WAVERLEY LIGHT RAIL

27 November 2013

Prepared by

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Quality Information

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01

Background

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1. Background

1.1 Project context

In December 2011 the Waverley Transport Plan (Waverley Council, 2011), defined the need to advocate for the reintroduction of Light Rail into Waverley to support public transport. Lobbying for Light Rail in Waverley is a key action in the Community Strategic Plan (WT2) as well as the Waverley Transport Plan.

Following the Waverley Transport Plan there was bi-partisan political support to investigate how Light Rail could contribute to public transport accessibility and how Light Rail could feasibly be re-introduced into the Waverley Local Government Area (LGA).

At a state level, the NSW government has been undertaking feasibility studies into Light Rail in Sydney, primarily focused on three key inner urban corridors in Sydney CBD and to the two major universities.

Transport for New South Wales (TfNSW) published its Light Rail strategic plan *Sydney's Light Rail Future* in December 2012. This defined the need to consider Light Rail as an appropriate response to Sydney's broader transport challenges, with a view to the long term planning of a future strategic Light Rail network for Sydney and future delivery of appropriate mass transit options for Sydney.

Council is highly supportive of the State Government initiatives to bring Light Rail from the CBD to the University of NSW and other Stage One priority projects identified in Sydney's Light Rail Future. Furthermore, Council is committed to pursuing further discussions with TfNSW to secure a Light Rail route into Bondi Junction Town Centre and onto Bondi Beach, as a priority route for the next stage of the Strategic Plan.

Waverley Council (Council) is committed to facilitating the delivery of transport infrastructure and transport services to meet the travel needs of its residents, businesses and visitors. Waverley Council has long supported the reintroduction of Light Rail as an efficient mass transit option that will offer an alternative to private car use and provide a more efficient public transport outcome.

1.2 Study scope

In 2012 Council determined to undertake a pre-feasibility study (this study) to determine whether Light Rail is appropriate to serve the travel task between Bondi Junction Town Centre and Bondi Beach. The purpose of this study was defined as 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.

AECOM were commissioned by Waverley Council in November 2012 to undertake this pre-feasibility study to assist council to understand and evaluate the potential for Light Rail in Waverley and communicate the vision for Light Rail.

1.3 Report structure

This report provides a high level assessment of the potential route options and the preferred route for Light Rail. The report is structured as follows:

- Section 2 establishes the project objectives, while providing discussion on appropriate modal choices and capacity. Corridor design plan, principles and the future role light rail will have in Sydney are also summarised.
- Section 3 provides an overview of the potential transport opportunities and constraints in Waverley, including current bus routes, traffic volumes, journey to work data and future land use patterns to develop a structure for the project.
- Section 4 presents the potential route options and provides a multi-criteria assessment based on the project objectives, which takes into consideration Light Rail design criteria, land uses, topography and slope, travel distances, potential impacts, demand and other opportunities. Based on the Multi-Criteria Assessment (MCA) a preferred route is proposed.
- Section 5 further analyses the preferred route, providing a concept design and visualisations.

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Project Objectives and Project Definition

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2. Project Objectives and Project Definition

2.1 Report objectives

The project objectives define the context for the potential reintroducing of light rail into the Waverley LGA (as set out below the objectives) define the problem and the potential role light rail can play as a solution. These project objectives have been defined as to:

- Resolve major congestion problems between Bondi Junction and Bondi Beach;
- Enable rapid and frequent movement of people in an efficient and safe manner;
- Keep routes as straight and direct as possible to reduce noise and maintain legibility;
- Define whether light rail is the appropriate modal response and avoid duplication of public transport routes
- Maintain bi-directional light rail movement to minimise negative impacts, maintain legibility and free up other streets for traffic; and
- Create high quality streets for business and people beyond the provision of an additional transport route.

The project objectives are fundamental to the process of defining the scope of the study and evaluation and assessment of options considered throughout this study.

2.2 Modal comparison

2.2.1 Defining the appropriate modal response

In order to define that Light Rail is indeed an appropriate response we need to consider a number of metrics related to what and how the mode can meet the project objectives, specifically in comparison to other modal alternatives. The solution to the travel task is to define an appropriate modal response which matches network and corridor opportunities and constraints and considers key operational factors such as travel demand, travel time, capacity, and reliability. The solution is also to define the mode which achieves the most efficient and appropriate response.

Figure 1 provides a useful comparison of the capacity of different modes. Based on the indicative single vehicle capacity by mode. This indicates the carrying capacity of different vehicle types and modes and speaks to the ability to meet higher order travel demand in the most efficient manner possible.

Buses meet a lower order demand for public transport services, providing flexibility to transport operators that is necessary in areas of low population density which are prevalent in Greater Sydney. However, buses only form part of the public transport hierarchy available to transport network service planners and operators.

Heavy rail is most capable of dealing with the highest passenger demands, although this level of infrastructure can be expensive to construct therefore without sufficient demand to justify the infrastructure cost intermediary modes can provide more appropriate transit service options.

At present, the hierarchy of public transport in Sydney is largely based around the use of buses and heavy rail, with buses performing the trunk travel route task in areas without heavy rail services. These trunk bus route are closely linked to the historic Sydney tram network, as trams fell out of vogue in the post second world war period, bus services replaced the aging tram network.

2.2.2 The role of Light Rail

Light Rail represents a step change in public transport over urban bus services. It can provide significantly greater capacity and reliability, reduce travel times and cater for a greater passenger volume given similar operating conditions than buses (in terms of public transport) and cars (in terms of private vehicles). It has the potential to improve the customer experience through legibility, operational performance (reliability, capacity) and complimentary design opportunities afforded within operating corridors. Light rail compliments urban streetscapes and in many cases has led to urban renewal and regeneration.

Modern Light Rail is capable of providing a higher order capacity of people movement in a more efficient manner than even the most modern bus fleets. One Light Rail vehicle can have a capacity of up to 300 people, compared to the highest capacity modern bendy bus which can carry up to 100 people. By considering the ability of Light Rail to more efficiently move greater numbers of people at a comparable frequency of service, as shown in Figure 2, we can realise the efficiency and advantage of the mode to potentially reduce congestion on highly utilised road corridors to benefit of all road users.

Light Rail therefore serves as a medium capacity mode, between buses and heavy rail, with a lot of the advantages of heavy rail but typically at a significantly lower capital cost. It is most efficient on trunk routes where large volumes of passengers can be transported in an efficient and reliable fashion, linking major hubs of high-medium residential and employment densities and other major trip generating land uses (commercial, retail, leisure, education, health precincts).

2.2.3 Light Rail in Sydney

Sydney's Light Rail Future forecasts that, in Sydney's CBD, Light Rail will be capable of replacing 180 buses in the busiest hour of the morning peak and when combined with broader bus network changes will facilitate the removal of up to 220 peak hour bus services from the highway network. This demonstrates the potential for Light Rail to contribute to broader transport network efficiency by reducing the congestion caused by high volumes of buses and private vehicles competing for a finite amount of road space.

Light Rail is also forecast to operate at significant levels of reliability which far exceed traditional urban bus services, with a forecasted 97 per cent of all services running within two to three minutes of the timetable. Currently, only between 19 and 34 per cent of buses achieve this in the proposed Light Rail alignment along Anzac Parade and through the CBD. Light Rail also has complimentary local urban realm benefits, contributing to vibrant, vital streets creating more room for pedestrians and local walking trips. (Source: Sydney's Light Rail Future (TfNSW, December 2012)).

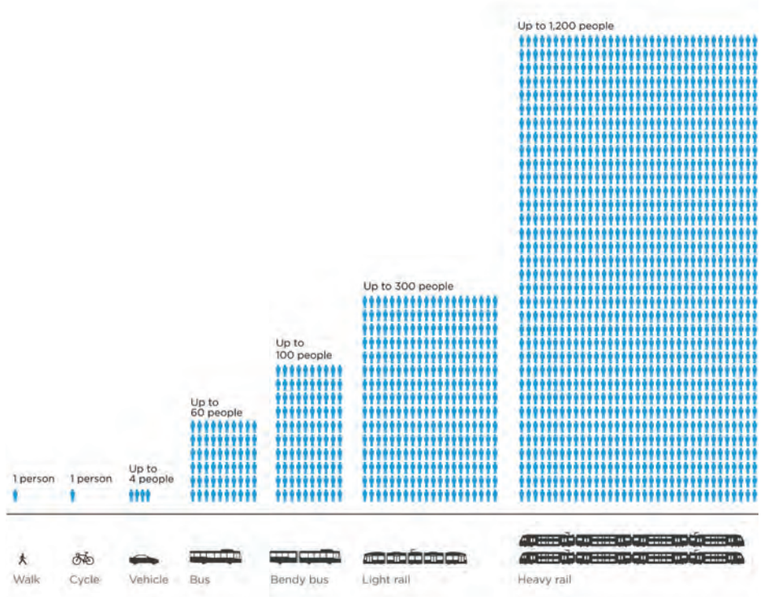


Figure 1. Indicative vehicle capacity by mode (single vehicle)
Source: Headway Consulting Group, 2012

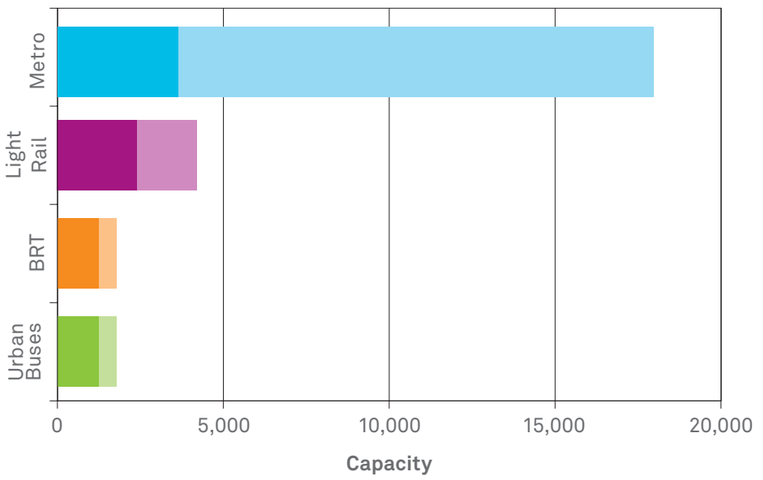


Figure 2. Capacity (patrons per hour)
Source: Headway Consulting Group, 2012

The hourly passenger capacity (based on a comparable five minute headway) for different modes is shown in Figure 2. The figure shows the range of capacities which can be achieved on this basis given a range of different operating and network conditions. Similar to the discussion presented above, there is a clear hierarchy of public transport modes, given comparable operating parameters. Metro rail or heavy urban rail has the highest capacity, although as discussed is typically accompanied by the largest capital investment. Urban buses are the least efficient mode in terms of patronage, but are cost effective and flexible to deploy, which has led to their widespread use across Sydney to meet a variety of travel needs. However, these are heavily subsidised by RMS and Council.

Metro or urban heavy rail has a capacity of between 3,600 and 18,000 passengers per hour (pph). For Light Rail, as with buses, the hourly capacity is largely related to the vehicle specification, such that a 30 metre fleet has capacity of up to 2,400 pph whereas a 45 metre fleet could have a capacity of 4,200 pph. This is shown in light green and dark green respectively in Figure 2.

BRT and Urban buses both have capacity for up to 1,260 passengers per hour based on an 18 metre fleet and up to 1,800 pph with a 24 metre fleet.

Light Rail provides greater capacity than urban buses, but without the investment required for metro rail. This results in Light Rail being an efficient mid-range public transit mode supporting efficient movement of significant passenger volumes on trunk routes where higher capacities are required and network capacity (highway capacity) is limited.

2.2.4 Efficient use of road space

Figure 3 elaborates on the discussion presented above by demonstrating the equivalent amount of road space required to carry a set volume of 300 people by alternative modes of transport.

On trunk routes with large numbers of passengers, it is clear that Light Rail can complete the transport task while utilising a minimal amount of road space. A Light Rail vehicle uses around half the space of the equivalent number of buses needed to cater for 300 passengers, while providing more reliable journey times and greater comfort. This could further increase road space as more commuters change mode in favour of Light Rail for its travel time benefits.

As shown in Figure 3 the following number of vehicles is required to cater for a demand of 300 people by alternative modes of transport in an on-street environment:

- 1 Light Rail vehicle
- 6 standard buses (with a capacity of 50 people)
- 150 private vehicles (based on one driver and one passenger)
- 300 private vehicles (based on a single driver)

From the above we can see the potential to significantly increase the efficiency of people movement in the corridor between Bondi Junction and Bondi Beach. By considering modal alternatives to meet the travel demands of all road users, potentially reducing bus volumes and vehicle trips, whilst ensuring public transport accessibility, there is the potential to optimise the efficiency of existing highway infrastructure and actually increase capacity.

Furthermore by promoting Light Rail as a mass public transit travel alternative to the private vehicle to and from Bondi Beach, as part of a broader, well-connected mass transit network, there is the potential to significantly reduce the current level of congestion experienced on Bondi Road.

2.3 Corridor planning principles

The key principles, planning and design criteria adopted for the concept planning and design of the corridors are set out below.

General corridor planning principles:

- A consistent centre running Light Rail alignment to enable ease of understanding by all road users, to create a legible route, to facilitate continued kerbside activity and to ensure complete segregation and priority for Light Rail in the long term, although retaining the potential for interim operations of shared running or quasi-priority (although this is less desirable from an operational perspective).
- The Light Rail system would operate a 'turn up and go' service across the weekday, evenings, weekends and nights, as a legible, attractive mass transit travel option.
- Light Rail vehicles of 45 metres in length with a capacity of 300 passengers per vehicle, consistent with the TfNSW Light Rail planning assumptions in Sydney's Light Rail Futures which envisages approximately 100 seated and 200 standing passengers per vehicle.
- Light Rail vehicles would be air-conditioned, accessible low-floor design and electric powered.
- The system could be capable of carrying up to 9,000 passengers per hour in each direction at peak operational capacity when fully developed with a high degree of service reliability that is not impacted by traffic congestion.
- Where feasible only the existing road reserve is used for development of the Light Rail route within the road corridor, preserving existing property, without requiring additional road reserve and retaining existing footways or replacing within the broader streetscape environment.
- Identification of complimentary streetscape enhancement opportunities where feasible alongside the Light Rail corridor, including pedestrian realm enhancements, improved bicycle paths and urban realm activation.

Road design criteria:

- A minimum lane width of 3.2 metres for general vehicular traffic where only a single travel lane is available in either direction.
- A minimum lane width of 3.0 metres for the second lane for general vehicular traffic where more than two lanes can be accommodated in one direction of travel.

Light rail alignment and stop design criteria:

- A uniform Light Rail developed kinematic envelope (DKE) of 3.2 metres – which allows for outline of the space occupied by the vehicle when in motion, including the effects of tilt, sway, track cant, etc.
- Stops are located an average of approximately 800 metres apart to maintain provision of appropriate travel times and levels of service frequency as well as provide a high level of public transport accessibility, with a walk-up catchment of up to 10 minutes. But with an allowance for proximate land uses and higher frequency of stops where required by higher densities of major hubs in key locations.
- All stops are designed as side platforms where feasible, with direct access to the pedestrian footway via signalised crossing facilities. Passengers are able to access all stops via controlled crossing facilities and wait at stops with dedicated waiting and boarding facilities (where feasible).
- A side platform width of 3 metres which allows for all necessary stop infrastructure and pedestrian circulation at the stop.
- Stop or kerb access height of 300mm for step-free access onto Light Rail vehicles at all stops.
- Step free stop access which is compliant with relevant DDA access requirements with ramps at or less than a 5% grade.

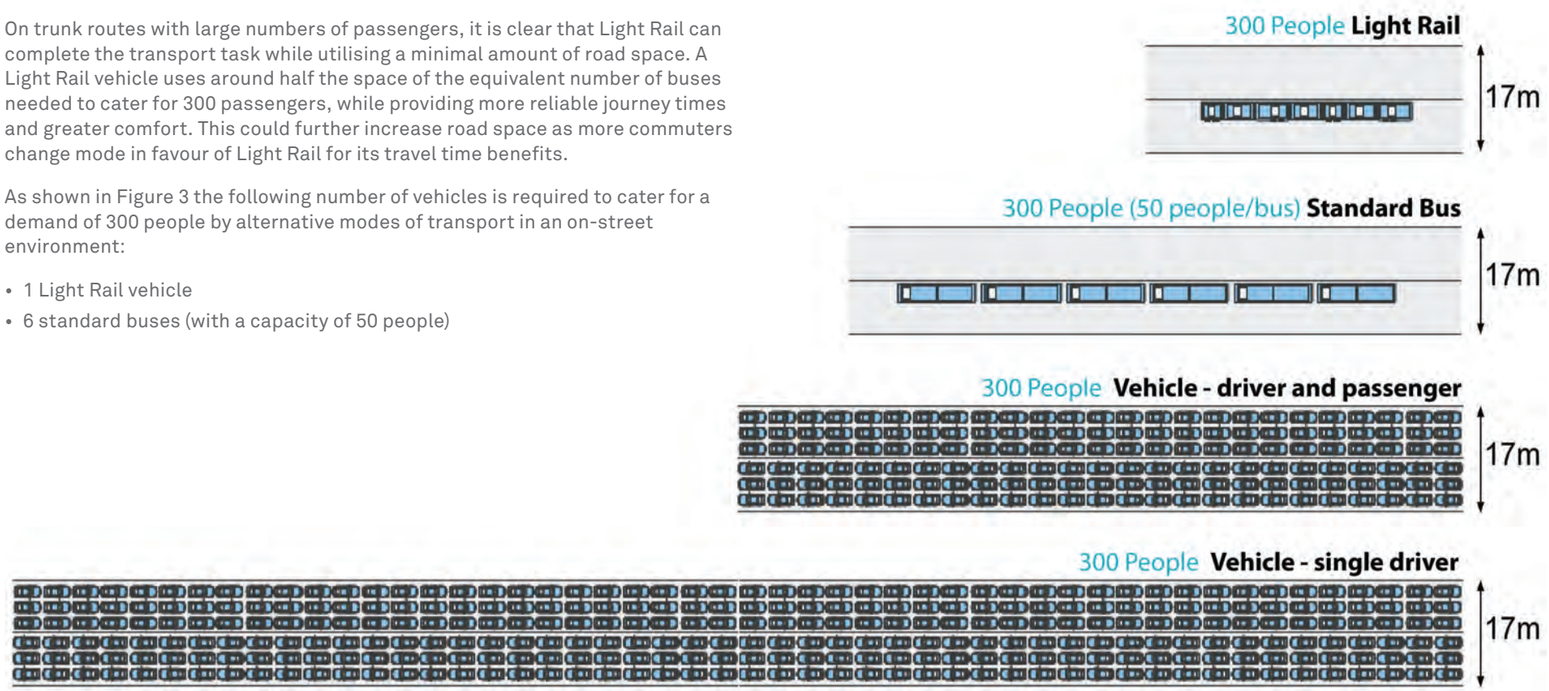
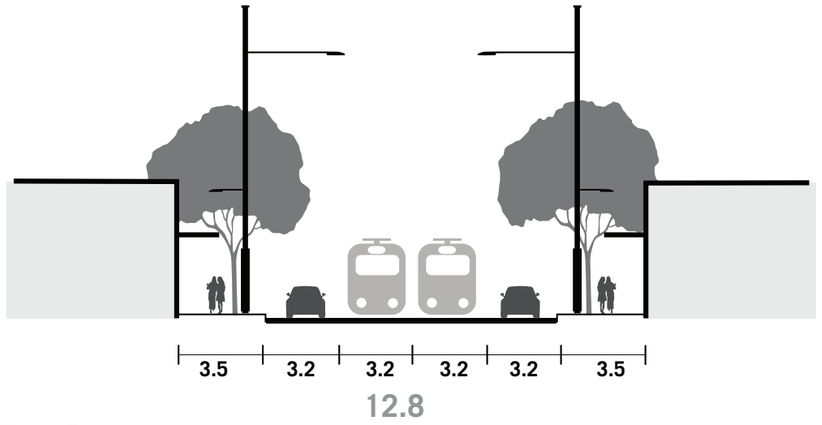
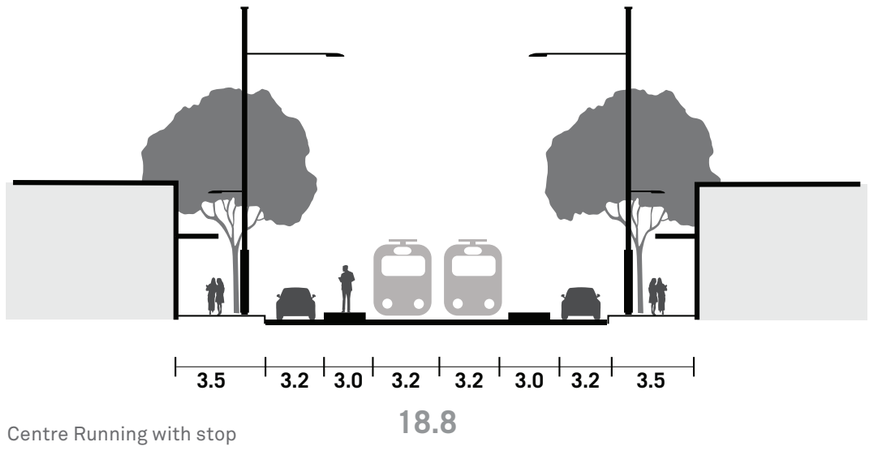


Figure 3. Modal comparison
Source: Transport for NSW, 2011

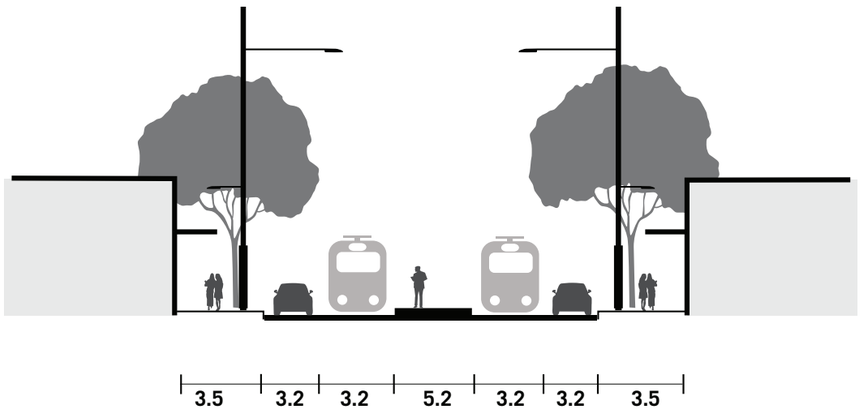
Light rail alignment and road position



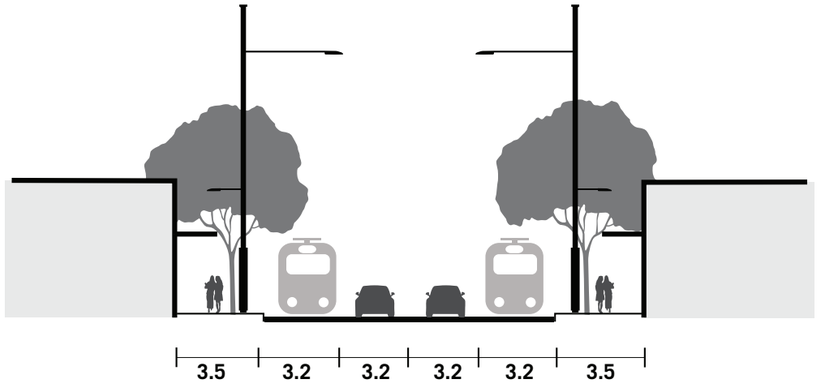
Centre Running



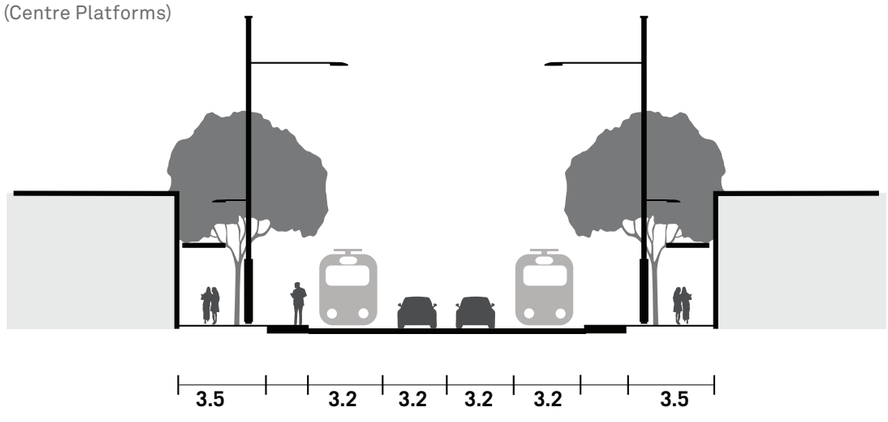
Centre Running with stop
(Side Platforms)



Centre Running with stop
(Centre Platforms)



Side Running



Side Running with stop

Option	Adjacent access for (un)loading/taxis	Provision of adjacent bus stops	Ability to provide car parking	Ease of accommodating right/left hand running movements for general traffic	Ability to provide LR stop and stop access
Centre running with stops (side platforms)	No unexpected impediments to service vehicles. Section of traffic lane adjacent to LR stops would remain clearways at all times.	Potentially run both buses and LR. Bus stops adjacent to proposed LR stops would need to be removed to allow one through lane as a minimum.	Existing parking adjacent to stop location would be removed to not impede through traffic.	Right hand turning movements would be conducted from LR lane. Signal controls would need to be revised/implemented to ensure LR is not delayed e.g. remove right-turn filter	LR platform would be built on-road. Platform would force funnelling of through traffic to outermost lanes.
Centre running with stop (centre island platform)	No unexpected impediments to service vehicles. Section of traffic lane adjacent to LR stops would remain clearways at all times.	Potentially run both buses and LR. Bus stops adjacent to proposed LR stops would need to be removed to allow one through lane as a minimum.	Existing parking adjacent to stop location would be removed to not impede through traffic.	Right hand turning movements would be conducted from LR lane. Signal controls would need to be revised/implemented to ensure LR is not delayed e.g. remove right-turn filter	LR platform would be built on-road. Platform capacity constraints accommodating patronage in both directions.
Kerb side running with stop	Shared running for LR and service vehicles. Potential conflicts/ delays between LR and service vehicles.	LR would likely replace buses to remove duplicate services.	Car parking not permitted. De-activation of street frontage.	Potential conflict between LR and left turning vehicles.	Potential property acquisition required for length of stop.

Table 1. Benefits and constraints of light rail alignment options

03

Transport opportunities and constraints

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3. Transport opportunities and constraints

3.1 Background

The Bondi Junction to Bondi Beach Link is a key focus for Waverley Council as pressure mounts on the road network and existing public transport system due to increasing population with increased mobility and willingness to travel and an increasing number of tourists and visitors to events and attractions at Bondi Beach. Road congestion along Bondi Road and Old South Head has long been a major transport issue for Waverley Council since they are the main east-west links between the hubs of Bondi Junction and Bondi Beach.

Bondi Beach is a major destination precinct attracting thousands of tourists and Sydney residents each year, with up to 50,000 visitors per day during special events. The Bondi Beach locality is also home to a significant residential and commercial population, creating a core 'commuter' travel demand market, in addition to the variable, but significant visitor travel market. This commercial and residential area is characterised by significant traffic and parking pressures due to the volume of vehicle traffic and modern levels of car ownership and which is exacerbated during the weekend and summer months by visitor demand.

Bondi Junction is a major regional centre and the primary commercial and retail hub for the eastern suburbs. As a major transport interchange, Bondi Junction serves as a hub for the eastern suburbs with a number of public transport services to various destinations. The bus interchange is utilised by 23 bus routes with approximately 2,400 buses per day using the interchange. Bondi Junction is also the ninth busiest station on the CityRail network with approximately 39,000 passenger movements on a typical weekday. Bondi Junction is the closest major modal interchange to Bondi Beach providing an onward connection by public transport to the broader Sydney metropolitan area by heavy rail.

3.2 Strategic transport network context

The Sydney heavy rail (CityRail) network links into Bondi Junction via the Eastern Suburbs line, which provides a direct fast connection into Sydney CBD, as shown in Figure 4.

The preferred future Sydney CBD and South East (CSELR) Light Rail route proposed by the state government in the strategic Light Rail plan for Sydney run from Circular Quay in the CBD via Central Station, Surry Hills and Moore Park (Anzac Parade) to two south east termini at Nineways, Kingsford and at Randwick Junction, Randwick, as shown in Figure 5.

Figure 4. Sydney Rail Network
Source: Transport for NSW, 2013

Figure 5. Light Rail network plan (Proposed)
Source: Transport for NSW, 2012

3.3 Bus services

A number of existing bus services connect Bondi Beach to Bondi Junction as shown in Figure 6. These bus services run either via Bondi Road or Old South Head Road which cater for a variety of patrons with different travel needs.

Figure 7 highlights that the majority of bus routes in the Bondi Beach to Bondi Junction, a total of approximately 1,400 buses across a typical week, use the Bondi area corridor.

The volume of bus services on Bondi Road reflects the land uses served and the travel demands along this more populous and active corridor which has commercial and retail land uses both generating and attracting trips in the Bondi Beach to Bondi Junction corridor. It is also the most legible and direct travel route.

The significant volume of buses along Bondi Road however is one factor in the congested nature of Bondi Road especially during peak travel periods for weekday journeys to and from work and on weekends in summer. The congestion experienced and lack of priority afforded to buses even during peak periods results in reduced bus service reliability, increased travel time and delays and renders public transport an unattractive travel option.

There are four bus services which travel along the Bondi Road corridor, as shown in Figure 8. The four bus routes include:

- Route 333 – a prepaid route with limited stops between North Bondi and the City – Circular Quay via Bondi Beach and Bondi Junction.
- Route 380 – a normal bus route between North Bondi and the City – Circular Quay via Bondi Beach and Bondi Junction.
- Routes 381 and 382 – bus services between North Bondi, Bondi, Bondi Beach and Bondi Junction.

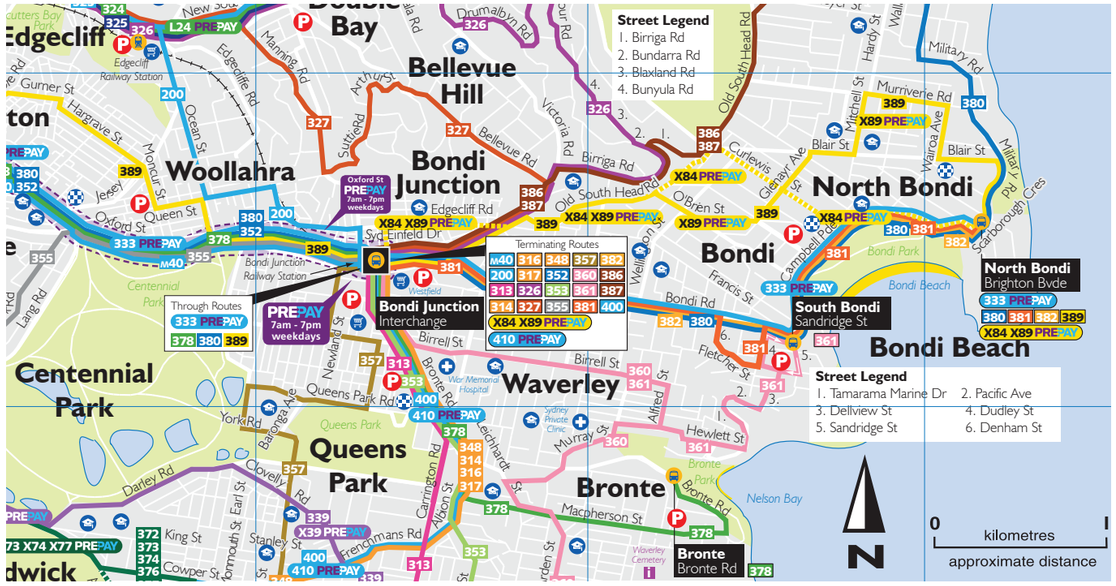

Figure 6. Bondi Junction to Bondi Beach bus services
Source: Sydney Buses, 2013

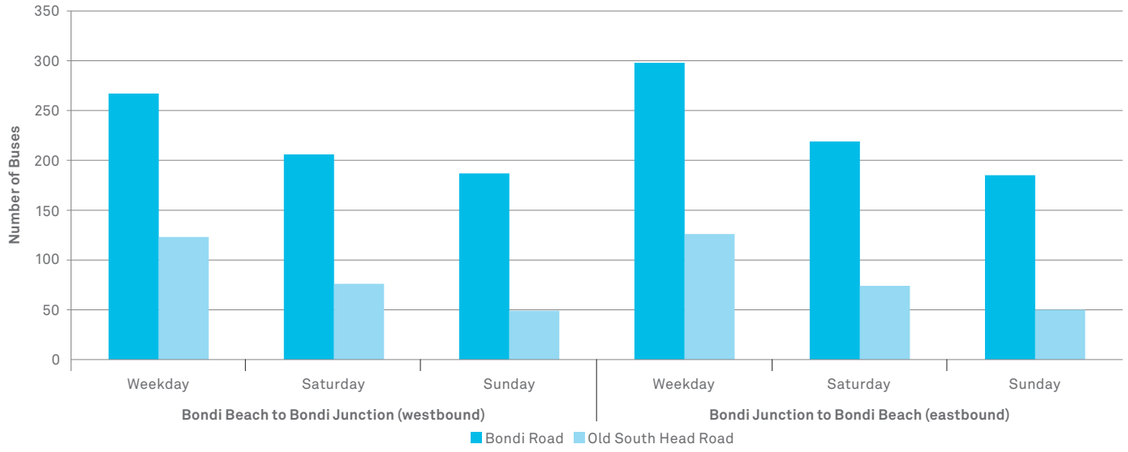

Figure 7. Number of buses along each corridor
Source: Sydney Buses, 2013

Further analysis of the bus volumes along Bondi Road shows a distinct peak direction on weekdays in each peak period, reflecting the travel demand between Bondi Beach, Bondi Junction and Sydney's CBD. In the morning peak, 53 buses operate between 7am and 9am in the westbound direction at an average frequency of 2 minutes and 16 seconds. Similarly in the evening peak, 65 buses operate in eastbound direction between 5pm and 7pm at an average frequency of 1 minute 51 seconds.

During the weekend similar bus service volumes are provided in each directions, reflecting the multitude of intermediary travel demands and land uses along the along Bondi Road corridor between the major destinations at either end. Between 2:00pm and 4:00pm there was a bus frequency of approximately 4 minutes.

The high volumes of bus services operating during peak periods in conjunction with general traffic volumes and resultant levels of delay and unreliability have resulted in the State Transit Authority (STA) capping the service volumes along the Bondi Road corridor, preventing potential increases in public transport capacity and patronage, in spite of increasing demand.

Without dedicated public transport priority in the form of bus lanes or clearways, no further increases in public transport service provision will be feasible. A weekend trial of clearways has previously been undertaken between December 2008 and March 2009 which reduced bus travel times on Bondi Road from between 20 and 30 minutes to as little as 7 minutes.

Therefore a step change is needed in terms of public transport service provision and crucially priority, to increase service reliability and improve efficiency of the corridor functionality not just for public transport but also for general traffic.

3.4 Roads

Road congestion along Bondi Road and Old South Head Road has long been a major transport concern for Waverley Council since these roads are the main east-west highway connections linking Bondi Beach and surrounding areas to Sydney CBD and the wider metropolitan area. Bondi Road performs the major commuter trunk travel task for both bus services and private vehicles, while Old South Head Road is also an important route for private vehicles.

The Average Annual Daily Traffic (AADT) data shown in Table 2, sourced from the NSW Department of Roads and Maritimes Services (RMS), describes typical average traffic volumes along Bondi Road between Wellington Street and Syd Einfeld Drive, and on Old South Head road at Edgecliff Road.

Bondi Road AADT's at Intersection with:	AADT
Wellington Street	24,528
Penkivil Street	33,220
Flood Street	29,247
Council Street	37,637

Old South Head Road AADT's at Intersection with:	AADT
Edgecliff Road	24,823

Table 3. AADT volumes (2005)
Source: RMS, 2013

Figure 8. Bondi Road bus routes
Source: Sydney Buses, 2013

Bondi Road bus services	Weekday			Saturday		Sunday	
	7 – 9	5 – 7	Total	2 – 4	Total	2 – 4	Total
Bondi Beach to Bondi Junction (westbound)							
333	20	4	94	12	74	8	56
380, 381, 382	33	16	173	17	132	18	131
Total	53	20	267	29	206	26	187
Bondi Junction to Bondi Beach (eastbound)							
333	7	20	95	12	74	8	54
380, 381, 382	7	45	203	17	145	21	131
Total	14	65	298	29	219	29	185

Table 2. Bondi Road Buses
Source: SydneyBuses, 2013

Traffic volumes are highest at the western end of Bondi Road. These increase from 25,000 vehicles per day at Wellington Street, to the east, in the heart of the Bondi Road retail and commercial strip, to 37,000 at the western end of Bondi Road at council street. On Old South Head Road, the busiest section is also to the west where recorded AADT volumes are 24,823 vehicles at the intersection with Edgecliff Road.

The typical capacity of a two way road with one effective lane in each direction is in the order of 16,000 to 20,000 vehicles per day. With one effective travel lane in each direction for the majority of its length the AADT's reported above described how the corridor is operating at effective theoretical capacity with unstable travel conditions across all modes.

3.5 Existing travel patterns

3.5.1 Travel for work (the 'commuter market')

Waverley LGA has one of the highest residential population densities in Sydney and Australia, with the suburbs of Bondi Junction, Bondi, Bondi Beach and North Bondi

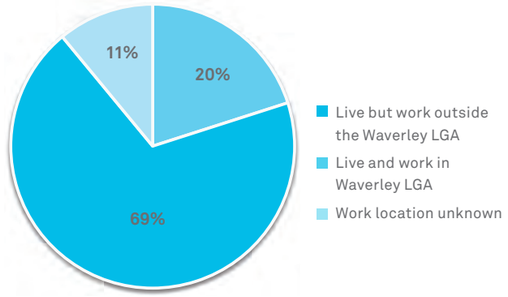

Figure 9. Waverley LGA resident's employment location
Source: BTS, Census of Population and Housing, 2013

the most populous within the LGA. Residents of these suburbs rely heavily on public transport, especially for journeys to work, which is reflected in the availability and frequency of public transport services in the area. Although the existing mass transit network only penetrates the western fringe of the LGA, at Bondi Junction rail station, buses carry out the a trunk travel task on routes throughout the remainder of the LGA, focused especially on Bondi Road and linking to the suburb of Bondi Beach.

The 2011 census reported that 23,500 (69%) residents in the Waverley LGA worked outside the area, as shown in Figure 9, with the majority of those working in Sydney CBD. An additional 6,800 (20%) lived and worked locally within Waverley LGA, but still need to travel for work.

Table 3 provides further detail on the destinations to which residents of Waverley LGA travel for work.

Direction	SLA/LGA	Proportion	Total
East	Sydney - Inner	23.8%	
	Sydney – East	7.5%	
	Sydney – South	4.4%	
	Sydney – West	3.8%	
	Woollahra	5.4%	44.9%

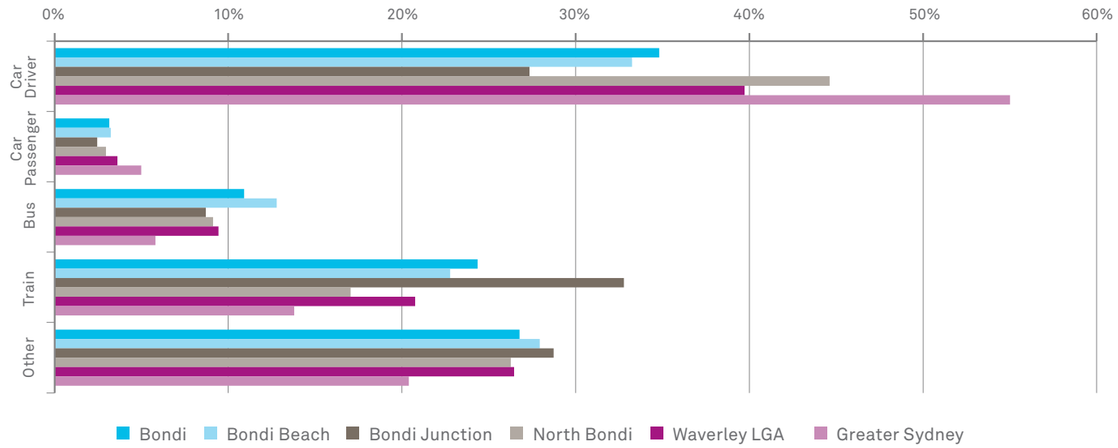

Figure 10. Mode of travel to work 2011
Source: BTS, Census of Population and Housing, 2013

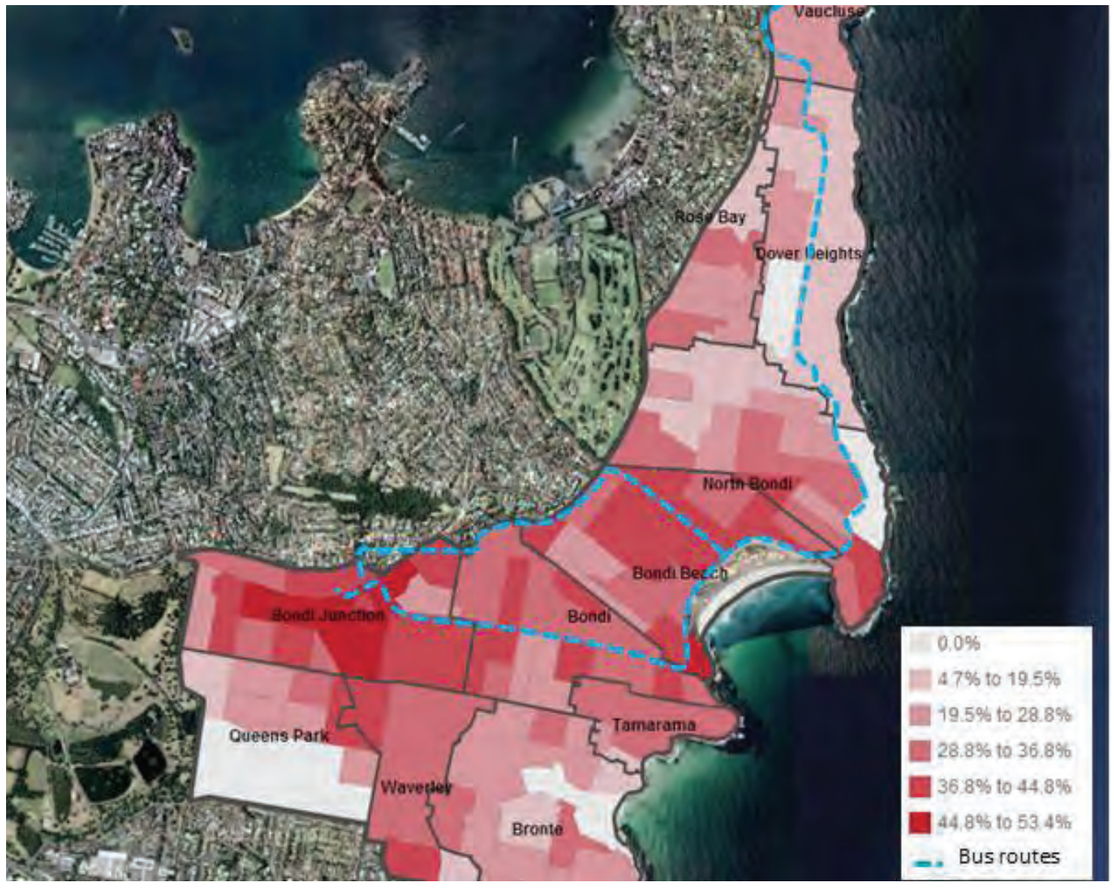

Figure 11. Public transport usage
Source: AECOM, 2013 adapted from profile.id, 2013.

Direction	SLA/LGA	Proportion	Total
Internal	Waverley	20.1%	20.1%
South	Randwick	4.7%	
	Botany Bay	2.4%	7.1%
North-east	North Sydney	3.7%	
	Willoughby	1.6%	5.3%
Greater Sydney	Other*	26.6%	22.6%

Note: *includes POW State/Territory undefined, POW No Fixed Address, POW not state and POW Capital city undefined

Table 4. Waverley LGA employment locations
Source: ABS, Census of Population and Housing 2011

Bondi Junction, Bondi, Bondi Beach and North Bondi residents accounted for 61.5% of the total employed residential population in the Waverley LGA, according to the 2011 census. This data highlights the importance of providing travel opportunities between the suburbs of Bondi Junction, Bondi Beach and the Sydney CBD.

	Population				Employment			
	2011	2026	2046	Growth per annum 2011-2046	2011	2026	2046	Growth per annum 2011-2046
Bondi	10,236	10,822	11,356	0.30%	1,143	1,210	1,302	0.37%
Bondi Beach	10,557	11,424	12,482	0.48%	2,709	2,819	3,103	0.39%
Bondi Junction	11,570	12,059	12,547	0.23%	13,765	15,976	18,544	0.86%
Bronte	7,154	7,472	8,216	0.40%	1,073	1,162	1,266	0.47%
Dover Heights	4,842	5,277	6,264	0.74%	773	863	960	0.62%
North Bondi	10,792	11,121	11,757	0.25%	1,769	1,835	2,001	0.35%
Queens Park	2,884	3,018	3,231	0.33%	647	708	776	0.52%
Rose Bay	3,367	3,427	3,491	0.10%	605	635	686	0.36%
Vaucluse	3,063	3,156	3,327	0.24%	282	299	314	0.31%
Waverley	4,397	4,631	5,086	0.42%	1,776	1,817	1,857	0.13%
Total	68,861	72,408	77,758	0.35%	24,542	27,323	30,809	0.65%

Table 5. Population and Employment Forecasts
Source: Bureau of Transport Statistics (BTS), 2013

Analysis of the 2011 method of travel to work data shows residents in the suburbs of Bondi, Bondi Beach and Bondi Junction have a higher usage of public transport for trips to work than the either the rest of Waverley LGA or Greater Metropolitan Sydney. This is shown in Figure 10. The high proportion of bus trips recorded for Bondi and Bondi Beach can be attributed to the high volume of bus services provided along Bondi Road, linking these suburbs with Bondi Junction interchange and onto Sydney CBD.

Within Waverley LGA, bus travel is greater for Bondi and Bondi Beach and train travel highest for Bondi, Bondi Beach and Bondi Junction. North Bondi has the highest proportion of car drivers when compared to the suburbs of Bondi, Bondi Beach and Bondi Junction and a higher car use than across Waverley LGA. This reflects the current availability and attractiveness of mass transit options in terms of journey time reliability and efficiency compared to other travel alternatives.

3.5.2 Tourist and Visitor Travel

Bondi Beach being a major tourist destination is estimated to attract approximately 50,000 visitors per day. As the majority of visitors are non-residents therefore this increases their reliance on public transport, and at present particularly bus services, for travel in the corridor between Bondi Junction and Bondi Beach.

The increasing number of major events held at Bondi Beach such as the City to Surf and Sculptures by the Sea puts additional pressure on the public transport system and on-street parking within the area. This adds further weight to the need to promote high quality public transport options between Bondi Beach and Bondi Junction.

3.5.3 Bondi Road travel patterns

In 2008, ACA Research was commissioned by Waverley Council to undertake street intercept interviews to assess the potential impact of the introduction of a bus lane on Bondi Road. 224 interviews were conducted on the weekend of 14 and 15 June 2008.

The key findings of the study were as follows:

- 79% of respondents visited Bondi Road for a specific reason, while 21% stopped on Bondi Road on the way to another destination;
- Only 20 % did not reside in the 2026 postcode (Bondi/Bondi Beach);
- Walking to Bondi Road was the primary transport mode used with 66% walking from their place of residence;
- 56% of respondents from other areas most often used a car to get to Bondi Road.

The ACA study reveals that the majority of people travelling to Bondi Road are locals who access the corridor as pedestrians, indicating the relative low level of private car usage compared to greater Sydney. It also indicates that 44 per cent of respondents from outside the area do not travel to Bondi Road by car. Based on the ACA study it would appear that many of these respondents would benefit from a Light Rail system along Bondi Road to access their desired destination, while this could also attract more people from outside the area onto public transport.

3.6 Future land use trends

Land use growth provides a sound indication of potential growth in travel demand. The following section analyses the projected population and employment growth forecasts for Waverley LGA and describes the potential impact on travel demand.

The key points which can be drawn out of these forecasts are:

- By 2046 the Waverley LGA's population and employment is expected to increase by 8,897 and 6,267 respectively.
- At 0.86% growth per annum, Bondi Junction is expected to experience the fastest percentage increase in employment, with an additional 4,779 jobs (76% of new jobs in the Waverley LGA).
- Bondi, Bondi Beach and Bondi Junction (the top 3 suburbs in the Waverley LGA for public transport usage) account for 45% of the future population increase.
- There is likely to be continued growth in demand for travel increasing the need to focus on efficient use of existing corridors and road space.
- Therefore the impact on bus and traffic congestion will continue to worsen, heightening the need to consider a step change in public transport priority and to a higher order mode with greater passenger capacity, i.e. light rail.

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04

Route options and assessment

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4. Route Options and Assesment

4.1 Introduction

This study primarily focuses on the link between Bondi Junction and Bondi Beach. However, more strategic connection linking this corridor with the CBD and other regional destinations are also considered at a high level.

Three routes have been identified for the Bondi Junction to Bondi Beach Light Rail link, these include:

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

The route options enable a broad analysis of the best location for Light Rail between Bondi Junction and Bondi Beach. The options have very different issues, constraints and opportunities ranging from different land uses, gradients, corridor widths, levels of activity, route length, residential catchment and directness.

Figure 12 shows the potential route options considered to serve the corridor between Bondi Junction and Bondi Beach.

Figure 12. Route options
Source: AECOM, 2013

4.2 Spatial Opportunities and Constraints

Travelling between Bondi Junction and Bondi Beach involves traversing a topographical difference from the higher plateau of Bondi Junction (at RL +110) to the lower lying land at sea level at and directly behind Bondi Beach (at RL +0). There is a major ridgeline oriented north-west to south-east from Bellevue Park to Hunter Park respectively. This broadly follows the alignment of the Edward Street and Hunter Street road corridor. The topography of the area is shown in Figure 13.

The height difference and the resultant change in gradient will pose a challenge for any route alignment option running between the two major hubs of Bondi Junction and Bondi Beach. A plan showing the gradient change throughout the vicinity is provided in Figure 14.

Figure 13. Topography
Source:AECOM, 2013

Generally all alignment options considered would be able to run on existing road alignments at gradients of up to 7%, which is generally considered well within the scope of modern electrified light rail systems globally. The steepest gradients above 7% will need further consideration through a more detailed engineering feasibility assessment to consider the cost benefits of the various alternative approaches available to respond to challenging sections of gradient. Such responses could relate to the vehicle fleet or system power supply and traction, to road re-grading or running the alignment off the existing road carriageway indicated. Therefore whilst the gradient of 7% has been highlighted as a potential challenge which needs further consideration, the gradient alone is by no means a 'show-stopper' and there are a multitude of potential responses available to meet this challenge.

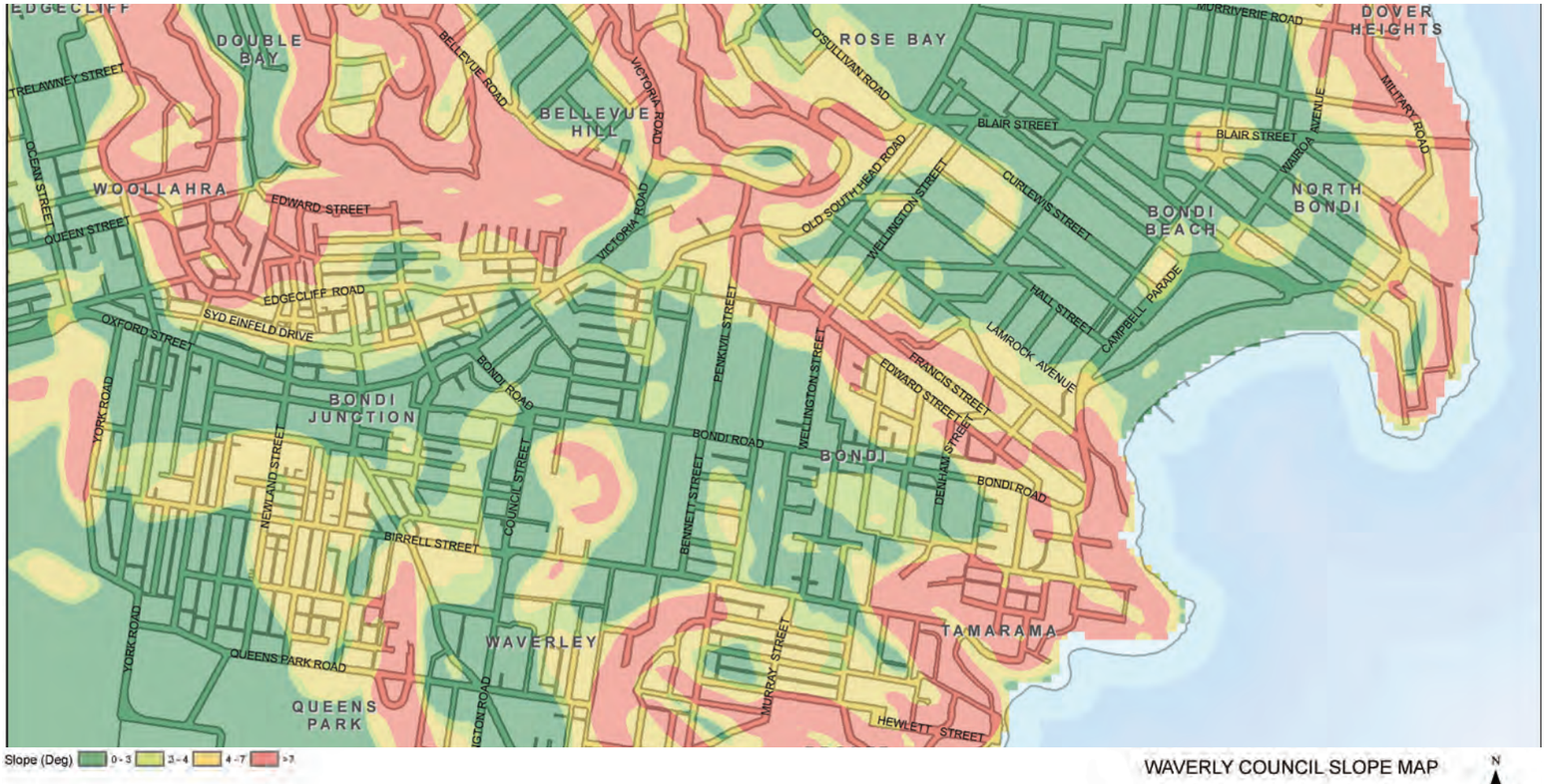


Figure 14. Waverley gradient
Source: AECOM, 2013

4.2.1 Floor Space Ratio (FSR) controls

Floor Space Ratios in Waverley reflect existing land use and density patterns, with high FSR around commercial and mixed use precincts, while remaining lower in residential areas, as shown in Figure 15. High ratios of 5:1 to 8:1 are concentrated around the Bondi Junction business centre and railway station, enabling higher development densities. Much of the remaining suburban areas are low density, with an FSR of between 0.5:1 and 0.9:1, reflecting the predominant residential land use. Development fronting Bondi Beach on Bondi Road is also higher is density, with an FSR of 3:1. This largely reflects the built form already existing along this highly visible precinct.

Figure 15. Development Floor Space Ratio (FSR) controls in the alignment vicinity
Source: Waverley Council, 2013

4.2.2 Building height controls

Building height controls generally reflect land use and built form patterns in the same way as FSR controls, as shown in Figure 16. Much of Waverley has a building height limit of 9.5 metres in place, which is consistent with two storey residential development. Due to the higher density controls in place for the Bondi Junction business centre, building height limits of up to 60 metres are in place in this area. Adjacent to Bondi Beach on Bondi Road there are height controls of 15 metres, serving to protect view corridors and retain the existing streetscape scale.

Figure 16. Maximum building height controls in the alignment vicinity
Source: Waverley Council, 2013

4.2.3 Land zoning controls

Zoning controls throughout Waverley are shown in Figure 17, reflecting existing patterns of land use in the area. The Light Rail route travels from Bondi Junction, a centre with commercial core and mixed use zonings, along Bondi Road to Bondi Beach. The route along Bondi Road is zoned medium and high density residential, with the addition of a mixed use zone between Penkivil Street and Denham Street which houses the small retail and commercial precinct. A mixed use zone is also located along Bondi Road adjacent to Bondi Beach, where a large retail and restaurant precinct is located, along with residential premises.

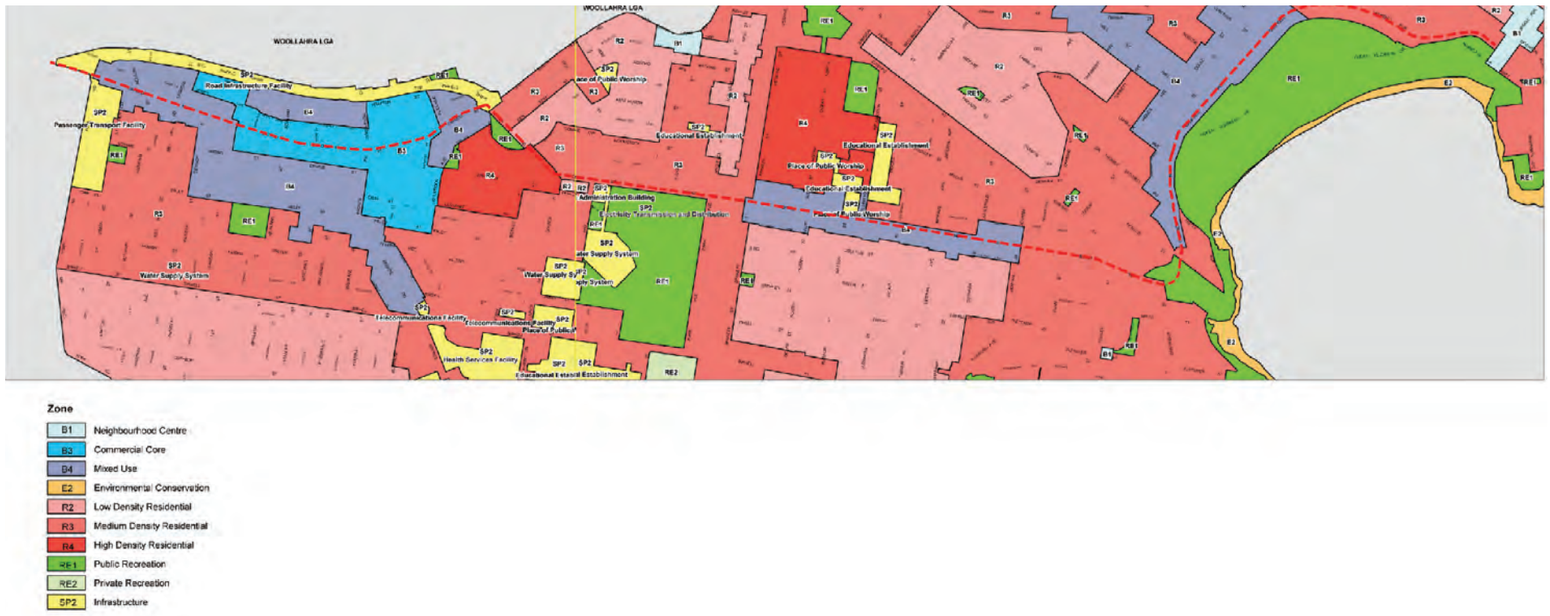


Figure 17. Land zoning controls in the alignment vicinity
Source: Waverley Council, 2013

4.3 Route Option 1

Table 5 summarises the assessment process and addresses the key issues involved in Light Rail. The alignment of Route Option 1 is detailed in Figure 18.

Bondi Junction to Bondi Beach via Old South Head Road, Birriga Road & Curlewis Street	
Length of Route	4.2 km
Light Rail Travel Time	8 mins 23 seconds (based on an average speed of 30km/h along the entire corridor)
Estimated passengers	• Route Option 1 covers a catchment area currently serviced by bus routes X84, X89 and 389. • These bus routes service an average of 1,800 passengers for the AM period (6-9:30am) from the nearby area with over 90% of passengers travelling on the city bound direction in 2011. • Assuming Route Option 1 will capture all the passengers currently serviced by the existing bus routes, and with an expansion to an average workday, the estimated daily patronage for Route Option 1 is 6,300 passengers (2011). • BTS land use projections show an increase of 13% from 2011 to 2036 for the surrounding areas. • Assuming patronage will grow in line with land use growth, the AM 6-9:30am patronage for 2036 is 2,000 and the estimated daily patronage for 2036 is 7,100. • Existing bus data does show a variation of up to +/-30% on a day by day basis. This may also apply to the estimated patronage numbers. • Improvement in travel time (against bus) and the extra convenience offered by Light Rail could generate additional induced demand for Route Option 1.
Key Land Uses	• Bondi Junction commercial/retail area • Bondi Junction residential area • Residential area along Old South Head Road and Birriga Road corridor • Woollahra Oval • Residential area along Curlewis Street • Bondi Beach • Bondi Beach commercial/retail area
Topography and slope	The gradient along this route is generally quite steep, with bends and a central concrete barrier further restricting the operation of an potential Light Rail system
Potential impacts – land use / traffic	• Land use along the route is mainly residential flat development, with some commercial development along Old South Head Road. Bellevue Hill Public School is also located near the intersection of Birriga Road and Victoria Road • Birriga Road, the main corridor used along Route Option 1, is a collector road with relatively low levels of traffic, while both Victoria Road and Old South Head Road perform a higher traffic function with increased traffic volumes • On street parking would need to be removed for entire length
Potential opportunities – Urban renewal	The area with greatest potential opportunity for small scale, localised urban renewal is around the intersection of Old South Head Road and Edgecliff Road, where there are some single dwelling houses. An potential development would be medium density/medium scale in keeping with existing character of the local area. Much of the remainder of the route is lined by strata lots, which makes redevelopment very difficult.

Table 6. Route Option 1

Figure 18. Route 1
Source: AECOM, 2013

4.4 Route Option 2

Bondi Junction to Bondi Beach via Bondi Road	
Length of Route	3.9 km
Light Rail Travel Time	7 mins 47 seconds (based on an average speed of 30km/h along the entire corridor)
Estimated passengers	• Route Option 2 covers a catchment area currently serviced by bus routes 333, 380, 381 and 382. • These bus routes service an average of 2,700 passengers for the AM period (6-9:30am) from the nearby area with over 90% of passengers travelling on the city bound direction in 2011. • Assuming Route Option 2 will capture all the passengers currently serviced by the existing bus routes, and with an expansion to an average workday, the estimated daily patronage for Route Option 2 is 14,800 passengers (2011). • There is also a very large travel demand market for visitation to Bondi Beach wich this potential corridor can best serve. • BTS land use projections show an increase of 13% from 2011 to 2036 for the surrounding areas. • Assuming patronage will grow in line with land use growth, the AM 6-9:30am patronage for 2036 is 3,000 and the estimated daily patronage for 2036 is 16,700. • Existing bus data does show a variation of up to +/-50% on a day by day basis for these bus routes. This may also apply to the estimated patronage numbers. • Improvement in travel time (against bus) and the extra convenience offered by Light Rail could generate additional induced demand for Route Option 2.
Key Land Uses	• Bondi Junction commercial/retail area • Waverley Council • Bondi Junction residential area • Waverley Park/Oval (civic/leisure users) • Bondi Road retail/mixed business • Residential area along Bondi Road • Bondi Beach • Bondi Beach commercial/retail area
Topography and slope	Generally gentle constant downward slope, until around east of Denham Street to Notts Avenue, where the gradient increases modern light rail technology should be adequate to service gradients on this section. Further detailed feasibility and costing would be required to evaluate the best capital cost option to meet the topographical changes i.e. to evaluate potential re-grading or property acquisition against specifying light rail vehicle fleet with increased traction / power capacity.
Potential impacts – land use / traffic	• Bondi Road is a key corridor between Bondi Junction and Bondi Beach, meaning any Light Rail development should carefully consider the impacts on traffic • Loss of parking lanes along Bondi Road
Potential opportunities – Urban renewal	There are several potential renewal opportunities along this route. When open space, churches, heritage items and strata lots are taken out, there still remains large areas of low-rise development which might be able to be redeveloped in the short to medium term. An potential development would be medium density/medium scale in keeping with existing character of the local area.

Table 7.Route Option 2

Figure 19. Route 2
Source: AECOM, 2013

Figure 20. The former Waverley tram network 1907 – 1920
Source: National Library of Australia, Digital Collection, 2013

Bondi Road was historically served by a tramline which was generally on the alignment of the proposed Route Option 2. As a result of the history of this corridor, present land use patterns and built form still reflect historic transport accessibility afforded by the old tram network. A map depicting the route locations of the former tram network in Waverley from 1907 to 1920 is shown above in Figure 20.

4.5 Route Option 3

The alignment of Route Option 3 is detailed in Figure 21.

Bondi Junction to Bondi Beach via Council Street, Birrell Street & Watson Street	
Length of Route	4.7 km
Light Rail Travel Time	9 mins 24 seconds (based on an average speed of 30km/h along the entire corridor)
Estimated passengers	• Route Option 3 covers a catchment area currently serviced by bus routes 333, 380, 381 and 382. • These bus routes service an average of 2,700 passengers for the AM period (6-9:30am) from the nearby area with over 90% of passengers travelling on the city bound direction in 2011. • Assuming Route Option 3 will capture all the passengers currently serviced by the existing bus routes, and with an expansion to an average workday, the estimated daily patronage for Route Option 3 is 14,800 passengers (2011). • BTS land use projections show an increase of 12% from 2011 to 2036 for the surrounding areas. • Assuming patronage will grow in line with land use growth, the AM 6-9:30am patronage for 2036 is 3,000 and the estimated daily patronage for 2036 is 16,600. • Existing bus data does show a variation of up to +/-50% on a day by day basis for these bus routes. This may also apply to the estimated patronage numbers. • Improvement in travel time (against bus) and the extra convenience offered by Light Rail could generate additional induced demand for Route Option 3.
Key Land Uses	• Bondi Junction commercial/retail area • Bondi Junction residential area • Residential area along Council Street, Birrell Street and Watson Street • Bondi Beach • Bondi Beach commercial/retail area
Topography and slope	Generally gentle constant downward slope, until around east of Denham Street to Notts Avenue, where the gradient increases
Potential impacts – land use / traffic	• Bondi Road is a key corridor between Bondi Junction and Bondi Beach, meaning any Light Rail development should carefully consider the impacts on traffic • Loss of parking lanes along Bondi Road, Watson Street, Birrell Street and Council Street
Potential opportunities – Urban renewal	The route along Council and Watson Street offers some urban renewal opportunity, however this is removed from the main strip of activity on Bondi Road. The potential for mixed use/active retail in this area may therefore be quite limited as pedestrian activity is not focussed in this area.

Table 8. Route Option 3

Figure 21. Route 3
Source: AECOM, 2013

4.6 Future (long term) connections to broader Sydney Light Rail network

The primary objective of this study has been to determine the feasibility of Light Rail to meet the travel demands in the corridor between Bondi Junction Town Centre and Bondi Beach providing for a significant core commuter travel market and a strong visitor travel market.

These travel markets combine to create bi-directional all-day travel demand which merits the consideration of higher order modes and public transit priority in the corridor.

The potential role of Light Rail to serve additional corridors has also been considered at a high level through this study. These additional corridor options would serve a different function entirely, linking into the preferred future Sydney CBD and South East (CSELR) Light Rail route proposed by the state government in the Strategic Light Rail plan for Sydney. The preferred CSELR route being that running from the CBD to two south east termini at Nineways, Kingsford and at Randwick Junction, Randwick, as shown in Figure 5 (in Section 3.2).

4.6.1 Route options for straegic connections

Future connection to Sydney Light Rail network have been considered, these being:

1. CBD via Randwick
2. CBD via Moore Park Road
3. CBD via Ocford Street

CBD via Randwick

One alternative corridor option considered would link Bondi Junction south to the proposed CSELR route terminus at Randwick Junction, Randwick. Therefore it would not achieve the key objective of this project to serve travel demand in the Bondi Junction to Bondi Beach corridor, to relieve congestion in this corridor and improve public transport accessibility, through legible, direct, efficient routes which can move people rapidly and frequently between their desired origin and destination.

The significant commuter demand from the suburbs in the Bondi Junction to Bondi Beach corridor is focused on destinations to the west, Bondi Junction, Sydney CBD and other employment destinations west beyond Sydney CBD. Therefore, a need exists for high capacity, rapid, direct public transit routes with fast journey times serving this demand. The need for public transit to serve the visitor and tourist market to Bondi Beach is also a significant driver of the project in the Bondi Junction to Bondi Beach corridor.

The alternative corridor between Bondi Junction and Randwick would not serve the same markets. It would serve a different function increasing cross-regional accessibility between two major hubs: Bondi Junction, as a primary commercial and retail centre; and Randwick designated as a specialised centre and an education and health precinct. The University of New South Wales (UNSW), Prince of Wales hospital, National Institute of Dramatic Art (NIDA) provide a significant student and staff travel market to the Randwick precinct supplemented by Randwick Racecourse a significant attractor for major events.

An alignment that provides a north-south connection between Bondi Junction and Randwick has been considered, this closely replicates the existing 400 series bus routes (400 and 410).

The characteristics and potential demand for this Bondi Junction and Randwick alignment are discussed in the table below.

Bondi Junction to Randwick	
Length of Route	3.6 km
Light Rail Travel Time	7 mins 12 seconds (based on an average speed of 30km/h along the entire corridor)
Estimated passengers	• This alternative route covers a catchment area currently serviced by the 400 series bus routes (400 and 410). • Within the catchment area, these bus routes currently service an average of 1,200 passengers for the AM period (6-9:30am) from the nearby area with 65% of passengers travelling on the northbound direction. • Assuming the alternative route will capture all the passengers currently serviced by the existing bus routes, and with an expansion to an average workday, the estimated daily patronage is 10,100 passengers (2011). • BTS land use projections show an increase of 26% from 2011 to 2036 for the surrounding areas and there are high growth rates at the University and its surroundings. • Assuming patronage will grow in line with land use growth, the AM 6-9:30am patronage for 2036 is 1,600 and the estimated daily patronage for 2036 is 12,800. • Existing bus data does show a variation of up to +/-30% on a day by day basis for these bus routes. This may also apply to the estimated patronage numbers. • Improvement in travel time (against bus) and convenience offered by Light Rail could generate additional induced demand.
Key Land Uses	• Bondi Junction commercial/retail area • Bondi Junction residential area • The University of NSW
Potential impacts – land use / traffic	The alignment intersects with some key roads and intersections in the area including Newland Street, Carrington Road, Frenchmans Road, Avoca Street and High Street. There could also be potential loss of parking lanes along the key roads.
Potential opportunities – Urban renewal	Commercial / retail area along Avoca Street

Table 9. Alternate Route

Within the corridor, the University of NSW is a major trip generator, particularly for education trips. To further understand the spatial distribution of the student trips, student postcode data has been analysed and the home locations of the students are shown in Figure 17 below. As shown in the figure, the majority of the student residences are around the University and the Anzac Parade corridor rather than the alternative alignment.

Therefore, this market is unlikely to provide any additional uplift in demand for this corridor.

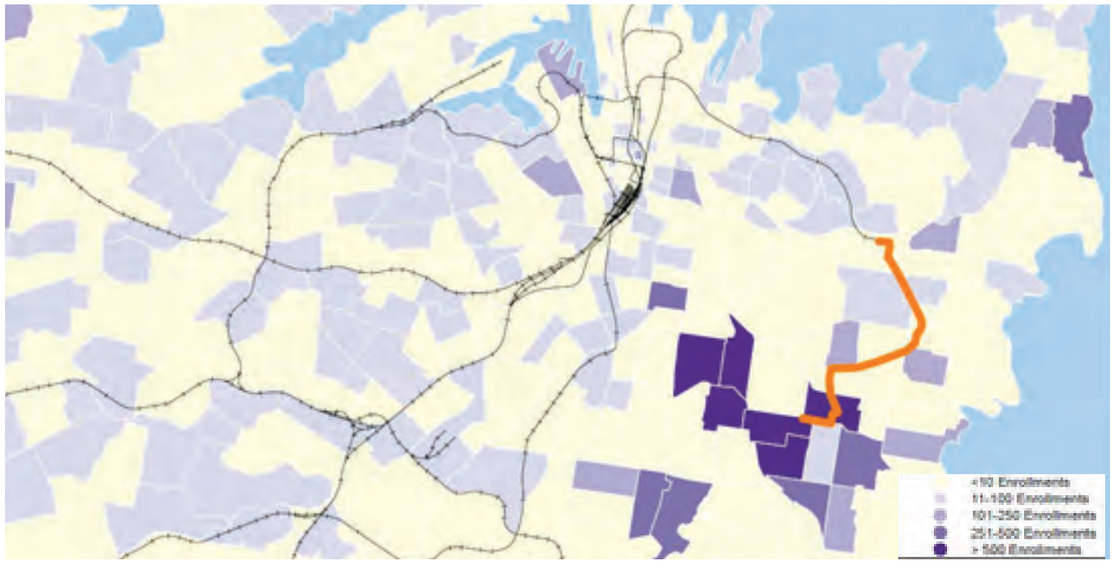


Figure 22. Spatial distribution of UNSW student residences
Source: UNSW student enrolment postcode data

This route option is not considered a legible, fast and efficient connection to the broader strategic light rail network. Alternative options which follow existing core public transport corridors, in line with travel demand patterns are discussed below. It is recommended this option not be considered for further investigation and a more direct east-west connection to / from the CBD is preferred.

CBD Via Moore Park Road / Oxford Street

Any potential medium tram light rail connection from Bondi Junction to Bondi Beach linking onward into the broader strategic network would be well serviced in the long term through a direct surface transit connection east-west on to Sydney CBD.

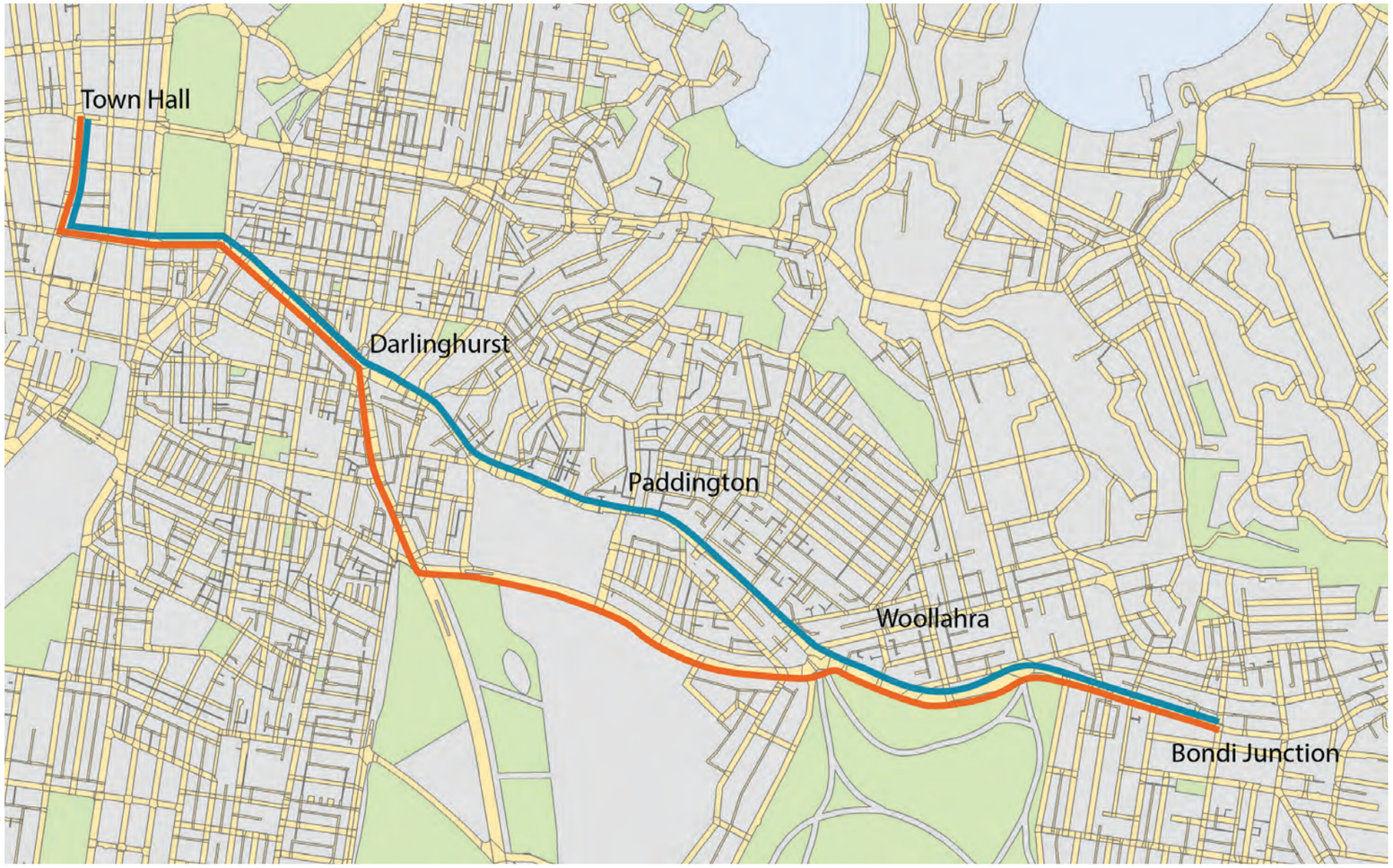
There would be two potential primary routes which an onward connection west from Bondi Junction could turn to link into the CBD light rail on George Street these being:

Oxford Street (Bondi Junction) to Town Hall via **'Moore Park Road'** (Along South Dowling Street and Oxford Street (Darlinghurst))

Oxford Street (Bondi Junction) to Town Hall via **'Oxford Street'** (Through Paddington and Darlinghurst)

Of these two alternatives, Moore Park Road has a function as a strategic traffic corridor linking the eastern suburbs to both the CBD and the eastern distributor motorway. Oxford Street through Paddington has a local distributor function, is a core public transport corridor, with urban activation along its entire length, intermediate trip origins and destinations and greater potential for urban renewal and streetscape enhancements along side any public transit improvements. Therefore, from a strategic level assessment Oxford Street would be recommended as a preferred route option.

A more detailed feasibility assessment is required to consider these route option alternatives for long term strategic network connectivity.



4.7 Comparative Assessment of Bondi Junction to Bondi Beach Route Options

This section sets out a multi-criterai assessment (MCA) which rates each of the potential route options, to serve the Bondi Junction to Bondi Beach link, againts the project objectives.

Option	Reduce Congestion along corridor[1]	Efficiency of people movement in corridor[1]	Legibility	Efficiency of PT service provision	Ability to provide LR service	Complimentary streetscape improvements	Travel time	Land uses	Overall rating
1	●	●	●	●	●	●●	●●	●	●
	Possibility of reducing 333 buses	Does not provide a link to Bondi Road corridor	Route includes winding turns along Birriga Road		Steep gradient and cement barrier along Old South Head Road		(+8%)	Mainly serves residential areas – catchment area does not serve much of the Waverley LGA	
2	●●●	●●●	●●	●●●	●●	●●●	●●●	●●●	●●●
	Significantly reduces number of bus services along the corridor	Provides a link to the whole Bondi Road corridor	Most direct route between Bondi Junction and Bondi Beach		Gradient along Bondi Road (between Lamrock Ave and Dudley St) may be an issue	Opportunity to improve frontages along the commercial and leisure areas of Bondi Road	(–)	Serves the residential, commercial and leisure land use areas along Bondi Road	
3	●	●●	●	●	●●	●●	●	●●	●●
	Possibility of reducing 333 buses	Provides a link to the eastern part of the Bondi Road corridor	Longest route between Bondi Junction and Bondi Beach.		Gradient along Bondi Road (between Lamrock Ave and Dudley St) may be an issue		(+21%)	Serves part of the residential, and leisure land use areas along Bondi Road	

NOTE: (1) Corridor refers to the Bondi Road corridor between Bondi Junction and Bondi Road

● OK

●● Good

●●● Very Good

MCA of route options

Following analysis and a qualitative multi-criteria assessment of the potential route options, **Option 2** along Bondi Road was chosen as the most optimal route for the operation of a Light Rail line running from Bondi Junction to Bondi Beach. It is 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 implementation of the Bondi Road option would also result in the largest reduction to public transport congestion of the three options, with the number of bus routes operating along the corridor significantly reduced, especially during peak periods.

Passenger demand forecasting estimates that Route Option 2 has the potential to attract patronage, far outweighing the alternative Options 1 or 3. In 2036, Route Option 1 could have a daily patronage of 7,100, while Route Option 2 could have daily patronage of 16,700.

Replacing buses with light rail (if implemented) on this corridor would be a positive public transport outcome enabling efficiency in road space utilisation, passenger capacity and journey times. A significant potential customer experience benefit could therefore be realised.

These improvements to public transport travel options, including seamless integration into the broader network to light rail, heavy rail and other modes indicates significant potential for further included demand and modal shift, for example from private car trips to light rail.

05

Concept design and visualisation of the preferred corridor

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5. Concept design and visualisation of the preferred corridors

Figure 23. Aerial of the preferred Bondi Road corridor
Source: AECOM, 2013

Figure 24. Alignment opportunities
Source: AECOM, 2013

5.1 Corridor overview

The preferred corridor to provide Light Rail between Bondi Junction and Bondi Beach would follow Oxford Street, Bondi Road and Campbell Parade. This is the most legible corridor, has the best patronage potential and would directly serve the intermediary land uses along the corridor. This route needs to be subject to further more detailed engineering feasibility studies, however, following the analysis conducted in Section 4, it has been found to be optimal from a project feasibility perspective (including feasibility based on patronage) and best responds to the project objectives defined.

This corridor along Bondi Road is the most optimal route for the operation of a Light Rail line running from Bondi Junction to Bondi Beach. It is the fastest, most direct and legible route between the two centres, while also providing the best opportunity for urban renewal of the commercial precinct along Bondi Road.

The implementation of the Bondi Road option would also result in the largest positive impact on congestion of the three options and has the greatest potential to achieve the efficiency objective for use of the Bondi Road corridor, ensuring efficiency of overall people movement as well as optimising public transport efficiency. The number of bus routes operating along the corridor could be significantly reduced, especially during peak periods, thereby easing road congestion, whilst at the same time improving public transport capacity in the corridor and improving operational reliability and customer experience.

Passenger demand forecasting estimates that Route Option 2 could attract a daily patronage in excess of 16,000 people per day in 2036, based solely on existing bus patronage and projected land use change. Induced demand and the additional uptake of such a high quality, rapid public transport system has not been considered, even though there is undoubtedly latent public transport demand which is unmet by current public transport service provision, in the corridor.

5.2 Stop development and definition

The ‘Bondi Road’ corridor has been shown to be the preferred option from a project perspective but there remain a number of challenges to be met to achieve the desired project outcome, notably, the width constraint of the existing road reserve. The Bondi Road ‘road reserve’ can easily accommodate the light rail alignment but accommodating stops at key locations is more complex. The challenges on Oxford Street and Campbell Parade are less acute due, respectively, to the existing pedestrianised zone and the wider corridor.

From a legibility and customer experience perspective and, also for the benefit of all road users, including car drivers, maintaining simplicity in road function and corridor operation is optimal. The planning principles and design criteria set out in section 2.3 have been designed to meet these objectives and adopted throughout the corridor. However, each specific stop location potentially requires specific treatment to meet the planning and design criteria and to ensure effective operation of the corridor by all modes which includes light rail, cars, cyclists and pedestrians.

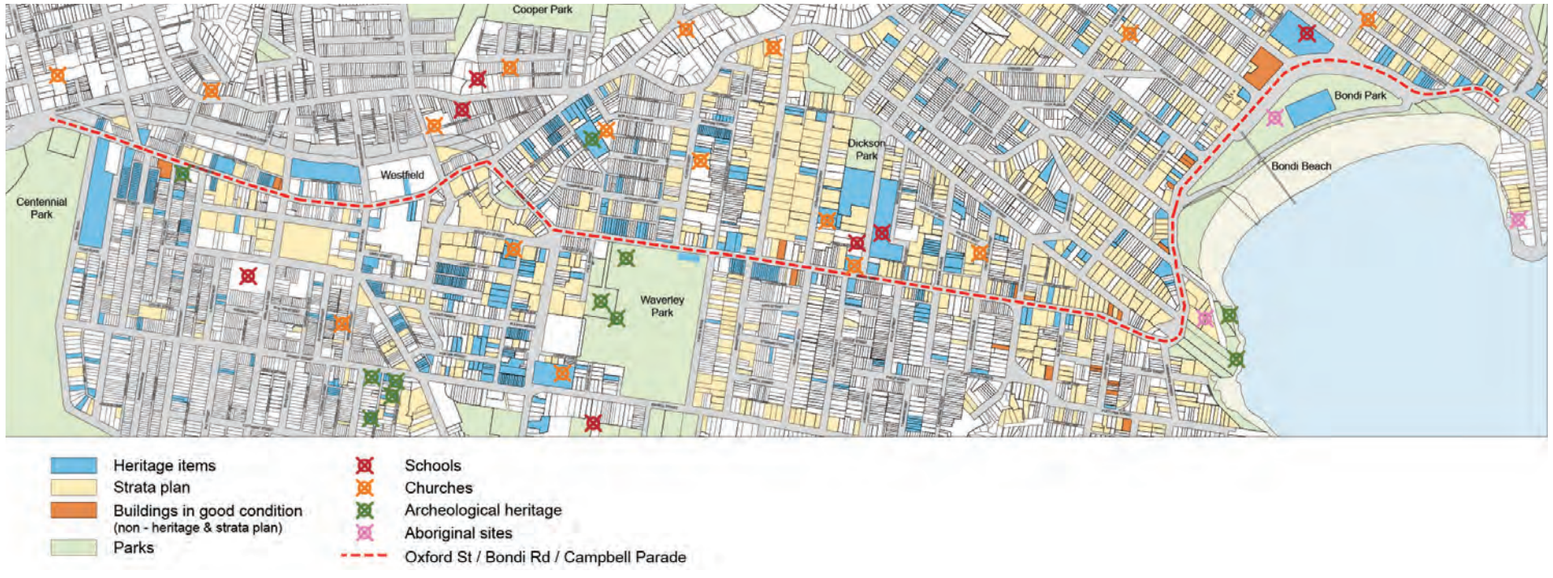


Figure 25. Alignment constraints
Source: Waverley Council, 2013

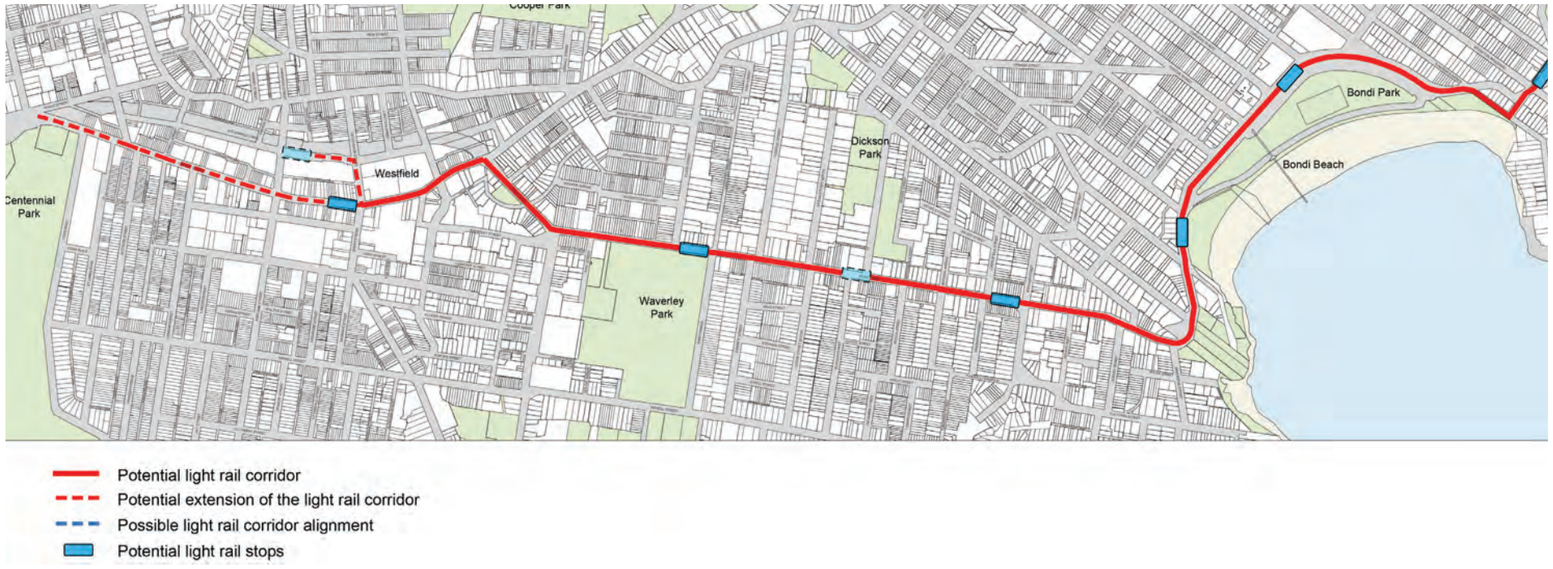


Figure 26. The preferred Bondi Road alignment
Source: AECOM, 2013

The 'kerb to kerb' (width) along Bondi Road is typically approximately 12.8 metres between Council Street and Campbell Parade. This effectively allows for either:

- 4 lanes of general traffic (including turning lanes at intersections and parking lanes); or
- 2 lanes of general traffic and 2 dedicated light rail lanes;
- This existing corridor width could also accommodate 2 dedicated light rail lanes and two side platforms
  - however this leaves no effective general vehicle lanes and renders the corridor inoperable from a general traffic perspective.

Therefore, the Bondi Road cross section does not allow for dedicated light rail stop infrastructure as well as bi-directional light rail running lanes and bi-directional traffic lanes. A stop feasiblity exercise has been undertaken to review opportunities to develop stops in key locations. A series of plans and cross sections have been designed to indicate how all the necessary infrastructure could be accommodated. Figures 27 to 45 illustrate the available 'road reserve' and 'kerb to kerb' widths at key locations along the corridor and provide examples of design responses as to how Light Rail could be accommodated in the corridor.

5.2.1 Stop Locations

The following potential stop locations were identified and considered in consultation with Waverley Council:

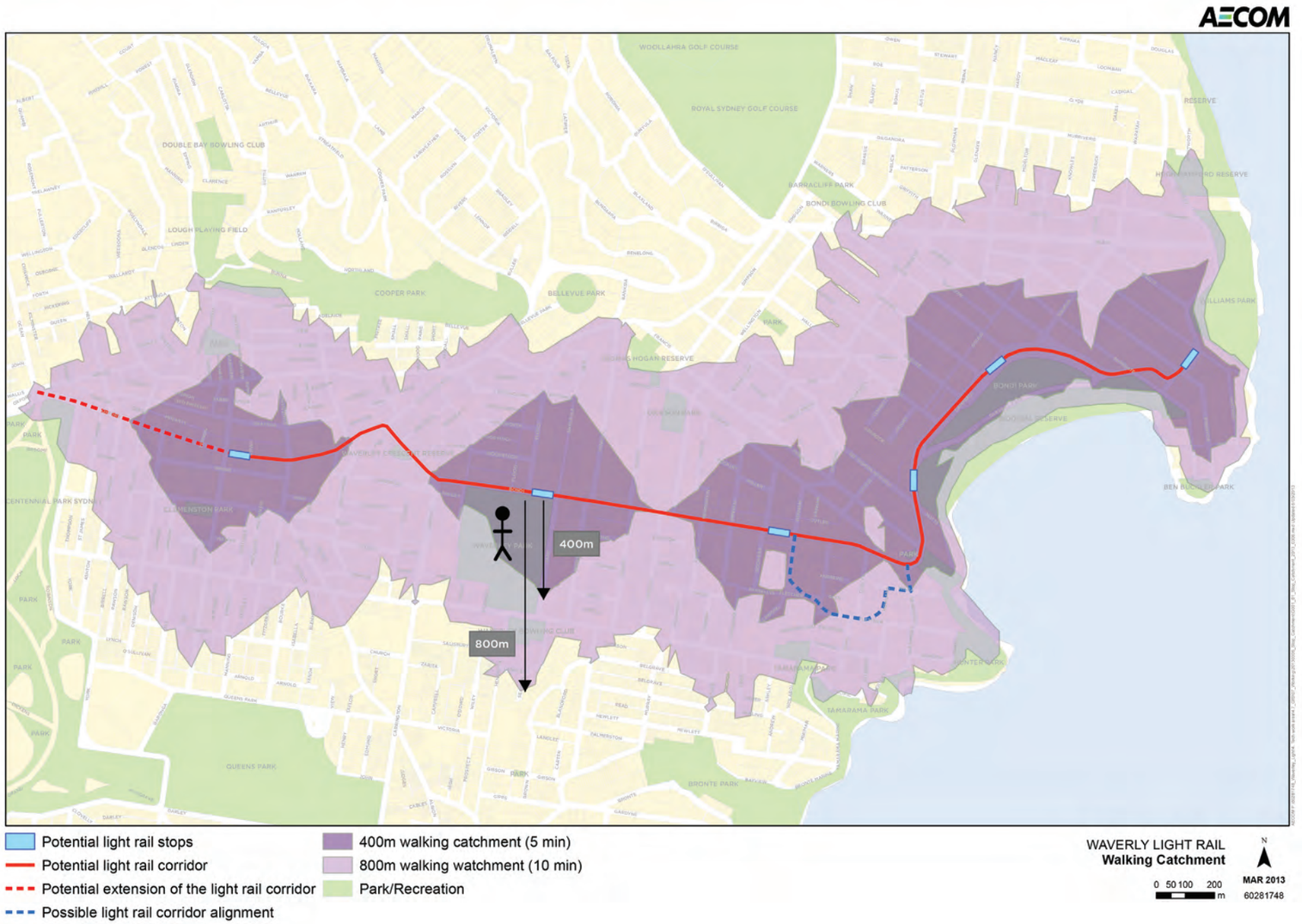
- Bondi Junction Terminus Option 1 – Grafton Street
- Bondi Junction Terminus Option 2 – Oxford Street Mall
- Bondi Road West – Waverley Park
- Bondi Road Central – Watson Street/ Wellington Street
- Bondi Road East – Denham Street
- Bondi Beach South – Notts Avenue
- Bondi Beach North – Beach Road/ Bondi Pavilion
- North Bondi Terminus - Ben Buckler Point

These stop locations were identified based on the key planning criteria set out in section 2.3 to create efficient journey times, provide good accessibility to public transport and the ability to serve key land uses and destinations. It was a prerequisite that all stops could provide direct access to the adjacent pedestrian footway, via signalised pedestrian crossings, and also allow step free boarding access.

The recommended distance between stops is approximately 800m. This means that at any point on the corridor you will be no more than 600m or a 5 min walk from the nearest stop. This is to achieve an efficient balance between stop catchment coverage, number of stops over time track speed and efficiency the optimal number of stops will achieve a balance between these factors.

The table below shows that 6 stops are recommended to serve Waverley LGA between Bondi Junction and North Bondi from an integrated transport planning perspective. This will provide adequate opportunity for access to light rail from surrounding precincts and land uses, interchange with heavy rail at Bondi Junction, the ability to continue the alignment towards Sydney CBD and provides Light Rail with prominence and legibility.

A pedestrian catchment analysis has been undertaken for the 'preferred' stop locations, indicating 400 metre and 500 metre catchments around each stop. These equate to a 5 minute and 10 minute walk time for access to the stops, based on a typically assessed walk speed for an average person.



The figure above highlights the catchment analysis undertaken and demonstrates that the six stops recommended for the corridor (including termini) provide coverage to the majority of land uses along the corridor within 400m of the proposed stop. Therefore, very good local accessibility would be afforded by the system aligned to efficient journey times from end to end of the system.

5.2.2 Stabling and storage

Potential stabling and storage facilities for vehicles would need to be accommodated at or near termini. Whilst this would be subject to future design feasibility, potential location should include the North Bondi terminus, the STA bus depot at Centennial Park (west of Bondi Junction) or co-joined stabling facilities linked into the broader strategic Sydney Light Rail network.

Location	Rationale and comments (including distance from preceding stop)
Bondi Junction Terminus Option 1 – Grafton Street	This stop would be the western terminus of the corridor for interchange with suburban heavy rail at Bondi Junction. It provides easy access to the northern entrance of Bondi Junction, for heavy rail and is close to Bondi Junction Bus Station. The stop is located on the northern fringe of Bondi Junction Town Centre on Grafton Street, in a location with little existing urban activity and no frontage. Therefore it is unlikely to encourage activation and further renewal of the centre itself. A stop in this location could potentially draw interchanging passengers, who otherwise have to use Oxford Street Mall for Bondi Beach buses, away from the heart of the retail and commercial centre. A stop in this location could create additional conflicts with existing bus movements on Grosvenor Street and could be difficult to accommodate with proximate major car park accesses and related traffic movements. **This stop location is not supported.**
Bondi Junction Terminus Option 2 – Oxford Street Mall	This stop would be the western terminus of the corridor for interchange with suburban heavy rail at Bondi Junction. It provides direct access to the southern entrance of Bondi Junction Station, for interchange with heavy rail, and is centrally located in the Bondi Junction major regional centre which is a significant area of employment and retail activity. A stop in this location can be centrally accommodated in the middle of the existing pedestrianised zone, allowing for adjacent pedestrian circulation on the outside of the stop location. This is shown in Figure 28. The stop can be integrated into the existing streetscape with potential enhancements to design and character with integration of adjacent seating and architecture into the urban domain. Relocation of some existing on-street activity (such as markets) may be required. Although this can easily be accommodated in the adjacent sections of Oxford Street Mall although not at the stop itself. This is shown in Figure 29. The stop has the potential to stimulate on-street activity in all time periods and lead to rejuvenation and renewal of Oxford Street Mall. **This stop location is supported.**

Location	Rationale and comments (including distance from preceding stop)
Bondi Road West – Waverley Park	*+950m from Bondi Junction Terminus Option 2* This stop would be the first stop outside Bondi Junction Centre and serve a predominantly residential catchment in the vicinity of Bondi Road and Waverley Park. This stop would provide access to leisure facilities around Waverley Park and also to civic land uses at Waverley Council. A stop in this location can be accommodated by utilising the adjacent parkland on the southern side of Bondi Road with minor realignment of the existing westbound carriageway and footpath. The stop design allows for a new cycle path incorporated into the park fringe. This is shown in Figure 31. This stop would also provide for access to the western end of the Bondi Road retail. **This stop location is supported.**
Bondi Road Central – Watson Street/ Wellington Street	*+400m from Bondi Road West – Waverley Park* This stop location would directly serve the Bondi Road retail land uses and the centre of the Bondi Road corridor. It is however very close to the preceding stop being only 400 metres from the Waverley Park stop. It is challenging to accommodate a stop in this location due to the corridor width, the existing block sizes, multiple land ownership restricting renewal and existing intersections and turning movements, without severely impacting on access or requiring major urban renewal. In order to accommodate the geometry required to create a stop in this location it is likely that major urban renewal would be required on both sides of the Bondi Road corridor. **This stop location is not supported.** (Subject to further engineering feasibility.)
Bondi Road East – Denham Street	*+400m from Bondi Road Central – Watson Street/ Wellington Street* *Note: This stop is also +800m from Bondi Road West – Waverley Park* The stop is at the eastern end of the Bondi Road retail corridor and would serve the Bondi Road retail land uses as well as a significant residential catchment. This stop can be easily accommodated in the existing road corridor width in the short term with a split stop arrangement. This would utilise the existing pedestrian footway for passenger waiting and storage, but with a raised table crossing to enable step free boarding across one traffic lane from the footway to a light rail vehicle. A signallised crossing would be used to manage safe passenger access for boarding and alighting, with the crossing triggered by an approaching light rail vehicle. This is shown in Figure 35. A long term option for this stop, with two dedicated side platforms, could potentially be accomodated by urban renewal on one side of Bondi Road. In this location it has been identified that there is better potential for urban renewal, although this would still need consolidation of land ownership, though this is a longer term goal. **This stop location is supported.**
Bondi Beach South – Notts Avenue	*+600m from Bondi Road East – Denham Street* This stop location would be the first stop for Bondi Beach (from Bondi Junction) and would replace the existing bus stops at the southern end of Bondi Beach. The stop location as specified could improve access between public transport stops (in both directions) and Bondi Beach itself by providing direct access to both platforms from the east side of Campbell Parade. This stop would serve the southern end of the Bondi Beach retail and commercial strip as well as a residential catchment. **This stop location is supported.**
Bondi Beach North – Beach Road/ Bondi Pavilion	*+650m from Bondi Beach South – Notts Avenue* This stop would serve as the central stop for Bondi Beach, serving all retail, commercial, leisure, education and special events uses. The stop can easily be accommodated in the existing road reserve with minimal change to existing carriageways. One lane of parking on the beach side of Campbell Parade would be affected for the block in which the stop is located. However, it will be possible to create new segregated bicycle lanes in each direction of travel. This is shown in Figure 39. **This stop location is supported.**
North Bondi Terminus	*+650m from Bondi Beach North – Beach Road/ Bondi Pavilion* This stop would be the eastern terminus of the Waverley Light Rail. It would serve a predominantly residential catchment in the North Bondi suburb with good access to Ben Buckler Point and would be a direct replacement for existing North Bondi terminating bus services. This is shown in Figure 41. The stop location can be accommodated in the existing bus terminus area, which was previously used by terminating services as a tram terminus. **This stop location is supported.**

Table 10. Appraisal of potential Light Rail stop locations

5.3 Concept Design of Preferred Alignment and Stops

5.3.1 Bondi Junction Mall

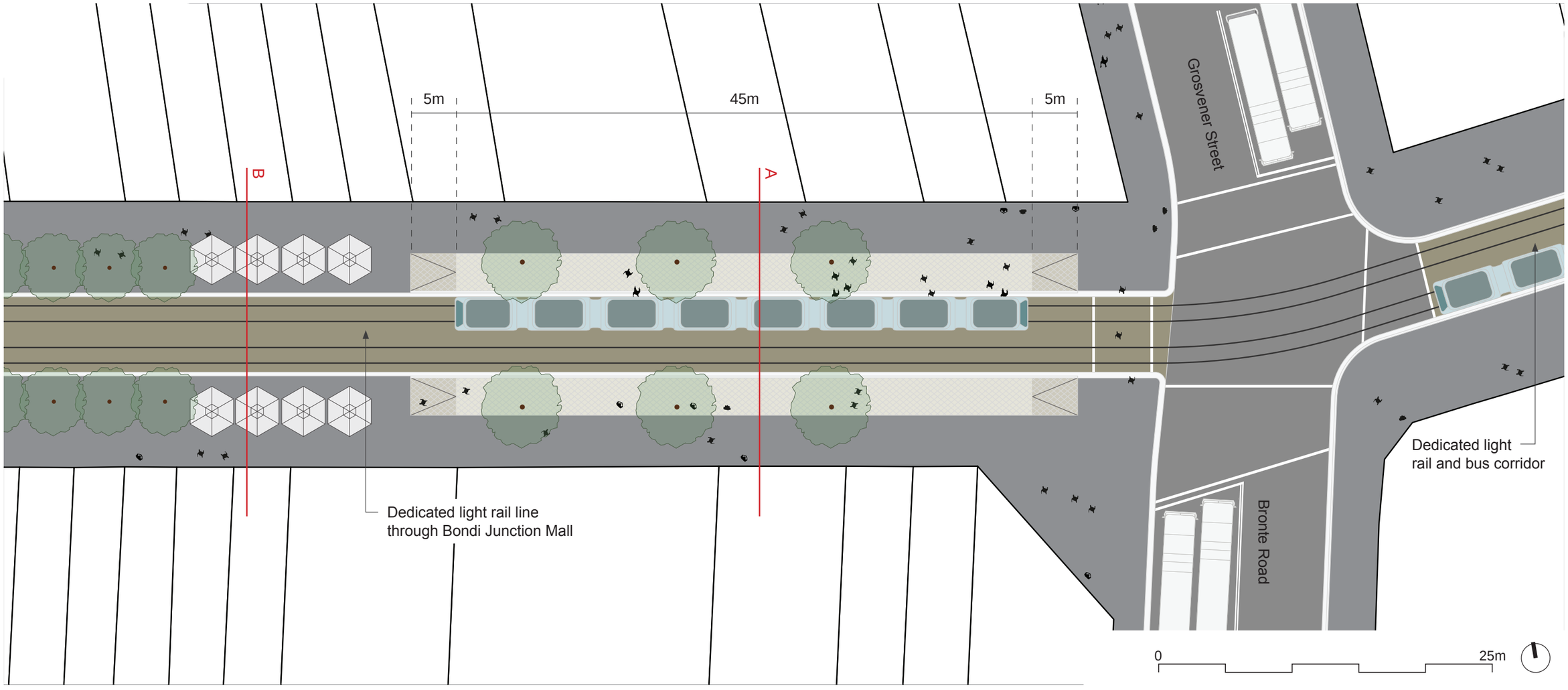


Figure 27. Bondi Junction Mall: Indicative Layout
Source: AECOM, 2013

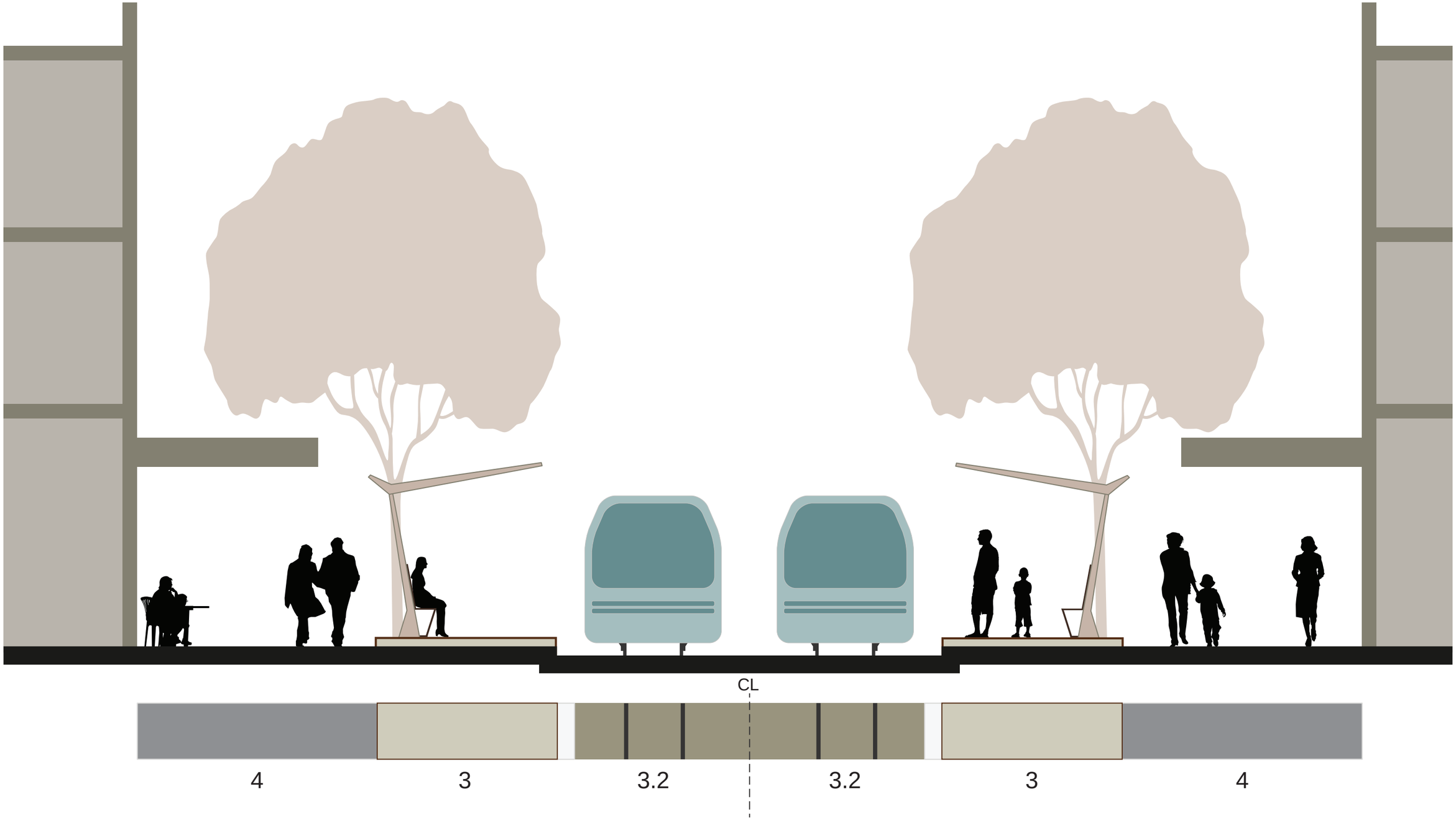


Figure 28. Bondi Junction Mall: Indicative Cross Section A
Source: AECOM, 2013

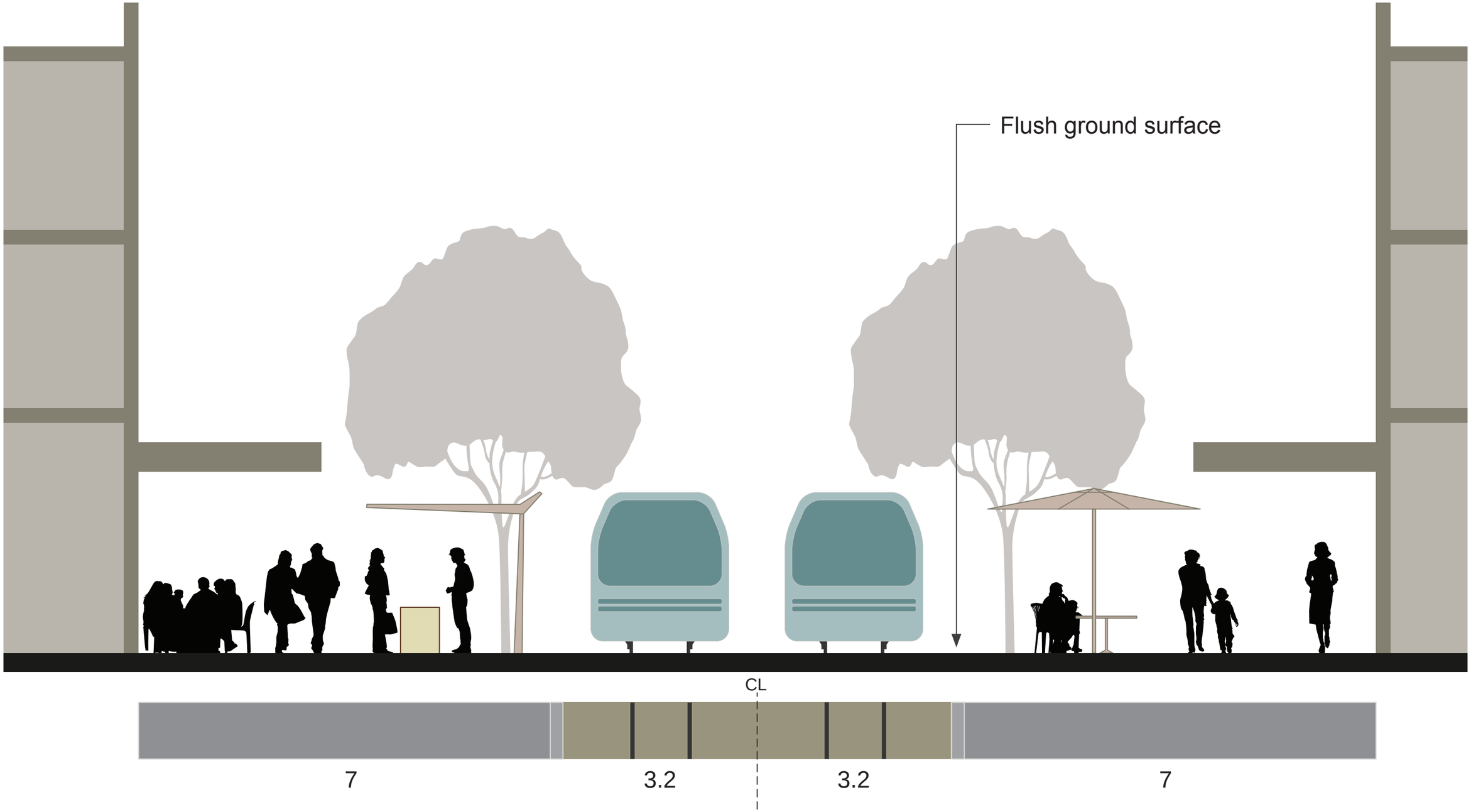


Figure 29. Bondi Junction Mall: Indicative Cross Section B
Source: AECOM, 2013

5.3.2 Waverley Park Stop

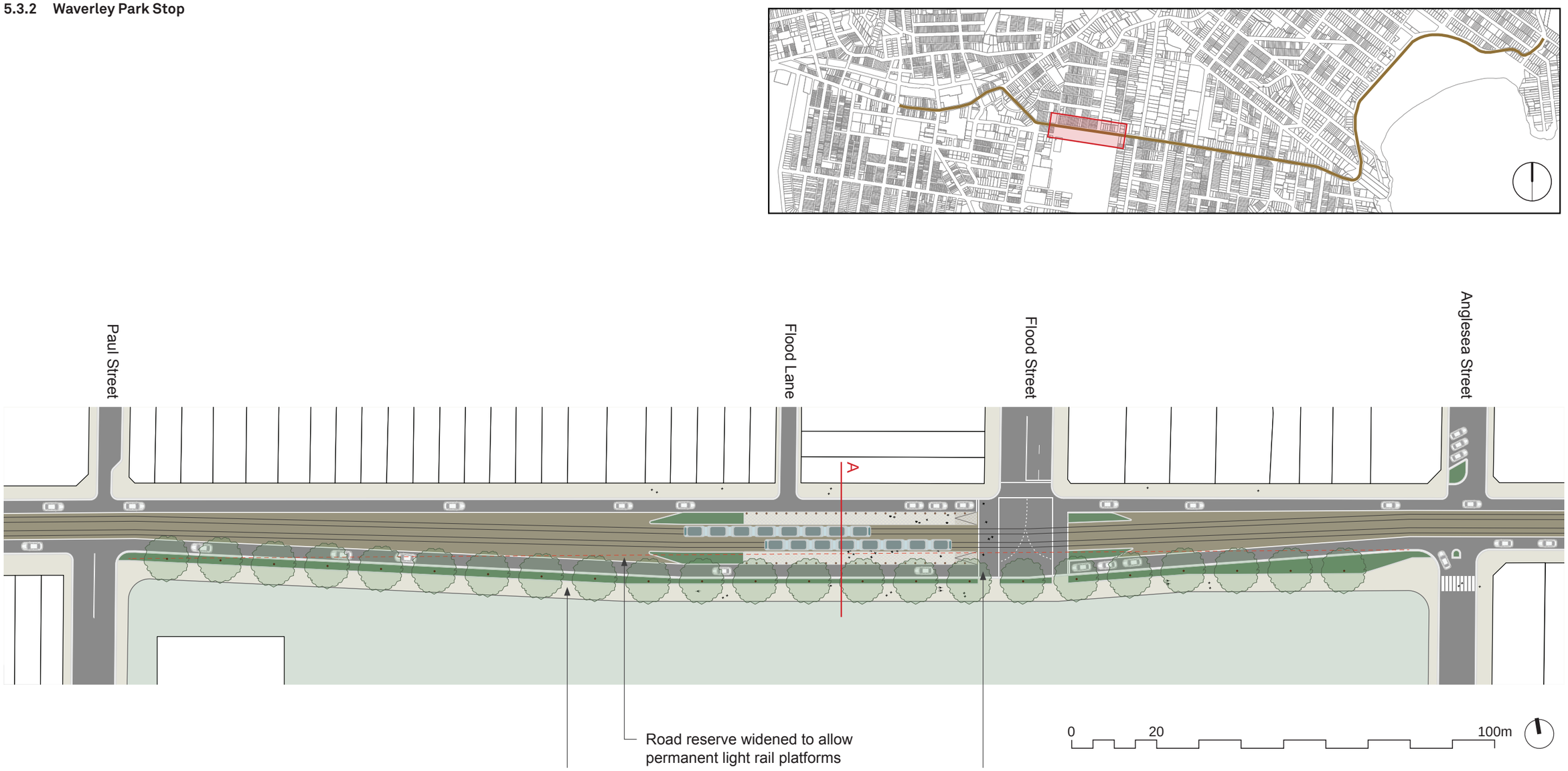


Figure 30. Waverley Park Stop: Indicative Layout
Source: AECOM, 2013

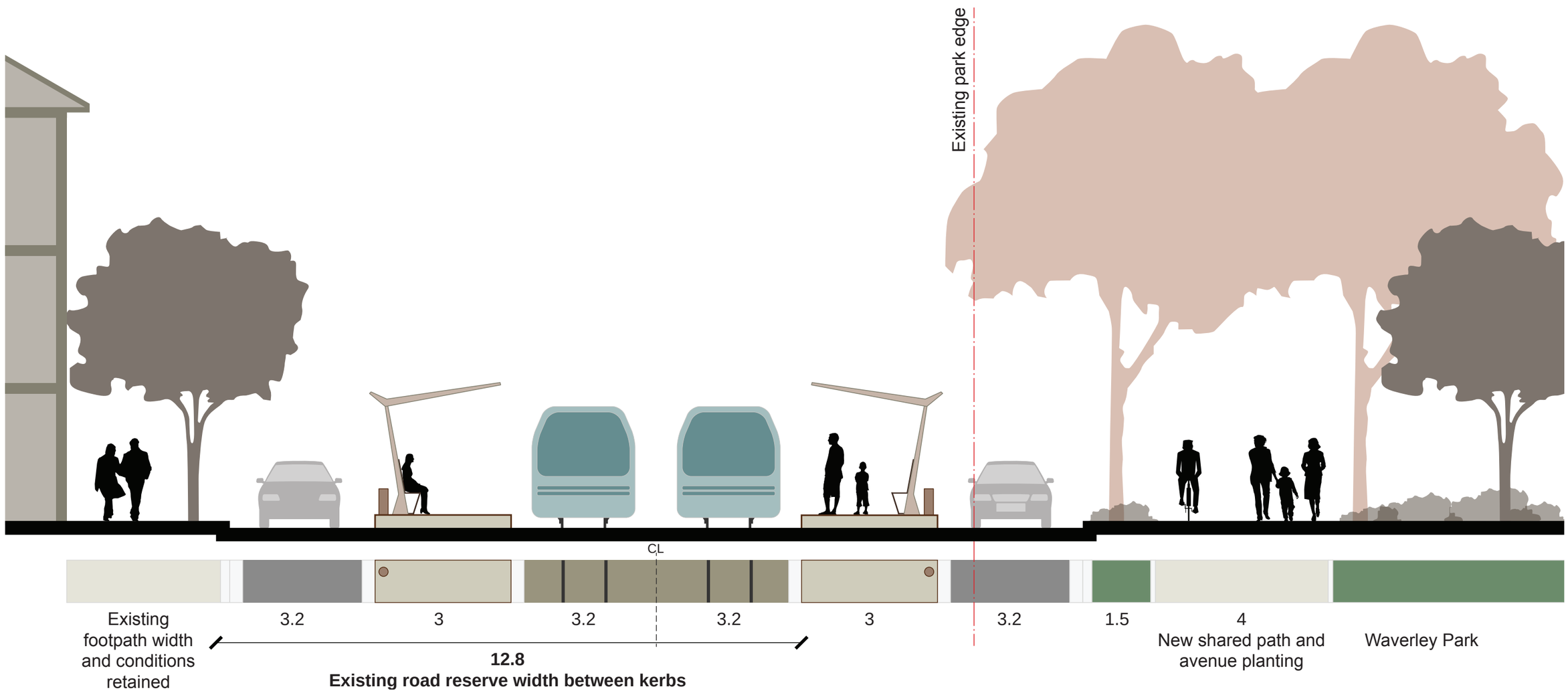
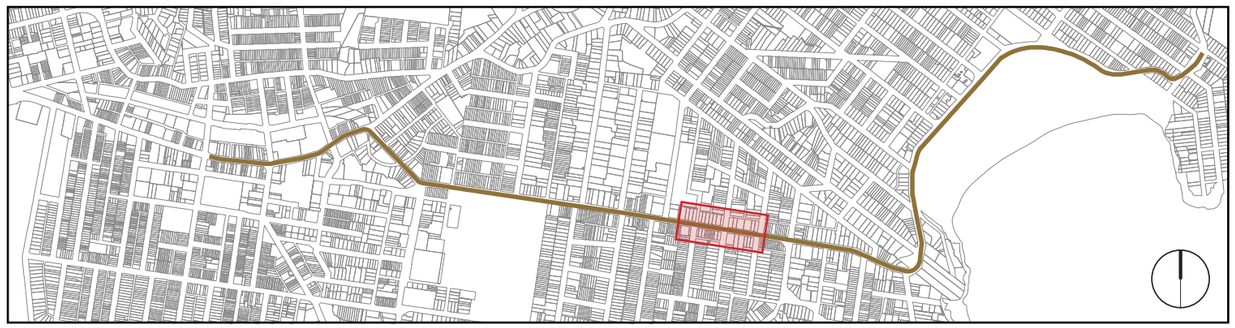


Figure 31. Waverley Park Stop: Indicative Cross Section A
Source: AECOM, 2013

5.3.3 Bondi Road Typical Carriageway



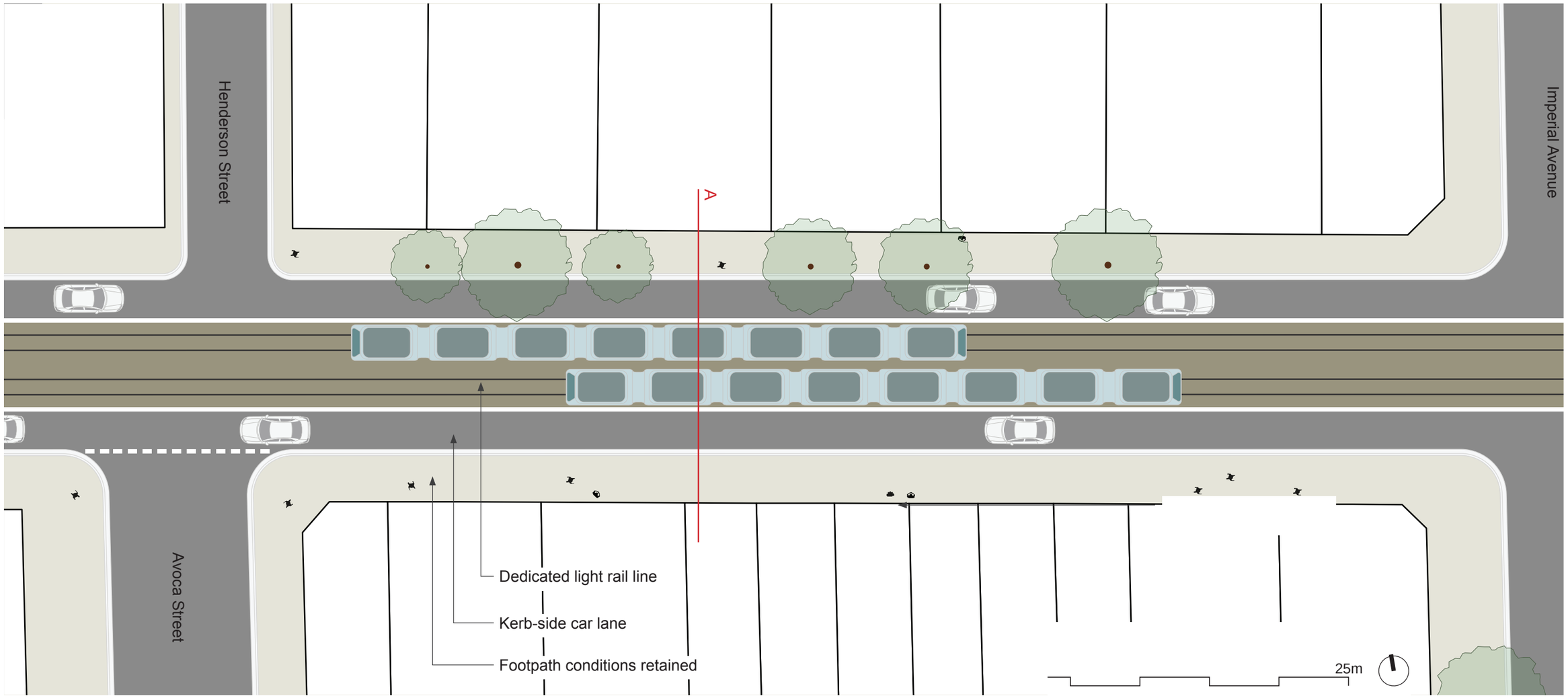


Figure 32. Bondi Road Typical Carriageway: Indicative Layout
Source: AECOM, 2013

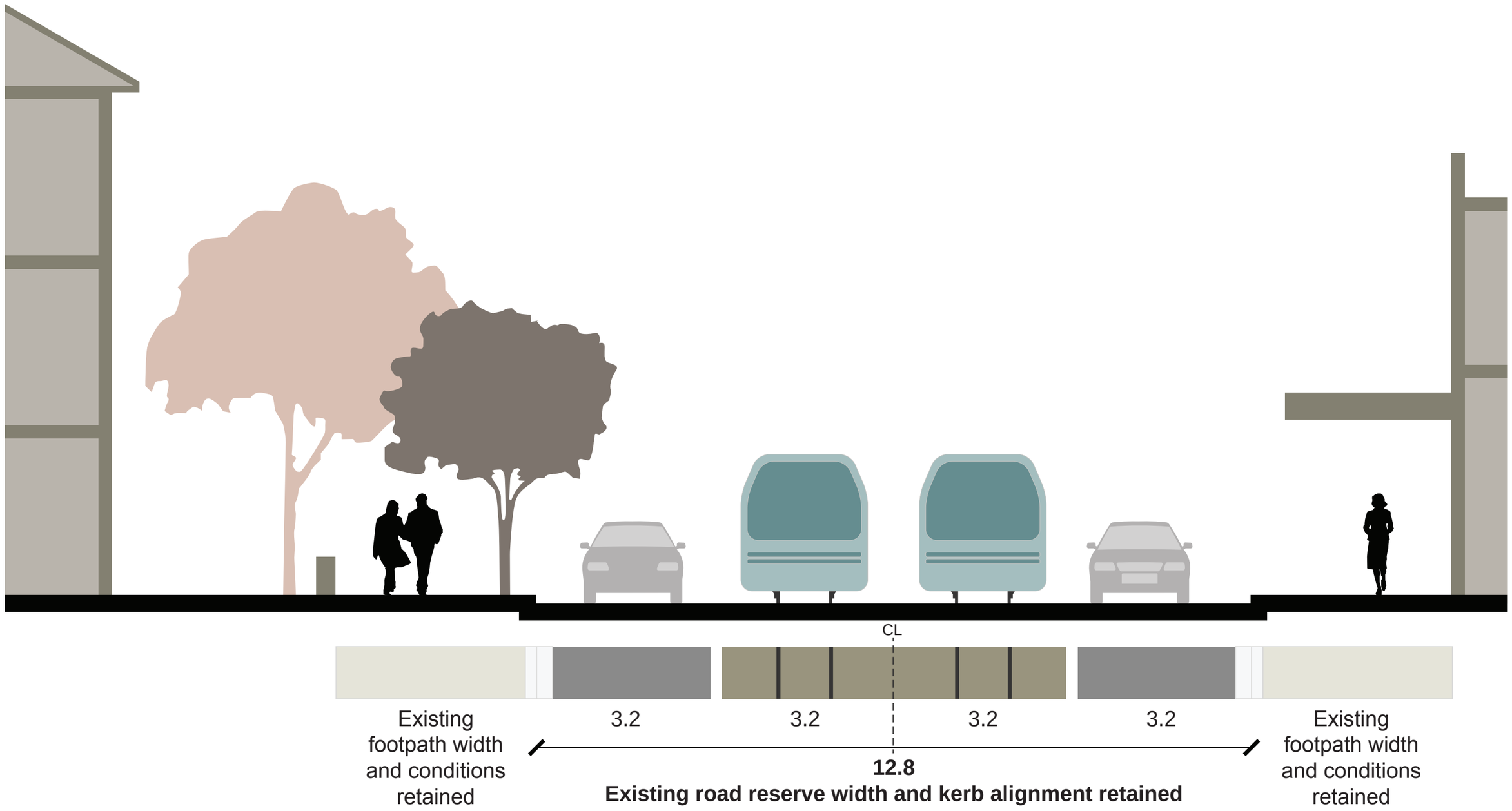
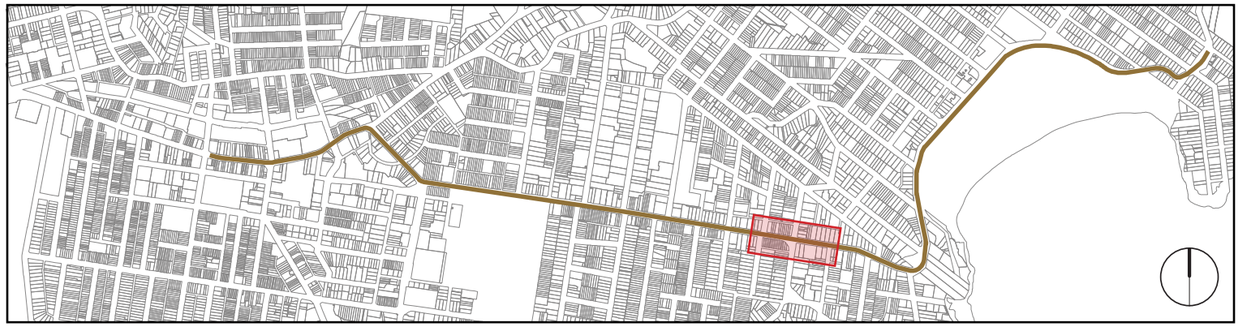


Figure 33. Bondi Road Typical Carriageway: Indicative Cross Section A
Source: AECOM, 2013

5.3.4 Denham Street Stop



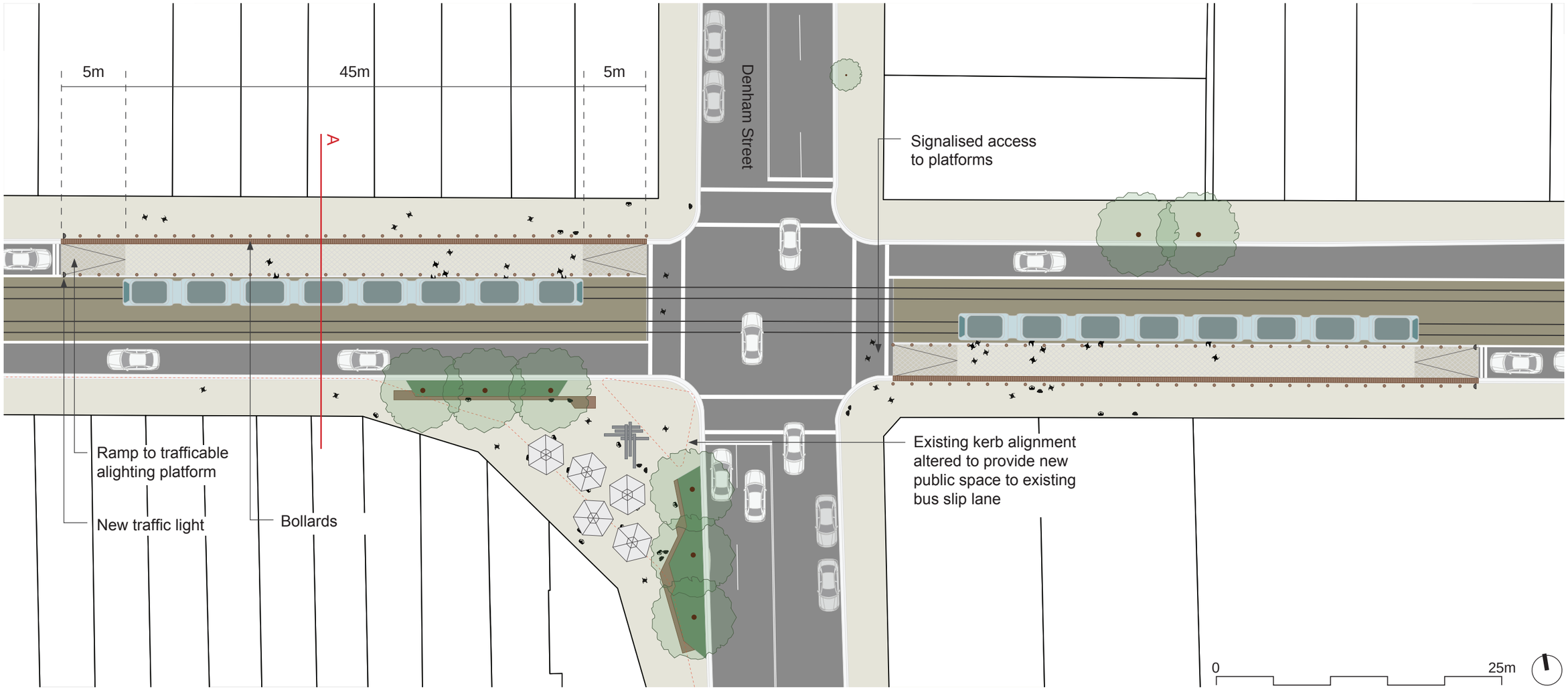


Figure 34. Denham Street Stop: Indicative Layout
Source: AECOM, 2013

Source: Google Street view
http://maps.google.com.au/maps?hl=en&q=light+rail+danks+st+albert+park+melbourne&bav=on.2,or.r_qf.&bvm=bv.47244034,d.aGc&biw=1056&bih=919&um=1&ie=UTF-8&sa=N&tab=wl

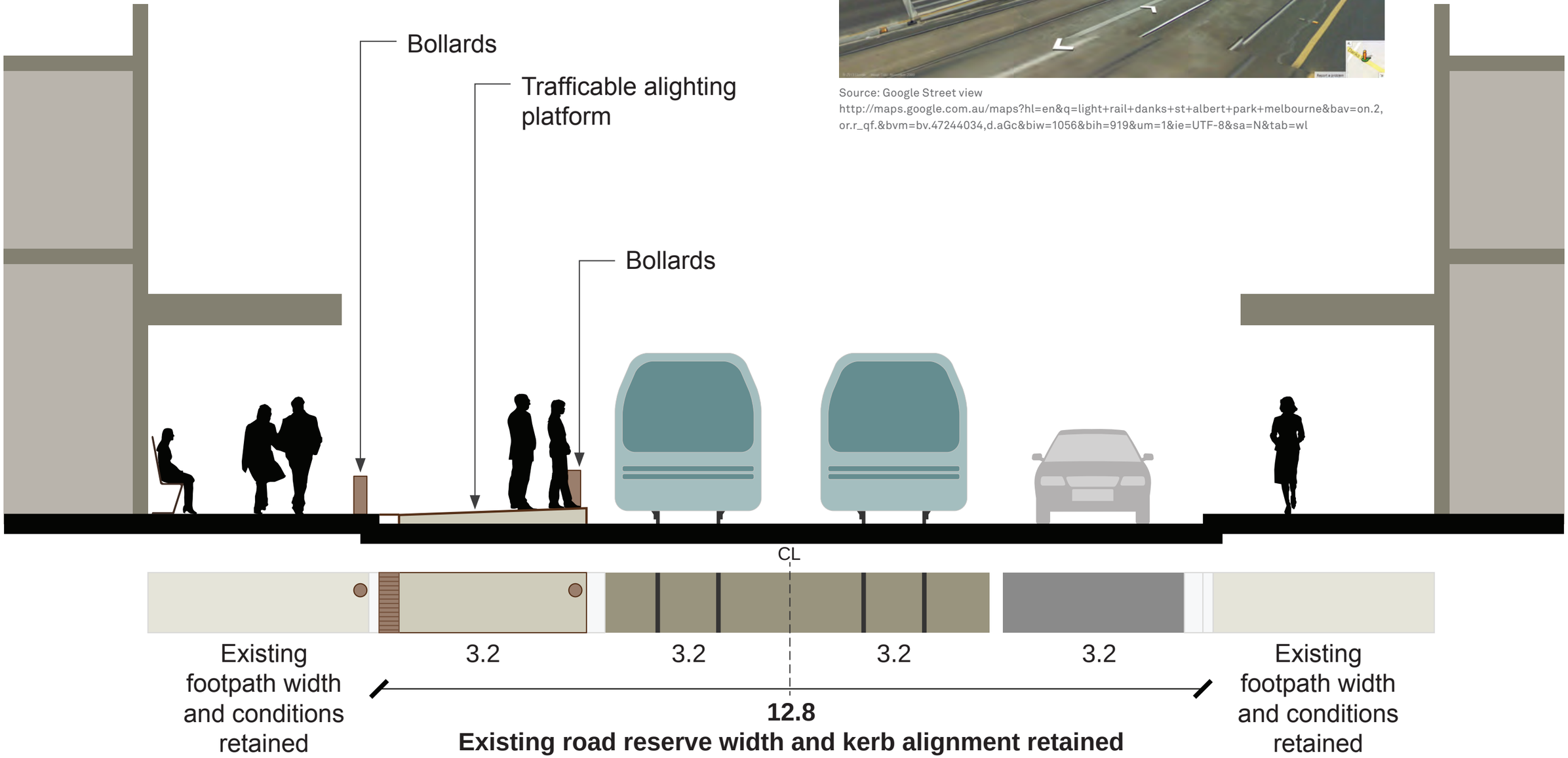


Figure 35. Denham Street Stop: Indicative Cross Section A
Source: AECOM, 2013

5.3.5 Notts Avenue Stop

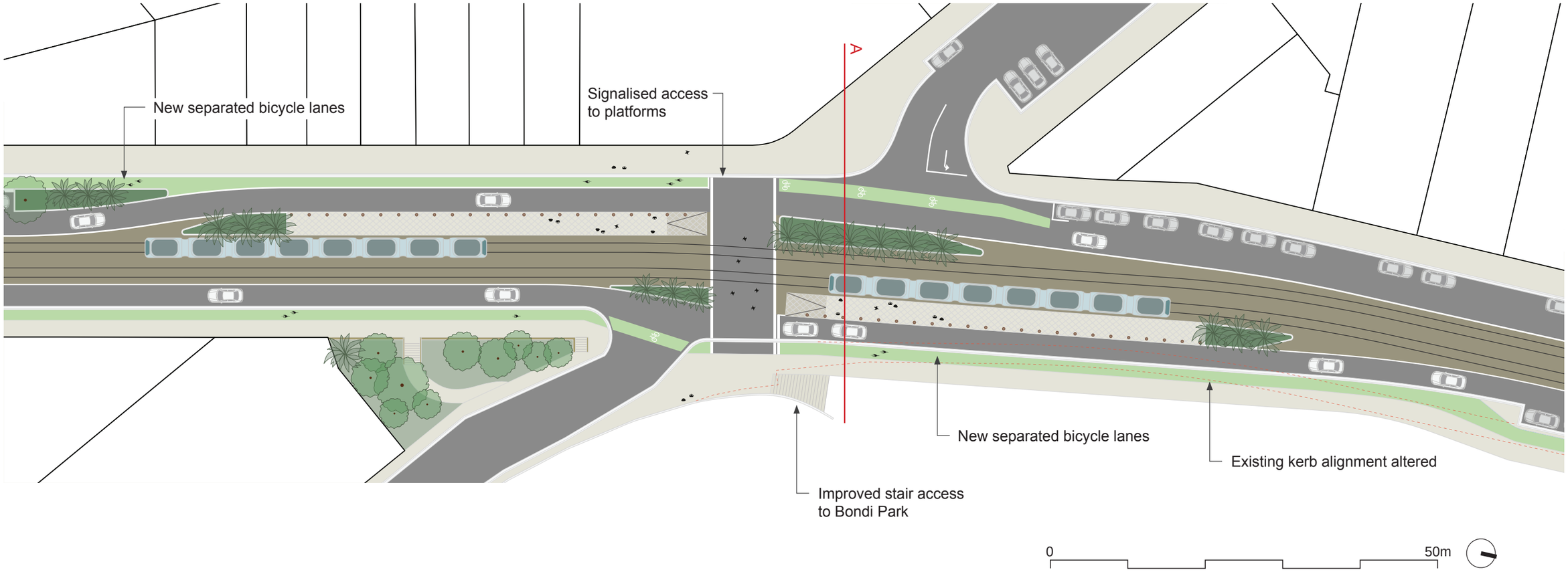


Figure 36. Notts Avenue Stop: Indicative Layout
Source: AECOM, 2013

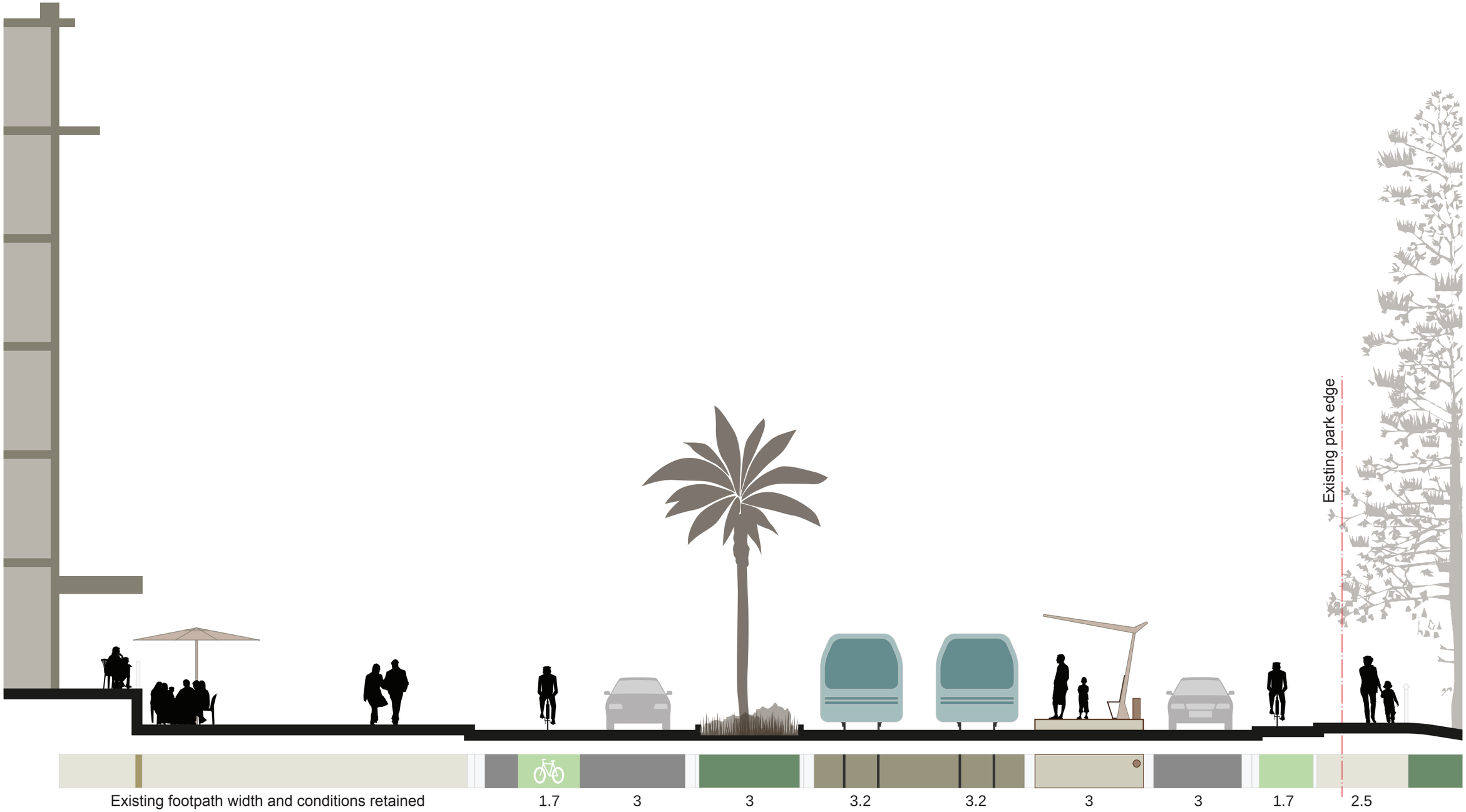


Figure 37. Notts Avenue Stop: Indicative Cross Section B
Source: AECOM, 2013

5.3.6 Campbell Parade Typical Carriageway

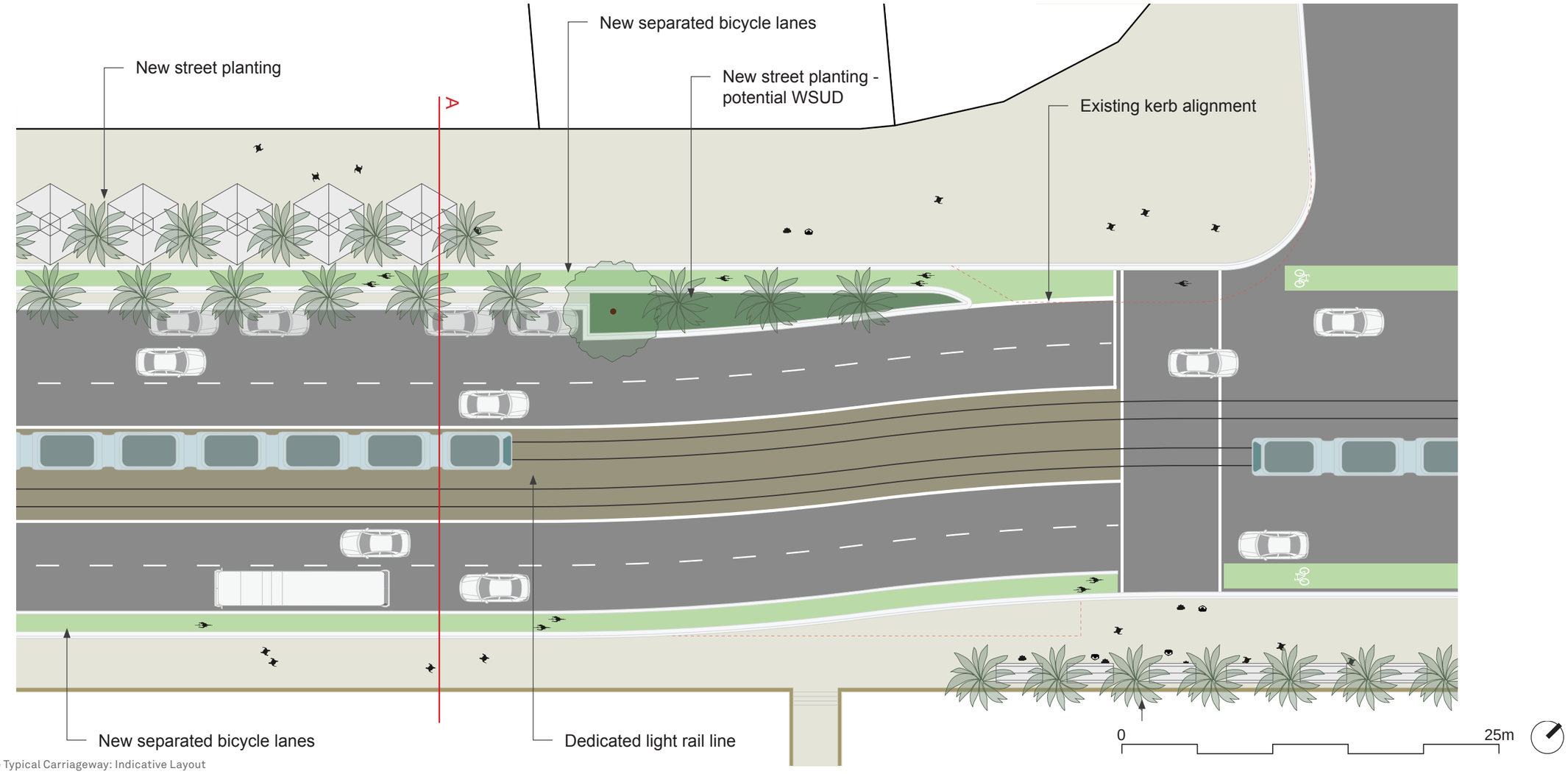


Figure 38. Campbell Parade Typical Carriageway: Indicative Layout
Source: AECOM, 2013

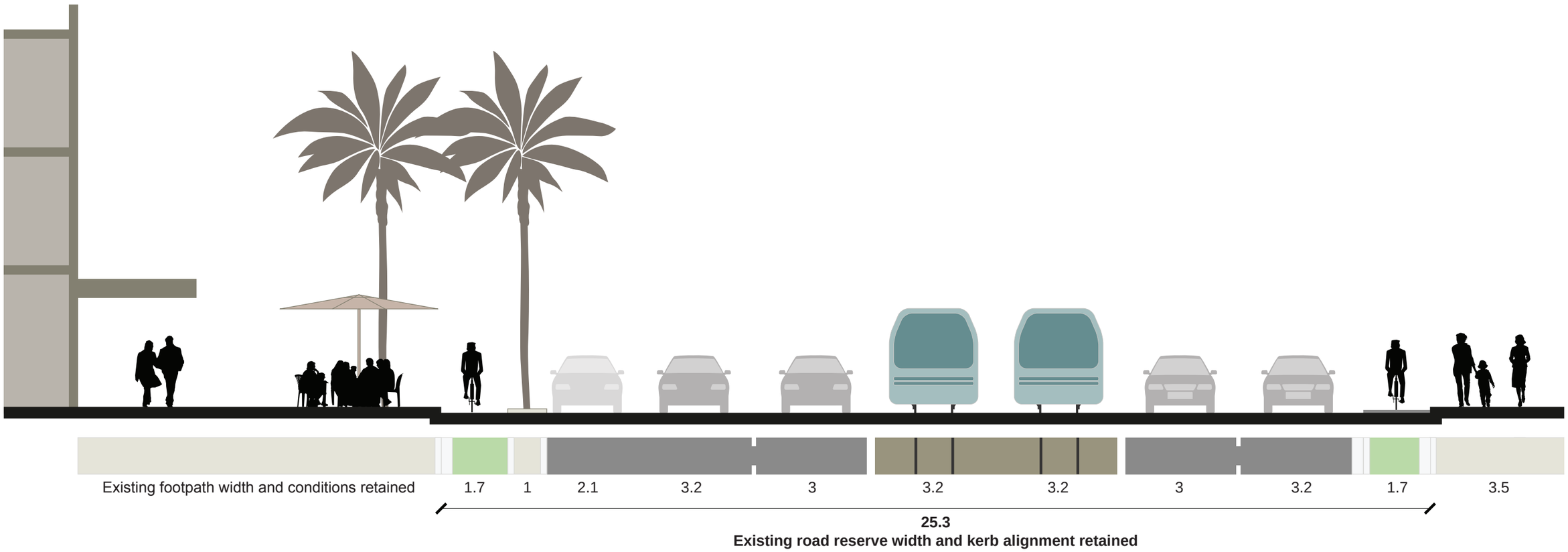


Figure 39. Campbell Parade Typical Carriageway: Indicative Cross Section B
Source: AECOM, 2013

5.3.7 Beach Road Stop (The Pavillion)

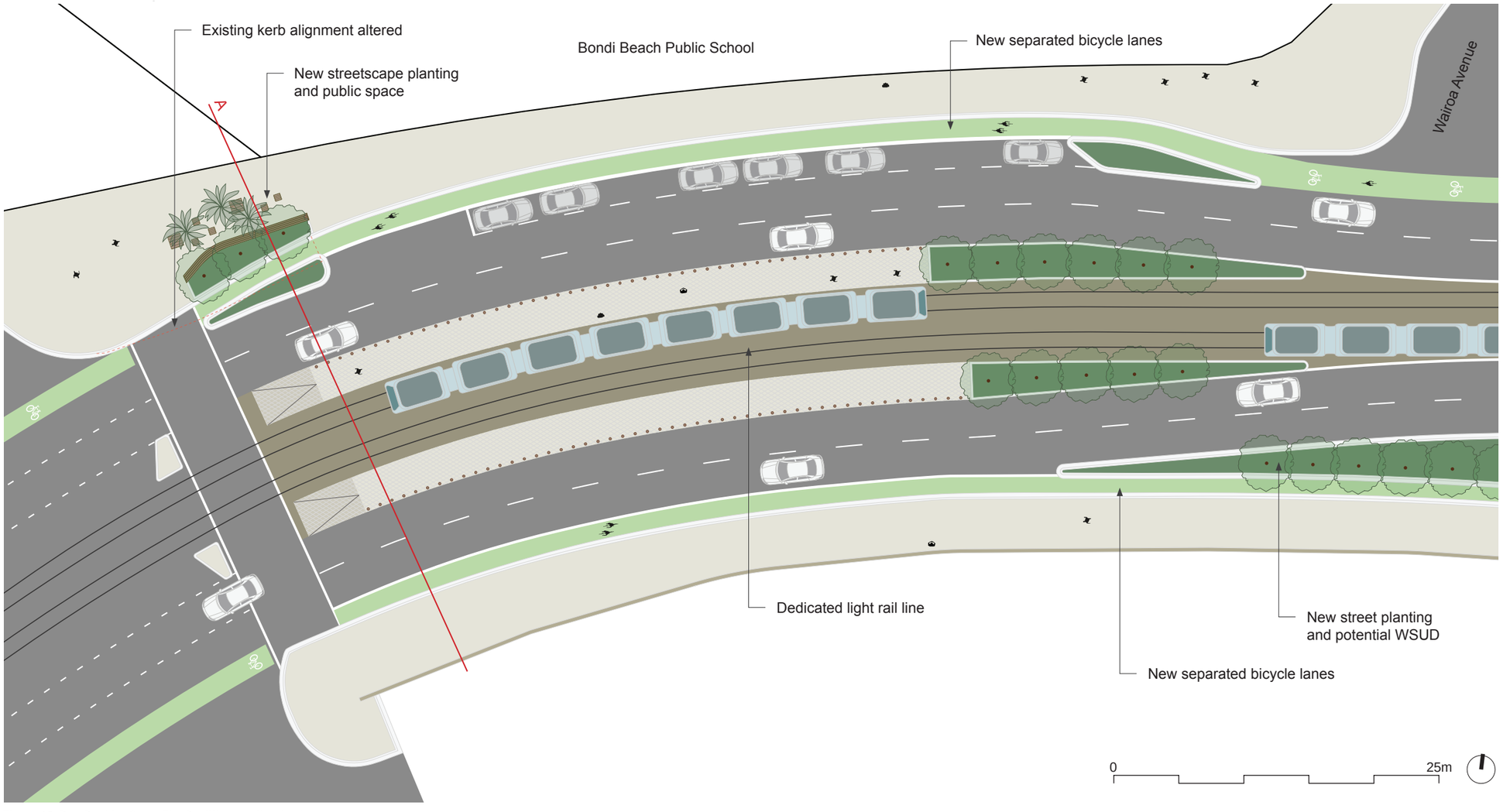


Figure 40. Ben Buckler Stop (The Pavillion): Indicative Layout
Source: AECOM, 2013

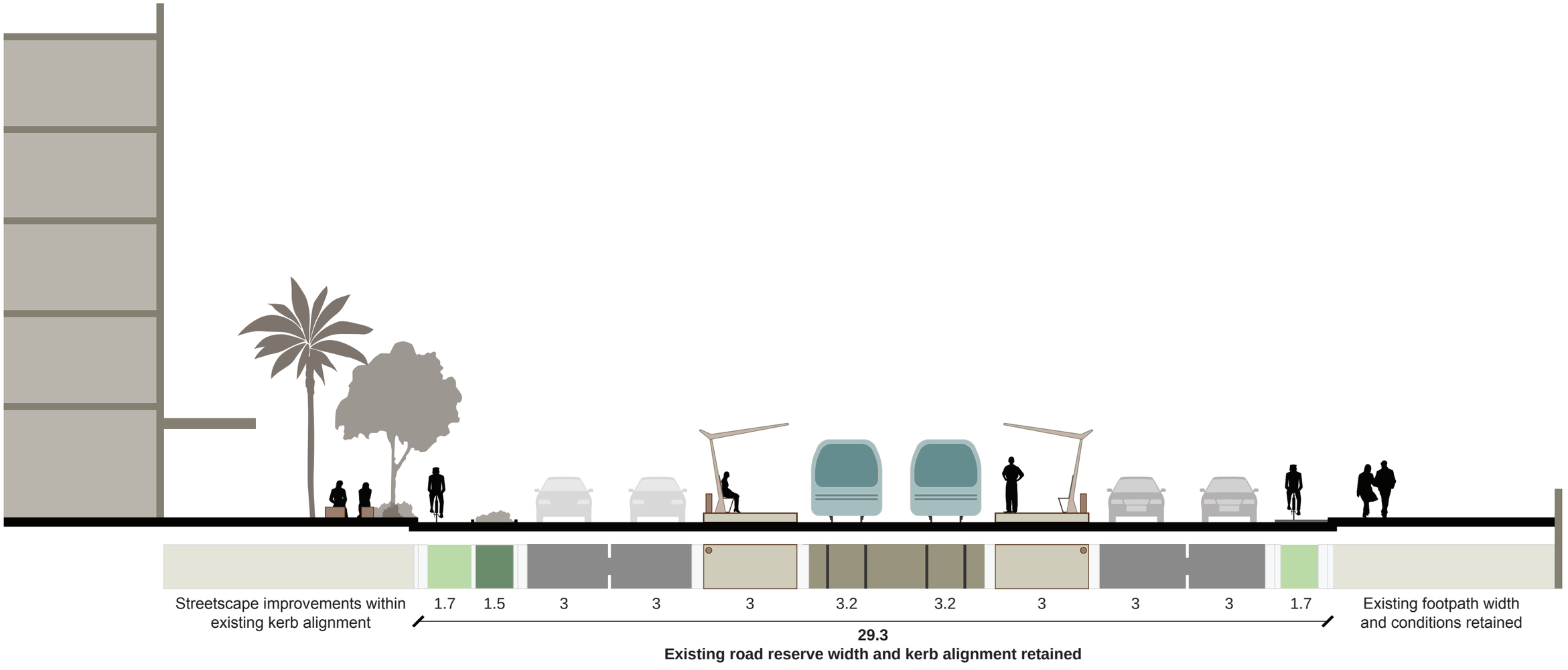


Figure 41. Beach Road Stop (The Pavillion): Indicative Cross Section A
Source: AECOM, 2013

5.3.8 North Bondi Stop (Option 1)

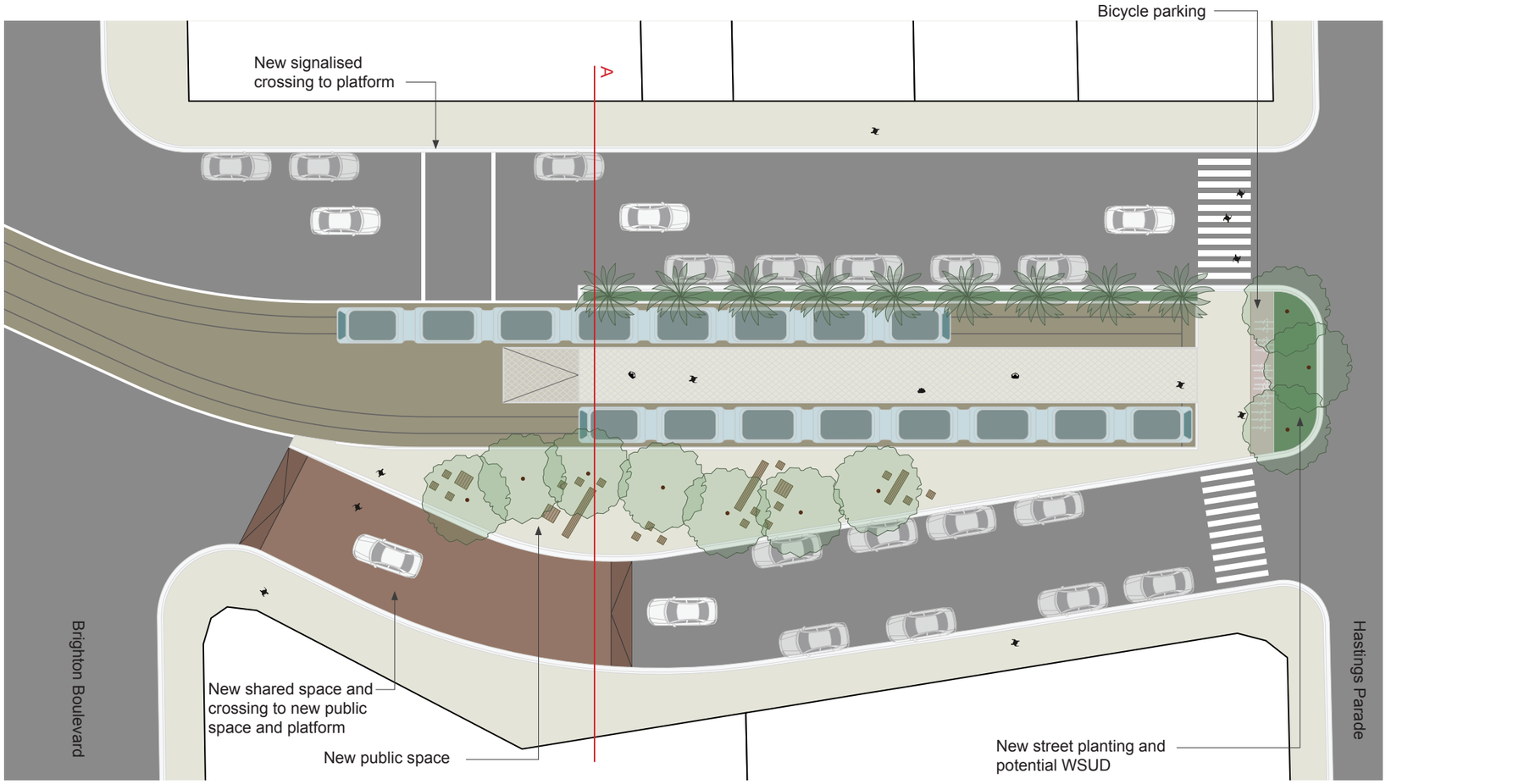


Figure 42. North Bondi Stop: Indicative Layout
Source: AECOM, 2013

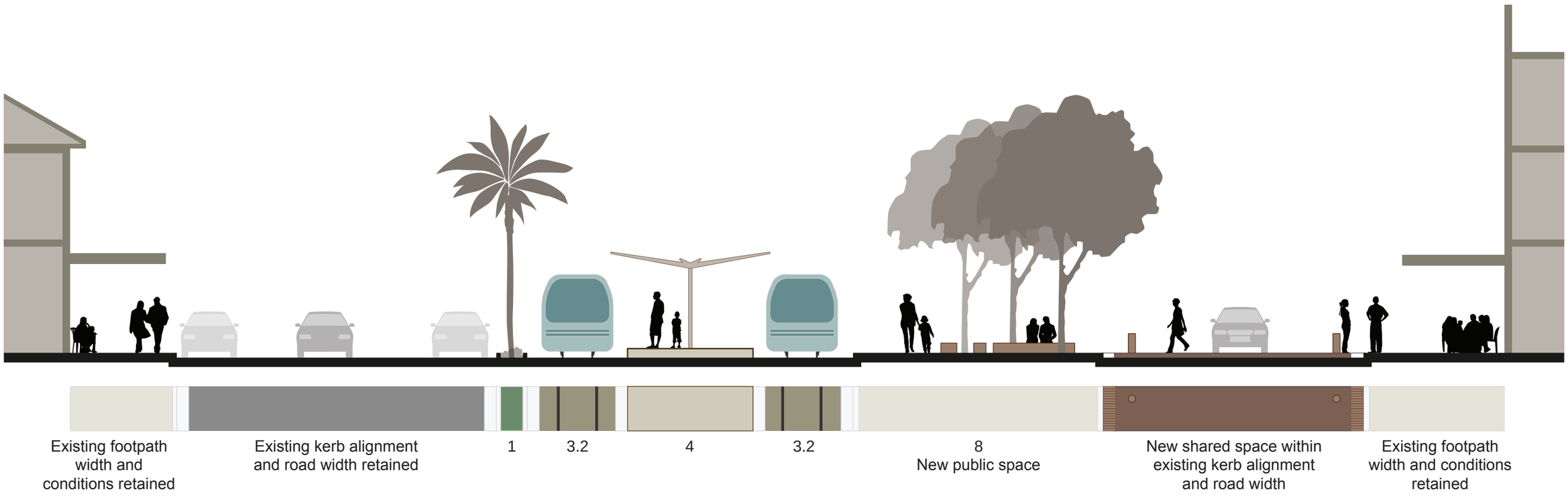


Figure 43. North Bondi Stop (Option 1): Indicative Cross Section A
Source: AECOM, 2013

5.3.9 North Bondi Stop (Option 2)

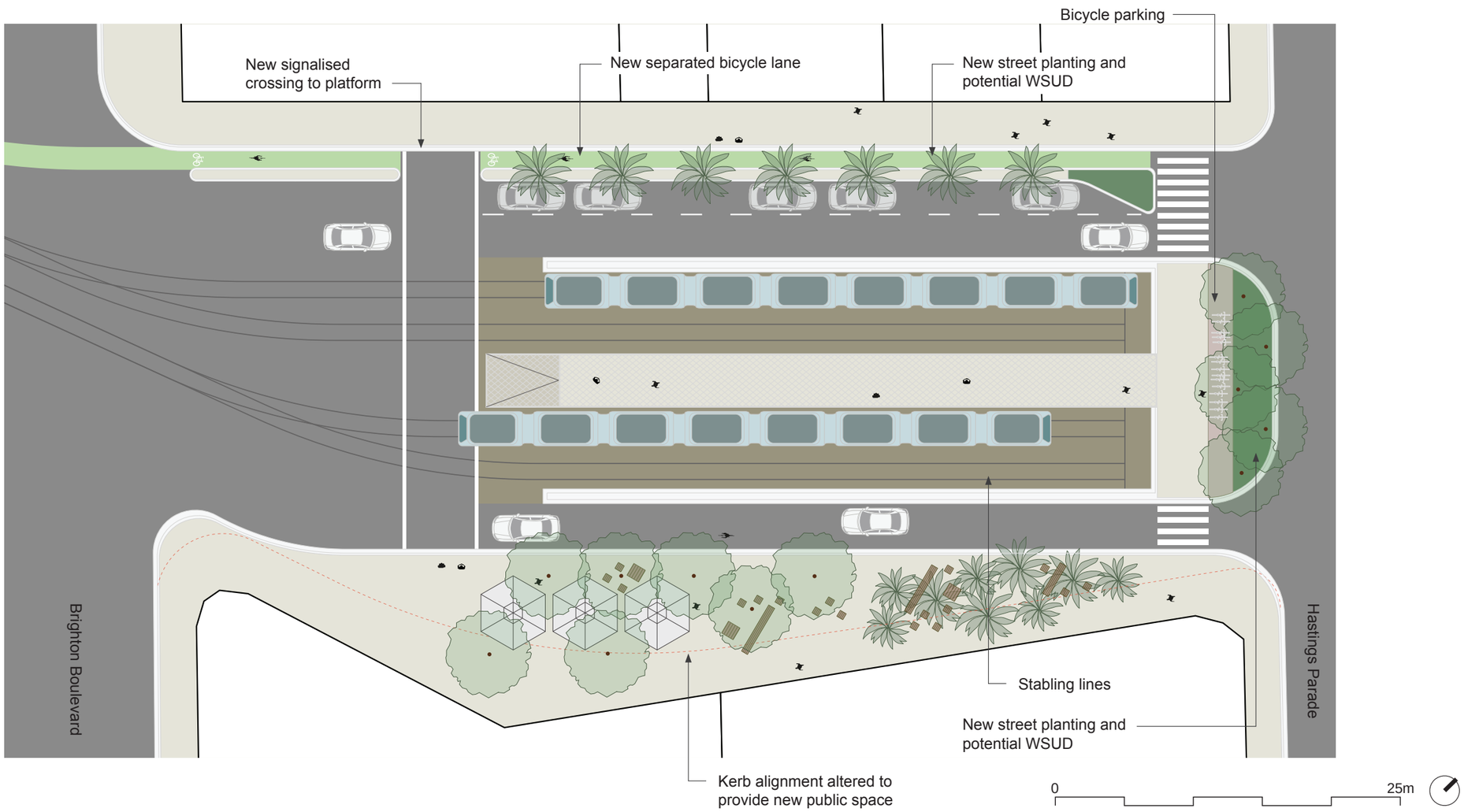


Figure 44. North Bondi Stop (Option 2): Indicative Layout
Source: AECOM, 2013

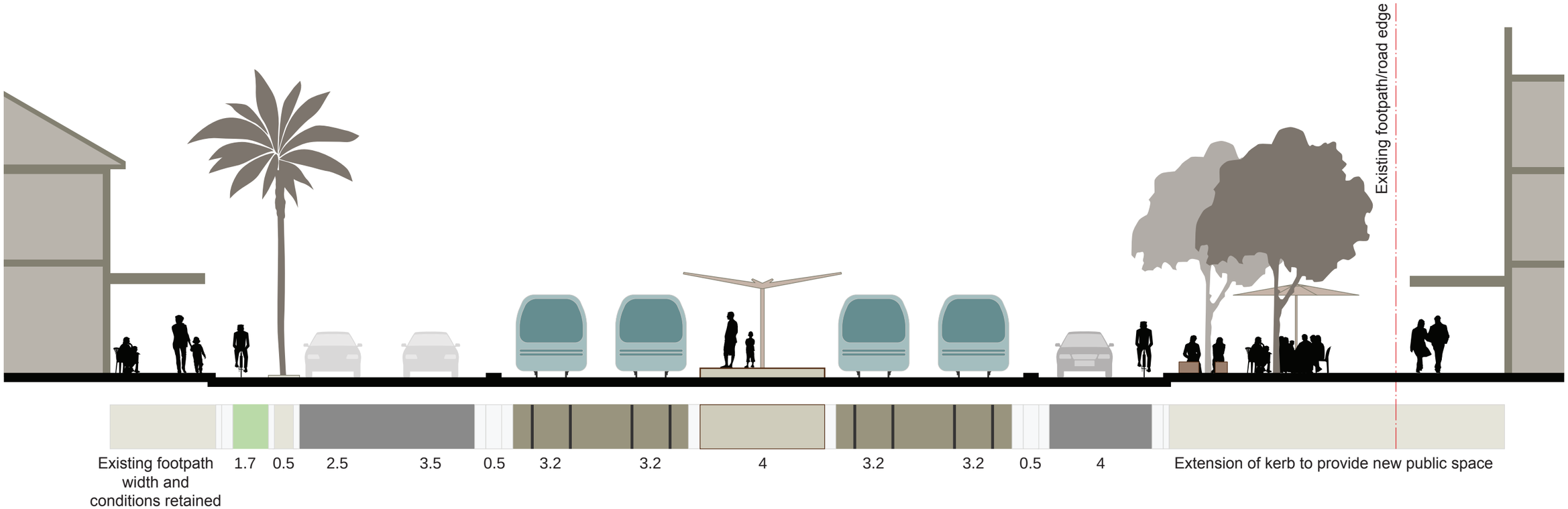


Figure 45. North Bondi Stop (Option 2): Indicative Cross Section A
Source: AECOM, 2013

5.4 Visualisations

5.4.1 Bondi Junction

Figure 46. Bondi Junction Light Rail Artist Visualisation
Source: AECOM, 2013

5.4.2 Bondi Road

Figure 47. Denham Street Light Rail Artist Visualisation
Source: AECOM, 2013

5.4.3 Bondi Beach

Figure 48. Bondi Beach Light Rail Artist Visualisation
Source: AECOM, 2013

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