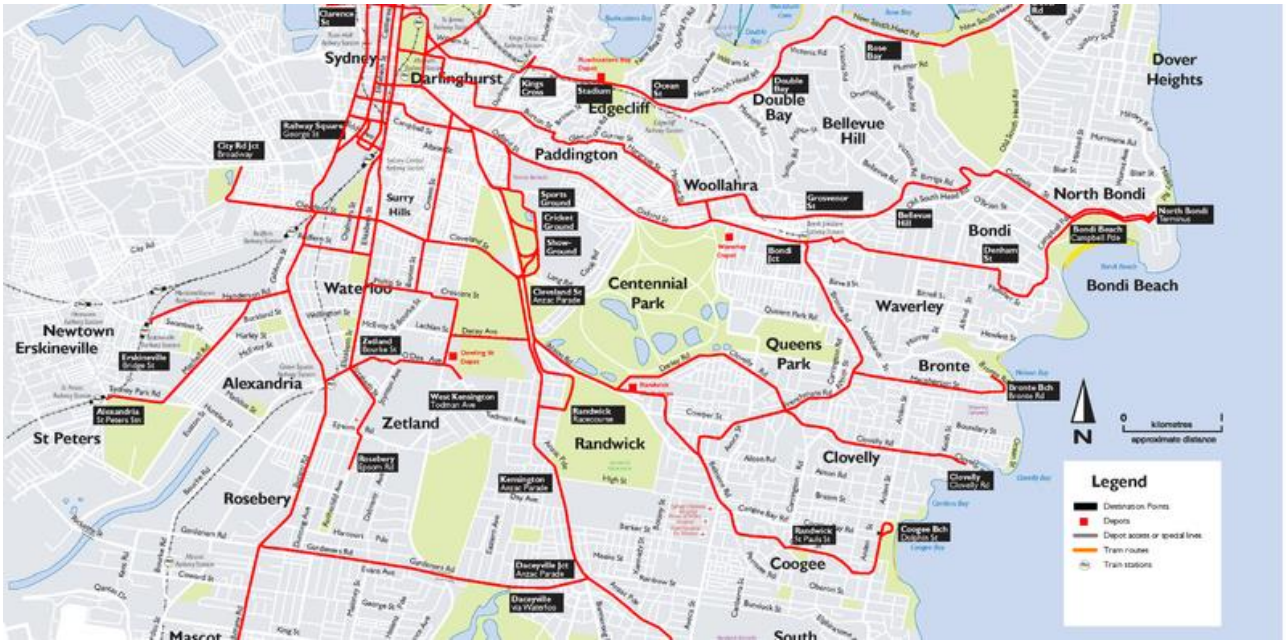


Figure 2.2 Eastern Sydney tram routes at maximum extent

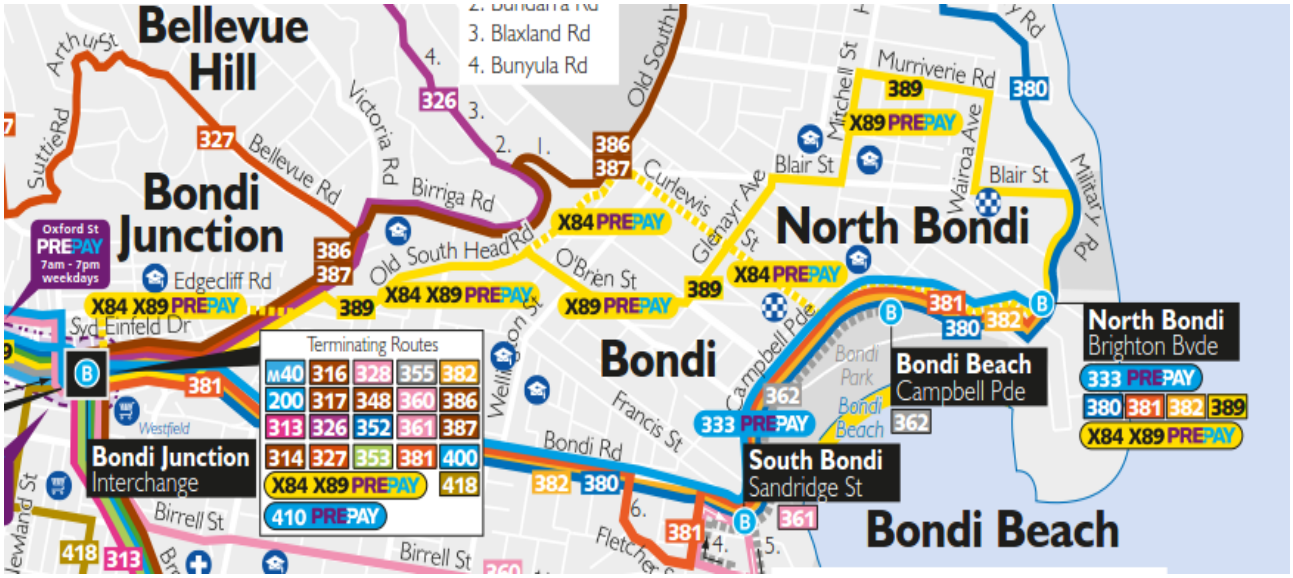
2.2 The transport corridor today

The Bondi Road corridor of today is representative of an inner urban street which began its life as an undeveloped connection from the evolving areas of Sydney to Bondi Beach and has intensified in its use, and its surrounding land use, in response to the growth of Sydney. The road corridor today serves a multitude of functions and often struggles under the diverse role that it plays.

The road corridor is about 20 m wide and accommodates two traffic lanes in each direction, and 3.5 m wide pedestrian zones on each side. There is limited use of nature strips and plantings with these restricted largely to residential precincts along the corridor.

Key observations about existing transport in the corridor include:

- *Traffic access to Bondi Junction and the Sydney CBD* – Bondi Road is the principal road connection between the Sydney CBD and Bondi Beach from Bondi Junction. It also serves to connect residents of Bondi area to the strategic centre located at Bondi Junction. Bondi Road is experiencing traffic congestion caused by peak period flows and special events held at Bondi Beach. However, the road also performs a local connectivity function with a significant number of local north–south journeys, and trips to Bondi Junction also using sections of the road. These increasingly put pressure on the corridor at times when the normal two traffic lanes are reduced to a single through lane due to parking during off-peak periods.
- *Public transport access to Bondi Junction and the CBD* – The corridor contains a number of bus services as indicated in Figure 2.3. Buses operate within the general traffic flow, generally sharing the kerbside lane with cars during peak periods when parking is restricted, and using the centre lane during off peak periods when car parking occupies the kerbside lanes. Bus stops provide a high level of access being spaced at around 150 m intervals through the commercial precincts (which represent most of the corridor) but can stretch out to nearly 400 m on other parts of the route. All buses call at the Bondi Junction Station interchange with Route 333 and 380 continuing along Oxford Road to the CBD.



Source: Sydney Buses (January 2016)

Figure 2.3 Bus routes serving the Bondi area

- Sustainable transport modes – There is no special provision along Bondi Road to promote cycling activities, with bicycle riders currently sharing general traffic lanes and negotiate the space between parked cars and the flowing traffic introducing risks associated with vehicle strike and 'car dooring'. From a pedestrian perspective the road corridor provides a significant barrier between activities on each side of the corridor, with the only crossing points located at signalised intersections which are few and far between. This encourages people to try to cross the road mid-block in an environment that does not support the safety of pedestrians.
- Emergency services – Bondi fire station is located in north Bondi and units from this brigade use portions of Bondi Road to access areas to the south. When support is required from other stations (such as Woollahra) then Bondi Road provides the most direct route to the Bondi area. The closest ambulance stations are located at Bondi North and Paddington with Bondi Road being an important access route to the major hospitals such as St Vincent's, Royal Prince Alfred, and also Prince of Wales Sydney Children's' Hospitals in Randwick.

2.3 Land use

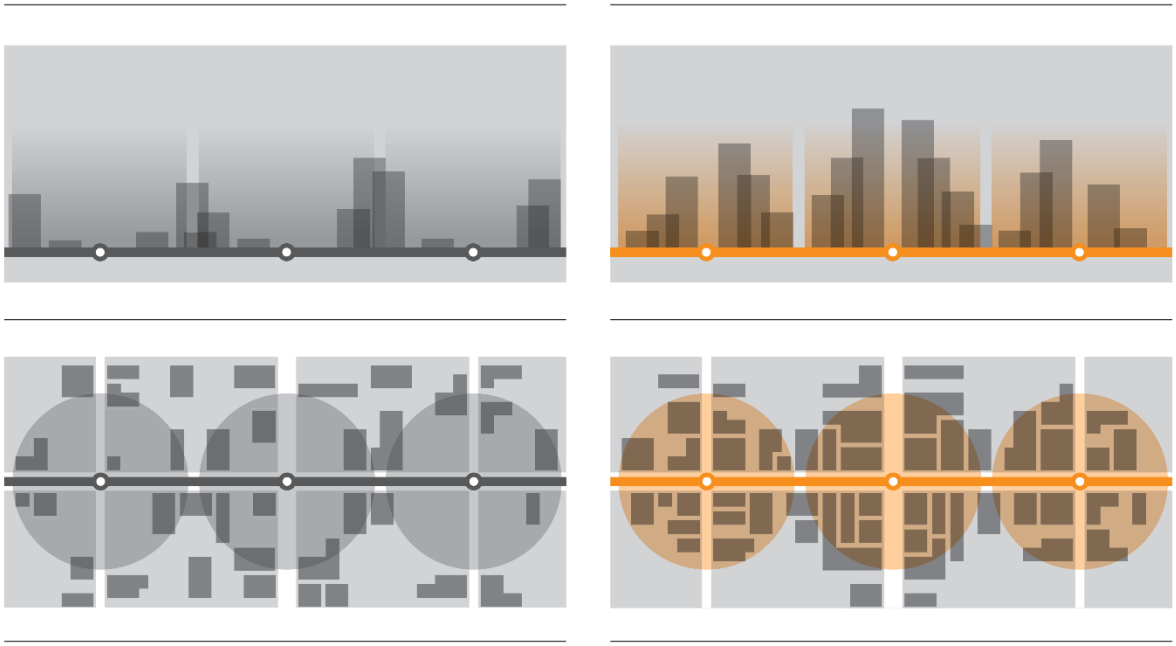
2.3.1 Context

The road is lined by a variety of land uses, the most dominant of which is retail/commercial activities linearly aligned in a manner consistent with strip shopping centres. Also residential uses are dominant within the corridor in the form of two and three story higher density residences, with some extending to 10 stories, as well as a small number of semi-detached.

Bondi Junction is composed of mostly high density, mixed land use with a significant volume of commercial, retail and residential development. This location has a relatively high number of car parking bays overall. The Bondi Junction area is part of the State Government Parking Levy (Category 2) and contributes $1.1 million per annum to this levy.

However, development control plans have limited the supply of additional car parking in both Bondi Junction and Bondi Beach in the recent past. Consequently there has been no increase in the number of vehicles per dwelling for the past 20 years in both of these locations (1986–2011 Census data).

Along the Bondi Road corridor there are pockets of both low/medium density (1–2 storeys) and high density (4–6 storeys). The current Local Environment Plan (LEP) does not allow for significant changes to this pattern. In order to substantiate an investment in mass transit style solutions for the corridor, there would need to be a significant increase in land use intensity over the length of the corridor, with a focus around the location of public transport stops/stations.



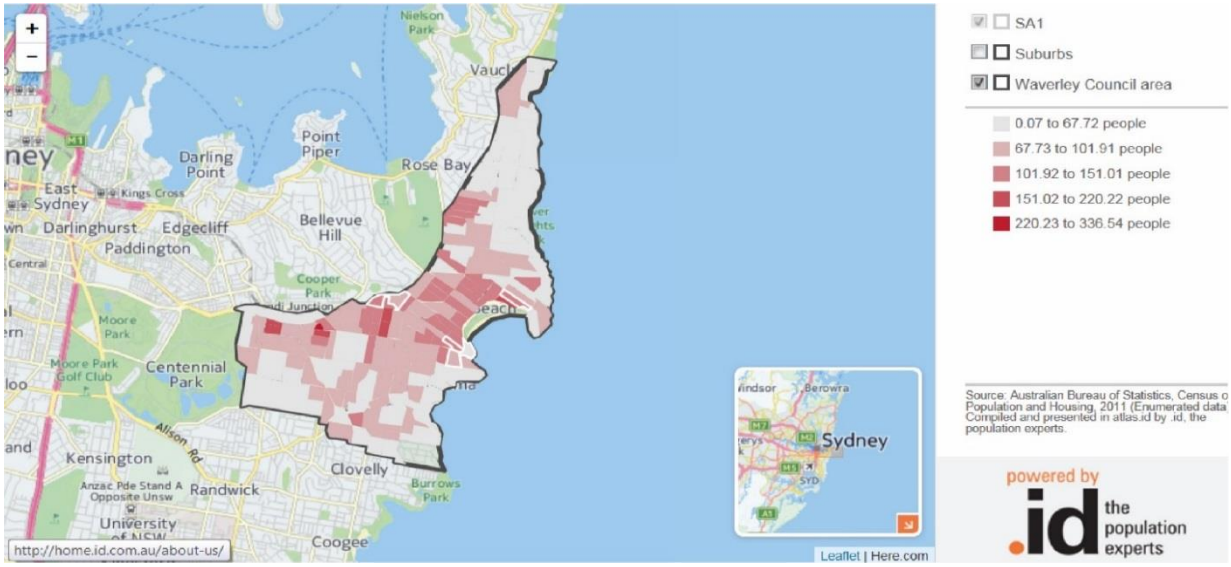
Source: Translink Canada (2011)

Figure 2.4 Car orientated (left) and transit orientated (right) density distribution

The Bondi Beach area is characterised by interwar walk-up residences, with some newer developments of higher density. With the recent changes to the NSW strata title legislation there may be opportunities for older residential strata units to redevelop.

2.3.2 Existing land use character

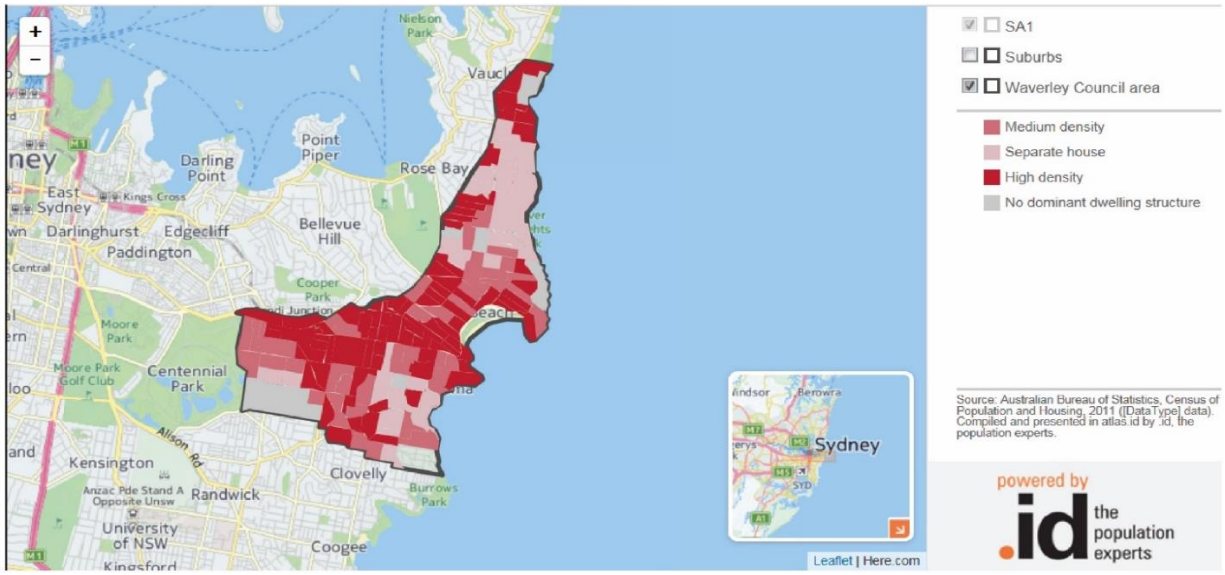
The Waverley LGA population stands at just under 73,000 according to ABS data (2015). 44,600 residents are employed and there are approximately 26,600 jobs in the LGA according to NIEIR data (2015). The highest population densities reflect the settlement pattern along the coastline and Old South Head Road and the concentrations around the Bondi beach 'town centre' and Bondi Junction strategic centre.



Source: Atlas id, 2016

Figure 2.5 Population Density in Waverley LGA

Housing Density across the LGA reflects the historical 'full lot footprint' development of much of the eastern suburbs in the 1960s and 70s, leaving a legacy of mid-scale townscape but high density apartment living. In recent years, a wave of new high rise development has occurred during the property boom, leaving towers across the skyline of Bondi Junction and the beachfront at Bondi. The Bondi Beach area has become increasingly urbanised as demand to access and live by the beach has increased in line with the rise in premium lifestyles and property prices.



Source: Atlas id, 2016

Figure 2.6 Housing Density in Waverley LGA

In terms of commercial development, the retail and entertainment strips around the Bondi Beach 'bowl' have now consolidated around Campbell Parade and Curlewis, O'Brien and Hall Streets which stretch inland. Much of the traditional 'high street' townscape remains intact although some contemporary mid to high rise development has been assembled, renewing the building stock within certain scale limitations.

Bondi Junction remains the substantial retail and commercial core of Waverley, largely contained between Ebley Street to the south and Syd Einfield Drive to the north, with strip development at commercial scales increasing along Bronte Road to the south-east. The limitations of Bondi Junction as an attractive urban centre are well documented, with the majority of activity contained within the extensive Westfield Shopping Centre and many poor quality, inactive, traffic dominant streetscapes. The local Council has attempted to address this through its Complete Streets policy.

Source: Google, 2016

Figure 2.7 Bondi Junction Centre

Bondi Road provides the direct east-west axis to the coastline from the Junction and is lined by a variety of land uses. Retail/commercial activity is the most dominant, with some 'shop-top' housing. The traditional terraced townscape form has survived along this corridor with substantial blocks of detached and semi-detached residential suburbs behind. Built form of two and three storeys is the dominant typology, with occasional apartment blocks extending up to ten stories in some areas.

Open space is at a premium and a valued community commodity in such a densely developed inner city district. Apart from the coveted coastline, any substantial parkland or sports fields that exist are strategic (or linked to schools and clubs), well protected and unlikely to be developed.

2.3.3 Future Land Use and Development

Regional Planning Strategy

The metropolitan strategy for Sydney – 'A Plan for Growing Sydney 2014' – identifies Bondi Junction as a strategic centre on the eastern edges of the Global Economic Corridor. The centre is acknowledged as an important gateway to Sydney's eastern beaches as well as an important transit and retail hub.

Bondi Beach and the adjacent coastline are identified as the third most popular tourist destination in Sydney and an important asset to the liveability of a global knowledge city. The strategy refers to a 'missing link' in

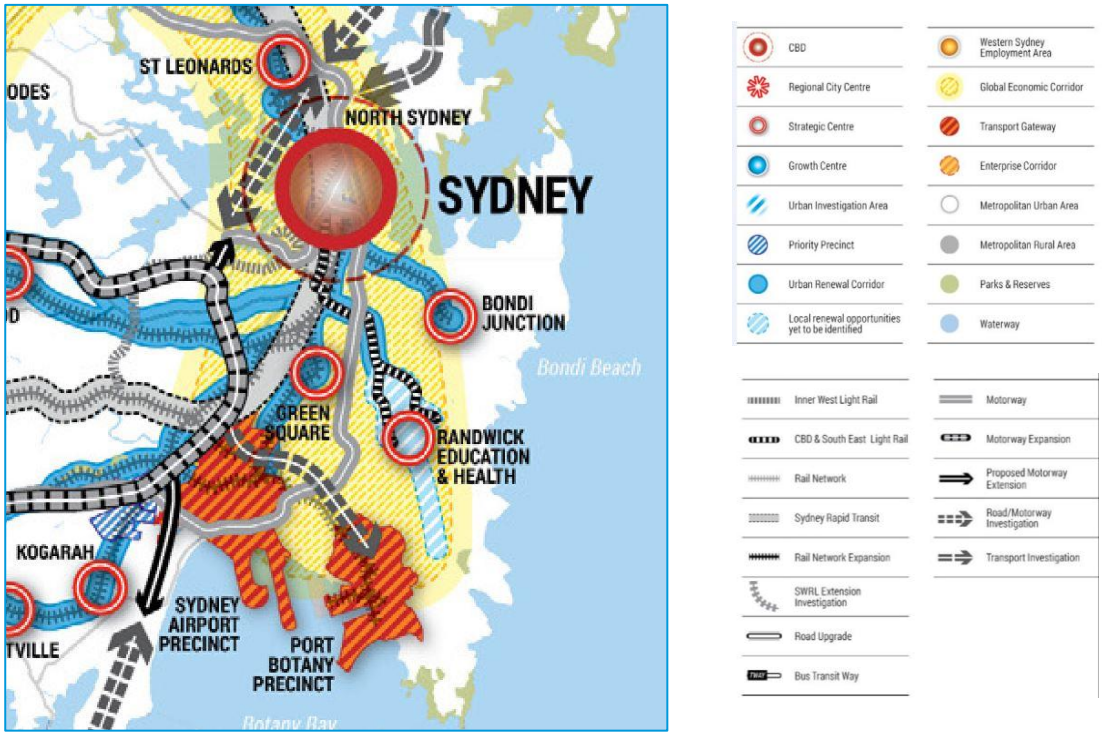
the overall vision for Bondi Beach and its relationship to the city. It refers to the need for a mass transport solution which can respond to the high transport demand between Bondi Junction and Bondi Beach, alleviate congestion and provide options for commuters.

The metropolitan strategy reflects that the Bondi area will not have significant growth within the life of the planning strategy (to 2036). It refers to the 'great potential' for urban renewal along the corridor between Bondi Junction and Bondi Beach, based around a new mass transit solution such as light rail. It points out that, to the west of Bondi Junction, the route back to Sydney CBD is identified as an urban renewal corridor owing to the Eastern Suburbs Railway Line and related opportunities for improving infrastructure and developing higher density housing.

The Metro Strategy has moved away from allocating housing requirements or targets to local Council areas and therefore, in terms of forecast growth, BTS data is a starting point. For the Waverley LGA, the prediction at 2036 is a population of 85,427, with 32,699 local jobs in the area (BTS). That's an increase of 17% and 22% respectively. These are notable increases over the next 20 years given that the land use planning strategy does not suggest a scale of growth. It raises questions about where this growth will be accommodated and in what forms.

The *Bondi Junction Floor Space Study* commissioned by Waverley Council forecasts significant growth in retail trade, health care and social assistance industries which highlights the continuing strategic role of Bondi Junction as an employment and social service destination. The State Government's *A Plan for Growing Sydney* identifies Bondi Junction as a Strategic Centre with two specific objectives: to retain a commercial core in Bondi Junction for long-term employment growth; and to provide capacity for additional mixed-use development including offices, retails, services and housing.

An ongoing issue for the Bondi area is that increased intensification of land use will place more pressure on Bondi Road, which is already congested, as the additional residents seek to commute to CBD based jobs. This would tend to suggest that any proposed future population growth should be supported by a similar number of local employment opportunities in a balanced strategic approach.



Source: 'A Plan for Growing Sydney', 2014

Figure 2.8 Metropolitan Strategy Key Diagram

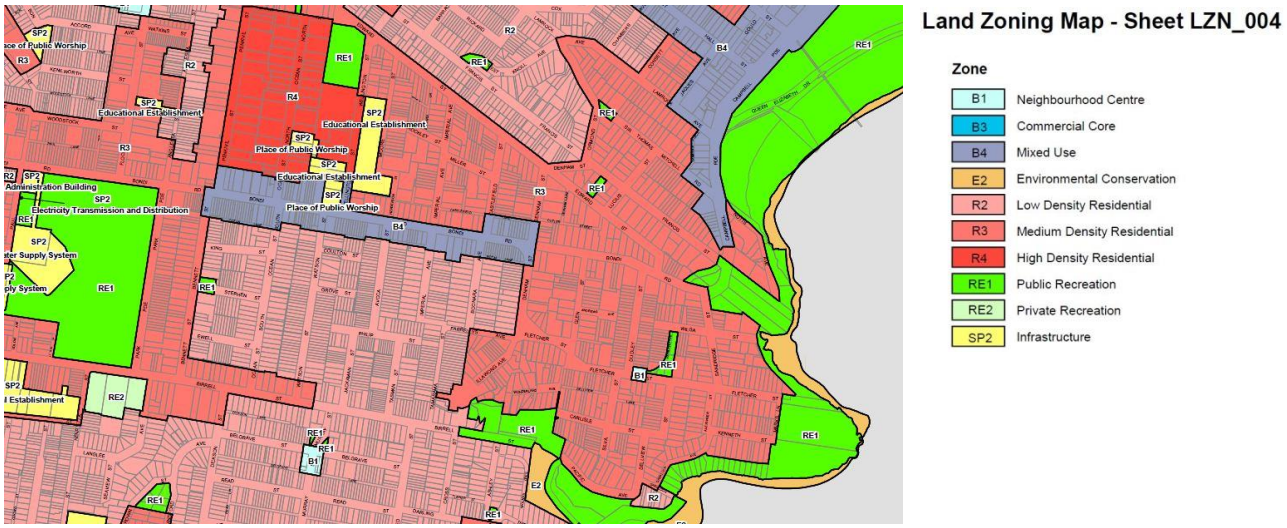
Recent changes to sub-regional planning will see a more significant role of the Greater Sydney Commission (GSC). The GSC will be responsible for metropolitan planning in a partnership between State and local government. The Commission will work closely with local councils and communities, helping Sydneysiders to get the most out of their neighbourhoods and suburbs. They will be responsible for the creation and implementation of key plans for Greater Sydney. The plans will be focussed on improving housing supply, business activity, jobs growth, and infrastructure planning. This presents Council with an opportunity to establish a new urban outcome for the corridor centred on the provision of high capacity street based public transport.

Local Planning Strategy

Bondi Junction remains the major sub-regional centre and growth pole for the eastern suburbs and the future development focus is oriented around this centre in the Waverley Local Environmental Plan (2012). The Junction's primary role as a Commercial Centre is highlighted to the extent that residential development should enhance rather than replace commercial space. Notwithstanding this, over 70% of 'Bondi Junction' suburb is zoned as Residential/B4 mixed use.

Outside of Bondi Junction, there are few areas where land use policy is seeking to intensify land use around existing nodes or centres. The preferred Bondi Road corridor is primarily zoned R2 Low Density Residential and R3 Medium Density Residential. There is a mid-section of Bondi Road bounded by Bennett Street and Denman Street that is zoned B4 Mixed Use. The objective of the zone is to integrate suitable business, office, residential, retail and other development in accessible locations to maximise public transport patronage. However, the 13 m Height of Building control and the 1:1–1.5:1 FSR control limit the potential for any significant urban renewal within this mixed use zone.

Other major land use zones include SP2 Infrastructure and RE1 Public Recreation.



Source: Waverley Council, 2012

Figure 2.9 Waverley LEP Land Use Zoning for Bondi Road Corridor

2.3.4 Potential land use uplift (via Mode)

The potential for land use intensification or Transit Oriented Development allied to different modes of mass transit is a topic of many research studies that have been commissioned around Australia and in overseas nations. There are many well established precedents for this type of investigation, including recent analysis of intensification around existing tram corridors (in Melbourne) and new/planned light rail lines (Gold Coast and Parramatta).

The relative potential for each mode to contribute to land use uplift along the Bondi Road corridor, and the perceived attractiveness of each mode, is limited to anecdotal experience and urban outcomes from other places and sources. A focussed piece of future research would provide a more evidence based evaluation.

LRT and BRT offer scope for broader activation along transit corridors due to their street based nature, although these modes can be segregated or grade separated. Aside from population and employment density within walkable catchment of the alignment, kerbside access and permeability of urban form are key to maximising land use uplift potential and stimulation of street activity.

Grade separated modes such as monorail and heavy rail have less continuous interaction with the city, relying on more strategic station locations and pop up sites where they can engage with neighbourhoods or urban centres. These larger scale transport modes can accommodate greater passenger capacities and frequency of services, including park-and-ride, that could not be achieved by surface based modes and they therefore offer the scope for high value economic activity and redevelopment at greater densities in strategically positioned sites along corridors.

Within the broader transit corridor from Bondi Junction to Bondi Beach and the prevailing urban form characteristics of the Waverley LGA, it is considered that there are three potential redevelopment areas offering the scope for redevelopment of any significant scale:

- Bondi Beach (opportunity site/block to be identified)
- Bondi Road Corridor
  - opportunity site/block to be identified
  - redevelopment of existing strata blocks due to change in strata title legislation
- Oxford Street bus depot, Bondi Junction.

Opportunities 1) and 2) may rely on amalgamation of properties to enable a sizeable development site to be assembled. The public sector can play a role in this, facilitating market intervention through land rezoning and acquisition in these areas.

Opportunity 1) would offer a suitable terminus location for all modes of transit whereas Opportunities 2), 3) and 4) are in less strategic locations on the network and from a patronage catchment point of view. Locations 2), 3) and 4) are better suited to surface based transport modes such as LRT and BRT.

Opportunity 4) is also highlighted on the basis that, with the introduction of a higher mode of transport such as light rail, the bus depot may be re-purposed in the future around re-orientation of the local bus network. It also assumes that, for the light rail option, the maintenance and stabling depot would be located outside of the Waverley Council boundaries.

Further investigations would be required to determine the scope for intensification in the ‘eastern suburbs’ sub-region around a future mass transit network comprising either new bus rapid transit, heavy/metro rail or light rail services. It is also advisable to place any further light rail investigations within the context of a long term integrated transport/land use for this sub-region that explores the economic, urban renewal and cross funding potential of optional rapid transit corridors between coastal communities and Sydney CBD.

2.3.5 Potential corridor land use uplift (via Policy settings)

The opportunity for land use intensification around a new mode of urban mass transit within the Waverley area will be influenced by market investment and property acquisition, although largely determined by local planning policies, rezoning and development control decision making.

Outside of Bondi Junction, there are currently no plans or policies to intensify land use around existing public transport nodes in the corridor area. However, as the Bondi Road corridor is the primary public transport corridor, it is appropriate to reconsider future land use along the corridor as a transit oriented development.

The existing corridor zonings do not currently allow capacity for 'higher value' use such as commercial or mixed use land use. Existing zoning is predominantly residential. There is limited opportunity for the commercial intensity of Bondi Junction and the so-called Global Economic Corridor to continue east to Bondi Beach under current zoning. Other constraints include fragmented ownership, small lot sizes and heritage present challenges for large scale renewal. The Bondi Road corridor itself remains fine grain in scale and lot size, a character that has been valued locally. Bondi Beach and the commercial/mixed-use streets of O'Brien/Hall/Roscoe/Curlewis are the more obvious places for future scale around a transit hub.

The opportunities to the west of the Waverley area have not been assessed as part of this study. There are a number of alternative strategic transit corridors between central Sydney and the eastern suburbs which, in the context of planned local government amalgamation, could be investigated in a future stage of work, including:

- Bondi Junction to Watsons Bay via Double Bay and Rose Bay
- Bondi Junction to Watsons Bay via Old South Head Road
- Bondi Junction to Coogee via Waverley
- Bondi Junction to Coogee via Randwick (including hospital & university)
- Bondi Junction to Sydney Airport.

In the new district and local planning context, there will be greater potential within the wider sub-region to explore the economic, urban renewal and cross funding potential of optional rapid transit corridors between the coastal communities and the CBD.

Figure 2.10 LGA Amalgamation in Eastern Suburbs

2.4 Relevant policy documents and previous reports

2.4.1 NSW Long Term Transport Master Plan – December 2012

The NSW Long Term Transport Master Plan sets the framework for the NSW Government to deliver an integrated, modern transport system based on the needs of customers.

The NSW Long Term Transport Master Plan plays two fundamental roles:

- Prioritise actions to support the State's economic and social performance
- Identify a planned and coordinated set of actions (reforms, service improvements and investments) to address the challenges.

The purpose of the plan is to identify and deliver:

- A fully integrated transport system
- A modern railway system
- A modern light rail system
- A modern bus system
- A connected motorway network in Sydney
- Unclogging the Sydney CBD
- Supporting the growth of new economic centres
- Connecting regional communities
- Improving freight efficiency and productivity
- Improve access to international gateways
- Boost walking and cycling and support its integration with public transport
- Preserve future transport corridors to ensure that as demand increases the transport networks can be expanded.

The plan is the overarching document to which the 'Sydney's Bus Future' and 'Sydney's Light Rail Future' documents respond. Both these documents are summarised in the following sections.

2.4.2 Sydney's Bus Future – December 2013

The strategy proposes simpler, faster, better bus services through a three-tiered network operations hierarchy with each level delivering a defined level of service consistency and reliability as follows:

- Rapid service routes form the backbone of the new bus network, offering fast, reliable bus travel for customers between major centres. Rapid routes provide customers with mass transit level services between centres which are not linked by trains or light rail.
- Suburban service routes and Local service routes build on this foundation to improve access to local, neighbourhood destinations.

The report purposes a staged approach be taken to introducing BRT on targeted rapid service routes. In the long term, it may be possible to convert rapid routes to light rail in areas with high growth and density. Key high growth corridors proposed to be investigated included:

- Parramatta Road
- Victoria Road
- Anzac Parade between Kingsford and Maroubra or Malabar
- Northern Beaches
- Proposed Western Sydney Light Rail Network.

A total of 13 Rapid bus routes were identified in Sydney's bus future which included North Bondi to CBD. The key actions identified included:

- Short term action to extend bus operating hours and speed up services through wider stop spacing
- Implement bus priority infrastructure along the corridor
- High capacity vehicles
- High quality interchanges with consistent wayfinding and signage
- Address bus pinch points with bus priority treatments on:
  - Campbell Parade (in conjunction with Waverley Council)
  - Bondi Road
  - Oxford Street through Bondi Junction, Paddington and Darlinghurst to the CBD.

The longer term actions included:

- Investigation of Bus Rapid Transit
- Interchange enhancements at Bondi Junction.

It proposes that the challenge of improving the bus network be addressed through the following steps:

- Improve bus customers' experience
- Integrate bus services across Sydney
- Serve future growth through:
  - Implement bus lanes and additional infrastructure based priority measures on key corridors
  - Continue to review bus services as travel patterns evolve and as demand levels shift
  - Closely monitor service requirements of key centres where customers live and work
  - Continue to improve access into and between major centres, in line with high population growth and demand
  - Undertake infrastructure improvements, and investigate BRT services, for the Northern Beaches
  - Investigate BRT and long term light rail for high growth corridors, including Parramatta Road (in association with WestConnex), Victoria Road and other established high demand corridors.

2.4.3 Sydney's Light Rail Future – December 2012

The report identifies four key challenges for the public transport network into the future:

- Catering to a growing city
- Supporting urban renewal
- Promoting global competitiveness
- Unlocking capacity in Sydney's CBD.

It proposes that these challenges be addressed through the following stepped process:

- Service integration and improvements
- Modernising and extending the existing network
- Delivering a new CBD and south east light rail service
- Undertaking longer term investigations including:
  - Feasibility investigations of light rail or other high capacity public transport, like Bus Rapid Transit, for additional corridors including Victoria Road, Parramatta Road, Anzac Parade to Maroubra and potentially Western Sydney
  - Continued support to councils investigating potential light rail schemes
  - Growing the light rail network in line with demand and integrated with new urban development
  - Investigating potential extensions to the line such as to Malabar, Walsh Bay and Barangaroo North.

The report proposes two key light rail projects as the cornerstone of the Sydney light rail strategy:

- Inner West Light Rail Extension
- CBD and South East Light Rail (CSELR).

It is the latter of these two projects that has the most relevance to the Bondi situation. It proposes a new light rail line extending from Circular Quay through George Street to Central Station and to the University of NSW at Randwick via Anzac Parade and Alison Road. The route from the CBD to Randwick, currently under construction, has the following characteristics:

- Six kilometre route along a dedicated corridor
- Twenty minute journey time
- Seven stops between Central and Randwick, serving the Prince of Wales Hospital, University of NSW at Wansey Road, Randwick Racecourse and Moore Park
- Potential to join two vehicles together for special events at Moore Park – doubling capacity to move up to 18,000 commuters each hour in each direction
- Bus interchange at Randwick
- 'Turn up and go' services frequencies.

A key feature of the plan is the opportunity to rationalise bus services to create simpler, faster and better bus services with:

- More services on fewer routes to ensure buses are full when they enter the CBD
- More cross-city Metro-style bus routes, avoiding the city centre
- More buses on fewer streets with higher bus priority levels
- Seamless transfers between high-frequency, reliable buses, light rail and rail services.

2.4.4 Waverley Light Rail Report – 2013

In 2013 Council commissioned a pre-feasibility study to determine whether Light Rail is appropriate to serve the travel task between Bondi Junction Town Centre and Bondi Beach. The purpose of the study was to:

- Assist council with the definition of a preferred route for Light Rail
- Determine the issues and opportunities associated with the preferred route
- Develop visualisation tools to help Council illustrate the vision for Light Rail and to support submissions for funding for the reintroduction of Light Rail into Waverley.

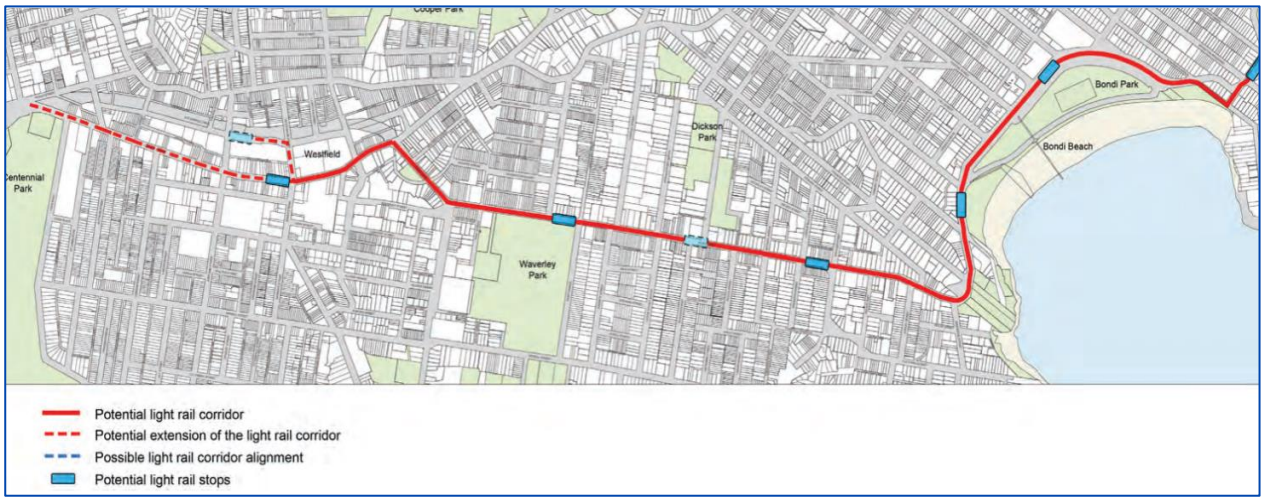
Three routes were identified for investigation as follows:

- *Option 1:* Bondi Junction to Bondi Beach via Old South Head Road, Birriga Road and Curlewis Street
- *Option 2:* Bondi Junction to Bondi Beach via Bondi Road
- *Option 3*: Bondi Junction to Bondi Beach via Council Street, Birrell Street and Watson Street.

Source: AECOM

Figure 2.11 Waverley Light Rail Pre-feasibility Report route options

Following analysis, and a qualitative multi-criteria assessment of the options, Option 2 along Bondi Road was chosen as the preferred route. It was determined that this would be the fastest, most direct and legible route between the two centres, while also providing the most opportunity for urban renewal along the existing commercial precinct along Bondi Road. The following diagram represents the option identified as the preferred route and the suggested location of stops.

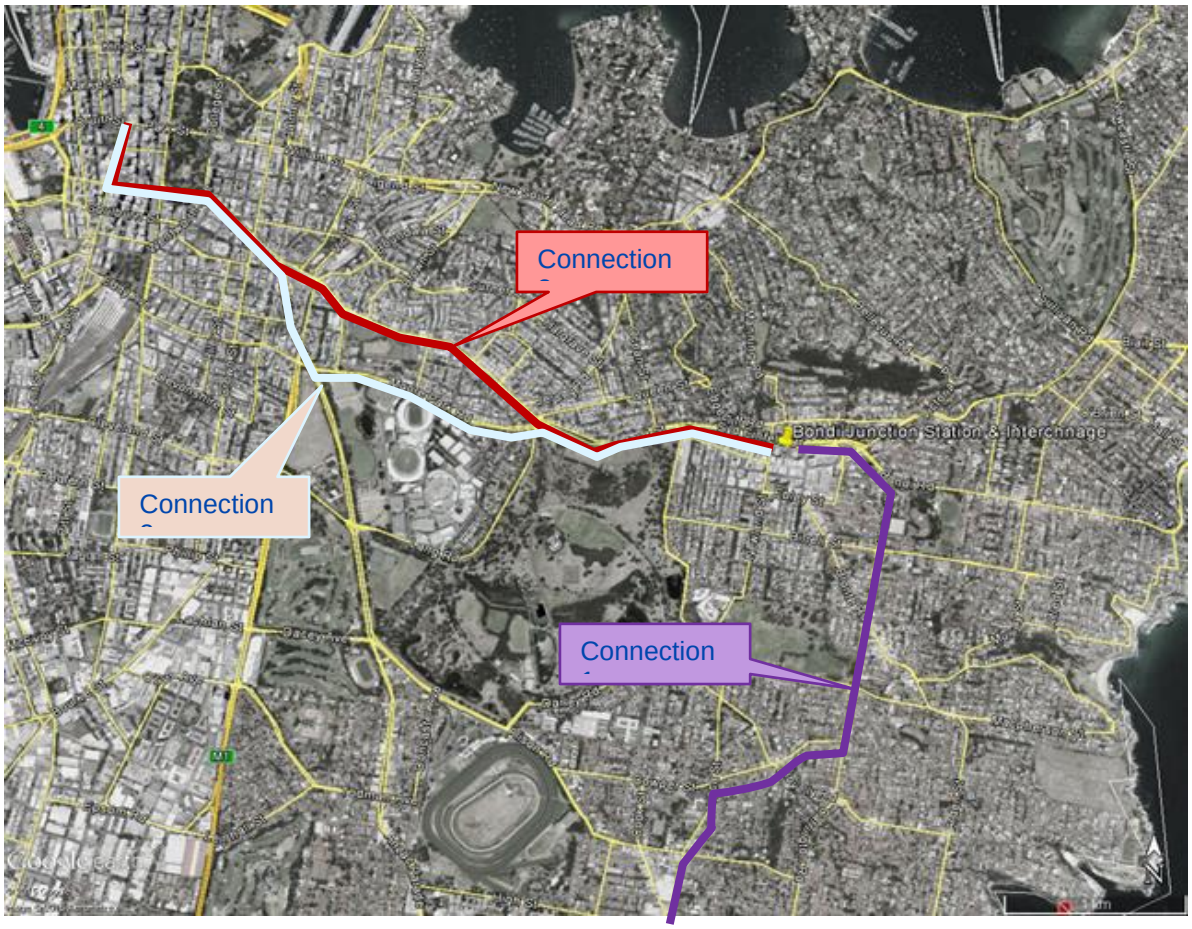


Source: AECOM 2013

Figure 2.12 Identified preferred route

The study also considered future connections to the wider Sydney Light Rail network and access to the Sydney CBD as follow:

- *Connection 1:* CBD via Randwick
- *Connection 2:* CBD via Moore Park Road
- *Connection 3:* CBD via Oxford Street.



Source: WSP | Parsons Brinckerhoff reconstructed from AECOM

Figure 2.13 Wider network connection options

The Randwick route was dismissed on the basis that it did not take people directly to the CBD and, although it does service the University of NSW (UNSW) a review of student enrolment data indicated that the route did not align well with the location of the majority of residential addresses and therefore would have a poor take up of ridership. The report does not determine the preferred route between Connection 1 and 2, instead recommending that further investigations need be undertaken.

3 Goal definition

Infrastructure Australia states that a goal-orientated approach aids in shifting decision-makers' focus towards the achievement of outcomes which can be delivered through a range of mechanisms, and away from decision making that is too readily directed towards investment oriented solutions. Goals can generally be categorised into economic, social and economic categories.

It is important to capture clear goal statements at the beginning of the project so the relevancy of options can be assured and to aid in the assessment of potential solutions.

Waverley Council has developed a range of goals for the development of its community through the production of strategic plans and the management of desirable land use outcomes. The table below has been developed in consultation with Council and reflects those goals most relevant to addressing the access and mobility needs of the population.

Table 3.1 Waverley public transport goals

Ref no.	Title	Description
Economic Goals		
1	Productivity	Improve the economic outcomes for Waverley and surround areas by promoting efficient transport of people and goods.
2	Congestion	Reduce the unproductive time that people and freight spends stuck in traffic by diverting trips to higher capacity public transport modes.
3	Growth	Encourage intensification of land uses around public transport nodes allowing the more efficient support of residential and commercial outcomes.
Social Goals		
4	Accessibility	Provide improved access to employment and recreational destinations within Waverley, particularly the Bondi Beach area through the use of public transport.
5	Mobility	Provide improved options for residents to move around the city to access shopping, health services, recreation and social activities.
6	Health	Reduce health issues resulting from increasing traffic operations. Promote more active forms of transport.
7	Equity	Improve social equity by providing low cost, efficient, and accessible public transport.
Environmental Goals		
8	Sustainability	Deliver more sustainable forms of transport to encourage people to move away from carbon based fuel use and as a result reduce greenhouse gas emissions.

4 Problem identification

Problems prevent (or are likely to prevent) the achievement of the identified goals. Although Infrastructure Australia uses the word 'problem', it is important to recognise that problem statements are to be expressed in a positive sense so as to provide a challenge against which potential solutions can be assessed.

Problems need to be identified before the causes and effects of these problems can be analysed. This requires the gathering of meaningful observations and supporting the statement with facts and figure that support the recognition of the problem. It is important not only consider existing problems but also potential future problems because often the infrastructure solutions employed to address those problems have a long operational life. Impacts from future changes in land use, or changes in people's travel patterns are just important as hard data such as traffic counts, public transport patronage volumes and journey times.

Table 4.1 Waverley public transport challenges (in no particular order)

Ref no.	Title	Description
A	Mode share	Reduce reliance on motor vehicles and encourage the use of public transport.
B	Travel demand	Cater for the growing travel needs of the local population and those visiting Bondi, particularly during the summer period and for special events.
C	Travel time	Reduce the traffic congestion experienced on Bondi Road and provide improved travel times to the CBD during peak travel periods.
D	Travel time reliability	Deliver more predictable and consistent travel times.
E	Network connectivity	Better connect Bondi to the fixed infrastructure public transport network to provide improved access to more travel destinations.
F	Technical Feasibility	Provide traffic management and infrastructure construction solutions that enhance the role of Bondi Road.
G	Public opinion	Demonstrate the advantages of mass rapid transit, as part of a holistic solution for the reallocation of road space. Find acceptable solutions to any impacts on local interests and property owners along the proposed route.
H	Liveability	Reduce the undesirable impacts on land uses adjacent to road corridors from noise, vibration and pollution and improve amenity of public spaces.
I	Sustainability	Increase the use of more sustainable transport modes such as public transport, walking and cycling.
J	Safety	Does not adversely impact the safety of all road space users, and preferably demonstrates a net improvement.
K	Land use outcomes	Unlock the potential to selectively intensify land uses to realise economic growth.
L	Value for Money	Justifiable economic return on investment.

5 Problem analysis

5.1 Sources and quality of available data

5.1.1 Public transport trips in the Bondi Road Corridor

Public transport trip data for the Bondi Road Corridor has been extracted from a 17 November 2015 sample of Opal data. The use of November 2015 data does present some issues for the analysis because it represents an early period in the implementation of the Opal Card with a number of travellers still using paper tickets for which it is not possible to identify trip origin or destination. Data for subsequent months would have been affected by the Christmas holiday period and therefore difficult to also interpret reliably.

Opal data used throughout this analysis has been adjusted as follows:

- The total number of trips *to* Bondi over the observed period has been scaled up to be equal to the number of trips *from* Bondi in order to account for people not 'tapping off'.
- Includes trips which start or end along Bondi Road and Campbell Parade, including trips on X84 services from the Campbell Parade terminus which do not travel on Bondi Road, as these trips would be expected to shift to the Bondi Road corridor if a high quality public transport corridor were implemented.
- Data has not been adjusted to account for non-opal PT trips or fare evasion.

Also note the below issues with interpreting the data:

- With the exception of at Bondi Junction, this data does not account for transfers. For example, where a trip includes a transfer from bus to rail at the CBD, the origin will be taken as the CBD. This is a limitation with the current Opal data.
- Transfers have been analysed at Bondi Junction, however a large amount of trips are still observed terminating at Bondi Junction. It is considered that transfers at Bondi Junction have not been adequately accounted for, and that a larger number of transfers likely occurs.

5.1.2 Motorised transport trips in the Bondi Road Corridor

Traffic data has been extracted from SCATS detected volumes along Bondi Road for Tuesday 17 November 2015. The date was chosen on the basis of being a typical weekday, and to align with the PT data so that total corridor movements could be assessed. Some minor inconsistencies were observed in the data for some locations, but overall the data provide a reasonable representation of vehicle movements along the corridor. It is important to note that SCATS counts the number of cars, not people as with Opal. A general rule of thumb of 1.2 people per car would be appropriate, but this has not been confirmed for specific trips on Bondi Road.

5.1.3 Wider transport demand origin/destination assessment

Strategic travel demand over the wider Sydney area has been assessed using the Sydney Strategic Travel Model (STM). The base year assessment was performed using 2016 data and future year projections were made at 5 year intervals out until 2036.

STM datasets have been aggregated into larger areas to aid analysis. These broad areas are used throughout the following analysis, and are shown in Figure 5.1.

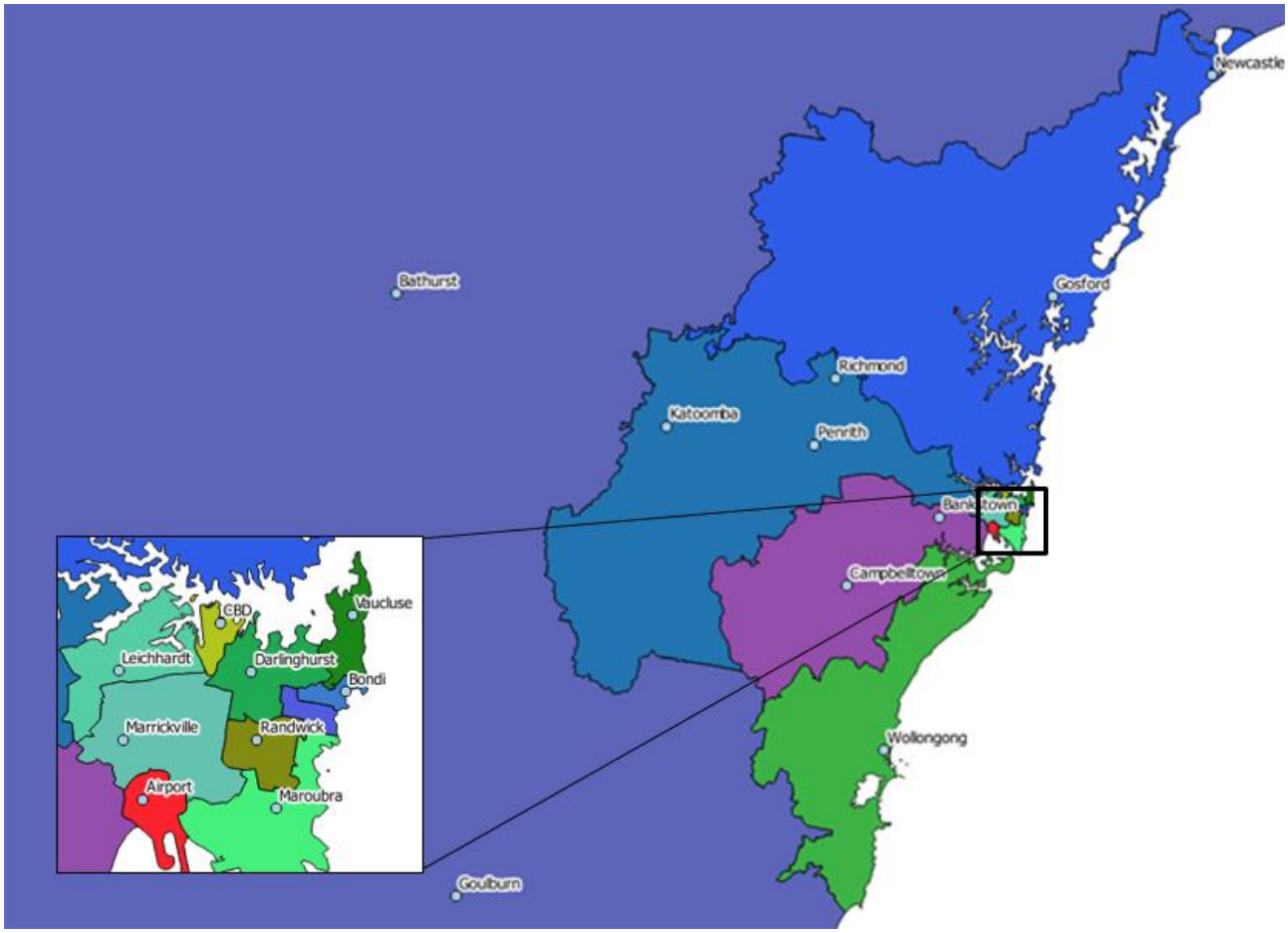


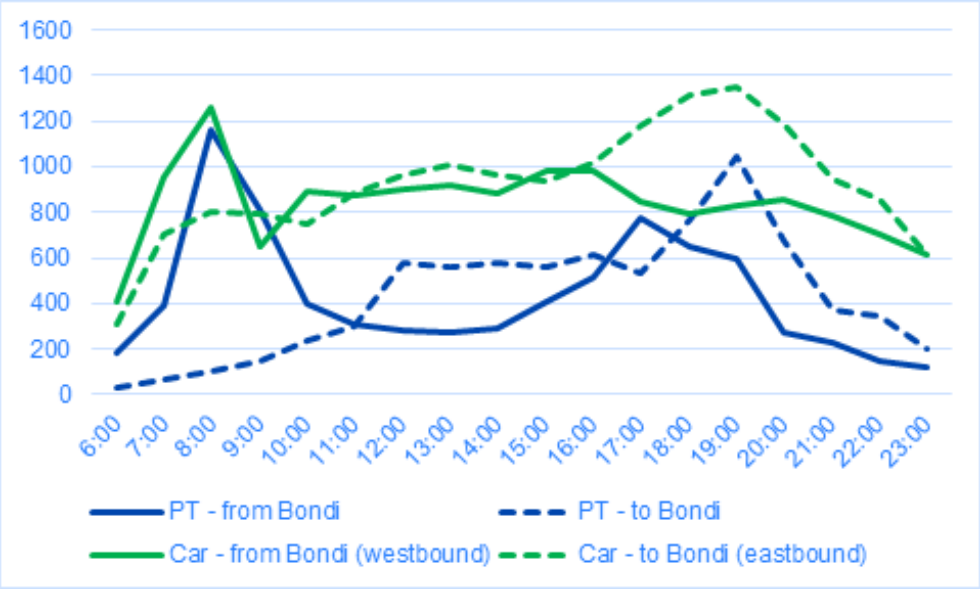
Figure 5.1 Travel zones definitions

5.2 Mode choice along the Bondi Road Corridor

Figure 5.2 and Figure 5.3 have been developed based on observations of flows on Bondi Road. Opal trips to and from the area have been used to determine the level of Public Transport on the corridor, with vehicle volumes based on vehicles detected at intersections. This methodology is further outlined in Section 5.1

Figure 5.2 shows public transport (PT) and car trips made along the Bondi Road corridor on an average weekday. Strong demand is observed for both modes across in the morning and evening peak periods, with a westbound morning peak from 7.00–8.00 am accommodating 2,500 people per hour, and a more dispersed eastbound travel behaviour with an afternoon peak occurring at 6.00–7.00 pm. A smaller counter peak movement is also present in public transport movements from 4.00–7.00 pm.

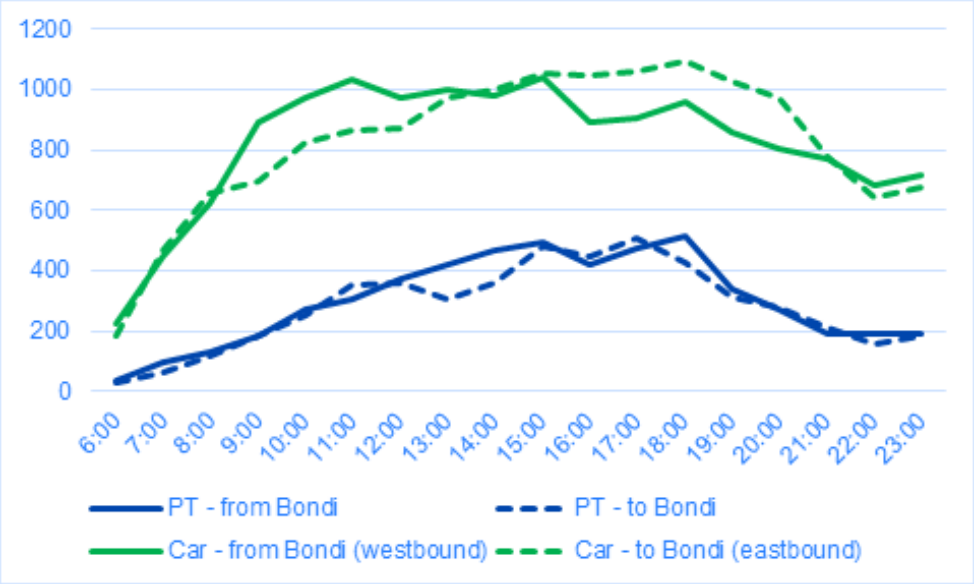
Public transport plays a significant role in providing mobility within the corridor, with roughly equal levels of car and public transport weekday trips in the peak direction during the peak hours, and a relatively high modal share for public transport at other times. Between and outside the peaks, however, car is by far the preferred mode of travel in the corridor.



Source: Adjusted Opal trip data, Tuesday 17 November 2015 and Observed SCATS data at Flood Street, 17–19 November adjusted for 1.2 people per car

Figure 5.2 Passenger trips on Bondi Corridor by time of day – weekday

Figure 5.3 shows trips made along the corridor on a weekend. While the modal share of public transport remains high, public transport plays a decreased role in providing for travel on weekends with car being the preferred mode of transport. Car travel is relatively flat from 8.00 am to 9.00 pm, with public transport use steadily increasing from 5.00 am to 3.00 pm, and decreasing after 6.00 pm. Trips on the weekend both to and from the corridor are broadly equal in each direction throughout the day.



Source: Adjusted Opal trip data, Saturday 21 November 2015 and Observed SCATS data at Flood Street, Saturday 21 November 2015 adjusted for 1.2 people per car

Figure 5.3 Passenger trips on Bondi Corridor by time of day – weekend

5.3 Traffic conditions along the Bondi Road corridor

Figure 5.4, Figure 5.5 and Figure 5.6 show the traffic volume profile along Bondi Road during the peak travel periods. It can be seen that traffic is highest at the western end of Bondi Road, with a smaller number of vehicles observed towards the Campbell Parade end.

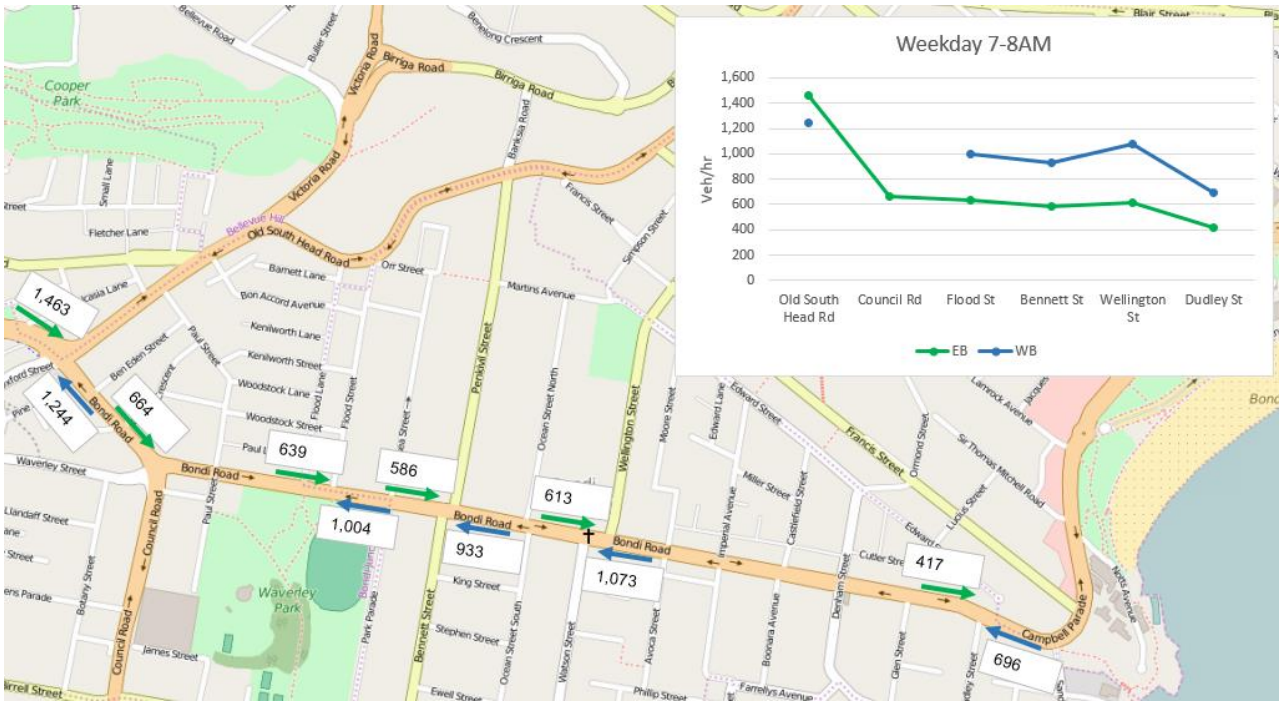


Figure 5.4 Weekday AM peak car volumes on Bondi Road

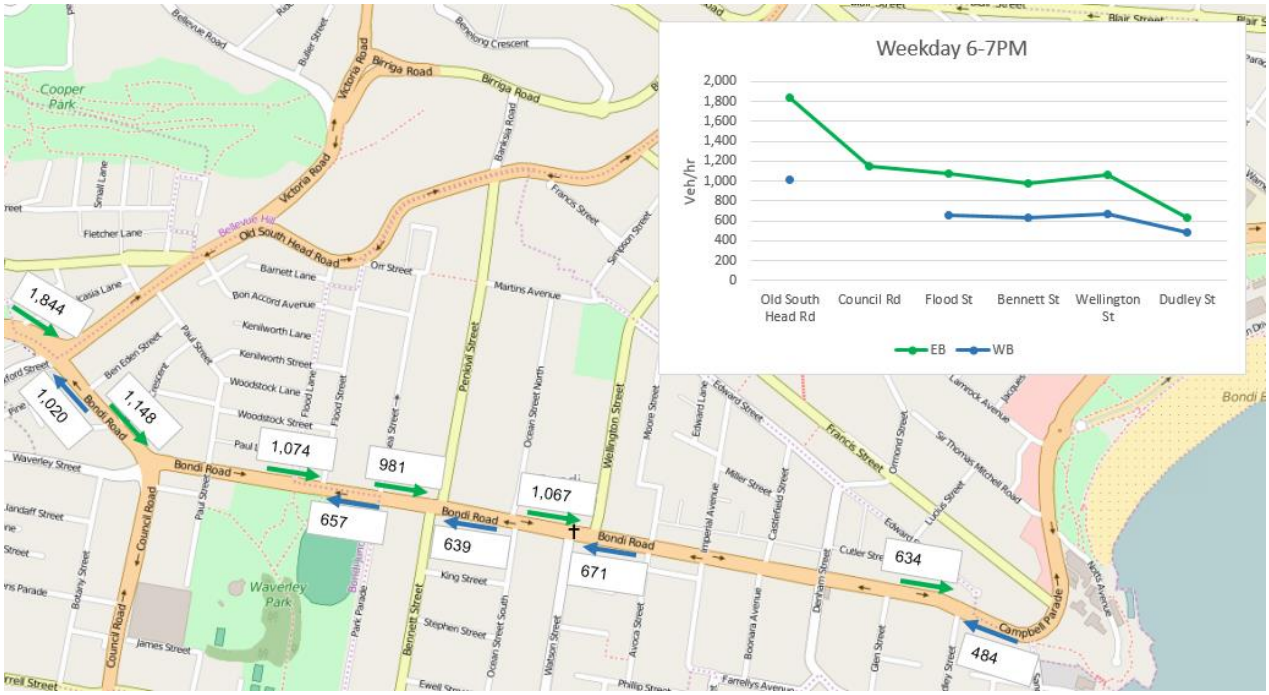


Figure 5.5 Weekday PM peak car volumes on Bondi Road

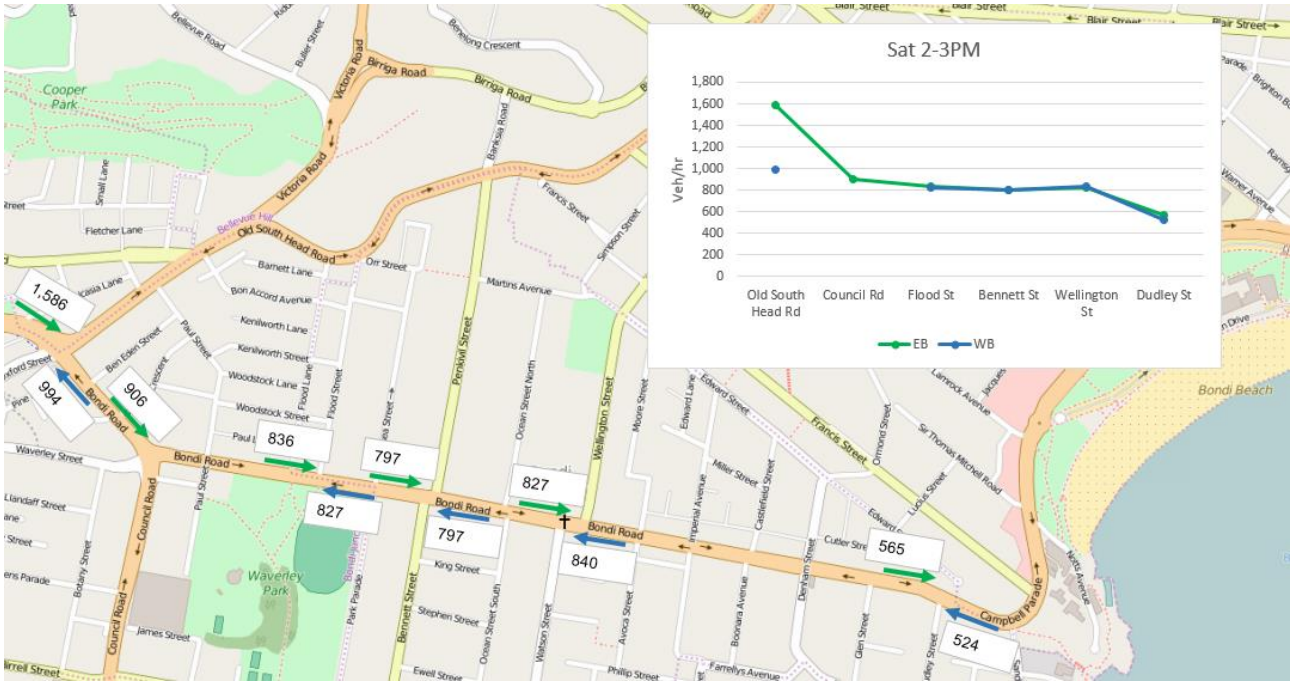


Figure 5.6 Weekend peak car volumes on Bondi Road (2.00–3.00 pm)

5.4 Capacity of the T4 Eastern Suburbs line

The T4 Eastern Suburbs rail line links Bondi Junction to the Sydney CBD and provides rail connections to the wider Sydney area. People travelling along Bondi Road from the east have the option to transfer to the train at Bondi Junction to access these alternative destination options, or as an alternative to continuing their journey on Bondi Road to a similar destination.

Table 5.1 shows that the T4 Eastern Suburbs Line sees the average train loadings of 62% and 46% during the AM and PM respectively. These values are the lowest observed across the network for major lines, and indicate that train network has ample capacity to provide for more trips.

Table 5.1 Average seated load factor of suburban trains during peak periods

	AM peak direction	PM peak direction
T4 Eastern Suburbs	62%	46%
Network Average	116%	93%
Network Range	62%-138%	46%-116%

Source: *BTS Train Peak Loads, May 2015*
Notes A train loading of 100% indicates that the number of people on the train is equal to the number of seats

From 1 September 2016 changes to Opal fares will remove the existing fare penalty that applies to change transport mode from bus to train and vice versa. Currently it is $2 cheaper for passengers travelling by bus through Bondi Junction to continue their journey by bus rather than transfer to the train.

The new Opal fare structure will remove this transfer penalty, making it the same price to travel from Bondi Beach to the CBD by bus and train, compared to taking the whole journey by bus only. Given the significant travel time savings (around 15 minutes depending on traffic), it is anticipated that more passengers will transfer to the train in order to travel between Bondi Junction and the CBD.

However, there is still a time and inconvenience penalty for passengers to transfer at Bondi Junction interchange. A major upgrade to the Bondi Junction interchange should seek to reduce these costs to passengers.

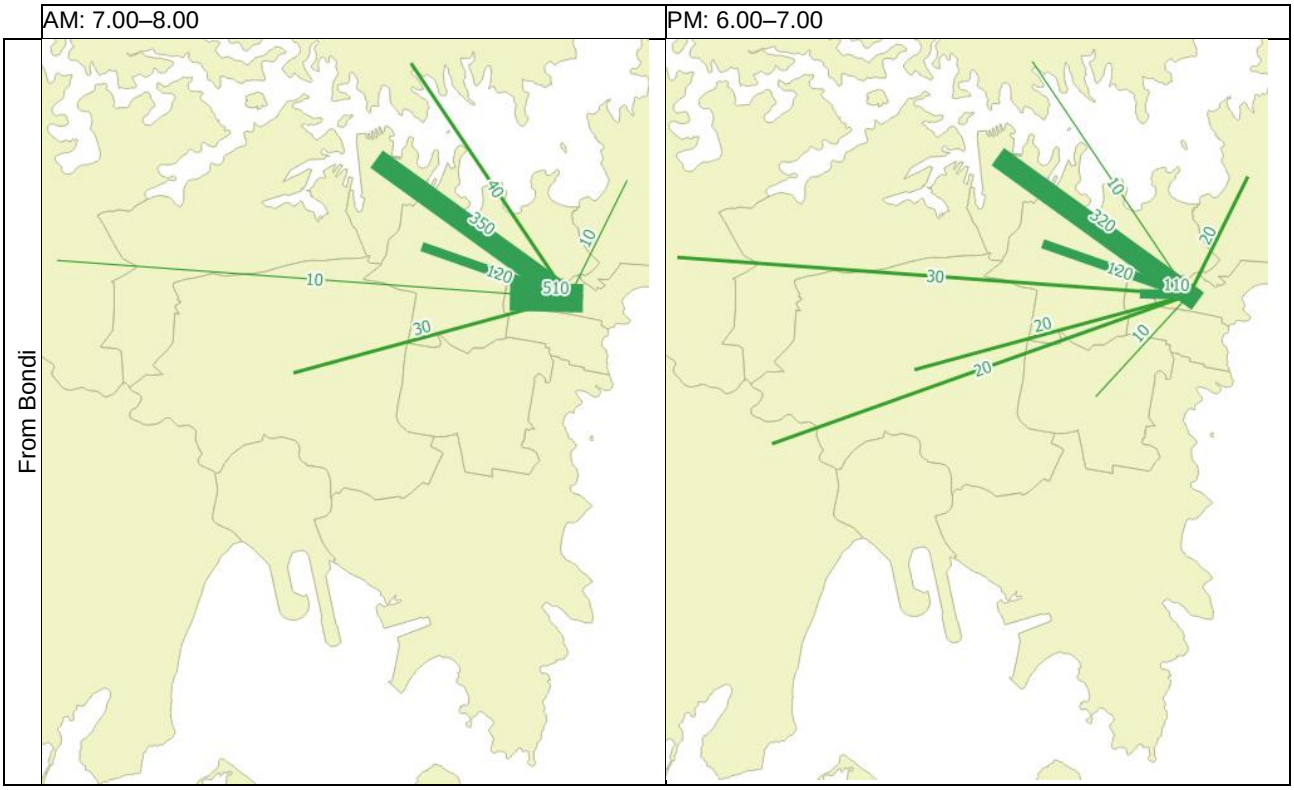
The T4 Eastern Suburbs rail line should be considered as an opportunity for any Bondi transit system, which will be able to meet the demand for trips to the city via an interchange with the rail line at Bondi Junction. The decision as to whether passengers are prepared to make the transfer will be dependent on the interchange time penalty, the inconvenience of making the change of modes, and their ultimate destination.

5.5 Strategic travel demand between Bondi and wider Sydney area

Figure 5.7 and Figure 5.8 visualise public transport trips to and from the Bondi Road corridor in the morning and afternoon peak hours (passengers per hour per day). They show that the majority of trips to and from Bondi are on the corridor between Bondi Junction and the CBD.

Trips from Bondi in the morning are almost entirely towards the city (with 980 trips observed to Bondi Junction, Darlinghurst and the CBD). This is matched in the afternoon, which sees 920 trips to Bondi from these areas, however the afternoon also sees a large number of trips departing the Bondi corridor. Only a small number of trips are observed travelling direct to other areas, with demands concentrated on trips either travelling to or transferring in the CBD.

Weekend peak hour trips are decreased as compared to weekday (Figure 5.9), and while the CBD/Darlinghurst areas still see the highest number of trips, there is an increase in the number of people travelling to Bondi from wider areas.



Source: Observed Opal trip data, Saturday 21 November 2015

Figure 5.7 Visualisation of public transport trips travelling to Bondi Corridor – Outbound peaks from Bondi

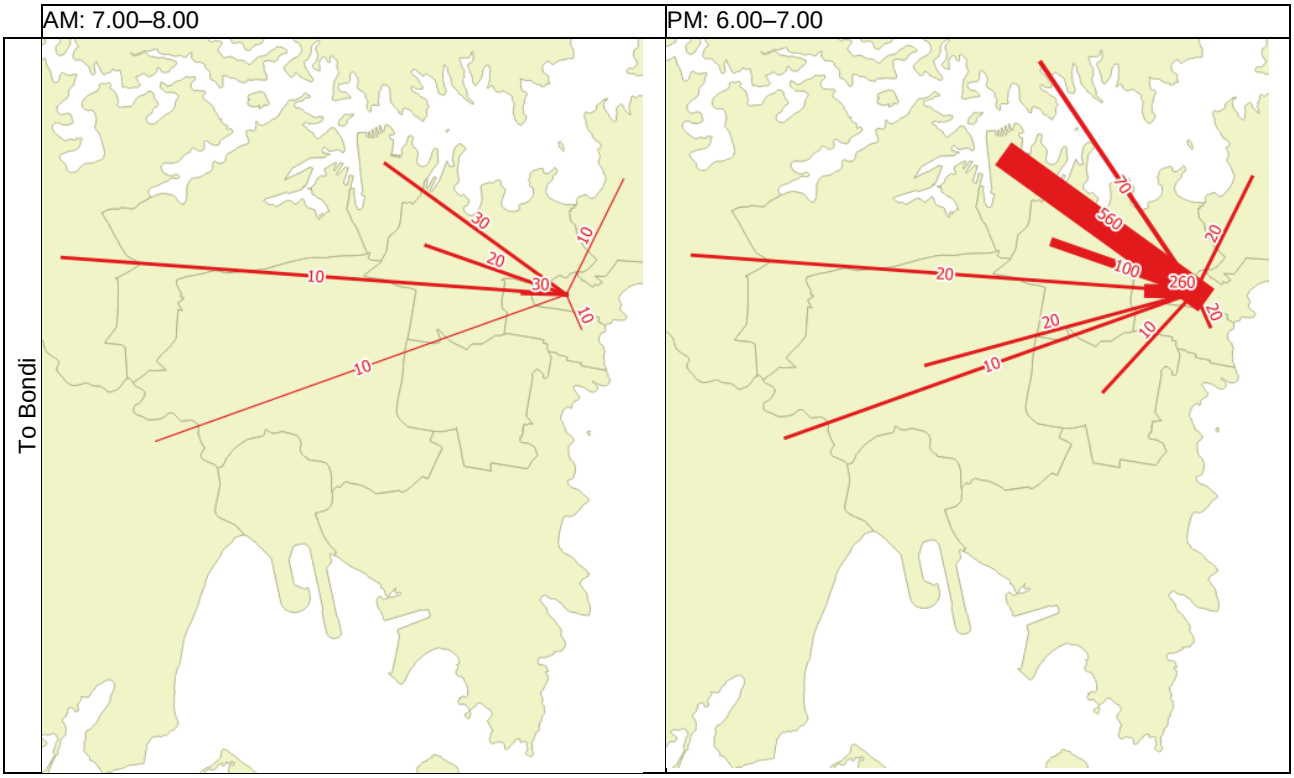
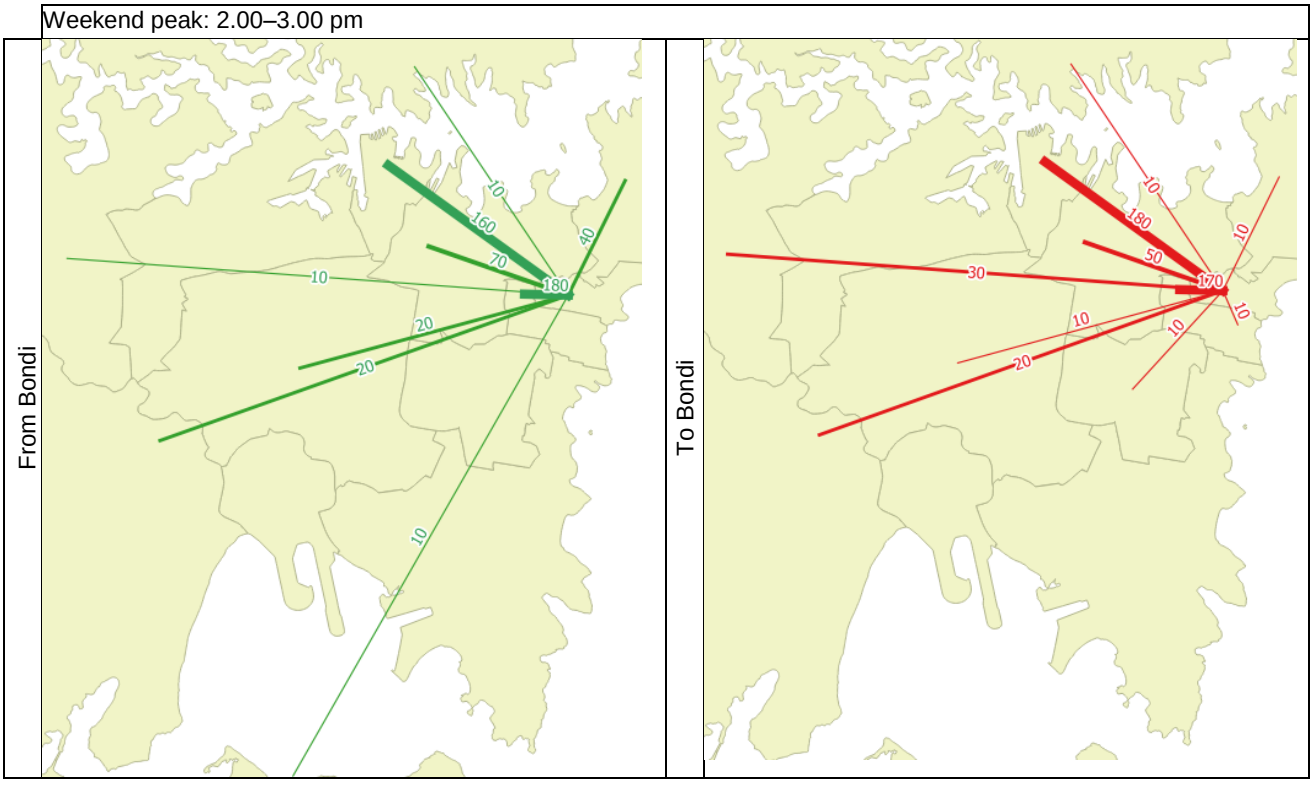


Figure 5.8 Visualisation of public transport trips travelling to Bondi Corridor – Inbound peaks from Bondi



Source: Observed Opal trip data, Saturday 21 November 2015

Figure 5.9 Visualisation of public transport trips travelling to Bondi Corridor – Weekend

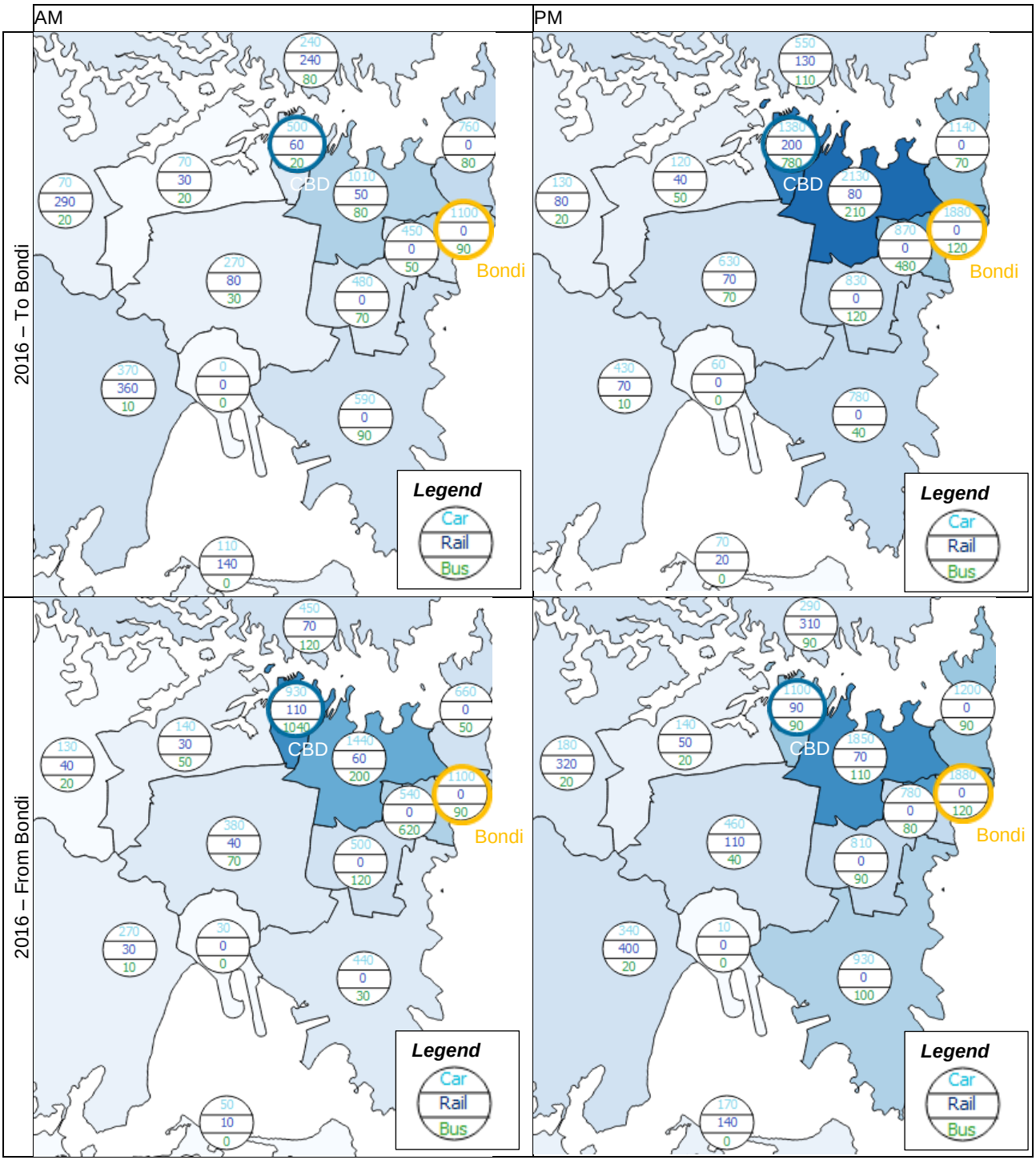
5.6 Current and future travel demands

Figure 5.10 and Figure 5.11 show ‘heat maps’ of the total transport demand for trips to and from the Bondi corridor for 2016 and 2036, as well as the number of trips in each area by transport mode. As with the Opal data previously analysed, the majority of trips are on the corridor from Bondi Junction to the CBD, with a large proportion of trips also see to/from the Randwick and Vaucluse areas.

The data sets shown in Figure 5.10 and Figure 5.11 are from the Sydney Strategic Travel Model. As this is a high level model, care should be taken in interpreting the results, as it may not accurately portray the finer details of the transport demands. However, it should accurately portray the broad transport patterns of the region.

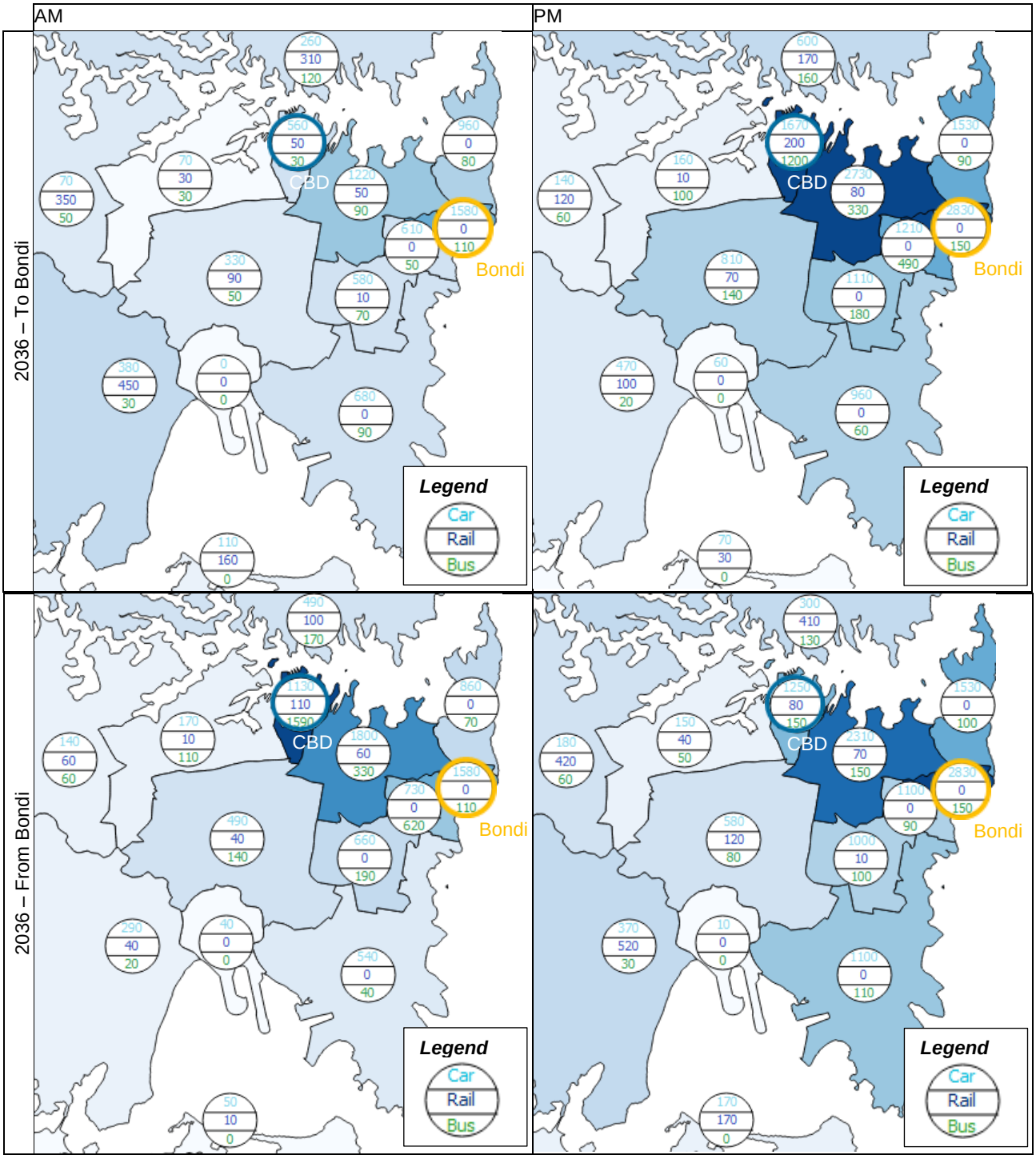
By 2036 total transport demand is projected by STM to increase by 30% in the peak direction, and 25% in the counter-peak direction, with the strongest growth occurring for internal trips within the Bondi corridor, and trips to/from Darlinghurst and the CBD.

Transport patterns observed in both the STM datasets and observed Opal data show that the strongest demands are for internal trips within the Bondi Road corridor, and trips to/from the CBD and Darlinghurst areas. On this basis, it is vital that any public transport system implemented on the Bondi Corridor has strong links to the CBD and Darlinghurst, either through the servicing the existing interchange at Bondi Junction or routes directly servicing the CBD, providing an integrated trip for Bondi travellers. As previously mentioned, there is sufficient capacity in the rail corridor to provide for these movements.



Source: Sydney Strategic Travel Model

Figure 5.10 Number of trips to/from the Bondi corridor – 2016



Source: Sydney Strategic Travel Model

Figure 5.11 Number of daily trips to/from the Bondi corridor – 2036

5.7 Bondi Road capacity

The Austroads Guide to Traffic Management gives the capacity of a one lane interrupted flow arterial as 900 vehicles per hour under clearway conditions. It is important to note that actual capacity in the kerbside lane of Bondi Road will be lower as a result of buses stopping at designated stops along the corridor and cars manoeuvring into and out of parallel parking spaces. This is important in the context of Bondi Road as it highlights the challenges with traffic congestion in the corridor, and it governs the ability to reallocate road space to public transport without affecting other road users.

Table 5.2 shows projected trips along the Bondi corridor in 2036. These values have been derived by imposing the STM growth to the observed volumes in the corridor. Examples of uplift in public transport use have also been included, to assist in understanding how the reallocation of a traffic lane for a high order public transport solution (e.g. LRT or BRT) may affect lane utilisation and hence the road's capacity to accommodate general traffic. It is important to note that this uplift is in addition to the existing public transport mode share which is already close to 50%. Projections for Bondi Road show that, currently, there are 16% more people in buses than cars travelling in the peak direction. By 2036, under a business as usual scenario, there will be 26% more people in buses than cars during the morning peak. There will also be an increase in the overall number of vehicles, further adding to congestion at peak times. This needs to be managed, so that the number of people moved along the Bondi Road corridor is maximised. The most efficient way to maximise this throughput is to increase the proportion of people travelling by public transport.

Table 5.2 Projected trip volumes on Bondi Road

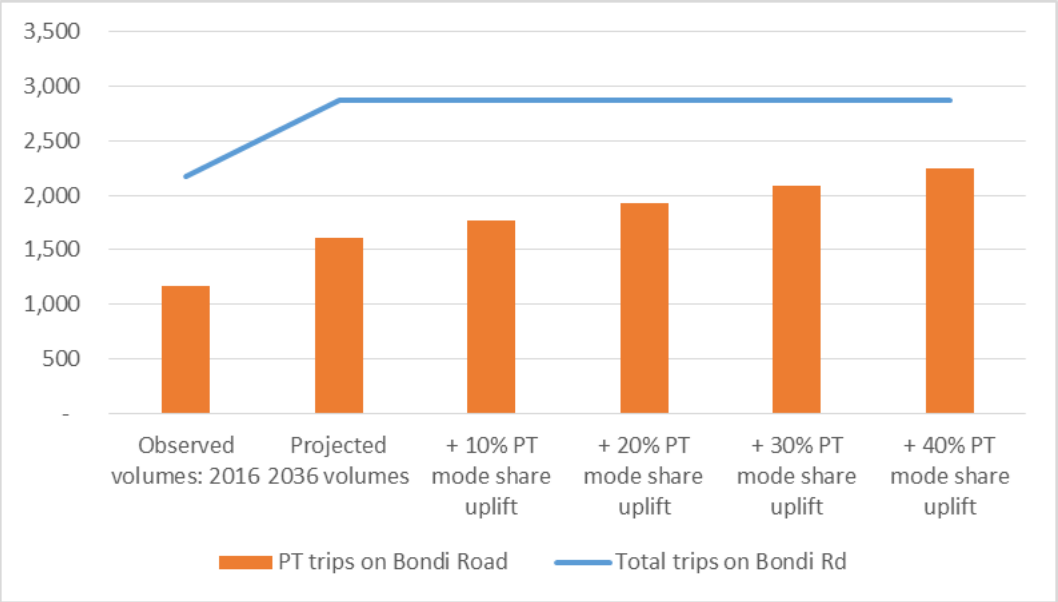
Scenario	Direction	AM_Car	AM_PT trips	PM_Car	PM_PT trips
Observed volumes (2016)	Eastbound	640	110	1,070	1,050
	Westbound	1,000	1,160	660	600
STM growth projection (2016 to 2036)	Trips to Bondi	23%	23%	31%	37%
	Trips from Bondi	27%	38%	27%	28%
STM projected volumes 'Business as Usual' (2036)	Eastbound	790	130	1,400	1,430
	Westbound	1,270	1,600	840	760
+ 10% mode shift to PT	Eastbound	770	140	1,260	1,580
	Westbound	1,110	1,760	760	840
+ 20% mode shift to PT	Eastbound	760	160	1,120	1,720
	Westbound	950	1,920	680	920
+ 30% mode shift to PT	Eastbound	750	170	970	1,860
	Westbound	790	2,080	610	990
+ 40% mode shift to PT	Eastbound	730	180	830	2,010
	Westbound	630	2,240	530	1,070

It should be noted that the actual future patronage demand for a BRT or LRT system would be determined through detailed patronage modelling using sophisticated state government endorsed transport models.

In the table, numbers shown in red indicate where the capacity of a single traffic lane is exceeded and a second lane is required to accommodate the forecast future volume of vehicles. Recent (2016) observations are that two lanes are required to move the traffic volumes during the peaks and this is currently facilitated by the use of peak direction 'no stopping' restrictions which make the parking lane available to supplement through traffic capacity demand.

The table indicates that it would be necessary for any mass transit solution, which requires the reallocation of a dedicated traffic lane, to achieve a 40% mode shift in order that the residual traffic to be accommodated in a single traffic lane. This prospect is challenged by the fact that:

- if only one traffic lane is available, then the flow of through traffic will be interrupted by turning movements at intersections meaning that the generic capacity of a single lane of 900 vehicles per hour is unlikely to be sustainable leading to the need for a greater than 40% mode shift to be achieved.
- raising the public transport mode share by 40% requires an extremely high public transport usage of 70%. To place the mode shift requirement into context, in 2036 with a 40% mode shift to public transport, public transport would be required to carry 75% (2,060 trips) of the total movements along Bondi Road (2,870 trips) as indicated in Figure 5.12.
- this mode share target is currently achieved in centres such as the Sydney CBD and North Sydney.



Source: OPAL and SCATS data for November 2015 escalated by STM growth forecasts

Figure 5.12 Forecast transport task by mode on Bondi Road

5.8 Conclusions

The observed data and information suggests:

- There is a strong demand for trips within the Bondi Road corridor, to and from Bondi Junction and the Sydney CBD from Bondi Beach.
- The key objective for efficient use of the corridor into the future is greater movement of people by public transport (and walking and cycling) than private vehicles.
- There is limited capacity within the footprint of current road width and property boundaries of the Bondi Road corridor to maintain the existing capacity for general vehicles and also accommodate high capacity public transport modes such as bus rapid transit or light rail transit.
- Corridor transport capacity is further constrained by current local requirements for turning movements and kerbside parking.
- There is a lack of alternative continuous parallel road routes due to the topography and established narrow local street network which needs to be carefully considered during construction.
- Future public transport modes shares similar to those currently achieved in Sydney CBD or North Sydney would be required along the Bondi Road corridor to ensure the desired balance of public transport trips and general traffic movements is achieved into the future.

6 Road upgrade options

This section outlines the options available if a 'do minimum - traffic focussed' solution was adopted for the Bondi Road corridor.

6.1 Traffic management options

The ability to accommodate additional volumes of vehicles within the existing road reserve is contingent on changing the way in which traffic is managed within the existing four lanes within the corridor. The essence of the solution is to remove impediments that slow down or restrict the flow of traffic. Concepts will encapsulate either removing impediments to the flow of traffic, or changing the way in which the road space is allocated.

Note that the corridor operations plan applies 'No Stopping' restrictions to the peak direction side of the road allowing for two lanes of traffic.

6.1.1 Traffic signal phasing

The amount of time in the traffic signal timing that is allocated to through traffic on Bondi Road will control the absolute capacity of the road to move vehicles during peak usage periods. The reallocation of green time to Bondi Road will however have an impact on traffic on side roads either moving across the corridor or wishing to join the corridor.

Given the capacity constraints of the corridor it will be necessary to decide how much additional priority could be allocated to Bondi Road traffic as opposed to traffic from the side streets.

6.1.2 Traffic signal co-ordination

Co-ordinating the green time of traffic signals to encourage uninterrupted flow of peak direction traffic will move platoons of vehicles along the road in a more efficient manner by reducing the need to stop at signals along the route.

6.1.3 Turn restrictions

Turning traffic pauses in the traffic lanes holding up following traffic until they are able to complete their turning movement. Left turning traffic holds up traffic in the kerbside lane waiting for pedestrians crossing side streets to clear before completing the turn. This delay disproportionately affects bus movement because they predominantly use the kerbside lane to access bus stops along the route. Right turns are more significant in affecting capacity than left turns because right turning traffic needs to wait for a break in oncoming traffic as well as waiting for crossing pedestrians to clear. The impact will not only be on the centre lane because traffic will tend to merge left placing additional demands onto the kerbside lane.

Banning right turn movements for traffic travelling in the peak direction could make a substantial improvement to the flow of vehicles on Bondi Road. This would come at the expense of local traffic accessibility and need to be considered in the context of availability of alternate routes.

6.1.4 Access restriction from side roads

Introducing left in left out movements for non-signalised side streets, or blocking off those streets altogether to encourage use of the signalised intersections will reduce the potential for mid-block disruptions to flow.

6.1.5 Consolidation of bus stops

Each time a peak direction bus stops at a kerbside bus stand during peak periods, the traffic in the lane behind must also come to a stand. Reducing the number of times the buses stop will improve their average speed through the corridor and allow the lane to move a higher volume of vehicles. The impact of this however is to make it less convenience for people to access buses and could encourage people to move away from using public transport, reverting to motor vehicles use which could in turn reduce the performance of the road by adding to traffic congestion.

6.1.6 Traffic lane management

Using an Intelligent Transport System (ITS) technology to reallocate road space to allow for three peak direction and 1 counter peak direction lane would substantially increase the capacity of the road to move peak direction traffic. There are a host of issues to address in order to assess the most appropriate technology and there are many stakeholder issues to resolve associated with loss of peak period parking on the counter peak side of the road, access to properties, clarity about the operating status of the road for motorists joining it from side streets, restrictions on turning movements for vehicles accessing from side streets and pedestrian amenity and safety.

6.2 Road infrastructure improvement options

6.2.1 Road widening

The ability to add an additional lane to the corridor would make a significant difference to the ability of the road to move traffic, however this solution is impractical given the nature of the land uses on either side of the road.

6.2.2 Turning lanes/pockets

The ability to store turning traffic clear of through traffic will improve the flow, and hence the capacity, of the corridor. To achieve this however, significant changes will be required to the design of intersection and the need for land acquisition will be inevitable given the existing corridor width. The impact on local land uses would be significant and such a solution is unlikely to be palatable.

6.2.3 Double decking

Increasing the number of traffic lanes by establishing an elevated structure over the top of the existing road is a high cost option that will have a significant impact on current land uses, and the general amenity and aesthetics, of the corridor. It will also be necessary to identify suitable land required to build the on and off ramps to the elevated structure.

The general benefit of this solution is questionable because Bondi Road performs a collector function, meaning that traffic joins it progressively along its length rather than travelling its full length.

6.2.4 Tunnelling

Tunnelling provides similar benefits to the double decking option however the implications for the amenity and aesthetics of the corridor are largely removed by the traffic be diverted to an underground route. The issues of access to the tunnel and the function it will perform would also need to be considered. The location of portals and associated tunnel ventilation are also key local considerations.

6.3 Conclusions

There are few options to enhance the performance of the corridor by further enhancing road capacity. The minor adjustment that could be considered will make only marginal improvements to the vehicle throughput capacity and are unlikely to offer even a medium term solution to handle the projected traffic growth. This approach is also not consistent with the function of the corridor as outlined in Council's Waverley People, Movement and Places study which identifies Bondi Road as the key public transport corridor in the local government area.

Therefore it will be necessary to consider alternative solutions to support the operation of the Bondi Road corridor into the future such as:

- New or enhanced public transport
- Changes to land use development and density to support use of sustainable transport modes and the configuration of the corridor
- Ongoing travel demand management.

The following sections of the report further explores these options.

7 Public transport options identification

7.1 Summary of options investigated

The potential to provide additional or new public transport options for the corridor as a means of easing congestion and/or increasing the potential for the corridor to cater for additional future demand have been explored. This investigation has focused on considering both the mode of transport, and the route upon which it is to be operated to ensure that a comprehensive set of solutions is considered.

Details of the modes and the routes combinations considered to provide potential solutions for the Bondi Road corridor are provided in Appendix A.

Table 7.1 on the following page contains a comprehensive matrix that summarises the relationship between modes of transport and route choices that have been examined as potential outcomes that may provide public transport solutions for the corridor.

The Waverley Light Rail Pre-feasibility Report (AECOM, 2013) identified a light rail route via Bondi Road which incorporated:

- An alignment at the eastern end of Bondi Road between Denham Street and Campbell Parade which has a significant gradient (greater than 7%) that cannot be negotiated by conventional light rail vehicles.
- 'Drive-over' light rail stops which require passengers to load and unload from the light rail vehicle across a self-managed traffic lane (i.e. no dedicated passenger platform).
- Absence of left and right turn lanes for general traffic along the alignment.

These three key light rail design considerations do not conform to TfNSW's design guidance for new light rail schemes and therefore have not been considered feasible in their current form.

7.2 Overview of public transport options

As a general rule, bus related options provide the greatest degree of flexibility when considering how to integrate them into existing road corridors. There is a hierarchy of outcomes that transition from minimalistic treatments focussed on local and suburban routes, through to fully segregated BRT schemes. These can be considered in the context of a staged upgrade program whereby higher levels of priority/segregation can be introduced progressively as patronage demand requires.

Light rail, to be effective as a transport solution, should only be considered for installation in a dedicated right of way. Whilst there are many examples of light rail operating in shared road space (e.g. Melbourne) these networks tend to be a result of historical network decisions and provide a very slow speeds and have a low level of service reliability. It is acknowledged that due to established physical constraints or desired public domain outcomes shared LRT operation with general traffic, other public transport modes or pedestrians may be required for limited sections of a system. TfNSW's preferred outcome is for dedicated rights of way for as much of a planned scheme as possible.

Monorails are a bespoke solution that capitalise on using the available airspace, such as above road corridors, to provide additional transit capacity without reducing traffic capacity on the roadway below. Sydney has recently removed its former monorail system which was established as a tourist focussed people mover in 1988.

Table 7.1 Summary of potential transport mode and route options combinations

Route	Bondi North to Bondi Junction			Bondi North to CBD			Bondi North to Randwick	Randwick to CBD	
Option	1a: Via Bondi Road	1b: Via Bondi Road and Rowland Avenue/ Fletcher Street	1c: New underground direct alignment	2a: Interchange to existing heavy rail	2b: Via Oxford Street	2c: Via Moore Park Road and Flinders Street	3a: Via Carrington and Frenchmans Roads	4a: Interchange to proposed LRT	4b: Direct to CBD
Do Nothing – continue open access for motor vehicles until congestion becomes unmanageable									
Public transport – Street level options									
A1: Bus priority in shared lane	✓			✓	✓	✓	✓	✓	✓
A2: Bus priority in shared transit lane	✓			✓	✓	✓	✓	✓	✓
A3: BRT in dedicated lane (with intersections)	✓			✓	✓	✓	✓	✓	✓
A4: LRT in shared lane	*	✓		✓	✓	✓	✓	✓	✓
A5: LRT in dedicated lane (with intersections)	*	✓		✓	✓	✓	✓	✓	✓
Public transport – Elevated options									
B1: Heavy rail				**					
B2: Light Metro (LRT)				✓			✓	✓	
B3: Monorail	✓			✓			✓	✓	
B4: Personalised Rapid Transit (PRT)	****								
Public transport – Underground options									
C1: Heavy rail			✓	***					
C2: Metro rail			✓	✓	✓				
C3: Light Metro (LRT)			✓	✓				✓	

Notes:* The AECOM report recommends this as the preferred route, however the steep gradient at the eastern end of Bondi Road (greater than 7%) cannot be negotiated by conventional light rail vehicles and therefore this route is not considered further (Refer to discussion in the text).

** Not considered further due to vertical difference between existing underground station at Bondi Junction and an elevated solution further east.

*** Interchange is not required because the existing heavy rail would be extended to Bondi for any underground option.

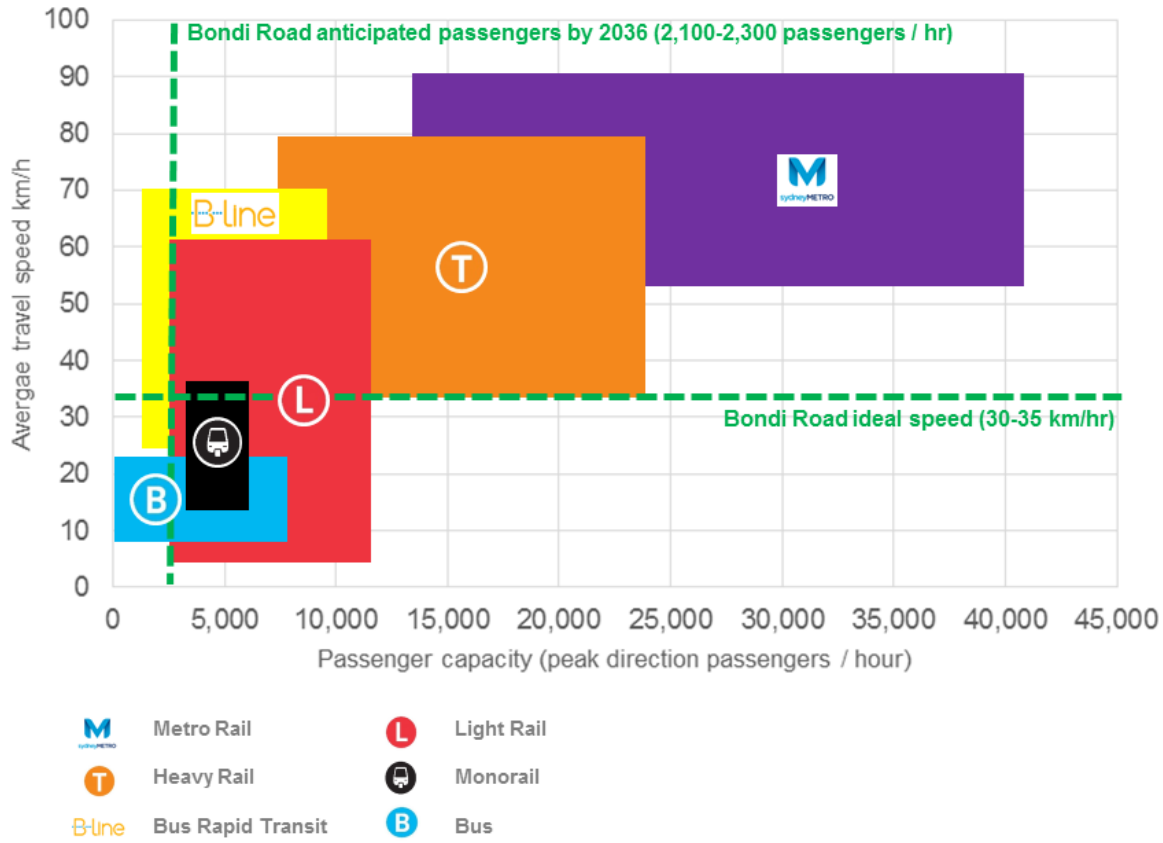
**** Not considered suitable for route operations along Bondi Road (or other corridors).

Heavy rail outcomes are greatly constrained by limits imposed by maximum gradients and minimum curve radii and general require a heavily engineered alignment which is inconsistent with existing land uses. As such they will need to be considered in the context of complete grade separation (i.e. tunnel). They are also heavily influenced by wider network operational constraints.

Metro Rail would be compatible with the technology applied to the current Sydney Metro project and may provide some synergies in operation and route planning. Some sections of the Sydney Metro network currently under construction utilise conversions of sections of the Sydney Trains heavy rail network.

Light metro rail is a small scale version of heavy rail that takes advantage of steeper gradient, tighter curves, and smaller outline to better integrate into urban environments at lower cost. Whilst it still requires complete grade separation, this provides an opportunity to use updated technologies such as automated operation. This technology has not yet been utilised within Australia.

Figure 7.1 outlines the operating speed and passenger capacities of the local public transport modes considered. It should be noted that the B Line is the local branding of the kerbside Bus Rapid Transit system being implemented for the Northern Beaches. The operating speeds and passenger capacities also represent those carried on Sydney's Tways and Busways (e.g. M2 Busway).



Source: adapted from Transit Capacity and Quality Service Manual (TRB 2003)

Figure 7.1 Typical travel speed and capacity ranges for local transit modes

7.3 Rapid assessment options

The purpose of the rapid assessment process is to generate a short list of public transport solutions to take forward for more detailed assessment and prioritisation. A process based on logical exclusion, historical context and impact assessment has been used to identify options that would be difficult to support for investment and could be considered no further.

The sections below provide the advantages and disadvantages of various options and combinations, in order to assist in the process of developing a short list to be subjected to a multi-criteria assessment to choose the most useful options.

7.3.1 Bondi Beach to Bondi Junction

The primary challenge is to accommodate a rapid transit solution into an already congested and constrained road corridor along Bondi Road, with no other suitable alternative surface routes being available for the redirection of traffic.

The existing situation of buses operating in a mixed traffic environment has already been identified as being unacceptable and is one of the catalysts for this study being undertaken. Therefore the continuation of the current situation will not be included in the list of solutions, other than for the purpose of comparison as a Base Case. A higher order bus solution will need to be considered, involving improved priority measures. Given the nature of the Bondi Road corridor the ability to achieve a pure BRT solution, requiring a completely segregated right of way and priority, would require property acquisition and modifications to the local road network.

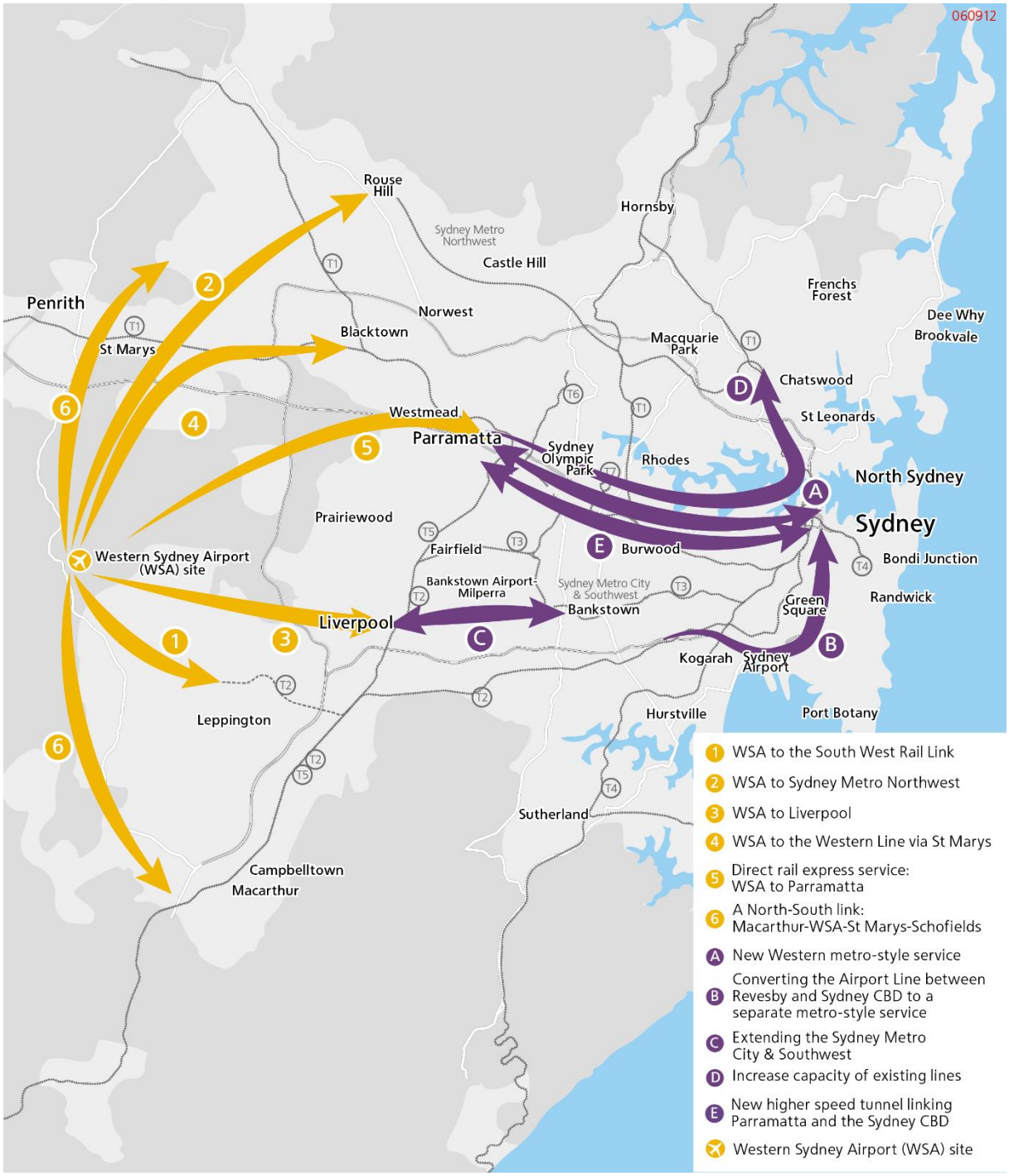
The option of light rail operating in mixed traffic conditions is certainly below best practice and will do little to increase the capacity of the corridor with the only advantage being that more people will be 'stored' in less space than if they were sitting within a motor vehicle stuck in traffic. Service reliability will be non-existent, with unpredictable and slow journey times. This approach is also not consistent with TfNSW's objectives for light rail. Modern LRT schemes rely on the provision of a dedicated corridor and are comparable in design space requirements to BRT solutions. Only a segregated LRT solution will be considered further.

Whilst it is possible to move directly to one of these segregated road based modal outcomes (BRT or LRT), it is likely that the first step will be a continuum of public transport enhancement from today's road based public transport services (i.e. conventional buses), to solutions involving improved bus priority measures in the current corridor constraints, to dedicated bus lanes through the rapid route corridor program outlined in Sydney's Bus Future, and finally dedicated LRT lanes as demand continues to increase. It is therefore proposed that these three scenarios be taken through to multi-criteria assessment based on the concept that the most appropriate solution will be applied based on the progression of demand growth and community preparedness to accept the resultant outcomes/impacts.

The application of rail based outcome is more difficult to support due to the cost of construction and operation and will most likely only become attractive once the capacity of the road corridor has reached the extent of its functional capacity, and community tolerance. The exception to this situation may be the case of the further development of the Sydney Metro network. The Federal and State governments are currently jointly investigating the rail needs of Western Sydney through the Western Sydney Rail Needs Scoping Study, a study to link Western Sydney Airport to Parramatta and further east to the Sydney CBD. Options that connect Western Sydney to other areas in Sydney have been identified in a discussion paper (Figure 7.2). Option A is a new western metro-style service where a CBD terminus would be required. Given the cost and practicalities of providing this under the CBD, there may be an opportunity to extend the line towards the eastern suburbs where a more suitable site for the terminus may be available. In this case, Council may have the opportunity to lobby for that terminus to be placed so as to relieve the demands on the Bondi Road corridor.

Due to the current low level of patronage on the T4 Eastern Suburbs Line in comparison to the rest of the Sydney Trains network, it is unlikely that an extension of the existing line east of Bondi Junction would be considered financially viable without some land use uplift component or tourism/cultural focussed initiative.

A further consideration is the reconfiguration of the T4 Eastern suburbs line from the Sydney CBD to Bondi Junction and potentially beyond as part of the aforementioned western metro style service. Either of the heavy rail or rapid transit schemes would require a change to the current district planning schemes developed by DP&E as outlined in A Plan for Growing Sydney.



Source: Western Sydney Rail Needs Scoping Study (Transport for NSW September 2016)

Figure 7.2 Western Sydney rail options

The concept of an elevated rail solution has already been identified as impractical, and too intrusive on local land uses, and therefore is not considered further.

Monorails provide a unique outcome that is significantly different to other public transport solutions currently applied in Australia (noting that Japan has been using this mode in some cities for many years). They have the ability to utilise the airspace above existing roads with minimal impact on the capacity of the roadway below thus increasing total corridor capacity without significant impact on existing users or the need to identify a new corridor. Modern monorail designs provide a similar capacity outcome to light metro systems, but with far less impact along the corridor and therefore deserve further consideration.

7.3.2 Bondi Junction to CBD

The dominant public transport feature at Bondi Junction is the existing underground railway which connects to the CBD via Edgecliff, Kings Cross, Martin Place and Town Hall to Central Station. Despite the deviation of the alignment to the north of the direct route to the CBD, running times from Bondi Junction to Town Hall are only 11 minutes, which represent a very efficient transit time.

The opportunity for any new transit system is to provide a more direct surface route to the CBD to service the inner suburbs of Woollahra, Paddington and Darlinghurst. There are two main road corridors that could potentially be available for this purpose, Oxford Street and Moore Park Road.

As indicated in Figure 7.3, the Oxford Street corridor is already extremely well serviced by bus routes whilst the Moore Park Road corridor has a smaller catchment along its length (due to parklands) and leads to Anzac Parade which is also very well serviced by buses and light rail in the future and also incorporates portals to the Eastern Distributor Motorway.

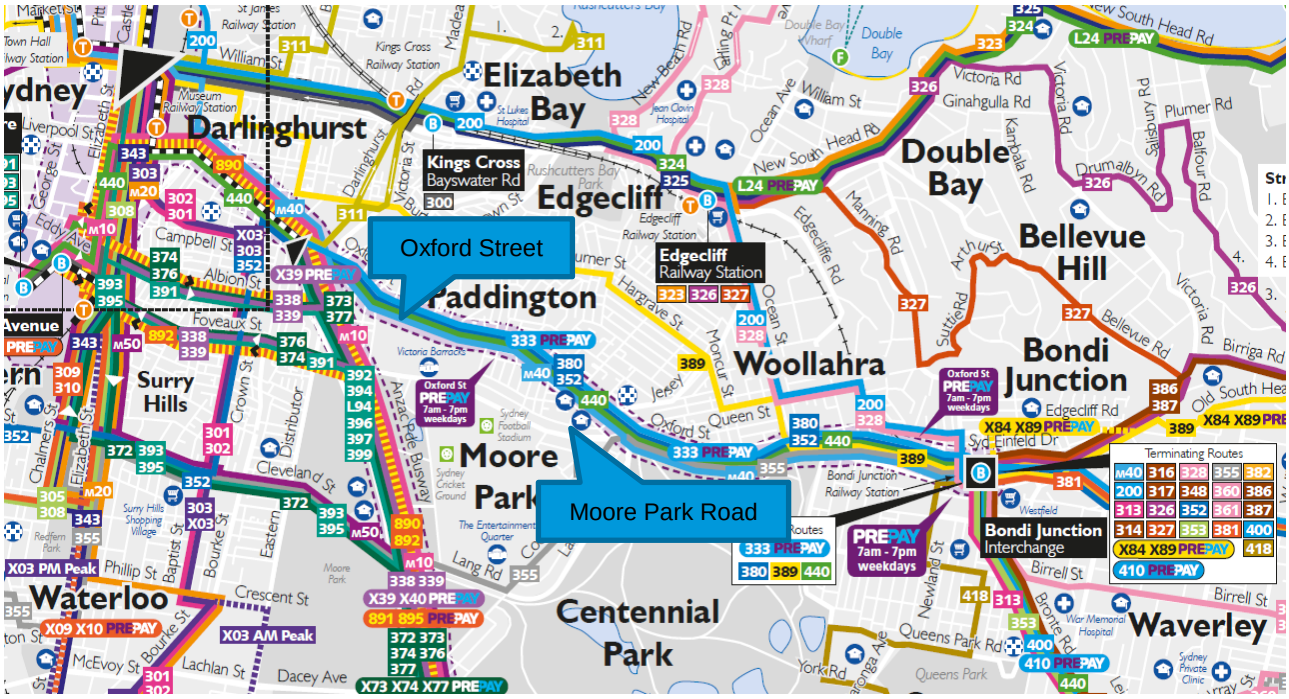


Figure 7.3 Inner suburbs bus routes

In order to be successful, any new transit system will need to be capable of converting the existing bus patronage to allow a rationalisation of the bus routes and services. The challenge is that the existing multiple bus routes within the corridors link to a number of different locations.

The opportunities available for the rationalisation of the bus routes will include:

- Consolidate existing bus routes to allow an improved bus corridor from Bondi Junction to the CBD via Bondi Road to carry the bulk of the patronage
- Establish a new priority bus route via Moore Park Road to connect into the Anzac Parade Busway
- Establish a new BRT or LRT route via Oxford Street
- Establish a new BRT or LRT route via Moore Park Road.

Whilst any proposed BRT solution could access the CBD directly via Oxford Street, the challenge for the introduction of a new LRT corridor is how the route will be integrated into the scarce number of roads that access the CBD:

- The first option would be to link with the proposed CBD and South East Light Rail (CSELR) in the vicinity of Moore Park. How the CSELR crosses South Dowling Street, the Eastern Distributor, Moore Park West and Anzac Parade and this is a complex part of that project alignment design. The light rail route is proposed to cross South Dowling Street and the Eastern Distributor via a new bridge at road level before entering a shallow cut and cover tunnel at the western edge of Moore Park's playing fields. The tunnel would extend under Moore Park and Anzac Parade with the Moore Park stop located at-grade adjacent to the current busway and close to the Sydney Cricket Ground. The route will continue south adjacent to the busway until the intersection of Alison Road and Anzac Parade. This means that the proposed new Bondi LRT would need to negotiate around the Sydney Cricket Ground sports complexes in order to connect to this route. It is noted that even if this connection is feasible then the next challenge is the capacity of CSELR to accommodate the additional light rail presented from the Bondi route. It is understood that current planning suggests that suitable capacity may not be available.

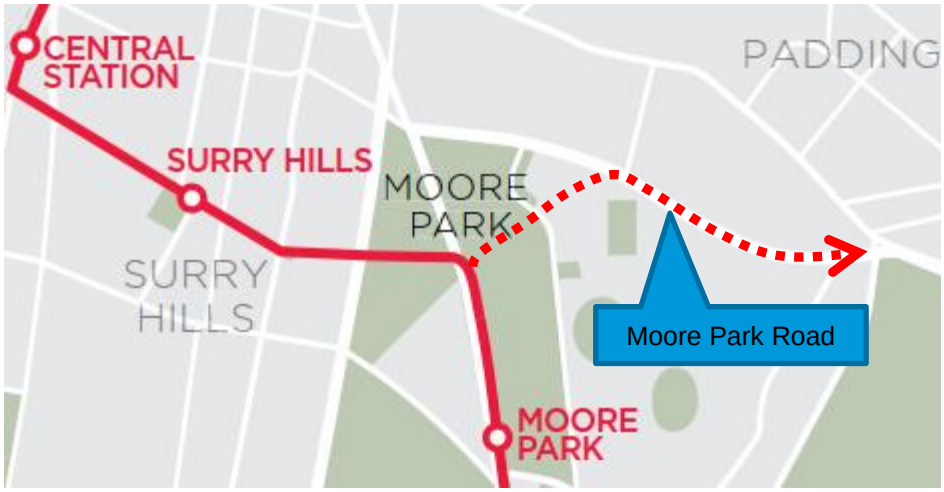


Figure 7.4 Proposed route of the CBD and South East Light Rail

- The second approach would be to continue the LRT route within existing road spaces to create another route into the CBD. The Sydney City Centre Access Strategy 2013 identifies the priority uses for the various access roads into the CBD as shown in Figure 7.5. Although it is not within the scope of this study to identify or resolve route options, for the purpose of ensuring that a practical solution may be available, the following observations are made:
  - An Oxford Street LRT route would need to continue along Liverpool Street

- A Moore Park Road LRT route has a choice of four routes. These routes were previously examined as part of the early planning for CSELR and were deemed to be too steep to accommodate light rail. Goulbourn Street also now plays a significant role for cross-town traffic movements with the closure of George Street for CSELR.
- There is little or no opportunity to connect to the proposed CSELR.

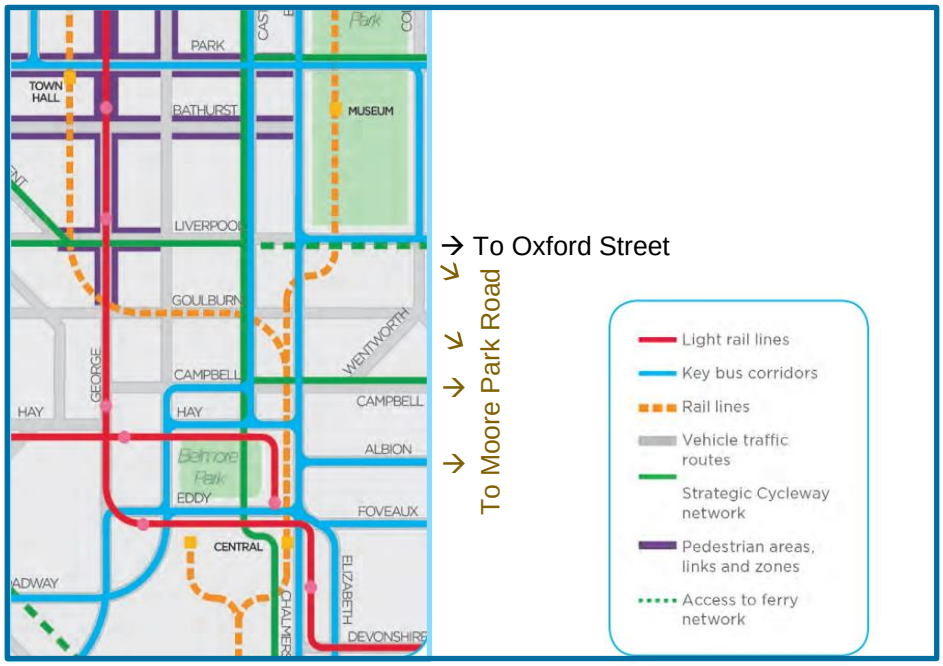


Figure 7.5 CBD access strategy

On the basis of the above discussions it would appear feasible that a solution may be available for either an LRT or BRT solution from Bondi Junction to the CBD, albeit that there are some planning issues to overcome. Such decisions will need to be traded off against the alternative option which is to interchange to the existing heavy rail network at Bondi Junction.

The final consideration is whether the extension of the monorail option to the CBD provides an alternative outcome to BRT or LRT. It is certain that it will be easier to introduce the monorail structure into the existing road spaces, however the issues that will require the closest consideration will be that of station placement. If a monorail is to replace buses, it will be difficult to justify the high costs and social/environmental impacts of monorail stations at the same spacing as the current bus stops. Therefore the desired outcome of reducing the number of buses operating in the corridor may be compromised. As a result the monorail may be better focussed towards providing more express style services and taking the capacity off the road network rather than replacing the street based public transport.

7.3.3 Bondi Junction to Randwick and CBD

The purpose of this route is to link Bondi Beach to the CBD via the Randwick area. It is presented as an alternative to the use of the more direct corridors via Oxford Street or Moore Park Road. There are a number of issues associated with this option including:

→ Travel times between Bondi Beach and the CBD will be considerably longer than via a more direct route, such as one that follows Oxford Street. Therefore it cannot be envisioned that motorists using the Bondi Road corridor would find this route option attractive enough to make a mode shift to public transport

- There is potential to service a travel market associated with the Randwick retail centre, University of New South Wales, and the Randwick Racecourse. However, travel data presented in section 5 would suggest that the demand for travel between Bondi Beach and Randwick is not strong enough to justify investment in a higher order transit system. It is noted that some of the buses that operate south from Bondi Junction carry high passenger loads, but the destination of these trips is largely to the south of Randwick. Trips of this nature are not within the scope of this study because the potential transport solutions do not significantly improve the operation of the Bondi Road corridor.
- The option relies upon joining the CSELR at Randwick for the balance of the route to the CBD. For this to be a credible option there needs to be sufficient latent capacity in the design of that route to accommodate the additional light rail services required for the Bondi operation. Current analysis is showing that this is not the case with the route CSELR expected to be operating close to its capacity.

The advantages of the route are that it may be cheaper to provide a connection to the CBD because of a shorter construction length (Bondi Junction to Randwick to join the proposed CSELR), but the additional total route length will result in higher ongoing operating costs, unless an interchange is to be provided at Randwick. The route may also be supported as a means of avoiding some of the difficulties associated with inserting a new transit route into Oxford Street and the inner city areas by using the already agreed route of the CSELR.

There seems to be very little argument to support a route via Randwick over more direct connections, including interchange to heavy rail at Bondi Junction, therefore it is not proposed to include it in the shortlisted options. However, if none of the shortlisted options can ultimately be justified, or have constraints that affect their delivery, then it could be appropriate to revisit this option at that time.

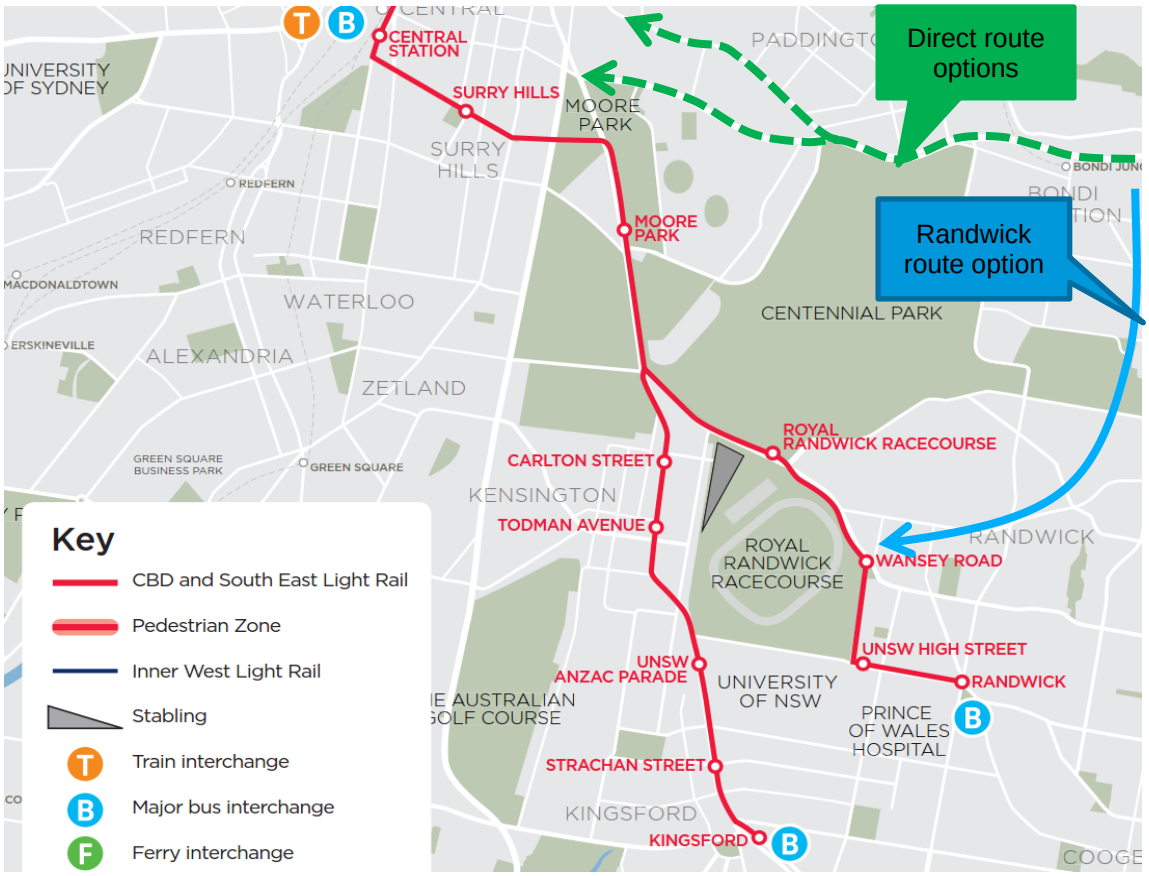


Figure 7.6 Proposed route of the CBD and South East Light Rail

7.4 Recommended shortlist of options for further assessment

The following table highlights the shortlisted options to be taken through to the next stage of assessment. The options have been categorised as 'core concepts' representing potential solutions for the Bondi to Bondi Junction corridor, and 'add-on concepts' which provide the alternative to connect with train services at Bondi Junction, or to continue the mode choice all the way to the CBD.

Table 7.2 Shortlisted options for further assessment

	Core concepts		Add-on concepts	
	Bondi to Bondi Junction via Bondi Road	**Bondi to Bondi Junction via Bondi Road and Rowland Avenue**	**Bondi Junction to CBD via Interchange to Rail**	**Bondi Junction to CBD direct via a route to be determined**
Bus priority in shared traffic lane	Concept 1		✓	✓
Bus Priority in shared transit lane	Concept 2		✓	✓
Bus in dedicated transit lane	Concept 3		✓	✓
LRT in dedicated transit lane	See note (1)	Concept 4	✓	✓
Monorail	Concept 5		✓	✓
Metro Rail	Concept 6(2)			✓

Notes:

(1) The AECOM report recommends this as the preferred route, however the steep gradient at the eastern end of Bondi Road (greater than 7%) cannot be negotiated by conventional light rail vehicles and therefore this route is not considered further (Refer to discussion in the text).

(2) Metro rail route alignment will not necessarily follow the Bondi Road alignment

Assessment of these options against the goals identified earlier in section 3 confirms that each will contribute to achieving the outcomes desired for the project. The following table provides commentary on the strength of the options against the goals, as a reference point for consideration at the assessment stage.

Table 7.3 Short listed concepts mapped against the Waverley public transport goals

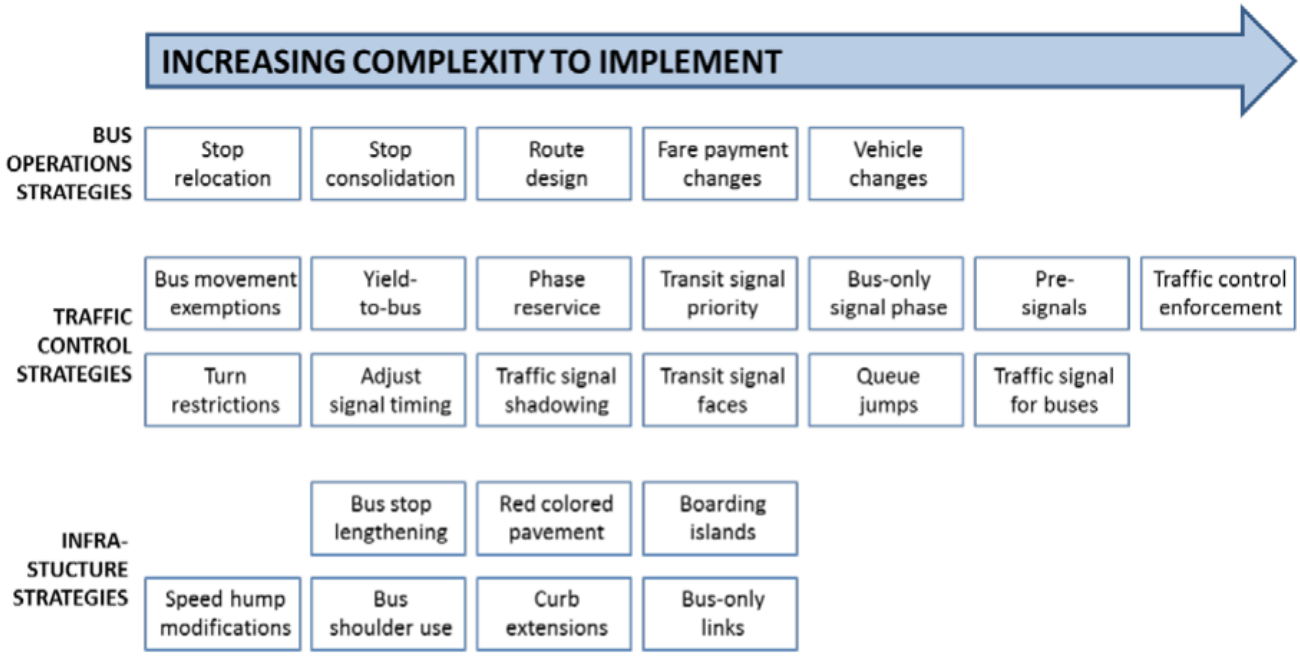
Ref No.	Goal	Concept 1 Bus priority	Concept 2 Shared transit lane	Concept 3 Dedicated transit lane	Concept 4 LRT in dedicated lane	Concept 5 Monorail	Concept 6 Metro Rail
1	**Productivity**	More of the same	Better utilisation of road space for higher capacity vehicles	Faster and more reliable services	Faster and more reliable services	Provides added capacity with an additional transport corridor	Very fast and reliable services
2	**Congestion**	More of the same	Could increase traffic congestion if the transit lane capacity is not used efficiently	Removes one traffic lane placing pressure on the remaining lane	Removes one traffic lane placing pressure on the remaining lane	Increases vehicle capacity by removing public transport from the road corridor	Provides additional capacity without affecting the road corridor
3	**Growth**	Continued competition for capacity between buses and traffic	Slight uplift in capacity by giving priority to higher capacity vehicles	Huge potential for uplift in public transport capacity but also a reduction in traffic capacity down to a single lane	Huge potential for uplift in public transport capacity but also a reduction in traffic capacity down to a single lane	Huge potential for uplift in public transport capacity without impact on traffic capacity	Huge potential for uplift in public transport capacity from the Bondi area
4	**Accessibility**	No change	No change	Opportunity for easy access stops	Opportunity for easy access stops	Reduced due to the elevated nature of the stations	Reduced due to the underground nature of station
5	**Mobility**	No change	No change	Reduction in number of bus stops may increase walking distances	Fewer stopping locations will mean increased walking distances	High costs, and large footprint, of stops will result in far fewer access points. Reduction in footpath capacity for supports.	Only one or two station sites are likely to be included
6	**Health**	No change	Slight improvement by encouraging better occupancy levels per vehicle	Opportunity to use larger buses and/or electric traction to reduce noise and air pollution	Larger vehicles and/or electric traction to reduce noise and air pollution	Larger vehicles and/or electric traction to reduce noise and air pollution	Completely segregated from the community
7	**Equity**	No change	No change	Improvement potential depends on policy settings	Improvement potential depends on policy settings	Improvement potential depends on policy settings	Improvement potential depends on policy settings
8	**Sustainability**	No change	No change	Opportunity to move to electric traction	Uses electric traction	Uses electric traction	Uses electric traction

8 Development of the shortlisted concepts

Based on the preceding discussions a number of concepts have been shortlisted for further consideration. The following sections seek to further define the concepts to the extent that they can be assessed through a more rigorous MCA process.

8.1 Concept 1: Bus priority in shared traffic lane

This concept is essentially an organic improvement to the current bus operation conditions in the corridor to further improve transit times and journey time reliability with the ultimate aim of enhancing the mode share of buses. The sorts of measures that could be considered, and the complexity of their implementation can be summarised as follows:



Source: Adapted from Ryus, P, K. Laustsen, K. Blume, S. Beaird, and S. Landgon. 2016. A Guidebook on Transit-Supportive Roadway Strategies

Figure 8.1 Bus priority options

Whilst it may be possible to marginally escalate the movement of buses through the congested road corridor by applying one or more of the above measures, essentially the majority of the bus journey will remain dependent on the average speed of the general traffic flow.

Table 8.1 Bus priority in shared traffic lane

Advantages	Disadvantages
→ Low cost solution.	→ Provides only small travel time and reliability improvements.
→ Can be progressively implemented to reduce impact on traffic during construction/installation.	→ The improvement in bus performance will be at the expense of general road users who will perceive resultant delays/congestion.
→ Can be progressively implemented in response to funding availability and timing.	→ Express buses have a greater potential to not be fully loaded thus increasing the number of vehicles operating in the corridor and thus congestion.
→ Express buses will reduce transit time for some passengers.	

8.2 Concept 2: Bus priority in shared transit lane

Bondi Road (and Oxford Street) operates with peak direction clearways to ensure that there are two peak direction traffic lanes available for the dominant traffic flow. General traffic has the option as to which lane it chooses to use, however buses are largely limited to the kerbside lane due to the frequency of stops to be serviced. There is a preference for general traffic to use the centre lane so as not to be affected by the stopping buses.

There are a number of options as to how this could be applied in the corridor and the choice needs to be made from the following (noting that dedicated transit lanes are dealt with in Concept 3):

- → T2 lane – minimum of two persons required in a car to use the lane. This is the most common application used
- → T3 lane – minimum of three persons required in a car to use the lane. Usually only applied where there is a high level of car share being used or encouraged.

There is a trade-off in the application of transit lanes in the context of corridors such as Bondi Road. If the kerbside lane is chosen, then the constant stopping of buses erodes the benefit for motorists looking for an expedited journey. If the centre lane is chosen then buses would need to diverge into the kerbside lane to stop at regular intervals.

It should be noted that Roads and Maritime have moved away from the designation of transit lanes in favour of bus lanes and bus only lanes as they prove difficult to enforce.

The concept adopted for the purpose of assessment will be a T2 lane applied to the centre lane linked with the increased use of express bus services. Stopping services would continue to use the general traffic lane (delaying general traffic at stops).

Table 8.2 Bus priority in shared T2 transit lane

Advantages	Disadvantages
→ Reasonably low cost to install through the use of line marking and signage.	→ Transit lanes are difficult to enforce due to the need to detect the number of occupants in cars, the ability to apply a fine, and then the resources required to undertake the enforcement.
→ Applies priority to vehicles that more efficiently utilise the available road space.	→ Depending on the ratio of cars with only one occupant, then the T2 lane may appear underutilised whilst the general traffic lane becomes even more congested. Where there a disproportionate number of cars with more than one occupant then the T2 lane will become congested and no real benefit will flow to bus operations.

8.3 Concept 3: Bus in dedicated transit lane

Where transit buses are assigned a dedicated lane, this removes the potential from delays caused by general traffic movements and congestion. In their purest form, such schemes are referred to as Bus Rapid Transit (BRT). The concept of what constitutes BRT is difficult to define with the terminology being applied equally to fully segregated (off-road) systems, through to allocated lanes operating in existing road corridors.

The current conditions in the Bondi Road corridor do not allow the application of the purer forms of BRT, therefore whatever solution is to be adopted will be a compromise between the needs of the bus system and the needs of other road users, including pedestrians and bicycle riders. For this reason the term 'dedicated bus lane' has been used in preference to the term BRT, and to distinguish this concept from the 'shared transit lane' concept discussed above.

There are four principal ways in which a dedicated bus lane could be inserted into Bondi Road:

1. *Temporary assignment of the kerbside lane* – this option is already partially applied in Bondi Road with the kerbside lane, which is normally used for parking and to facilitate turning movements, being declared as a clearway during peak periods in the peak flow direction. However this option would also require the removal of general motor vehicle movements from the lane, compressing all traffic into the remaining traffic lane. There are three primary reasons why this approach is unlikely to be successful:
   - **a)** Congestion – during peak periods the capacity of two lanes is available. The removal of use of one lane requires existing traffic to be accommodated in a single lane which will halve the capacity of the corridor to move motor vehicles. The only way to avoid this is to assume that 50% of road users either modify their travel patterns or choose to use the buses as an alternative to using their cars. In order to achieve mode shift at such a high level, the buses would need to demonstrate fulfilment of the needs of drivers in terms of both end to end journey time, comfort, and access to desired destinations.
   - **b)** Perceptions – The fact is that a bus lane with one bus every 5 minutes (80 people per bus with 12 buses per hour = 960 pphpd) can move the same number of people as a single congested lane of traffic (assuming 800 vphpd with 1.1 people per car = 880 pphpd). The observation from the motorists' point of view is one of an empty lane they could be using instead of being stuck in traffic. Of course, the moment they are allowed into the lane the efficiency of the buses is lost and the concept breaks down.
   - **c)** Turning movements – as observed earlier, there are a large number of turning movements out of Bondi Road. This is currently addressed at critical locations, where turning traffic queuing occurs that disrupts through movements, by providing a shared turning lane and, in some cases, traffic signal priority. In these situations, although one lane can be temporarily disrupted the other lane continues to flow. By allocating one of the two available lanes to buses, the remaining lane will have a reduction in flow caused by the turning vehicles, thus further reducing its capacity.

2. *Permanent conversion of the kerbside lane* – permanent conversion of the lane faces the same issues as articulated for the temporary allocation of a lane to transit, except that the impacts on car traffic (and the benefits to bus users) will occur throughout the day. There are four additional issues that this raises:

   a) Non peak traffic congestion – traffic counts and observations along the corridor in non-peak periods when the clearways are not in force indicates that the capacity of the single traffic lane is approaching its capacity and there are delays caused by turning movements and parking activity.

   b) Car parking – outside of the clearway times, the kerbside lane is used for parking associated with retail, commercial, recreational and educational activities. This road space use would need to be either removed (which is likely to draw strong resistance from businesses), or be relocated. The relocation option could involve the purchase of properties behind the key activity centres along the road, or could involve the use of side streets. Both of these options are likely to impact residential areas.

   c) Property access – there are a large number of kerb crossing points along the road. People access or departing these properties will need to cross the transit lane introducing an additional interface with the bus operations and potential safety issues.

   d) Mode share – during the non-peak periods the number of people seeking to use bus services compared to those using motor vehicles falls considerably. This may make it difficult to justify the permanent allocation of road space to buses given the strong competition for road space from other uses.

3. *Lane management* – Bondi Road has a dominant traffic flow in the morning peak towards the CBD and in the afternoon peak towards Bondi Beach. In addition, bus usage is stronger during peak periods than during other times of the day. These circumstances suggest that dynamic lane assignment could help to increase the capacity of the corridor during peak periods and could include the opportunity to provide a bus transit lane. The concept is to use Intelligent Transport Systems (ITS) to boost peak direction flows by allocating (using dynamic lane signage) three peak direction lanes and one counter peak lane during each peak period. This provides an improvement in corridor capacity from two peak direction lanes to three. To achieve this it would be a requirement to restrict car parking on both sides of the road as opposed to the current practice of restricting it only on the peak flow side. The proposed lane allocations would be:

   - One peak direction bus lane adjacent to the kerb
   - Two peak direction traffic lanes
   - One counter peak direction general traffic lane.

   This approach adds a bus lane in the peak direction whist maintaining the same capacity for existing road users. The trade-off is that there is some additional loss of parking capacity on the counter peak side of the road. Counter peak buses and cars would share a single lane as they do at present but buses will no longer be able to pull out of the traffic flow to service bus stops. Some would argue that this is a better outcome for public transport and enhances safety whilst having minimal impact on total transit time for motorists over the length of the corridor. Whilst there are a number of issues of detail to work through in terms of engineering, safety, and community response, this option provides an opportunity to introduce an improved transit outcome for the corridor in the short to medium term, and provides the opportunity to enhance perceptions of public transport so as to boost mode share as a precursor to installing a higher order transit system.

4. Grade separation – the use of grade separated intersection, or segments of road, has the potential to accelerate the progress of buses past known delay points. The costs associated with the construction of this solution, and the impact on the local amenity of the corridor, would be substantial. It is also unlikely that the time savings for buses will be significant. For these reasons it is not proposed to consider this option further.

Based on the proceeding discussion, it is considered that dynamic lane management of the Bondi Road corridor to create a peak direction bus transit lane is likely to provide the best outcome in the shorter term.

The option to move towards a dedicated bus transit lane on each side of the corridor in the future would be preserved, however the size of the potential impacts from the allocation of the kerbside lanes to buses are significant and would need to be resolved before committing to this solution in the long term.

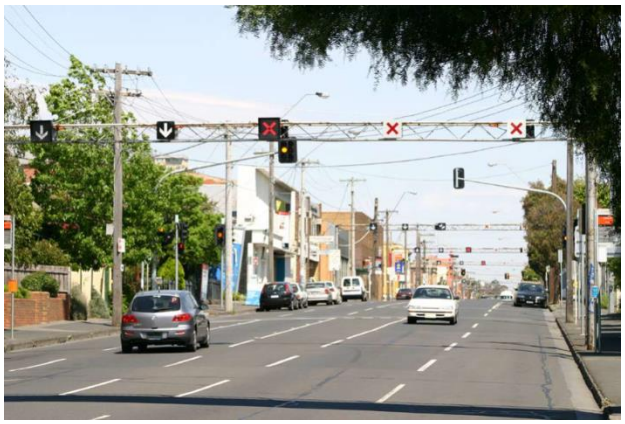


Photo 8.1 Lane management using overhead lane indicators

Table 8.3 Bus in dedicated bus lane – Dynamic lane management

Advantages	Disadvantages
→ Increases total peak direction corridor capacity.	→ Loss of additional car parking during peak traffic periods on the counter-peak side of the road.
→ Creates space for a dedicated bus transit lane in the peak direction during peak times.	→ Counter-peak motorists will need to wait behind buses at stops (although this provides a better outcome for public transport).
→ Relatively low cost solution to corridor management.	→ Design and safety issues will need to be resolved during further investigations.
→ Minimal impact on existing traffic operations with two lanes retained in the peak direction.	→ Emergency service access in the counter peak direction could be affected by the traffic flow in the single allocated lane.

8.4 Concept 4: LRT in dedicated lane

As indicated in earlier discussion, the installation of modern light rail systems expect the provision of a dedicated corridor in order to realise the potential benefits and justify the high cost of investment. From the outset, it must be acknowledged that applying this approach to the Bondi Road corridor will result in the permanent loss of one traffic lane in each direction, leaving only one lane for other road uses, including traffic. This means that parking along the length of the corridor will need to be removed/relocated in order to free up the lane for traffic use. The corridor in its current configuration is constrained to the extent that it will be very difficult to widen the road without property acquisition to accommodate turning lanes therefore turning traffic will either hold up through traffic, or turning vehicles would need to be allowed onto the light rail tracks creating an interface with light rail operation thus affecting running times and reliability. Localised property acquisition would also be required to establish compliant light rail stops, preferably at intersections.

The question as to where in the road corridor the light rail tracks will be located will be governed by the following considerations:

- *Kerbside lane* – aligning the tracks along the edge of the road corridor has some significant benefits from a passenger perspective. It allows direct boarding from the footpath without the need to interact with traffic, and saves road space by integrating the stop infrastructure with the footpath saving on corridor space. Whilst this solution can work well in shared spaces (traffic calmed areas or malls), there are a number of issues that work against kerb side running in corridors with characteristics such as Bondi Road:
  - Segregation – running the tracks alongside a pedestrianised area, such as the narrow footpaths in Bondi Road, will require some form of barrier to prevent pedestrians from accidentally straying onto the tracks, and to also stop mid-block crossing of the road which will no longer be acceptable due to the absence of pedestrian refuges between the different lane uses. Positive segregation from the adjacent traffic lane will also be required to protect the right of way of the light rail.
  - Road camber – Bondi Road is constructed with a camber towards the kerbs to promote drainage towards the gutters. Light rail track design requires a level surface and this is difficult to establish at the edge of road corridors where the camber is at its greatest.
  - Drainage – drainage is collected in gutters at the edge of the roadway. Not only is it expensive to modify the drainage system but the method of capturing lineal flows along to the light rail corridor will require special attention.
- *Centre Lane* – placing the tracks in the middle of the road is a relatively conventional approach used for tramway design. A flat area can be established without the need to substantially modify the structure of the roadway and there is no need to significantly modify drainage. Perhaps the biggest issue to address with placing the light rail in the middle of the road is the location and design of the stops because modern standards for accessible light rail stops require a platform to be provided. The width of the Bondi Road corridor is only 20 m and is wide enough to accommodate footpaths, two traffic lanes and two light rail tracks.

For the purpose of the analysis, it is decided to use light rail in the centre of the roadway as the preferred concept to take through to evaluation.

One further issue that needs to be considered in respect to LRT is its terminus locations. At the eastern end of the route, termination in Campbell Parade will become increasingly difficult to justify the further north it is located due to its diminishing passenger catchment potential. At the western end, the ideal situation would be for the LRT to take people directly to the CBD, however the cost, and how it would integrate into the streets will be significant issues to be addressed. The alternative is to terminate at Bondi Junction, but this creates an isolated network (requiring its own maintenance and stabling facilities) and necessitates a modal interchange at Bondi Junction which could add inconvenience and transfer time to journeys.

Table 8.4 LRT in dedicated lane

Advantages	Disadvantages
High capacity public transport mode that will increase the capacity of the Bondi Road corridor.	Fixed route that cannot be adjusted over time if there is a shift in demand or new trip generating locations.
Highly visible and likely to have greater attraction than the existing bus services.	Need to extend the concept through to CBD or experience interchange at Bondi Junction.
Could replace all existing bus services with the operating savings offsetting LRT operating costs.	Expensive to build and operate.
Perceived as cleaner and more aesthetically pleasing then buses.	Has significant impacts on road capacity and parking provisions.
Emergency services could gain improved access by using portions of the LRT corridor.	

8.5 Option 5: Monorail

Proponents that support monorails will argue that they can provide a similar capacity and service quality for users as LRT, the only difference being that the operation is elevated above the street. The advantage of this is that a monorail could potentially be installed above Bondi Road without affecting the existing operation of the road, and potentially improving congestion by removing buses from the traffic mix. Once again, the issues of stop design and placement are critical to the success but the stops will be large, occupying area areas of airspace above the corridor, and expensive, meaning that it will not be feasible to provide a stop frequency that matches the current bus services. As with LRT also, the issue of where to terminate the route will be critical to the success or otherwise of the solution.

The most significant concerns related to the use of a monorail solution are the impact that the structures will have on the streetscape below, and the vertical transport required to access the monorail which adds time to the journey and its ease of use.

It is also uncertain how the monorail would handle the steep gradient at the eastern end of Bondi Road and whether during the design stage a suitable engineering solution would be possible (such as through the use of the changes in elevation of the track above ground)

Table 8.5 Monorail

Advantages	Disadvantages
→ Creates a new pathway within the corridor in addition to the existing road space thus increasing the total capacity to move people.	→ Aesthetic impacts of the elevated beams and particularly the stations.
→ High capacity public transport mode.	→ Bespoke design not compatible with other public transport technologies used in Sydney.
→ Could replace all existing bus services with the operating savings offsetting Monorail operating costs.	→ Need to extend the concept through to CBD or experience interchange at Bondi Junction.
→ Perceived as cleaner and more aesthetically pleasing then buses.	→ Fixed route that cannot be adjusted over time if there is a shift in demand or new trip generating locations.
→ No significant impact on access for existing corridor users (i.e. traffic, pedestrians, bicycle riders, emergency services).	→ Impact on footpath capacity for support structures, particularly at stations

8.6 Summary of concepts for further evaluation

8.6.1 Mode concepts

Do nothing

Concept 1: Bus priority in shared traffic lane:

- → Short sections of bus only lanes at critical congestion points
- → Bus activated, priority traffic signal control
- → Rationalisation of spacing between bus stops
- → Introduction of higher capacity buses
- → Improved access to bus boarding points through the integration of transit car parking, co-location of pedestrian road crossings and provision of stop infrastructure (shelter, seating, bicycle parking)

- Stopping buses in the traffic lane at stops such that they do not lose their spot in the traffic queue, and removes safety issues associated with pulling out from the kerb to re-join the traffic flow
- Introduce a higher proportion of express bus services that do not stop at every stop but just at those stops with high boarding numbers.

Concept 2: Bus priority in shared transit lane:

- T2 lane applied to the centre lane of Bondi Road in the peak direction
- Increased use of express/limited stop bus services operating in the T2 lane
- Stopping bus services would continue to use the general traffic lane (delaying general traffic behind the bus at stops)
- Right turning movements at major intersections from the T2 lane with traffic signals giving priority to clear turning vehicle from the path of peak direction express buses
- Right turn into properties banned (left in/left out only).

Concept 3: Bus in managed dedicated bus lane:

- Use of high capacity buses using alternative power sources (such as electric, or gas)
- Dynamic lane management of the Bondi Road corridor to create a peak direction bus transit lane
- Use of overhead gantries and line marking to indicate a change in lane usage in the morning and afternoon peak periods
- Parking restrictions apply to both sides of Bondi Road during the morning and afternoon peaks
- Lane usage would change depending on the peal direction flow and be allocated as follows:
  - one peak direction bus lane adjacent to the kerb
  - two peak direction general traffic lanes
  - one counter peak direction general traffic lane adjacent to the kerb
- Right turn into properties banned (left in/left out only).

Concept 4: LRT in dedicated lane:

- Light rail tracks placed in the centre of the Bondi Road as a dedicated right-of-way
- Diversion via Rowland Avenue, Fletcher Street and Denham Street, to bypass the steep gradient in Bondi Road, is expected
- Use of catenary free light rail (or other traction power options) used to avoid the need to erect overhead wiring
- Placement of accessible stops at acceptable intervals to promote the removal of buses from the corridor is likely to require property acquisition
- All parking in Bondi Road to be removed/relocated to allow the kerbside lanes in each direction to be allocated on a full time basis to general traffic movements
- Right turning movements at major intersections only
- Right turn into properties banned (left in/left out only).

Concept 5: Monorail:

- Use of multi-car vehicles to provide a capacity similar to LRT vehicle
- Monorail to be elevated above the Bondi Road corridor

- Stations to be constructed above larger intersections separated by suitable distances to promote accessibility and allow the removal of buses from the corridor
- No change to lane availability provided that supporting structures for the monorail beam can be designed to fit within the available road space.

8.6.2 Route variations

The preferred route for all modes is via Bondi Road to Bondi Junction with the exception that, due to steep gradients towards the eastern end of the corridor, it is expected that the LRT option may need to be diverted via Rowland Avenue, Fletcher Street and Denham Street.

The issues as to whether the future transport solution should connect into the heavy rail network at Bondi Junction or be continued through to the CBD is dependent on the:

- Interchange – interchange between modes will cause a degree of inconvenience to passengers, experienced as delays to the journey (including walking and wait times) and inconvenience (needing to leave one vehicle to enter the other) Given that the heavy rail at Bondi is two levels underground, the most convenient interchange will be from surface modes (i.e. bus and LRT) and the least attractive would be from elevated modes such as monorail
- Passenger preferences – general experience is that passengers prefer a legible journey that provides a single vehicle for the entire journey and a route that is easy to interpret (i.e. how to get from one location to another). Interchange interferes with this process
- Level of demand – the lower the level of demand for a service the lower the viability to build and operate the service over longer distances (the rule of diminishing returns)
- Characteristic of the mode to be adopted – modes that interact with, or compete with, motor vehicle operations at street level are less likely to be successful the closer the route is taken to the CBD
- Cost - the closer to the CBD, the more expensive it is to construct and to resolve the interfaces with surrounding land uses
- Environmental/planning – the more densely populated and established an area is the harder it is to obtain the planning and environmental approvals for the project
- Commitment – public transport will need to compete for road space with motor vehicles meaning that motorists and other street users will need to vary their travel patterns. The feedback from these people will have the tendency to limit the public transport outcomes that can be achieved.

The following figure provides a high level assessment of how easy it is likely to be to extend each of the modes through to the CBD based on engineering and environmental/planning factors.

Figure 8.2 Difficulty associated with extending Concepts from Bondi Junction to CBD

8.7 Comparison of impacts from the public transport concepts

A high level assessment that assists in understanding the differences between the selected concepts and their impacts on the corridor, community and land uses can be found in Appendix B.

9 Concept assessment

9.1 Developing the assessment criteria

In section 4 the problems associated with the current transport operations in the Bondi Road corridor were identified. A range of public transport options with the potential to address these problems were identified in sections 7, and in section 8 these options were reduced to a short list of five potential solutions for further evaluation.

The following table breaks down the identified problems into components to allow a multi-criteria assessment to be undertaken of the concepts.

Table 9.1 Assessment criteria

Problem	Assessment criteria	Assessment guidelines
A: Mode share	A1: Ability to encourage ridership through mode transfer	Is the proposed option perceived to be attractive for travellers thus encouraging them to change their travel preferences (this is about perception rather than functionality)?
	A2: Desirable origin/destinations	Does the proposed option provide direct access to destinations desired by travellers?
	A3: Distance between stops	Are the stops likely to be placed close enough together to make it easy to access the option? How does this compare to the spacing of the existing bus stops?
B: Travel demand	B1: Potential to accommodate future travel demand increase	Does the option have the potential to provide adequate capacity to meet demand?
C: Travel time	C1: Time to reach Bondi Junction	To what extent does the option improve public transport travel time between Bondi Beach and Bondi Junction?
	C2: Time to reach CBD	To what extent does the option improve public transport travel time between Bondi Junction and the CBD?
D: Travel time reliability	D1: Predictability of journey time	How more predictable are travel times likely to be by removing impediments to the movement of public transport vehicles?
	D2: Comparable journey times in peak and off peak periods	Are travel times consistent across the day, or how big is the peak hour journey time variance due to interface with traffic congestion?
E: Network connectivity	E1: Efficiency of linking to the CBD	How well does the option provide easy and timely connection with other public transport options providing wider access to metropolitan area?
	E2: Efficiency of linking to the wider Sydney area	Where interchange is required, how user friendly is the interchange and how large is the potential time penalty?
F: Technical feasibility	F1: Installation of the right of way in the available road space	Is it technically feasible to install the option within the available road space? This includes not only the right of way but also the stops.
	F2: Ability to resolve traffic throughput capacity	How likely is it that the road space remaining for use by general road traffic will be sufficient to accommodate through traffic and property service functions (e.g. deliveries, garbage collection etc.)?

Problem	Assessment criteria	Assessment guidelines
	F3: Design of intersections	How likely is it that intersection design will support turning movements without disruption of through traffic movement and public transport?
G: Public opinion	G1: Removal of car parking	What is the degree of impact on the provision of car parking along Bondi Road?
	G2: Minimisation of resultant traffic congestion	Will the public perceive that the proposed solution will deliver on the potential to reduce traffic congestion?
	G3: Impact on visual amenity	How significantly will the visual impact from the option affect the attractiveness of the road corridor for other users and residents?
	G4: Visual impact	How will the visual aspects of the corridor be affected by the transitway and stop design?
	G5: Impact on retail	How great an impact will be incurred on the retail activities along Bondi Road?
H: Liveability	H1: Noise	How will the proposed solution affect noise levels?
	H2: Vibration	How will the proposed solution affect vibration levels?
	H3: Air quality in the corridor	How will the proposed solution affect air quality levels?
I: Sustainability	I1: Use of non-polluting fuel sources	Does the solution provide the opportunity to utilise less polluting forms of traction power?
	I2: Ability to accommodate walking and cycling	Does the potential design of the public transport solution allow the provision of adequate road space for walking and cycling?
J: Safety	J1: Pedestrians crossing the street mid-block	Is there an increased risk to pedestrians who choose to not cross at traffic signals? Hoe convenient is it to access designated signalised crossing points?
	J2: Traffic management	Are motor vehicles exposed to a greater risk of collision as a result of changes in the way in which intersections operate?
	J3: Stop design	How easily can accessible stops be designed into the road space to avoid passenger/car conflicts?
K: Land use outcomes	K1: Ability to use stops to focus land use development	How will the style of stops help to provide a focus for uplift of land uses?
	K2: Land use planning	Does the Planning Scheme support land use intensification around stops, and is there a preparedness to change the scheme to support public transport mode share increase?
L: Value for money	L1: Construction cost vs uplift in capacity	Can the additional construction costs be offset by an increase in ridership? What is different that will attract more people to public transport?
	L2: Utilisation of existing public transport infrastructure investment	How does the concept support existing investments in the public transport network?

9.2 Multi-criteria assessment outcomes

A workshop was held involving representatives from Waverley Council and Transport for New South Wales in order to undertake an assessment of the short listed concepts to assist and focus the development and refinement of transport solutions for inclusion in the strategy.

Details of the outcome from the multi-criteria assessment can be found in Appendix C and summary of the score outcomes is summarised in Figure 9.1.

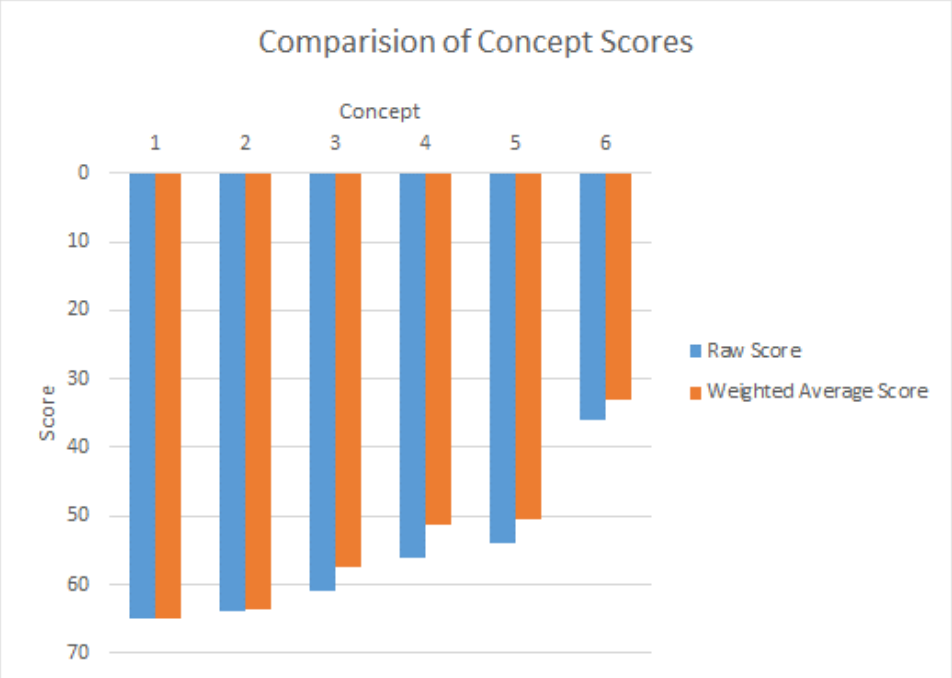


Figure 9.1 Summary of Multi-criteria scoring outcome

The general conclusion drawn from the assessment is that public transport concepts that provided additional capacity through the provision of a new/additional corridor to complement the capacity of the Bondi Road corridor scored strongest (i.e. Metro Rail and Monorail). Next were the concepts that provided a segregated public transport corridor within Bondi Road (LRT and BRT). Concepts that endeavoured to optimise the operation of the corridor within existing traffic and infrastructure constraints were least favoured.

9.3 Indicative scheme costs

It is difficult to be definitive about the potential cost of providing the required infrastructure for each concept given that design has not yet been commenced. Therefore it has been necessary to generalise about the costs based on unit rates per kilometre identified from similar projects. But even then, the availability of relevant examples are few and far between, often the costs have not been available in the public domain and/or the nature of the project design is not necessarily consistent with the needs of the Bondi corridor (e.g. number of stations, difficulty of design/construction etc.).

There are also site specific considerations that might significantly impact the costs (property values, utilities, etc.). Therefore, the cost details provided below should be taken as a guide only and are best used for comparative purposes between the concepts. A search of publically available data has generated the following examples:

Table 9.2 Indicative infrastructure costs (excludes rolling stock)

Concept	Comparative project	Source of cost	Corridor cost per km ($m)	Length of Bondi Route (km)	Indicative Total cost ($M)
Bus priority	No attempt has been made to apply a cost to this concept without a definition of scope.	n/a	-	-	-
Managed tidal flow lanes	n/a	Internal WSP | Parsons Brinckerhoff experience.	TBA	TBA	$10M
Bus Rapid Transit	Sydney Northern Beaches B-Line	The project is 27 km long and $230M of funding has been allocated.	$8.5M	3.9 km Bondi Junction to North Bondi 8.5 km CBD to North Bondi	$33M $72.3M
Light Rail	Sydney CSELR	The George Street section is reported to cost $1.4b of the $2.1B for the 15 km project from the CBD to Randwick. Therefore the balance is expected to cost $700M for the remaining 13 km.	$53M	3.9 km Bondi Junction to North Bondi 8.5 km CBD to North Bondi	$207M $450M
Monorail	Various international schemes	There is no Australian experience. International experience suggest US$40M per km in 2006 dollars.	$60M	3.9 km Bondi Junction to North Bondi	$234M
Heavy Rail Metro Rail	Epping Chatswood Rail Link Sydney Metro NW	(Heavy rail) – $2.35B for 12.5 km (2009) Metro rail – NW metro project $8.3B cost for 23km	$193M $345M	4.3 km Bondi Junction to Bondi Beach 8.5 km CBD to North Bondi	$830M $2.93B

Note: Costs are for route infrastructure only and exclude the cost components such as of stations and rolling stock

What the table indicates is:

- Modifications to tweak the existing bus network are relatively low cost
- The application of managed tidal flow lanes will improve road capacity at a moderate cost
- BRT introduces a step in the cost function but represents the lowest cost form of mass public transport
- The cost of LRT and Monorail are of a similar magnitude
- Construction of a Metro Rail (heavy rail) is by far the most expensive solution.

10 Public transport implementation strategy

10.1 Staging the development of public transport solutions

It is important that the implementation of public transport solutions within the Bondi Road corridor matches the demand so as to ensure that the capital investment is optimised against the needs of the community. The existing bus services, operating at 17 buses per hour have been estimated to have the capability to carry approximately 1,120 people/hour/day which equates to the current level of demand meaning that users will be experiencing overcrowding and delays in their journey. This prompts two questions:

- Would more people use public transport if the capacity was greater?
- Is it possible to increase the service level?

Quite clearly traffic congestion in the corridor is becoming severe, with flow in both of the two peak direction lanes breaking down during both the morning and afternoon peak periods. Significant congestion is also experienced during off peak periods, and especially during the summer months when access to the beach is high and during special events. If public transport is to play a more important role in the corridor then motorists must be willing to transfer from their private vehicles. This will only happen if:

- Public transport offers a better door to door journey time
- Motorists perceive that public transport use provides them with a better outcome when the perceived loss of amenity/comfort of their private vehicle is forgone.
- Traffic congestion causes a degree of frustration making the private vehicle trip unacceptable

There are indications that motorists are finding the journey along Bondi Road onerous and could be seeking an alternative should a suitable one be available.

As to whether the existing frequency of service can be increased to accommodate more people, this is a complex issue that needs resolution on several fronts:

- The current service levels of 17 buses per hour (or a bus every 3.5 minutes) is not considered a high frequency by international standards. The ultimate capacity will be determined not just by traffic congestion but also the phasing of traffic signals along the corridor. Assuming a 90 second signal cycle it should be possible to increase service levels to 40 buses per hour with an average of one bus per cycle.
- Interaction with traffic will slow down buses and make it harder to enter/leave traffic flows and to make turning movements. Fortunately, during peak periods there are few such movements required.
- Capacity of stops will limit how many buses can be processed at a time. For street stops this will relate to the length of the stop, but at Bondi Junction the configuration of the interchange will need consideration.
- The capacity of the Sydney CBD streets (and stops) to accept more buses needs consideration with the CSELR poised to change the operations strategy for many CBD streets.
- More frequent services levels will drive the need for investment in additional buses, which may only achieve one or two return trips during each peak. The low utilisation of these additional vehicles may make the justification of their purchase challenging.
- If more buses were to be purchased then they will need to be stored and serviced somewhere so the capacity of existing depots will need consideration.

This report does not aim to resolve those issues. However, there would be a case to support further investigation into increasing bus frequency as outlined in Sydney's Bus Future. However, to do this it would be important to also improve the passage of buses along the corridor through the use of increased bus priority measures as a means of attracting mode shift and increasing the overall capacity of the corridor. Further investigation of this matter is worthy of investigation as a means of increasing the capacity of the corridor in the short term.

After optimising the existing system to maximise its capacity the next step would be a quantum shift in the way in which bus services are provided in the corridor. There are two streams:

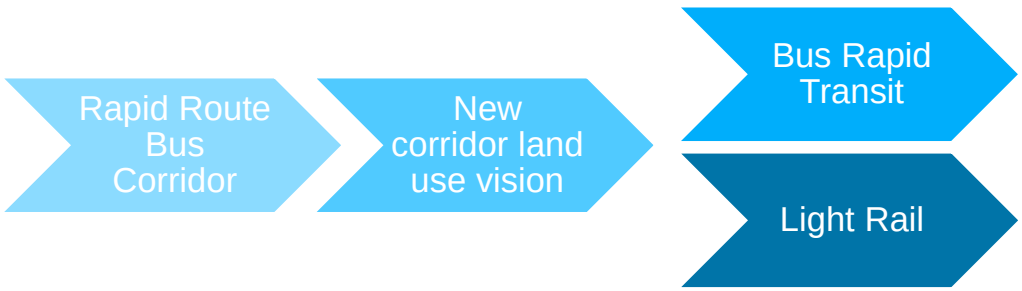
- Move towards managed traffic lanes that provide for a part time bus lane whilst maintaining peak direction traffic flows. The net impact of such a strategy would be to increase the capacity of Bondi Road and enable the potential for an increased number of trips towards Bondi Junction and the CBD. There is the potential for some mode shift driven by improved service frequency and speeds.
- Introduce a bus lane and BRT style operations by reallocating a traffic lane to the exclusive use by buses. This will allow some quantum changes in the way in which bus services are provided and substantially lift capacity. The trade-off however is the loss of a peak direction traffic lane meaning that at least 50% of car based commuters would need to mode shift to public transport so that the remaining traffic lane can cope with demand.

The alternative to persisting with the use of buses to fulfil travel requirements would be to make a "step change" to a new street based transit system choosing from one of the following:

- LRT requires reallocating a traffic lane to the exclusive use by LRT vehicles. The trade-off however is the loss of a peak direction traffic lane meaning that at least 50% of car based commuters would need to mode shift to public transport so that the remaining traffic lane can cope with demand. This would also require the removal of parking and local property acquisition at intersections to accommodate compliant light rail stops
- Monorail would be elevated above the corridor and therefore has the potential to add capacity to it. However the technical feasibility of accommodating the guide rail support structures within the available width requires further consideration. The issue of impacts to visual amenity and potential loss of footpath capacity are also likely to be key community issues.

The final quantum step in the provision of public transport would be to remove mass public transport provision from the corridor, leaving it largely to motor vehicles and a local bus services, by providing a new Metro style underground rail service on a totally new dedicated corridor.

The strategy applicable to Bondi Road would best be represented by a transitional approach that responds to levels of demand supported by land use change through a staged implementation pathway as indicated below:



There is a clear decision point once the rapid route has been established and the future land use vision is developed. Whilst BRT could be implemented in the first instance on the premise that LRT would be installed at a later date, there are few international examples where such a transition has been made between modes because there are challenges associated with continuing to provide BRT operations whilst the new light rail infrastructure is constructed. Further investigations would be required to examine the technical design implication of such an approach.

Without a significant change to the land use strategy to allow substantial intensification of land uses generally across Waverley beyond Bondi Junction, the mode choice decision is not expected to be implemented for many years, provided that sufficient priority is provided to rapid route buses, and there is a sufficient uptake of public transport use in the meantime to help ease motor car transport demands on the corridor. The exception to this, and the issue that may bring forward the decision, will be how successfully the rapid route bus solution is in capping traffic demand given the existing congestion in the corridor.

10.2 Scope of delivery

Consideration is required as to where the termini for the new network are to be provided. The longer the route the higher the cost and the greater the task to secure funding.

Existing bus routes terminate at North Bondi, at the northern end of Campbell Parade on the site of the original tram terminus. At the western end, some routes terminate at Bondi Junction to allow access to precinct and the heavy rail interchange, whilst others continue through to the CBD.

Given the relatively low cost of each of the bus related concepts, and the existing presence of bus lanes along Oxford Street to the CBD, then it would be logical to continue this service pattern.

However, given the higher cost of the LRT and Monorail concepts, then it is appropriate to question the justification for extending these routes past the centre of Bondi Beach saving about 0.7 km (or $37M) of route construction. It may be necessary to consider some of the bus routes from North Bondi to interchange with the light rail in order to maintain connectivity to the more northern suburbs of Waverley.

The more important decision for these modes is the question as to whether they should be extended further west than Bondi Junction where there would be the opportunity to interchange to heavy rail for the balance of the trip to the CBD. The challenge is to justify the additional infrastructure cost in relation to the additional patronage such a strategy would deliver, particularly considering the investment already committed by government to the construction of the T4 Eastern Suburbs line which is operating below its operational capacity. In a previous section of the report there has been some discussion regarding the difficulty in identifying a suitable route into the CBD, and raising the issues as to where the network would operate within the CBD.

Another issue relates to the provision of stabling and maintenance facilities. With a Monorail, the technology would be bespoke and have no synergies with other transport modes, therefore it would be necessary to identify a suitable depot site somewhere along the proposed route. The LRT situation is slightly different in that a connection to the CBD could provide a link to the rest of the Sydney Light Rail network providing access to depots in other areas of the city, if not to meet all requirements but at least for heavy maintenance which would reduce the size of any depot to be provided on the Bondi route. However, if the LRT only runs between Bondi and Bondi Junction it would be essential to identify a suitable, sizeable area of land to fulfil this depot function within the key centre.

The issues associated with any Metro rail option are somewhat straightforward. The reason for this is that it is not expected that Waverley could justify such an investment based on travel demand alone. Therefore the potential for this solution lies with a need to terminate trains operating on any future Sydney Metro West line, a function that would be difficult/expensive to achieve under the CBD.

10.3 Sources of funding

Local Government

Council owns, operates and/or manages a range of assets within the Bondi Road corridor and therefore has the potential to influence travel behaviour to help achieve desired outcomes. For example, prioritising more sustainable travel options for local trips by improving walking and cycling infrastructure, will reduce local motor vehicle trips made by residents, and reduce parking demand. Funding for such complementary works could come from Council's recurrent or capital budgets or could be sourced from the sale of assets, or from rate increases or levies on local property owners.

State Government

The funding of public transport infrastructure has traditionally been provided by state governments with support from federal government. This practice has come under significant pressure in recent years due to budgetary constraints, the volume of projects seeking funding, and other priorities.

Much has been discussed around the use of value capture as a funding source that can supply a cash stream to government to offset the capital cost and interest payments on borrowed money. To date there are no known recent public transport projects in Australia that have been successful in capturing capital gains in property values. The basic reason is that the ownership of properties along the corridor is generally in small lot private holdings, and the main taxation basis for these properties is via Council Rates which are retained by local government for their own use. There are some projects where developer contributions have acted as a quasi-tax on value realised from the development of a property but these effects tend to be localised in nature and do not necessarily apply over the length of a corridor such as Bondi Road where there are substantial numbers of established, small lots. In 2013, KPMG undertook an assessment of value capture opportunities to support the upgrade of street infrastructure as part of Waverley Council's Complete Streets project. They identified two options that could potentially be applied, but noted that there would be issues to resolve before such an approach could successfully proceed:

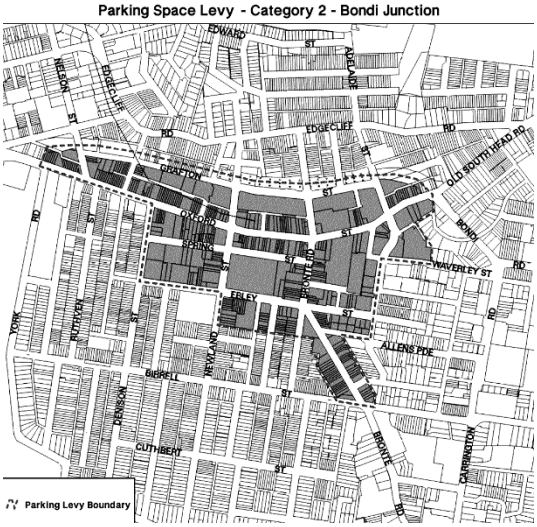
- Option 1: A special levy – provides the greatest scope for raising all of the funds required for the Complete Streets Project but there is uncertainty surrounding the administrative process for gaining approval from the State Government.
- Option 2: Voluntary planning agreements – these have a better defined administrative process but there is less funding certainty – i.e. the levies differ for each development and in the absence of sufficient funds Council need to access revenue sources that are not directly tied to the Project or the region.

The office of State Revenue NSW administers the Parking Space Levy. It was introduced in 1992 to discourage car use in business districts by imposing a levy on off-street commercial and office parking spaces. The parking space levy is a levy on parking spaces within nominated leviable districts, which include Bondi Junction.

The levy applies to any residential and non-residential off-street space used or reserved for a motor vehicle, including:

- commercial and office parking spaces
- parking spaces in parking stations
- marked and unmarked spaces
- vacant land used for parking motor vehicles
- car spaces in a residential block not used by the owner or tenant.

Parking Space Levy - Category 2 - Bondi Junction



The NSW Parking Space Levy Act (2009) stipulates that funds raised are reserved in the Public Transport Fund in order to:

- finance public transport services
- finance projects that facilitate access by public transport to and from, or within, leviable districts
- finance initiatives for the communication of information to commuters (such as real time information).

Each leviable car parking space in Bondi Junction contributes $840 per annum (indexed to the consumer price index) to the NSW Parking Space Levy. Bondi Junction overall contributes $1.1 million per annum to the total $105 million collected annually by the Office of State Revenue. The amount per space commenced at $400 per space (year 2000) and is now $840 per space (July 2016). Hypothecated over a 20 year period, the Bondi Junction contribution equates to around $22 million. There is a reasonable case for this contribution to be used towards improving the Bondi Junction transport interchange and Bondi Road corridor including upgrades to pedestrian access, bicycle parking, real time information, and improved bus operations

It should also be recognised that the Bondi Road corridor has already been designated as a rapid bus route in Sydney's Bus Future. This suggest that the funds for its initial implementation and future planning are captured within this program by Transport for NSW.

Federal Government

City Deals are a new federal government initiative as part of the Smart Cities Plan. City Deals between the Australian Government, a state or territory government, and local governments are planned to improve cities better to make them better places to live in and do business. Through City Deals, governments, industry and communities will develop collective plans for growth and commit to the actions, investments, reforms and governance needed to implement them.

Through making the most of new and existing investments of governments, City Deals will set out the specific investments and reforms needed to unlock business and industry development and ensure community wellbeing. In addition to being more strategic, City Deals will drive reform through incentivising actions and accountabilities at the state and local level.

By bringing together all levels of government, the private sector and the community, City Deals will provide a coordinated investment plan for our cities. A partnership approach, across all levels of government, private sector and the community, will allow the Australian government to capitalise on the opportunities in each city. Cities, or parts of cities, will be selected though consultation with state and territory governments, prioritising areas where the opportunities are greatest.

Private Industry

The most likely source of non-government funding will come from private ownership and operation models for public transport options. There are several different models available for this:

- Public private partnership (PPP)
- Build, own, operate and transfer (BOOT)
- Private ownership
- Crowd sourcing.

The issue is that it will be hard for a private company to justify the investment in a high level public transport scheme within the corridor because of the low ridership and relatively short distance involved which reflects in low revenue return on the investment. It is likely that fare box revenue will struggle to meet operating costs and some form of Government subsidy could be required to make the proposition attractive to the private sector. Options available include revenue subsidies, shadow payments, or fee for service contracts based on trips operated. Also, a private company may find it more difficult to resolve property issues, traffic priority changes, and address public opinion given the developed nature of the corridor. However a private company may well be in a better position to leverage property development outcomes to offset the cost of the scheme.

Whatever the outcome it is expected that there will need to be a government contribution towards the capital cost, and most likely an ongoing subsidy for operations. The magnitude of these contributions would need to be confirmed through a rapid assessment business case.

10.4 Engaging the local community

As outlined throughout this report, there are a number of key local issues associated with implementing higher capacity modes of public transport on the Bondi Road corridor such as:

- Removal of on-street parking
- Changes to traffic operations:
  - Likely restriction of some local road and property access due to the reduction of turning movements for general traffic
  - Changes to traffic signal phasing at cross-streets
- Required property acquisition to establish safe and compliant stops/stations and maintain traffic flow
- Likely requirements for land use uplift around stops and stations to support the funding of higher capacity public transport modes such as light rail, heavy rail or metro rail
- Increased intensity of development along the corridor to justify a substantial increase in transport servicing and investment.

The issues listed above are likely to impact local business and residents along the corridor. The introduction of public transport can also benefit (over a longer period) these same constituents however a case clearly needs to be articulated by the projects proponent/s. It is recommended that these issues be clearly tied to a new land use vision for the corridor in coordination with the provision of a new public transport mode.

It is also acknowledged that previous high capacity public transport schemes proposed in the area had the potential to improve the movement of residents and visitors into and out of the Bondi Beach area, this was not viewed as a positive outcome by some parts of the local community. This position should be revisited with the community to gauge more current opinions on this, particularly in the light of increasing road based congestion on the corridor and the scope to change the previously controversial station location.

These issues are not unique to this corridor and can be addressed through project planning, environmental approvals and stakeholder engagement. It is recommended that Council continue to engage with the community and educate them on the benefits and challenges of implementing higher capacity public transport solutions and gauge the community support for such step change in public transport in their community. An acknowledgement of the wider benefits and impacts to adjacent suburbs to the corridor and the entire Waverley LGA is also a key consideration.

10.5 Working with state government

The solutions outlined in this study are linked back to a number of state government transport and planning initiatives. It is recommended that Council build upon the state government relationships established through this study to progress the public transport solutions for the Bondi Road corridor.

The initial step would be establishing the priority status of the implementation of the rapid route bus measures from Bondi North to the CBD as outlined in Sydney's Bus Future. This is the first step in upgrading public transport in the corridor and will provide a platform for future public transport growth in the corridor in the short to medium term.

Council should also be active in the district level discussions and planning (Central District) being undertaken by the Greater Sydney Commission as they are the agency responsible for coordinating local and state government planning and infrastructure initiatives. This provides a unique opportunity to raise the awareness of the Bondi Road corridor as a vital network link to support the operation of the key centre of Bondi Junction. This approach can also facilitate the required support from state government to pursue a City Deal with the Australian Government to assist in funding for the upgrade of this vital public transport corridor.

The final step is for Council to continue its dialogue with state government generated through this study about the potential for additional medium term public transport measures such as light rail and metro rail/heavy rail extensions into the Waverley area as part of larger public transport projects currently being investigated. As the current future demand forecasts suggest there is little additional growth to support extension of the rapid transit, there is an opportunity to develop a new land use vision and urban outcome for the Bondi Road corridor as a 'boulevard to the beach' which will reinforce the status of this key public transport corridor within Waverley and the Central District of Sydney.

Appendix A

PUBLIC TRANSPORT OPTIONS INVESTIGATION

A.1 Public transport options investigation

A.1.1 Route options

A.1.1.1 Option 1: Bondi North to Bondi Junction

Option 1a: Via Bondi Road

Bondi Road is an existing road corridor that provides a relatively direct surface corridor between Bondi and Bondi Junction. Predominantly, the road is four lanes wide and has a cross section width of approximately 20 m. Whilst the curvature of the road is consistent with the requirements for all street based forms of public transport design, the gradient towards the eastern end, on the curve that descends to Campbell Parade is about 20% (1:5) as compared to the maximum design gradient for light railways which is typically around 7% (1:16). Whilst this gradient is clearly too steep for a light rail solution, buses regularly navigate this road, therefore only bus based solutions have been considered for this route which is a departure from the Waverley Light Rail Study (AECOM, 2013). A monorail solution has also not been ruled out on the basis of gradient because the supporting structure could potentially be adjusted to allow the gradient of the hill to be eased by changing the height of the rail above the ground.

Option 1b: Via Bondi Road and Rowland Avenue/Fletcher Street

This route is representative of the route taken by the original Bondi tram tracks. The alignment diverges from Campbell Parade north of Francis Street and travels through parkland before passing under Bondi Road towards Rowland Avenue in its own reservation, before returning to street operation via Fletcher Street and Denham Street, and returning to Bondi Road at the top of the steep part of the gradient. The additional route length allows easing of the gradient to around 7% (1:16) which is acceptable for light rail operations. This is a departure from the findings of the Waverley Light Rail Study (AECOM, 2013).The challenges faced with reinstating this option will largely be associated with:

- The need to demolish two three storey residential buildings built on the alignment
- The need to undertake earthworks to reinstate the original gradient
- The narrow width of Rowland Avenue (~15 m)
- The potential impacts on existing land uses along the route, which are largely residential.

Option 1c: New direct alignment

The application of a new, more direct route, between Bondi to Bondi Junction is only feasible as a new underground solution due to consideration of:

- *Land use* – a direct route that does not follow an existing road corridor will deliver the fastest possible journey time and resolve geometric issues associated with following road geometry which has tighter curves than can be negotiated by heavy rail. However the land use along the corridor is predominately medium density residential. Therefore anything other than an underground solution is likely to present an unacceptable community outcome.
- *Topography* – There is a significant height difference between Bondi Beach and Bondi Junction and there is a hill situated between the two locations. If the transit solution were to follow the natural gradient then the average climb to the top of the hill is 1:22, however due to the unevenness of the ground some sections exceed the maximum allowable gradient for railway operation, suggesting that there would be a need for significant earthworks. Further investigation would be required should such an option be adopted.

- *Geometric transition* – Bondi Junction Station is located underground, and has a train turn back and stabling facility that curves to the south of Bondi Road. For the heavy rail to transition from its underground situation to a ground or elevated position, a considerable length of tunnel dive would be required with a significant impact on existing properties. The ability to connect to the existing underground infrastructure needs to be investigated, however extending the existing tunnel would push the new alignment towards the south east before it could curve back towards Bondi adding construction cost and travel time to the project assessment.

A.1.1.2 Option 2: Bondi North to CBD

Option 2a: Existing heavy rail network (incl. interchange at Bondi Junction)

The existing heavy rail corridor from Bondi Junction to Central Station provides direct access to the CBD and connections to the wider rail network. Given the investment that has already been made to develop this corridor, it is attractive to optimise its use and avoid the need to establish a further transit corridor towards the CBD. However, in order to use this to complete a journey from Bondi to the CBD there will be a need to interchange from the mode used between Bondi and Bondi Junction, unless the heavy rail is to be extended. This inserts an interchange time penalty into any such trips and reduces the attractiveness of this option compared to a single mode solution.

Option 2b: Via Oxford Street

Oxford Street provides the most direct street-based link to the CBD and is the route of the original Bondi tram. Given the changed land uses and increased reliance on the street by motor vehicles in more recent times, consideration will be required to determine if it is possible to reinstate light rail back into this street.

Option 2c: Via Moore Park Road and Flinders Street

This route provides an alternative to the use of Oxford Street. It's wider road reservation (up to 30 m) and less sensitive land uses along most of the corridor provides better outcomes for a dedicated public transport corridor. However the Eastern Distributor Motorway tunnel exit near Greens Road may present some engineering challenges. Flinders Street already has part time, kerbside bus lanes which could be incorporated into any proposed transit solution. Reducing road capacity in the events precinct is also a concern for this option.

A.1.1.3 Option 3: Bondi North to Randwick

Option 3a: Via Carrington and Frenchmans Roads

There was a historic tram route which followed Bronte Road to Frenchman's Road towards Randwick. However the width of the Bronte Road corridor and the existing adjacent land uses (such as the Bondi Junction and Waverley shopping centres) would suggest that Carrington Street may provide a more acceptable option. The route is predominantly along roads that are four lanes wide, but the ability to insert a dedicated transit corridor becomes more challenging closer to Randwick where the road reservation narrows and becomes flanked by commercial/retail properties and their associated parking demands. Also, avoiding the congestion of Bondi Junction removes the possibility of an effective interchange with the heavy rail system, thus imposing a longer and much slower journey towards the CBD.

A.1.1.4 Option 4: Randwick to CBD

Option 4a: Interchange to proposed CSELR at Randwick

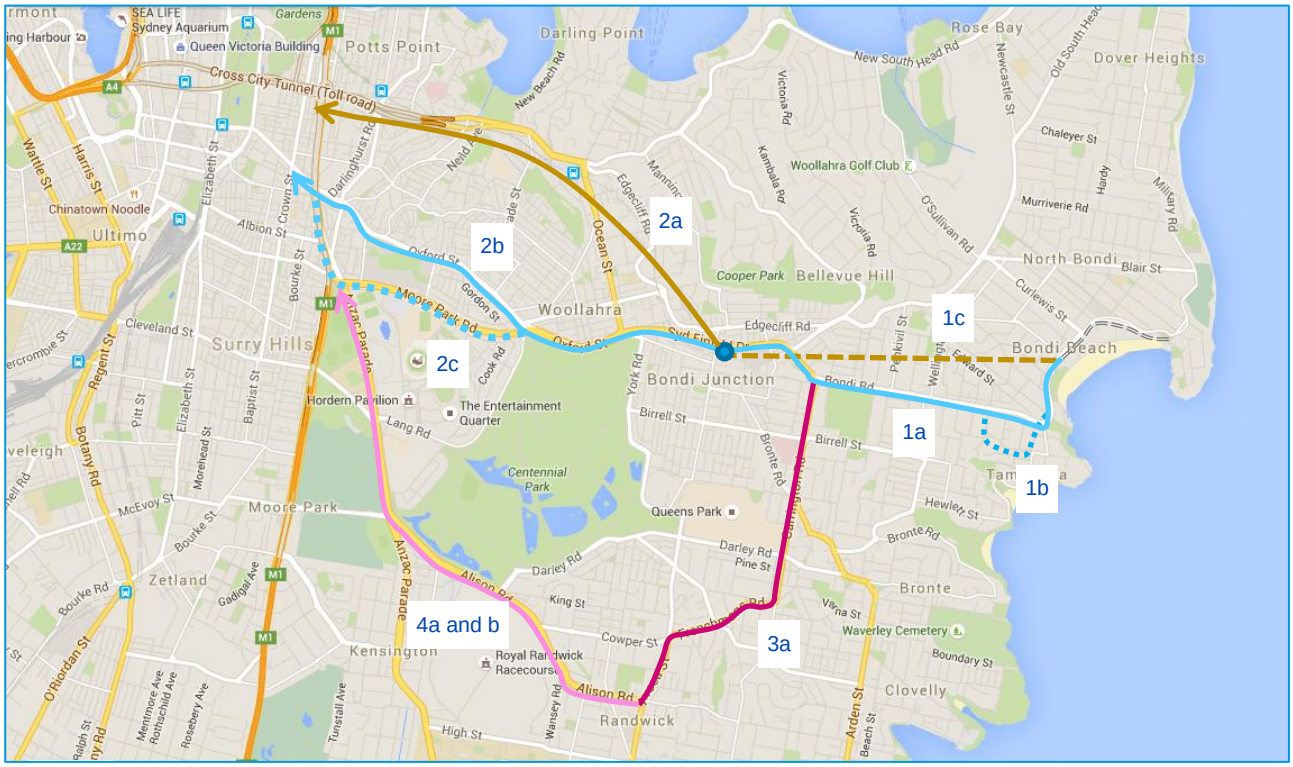
The '*Sydney's Light Rail Future'* document proposes a future light rail route through Randwick via Alison Road from the direction of the CBD (CSELR). One option is to provide an interchange between the Bondi service and the planned CSELR service. This will impose a further time penalty on Bondi travellers wishing to access the CBD as a result of the interchange activity. The advantage that keeping the two routes separate is that it may allow the use of smaller vehicles to be used on the Bondi section of the route thus reducing operational impacts in the Bondi area as a result of the use of more appropriately sized vehicles.

Option 4b: Direct to CBD via CSELR

This option involves operating light rail vehicles direct between Bondi and the CBD by sharing the proposed CSELR corridor. The ability to achieve this will be dependent on services frequency on each of the corridors over the common set of tracks. Despite this, it is expected that the journey time for Bondi travellers will be considerably longer than via the more direct routes via Oxford Street or Moore Park Road.

A.1.1.5 Summary of route options

The following map identifies each of the route options identified above.



A.1.2 Mode options

A.1.2.1 Do nothing

The do nothing option involves the retention of the existing street bus network as the sole source of public transport for the Bondi area. This is the benchmark against the alternative transport outcomes can be compared. For detail of the bus routes serving the area, refer to Figure 2.3.

The Sydney Transport Model (STM) shows that, under a 'business as usual' scenario, by 2036 the volume of traffic along Bondi Road would be untenable. The number of cars travelling in the peak direction along Bondi Road would reach up to 950 in the mornings and 1,400 in the afternoons. This would require two dedicated lanes of traffic to move cars, with no room for a bus priority lane.

The existing bus service system, operating under ideal conditions, has been assessed as having the potential to move around 1,360 passengers per hour. The 'business as usual' scenario shows a projected 1,600 people travelling by bus in the morning peak direction of travel and 1,430 people in the afternoon. It is clear that the number of projected passengers cannot be accommodated using the existing bus system under a 'do nothing' scenario.

A.1.2.2 Option A: Street Level Options

Option A1: Bus priority in shared traffic lane

This represents a minor enhancement to the existing bus system to decrease transit time and enhance running time reliability performance. The basic outcome is a bus that moves with the traffic along the corridor but gains an advantage at intersections and potentially congested sections of the corridor.

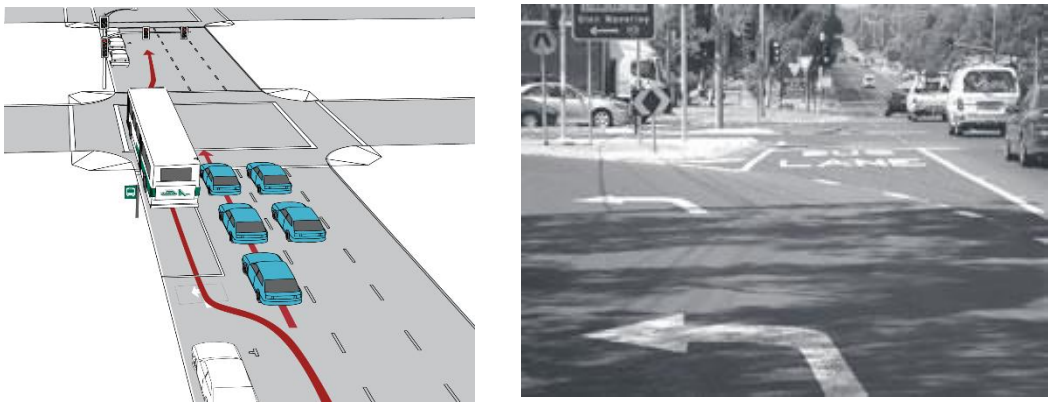


Photo A.1 Examples of bus priority treatments

Option A1: Bus Priority (in traffic)	
Description	→ An enhanced bus network on selected existing roads providing greater priority than present at intersections and selectively along corridors. → Bus vehicles similar to existing. → Capacity of 80 passengers per vehicle peak loading.
Characteristics	→ Bus priority at intersections provided by the use of queue bypass lanes and bus jump cycles at signalised intersections. → Could be developed incrementally as opportunities arise and resources become available. → Could be implemented relatively quickly due to a limited requirement for planning, consultation end environmental assessments. → Minimal reduction in road capacity for motor vehicles. → Bus operation still significantly impacted by general road congestion.
Impacts	→ This option will provide a small reduction in transit time and improvement in service reliability → A typical maximum capacity peak of 5,000 pphpd* could be expected as calculated using the following assumptions: ▪ 1 minute headways between buses ▪ 80 passengers per bus. → In Bondi Road, actual scheduling is currently limited to an average of 3.5 min headways which would indicate that a capacity of about 1,360 people per hour is being achieved

Notes: * pphpd = people per hour in the peak direction

Option A2: Bus priority in shared transit lane

This option provides a greater degree of bus priority along the whole corridor with a traffic lane nominated for use by buses. However, depending on the designation of the lane, it may also be used by other vehicles such as bicycles, motor bikes, taxis, motor vehicles with a designated minimum number of occupants (e.g. T2 lane allowing cars with two or more occupants to use the lane). The impact of this treatment for the public transport traveller is to reduce the level of congestion experienced by the bus by restricting vehicle numbers. However, in a mature corridor of fixed width, this means that the displaced traffic will be relocated to the remaining lane(s) adding to the congestion and delays experienced by other road users. However a lane carrying one bus every 5 minutes will move the equivalent number of people as a congested traffic lane, but this may not be understood by drivers in the adjacent congested general traffic lane when the bus lane appears to be underutilised.

Photo A.2 Examples of shared transit lanes

Option A2: Bus Priority (in transit lane)	
Description	→ Provision of a lane for use by buses in order to provide segregation from general traffic. → The lane may be shared by other selected vehicles depending on the preferred outcome and expected benefits. → Larger buses could potentially be used including articulated, due to the reduced need to interact with general traffic. → Capacity of up to 120 passengers per large vehicle peak loading.
Characteristics	→ Allocation of a traffic lane for primary use by buses. → Potential to selectively introduce other modes such a bicycles, motor bikes and taxis. → Potential to consider the lane as a T2 Transit Lane depending on traffic demand and the impact on buses.
Impacts	→ This option will provide a small increase in capacity due to the use of larger buses. → The main benefit will flow from more predictable and faster traffic times as a result of removing the buses from the general traffic congestion. → A typical capacity peak of 7,000 pphpd* could be expected as calculated using the following assumptions: ▪ 1 minute headways between buses ▪ 120 passengers per bus. → For the less than ideal traffic conditions in Bondi Road a service frequency of around 2 minutes using non articulated buses could be more realistic in delivering 2,400 pphpd.

* pphpd = people per hour in the peak direction

Option A3: BRT in dedicated lane (with intersections)

The term BRT is applied in a variety of forms. Given the corridor characteristics of Bondi Road, it is not possible to apply a pure BRT application where the buses are operated in a completely segregated corridor allowing the vehicles to be increased in size significantly. At a minimum along Bondi Road, buses will still have an interaction with traffic at intersections (whether signalised or otherwise) and at the ends of the journey where common roads/lanes will be required to reach the destination. There will also be issues associated with property access along the route, and space available to provide a positive hard barrier between the BRT corridor and any general traffic lanes.

Photo A.3 Examples of transitways

Option A3: BRT in dedicated lane	
Description	→ Dedicated BRT lanes as well as other system improvements to enhance frequency and journey times. → Modern low floor articulated bus vehicles. → Capacity of 180 passengers per vehicle peak loading.
Characteristics	→ Provides a new high capacity and high quality buses running on dedicated bus lanes with coordinated traffic signals. → 'Open' transitway allowing all buses on the corridor to use sections of the transitway. → Will require the removal of one traffic lane in each direction along the entire corridor on a full time basis and therefore rely on a high degree of mode shift in order to avoid increased traffic congestion.
Impacts	→ This option will provide a significant increase in corridor capacity due to the use of larger buses. → Travel times will be more predictable and faster due to the segregation from general traffic. → Traffic signal interaction is likely to be the controlling feature. → A typical capacity peak of 11,000 pphpd* could be expected in a segregated corridor as calculated using the following assumptions: ▪ 1 minute headways between buses ▪ 180 passengers per bus. → If operation is limited to the existing style of articulated bus currently operating in Bondi Road, due to the need to operate beyond the corridor, then a capacity of 7,200 pphpd may be more realistic.

* pphpd = people per hour in the peak direction

Option A4: LRT in shared lane

When LRT vehicles operate in mixed traffic conditions then there transit time and reliability will be no better than the surrounding traffic with average transit times of less than 20 km/h often observed. The main benefit flows from the number of people transported per area of road space. Therefore, this option would best be employed to increase the number of people that can be moved along a congested corridor, without any marked improvement in trip quality. The characteristics of the operation would be similar to 'Option A1: Bus priority in shared traffic lane' although capacity will be higher due to increased size of the vehicles.

Photo A.4 Examples of trams in shared traffic lanes

Option A4: LRT in shared lane	
Description	→ An LRT route on selected existing roads with appropriate priority measure employed to facilitate the efficient movement of the vehicles through the congested streets. → Capacity of 270 passengers per vehicle peak loading based on the new Sydney light rail design.
Characteristics	→ Light rail priority at intersections provided by the use of segregated approach lanes and jump cycles at signalised intersections. → Requires the entire route to be built up front meaning there is no opportunity to stage implementation. → Long lead times for approvals and construction. → Minimal reduction in road capacity for motor vehicles. → Light rail operation significantly impacted by general road congestion.
Impacts	→ This option will provide similar travel time and trip time predictability as for motor vehicles using the same corridor. → A typical capacity peak of 8,000 pphpd* could be expected as calculated using the following assumptions: ▪ 2 minute headways between light rail due to traffic congestion ▪ 270 passengers per vehicle.

* pphpd = people per hour in the peak direction

Option A5: LRT in dedicated lane (with intersections)

The operation of LRT vehicles under these conditions will be similar to the circumstances to be encountered for BRT operation, except that the larger LRT vehicles will boost capacity.

Photo A.5 Examples of trams operating dedicated lanes

Option A5: LRT in dedicated lane (with intersections)	
Description	→ Dedicated LRT corridor as well as other system improvements to enhance frequency and journey times. → Capacity of 270 passengers per vehicle peak loading based on the new Sydney light rail design.
Characteristics	→ Provides segregated light rail corridor within the road reserve with co-ordinated traffic signals. → Will require the removal of one traffic lane in each direction along the entire corridor on a full time basis and therefore rely on a high degree of mode shift in order to avoid increased traffic congestion.
Impacts	→ This option will provide improved trip time predictability because of the segregation of motor vehicles using the same corridor and will increase road space utilisation. → Reliability slightly lower than for BRT because buses can divert around obstructions if necessary. → A typical capacity peak of 16,000 pphpd* could be expected for a fully segregated LRT route as calculated using the following assumptions: ▪ 1 minute headways between light rail ▪ 270 passengers per vehicle ▪ In Bondi Road, the LRT frequency will be controlled by traffic signal cycle frequency and a lower operating headway may be experienced. If this is 90 seconds (1.5 mins) then carrying capacity will be reduced to 10,800 pphpd

* pphpd = people per hour in the peak direction

A.1.2.3 Option B: Elevated Options

Option B1: Heavy rail

Sydney already has a number of locations where the traditional design of rail network operates on an elevated alignment, and the new Sydney Metro will use a similar approach for extended lengths of track. This solution works well when the topography is right, and there is a credible corridor alignment along which to construct the structure. In the case of the Bondi area, which is one of the densest suburban areas in Australia, there is little opportunity to create a new corridor without significant social dislocation. The hilly nature of the suburbs would also an engineering challenge. Therefore the alignment would most likely need to follow an existing road corridor, with Bondi Road being an obvious candidate. The issues as to whether a massive elevated structure running along Bondi Road with the associated overshadowing effects is likely to draw a great deal of opposition from local interest groups and residents. Furthermore, the railway would need to connect to the existing subterranean system at Bondi Junction meaning that the length of the tunnel dive to connect the two would be substantial. It is not considered that this option could not be considered as a viable solution.

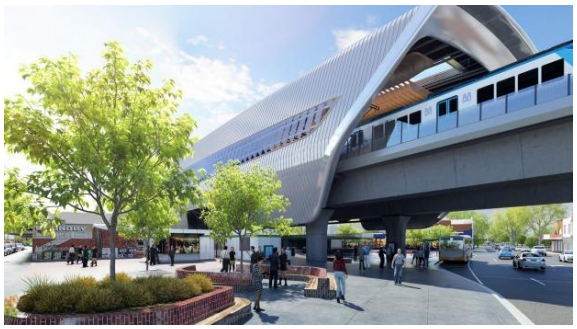


Photo A.6 Examples of elevated rail in urban areas

Option B1: Heavy rail (elevated)	
Description	→ Completely segregated, elevated corridor. → Compatibility with existing Sydney rail design, operations and infrastructure is preferred.
Characteristics	→ Elevated structure dimensioned to accommodate up to two heavy rail track, however the option of utilising a single track could be examined. This would be determined by patronage and operations considerations. → May be difficult to justify more stops than just the terminal station. → Requires the identification of a suitable corridor and the ability to connect to the existing underground railway line at Bondi Junction.
Impacts	→ This option will provide improved trip time predictability and reliability. → A typical capacity peak of 24,000 pphpd* could be expected (similar to the existing Bondi Junction rail line) as calculated using the following assumptions: ▪ 3 minute headways between trains ▪ 1,200 passengers per train ▪ If a single track option is adopted, then capacity is likely to be diminished to 12,000 pphpd ▪ 6 minute headways between trains ▪ 1,200 passengers per train.

Option B2: Light Metro (LRT)

Light metro railways are a crossover between heavy rail and light rail. They are cheaper to construct due to the smaller profile and easier to retrofit into the landscape because they can negotiate tighter corners and steeper gradients. There are two issues that suggest that this option should not be considered as an elevated solution for Bondi. First, the design suffers similar interface constraints with the local land uses, but also, it requires interchanges for passengers at Bondi Junction (if it is to be a feeder to the existing heavy rail network) meaning a substantial vertical transport task for passengers from the elevated structure to the subterranean existing station. Therefore this option should not be considered as a priority.

Photo A.7 Elevated light metro system examples

Option B2: Light Metro (elevated)	
Description	→ Completely segregated, elevated corridor. → Standalone system designed to be operated as a segregated rail operation.
Characteristics	→ Elevated structure dimensioned to accommodate two tracks. → Will require a number of stops along the route to encourage ridership. → Could be a privately owned/operated system. → Potential for driverless trains to reduce operating costs. → Requires the identification of a suitable corridor. → Requires a significant vertical interchange at Bondi Junction from elevated light metro to subterranean heavy rail.
Impacts	→ This option will provide improved trip time predictability and reliability. → A typical capacity peak of 24,000 pphpd* could be expected as calculated using the following assumptions: ▪ 2 minute headways between trains ▪ 800 passengers per train.

Option B3: Monorail

Monorails are designed specifically for elevated operation. The permanent way, or rail, is less intrusive than that required for railway design and therefore more compatible with urban areas than other elevated options. However, the airspace required for stations is substantial and these will impose a major impact on surrounding land uses. This means that monorails are not well suited to situations where there is a need to have frequently placed stations. The construction of the monorail rails requires a considerable diameter pillar(s) which will need to be inserted into the Bondi road space, which is already largely fully allocated. However monorails can negotiate tighter corners (typically as small as 46 m radius) and can be automated to reduce operating costs.

Monorail systems have developed significantly since the recently removed Sydney Monorail but they still lack an open un-patentable standard, which means that any solutions identified will be largely bespoke.

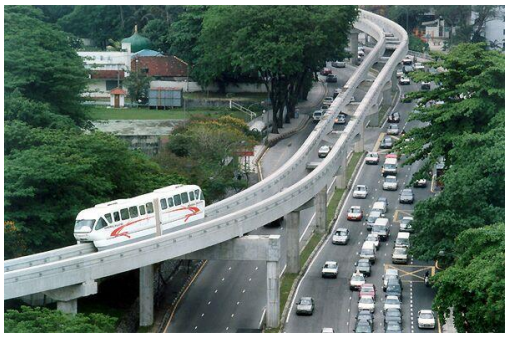


Photo A.8 Example of monorail systems

Option B3: Monorail	
Description	→ Completely segregated, elevated corridor. → Standalone, bespoke system design.
Characteristics	→ Elevated structure dimensioned to accommodate support beams. → Will require a number of stops along the route to encourage ridership. → Could be a privately owned/operated system. → Potential for driverless operation. → Requires the identification of a suitable corridor, most likely along Bondi Road. → Requires a significant vertical interchange at Bondi Junction from monorail to subterranean heavy rail.
Impacts	→ This option will provide improved trip time predictability and reliability. → A typical capacity peak of 24,000 pphpd* could be expected (similar to the existing Bondi Junction rail line) as calculated using the following assumptions: ▪ 2 minute headways between vehicles ▪ 800 passengers per monorail.

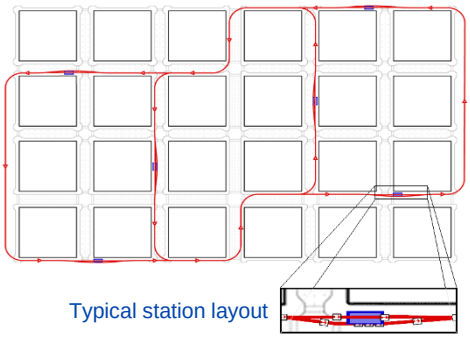
Option B4: Personalised Rapid Transit (PRT)

PRT terminology refers to the use of small autonomous vehicles (often referred to as pods) that travel from multiple origins to multiple destination, on demand, via a network of elevated guideways.

PRT is best suited to use in complex networks were there are random trip demand distributed fairly evenly over an extended time period. The system is accessed through a series of elevated stations, where a 'call' button is used to summons an available pod to visit the station. Upon boarding, the user programs a destination and the pod automatically conveys the user via the most efficient route.

The system is less effective in situation where demand in linear (such as along a corridor) where there are heavy boarding demands from one or two locations. This is because the system struggles to position pods quickly enough to clear peaks in demand without establishing a very large transfer station. In such circumstances, mass transit solutions can perform the same task much more efficiently.

Because the Bondi Road corridor is very linear in nature, and the need to interchange with trains at Bondi Junction where peak demands are created by the arrival of each train, this application is not well suited to the use of PRT. This, combined with the relatively high cost of construction, and the fact that to date a fully functional commercial networked system has not been built, the concept is not considered a viable solution.



Typical station layout

SkyCube, Korea

Figure A.1 Typical network design concept and vehicles

Option B4: Personalised rapid transit (PRT)	
Description	→ Small automated vehicles operating on a network of specially built guideways.
Characteristics	→ Network-wide deployment with many lines and closely spaced stations. → Elevated guideways. → Fully automated operation. → Only purpose designed systems have been built to date (such as from Terminal 5 to the carpark at Heathrow airport).
Impacts	→ The capacity of PRT is complex to establish because it is designed to work as a network with multiple trips to multiple locations. → In a linear application (such as Bondi Road) the capacity will be largely determined by the number of platforms provided at the terminal station (i.e. Bondi Junction) and the time allowance for boarding of people. Assuming average pod load of three persons, six loading points at the terminal station and a 20 second loading time, then the capacity would be 3,240 pph.

A.1.2.4 Option C: Underground Options

Option C1: Heavy rail

The heavy rail option allows the Bondi line to be an extension of the existing Bondi Junction line. The key to minimising capital and operating cost will be to identify the most direct route and suitable stop locations. There is potential to further reduce costs by considering a single track rail solution however this will introduce capacity constraints, flexibility issues with scheduling the Bondi Junction line, and reduced reliability from an increased risk of delayed running. As with the elevated heavy rail solution, stations will be expensive to provide and it will be challenging to identify suitable sites, therefore there is the potential that only a terminal station may be considered. System characteristics and passenger capacity will be as previously identified for the elevated option, but the biggest improvement is the ease of connection into the existing tracks under Bondi Junction.

Photo A.9 Sydney Trains heavy rail station

Option C2: Rapid Transit (Metro)

Rapid transit (metro) to Bondi would be a logical extension of a new metro line entering the CBD (potentially from the west). Due to potential capacity constraints of the second harbour crossing (to connect with Sydney Metro Northwest and a potential future link to the Northern Beaches) and a metro corridor already established to the south (Sydenham and Bankstown/Liverpool), a link to the east is the most logical future extension of the metro rail network in terms of balancing and maintaining network capacity. It is not preferable to terminate metro lines within the CBD.

Due to the presence of the existing heavy rail via the New South Head Road corridor, a more direct route from the CBD to Bondi beneath Oxford Street could also serve Darlinghurst, Paddington (Moore Park), Bondi Junction, Bondi and Bondi Beach. These destinations also have metropolitan functions (sporting, tourism and retail) as well as the commuter task which is the focus of the Sydney Metro. This mode would be located totally underground which creates some flexibility around the route that can be taken by the tunnel because it does not need to consider the location/geometry of the existing tracks. System characteristics and passenger capacity would be of the highest order. Whilst the significant grade separation of the interchange would appear to be resolved, design considerations will require the need to include vertical transport to access the existing heavy rail platforms at Bondi Junction.

A further option could be the conversion of the existing T4 Eastern Suburbs line (heavy rail) to Metro Rail (like the Macquarie Park and Bankstown Lines) between the CBD and Bondi Junction together with an extension to Bondi.

Source: Transport for NSW (2015)

Photo A.10 Sydney Metro North West station

Option C3: Light Metro (LRT)

Light metro would need to remain a standalone solution requiring interchange at Bondi Junction. However this creates some flexibility around the route that can be taken by the tunnel because it does not need to consider the location/geometry of the existing tracks. System characteristics and passenger capacity will be as previously identified for the elevated option. Whilst the significant grade separation of the interchange would appear to be resolved, design considerations will require the need to include vertical transport to access the existing platform (an island) between the two heavy rail tracks.

Appendix B

COMPARISON BETWEEN THE PUBLIC TRANSPORT CONCEPTS

B.1 Comparison between the public transport concepts

Right sizing the solution

Each of the short listed concepts has the ability to deliver significantly different volumes of passengers. The capacity of the concepts is difficult to estimate exactly because it can be influenced by the frequency of services, size of vehicles, and interactions with traffic management systems such as traffic signals. Table B.1 shows the assumptions that have been made about the potential mode capacities in mixed traffic conditions such as those experienced along Bondi Road.

Table B.1 Potential capacity of the short listed concepts

Concept No.	Mode	People per hour	Service frequency (mins)	Vehicles per hour	Vehicle capacity
Concept 1	Bus priority (in shared traffic lane)	1,600	3	20	80
Concept 2	Bus priority (in shared transit lane)	4,800	1	60	80
Concept 3	Bus/BRT (in dedicated managed transit lane)	7,200	1	60	120
Concept 4	LRT (in dedicated transit lane)	10,800	1	60	180
Concept 5	Monorail	24,000	2	30	800
Concept 6	Metro Rail	36,000	2	30	1200

Further traffic modelling would be required to test the capacity assumptions give widely differing experience depending on the characteristics of the corridor. For example:

- Trams operating on St Kilda Road in Melbourne operate at 60 per hour carrying 180 people giving 10,800 pphpd
- Brisbane's South East Busway busiest point accommodates up to 300 buses per hour (one every 12 seconds). Given the average capacity of a majority of Brisbane Transport buses is 62, the system can move 18,228 pphpd
- Bondi Road corridor already has 17 buses per hour already scheduled during the peak giving a potential capacity of around 1,360 pphpd.

Comparing these numbers to the patronage statistics presented in Figure 5.2 it would suggest that the existing bus network is operating close to its scheduled carrying capacity and therefore requires some form of uplift in capacity if patronage increases through population growth or mode shift are to be accommodated.

On the other hand the potential capacity of BRT and LRT style options are well above the approximate 1,200 pphpd currently being experienced in the corridor, and the potential capacity from Monorail and Metro Rail options far exceed any reasonable future expectation of patronage even under very ambition land use development scenarios.

Design and constructability

The installation of a mass transit system within the Bondi Road corridor will significantly change the allocation of road space and hence the functionality and design of the road. The challenge will be to identify a design solution that will, as far as possible, retain that functionality and provide sufficient space to support the public transport infrastructure required to support an efficient service.

The construction of new transit alignments can take lengthy periods and will inevitably cause impact on corridor users. Given that Bondi Road provides exclusive access opportunities from Bondi to the CBD then the impact of these activities can be significant. Also, the increase in construction traffic volumes is likely to extend the impact through wide areas of the community and most likely add to congestion on Bondi Road.

Table B.2 Construction impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Given the range of measured that could be applied it is difficult to draw any firm conclusions. The measures that will have the greatest impact are intersection treatments such as the provision of an additional lane for bus priority (bus jump). Corridor width is heavily constrained by property lines on both sides of the corridor and footpaths are already quite narrow in some places, therefore such measures could result in the need for property acquisition. Other measures that affect the methods of operation, or the passage of buses within existing traffic lanes could potentially be technically accommodated.
Concept 2	Bus priority (in shared transit lane)	Managed lanes reallocates the use of existing traffic lanes to improve the efficiency of the corridor, therefore will not require changes to the road infrastructure. Construction would require short road closures to facilitate the erection of gantries across the road to hold the necessary signage systems.
Concept 3	Bus/BRT (in dedicated managed transit lane)	The proposed BRT concept simply reallocates the use of the kerbside lanes to public transport without the need to change the design of the road. Short traffic lane closures would be required to allow remaking of road surfaces and upgrade stop infrastructure. The main impact is on the footpath space which would need to accommodate any additional proposed stop infrastructure.
Concept 4	LRT (in dedicated transit lane)	To install LRT there is a need to reallocate a traffic lane and to construct the track infrastructure. The AECOM report provides a design concept for the integration of the light rail infrastructure within the corridor. Generally, the running tracks fit within existing lane widths, however the major impact occurs at stop locations where additional width is required to accommodate the platforms. This additional width general requires a localised corridor of at least 30 m (Bondi Road is about 20 m) meaning that land acquisition is required or careful choice of stop design and placement is required. The AECOM scheme addresses this by limiting stop placement to locations where additional width exists (or can be borrowed from parklands etc.) and by using drive-over stop designs where traffic and pedestrians share the same road space. Stop location is therefore drive by corridor constraints rather than user requirements. LRT installation requires the total closure of the road for an extended period to allow the relocation of services, installation of the tracks and construction of the stops. Significant volumes of construction materials will need to be delivered.

Concept No.	Concept	Impact
Concept 5	Monorail	The two features that impact on corridor design are the need to accommodate the piers to support the running rails, and the width required to accommodate the stations. The diameter of supporting piers will vary depending on the design requirements. If a single central pier is to be used to support all the track structure there it is reasonable to expect the diameter of the pier would be in the order of 2 to 3 m. There is insufficient room within the road space of the corridor to accommodate this (and associated impact protection). An alternative available would be to use a straddle beam support with the piers placed outside the kerb line on each side of the road. Whilst this potentially can reduce the size of each support pier, There is insufficient footpath space available to accommodate the structure and there would also be implications for building verandas, traffic signals, signage and power transmission lines that use this space. Closure of short sections of roadway could be required to allow construction of supporting piers and major localised corridor closures to allow construction of stations. Assuming the beams will be launched and not lifted into position then a suitable work site will be required for delivery and uplift of the beams. Significant volumes of construction materials will need to be delivered.
Concept 6	Metro Rail	Will have little direct effect on traffic other than local road closures around station sites and vents during construction. However there will be a need to remove significant volumes of spoil material and to deliver large quantities of construction materials to the work sites and the tunnel access point.

Operation of intersections

The corridor traverses a dense urban environment and there are a significant number of signalised and non-signalised intersections to be negotiated. These intersection play an important role of introducing traffic to this major east/west corridor, as well as facilitating local north/south movements across the corridor and therefore there is little opportunity to rationalise there number. This means that operations along any form of segregated transit corridor will be punctuated by traffic signal delays which will affect journey time and reliability.

Table B.3 Intersection impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Some minor reconfiguration of intersection but net impact on the number or their purpose.
Concept 2	Bus priority (in shared transit lane)	Special management of traffic entering the corridor will be required to ensure that it joins the correct lane safely. Signalised intersections will continue with the same functionality but unsignalised intersections will be restricted to left-in/left-out movements whilst the managed lanes are in operation.
Concept 3	Bus/BRT (in dedicated managed transit lane)	Signalised intersections can be retained. Most minor side streets will require some specialised intersection treatment but could be retained with all movements.
Concept 4	LRT (in dedicated transit lane)	Signalised intersections can be retained. Access to minor side streets will be disrupted by the segregation of the light rail corridor in the middle of Bondi Road. This will mean that these roads will be restricted to left-in/left-out movements only.
Concept 5	Monorail	No change to traffic operations.
Concept 6	Metro Rail	No change to traffic operations

Turning movements

There are a number of intersections that have a high level of turning movements that are currently accommodated by the use of one of the two available traffic lanes. Should one of these lanes be reallocated to a rapid transit corridor, then these turning movements will need to be made from the remaining lane, thus delaying through traffic movements. The ability to restrict turning movements at some intersections may be possible, however the opportunities are limited. Other options include allowing turning movements to share the transit corridor, applying left turn only provisions, or acquiring additional road space. This can be accommodated with some impact on transit operations.

Table B.4 Impact on turning movements

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Where bus jump lanes are considered then either the road area will need to be expanded or turning lanes removed to create the space.
Concept 2	Bus priority (in shared transit lane)	The capacity of the intersection can be retained through the use of overhead lane indicators (instead of road makings) with no net impact on intersection capacity.
Concept 3	Bus/BRT (in dedicated managed transit lane)	BRT removes one lane from the corridor, therefore leaving only one lane for through traffic and removing the ability to separate turning traffic from through traffic thus reducing intersection capacity.
Concept 4	LRT (in dedicated transit lane)	LRT removes one lane from the corridor, therefore leaving only one lane for through traffic and removing the ability to separate turning traffic from through traffic thus reducing intersection capacity. Furthermore, the placement of stops would require careful design solutions.
Concept 5	Monorail	With proper design to ensure that support piers do not impact on turning lane space at intersections then there should be no net reduction in intersection capacity. The placement of elevated stations would require careful design solutions.
Concept 6	Metro Rail	Given that the corridor is segregated, there should be no net reduction in intersection capacity.

Property access

There are a considerable number of kerb crossing along both sides of the corridor. If a dedicated transit lane is provided along the of the road corridor, then access to these properties could be restricted.

Table B.5 Property access issues

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Only minor localised impacts would need to be considered.
Concept 2	Bus priority (in shared transit lane)	Access to properties would need to be restricted to left-in/left-out movements.
Concept 3	Bus/BRT (in dedicated managed transit lane)	With the running lanes adjacent to the kerb then there may be some delay issues with vehicles backing out of properties, but safety will not be significantly altered.
Concept 4	LRT (in dedicated transit lane)	Because of the segregated corridor down the middle of the road, access must be restricted to left-in/left-out. This may not be an ideal outcome for property owners, therefore U-turns may need to be accommodated which would generated increased volumes of turning movements at intersections which have already had their turning capacity compromised (refer to Table B.4).
Concept 5	Monorail	Localised impacts could occur in the vicinity of supporting piers and elevated stations.
Concept 6	Metro Rail	No impact.

Parking

Kerbside parallel parking is provided along a considerable length of the corridor. If the aim is to allocate a dedicated lane to a transit mode then all parking will need to be removed in order to accommodate a through traffic lane in the remaining road space. There is likely to be considerable resistance to such an outcome from residential, retail and commercial property owners/users along the corridor. The only solutions available are to relocate parking spaces to nearby side streets or for properties behind the retail/commercial centres to be acquired for parking purposes (an approach used widely elsewhere but is not without its challenges).

Table B.6 Parking impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Only minor localised impacts would need to be considered.
Concept 2	Bus priority (in shared transit lane)	Parking on the peak flow direction side of the road is already restricted during peak periods with 'No stopping' zones. There would be a need to restrict parking on both sides of the road during each peak. Given the counter-peak flow is restricted to one lane, then the 'No stopping' designation would need to be altered to 'Clearway' status.
Concept 3	Bus/BRT (in dedicated managed transit lane)	A total restriction on parking would be required along the retire length of the corridor.
Concept 4	LRT (in dedicated transit lane)	A total restriction on parking would be required along the retire length of the corridor.
Concept 5	Monorail	Likely change required to the current conditions to accommodate structural elements.
Concept 6	Metro Rail	No significant change to the current conditions in Bondi Road but there may be local issues around the proposed station site.

Traffic congestion

During peak periods there is clear evidence of high levels of traffic congestion, particularly for morning trips heading west and in the evening heading east. The impact has been somewhat reduced by the use of peak direction no parking restrictions, meaning that both lanes can be allocated for through traffic rather than used for parking. If a dedicated transit corridor is to be installed then the peak direction traffic capacity of the corridor will be halved. This means that, in order for there to be no net increase in traffic congestion, at least 50% of drivers would need to transfer to the rapid transit mode before considering growing demand in future years. The mode shift requirement would be even greater once turning movement impacts are superimposed onto the remaining lane.

Table B.7 Traffic congestion impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Only minor localised impacts would need to be considered.
Concept 2	Bus priority (in shared transit lane)	No significant change to the current conditions for peak flow traffic or off peak traffic. However, counter peak traffic would be reduced to a single lane and flow would be interrupted by buses stopping at kerbside stops and by turning traffic.
Concept 3	Bus/BRT (in dedicated managed transit lane)	The current two lanes of traffic would be reduced to a single lane at all times with corresponding increases in congestion. One mitigation could be to only operate bus lanes during peak periods.
Concept 4	LRT (in dedicated transit lane)	The current two lanes of traffic would be reduced to a single lane at all times with corresponding increases in congestion with no mitigation option for off peak periods.
Concept 5	Monorail	No significant change to the current vehicular conditions.
Concept 6	Metro Rail	No significant change to the current conditions in Bondi Road but there may be local issues around the proposed station site.

Access to transit

Considering what is required to impose a transit lane into the corridor is not the full story because without sufficient and suitable stops, where people can board and alight, ridership goals will not be obtained. The design of the stops will also be an issue given a requirement that they not only store sufficient people, but also must satisfy access requirements for disabled persons. The road space required to provide this functionality will need to compete with the road space currently allocated to traffic.

Table B.8 Transit access impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	No significant change to the current conditions.
Concept 2	Bus priority (in shared transit lane)	Bus stop locations should be reviewed and consolidated.
Concept 3	Bus/BRT (in dedicated managed transit lane)	For a transit corridor along the kerb line the design would need to rely upon footpath space for the stop infrastructure (but existing footpaths are not wide) or require property acquisitions. The frequency of stops will also need consideration. If this is to perform a local transport function then stops will need to be closer together than if the corridor is to be a rapid service from point to point.
Concept 4	LRT (in dedicated transit lane)	The LRT corridor will be located in the middle of the road meaning that passengers will need a safe access route to them. For this reason they are usually located adjacent to intersections (which has impacts on turning movements) to take advantage of the existing traffic signals, or are supported by their own signalised pedestrian crossing (which further disrupts free traffic flow). The size and width of the stops means that they will need to be infrequently placed within the corridor reducing accessibility for users along the corridor.
Concept 5	Monorail	There are two main issues for access to monorail stations, the first being the vertical transportation need to get up to them which makes it less convenient for users, and the fact that they will be infrequently placed within the corridor reducing accessibility for users along the corridor.
Concept 6	Metro Rail	Underground railway stations are expensive to construct (particularly if they are above or below ground level), and there spacing determines the total journey time. Therefore there is a general rule that stations should be placed no closer than 1.5 km apart (unless there are significant demand generators that cause the stations to be closer together). Given the short length of the rail corridor (less than 4 km from Bondi Junction to Bondi Beach, the absence of intermediate demand nodes, and the difficulty in finding suitable sites for stations in the mature urban landscape, past proposals for an underground railway connection have only consider a terminal station with no intermediate stations along the route.

Pedestrian access

Pedestrian access can be affected in two ways:

- Movement along the corridor via the footpaths
- Movements across the corridor via crossing points of the road via formal locations and via random intermediate locations (including J-walking).

Pedestrian access is a critical function of the corridor because it supports the retail and commercial land uses on each side of the road.

Table B.9 Pedestrian movement impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Only minor localised impacts would need to be considered.
Concept 2	Bus priority (in shared transit lane)	Footpath movements would be largely unaffected other than a slight narrowing of the footpath width around the footings of the overhead structures. Crossing of the corridor between signalised locations would be more dangerous when the managed lanes are in operation due to the need to judge the movement of traffic in three lanes moving in the same direction.
Concept 3	Bus/BRT (in dedicated managed transit lane)	Little change in pedestrian conditions other than at bus stops where additional infrastructure may be provided, and or passenger number increase result in more people waiting for a bus.
Concept 4	LRT (in dedicated transit lane)	Little change to movements along the corridor depending on the light rail stop designs applied. Crossing the road will become much more dangerous as there will be little opportunity for pedestrian refuge if the crossing is miss-timed. Trip issues are also introduced from the physical segregation of LRT from the traffic lanes on either side (recent death in Melbourne).
Concept 5	Monorail	If structures can be accommodated in the middle of the road then pedestrian refuge locations would become available. If the structures are placed in the footpaths then there will be an impediment to movement along the corridor
Concept 6	Metro Rail	No significant change to the current conditions in Bondi Road but there may be local issues around the proposed station site.

Emergency services

It is highly important that access to properties and locations along Bondi Road is maintained for police, ambulance and fire service vehicles. It is also important to consider the impact on the operation of the corridor should an incident be in progress. The following table considers movements along the corridor, whereas in some circumstances access may be via cross roads to avoid the corridor.

Table B.10 Emergency services impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	Only minor localised impacts would need to be considered.
Concept 2	Bus priority (in shared transit lane)	Passage of emergency vehicles could be assisted in the peak flow direction due to the availability to move freely between three lanes including the bus lane which will have low utilisation compared to the traffic lanes. However, in the counter peak direction only one lane would be available making progress difficult and if there is a need to stop to attend an incident then the only traffic lane would be blocked until the incident has been resolved.
Concept 3	Bus/BRT (in dedicated managed transit lane)	There would be a slight improvement to access due to reduced traffic congestion issues associated with the bus lanes operating on each side of the road as compared to the total road congestion that currently exists. An incident in the corridor is likely to block the bus lanes, given that they are adjacent to the kerb, but buses would be able to leave the lane to negotiate around the incident.
Concept 4	LRT (in dedicated transit lane)	LRT provides a segregate corridor down the middle of the road. The method of segregation has an impact on emergency services access. Raised kerbs provide the greatest barrier, whilst tactile markings the least. Emergency vehicles have the opportunity of using the light rail tracks to obtain largely un impeded access provided that light rail drivers co-operate by moving adjacent vehicles to open up access. At the site of an incident, the traffic lane would be blocked for the duration of the incident. If hard barriers are installed between the traffic lane and the LRT corridor then all movements will be prevented, but the use of drive-over solutions could provide an option to traverse around the sit.
Concept 5	Monorail	The elevated structure will allow similar access as to present conditions. New operational considerations will need to be implemented to deal with any emergency conditions associated with the elevated monorail vehicles.
Concept 6	Metro Rail	No significant change to the current conditions in Bondi Road but there may be local issues around the proposed station site.

Overshadowing

Overshadowing issues will only be relevant to elevated solutions and therefore are relevant to the Monorail concept. The elevated beams of the monorail track will reduce light penetration along Bondi Road, which would be more dominant in the retails areas where shop awnings already shadow the footpaths. There will be a major impact at station sites where a substantial elevated structure will be suspended over the corridor from boundary to boundary and for a length exceeding 100 m. This has implications in terms of activities under the structure, but also has implications for adjacent properties in terms of shading from sun light and the level of ambient light available.

Noise

The introduction of a mass transit solution will change the nature of noise generated within the corridor. Whilst some transport modes create their own unique sound profile, the impact of the generated noise needs to be kept in context with the existing noise level generated by the congested traffic conditions of the corridor in including motor noise, horns etc.

Table B.11 Noise impacts

Concept No.	Concept	Impact
Concept 1	Bus priority (in shared traffic lane)	No significant change to the current conditions.
Concept 2	Bus priority (in shared transit lane)	Some increase in traffic noise due to the additional carrying capacity of the corridor.
Concept 3	Bus/BRT (in dedicated managed transit lane)	The noise impact will be greatly affected by the technology applied for the motive power of the vehicles. If traditional diesel engines are used then localised noise levels will be similar to those experienced in close proximity to the buses as at present, wider area noise levels could be expected to change in proportion to the volumes of buses in the corridor. These could be offset to some degree by the reduction in general traffic given that the corridor will be reduced to a single traffic lane. However, bus technology is evolving rapidly and it is reasonable to expect that electric traction will become a viable option within the time frame of construction of this option. Should this be the case then there would be a significant reduction in noise impacts.
Concept 4	LRT (in dedicated transit lane)	The electric traction used by LRT vehicles provides a lower noise level compared to combustion engines, although the whin of the traction motors and regenerative braking systems sometime presents different reactions. Wheel rail interface noise is greatly reduced with continuous welded rail but localised noise will result from expansion joints and turnouts.
Concept 5	Monorail	The monorail vehicles will have a similar sound profile as LRT, although is rubber tired design is applied then rail noise will be less. However, the elevated structure will project the noise of a greater area, even if the total noise level may be less, creating impacts on properties that may be shielded from the existing noise profile of the corridor.
Concept 6	Metro Rail	No significant change to the current conditions in Bondi Road but there may be local issues around the proposed station site.

Vibration

Vibrations transmitted through the ground result in resonation within buildings and are often experienced as noise. Rubber tyred transit systems (i.e. buses and monorails) transmit low levels of vibration. Underground systems (Metro rail) will be deep enough (the Bondi line would pass under a hill for most of its length) to almost eliminate this risk, and where necessary resilient fastening of the track is usually sufficient to overcome any problems. LRT systems rely on a steel wheel interfacing with a steel track which inherently generates vibration from imperfections in the surfaces. The use of rubber packing of the rail (e.g. rail boot) reduces this vibration affect but it is more expensive to install and maintain. Flat spots on wheels cause by wheel skids greatly increase this noise level (although modern braking systems reduce this possibility) and flange squeal around corners are a regular source of complaints.

Visual aesthetics

The impact of ground level concepts will be restricted to the immediate streetscape within the corridor itself, whereas the elevated monorail concept makes the new transit system visible from a greater distance and may be perceived as changing the nature of the surrounding areas.

Air pollution

Give that all the proposed option have the potential to utilise electric traction then there will be a net reduction in localised air pollution due to the reduction in the flows of motor vehicles in the corridor. However, when considering the source of electricity, the overall environmental impact of the generation source would need to be considered.

Land use outcomes

New mass transit systems provide the capability to move more people and provide better accessibility to destination (e.g. employment, recreation, retail etc.) thus encouraging travel. The attractiveness of this outcome has the potential to drive more intense land use outcomes, particularly around transport stops/stations. Fixed route systems are understood to provide a strong signal to developers and purchasers due to the sense of permanency and legibility they provide. It is generally accepted that the strength of impact from the different modes is as follows:

- Railways
- LRT
- BRT
- Monorail
- Street bus.

Also, the justification for the capital expenditure is linked to the potential for ridership and therefore there is usually an expectation the land uses will intensify in response to the installation of the new transport mode Because of the high carrying capacity and cost of building and operating railways, there is a need to maximise the number people using them. This results in a need to change the land use paradigm through changes to the planning scheme, and this is not always consistent with the expectation of local land owners.

Community attitudes

New and improved public transport systems are usually funded by Governments, and always the decision to proceed with a particular project is made by governments. This means that there will be a strong political link in the decision making process which provides the opportunity for local interests and these can often drive the agenda. So it is important to ensure the proposed solution is consistent with local opinion and has the general acceptance by the community.

The Bondi Road corridor traverses a mixture of commercial, and residential areas so it will be important the proposed solution is able to meet the expectation of these interest groups, or at least not create sufficient angst that results in an organised opposition to the plans.

The strongest influence will come from those interests located along either side of the corridor. Often referred to as ‘not in my back yard’ (NIMBY) issues. Ground level concepts within the corridor will likely have the greatest effect on commercial interests in the corridor as a result of loss of car parking and delivery options. However, there will also be a level of concern from motorists who use the corridor due to the loss of traffic capacity resulting from the reallocation of road space and the expectation that there will need to be a mode shift (i.e. loss of their preference to use their private vehicle) in order to balance usage of the road space and support the mass transit investment. This concern will be wide spread across the Bondi area and adjacent suburbs.

Elevated options such as the monorail concept will have reactions beyond the immediate corridor due to its visibility and impacts over a wider area around the corridor.

Metro rail removes the interfaces with stakeholders along the corridor but will focus the potential for opposition around proposed station sites where land acquisitions and traffic impacts can be expected.

A final word on community attitudes relates to the functionality the new mass transit system would provide. Most of the focus (and justification for the project) centres on trips towards Bondi Junction and the CBD. However the new system will also provide increased access to the Bondi area. This is very beneficial for special events, however it means easier access to tourism and recreation areas such as Bondi Beach. It is likely as a result that land use in the beach area will change increasing towards servicing the tourism market and away from the needs of locals who most likely chose to live in the area for the amenity as it exists today.

Appendix C

MULTI CRITERIA ASSESSMENT WORKSHOP OUTCOMES

C.1 Multi criteria assessment workshop outcomes

C.1.1 Background

A workshop was held on 9 March 2016 to present the shortlisted public transport concepts and to undertake a multi-criteria assessment to determine the relative merits of each. Attendees at the workshop included representatives from Waverley Council and Transport for New South Wales.

A wide range of assessment criteria were discussed and then a score was assigned against each criteria for each concept. It was also proposed to apply a weighting to each of the criteria during the workshop however, due to time constraints, the weights were subsequently provided by representatives of the Waverley Council Project Steering Group.

C.1.2 Summary of the assessment outcomes

A summary of the scoring outcomes is provided in tabular and graph formats on last page, and the sections below provide an interpretation of the results by criteria:

A: Mode share

Interpretation – Better scores were applied to those concepts that had the greatest potential to attract people away for motor vehicles and to use public transport as the preferred mode for their journey.

Outcomes – The criteria identified a clear difference between those modes that could achieve patronage mode share though their perception/presence, and those that achieve this at street level through the provision of stopping points at frequent intervals. The results indicate that those modes where stops are located a close intervals and serve the various land uses along the corridor were preferred to those where the stops are further apart or remote from the commercial areas of the corridor.

B: Travel demand

Interpretation – Better scores were applied to concepts that had the potential capacity to carry the most passengers and hence satisfy growth in future demand.

Outcomes – Those concepts which apply marginal improvements to the existing bus services scored poorly given that their capacity is already being tested in peak periods, and those concepts that had greater latent capacity as a combination of speed/frequency and vehicle size scored better.

C: Travel time

Interpretation – Travellers apply a high importance to minimising their journey time, therefore those concepts that have the potential to provide the shortest journey time through the corridor were scored better.

Outcomes – Those concepts that had few stops, and high transit speed between stops, fared better that those concepts that had interactions with traffic within the Bondi Road corridor. For the modes required to operate within Bondi Road corridor, those that had a degree of segregation from general traffic scored better.

D: Travel time reliability

Interpretation – Travellers usually plan their journey based on arrival time therefore those concepts that have the potential to provide a higher degree of certainty around arriving on time were scored better.

Outcomes – Once again, concepts that were segregated from the traffic congestion along the Bondi Road corridor scored better than those that would need to interact with it.

E: Network Connectivity

Interpretation – Considers how well the mode can integrate with the wider Sydney public transport network.

Outcomes – Workshop participants were unable to distinguish any significant differences between the concepts because they all have the potential for interchange to the heavy rail network either at Bondi Junction or in the CBD.

F: Technical feasibility

Interpretation – Considers how disruptive the design would be to the operation of the Bondi Road corridor with those options being easier to resolve technically receiving the better score.

Outcomes – Metro Rail is an underground solution that has few barriers to construction and therefore scored well, as did bus priority upgrades because of the minor nature of the works. Monorail requires the placement of piers within the corridor which requires creating sufficient space, whilst those options that require the installation of a dedicated lane within the corridor (i.e. LRT and BRT) scored relatively poorly.

G: Public opinion

Interpretation – This criteria considers how well the general public may perceive the concept in terms of how it helps or impacts their residential lifestyles, supports their travel requirements, and/or impacts their commercial businesses.

Outcomes – Concepts that are perceived as adding to traffic congestion scored poorly, including the BRT and LRT concepts that will remove a traffic lane from the corridor affecting peoples' desire to use their motor vehicle by increasing congestion. Also options that impacted how road space is utilised through reduced car parking or restricted access to shops/businesses also scored poorly. Because Metro Rail is segregated from the corridor and is out of sight underground, it scored well.

H: Liveability

Interpretation – This criteria considers the impact of the concept on the amenity in the local area as a result of the operations of the mode in terms of noise, vibration and air quality.

Outcomes – Street level concepts tended to score poorly because of their close proximity to properties along the corridor and their integration with traffic. Those options which provide a degree of physical separation from street level scored better such as the Monorail and Metro Rail concepts.

I: Sustainability

Interpretation – Promotion of sustainability considered the use of alternative fuels and also how the concept could support the promotion of sustainable transport modes such as walking and cycling.

Outcomes – Those concepts that sought to install additional infrastructure within the streetscape of Bondi Road had the potential to exclude to provision of footpath and bicycle lane facilities and therefore were marked down. Those concepts that had the potential to use electric power sources scored better in term of sustainability. It is noted that BRT was scored badly based on the perception of diesel power source, however it is likely that electric buses will become more common by the time that a BRT style concept is implemented.

J: Safety

Interpretation – Considers the net impact on the operational safety of the corridor upon implementation of a concept.

Outcomes – Those modes that provided total segregation from the corridor (Monorail and Metro Rail) scored best whilst those options that had high levels of interaction with other corridor users scored poorly. LRT was marked down on the premise that it is the only concept the required central roadway operation thus increasing the interaction between passengers accessing the mode and traffic.

K: Land use outcomes

Interpretation – Land use of transport outcomes are interdependent. Land use is enabled by good transport and transport responds to land use outcomes. This criteria considers how well the concepts that support land use outcomes in Bondi

Outcomes – Concepts that do not substantially change stop locations (i.e. bus based options) are unlikely to promote improved land use outcomes. Those that provide a strong focal point around the stops (i.e. metro Rail) are likely to encourage localised land use intensification. LRT has been scored mid-range because, although it provides focal points around its stops, there will be far fewer stops as compared to a BRT outcome.

C.1.3 Conclusions

The general conclusion that can be drawn from the analysis is that concepts that provided additional capacity through the provision of a new/additional corridor to complement Bondi Road capacity scored strongest (i.e. Metro Rail and Monorail). Next were the concepts that provided a segregated public transport corridor within Bondi Road (LRT and BRT). Concepts that endeavoured to optimise the operation of the corridor within existing traffic and infrastructure constraints were least favoured.

Bondi Public Transport Mode Multi-criteria Assessment

Results from Workshop

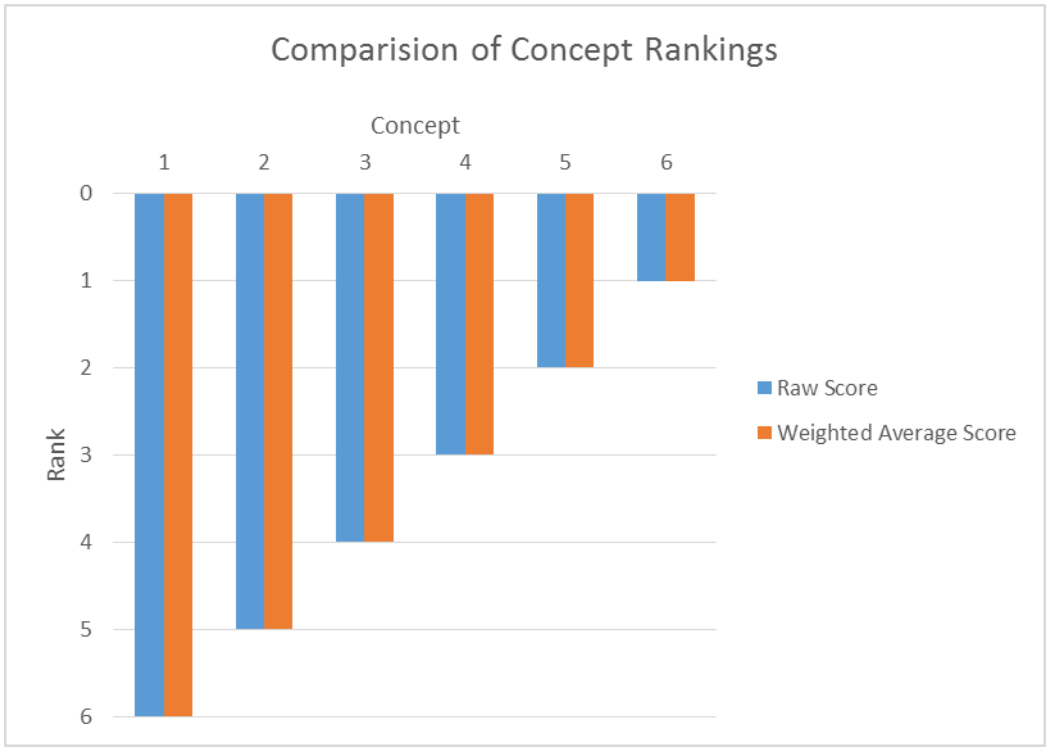
Assessment scoring legend

- 1 = Excellent outcome showing strong benefits with minimal negative impacts
- 2 = Good outcome or some manageable negative impacts
- 3 = Fair outcome or a considerable number of negative impacts
- 4 = Poor outcome or unmanageable negative impacts

Weighted Score Legend

10 = Very important
0 = Extremely unimportant

	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	
	Bus Priority in shared traffic lane	Bus priority in managed lane (ITS)	BRT in dedicated transit lane	LRT in dedicated transit lane	Monorail	Rail	*Weighting*
A: Mode share							
A1: Ability to encourage ridership through mode transfer	4	4	3	2	2	1	*10.00*
A2: Desirable origin/destinations	1	1	1	2	4	3	*7.67*
A3: Distance between stops	1	1	2	2	3	4	*5.00*
B: Travel demand							
B1: Potential to accommodate future travel demand increase	4	4	3	2	2	1	*8.00*
C: Travel time							
C1: Time to reach Bondi Junction	4	3	2	2	1	1	*10.00*
C2: Time to reach CBD	4	2	2	2	1	1	*7.33*
D: Travel time reliability							
D1: Predictability of journey time	4	3	3	2	1	1	*9.67*
D2: Comparable journey times in peak and off peak periods	4	4	2	2	1	1	*8.67*
E: Network connectivity							
E1: Efficiency of linking to the wider Sydney area	2	2	2	2	2	2	*8.67*
F: Technical feasibility							
F1: Installation of the right of way in the available road space	1	2	3	3	4	1	*8.00*
F3: Design of intersections/widening/acquisitions	1	2	4	4	2	1	*6.33*
G: Public opinion							
G1: Removal of car parking	2	2	4	4	2	1	*4.00*
G2: Traffic congestion impacts	4	2	4	4	2	1	*5.00*
G3: Public transport perception (does it help me)	4	3	2	1	4	2	*7.33*
G4: Visual impact	2	3	2	2	4	1	*7.67*
G5: Construction impact	1	1	2	4	4	3	*3.00*
H: Liveability							
H1: Noise	3	3	2	1	3	1	*5.33*
H2: Vibration	1	2	2	3	1	1	*6.33*
H3: Air quality in the corridor	2	2	2	1	2	2	*6.67*
I: Sustainability							
I1: Use of non-polluting fuel sources	4	4	4	1	1	1	*4.67*
I2: Ability to accommodate walking and cycling catchment enhancemen	3	3	2	2	2	2	*6.67*
J: Safety							
J1: Pedestrians crossing the street mid-block	1	2	2	2	1	1	*8.00*
J2: Traffic management (accidents)	3	4	2	2	1	1	*5.00*
J3: Stop design	1	1	1	2	1	1	*5.00*
K: Land use outcomes							
K1: Ability to use stops/route to focus land use development	4	4	3	2	3	1	*8.00*
Raw Score	65	64	61	56	54	36	
Ranking	**6**	**5**	**4**	**3**	**2**	**1**	
Weighted Average Score	65	64	58	51	51	33	
Ranking	**6**	**5**	**4**	**3**	**2**	**1**	


Comparision of Concept Rankings
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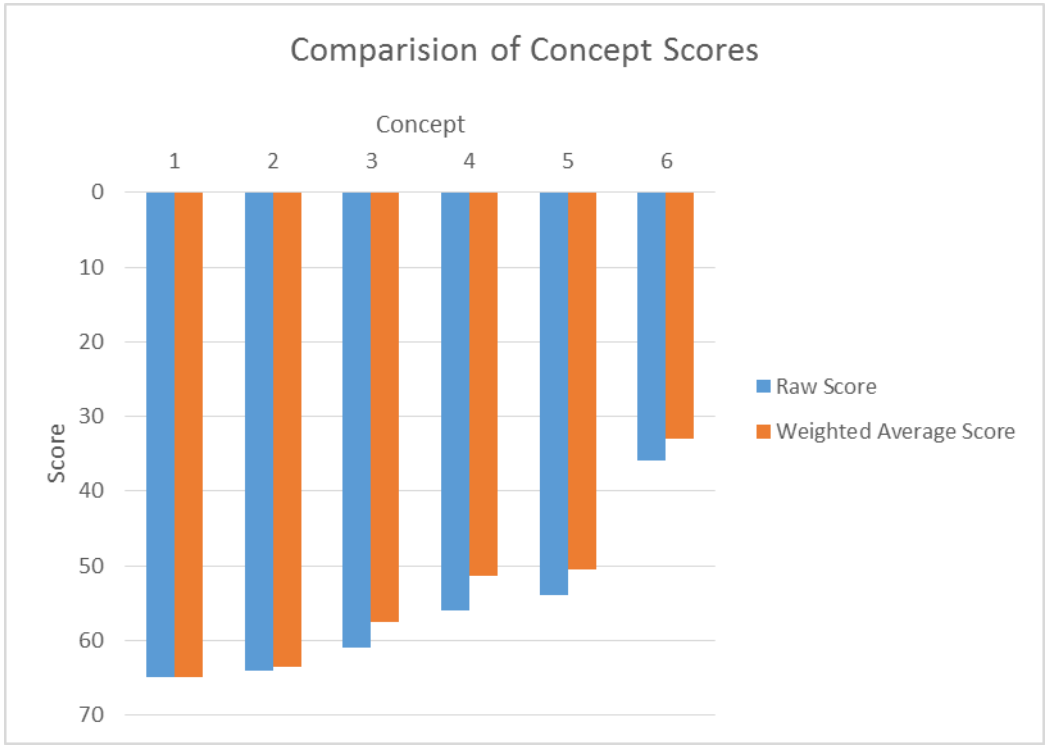
Comparision of Concept Scores
Concept
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