Intersection performance

A summary of the performance of key intersections along Alison Road and High Street is provided in Table 2-43. The AM and PM peak intersection performance results include an overall intersection LoS, intersection delay and DoS from the base case models. The results are focussed on those intersections currently experiencing capacity constraints. Refer to Section 2.2 for the global assumptions used in the intersection analysis.

Table 2-43: Randwick precinct key intersection performance[65]

Intersection	Peak Hour	Existing		
		LoS	DoS (vehicle/capacity)	Av. Delay (seconds)
Alison Road / Darley Road	PM	B	0.86	25.0
High Street / Belmore Road / Avoca Street	AM	E	1.00	68.0
	PM	F	1.00	82.9

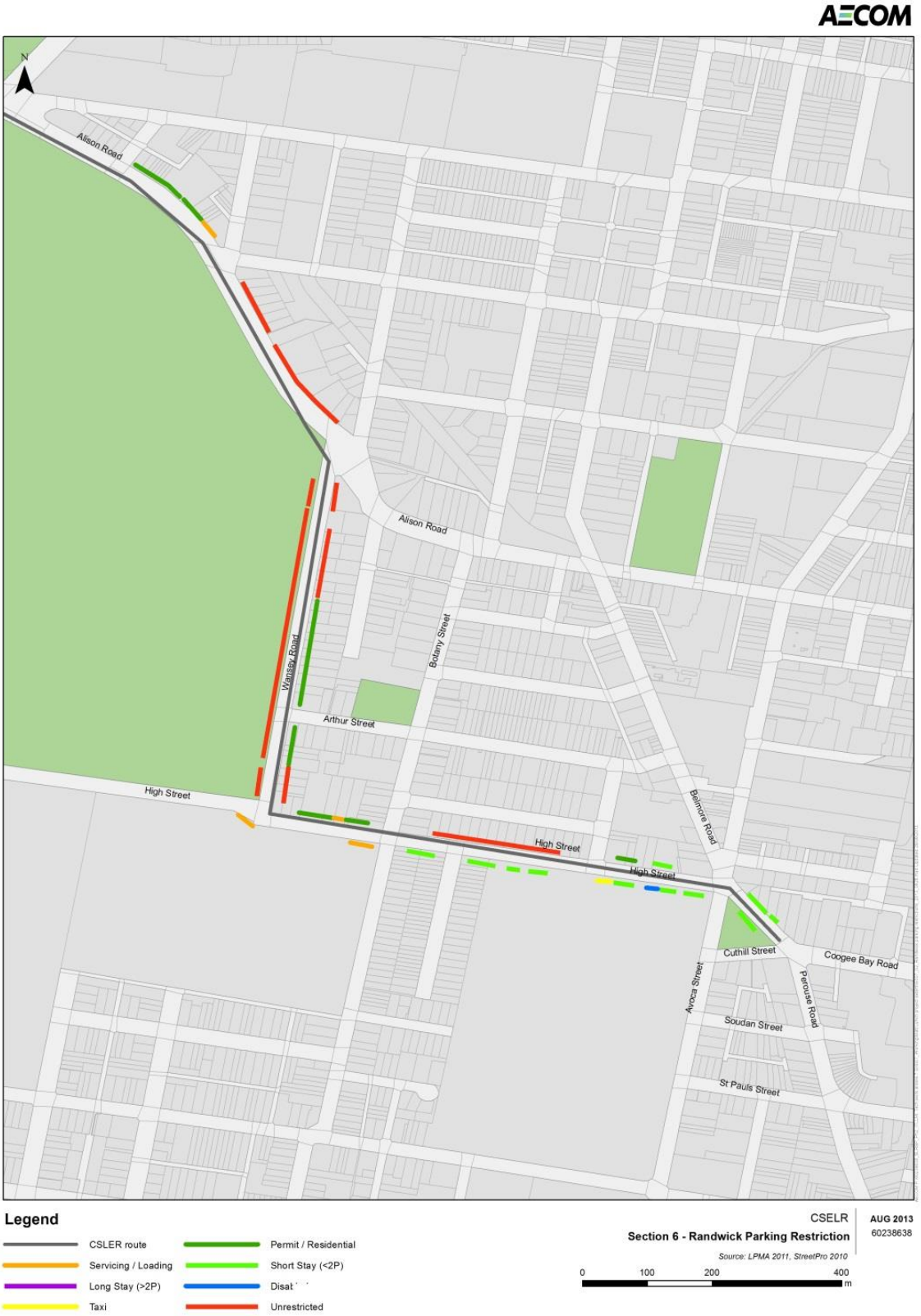
The intersection of High Street, Belmore Road and Avoca Street have the lowest level of performance with average delays greater than 60 seconds during both the AM and PM peak.

2.9.2. Parking and kerbside access

Limited on-street parking is provided on Alison Road between Anzac Parade and Darley Road. On-street parking around Royal Randwick Racecourse is located predominantly on the eastern edge of Alison Road. Bus stops and on-street parking are common along the rest of the corridor. The Randwick precinct currently caters for a range of private vehicle parking (refer to Figure 2-32).

[65] *Source: LinSig modelling undertaken as part of ITLU Milestone Option Assessment*

Figure 2-32: Randwick precinct existing parking restrictions[66]



[66] AECOM, 2013

As outlined in Table 2-44 the Randwick precinct has a number of private vehicle parking spaces.

Table 2-44: Randwick precinct special kerbside uses and parking supply

Randwick Kerbside Restriction	Special Kerbside Uses and Parking Supply by Time Period		
	Pre AM Peak	Inter Peak	Post PM Peak
Car Share, Hospital, Mail Zone	3	3	3
Disability Parking	2	2	2
Loading Zone	1	1	1
Taxi Zone	1	1	1
Total – Special Kerbside Uses	**7**	**7**	**7**
Short Stay Parking (≤1P)	70	64	64
Long Stay Parking (Restricted)	45	45	45
Long Stay Parking (Unrestricted)	187	193	193
Total – General Parking	**302**	**302**	**302**

Further discussion on the project parking strategy to mitigate impacts on existing supply can be found in Section 6.

2.9.3. Property Access

Currently there are a number of property accesses along the light rail corridor within Randwick precinct. Driveway access maps of the Randwick precinct are provided in Figure 2-33.

Figure 2-33: Randwick property accesses

Within the Randwick precinct, driveway accesses are predominantly to private residential addresses which are located at regular intervals along its length. Figure 2-33 above highlights the higher order driveway accesses i.e. to businesses, major land uses or high density unit dwellings.

Alison Road accesses are predominantly related to the racecourse (four access points) and residential driveways (six). The racecourse's main entrance is accessed off Alison Road and includes a short right turn bay for vehicles approaching from the west. Access to the racecourse for buses during event days is via the four-way intersection with Darley Road (entry only) and by a left out further west along Alison Road. The area experiences significant congestion when events are hosted at the racecourse, particularly around the bump-in and bump-out periods when there is a heavy demand on these main access points. Two service stations are also located on the northern side of Alison Road between Darley and Cowper Streets.

Wansey Road driveways are predominantly associated with the low density housing along the eastern side. In addition, the racecourse has a further two accesses on the western side to service the stables, which attract activity throughout the working day.

High Street has a number of major driveway accesses related to the predominant land uses of UNSW and Prince of Wales Hospital. Gate 9 to UNSW acts as a secondary access to the University's Botany Street parking station and is located to the east of the Wansey Road intersection. Three separate hospital accesses are provided, including emergency vehicle access to the Children's Hospital that requires efficient access 24 hours a day.

2.9.4. Pedestrians & cyclists

Pedestrian access

The existing pedestrian accesses to the Randwick precinct are facilitated by footpaths, marked and signalised pedestrian crossings and kerb ramps. Table 2-45 identifies the existing pedestrian access types along the light rail route within Randwick precinct.

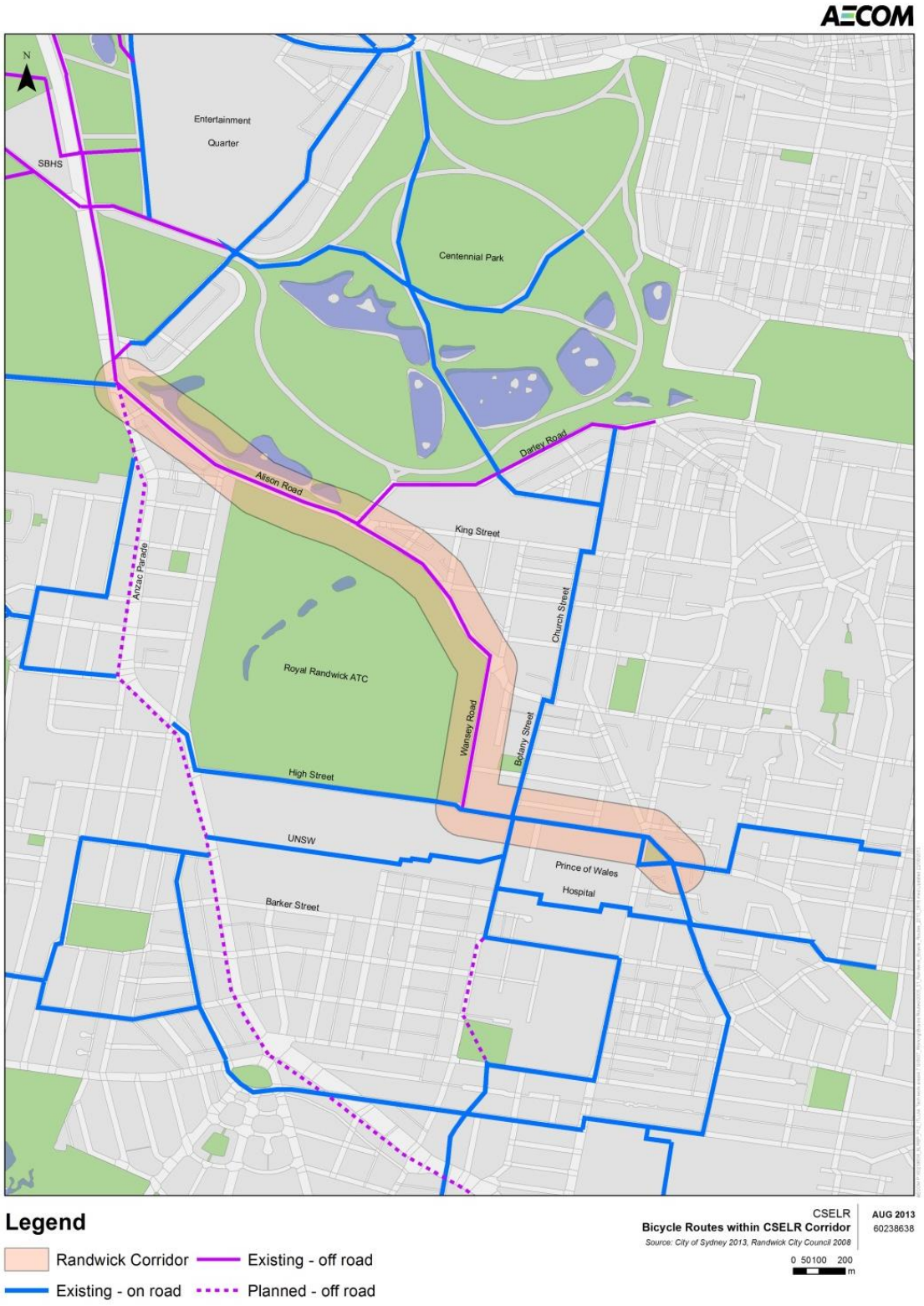
Table 2-45: Existing Pedestrian Access within the Randwick precinct

Precinct	Corridor Location	Description	Pedestrian Access Type
Randwick Precinct	Alison Road	Pedestrian traffic is mainly generated by the Prince of Wales Hospital, the UNSW, Royal Randwick Racecourse, hotels and residential properties.	Sealed footpaths, pedestrian crossings at 3 x signalised intersections and kerb ramps are provided to facilitate pedestrian movements across Alison Road.
	Wansey Road	Pedestrian traffic within Wansey Road is mainly generated by the residential properties, recreational activities, the UNSW in the area.	The pedestrian facilities such as sealed shared path on eastern side, footpath on western side and kerb ramps are provided to facilitate pedestrian movements across Wansey Road.
	High Street	Pedestrian activity associated with High Street is highly influenced by the trips made to UNSW, the hospitals and residential properties within the area.	Two signalised intersections and two marked pedestrian crossing are located within the High Street corridor. The marked pedestrian crossings are located in front of the UNSW campus and Prince of Wales Hospital. The hospital crossing is used by a high number of disabled and elderly people who require extended crossing times. Other pedestrian facilities such as footpaths and kerb ramps are also provided to facilitate pedestrian movements across High Street.

Bicycle access

There are several on-road and off-road cycle paths in the vicinity of the proposed light rail corridor within the Randwick precinct. Figure 2-34 and Table 2-46 describe the bicycle network within the Randwick precinct. The cyclist facilities consist of designated pathways across Centennial Park, and off-road routes along Alison Road, Darley Road and Wansey Road.

Figure 2-34: Existing bicycle network within the Anzac Parade/Alison Road precincts[67]



[67] *Source: Randwick City Council, Cycling and Walking Map for Randwick City (available from http://www.randwick.nsw.gov.au/Looking_after_our_environment/Sustaining_our_city/Greenhouse/sustainable_transport_options/index.aspx)*

Table 2-46: Existing bicycle routes along key roads within the Randwick precinct

Precinct	Corridor Location	Bicycle Route Type	Description
Randwick Precinct	Alison Road	Off-road	Randwick City Council identifies an off-road pedestrian / cycle path which runs along the corridor from Anzac Parade to Wansey Road. Between Anzac Parade and Darley Road, the route runs on the north side of Alison Road. Between Darley Road and Wansey Road, the route runs on the south side. A signalised crossing at Darley Road enables cyclists to cross from one side of Alison Road to the other.
	Wansey Road	Off-road	The Randwick City Council bicycle route map designates Wansey Road as an off-road pedestrian/bicycle route, which runs along the western side of the corridor.
	Botany Street / Church Street	On-road	Between Darley Road and Barker Street, Randwick City Council identifies Botany Street and Church Street as on-road cycle routes.
	High Street	On-road	The Randwick City Council bicycle route map designates High Street as an on-road route.
	UNSW	On-road	An on-road cycle route through UNSW comprising the University Mall, Library Road, Library Walk and Samuels Avenue provides an east-west connection between Botany Street and Anzac Parade.

3. Future Transport Network Needs

3.1. Review of land use and planned major developments

Under the direction of Government planning instruments such as the NSW Metropolitan Strategy, the face of Sydney is constantly shifting. Changes in land-use, employment patterns, major developments and increasing densities influence travel patterns across Sydney – a trend that is particularly evident in the CSE corridor.

Major trip generators – employers, hospitals, Universities, schools and special events – are evolving in this corridor at a rapid rate and catering for the changing profile of demand has been a key area of examination through the development of the CSELR Project.

3.1.1. Inner Sydney's growth

Sydney's CBD caters for hundreds of thousands of workers, residents and visitors every day, generating enormous economic value for both NSW and Australia. On a typical weekday, the Sydney City Centre grows from about 60,000 residents to half a million people representing the highest concentration of people and trips in the country. This includes approximately 330,000 people working in the City Centre daily[68].

In the future, increasing travel demand across Sydney's transport network will be driven by on-going growth in population and employment, and the accompanying major trip generating land uses including retail, tourism, health and education.

NSW Government forecasts depict strong growth in both population and employment in the Study Area. Table 3-1 categorises this growth, while

Figure 3-1 illustrates the population and employment growth projections between 2006 and 2031.

Key changes within the City of Sydney and Randwick LGAs are expected to include:

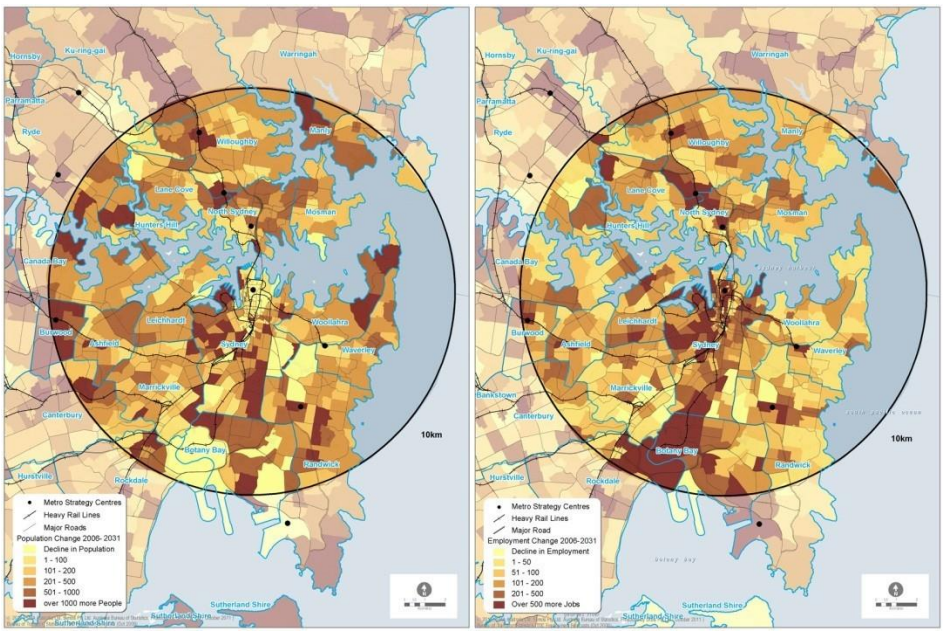
- Large population increases expected in both the City of Sydney (99,000, growth of 60 per cent) and Randwick (24,000, growth of 19 per cent) LGAs. These population changes are expected to result in a large increase in residential density (persons/hectare) in the Sydney LGA and a moderate increase in the Randwick LGA.
- Employment increase of 140,000 workers in the Sydney LGA, up from 430,000 to 570,000 (growth of 33 per cent), and an employment increase of 13,000 in Randwick LGA (growth of 31 per cent). These employment changes are expected to result in a large increase in employment density (persons/hectare) in the Sydney LGA and a moderate increase in the Randwick LGA.

[68] Transport for NSW, *NSW Long Term Transport Master Plan*, December 2012

Table 3-1: Forecast growth in the Study Area[69]

Category	Current (2012)	Future (2031)
Residential population	292,000 residents in the City of Sydney and Randwick LGAs. Residential density of 62 persons/hectare in the City of Sydney LGA and 35 in Randwick LGA.	425,000 residents in the City of Sydney and Randwick LGAs. Densities expected to increase to 99 persons/hectare in the City of Sydney LGA and 41 in Randwick LGA.
Employment	473,000 workers in the City of Sydney and Randwick LGAs.	626,000 workers in the City of Sydney and Randwick LGAs.
Economy	$50 billion in Sydney's CBD. $3.5 billion in retail sales for the CBD, which is 9 per cent of retail turnover in metropolitan Sydney.	$60 billion in Sydney's CBD. Importance of retail in Sydney CBD expected to continue with more flagship stores and continuing residential and employment growth.
Tourists	Sydney received nearly 7.6 million domestic overnight visitors in 2011, up 5.6 per cent on 2010, and 2.6 million international overnight visitors in 2011.	Ongoing growth in visitor nights of 3 – 4 per cent per annum predicted by the State Tourism Forecasts, compiled by the Commonwealth Government.
Special Events	Buses to Moore Park and Randwick affected by congestion, resulting in low mode share to special events.	Significant growth in demand at sporting and entertainment precinct, driven by continued investment and greater usage of these regionally important venues.

Figure 3-1: Population and employment growth projections in Inner Sydney between 2006 and 2031[70]



[69] *Urbis, 2011 and Destination NSW, 2012*

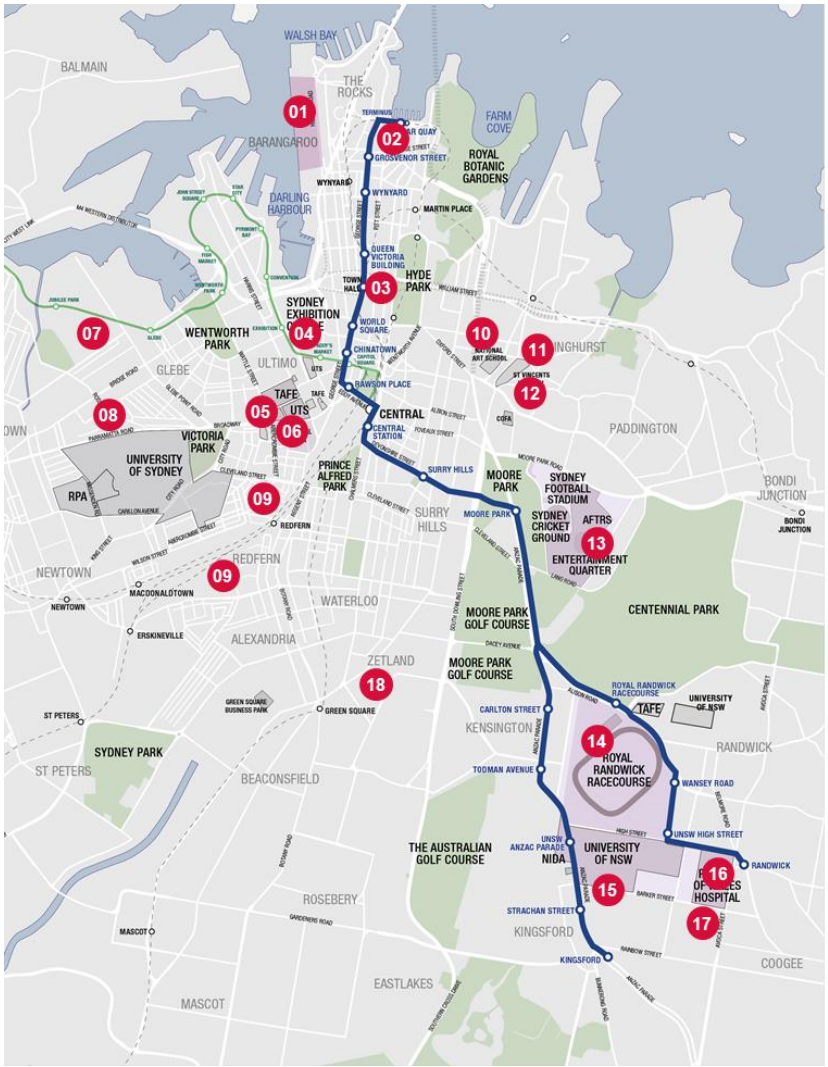
[70] *Urbis, 2011*

3.1.2. Urban renewal and growth in travel demand

The CBD and South East contains a wide variety of land uses, incorporating residential areas, employment areas, retail, educational centres, health precincts and major recreational destinations, all within a short to moderate distance from the Sydney CBD. As Sydney's CBD continues to expand due to population growth and development the number of people commuting daily to and from the city will swell. The need to move large numbers of people into and through a constrained area within a narrow time period places strain not only on the transport network in the City Centre, but on the whole metropolitan transport system. Car, bus and rail networks all experience congestion in the Sydney CBD and on major approaches from the South East.

To capture the current state of urban renewal in the region, a review was undertaken that considered existing built form typologies in the area, existing and draft Local Environmental Plans, available master plans, local planning strategies, high level planning strategies for the subregion including the *Metropolitan Plan for Sydney 2036* and the Sydney City, east and Inner west Draft Subregional Strategies. A summary of significant sites currently under development or planned for renewal is presented in Figure 3-2.

Figure 3-2: Planned Renewal in the Study Area[71]



PLANNED RENEWAL SITES

CBD Route
01 – Barangaroo Concept Plan
02 – APDG Site Draft Sydney DCP 2010
03 – Town Hall Urban Design Study 2010
04 – Sydney Convention & Entertainment Centre (project approval)

USYD Route
05 – UTS Concept Plan
06 – Central Park Development (under construction)
07 – Harold Park Draft Sydney DCP 2010
08 – Ryvita Sites Draft Sydney DCP 2010
09 – Redfern Waterloo Authority Built Environment Plan 2006

UNSW North Route
10 – Carvatis Site Concept Plan
11 – St. Vincent's Hospital Research Precinct
12 – St. Vincent's Hospital
13 – Moore Park Showgrounds Concept Plan

UNSW South Route
14 – Royal Randwick Racecourse DCP 2007 Concept Plan
15 – University of New South Wales DCP
16 – Sydney's Children's Hospital
17 – Prince of Wales Hospital
18 – Green Square Development

[71] *Hassell, 2012*

Of the major developments planned within / adjacent to the Study Area, a number of key sites are discussed below:

- Barangaroo;
- Sydney International Convention, Exhibition and Entertainment precinct (SICEEP);
- UNSW Campus Development;
- Royal Randwick Master Plan; and
- Green Square Town Centre.

3.1.2.1. Barangaroo

Formerly constituting 22 Ha of disused container wharves, the Barangaroo site is located on the western side of the CBD. The site is owned by the NSW Government and managed by the Barangaroo Delivery Authority (BDA). Development of the site is valued at over $6 billion and will completely transform the site with new parkland, residential, and commercial sectors dividing the site into three distinct zones:

- Headland Park (Barangaroo north) – landscaped with parklands and pedestrian pathways, this 5 Ha sector of the site includes a cultural centre and 300 space underground car park and is scheduled to open in 2015;
- Barangaroo Central – while the development brief is currently being progressed with public consultation having begun in April 2013, it is expected this zone will include low-rise residential, commercial and civic buildings; and
- Barangaroo south – a 7.5 Ha extension of the CBD incorporating high-rise retail, corporate and housing, this area of the site is currently under development in partnership with Lend Lease. The first building is scheduled for completion in 2015, and by full completion in 2020 the site will include a 6 star luxury hotel, 800 apartments, 320,000 sqm of office space, and up to 33,000 sqm of mixed retail and leisure.

Figure 3-3 illustrates the three zones within the Barangaroo site.

Figure 3-3: Barangaroo Development Concept Plan[72]

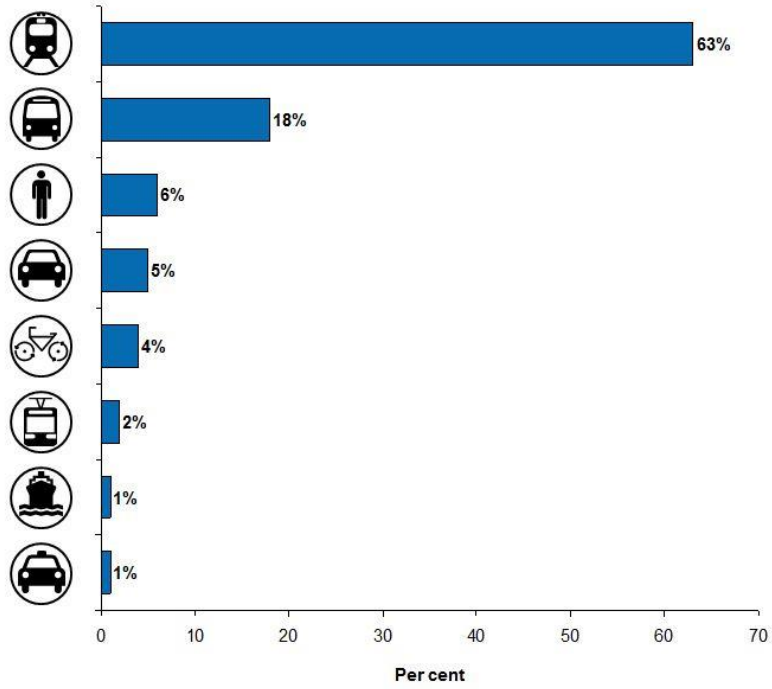
When fully occupied, Barangaroo is forecast to generate about 22,000 trips in the AM peak 2 hours, and about 25,000 trips in the PM peak 3 hours, based on the 'moderate growth' scenario.

[72] *PWP Landscape Architecture*

It is forecast by BDA that 33,000 visitors per day (business and leisure) will arrive at the site. The majority are expected to be travelling off-peak and to come from many directions, not only via Wynyard. This leads to a demand profile with a greater 'spread' into the off-peak than is typical for the northern CBD; however the development is still anticipated to contribute to growing peak hour demand and will contribute to a growing concentration of financial and professional service jobs in the northern CBD.

To ensure that Barangaroo did not contribute to additional CBD surface transport congestion, planning approval for Barangaroo south (the commercial, 'CBD extension' component of the Project) was based on the principle of achieving high usage of public transport to the site. Shown in Figure 3-4, these targets anticipate only 5% of trips will be undertaken by private vehicle.

Figure 3-4: Barangaroo Mode Share Targets[73]



Note that the 2% light rail mode share assumed no light rail stop at Wynyard, requiring customers to change either to bus at Haymarket or heavy rail at Central.

Given the significant numbers of people commuting to and from the development it is imperative that appropriate transport solutions are in place. The CSELR project will positively contribute to linking Barangaroo with Sydney's South East. Customers travelling to the development will disembark at Wynyard light rail stop and proceed on foot via Wynyard Walk.

3.1.2.2. SICEEP

The NSW Government has embarked on a redevelopment and expansion strategy for the Entertainment Centre, the Exhibition Centre and the Convention Centre, collectively the SICEEP, located in the southern sector of Darling Harbour. The works aim to create an integrated entertainment facility in the heart of Sydney with additional commercial, retail, hotel and residential floor space. The new International Convention Centre Sydney (ICC Sydney) will compete more effectively in the global convention and exhibition market, further enliven the southern part of Darling Harbour and improve linkages with surrounding areas, especially Chinatown.

[73] *Barangaroo Integrated Transport Plan*

The scheduled completion date for core cultural facilities is 2016, with the remaining retail, commercial, hotel and residential development expected to finish in 2021.

Figure 3-5: Concept Designs of the ICC Sydney and Multi-Function Entertainment Centre[74]

The redevelopment of the SICEEP is anticipated to increase off-peak demand to the Darling Harbour precinct as increasingly large events are hosted in Sydney. Transport services to the precinct were assessed through the Environmental Assessment process for that project, however it is worth recognising that the construction of CSELR will complement the existing Inner West light rail system adjacent to the precinct and provide for a simple connection to the primary CBD spine and key areas of accommodation for international and interstate visitors who are anticipated to be major users of the site.

The precinct will on completion be Australia's largest exhibition space to date with increased space to accommodate for previously unmet excess demand. Banqueting and meeting facilities are estimated to double the current capacity, whilst there will be a reduction in capacity for entertainment facilities, indicating a focus on international and national conventions and exhibitions as key economic drivers, with aims to generate more and bigger events than current capacity constrictions permit. Event attendee increases will be combined with both short-term and long-term increases in the precinct's population, with anticipated employment generation of 1,600 jobs during construction and 4,000 ongoing positions, and 2,100 construction jobs and 2,000 ongoing positions associated with the consequential city hub 'The Haymarket'.

The SICEEP recognises the increase in transport demand resulting from the higher activity-levels within the precinct, with the responding environmentally sustainable design strategy that promotes the use of public transport, specifically through supporting accessibility to existing light rail stations on Darling Drive via new pathways and pedestrian crossings. Parking provisions will concurrently be reduced by around 500 spaces to promote a shift towards sustainable transport modes. The initiatives will promote patronage of light rail and support investments such as the IWLR extension and the CSELR. The SICEEP and CSELR are projects with undeniable interdependencies and mutually beneficial impacts, with promotion of the precincts increasing light rail demand, and light rail network providing easy access to the precinct from surrounding areas and key strategic locations such as the CBD.

[74] *Infrastructure NSW*

3.1.2.3. UNSW campus development

Cumulatively between 25,000 and 30,000 people arrive at the UNSW Kensington campus by bus during semester times and the Central Station to UNSW Kensington campus bus route is one of the busiest point to point bus routes in Sydney.

The University of New South Wales has more than 50,000 students including approximately 12,000 international students that generate between $350m - $400m of export income for the State each year. UNSW is regularly ranked in the top 100 universities in the world.

The continuation of reliable transport services throughout the construction process is vital to the operation of the University and the ability to attract and retain students. This includes not only connections to Central Station but also cross regional bus services that connect to the UNSW Kensington campus.

In addition to delivery of a high-quality piece of transport infrastructure, the University is investing approximately $400 million across three major projects at its Kensington campus:

- $110 million Kensington Colleges development
- $145 million Wallace Wurth building redevelopment
- $145 million Materials Science and Engineering Building (MS&EB)

An overview of each of these projects is provided below.

Kensington Colleges development

Construction of five new colleges to replace the three colleges previously demolished. The colleges will provide housing for up to 920 students and are expected to open in early 2014 at a total cost of $110 million.

Wallace Wurth building redevelopment

Redevelopment of the existing Wallace Wurth building will modernise facilities and expand floor space from 13,000 to 21,000 square metres. The building will house the Kirby institute and contribute to creating a biomedical research precinct on UNSW's upper campus. Scheduled for completion in March 2014, the building is expected to accommodate over 1250 students and 750 research personnel at a total cost of $145 million.

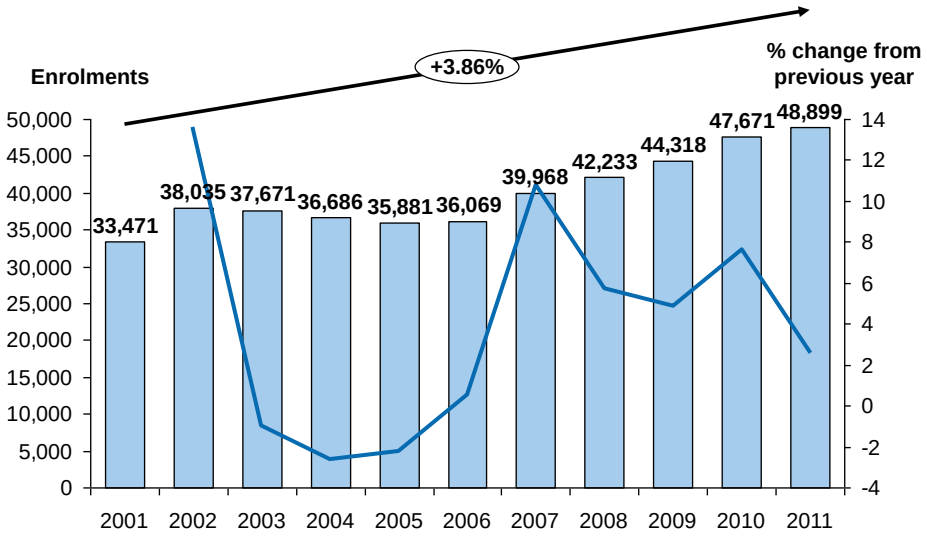
MS&EB

Construction of a new building will support the teaching and research of materials science and engineering. The building will be ten stories high with approximately 20,000 square metres floor space. Planned for completion in 2015, the expected total cost of the Project is $145 million. Figure 3-6 shows the concept design for the MS&EB.

Figure 3-6: UNSW's Planned MS&E Building[75]

Historic growth in trips to UNSW has been relatively strong, with internal enrolments at UNSW (reflecting the majority of Kensington campus students) increasing at a rate of 3.9% over the past decade as illustrated in Figure 3-7. However, there has been significant variability in year to year growth over that time – particularly due to changes in Commonwealth Government policy settings. The removal of the cap on Commonwealth Supported Places in 2009 saw a reinvigoration of demand that may be expected to continue as Universities seek to ensure secure sources of funding in the future.

Figure 3-7: Number and Change in Internal Enrolments at UNSW, 2001-2011[76]



An increasing majority of students are using public transport to access the campus, as the supply of nearby parking spaces has remained static, with around half of students accessing the campus between 8am and 10am. In the evening, peak student departure time more closely aligned with the regular peak period with 51% of students departing between 4pm and 7pm[77].

[75] *UNSW*

[76] *Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2012*

[77] *UNSW Travel Survey, 2012*

It is anticipated that this profile of demand will continue in the future, with public transport assuming an increasing share of the transport task due to ongoing limitations to parking supply in the precinct. Light rail is well-positioned to take up this task, with the current design including stops near the University Mall on Anzac Parade and Gate 9 on High Street, used by more than half of students and staff to access the University.

3.1.2.4. Royal Randwick Master Plan

The Australian Turf Club (ATC) has recently invested approximately $150 million on a new grandstand and amphitheatre which opened for the 2013 racing season. The facilities increase the seating capacity of the venue by 112% and aims to modernise the race day experience.

The ATC has developed a Royal Randwick Master Plan which is currently going through the development approval process. The master plan includes construction of a 170 room hotel (expected completion 2015), six new 100 stable buildings, a convention centre and a centre of excellence / lifestyle centre. These new facilities are expected to enhance the experience of racegoers and expand the scope of events held at Royal Randwick.

Figure 3-8: Royal Randwick's New Grandstand[78]

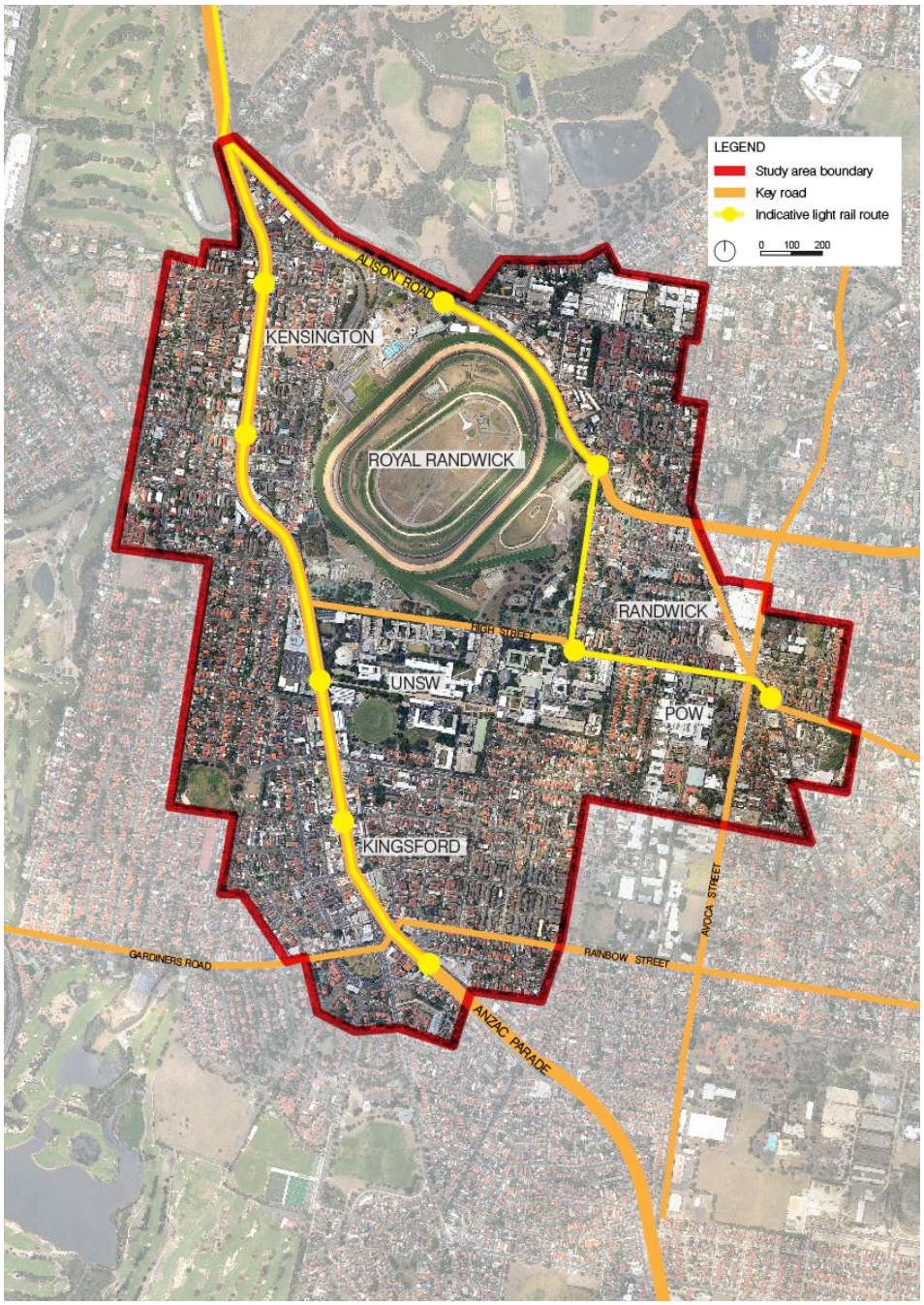
Royal Randwick's development will primarily impact transport demand for special events, which is discussed in more detail in Section 3.3 of this report. At a high-level, the development of Royal Randwick is expected to shift transport patterns from their current focus around a small number of race days to a more diverse range of events from major music festivals to smaller corporate conferences.

3.1.2.5. Randwick Urban Activation Precinct

In March 2013, the NSW Government announced an Urban Activation Precincts (UAP) Program as part of a wider package of housing and jobs initiatives. The UAP Program seeks to improve the delivery of in-fill development through a structured approach to housing release and infrastructure development. Anzac Parade South, within Randwick City Council, as well as Randwick itself are two of the first eight precincts identified for inclusion in the UAP Program. The area under examination is shown in Figure 3-9.

[78] *Australian Turf Club*

Figure 3-9: Boundary of Randwick Urban Activation Precinct Study Area[79]



While still in the early stages of planning, the NSW Government has recognised that the construction of light rail in the precinct will provide a catalyst for urban renewal and consolidation. The delivery of a high-capacity and reliable mode of transport through the area will support the additional social and community infrastructure being delivered through the UAP program.

[79] *NSW Department of Planning & Infrastructure*

3.1.2.6. Green Square Town Centre

Green Square Town Centre is an $8 billion development located 3.5km south of the City Centre and 2km west of Royal Randwick Racecourse. The development covers a 278 Ha area and includes planned construction of residential and commercial buildings, and community facilities including a community hall, exhibition galleries, multi-purpose recreation area and aquatic centre, and a 6,500 square metre park.

Following the initiation of site works in 2013, the first residents are expected to move in between 2015 and 2016. The town centre building sits at the heart of the Project and is planned to accommodate approximately 6,800 residents and 8,600 workers. On completion in 2030 the development is expected to attract up to 40,000 new residents and 22,000 new workers to the Green Square precinct. Concept design cross-sections of the development are provided in Figure 3-10.

Figure 3-10: Green Square Town Centre Cross-sections[80]

This project will significantly alter transport patterns in the precinct from a primarily industrial and manufacturing use to a mixed-use commercial and residential precinct. While employment growth in the area is more moderate than residential growth, the nature of employment purposes in the precinct will change as the nature of businesses shifts from current industrial use to more generic commercial and retail. In addition, the peak flow nature of transport movements in the area driven by employment purposes will moderate and residents who live in the Green Square precinct but work outside it begin to increase demand for contra-peak transport flows.

Despite the significant increase in travel demand as a result of the development, the precinct is already relatively well-served by public transport with a mix of buses and heavy rail services nearby. While Green Square will shift travel patterns over the time, the transport task is not unmanageable through a reorganisation of the transport system and mode hierarchy in the future. The introduction of CSELR can play a part in this as a reduction in demand for bus fleet in the eastern suburbs permits the reallocation of fleet for other purposes including, if necessary, supplementary services along the Botany Road corridor.

[80] *Landcom*

3.2. Future Demand

On-going population and employment growth in major developments, land release areas and urban regeneration sites will all drive additional demand for transport services within the study area. To guide the transport planning process, Transport for NSW commissioned the development of a demand model specific to the requirements and intricacies of the CSELR project. This model – the Public Transport Project Model (PTPM) – extended the capabilities of existing models such as the Strategic Travel Model (STM) to deal with key aspects of anticipated future demand. The PTPM uses inputs including land-use patterns, rail operating plans, bus operating strategies, road network plans and parking availability and charging to understand the anticipated profile of demand under a range of future scenarios.

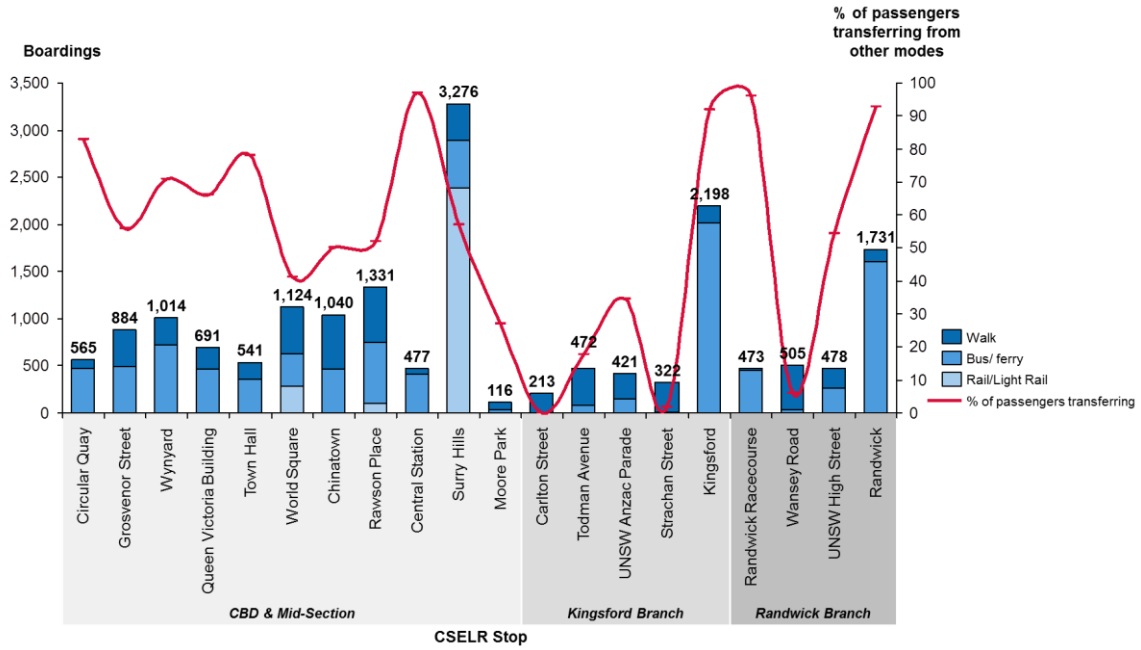
The PTPM provides transport planners with a tool to understand future travel requirements and demand patterns to ensure an appropriate level of service is provided to meet community expectations. Outputs from the PTPM were used in a number of stages to inform the development of the future traffic and transport network. Key elements of the profile of future demand are summarised below. More detail can be found in Transport for NSW's Demand Report.

- The Project is expected to attract about 18,000 AM peak hour boardings in both directions in 2021, growing to around 23,000 by 2036[81];
- Line load on the CSELR peaks at more than 5,300 passengers per hour in the 2021 AM peak on the approach to Central Station[82];
- Driven primarily by student travel to UNSW, there is strong demand for contra-peak travel with line loads of approximately 4,100 passengers per hour in the 2021 AM peak hour and just over 3,300 alightings at the two UNSW stops[83]; and
- In the 2021 AM peak hour, over 2,000 passengers are forecast to transfer from buses to light rail at the Kingsford terminus and over 1,600 passengers at the Belmore Road (Randwick) terminus[84].
- Total demand to the CBD on the CSELR is expected to total almost 40,000,000 trips by 2036[85];

While the effect is more pronounced at the key interchange stops of Central Station, Randwick and Kingsford, intermodal use will be a key feature of the CSELR at all stops. As shown in Figure 3-11, most stations anticipate transfers from other modes to varying degrees depending upon the nature of the catchment and style of stops.

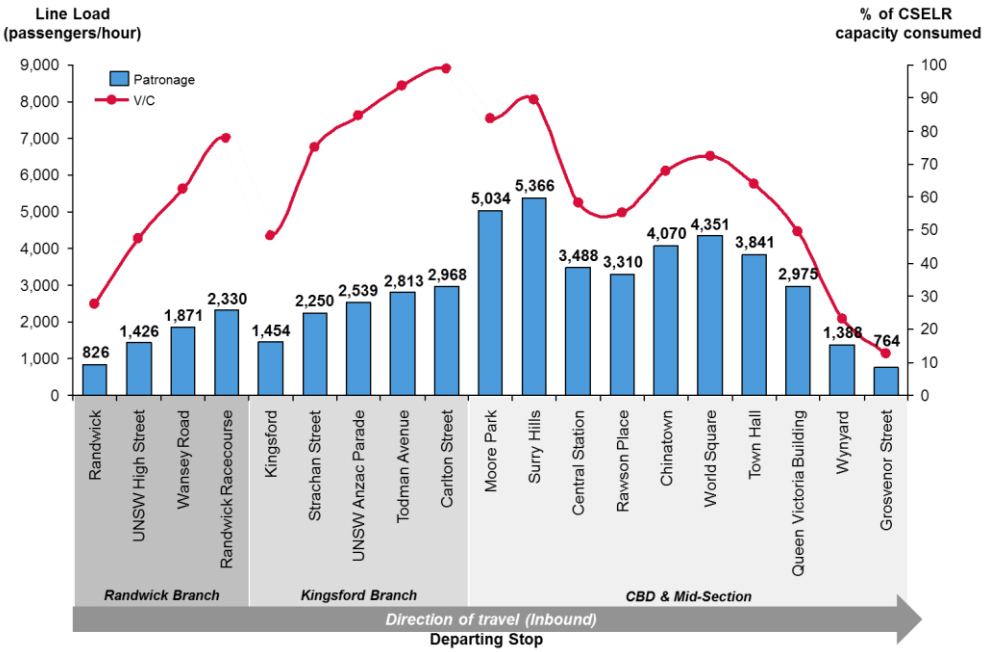
81 Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report*, 2013
82 *Ibid*
83 *Ibid*
84 *Ibid*
85 *Ibid*

Figure 3-11: 2021 AM Peak CSELR Boardings and Mode of Access by Light Rail Stop[86]



The CSELR is also anticipated to take a significant proportion of the growth in future demand from the eastern suburbs to the CBD. As shown in Figure 3-12, peak line loads inbound (based on the preliminary service specifications outlined by the Operations Adviser[87]) exceed 5,300 passengers per hour in the 2021 AM Peak Hour[88].

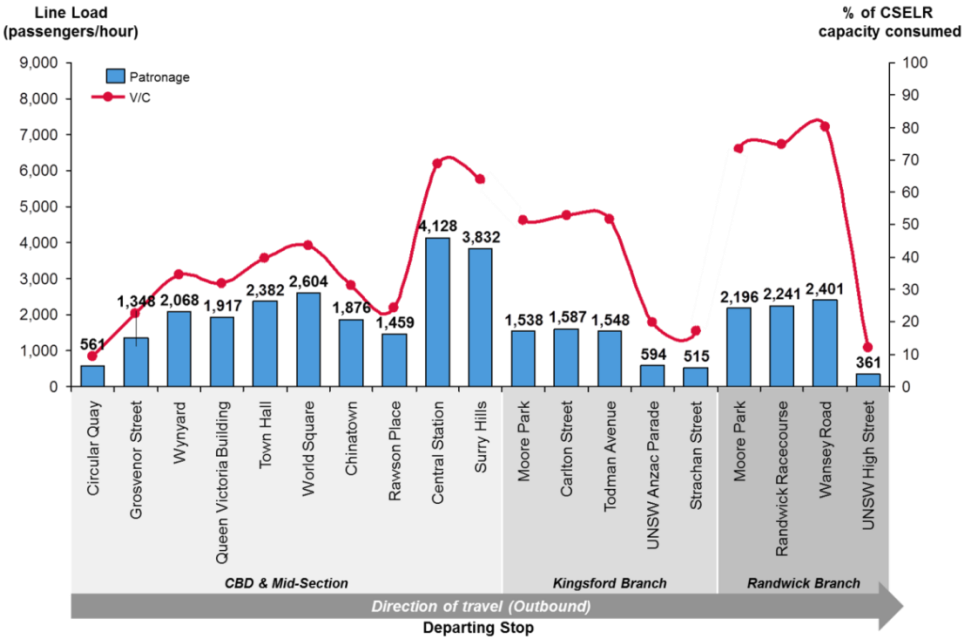
Figure 3-12: 2021 Inbound AM Peak CSELR Line Load and Capacity Consumed[89]



[86] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report,* 2013; Booz & Company analysis
[87] Interfleet, *Operations Adviser Initial Light Rail Operational Services Plan*, 2013
[88] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report,* 2013
[89] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report,* 2013; Booz & Company analysis

As shown in Figure 3-13, peak line loads outbound (based on the preliminary service specifications outlined by the Operations Adviser[90]) while lower than inbound, still exceeds 4,100 passengers per hour in the 2021 AM Peak Hour[91]. This represents a good balance of demand, with the fixed and rolling infrastructure assets well-utilised in both directions due to the significant demand for access to the University of NSW and Randwick Health Precinct.

Figure 3-13: 2036 Outbound AM Peak CSELR Line Load and Capacity Consumed[92]



Finally, because trips on light rail may well be part of a longer journey, the PTPM provides an indication of the anticipated travel zone origin for trips beginning at particular light rail stops. Due to the relevance of this information to bus and road network planning, a summary of trip origins for the Kingsford and Randwick termini is shown in Figure 3-14 and Figure 3-15 respectively, however numerous origin/transfer plots were utilised during the development of the transport strategies for the South East.

[90] Interfleet, *Operations Adviser Initial Light Rail Operational Services Plan*, 2013
[91] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report,* 2013
[92] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report,* 2013; Booz & Company analysis

Figure 3-14: Anzac Parade terminus (Nine Ways) stop trip origins (2036)[93]

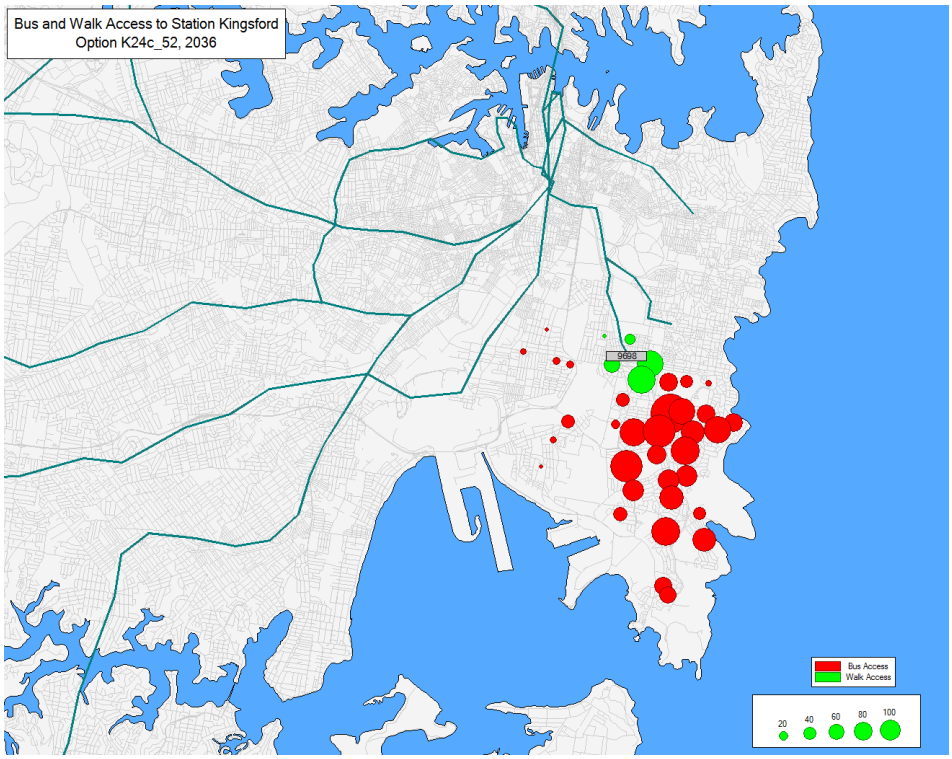
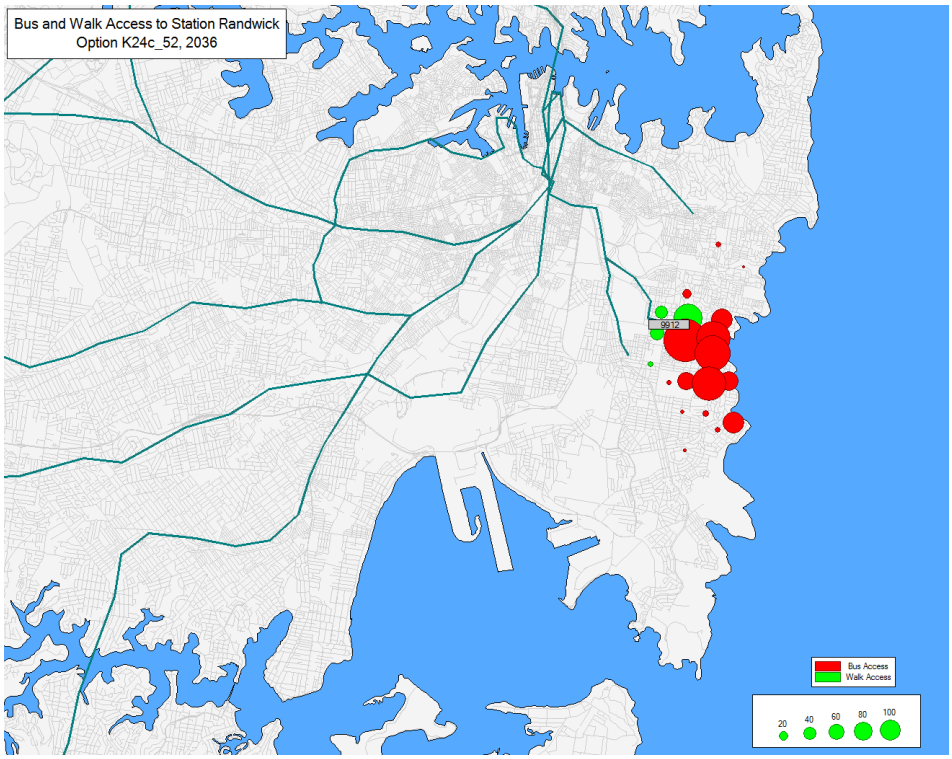


Figure 3-15: Belmore Road terminus stop trip origins (2036)[94]



[93] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report,* 2013
[94] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report,* 2013

3.3. Special Events

The introduction of the CSELR provides an opportunity to significantly enhance access to the major event precincts within the corridor, increase public transport mode share and reduce congestion. The CSELR corridor is, however, on the major CBD parade route on George Street and identification of appropriate public transport management strategies are required to minimise their impact on CSELR operations.

This section of the report discusses the benefits the CSELR can provide to existing and future special events at Moore Park and Royal Randwick, and sets out appropriate first steps for minimising the operational impact of CBD events.

3.3.1. Public transport mode share

Public transport mode share to special events along the CSELR corridor, particularly to Royal Randwick, has historically been relatively low in comparison with other major special event locations. Sydney Olympic Park at Homebush, which offers a multi-modal transport solution, averaged public transport mode share of 69% in 2010.[95]

CSELR presents a number of benefits over the existing special event bus transport solution. Light rail will be more reliable and more comfortable than event buses, which would contribute to higher customer satisfaction and should serve to increase mode share. Public transport mode share could further benefit from redeployment of duplicated bus services to link events to new areas of Sydney. In all instances, increasing public transport mode share will ultimately result in reduced congestion around event venues.

3.3.2. Moore Park

A traffic and transport services strategy for Moore Park was developed by Parsons Brinckerhoff[96] (PB) with the purpose of providing an integrated transport master plan for the precinct for both event and regular transport operations. It is expected that Moore Park will continue to host a significant number and wide variety of special events in future years of a similar complexion to the current mix. To understand the appropriate mix of modes and services required to satisfy the future demand at these events, PB has undertaken analysis of these requirements to suggest an appropriate Moore Park event strategy. Detailed analysis and specific infrastructure requirements are summarised in the PB report, a summary of which is provided in this section.

Special events at Moore Park will target the following mode share target following the introduction of light rail:

- Cricket/AFL capacity event (48,000 attendees) with 45m LRV – 68% non-car
- Cricket/AFL typical event (34,000 attendees) with 45m LRV – 66% non-car
- Rugby League/Rugby Union/Football typical event (34,000 attendees) with 45m LRV – 63% non-car
- Cricket/AFL capacity event (48,000 attendees) with 90m LRV – 71% non-car

Mode share targets for individuals modes under capacity events with 45 metre and 90 metre light rail vehicles in use are shown in Figure 3-16 and Figure 3-17. Note that these figures show total (not hourly) mode share to the event.

[95] *Parsons Brinckerhoff,* Sydney Light Rail Program Moore Park Precinct – All Modes Study, *June 2013*
[96] *Ibid*

Figure 3-16: Proposed Moore Park event transport mode share with LRT (48,000 - AFL) 45m LRV

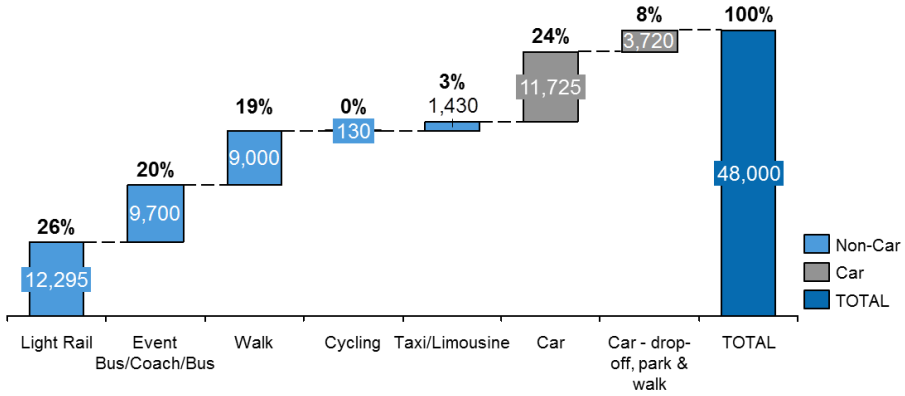
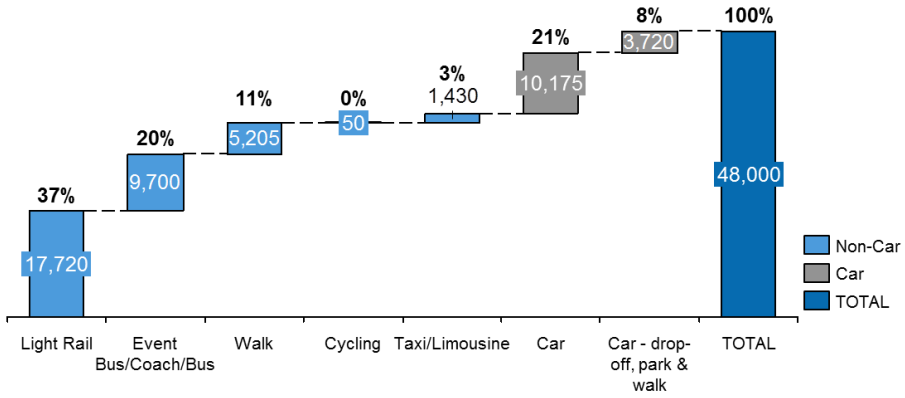


Figure 3-17: Proposed Moore park event transport more share with LRT (48,000 - AFL) 90m LRV



It is intended that light rail will replace the current special event bus operations between Moore Park and Central station. Regular light rail services will also replace the operation of dedicated park-and-ride shuttle to the University of NSW and Randwick Racecourse that operate for some events. With a combination of event shuttles and regular services, a maximum headway of 2.5 minutes can be achieved in the peak direction during the post-match period. With passenger capacity of 5 passengers per square metre, a total hourly capacity is possible of:

- 45 metre LRV – 9,836 passengers/hour (both directions combined)
- 90 metre LRV – 14,175 passengers/hour (both directions combined)

Based upon maintaining a 36% mode share to light rail for all crowd sizes, the likely duration of event specials will range from 20-55 minutes following an event depending on capacity required and operational strategy employed.

In addition to light rail, buses will continue to play an important role in the event transport task in the Moore Park precinct. The current major event bus hub at Moore Park is required to be relocated to facilitate the construction of a light rail stop in its place. The new facility is proposed to be located north of Tramway Oval between the bus roadway and Kippax Lake (shown in Figure 3-18). The facility is proposed to be 235m long and 37m wide, with sufficient capacity for 10 standard buses or 4 standard and 5 articulated buses.

While the main event bus connection between Central and Moore Park will be replaced by light rail, it is envisaged by Parsons Brinckerhoff that a number of bus routes will remain to provide access to catchments in the Sydney metropolitan area not well served by the heavy or light rail network. These include:

- Existing event bus services between Circular Quay and Moore Park (Route 3);
- Castle Hill to Moore Park (Route 15A);
- Dural to Moore Park (Route 18);
- Warringah Mall to Moore Park (Route 50);

This results in Routes 1, 52, 60 and 62 being replaced by the CSELR.

Walking has always been a popular mode of access to Moore Park, with up to 9,000 spectators expected to walk to the precinct for a capacity event, including people walking the 1.5-2 km's from Central station and other transport nodes. The PB study recommended that a pedestrian bridge across Anzac Parade be provided to improve the pedestrian connections between Central Station and Moore Park.

The complete event transport plan for Moore Park is shown in Figure 3-18.

Figure 3-18: Moore Park precinct Integrated Event Transport Plan

3.3.3. Royal Randwick

Royal Randwick is currently served by special event buses (Route 32) during Saturday race days throughout the year, and Future Music festival held annually in March. While bus mode share to Future Music festival averages 33%, race day mode share averages fewer than 10%.

The CSELR presents an opportunity to increase public transport mode share to Royal Randwick events. Given the CSELR will duplicate the event bus transport solution provided by the Route 32, these bus services could either be redirected elsewhere on the network or redeployed to supplement the new light rail service, linking the venue with other parts of Sydney. Redeployed services could run from other key transport hubs, resulting in increased public transport mode share to events at Royal Randwick.

The venue is currently undergoing a major development including construction of a 170 room hotel (expected completion 2015), a convention centre and a centre of excellence / lifestyle centre. The development is expected to increase attendance and attract a more diverse array of events. Future transport solutions will have to meet both the changing needs of existing events, as well as the transport demand from new events.

The addition of new facilities and modernisation of existing facilities is likely to increase attendance of currently held special events, as well as facilitating a shift in the type and number of special events held at Royal Randwick. Increases in attendance for future race days will be better supported under the new light rail transport solution, as compared with the existing event buses. In addition, the higher capacity, improved reliability and simple scalability of a transport solution involving light rail makes it better positioned to respond to the shifting nature of events to be held at Royal Randwick.

The active promotion of Royal Randwick as a prime location for non-racing events such as music festivals could see significant spikes in peak transport demand, albeit over only a one or two day period. As seen with Future Music festival currently held at the venue, music festivals tend to have a much higher public transport mode share.

3.3.4. CBD

There are currently a large number of events held in the CBD which impact traffic along George and Alfred streets. A list of these events and a short description of their impact is provided in Figure 3-19. Due to the fixed nature of light rail infrastructure, these events (which force diversions of existing bus services) may require partial or full closure of the CSELR in the CBD.

Figure 3-19: Annual Events Directly Impacting the CSELR

Indicative Month	Event	Comment
January	Australia Day Wheelchair Race	Course runs West along Alfred Street at Circular Quay
January	Chinese New Year Twilight Parade	Parade down George Street between Park and Goulburn Streets
March	St Patricks Day Parade	Parade down George Street between Park and Bathurst Streets
April	Anzac Day Parade	Parade down George Street between Martin Place and Bathurst Street
April	Sydney Easter Parade	Parade down George Street between Park and Bathurst Streets
May	May Day March	Parade down George Street between Park and Bathurst Streets
May	SMH Half Marathon	Course runs West along Alfred Street at Circular Quay
June	MS Walk / Run	Short section of the run along George Street near Martin Place
June	Procession of the Blessed Sacrament	Procession moves down George Street between Bridge and Hunter Streets
September	Sydney Running Festival	Course runs West along Alfred Street at Circular Quay, and East through the pedestrian section of Circular Quay station (?)
October	Moveable Feast	Closure of George Street between Park and Bathurst Streets
November	Sydney Christmas Parade	Parade down George Street between Hunter and Liverpool Streets
December	New Year's Eve	Closure of George Street between Grosvenor and Alfred Streets, closure of Alfred Street at Circular Quay
N/A	Olympic / Sporting Parades	I.e. Sydney Swans celebratory parade 2012

To minimise the impact of CBD special events on CSELR operations, Government should review events held along George and Alfred streets to assess the capacity of those events to be suitably relocated elsewhere in the CBD. In cases where events must retain use of the CSELR corridor, operations along the line will be impacted and may need to be supplemented with bus services.

The current CSELR design includes a cross-over at Town Hall which may facilitate short-running of light rail services between Central and Town Hall if events are held on George Street north. Under these circumstances, replacement bus services may not be required as sufficient regular bus services exist on adjacent streets supplemented by heavy rail services on the City Circle line.

However, if the event requires the full closure of the CSELR between Eddy Avenue and Circular Quay, replacement bus services may be required to provide sufficient capacity and accessibility to destination along the CBD light rail alignment. Under these circumstances, replacement bus services would be anticipated to operate north-south on the Elizabeth Street/Castlereagh Street pair.

Assessment of the necessity to provide alternative transport arrangements would be made through the normal processes involving Transport for NSW, the Transport Management Centre, Roads & Maritime Services, Destination NSW, the City of Sydney and event organisers taking into account:

- The nature of the event;
- The timing and location of the event;
- The magnitude of demand expected to be attracted to the event;
- The capacity of the base public transport system to cater for the event, including the ability of other modes to 'scale up' to provide additional capacity;
- Other conflicting events that may multiple the load experienced by the transport system; and
- The presence of integrated ticketing or other arrangements that improve the efficiency of the transport system at times of ultra-peak loadings.

4. Bus Strategy

4.1. Context

The CSELR proposal represents two components of the Sydney City Centre Access Strategy (CCAS) – light rail and pedestrianisation of George Street. One other component of the CCAS of particular relevance to the CSELR is the bus network redesign to deliver a fully-integrated and coherent public transport system in Inner Sydney.

Bus service changes have been developed in parallel with the development of the CSELR proposal and are consistent with the CSELR proposal to ensure a fully integrated transport solution. However any changes to bus services and infrastructure in the CBD and South East, as well as traffic management changes and other impacts associated with these changes, will be assessed as part of the CCAS. These will not, therefore, form part of the EIS for the CSELR proposal, with the exception of cumulative impact considerations.

The detailed bus strategy is documented in the CCAS. Given the particular relevance of buses to the CSELR (i.e. both being road based public transport systems which are being designed to integrate) the proposed bus network is discussed in this section, including a summary of the redesigned CSELR corridor bus network as well as the Sydney city centre bus network redesign.

4.2. Definition of the future network

4.2.1. Sydney city centre bus network redesign

The redesign of the Sydney city centre bus network aims to create an integrated public transport solution for the Sydney CBD through the coordination of light rail, rail and bus services. It includes rationalisation of Sydney bus services to accommodate the introduction of the North West Rail Link, expansion of light rail services, and the pedestrianisation of George Street.

The bus network redesign is a key element for the delivery of the CSELR project, in particular the relocation of existing bus services from George Street. It was developed in parallel to the development of South East bus networks with a focus on aligning the networks developed in response to the CSELR project.

A summary of the key objectives and proposed network for the city centre bus network redesign is provided in this section.

A key objective of the redesign is to provide improved legibility and access for existing and future customers to use buses while the buses are operated more efficiently on the city streets and into the City Centre. Some objectives of Sydney's Bus Future[97] specific to the City Centre were identified as follows:

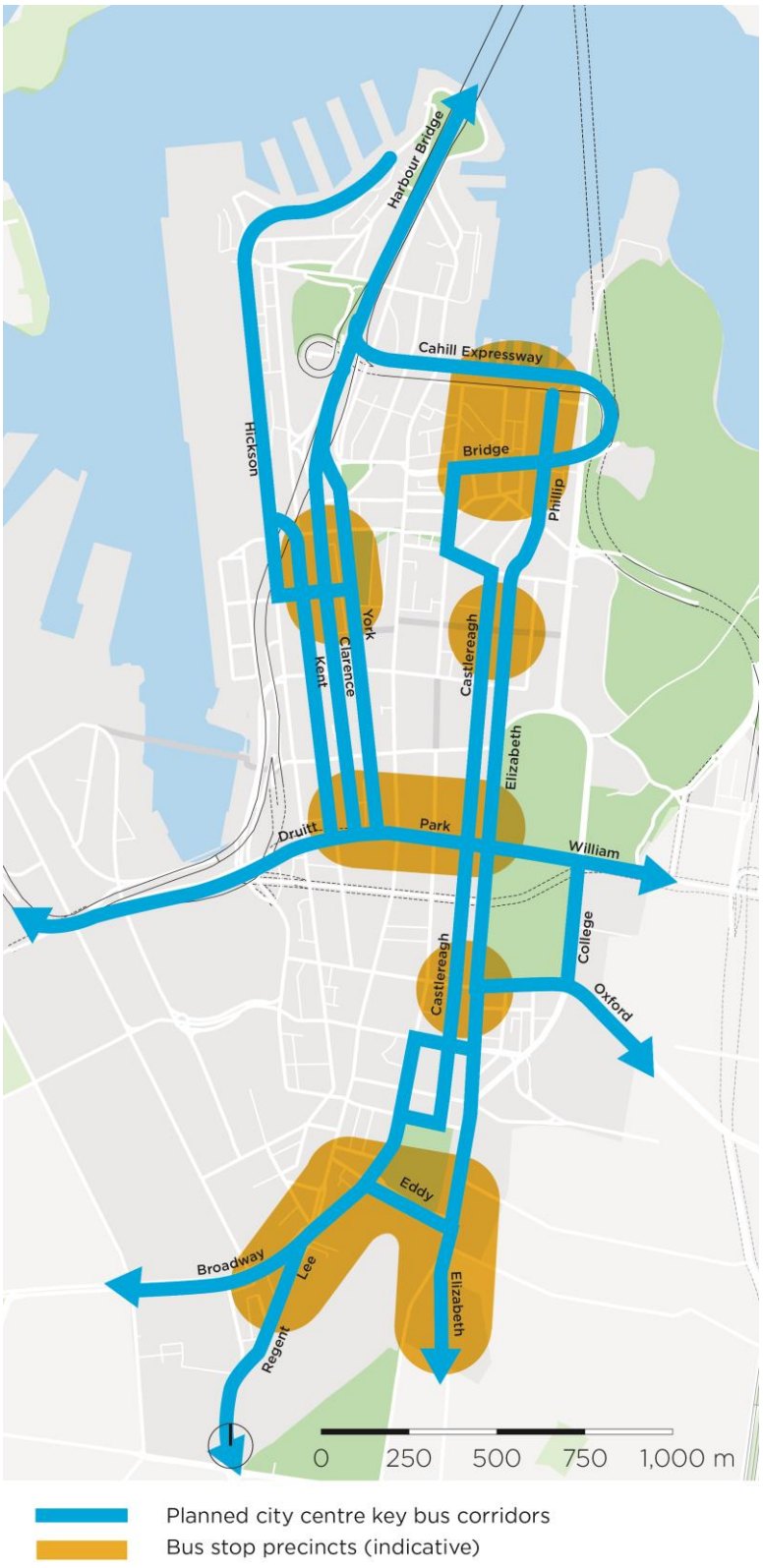
- Create a simpler, all-day City Centre bus network;
- Accommodate high volumes of buses through the City Centre more efficiently with fewer turns and more bus priority; and
- Minimise the need for terminating services in the City Centre and provide sufficient capacity at convenient located layover facilities.

[97] *Accurate at time of writing, document still in draft*

The key bus route paths and interchange precincts for the new Sydney city centre bus network redesign are illustrated in Figure 4-1 and key features are summarised as follows:

- No buses to travel along George Street between Rawson Place and Hunter Street to be consistent with the planning for the Sydney CBD light rail project.
- In-service buses will only be allowed to access George Street within the City Centre to cross at Park Street/Druitt Street, to turn left from Rawson Place south into George Street and to turn left and right at Bridge Street/George Street. Out of service or dead running services will also be allowed to cross George Street at Market Street, Bathurst Street and Goulburn Street.
- Turning movements would be reduced at the Elizabeth Street and Park Street intersection. This would help simplify bus movements through the city centre.
- Sydney Harbour Bridge services will operate either via York Street to Town Hall/QVB or via the Cahill Expressway and Castlereagh Street/Elizabeth Street
- Buses from the Eastern Suburbs via William Street would run to Barangaroo and Walsh Bay to Pyrmont.
- About 50% of Inner West bus routes will terminate after stopping at the Rawson Place light rail stop and in Campbell Street north of Belmore Park. The remaining Inner West bus routes will continue to northern end of City Centre via the Elizabeth Street/Castlereagh Street couplet.
- Routes from the south-east suburbs and from the Oxford Street corridor will only use Elizabeth Street to and from Circular Quay.
- Several routes would be connected to operate as through-routed services to reduce the overlap of bus services on city centre streets and the need for bus lay-over in the city centre.
- Victoria Road bus routes that currently use George Street and terminate at Circular Quay would either continue through the city centre via Druitt Street and Park Street to lay-over outside the city centre or terminate at Wynyard.

Figure 4-1: Key Bus Route Paths in the Sydney City Centre[98]



[98] Transport for NSW, *Sydney City Centre Access Strategy*

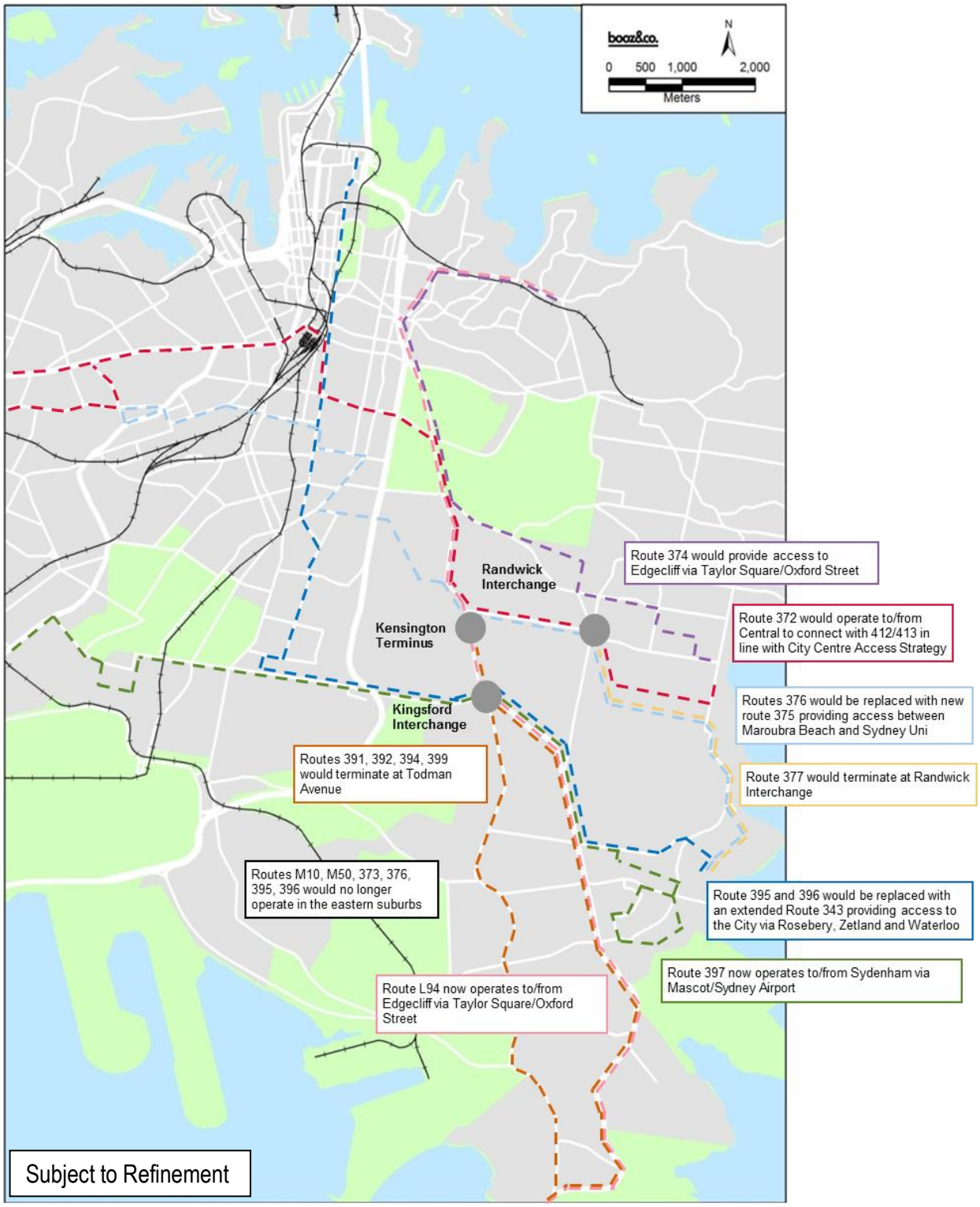
4.2.2. South East bus network

This section provides an overview of the bus service changes that will deliver an integrated bus and light rail public transport network in the South East CSELR corridor. The key elements of the South East Bus Network are described below with the route changes illustrated in Figure 4-2 and summarized in Table 4-1. Those bus routes not mentioned should be assumed to continue operating on their existing routes. At this stage the proposed bus service changes in the South East are draft and will be subject to further refinement through community consultation.

In general the changes propose the establishment of an all 'day network' of light rail trunk services to the city with feeder and cross regional bus services. The strategy proposes to retain selected express buses during the peak periods to the northern end of the Sydney CBD to complement the 'all day' network. The key features include:

- The majority of existing All-stop CBD bus services which operate along Alison Road and Anzac Parade in duplication of the CSELR are proposed to no longer operate to the CBD but change to become feeder routes for the light rail. These provide all day connections to light rail stops in the eastern suburbs. Examples include:
  - Some Anzac Parade services (Routes 391, 392, 394, and 399) feed the CSELR at Kingsford but continue on to Todman Avenue, Kensington providing direct connections from the south to the UNSW;
  - Randwick bus services feed the CSELR at Randwick but instead of terminating they generally extend to Bondi Junction or other new cross regional links, or terminate on Belmore Road at Alison Road.
- Additional cross-regional routes would be introduced to satisfy growing demand between key trip generators such as the Airport, Green Square, the University of Sydney, Edgecliff and Paddington as well as provide improved connections to the CSELR;
- UNSW will be served by cross-regional routes via High Street including routes 348, 370, 375, 400 and 410;
- CBD express bus services which operate via the eastern distributor are proposed to be retained to provide a direct journey for customers travelling to destinations in the northern CBD during the peak periods only;
- In the PM peak, CBD Express services are proposed to operate via Elizabeth Street and Oxford Street rather than through the Eastern Distributor (as existing);
- University Express Bus Services provided between Central Station and the UNSW would be replaced by the CSELR;
- School Special Bus Services provided between Central Station and Sydney Boys High School and Sydney Girls High School would be replaced by the CSELR;
- Special Event bus services provided between Central Station and Moore Park precinct and Royal Randwick Racecourse are expected to be redesigned to provide new links during events to supplement the CSELR and increase public transport mode share for special events as discussed in Section 3;
- Metrobus routes M10 and M50 are not proposed to operate in the Eastern Suburbs as their function is largely undertaken by the CSELR.

Figure 4-2: Proposed Key South East Bus Network Changes (AM Peak inbound)[99]



[99] *Note: Only illustrates bus routes changed. Those bus routes not mentioned should be assumed to continue operating on their existing routes.*

Table 4-1: South East Bus Network Scenario Route Changes (AM Peak)

Route Number	Old Route	New Route
372	Coogee-Railway Square via Cleveland Street	Coogee-Railway Square via Cleveland Street, through-routed with 412/413 to align with the city centre bus network redesign
373	Coogee-Circular Quay via Oxford Street	Route cancelled
374	Coogee-Circular Quay via Foveaux Street	Operates existing route to Anzac Parade, then travels to Edgecliff via Darlinghurst Road and William Street (subject to detailed implementation planning on routing)
375	N/A	New service operating Maroubra Beach-Sydney University via Randwick Junction, High Street and Todman Avenue
376	Maroubra Beach-Circular Quay via Marine Parade, Alison Road and Foveaux Street	Route cancelled, replaced with 375
377	Maroubra Beach-Circular Quay via Marine Parade, Alison Road and Oxford Street	Operates existing route to Alison Road via Belmore Road and terminates
395/396	Maroubra Beach-City via Maroubra Junction and Anzac Parade	Routes cancelled, to be replaced with extended Route 343
343	Kingsford-City via Gardeners Road and Elizabeth Street	Route extended to operate to/from Maroubra Beach along old 395/396 alignment
397	South Maroubra-City via Anzac Parade	Operates existing route to Kingsford interchange, then Gardeners Road to Sydenham via Mascot/Sydney Airport
M10	Metrobus route between Maroubra Junction and Leichhardt	No longer operates in the eastern suburbs to align with the city centre bus network redesign
M50	Metrobus route between Drummoyne and Coogee	No longer operates in the eastern suburbs to align with the city centre bus network redesign
391	La Perouse-City via Bunnerong Road and Anzac Parade	Operates existing route to Todman Avenue, Kensington and terminates
392	Little Bay-City via Anzac Parade	Operates existing route to Todman Avenue, Kensington and terminates
393	La Perouse-City via Bunnerong Road and Anzac Parade	Operates existing route to Todman Avenue, Kensington and terminates
394	La Perouse-City via Bunnerong Road and Anzac Parade	Operates existing route to Todman Avenue, Kensington and terminates
399	Little Bay-City via Anzac Parade	Operates existing route to Todman Avenue, Kensington and terminates
L94	La Perouse-City via Bunnerong Road and Anzac Parade	Operates existing route to Anzac Parade, then travels to Edgecliff via Darlinghurst Road and William Street (subject to detailed implementation planning on routing)

4.2.3. Precinct Specific Bus Management

4.2.3.1. Central Station rail replacement buses

Rail track work is an on-going necessity for Sydney Trains and NSW Trains to maintain required safety levels, and ensure reliability and efficiency of services. Most scheduled maintenance is undertaken during times of lower patronage, such as weekends. During these times, rail replacement buses are required to minimise disturbance to customers' travel patterns by providing a convenient alternative travel mode.

Rail replacement bus operations

Contracted operators provide rail replacement bus service operations, including the provision of bus marshals responsible for directing passengers to appropriate replacement service. Bus service operations are currently provided with limited infrastructure. Requirements include:

- Legibility for customers to aid their understanding of reasons for the shutdown.
- Provision of clear replacement directions for customers.
- A bus layover area and pick up stands with sufficient kerb side space.
- Wheelchair transport accessibility and a temporary shelter for waiting services.

Figure 4-3: Chalmers Street Rail Replacement Buses, 2011[100]

Impacts of Light Rail

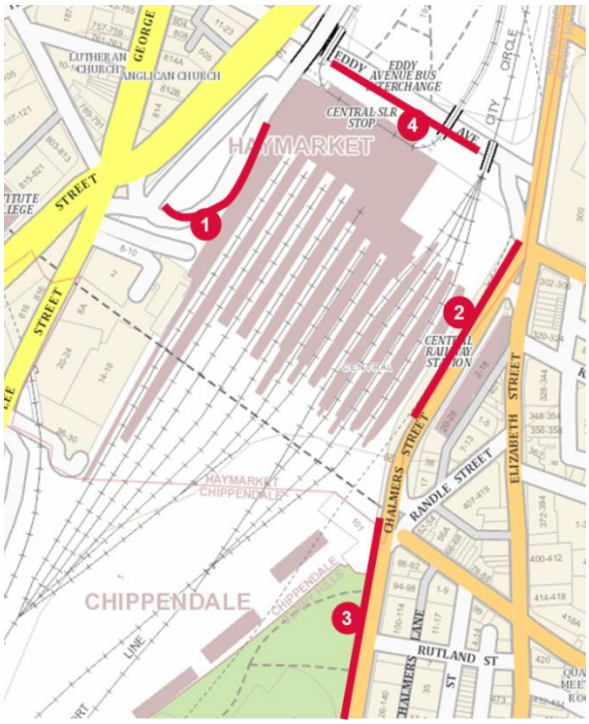
Construction and operation of the CSELR project will have impacts on rail replacement bus arrangements on Chalmers Street and Eddy Avenue as existing space used for layover and pick-up by rail replacement buses is required for the CSELR. Figure 4-4 below shows the current locations for pick-up and drop-off when rail replacement buses are required. The CSELR project impacts bussing operations at Central Station through:

- Full closure of position 2 for construction and operation of the Central Station light rail stop and light rail special event operations;

[100] Booz & Company

- Closure of position 4 for construction and operation of the light rail line in the Eddy Avenue kerbside lane;
- Restrictions on use of position 3 as this moves from being primarily a layover zone to an intensive pick-up zone.

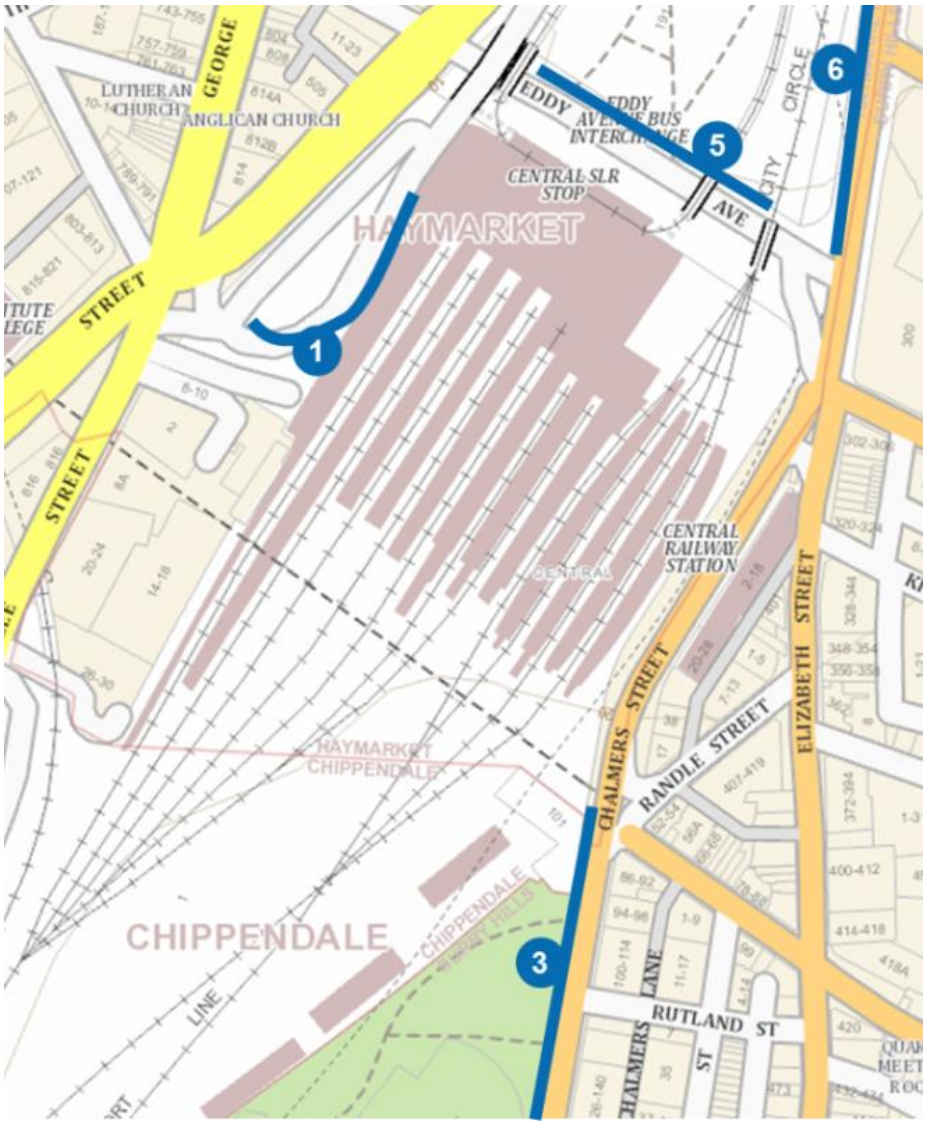
Figure 4-4: Rail Replacement Bus Operations, 2013



Future rail replacement bus scenarios

To facilitate rail replacement bussing arrangement following the introduction of CSELR, a high-level review of Sydney Trains and NSW Trains future track possession and bussing expectations was undertaken, as well as consultation with Sydney Trains and NSW Trains. This process yielded four potential locations for layover and pick-up during rail replacement scenarios, shown in Figure 4-5.

Figure 4-5: Rail Replacement Bus Operations, 2021



The specific operation and use of each position is dependent on Sydney Trains and NSW Trains line 'possession' configurations (the railways lines and services taken out of operation for track work). At Central, there are four configurations requiring the introduction of rail replacement that were considered to be significantly impacted by the light rail. The specific arrangements for each configuration are a function of the demand to be experienced as a result of the possession as well as the desired destinations of the customers affected. The four configurations are:

- **Configuration 1 –** this configuration suspends rail services on the Illawarra and Eastern Suburbs lines between Bondi Junction and Dapto;
- **Configuration 1a –** this is a variation of the above configuration which suspends services between Bondi Junction and Dapto, plus services between Central and Sydenham on the Bankstown Line;
- **Configuration 9 –** this configuration suspends rail services on the Newcastle & Central Coast Line between Central, Newcastle, Scone and Dungog;
- **Configuration 15 –** this configuration requires the suspension of rail services on the City Circle, Airport & East Hills line between Sydenham and Central and Inner West line between Ashfield and Central.

Proposed alternative transport arrangements for each configuration are described below.

Configuration 1: Bondi-Dapto possession

Eastern suburbs rail services are high activity services and have to provide replacement buses for a high number of commuters, which will put pressure on the layover capacity at Prince Alfred Park for future arrangements, and provide challenges for future arrangements.

Buses serving the South Coast will continue to operate from position 1 as currently, while services to Bondi will operate at position 3 instead of position 2 due to the introduction of light rail. Services to Cronulla/Waterfall will continue to operate from position 3. Detailed analysis of layover capacity, with investigation of alternative nearby layover space (particularly for standby buses) will need to be undertaken by Sydney Trains to determine the suitability of this arrangement.

Configuration 1a: Bondi-Dapto plus Central-Sydenham possession

The above scenario combined with buses to provide Sydenham services (currently operated at position 4) will put significant pressure on position 3, which will be unable to accommodate demand for replacement buses after the layout change in 2021.

Alternative options have been investigated to provide Transport for NSW and Sydney Trains/NSW Trains with a range of operational responses including:

- Realignment of Configuration 1a possessions to permit operation of Eastern Suburbs line services to either Central or Town Hall, thereby mitigating the need to provide substantial numbers of buses to replace these services;
- Operating Sydenham bus services at newly configured positions 5 and 6 which would take pressure off position 3 at Prince Alfred Park noting, however, this arrangement has some drawbacks including:
  - Poor legibility of alternative arrangements due to a lack of line-of-sight access to the temporary bus pick-up position, and
  - Potentially hazardous road crossings due to the lack of a signalized intersection at the corner of Eddy Avenue and Elizabeth Street. Customers may be tempted to run across the road illegally, rather than back-track to the signalized intersection further west on Eddy Avenue.

Further examination of possible arrangements for this configuration by Sydney Trains is necessary to determine the best method of accommodating rail replacement services in the future.

Configuration 9: Central-Newcastle/Scone/Dungog possession

Replacement services for Newcastle, Scone, and Dungog do not pose significant challenges for future arrangements, due to substantially lower levels of patronage. Buses will continue to drop off at position 1, before circling the block to pick-up northbound passengers at position 3.

Configuration 15: City Circle, Airport & Inner West possession

Configuration 15 is a high-impact possession arrangement requiring significant numbers of replacement buses to provide alternative transport arrangements at the heart of the transport network. Following CSELR introduction, management of this configuration will become simpler with a high-quality, frequent and high-capacity transport mode already providing a convenient alternative. It is anticipated that City Circle rail services would be replaced with the light rail, with regular weekend frequencies increased to match the anticipated demand. It is also recommended that further investigation of trips currently using Museum and St James stations be undertaken by Sydney Trains to determine whether the CSELR adequately serves destination nearby those stations, or whether a replacement bus service should be provided.

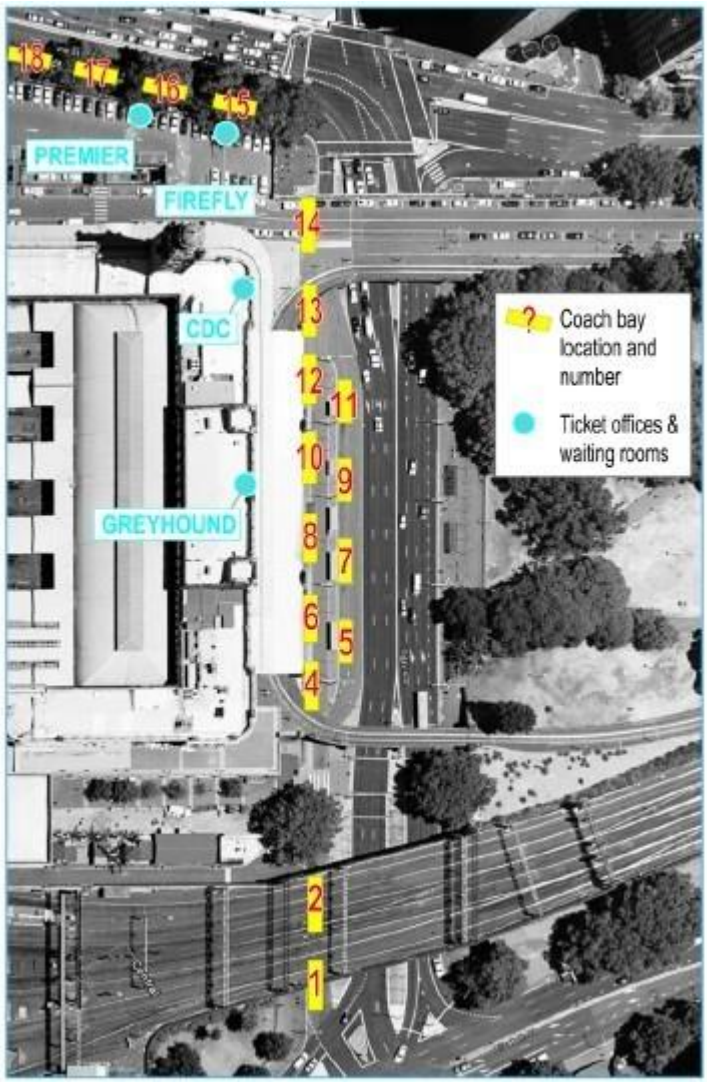
Inner West bus services will operate from position 1 and airport buses will shift operation from position 4 to now operate exclusively at position 3.

4.2.3.2. Central Station coach terminal

Existing situation

The Central Station bus coach terminal currently operates with 18 bays in three main areas; along the eastern side of Pitt Street, along the southern side of Eddy Avenue, and on a narrow island amid Eddy Avenue as illustrated in Figure 4-6. Coaches currently stop away from the kerb in existing bays adjacent to the walkway on Pitt Street and Eddy Avenue, to allow for luggage doors to open. The terminal is accessible from the Pitt Street and Eddy Avenue intersection, and the Elizabeth Street, Eddy Avenue, and Chalmers Street intersection.

Figure 4-6: Current Coach Facilities at Central Station[101]



Forecast growth and requirements

The Coach Terminal study undertaken in 2010 by MR Cagney as commissioned by Transport for NSW estimated current operational requirement at 7 bays with no time restrictions, and 6 bays with time restrictions. Allowing for future growth increases the number of bays to 9 and 8 bays without or with time restrictions respectively.

[101] McCormick Rankin Cagney, *Sydney Coach Terminal Scoping Study,* 2010

Light Rail design - Central precinct

The recommended design option for light rail on Eddy Avenue includes three light rail tracks on the southern side of Eddy Avenue and a 45 metre turn back track to allow light rail services to efficiently turn back for services to Moore Park.

Impacts of Light Rail Operations

With the introduction of light rail there will be loss of existing coach parking, although this will be mitigated by a proposed 4.5 metre wide dedicated island coach platform that allows for up to four coaches to load in indented bays. This platform would be accessible from existing traffic lanes, and the existing six traffic lanes would be retained as current.

Operations of light rail on Eddy Avenue would require reducing the number of bays to 8, which meets the medium term requirement of 8-9 bays to accommodate for growth.

Mitigation strategies for layover facility

To accommodate for demand increases, bays would only be used for active passenger pick up and set down (not layover), while layover facilities are required in alternative locations. The MR Cagney 2010 study discussed options for relocation of the current coach terminal. This study provides insights into possible locations for layover facilities should the need arise, with the locations to be discussed with coach operators to determine suitability.

Central Station Western Forecourt

The Western Forecourt is situated along Pitt Street adjacent to the Western entrance to Central Station. The northern section of the forecourt is currently used for parking, passenger set-down, and a taxi rank, while the southern section is used mainly for parking, and temporary bus stops for rail-replacement services.

This location would be possible for a layover facility due to its proximity to the coach terminal, however would require minor surface levelling for safe vehicle movement and agreement with Sydney Trains to confirm available space and impact on current uses.

Chalmers Street

For short term layover, a site has also been identified on Chalmers Street adjacent to Prince Alfred Park. The western kerb side lane could only be used outside of peak periods as it is zoned as a Bus Lane for regular route buses during the AM and PM peak periods. Longer-term layover would not be appropriate in this location and alternative sites outside the CBD or at the King Street coach layover facility should be utilised.

5. Road Network, Traffic and Access

5.1. Context

A light rail system, by its nature, needs to be designed into the road network and requires the detailed consideration of all surface transport modes. This integration of light rail within the urban road environment requires a reallocation of road space from other uses which includes parking/loading (see Section 6 for further detail), general traffic lanes and bus only lanes. In this context a balance needs to be achieved between offering a fast, reliable light rail service while minimising any adverse effects.

Ultimately the objective of the light rail project is to maximise the level of passenger carrying capacity along the corridor and ensure a superior customer experience that encourages mode shift from private vehicles.

The introduction of light rail and the pedestrianisation of George Street will fundamentally alter the nature of the corridor with a shift in priority from private vehicles to public transport, walking and other sustainable travel modes. In doing so it will generate significant benefits including improved journey times, greater reliability and amenity, and reduced environmental impacts such as greenhouse gas emissions. It will however require changes to the existing road network, traffic and access arrangements which could potentially have a negative impact on some users of the system, particularly general traffic. It will also require changes in travel behaviour as people adjust to the new network.

The proposed changes to the existing road network, traffic and access operating arrangements that are required to accommodate the introduction of light rail have been developed with an overarching objective to maximise transport system performance and deliver the best outcome for the community as a whole. The Traffic and Transport Management Framework, as illustrated previously in Figure 1-3, guided the development of these changes. It ensured that, wherever possible, negative impacts were either avoided or mitigated, or in cases where this was not possible, alternative arrangements were developed to ensure that the community will continue to have appropriate access to the transport system.

Safety for all road users is important. It has been given a high priority in the scheme design and development of mitigation measures. A Road Safety Audit has been undertaken to review the safety of the Project.

The proposed changes to the road network and alternative operating arrangements are discussed below in Section 5.3, with an assessment of the future road network performance outlined in Section 5.5.

5.2. Road network strategy development principles

Principles were defined to guide the development of the future road network strategy. The principles were designed to ensure that, in specifying the road network, the overall objective of maintaining safety for all users, maximising transport system performance and usage, and successfully integrating the light rail network with the road network, was upheld. The key principles are outlined below:

- Consolidation of right turn movements across the alignment which would only be permitted at signalised intersections. This provides light rail reliability benefits as well as traffic capacity and safety improvements by minimising uncontrolled conflicting vehicle movements;

- However some exceptions would apply on George Street for local property access.

- Balancing the future needs of the various transport modes within the limited cross sectional road space available;
- Providing signal controlled pedestrian crossing access to stops. This ensures less mobile passengers or those with a disability are given audible and visual invitations to cross traffic under full signal protection;
- Providing high quality interchange functionality with sufficient capacity for future operations;
- Minimising traffic capacity reduction;
- Providing sufficient capacity on footways and crossing points to accommodate the growth in pedestrian traffic (particularly around light rail stops);
- Providing bus lanes where bus volumes are such that bus priority measures are warranted; Retaining all current property accesses on the corridor, although time or movement restrictions may be applied in specific locations.

5.3. LRV Road Network Integration

An essential feature of the CSELR is the operation of Light Rail Vehicles (LRVs) within the road network. The safe interaction of LRVs with other road users has been a major consideration of the development to date. Furthermore, this interaction influences the overall journey time and service reliability.

A key feature of the CSELR is that, for the majority of the proposed route, LRVs will operate within an exclusive right of way. This provides an operating environment that is both safe and free from the adverse effects of road congestion. However, at intersections and at a limited number of other locations, LRVs will share the right of way with other road users.

It is proposed that LRVs will progress through intersections under signal control. Traffic signals will be designed to detect the approach of an LRV in sufficient time to activate a ("call") green signal for the LRV as it approaches the intersection. The traffic light controller would ensure that other conflicting movements (i.e. cross roads and pedestrian crossings) face red or stop signals. The design intent is for LRVs to be able to proceed through all intersections with minimal delay.

However, the design of each intersection will have regard to all road users and the overall performance of the transport network. The Sydney Coordinated Adaptive Traffic System (SCATS) is designed to ensure the operation of each intersection achieves the optimal performance for the network as a whole. The road network management system will be expanded in future to accommodate LRV operation as well.

In practice, LRVs are expected to experience small delays at some intersections depending on the direction of travel and the time of day. This is due to the need to maintain effective signal coordination for the road network. Estimates of these delays to LRVs have been factored into the proposed light rail journey time forecasts. The amount of delay will depend on the final design of the intersections and traffic light control system which will be completed during the detailed design phase of the project.

There are limited locations where LRVs will operate in a shared environment, as described below:

- LRVs will share the existing (modified) busway from Anzac Parade to Doncaster Avenue
- Buses will share the LRV right of way from the Kingsford terminus through to UNSW
- Right turning vehicles will also be permitted to share the LRV right of way in High Streeet at Botany Street.

In each case these arrangements are proposed to avoid increasing the land required for the project and to avoid unreasonable impacts on other road users.

5.4. Future road network and access

Light rail will be integrated within the surface street environment and as such requires a number of significant changes to the way in which the road network operates and is designed. The key functional changes and high level operational characteristics are detailed below by precinct.

5.4.1. CBD precinct

The functional characteristics of the CBD precinct are shown in Figure 5-1 and Figure 5-2 with additional detail provided in the following sections.

Figure 5-1: CBD North proposed functional Characteristics

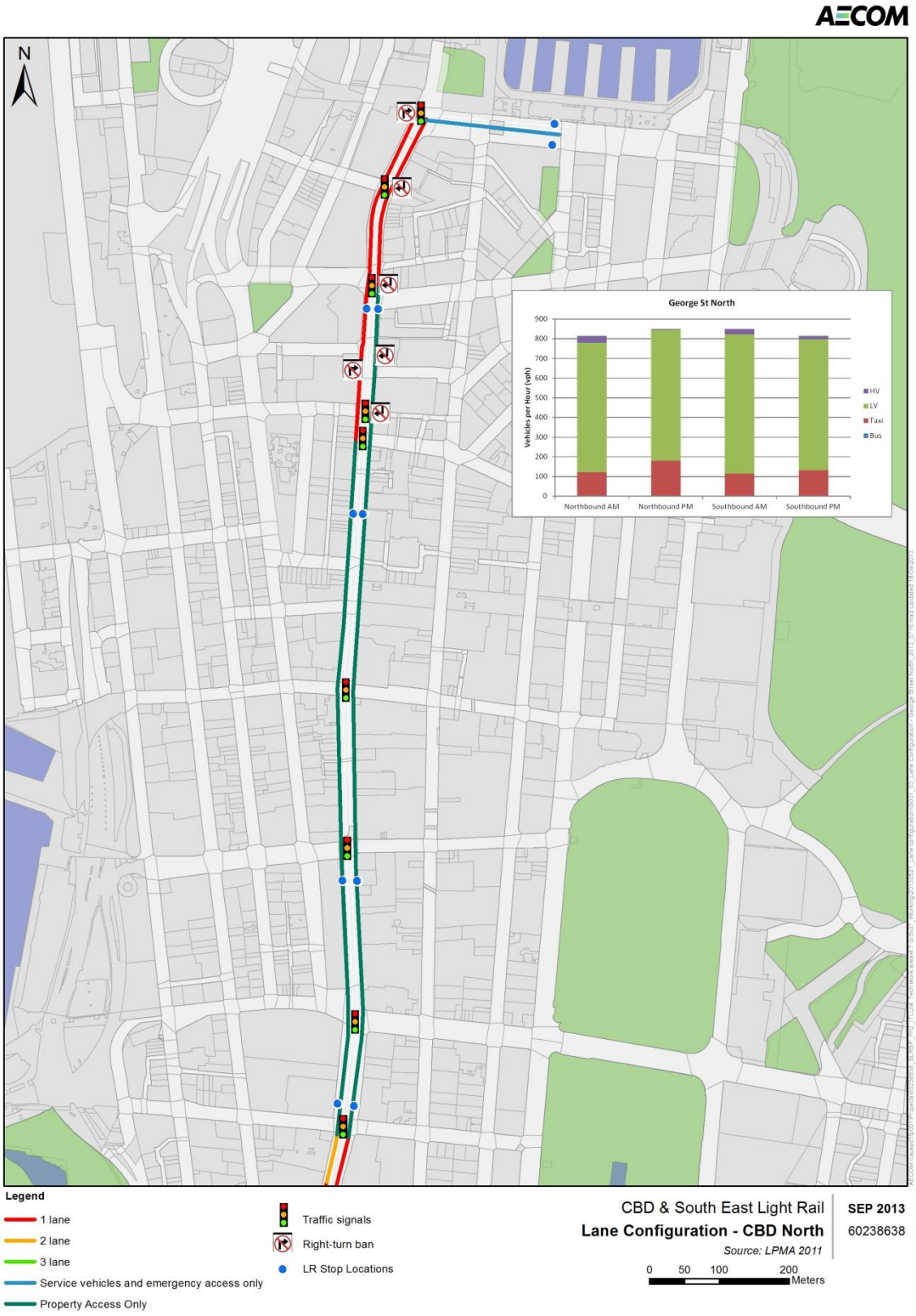
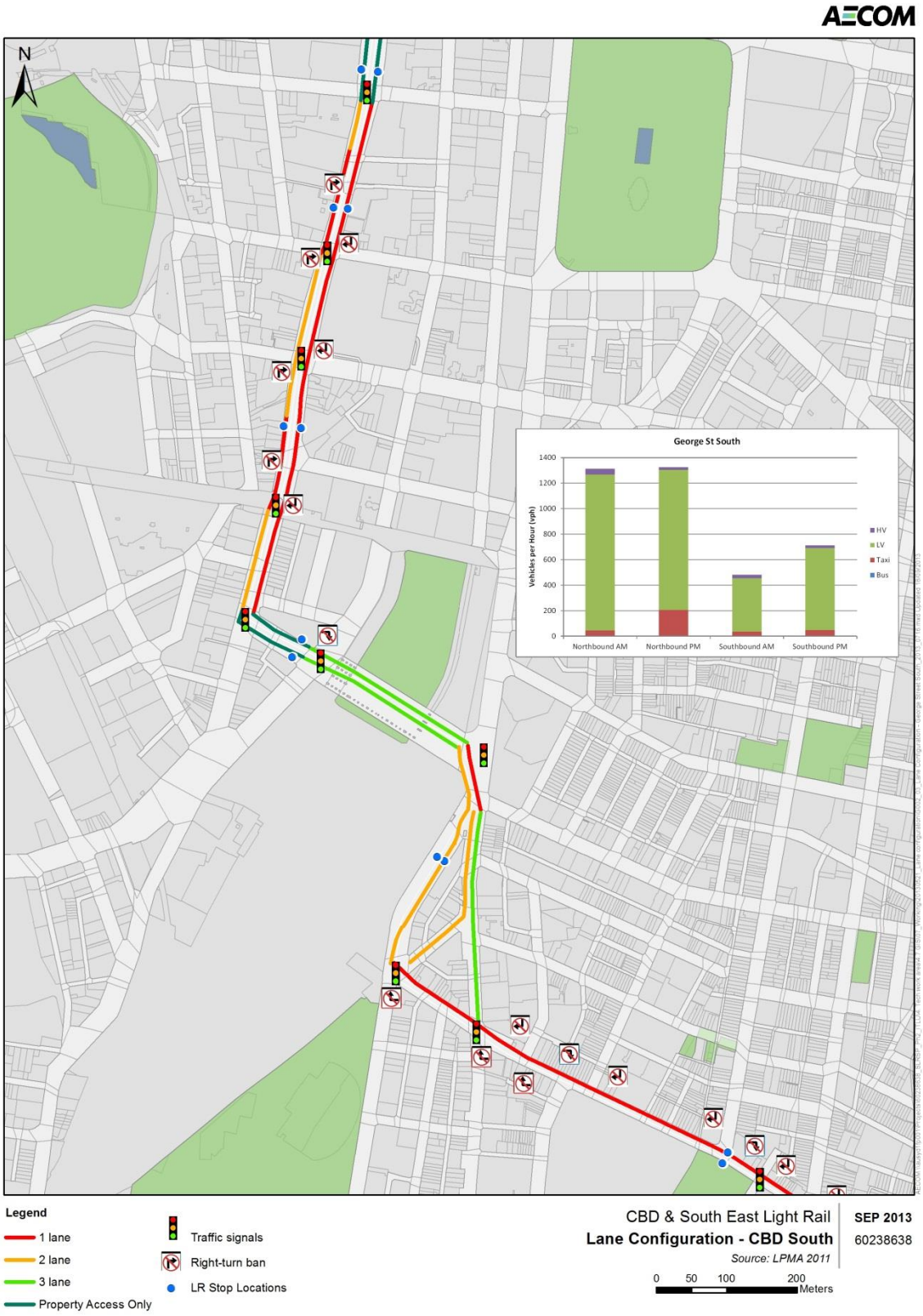


Figure 5-2: CBD South proposed functional characteristics



5.4.1.1. George Street

As outlined previously, George Street forms the north–south spine for light rail through the CBD. Significant changes to the functional characteristics of George Street will be required to accommodate light rail. A major change will be the pedestrianisation of George Street between Hunter and Bathurst Streets and at Alfred Street. The functional changes along George Street both outside and within the pedestrianised zones are outlined below, along with the functional changes associated with complimentary works on Pitt and Hunter Streets.

Functional changes

Outside the pedestrianised zones

Outside of the pedestrianised zone, the standard George Street cross section will consist of a single kerbside traffic lane in each direction with centre running light rail. The reallocation of existing traffic lanes to dedicated light rail running will serve to reduce the importance of George Street as a route for through running traffic.

Where cross sectional width permits, additional traffic lanes will be provided, particularly on the approach to intersections to ensure turning vehicles do not unnecessarily delay through traffic. Those locations that deviate from the single traffic lane cross sections are detailed below:

- Between Rawson Place and Hay Street two northbound and a single southbound traffic lane will be provided;
- North of the Chinatown stop to Liverpool Street will operate with two northbound lanes;
- The northbound approach to Bathurst Street will operate with two right turn lanes; and
- Between Hunter and Grosvenor Streets a single northbound lane and no southbound lane will be provided. This is due to the limited cross sectional width being unable to accommodate two-way traffic movements past the Grosvenor Street stop.

Within the pedestrianised zones

On George Street between Bathurst and Hunter Streets a pedestrian and vehicle shared zone is proposed adjacent to the Light Rail corridor. This shared zone allows vehicles to utilise an area of the pedestrianised zone to travel down the side of the light rail corridor (at a maximum speed of 10km/hr) to access driveways and loading areas where vehicles can park to service properties on either side of George Street.

Where the shared zone is adjacent to building entrances and street furniture, urban design would be used to guide vehicles away from pedestrian conflict points to maintain safe sight distances.

At signalised intersections and stop lines, queuing and turning movements will be controlled. Signposting and traffic restrictions would be determined by the relevant road authority and could be flexible depending on policy. Vehicles could be discouraged from travelling further than one block by signposting.

Vehicle restrictions will ensure only local access, service and emergency vehicles are permitted. The detailed streetscape design of George Street should include defined areas for pedestrians and light rail vehicles through visual cues, such as changing pavement types. This is important to provide a safe environment for all road users. Signalised pedestrian crossing facilities will be provided on all arms of existing signalised intersections to provide controlled crossing points of the light rail alignment. This provides protection and improved amenity and accessibility for visually, hearing or mobility impaired pedestrians.

Pitt and Hunter Streets complementary works

As a result of the pedestrianisation of Alfred Street, access to properties along the northern section of Pitt Street between Hunter Street and Alfred Street would be via Loftus Street and the narrow laneway of Reiby Place. To improve access from the west and reduce the total traffic volumes on Reiby Place, which has a substandard footpath and is used by pedestrians connecting through to Circular Quay station, alternative access is required.

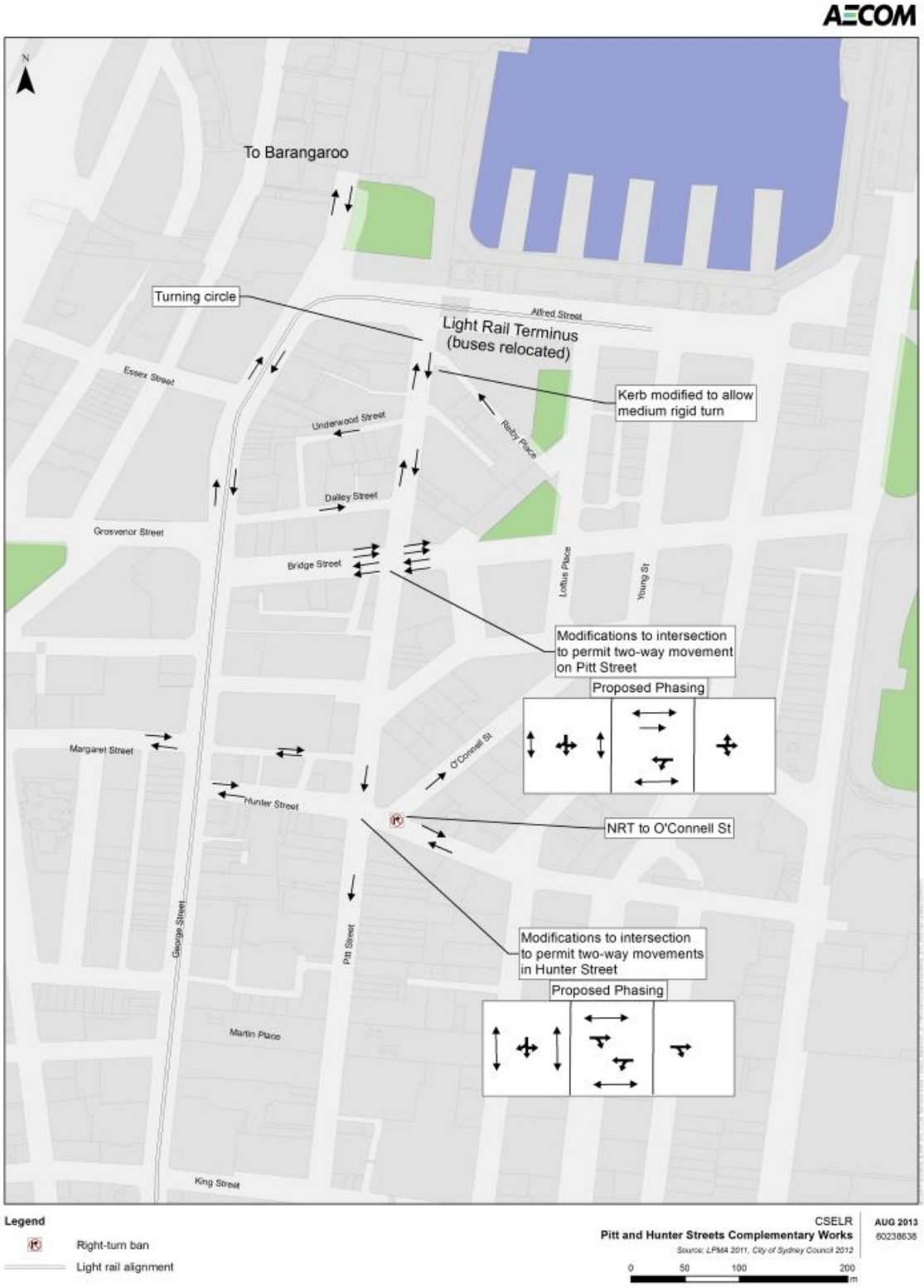
This can be achieved through conversion of Pitt Street to two-way operation between Alfred Street and Bridge Street as shown in Figure 5-3. Introduction of a northbound traffic lane in Pitt Street will enable direct property access to the northern end of Pitt Street. It will require the following changes to traffic operations:

- Provision of a turning circle at the northern terminus of Pitt Street;
- A reduction in a southbound traffic lane; and
- Modification of traffic signals at the Pitt Street / Bridge Street intersection (Refer to Figure 5-3).

Hunter Street is also proposed to be converted from one-way operation (westbound) to two-way operation between Pitt Street and George Street. This will provide enhanced traffic connectivity to the east and west via the dogleg movement between Hunter and Margaret Streets.

Hunter Street is currently four lanes wide on approach to George Street, but with future pedestrianisation south of Hunter and a single traffic lane north of Hunter, only one of these four available lanes will be required. Two-way operation of Hunter Street would therefore maximise the utilisation of road space, whilst still providing an enhanced pedestrian environment and the opportunity to provide loading/parking on Hunter to offset losses to this type of kerbside activity along George Street.

Figure 5-3: CBD North Traffic Proposed Management Changes



Proposed network characteristics

An outline of the effects the proposed functional changes along George Street will have on road network uses is provided in Table 5-1. In summary the functional changes along George Street, required to accommodate light rail, will place some restrictions on general traffic movements, require a re-allocation of bus services and result in a reduction in parking spaces, loading/unloading bays and taxi zones. It will however create an enhanced pedestrian environment and increase passenger capacity on the corridor.

Table 5-1: George Street - Potential Road Network Characteristics

Use	Future network characteristics
General traffic	General traffic movements will be significantly restricted through road closures, banned turning movements and implementation of the pedestrianisation. Key changes are being investigated and may include: ▪ The closure of Alfred Street between Pitt Street and George Street. ▪ Pedestrianised zone between Hunter Street and Bathurst Street with local and emergency access via a shared traffic and pedestrian area. ▪ Banned right turn movement from George Street into Essex Street. ▪ Removal of southbound traffic between Bridge Street and Hunter Street due to the enhancement of footpath along the eastern kerb. ▪ Establish two-way movement along Pitt Street between Hunter Street and Alfred Street to improve connectivity. (Parking and loading zones to be retained). ▪ Reverse the operation of O'Connell Street to improve the intersection performance at Hunter and Pitt Street. ▪ Central Street traffic flow reversal to one-way eastbound with access from George Street left-in only. ▪ Wilmot Street traffic flow reversal to one-way westbound to George Street with left-out only. Two-way operation from middle of Wilmot Street to Pitt Street.
Bus services	With the introduction of light rail along George Street the existing bus services will be relocated in accordance with the city centre bus network redesign. The majority of north-south services are transferred to the Elizabeth Street / Castlereagh Street corridor.
Property accesses	All existing property accesses along George Street would be maintained during the operational phase of the CSELR proposal; however, certain turning restrictions are likely to apply. These would be developed and implemented by the relevant road authority and could include: ▪ Access restrictions implemented by the City of Sydney to provide for appropriate safety and amenity for pedestrians. These measures would be determined by City of Sydney, in consultation with Transport for NSW. ▪ Limitations on driveway access along the proposed CSELR corridor to left-in left-out only, where feasible.
On-street parking	The central running light rail alignment and pedestrianisation zone between Bathurst Street and Hunter Street removes the opportunity to provide extensive parking along George Street with the only potential being for off-peak parking along the western kerb of George Street between Rawson Place and Pitt Street.
Loading/ unloading spaces	To accommodate light rail, the existing provision of loading zones along the George Street will not be retained. Outside of the pedestrianised zone, the constrained George Street cross-section at most provides a single through traffic lane in each direction. Network changes to George Street intersections provides an opportunity to mitigate the impacts by relocating loading zones to the additional kerb provided at the cross streets .e.g.: turn bays no longer required. The current design allows for the loading zones to be relocated adjacent to the following intersections: ▪ Essex Street ▪ Bridge Street ▪ Jamison Street ▪ Margaret Street ▪ Hunter Street ▪ King Street ▪ Market Street ▪ Bathurst Street ▪ Liverpool Street ▪ Ultimo Road

Use	Future network characteristics
Pedestrian access	The pedestrian environment along George Street will transform with the introduction of light rail. The pedestrianisation between Hunter Street and Bathurst Street improves connectivity by removing conflicts and barriers to pedestrian movements. The following summarise the key pedestrian improvements with the introduction of light rail: ▪ Pedestrianisation of George Street between Hunter Street and Bathurst St. ▪ Widening of footpath along the eastern kerb between Bridge St and Hunter St. ▪ Widening of footpath along the eastern kerb between Liverpool Street and Bathurst Street. ▪ Significant reduction in general traffic along George Street currently in conflict with pedestrians. ▪ Opportunity to reduce pedestrian crossing distances at signalised intersections along George Street.
Cyclist access	▪ George Street would no longer be promoted as a bicycle route, with cyclists being directed to alternative existing north-south corridors such as Pitt Street, Castlereagh Street and York Street. ▪ Existing City of Sydney bicycle routes crossing George Street would be maintained ▪ The CSELR proposal presents an opportunity to provide additional priority to east west cycle movements crossing George Street.
Taxis zone	The affected taxi zones along George Street could potentially be relocated to: ▪ George Street, eastern kerb on approach to the Alfred Street intersection. ▪ Bridge Street, northern kerb on the western side of George Street. ▪ George Street, western kerb on approach to Rawson Place intersection. Locations to be confirmed based on the SSCAS.
Tourist coach buses	The operation of tourist coaches along George Street would not be precluded with the introduction of light rail. However, no coaches will be permitted within the pedestrianised zone of George Street.

5.4.1.2. Rawson Place

Functional changes

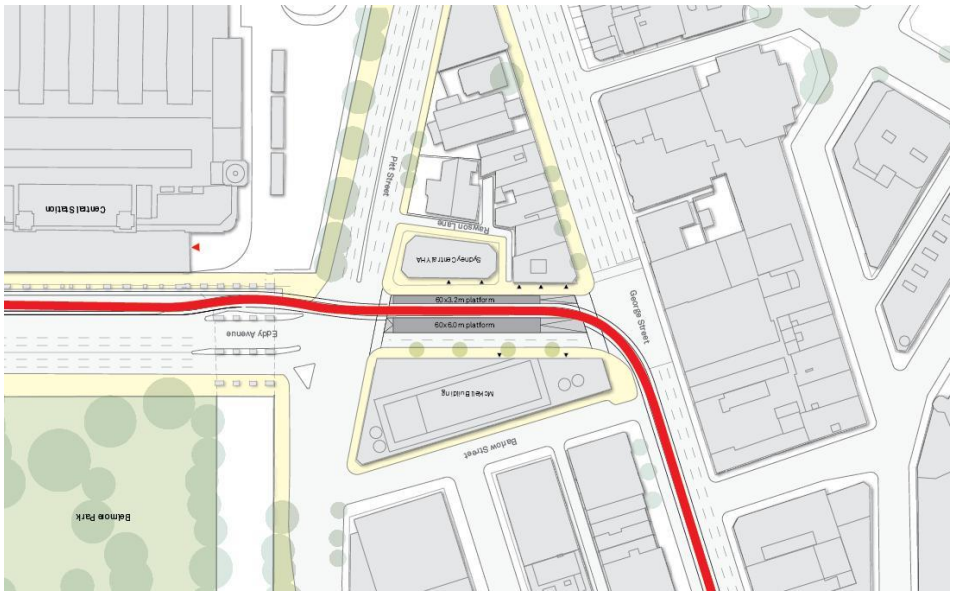
With the implementation of light rail on George Street and the city centre bus network redesign, Rawson Place will become a major interchange for bus and light rail passengers (Figure 5-4). To facilitate efficient bus and light rail movements Rawson Place will only accommodate bus (westbound only) and light rail. As such, the functional changes to Rawson Place have been designed to complement the city centre bus network redesign and to provide the required bus stopping and turn around capacity required to operate reliable bus services to the CBD. Existing local traffic that uses Rawson Place will be diverted via Pitt and Barlow Streets, whilst through traffic is likely to divert via alternative corridors such as Elizabeth and Goulburn Streets.

Buses will be provided with a bus stopping lane adjacent to the light rail platform (i.e. provides cross platform interchange) and an additional passing lane to the north. Traffic signals at the eastern end of Rawson Place will provide controlled access for turning buses into Rawson Place from Pitt Street and Eddy Avenue. At the western end of Rawson Place traffic signals will permit buses to turn left into George Street and across the light rail alignment. Both sets of traffic signals will provide convenient pedestrian access to Rawson Place and across George and Pitt Streets.

Due to the volume of bus services in this precinct, additional stops for city bound bus services will be provided on the western side of Pitt Street just north and south of Rawson Place. These stop locations enable bus passengers to transfer to light rail without crossing any traffic movements.

Eddy Avenue cannot be used by the bus routes that are stopping adjacent to, or at, Rawson Place as it is not possible to turn right from Pitt St into Eddy Ave from the kerbside lane or north of Rawson Place. This is consistent with the city centre bus network redesign.

Figure 5-4: Light rail alignment along Rawson Place corridor



Proposed network characteristics

An outline of the effects the proposed functional changes along Rawson Place will have on road network uses is provided in Table 5-2. In summary, whilst the functional changes required along Rawson Place to accommodate light rail would displace general traffic, it will facilitate efficient bus and light rail operations and interchange.

Table 5-2: Rawson Place - Potential Road Network Impacts

Use	Future network characteristics
General traffic	The key changes to general traffic operation in the vicinity of Rawson Place include: ▪ No general traffic access to Rawson Place. ▪ Introduction of right turn movement from Eddy Avenue to Pitt Street. ▪ To accommodate light rail and bus interchange, Rawson Ln between Rawson Place and Pitt St will be closed to general traffic.
Buses	With the introduction of light rail along George St the existing bus services will be relocated in accordance with the city centre bus network redesign. The future changes to the bus services include: ▪ City bound bus services currently using George St will be rerouted to Pitt St and Elizabeth St. ▪ Out bound bus service will be rerouted via Pitt St and Rawson Pl. ▪ Major interchange between bus and light rail at the Rawson Pl.
Property access	Access to Rawson Lane from Rawson Place would not be possible due to the light rail stop location. It has been observed that current service vehicles are able to turn around within the lane way.
On-street parking	The closure of Rawson Pl necessitates the removal of short stay parking and loading zones along Rawson Pl. However, opportunities to relocate the loading zones include: ▪ Pitt St, south of Eddy Avenue ▪ Barlow St, east of George St ▪ George St, south of Rawson Pl

5.4.1.3. Eddy Avenue

Light rail will occupy the southern side of Eddy Avenue, utilising the existing bus only lanes through the southernmost arch of the rail bridge. The light rail alignment will occupy the current kerbside coach stops, which will be relocated between the light rail and traffic lanes (Figure 5-5). A dedicated 4.5m wide island coach platform will be accessed from the existing Eddy Avenue traffic lanes, with retention of the existing 6 traffic lanes (three in each direction). By relocating coaches away from the kerb, any conflict between coach and light rail vehicle movements will be

removed. A turn back track will be accommodated alongside the colonnade to optimise operations and enable light rail vehicles to turn back during special events and short running of services.

Pedestrian access to the coach station island platform will be provided via the existing Eddy Square pedestrian crossing at the eastern end and a new crossing at the western end will allow pedestrian movement between the existing coach booking office and the coach platform. The 4.5m wide coach platform complies with all Disability Standards for Accessible Public Transport (DSAPT). Excluding seating and platform furniture, the island platform will have 3700mm clear width which also allows for coach luggage loading / unloading and represents an improvement over current space available.

Figure 5-5: Light rail alignment along Eddy Avenue corridor[102]

Proposed network characteristics

An outline of the effects the proposed functional changes along Eddy Avenue will have on road network uses is provided in Table 5-3. In summary, the functional changes required to accommodate light rail will require the relocation of coach bus services from the southern kerb of Eddy Avenue.

Table 5-3: Eddy Avenue - Potential Road Network Future Network Characteristics

Use	Future network characteristics
General traffic	Reconfiguration of Eddy Ave intersections to cater for the introduction of light rail. The key changes include: Pitt St – The through movement from Eddy Ave into Rawson Pl will be no longer permitted due to the closure of Rawson Pl to general traffic. – Introduce right turn movement from Eddy Ave into Pitt St. Elizabeth St – Reconfigure the Chalmers St approach to permit bus and left turn Eddy avenue movements only, with the northbound through movement directed to the proposed two way movement on Elizabeth St via Randle St.

[102] Transport for NSW, *Draft Design Drawings (Unpublished), 2013*

Use	Future network characteristics
Coach/buses/ light rail	The proposed light rail alignment along Eddy Ave utilises the space along the southern kerb currently used by coach services. – Coach operations no longer permitted on the southern kerb of Eddy Ave within segregated section. – Right turn bus only movement from Elizabeth St to the southern rail bridge arch no longer permitted. – Potential mitigation measures include an indented coach layover adjacent to the westbound traffic lanes.
Property access	Loading dock access on the southern side of Eddy Avenue will require management across the light rail alignment through time restricted access and/or audio visual warnings
On-street Parking/loading/ unloading	There are no parking / loading provisions available along this section. Therefore no impact.
Taxis	Light rail alignment along the southern kerb of Eddy Ave precludes the provision of taxi zones. However, potential to utilise space within the median separating the westbound traffic lanes and light rail alignment for taxi zone.
Pedestrian access	Eddy Avenue will continue to provide a major pedestrian connection for the transfers between Sydney Trains, NSW Trains and bus services, in particular during special event modes. However, with the introduction of light rail the major passenger interchange is expected to be undertaken at the Central Station light rail stop on Chalmers St.

5.4.1.4. Chalmers and Elizabeth Streets

Chalmers Street will become the major interchange between light rail and heavy rail at Central Station. The functional changes required to accommodate light rail along Chalmers Street are discussed below.

Functional changes

The light rail stop will be located on the western side of Chalmers Street, which will reduce the number of lanes available to buses and general traffic (as illustrated in Figure 5-6). The design shown requires a potential realignment and reconfiguration of the traffic lanes in the Chalmers Street precinct to assist with the introduction of the light rail interchange. Three platform faces will be provided, with the eastern most track and platform face only being utilised during special event operations. This provides additional capacity to enable a light rail shuttle service with 90m vehicles to operate between Moore Park and Central.

Outside of special event operations the easternmost track would operate as a bus lane to provide bus priority during most times of the day and maximise usage of the available road space. A 45m northbound bus stop would be integrated with the northern end of the light rail stop to provide convenient interchange between bus and light rail. During special events, this bus stop would not be available for regular bus services.

The existing bus stop in Chalmers Street near Devonshire Street will also be retained. This stop would be used during special events, and would be the boarding location for passengers previously using the Chalmers Street near Eddy Avenue stop.

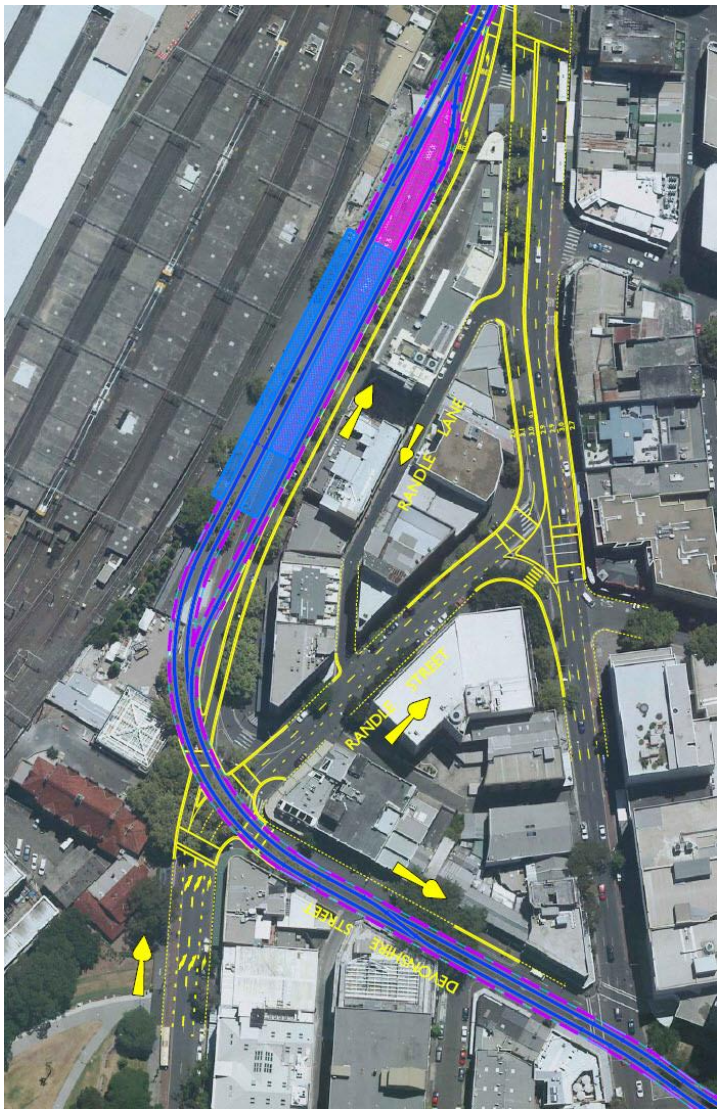
To offset the reduction in northbound traffic lanes within Chalmers Street, Randle Street will be reversed from one-way southbound to one-way northbound. Two northbound traffic lanes will be provided which will continue into Elizabeth Street (which currently operates as southbound only). Provision of two northbound traffic lanes could be provided in Elizabeth with the loss of only one southbound lane through kerb and lane adjustments.

The above traffic operations in Chalmers, Elizabeth and Randle Streets will require advance signage on approach to the newly signalised Chalmers Street / Randle Street / Devonshire Street intersection to direct drivers to Elizabeth Street via Randle Street. Signalisation of the Chalmers Street, Elizabeth Street and Randle Street intersection is required to manage light rail, traffic and

pedestrian movements, whilst providing improved pedestrian access to Central Station and light rail transport hubs.

Due to the two way movements in Elizabeth Street, direct access to Randle Lane from the north will not be possible, but will be maintained via Rutland, Chalmers and Randle Streets.

Figure 5-6: Proposed light rail alignment along Chalmers Street corridor[103]



These modifications to the precinct's operation will require a change to the existing parking provisions which are detailed in Section 6 of this report.

Impact on cycle routes

The City of Sydney currently designates Chalmers Street as both an on-road and off-road cycle route. The on-road cycle route is northbound only, between Devonshire Street and Elizabeth Street. The two-way off-road cycle route is located on the western side of Chalmers Street. A signalised pedestrian crossing on Eddy Avenue connects the off-road cycle route with Belmore Park, providing an important link between the CBD and the city's inner south.

[103] Transport for NSW, 2013

The current location of the off-road cycle route would act as an impediment for customers trying to interchange between heavy and light rail at the Central Station stop. Consequently Transport for NSW proposes realigning the cycle route to segregate cyclists from pedestrians. The new alignment would link with the signalised pedestrian crossing on Eddy Avenue, maintaining the important north-south link between Belmore Park and Prince Alfred Park.

Proposed network characteristics

An outline of the effects the proposed functional changes along Chalmers Elizabeth Street will have on road network uses is provided in Table 5-4. In summary, whist the introduction of light rail will displace general traffic movements, measures such as alternative arrangements along Randle Street have been proposed to mitigate and impacts.

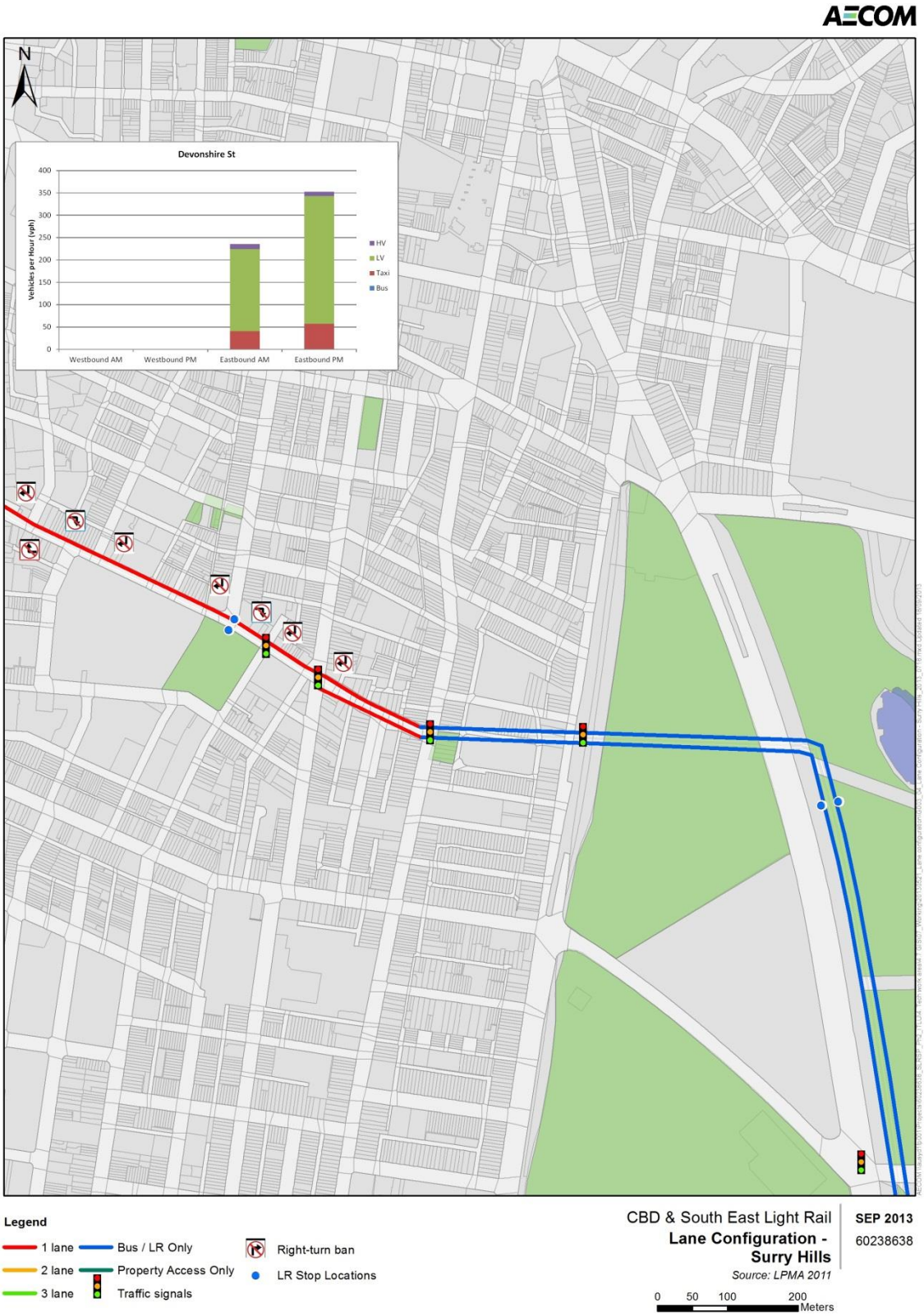
Table 5-4: Chalmers Street / Elizabeth Street Future network characteristics

Use	Future network characteristics
General traffic	Chalmers Street will continue to provide a general traffic connection to Elizabeth Street, however the key local network changes include: ▪ Introduce a signal control at the intersection of Chalmers St, Randle St and Devonshire St. ▪ Reverse the one-way operation of Randle St to eastbound only. ▪ Elizabeth St converted to two-way between Randle St and Chalmers St. ▪ All Chalmers St northbound through traffic diverted to Elizabeth St via Randle St. ▪ Only Elizabeth St buses to remain on Chalmers St north of Randle St intersection.
Buses	Under normal light rail operation, the bus only lanes will continue along Chalmers St, however during special event mode, the bus only lane will cease on approach to the Randle St intersection. The existing Elizabeth St southbound bus lane will remain unaffected by the proposed two way operation traffic operation north of Randle St.
Property access	The existing access to the Sydney Trains car park located opposite Devonshire Street will be integrated with the new traffic signals at this location.
On-street parking / loading / unloading	The location of the Central light rail stop on Chalmers St reduces the available carriageway width and precludes on-street parking north of Randle St. The existing provision of short and long stay parking available along Chalmers St south of Devonshire St will be retained.
Taxis	The existing taxi zones are located within the footprint of the Central light rail stop. Potential to relocate the taxi zone on Chalmers St south of Devonshire St.
Pedestrian access	Pedestrian activity along Chalmers Street is primarily associated with commuter traffic crossing Chalmers St at Devonshire St and Elizabeth Street to access the City Rail network. The proposed light rail alignment and local network changes ensure the existing and future pedestrian desire lines receive priority to cross Chalmers St.
Cyclists	Chalmers Street is currently identified as having both on and off-road cycle routes. Transport for NSW proposes realigning the off-road cycle route, segregating cyclists from pedestrians whilst maintaining the important north-south link between Belmore Park and Prince Alfred Park.

5.4.2. Surry Hills Precinct

The functional characteristics of the Surry Hills precinct are shown in Figure 5-6 and described in more detail in the following sections.

Figure 5-7: Surry Hills precinct proposed functional characteristics



5.4.2.1. Devonshire Street

The objective of the Devonshire Street functional changes has been to ensure safe, reliable and efficient light rail operation can occur, whilst maintaining necessary access for residents and businesses, including consideration of light rail operations during Special Event scenarios. A summary of these changes is provided below.

Functional Changes

The proposed functional changes to accommodate light rail along Devonshire Street alignment will include:

- A single eastbound traffic lane
- The existing right turn movements for vehicles travelling eastbound along Devonshire Street wishing to head south are consolidated to Elizabeth Street and Crown Street only
- Closure of a number connecting streets at the intersection of Devonshire Street, including:
  - Buckingham Street
  - Holt Street
  - Waterloo Street
  - High Holborn Street
  - Clisdell Street
- No provision for parking provided along Devonshire Street (see Section 6 for further detail regarding mitigation)
- Light rail alignment precludes access to the existing Langton Centre off-street car park at Parkham Place.

To mitigate the impacts to local access the following network changes are proposed to improve accessibility whilst maintaining the benefits to light rail operation:

- Signalise the intersection of Devonshire Street and Marlborough Street
- Signalise the intersection of Devonshire Street and Bourke Street
- Reinstate the Cooper Street connection to Riley Street to provide access for local residents
- Introduce a westbound service lane connection between Bourke Street and Crown Street.
- Provision of relocated Langton Centre off-street parking within the general vicinity of the clinic.

The proposed signal control at Marlborough Street and Bourke Street intersections will improve pedestrian access to the Ward Park stop, providing safe, efficient interchange to Crown Street buses and ensure light rail and traffic interactions are effectively managed.

The consolidation of direct access onto Devonshire Street reduces the potential for general traffic and light rail conflicts. The closure treatments will need to provide appropriate turnaround facilities or service road access to adjacent streets.

Uncontrolled priority intersections along Devonshire Street will be limited to left in / left out operation only. With the exception of Chalmers Lane, which will become one-way northbound with a right turn out onto Devonshire Street. Swept path turning assessments were undertaken at the side roads to identify potential impacts associated with the reduced cross section available to general traffic. The swept paths assessment identified the following:

- Kerb adjustments at Adelaide Place, Steel Street and Little Riley Street are required to provide light vehicle access to minor lanes without encroaching on the light rail alignment

- Service vehicles are capable of undertaking left in left out turning movements from the significant side road accesses, namely Elizabeth Street, Riley Street, Marlborough Street, Crown Street and Bourke Street
- Heavy Rigid Vehicles (12.5m) may potentially encroach onto the eastbound light rail alignment when entering or exiting side roads
- The provision of service lane connection on the southern side of Devonshire Street between Bourke Street and Crown Street will provide access for Nickson Street and Nickson Lane

As illustrated in Figure 5-8 the introduction of a service lane along the southern kerb of Devonshire Street between Bourke Street and Crown Street will ensure access to the side roads is maintained. The service road will permit left in left out movements from Nickson Lane and Nickson Street to be undertaken clear of the light rail alignment.

Figure 5-8: Light rail alignment along Devonshire Street corridor

The proposed light rail alignment along Devonshire Street does not have sufficient available width to accommodate a dedicated cycle facility. Chalmers Street to the west is already a challenging interface for cyclists and will become more so following the implementation of light rail. Alternative parallel cycle corridors with better gateway entries to the CBD have been assessed by RMS[104], and the preferred alternative is via Cooper Street and Arthur Street. Appropriate signposting would be required to direct cyclists from the crossing location at Devonshire Street and Bourke Street.

Pedestrians will benefit from improved amenity, particularly where streets are closed at their intersection with Devonshire Street as this presents an opportunity to increase footpath area.

During special events 90m light rail vehicles may be in operation between Central and Moore Park. To ensure traffic and pedestrians are not adversely affected by these larger vehicles waiting at traffic signals and blocking adjacent intersections, light rail priority will be in place along Devonshire Street. This will ensure that vehicles are detected on their approach to the Devonshire Street corridor and once they enter this section of the alignment they are given signal

[104] *Strategic concept study: Improved pedestrian and cyclist access between Central Railway Station and Moore Park, RMS, 2013*

priority through the signalised intersections. This will ensure that, where possible, light rail does not stop at any of the signalised intersections along Devonshire Street.

South Dowling Street and Eastern Distributor crossing

At the eastern end of the Devonshire Street alignment, light rail will cross South Dowling Street at grade, pass over the Eastern Distributer and enter Moore Park. The alignment will pass through the site currently occupied by Olivia Gardens. To manage light rail conflicts with pedestrian and traffic movements safely, signalised control of the South Dowling Street southbound and northbound traffic lanes will be provided. The bridge structure will provide pedestrian and cyclist access into Moore Park and will replace the existing pedestrian/cyclist bridge and associated crossings located adjacent to Parkham Street.

Assessment of the traffic capacity impacts of an at grade light rail crossing at the proposed location was conducted under standard operations and Special Event operations, when 90m vehicles may be utilised. Details of this analysis can be found in Section 5.5.2.

Impact on cycle routes

The City of Sydney currently designates Devonshire Street as an on-road cycle route. Devonshire Street will be limited to a single eastbound traffic lane with the introduction of light rail, reducing its capacity as a suitable cycle route. Consequently, the following east-west corridors were assessed to replace the Devonshire Street cycle route;

- Option one; Foveaux Street
- Option two; Arthur and Cooper Streets
- Option three; Cleveland Street

Through RMS' Central Railway Station to Moore Park Pedestrian Access Study[105], option one was found to be the steepest corridor and only operates in one direction (westbound). Option three was found to have high volumes of traffic and thus would result in an unpleasant cycling experience. Therefore option two has been determined as the most suitable replacement cycle route for Devonshire Street.

Arthur Street is already classified as an on-road cycle route by the City of Sydney. It connects Surry Hills to Moore Park via a pedestrian / cycle bridge over South Dowling Street. In order to make the new east-west corridor more legible for cyclists, Cooper Street would require pavement markings, paint and signage to function as an on-route cycle route. The Cooper Street / Elizabeth Street intersection would also need to be reconfigured to be safer for cyclists. Randle Street would provide access to Cooper Street from the south and west, with Elizabeth Street the northern connection.

The existing pedestrian and cycle crossing linking Arthur Street to Moore Park will be retained to provide a continuous cycle link between Moore Park and Central Station through Surry Hills.

Proposed network characteristics

An outline of the effects the proposed functional changes along Devonshire Street will have on the road network uses is provided in Table 5-5. In summary, the functional changes along Devonshire Street will displace general traffic, however pedestrians and public transport users will benefit from improved amenity and accessibility.

[105] Strategic concept study for improved pedestrian and cyclist access between Central Railway Station and Moore Park, SKM, Feb 2013

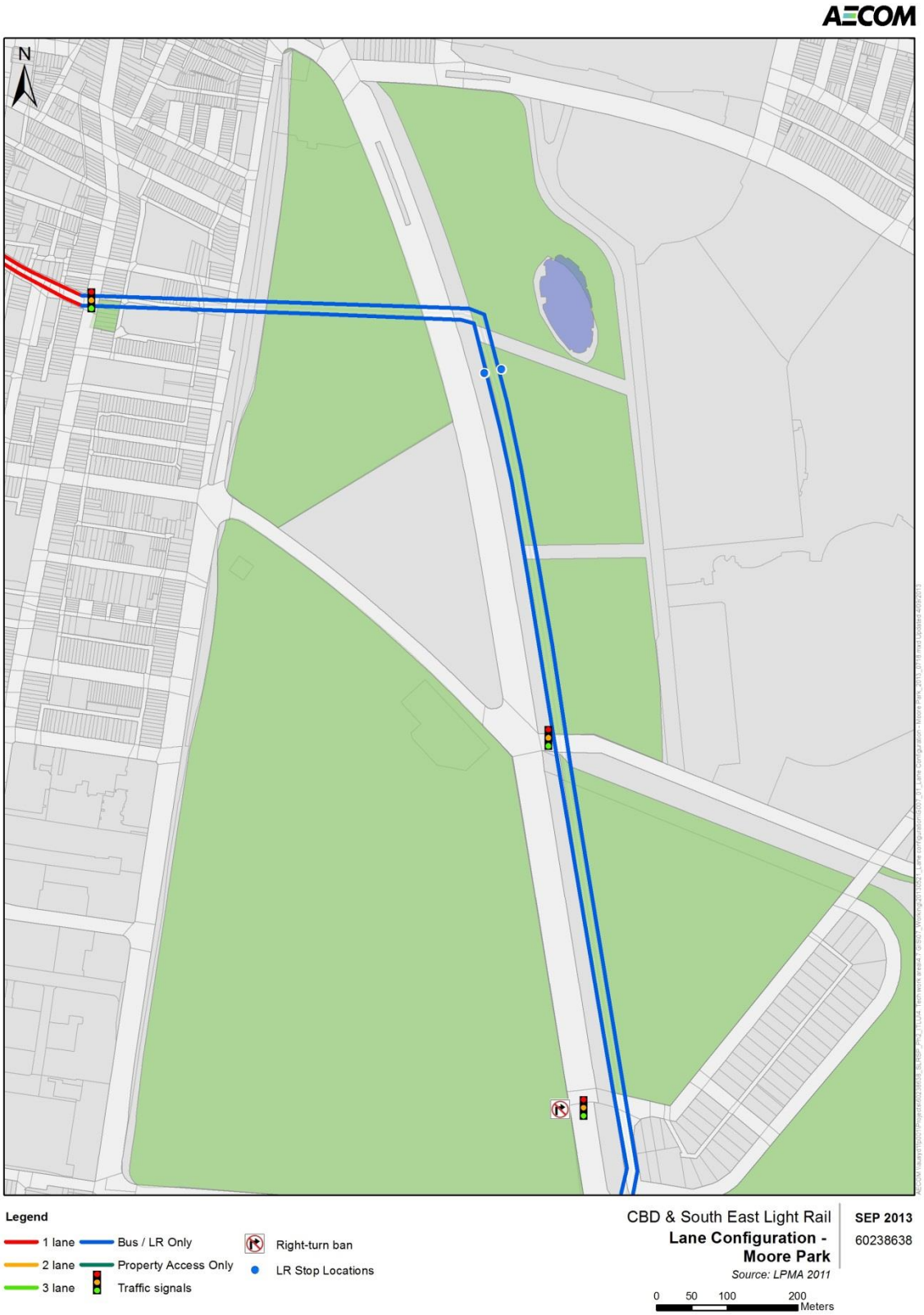
Table 5-5: Devonshire Street – Future network characteristics

Use	Future network characteristics
General traffic	With the introduction of light rail along Devonshire Street corridor the following provides a summary of the key impacts to general traffic: ▪ The Devonshire Street carriageway is limited to a single eastbound traffic lane between Chalmers Street and Bourke Street. ▪ Introduce one-way operation northbound along Chalmers Lane ▪ Close Buckingham Street access to Devonshire Street. ▪ Close Clisdell Street access to Devonshire Street ▪ Introduce signal control at Devonshire Street and Marlborough Street. ▪ Provide a westbound service lane connecting Bourke Street to Crown Street. ▪ Introduce signal control at Devonshire Street and Bourke Street.
Property accesses	Access to existing driveways along Devonshire Street will be limited to left in left out. The off-street parking provided within the existing Langton Centre may be replaced with a similar number of spaces within the vicinity of the clinic.
On-street Parking	With the introduction of light rail, the Devonshire Street carriageway is limited to a single eastbound traffic lane with no provision of on-street parking.
Loading / unloading	With the introduction of light rail, the Devonshire Street carriageway is limited to a single eastbound traffic lane with limited provision for loading.
Pedestrian access	The Devonshire Street corridor with light rail will continue to provide a strong east west pedestrian connection through Surry Hills.
Cyclist access	With the introduction of light rail, the Devonshire Street carriageway is limited to a single eastbound traffic lane. Cyclist access between Central Station and Moore Park would be provided via Cooper Street and Arthur Street. Bourke Street and Riley Street can both be emphasised as key north-south routes that connect with east-west routes, providing direct cyclist connections into the Sydney CBD.
Taxi zone	No taxi zones would be located along Devonshire Street

5.4.3. Moore Park precinct

The functional characteristics of the Moore Park precinct are shown in Figure 5-9 and described in more detail in the following sections.

Figure 5-9: Moore Park precinct proposed functional characteristics

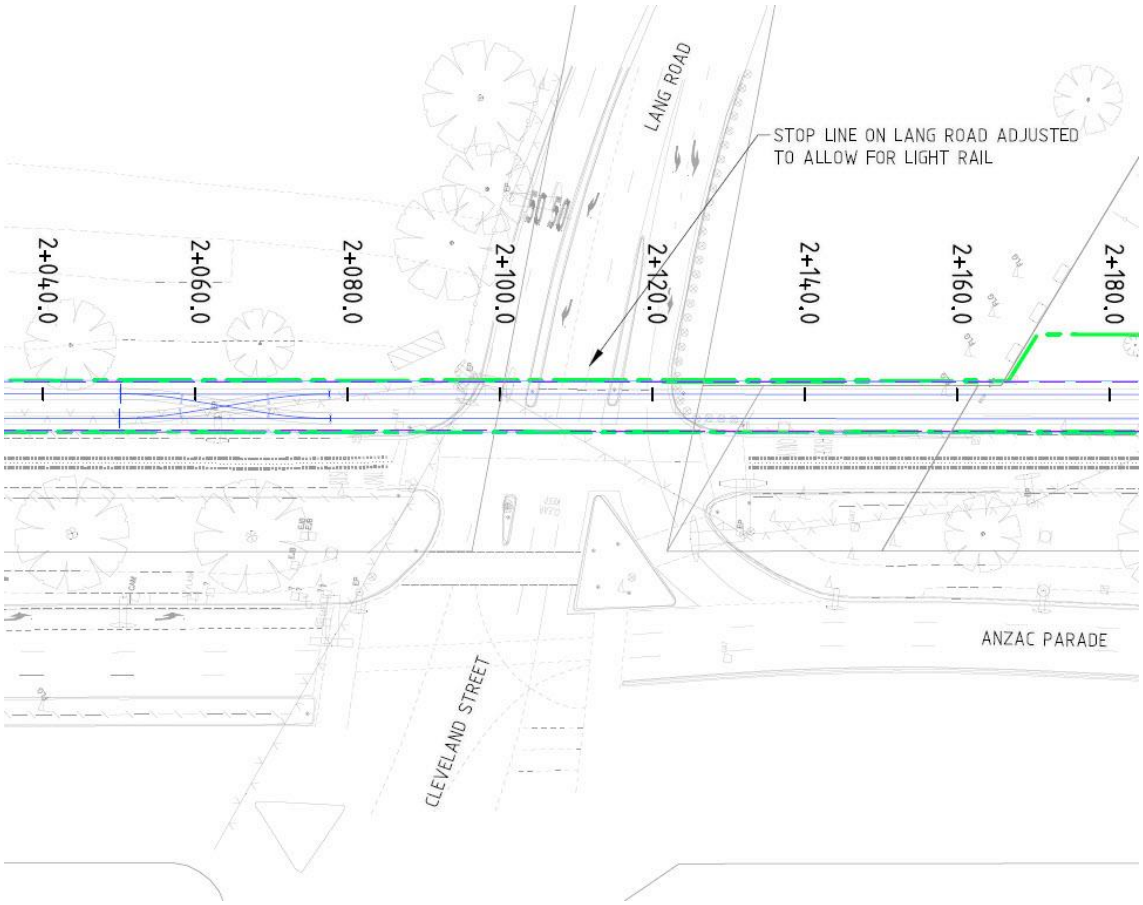


Functional changes

The light rail alignment through Moore Park West will be in tunnel to minimise impact to the park and existing bike and pedestrian pathways. This tunnel will continue under Anzac Parade to the eastern side where Moore Park station will be located. The alignment will surface on the eastern side of the existing bus way, but will not impact on its operation. The existing bus loop used for special events will be relocated to the north.

As a result the only changes to Anzac Parade in this precinct will be at the intersection with Lang Road where the alignment running adjacent to the existing bus way will widen the intersection footprint as shown in Figure 5-10. This will result in a small increase to the intersection clearance times, and a corresponding reduction to intersection efficiency.

Figure 5-10: Lang Road intersection changes[106]



Proposed network characteristics

An outline of the effects the proposed functional changes in the Moore Park precinct will have on the road network users is provided in Table 5-6.

[106] *CSELR Draft Definition Design Report – Volume 3 – South East Corridor, 2013*

Table 5-6: Moore Park precinct – Future network characteristics

Use	Future network characteristics
General traffic	The only impact to general traffic in this precinct will be a small reduction in operational efficiency at the Lang Road intersection due to an increased footprint
Property accesses	No change to existing property accesses
Buses	No change to the existing busway, special event bus loop to be relocated to the north
On-street Parking	No change to existing parking provisions
Loading / unloading	No change to existing loading facilities
Pedestrian access	Existing pedestrian crossing facilities will be retained and additional signalised facilities provided for safe crossing of the at grade alignment
Cyclist access	Existing cycle facilities on both sides of Anzac Parade will be retained, with the western off-road cycle route running adjacent to the light rail corridor.
Taxi zone	No taxi zones would be located in the Moore Park precinct

5.4.4. Kingsford precinct

The functional characteristics of the Kingsford precinct are shown in Figure 5-11 and Figure 5-12 and described in more detail in the following sections.

Anzac Parade

Anzac Parade is a key arterial connection providing access between CBD and South East Sydney. The Anzac Parade corridor design has been developed to achieve maximum utilisation of the available corridor width, improve public transport reliability, accessibility and retain existing parking opportunities where possible. A summary of the proposed functional changes along Anzac Parade required to accommodate light rail are outlined below.

Figure 5-11: Anzac Parade (North) proposed functional characteristics

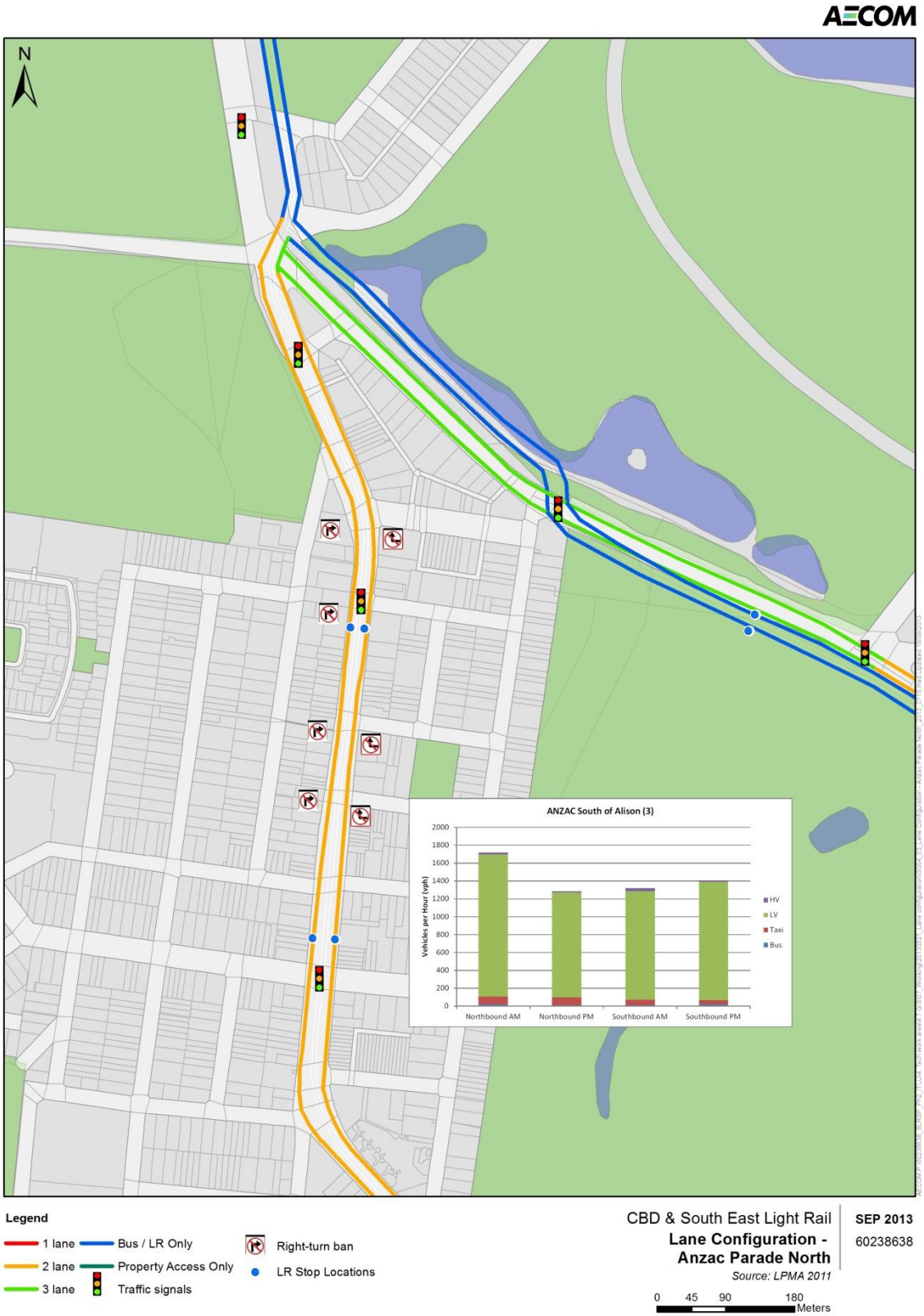
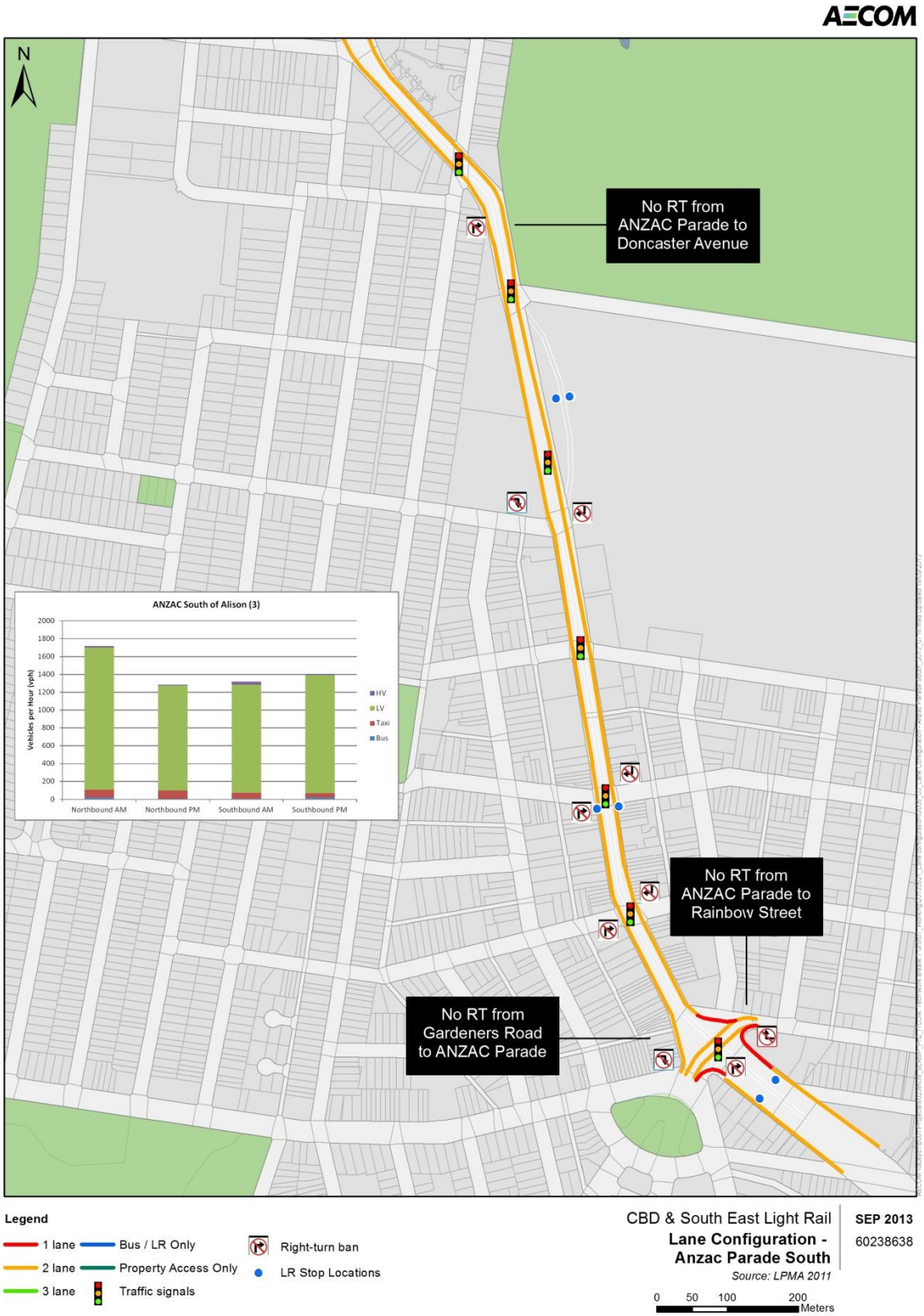


Figure 5-12: Anzac Parade (South) proposed functional characteristics



Functional changes

The key changes along Anzac Parade have been developed taking into consideration the constrained Anzac Parade cross section and the need to accommodate stops at strategic locations to service the residential catchments and other land uses in the area. The functional changes along Anzac Parade will include:

- Retention of a minimum of two traffic lanes along Anzac Parade in each direction. Where achievable an additional city-bound lane will be been provided which operates as a peak period bus only lane and off-peak parking
- 3.5m wide shared bus and light rail running lanes between the Kingsford interchange and Meeks Street for normal bus services. Includes an additional short bus only lane adjacent to the light rail track on approach to Meeks Street (southbound)
- A minimum 4.4m wide light rail island platform will be located along the middle of the corridor
- Right turn movements that provide access to Doncaster Avenue will be consolidated into a single right turn at Todman Avenue, as illustrated in Figure 5-13.
- The right turn from Anzac Parade into Day Avenue will be banned. This will require rerouting of bus services that currently make this manoeuvre. Pending further Council approval and investigation of impact to bike lanes this route will likely to be via Doncaster Avenue
- Right turn movements from Anzac Parade between Barker Street and Meeks Street will be consolidated into a single right turn at Barker Street, as illustrated in Figure 5-13.
- The existing signalised pedestrian crossing will be relocated to be adjacent to the Carlton Street stop.
- The existing Nineways roundabout intersection will be upgraded to signal control
- There will potentially be a need for physical separation between light rail and general traffic, particularly at locations where right turns off Anzac Parade were previously permitted but will be prohibited in the future
- An off-line UNSW Anzac Parade stop to cater for the large light rail travel demand to the University.

These measures aim to maximise utility of the available road space whilst ensuring light rail, bus and traffic operations are balanced as effectively as possible.

Due to the operation of light rail in the median, a reduction in existing right turn locations has been required south of Alison Road, however, the following right turns would be permitted in the future :

- Southbound right turn into Dacey Avenue;
- Southbound and northbound right turns into Todman Avenue;
- Northbound right turn into High Street;
- and Southbound and northbound right turn into Barker Street.

Figure 5-13 shows the permitted right turn provisions from Anzac Parade.

Figure 5-13: Proposed right-turning provisions from Anzac Parade

Anzac Parade / Alison Road intersection

To minimise traffic capacity reduction at the Anzac Parade / Alison Road intersection a two stage transition will be adopted to transfer the light rail alignment from the eastern side of Anzac Parade into the median, south of Alison Road. This two stage crossing will allow light rail to run concurrently with key traffic movements which will in turn provide a 20%-35% reduction in light rail delays at the intersection and an increase in traffic capacity of 5% when compared to a single transition through the intersection. The specific design details of this intersection and the transition are currently under review by RMS and the CSELR team.

Bus and Light Rail shared running

In order to maintain bus priority, an option for 'shared running' of bus and light rail has been explored. The design would allow for buses and light rail to share the same road space in the centre of Anzac Parade between Rainbow Street and the UNSW Mall. Shared running north of Meeks Street would only be made available to those express bus services proposed to be retained to minimise the operational impacts to light rail. This would equate to a total of 16-20 buses during the AM peak hour in 2021. It is anticipated that the retained express services would re-join the main traffic flow adjacent to the UNSW mall crossing and would do so during the dedicated light rail phase at this crossing point. Buses would not stop while undertaking shared running to avoid delays to CSELR.

Non-express services would exit the shared running alignment at the Meeks Street intersection via a bus only signal phase to allow them to access the kerbside bus stops along Anzac Parade.

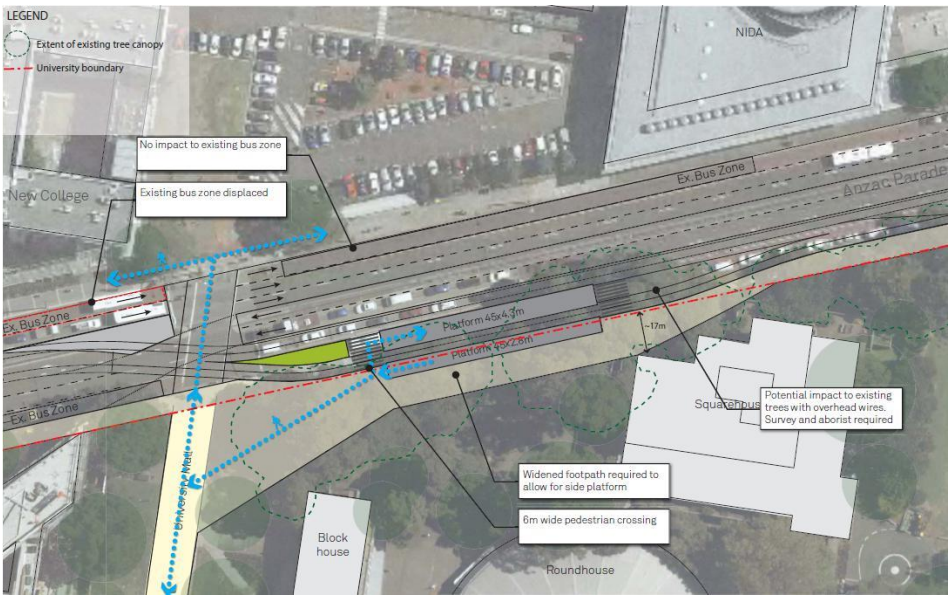
If they were to operate, PTPM model forecasts expect the Anzac Parade express bus services (X92, X94, X96, X97, and X99) to carry approximately 2,800 passengers in the AM peak hour[107], which is similar to the forecast light rail patronage at Kingsford. The need to efficient light rail operations at the same time as priority for these bus routes was therefore an important consideration for this corridor.

UNSW Anzac Parade Stop

UNSW Anzac Parade is one of the busiest stops along the alignment in terms of forecast boarding and alighting passengers. As such the stop design deviates from the centre alignment of Anzac Parade and interfaces directly with the campus on the eastern side, with the objective of creating a safe and direct access for students and staff, without the need to cross Anzac Parade in either direction. The use of University land to accommodate part of the stop infrastructure also provides an opportunity to minimise impacts to the existing road cross section.

[107] Transport for NSW, *Sydney Light Rail Round 5.1 Demand Report*, 2013

Figure 5-14: UNSW Anzac Parade Stop[108]



Proposed network characteristics

An outline of the effects the proposed functional changes along Anzac Parade will have on road network uses is provided in Table 5-7. In summary, the functional changes required to accommodate light rail will displace general traffic and reduce the level of parking and loading/unloading bays. No major impacts on cycle or pedestrian access are expected, pedestrian access could potentially improve, particularly during special events.

Table 5-7: Anzac Parade Future network characteristics

Use	Future network characteristics
General traffic	Anzac Parade will continue to provide the major arterial connection between the CBD and the South Eastern suburbs. The proposed alignment includes a combination of off-street, kerbside and centre running alignment aimed to minimise impact to the existing traffic network. The key impacts to general traffic are summarised below: ▪ The Anzac Parade corridor maintains a minimum two through general traffic lanes in each direction. ▪ City bound bus lane retained in the AM peak, except for adjacent to the Carlton St stop due to the limited cross sectional width. ▪ Redesign of the Anzac Pde /Alison Rd intersection to allow a two stage transition of the alignment from the eastern side to centre running. ▪ At-grade light rail crossing of Lang Rd adjacent to the existing bus-way. ▪ At-grade crossing of Alison Rd and Anzac Parade intersection ▪ Restrict Anzac Parade access to Abbotford St to Left-in Left-out. ▪ Relocate the northbound right turn movement from Anzac Parade into Doncaster Ave. further north to the intersection of Anzac Parade and Todman Ave. ▪ Restrict Anzac Parade access at Day Ave to Left-in Left-out at ▪ Consolidate right turn movements within Kingsford town centre to the Barker St and Anzac Parade intersection. ▪ Introduce signal control to the Kingsford 9-ways intersection. Consolidate signal phasing by prohibiting right turn movements from Rainbow St and Gardeners Rd into Anzac Parade.

[108] *Source: ERSUD, 2013*

Use	Future network characteristics
Buses	Introduction of light rail along the Anzac Parade corridor reduces the cross section available for general traffic and bus priority lanes, To mitigate the impacts to existing bus priority the following ▪ In locations where the cross-section permitted five traffic lanes, the design introduces a dedicated city-bound bus only lane. ▪ Kingsford interchange provides direct platform interchange for bus and light rail passengers. ▪ Shared running of bus and light rail movement through the proposed signalised nine-ways intersection.
Property accesses	The proposed light rail alignment for Anzac Parade is predominately along the centre of the median as such: ▪ Existing access is maintained throughout the corridor
On-Street parking	▪ During off-peak hours, on-street parking within the proposed bus only lanes will be retained. The city bound bus only lane extend along Anzac Parade between UNSW and Alison Rd, except adjacent to the Carlton St stop where the carriageway is restricted to two traffic lanes in each direction (refer to section 6 for further detail)
Loading / unloading	▪ On-street loading/unloading zones will be retained wherever possible within the western kerbside bus lanes outside of peak hours. (refer to section 6 for further detail)
Pedestrian access	There are seven signalised intersections and five signalised pedestrian crossing within this section of the Anzac Parade. ▪ Pedestrian activity is expected to increase in the vicinity of the proposed light rail stops and crossing facilities will be provided to permit safe access. ▪ Enhancement to the pedestrian environment surrounding the Moore Park light rail stop, particularly during special events.
Cyclist access	The existing off-road path along the eastern kerb of Anzac Parade between Moore Park Rd and Alison Rd will be retained with the introduction of light rail. ▪ Provision of cycle storage facilities at the Kingsford light rail terminus.
Taxi zone	No Taxi zones are located along Anzac Parade

5.4.4.1. Kingsford Interchange

At its southern end, the light rail terminus at Kingsford will operate as the key interchange between South Eastern suburb buses and light rail. A summary of the functional changes to the road network required to accommodate the light rail terminus at Kingsford along with a summary of the likely impacts is provided below.

Functional changes

The Kingsford Interchange, as illustrated in Figure 5-15 and Figure 5-16, will be a critical bus to light rail transfer point, as the southern terminus on the Anzac Parade corridor, servicing approximately 90 buses per hour in the peak direction during the AM and PM peaks. The interchange must provide for highly legible, efficient bus to light rail and light rail to bus transfers as this will shape customer experience and hence has formed a key design consideration.

Whilst serving the immediate catchment of Kingsford, the interchange is also designed to service a wider catchment, including La Perouse, Maroubra and suburbs to the south. The Kingsford Interchange is therefore planned to operate as the primary interchange for customers from the South Eastern suburbs, some of whom are anticipated to change modes from bus to light rail for their journey to the CBD. It is expected that the light rail service will reduce the need for existing bus services to connect to the CBD, although express bus services to the north of the CBD are proposed to remain in operation to continue to provide passengers a direct connection to the north of the CBD.

PTPM modelling[109] forecasts 1,454 passengers will access light rail at Kingsford during the AM peak hour, with 1,277 (88%) transferring from bus and 177 (12%) from walk up.

Figure 5-15: Light rail alignment at Kingsford Interchange (AM Peak)[110]

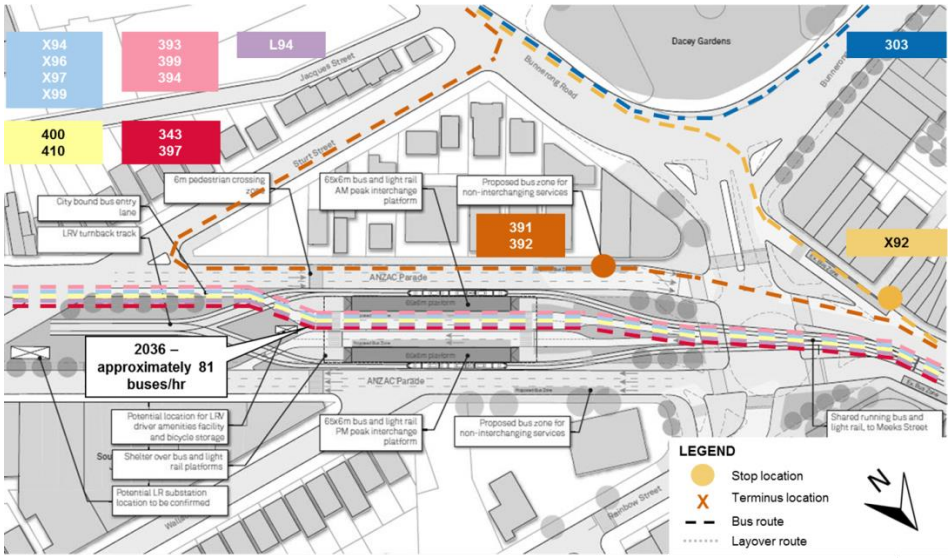
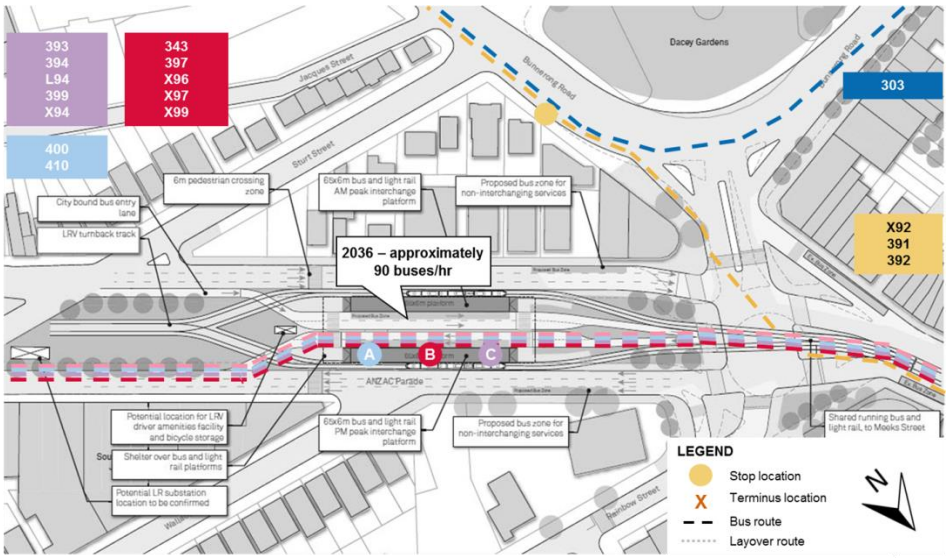


Figure 5-16: Light rail alignment at Kingsford Interchange (PM Peak)[111]



New stop on Bunnerong Road subject to consultation with Randwick Council and State Transit Authority

The design will provide a guaranteed cross platform interchange between bus and light rail in both directions of travel. The interchange will be located in the centre median of Anzac Parade to the south of the Nineways intersection. This design will provide separation of bus and light rail movements between the platforms and the Nineways intersection, before converging into a shared bus and light rail running arrangement to ensure bus passengers continue to receive a degree of priority over general traffic as at present.

[109] Transport for NSW, *Sydney Light Rail Round 5.2 Demand Report*, 2013

[110] *2036 bus frequencies*

[111] *2036 bus frequencies*

Conversion of the Nineways roundabout to a signalised intersection is required to allow integration of the Kingsford interchange and to provide safe, controlled pedestrian access points across Anzac Parade. Initial modelling of the intersection by Transport for NSW indicates the current intersection design will operate at a LoS E in the AM peak and LoS C in the PM peak. This indicates that whilst the intersection operates with spare capacity in the PM peak, it will be operating at capacity in the AM peak. Further design work is ongoing to optimise the intersection in consultation with Transport for NSW and RMS.

A priority Light Rail / Bus phase city bound at the Nineways intersection, coordinated with the main north/south traffic phase at Meeks Street will ensure light rail priority and safe merging of these movements. Shared running of all bus services and light rail will continue between the Nineways intersection and Meeks Street. Non-express (local) bus services will then merge/diverge from the light rail alignment on approach to the Meeks Street intersection via short bus "turn" bays adjacent to the light rail lanes on the Anzac Parade approaches to the intersection. The bus only lanes would operate in separate phase to light rail to allow co-ordinated movements into and out of the central alignment.

A turn back tail track will be provided to allow light rail vehicles to operate via dedicated inbound and outbound platforms, which are co-located with inbound and outbound bus services respectively.

Proposed network characteristics

An outline of the effects the proposed functional changes at the Kingsford interchange will have on road network uses is provided in Table 5-8.

Table 5-8: Kingsford Interchange Future network characteristics

Use	Future network characteristics
General traffic	▪ Conversion of the existing roundabout at nine-ways into a signalised intersection ▪ Restriction to right turning movements at the new nine-ways intersection, with local alternative routes available
Property accesses	▪ Property accesses retained
On-Street parking	▪ Loss of median and kerbside parking in vicinity of light rail
Loading / unloading	▪ No designated loading zones currently within the vicinity of the interchange, but may be introduced as part of parking strategy (see section 6)
Pedestrian/cyclist access	▪ Pedestrian access to the interchange will be provided via signalised crossings on all approaches to the nine-ways intersection ▪ Cyclist facilities will be provided at the interchange (details provided in Section 7)
Taxi zones	▪ Taxi bays would be provided at the terminus (see Section 7)

5.4.5. Randwick precinct

The functional characteristics of the Randwick precinct are shown below in Figure 5-17 and discussed in further detail in the following sections.

Figure 5-17: Randwick precinct proposed functional characteristics

5.4.5.1. Alison Road

Functional changes

The proposed functional changes along Alison Road to accommodate light rail are discussed below, with a particular focus on:

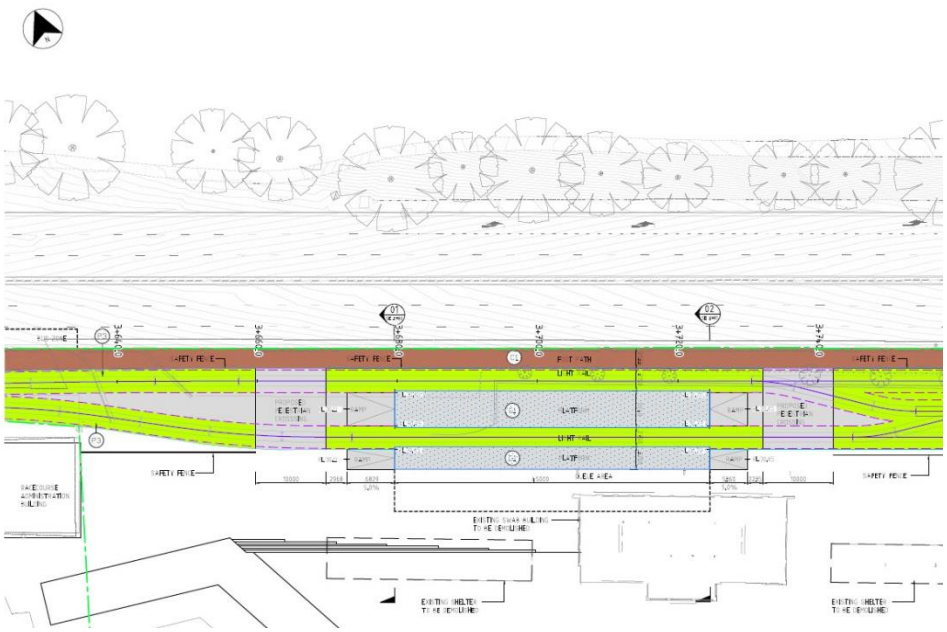
- Alignment adjacent to Randwick Racecourse
- The bus roadway
- Stabling and maintenance facility adjacent to Randwick Racecourse

Alignment adjacent to Royal Randwick Racecourse

The key design parameter for the alignment through this section of Alison Road is the major event stop at Royal Randwick Racecourse. Due to the level of pedestrian activity during events it is vital the stop is located adjacent to the racecourse, therefore removing the major pedestrian conflict associated with crossing Alison Road. This will require a transition of the alignment from the northern side of Alison Road to the southern, which will be undertaken at Alison Road / Doncaster Avenue which has a greater level of spare capacity when compared to Alison Road / Darley Road. Utilising the intersection at Doncaster Avenue will minimise the impacts (delay) to light rail, traffic and bus operations by providing the light rail crossing of Alison Road at a location where existing traffic lane geometry will not be constrained by the light rail alignment. There is also the opportunity to incorporate the light rail crossing at Doncaster Avenue into the signal phase for the existing off-line bus way, therefore maintaining the current three phase operation.

This light rail stop will cater for Royal Randwick Racecourse, Randwick TAFE, UNSW Randwick campus on King Street, Centennial Park via the Randwick Gate on Darley Road and the residential catchment between Alison Road and Darley Road. Located within the ATC site the stop will be configured as a 45m island platform with a trailing pocket track cross-over to allow special event shuttle services to turn back, with an additional event-only side platform for post event loading. The stop layout is shown in Figure 5-18.

Figure 5-18: Randwick stop layout[112]



[112] *CSELR Draft Definition Design Report – Volume 3 – South East Corridor, 2013*

By locating the stop within the ATC site, customer safety will be addressed during an event as customers can board and alight the light rail without the need to cross Alison Road and can be marshalled safely within the ATC site.

The light rail alignment will diverge from the Alison Road busway at Doncaster Avenue and run parallel to the existing footpath along Alison Road within the ATC site. The alignment will clear the existing ATC administration building, and then diverges to allow the stop to be located south of the administration building, allowing sufficient length for the pocket track, before the alignment swings back onto the southern kerb lanes of Alison Road at the Darley Road intersection.

To enable sufficient area to marshal special events, and to maintain safe, clear access and sight lines around the light rail stop, the existing Swab building will need to be demolished.

Local bus services will stop on the kerbside adjacent to the light rail stop for passengers interchanging from eastern suburbs buses in the inbound direction. Outbound bus interchange will require light rail passengers to cross Alison Road to reach the closest bus stop. This configuration is unchanged from the existing.

Further work is needed to determine the optimum location for special event buses, although it is currently envisaged that these services will be able to stop on the southern side of Alison Road kerbside, between the Administration building and Doncaster Road. During special events a bus and taxi staging area will be made available on the kerbside lane of Darley Road.

Bus roadway

The existing bus roadway adjacent to Anzac Parade is utilised by express and stopping bus services operating between the City and Coogee-Randwick. It is anticipated that Routes 339, 374 and L94 which will operate all day would stop in the roadway totalling 23 services in the 2036 AM peak hour.

Despite fewer stopping services, it is suggested to retain the Anzac Parade Bus Roadway for a number of reasons.

- Provision of bus priority is required to maintain efficient and reliable journey times for bus services and is practically achieved without further infrastructure investment by the existing bus roadway making best use of a scarce resource, in particular:
  - The Alison Road, Anzac Parade, Dacey Avenue intersection is congested during the peak periods operating at a degraded Level of Service F. The bus roadway allows bus services operating from the Coogee-Randwick precinct to avoid the congested intersection.
  - During special events, roads in the Moore Park precinct become heavily congested and use of the roadway will be essential to maintain reliability for regular timetabled services operating through the precinct.
- Retention of the bus roadway provides for a degree of 'future-proofing' as Express services (if retained) are anticipated to continue growing strongly with the express buses from Randwick forecast to carry 3,300 passengers in the 2021 AM peak.
- Passenger transport to special events at Moore Park and Randwick Racecourse are proposed to be provided by both Light Rail and supplementary special event bus services.

The roadway is currently fenced in response to accidents previously experienced where pedestrians conflicted with buses operating at high speeds. Fencing breaks are provided at stop locations to facilitate pedestrian access. With the light rail operating adjacent to the roadway, provision of access to bus stops across the light rail alignment is to be considered as part of the detailed design process.

Impact on cycle routes

Between Darley Road and Wansey Road, the light rail alignment will run on the southern side of Alison Road. As a result, the off-road cycle route would be realigned between the light rail corridor and the Australian Turf Club site. At the signalised intersection of Alison Road and Darley Road, cyclists would still be able to move between off-road cycle routes, however they would also need to cross the light rail alignment.

Proposed network characteristics

An outline of the effects the proposed functional changes along Alison Road will have on road network uses is provided in Table 5-9. The functional changes required to accommodate light rail will impact general traffic movements. On the other hand however, it will generate significant public transport and pedestrian access improvements to key locations such as Randwick Racecourse, Randwick TAFE and UNSW Randwick.

Table 5-9: Alison Road Future network characteristics

Use	Future network characteristics
General traffic	Several changes to the existing local road network are required to introduce light rail along Alison Road. The key local network changes include: ▪ Geometric and traffic signal changes to Alison Rd and Anzac Parade. Existing traffic movements and lane configuration retained. ▪ Geometric and signal changes to the Doncaster Ave and Alison Rd intersection to permit the light rail to cross Doncaster Ave between Abbotford St and the Racecourse. ▪ Geometric and signal changes to the Darley Rd and Alison Road intersection to accommodate the light rail and access to Randwick Racecourse site. City bound through movement along Alison Rd reduced to two through traffic lanes. ▪ Introduce signal control to the Alison Road and Wansey Rd intersection to improve pedestrian access to the adjacent stop.
Property accesses	Property accesses located on the eastern side of Alison Road would be unaffected by CSELR. ▪ The gate access to Royal Randwick Racecourse (RRR) located on the eastern side of Alison Road may be subject to restrictions or controls.
On-Street parking	No provision for on-street parking along Alison Rd between Darley Rd and Wansey Rd due to the constrained cross section with the light rail alignment along the southern kerb.
Loading / unloading	▪ There are no loading/unloading spaces available within the corridor.
Pedestrian/cyclist access	▪ The existing off-road shared path running along the northern side of Alison Road will be retained. ▪ The off-road shared path between Darley Rd and Wansey Rd will be reinstated between the light rail alignment and the racecourse. ▪ Randwick Racecourse stop location within existing ATC land will ensure a safe and direct connection into the racecourse, particularly during special events. ▪ The Alison Road alignment will encroach upon the western side of Tay Reserve (existing parkland), which will require the relocation of the existing pedestrian footpath on that side. This footpath could be relocated to the eastern side of the track within the park, and the park could be re-designed to tie-in with the future light rail track.
Taxi zones	Provision for a taxi zone may be provided on Alison Road adjacent to the Racecourse stop during special events.
Bus	The existing westbound bus stop on the southern side of Alison Road adjacent to Darley Road would be displaced with this alignment – passengers would be expected to utilise the stop to the west.

Stabling and maintenance facility adjacent to Randwick Racecourse

The Randwick stabling and maintenance facility is located adjacent to Randwick racecourse, backing onto properties facing Doncaster Avenue. Based on the Final Fleet Stabling Requirements and Operating Protocols Report prepared by the Light Rail Network Operations and Management Service Provider (Interfleet), it is proposed that stabling and maintenance work on CSELR light rail vehicles would be undertaken at the Randwick stabling facility. It is identified that the facility would be expected to provide office space, a workshop, stores and approximately 100-120 car parking spaces for staff and visitors. An internal road network would cater for independent heavy vehicle movement and be designed to RMS and AS standards and guidelines.

Vehicle access to the facility would be via an existing vehicular access located at a roundabout intersection at Ascot Street and the exit point would be on the eastern side of Doncaster Avenue, south of the intersection with Alison Road. The current AM peak hour traffic volume at the intersection of Anzac Parade / Doncaster Avenue is 3,700 vehicles and Alison Road / Doncaster Avenue is 4,800 vehicles, with both intersections are operating at Level of Service (LoS) C or better during the peak hours. This traffic is mainly generated by local land uses but also consists of some through traffic rat running to avoid the congested Anzac Parade / Alison Road intersection. At present, parking is permitted along both sides of the Doncaster Avenue. The Randwick Council bicycle route map designates Doncaster Avenue as an existing signed on-road bicycle route. This route connects with a segregated cycle path running along the northern side of Alison Road.

It is considered that the existing vehicular crossings at Doncaster Avenue can be adapted for use during operation of the maintenance facility. During the operation of the stabling facility, peak traffic generation would be attributable to periods of shift changeovers where staff vehicles would be entering and exiting the site. The 100-120 parking spaces proposed on site would be sufficient to accommodate all traffic associated with each shift of the maintenance facility; therefore the impact on adjacent on-street parking provisions would be minimal. It is assumed that the shift change over period would be outside peak periods for the road network and as such is unlikely to impact existing intersection performance and traffic conditions.

The impact of the additional traffic generated by the maintenance facility is considered low for the following reasons:

- Peak movements to the site associated with the shift changeover period would likely occur outside of the network peak;
- Use of existing accesses with no anticipated requirement for significant upgrade;
- Entry and exit arrangements to the facility through existing separate vehicular access points would reduce the vehicle conflicts.

5.4.5.2. Wansey Road

The functional road network changes required to accommodate light rail along Wansey Road and the potential impacts associated with these changes are outlined below.

Functional changes

The light rail design alignment is located on the western edge of Wansey Road. The light rail stop runs parallel to Wansey Road near the corner of Alison Road (see Figure 5-19), whilst The UNSW High Street stop is parallel to Wansey Road near the corner of High Street (see Figure 5-20). The outbound track is in the approximate location of the existing kerbside parking lane and the inbound track is located on the off-road pedestrian/cycle path.

Two-way traffic will be retained but no provision for on-street parking will be possible due to the reduced road cross section along Wansey Road. The off-road pedestrian/cycle path will be realigned on the western side.

Figure 5-19: Light rail alignment Wansey Road north

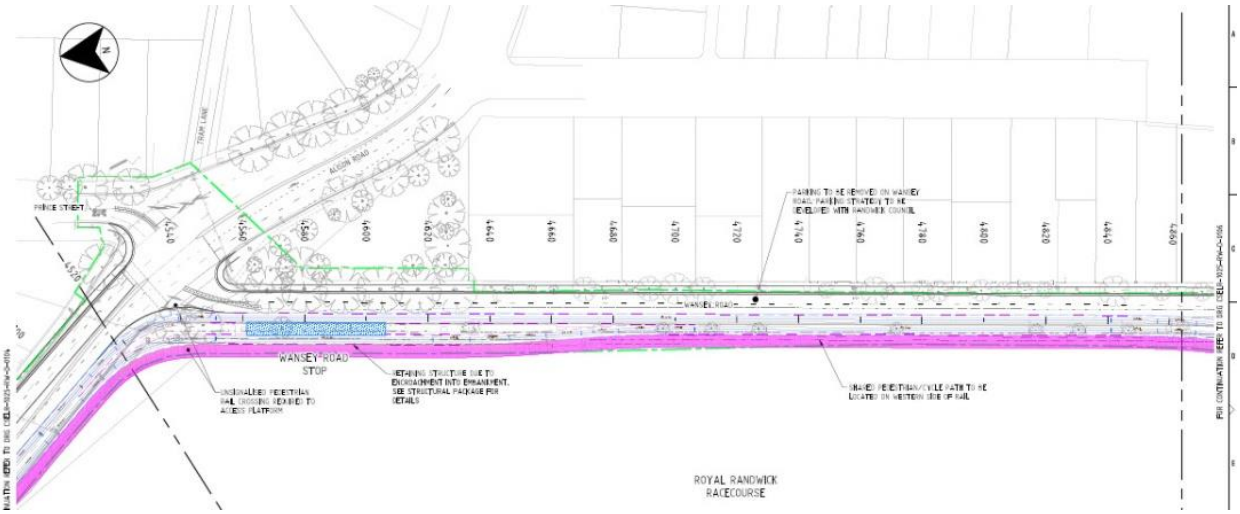


Figure 5-20: Light rail alignment Wansey Road south

This design will require regrading towards the southern end of Wansey Road, which will result in the stop being in a slight cutting. Sections of the existing Wansey Road corridor are supported on a masonry retaining wall which will likely require reconstruction to accommodate light rail.

To provide pedestrian access from the residential catchments in the north and east to the Wansey Road stop, the intersection of Wansey Road / Alison Road will be signalised. The signalised intersection will provide pedestrian crossing points on all arms. Alternatives to provide a signalised pedestrian crossing offset from the intersection, were investigated, but would not satisfy the pedestrian desire lines and could not be accommodated safely in close proximity to the existing intersection.

The intersection of High Street / Wansey Road will also require signalisation to accommodate pedestrians and the light rail turning movements between Wansey Road and High Street. Pedestrian crossings will be provided across Wansey Road and the eastern arm of High Street as a minimum, which will replace the existing zebra crossing on High Street. This provides enhanced pedestrian facilities as pedestrians currently have no protected facilities to cross Wansey Road.

Impact on cycle routes

The existing off-road cycle route on Wansey Road would be relocated between the light rail alignment and the ATC site. This is consistent with the treatment of the Alison Road off-road cycleway, ensuring the route remains connected and segregated from vehicular traffic between Darley Road and High Street. A signalised intersection with pedestrian crossings at Wansey Road and High Street would improve connections to UNSW.

Proposed network characteristics

An outline of the effects the proposed functional changes along Wansey Road will have on road network uses is provided in Table 5-10. In summary, the main impacts to general traffic will be the introduction of traffic signals which would result in a slight increase in delay during off-peak periods, but would improve access and safety for traffic accessing Wansey Road, particularly during peak times. The existing on-street parking along Wansey Road would also be lost due to the limited road space available, the parking mitigation measures are discussed further in section 6 of this report. The shared cycleway and footpath on the western side of Wansey Road would be retained.

Table 5-10: Wansey Road Future network characteristics

Use	Future network characteristics
General traffic	Wansey Road will continue to provide access to residents with all existing movements maintained. The impacts to general traffic movements include: ▪ Traffic signals introduced at Wansey Rd and Alison Rd to improve pedestrian access. ▪ Traffic signals introduced at Wansey Rd and High St to provide necessary access for light rail.
Property accesses	The proposed light rail alignment impacts access to property along the western side of Wansey Rd. The accesses directly impacted include: ▪ Two existing driveway accesses into Randwick Racecourse. Alternative access is available through the internal racecourse road network via High Street
On-Street parking	There will be no parking available along the corridor (see section 6 for mitigation measures).
Pedestrian / cyclist access	▪ Pedestrians within Wansey Rd are mainly generated by the residential properties, recreational activities and the University of New South Wales. ▪ The Wansey Rd off-road shared path between Alison Rd and High St will be reinstated between the light rail alignment and the ATC site.

5.4.5.3. High Street

The functional road network changes required to accommodate light rail along High Street and the potential impacts associated with these changes are outlined below.

Functional changes

Due to nature of the land use and access requirements along High Street, the following key design parameters guided the design development in this area:

- Maintain a minimum single traffic lane along High Street in each direction (as existing)
- Provide signal control at intersections where general traffic movements are permitted to cross the light rail alignment
- Relocate existing bus stops or provide indented bus bays that allow general traffic to pass a stopped bus
- Maintain access for emergency vehicles to the hospital

These measures will optimise the operational efficiency for all modes within the available corridor width, improve public transport reliability and maintain access to land uses along High Street.

As illustrated in Figure 5-13 the light rail alignment will operate in a dedicated light rail 'centre running' configuration along High Street with a single kerbside traffic lane in each direction. This will necessitate changes to parking, loading and kerbside access, consistent with other sections of the corridor. Mitigation measures to address this issue are proposed in Section 6 of this report.

A summary of the key road characteristics are:

- A traffic signal control will be introduced at the intersection of High St and Hospital Road
- A traffic signal control will be introduced at the intersection of High St and Clara Street
- Access to Eurimbla Avenue will be restricted to Left In Left Out
- An intended bus bay for westbound buses on High Street will be introduced adjacent to the Adult hospital
- The westbound bus stop adjacent to the Children's Hospital emergency entrance will be relocated to Clara Street, with access to the hospital via a signalised intersection
- An indented bus bay for westbound buses will be provided on High Street between Botany Street and Wansey Road. This will require a localised diversion of the footpath into UNSW land.
- As a result of these changes, there is a significant spacing between bus stops utilised by the 370 and 372 considered necessary to avoid unacceptable congestion on High Street

Driveway accesses

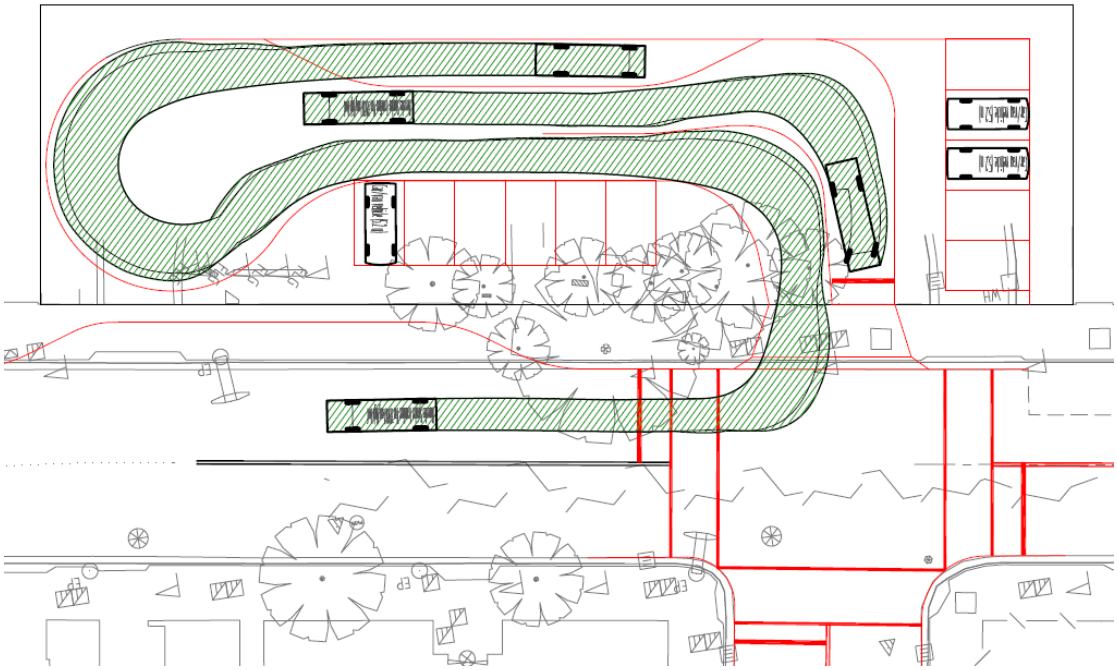
The introduction of signal control at Hospital Road and Clara Street will enable right turn movements into and out of the side roads to be maintained. The signals will ensure traffic movements in conflict with the light rail alignment are controlled. Access to Eurimbla Avenue and driveways along High Street will be restricted to left in left out only.

The consolidation of accesses along the High Street corridor is necessary to minimise turning vehicle conflicts with light rail which would represent a significant safety and reliability issue for operations. Essential accesses to the Prince of Wales Hospital from High Street will been maintained as follows:

- The porte cochere entrance to the Adult Hospital will be modified and integrated with a four way signalised intersection at Clara Street. The design will also provide an indented westbound bus bay on High Street (as shown in Figure 5-21).
- The operation of the porte cochere entrance to the Children's Hospital will be reversed to provide entry via Hospital Road. Exit would be limited to a left turn only onto High Street
- Emergency vehicle access to the Children's hospital will remain the same.

Right turning movements off High Street at the signalised intersections with Wansey Road, Botany Street, Hospital Road Clara Street and Belmore Road / Avoca Street will be undertaken from a short shared section of the light rail alignment on approach to each of these intersections. At the Belmore Road / Avoca Street intersection these right turn movements will be restricted to buses only.

Figure 5-21: Modification to porte cochere entrance to the Adult Hospital



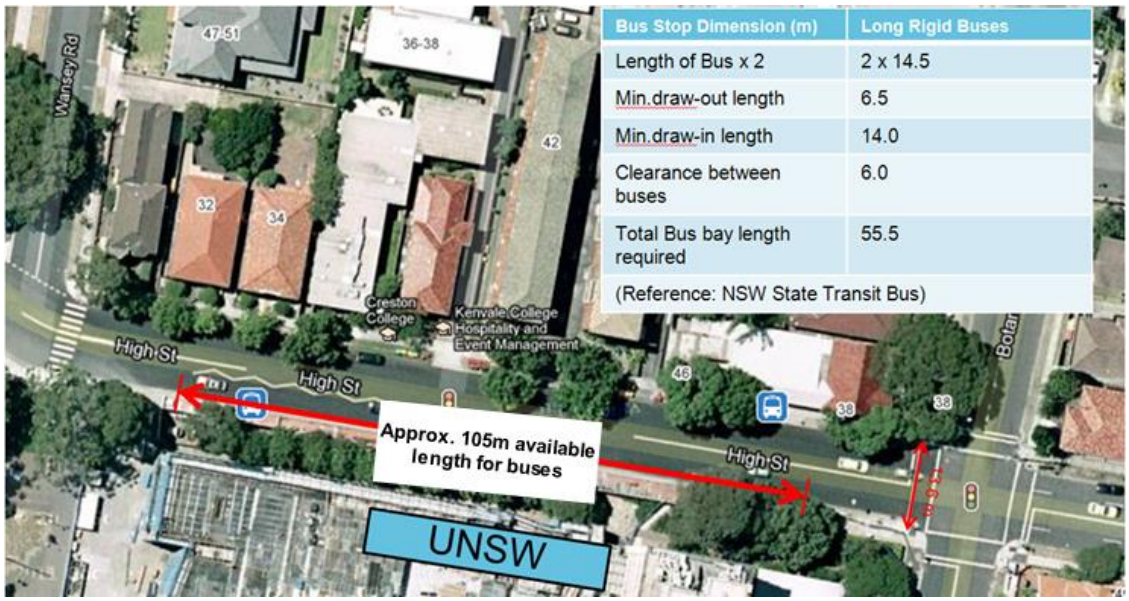
High Street bus stops

The implementation of light rail in the High Street corridor will necessitate the relocation of existing bus stops on High Street. Currently stops are provided at the following locations in this section of High Street:

- Outside UNSW frontage (westbound only)
- West of Botany Street (eastbound only)
- West of Clara Street (eastbound and westbound)

The current westbound UNSW stop will be replaced by an indented bay within University land as shown in Figure 5-22. It is anticipated that the bay will be required to accommodate two buses due to the forecast bus numbers.

Figure 5-22: Proposed Bus Bay along High St Corridor near UNSW



The bus stop west of Botany Street cannot be retained due to the need to provide an unimpeded traffic lane. It is anticipated passengers currently utilising this stop will be required to use the stop west of Wansey Road.

Outside the hospital, the eastbound stop currently located on High Street cannot be retained to the limited cross sectional width on High Street. The stop location will therefore be reconfigured along Clara Street as shown in Figure 5-23. The stops relocated within Clara Street will benefit from safe pedestrian access to the hospital via the newly signalised Clara Street intersection. This will however, require those customers on bus routes that continue along High Street, to access their bus services at the Randwick Interchange The requirement for suitable eastbound alternative stop locations will be investigated further with Randwick Council and the Prince of Wales Hospital.

Figure 5-23: Proposed bus stop locations outside the hospital

Impact on cycle routes

The light rail alignment would run on High Street between Wansey Road and the Randwick terminus. High Street is currently identified as an on-road cycle route, linking Belmore Road and Anzac Parade. Future light rail operations on High Street are incompatible with an on-road cycle route. Therefore, in order to maintain cyclist access to the Randwick town centre, Arthur Street would be designated as an on-road cycle route between Wansey Road and Belmore Road. Cyclists using the off-road cycleway on Wansey Road would cross the light rail alignment and Wansey Road to access Arthur Street. Arthur Street connects with Belmore Road, providing cyclists with access to on-road cycle routes to the south and east.

Proposed network characteristics

An outline of the effects the proposed functional changes along High Street will have on road network uses is provided in Table 5-11.

Table 5-11: High Street Future Network Characteristics

Use	Future network characteristics
General traffic	With the introduction of light rail along the High St corridor the following provides a summary of the key impacts to general traffic: ▪ Traffic signal control will be introduced at the intersection of High St and Hospital Rd ▪ Traffic signal control will be introduced at the intersection of High St and Clara St ▪ Access to Eurimbla Avenue will be restricted to Left In Left Out
Buses	Bus services will be affected in the following way: ▪ Right turn movements out of Clara Street will now be under signal control ▪ An intended bus bay for westbound buses on High Street will be introduced adjacent to the Adult hospital ▪ The westbound bus stop adjacent to the Children's Hospital emergency entrance will be relocated to Clara Street, with access to the hospital via a signalised intersection ▪ An indented bus bay for westbound buses will be provided on High Street between Botany St and Wansey Rd adjacent to UNSW . ▪ 800m spacing between eastbound bus stops utilised by the 370 and 372, an increase of approximately 500m.
Property accesses	Most property access arrangements will be restricted to left-in-left-out operation with the exception of the right turn accesses into the hospital, which will be maintained. This requires reconfiguration of the existing access configurations
On-Street parking	There are will be no provision for parking on High Street between Wansey Road and Belmore Road
Loading/unloading	There are will be no provision for parking on High Street between Wansey Road and Belmore Road during light rail operational hours.
Pedestrian access	Pedestrian crossing facilities will be provided at the new signalised intersections with: ▪ Wansey Road ▪ Hospital Road ▪ Clara Street ▪ Belmore Road Existing zebra crossings will be replaced by the new signalised pedestrian crossings.
Cyclist access	No dedicated cycle facilities will be provided on High Street. An alternative on-road cycle route would be established on Arthur Street to provide cyclist access to the Randwick town centre, and to link with the on-road Botany Street and off-road Wansey Road cycle routes.
Taxi zone	There is no provision for a taxi rank on High Street between Wansey Road and Belmore Road. However space(s) could be allocated within the reconfigured porte cochere subject to consultation.

5.4.5.4. Randwick interchange

The light rail and bus interchange, located adjacent to High Cross Park at Randwick will be a critical transport interchange that provides an integrated, seamless modal change between bus and light rail for public transport passengers. A summary of the functional changes to the road network required to accommodate the light rail terminus at Randwick along with a summary of the likely impacts is provided below.

Functional changes

The interchange is located within the civic precinct of Randwick as well as servicing the Prince of Wales Hospital and surrounding residential and retail areas. The terminus will also serve a wider catchment of the South Eastern suburbs extending to Coogee and Maroubra through interconnecting bus services.

It is expected that this interchange will achieve high patronage in the AM and PM peak periods. The interchange has been designed for compatibility and future capacity requirements for the South East bus network, as described in Section 4.

The design provides two 45m light rail platforms on the eastern side of High Cross Park, optimised for passenger interchange with AM peak period buses. The eastern platform will operate as a cross-platform bus-light rail interchange, providing for efficient transfer of passengers in the AM peak.

Figure 5-24 and Figure 5-25 present the proposed bus operating volumes and stopping arrangements in both peak periods. The 45m platforms will allow for an additional bus lane within Cuthill Street, providing for an additional bus zone to service the PM peak buses. This creates a short walk across High Cross Park for interchanging passengers in the PM peak.

Figure 5-24: Randwick Interchange AM Peak

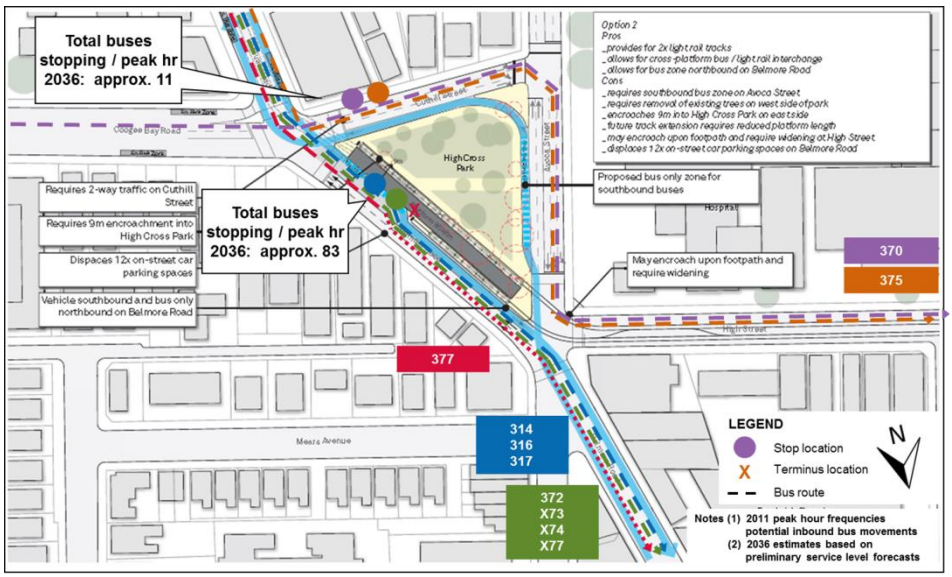
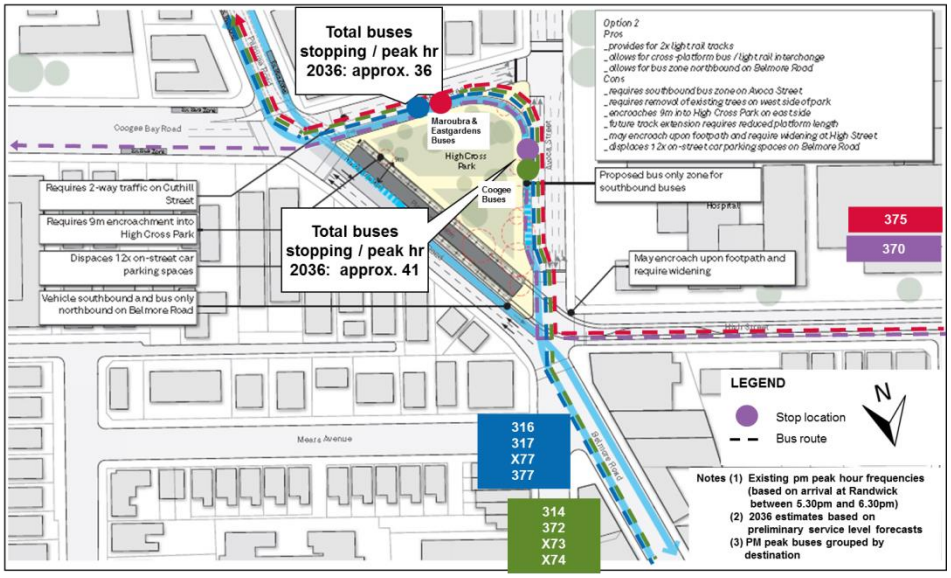


Figure 5-25: Randwick Interchange PM Peak



The proposed design provides a safe, highly efficient passenger interchange in both AM and PM peak periods.

Opportunities exist to fully integrate the interchange within the existing park – partially offsetting the impact of construction with improvements such as new tree planting, a public plaza and new landscaping. This is an opportunity to create an active 'transit park' integrated with Randwick's civic, retail and health precinct.

Proposed network characteristics

An outline of the effects the proposed functional changes at the Randwick interchange will have on road network uses is provided in Table 5-12.

Table 5-12: Randwick Interchange Future network characteristics

Use	Future network characteristics
General traffic	▪ Belmore road will be made two-way with the following restrictions: ○ bus only in a northbound direction ○ southbound only for general traffic ▪ Right turn from High Street into Avoca Street will be bus only
Property accesses	▪ Accesses to properties on Belmore Road will be retained as left-in-left-out movements
On-Street parking	▪ Parking on Belmore Road will be lost during peak hours ▪ Existing parking controls retained on Cuthill street
Loading/unloading	▪ No designated loading zones currently within the vicinity of the interchange, but may be introduced as part of parking strategy (see section 7)
Pedestrian/cyclist access	▪ Improved crossing facilities to be provided at the Avoca St/High St/ Belmore intersection.
Taxi zones	▪ No existing taxi zones in the vicinity of the interchange

5.4.6. Rozelle stabling & maintenance facility

The Rozelle maintenance facility is located at the former goods and marshalling yard in Lilyfield, situated adjacent to the existing Lilyfield Light Rail Station. The site is bounded by Lilyfield Road and Citywest Link with mainly residential developments and a mixture of light industrial developments east and south. Based on the Final Fleet Stabling Requirements and Operating Protocols Report prepared by the Light Rail Network Operations and Management Service Provider (Interfleet), it is proposed that maintenance work on light rail vehicles would be undertaken at the Rozelle maintenance facility. The facility would accommodate maintenance facilities to cater for both CSELR and Inner West light Rail operations including:

- Office space;
- Staff facilities;
- An 800 m^2 storage area;
- Plant rooms; and
- Approximately 50 car parking spaces.

An internal road network would cater for independent heavy vehicle movement and be designed to RMS and AS standards and guidelines.

Lilyfield Road adjacent to Catherine Street was formally a major collector road, prior to the installation of the City West Link. Since then, traffic volumes have considerably reduced and the road re-classified to local road status with load restrictions. Traffic volume on Lilyfield Road is significantly lower than City West Link and operates well within its available capacity. At present, parking is permitted along both sides of the street with a large number of Light Rail commuters parking along the southern side of the street. Spanning the entire length of Lilyfield Road are on-street cycle lanes connecting Hawthorne Canal and Anzac Bridge and is well utilised by cyclists during peak periods.

Vehicle access to the facility and adjacent commercial properties within the rail corridor would be maintained via the existing driveway located on Lilyfield Road, east of Catherine Street and the existing internal site access road. The existing driveway located on Lilyfield Road historically accommodated heavy vehicle movements for the purposes of hauling freight and materials to / from Lilyfield Road. As such, the existing vehicular crossing can be adapted for use during both construction and operation of the maintenance facility. The majority of vehicle movements, especially heavy vehicles, would be via the City West Link, with vehicles accessing Balmain Road and Catherine Street for movements in and out of the site. Given the proximity of these links and the low traffic volumes currently on Lilyfield Road, the traffic impact of additional traffic generated by the maintenance facility along Lilyfield Road would be limited.

During the operation of the maintenance facility, peak traffic generation would be attributable to periods of shift changeovers where staff vehicles would be entering and exiting the site. To ensure efficient operation of the system, parking for staff vehicles would be accommodated internally, with approximately 50 parking spaces provided for both staff and visitors. This would be sufficient to accommodate all traffic generated by the maintenance facility and therefore, impact on adjacent on-street parking provisions would be minimal.

Furthermore, as the development of the maintenance facility at Rozelle would wholly be contained within the former good and marshalling yard with minimal changes to the existing access arrangements, it is considered that the traffic impacts on pedestrians, cyclists, existing light rail users and other road users would be minimal

5.4.7. Property access

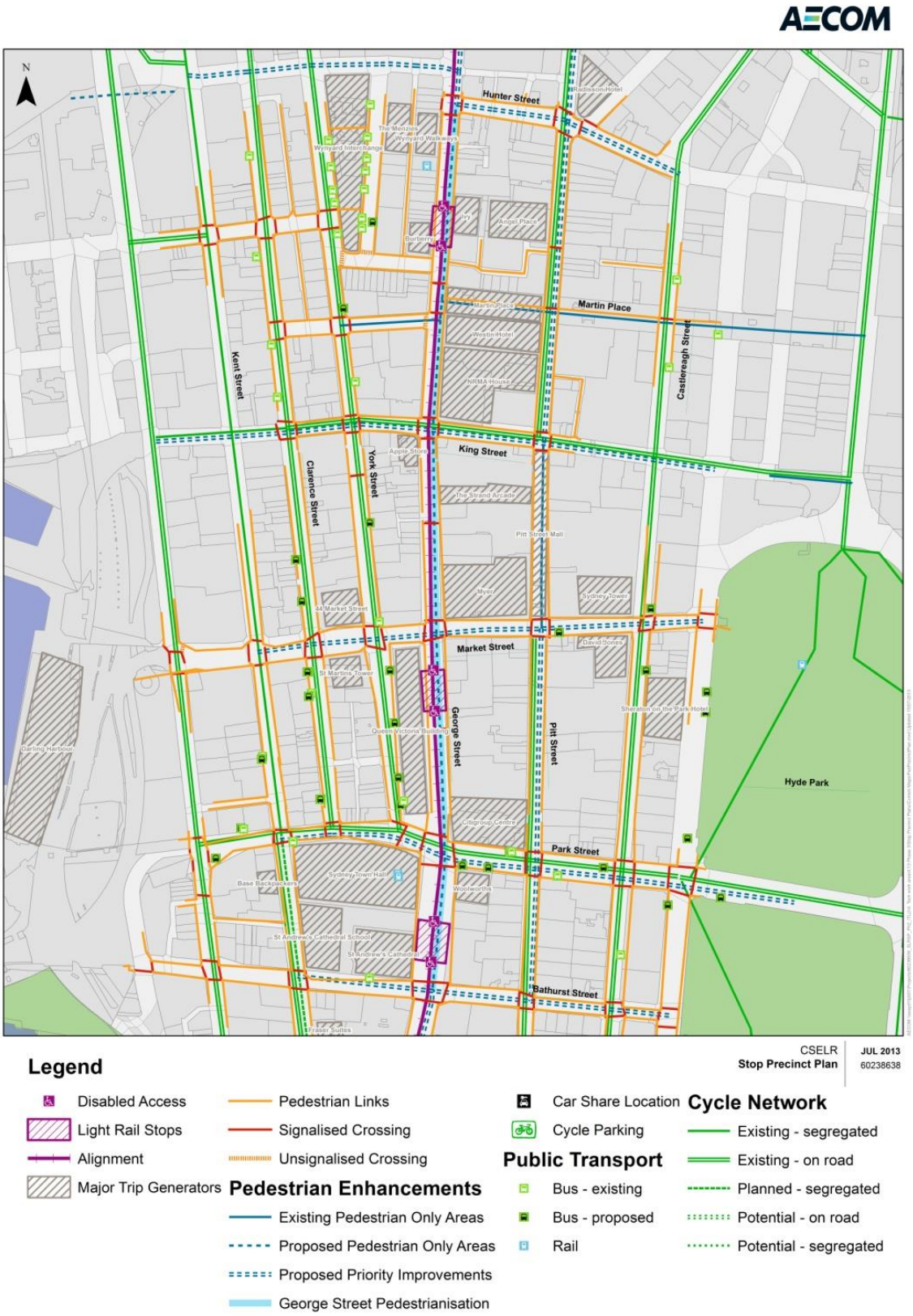
With the introduction of light rail, there are changes to the existing road capacity and new provisions proposed for the operation of general traffic and commercial vehicles within the corridor. Vehicles entering or leaving private driveways have the potential to impact light rail operations and when undertaking turning movements across the alignment represent a safety hazard. In order to manage these impacts effectively, the following measures are proposed for the treatment of private and commercial vehicle driveways within the light rail corridor:

- General traffic access to the pedestrianised section of George Street between Bathurst Street and Hunter Street will be under restrictions to be developed as part of the city centre access plan. No Entry controls with appropriate exceptions for residents, light commercial deliveries, emergency vehicles and taxis.
- Introduction of restricted operating hours for heavy vehicles to the existing accesses within the pedestrianised section of George Street between Bathurst Street and Hunter Street. Heavy vehicles would be subject to time restrictions between 11-2pm to minimise risk to lunch time crowds, while further restrictions may be appropriate in the light rail peak operation periods. Articulated trucks will not be permitted at any time.
- Maintain taxi access to key hotels and other areas within the light rail corridor.
- Where feasible limit driveway accesses to left in / left out arrangements.
- Access for emergency vehicles will be maintained at all times. Emergency vehicle access is required to all building frontages along George Street. In the event of fire, access for snorkel appliances for building evacuation and/or fire fighting would require the ability to position the vehicle at the frontage.
- These controls will result in some increased travel distances for service vehicles as their approach routes will be affected by the right turn bans. However all accesses onto the corridor will be maintained. Any controls would be subject to further consultation between the affected parties, Transport for NSW and the appropriate local council (City of Sydney Council or Randwick Council).

5.4.8. Pedestrians and cyclists

Sustainable travel modes such as walking and cycling will benefit from the light rail scheme, particularly in the newly pedestrianised area of George Street. Integration of these networks with light rail is essential to developing a sustainable transport solution. Section 7 details how each of the stops will be integrated with these travel modes and Figure 5-26 below highlights the key connections in the pedestrianised zone.

Figure 5-26: Pedestrian & cyclist integration in the pedestrianised zone



Pedestrians

With the introduction of light rail alignment along CBD and south-eastern suburbs, trips made by light rail will generate additional pedestrian flows along the proposed corridors. As part of the light rail project, pedestrian facility improvements will be provided on the corridor and the existing pedestrian access points will be retained. The Sydney City Centre Access Strategy will further develop the pedestrian and cycle network in the CBD to ensure integration with light rail.

The pedestrianisation of Alfred Street and George Street between Hunter and Bathurst Streets will provide safe pedestrian access, with only local access & service vehicles (during restricted hours) and emergency vehicles permitted along this section. Pedestrian analysis undertaken in the pedestrianised zone and shown in Table 5-13 demonstrates the improved level of service pedestrians will experience as a result of the light rail project. A number of intersections that currently experience extensive congestion and crowding at LoS F (such as George Street / Market Street) will operate at LoS C or better which will result in improved pedestrian amenity, safety and reduced journey times.

This is a significant improvement given up to 80% of the total traffic that passes through these intersections are pedestrians. Such an improvement to the CBD pedestrian environment will also contribute to the NSW 2021[113] goal 8, which specifies a target to "Increase the mode share of walking trips made in the Greater Sydney region, at a local and district level, to 25% by 2016".

[113] NSW Government, *NSW 2021 A Plan to Make NSW Number One*, *2011*

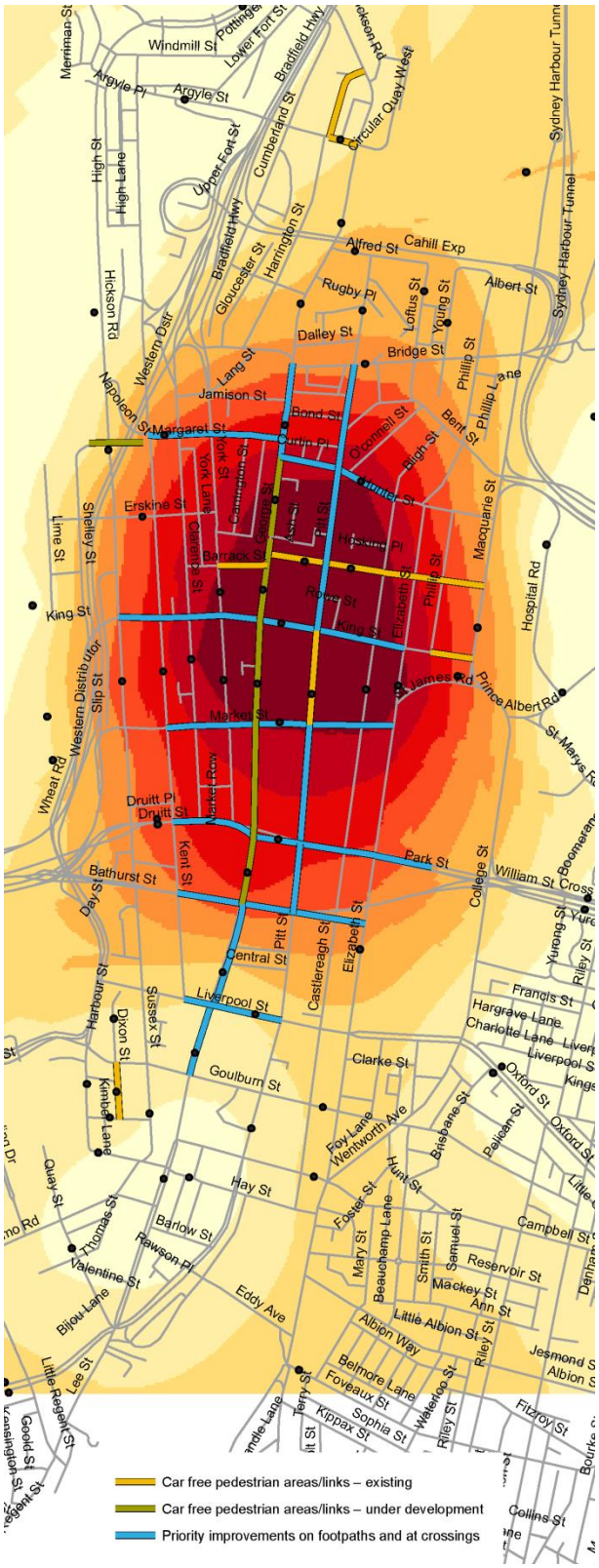
Table 5-13: Pedestrian peak hour LoS analysis

Intersection	Corner	Pedestrian Analysis			
		Existing		Proposed	
		LoS	Waiting Area	LoS	Waiting Area
Hunter Street / George Street	NW	D	25	D	25
	NE	E	20	D	25
	SE	F	20	C	60
	SW	E	25	C	45
King Street / George Street	NW	D	20	C	35
	NE	D	20	C	35
	SE	E	20	C	45
	SW	D	25	A	80
Market Street / George Street	NW	E	25	C	50
	NE	F	20	C	45
	SE	F	20	C	60
	SW	F	20	C	60
Park Street / George Street	NW	C	25	A	55
	NE	C	25	A	60
	SE	C	25	A	115
	SW	C	30	A	130
Bathurst Street / George Street	NW	D	20	A	70
	NE	B	30	A	65
	SE	B	35	A	100
	SW	E	20	C	45

As illustrated in Figure 5-26 priority improvements, by way of signalised pedestrian crossing facilities, will be provided on all arms of existing signalised intersections to provide controlled crossing points of the light rail alignment. This provides protection and improved amenity for visually, hearing or mobility impaired pedestrians.

The wider CBD improvements proposed as part of the CCAS are illustrated in Figure 5-27 and Figure 5-28 to cater for the CBD areas with greatest pedestrian demand. The CSELR project contributes to this wider strategy through the transformation of the George Street corridor.

Figure 5-27: CBD Pedestrian activity areas and proposed improvements[114]



[114] Transport for NSW, *(Unpublished Analysis), 2013*

Figure 5-28: Proposed pedestrian improvement corridors[115]

[115] Transport for NSW, *(Unpublished Analysis), 2013*

Cyclists

The proposed light rail stations and associated pedestrian / cyclist improvement developments around the corridor would create significant opportunities to encourage cycling for short trips to key destinations including employment, residential, health and educational precincts in the vicinity of the light rail stations. Whilst cycle routes along the light rail corridor will be impacted, all will be relocated and the reduction in private vehicle trips that will occur as a result of implementing light rail will create an improved cyclist environment in the wider network. The strategic bicycle network within Sydney CBD is illustrated in Figure 5-29 below.

Figure 5-29: Proposed Bicycle Network surrounding the George Street Light Rail Corridor[116]

[116] Transport for NSW, 2013

As illustrated in Figure 5-29, the proposed strategic cycleway network provides cycleway access within and through the CBD avoiding George Street and thus interaction with light rail operations. The as yet undetermined route between Prince Alfred Park and Elizabeth Street will not be precluded by light rail.

5.5. Road network performance assessment

5.5.1. Methodology

Implementation of light rail on the defined corridor, along with the wider associated bus network changes in the CBD and South Eastern suburbs (as discussed in Section 4), will result in a considerable change to current traffic operating patterns. The light rail project objective is to provide a step change in public transport carrying capacity and journey time reliability that is achieved through reallocation of available road space and providing segregated running of light rail wherever possible. As such a likely outcome of the Project is that existing traffic on the light rail corridor will be displaced. This traffic will adopt one of three alternative behaviours:

- **Change Mode** – Current road users could be expected to change mode from private vehicles to public transport, taking advantage of the reduced journey times and improved reliability the light rail system will provide through the CBD.
- **Change time of travel** – Increasingly flexible working arrangements provide some commuters with the ability to adjust their time of travel to avoid the most congested periods of the day.
- **Reroute to other corridors** – Displaced traffic will seek alternative routes that provide a lower level of delay. However, given much of the network is congested during the peak hours, alternative options are likely to be limited.

Development of a modelling methodology required the above behaviours to be considered, and quantified whilst also providing a tool to provide feedback to the design development process.

As such a two tiered approach has been adopted during the Project life cycle to first address localised design issues and secondly identify the wider network effects.

- Tier 1 – localised design assessment
- Tier 2 – future network assessment

Each of these Tiers is explained in more detail below.

5.5.1.1. Tier 1 - localised design assessment

As part of the Project design process localised intersection models have been developed in areas requiring analysis of traffic performance. These models were developed prior to future year traffic forecasts being available for the light rail project. As such the models use 2011 traffic volumes which enabled relative performance of design options to be assessed, but does not provide accurate future intersection statistics such as level of service to be produced. This first tier of assessment utilised the following modelling packages:

- LinSig – the primary modelling tool used to assess co-ordinated signal operations on sections of the corridor. These models were based on those produced for the SLRSP Milestone 5 report
- SIDRA – used to assess a number of isolated intersection operations and optimise designs

- VISSIM – a single microsimulation model was produced to assess the impacts of an at grade light rail crossing of South Dowling Street in the Surry Hills precinct. This was used due to its ability to model light rail priority through selective vehicle detection and signal actuations

5.5.1.2. Tier 2 – future network assessment

To provide analysis on future network and corridor operations with the introduction of light rail, a second stage of modelling was undertaken by TfNSW.

The modelling platform proposed includes the development of an area wide mesoscopic model with a large part modelled using a hybrid model concept. The hybrid simulator concept allowed for dynamic simulation of an area large enough to account for regional route diversion (as shown in Figure 5-30), as well as micro-simulation modelling of smaller pockets that require representation of individual vehicle dynamics in the detailed road network.

Figure 5-30: Mesoscopic Model Area

5.5.2. South Dowling Street at grade crossing

VISSIM modelling of South Dowling Street between Cleveland Street in the south and Fitzroy Street in the north was undertaken to test the impact of an at grade Light Rail crossing of South Dowling Street. The modelled network consists of South Dowling Street/Cleveland Street, South Dowling Street/Moore Park Road/Fitzroy Street and pedestrian crossings located between these intersections as shown in Figure 5-31.

Figure 5-31: Modelled Network

The AM and PM peak periods were identified as the periods where the greatest midblock northbound/southbound volume was experienced along South Dowling Street between Fitzroy Street and Cleveland Street. The volumes were extracted from SCATS flow data received for Wednesday the 21st of November 2012. The AM peak was identified as 6:15 – 7:15 AM, while the PM peak was identified as 15:45 – 16:45.

It should be noted that the peak periods identified may not be consistent with the peaks for the intersections. However, these periods were chosen due to the maximum midblock volume occurring on South Dowling Street, which would have the greatest impact on the Light Rail crossing. Traffic signal timings for the AM and PM peak hour models were based on SCATS IDM data provided for the 15th of April 2013.

In the Light Rail scenario models, provision of a Light Rail crossing was assumed near the existing southernmost pedestrian crossing and adjacent to Olivia Gardens.

5.5.2.1. Key model assumptions

The following key assumptions were adopted in the models:

- Based on IDM data the existing pedestrian crossing was called (on average) every third cycle of the South Dowling Street/Cleveland Street traffic signals
- Based on existing (2012) traffic volumes. Future traffic patterns likely to be affected by light rail and should be assessed once wider area modelling by Transport for NSW is available
- No Special Events traffic volume data available at this stage, further analysis of special event traffic conditions may be required
- Frequency of Light Rail: every 2 minutes in each direction with element of variability in arrival pattern
- Assumed Light Rail Line Speed: 30km/hr
- Length of modelled Light Rail car: 45 metres
- No Priority Option: Phase for Light Rail is called only during green phase for Cleveland Street at the South Dowling Street/Cleveland Street intersection (Phase D)
- Medium Priority Option: Phase for Light Rail is called at any time during Phases D, E and F at the South Dowling Street/Cleveland Street intersection
- Special Event Option: 90m Light rail vehicles were tested in the PM peak only under the medium light rail signal priority. No AM peak modelling was undertaken for this scenario as special event, 90m shuttles, will only coincide with the PM peak hour.

5.5.2.2. Model output parameters

Comparison of the Base and Scenario models was undertaken using the following statistics:

- Vehicle travel times on South Dowling Street (northbound and southbound)
- Vehicle maximum queue lengths, and
- Intersection Level of Service
- Delay experienced by Light Rail
- Green time distribution at the Light Rail intersection

5.5.2.3. Model results

Table 5-14 to Table 5-18 detail the network performance statistics for the network.

Table 5-14 compares vehicle travel times along South Dowling Street under existing conditions with the expected travel times with the introduction of light rail under the “no priority” and “medium priority” scenario (during both the AM and PM peak).

Table 5-14: Comparison of vehicle travel times (seconds)

	AM peak			PM peak			Special Events
Travel time (s)	Base	No Priority	Med. Priority	Base	No Priority	Med. Priority	
South Dowling Street NB	107	111	114	132	136	132	138
South Dowling Street SB	97	99	106	109	106	115	122

Table 5-13 indicates that (relative to existing operation (i.e. base)) under the medium priority scenario vehicle travel times on South Dowling Street experience a 7% increase in the AM peak and show no change in the PM. Under the special event scenario the PM peak travel times increase further, showing a 5% increase when compared to existing operation.

Table 5-15 compares the maximum queue lengths at key intersections under existing conditions with the queue lengths expected with the introduction of light rail under the "no priority" and "medium priority" scenario.

Table 5-15 indicates that maximum queue lengths at the South Dowling Street/Cleveland Street intersection and South Dowling Street/Moore Park Road/Fitzroy Street intersection can be seen to be unaffected by the light rail crossing. Maximum queue lengths on the integrated Light Rail/Pedestrian crossing can be seen to increase up to maximum of 158m in the Special Event Scenario. These queue lengths can be contained within the existing storage space available and does not impact upon network operations.

Table 5-15: Comparison of Maximum queue lengths (m)

	AM peak			PM peak			Special Events
Queue lengths (m)	Base	No Priority	Med. Priority	Base	No Priority	Med. Priority	
South Dowling Street NB	233	232	231	219	224	218	214
Cleveland Street EB	130	126	133	118	114	116	117
South Dowling Street SB	71	78	78	144	130	158	135
Cleveland Street WB	224	225	225	128	126	122	126
Pedestrian Crossing NB	29	96	158	65	85	122	139
Pedestrian Crossing SB	20	55	63	49	112	109	119
South Dowling Street NB	122	99	118	93	81	84	73
South Dowling Street SB	39	39	39	80	78	78	78
Moore Park Road	97	95	95	114	104	108	105

Table 5-16 compares the level of services for key intersections under existing arrangements with the expected level of service assuming the introduction of light rail for both the "no priority" and "medium priority" scenario. Table 5-16 indicates that intersection levels of service are largely unaffected by the introduction of light rail.

Table 5-16: Comparison of Level of Service

	AM peak			PM peak			Special Events
Level of Service	Base	No Priority	Med. Priority	Base	No Priority	Med. Priority	
S. Dowling/ Cleveland Intersection	D	D	D	C	C	C	C
Pedestrian Crossing/LR Intersection	A	A	A	A	A	A	A
S. Dowling/Moore Intersection	B	B	B	B	B	B	B

Table 5-17 compares the average delay experienced by light under the "no priority" and "medium priority" scenario. Table 5-17 illustrates that the level of delay experienced by light rail varies considerably depending upon the level of priority offered. Delays of between 11-23 seconds can be achieved with a medium level of priority that maintains traffic coordination of the key north-south intersections. Under the Special Events scenario this delay decreases further to 4-9 seconds as a result of the longer green times provided at the crossing (see Table 5-18 below).

Table 5-17: Comparison of Average Delay experienced by Light Rail (seconds)

	AM peak			PM peak			Special Events
Delays	Base	No Priority	Med. Priority	Base	No Priority	Med. Priority	
Light Rail EB	N/A	44	20	N/A	46	11	9
Light Rail WB	N/A	53	22	N/A	54	23	4

Table 5-18 outlines the green time distribution during the traffic phase and light rail phase for both the "no priority" and "medium priority" scenario.

Table 5-18: Comparison of green time distribution on Light Rail intersection

	AM peak			PM peak			Special Events
Green distribution (s)	Base	No Priority	Med. Priority	Base	No Priority	Med. Priority	
Traffic phase	120	98	59	120	98	50	58
Light Rail phase	N/A	19	22	N/A	21	21	38

5.5.2.4. Conclusions

Analysis of above results shows that introduction of a signalised, at grade crossing for light rail marginally affects current performance of the road network. Introduction of the crossing does

increase traffic journey times by up to 7% in this section of the road network, but intersection levels of service and queue lengths are not significantly affected.

It should be noted that further analysis using special event traffic volumes and post light rail traffic assignments would provide a greater level of certainty to the road network impacts.

5.5.3. Network assessment

The reallocation of road space from traffic lanes to dedicated light rail running will result in a change to existing traffic patterns and network performance on and around the light rail corridor. These impacts have been assessed and determined through a mesoscopic modelling assessment undertaken by TfNSW. The following data, findings and mitigation measures are based on the initial modelling analysis undertaken by TfNSW. The modelling and analysis is subject to on-going development and consultation with RMS as the road network is refined for operation with CSELR.

5.5.3.1. Network performance measures

Global performance

The high level network statistics provide a good indication of how the network performs and these can be defined in terms of average speed, vehicle hours travelled (VHT) and vehicle kilometres travelled (VKT) for all vehicles in the network in the defined study area. Such statistics enable a relative comparison to be made between the 'with' and 'without' Light Rail scenarios. Increases in VKT indicate that vehicles are travelling longer distances to avoid congestion and thus minimise delay. Increases in VHT indicate increased delays and build-up of congestion in the network.

In addition, the number of vehicles that passed through and waiting outside the network can provide an indication of the ability of modelled road network to cater for future demands.

Network traffic volumes

The introduction of Light Rail results in a reduction in traffic capacity on several key roads within the CBD and south-east suburbs, including George Street, Rawson Place, Chalmers Street / Elizabeth Street, Devonshire Street, Anzac Avenue and Alison Road. Traffic volume changes on roads are an indicator of traffic redistribution resulting from traffic 'hot spots'.

Network speeds

Complementary to traffic volumes changes, variations to the travel speeds by road segment throughout the network were also assessed. This is a measure of congestion on various roads as indicated by low operating speeds.

Intersection delays

The intersection average delay is the primary criteria for assessing the level of service (LOS) for signalised intersections. The intersection average delay is calculated in the model by determining the average delay for each approach to the node.

5.5.3.2. 2021 assessment year and demand development

An assessment year of 2021 was adopted for consistency with TfNSW's Public Transport Project Model (PTPM) and the Freight Movement Model (FMM). These models provided the basis for future road network demand that was used as a direct input to the mesoscopic modelling. The resulting traffic demand is shown in Figure 5-32. These demand totals indicate there is a 7% increase in traffic demand between 2012 and 2021 without the introduction of Light Rail, and only

a 6% increase in the same period with the introduction of Light Rail as a result of increased public transport usage.

It should be noted that due to the level of congestion in the PM peak model, a flat demand profile across the 4 hour period has been assumed. This reflects peak spreading, which is a common driver response to increased congestion during peak periods.

Figure 5-32: Traffic demand [117]

Table 3.1: Growth between 2012 and 2021 (AM four hour peak period)

Scenario	Total Demand	Difference to 2012 Base
2012 Base	286,400	
2021 No Light Rail	305,800	19,400 (7%)
2021 With Light Rail	302,300	15,900 (6%)

Table 3.2: Growth between 2012 and 2021 (PM four hour peak period)

Scenario	Total Demand	Difference to 2012 Base
2012 Base	335,200	
2021 No Light Rail	357,900	22,700 (7%)
2021 With Light Rail	353,900	18,700 (6%)

5.5.3.3. 2021 Do-minimum assessment

To provide a basis for comparative assessment of the future road network impacts of light rail a do-minimum scenario model was developed. This accounts for future traffic growth on the road network without the implementation of the light rail project. The network wide statistics are provided below in Figure 5-33 and Figure 5-34 and compared to the existing situation.

[117] Mesoscopic traffic modeling undertaken by Transport for NSW, 2013

Figure 5-33: 2021 Do-minimum network performance statistics – AM peak[118]

Statistic	2012 Base	2021 Do Minimum Scenario	% Change
Full Model Area			
VHT (8-9am)	11,045hrs	12,776hrs	16%
Normalised VHT (6-10am)	36,338hrs	43,642hrs	20%
VKT (8-9am)	364,316km	381,468km	5%
Normalised VKT (6-10am)	1,259,408km	1,314,229km	4%
Average Speed All (8-9am)	34.0km/h	31.4km/h	-8%
Normalised Average Speed All (6-10am)	34.6km/h	31.4km/h	-9%
Average Speed Bus (8-9am)	18.6km/h	22.2km/h	19%
Average Speed Bus (6-10am)	19.4km/h	22.6km/h	16%
Average Delay (8-9am)	64sec/km	74 sec/km	16%
Average Delay (6-10am)	56sec/km	68 sec/km	21%
Vehicles in Network (at 10am)	8,705	13,015	50%
CBD Cordon			
VHT (8-9am)	2,651hrs	3,103hrs	17%
VHT(6-10am)	8,216hrs	10,288hrs	25%
VKT (8-9am)	72,287km	73,738km	2%
VKT (6-10am)	243,603km	251,814km	3%
Average Speed All (8-9am)	27.2 km/h	23.8 km/h	-13%
Average Speed All (6-10am)	29.6 km/h	24.5 km/h	-17%
Average Speed Bus (8-9am)	10.5 km/h	13.5 km/h	29%
Average Speed Bus (6-10am)	10.9 km/h	13.4 km/h	23%
Vehicles in Cordon (at 10am)	2,112	2,912	38%

[118] Mesoscopic traffic modeling undertaken by Transport for NSW, 2013

Figure 5-34: 2021 Do-minimum network performance statistics – PM peak[119]

Statistic	2012 Base	2021 Do Minimum Scenario	% Change
Full Model Area			
VHT (5-6pm)	11,816hrs	15,433hrs	31%
Normalised VHT (3-7pm)	46,278hrsc	60,956hrs	32%
VKT (5-6pm)	370,895km	379,403km	2%
Normalised VKT (3-7pm)	1,429,419km	1,590,409km	11%
Average Speed All (5-6pm)	32.8km/h	28.3km/h	-14%
Normalised Average Speed All (3-7pm)	30.9km/h	26.1km/h	-16%
Average Speed Bus (5-6pm)	16.8km/h	15.4km/h	-8%
Average Speed Bus (3-7pm)	17.2km/h	16.8km/h	-2%
Average Delay (5-6pm)	70sec/km	106sec/km	51%
Average Delay (3-7pm)	69sec/km	99sec/km	43%
Vehicles in Network (at 7pm)	12,057	22,616	88%
CBD Cordon			
VHT (5-6pm)	2,894hrs	4,236hrs	46%
VHT(3-7pm)	10,829hrs	15,031hrs	39%
VKT (5-6pm)	71,778km	71,558km	0%
VKT (3-7pm)	278,874km	279,102km	0%
Average Speed All (5-6pm)	24.8km/h	16.9 km/h	-32%
Average Speed All (3-7pm)	25.7km/h	18.6 km/h	-28%
Average Speed Bus (5-6pm)	9.6km/h	7.4 km/h	-23%
Average Speed Bus (3-7pm)	9.9km/h	8.0 km/h	-19%
Vehicles in Cordon (at 7pm)	2,296	5,443	137%

These statistics clearly demonstrate that by 2021, without the implementation of light rail, the Sydney road network will experience significant increases to delay and congestion compared to existing levels as a result of the forecast increase in traffic demand on the network. Key statistics include a:

- A significant increase of between 4,000 to 10,000 vehicles retained in the network at the end of the peak periods. This indicates that there is a significant shortfall in network capacity that prevents these vehicles from completing their trip by the end of the peak periods.
- 17% reduction in general traffic speeds in the CBD and a 9% reduction in the wider network during the AM peak.
- 23% increase to bus speeds in the CBD and a 16% increase outside the CBD as a result of the do minimum bus changes that would be implemented if CSELR were not to be constructed. The additional improvements within the CBD cordon may also result from the increased congestion on the periphery of the network preventing vehicles from reaching the CBD therefore frees some capacity for buses.
- 28% reduction in general traffic speeds in the CBD and a 16% reduction in the wider network during the PM peak.
- 19% reduction in bus speeds in the CBD and a 2% reduction in the wider network during the PM peak as a result of increased traffic congestion.

[119] Mesoscopic traffic modeling undertaken by Transport for NSW, 2013

5.5.3.4. 2021 with light rail scenario

Network statistics

The network wide statistics of the with Light Rail scenario in 2021 are provided below in Figure 5-35 and Figure 5-36 with a comparison provided to the 2021 Do Minimum scenario.

Figure 5-35: 2021 light rail network performance statistics – AM peak[120]

Statistic	2021 Do Minimum Scenario	2021 Light Rail Scenario Model	% Change
Full Model Area			
VHT (8-9am)	12,776hrs	13,015hrs	2%
Normalised VHT (6-10am)	43,642hrs	43,155hrs	-1%
VKT (8-9am)	381,468km	383,269km	0%
Normalised VKT (6-10am)	1,314,229km	1,366,034km	4%
Average Speed All (8-9am)	31.4km/h	31.2km/h	-1%
Normalised Average Speed All (6-10am)	31.4km/h	31.6km/h	1%
Average Speed Bus (8-9am)	22.2km/h	21.1km/h	-5%
Average Speed Bus (6-10am)	22.6km/h	21.7km/h	-4%
Average Delay (8-9am)	74 sec/km	79 sec/km	7%
Average Delay (6-10am)	68 sec/km	70 sec/km	3%
Vehicles in Network (at 10am)	13,015	10,986	-16%
CBD Cordon			
VHT (8-9am)	3,103hrs	3,224hrs	4%
VHT(6-10am)	10,288hrs	10,115hrs	-2%
VKT (8-9am)	73,738km	74,141km	1%
VKT (6-10am)	251,814km	253,369km	1%
Average Speed All (8-9am)	23.8 km/h	23.0 km/h	-3%
Average Speed All (6-10am)	24.5 km/h	25.0 km/h	2%
Average Speed Bus (8-9am)	13.5 km/h	13.0 km/h	-4%
Average Speed Bus (6-10am)	13.4 km/h	13.6 km/h	1%
Vehicles in Cordon (at 10am)	2,912	2,677	-8%

The AM results indicate the following when compared to the 2021 Do Minimum:

Full Model Area:

- 2% increase in total time travelled by all vehicles
- 4% increase in total distance travelled by all vehicle
- Average speed for all vehicles decreases by 1% from 13.6km/h to 13.4km/h
- A decrease in average speed for buses from 22.6km/h to 21.7km/h (-4%)
- An increase in average delay for all vehicle from 68sec/km to 70sec/km (+3%)
- A 16% reduction in vehicles remaining in the network at the end of the AM peak.

The significant reduction in vehicles contained within the network indicates an overall increase in network capacity as a result of CSELR and the revised bus networks. The above results appear to indicate a 3-4% increase in delay to both buses and general traffic in the wider model area,

[120] Mesoscopic traffic modeling undertaken by Transport for NSW, 2013

however this will in part be due to the increased network capacity permitting additional vehicles to enter the network that were unable to do so in the Do Minimum scenario.

CBD Cordon:

- 2% reduction in total time travelled by all vehicles
- 1% increase in total distance travelled by all vehicles
- Average speed for all vehicles increases by 2% from 24.5km/h to 25.0km/h
- Average speed for buses increases by 1% from 13.4km/h to 13.6km/h
- An 8% reduction in vehicles remaining in the network at the end of the AM peak

In the CBD, a slight increase in the distance travelled by vehicles occurs as a result of changed circulation and diversion of traffic off George Street. However all other statistics demonstrate that the CBD operates more efficiently. Average bus and general traffic speeds are maintained whilst fewer vehicles remain in the network at the end of the AM peak period indicating an increased level of capacity.

Figure 5-36: light rail network performance statistics – PM peak[121]

Statistic	2021 Do Minimum Scenario	2021 Light Rail Scenario Model	% Change
Full Model Area			
VHT (5-6pm)	15,433hrs	14,540hrs	-6%
Normalised VHT (3-7pm)	60,956hrs	58,377hrs	-4%
VKT (5-6pm)	379,403km	379,212km	0%
Normalised VKT (3-7pm)	1,590,409km	1,584,329km	0%
Average Speed All (5-6pm)	28.3km/h	29.9km/h	6%
Normalised Average Speed All (3-7pm)	26.1km/h	27.1km/h	4%
Average Speed Bus (5-6pm)	15.4km/h	16.0km/h	4%
Average Speed Bus (3-7pm)	16.8km/h	16.6km/h	-1%
Average Delay (5-6pm)	106sec/km	96sec/km	-9%
Average Delay (3-7pm)	99sec/km	94sec/km	-5%
Vehicles in Network (at 7pm)	22,616	15,102	-33%
CBD Cordon			
VHT (5-6pm)	4,236hrs	3,630hrs	-14%
VHT(3-7pm)	15,031hrs	13,562hrs	-10%
VKT (5-6pm)	71,558km	71,054km	-1%
VKT (3-7pm)	279,102km	285,792km	2%
Average Speed All (5-6pm)	16.9 km/h	19.6km/h	16%
Average Speed All (3-7pm)	18.6 km/h	21.1km/h	13%
Average Speed Bus (5-6pm)	7.4 km/h	7.9km/h	7%
Average Speed Bus (3-7pm)	8.0 km/h	8.4km/h	5%
Vehicles in Cordon (at 7pm)	5,443	2,885	-47%

[121] Mesoscopic traffic modeling undertaken by Transport for NSW, 2013

The PM results indicate the following when compared to the base case:

Full Model Area:

- 4% reduction in total time travelled by all vehicles
- No change in total distance travelled by all vehicles
- An increase in average speed for all vehicles from 26.1km/h to 27.1km/h (4%)
- A decrease in average speed for buses from 16.8km/h to 16.6km/h (-1 %)
- A decrease in average delay for all vehicles from 99sec/km to 94sec/km (-5%)
- A 33% reduction in vehicles remaining in the network at the end of the PM peak

As with the AM peak, the PM peak modelling indicates a significant increase to the wider network capacity, with 7,000 fewer vehicles remaining in the network at the end of the peak period. This additional capacity is achieved with reduced average delay and increased speeds for general traffic and only a marginal reduction in bus speeds.

CBD Cordon:

- 10% decrease in total time travelled by all vehicles
- 2% increase in total distance travelled by all vehicles
- Average speed for all vehicles increases by 13% from 18.6km/h to 21.1km/h
- Average speed for buses increases by 5% from 8.0km/h to 8.4km/h
- A 47% reduction in vehicles remaining in the network at the end of the PM peak

The CBD experiences an even greater improvement to performance, with approximately half of the residual demand in the network at the end of the peak when compared to the Do Minimum. This improved level of capacity also results in improved speeds for buses (+5%) and general traffic (13%).

Traffic flow changes

The impacts of the proposed Light Rail network along with the new city centre bus network redesign result in a complex and varied change in traffic conditions throughout the average weekday.

These traffic pattern changes can be summarised as follows:

- Traffic accessing the CBD from Parramatta Road/Broadway is likely to divert to Wattle Street/Harris Street to access city via Western Distributor/King Street, William Henry Street/Pier Street and Ultimo Road to avoid George Street/Pitt Street where capacity has been reduced due to the Light Rail.
- Kent Street, Sussex Street and Clarence Street (for buses) will take on a higher order role for access to the northern CBD as well as access to the Harbour Bridge. There will be a need to consider the management of these streets in terms of an arterial function as opposed to local access function.
- Kent Street will take on a more important access role for the Rocks, Dawes Point, and Barangaroo.
- Castlereagh Street and Elizabeth Street will be subject to significant increased usage by general traffic and buses and there is a clear need to develop supplementary north south traffic corridors on the CBD eastern periphery such as Macquarie Street, College Street, and Wentworth Avenue, as per the SCCAP.

- Capacity reduction due to Light Rail along Devonshire Street and the Railway Square precinct is likely to see increased traffic filtering through Surry Hills via Campbell Street, Hunt Street, and Goulbourn Street.
- A east-west traffic diversion to Cleveland Street is forecast, which will call for a management plan to further improve the operation of this already congested corridor.
- In the north-south direction, there are diversions to the Cahill Expressway/Eastern Distributor to avoid the CBD surface road system.
- To the south in Kensington, Randwick and Kingsford, Light Rail implementation will require a number of turn restrictions in Anzac Parade as well as capacity reductions along the entire corridor. This results in forecast traffic diversions to the local street network.

To address the effects of these potential changed traffic patterns, TfNSW and RMS are working together to identify appropriate upgrade measures. These will be developed around the CCAS and associated priority corridors by mode. This work is on-going and includes additional modelling assessment at the strategic and operational levels to refine the optimal solution. This work will be completed prior to construction of CSELR commencing.

Intersection performance statistics

CBD & Surry Hills – light rail corridor

The CBD is subject to other major changes in its functionality as part of the CCAS, of which CSELR and the city centre bus network redesign form part. The CCAS and bus network redesign will undergo a separate public consultation process and therefore do not form part of the EIS for the CSELR. Due to the on-going work to define the network management approach at the intersection level, detailed assessment of the CSELR impacts has been restricted to the corridor, as shown in Table 5-19.

Table 5-19: CBD CSELR corridor intersection performance

Intersection	8-9AM		5-6PM	
	2021 Scenario 1		2021 Scenario 1	
	Delay	LoS	Delay	LoS
George St / Albert St	10	A	8	A
George St / Essex St	14	A	22	B
George St / Grosvenor St / Bridge St	37	C	42	C
George St / Bond St	46	D	71	F
George St / Hunter St	47	D	49	D
George St / King St	15	B	14	A
George St / Market St	39	C	31	C
George St / Park St / Druitt St	52	D	30	C
George St / Bathurst St	27	B	38	C
George St / Central St	6	A	12	A
George St / Liverpool St	12	A	19	B
George St / Goulburn St	12	A	32	C
George St / Campbell St	14	A	14	A
George St / Hay St	31	C	13	A
George St / Ultimo Rd	26	B	37	C
George St / Rawson Pl	55	D	57	E
Pitt St / Rawson Pl	81	F	57	E

Intersection	8-9AM		5-6PM	
	2021 Scenario 1		2021 Scenario 1	
Eddy Ave Crossing	55	D	4	A
Elizabeth St / Eddy Ave / Foveaux St	49	D	19	B
Devonshire St/ Chalmers St	27	B	35	C
Devonshire St/ Elizabeth St	30	C	41	C
Devonshire St/ Crown St	27	B	31	C
Devonshire St/ Bourke St	16	B	20	B

The above statistics demonstrate that of 23 key signalised intersections 22 will operate within capacity at an acceptable LoS (between A-D) in the AM peak, reducing to 20 in the PM peak. Those sites that are operating either at or over capacity are as follows:

- George Street / Bond Street – Is expected to operate at LoS F in the PM peak. This is due to increased demand on Bond Street making use of the westbound connection provided by Bond and Jamison Streets across the light rail corridor.
- George Street / Rawson Place – is expected to operate at LoS E in the PM peak. This is due to the competing bus light rail and traffic movements that occur at this intersection. Opportunities to optimise the phase timings will be investigated to provide improved performance.
- Pitt Street / Rawson Place – Is expected to operate at LoS F in the AM peak and LoS E in the PM peak. This is due to the provision of an additional right turn bus only phase to allow buses to turn right from Pitt Street into Eddy Avenue. The requirement for this phase is under review as part of the bus planning process and its removal would result in improved intersection LoS.