Veitch Lister Consulting Pty Ltd

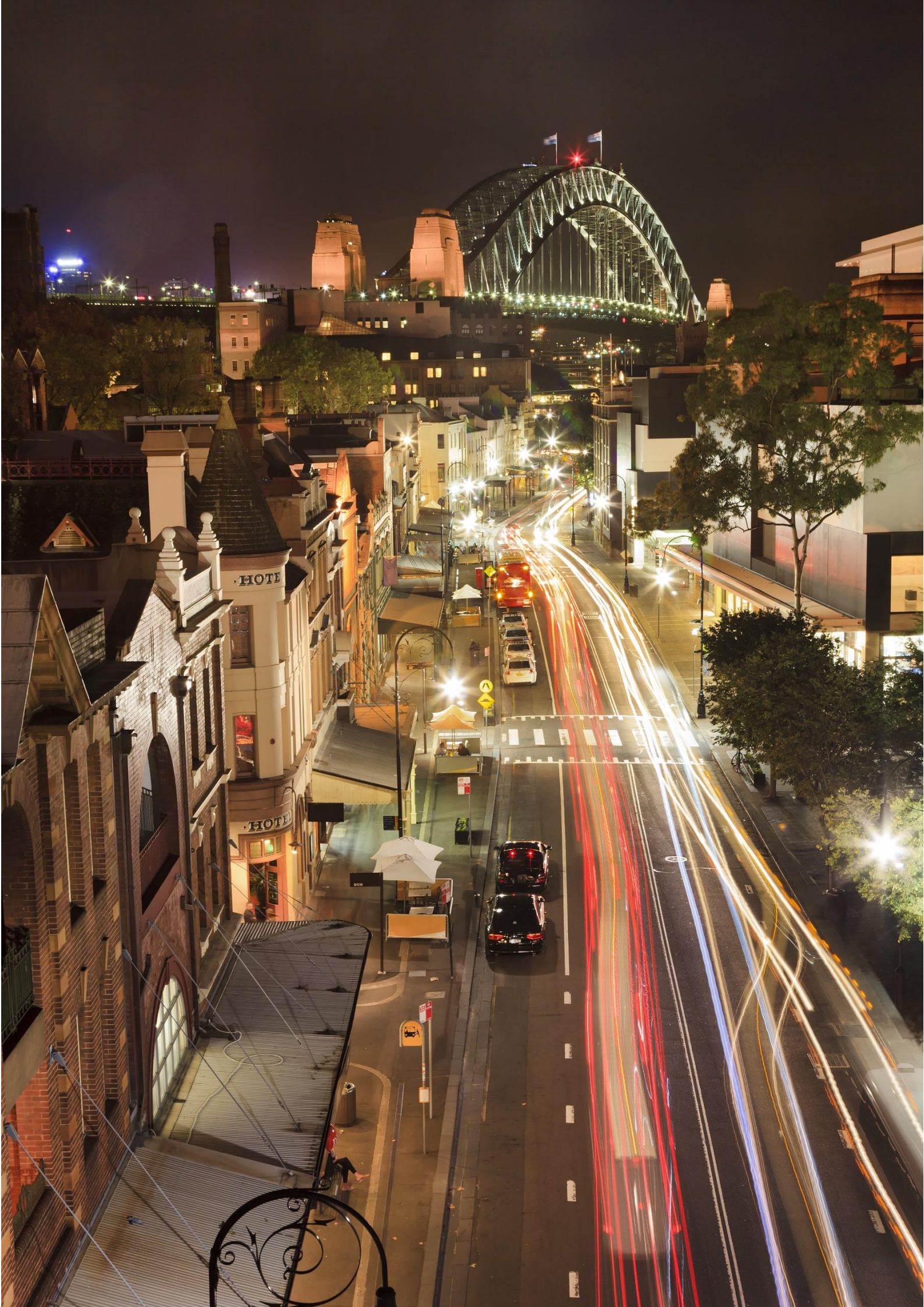
Prepared for

Australian Government
Infrastructure Australia

Transport Planning for the Australian Infrastructure Audit

Transport Modelling Report for Sydney

March 2019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Transport Planning for the Australian Infrastructure Audit

FINAL

Transport Modelling Report for Sydney

Project No. 18-025

Date	Revision	Prepared By	Checked By	Approved By	Description
12/10/2018	A	N Ng / A Mak	D Veryard	D Veryard	Draft Report
7/12/2018	B	N Ng	L Walker	D Veryard	Draft Report
07/12/2018	C	L Walker	L Walker	D Veryard	Draft Report
15/02/2019	D	N Ng	D Veryard	D Veryard	Final Draft Report
20/03/2019	E	N Ng	D Veryard	D Veryard	Final Report

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1. Introduction

1.1 Background

The first Infrastructure Audit, undertaken over 2014-15, for the first time provided evidence developed on a consistent basis to support the identification of current and emerging infrastructure problems. This helped IA to identify the most nationally significant problems that were not necessarily being identified or addressed by bottom-up state, territory and private sector proposals. Combining bottom-up submissions with top-down evidence developed through the Infrastructure Audit allows a more comprehensive and independent picture of national priorities.

Veitch Lister Consulting (VLC) supported the first Audit by modelling travel demands in six major mainland cities under base year (2011) and future year (2031) conditions using our multi-modal Zenith model. In the intervening four years, the landscape of Australian cities has changed considerably. New major transport projects have received significant political and financial commitment, while certain projects included in the original Audit have been cancelled or scaled down. Similarly, population growth has run ahead of projections in some urban areas but has slowed in other parts of the country.

It is important to note Infrastructure Australia does not view this modelling as a single version of the future. The modelling necessarily uses a set of assumptions about future projects, transport costs and technology. The chosen assumptions reflect a business as usual future, where there is minimal change to current conditions. However, in reality there is significant uncertainty about how these important inputs will change over time. The results in this modelling are therefore indicative and one of many potential futures.

1.2 Scope of this report

In response to these changed circumstances IA is updating their evidence base and VLC is assisting in this update by revising the travel modelling. Specific changes include:

- Updated future population and employment assumptions
- Revised transport system assumptions, including both networks and cost parameters
- Modelling with capacity-constrained public transport networks, and
- A wider range of transport-related indicators of success and challenges, including access to opportunities for employment, education, health and recreation, as well as the economic costs of crowding and road congestion.

This report summarises the results of this updated modelling for Sydney. Specifically, it evaluates the performance of Greater Sydney's transport network in 2031 based on an evaluation framework that includes transport, economic, environmental and social indicators.

VLC is also assisting IA to test an alternative road-user charging regime. The results of this alternative policy scenario will be documented in a separate report.

***A note on tables and figures in this report**:*

All tables and figures which quote numbers have been rounded to reflect that these forecasts are subject to considerable uncertainty. Where a numerical or percentage change has been quoted, it has been calculated using the unrounded data and then rounded appropriately. As such, the calculations are reflective of the actual data, not the other rounded numbers in the table.

2. Sydney in the future

Understanding how Sydney's transport network might perform in the future requires a detailed vision of what the region may look like at specific future planning horizons. The scale and distribution of population and job opportunities, upgrades to the transport network, as well as the cost of parking, public transport fares and fuel all require consideration in order to produce robust travel demand forecasts. This section of the report provides an overview of the assumptions underpinning the Zenith model of Greater Sydney. More detailed assumptions can be found in the appendices.

2.1 People and jobs

The number of people living and working in Sydney, as well as the locations in which they live and work, are the main determinants of the nature and scale of the city's transport task. In 2016, just over 5 million people resided in the Sydney Greater Capital City Statistical Area (GCCSA), an area covering the Central Coast, Hawkesbury and Blue Mountains, but not the Hunter Valley and Illawarra. Figure 2-1 describes the city's population in more geographic detail using two metrics – total population by Level 3 Statistical Area (SA3) and gross population density by travel zone.

The highest population densities are in eastern SA3 regions, such as Sydney Inner City, Eastern Suburbs and North Sydney - Mosman. Western inner SA3s, such as Parramatta, Auburn and Bankstown, also have relatively high densities, as a secondary CBD in Sydney. Conversely, outer SA3s are less dense in population. In absolute terms, Sydney Inner City is also the most populous SA3 (232,000 residents), followed by Fairfield (193,000 residents) and Bankstown (180,000 residents) in the west, and Kogarah – Rockdale in the south (145,000 residents).

Beyond the Sydney GCCSA, relatively high population density areas are contained in the narrow coastal strip between Stanwell Park and Nowra to the south, and the Central Coast to Newcastle in the north (Figure 2-1).

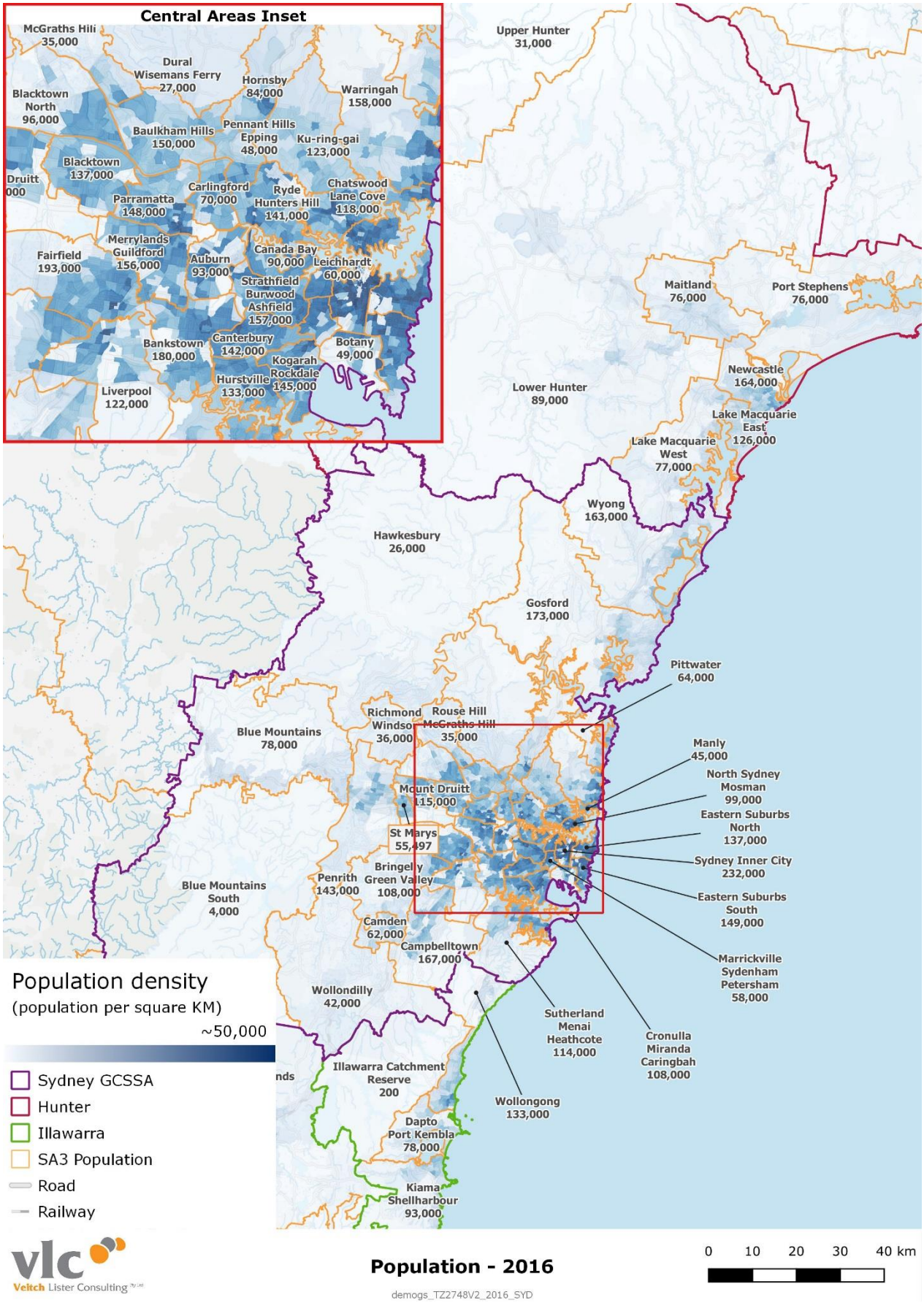
By 2031, NSW Government projections indicate that Sydney GCCSA's population will increase by 27 per cent to almost 6.4 million, an increase of just over 1.3 million from 2016 (Figure 2-2). Already relatively high population densities in Sydney Inner City and the Eastern Suburbs are expected to attract further population growth (Figure 2-3). Substantial increases in population are expected in western SA3s, particularly in Bringelly – Green Valley (123%), Rouse Hill – McGraths Hill (104%), Blacktown North (89%) and Parramatta (46%), which reflects the NSW Government's plan to develop the northwest and southwest regions, construction of Western Sydney Aerotropolis, as well as further development of Parramatta as part of the Greater Sydney Commission's (GSC) plan for a Metropolis of Three Cities[1]. Other inner areas comprising Metropolitan Sydney are forecast to experience a more modest population growth in line with overall population growth, including Kogarah – Rockdale in the south, and Ryde and Hornsby in the north. The Eastern Suburbs and Northern Beaches, as well as much of Sydney's fringe, are expected to have more limited growth.

Beyond the Sydney GCCSA, Newcastle is the only SA3 expected to experience large population growth, with 33,000 extra people by 2031. Areas in the southern end of the Illawarra (Kiama – Shellharbour and Dapto – Port Kembla) and north of Newcastle (Maitland and Port Stephens) are

[1] NSW Greater Sydney Commission. (2018). *Greater Sydney Region Plan – A Metropolis of Three Cities.* Retrieved from https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/greater-sydney-region-plan-0618.pdf?um1yQVuoNxc4QgC4oBK1neLtLPaiKNk8

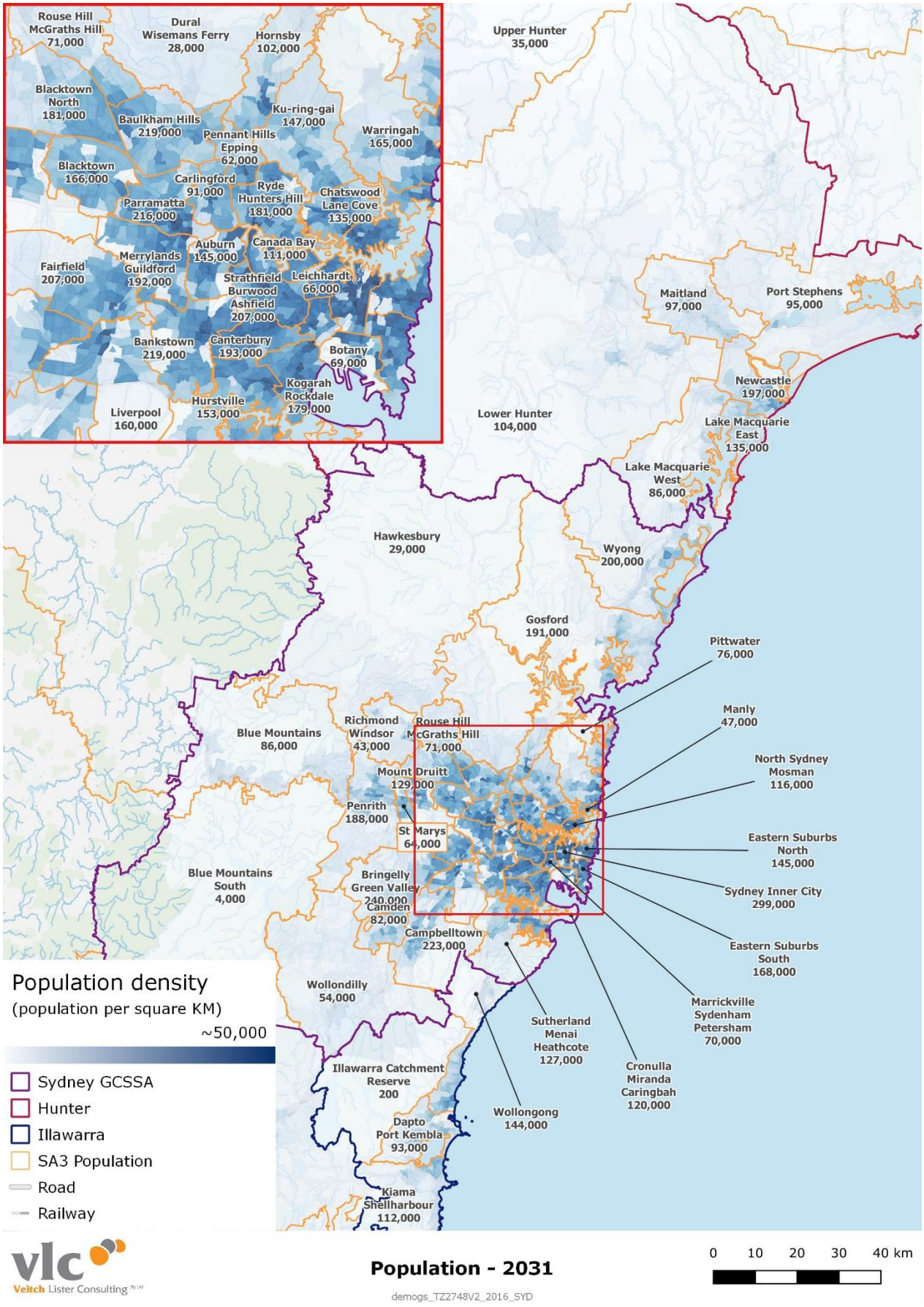
expected to experience significant population growth between 15,000 and 20,000 additional people by 2031. Overall, the forecasted trends in population growth reflect the infrastructure development plans currently proposed by the NSW Government, including the rejuvenation of populous regions, as well as greenfield development. Since the previous Audit, forecasted total population and employment in Greater Sydney for 2031 has increased, with the differences mostly accommodated in the growth areas in western Sydney.

Figure 2-1 – Sydney, Hunter and Illawarra population density and SA3 totals in 2016



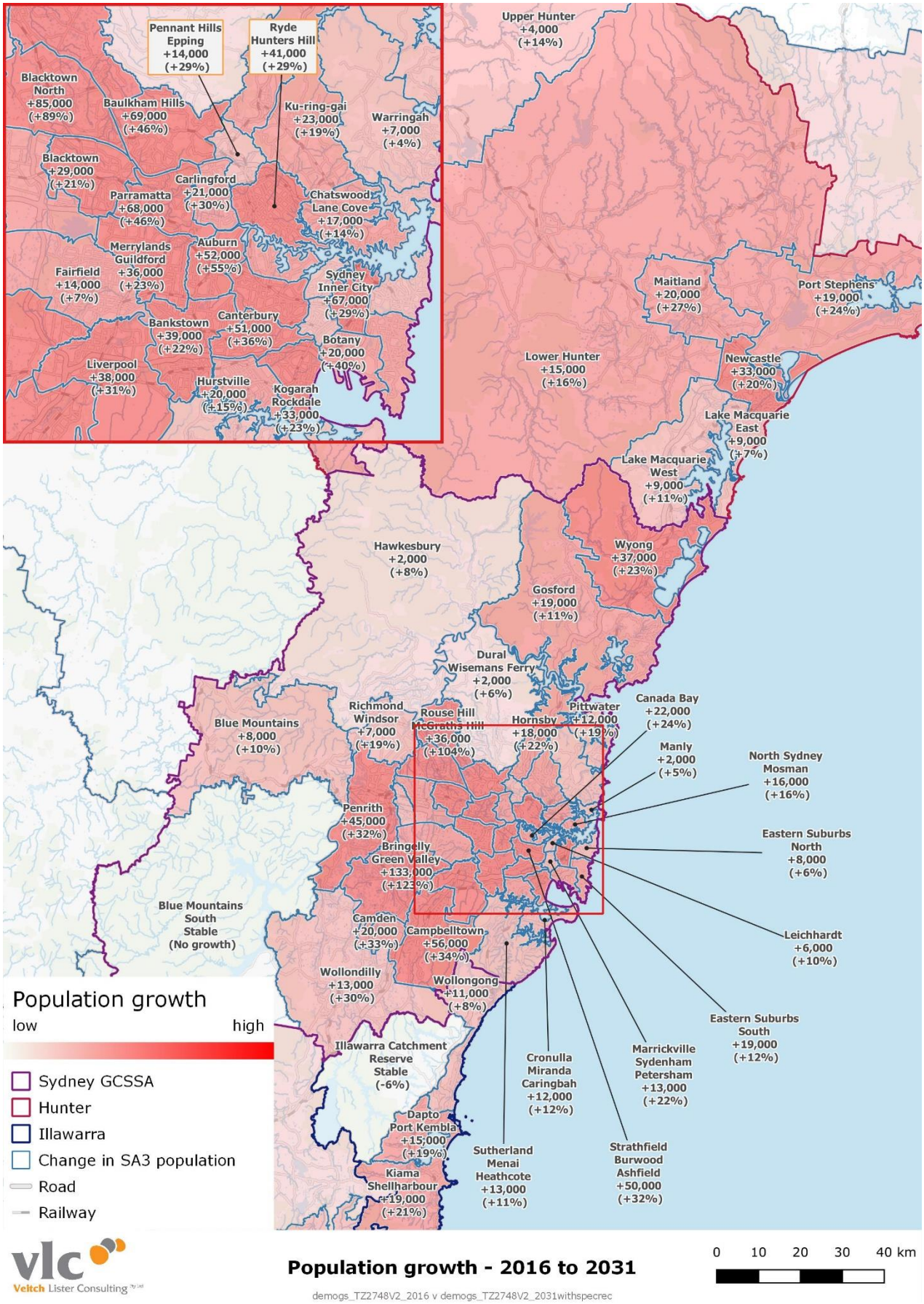
Source: ABS 2016 Census, disaggregated to Zenith travel zones

Figure 2-2 – Sydney, Hunter and Illawarra population density and SA3 totals in 2031



Source: NSW Government population forecasts, disaggregated to Zenith travel zones

Figure 2-3 – Sydney GCCSA population growth by SA3 2016 to 2031 forecast



Source: NSW Government population forecasts, disaggregated to Zenith travel zones

In addition to location of residence, the location of employment is a further determinant of travel choices. In 2016, just under three million jobs were located in the Sydney GCCSA. Figure 2-4 describes both the total number of jobs by SA3 and density of jobs at a travel zone level.

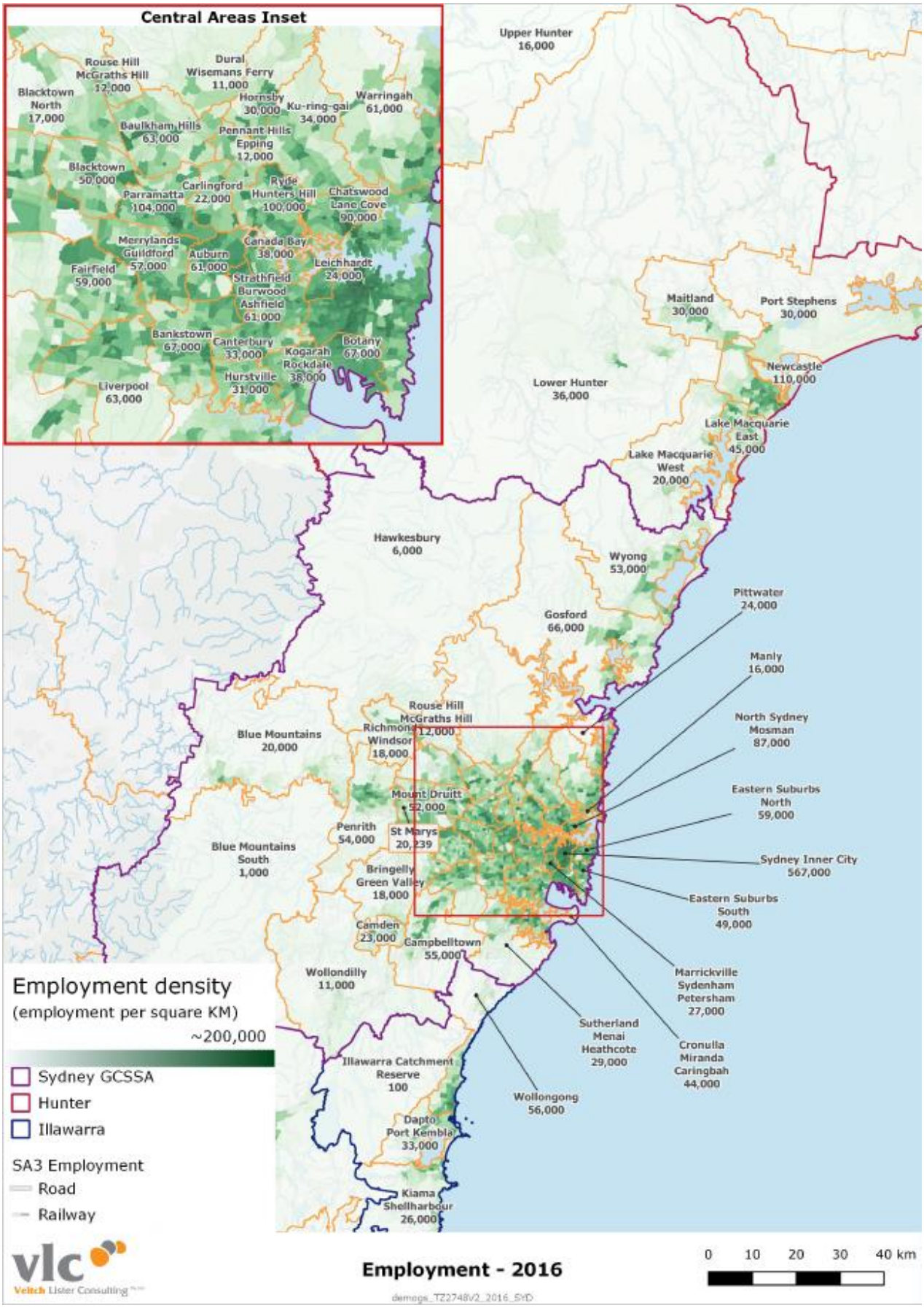
While the previous section identified that population is relatively dispersed across the city, employment is much more concentrated in distinct hubs. The most significant employment hub is the Sydney CBD, with the Sydney Inner City SA3 accommodating almost 23 per cent of Sydney's jobs and over five times as many jobs as Parramatta – the SA3 with the second highest number of jobs. This is followed by employment clusters in Ryde – Hunters Hill, Chatswood and North Sydney.

By 2031, it is expected that Sydney GCCSA will be home to over 3.2 million jobs, which is an increase of 706,000 jobs or approximately 28 per cent on 2016. Employment is projected to more than double in the Bringelly – Green Valley, Rouse Hill – McGraths Hill, and Blacktown SA3s, which similarly reflects the NSW Government's plans for development in these areas (Figure 2-5). Other inner areas, including Kogarah – Rockdale, Strathfield and North Sydney are projected continue to attract moderate employment growth, with weaker growth expected in already well-established areas of Sydney Inner City and Chatswood (approximately 18%).

In general, by 2031 employment is projected to become increasingly drawn to key employment areas across Greater Sydney, particularly towards the Sydney CBD, Parramatta and, to a lesser extent, Bringelly – Green Valley (Figure 2-6). This trend is in line with the Metropolis of Three Cities plan, and is likely to increase demand for travel to these employment clusters. With similar growth patterns forecasted in population, this partly supports the GSC's ambition for 'job containment' for new residents in these centres, reducing the need to travel long distances to reach employment hubs. However, the population, particularly in far western Sydney is projected to be far greater than the available employment projected in western areas. As such, travel between the three sub-regions of Sydney is also forecast to increase, and is further discussed in Section 4 and Section 5.

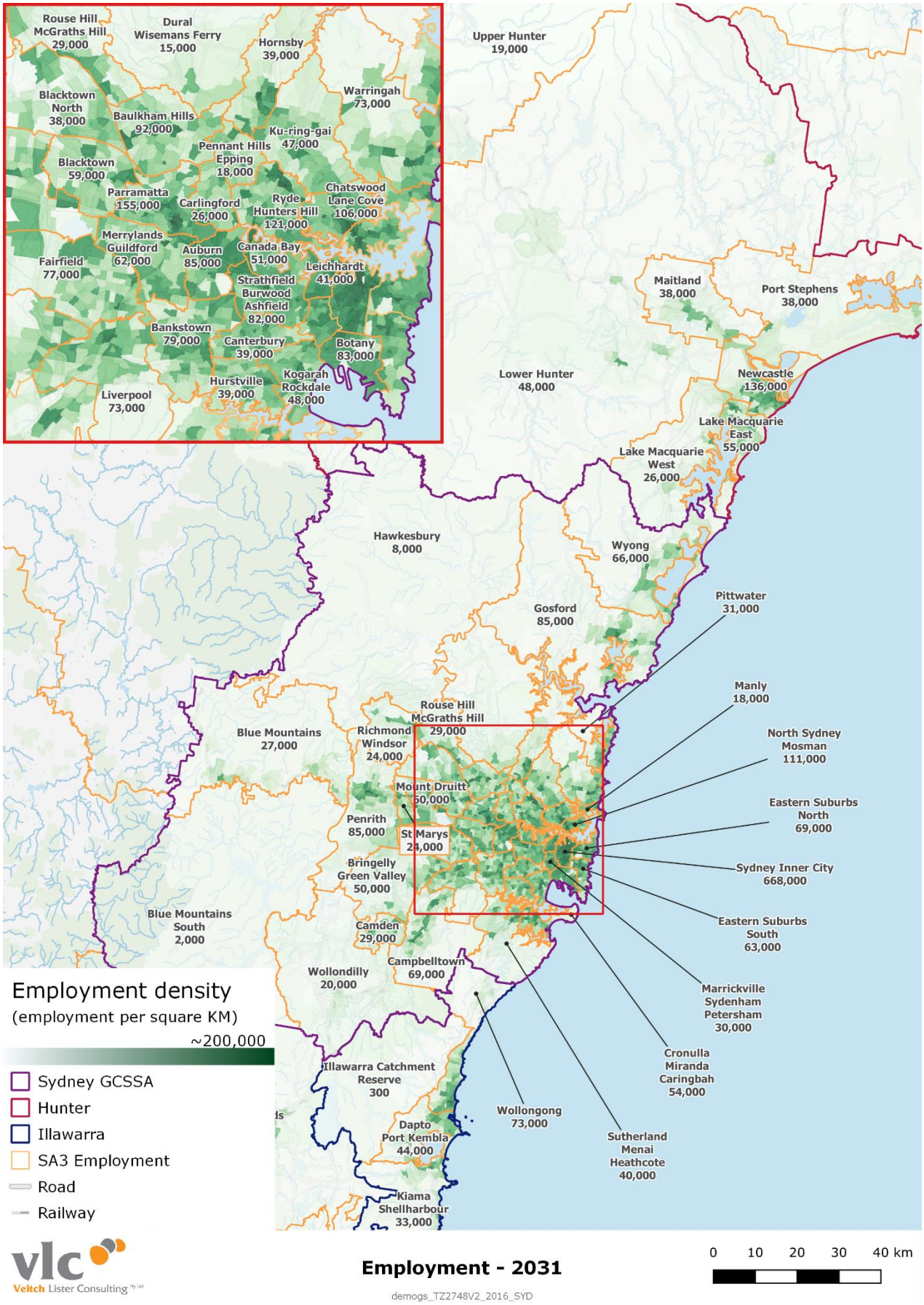
Beyond the Sydney GCCSA, employment growth in the major centres of Newcastle and Wollongong grow more strongly than population growth, reducing the need for new residents to travel longer distances to employment centres in Sydney.

Figure 2-4 – Sydney, Hunter and Illawarra employment density and SA3 totals in 2016



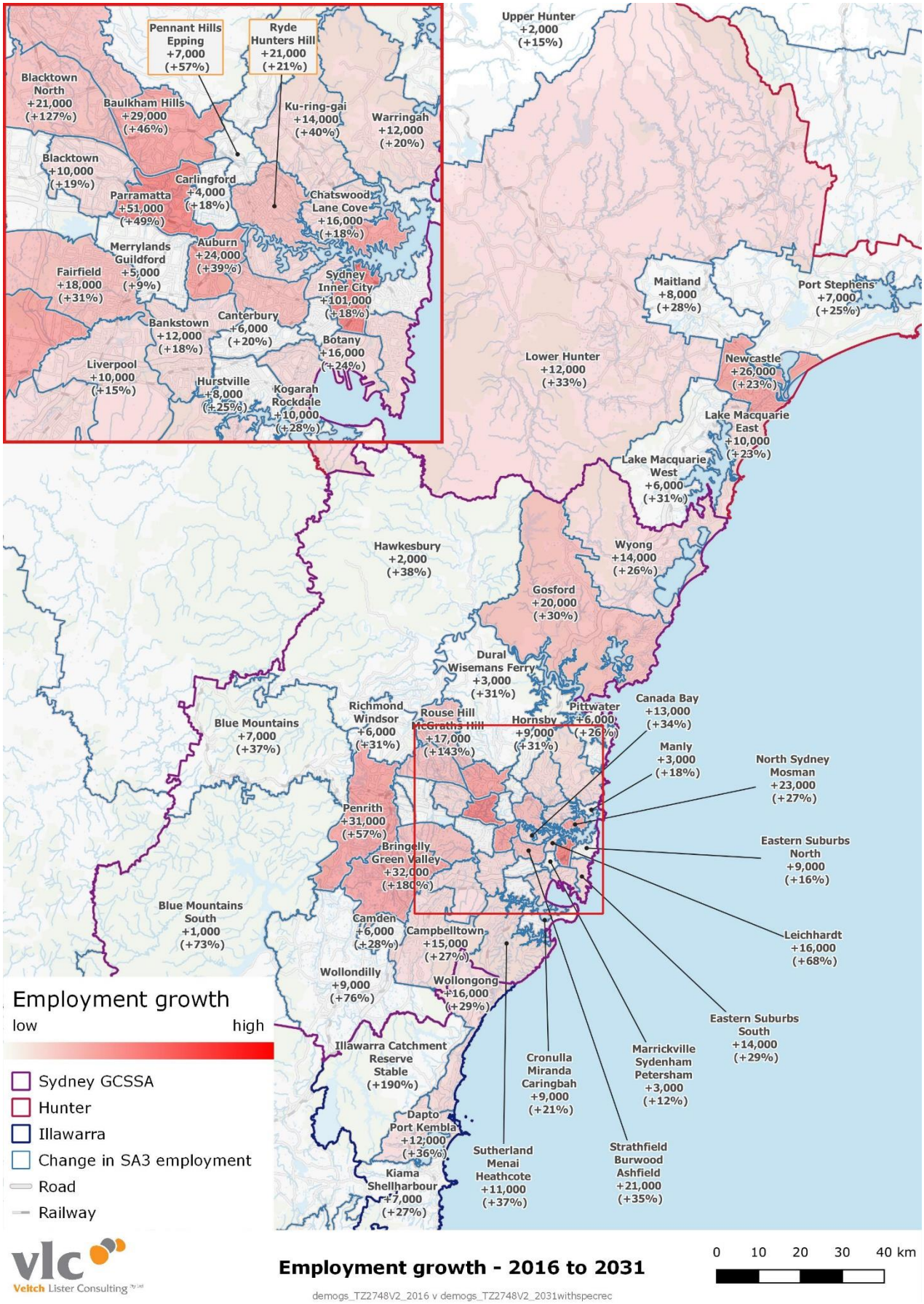
Source: ABS 2016 Place of Work, disaggregated to Zenith travel zones

Figure 2-5 – Sydney, Hunter and Illawarra employment density and SA3 totals in 2031 forecast



Source: NSW Government employment forecasts, disaggregated to Zenith travel zones

Figure 2-6 – Sydney, Hunter and Illawarra employment growth by SA3 2016 to 2031 forecast



Source: ABS 2016 Place of Work and NSW Government employment forecasts, disaggregated to Zenith travel zones

2.2 Transport networks

The transport network assumed in any given year will determine how (and how easily) populations will get between their homes, jobs, schools, shops and other activity areas. The 2031 transport network for Sydney has been developed using a minimal-intervention approach. Included projects were (at the time of modelling in August 2018) either under construction, under procurement, or had a public commitment to fund construction from all relevant governments. It is important to note that some projects fall outside of government's budget forward estimates, so some modelled projects may not be fully funded. Finally, some bus routes have also been expanded to support the development of new suburbs. A selection of the most significant projects is described in more detail below, and can be referenced on Figure 2-7. A full list of network assumptions can be found in Appendix A.

***Sydney Metro** will be the first fully-automated metro rail network in the country. It currently consists of two stages: **Sydney Metro Northwest** which will connect the North West Growth Area to Chatswood by a mix of new track to Epping then conversion of an existing line between Epping and Chatswood; and **Sydney Metro City & Southwest** which will provide new track from Chatswood to Sydenham and convert the Bankstown line to metro operation. In 2031, it is assumed that services will run every four minutes during the peak and every ten minutes outside peak periods. The first two stages are due to open in 2019 and 2024, respectively, and have been included in the model while a proposed extension connecting Parramatta to Sydney CBD is still in the planning stage and has not been included.*

***WestConnex** is a major road project that has been jointly funded by Federal and State Governments. It is currently under construction, with an expected completion date in 2023. It includes an extra lane in each direction the existing M4 from Parramatta to Homebush, and the construction of the new motorway from Homebush to the existing M5 at Beverly Hills, with an interchange at Rozelle connecting to Victoria Road, and provision at the St Peters interchange to connect to the proposed Sydney Gateway (a project which has not been included in the modelling).*

*The **Western Sydney Infrastructure Plan** is a collection of projects including the construction of the **M12 Motorway** (by 2026), and the upgrade of **The Northern Road** and **Bringelly Road** (in 2020). The M12 Motorway will provide a connection between the Northern Road and the M7 and has been jointly funded by the Federal and State Governments. The **North-South Rail Link** connecting the Western Sydney Airport to the existing network at St Marys has been included in the 2031 network.*

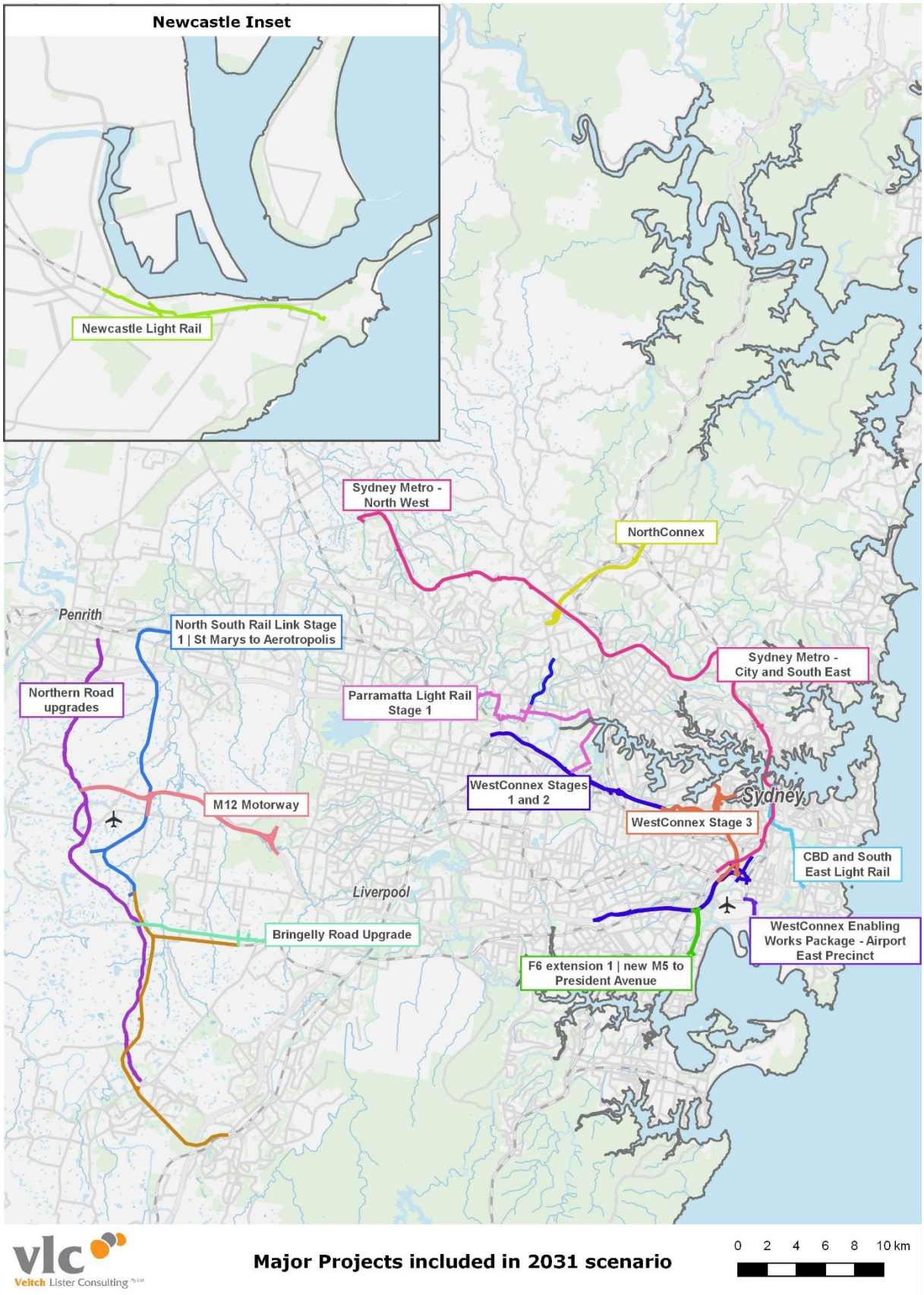
*Several light rail projects are currently under construction. The **CBD and South East Light Rail (CSELR)** is expected to be complete in 2020. It will extend south from the existing light rail network at Central Station to Kingsford and Randwick, and north to Circular Quay. Stage 1 of the **Parramatta Light Rail** connecting Westmead to Carlingford via Parramatta CBD is expected to open in 2023, while Stage 2 connecting Parramatta CBD to Sydney Olympic Park is currently in the planning stage so was not included in the model. The **Newcastle Light Rail** is expected to open in 2019. It will extend from the Newcastle Interchange at Wickham to Pacific Park in Newcastle East.*

*The **NorthConnex** is a tolled tunnel which will connect the M1 at Wahroonga to the M2 at West Pennant Hills, as an alternative to Pennant Hills Road. The project has been part funded by Federal and State Governments, with the remaining funding sourced from toll charges which includes the extended M7 concession changes. It is under construction and is expected to be complete in 2019.*

*Stage 1 of the **F6 extension** will be a tunnel connecting the New M5 at Arncliffe to President Avenue at Kogarah and has been included in the model. It will provide a connection to the motorway network*

from the south and is expected to open in 2024. Further stages between Kogarah and Loftus, and to Taren Point (Section B) and Loftus (Section C), have not been included in the 2031 network.

Figure 2-7 – Sydney, Illawarra and Hunter major projects included in 2031



Beyond the major projects, public transport services are also assumed to improve incrementally through increased service frequencies and extending routes into growth areas. The combined impact of the major projects and the 'business as usual' is that total in-service kilometres increase 28 per cent by 2031. In the context of Sydney's 24 per cent population growth, the increase reflects an expansion in service provision on a per-user basis (Table 2-1). These metrics have also been included for the Hunter and Illawarra regions in Appendix Table F-1.

Table 2-1 – Sydney GCCSA public transport in vehicle service kilometres[2]

Metric	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	17,000	22,000	+5,000	+28%
	Inter-peak (9AM-4PM)	41,000	48,000	+7,000	+17%
	PM peak (4-6PM)	16,000	21,000	+5,000	+34%
	Off-peak (6PM-7AM)	48,000	63,000	+15,000	+30%
	Daily total	**121,000**	**153,000**	**+32,000**	**+26%**
Light rail	AM peak (7-9AM)	300	1,200	+900	+257%
	Inter-peak (9AM-4PM)	800	3,100	+2,300	+267%
	PM peak (4-6PM)	400	1,200	+900	+234%
	Off-peak (6PM-7AM)	900	3,700	+2,800	+318%
	Daily total	**2,400**	**9,300**	**+6,800**	**+279%**
Bus	AM peak (7-9AM)	88,000	108,000	+20,000	+22%
	Inter-peak (9AM-4PM)	187,000	237,000	+50,000	+27%
	PM peak (4-6PM)	83,000	102,000	+19,000	+23%
	Off-peak (6PM-7AM)	148,000	201,000	+53,000	+36%
	Daily total	**507,000**	**648,000**	**+141,000**	**+28%**
Ferry	AM peak (7-9AM)	1,200	1,400	+200	+16%
	Inter-peak (9AM-4PM)	3,100	3,400	+300	+8%
	PM peak (4-6PM)	1,000	1,200	+200	+17%
	Off-peak (6PM-7AM)	2,100	2,200	+200	+8%
	Daily total	**7,400**	**8,200**	**+0,800**	**+11%**
Total	AM peak (7-9AM)	107,000	132,000	+26,000	+24%
	Inter-peak (9AM-4PM)	232,000	291,000	+59,000	+26%
	PM peak (4-6PM)	100,000	125,000	+25,000	+25%
	Off-peak (6PM-7AM)	199,000	270,000	+70,000	+35%
	Daily total	**638,000**	**819,000**	**+181,000**	**+28%**

[2] Service kilometres include all public transport lines servicing the Sydney GCCSA (and not exclusively kilometres operating within the Sydney GCCSA).

3. Travel demands

Given the 24 per cent population and 27 per cent employment growth projected for Sydney between 2016 and 2031, the transport task is expected to grow. This part of the report includes the Zenith model's estimates and forecasts for travel in the 2016 base and the 2031 forecast. Individual metrics are reported on under the following themes:

- Growth in person travel,
- Growth in road network demand, and
- Growth in public transport demand.

3.1 Growth in person travel

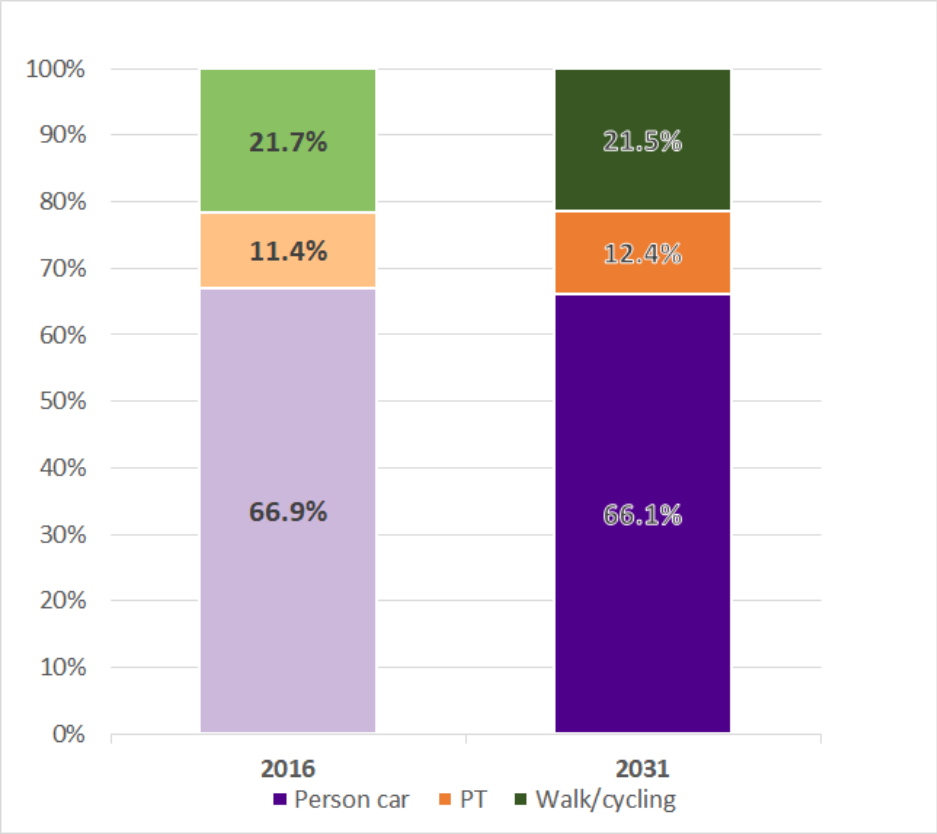
Between 2016 and 2031 the total number of weekday trips in the Sydney GCCSA is expected to increase by 28 per cent, with almost 2.9 million extra daily trips by car (Table 3-1). This is somewhat above the population growth of around 24 per cent. This reflects the way the Zenith model responds to a decrease in average household size into the future within the NSW Government projections. For example, two single-person households are modelled to produce more trips than a single two-person household. This 'de-coupling' of growth in population and households is not apparent in all markets analysed in this Audit. In most other jurisdictions household projections are not explicitly provided, so VLC assumes a stable household size into the future, which results in broadly proportional population and trip growth.

Car travel retains its dominance over other modes with person car's mode share forecast to fall only marginally from 67 per cent in 2016 to 66 per cent in 2031 (Figure 3-1). This suggests that in spite of the large investments being made in public transport, a majority of residents of Sydney will still find driving to be the most convenient option for most of their travel. This in turn reflects sustained major investments in road infrastructure as well as the dispersed land patterns that are difficult to cost effectively serve by public transport.

Table 3-1 – Sydney GCCSA person trips by mode

Metric	Time period	2016	2031	Change	% change
Person car trips	AM peak (7-9AM)	1,586,000	1,968,000	+381,000	+24%
	Inter-peak (9AM-4PM)	4,758,000	6,061,000	+1,304,000	+27%
	PM peak (4-6PM)	1,705,000	2,131,000	+426,000	+25%
	Off-peak (6PM-7AM)	2,802,000	3,549,000	+747,000	+27%
	Daily total	**10,851,000**	**13,709,000**	**+2,858,000**	**+26%**
Public transport trips	AM peak (7-9AM)	410,000	573,000	+163,000	+40%
	Inter-peak (9AM-4PM)	712,000	977,000	+265,000	+37%
	PM peak (4-6PM)	355,000	499,000	+145,000	+41%
	Off-peak (6PM-7AM)	376,000	517,000	+141,000	+37%
	Daily total	**1,852,000**	**2,566,000**	**+714,000**	**+39%**
Walk/cycling trips	AM peak (7-9AM)	368,000	468,000	+100,000	+27%
	Inter-peak (9AM-4PM)	1,862,000	2,355,000	+493,000	+26%
	PM peak (4-6PM)	498,000	636,000	+138,000	+28%
	Off-peak (6PM-7AM)	785,000	997,000	+211,000	+27%
	Daily total	**3,512,000**	**4,455,000**	**+943,000**	**+27%**
Total trips	AM peak (7-9AM)	2,363,000	3,008,000	+645,000	+27%
	Inter-peak (9AM-4PM)	7,332,000	9,393,000	+2,062,000	+28%
	PM peak (4-6PM)	2,557,000	3,266,000	+709,000	+28%
	Off-peak (6PM-7AM)	3,963,000	5,062,000	+1,099,000	+28%
	Daily total	**16,215,000**	**20,730,000**	**+4,515,000**	**+28%**

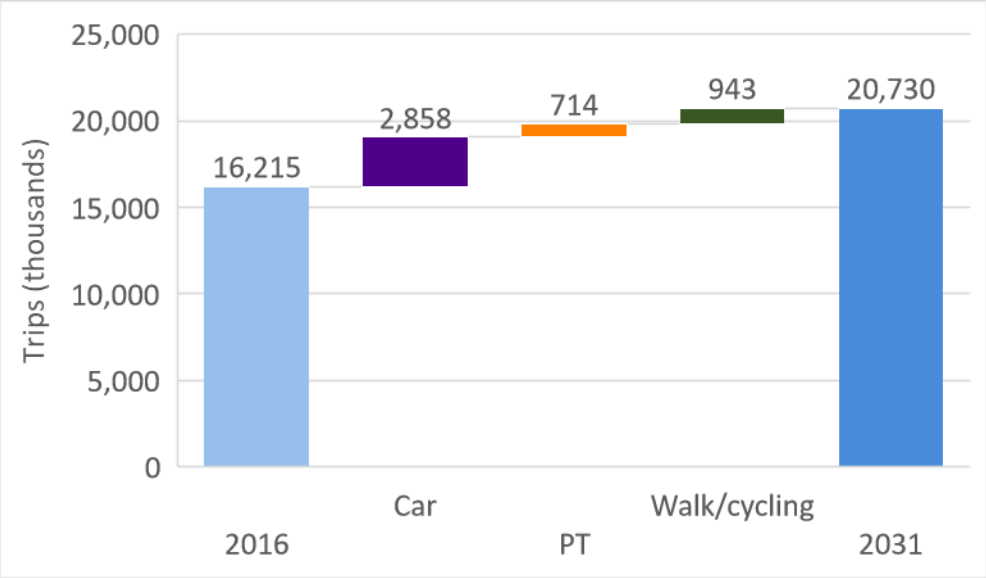
Figure 3-1 – Sydney GCCSA mode share of daily trips, 2016 and 2031



Public transport trips are forecast to grow by 39 per cent across the day with an additional 714,000 trips (Figure 3-2). This growth is from a low base share; public transport's share of trips grows from 11 per cent in 2016 to 12 per cent in 2031 (with higher shares in the AM and PM peak periods). The growth in public transport use to 2031 will be driven by population growth and an expansion of the public transport network. Growth is likely also partly attributable to the future levels of road congestion; congested roads make public transport more competitive. The relative cost of car travel is also a factor in the forecast public transport patronage growth. Public transport travel is assumed to become slightly cheaper relative to car travel to 2031 (public transport fares are assumed to be flat in inflation-adjusted terms while parking charges for cars grow at 1.5% per annum on this basis).

Walking and cycling trips are expected to grow by around 27 per cent between 2016 and 2031, slightly above the population growth forecast. This slight increase in share is a result of the increased density of residential and commercial land use patterns that allow for some activities (e.g. shopping and recreation) to be undertaken close to home; such short trips are good candidates for active modes particularly with increased road congestion dissuading driving. A real increase in parking charges is particularly relevant for walking and cycling trips as parking charges are applied in Sydney's denser inner areas.

Figure 3-2 – Sydney GCCSA growth in daily person trips, 2016 to 2031



These travel demand metrics have also been reported for the Hunter and Illawarra regions in Appendix Table F-2.

3.2 Growth in vehicle travel

Traffic on the road network is split between car (93%) and commercial vehicle travel (7%) (see Section D.3.5 for VLC's commercial vehicle definitions). Trip growth is forecast to be largely in line with population growth (24%) for both vehicle types, growing by 26 and 24 per cent respectively (Table 3-2 and Table 3-3).

Table 3-2 – Sydney GCCSA car traffic statistics

Metric	Time period	2016	2031	Change	% change
Trips	AM peak (7-9AM)	1,141,000	1,414,000	+273,000	+24%
	Inter-peak (9AM-4PM)	3,432,000	4,373,000	+940,000	+27%
	PM peak (4-6PM)	1,265,000	1,578,000	+313,000	+25%
	Off-peak (6PM-7AM)	1,985,000	2,511,000	+526,000	+27%
	Daily total	**7,824,000**	**9,877,000**	**+2,053,000**	**+26%**
Kilometres	AM peak (7-9AM)	13,508,000	17,168,000	+3,660,000	+27%
	Inter-peak (9AM-4PM)	36,392,000	48,047,000	+11,655,000	+32%
	PM peak (4-6PM)	14,769,000	18,918,000	+4,149,000	+28%
	Off-peak (6PM-7AM)	24,497,000	32,018,000	+7,521,000	+31%
	Daily total	**89,166,000**	**116,151,000**	**+26,984,000**	**+30%**
Hours	AM peak (7-9AM)	428,000	657,000	+229,000	+54%
	Inter-peak (9AM-4PM)	781,000	1,144,000	+363,000	+46%
	PM peak (4-6PM)	449,000	705,000	+256,000	+57%
	Off-peak (6PM-7AM)	457,000	618,000	+161,000	+35%
	Daily total	**2,115,000**	**3,124,000**	**+1,009,000**	**+48%**
Average assigned speed (kph)	AM peak (7-9AM)	32	26	-5	-17%
	Inter-peak (9AM-4PM)	47	42	-5	-10%
	PM peak (4-6PM)	33	27	-6	-18%
	Off-peak (6PM-7AM)	54	52	-2	-3%
	Daily total	**42**	**37**	**-5**	**-12%**

Table 3-3 – Sydney GCCSA commercial vehicle traffic statistics

Metric	Time period	2016	2031	Change	% change
Trips	AM peak (7-9AM)	85,000	107,000	+22,000	+25%
	Inter-peak (9AM-4PM)	276,000	343,000	+67,000	+24%
	PM peak (4-6PM)	99,000	123,000	+24,000	+24%
	Off-peak (6PM-7AM)	144,000	179,000	+34,000	+24%
	Daily total	**605,000**	**752,000**	**+147,000**	**+24%**
Kilometres	AM peak (7-9AM)	1,325,000	1,669,000	+344,000	+26%
	Inter-peak (9AM-4PM)	4,145,000	5,182,000	+1,037,000	+25%
	PM peak (4-6PM)	1,496,000	1,842,000	+346,000	+23%
	Off-peak (6PM-7AM)	2,651,000	3,288,000	+637,000	+24%
	Daily total	**9,617,000**	**11,981,000**	**+2,364,000**	**+25%**
Hours	AM peak (7-9AM)	37,000	57,000	+20,000	+54%
	Inter-peak (9AM-4PM)	82,000	115,000	+33,000	+41%
	PM peak (4-6PM)	41,000	64,000	+23,000	+54%
	Off-peak (6PM-7AM)	45,000	58,000	+13,000	+29%
	Daily total	**205,000**	**294,000**	**+89,000**	**+43%**

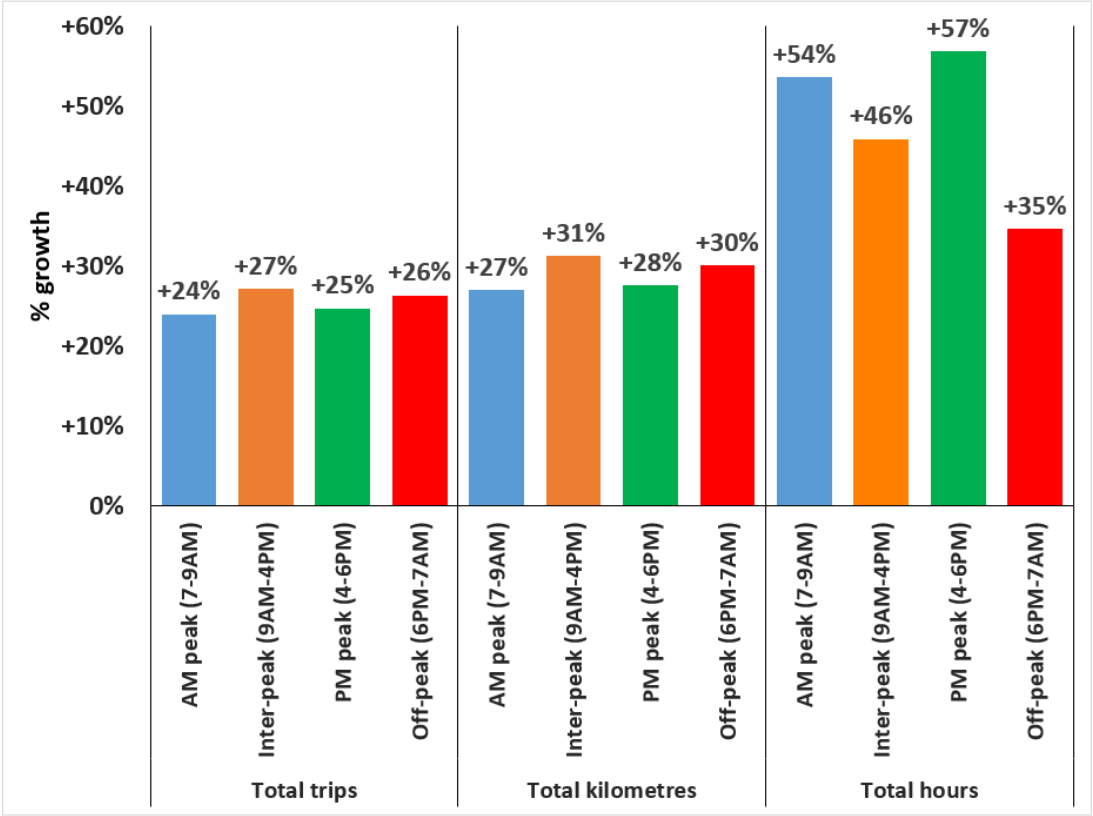
Total vehicle kilometres grow relatively uniformly across the day (though growth is faster outside the peak periods) and slightly above total trip growth (Figure 3-3). This indicates that the average trip length will increase slightly – a result of population growth in outer areas (Section 2.1).

In contrast, the growth in hours travelled is much more variable across the day. Total vehicle hours on the road network are forecast to increase by around 55 per cent in the AM and PM peak periods, reflecting worsening congestion. This is a result of the underlying dynamics of traffic flow (when

additional traffic is added to an already congested road, the resultant delay is disproportionately higher than in less congested conditions). Total vehicle hours in the interpeak time period are also predicted to grow significantly, indicating emerging and worsening congestion in the middle of the day. This increased congestion occurs in spite of large road capacity expansions to 2031, as population and employment growth spread throughout the city play a larger role in determining total road network performance. The off-peak is expected to remain relatively uncongested with the increase in amount of time spent driving (35%) closer to the increase in trips (26%).

These metrics have also been included for the Hunter and Illawarra regions in Appendix Table F-3 and Appendix Table F-4.

Figure 3-3 – Sydney GCCSA weekday vehicle metrics - growth between 2016 and 2031



3.3 Growth in public transport ridership

By 2031 the demand placed on the public transport system is expected to increase significantly with public transport boardings, in-vehicle passenger kilometres and in-vehicle passenger hours increasing by around 45 per cent from 2016 (Table 3-4).

In-vehicle passenger kilometres *(or passenger kilometres) are a measure of movement of passengers for a particular mode or the public transport network as a whole. In-vehicle passenger kilometres are calculated through the network wide summation of the distances travelled by users onboard vehicles. This excludes the distance travelled (by car, walk or bike) accessing the service.*

In-vehicle passenger hours *(or passenger hours) are an analogous metric which is calculated through the network wide summation of the time spent by users onboard vehicles.*

A ***boarding*** *counts a person entering any public transport vehicle, irrespective of whether this is the first vehicle they have boarded for their trip, or whether they have transferred from another vehicle. One trip may include multiple boardings.*

Table 3-4 – Sydney GCCSA total public transport, key metrics

Metric	Time period	2016	2031	Change	% change
Boardings	AM peak (7-9AM)	522,000	768,000	+247,000	+47%
	Inter-peak (9AM-4PM)	896,000	1,276,000	+381,000	+43%
	PM peak (4-6PM)	452,000	686,000	+233,000	+52%
	Off-peak (6PM-7AM)	457,000	653,000	+196,000	+43%
	Daily total	**2,326,000**	**3,383,000**	**+1,057,000**	**+45%**
In vehicle passenger kilometres	AM peak (7-9AM)	7,983,000	11,903,000	+3,920,000	+49%
	Inter-peak (9AM-4PM)	10,950,000	15,542,000	+4,592,000	+42%
	PM peak (4-6PM)	6,814,000	10,239,000	+3,425,000	+50%
	Off-peak (6PM-7AM)	5,942,000	8,436,000	+2,494,000	+42%
	Daily total	**31,690,000**	**46,120,000**	**+14,431,000**	**+46%**
In vehicle passenger hours	AM peak (7-9AM)	206,000	300,000	+94,000	+45%
	Inter-peak (9AM-4PM)	273,000	386,000	+112,000	+41%
	PM peak (4-6PM)	177,000	260,000	+83,000	+47%
	Off-peak (6PM-7AM)	143,000	199,000	+56,000	+39%
	Daily total	**799,000**	**1,144,000**	**+345,000**	**+43%**

Heavy rail is easily the most intensively used public transport mode in Sydney, an outcome that is expected to continue to 2031 (Table 3-5 to Table 3-7). Heavy rail is also expected to experience significant growth across the three transport metrics, at approximately 45 per cent. This is because the interconnected suburban rail network is well established across Sydney, and also facilitates long distance travel by providing commuters in outer areas with a direct service to the city's central employment hubs. This role will be expanded through the Metro program of new and converted lines.

The rail network is supported by the bus, light rail and ferry networks, which cover those areas not easily accessible by rail. Bus use is forecast to grow above the rate of population growth (Table 3-7). Passenger kilometres, passenger hours and boardings for light rail are expected to increase four-fold. Ferry use is forecast to be broadly stable.[3]

[3] This may be a result of travellers responding to improved services on some alternative routes. For example, additional bus priority, Parramatta light rail, and B-Line, which are viable alternative modes to the ferry services on Parramatta River and Northern Beaches to the Sydney CBD. Ferry services also have limited catchment areas; population densities are not projected to increase significantly in these waterside locations.

Appendix Table F-5 to F-8 details these metrics for the Hunter and Illawarra regions.

Table 3-5 – Sydney GCCSA in-vehicle passenger kilometres

Metric	Time period	2016	2031	Change	% change
Rail and Metro	AM peak (7-9AM)	6,618,000	10,002,000	+3,385,000	+51%
	Inter-peak (9AM-4PM)	8,710,000	12,456,000	+3,746,000	+43%
	PM peak (4-6PM)	5,663,000	8,656,000	+2,994,000	+53%
	Off-peak (6PM-7AM)	4,922,000	7,054,000	+2,132,000	+43%
	Daily total	**25,912,000**	**38,168,000**	**+12,257,000**	**+47%**
Light rail	AM peak (7-9AM)	19,000	119,000	+100,000	+535%
	Inter-peak (9AM-4PM)	38,000	206,000	+168,000	+447%
	PM peak (4-6PM)	20,000	119,000	+99,000	+497%
	Off-peak (6PM-7AM)	22,000	111,000	+89,000	+414%
	Daily total	**98,000**	**555,000**	**+457,000**	**+466%**
Bus	AM peak (7-9AM)	1,249,000	1,695,000	+447,000	+36%
	Inter-peak (9AM-4PM)	2,135,000	2,798,000	+663,000	+31%
	PM peak (4-6PM)	1,051,000	1,381,000	+330,000	+31%
	Off-peak (6PM-7AM)	974,000	1,253,000	+278,000	+29%
	Daily total	**5,409,000**	**7,127,000**	**+1,718,000**	**+32%**
Ferry	AM peak (7-9AM)	98,000	87,000	-11,000	-12%
	Inter-peak (9AM-4PM)	68,000	82,000	+14,000	+21%
	PM peak (4-6PM)	80,000	82,000	+2,000	+2%
	Off-peak (6PM-7AM)	24,000	19,000	-5,000	-22%
	Daily total	**271,000**	**270,000**	**-1,000**	**-0%**

Table 3-6 – Sydney GCCSA in-vehicle passenger hours

Metric	Time period	2016	2031	Change	% change
Rail and Metro	AM peak (7-9AM)	144,000	215,000	+71,000	+49%
	Inter-peak (9AM-4PM)	190,000	268,000	+78,000	+41%
	PM peak (4-6PM)	124,000	187,000	+63,000	+51%
	Off-peak (6PM-7AM)	111,000	154,000	+43,000	+39%
	Daily total	**569,000**	**824,000**	**+256,000**	**+45%**
Light rail	AM peak (7-9AM)	1,000	5,000	+4,000	+446%
	Inter-peak (9AM-4PM)	2,000	10,000	+7,000	+352%
	PM peak (4-6PM)	1,000	6,000	+4,000	+380%
	Off-peak (6PM-7AM)	1,000	5,000	+4,000	+320%
	Daily total	**6,000**	**26,000**	**+20,000**	**+368%**
Bus	AM peak (7-9AM)	58,000	76,000	+18,000	+32%
	Inter-peak (9AM-4PM)	79,000	105,000	+26,000	+33%
	PM peak (4-6PM)	49,000	64,000	+16,000	+33%
	Off-peak (6PM-7AM)	30,000	39,000	+9,000	+29%
	Daily total	**216,000**	**285,000**	**+69,000**	**+32%**
Ferry	AM peak (7-9AM)	3,200	2,900	-300	-10%
	Inter-peak (9AM-4PM)	2,400	2,600	+300	+11%
	PM peak (4-6PM)	2,800	2,900	+100	+2%
	Off-peak (6PM-7AM)	600	500	-200	-24%
	Daily total	**9,000**	**8,900**	**-100**	**-1%**

Table 3-7 – Sydney GCCSA public transport boardings

Metric	Time period	2016	2031	Change	% change
Rail and Metro	AM peak (7-9AM)	348,000	519,000	+171,000	+49%
	Inter-peak (9AM-4PM)	563,000	794,000	+231,000	+41%
	PM peak (4-6PM)	303,000	455,000	+153,000	+50%
	Off-peak (6PM-7AM)	323,000	449,000	+125,000	+39%
	Daily total	**1,537,000**	**2,217,000**	**+680,000**	**+44%**
Light rail	AM peak (7-9AM)	6,000	32,000	+26,000	+470%
	Inter-peak (9AM-4PM)	15,000	74,000	+60,000	+408%
	PM peak (4-6PM)	8,000	46,000	+39,000	+496%
	Off-peak (6PM-7AM)	8,000	43,000	+35,000	+442%
	Daily total	**36,000**	**196,000**	**+160,000**	**+444%**
Bus	AM peak (7-9AM)	157,000	207,000	+50,000	+32%
	Inter-peak (9AM-4PM)	307,000	396,000	+89,000	+29%
	PM peak (4-6PM)	132,000	173,000	+42,000	+32%
	Off-peak (6PM-7AM)	123,000	159,000	+36,000	+30%
	Daily total	**719,000**	**935,000**	**+216,000**	**+30%**
Ferry	AM peak (7-9AM)	11,300	10,500	-800	-7%
	Inter-peak (9AM-4PM)	10,100	12,100	+2,000	+20%
	PM peak (4-6PM)	9,800	10,300	+400	+4%
	Off-peak (6PM-7AM)	2,800	2,100	-700	-25%
	Daily total	**34,000**	**35,000**	**+1,000**	**+3%**

4. Road network performance

The previous section demonstrated that travel demand in Sydney is expected to increase significantly by 2031, and gave some indications of deteriorating road network performance. This section analyses this performance in more detail using the following metrics:

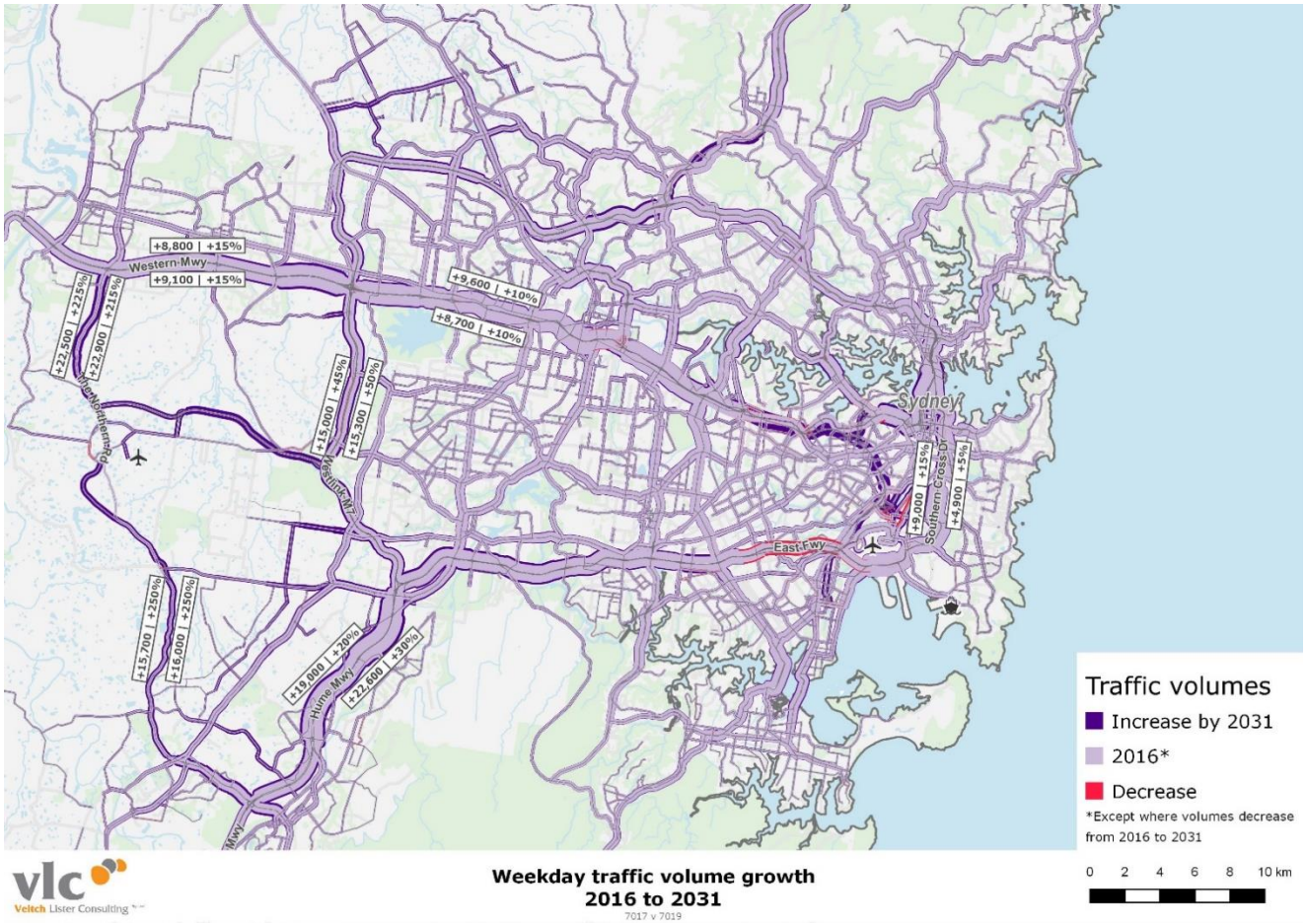
- *Volume capacity (V/C) ratio*. The V/C ratio for a section of road is a useful metric to gauge its level of congestion. As the demand placed on the link approaches capacity, the travel speed deteriorates, causing congestion. In strategic modelling it is possible for the V/C ratio to exceed 1.0. When this occurs, travel speed on this link deteriorates further.
- *Average speed*. Average speed reflects the amount of delay on the road network as a whole, it is the total distance travelled on a network divided by the time taken to do so. Average speed can be calculated either for an entire day or for a particular time period.

The largest increases in road demand can be seen at Sydney's planned major freeway and arterial developments (Figure 4-1). In particular, the construction of the WestConnex, NorthConnex, M12, F6 Extension, as well as The Northern Road upgrades, attracts large volumes of traffic, partly diverted from alternative routes. In spite of these developments, Sydney's existing freeways and arterial roads continue to experience growth in travel demand. The main driver of traffic growth is population and employment growth. As such, the largest increases are expected on the roads which link the major activity centres to new population growth areas. Strong population and employment growth in the southwest, which is partly driven by development of the Western Sydney Airport, drive an increased demand for travel along roads connecting it to the rest of Sydney, particularly east towards Liverpool and the Sydney Inner City, north towards Penrith, and south towards Campbelltown. Traffic is also forecast to grow strongly on the arterial and local roads in areas with high population growth, such as the northwest region.

Conversely, a decrease in traffic volumes is forecasted along the M5 East, as a result of the introduction of tolls on that section as part of the funding of WestConnex as well as some diversion of trips onto the F6. A decrease is also visible in O'Riordan and Bourke Streets to the north of the Airport, which reflects their conversion into one-way streets as part of Airport North precinct upgrades.

Similar traffic volume maps have also been produced for the Hunter and Illawarra regions (Appendix Figure F-1).

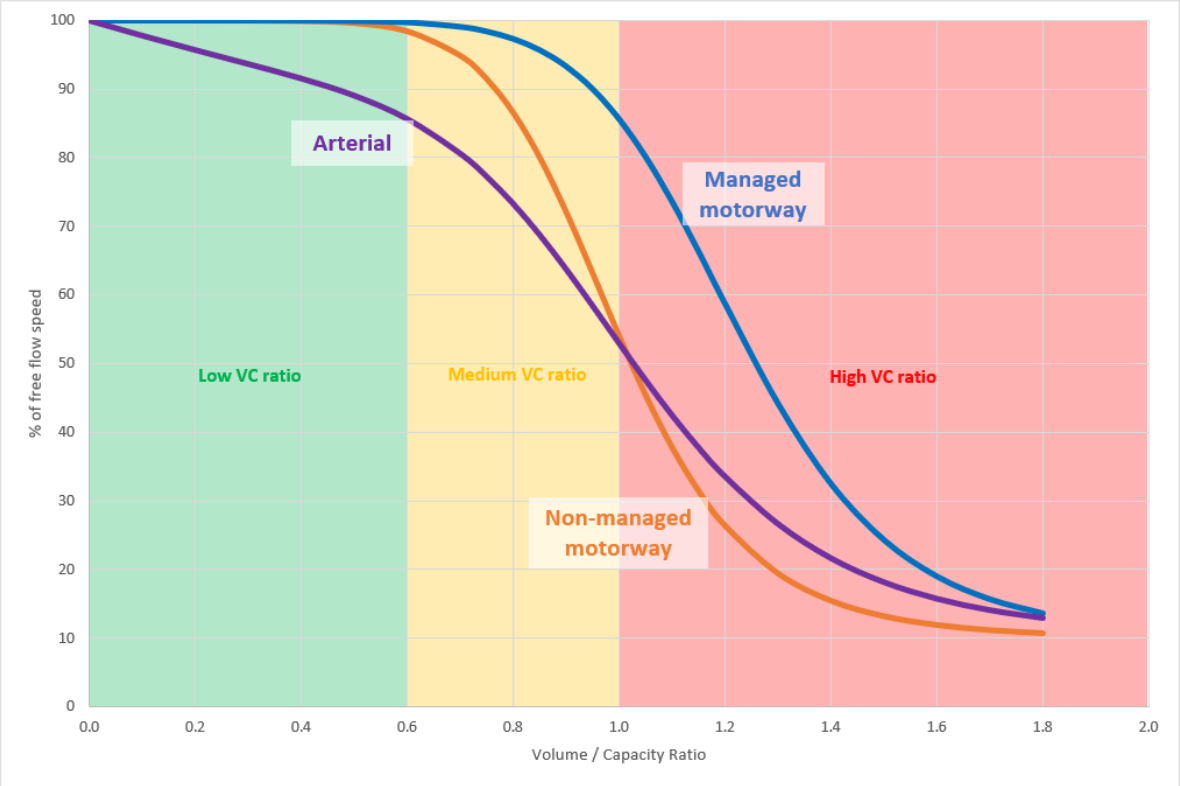
Figure 4-1 – Sydney GCCSA weekday traffic volume growth - 2016 to 2031



The following traffic volume / road capacity (V/C) images illustrate the levels of congestion observed in 2016 and in 2031. The V/C ratios are shown as the worst hour in the 2-hour peak. This peak one hour is assumed to be 56 per cent of the AM peak, and 52 per cent in the PM peak, an assumption developed based on observed travel data from various Australian cities. The colour of the bandwidth indicates the level of congestion, and the width is proportional to the volume of traffic using this link. (Minor links have been excluded for clarity, as in general these minor roads carry low volumes of traffic and are relatively uncongested.)

Figure 4-2 shows how congestion in the model impacts travel speeds on the network. For arterials, increasing V/C ratios result in a gradual decline in travel speeds to about 0.6 (where speeds reduce to 85% of free flow), with a steeper decline between ratios of 0.6 and 1.0 (50% of free flow). Travel speeds on motorways are less affected by congestion up to a V/C ratio of 0.6 but experience a much steeper reduction in travel speeds thereafter. Managed motorways can accommodate far more vehicles relative to capacity before travel speeds are materially impacted (though there are no managed motorways in the 2031 forecast for Sydney).

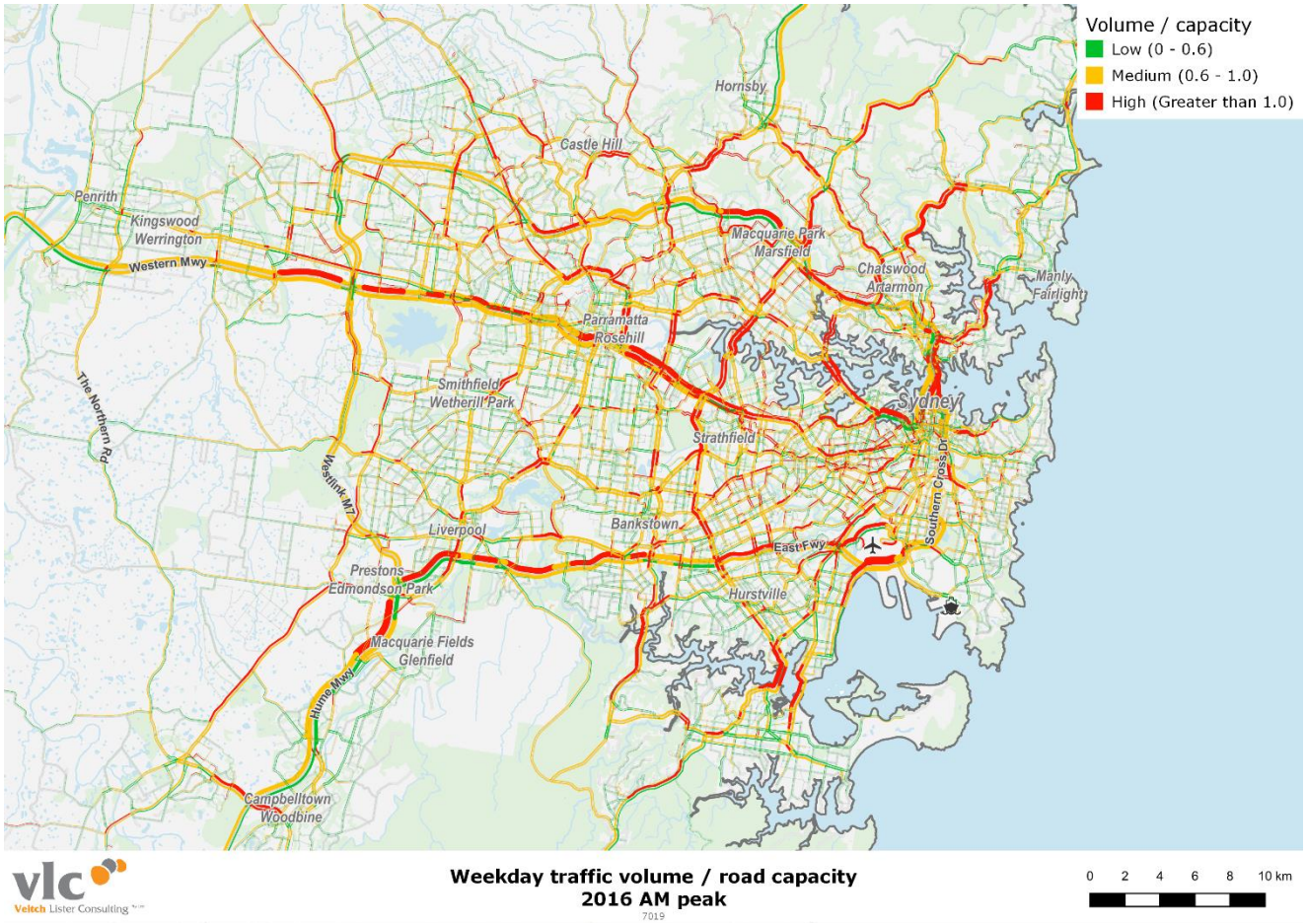
Figure 4-2 – Speed flow to volume / capacity ratio relationship



In 2016, major freeways have some the highest levels of congestion on Sydney's road network (Figure 4-3). In the AM peak period there is substantial congestion on the approaches to the CBD. High-traffic routes that exceed modelled capacity include sections of the M4 from Michinbury in the west through to Sydney CBD, as well as from Sydney CBD to Parramatta, Macquarie Fields to Sydney Airport (via the M7 and M5), the M1 south of Sydney Airport, and the M2 from Epping to Macquarie Park. These congestion points reflect the high travel demand towards employment clusters in Sydney CBD, Parramatta and Macquarie Park, as well as landside travel to the airport.

Some lower capacity sections of the road network experience levels of congestion comparable to that on the congested freeways in 2016. Many of these are arterials that feed the freeways or otherwise collect traffic bound for the Sydney CBD. These include Alfords Point Road in the south, Mona Vale Road and Warringah Road from the Northern Beaches, and Pennant Hills Road towards the northwest. High levels of congestion are also recorded on key bridges and tunnels where movements are constrained. Examples include the Sydney Harbour Tunnel, Spit Bridge, and Captain Cook Bridge and the Princes Hwy across St Georges River.

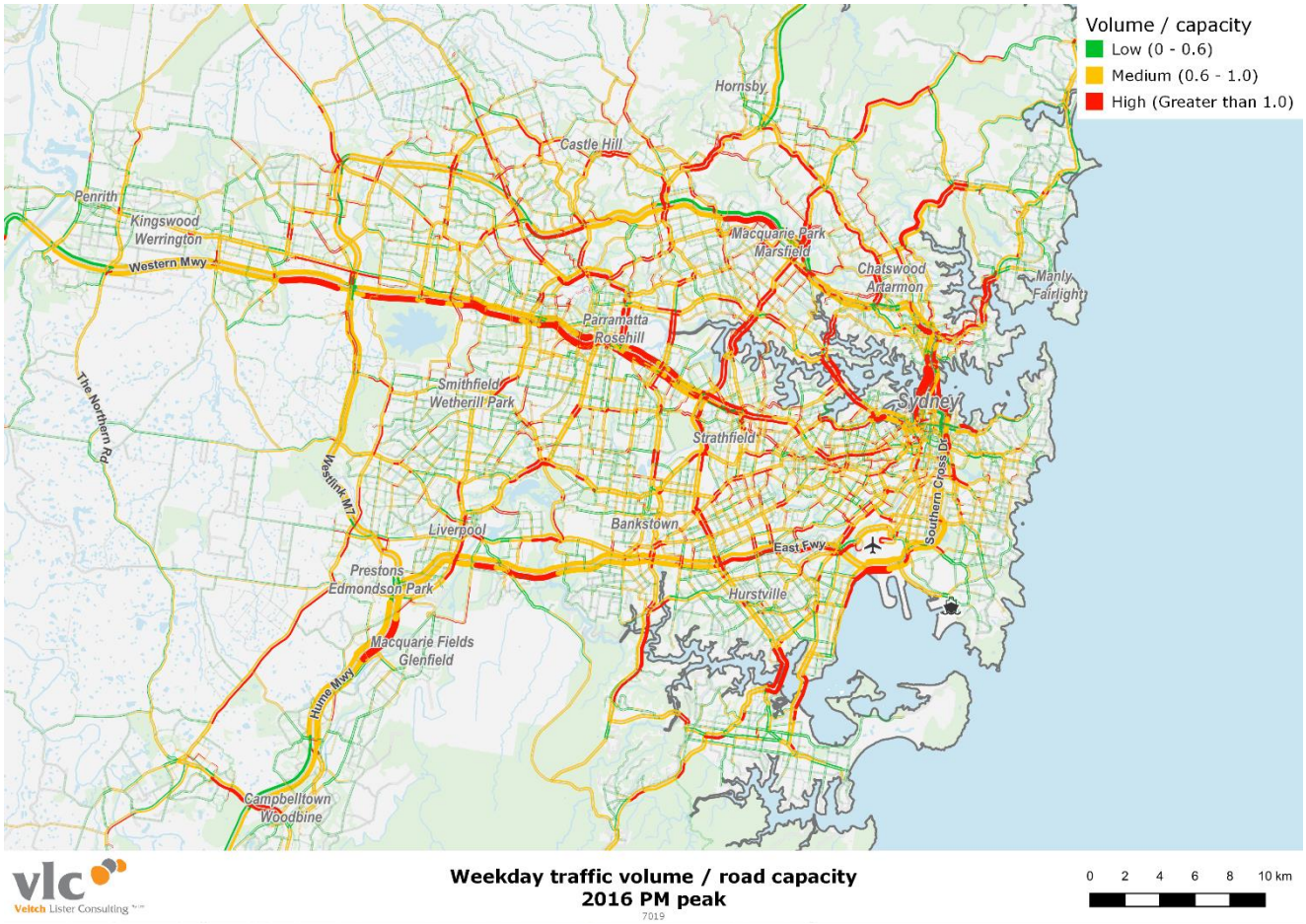
Figure 4-3 – Sydney GCCSA weekday traffic volume / road capacity - 2016 1-hour AM peak



In the PM peak a similar pattern of congestion can be seen in the opposite direction compared to the AM peak (Figure 4-4). There are a number of corridors with substantial two-way congestion in both peaks, most notably the M4 corridor between Parramatta and the Sydney CBD.

V/C maps for the Hunter and Illawarra regions for 2016 and 2031 in the AM and PM peaks can be found from Appendix Figure F-2 to Appendix Figure F-5.

Figure 4-4 – Sydney GCCSA weekday traffic volume / road capacity - 2016 1-hour PM peak



Between 2016 and 2031, Sydney's congestion is expected to worsen substantially (Figure 4-5 and Figure 4-6). In the 2031 peak periods, very severe congestion is expected to extend along the M4, from Kingswood towards Parramatta, as well as along the M5, between Campbelltown and Beverly Hills. Similarly, significant increases in congestion are forecasted on The Northern Road, the M2 between Winston Hills and Pennant Hills, the M1 in the Eastern Suburbs, as well as the M7. Increases in congestion on these major corridors is indicative of the increased travel demand caused by population and employment growth in the regions that they connect. This can also be seen in roads with smaller capacities that feed into the centres of these regions, particularly in the northwest. Mona Vale Road, Warringah Road, Spit Bridge and other constrained points from 2016 also show an exacerbation of congestion.

With the increased capacity of the WestConnex, however, on some sections of the M4 between Parramatta and Strathfield, congestion falls below 2016 levels by 2031, with traffic volume decreasing below capacity. This can also be seen in the M5 East, between Beverly Hills and Sydney Airport, reflecting the decrease in traffic volume described previously.

Nevertheless, motorists travelling in the peak periods and peak direction can expect to encounter congestion earlier on the morning commute and for longer on their way home. Significant increases in congestion on arterial roads in outer areas will also cause delays in travel time for both motorists and buses where bus priority is not provided.

Figure 4-5 – Sydney GCCSA weekday traffic volume / road capacity - 2031 1-hour AM peak

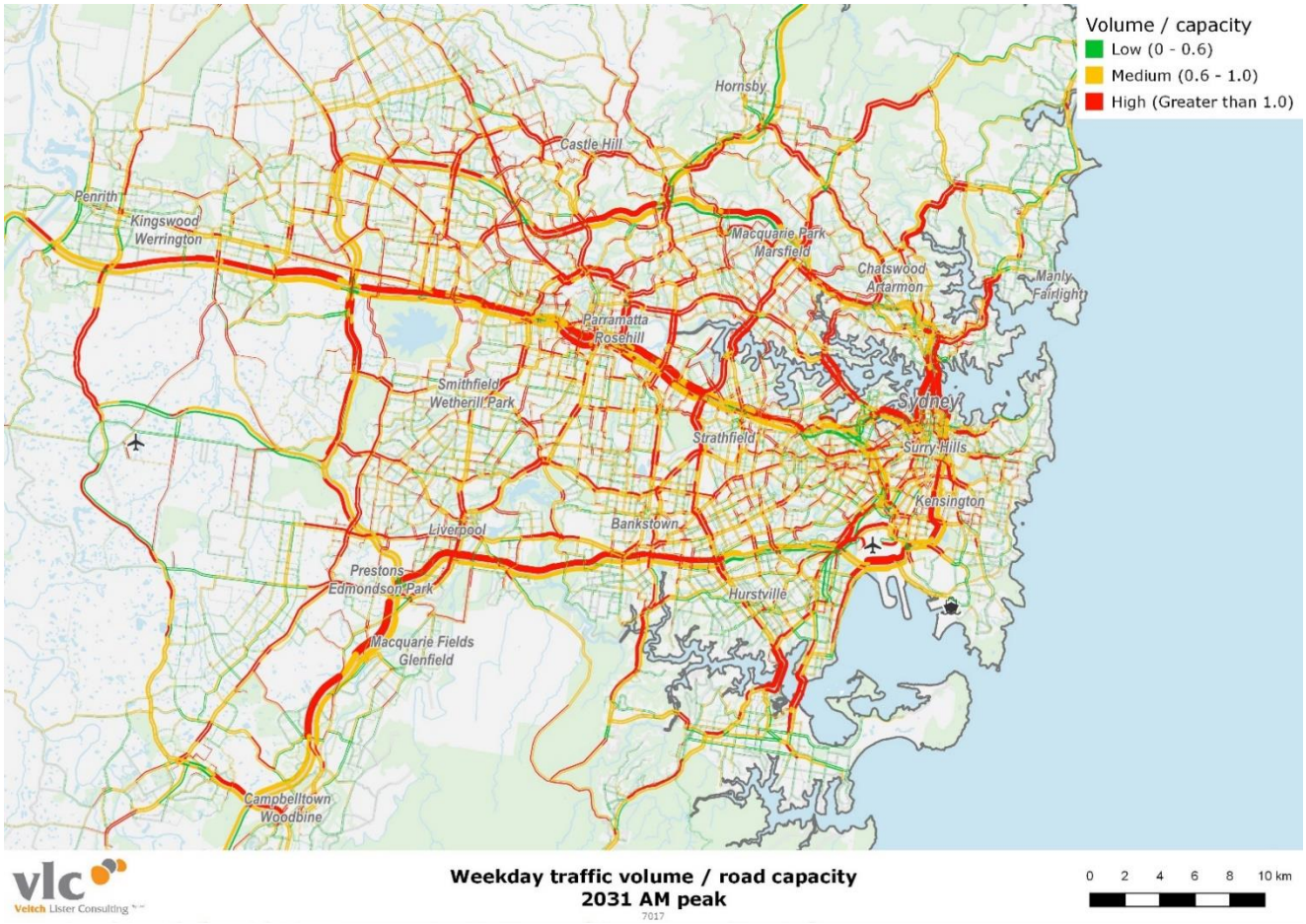
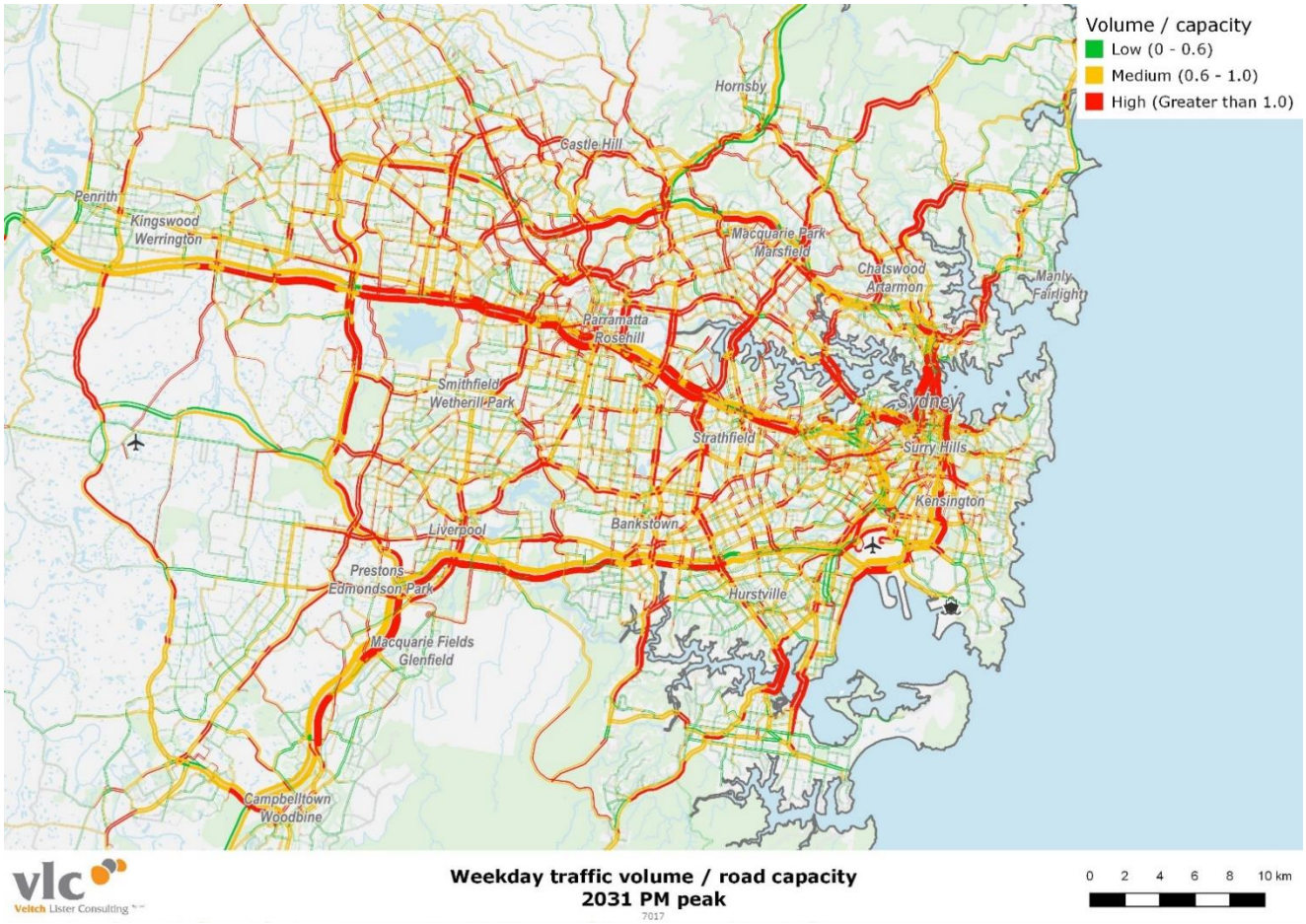
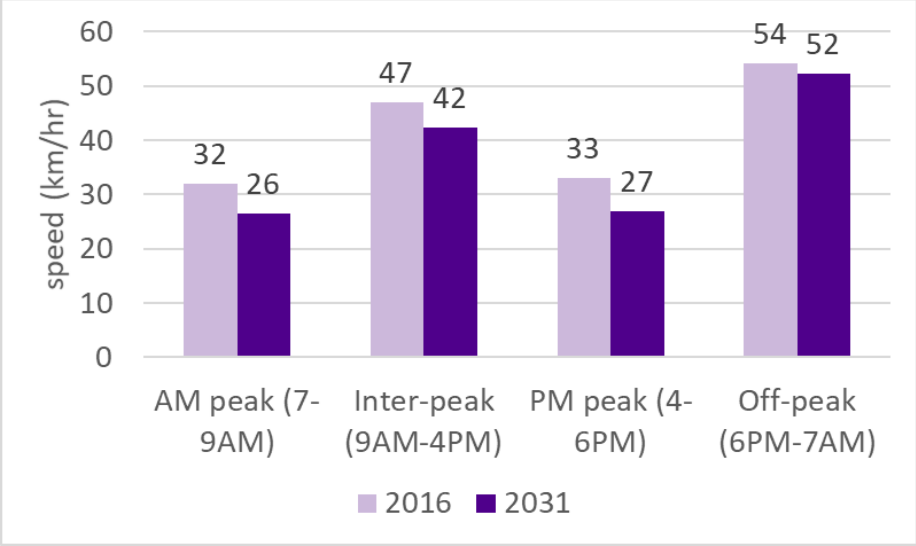


Figure 4-6 – Sydney GCCSA weekday traffic volume / road capacity - 2031 1-hour PM peak



The majority of the road network exhibits significant declines in speeds across all time periods, with the AM and PM peaks both experiencing a decline of 6 km per hour, closely followed by the decline during the interpeak (5 km per hour) (Figure 4-7). The off-peak time period offers an indication of vehicle speeds on a relatively uncongested network, but is still forecast to experience a decline of 2km per hour.

Figure 4-7 – Sydney GCCSA average speeds on the road network



Congestion causes substantial delay hours for vehicles on the road networks of Sydney, the Hunter and the Illawarra (Table 4-1). Delays are most intense in the peak periods with moderate delay in the inter-peak and a small amount of delay in the off-peak. By 2031 daily traffic delay is forecast to almost double.

Table 4-1 – Road network total delay hours for Sydney, Hunter and Illawarra

	Time period	2016	2031	Change	% change
Sydney GCCSA	AM peak (7-9AM)	196,000	370,000	+174,000	+89%
	Inter-peak (9AM-4PM)	158,000	329,000	+171,000	+108%
	PM peak (4-6PM)	197,000	391,000	+194,000	+98%
	Off-peak (6PM-7AM)	45,000	81,000	+36,000	+80%
	Daily total	**595,000**	**1,170,000**	**+575,000**	**+97%**
Hunter	AM peak (7-9AM)	22,000	40,000	+18,000	+82%
	Inter-peak (9AM-4PM)	32,000	65,000	+33,000	+103%
	PM peak (4-6PM)	25,000	48,000	+23,000	+92%
	Off-peak (6PM-7AM)	11,000	19,000	+8,000	+73%
	Daily total	**91,000**	**172,000**	**+81,000**	**+89%**
Illawarra	AM peak (7-9AM)	5,000	11,000	+6,000	+120%
	Inter-peak (9AM-4PM)	5,000	11,000	+6,000	+120%
	PM peak (4-6PM)	6,000	12,000	+6,000	+100%
	Off-peak (6PM-7AM)	2,000	3,000	+1,000	+50%
	Daily total	**17,000**	**37,000**	**+20,000**	**+118%**

5. Public transport system performance

Section 3.3 identified large increases in the use of Sydney's public transport networks. This section analyses the spatial distribution and the likely impacts of these increased passenger demands on network performance.

Compared to other Australian cities, Sydney's rail network is complex, with branches connecting major population and employment clusters, rather than just a single CBD. Despite this, the majority of rail lines and services converge on the CBD in the east rather than serve a wide variety of orbital movements. In suburban areas in particular, rail corridors tend to be fed by buses. For suburbs that fall outside of rail catchments, buses provide a direct public transport route to the major centres, particularly the CBD. Although there is some evidence of travel in counter peak directions, this behaviour is comparatively limited.

Rail patronage is expected to grow substantially to 2031 (Figure 5-1), particularly between Parramatta and Sydney CBD, with strong patronage also expected on the new Metro lines closer to the CBD. A decrease in rail volumes along the T1 North Shore line from Chatswood to Sydney CBD, as well as T3 Bankstown line between Erskineville and Sydenham is also indicative of a proportion of rail travellers shifting to the Sydney Metro when available. Growth is also forecasted towards Penrith and Edmonson Park, reflecting the urban development there. Patronage growth for the remainder of the rail network is expected to be more modest.

Rail investments that expand service catchments and capacity on presently crowded sections such as the lower North Shore, coupled with strong population growth, are the main drivers of the increase in demand for rail services. However, future road congestion supports a modest mode shift from private vehicle to rail.

Sydney's bus network is also forecast to experience widespread patronage growth (Figure 5-2). As with rail, population growth in both emerging and established areas is a key driver of much of this growth. Significant growth is expected between the Northern Beaches and Sydney CBD, adding to already high volumes. The growth is due to high levels of future road congestion on Military Road to the Spit Bridge, a lack of rail alternatives, as well as the introduction of the Bus Priority Infrastructure Program and the B-Line service in this corridor.

The introduction of the CSELR is forecasted to result in a shift away from bus services, particularly between Surry Hills and Kensington. This pattern can also be seen where the Sydney Metro North West provides a better public transport alternative (e.g. between Rouse Hill and Chatswood), as well as in the vicinity of the Parramatta Light Rail.

Figure 5-1 – Sydney GCCSA weekday rail passenger volume growth - 2016 to 2031

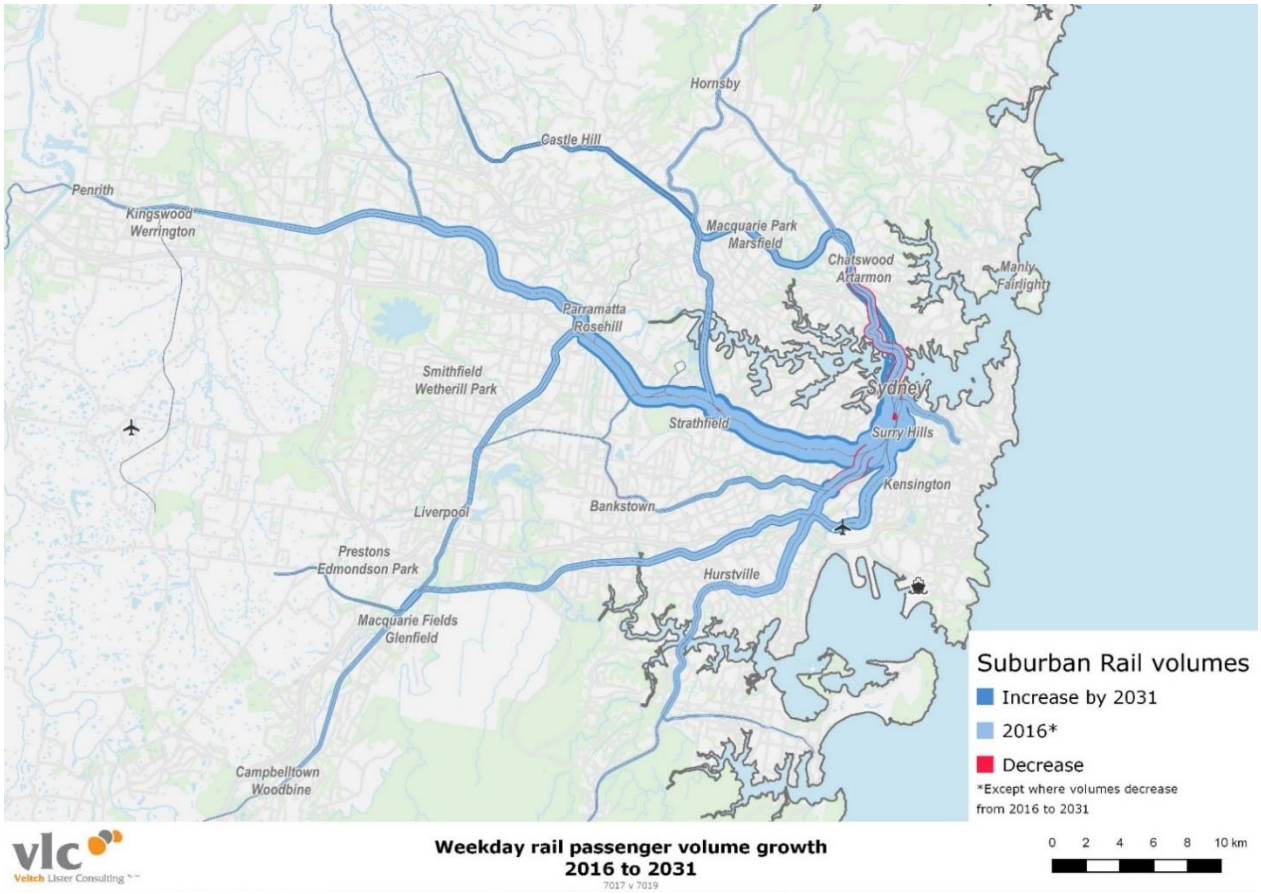
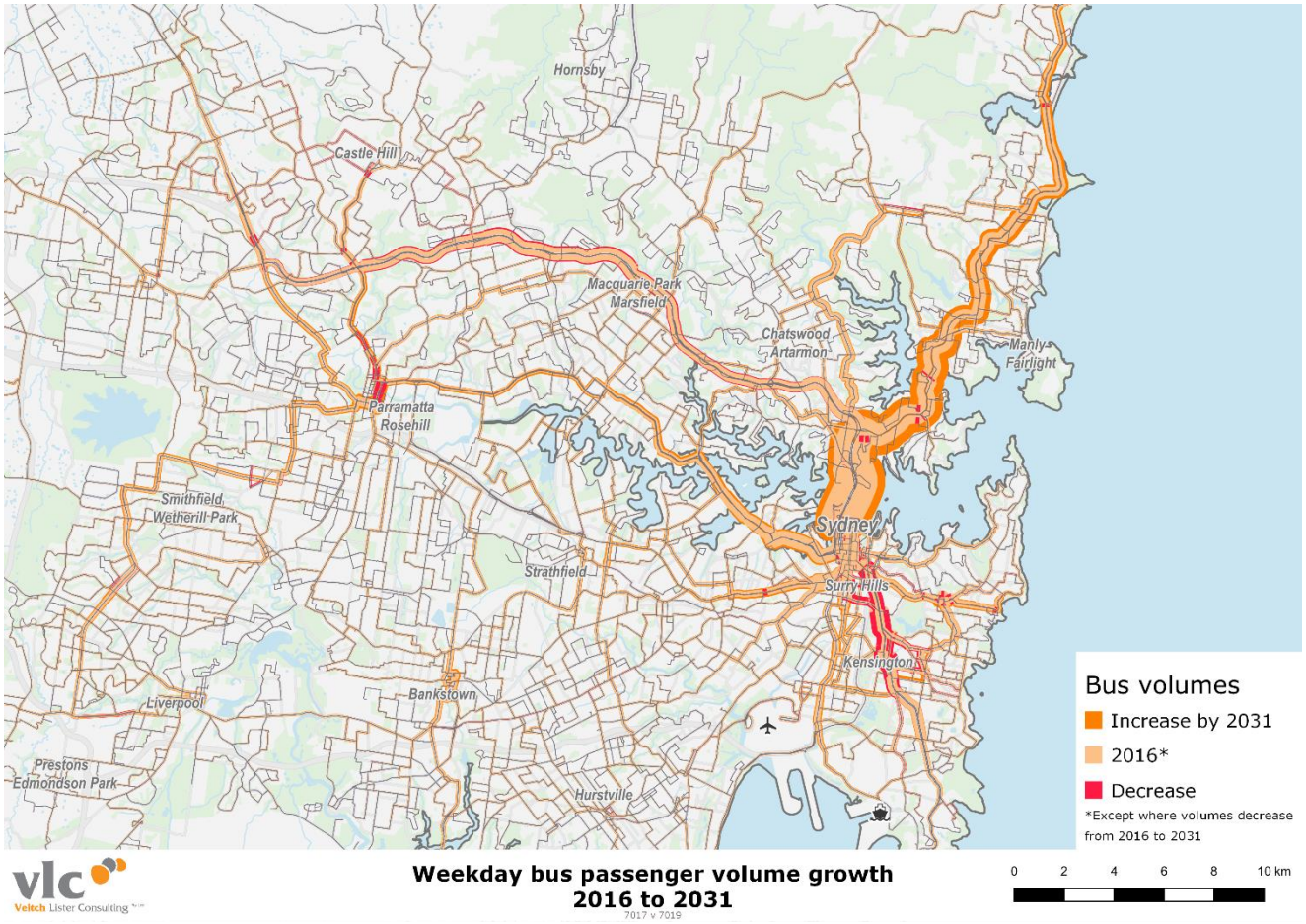


Figure 5-2 – Sydney GCCSA weekday bus passenger volume growth - 2016 to 2031



The high growth in public transport volumes in recent decades has resulted in peak crowding across most modes. This has been measured by using a V/C ratio, where the number of passengers on each service on a line is divided by the crush capacity of the rail rolling stock allocated to that service during the worst hour in the peak period. The worst hour in the 2-hour peak is assumed to be 55 per cent of that period, an assumption developed based on observed travel data from various Australian cities.

***Limitations of crowding measures**:*

While the model provides a sophisticated representation of the impacts of passenger crowding on the public transport network, there are two primary limitations to the crowding metric used in this report:

Firstly, the model represents 'timetabled' public transport operating conditions. When severe crowding occurs, it is often a result of service delays, cancellations or incidents not captured in the modelling.

Secondly, the V/C ratios represent a weighted average of all services on each corridor. This means that the measure does not reflect the complexity of the crowding on each individual service. For example, there may be uneven demand across services on the same line (e.g. more passengers on an express service compared with an all-stopper or higher loadings at 8 a.m. compared with 7.15 a.m.), or within a single service (e.g. one carriage is at capacity while another is much less crowded).

In the morning peak, suburban rail services become more crowded as they approach the Sydney CBD. The opposite pattern occurs in the evening, with services becoming less crowded as they get further from the city. Patronage in the counter peak direction is relatively low, suggesting that most

suburban rail commuters use the system to travel to and from the inner city for daytime working hours.

In 2016, the levels of crowding on Sydney's rail network in both the AM and PM peaks are estimated to approach, but not exceed, crush capacity (Figure 5-3 and Figure 5-4). The T1 Western and T2 Inner West lines between Sydney CBD and Parramatta, T8 Airport and South line (between Sydney CBD and East Hills), the T4 Illawarra and Cronulla Line (between Hurstville and the CBD) and T1 North Shore line (between Chatswood and Sydney CBD) carry the highest of number of passengers and experience the highest levels of crowding.

As detailed in the Appendix D: Model Assumptions, the Zenith model incorporates a crowding cost function, which means that travellers perceive a penalty for public transport journeys that are made under crowded conditions, increasing in response to level of crowding. Beyond an assumed crush capacity of 1430 passengers, or a seated load factor of 160 per cent, this penalty increases rapidly. In highly crowded conditions, this incentivises travellers to choose an alternative transport mode or service routing, and thus partly emulates the realistic limits of breaching crush capacity.

Sections of the rail network towards Sydney's fringe, such as the T5 Cumberland line and the northern sections of the T1 North Shore line (north of Chatswood) carry fewer passengers and do experience comparatively little crowding.

Figure 5-3 – Sydney GCCSA weekday rail passenger volume / crush capacity - 2016 1-hour AM peak

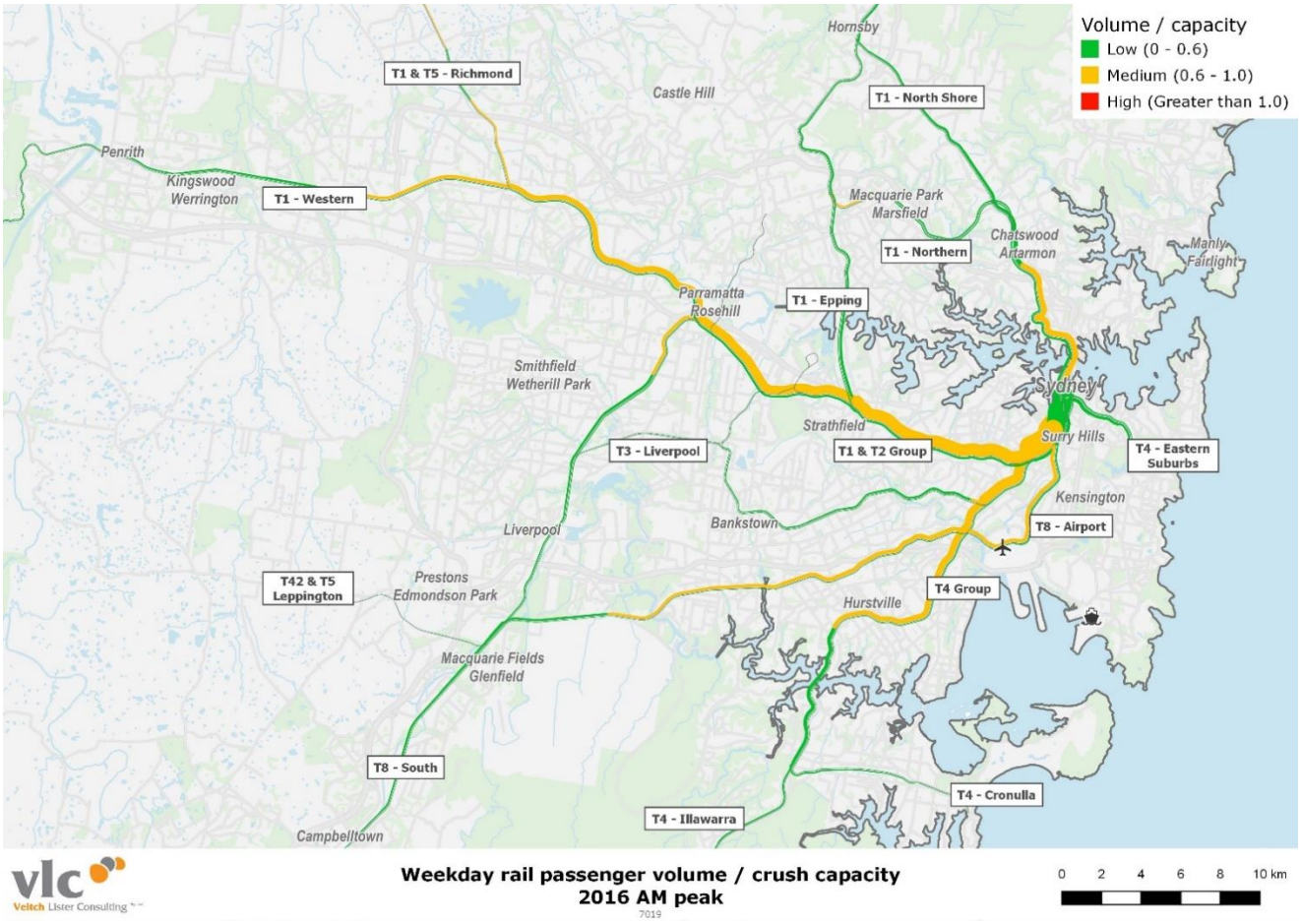
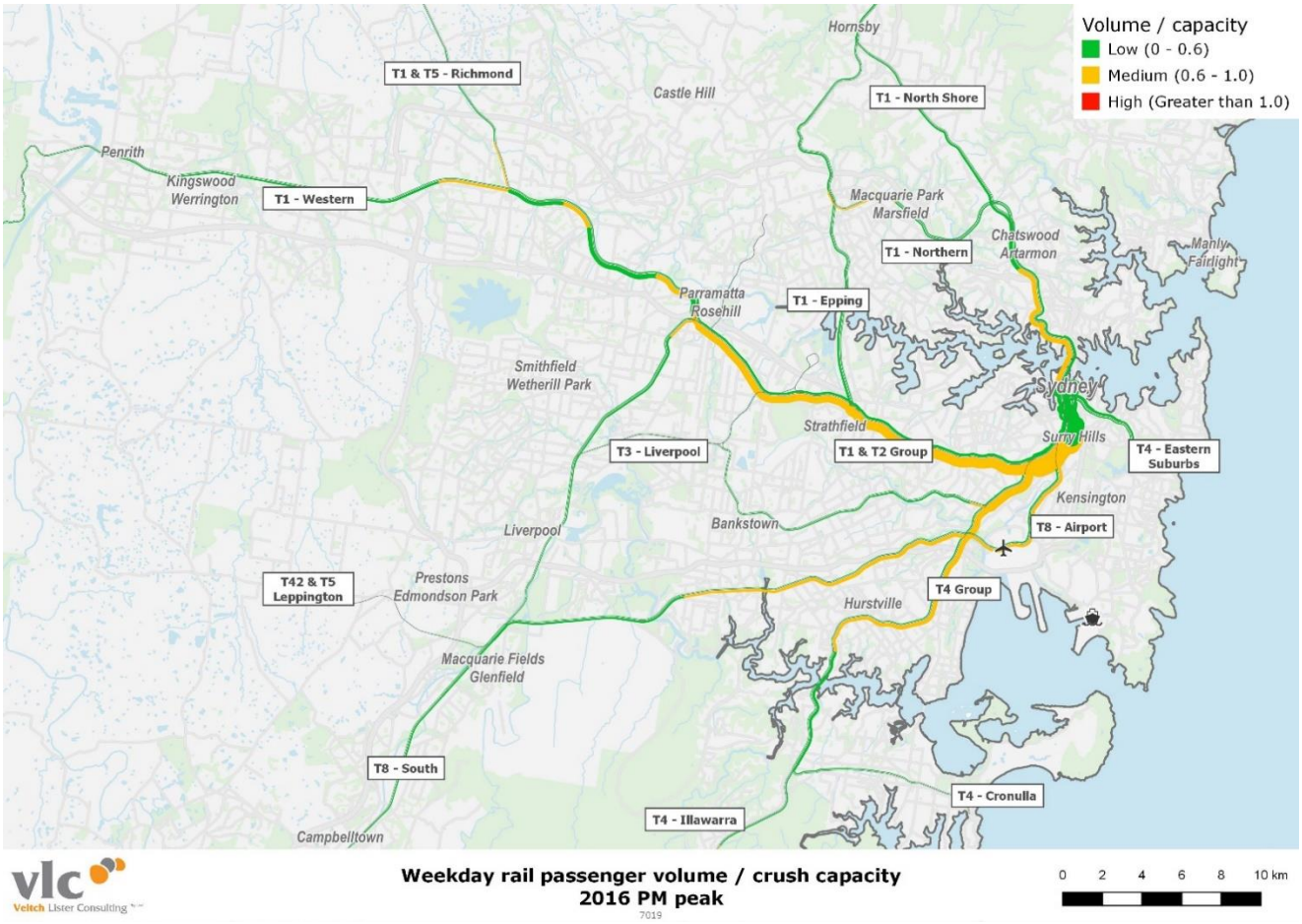


Figure 5-4 – Sydney GCCSA weekday rail passenger volume / crush capacity - 2016 1-hour PM peak



Sydney's suburban rail network is expected to come under considerable pressure in the 2031 peak periods, with most peak direction lines well above seated capacity. In terms of the displayed crush capacity metric, few lines are forecast to exceed capacity once demand responses to high crowding levels are accounted for. Most notably it is forecasted that the T8 Airport and South line (between Mascot and Sydney CBD, and between Panania and Revesby), as well as the T2 Inner West and T5 Cumberland lines (between Merrylands and Parramatta) will exceed crush capacity in the AM peak, and approach crush capacity in the PM peak (Figure 5-5 and Figure 5-6).

The most substantial section of high crowding (above crush capacity) is forecast for peak periods in 2031 on the T8 Airport and South between Mascot and Sydney. This reflects ongoing intensive residential and commercial redevelopment of the southeast Sydney light industrial areas, including Zetland, Mascot, Rosebery and Alexandria. These areas are forecast to have a 50 per cent population growth. Employment in Zetland is also expected to almost triple. Under the 'do-minimum' infrastructure scenario that has been applied for the 2031 forecast, the only projects that have been committed and included around this corridor are the CSELR, and Sydney Metro and Southwest, and the new M5 (WestConnex Stage 2). VLC understands that work is underway in the NSW Government to examine the transport needs in this growth corridor. In light of this, the high levels of crowding forecast on this section of the rail network may not be realised, but does highlight the risks if further infrastructure or policies are not implemented in high-growth corridors.

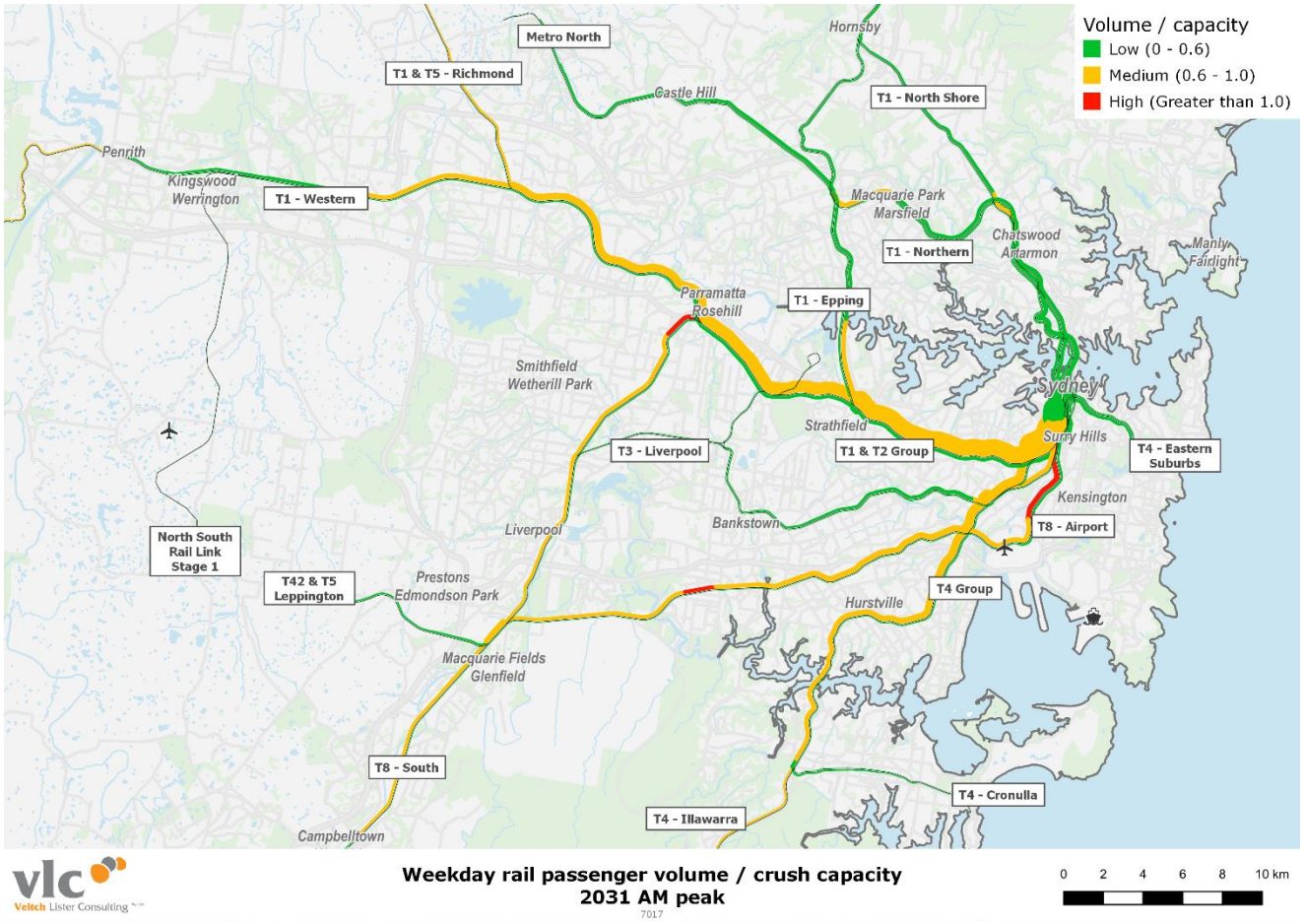
Revesby and Parramatta appear to be pinch points, as additional services begin at these stations, heading towards Sydney CBD. This means that as longer-distance services approach these stations

they become increasingly crowded until the additional services increase the capacity of the line and alleviate crowding.

More generally, the T1 Western, T1 North Shore, T2 Inner West, T4 Illawarra and Cronulla, T8 Airport and South lines are expected to experience widespread increases in crowding (except in sections where Metro provides additional parallel capacity). In spite of the increased loads, services on these lines are not predicted to reach crush capacity for a number of reasons. The additional travel penalty introduced by the crowding function further deters commuters from using these lines once crush capacity is approached.

On the main east-west rail corridor, land use plans have changed since the previous Audit, with increased concentration of growth in both population and employment towards Parramatta and the southwest (Appendix E). This moderates future demand growth forecast on corridors in the east-west directions during the AM and PM peaks since travel behaviour associated with employment is more contained in these regions requiring travel to jobs in the east (Sydney and North Sydney CBDs).

Figure 5-5 – Sydney GCCSA weekday rail passenger volume / crush capacity - 2031 1-hour AM peak

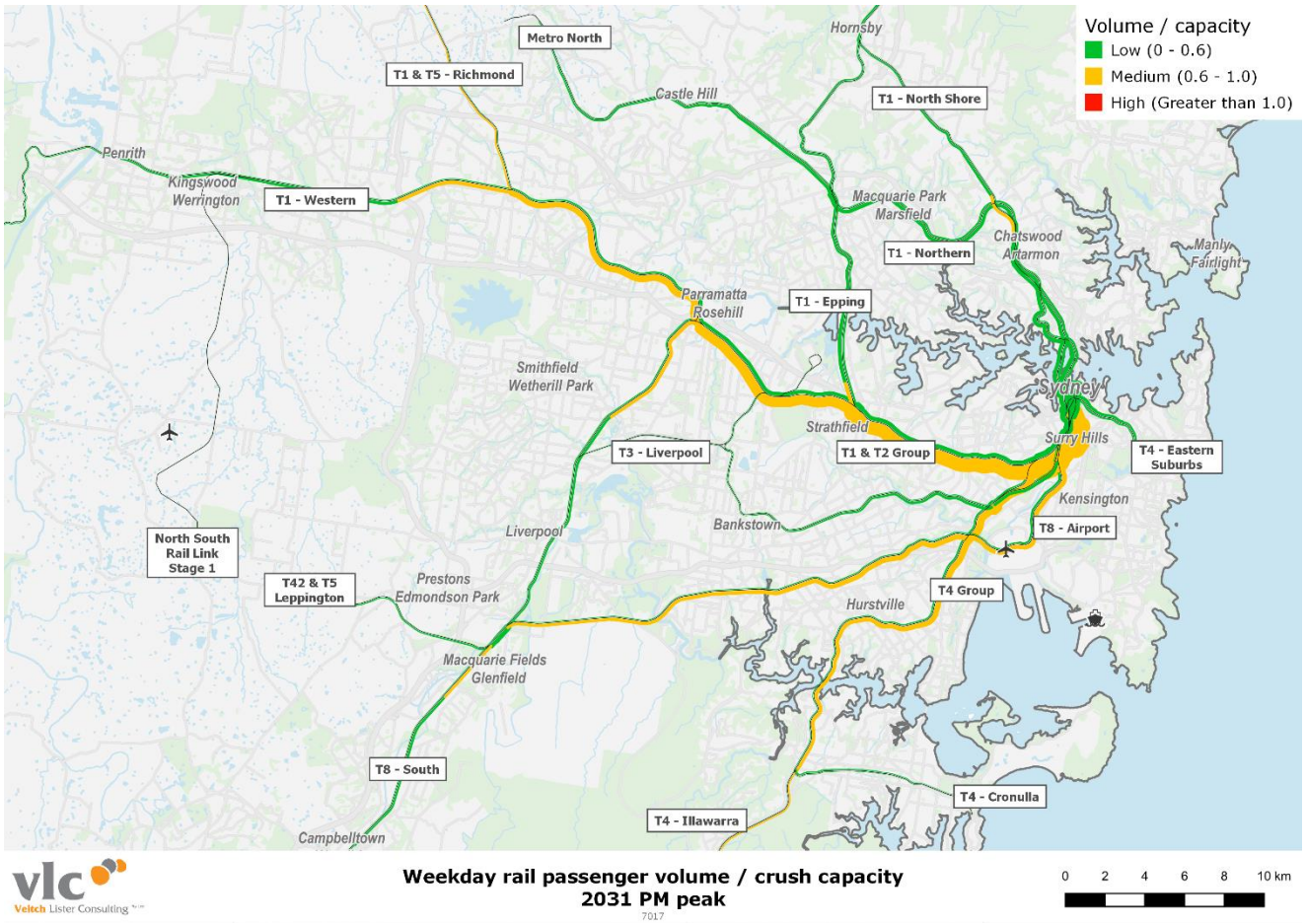


Further, service frequency on the T1 Western line was increased by 6-7 services per hour in 2017, significantly expanding the total line capacity. And more subtly, the introduction of the second rail Harbour Crossing may draw passengers from the Epping area away from the T1 Western line (services via Strathfield) to the Metro Northwest corridor via Chatswood. Furthermore, the WestConnex alignment has also changed since the last Audit, and now more readily allows east-west road access, which attracts a modest portion of potential T1 Western line rail travellers to car travel.

The new Sydney Metro North West line is shown to have moderate patronage, but is not expected to experience significant crowding in 2031.

Stage one of the North South Rail Link appears to attract minimal patronage or crowding, however, patronage is likely to be underestimated. As a region-wide forecast, public transport demand attributes for Western Sydney airport reflect the attributes of the broader geographical region of outer-suburban Sydney. Therefore, the impact of landside demand specifically generated by the Western Sydney Airport has not been accounted for in detail, as it would otherwise be in a model for this specific project, region and travel purpose. Additionally, the exact alignment of the North South Rail Link project and airport terminals has not been defined in detail by government planning documents at the time of writing. As such, the modelled level of accessibility between airside terminals and landside rail stations at Western Sydney airport may not reflect what is ultimately built.

Figure 5-6 – Sydney GCCSA weekday rail passenger volume / crush capacity - 2031 1-hour PM peak



The most heavily patronised bus corridors in 2016 are those that provide commuters from the northwest, Northern Beaches and Eastern Suburbs with access to the Sydney CBD. Notably, services in the Northern Beaches and Eastern Suburbs, as well as the M2 in the Hills District, are shown to approach crush capacity, as these areas currently have no rail alternatives. Bus corridors are crowded in the peak directions, with low patronage in the counter peak direction. Mostly higher levels of crowding are demonstrated during the AM peak compared to the PM peak, which is suggestive of travel patterns of commuters whom have a more rigid ‘start of work’ time and more variable work departure time (Figure 5-7 and Figure 5-8).

Where bus routes are designed to feed the rail network, there are lower levels of crowding, with exceptions on the Liverpool – Parramatta T-way and routes between Parramatta and Epping, where crowding also approaches crush capacity. These routes are the quickest public transport option for many commuters; The T-way is comprised of bus-only lanes, and so does not suffer from congestion, while taking the bus between Parramatta and Epping is a more direct route than travelling by rail. Rail feeder bus routes have a more balanced numbers of users travelling on buses *from* train stations in the morning and *to* stations in the evening compared with the bus-all-the-way corridors.

Figure 5-7 – Sydney GCCSA weekday bus passenger volume / crush capacity - 2016 1-hour AM peak

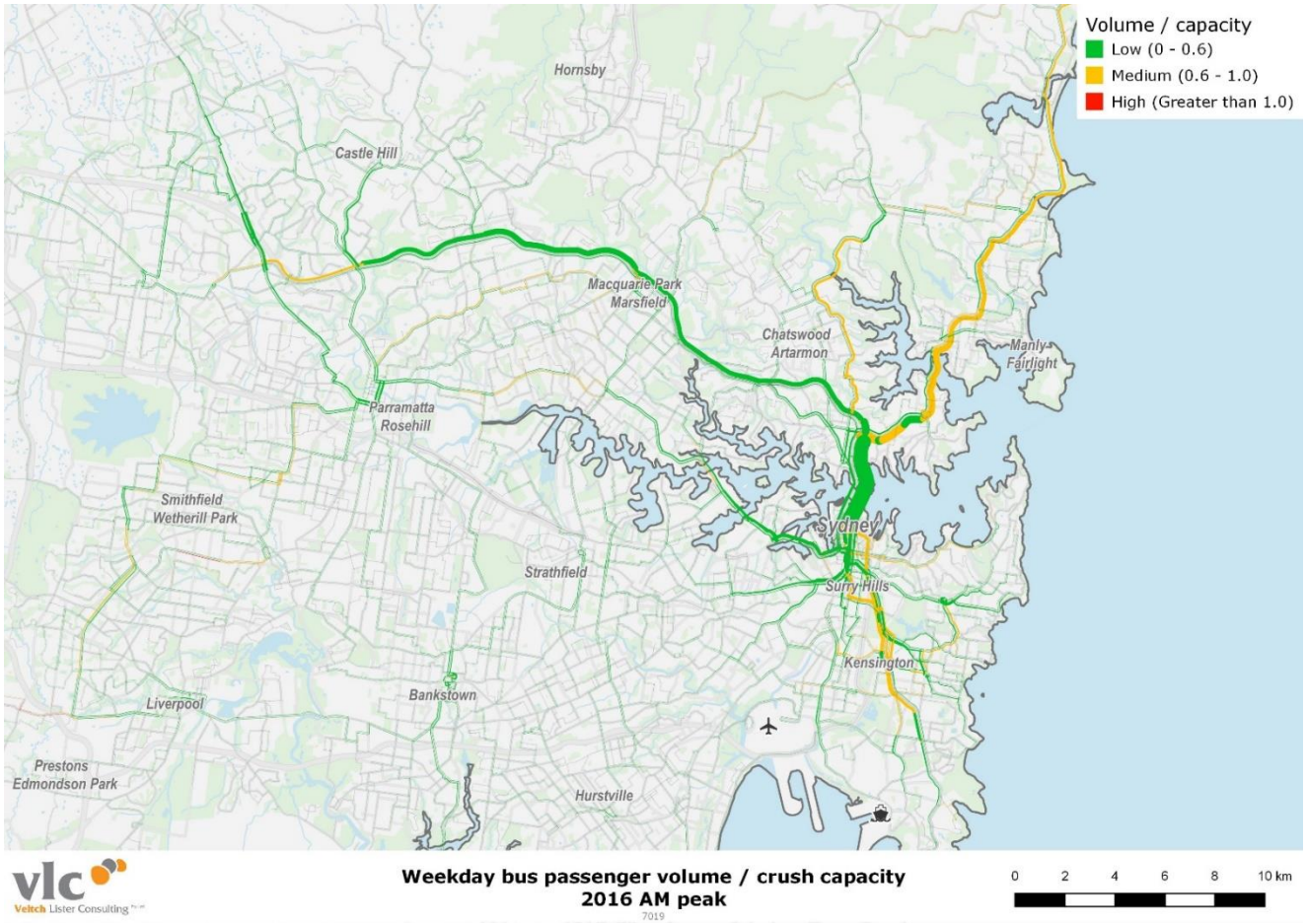
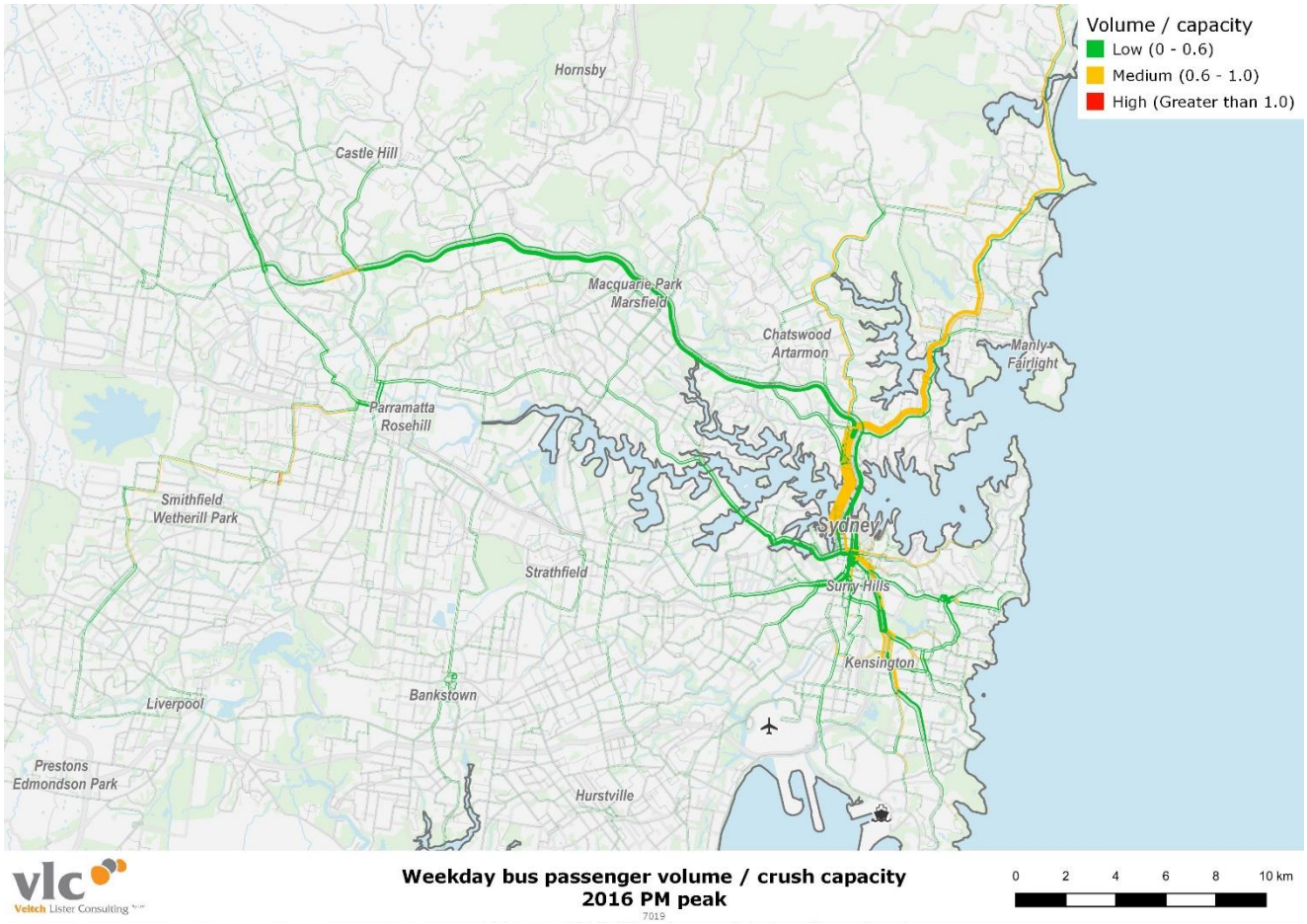


Figure 5-8 – Sydney GCCSA weekday bus passenger volume / crush capacity - 2016 1-hour PM peak

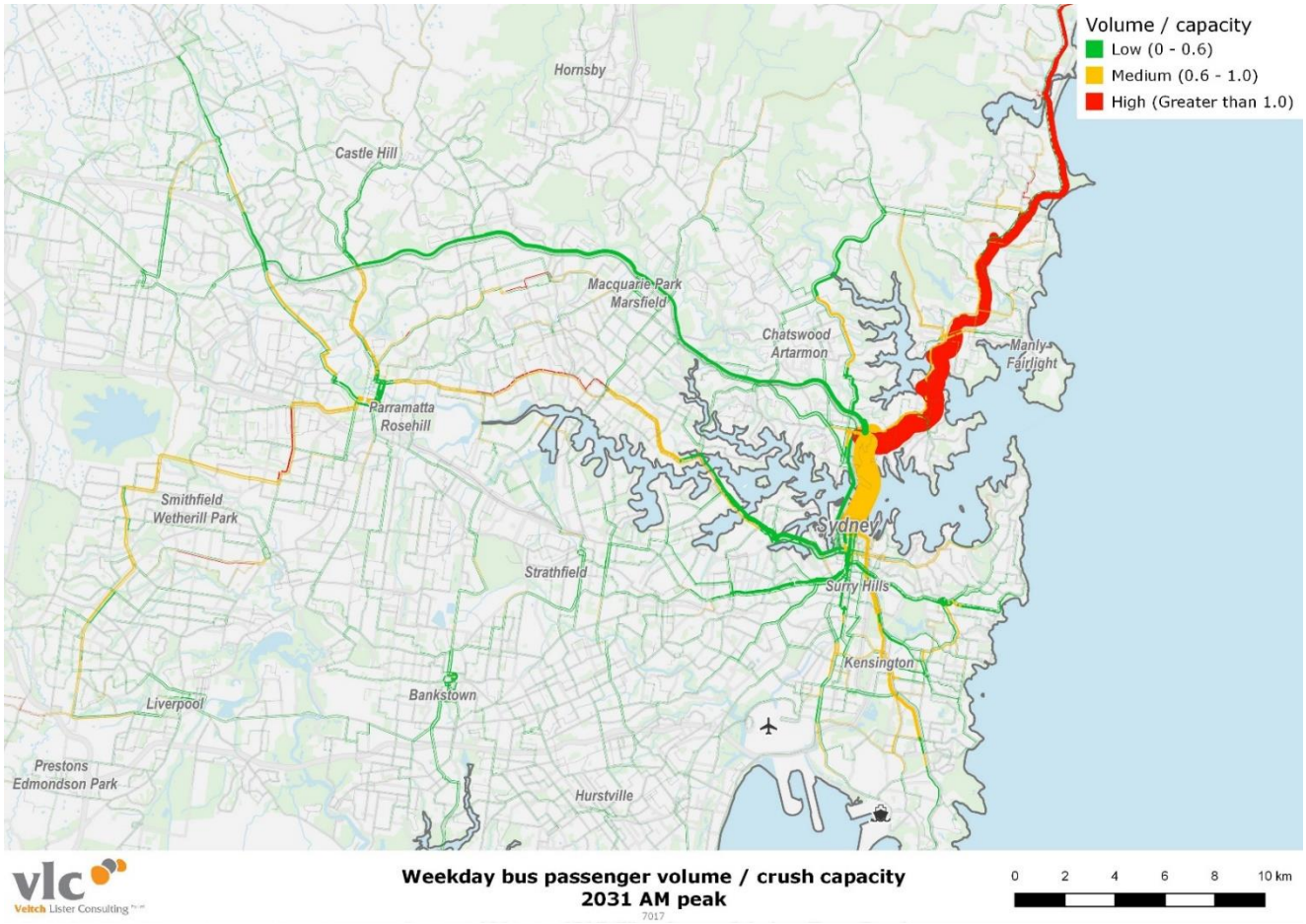


Crowding on Sydney's buses is also projected to worsen by 2031 (Figure 5-9 and Figure 5-10). In particular, routes serving the Northern Beaches are forecast to exceed crush capacity for the majority of the services to the Sydney CBD, while much of the Liverpool – Parramatta T-Way and routes running parallel to the T1 Western line from Parramatta either approach or exceed crush capacity. This is a result of the bus priority upgrades planned for these routes as well as the introduction of the B-Line servicing the Northern Beaches[4]. The improvements allow buses to travel at uncongested speeds along these routes, some of which are otherwise heavily congested during peak hours. This attracts more passengers from alternative modes, due to the relatively high travel speeds and reliability. Conversely, in the northwest, crowding levels are predicted to be alleviated in response to commuters switching to travel on the Sydney Metro North West.

Bus services planned to travel between Parramatta and Liverpool in the southwest, are also expected to exceed crush capacities. This is indicative of the increased travel demand between these two growth areas, coupled with limited bus service improvements included in this 'minimum intervention' future scenario.

[4] A network-wide set of seated and standing capacities have been modelled, even though a new vehicle fleet with alternative capacities will be applied as part of the B-Line services. This will have a small effect on the estimated V/C ratio in this corridor.

Figure 5-9 – Sydney GCCSA weekday bus passenger volume / crush capacity - 2031 1-hour AM peak



Buses are most affected by traffic during the AM and PM peak periods, with less delay expected for the middle of the day (Figure 5-11). In the off-peak period, buses likely operate with very little delay and thus it can be assumed that speeds of around 32 km per hour constitute largely unimpeded operating conditions. In spite of significant increase of road congestion to 2031, average bus speeds across all time periods are expected to be stable. In the AM peak, a slight improvement is expected. Where buses run in mixed traffic, the Zenith model applies congested speeds between bus stops, so this result reflects the net result of worsening congestion in some (unprioritised) corridors being approximately offset by speed improvements due to bus priority upgrades in other bus corridors, such as Parramatta, Mona Vale, and North Bondi, to the Sydney CBD.

Figure 5-10 – Sydney GCCSA weekday bus passenger volumes / crush capacity - 2031 1-hour PM peak

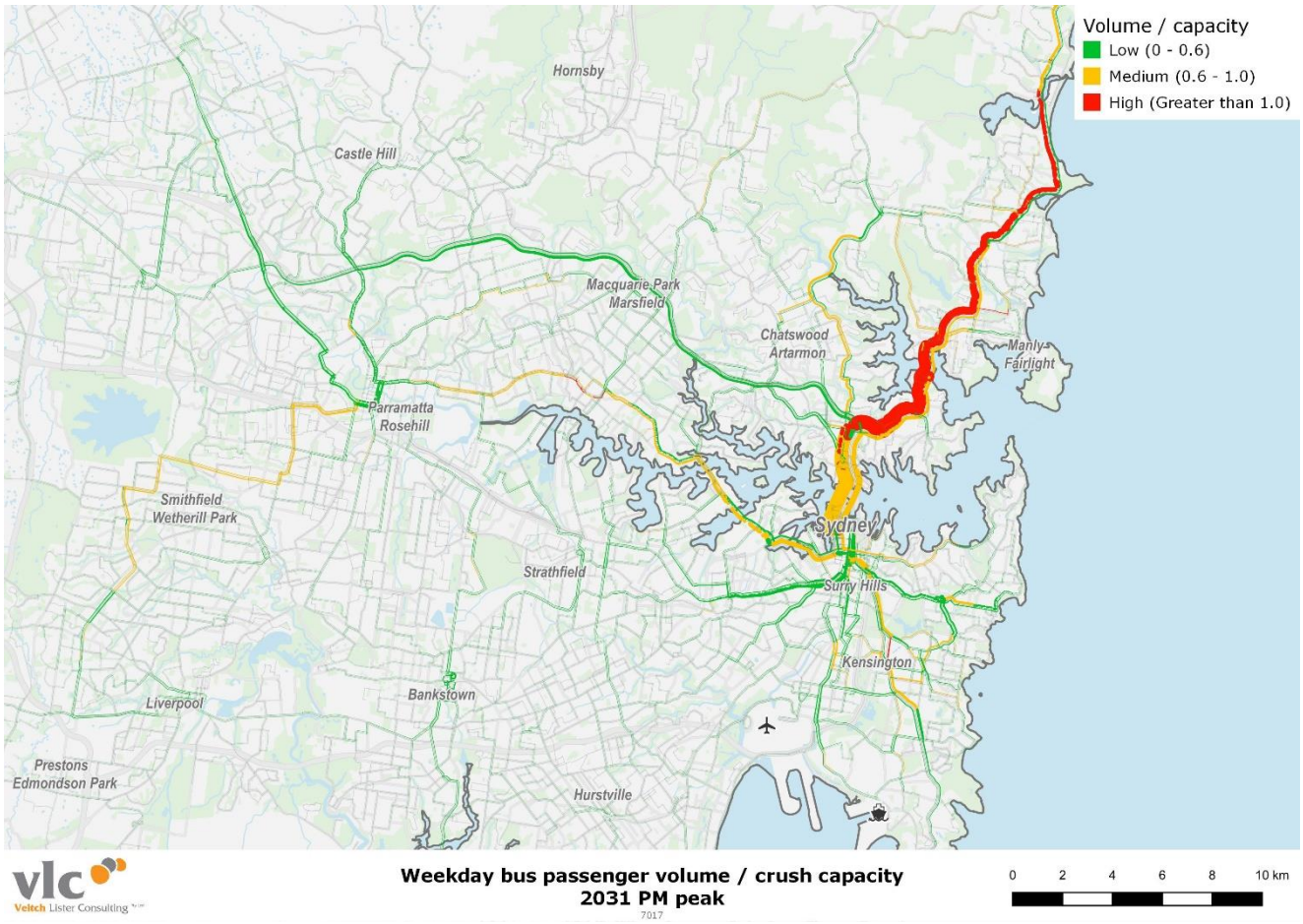
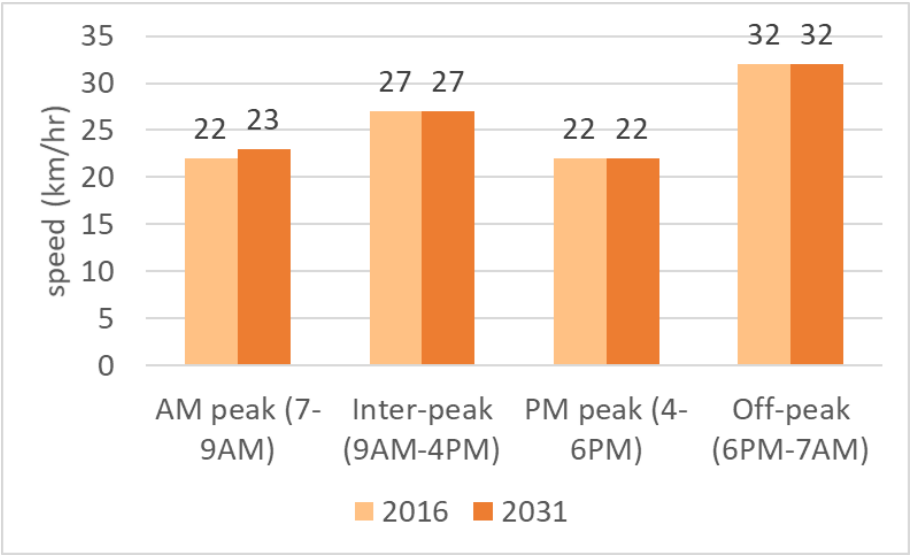


Figure 5-11 – Sydney GCCSA average bus speeds



6. Accessibility and social inclusion

The ability to participate in society is greatly affected by access to services and opportunities. Hospitals, schools, child care services and green space are all vital types of social infrastructure that can enhance the wellbeing of individuals and the community generally. Conversely, poor transport connections and lack of access to these kinds of services can lead to social isolation and exclusion.

This section of the report examines the extent to which areas across Greater Sydney have adequate access to key services and opportunities both now and in the future. Services have been considered at two levels of geography – local and regional (Table 6-1). Shorter travel times would be expected for services in the former group, while longer travel times are more acceptable for regional social infrastructure.

Two factors affect a person's accessibility to services. The first is the travel times across the transport network. For example, increased congestion on the road network causes longer travel times, resulting in lower accessibility. New road connections, on the other hand, may reduce travel times, resulting in higher accessibility. Accessibility is measured by both car and public transport travel times.

The second factor is the spatial distribution of services. The addition of more jobs, a new hospital, or a new park would result in an improvement to accessibility for adjacent areas, even without apparent changes to travel times. The locations of child care services, hospitals, schools and green space are assumed to remain static between 2016 and 2031. In reality this is unlikely to be the case, and new services will almost certainly be developed over the coming years. While to some extent this is a limitation of these measures, it also provides an opportunity to highlight where new social infrastructure development should be focused if it is not already in planning.

Limitations of strategic accessibility modelling:

All travel times represent journeys between travel zones – one zone is at the home end of the trip and the other at the destination. Demand produced from each travel zone is fed onto the transport network from a single point (the 'centroid') via a notional link known as a 'centroid connector'. The precision of modelled travel times is therefore highly dependent on the granularity of travel zones at either end of the journey. Geographically larger travel zones (generally at the fringes of the urban area) have a greater imprecision associated with the location of the centroid versus the actual locations of households. Larger zones also have longer centroid connectors, so the travel time on these connectors to reach the realistic transport network becomes a proportionally longer component of the overall trip. The model is not able to estimate travel times for trips made by public transport entirely within a travel zone – 'intrazonal trips'. Travel times for these trips are therefore based on walk times. Finally, the model does not consider all factors that can affect end-to-end car travel time, such as locating a car park.

To aid interpretation, two adjustments are made to the maps of PT accessibility: large and low population density zones are not mapped, and remaining zones containing the relevant social infrastructure are capped at 30 minute access time.

Table 6-1 – Social infrastructure services

Service	Accessibility metric	Rationale	Spatial data source
		Local	
Child care services	Average travel time to the nearest five child care centres	The availability of child care services is an important driver for participation in social activities for parents and children alike. Having a choice of more than one service increases the likelihood that parents and children will find a centre to meet their specific needs, for example in terms of opening hours or style of care.	Approved education and care services in 2018 from the Australian Children's Education & Care Quality Authority.
Public schools (primary/ secondary)	Travel time to the nearest school	School is generally the most significant social activity for school age children and teenagers. This metric has been limited to public schools to cover all residents.	Schools in 2016 from the Australian Curriculum, Assessment and Reporting Authority
Green space	% of the residential population in an SA3 within a 10-minute walk of green space	Green space is a vital component of liveable cities and provides an opportunity for recreation and socialising for residents.	Parkland classified meshblocks in the 2016 Census. This includes nature reserves, conserved/protected areas, and public open space. It may also include sporting facilities not open to the public. Minor alterations have been made based on satellite data.
		Regional	
Jobs	Number of jobs that can be reached within 30 minutes by car and public transport	Access to jobs is a critical indicator of social inclusion. The more employment opportunities within a reasonable travel time from a person's home, the higher the likelihood of that person finding a job that appropriately matches their skills and experience.	2016 and 2031 employment data from Zenith, which is adapted from the 2016 ABS Census and 2031 NSW Government projections
Hospitals (public/ emergency)	Travel time to the nearest public/emergency hospital	Limited access to healthcare can negatively impact health outcomes and overall quality of life. This metric has been limited to public hospitals and/or hospitals with an emergency department to ensure that the service is usable by all residents.	Hospitals in 2018 from the MyHospital database (Australian Institute of Health and Welfare)

6.1 Accessibility in 2016 and 2031

Local infrastructure should be accessible within short travel times. Ideally, residents should also have options to choose motorised or active modes of transport for these journeys.

The modelling indicates that for the average Sydney resident with access to a car, child care and public schools are within a six-minute trip in 2016 and a seven-minute trip in 2031 (Table 6-2). For residents who are dependent on public transport or active transport modes, travel times are longer – generally between 15 and 20 minutes for child care services and public primary schools in 2016 and 2031, with public secondary schools averaging 26 minutes. Looking towards 2031, public transport and car travel times worsen somewhat, although many inner and middle SA3s are forecast to experience modest improvements in average public transport travel times (Table 6-3).

Table 6-2 – Sydney GCCSA population-weighted average travel times to child care and public schools - AM peak (7-9AM)

Service	Car (mins)		PT (mins)	
	2016	*2031*	*2016*	*2031*
Child care services	3.5	4.0	18.6	18.9
Public primary school	3.1	3.6	16.3	16.9
Public secondary school	5.2	6.1	26.2	26.8

Figure 6-1 highlights average travel times to the nearest five child care centres by car in more spatial detail for 2031. Consistent with the city-wide average travel time of four minutes, most parts of Sydney can reach a range of child care centres within a five-minute drive from home in 2031, providing they have access to a car. The main exceptions are SA3s in predominantly regional areas, such as the Hawkesbury, Blue Mountains – South, and Wollondilly (Table 6-3). Wollondilly, Bringelly – Green Valley, Blacktown – North and Rouse Hill – McGraths Hill are also projected to experience the greatest increases in average travel times across services and transport modes (Figure 6-1 to Figure 6-6). This estimated reduction in accessibility is a function of significant population growth projections coupled with the limited existing supply of both transport and social infrastructure in designated growth areas. The large model travel zones in these areas also mechanically boosts estimated travel times to and from newly populated areas, so results should be interpreted with a degree of caution (see ‘Limitations of strategic accessibility modelling’ box above).

The much longer average travel times required for residents who are dependent on public transport is clearly evident in Figure 6-2 (child care centres), Figure 6-4 (public primary schools) and Figure 6-6 (public secondary schools). In some established areas in Sydney, public transport may offer a realistic alternative to car as a means of accessing child care centres, with travel times of between 10 and 20 minutes, including time walking to and from the stops. In areas on the urban fringe, travel times approaching 30 minutes will be required.

Figure 6-1 – Sydney, Hunter and Illawarra average time to nearest five child care centres by Car - 2031 AM peak (7-9AM)

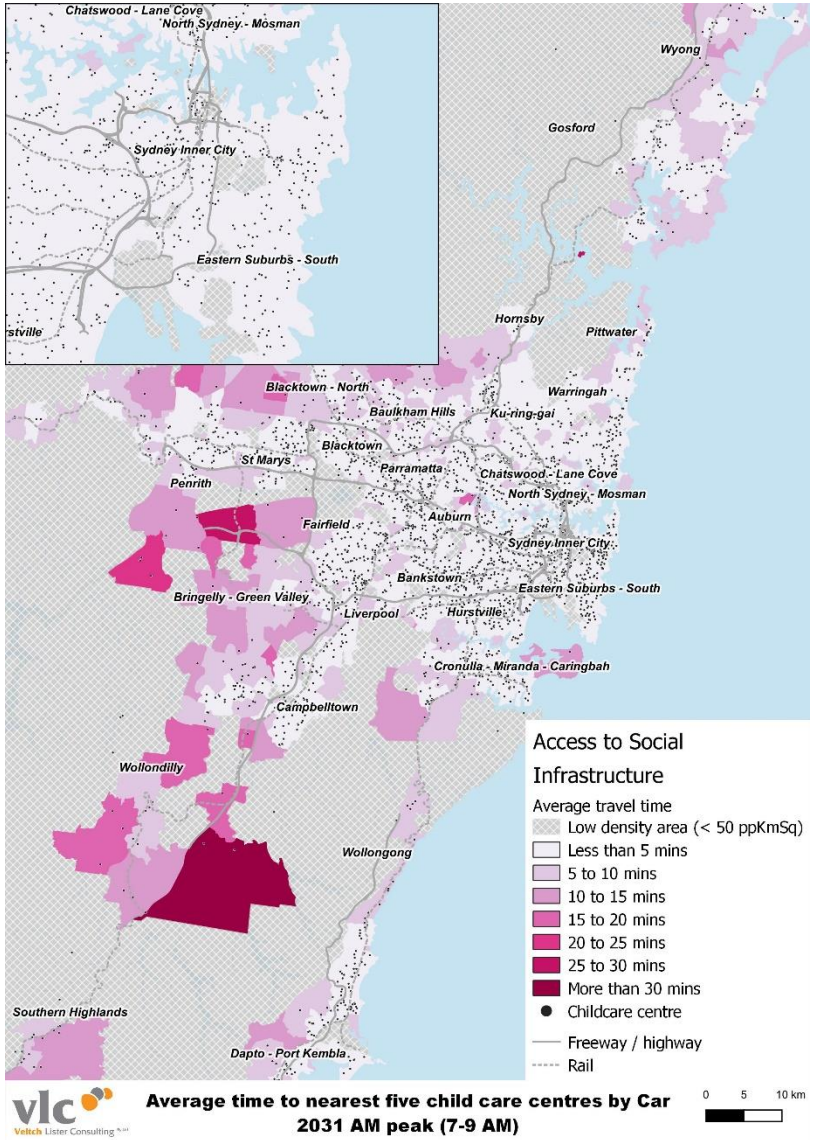


Figure 6-2 – Sydney, Hunter and Illawarra average time to nearest five child care centres by PT - 2031 AM peak (7-9AM)

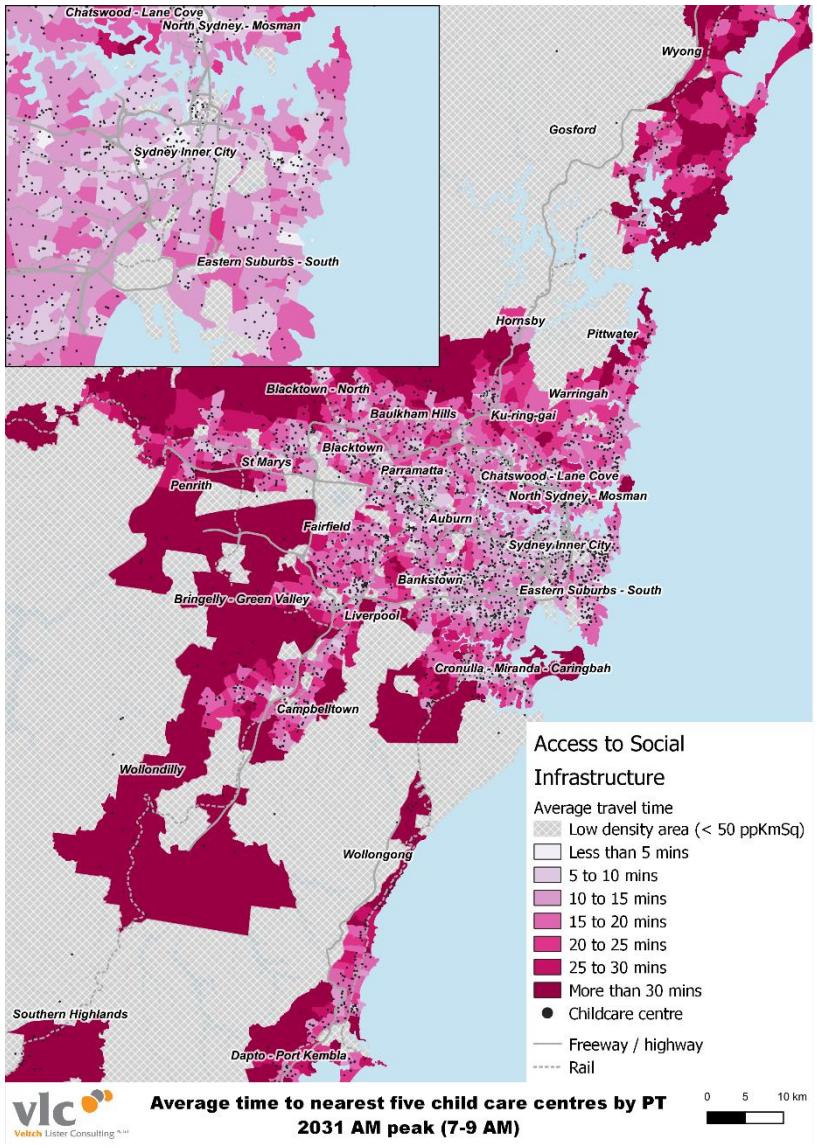


Figure 6-3 – Sydney, Hunter and Illawarra average time to nearest public primary school by Car - 2031 AM peak (7-9AM)

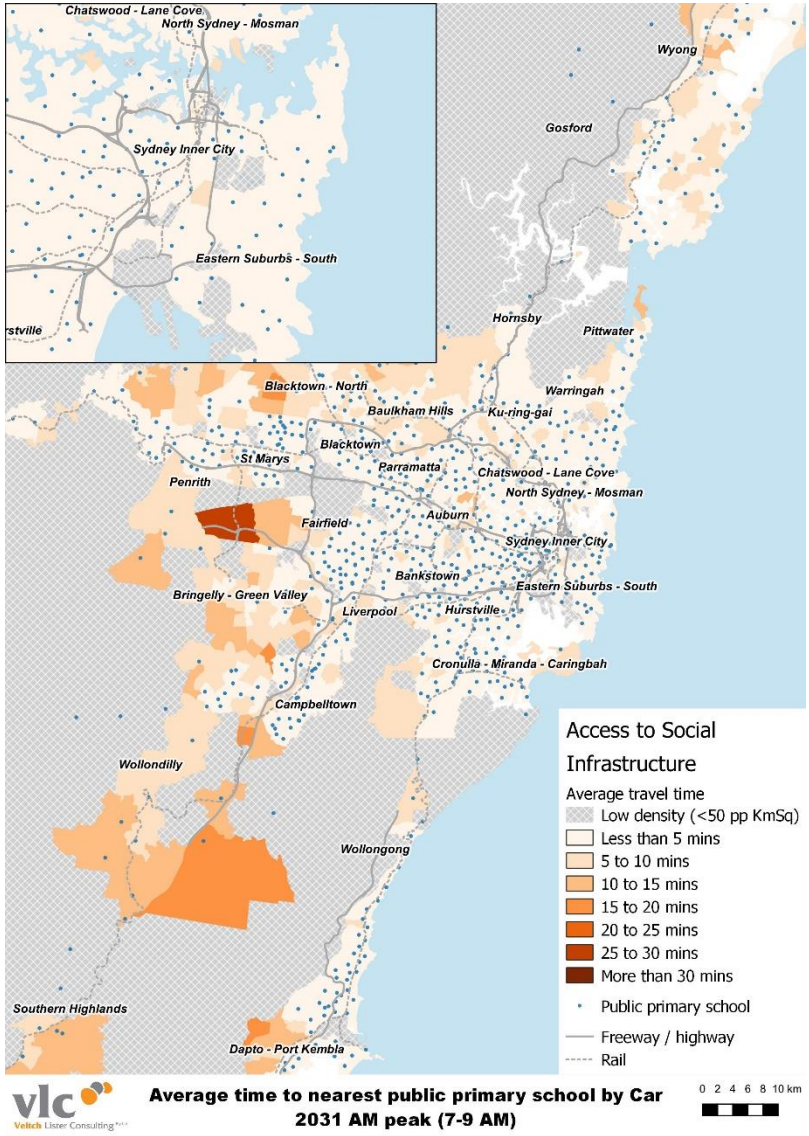


Figure 6-4 – Sydney, Hunter and Illawarra average time to nearest public primary school by PT - 2031 AM peak (7-9AM)

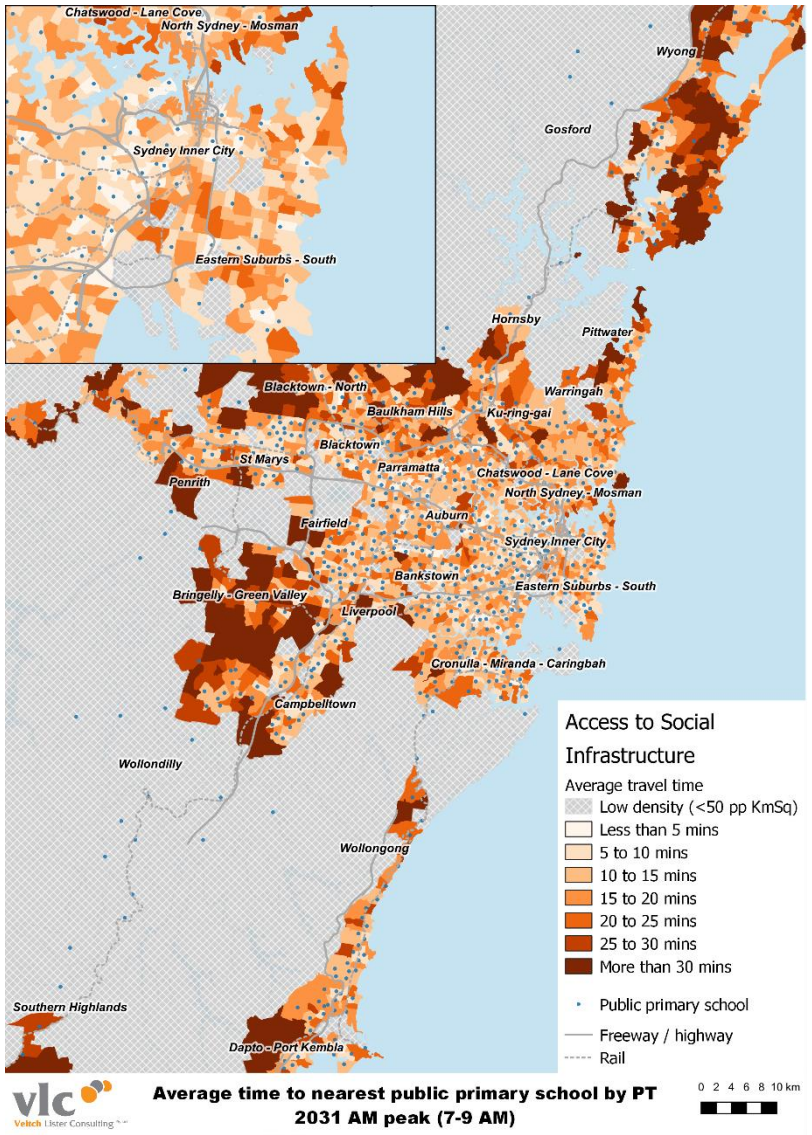
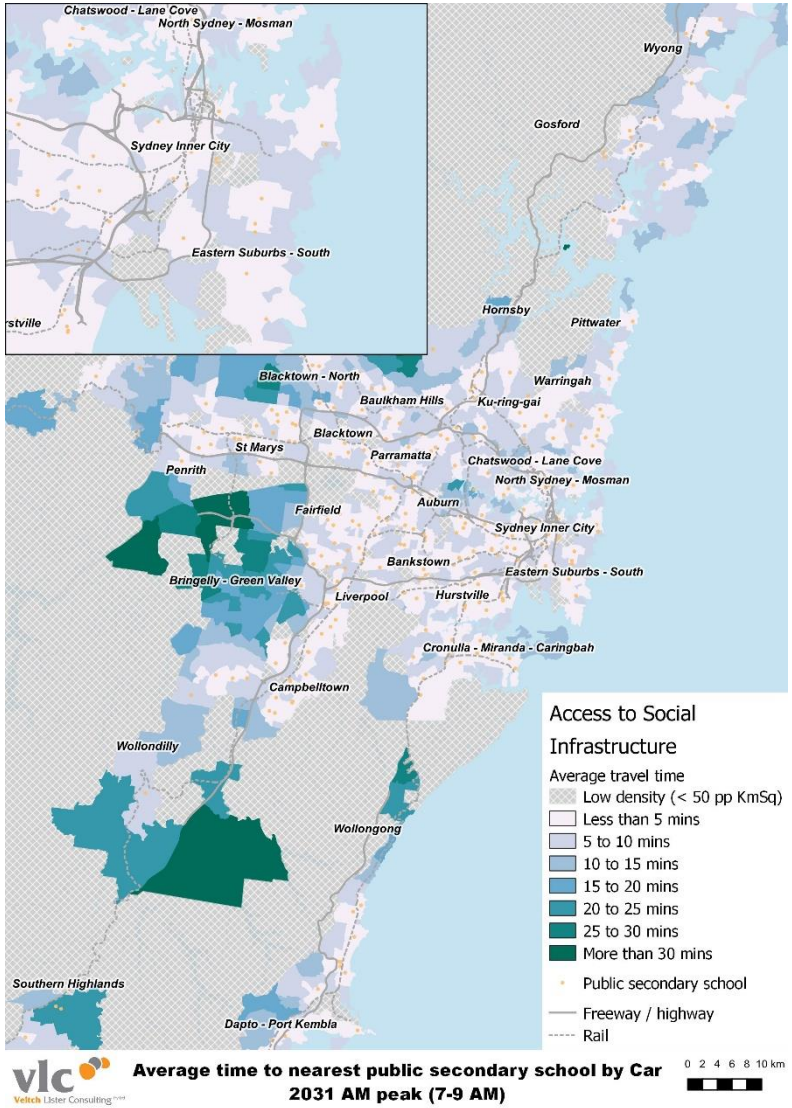
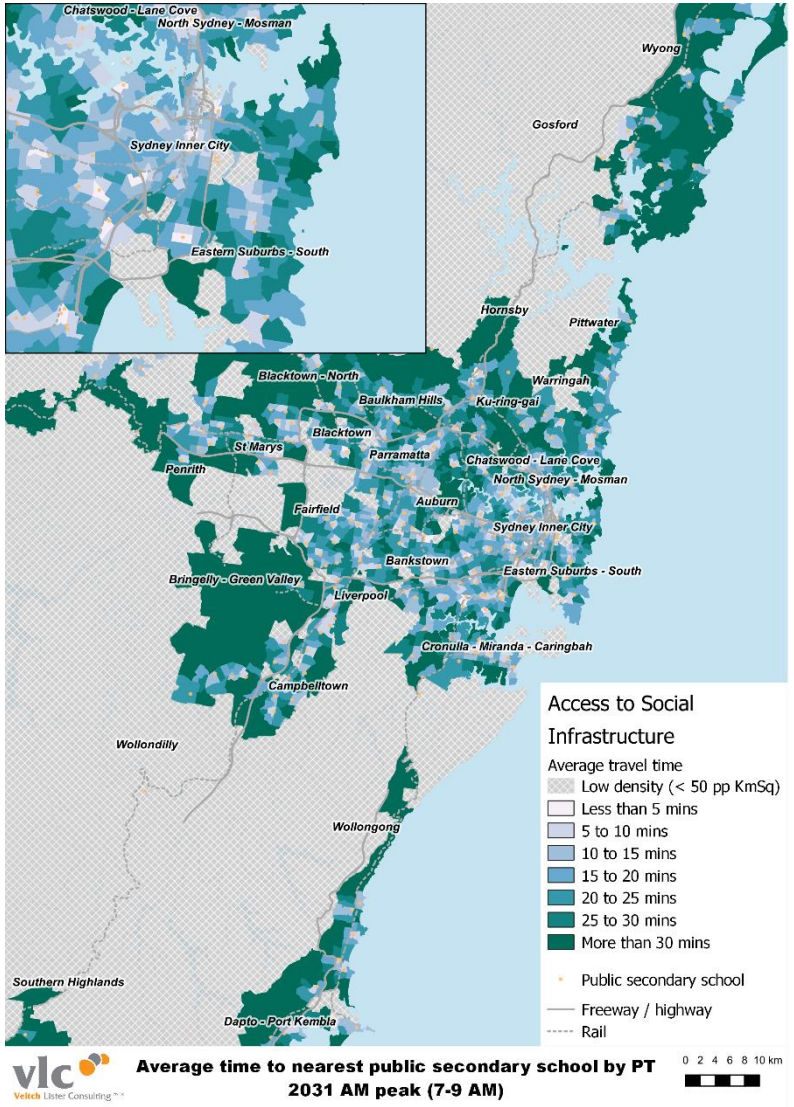


Figure 6-5 – Sydney, Hunter and Illawarra average time to nearest public secondary school by Car - 2031 AM peak (7-9AM)



Average time to nearest public secondary school by Car
2031 AM peak (7-9 AM)

Figure 6-6 – Sydney, Hunter and Illawarra average time to nearest public secondary school by PT - 2031 AM peak (7-9AM)



Average time to nearest public secondary school by PT
2031 AM peak (7-9 AM)

Table 6-3 – Sydney, Hunter and Illawarra population-weighted average travel times to child care and public schools by SA3 - AM peak (7-9AM)*

SA3	Child care (nearest five, mins)						Nearest public primary school (mins)						Nearest public secondary school (mins)					
	Car			PT			Car			PT			Car			PT		
	2016	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*
Auburn	2.9	4.9	*+2.0*	13.2	13.7	*+0.4*	2.6	4.4	*+1.8*	12.6	14.6	*+1.9*	5.9	9.8	*+3.9*	26.7	28.2	*+1.6*
Bankstown	2.5	2.5	*+0.0*	13.9	13.3	*-0.6*	2.3	2.4	*+0.1*	12.6	12.2	*-0.4*	3.8	4.0	*+0.2*	20.1	19.3	*-0.8*
Baulkham Hills	3.7	4.5	*+0.8*	17.8	18.2	*+0.4*	3.8	4.8	*+1.0*	18.7	19.6	*+0.9*	5.2	6.2	*+1.1*	26.4	26.8	*+0.4*
Blacktown	3.0	3.3	*+0.3*	16.1	15.5	*-0.6*	2.6	3.0	*+0.4*	13.8	13.9	*+0.1*	4.4	5.1	*+0.7*	23.1	22.1	*-0.9*
Blacktown - North	4.0	5.9	*+1.9*	18.0	25.7	*+7.7*	3.4	5.0	*+1.6*	16.3	22.3	*+6.0*	5.7	8.7	*+3.0*	25.9	35.4	*+9.5*
Blue Mountains	5.8	5.9	*+0.2*	32.4	32.3	*-0.2*	4.2	4.3	*+0.1*	23.7	23.5	*-0.2*	11.7	12.0	*+0.3*	56.4	57.2	*+0.8*
Blue Mountains - South	23.5	24.1	*+0.7*	132.9	127.8	*-5.1*	19.6	20.1	*+0.5*	102.6	100.0	*-2.5*	31.4	31.9	*+0.5*	130.4	126.1	*-4.3*
Botany	2.9	3.2	*+0.3*	13.8	13.9	*+0.1*	2.5	2.9	*+0.4*	13.1	13.5	*+0.4*	4.9	5.3	*+0.4*	21.7	22.4	*+0.6*
Bringelly - Green Valley	4.9	7.1	*+2.2*	27.0	34.7	*+7.7*	4.1	5.9	*+1.8*	21.7	27.6	*+5.9*	7.3	13.4	*+6.0*	39.0	51.2	*+12.2*
Camden	4.5	4.8	*+0.4*	24.1	23.6	*-0.5*	4.0	4.3	*+0.3*	20.7	19.7	*-1.0*	5.5	5.8	*+0.4*	31.2	30.4	*-0.8*
Campbelltown	3.5	4.4	*+0.9*	20.6	22.6	*+1.9*	2.8	3.6	*+0.8*	15.9	18.9	*+3.0*	3.9	5.3	*+1.4*	23.9	26.9	*+3.0*
Canada Bay	3.4	4.0	*+0.5*	11.1	10.4	*-0.7*	3.4	4.1	*+0.7*	11.9	11.3	*-0.6*	7.8	9.8	*+2.0*	22.9	22.3	*-0.5*
Canterbury	2.1	2.2	*+0.1*	11.1	10.9	*-0.1*	2.2	2.4	*+0.2*	11.5	11.5	*-0.0*	4.1	4.5	*+0.5*	19.2	18.6	*-0.6*
Carlingford	3.1	3.6	*+0.5*	15.6	14.3	*-1.3*	2.8	3.1	*+0.4*	12.7	12.2	*-0.6*	4.5	5.3	*+0.8*	22.8	21.0	*-1.8*
Chatswood - Lane Cove	2.4	2.5	*+0.1*	12.0	11.7	*-0.3*	2.8	2.9	*+0.1*	14.1	13.8	*-0.3*	4.6	5.1	*+0.4*	20.8	20.0	*-0.7*
Cronulla - Miranda - Caringbah	2.6	2.6	*-0.0*	16.0	15.4	*-0.6*	2.3	2.3	*-0.0*	13.7	13.4	*-0.3*	3.5	3.4	*-0.1*	21.5	20.3	*-1.1*
Dural - Wisemans Ferry	14.5	14.8	*+0.3*	71.7	68.0	*-3.7*	9.9	10.0	*+0.1*	53.3	51.1	*-2.2*	18.0	19.2	*+1.2*	87.2	83.0	*-4.2*
Eastern Suburbs - North	2.2	2.2	*+0.0*	11.6	11.2	*-0.4*	2.3	2.4	*+0.0*	12.6	12.1	*-0.5*	5.4	5.7	*+0.3*	26.3	25.4	*-0.9*
Eastern Suburbs - South	2.4	2.5	*+0.1*	11.7	11.9	*+0.2*	2.6	2.7	*+0.2*	12.9	13.3	*+0.4*	4.2	4.8	*+0.5*	18.8	19.8	*+1.0*
Fairfield	3.1	3.4	*+0.3*	16.8	16.5	*-0.3*	2.8	3.0	*+0.3*	14.9	14.6	*-0.2*	3.8	4.2	*+0.5*	21.5	21.0	*-0.5*
Gosford	5.0	5.2	*+0.2*	29.9	29.1	*-0.9*	4.0	4.2	*+0.2*	24.2	23.8	*-0.3*	6.5	6.7	*+0.2*	38.9	36.9	*-2.0*
Hawkesbury	25.0	24.9	*-0.0*	135.4	126.5	*-8.9*	14.8	14.8	*-0.1*	84.7	79.4	*-5.3*	24.9	25.1	*+0.2*	140.2	130.7	*-9.5*
Hornsby	3.8	3.9	*+0.1*	20.4	19.6	*-0.7*	3.3	3.3	*+0.0*	17.7	17.0	*-0.7*	6.1	6.2	*+0.1*	27.4	25.8	*-1.6*
Hurstville	2.3	2.3	*+0.1*	12.7	12.2	*-0.5*	1.9	2.0	*+0.1*	11.0	10.9	*-0.1*	2.9	3.0	*+0.1*	16.9	16.4	*-0.5*
Kogarah - Rockdale	2.3	2.5	*+0.2*	12.5	12.5	*-0.0*	2.2	2.3	*+0.1*	11.6	11.3	*-0.3*	4.1	4.7	*+0.5*	20.5	20.1	*-0.4*
Ku-ring-gai	3.8	3.9	*+0.1*	20.0	19.5	*-0.5*	3.4	3.5	*+0.2*	18.6	18.7	*+0.1*	6.3	6.7	*+0.4*	31.5	31.0	*-0.5*
Leichhardt	1.7	1.7	*+0.1*	9.2	9.0	*-0.3*	1.7	1.8	*+0.1*	9.2	9.1	*-0.1*	2.5	2.6	*+0.1*	14.8	14.4	*-0.4*
Liverpool	3.0	3.4	*+0.4*	15.9	16.3	*+0.4*	2.9	3.4	*+0.5*	15.8	16.3	*+0.5*	4.1	4.8	*+0.7*	24.3	24.3	*+0.1*
Manly	2.2	2.3	*+0.0*	14.3	13.9	*-0.4*	2.0	2.1	*+0.0*	13.1	12.8	*-0.2*	3.7	3.8	*+0.1*	20.9	21.1	*+0.2*
Marrickville - Sydenham - Petersham	2.3	2.3	*+0.0*	11.1	11.3	*+0.2*	1.8	1.9	*+0.1*	8.8	9.2	*+0.4*	3.0	3.0	*+0.0*	14.8	14.4	*-0.4*
Merrylands - Guildford	2.4	2.7	*+0.3*	12.0	11.7	*-0.3*	2.3	2.7	*+0.4*	11.7	12.1	*+0.4*	3.8	4.4	*+0.6*	19.1	19.1	*-0.0*
Mount Druitt	3.5	3.7	*+0.2*	16.6	16.1	*-0.5*	2.8	2.9	*+0.1*	12.5	12.4	*-0.1*	4.7	5.1	*+0.4*	24.2	23.5	*-0.7*

SA3	Child care (nearest five, mins)						Nearest public primary school (mins)						Nearest public secondary school (mins)					
	Car			PT			Car			PT			Car			PT		
	2016	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*	*2016*	*2031*	*Diff*
North Sydney - Mosman	2.2	2.3	*+0.1*	11.5	11.0	*-0.5*	2.6	2.7	*+0.1*	13.8	13.2	*-0.5*	3.5	3.8	*+0.3*	17.5	16.7	*-0.8*
Parramatta	2.3	2.7	*+0.4*	11.3	10.4	*-0.9*	2.3	2.8	*+0.5*	11.2	10.6	*-0.6*	3.5	4.5	*+1.1*	17.2	16.6	*-0.7*
Pennant Hills - Epping	2.4	2.5	*+0.1*	12.4	11.8	*-0.6*	2.4	2.4	*+0.0*	11.7	11.0	*-0.7*	5.1	6.7	*+1.6*	23.7	24.0	*+0.3*
Penrith	4.6	5.5	*+0.9*	23.7	24.3	*+0.6*	3.7	4.7	*+0.9*	19.5	21.1	*+1.5*	6.2	7.6	*+1.4*	29.4	31.1	*+1.6*
Pittwater	4.2	4.5	*+0.3*	23.5	22.9	*-0.5*	3.7	4.1	*+0.4*	21.2	21.7	*+0.6*	5.1	5.5	*+0.5*	28.3	29.8	*+1.4*
Richmond - Windsor	6.3	6.6	*+0.3*	36.2	35.1	*-1.0*	4.7	4.7	*+0.0*	27.3	25.9	*-1.4*	9.6	10.7	*+1.2*	49.9	49.5	*-0.4*
Rouse Hill - McGraths Hill	5.7	7.7	*+2.1*	31.5	39.2	*+7.7*	4.5	7.3	*+2.8*	24.9	35.6	*+10.7*	6.8	9.9	*+3.0*	41.1	49.9	*+8.8*
Ryde - Hunters Hill	2.9	3.1	*+0.2*	14.8	13.8	*-1.0*	2.6	3.1	*+0.4*	14.0	14.2	*+0.1*	4.9	5.7	*+0.9*	23.6	23.7	*+0.1*
St Marys	3.3	3.4	*+0.1*	18.3	17.8	*-0.5*	2.4	2.5	*+0.1*	12.2	12.1	*-0.1*	3.7	3.8	*+0.1*	21.2	20.0	*-1.2*
Strathfield - Burwood - Ashfield	2.3	2.6	*+0.2*	11.5	11.4	*-0.1*	2.4	2.6	*+0.2*	11.6	11.2	*-0.4*	3.6	3.9	*+0.2*	16.6	16.0	*-0.7*
Sutherland - Menai - Heathcote	4.7	4.8	*+0.1*	25.0	24.0	*-1.0*	3.5	3.5	*+0.1*	17.5	17.3	*-0.2*	5.8	5.9	*+0.1*	30.4	29.3	*-1.0*
Sydney Inner City	2.0	2.2	*+0.2*	8.4	8.3	*-0.1*	2.5	2.9	*+0.4*	11.0	11.6	*+0.6*	3.4	4.0	*+0.5*	14.3	14.5	*+0.3*
Warringah	3.2	3.3	*+0.0*	17.0	16.7	*-0.3*	3.0	3.1	*+0.0*	15.3	15.0	*-0.3*	4.4	4.5	*+0.1*	23.7	22.2	*-1.5*
Wollondilly	16.0	18.6	*+2.6*	83.0	87.3	*+4.3*	11.0	12.2	*+1.2*	64.6	65.1	*+0.6*	19.8	22.9	*+3.1*	97.2	100.2	*+3.0*
Wyong	6.0	6.2	*+0.2*	35.1	33.3	*-1.9*	4.6	4.7	*+0.1*	27.6	26.1	*-1.5*	6.9	7.2	*+0.3*	39.8	37.7	*-2.1*
Sydney GCCSA	**3.5**	**4.0**	***+0.5***	**18.6**	**18.9**	***+0.3***	**3.1**	**3.6**	***+0.5***	**16.3**	**16.9**	***+0.6***	**5.2**	**6.1**	***+1.0***	**26.2**	**26.8**	***+0.6***
Lake Macquarie - East	4.9	5.1	*+0.2*	28.4	27.2	*-1.2*	3.1	3.3	*+0.2*	17.1	16.8	*-0.3*	5.9	6.3	*+0.4*	35.0	32.1	*-2.9*
Newcastle	4.5	4.9	*+0.4*	22.4	22.0	*-0.4*	3.4	3.7	*+0.3*	17.5	17.7	*+0.2*	6.1	6.9	*+0.8*	29.4	29.4	*+0.0*
Lake Macquarie - West	7.8	8.8	*+1.0*	46.6	47.8	*+1.2*	4.9	5.5	*+0.6*	29.4	30.5	*+1.1*	10.0	11.2	*+1.2*	57.6	57.4	*-0.1*
Upper Hunter	25.3	26.1	*+0.8*	224.7	220.8	*-3.9*	18.0	18.7	*+0.7*	125.5	126.2	*+0.7*	22.1	22.9	*+0.8*	168.2	167.4	*-0.8*
Maitland	6.6	7.2	*+0.6*	35.5	34.2	*-1.3*	5.4	5.9	*+0.5*	28.0	27.5	*-0.5*	9.2	10.6	*+1.3*	51.7	51.5	*-0.2*
Port Stephens	11.3	11.3	*-0.0*	65.7	63.3	*-2.5*	7.3	7.4	*+0.1*	45.4	43.5	*-1.9*	15.4	16.2	*+0.8*	88.4	83.2	*-5.3*
Shoalhaven	11.1	11.3	*+0.3*	71.2	69.0	*-2.2*	8.6	8.7	*+0.1*	59.4	58.5	*-0.9*	13.1	13.6	*+0.5*	81.7	79.4	*-2.4*
Lower Hunter	19.9	22.7	*+2.9*	121.7	122.5	*+0.8*	13.8	16.0	*+2.1*	82.1	81.9	*-0.2*	20.4	24.2	*+3.8*	127.1	127.8	*+0.7*
Hunter Region	**9.4**	**10.1**	***+0.7***	**58.8**	**57.6**	***-1.2***	**6.7**	**7.2**	***+0.5***	**40.7**	**40.2**	***-0.5***	**11.1**	**12.3**	***+1.2***	**66.4**	**65.0**	***-1.4***
Kiama - Shellharbour	4.8	5.2	*+0.5*	33.9	33.3	*-0.6*	4.1	4.5	*+0.4*	26.1	26.7	*+0.6*	6.0	6.8	*+0.8*	44.6	44.0	*-0.6*
Wollongong	3.8	3.9	*+0.1*	23.0	22.6	*-0.4*	2.8	2.9	*+0.1*	16.5	16.4	*-0.1*	6.1	6.4	*+0.4*	34.1	34.1	*-0.0*
Dapto - Port Kembla	4.3	5.0	*+0.7*	27.0	28.0	*+1.0*	3.6	4.2	*+0.7*	20.9	22.8	*+1.8*	5.0	6.0	*+1.0*	30.6	32.0	*+1.4*
Illawarra Catchment Reserve	30.0	32.4	*+2.4*	162.9	180.8	*+18.0*	27.5	30.4	*+3.0*	148.4	166.6	*+18.3*	35.7	38.3	*+2.6*	172.0	189.4	*+17.4*
Illawarra Region	**4.2**	**4.6**	***+0.4***	**27.5**	**27.6**	***+0.1***	**3.4**	**3.8**	***+0.4***	**20.7**	**21.5**	***+0.8***	**5.8**	**6.4**	***+0.7***	**36.5**	**36.8**	***+0.3***

*The travel times reflect all modelled zones and so does not reflect adjustments made in Figures 6-2, 6-4 and 6-6 (see 'Limitations of strategic accessibility modelling' box above).

Most Sydney residents are assessed to have close access to green space. In 2016, 97 per cent of the population is assessed as being able to reach green space within 10 minutes, decreasing slightly to 96 per cent in 2031. This measure excludes population in large travel zones (mostly on the urban fringe or rural areas). Applying a similar filter at an SA3 level constrains the analysis largely to established areas – nearly all of which are assessed as having very good walking access to green space of some kind. Some SA3s either in the inner ring (Sydney Inner City and Eastern Suburbs – South) or outer edge (Blacktown – North) have below average access to green space (Figure 6-7).[5]

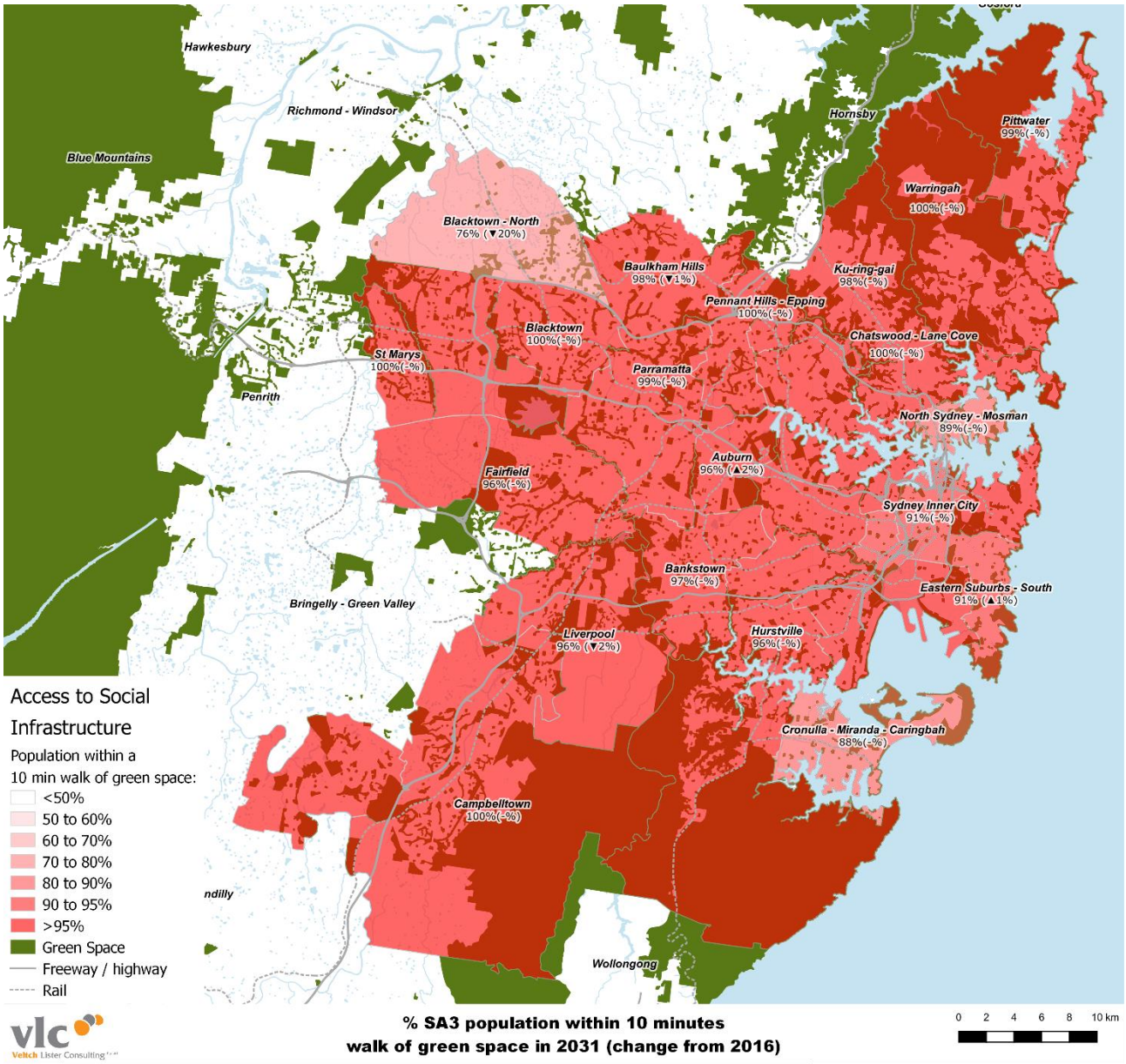
Limitations to measuring green space access:

Green areas defined in Figure 6-7 overleaf are used to estimate the green space accessibility metric. This interpretation of green space is quite broad, and does not account for the quality or quantity of the area. All residents in a travel zone are measured as having the same access to green space in one of two ways. The first is if the travel zone itself includes green space, it is assumed that walking time for everyone is 10 minutes or less. The second is if the walking time to nearby travel zones with green space is 10 minutes or less.

Both of these cases for estimation of metrics have issues on the urban fringe where travel zones are large. To overcome these issues, large and low-population-density travel zones have been excluded from the SA3 metrics mapped in Figure 6-7. Similarly, SA3s with more than 80 per cent of its population in large travel zones are not mapped.

[5] While not mapped, outer greenfield development areas, such as Bringelly – Green Valley, are assessed as experiencing large reductions in green space accessibility to 2031. This is likely due to a combination of the spatial distribution of projected population growth in these areas and a lack of resolution in modelling of the future land uses on the urban fringe (travel zones, pedestrian and local road infrastructure, as well as future parklands themselves). Plans for these areas are at an early stage for the growth area which limits the level of detail that can be input to the model and, in turn, the realism of accessibility outcomes for such a localised metric.

Figure 6-7 – Sydney GCCSA percentage of population within a 10-minute walk of green space in 2031



Access to employment opportunities across Sydney differs dramatically depending on where a person lives and what mode of travel they take. This accessibility also changes significantly between 2016 and 2031. Employment accessibility is measured here as the percentage of total jobs that can be reached within 30 minutes by car (Figure 6-8 and Figure 6-9), and by public transport (Figure 6-10 and Figure 6-11). As jobs represent a 'regional' level category of social infrastructure, travel times are generally expected to be longer than for child care, schools and green space.

The high current and future concentration of jobs within the eastern areas of Greater Sydney (especially Sydney and North Sydney CBDs) mean that the ease of access to these areas is the main driver of employment accessibility. Areas close to the city or near infrastructure that directly links to the CBD have the highest level of access by car and by public transport. Job accessibility by car generally reduces into the future, with many parts of Sydney being able to access a smaller percentage of available jobs in 2031 compared with 2016 in part due to growing road congestion and in part due to increasing dispersal of population relative to jobs. In areas such as Bringelly – Green Valley, Liverpool, Fairfield, Ryde – Hunters Hill and Blacktown large declines in job accessibility

suggest that the job growth forecasted in these growth areas is insufficient compared to both the local population growth and the number of new jobs in other employment hubs.

Job accessibility by public transport is relatively stable between 2016 and 2031, with most residents unable to reach a significant proportion of available jobs within a 30-minute commute. The SA3s with the greatest job accessibility are Sydney Inner City (14%) and North Sydney – Mosman (6%) where there is a high concentration of jobs, coupled with good public transport access to other employment areas. For areas with significant population and employment growth, such as Bringelly – Green Valley, Rouse Hill – McGrath Hill and Blacktown – North, poor future job accessibility by public transport indicate that the public transport infrastructure included in the minimum development 2031 scenario is insufficient to offer good enough connections to external job opportunities, nor is there sufficient local employment to allow enough people to access work in a short commute.

Access to critical healthcare is measured by the travel time to the nearest public hospital, or hospital with an emergency department, by car and public transport (Figure 6-12 and Figure 6-13). Car accessibility to hospitals is vastly superior to that available by public transport. The shortest average travel time to the nearest public hospital via public transport is just over 20 minutes, for residents in Sydney Inner City, while most Sydney residents needing to travel for more than 30 minutes, with exceptions for those who live very close to a hospital (Table 6-4).

Figure 6-8 – Sydney, Hunter and Illawarra access to jobs by Car - 2016 AM peak (7-9AM)

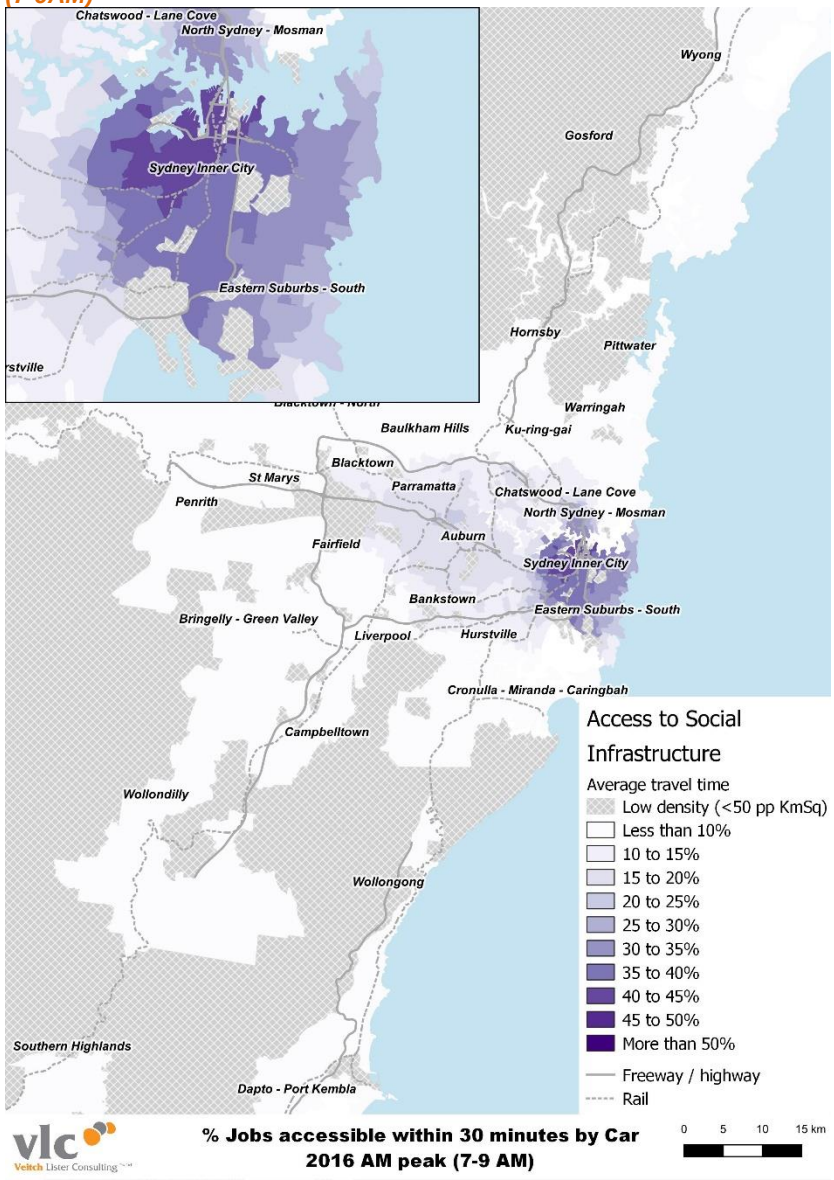


Figure 6-9 – Sydney, Hunter and Illawarra access to jobs by Car - 2031 AM peak (7-9AM)

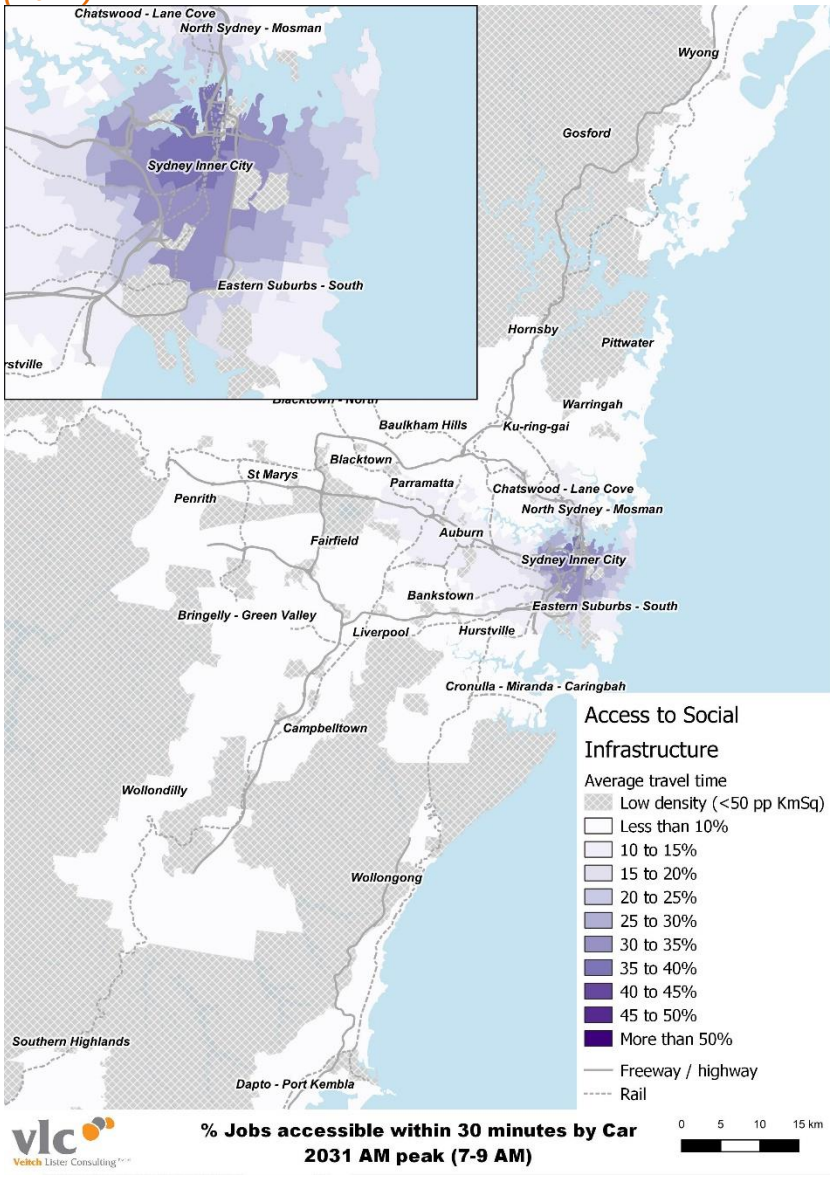


Figure 6-10 – Sydney, Hunter and Illawarra access to jobs by PT - 2016 AM peak (7-9AM)

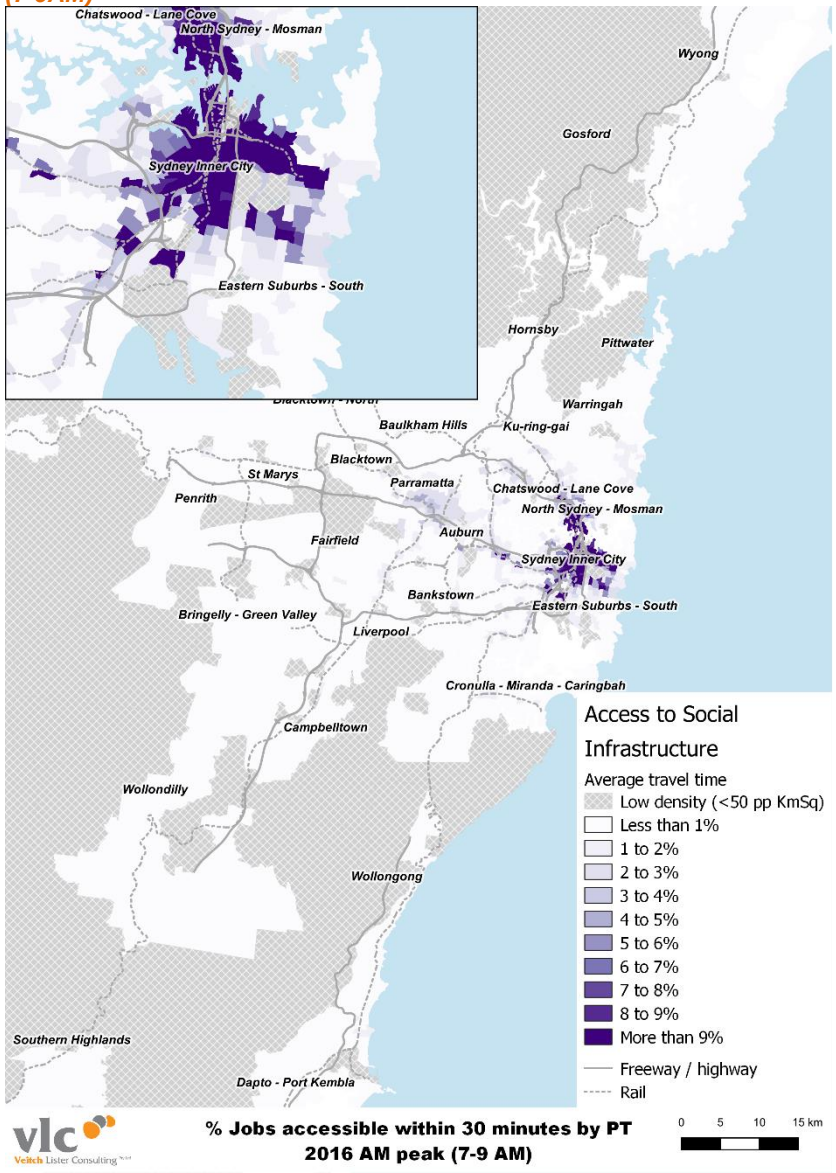


Figure 6-11 – Sydney, Hunter and Illawarra access to jobs by PT - 2031 AM peak (7-9AM)

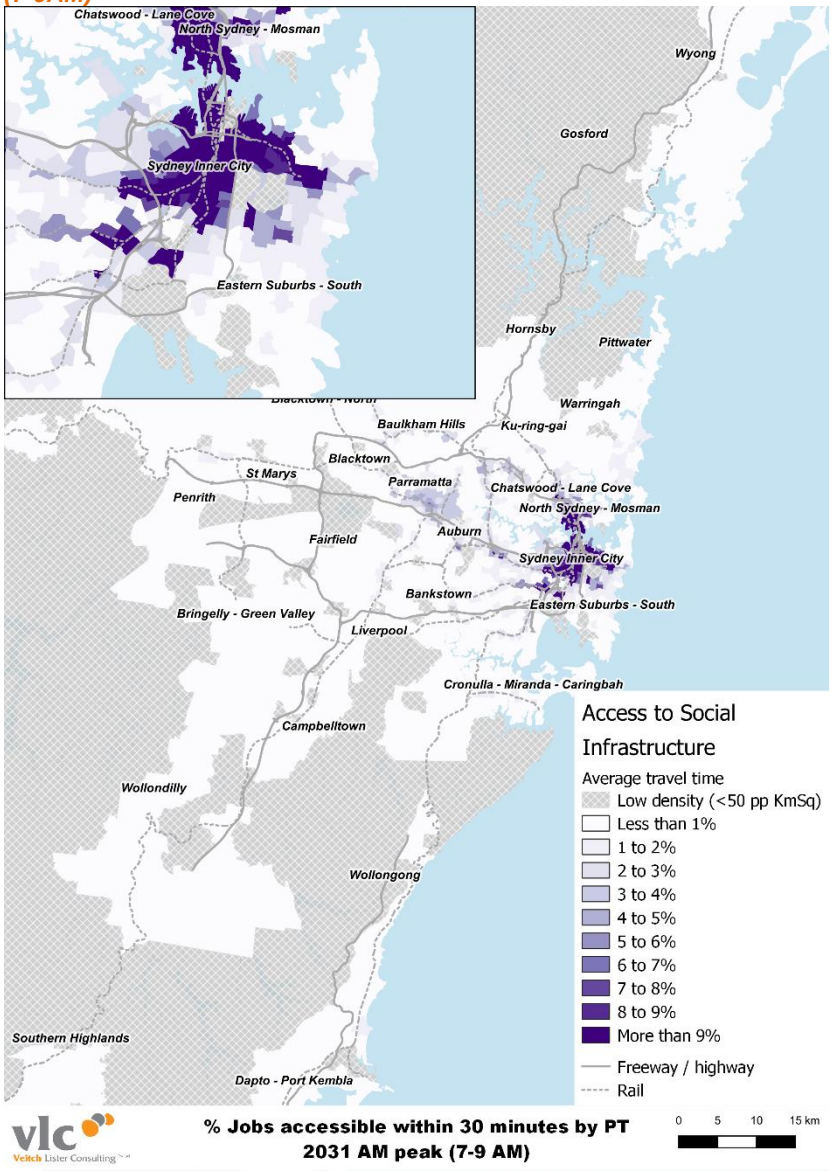


Table 6-4 – Sydney, Hunter and Illawarra population-weighted average travel time to the nearest public hospital by SA3 - AM peak (7-9AM)*

SA3	Car			PT		
	2016	2031	*Change*	2016	2031	*Change*
Auburn	4.9	8.9	*+4.0*	24.9	28.3	*+3.4*
Bankstown	8.6	9.6	*+1.0*	37.9	37.0	*-1.0*
Baulkham Hills	25.1	31.6	*+6.5*	65.0	52.5	*-12.5*
Blacktown	8.7	10.6	*+1.9*	37.9	35.8	*-2.2*
Blacktown - North	22.3	25.9	*+3.7*	55.0	63.3	*+8.3*
Blue Mountains	11.6	11.9	*+0.2*	57.8	56.8	*-1.0*
Blue Mountains - South	35.6	37.3	*+1.7*	162.1	159.3	*-2.8*
Botany	11.0	13.0	*+2.0*	35.9	36.4	*+0.5*
Bringelly - Green Valley	17.7	25.0	*+7.2*	62.2	70.5	*+8.3*
Camden	10.0	10.8	*+0.8*	46.8	45.8	*-1.1*
Campbelltown (NSW)	12.4	14.8	*+2.4*	48.7	49.0	*+0.3*
Canada Bay	12.0	14.0	*+2.0*	31.9	30.1	*-1.9*
Canterbury	6.4	6.7	*+0.3*	30.4	27.4	*-3.0*
Carlingford	13.3	16.3	*+3.0*	51.7	42.5	*-9.2*
Chatswood - Lane Cove	8.5	9.1	*+0.6*	28.3	27.3	*-1.0*
Cronulla - Miranda - Caringbah	5.5	5.5	*+0.0*	31.9	30.2	*-1.7*
Dural - Wisemans Ferry	37.5	42.3	*+4.7*	148.3	126.2	*-22.1*
Eastern Suburbs - North	6.1	6.6	*+0.5*	25.0	24.5	*-0.5*
Eastern Suburbs - South	5.6	6.8	*+1.2*	24.6	24.4	*-0.2*
Fairfield	8.0	9.6	*+1.5*	34.2	33.9	*-0.3*
Gosford	11.3	12.0	*+0.7*	55.1	52.5	*-2.6*
Hawkesbury	42.9	44.3	*+1.4*	170.5	163.2	*-7.3*
Hornsby	9.2	9.7	*+0.5*	41.8	39.5	*-2.2*
Hurstville	12.1	13.0	*+0.9*	44.9	45.2	*+0.3*
Kogarah - Rockdale	7.0	7.7	*+0.7*	28.0	27.7	*-0.2*
Ku-ring-gai	12.1	13.8	*+1.7*	40.4	39.4	*-1.1*
Leichhardt	5.2	5.6	*+0.4*	21.0	18.9	*-2.1*
Liverpool	12.3	17.7	*+5.4*	40.9	45.1	*+4.2*
Manly	7.1	7.1	*-0.0*	46.2	39.1	*-7.0*
Marrickville - Sydenham - Petersham	10.9	11.8	*+0.9*	32.5	30.2	*-2.3*
Merrylands - Guildford	10.5	13.1	*+2.6*	35.9	36.2	*+0.3*
Mount Druitt	8.8	9.7	*+0.9*	43.1	42.3	*-0.8*
North Sydney - Mosman	11.0	11.6	*+0.6*	31.9	27.9	*-4.0*
Parramatta	11.7	14.7	*+3.0*	30.9	28.1	*-2.8*
Pennant Hills - Epping	13.0	14.6	*+1.5*	39.3	37.7	*-1.6*
Penrith	10.6	13.0	*+2.4*	51.1	50.2	*-0.8*
Pittwater	8.5	9.1	*+0.5*	36.9	34.9	*-2.0*
Richmond - Windsor	12.7	14.3	*+1.6*	66.6	64.9	*-1.8*
Rouse Hill - McGraths Hill	19.9	23.5	*+3.6*	68.0	77.3	*+9.3*
Ryde - Hunters Hill	5.3	5.9	*+0.6*	26.7	25.4	*-1.3*
St Marys	13.5	14.9	*+1.3*	51.3	49.2	*-2.1*
Strathfield - Burwood - Ashfield	10.2	11.7	*+1.5*	35.2	32.8	*-2.3*
Sutherland - Menai - Heathcote	18.6	20.5	*+2.0*	59.1	59.0	*-0.1*
Sydney Inner City	5.2	6.4	*+1.2*	17.7	18.2	*+0.5*
Warringah	13.2	13.6	*+0.4*	50.5	47.7	*-2.8*
Wollondilly	34.6	40.9	*+6.3*	117.7	121.6	*+3.9*
Wyong	11.9	12.3	*+0.4*	64.1	57.6	*-6.5*
Sydney GCCSA	**11.1**	**13.4**	***+2.3***	**42.3**	**41.7**	***-0.6***
Lake Macquarie - East	11.9	13.8	*+1.9*	54.6	50.6	*-4.0*
Newcastle	11.9	13.6	*+1.7*	48.7	45.0	*-3.7*
Lake Macquarie - West	22.7	25.2	*+2.5*	103.5	103.0	*-0.5*
Upper Hunter	20.3	21.0	*+0.7*	149.8	150.0	*+0.2*
Maitland	15.4	19.2	*+3.8*	62.5	61.1	*-1.4*
Port Stephens	26.7	30.2	*+3.5*	129.3	130.9	*+1.7*
Shoalhaven	19.2	19.5	*+0.3*	113.8	109.0	*-4.8*
Lower Hunter	20.5	24.1	*+3.6*	127.5	131.6	*+4.0*
Hunter Region	**17.3**	**19.6**	***+2.3***	**87.8**	**85.9**	***-1.8***
Kiama - Shellharbour	8.1	8.8	*+0.7*	61.4	57.2	*-4.2*
Wollongong	7.2	7.5	*+0.3*	38.3	37.6	*-0.7*
Dapto - Port Kembla	11.2	13.7	*+2.5*	51.6	53.6	*+2.0*
Illawarra Catchment Reserve	34.3	38.5	*+4.2*	173.6	193.2	*+19.5*
Illawarra Region	**8.5**	**9.6**	***+1.1***	**48.9**	**48.3**	***-0.6***

*The travel times reflect all modelled zones and so does not reflect adjustments made in Figure 6-13 (see 'Limitations of strategic accessibility modelling' box above).

Figure 6-12 – Sydney, Hunter and Illawarra average time to nearest public/emergency hospital by Car - 2031 AM peak (7-9AM)

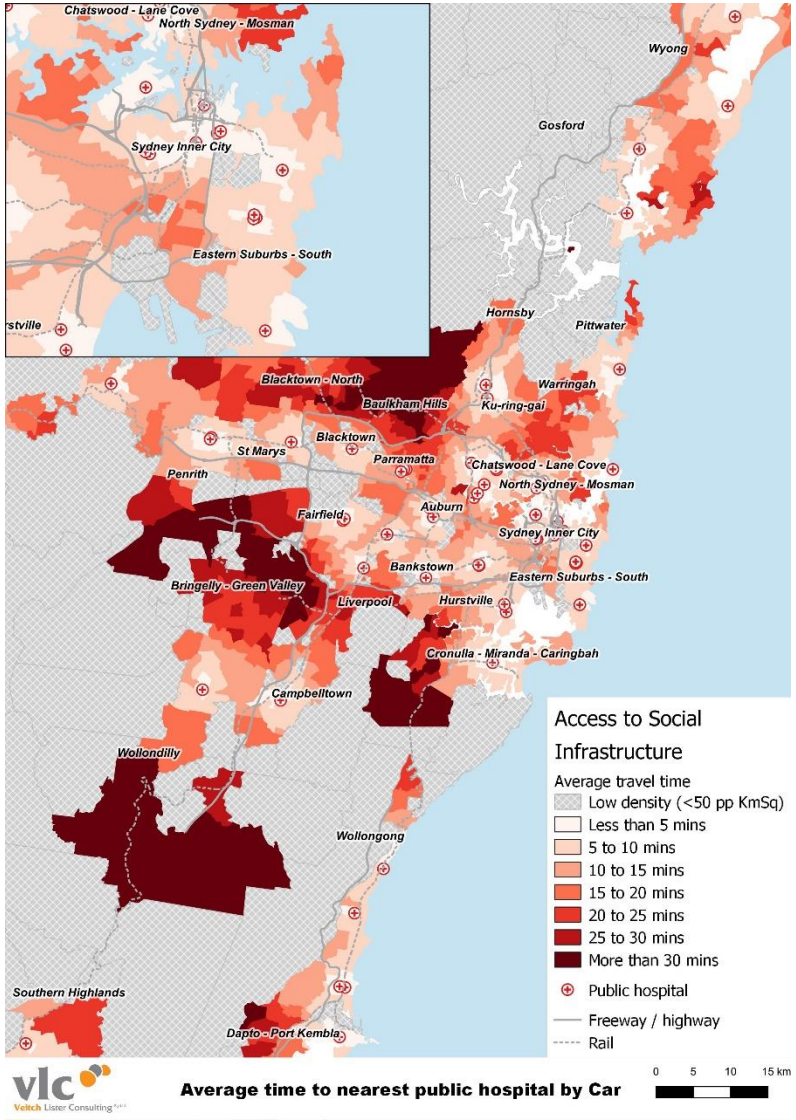
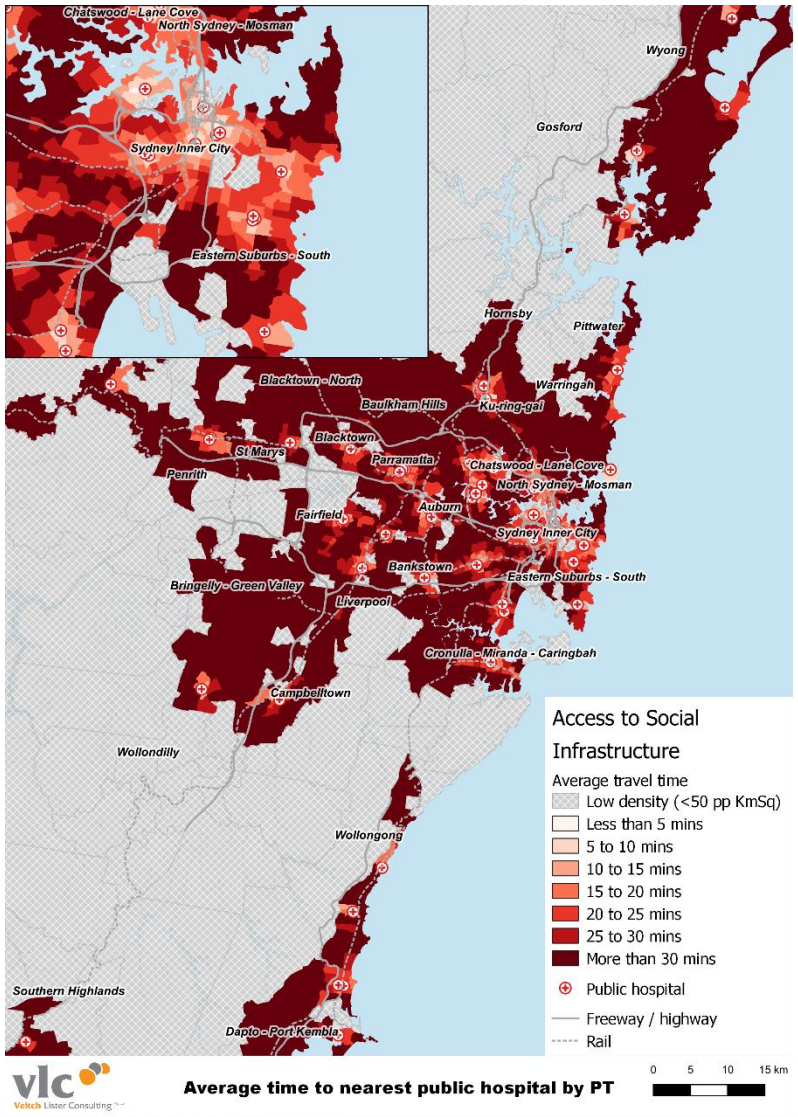


Figure 6-13 – Sydney, Hunter and Illawarra average time to nearest public/emergency hospital by PT - 2031 AM peak (7-9AM)



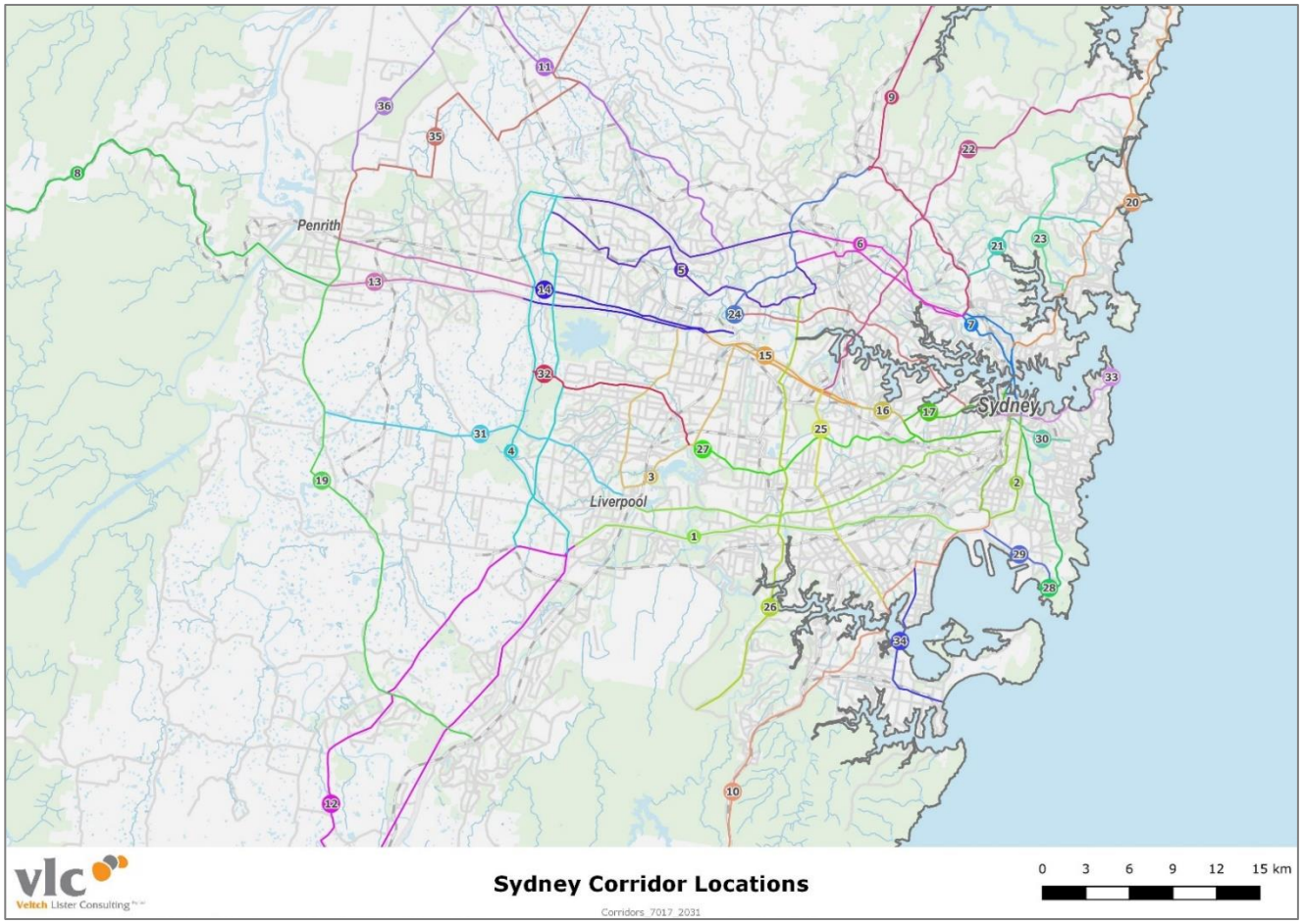
7. Assessment

This section draws together the analysis of the preceding sections and assesses transport network performance along two dimensions: corridors and regions. It also discusses some of the economic impacts of the deteriorating network performance.

7.1 Corridor deficiencies

Demand on Sydney's road and rail networks is forecast to increase by 2031. As a result, the performance of key corridors is likely to decline substantially, causing significant delays for motorists and, to an extent, users of buses. Increasing demand can also increase crowding on public transport services if service frequencies do not keep pace. In this section we measure network performance for road, rail and bus corridors in 2016 and 2031 using key multi-modal corridors that were identified with Infrastructure Australia (Figure 7-1 and Appendix Table C-1).

Figure 7-1 – Sydney GCCSA transport corridors



Performance of road corridors is measured in two ways: delay hours (an aggregate measure) and percentage of journey time accounted for by congestion (a measure of individual road user experience).

In terms of total hours of delay, the Central Coast to Sydney and the M5 are forecast to be the worst performing corridors with peak period delay hours increasing to around 9,600 and 9,200 respectively (Table 7-1). By 2031, users of these corridors at peak times can expect around 10 and 20 minutes of delay for each 10 kilometres they travel on these respective corridors (Table 7-2).

The influence of WestConnex is also clear, as total delay hours decrease by 20 to 40% for the Parramatta Rd (M4) corridor between Strathfield and Haberfield during the AM and PM Peaks. There is a similar easing of congestion on the M5 East but overall, the congestion on the East West corridor – M5 worsens. The impact of NorthConnex is more limited as the Pennant Hills Rd corridor remains at a similar level of congestion, with a less than 5% increase in total delay hours during the AM and PM peaks. These corridors are not in the ten most delayed road corridors listed in Table 7-1 and Table 7-2, however, they are some of the most congested corridors from a user's perspective in 2016 (Table 7-3).

Increased delay hours are also seen for traffic to and from the southwest, such as the Mittagong to South West Sydney via Hume Motorway, in line with the southwest growth planned. Corridors enabling travel between the Northern Beaches and Sydney CBD are also expected to remain congested, including Mona Vale to Homebush Bay, Northern Beaches – North Sydney, and Narraweena to Chatswood via Warringah Road.

Table 7-1 – Sydney GCCSA 2016 ten most delayed road corridors (ranked by total delay)

	Corridor Name	Number	Direction	Delay Hours
	AM peak (7-9AM)			
1	Central Coast to Sydney	9	SB	6,200
2	South Coast to Sydney	10	NB	5,800
3	East West corridor - M5	1	EB	4,900
4	Mona Vale to Homebush Bay Corridor (A3)	22	SB	4,900
5	Northern Beaches - Nth Sydney Corridor	20	SB	3,900
6	Victoria Rd (A40)	18	EB	3,200
7	Sutherland - Ryde/Parramatta Corridor	26	NB	3,100
8	Narraweena to Chatswood via Warringah Rd	21	WB	3,000
9	Western Hwy (M4): Hawkesbury Rd to Strathfield	15	EB	2,900
10	Mittagong to SW Sydney via Hume Mwy	12	NB	2,800
	PM peak			
1	Sydney to Central Coast	9	NB	5,800
2	Sydney to South Coast	10	SB	4,700
3	Homebush Bay to Mona Vale Corridor (A3)	22	NB	4,600
4	Nth Sydney - Northern Beaches Corridor	20	NB	3,800
5	East West corridor - M5	1	WB	3,500
6	Eastern Dist/Gore Hill/Warringah Fwys/SHB	7	WB	2,900
7	Ryde/Parramatta - Sutherland Corridor	26	SB	2,900
8	Chatswood to Narraweena via Warringah Rd	21	EB	2,800
9	Western Hwy (M4): Strathfield to Hawkesbury Rd	15	WB	2,800
10	Mona Vale to Homebush Bay Corridor (A3)	22	SB	2,700

Table 7-2 – Sydney GCCSA 2031 top ten most delayed road corridors (ranked by total delay)

	Corridor Name	Number	Direction	Delay Hours
	AM peak (7-9AM)			
1	Central Coast to Sydney	9	SB	9,600
2	East West corridor - M5	1	EB	9,200
3	South Coast to Sydney	10	NB	8,400
4	Mona Vale to Homebush Bay Corridor (A3)	22	SB	7,100
5	Mittagong to SW Sydney via Hume Mwy	12	NB	6,100
6	Sutherland - Ryde/Parramatta Corridor	26	NB	5,300
7	Northern Beaches - Nth Sydney Corridor	20	SB	4,900
8	Western Mwy (M4): A28 to Hawkesbury Rd	14	EB	4,800
9	Victoria Rd (A40)	18	EB	4,400
10	Western Hwy (M4): Hawkesbury Rd to Strathfield	15	EB	4,100
	PM peak			
1	Sydney to Central Coast	9	NB	8,700
2	Sydney to South Coast	10	SB	7,500
3	Homebush Bay to Mona Vale Corridor (A3)	22	NB	7,100
4	East West corridor - M5	1	WB	6,800
5	SW Sydney to Mittagong via Hume Mwy	12	SB	5,400
6	Ryde/Parramatta - Sutherland Corridor	26	SB	5,400
7	Nth Sydney - Northern Beaches Corridor	20	NB	5,200
8	Western Mwy (M4): Hawkesbury Rd to A28	14	WB	5,000
9	Mona Vale to Homebush Bay Corridor (A3)	22	SB	4,800
10	Eastern Dist/Gore Hill/Warringah Fwys/SHB	7	WB	4,300

By 2031, Sydney's motorists can expect longer traffic delays, where users can expect to spend approximately 70 to 90 per cent of their travel time stuck in traffic, compared to 60 to 80% of travel time in 2016 (Table 7-3 and Table 7-4). The worst performers in both 2016 and 2031 for both peak periods include the Eastern Distributor / Gore Hill / Warringah Freeway, and Narraweena to Chatswood via Warringah Rd.

As observed in the delay hours, the East West M5 corridor is forecast to spike in congestion, by almost 10 per cent of journey time in the AM peak, and reaching the top ten congested corridors in the PM peak by 2031. Reflecting the improvements from WestConnex, the M4 corridor from Strathfield to Haberfield drops out of the top ten most congested corridors. The improvements lead to a decrease of 1 to 3 per cent in congested travel time despite increases in demand across time. Regarding the NorthConnex, motorists on the Pennant Hills Road corridor from Hornsby to Parramatta are expected to still spend approximately the same proportion of their travel time stuck in traffic. NorthConnex allows traffic to travel along these corridors more readily, and in turn this attracts more commuters onto these roads such that an individual's congested travel time decreases only modestly.

Increases in congestion are also forecast for the North West Middle corridor (M7 and M2), as well as the Ryde/Parramatta - Sutherland corridor, while the City West Link and Anzac Bridge is also expected to remain congested. This is indicative of increased travel between Parramatta and surrounds with the rest of Sydney, due to population and employment growth there.

The Sydney to South Coast, and Central Coast to Sydney corridors extend from the Sydney GCCSA to the Illawarra and Hunter regions respectively. Of these corridors, the Hunter Expressway to Wyong Road (Hunter) is the corridor segment with the greatest delay hours in the AM peak, at 1,100 delay hours in 2016, and forecast to reach 1,300 delay hours by 2031. It also has the longest delay hours in

the PM peaks in both years, reaching almost 1,000 delay hours in 2016, and predicted to reach 1,400 delay hours in 2031. This overestimates congestion from the user's perspective, however, as it is a much longer segment, comprising one-third of the length of the Central Coast to Sydney corridor. From a user's perspective, motorists experience significant congestion on the entry and exit to Newcastle. Motorists on Thomas Street to Newcastle Inner City Bypass will experience the most congestion in the AM peak in 2016 and 2031, spending 70 to 78 per cent of their travel time stuck in traffic. In the PM peaks across both years, Minmi Road to Cameron Park Drive is the most congested, with motorists spending 70 to 81 per cent of their travel time in traffic.

The Illawarra region experiences comparatively minimal congestion, with the most congested corridor segment of the Princes Motorway from Thirroul to Picton Road, recording less than 300 delay hours in the 2016 peaks, and only reaching 500 delay hours in 2031. Similarly from a user's perspective, motorists will spend 20 to 35 per cent of their travel time in traffic in the 2016 and 2031 AM peaks at the worst segments, from Memorial Drive to Mount Ousley Road, and Picton Road to Mount Ousley Road. The Princes Motorway at Thirroul to Picton Road is forecast to be more congested in the PM peaks, with motorists spending 40 per cent of their travel time in traffic in 2016, reaching just over 50 per cent in 2031.

Table 7-3 – Sydney GCCSA 2016 top ten most delayed road corridors (ranked by user delay)

	Corridor name	Number	Direction	Length (km)	% of journey time accounted for by congestion	Delay per vehicle (mins)	Congested travel time (mins)
			AM peak (7-9AM)				
1	Eastern Dist/Gore Hill/Warringah Fwys/SHT	7	EB	4	81%	16	19
2	City West Link and Anzac Bridge	17	EB	9	69%	22	32
3	Narraweena to Chatswood via Warringah Rd	21	WB	12	68%	26	39
4	Pennant Hills Rd - Hornsby to Parramatta	24	SB	16	67%	34	50
5	Eastern Dist/Gore Hill/Warringah Fwys/SHB	7	EB	11	67%	20	29
6	Western Hwy (M4): Hawkesbury Rd to Strathfield	15	EB	12	67%	17	26
7	Parramatta Rd (M4): Strathfield to Haberfield	16	EB	4	67%	9	13
8	Parramatta Rd (A22): Haberfield to Chippendale	17	EB	7	66%	18	27
9	East West corridor - M5	1	EB	28	65%	34	51
10	Mona Vale to Homebush Bay Corridor (A3)	22	SB	35	62%	54	88
			PM peak (4-6PM)				
1	Eastern Dist/Gore Hill/Warringah Fwys/SHT	7	WB	4	74%	11	14
2	Chatswood to Narraweena via Warringah Rd	21	EB	12	68%	26	38
3	Pennant Hills Rd - Parramatta to Hornsby	24	NB	16	66%	32	49
4	Western Hwy (M4): Strathfield to Hawkesbury Rd	15	WB	12	66%	16	24
5	Eastern Dist/Gore Hill/Warringah Fwys/SHT	7	EB	4	66%	7	11
6	Western Mwy (M4): Hawkesbury Rd to A28	14	WB	12	63%	13	21
7	Parramatta Rd (M4): Haberfield to Strathfield	16	WB	4	63%	7	12
8	City West Link and Anzac Bridge	17	WB	9	61%	15	25
9	Homebush Bay to Mona Vale Corridor (A3)	22	NB	35	59%	49	83
10	Parramatta Rd (M4): Strathfield to Haberfield	16	EB	4	59%	6	11

Table 7-4 – Sydney GCCSA 2031 top ten most delayed road corridors (ranked by user delay)

	Corridor name	Number	Direction	Length (km)	% of journey time accounted for by congestion	Delay per vehicle (mins)	Congested travel time (mins)
	AM peak (7-9AM)						
1	Eastern Dist/Gore Hill/Warringah Fwys/SHT	7	EB	4	84%	19	23
2	Western Mwy (M4): A28 to Hawkesbury Rd	14	EB	13	75%	25	33
3	East West corridor - M5	1	EB	28	74%	49	67
4	City West Link and Anzac Bridge	17	EB	9	73%	27	36
5	Eastern Dist/Gore Hill/Warringah Fwys/SHB	7	EB	11	72%	25	34
6	Narraweena to Chatswood via Warringah Rd	21	WB	12	71%	30	43
7	Western Hwy (M4): Hawkesbury Rd to Strathfield	15	EB	12	71%	21	29
8	NW Middle Corridor (M7/M2)	5	EB	18	69%	26	37
9	Pennant Hills Rd - Hornsby to Parramatta	24	SB	16	68%	36	52
10	Sutherland - Ryde/Parramatta Corridor	26	NB	32	68%	67	98
	PM peak (4-6PM)						
1	Eastern Dist/Gore Hill/Warringah Fwys/SHT	7	WB	4	81%	15	19
2	Eastern Dist/Gore Hill/Warringah Fwys/SHT	7	EB	4	79%	14	17
3	Western Mwy (M4): Hawkesbury Rd to A28	14	WB	12	76%	25	32
4	Chatswood to Narraweena via Warringah Rd	21	EB	12	72%	32	44
5	City West Link and Anzac Bridge	17	WB	9	69%	22	32
6	NW Middle Corridor (M7/M2)	5	WB	18	69%	25	37
7	Eastern Dist/Gore Hill/Warringah Fwys/SHB	7	WB	12	67%	20	30
8	Ryde/Parramatta - Sutherland Corridor	26	SB	32	67%	63	95
9	Pennant Hills Rd - Parramatta to Hornsby	24	NB	16	67%	34	50
10	East West corridor - M5	1	WB	27	67%	36	54

The additional demand placed on Sydney's public transport system to 2031 is expected to result in a deterioration in network performance in areas where new services are not introduced. In this study, high levels of crowding are taken as a marker of poor network performance, with Table 7-5 and Table 7-6 highlighting the crowded sections of the suburban rail network. (In reality, other adverse network performance outcomes not modelled by VLC are likely to result from high loadings of services, such as increased dwell times at stations, reduced reliability and passengers being unable to board their preferred service.)

By 2031 the crowding expected on the T8 Airport and South line is expected to have worsened significantly, particularly during the AM peak. As was identified previously in Section 5, services will experience crowding on the T1 Western and T2 Inner West lines, particularly between Parramatta and Sydney CBD. In 2031, Glenfield to Wolli Creek is forecast to become one of the more crowded sections on Sydney's suburban rail network, as commuters seek to travel towards the South West growth area.

The rail corridors between Chatswood and Epping, Chatswood and Sydenham, and Cudgegong Road and Epping are also expected to reach volume / seated capacity ratios of around 1.3 to 1.9. However, they do not exceed crush capacity because of the different seating configurations on the Metro services on those corridors.

Table 7-5 – Sydney GCCSA most crowded sections of 2016 suburban rail network

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Airport to CBD	NB	1.2	0.7
Parramatta to Strathfield	EB	1.1	0.7
Ashfield to Central	EB	1.0	0.7
Strathfield to Ashfield	EB	1.0	0.7
Doonside to Parramatta	EB	1.0	0.7
PM peak (4-6PM)			
CBD to Airport	SB	1.1	0.7
Strathfield to Parramatta	WB	1.0	0.7
Central to Ashfield	WB	1.0	0.7
Sydney to South Coast	SB	1.0	0.6
Ashfield to Strathfield	WB	1.0	0.6

Table 7-6 – Sydney GCCSA most crowded sections of 2031 suburban rail network

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Airport to CBD	NB	1.6	1.0
Glenfield to Wolli Creek	EB	1.5	0.9
Parramatta to Strathfield	EB	1.3	0.8
Glenfield to Parramatta	NB	1.3	0.8
Mittagong to SW Sydney	NB	1.3	0.8
PM peak (4-6PM)			
CBD to Airport	SB	1.3	0.8
CBD to South Coast	SB	1.3	0.8
Wolli Creek to Glenfield	WB	1.2	0.8
Central to Ashfield	WB	1.2	0.7
Strathfield to Parramatta	WB	1.2	0.7

Some of Sydney's major bus routes are also likely to experience high levels of crowding in 2031. Crowding above vehicle crush capacities is expected on the Bells Line of Road – Castlereagh Connection, as well as the Northern Beaches – North Sydney corridor, during both peak periods (Table 7-7 and Table 7-8). In the case of the northwest routes this crowding is more likely due to a low

assumed service provision; but for the Northern Beaches routes, even the high-frequency high-capacity services are forecast to be highly crowded (compare with Figure 5-9 and Figure 5-10). By 2031, the Wakehurst Parkway is also expected to become more crowded, likely due to commuters' route shifts from excessive crowding on the Northern Beaches – North Sydney corridor.

Table 7-7 – Sydney GCCSA crowded sections of 2016 bus network

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Airport to CBD - M1	NB	1.0	0.7
Northern Beaches - Nth Sydney Corridor	SB	0.9	0.7
Watsons Bay to CBD West	WB	0.8	0.6
Pennant Hills Rd - Parramatta to Hornsby	NB	0.8	0.6
Narraweena to Chatswood via Warringah Rd	WB	0.8	0.6
PM peak (4-6PM)			
CBD to Airport - M1	SB	1.1	0.8
Nth Sydney - Northern Beaches Corridor	NB	1.1	0.8
CBD West to Watsons Bay	EB	0.9	0.7
Chatswood to Narraweena via Warringah Rd	EB	0.8	0.6
Eastern Dist/Gore Hill/Warringah Fwys/SHT	WB	0.8	0.6

Table 7-8 – Sydney GCCSA crowded sections of 2031 bus network

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Bells Line of Rd - Castlereagh Connection	SB	1.7	1.3
Northern Beaches - Nth Sydney Corridor	SB	1.5	1.1
Wakehurst Parkway Corridor	NB	1.1	0.9
Wakehurst Parkway Corridor	SB	1.0	0.8
City West Link and Anzac Bridge	WB	0.9	0.7
PM peak (4-6PM)			
Nth Sydney - Northern Beaches Corridor	NB	1.5	1.1
Bells Line of Rd - Castlereagh Connection	NB	1.1	0.9
Wakehurst Parkway Corridor	NB	1.1	0.9
Wakehurst Parkway Corridor	SB	1.0	0.8
CBD to Airport - M1	SB	1.0	0.8

7.2 Regional deficiencies

Despite growth in congestion to 2031, residents across Greater Sydney are generally well-served by local social infrastructure, providing they have access to a car or live in inner-city areas. In 2031, the average resident in SA3s in the Sydney GCCSA can reach the nearest five child care centres, nearest public primary school and nearest public secondary school within a ten-minute drive in the morning peak. Residents at Sydney's fringe, however, have much longer average travel times, approaching 30 minutes. This is a result of modelled growth in congestion around these SA3s, that partly reflects limitations in the knowledge of the future networks (section 6.1). However, the

modelling highlights what could happen if public transport services, local road networks and social infrastructure investment does not keep pace with projected increases in population.

Accessibility for Sydney residents without regular car access is considerably poorer, particularly those living in outer suburbs. Residents in areas such as Rouse Hill, Dural, Richmond would need to spend upwards of 30 minutes on public transport to accompany their young child to care or primary school. High school students in these areas would also expect to travel close to 50 minutes or more. This is largely due to lower walkability of these areas, coupled with the limited ability of Sydney's fairly radial public transport system to cater for localised travel needs.

Increasing congestion on Sydney's roads will affect access to jobs. Residents in Liverpool, Fairfield, Ryde – Hunters Hill and Blacktown are expected to face reduced access to jobs, as local population growth is not sufficiently serviced by corridors connecting these western suburbs to employment opportunities in the Sydney CBD. Job accessibility for residents in Bringelly – Green Valley is expected to remain low in 2031, suggesting that although substantial local employment growth is forecast, this is still insufficient to cater for the accompanying forecasted local population boom. As such, it is likely that many residents will still travel long distances to other employment clusters across Sydney.

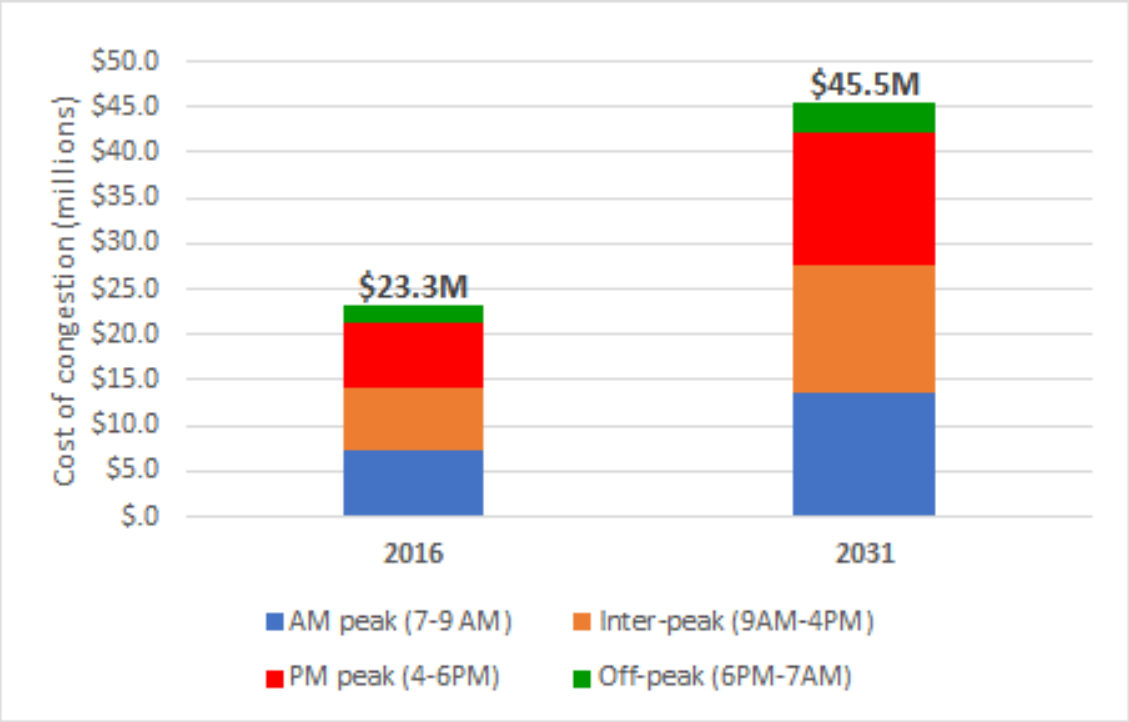
7.3 Economic impacts

Congestion, traffic delays and poor travel time reliability result in widespread negative impacts on the community and economy. Delays (particularly where they are unexpected) can result in missed appointments, wasted time and frustration for users of the transport system.

VLC has estimated the dollar value of the cost of congestion in the Sydney GCCSA, Hunter and Illawarra regions in 2016 and 2031 based on the way people are prepared to trade off money for reductions in the time spent travelling (see Appendix D.4 for a detailed calculation methodology). The daily cost of congestion is estimated to almost double, from $23.3 million in 2016 to $45.5 million in 2031 (Figure 7-2). This is consistent with the deteriorating network performance described in the preceding chapters.

Each modelled time-period contributes a different amount to the total daily congestion cost. The highest costs are accrued in the PM peak (31.5% in 2016, growing to 31.8% in 2031). Conversely, the contribution of the AM peak is forecast to decrease marginally, from 31.2% in 2016 to 30.1% in 2031. The hourly cost incurred is also highest in the PM peak in both years ($3.7 million in 2016 and $7.2 million in 2031), closely followed by the AM peak, while the inter-peak period has a much lower cost, though it is forecast to almost double (Figure 7-4).

Figure 7-2 – Sydney, Hunter and Illawarra average weekday cost of congestion, 2016 and 2031



As the region with densest activity and growth, the majority of costs are accrued in the Sydney GCCSA in both 2016 and 2031, and also continues to become the most prominently congested area of the three regions (Figure 7-3). It contributes 83.2 per cent of total congestion costs, with the value almost doubling from $19.3 million to $37.8 million. Congestion costs in the Illawarra region also grow, however this region only contributes 2 per cent of the overall daily congestion cost. The Hunter region plays a slightly larger role, contributing 15.2 per cent of congestion costs in 2016, however this share is forecast to decrease to 14.5 per cent in 2031.

Total congestion costs by region and time period are provided in Table 7-9, while the estimated annualised cost of congestion is shown in Table 7-10.

Figure 7-3 – Sydney, Hunter and Illawarra average weekday cost of congestion by region, 2016 and 2031

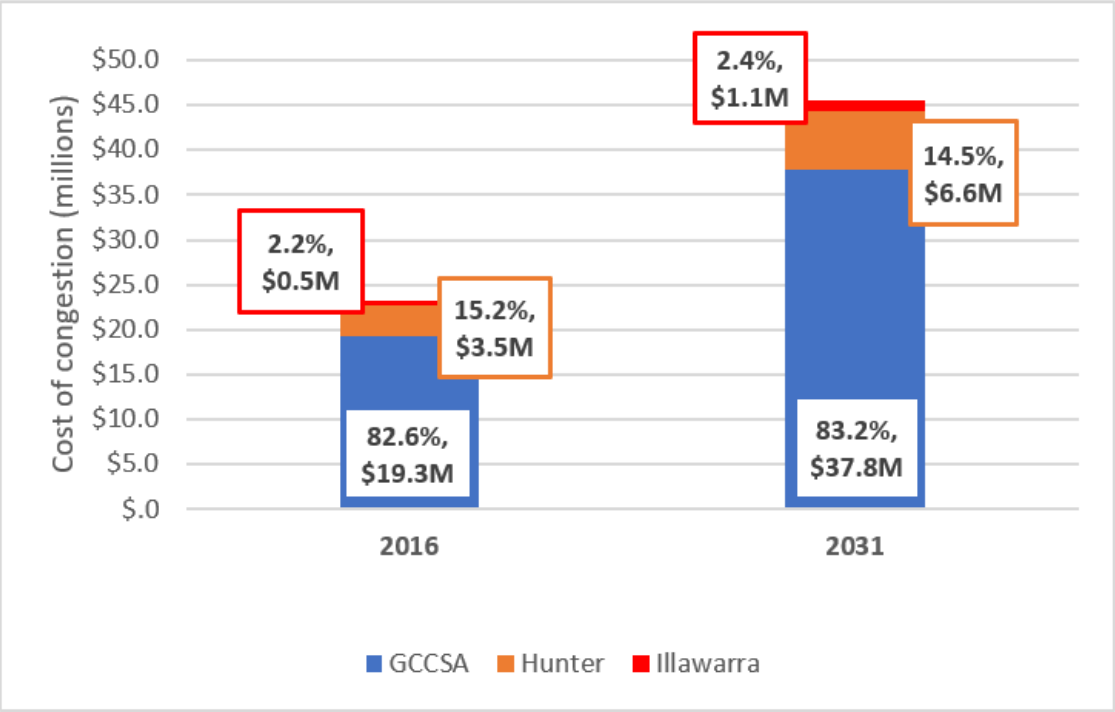


Figure 7-4 – Sydney, Hunter and Illawarra average weekday hourly cost of congestion by time period, 2016 and 2031

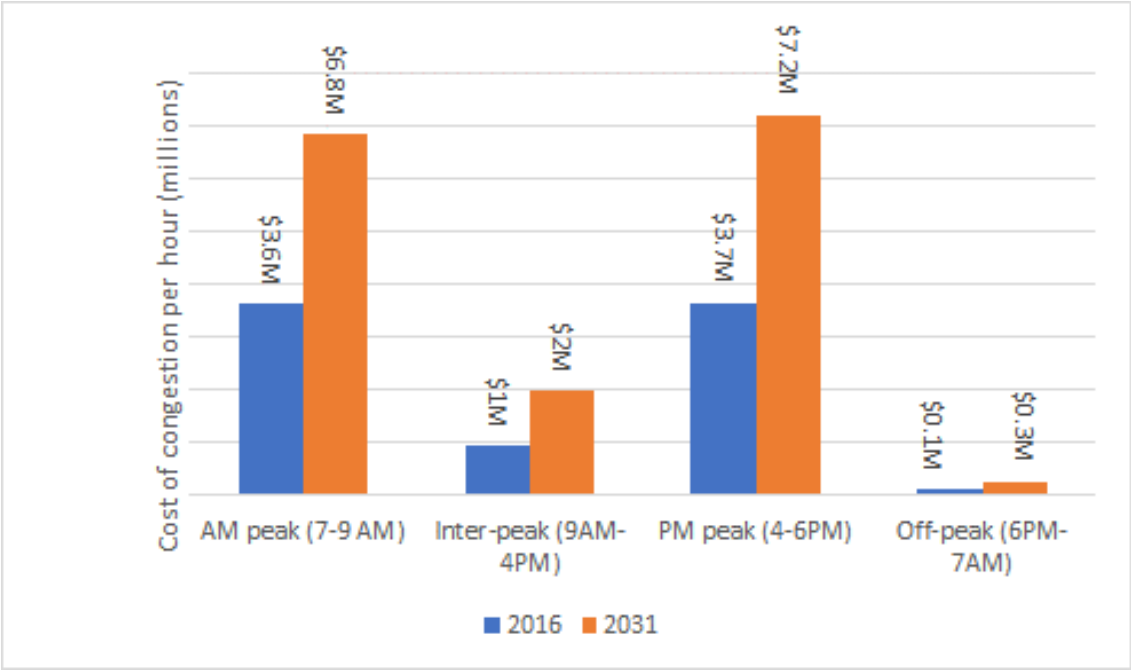


Table 7-9 – Sydney, Hunter and Illawarra average weekday cost of congestion by time period

	Time period	2016	2031
Sydney GCCSA	AM peak (7-9AM)	$6,269,000	$11,843,000
	Inter-peak (9AM-4PM)	$5,329,000	$11,102,000
	PM peak (4-6PM)	$6,221,000	$12,336,000
	Off-peak (6PM-7AM)	$1,431,000	$2,550,000
	Daily total	**$19,250,000**	**$37,831,000**
Hunter	AM peak (7-9AM)	$864,000	$1,525,000
	Inter-peak (9AM-4PM)	$1,294,000	$2,518,000
	PM peak (4-6PM)	$954,000	$1,775,000
	Off-peak (6PM-7AM)	$431,000	$766,000
	Daily total	**$3,543,000**	**$6,584,000**
Illawarra	AM peak (7-9AM)	$141,000	$325,000
	Inter-peak (9AM-4PM)	$156,000	$328,000
	PM peak (4-6PM)	$159,000	$336,000
	Off-peak (6PM-7AM)	$48,000	$81,000
	Daily total	**$504,000**	**$1,070,000**

Table 7-10 – Sydney, Hunter and Illawarra estimated annual cost of congestion by region

Region	2016 (millions)	2031 (millions)
Sydney GCCSA	$6,641	$13,052
Hunter	$1,222	$2,272
Illawarra	$174	$369
Total region	$8,038	$15,693

An economic cost can also be estimated for the crowding experienced by passengers on the public transport network reflecting the dislike people have when they have to stand during their ride, and particularly where vehicles are very full (again, see Appendix D.4 for a detailed calculation methodology). Crowding costs are based on the average crowding of services in each two-hour peak period (similar to chapter 5). As such, the cost of crowding would underestimate costs where there is high variability in crowding levels across services within this peak period.

Crowding costs are immaterial compared to the road congestion costs (Table 7-11). During the peak periods, crowding costs increase considerably for rail, bus and light rail users between 2016 and 2031. This is the result of increases in passenger kilometres outpacing increases in in-service kilometres. An increase in patronage is also partly due to the attraction of passengers to the new Metro and light rail lines. The cost of crowding for bus users is also forecast to increase dramatically into the future. Developments such as bus priority increases the attractiveness of these services as a transport option. Annually, the estimated cost of crowding in Sydney GCCSA, Hunter and Illawarra is $67.5 million in 2016, growing to $223.4 million in 2031.

Table 7-11 – Sydney, Hunter and Illawarra average weekday cost of public transport, 2016 and 2031

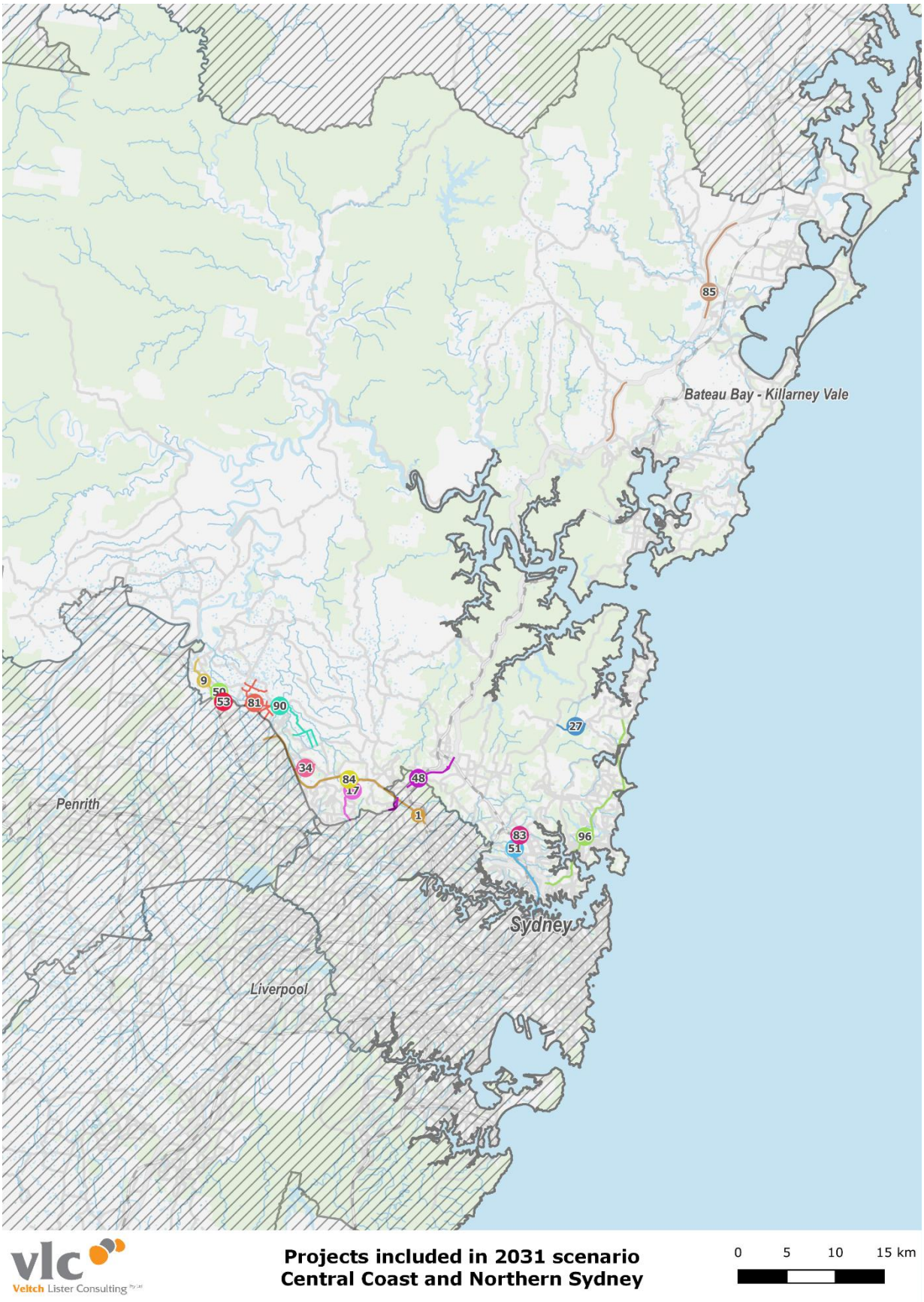
Mode	Time period	2016	2031	Change	% change
Sydney GCCSA					
Rail	AM peak (7-9AM)	$106,000	$276,000	$170,000	+160%
	PM peak (4-6PM)	$77,000	$159,000	$82,000	+106%
Bus	AM peak (7-9AM)	$21,000	$177,000	$156,000	+743%
	PM peak (4-6PM)	$25,000	$145,000	$120,000	+480%
Hunter Region					
Rail	AM peak (7-9AM)	$800	$1,500	$700	+88%
	PM peak (4-6PM)	-	-	-	-
Bus	AM peak (7-9AM)	$3,900	$10,800	$6,900	+177%
	PM peak (4-6PM)	$200	$1,000	$800	+400%
Illawarra Region					
Rail	AM peak (7-9AM)	$300	$3,800	$3,500	+1167%
	PM peak (4-6PM)	$1,700	$6,900	$5,200	+306%
Bus	AM peak (7-9AM)	$100	$ 400	$300	+300%
	PM peak (4-6PM)	-	$100	$100	-
Total Region					
Rail	AM peak (7-9AM)	$107,000	$281,000	$174,000	+163%
	PM peak (4-6PM)	$78,000	$166,000	$88,000	+113%
Bus	AM peak (7-9AM)	$26,000	$188,000	$162,000	+623%
	PM peak (4-6PM)	$25,000	$146,000	$121,000	+484%

Appendix A: Projects included in modelling

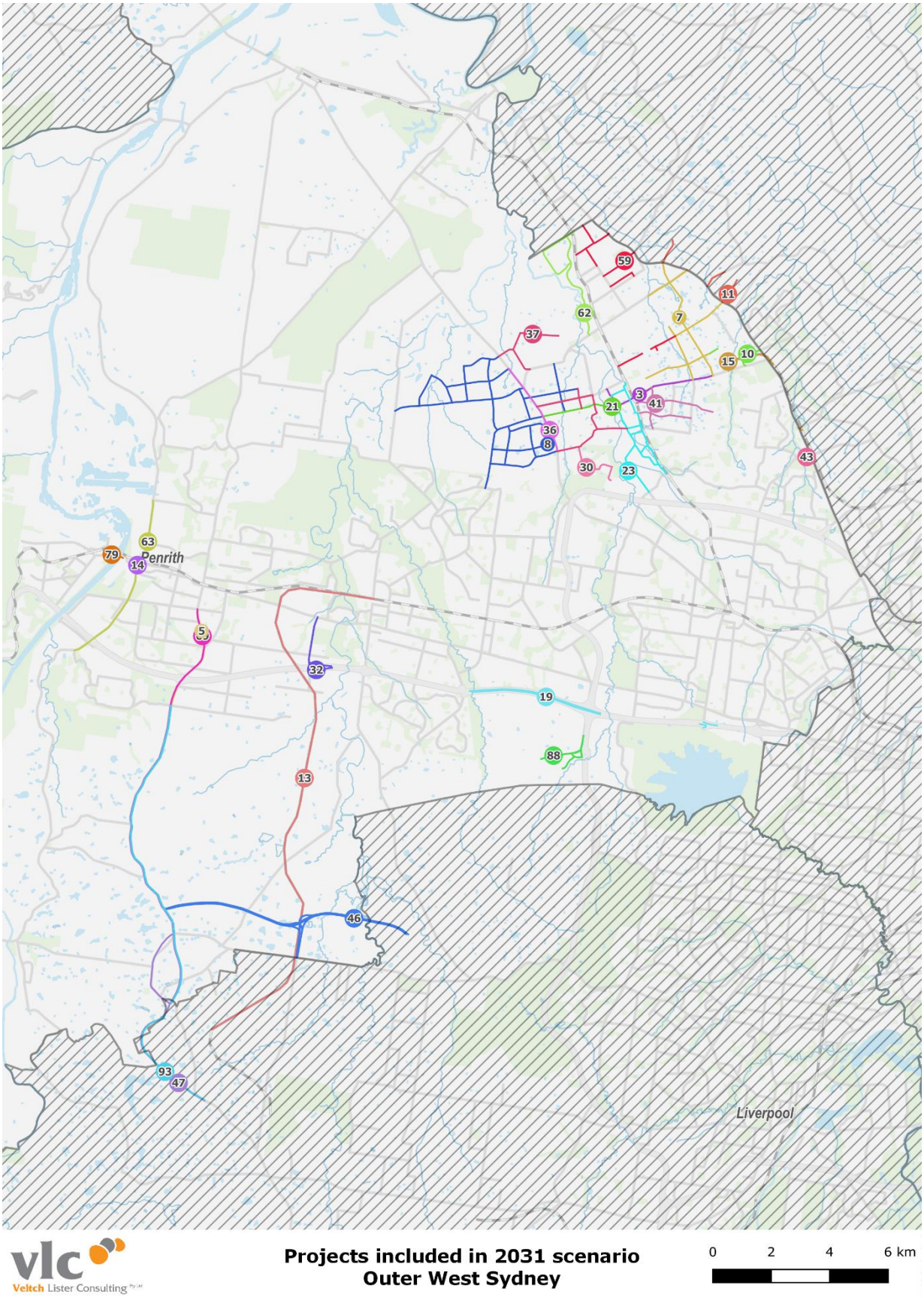
This section details the projects included in the modelling. A map for each SA4 has been included (Appendix Table A-1 gives an overview of the relevant SA4s). The numbers referenced in maps are linked to project names in Appendix Table A-1.

Appendix Figure A-1 – Greater Sydney and NSW SA4 model overview

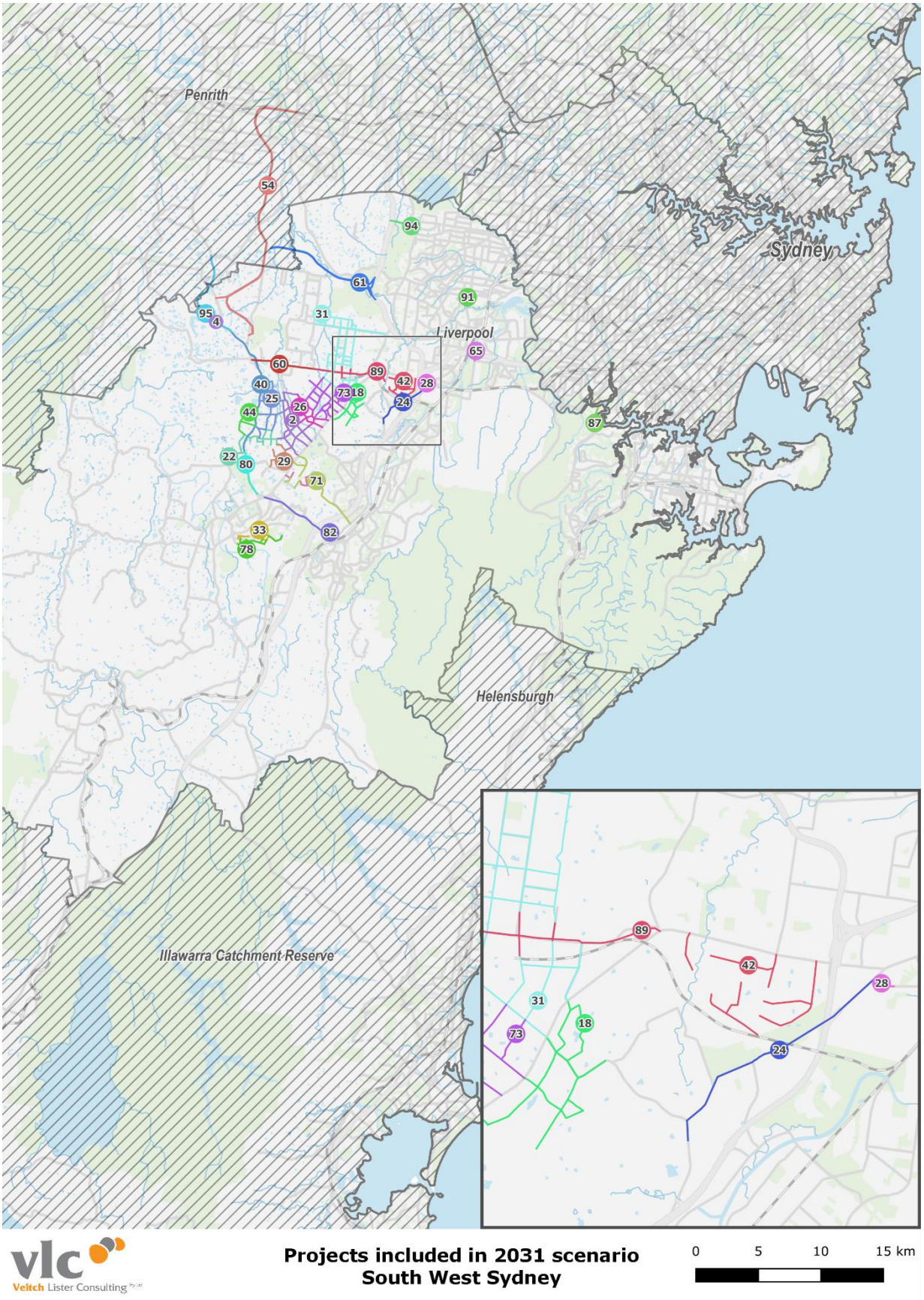
Appendix Figure A-2 – Projects included in the 2031 forecast SA4: Central Coast and Northern Sydney



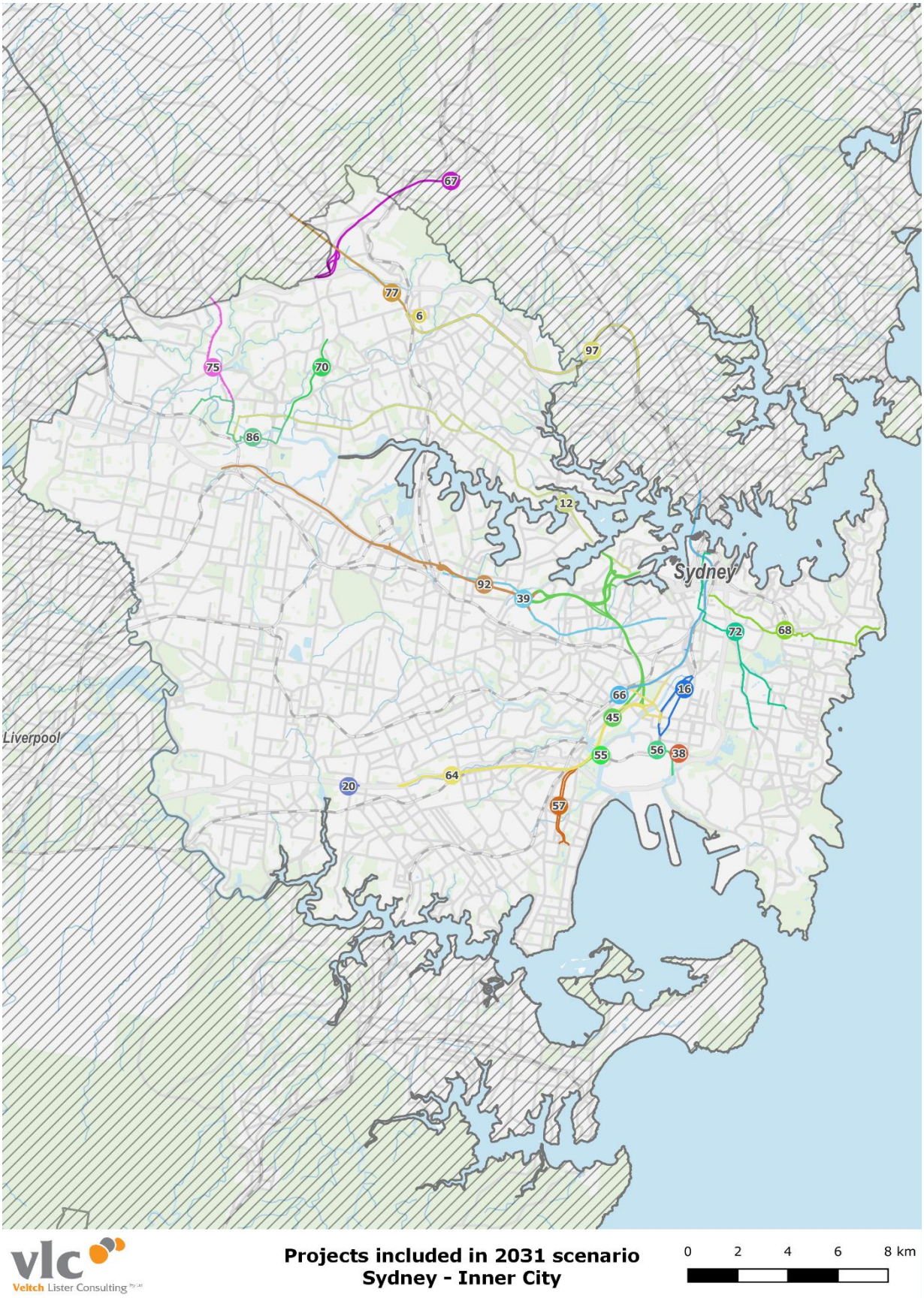
Appendix Figure A-3 – Projects included in the 2031 forecast SA4: Outer West Sydney



Appendix Figure A-4 – Projects included in the 2031 forecast SA4: South West Sydney



Appendix Figure A-5 – Projects included in the 2031 forecast SA4: Sydney Inner City



Appendix Figure A-6 – Projects included in the 2031 forecast SA4: Northern NSW

Appendix Figure A-7 – Projects included in the 2031 forecast SA4: Southern NSW

Appendix Table A-1 – Projects included in the 2031 forecast

Project no.	Name
1	Sydney Metro Northwest (Central Coast and Northern Sydney section) - includes 8 new stations, with more than ten trains per hour in the peak periods. See also project 15 (Outer West Sydney section) and 77 (Sydney – Inner City section).
2	South West Growth Centre - additional road networks to support developments in Catherine Fields.
3	Schofields Road Upgrade and Extension - Stage 2 - Between Tallawong Rd and Veron Rd. Expected new route in 2018.
4	Northern Road upgrades Stage 4 (Sydney – South West) - upgraded to a 4-lane divided road between Glenmore Parkway to Mersey Road. See also project 47 (Sydney – Outer West section).
5	Northern Road upgrade Stage 3 - addition of a dedicated bus lanes in both directions between Littlefields Road and Jamison Rd.
6	Project 1&2 - Epping Road upgrade – additional westbound lane between Essex Street and Blaxland Road
7	North West Growth Centre - additional road networks to support developments in Riverstone East Precinct.
8	North West Growth Centre - additional road networks to support developments in Marsden Park Precinct.
9	North West Growth Centre - additional road networks to support developments in Vineyard.
10	North West Growth Centre - additional road networks to support developments in Area 20 Precinct.
11	North West Growth Centre - additional road networks to support developments in Box Hill Precinct.
12	Parramatta to CBD via Ryde bus priority. Additional bus lanes, terminating to the west of the ANZAC Bridge.
13	North South Rail Link Stage 1 (Outer West Sydney section) – construction of a rail connection linking St Marys to Aerotropolis, via Western Sydney Airport. See also project 54 (South West Sydney section).
14	Jane Street and Mulgoa Road Infrastructure Upgrade - between Union Rd and Museum Dr, 3 lanes in each direction.
15	Sydney Metro Northwest (Outer West Sydney section). Includes 8 new stations, with more than ten trains per hour in the peak periods. See also project 1 (Central Coast and Northern Sydney section).
16	Bourke St / O'Riordan St upgrade project – widening of O'Riordan Street to 3 lanes in each direction between Bourke Road and Robey Street.
17	Castle Hill to Liverpool via Parramatta and T-way bus priority.
18	South West Growth Centre - additional road networks to support developments in East Leppington.
19	M4 Smart Motorway project Stage 1 – upgrade of M4 motorway between Church Street Parramatta and Glenbrook, including widening, intersection works, and managed motorways.
20	M5 Belmore Road ramps - construction of east facing on/off ramps that connects Belmore Rd with M5.
21	Schofields Rd Upgrade and Extension - Stage 3 - Schofields Road extended from Veron Road through South Street to Richmond Road and upgraded to 4 lane divided road.

Project no.	Name
22	South West Growth Centre - additional road networks to support developments in Oran Park.
23	North West Growth Centre - additional road networks to support developments in Schofields Precinct.
24	Campbelltown Road Upgrade - widening to a 4 lane divided road between Camden Valley Way and Brooks Rd.
25	South West Growth Centre - additional road networks to support developments in Marylands.
26	South West Growth Centre - additional road networks to support developments in Catherine Fields North.
27	Mona Vale Road Upgrade – widening to 4 lanes between McCarrs Creek Rd and Powder Works Rd.
28	Glenfield Road upgrade - widening of Glenfield Road from Campbelltown Road to 80m west of Brampton Road
29	South West Growth Centre - additional road networks to support developments in Catherine Fields (Part) 2021.
30	North West Growth Centre - additional road networks to support developments in Colebee.
31	South West Growth Centre - additional road networks to support developments Austral & Leppington.
32	Werrington Arterial Road (Gipps St) - Stage 1; Claremont Meadows – widening of Kent Road/Gipps Street to 4 lanes corridor between the M4 Motorway and the Great Western Highway, with east facing ramps on the M4 Motorway
33	Spring Farm Road Infrastructure Stage 1 - additional road networks to support developments in Spring Farm.
34	Memorial Avenue Upgrade - Widening between Old Windsor Rd and Windsor Rd.
35	Kooragang Island Connectivity - Tourle Street bridge duplication.
36	Richmond Road Upgrade - Stage 2 – widening to 4 lanes between Townson Rd and Elara Blvd.
37	North West Growth Centre - additional road networks to support developments in Schofields West Precinct.
38	WestConnex Enabling Works Package, Airport East Precinct - Removal of level crossing at General Holmes Dr with the construction of a road underpass that links General Holmes Drive; Botany Rd and Wentworth Ave.
39	Parramatta Road bus priority - between Burwood and the CBD.
40	Northern Road upgrades Stage 2 - upgrade to 4-lanes divided between Peter Brock Drive and Mersey Road.
41	North West Growth Centre - Alex Avenue Precinct – upgrade of collector roads between Railway Tce and Ridge Rd.
42	South West Growth Centre - additional road networks to support developments in Edmondson Park.
43	Memorial Avenue Upgrade - widening between Old Windsor Rd and Windsor Rd.
44	South West Growth Centre - additional road networks to support developments in Marylands.
45	WestConnex Stage 3 - tolled motorway tunnel linking the M5 north of the Sydney Airport to the M4 at Haberfield, with connections for Iron Cove Link and Rozelle Interchange.

Project no.	Name
46	M12 Motorway - New motorway along the Elizabeth Driver corridor
47	Northern Road upgrades Stage 4 (Sydney – Outer West section) - upgraded to a 4-lane divided road between Glenmore Parkway to Mersey Road. See also project 4 (Sydney – South West).
48	Northconnex - new motorway linking the M2 to the F3
49	Northern Road upgrades Stage 1 - upgraded to a 4-lane divided road between The Old Northern Road and Peter Brock Drive.
50	North West Growth Centre - additional road networks to support developments in Riverstone West Precinct.
51	Sydney Metro City & Southwest – Chatswood to Sydenham (Central Coast and Northern Sydney section). Includes 6 new stations, with more than 10 trains per hour in the peak periods. See also project 66 (Sydney - Inner City section).
52	South West Growth Centre - additional road networks to support developments in the Turner Rd precinct.
53	North West Growth Centre - additional road networks to support developments in Riverstone Precinct.
54	North South Rail Link Stage 1 (South West Sydney section) – construction of a rail connection linking St Marys to Aerotropolis, via Western Sydney Airport. See also project 13 (Outer West Sydney section).
55	WestConnex Enabling Works Package - Airport West Precinct.
56	WestConnex Enabling Works Package - Airport East.
57	F6 extension stage 1 - Between M5, Arncliffe and President Av.
58	Newcastle Light Rail - Between Wickham and Newcastle.
59	North West Growth Centre - Riverstone Precinct.
60	Bringelly Road Upgrade Stage 2 - Between King St and The Northern Rd.
61	M12 Motorway. New motorway along parallel to Elizabeth Drive between The Northern Road and the M7.
62	North West Growth Centre - additional road networks to support developments in Riverstone West Precinct.
63	Mulgoa Road - Between Glenmore Parkway, Glenmore Park and Andrews Road, Penrith.
64	WestConnex Stage 2, Beverley Hills to St Peters.
65	Upgrade of Moorebank Avenue to 4 lanes as part of the terminal development - Between Anzac Avenue and M5.
66	Sydney Metro City & Southwest – Chatswood to Sydenham (Sydney - Inner City section). Includes 6 new stations, with more than 10 trains per hour in the peak periods. See also project 51 (Central Coast and Northern Sydney section).
67	NorthConnex - tolled tunnel which will connect the M1 at Wahroonga to the M2 at West Pennant Hills, as an alternative to Pennant Hills Road.
68	North Bondi to CBD bus priority.
69	Northern Road upgrades Stage 3, between Glenmore Parkway and Jamison Rd.
70	Parramatta Light Rail Stage 1 - Rydalmere to Carlingford - Between Rydalmere and Carlingford. Expected new route in 2023.
71	South West Growth Centre - Turner Rd.
72	CBD and South East Light Rail.

Project no.	Name
73	South West Growth Centre - additional road networks to support developments in Leppington.
74	Princes Highway; Foxground and Berry Bypass - Between Toolijooa Rd and Croziers Rd.
75	Castle Hill to Liverpool via Parramatta and T-way bus priority.
76	Cary Street Upgrades - Between The Boulevarde and Bay Street.
77	Sydney Metro Northwest (Sydney – Inner City section). Includes 8 new stations, with more than ten trains per hour in the peak periods. See also 1 (Central Coast and Northern Sydney section) and project 15 (Outer West Sydney section).
78	Spring Farm Road Infrastructure Stage 2.
79	Nepean River Green Bridge at Memorial Avenue.
80	Northern Road upgrade Stage 1: bus lane - Between The Old Northern Road and Peter Brock Drive.
81	North West Growth Centre - additional road networks to support developments in Box Hill Precinct.
82	Narellan Road Upgrade - Between Camden Bypass and Blaxland Road.
83	Boundary Street Upgrade; Roseville.
84	Showground Road Upgrade; Castle Hill - Between Carrington Rd and Old Northern Rd.
85	M1 Productivity Package, widening of the M1 Pacific Motorway between Tuggerah and Doyalson.
86	Parramatta Light Rail Stage 1 - Westmead to Rydalmere - Between Westmead and Rydalmere.
87	Alford's Point Road Southern Approach - Between Georges River and Brushwood Dr.
88	Western Sydney Employment Area - Old Wallgrove Road upgrade - Between Roberts Rd and Wallgrove Rd.
89	Bringelly Road Upgrade Stage 1 - Between Camden Valley Way and King St.
90	North West Growth Centre - North Kellyville Precinct.
91	Cumberland Highway and Cabramatta Road Intersection - Between Cabramatta Creek and Intersection of Cumberland Highway and Cabramatta Road.
92	WestConnex Stage 1, motorway between Parramatta and Ashfield.
93	Northern Road upgrade Stage 4: bus lane - Between Mersey Road and Littlefields Road.
94	The Horsley Drive - Between M7 Mwy and Cowpasture Rd.
95	Northern Road upgrade Stage 4: bus lane - Between Mersey Road and Littlefields Road. See also project 93.
96	Mona Vale to CBD bus priority.
97	Sydney Metro Northwest - North West growth Area to Chatswood. See also project 1 (Central Coast and Northern Sydney section), project 15 (Outer West Sydney section) and project 77 (Sydney – Inner City section).

Appendix B: Public transport network assumptions

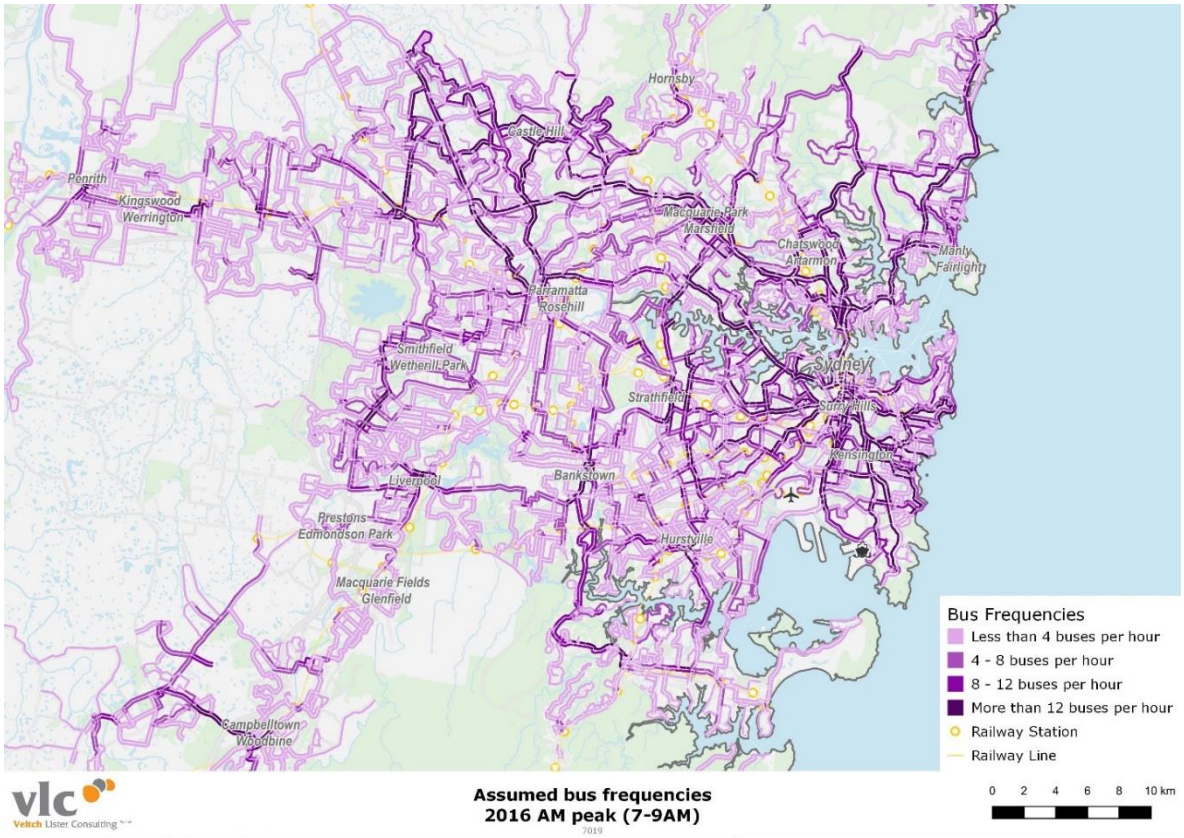
This section provides a high-level overview of the public transport networks used in the modelling.

Appendix Figure B-1 through Appendix Figure B-7 illustrate the frequencies assumed on Sydney's bus network.

Appendix Figure B-9 through to Appendix Figure B-15 illustrate the frequencies assumed on Sydney's rail network.

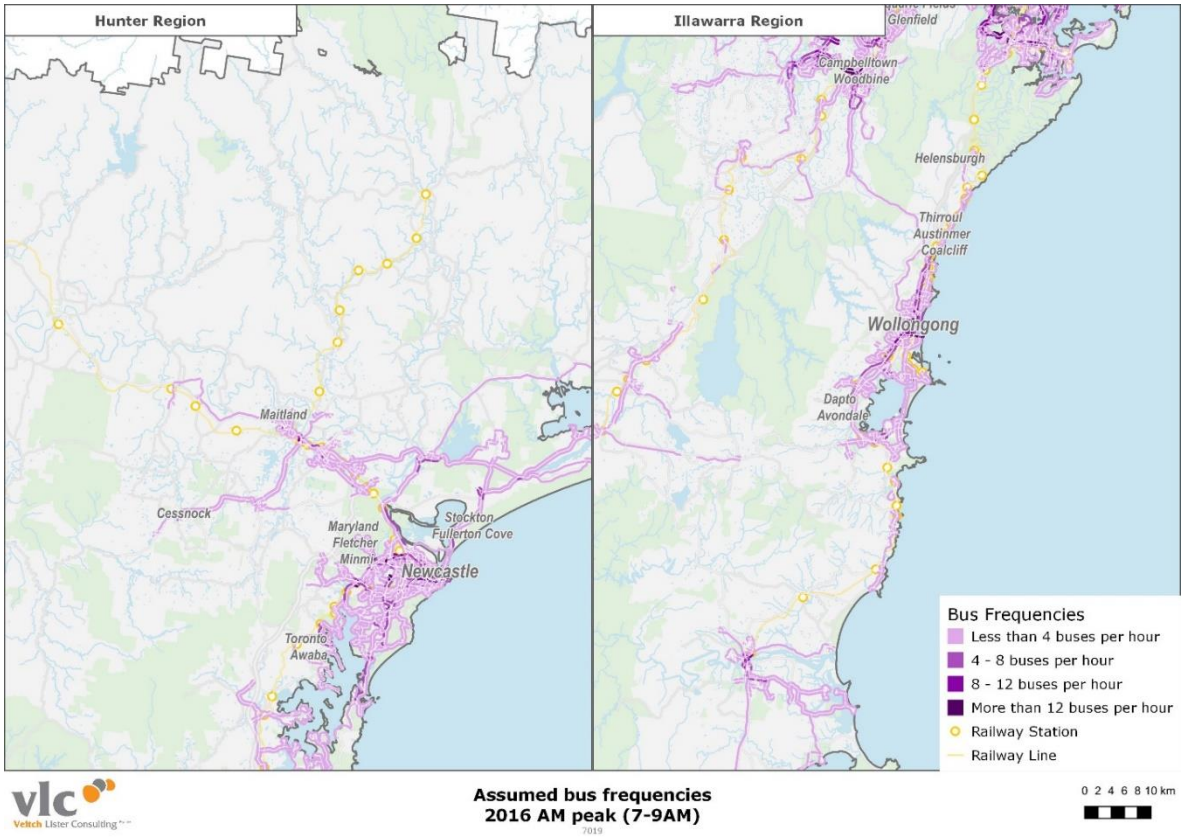
The 2016 routes and frequencies used in modelling were obtained from Transport for NSW. Details of how the 2031 network were developed can be found in Appendix D: Model Assumptions.

Appendix Figure B-1 – Sydney GCCSA assumed bus frequencies, 2016 AM peak (7-9AM)



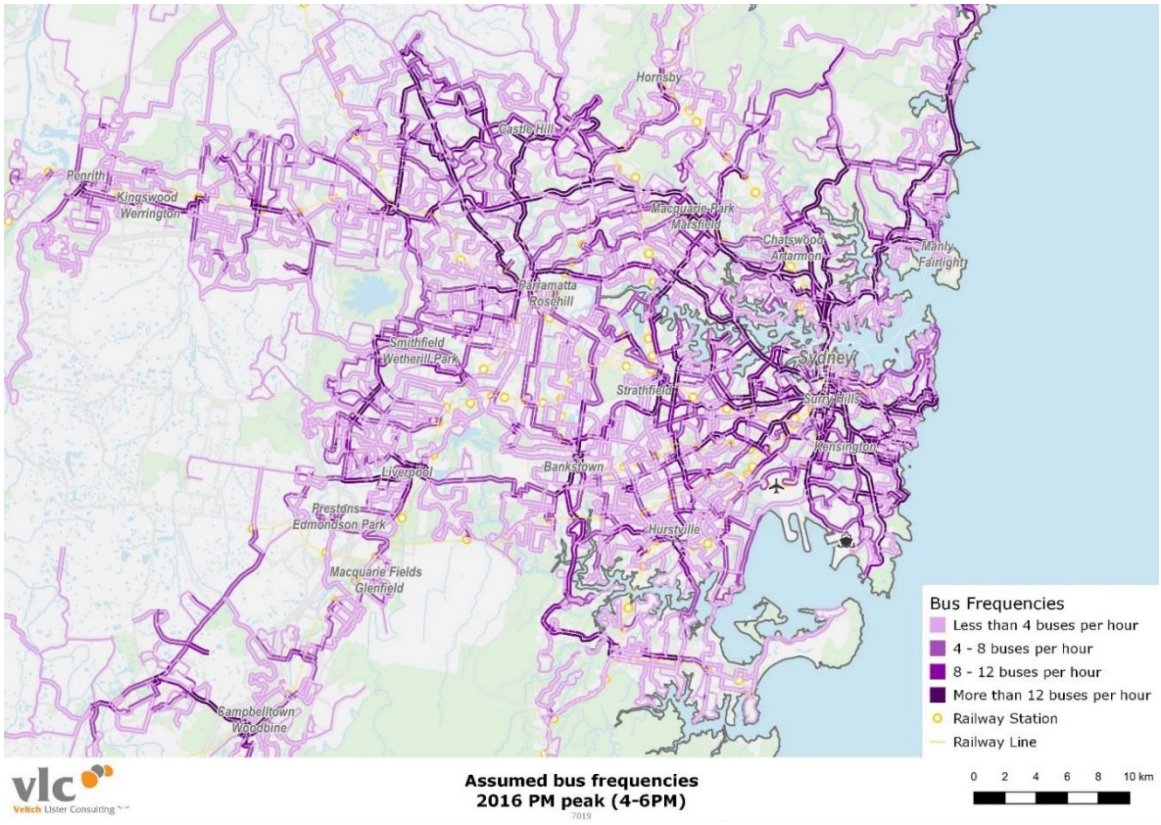
Source: Transport for NSW

Appendix Figure B-2 – Hunter and Illawarra assumed bus frequencies, 2016 AM peak (7-9AM)



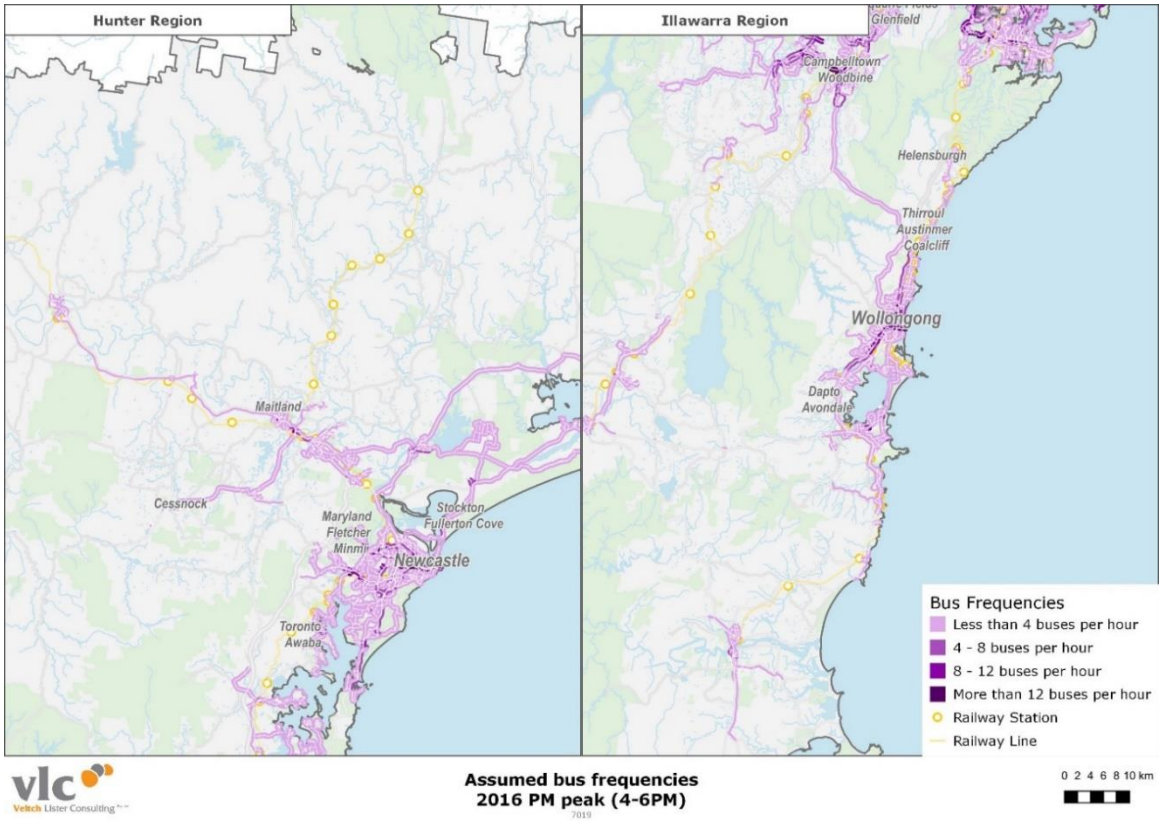
Source: Transport for NSW

Appendix Figure B-3 – Sydney GCCSA assumed bus frequencies, 2016 PM peak (4-6PM)



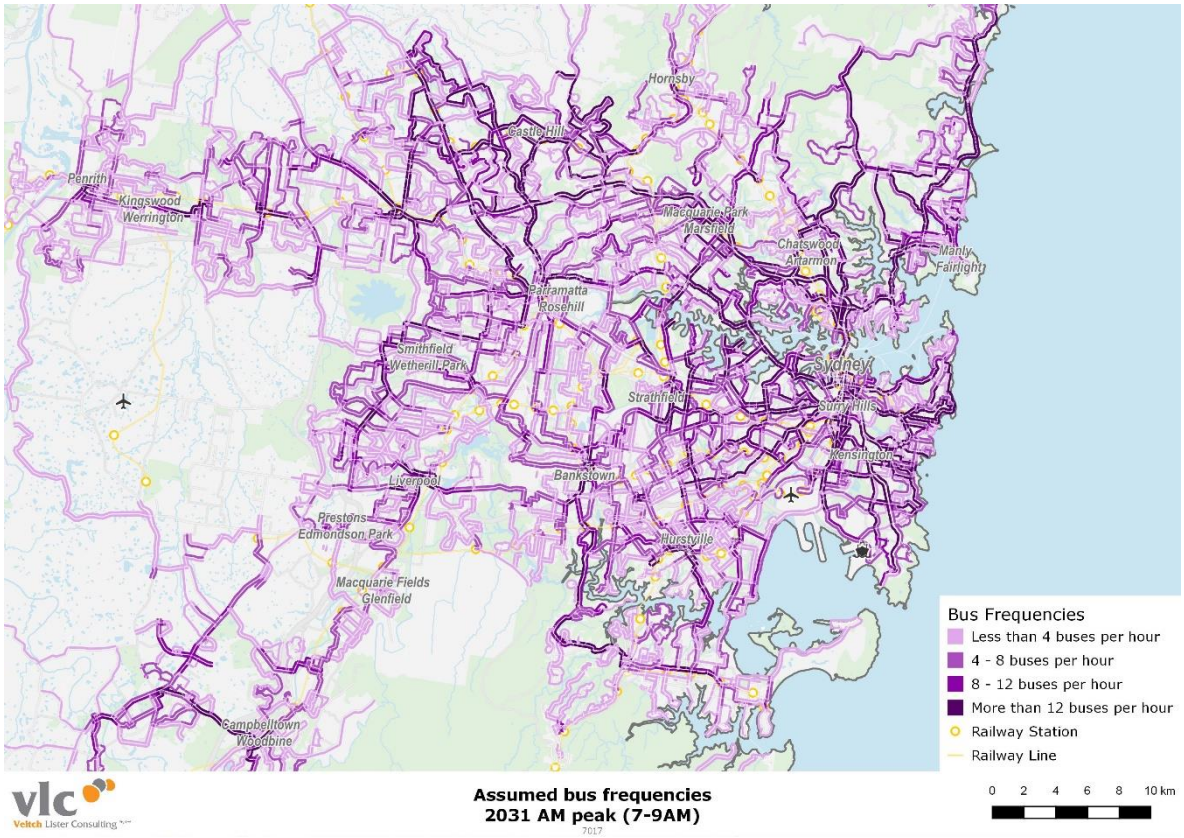
Source: Transport for NSW

Appendix Figure B-4 – Hunter and Illawarra assumed bus frequencies, 2016 PM peak (4-6PM)

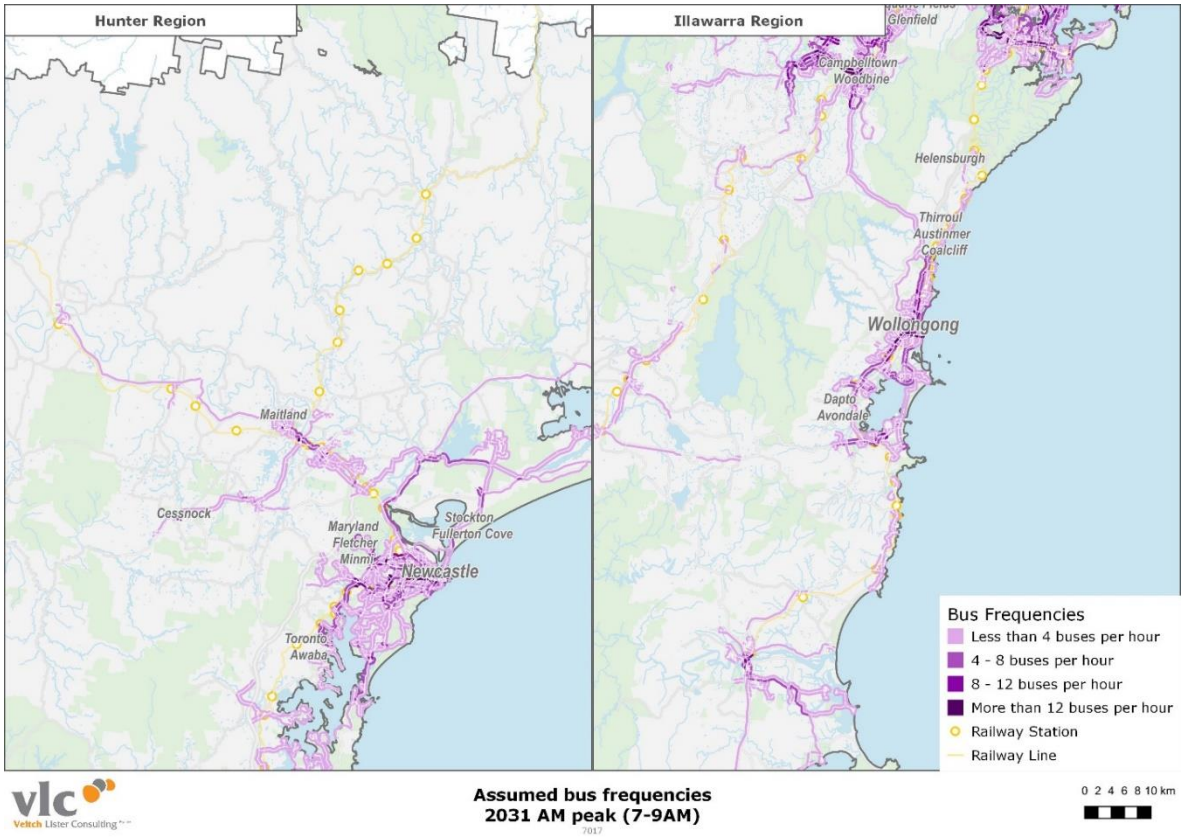


Source: Transport for NSW

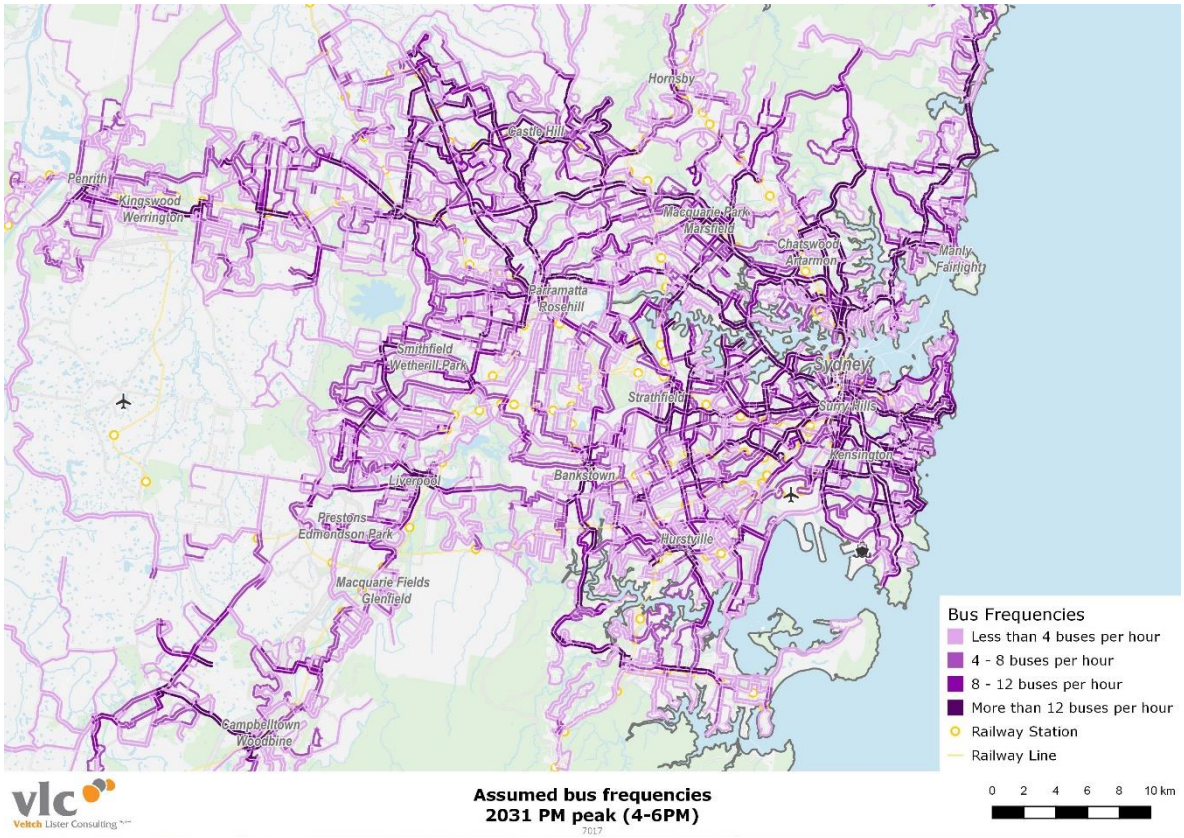
Appendix Figure B-5 – Sydney GCCSA assumed bus frequencies, 2031 AM peak (7-9AM)



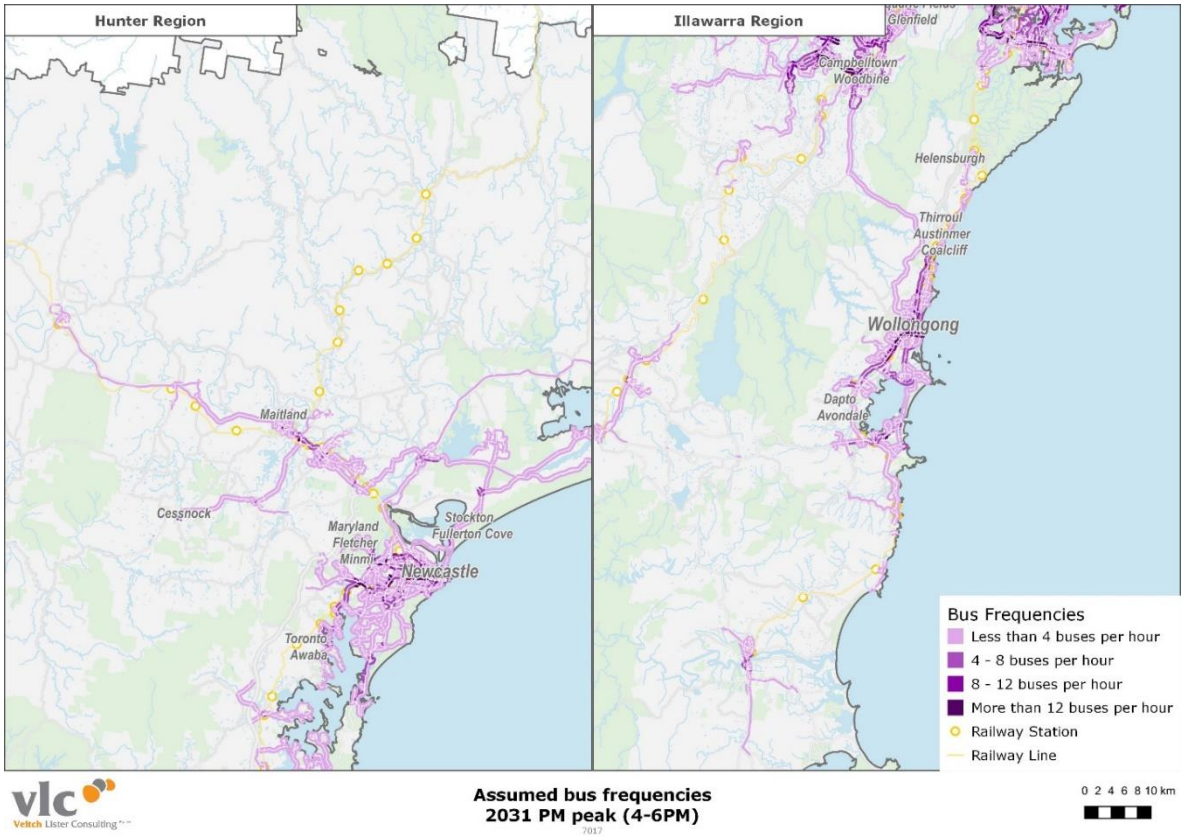
Appendix Figure B-6 – Hunter and Illawarra assumed bus frequencies, 2031 AM peak (7-9AM)



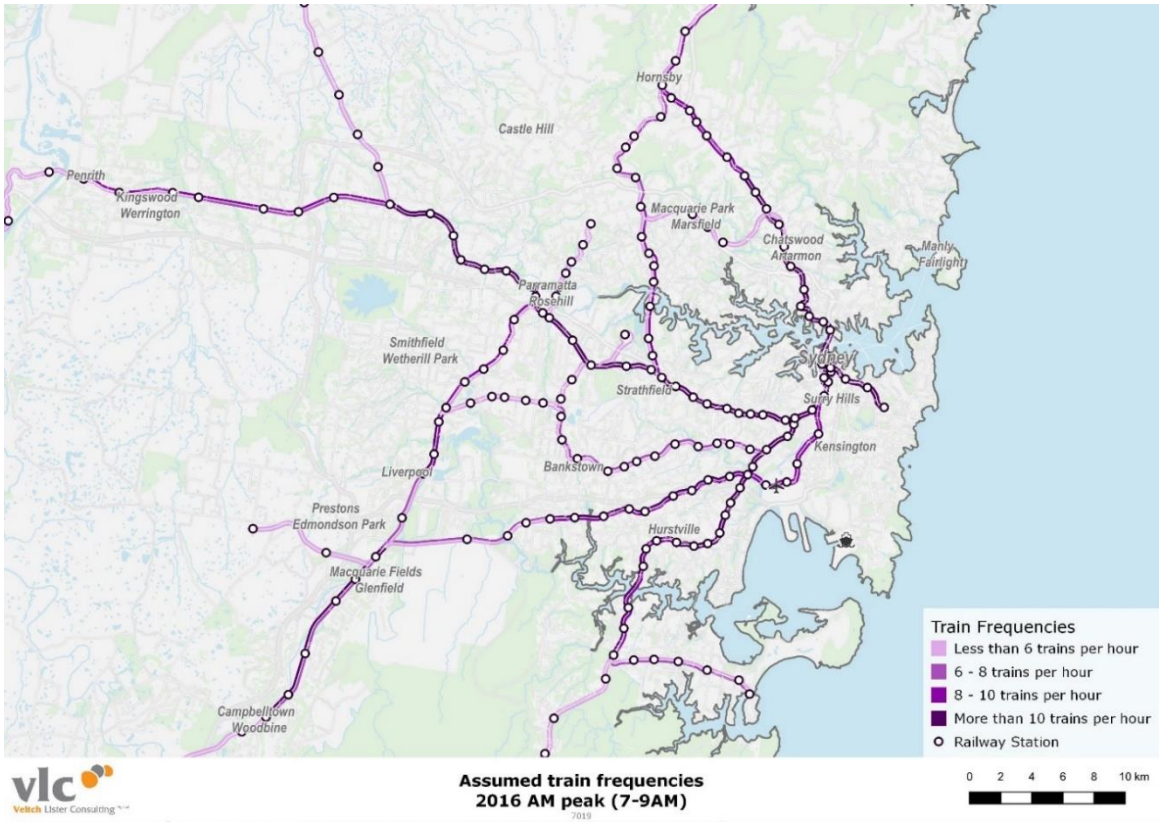
Appendix Figure B-7 – Sydney GCCSA assumed bus frequencies, 2031 PM peak (4-6PM)



Appendix Figure B-8 – Hunter and Illawarra assumed bus frequencies, 2031 PM peak (4-6PM)

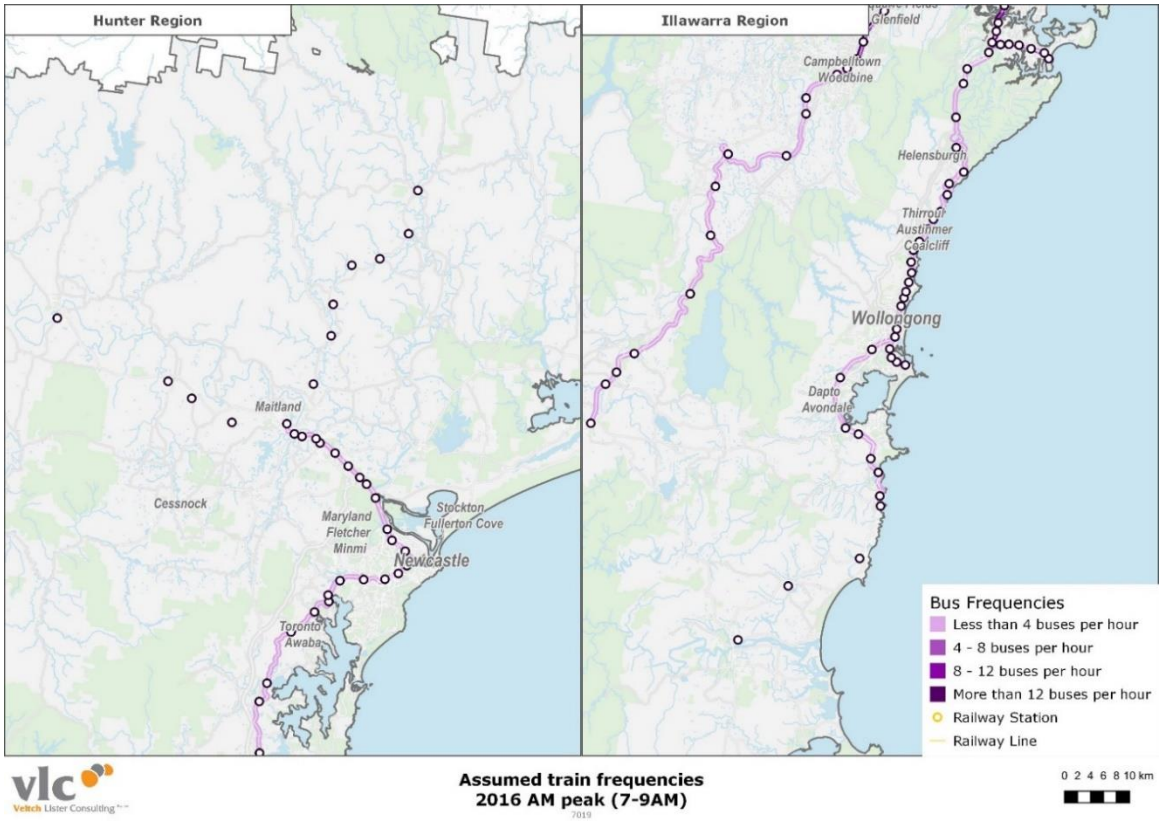


Appendix Figure B-9 – Sydney GCCSA assumed train frequencies, 2016 AM peak (7-9AM)



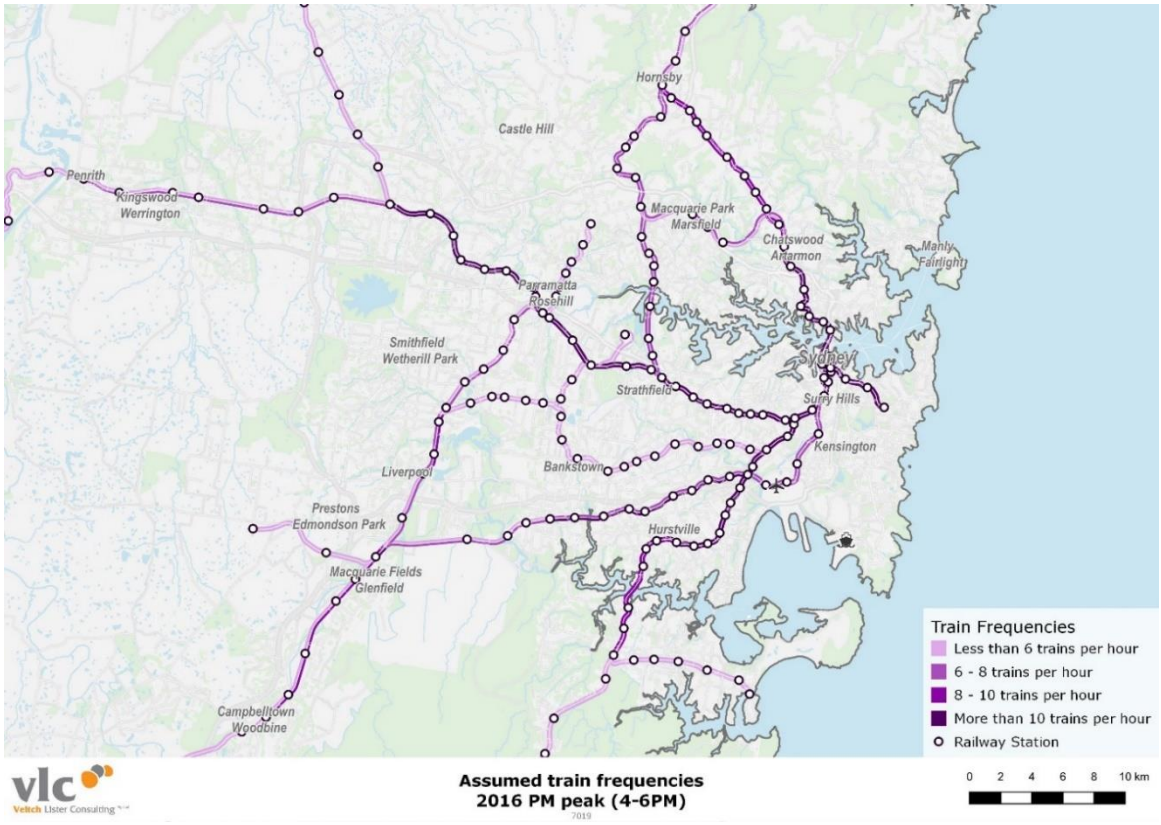
Source: Transport for NSW

Appendix Figure B-10 – Hunter and Illawarra assumed train frequencies, 2016 AM peak (7-9AM)



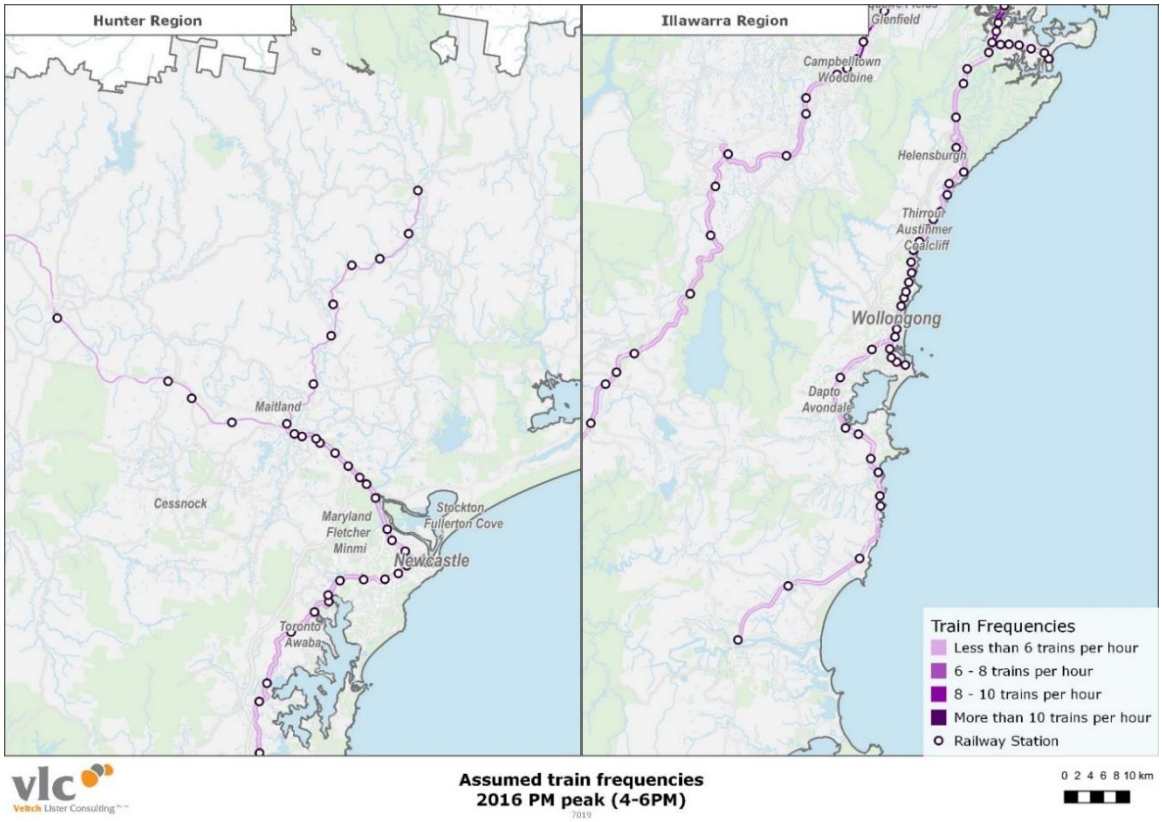
Source: Transport for NSW

Appendix Figure B-11 – Sydney GCCSA assumed train frequencies, 2016 PM peak (4-6PM)



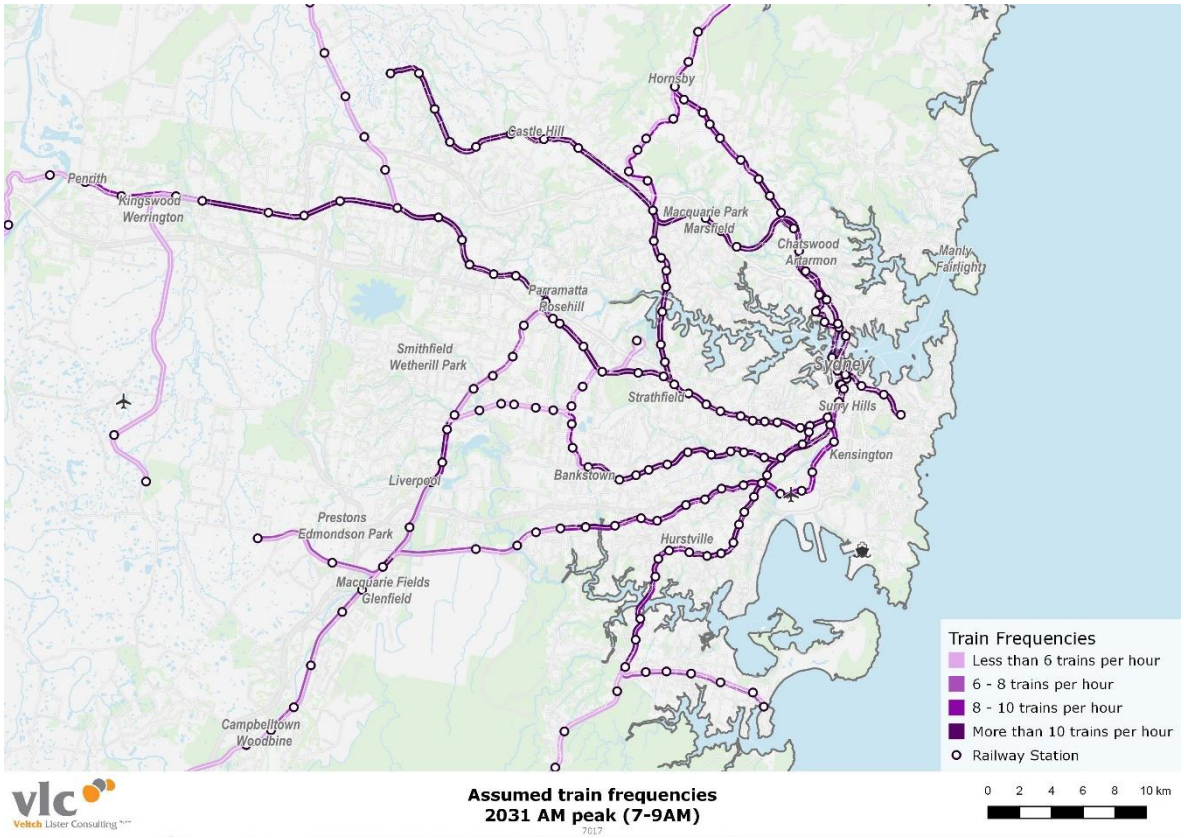
Source: Transport for NSW

Appendix Figure B-12 – Hunter and Illawarra assumed train frequencies, 2016 PM peak (4-6PM)

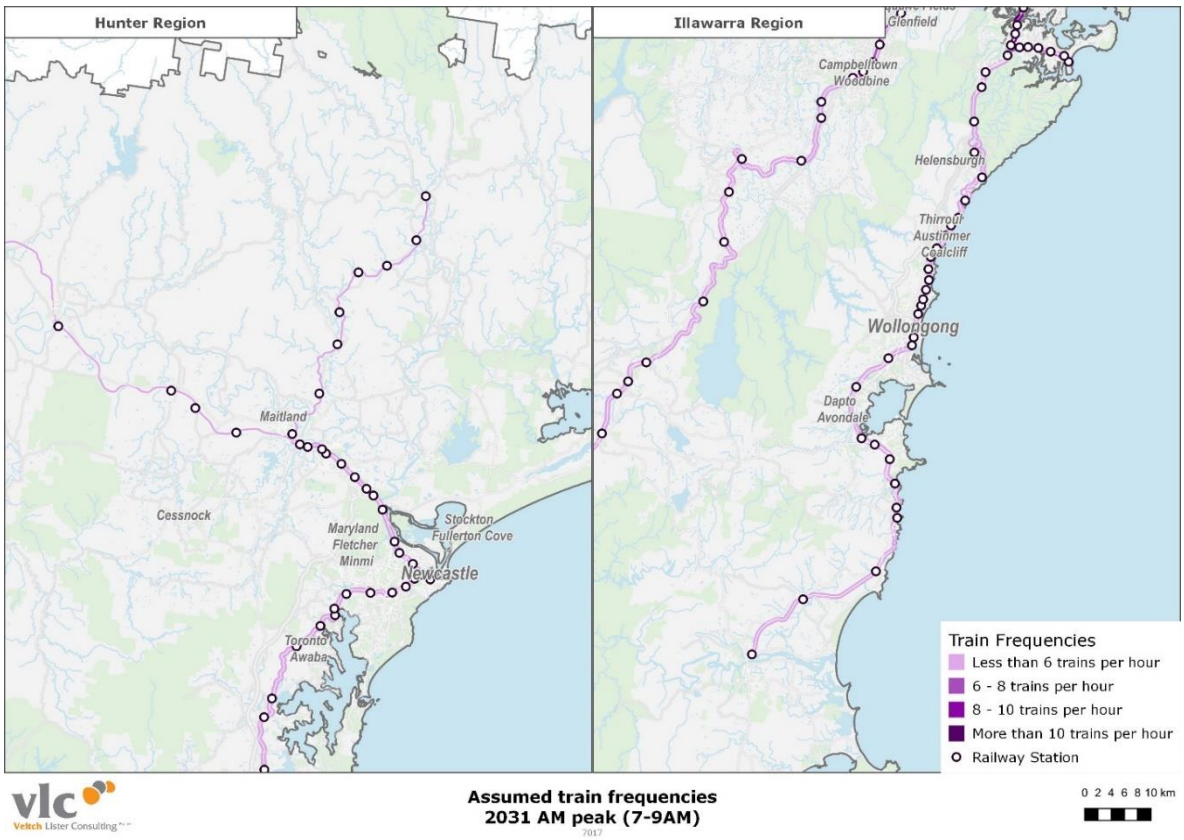


Source: Transport for NSW

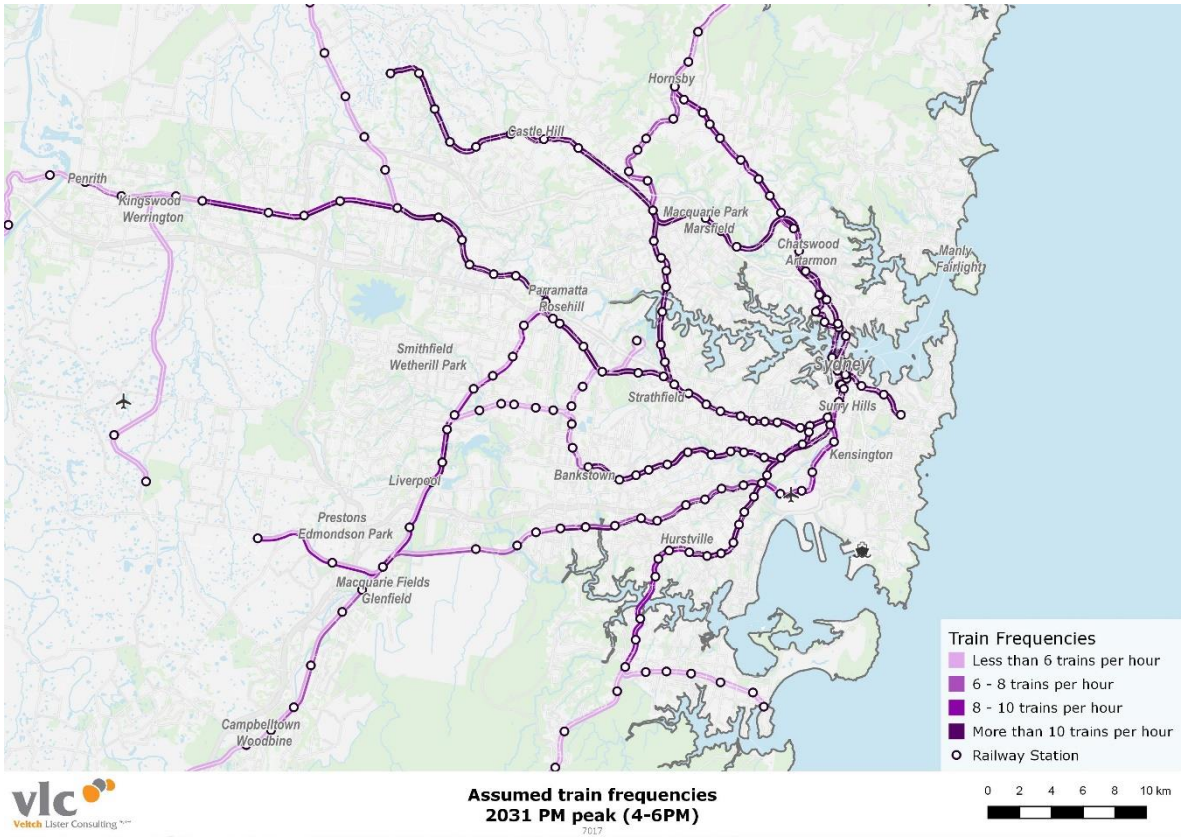
Appendix Figure B-13 – Sydney GCCSA assumed train frequencies, 2031 AM peak (7-9AM)



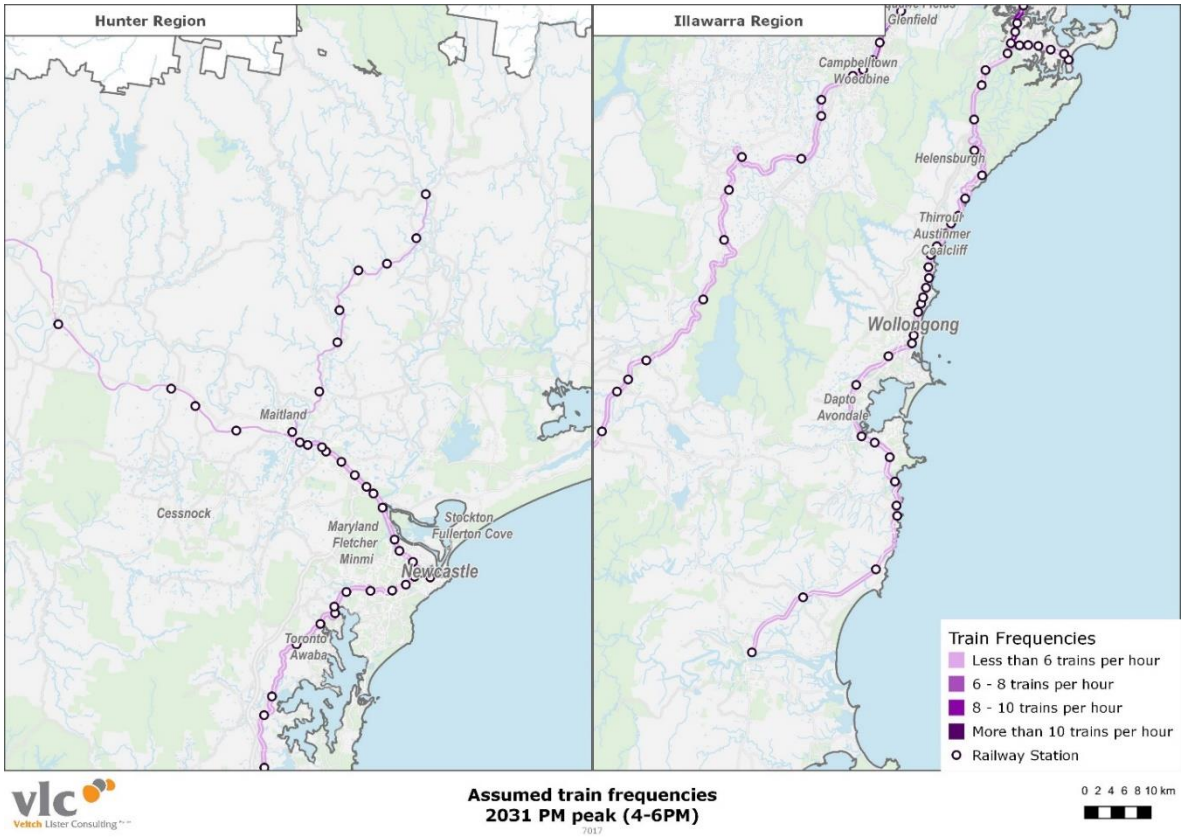
Appendix Figure B-14 – Hunter and Illawarra assumed train frequencies, 2031 AM peak (7-9AM)



Appendix Figure B-15 – Sydney GCCSA assumed train frequencies, 2031 PM peak (4-6PM)



Appendix Figure B-16 – Hunter and Illawarra assumed train frequencies, 2031 PM peak (4-6PM)



Appendix C: Sydney road corridors

Appendix Table C-1 – Sydney road corridors

Corridor number	Corridor name
1	East West corridor - M5
1	East West - A34
2	Airport to CBD - M1
2	Airport to CBD - Botany Rd/Regent St
3	Cumberland Hwy (Hume Hwy-M4)
3	Hume Hwy / Woodville Rd (Cumberland Hwy - M4)
4	North-South arterials East of M7
4	M7 North-South Corridor
5	NW Middle Corridor (M7/M2)
5	EW Arterials south of M7 and M2
6	EW Arterials parallel with M2/LCT
6	NW Inner Corridor (M2/LCT)
7	Eastern Dist/Gore Hill/Warringah Fwys/SHT
7	Eastern Dist/Gore Hill/Warringah Fwys/SHB
7	SHB to Pacific Hwy Artarmon
8	Gt Western Hwy: Wenthworth Falls to Western Mwy
9	Sydney to Central Coast
10	South Coast to Sydney
11	M2/M7 to Richmond
12	Mittagong to SW Sydney via Hume Mwy
12	Mittagong to SW Sydney
13	Western Mwy (M4): A9 to M7
13	Gt Western Hwy: A9 to M7
14	Western Mwy (M4): A28 to Hawkesbury Rd
14	Gt Western Hwy (A44): A28 to Parramatta
15	Western Hwy (M4): Hawkesbury Rd to Strathfield
15	Parramatta Rd (A44): Parramatta to Strathfield
16	Parramatta Rd (M4): Strathfield to Haberfield
17	City West Link and Anzac Bridge
17	Parramatta Rd (A22): Haberfield to Chippendale
18	Victoria Rd (A40)
19	The Northern Rd Corridor
20	Nth Sydney - Northern Beaches Corridor
21	Chatswood to Narraweena via Warringah Rd
22	Homebush Bay to Mona Vale Corridor (A3)
23	Wakehurst Parkway Corridor
24	Pennant Hills Rd - Parramatta to Hornsby
25	Princes Hwy-M4 Corridor via King Georges Rd
26	Sutherland - Ryde/Parramatta Corridor
27	Inner Hume Hwy Corridor
28	Little Bay to CBD East
29	Port Botany Industrial Area
30	CBD to Bondi Junction
31	SW Sydney Growth Area to Hume Hwy
32	The Horsley Drive Corridor
33	CBD West to Watsons Bay
34	Cronulla to Kogarah
35	Outer Sydney Orbital NB
36	Bells Line of Rd - Castlereagh Connection NB

Appendix D: Model Assumptions

D.1 Purpose

This appendix sets out the overarching assumptions and methodology applied in our modelling. It also documents some of the city specific assumptions such as parking charges and public transport fares.

D.2 Modelling methodology

This section briefly describes the Zenith Travel Models developed by VLC and used to undertake all modelling for the Audit.

D.2.1 Development of the Zenith Travel Models

The Zenith models have been established through applying behavioural relationships calibrated from household travel surveys and validating these against traffic counts and public transport passenger surveys. These relationships have been updated on several occasions over the past 18 years. Zenith models operate using OmniTRANS, offering a versatile and interactive platform for multimodal transport planning. The platform also adds value in the presentation and discussion of patronage forecasts.

The models simulate all travel undertaken by households and firms, and visitors to the region during an average weekday in each forecast year. Given a scenario of land use and demographic change, the models reflect the level of participation in a range of activities across the region and the frequency of travel to them, as well as the choice of destination, mode and route.

The models are unique in their ability to reflect access to public transport, which is a key influence on accessibility in Australian cities, and in reflecting the travel choices made by their residents and visitors.

Many of the parameters of the multimodal model have their genesis in the calibration of the Zenith model of Melbourne in 1995, which made extensive use of the Victorian Activity and Travel Survey (VATS) database. When household travel surveys later became available in other regions, this provided the opportunity to revalidate the regional models against local data and to recalibrate selected sub-models and market segments where appropriate to better reflect behaviour specific to each region.

VLC is continually undertaking research and development to ensure the Zenith models remain at the forefront of transport planning practice and incorporates evolving state-of-the-art techniques when it is appropriate to do so. All of the data sets underpinning the models are reviewed frequently and maintained to be consistent with the latest information available.

D.2.2 Model Architecture

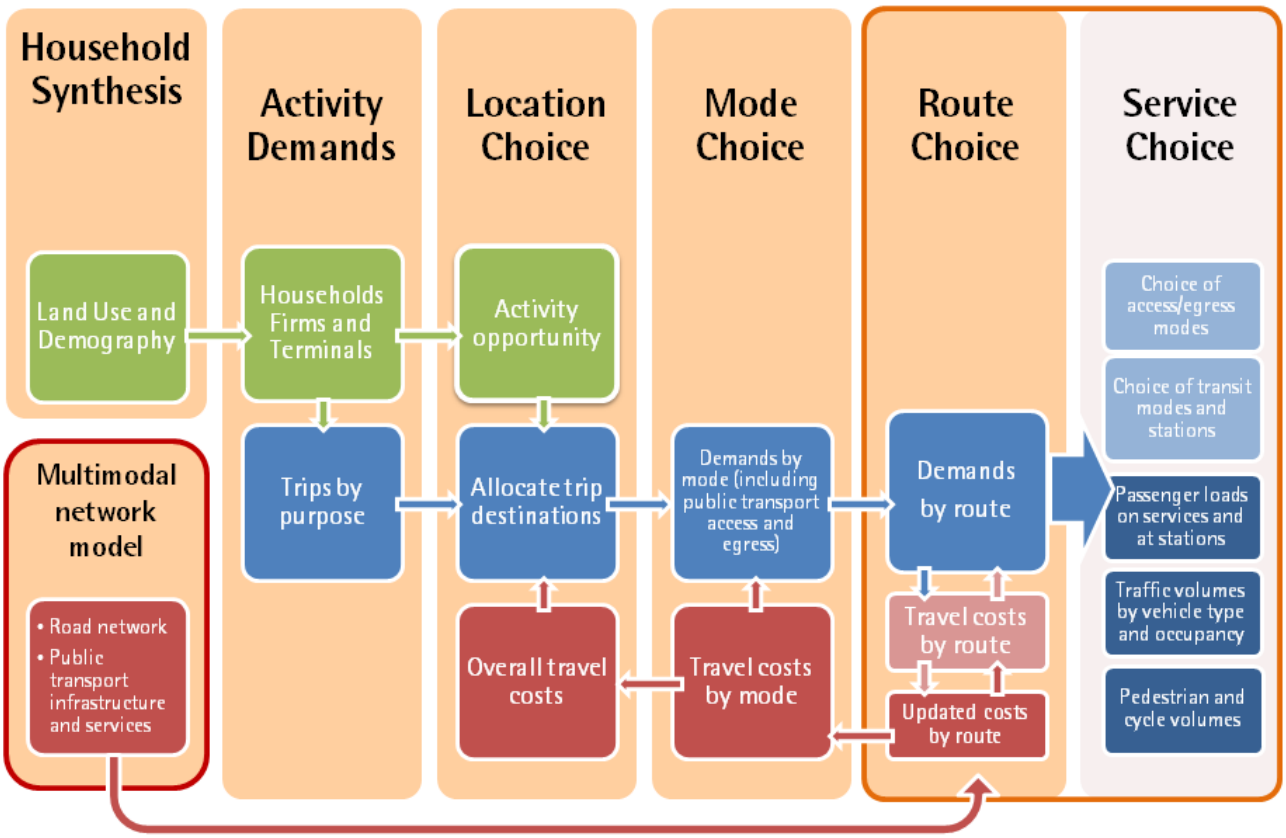
The prime objective of Zenith is to provide a planning tool to support the evolving policy issues of relevance to planners and government. This is accomplished through replicating the demand for travel by residents and visitors in the modelled region, which is derived from the demand for participation in activities. Travel choices may differ depending on the activity for which the travel is undertaken. The nature of the activity may influence the frequency, timing and duration of participation, the location, as well as the mode of travel and in some cases, the route chosen.

The Zenith travel demand model simulates the travel behaviour of households, firms and visitors within the modelled region associated with their participation in the range of activities described

above. The model makes use of information that is available to describe the potential demands for these activities in each location, such as statistics on employment in various industries, enrolments at educational facilities, and demographic variables such as population and households.

The key stages of the Zenith model process are illustrated in Appendix Figure D-1.

Appendix Figure D-1 – Key Stages of the Zenith Models



Each region is divided into several thousand travel zones, providing a high degree of resolution for forecasting movements between suburbs and across the city. A large range of demographic, socioeconomic and land use variables are used to identify the types of households and range of activities in each zone.

The model forecasts the number of trips made for work, education, shopping, personal business, recreation, social and "other" journey purposes (why travel?). It simulates the decisions made by households regarding the time period (when?), destination (where?) and mode of travel (how?) for each trip, with models developed from surveys of travel behaviour undertaken in each region.

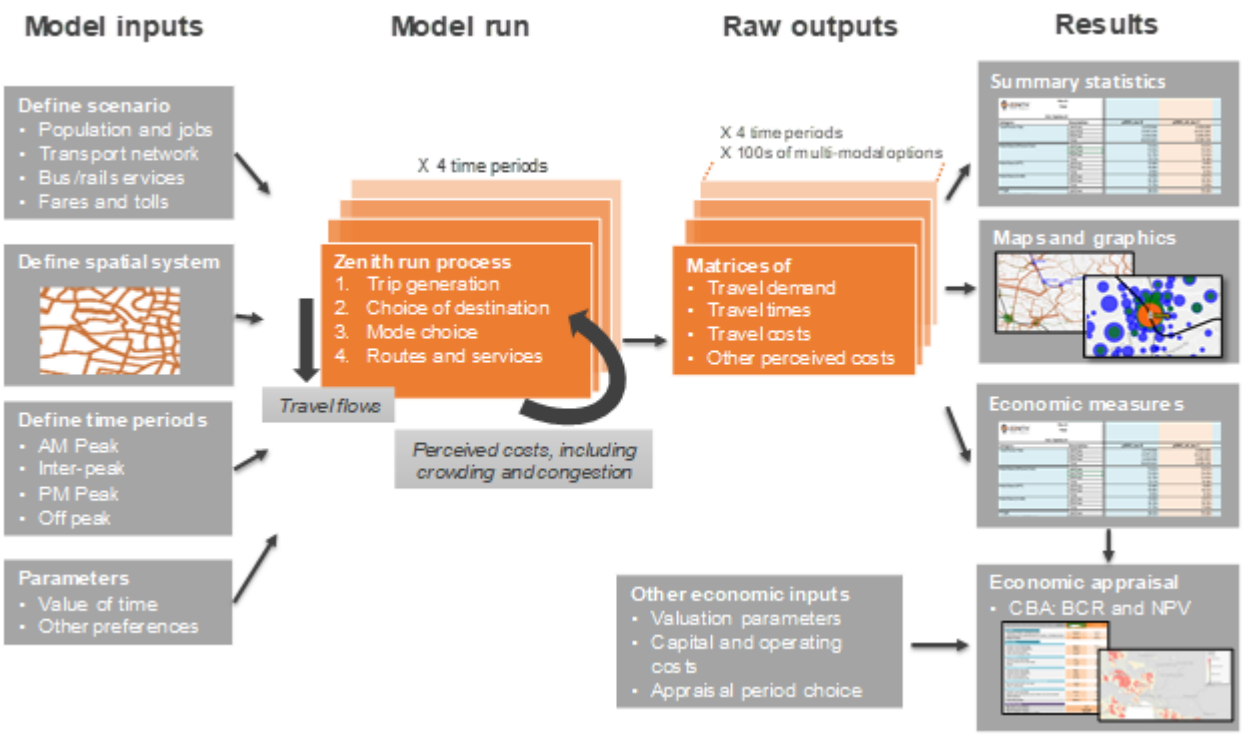
Having determined the destination and mode of travel, the model then reflects the choice of route for trips by private or commercial vehicle, public transport and active travel modes such as cycling and walking.

The more fine-grained the travel zone system, the more accurate travel forecasts have the potential to be. This is particularly the case on parts of the road network with lower traffic volumes, and on public transport services, as smaller zones capture vehicle movements on lower-order roads used to reach major arterials, and more closely reflect walking distances to the public transport stops.

D.2.3 Model process

The practicalities of establishing and running a given forecast year scenario are described in Appendix Figure D-2. For a given set of infrastructure and services assumptions, inputs are devised and entered into the Zenith user interface, the model is run, raw outputs are produced, and finally a range of detailed results are prepared.

Appendix Figure D-2 – Scenario testing with the Zenith model



Model inputs

- Define scenario – the distribution of population and employment in the forecast year, the nature of the transport network (including any upgrades assumed) as well as all of the service attributes (such as tolls, fares and service frequencies) must each be set.
- Define spatial system – the zone system determines how wide the model's coverage will be (generally the greater metropolitan area), how disaggregated the representation of the area will be in the model (number of zones), and which areas have more or less detailed representation (e.g. disaggregated zones in the corridor under consideration). In general, major capital cities are modelled In Zenith with between around 2000 and 4500 zones. More zones gives greater detail (for example for people choosing whether or not to walk to train stations), but requires longer model running times.
- Define time periods – some models only consider a single period of a weekday. Zenith applies a four-period breakdown of the weekday, with the actual hours distinguishing the AM and PM peaks potentially varying depending on local travel conditions.
- Input parameters – a range of behavioural parameters define the trade-offs people in the model are assumed to make, for example the trade-off between travel time and out-of-pocket spending is represented by the value of time. These parameters are estimated to best reflect existing travel behaviour.

Model run

The process of the Zenith model's operation is described in some detail in the remainder of this document. From the perspective of running a single model scenario, the most important feature is the iterative nature of the estimation of travel costs and travel demand. The model attempts to find an 'equilibrium' set of costs and demands for a wide range of travel modes, routes and services. Through making increasingly small adjustments to variables it converges towards the most consistent set of costs and demands for each period of the day.

Raw outputs

The key outputs of the model run are the equilibrium travel costs and travel demands for each origin-destination pair across each period of the day and each travel mode. Given the number of alternative travel options (e.g. walk to rail station 1, bus to rail station 2, car driver, car passenger, etc.) and the number of origin and destination zones, the resulting data is a very large number of matrices ('trip tables' and 'cost skims').

Results

The raw outputs can be adapted to any range of output formats to understand the implications of the modelled scenario, including tables, graphs, static maps and interactive maps. Common measures are total travel time, total vehicle kilometres (by road and vehicle type) and travel time spent in crowded public transport vehicles. Transport network performance measures can be estimated on a stand-alone basis or comparing scenarios across time (time series), across options (comparative), and between with and without-project (incrementally). Outputs can also be further processed to understand the incremental economic benefits of a 'with project' scenario compared to a 'without project' scenario for use in cost-benefit analysis, either within Zenith's economics module or with third-party economics spreadsheets.

D.3 Model inputs

Many of the model inputs described in Section D.2.3 above are specific to each modelled city and will be dealt with in the respective Technical Appendixes. However, there are a number of inputs that have been agreed with Infrastructure Australia and harmonised across all six major city Zenith models. These are assumptions to do with travel costs, technology and the approach to the value of travel time.

D.3.1 Travel costs

Fuel price

There is a range of influences on the unit cost of fuel consumed in urban transport, which can be affected by global and local conditions. The most significant influences on the costs of fuel include:

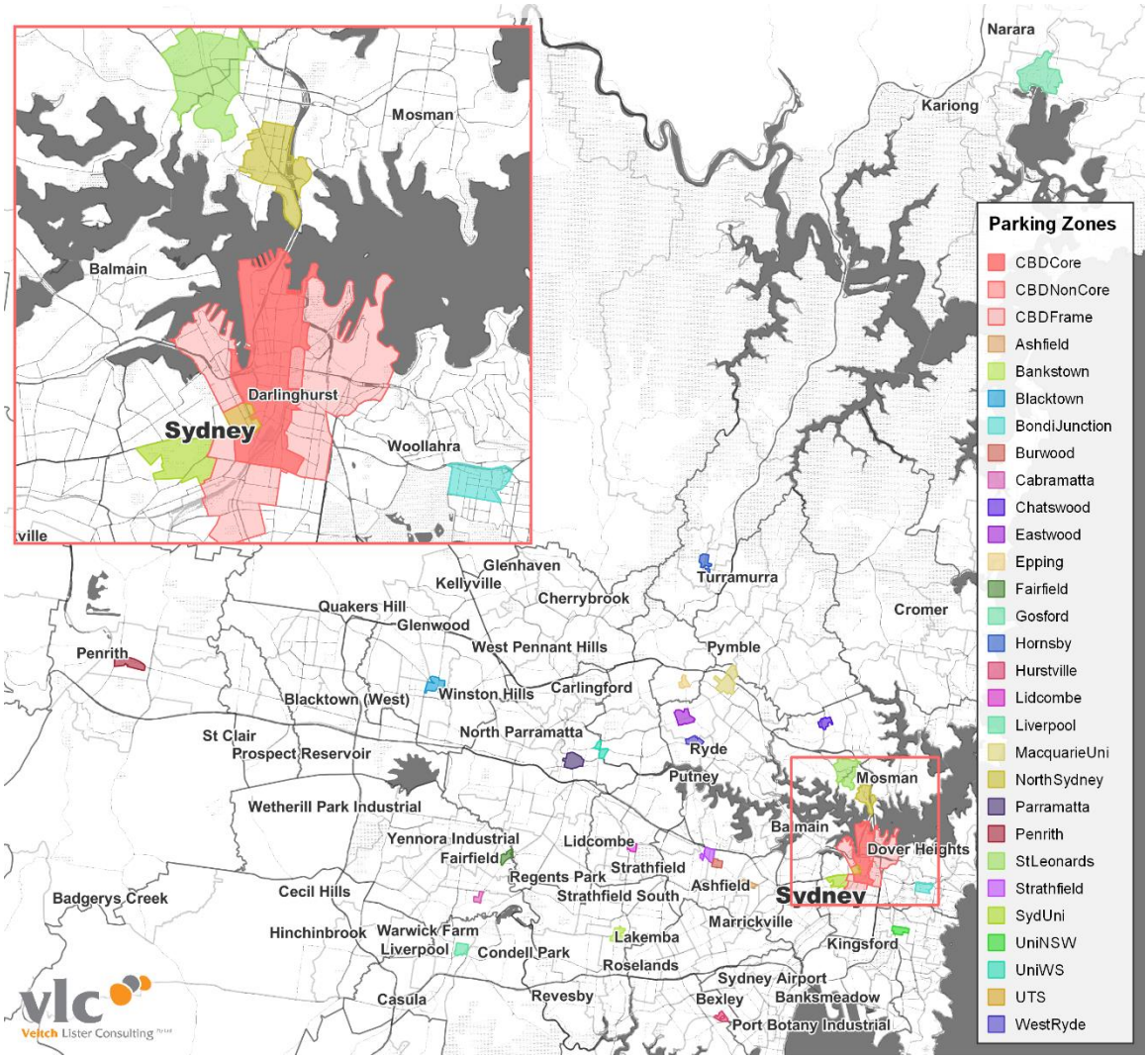
- real increases in the price of transport fuels; and
- reduction in the rate of fuel consumption due to improved vehicle efficiency and increased use of more efficient fuels within the vehicle fleet.

These two factors act to counter each other, and with insufficient evidence to indicate which will dominate in future, may well result in no real change in the average unit costs of fuel. For this work, it has therefore been assumed no real change in the unit of costs of fuel in future (i.e. fuel prices change in line with the Consumer Price Index - CPI).

Parking costs

A real annual increase of 1.5% (i.e. above CPI) in parking charges is assumed. The intention is to represent the strong pressures on price arising from increasing demand and constrained supply of parking in the CBD and major activity centres, as well as the non-linear increase in price associated with moving towards more parking structures rather than surface parking. This is consistent with the assumption applied for the modelling in the first Infrastructure Audit. The parking zones used in the modelling are illustrated in Appendix Figure D-3.

Appendix Figure D-3 – Sydney parking zones



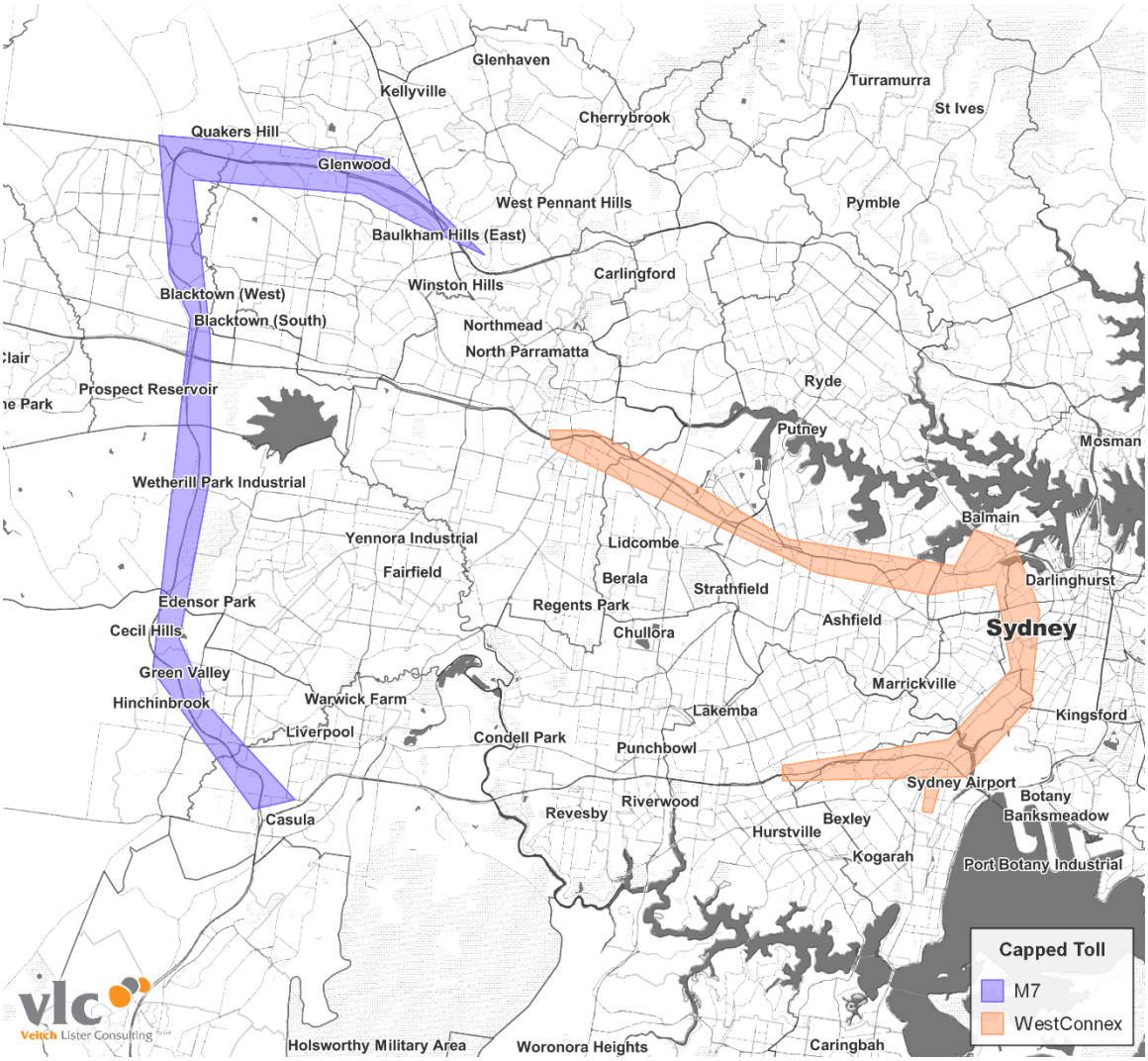
Tolls

It has been generally assumed that road tolls in the future will increase in line with CPI, resulting in no real increase in toll prices into the future. The exception to this is when a real increase in toll values between 2016 and the time of modelling in 2018 has occurred. Changes to Sydney's existing tolls, and future planned tolls are detailed in Appendix Table D-1. Sections with a capped toll strategy illustrated in Appendix Figure D-4.

Appendix Table D-1 – Planned changes to road tolls

Road Cost Parameters	Year	Zenith
Values used in Generalised Cost Car Value of Time (VOT), 2016 (AUD 2011)	2016	$12 / hour
Car VOT Change	2017-2046	unchanged
Car Vehicle Operating Costs (VOC) accounted for in fuel price, 2011 (AUD 2008)	2016	104.3c / litre
Car VOC change	2017-2046	Growth in line with CPI
TOLLS		
Tolls/Road Charges + Toll Caps, Existing Roads, 2016 (AUD 2011)	2016	Actual
Tolls/Road Change to 2031		
Cross City Tunnel		Growth in line with CPI
Eastern Distributor		Assuming same escalation as WestConnex
Millitary Rd E-Ramp		Cars: Growth in line with CPI GVs: 3x car from 2017
Harbour Bridge / Harbour Tunnel		Growth in line with CPI
M2		Assuming same escalation as WestConnex Assuming NorthConnex has the same toll as M2 at North Ryde Escalation (per year) = 0.04 CPI = 0.025 Escalation - CPI = 0.015
M5		Growth in line with CPI
M7		Cars: Growth in line with CPI GVs: 3x car from 2017
Lane Cove Tunnel		Cars: Growth in line with CPI GVs: 3x car as at Jan 2017. Post Jan 2017, escalated at 4% p.a., assumed to convert to a 1.5% p.a. increase in excess of CPI Source: Feb 2015, ASX media release, 'Financial Close on the NorthConnex Project in NSW' (CV Escalation (per year) = 0.04 CPI = 0.025 Escalation - CPI = 0.015)
Future Tolls/ Road Charges to 2031		
Westconnex		cents/km M4, M4ext, WCX = 47 cap M4, M4ext, WCX = 895 flagfall = 127
Toll change		Escalation M5 & M4 (per year) = 0.04 CPI = 0.025 Escalation - CPI = 0.015
Value of Travel Time Savings	2016 - 2031	1.34% CAGR
Car	2016 - 2031	1.44% CAGR
	2031 -	Unchanged in real terms
CV	2016 - 2031	1.68% CAGR
	2031 -	Unchanged in real terms

Appendix Figure D-4 – Sections using capped toll strategy



Public transport fares

Increases in the cost of public transport fares between 2016 and the time of modelling in 2018 have been factored into all future scenarios; beyond 2018 fares have been assumed to grow in line with CPI. The public transport fares and costs have been documented in Appendix Table D-2.

Appendix Table D-2 – Public transport costs and fares

Public Transport Cost Parameters		Zenith
Public Transport VOT, 2016 (AUD 2011)		$12 / hour
Public Transport Fares, 2016 (AUD 2011)		
Rail (Peak)	0 to 10km	$2.67
	10 to 20km	$3.31
	20 to 35km	$3.8
	35t o 65km	$5.09
	Over 65km	$6.55
Rail (Off Peak)	0 to 10km	$1.84
	10 to 20km	$2.29
	20 to 35km	$2.63
	35t o 65km	$3.52
	Over 65km	$4.53
Bus & Light Rail	0 to 3.2km	$1.54
	3.2 to 8km	$2.56
	Over 8km	$3.29
Ferry	0 to 9km	$5.28
	Over 9km	$6.55
Public Transport Fare growth	2017-2046	Growth in line with CPI

Source: TfNSW fares as at January 2018

D.3.2 Technology uptake

While transport models are useful planning tools, they are also limited in that they are estimated and calibrated based on historical survey data. There are numerous exogenous factors, particularly changes in technology, that are difficult to predict and quantify. These changes include:

- Electric vehicles;
- Shared mobility business models
- Driverless vehicles;
- Home deliveries; and
- Telecommuting.

Due to uncertainty around how these technologies might change how people travel, the current uptake of each is assumed to continue into the future modelled years.

D.3.3 Value of travel time

There are two approaches to the value of travel time: a ‘behavioural’ value that is relevant in trying to accurately predict how different market segments will respond to travel options, and an ‘economic’ value that is relevant for measuring community impacts of travel time. This section relates to the behavioural values used in modelling. Section D.4.1 discusses the relevant values for estimating economic costs of crowding – these values reflect equity values (ensuring infrastructure investment is not focused on areas with high incomes) and resource values (where travel time has real economic opportunity costs, e.g. due to people travelling during the course of their paid work).

The behavioural value of time spent travelling and its influence on travel behaviour depends on a range of factors, such as the reason for travel, and the use to which the time might otherwise be put. The modelling of travel choices reflects preferences that imply different values of travel time for each trip purpose and for each mode of travel, including walking and waiting associated with using public transport and the use of toll roads.

These behavioural values of time are indirectly estimated for each journey purpose and city travel market through the model estimation process (i.e. statistically estimating the model parameters that best describe traveller choices from household travel surveys). Consequently, these parameter values are not drawn directly from guidelines.

The values of time are estimated more or less for the current day, but an assumption is needed for modelling the way that travellers will trade off time and money in the forecast years. There is a significant volume of behavioural research that suggests values of travel time increase with growing average income. For the purposes of the modelling on this project VLC has assumed that values of travel time remain at current levels in the future.

The exception to this assumption is that people are assumed to have an increased willingness to pay tolls in the future. This is reflected in the application of an elasticity of 0.8 between value of time and increases in real average weekly earnings. This assumption is consistent with that applied in the previous Infrastructure Audit modelling.

D.3.4 Public transport frequencies

While public transport frequencies are partly driven by the completion of infrastructure projects, additional services are regularly added to the network. This includes more regular services along established public transport corridors, as well as new routes to growth areas. In both cases, this is generally in response to population growth.

Determining appropriate future public transport frequencies is based on a combination of the following approaches:

- Increasing service kilometres according to planning and policy documents (as documented in the project list for each market);
- Adding new bus routes to growth areas not serviced by other infrastructure proposals; and
- Increasing service kilometres on remaining bus services to bring overall network frequencies to growth rate of 1.5% per annum. This assumption was applied uniformly across jurisdictions based on actual growth in major-city scheduled bus kilometres documented in jurisdictions' budget papers where available over the past five years.

D.3.5 Commercial vehicle definitions

In the Zenith model private vehicle traffic is split into cars and commercial vehicles. Commercial vehicles are further split into sub-categories of light commercial vehicles and heavy commercial vehicles.

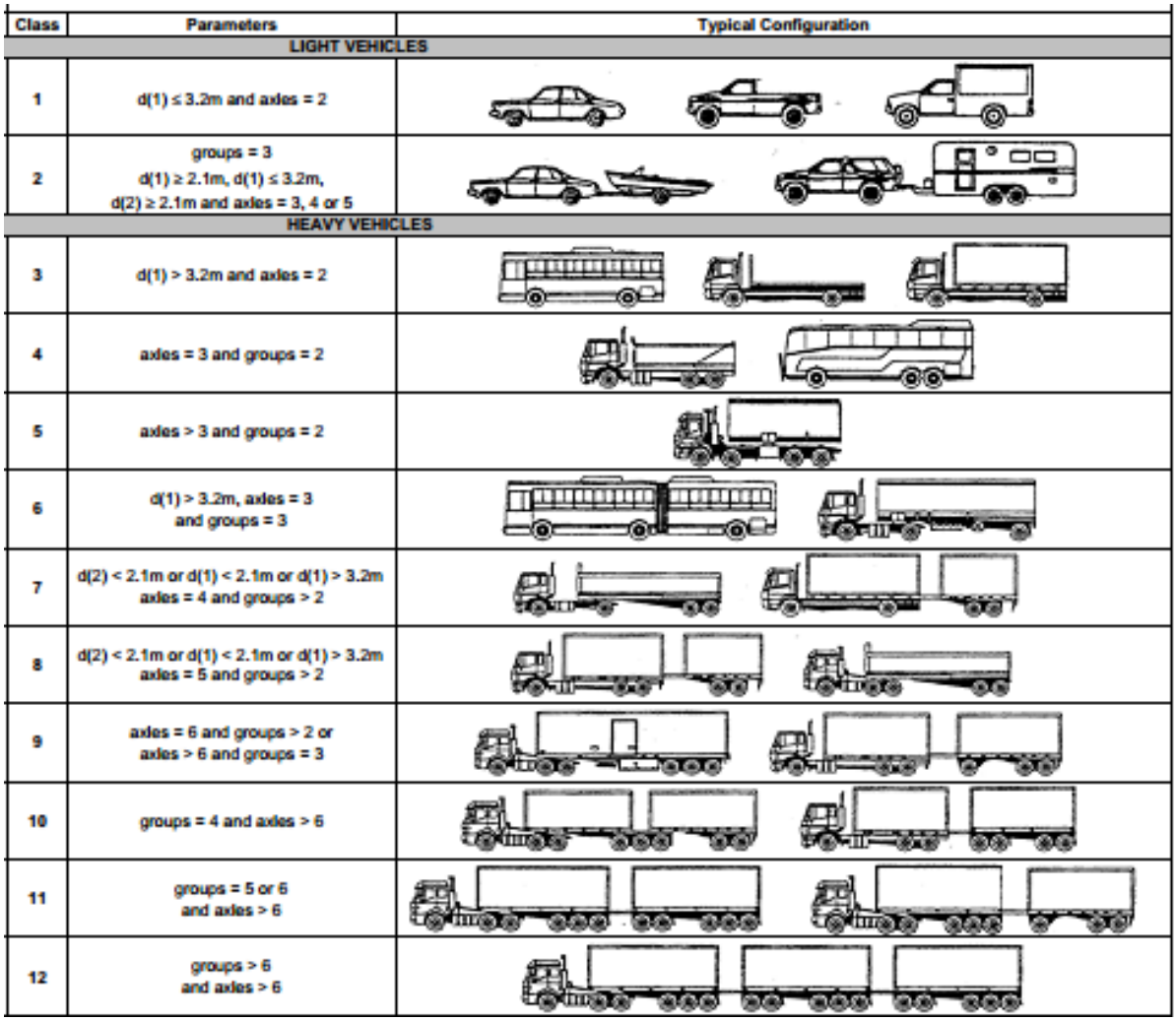
Vehicles are classified according to the Austroads Vehicle Classification System (Appendix Figure D-5).

Appendix Table D-3 details how the VLC vehicle types equate to Austroads vehicle classes.

Appendix Table D-3 – VLC vehicle types with Austroads classes

VLC vehicle type	Sub type	Austroads vehicle class
Car	NA	1 & 2
Commercial vehicles	Light commercial vehicles	3
	Heavy commercial vehicles	3 to 12

Appendix Figure D-5 – Austroads Vehicle Classification System



Source: Austroads

D.4 Economic cost methodology

VLC provides two measures of economic costs associated with the performance of the transport network: cost of road congestion and cost of public transport crowding. This section briefly outlines the methodology and input assumptions applied in all models.

D.4.1 Cost of road congestion

Modelling approach to estimate impacts

Congested travel times are calculated by comparing the total travel time for a road link under congested conditions, with the travel time of the same link under free-flow conditions.

The amount of time spent travelling under congested conditions is then aggregated to the desired geography in order to understand which parts of the network are most heavily affected by excess travel demand. Weekday forecasts of congested travel times are annualised by a factor of 345 in all cities, reflecting the relatively high traffic volumes on weekends (TfNSW 2016).[6]

Method to quantify

A monetary value of travel time factor is applied to the congested hours, distinguishing between business and non-business travel, as well as an additional freight value of time for commercial vehicles, which are separately identified in the model outputs. The values of time applied are estimated relative to average hourly earnings of the traveller or vehicle to reflect the differing economic costs associated with time lost for each type of trip.

The valuation parameters used are consistent with ATAP (2016) guidelines, updated to December 2017 values:

- Value of time per occupant (excluding freight vehicles):
    - Business-related travel (129.8% of hourly earnings = **$53.78/hr**). Applied using an average vehicle occupancy of 1.3 people per car.
    - Non-business travel (40% of hourly earnings = **$16.57/hr**). Applied using an average vehicle occupancy of 1.7 people per car.
- Freight value of time per vehicle (including occupants):
    - Light commercial vehicles = **$38.23/hr** (Austroads class 3 vehicle, two-axle truck)
    - Heavy commercial vehicles = **$71.36/hr** (Austroads classes 4-10, weighted average according to typical urban conditions Australia-wide, with the majority assumed to be within classes 4, 5, 9 and 10).

D.4.2 Cost of public transport crowding

Modelling approach to estimate impacts

The modelling approach to estimating crowding includes three components. These are:

- Measures of service capacity
- Crowding cost function, and

[6] Transport for NSW (2016), *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives - Transport Economic Appraisal Guidelines"*, Sydney, Australia.

- Linking of outward and return journeys.

Measures of service capacity

Measures of service capacity are provided as a model input, detailing the number of passengers that can be accommodated on each individual service in the modelled public transport network. Seated and standing passenger capacities are specified separately, as passenger comfort levels tend to differ considerably under crowded conditions depending on whether they are travelling in a seat or are standing in passages and doorways.

Appropriate capacities are determined for each city individually. Factors that are considered in specifying service capacities include:

- The rolling stock deployed on particular routes/lines
- The percentage of services run with higher or lower capacity rolling stock to determine 'average' seated and standing capacities (where that level of detail is available)

Appendix Table D-4 sets out the public transport vehicle seated and crush capacities used in the modelling (it is assumed that vehicle capacities remain the same in 2031 as they were in 2016).

Appendix Table D-4 – Public transport vehicle capacities

Vehicle	Seated Capacity	Crush capacity
Bus	45	60
Train	900	1430
Metro	378	1153

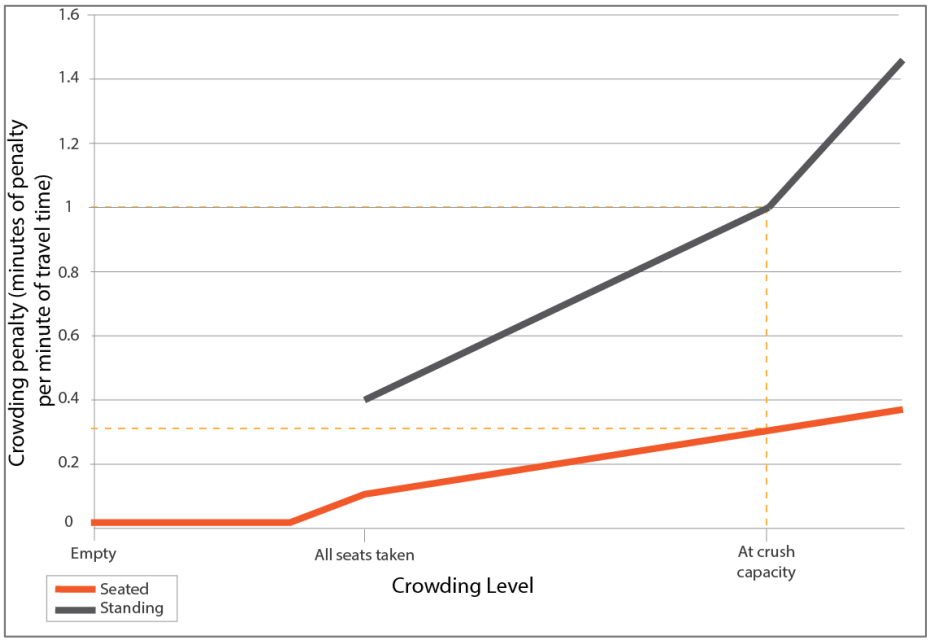
Source: Train seated capacity is sourced from TfNSW. Crush capacity is based on a 160% load factor, as specified by Sydney Trains.
Metro seated and crush capacities are sourced from the TfNSW Sydney Metro city and southwest Final Business Case Summary, October 2016.
https://www.sydneymetro.info/sites/default/files/Sydney%20Metro%20CSW%20Business%20Case%20Summary.pdf

Crowding cost function

The crowding cost function is an estimate of the level of discomfort experienced by passengers at different levels of crowding, depending on whether passengers are seated or standing. The function is based on parameters provided in Australian Transport Council (ATC) guidelines and is shown in Appendix Figure D-6.[7] These broadly align with the latest guidance from ATAP, though the ATAP guidelines do not provide adequate detail to quantify impacts for seated and standing travellers.

[7] Australian Transport Council. 2006. *Volume 4: Urban Transport*. Canberra: ATC.

Appendix Figure D-6 – Crowding cost function



The crowding cost function works by applying a penalty to journeys that are made under crowded conditions. Based on the function, a 10-minute journey at crush capacity would incur a three-minute penalty for seated passengers and a 10-minute penalty for standing passengers.

Beyond crush capacity, the penalty increases at a rapid rate in order to further deter passengers from boarding extremely crowded services. While loads in excess of crush capacity may seem to contradict the definition of crush capacity, passenger load surveys have observed services operating with passenger volumes significantly higher than their theoretical service capacity.

Linking of outward and return journeys

Zenith links outward and return journeys, ensuring that additional travel costs associated with crowded travel conditions impact on the mode of travel for both inbound and outbound trips. This ensures that the model produces balanced travel demands depending on the time period or direction of travel. This is an important feature, because passenger crowding experiences may be inconsistent depending on the time of day.

For example, in the morning peak passengers living at the end of a train line will generally be able to get a seat. Even if the train gets very crowded as it approaches the inner city, they will have a lower perceived cost of crowding than if they were forced to stand. Returning home in the afternoon, the same passengers may be required to stand for significant lengths of their journey, which is associated with a higher perceived cost of crowding. Using linked outward and return journeys, the likelihood of standing on the return journey will be factored into mode and destination choice decisions made for the outward journey as well. This not only ensures that the model has suitably consistent inbound / outbound passenger demands, but also that it is appropriately responsive to infrastructure and policies aimed at reducing crowding.

Method to quantify

Quantifying the cost of public transport crowding involves estimating traveller outcomes in a capacity constrained model run for current (2016) and future (2031) crowding levels.

The number of daily ‘disbenefit’ or ‘penalty’ hours experienced by public transport users due to crowding is first calculated. The number of seating and standing hours at different levels of crowded conditions are combined with the disutilities at each crowding level (Appendix Figure D-6).

For example, in the example in the previous subsection, passengers standing at crowded capacity (e.g. a loading factor (LF) of 200% of seated capacity, where LF is passengers / provided seats on services on a link) for a 10-minute journey would experience a crowding disutility of:

Journey time x crowding penalty (at the relevant load factor) = 10 x 1 = 10 minutes

Seated passengers would experience a crowding disutility of 3 minutes during the same journey in addition to their ordinary (uncrowded) travel time disutility of 10 minutes.

Generalising this calculation for a given link (potentially serving multiple lines) yields:

Link average crowding	Crowding disutility for seated passengers	Crowding disutility for standing passengers
Uncrowded LF < 0.7	0	0
Nearing seated capacity 0.7 < LF < 1.0	JT * Pax * (LF - 0.7) * 1 / 3	0 (or if people stand it is by choice with disutility as per seating passengers)
Crowded 1.0 < LF < Crush	JT * Seats * [0.1 + (Pax – Seats) * 0.2 / (Crush – Seats)]	JT * (Pax – Seats) * [0.4 + (Pax – Seats) * 0.6 / (Crush – Seats)]
Crushed LF > Crush	JT * Seats * [0.1 + (Pax – Seats) * 0.2 / (Crush – Seats)]	JT * (Pax – Seats) * [1 + (Pax – Crush) * 1.2 / (Crush – Seats)]

Notes: 1) Total crowding costs sum the two columns for any given load factor (LF)
2) LF is defined at a link level capturing all services operating on that link and all passengers travelling on the link (Pax) during a time period, such as the 2-hour AM peak
3) JT is the journey time across the link, including travel time and dwell time at stops
4) 'Seats' is the total seated capacity for vehicles operating services on the link during the time period
5) 'Crush' is the total crush capacity for vehicles operating services on the link during the time period.

For national consistency we follow ATAP (2018) guidelines by applying an annualisation factor of 286 to scale up the weekday average estimates, reflecting the perspective that crowding is primarily a weekday phenomenon.[8] Annualised disbenefit hours are multiplied by the value of time for non-business travellers ($16.57/hour from section D.4.1 above) to determine the annual cost.

[8] Australian Transport Assessment and Planning Guidelines (2018), *"M1 – Public Transport"*, ATAP, Canberra, Australia.

Appendix E: Differences between 2015 and current modelling

Modelling undertaken in the 2018-19 Audit differs considerably from work undertaken in 2014-15. Changes have been made to the models themselves as well as to the model inputs and assumptions. This section compares the 2018-19 Audit to the 2014-15 Audit, using the 2014-15 inputs / outputs as a base.

E.1 Changes to the models

Significant changes have been made to the Zenith models across all markets since 2014-15.

Appendix Table E-1 – Changes to the Zenith models since the 2014-15 Audit

Change	Detail	Affected markets
Demand model re-estimation	This is the process of using a household travel survey to estimate parameters used to model the behaviour of trips for different purposes, particularly for mode and destination choice steps. This affects the balance between trip lengths and trip numbers. While trip numbers decrease, network volumes remain broadly unchanged.	• SEQ and Sydney models have both undergone full re-estimation. • Adelaide and Perth models use parameters adapted from the SEQ re-estimation. • Melbourne and ACT models have not been re-estimated
Incorporation of crowding	Additional components were added into the four-step models to capture the perceived cost of travelling under heavily crowded conditions on public transport services. All models were run in 2018 on the basis of crowding levels influencing travel choices; none used this feature in 2014.	• SEQ, Sydney, Perth and Adelaide have undergone software upgrades to include public transport crowding • Melbourne and ACT models were previously public transport crowding-capable, but for consistency reasons this option was not used in 2014-15.
Changing to a 2016 base year	Population and employment inputs were updated to reflect the 2016 Census. Travel costs and transport networks were also updated. Of particular significance was the reduction in fuel price between 2011 and 2016. This was based on a structural decrease observed in fuel retail prices collected by the Australian Competition and Consumer Commission.	• All markets have updated base years • All markets have undergone re-calibration and validation to ensure that changes made to the models are both robust and appropriate.
Model calibration	After model parameters have been estimated (see above) model calibration is the process of adjusting these parameters. The aim is to improve the level of correlation between the model's outputs and observed measures of travel demand (traffic counts, public transport patronage, origin-destination surveys etc.)	

E.2 Changes to model inputs and assumptions

E.2.1 Population and land use

In the 2014-15 Audit, 2031 population projections for all six markets were derived from ABS Series B projections. In the latest work, projections have been provided by each state government. For Sydney, the impact is as follows:

Appendix Table E-2 – Comparison of modelled area (includes Sydney, Hunter and Illawarra) 2031 forecast population

	2014-15 Audit	2018-19 Audit	Difference
Modelled area population	7.3 million	7.5 million	+2%

A map showing this change spatially by SA3 is shown in Appendix Figure E-1. In addition to the a slightly higher population and employment, the mapping suggests the following key differences in demographic assumptions between 2014-15 and 2018-19 Audits:

- The areas in the Sydney's inner west are forecast to have larger populations than was previously expected.
- Large differences in forecast population are apparent in Sydney's northern and southern suburbs, (Bringelly/Green Valley and Rouse Hill/McGraphs Hill are forecast to have at least 70% more residents).

These differences will affect the model's results.

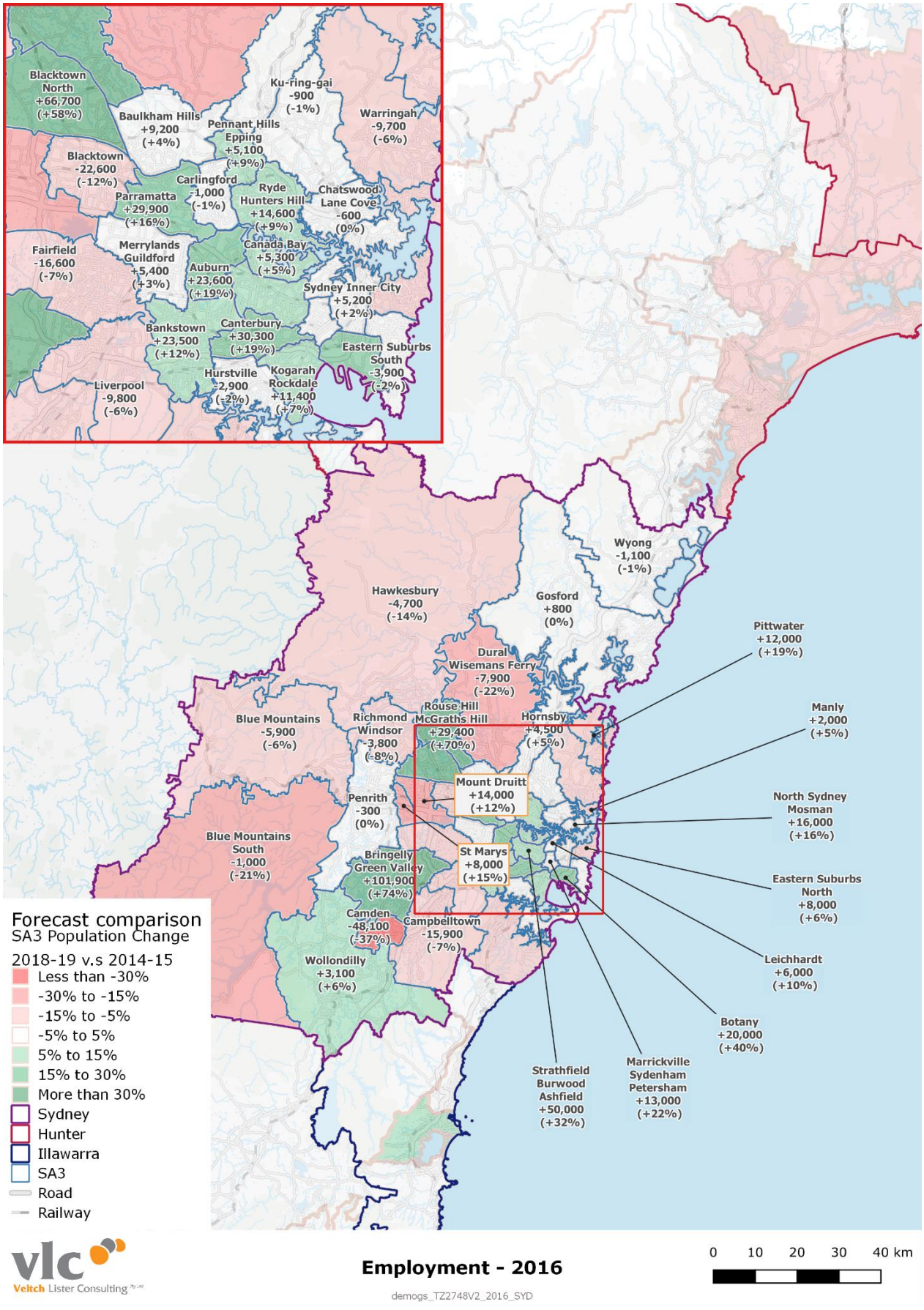
In the 2014-15 Audit, VLC has prepared forecasts for employment, consistent with the population projections constrained to the ABS B series forecast. The employment forecasts are based on projected levels of employment self-containment within each LGA, which recognise the structure planning of local authorities and the longer-term infrastructure and development planning by each state government. In the latest work, projections have been provided by each state government. For the modelled area (Sydney, Hunter and Illawarra), the impact is as follows:

Appendix Table E-3 – Comparison of modelled area (includes Sydney, Hunter and Illawarra) 2031 forecast employment and centralisation

	2014-15 Audit	2018-19 Audit	Difference
Modelled area employment	3.5 million	3.7 million	+5%
Proportion of employment in Sydney Inner City SA3	19%	18%	-1%

The way in which jobs are distributed across a city is a key determinant of trip destination, and as such mode choice (more jobs in the CBD encourages more PT travel). In strategic modelling, a gravity model is used to distribute trip destinations, with features such as jobs attracting trips. As such the attractiveness of an area is determined by its **share** of total employment rather than the actual **number** of jobs it contains. Thus, having more jobs in the 2018-19 Audit does not alter the balance between car and PT travel because the distribution of employment remains relatively similar (employment centralisation has been used as a proxy for the overall distribution of trip destinations) (Appendix Table E-3).

Appendix Figure E-1 – Sydney 2031 Population forecast - 2018-19 Audit compared to 2014-15 Audit base



E.2.2 Network assumptions

Both Audits use a similar approach to developing network assumptions – i.e. a 'minimal intervention' approach, that assumes only projects with funding or significant levels of political commitment will be completed by 2031. For Sydney (and the surrounding areas), key differences in network assumptions are as follows:

Major projects in 2014-15 NOT in 2018-19	Major projects in 2018-19 NOT in 2014-15
• NA	• Sydney Metro City & Southwest • Parramatta Light Rail • Newcastle Light Rail • Stage 1 F6 extension

E.2.3 Cost assumptions

Cost assumptions in Sydney (public transport fares and parking charges) and are consistent between 2014-15 Audits and 2018-19 Audits.

E.3 Impacts on model metrics and outputs

Model metrics and outputs are impacted by the changes made to the model inputs and model calibration.

Appendix Table E-4 compares the following high-level outputs:

- Total trips
- Car trips
- Car vehicle kilometres travelled
- Public transport trips.

The 2018-19 modelling forecasts lower 2031 travel demand across all four metrics. Details are provided in Appendix Table E-4.

On Sydney's worst performing corridors, the traffic volumes forecast in the 2018-19 Audit are similar to those in the 2014-15 Audit (Appendix Table E-5). Delay on these corridors is forecast to be worse than was seen previously. In general, Appendix Table E-5 shows that vehicle delays are forecast to increase by more than the corresponding change in traffic volumes. This is a function of the underlying dynamics of traffic flow (when additional traffic is added to an already congested road, the resultant delay is disproportionately higher than in less congested conditions).

Appendix Table E-4 – Changes in model inputs and key outputs between the 2014-15 and 2018-19 Audit modelling

		Demographic assumptions		Network assumptions		Travel cost assumptions				Model Parameters
		Population	*Jobs*	*Road investment*	*Public transport investment*	*Fuel*	*PT Fares*	*Parking*	*Tolls*	
	Change in inputs	⇧ **Population forecasts have increased (+2%)**	⇧ **Employment forecasts have increase (+5%), however the proportion of jobs in Sydney Inner City SA3 reduces slightly**	⇧ **More investment in the road network (+~21% network lane km)**	⇧ **More investment in the PT network (+~12% service kms)**	⇩ **Reduction in fuel price (140 c/L to 104 c/L AUD 2011)**	**-** **No change in other transport costs**			• **Recalibrated models have lower fuel prices (per observed reduction in fuel prices between 2011 and 2016)** • **Recalibrated models include capacity-constrained public transport networks**
Impact on output (AM peak)	Total trips (-24%)	⇧ Higher total population increases total modelled trips	- Total trips are generated by population assumptions and model parameters only.							• Changes to the model calibration have reduced the number of trips produced in the model. • Recalibration resulted in longer trip lengths, bringing the model closer to trips observed in the Journey To Work data from the 2016 ABS Census • The change in balance between trip lengths and trip numbers leaves network volumes broadly unchanged (see Appendix Table E-5).
	Car trips (-26%)	⇧ Higher total population increases total modelled car trips	- The distribution of employment is similar between the audits, as such a decline in overall employment does not substantially alter the balance between car and PT travel	⇧ Better roads encourage car travel	⇩ Better PT can encourage more PT travel and fewer car trips	⇧ Lower fuel prices encourage car travel	- No change = no impact			• Changes to the model calibration results in fewer trips in the model. By extension, there are fewer car trips.
	Car vehicle kms travelled (-4%)	- An overall increase in population increases car kilometres, while lower population growth at the urban fringe could reduce this metric. The net effect could be neutral	- The distribution of employment is similar between the audits, as such a decline in overall employment does not substantially alter the balance between car and PT travel	⇧ Better roads encourage car travel	⇩ Better PT can encourage more PT travel and fewer car kms	⇧ Lower fuel prices encourage car travel	- No change = no impact			• Changes to the model calibration results in fewer trips in the model, but slightly longer trip lengths. Both factors impact on car vehicle kilometres travelled
	Public transport trips (-18%)	⇧ Higher total population increases total modelled PT trips	- The distribution of employment is similar between the audits, as such a decline in overall employment does not substantially alter the balance between car and PT travel	⇩ Better roads encourage car travel and fewer PT trips	⇧ Better PT can encourage more PT travel	⇩ Lower fuel prices encourage car travel and reduce PT travel	- No change = no impact			• Capacity constraining public transport networks would reduce demand for services where crowding occurs • The model recalibration will also affect the number of public transport trips. • Total trips are relatively lower than the reduction in PT trips

Appendix Table E-5 – 2031 top ten most delayed road corridors for Sydney, Hunter and Illawarra - AM peak (ranked by total delay)

Rank IA Audit 2018-19	Direction	Corridor Name	Corridor	Average Peak Hour Traffic 2031 forecasts			Total Delay Hours 2031 forecasts			Rank IA Audit 2014-15
				IA Audit 2014-15	IA Audit 2018-19	% Diff	IA Audit 2014-15	IA Audit 2018-19	% Diff	
1	SB	Central Coast to Sydney	9	2,300	2,500	9%	3,700	9,600	158%	6
2	EB	East West corridor - M5	1	6,100	5,700	-7%	5,100	9,200	81%	3
3	NB	South Coast to Sydney	10	2,200	2,500	15%	5,300	8,400	59%	1
4	SB	Mona Vale to Homebush Bay Corridor (A3)	22	2,500	2,700	6%	5,200	7,100	37%	2
5	NB	Mittagong to SW Sydney via Hume Mwy	12	3,400	3,400	-1%	2,700	6,100	122%	9
6	NB	Sutherland - Ryde/Parramatta Corridor	26	2,200	2,300	3%	4,400	5,300	20%	4
7	SB	Northern Beaches - Nth Sydney Corridor	20	2,000	2,000	0%	4,000	4,900	22%	5
8	EB	Western Mwy (M4)	14	7,800	6,400	-19%	3,400	4,800	41%	7
9	EB	Victoria Rd (A40) Corridor)	18	2,300	2,600	12%	2,300	4,400	90%	15
10	EB	Western Hwy (M4) Corridor	15	5,800	6,400	10%	1,800	4,100	132%	20
11	NB	Homebush Bay to Mona Vale Corridor (A3)	22	2,000	2,200	12%	2,000	3,900	98%	18
12	EB	East West - A34	1	1,900	2,100	8%	2,500	3,900	56%	13
13	WB	Narraweena to Chatswood via Warringah Rd	21	2,900	3,000	4%	2,800	3,700	31%	8
14	EB	EW Arterials south of M7 and M2	5	2,200	2,300	4%	2,600	3,600	39%	11
15	EB	NW Middle Corridor (M7/M2)	5	4,100	4,300	5%	1,700	3,600	116%	21

Appendix F: Additional Outputs

Although the body of this report has focussed on the Sydney GCCSA, the Zenith model extent also includes the Hunter and Illawarra regions. This appendix contains a summary snapshot of key performance indicators of these regions.

Appendix Table F-1 – Sydney GCCSA, Hunter and Illawarra public transport in vehicle service kilometres

Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Rail	AM peak (7-9AM)	17,000	22,000	+5,000	+28%
	Inter-peak (9AM-4PM)	41,000	48,000	+7,000	+17%
	PM peak (4-6PM)	16,000	21,000	+5,000	+34%
	Off-peak (6PM-7AM)	48,000	63,000	+15,000	+30%
	Daily total	**121,000**	**153,000**	**+32,000**	**+26%**
Light rail	AM peak (7-9AM)	300	1,200	+900	+257%
	Inter-peak (9AM-4PM)	800	3,100	+2,300	+267%
	PM peak (4-6PM)	400	1,200	+900	+234%
	Off-peak (6PM-7AM)	900	3,700	+2,800	+318%
	Daily total	**2,400**	**9,300**	**+6,800**	**+279%**
Bus	AM peak (7-9AM)	88,000	108,000	+20,000	+22%
	Inter-peak (9AM-4PM)	187,000	237,000	+50,000	+27%
	PM peak (4-6PM)	83,000	102,000	+19,000	+23%
	Off-peak (6PM-7AM)	148,000	201,000	+53,000	+36%
	Daily total	**507,000**	**648,000**	**+141,000**	**+28%**
Ferry	AM peak (7-9AM)	1,200	1,400	+200	+16%
	Inter-peak (9AM-4PM)	3,100	3,400	+300	+8%
	PM peak (4-6PM)	1,000	1,200	+200	+17%
	Off-peak (6PM-7AM)	2,100	2,200	+200	+8%
	Daily total	**7,400**	**8,200**	**+0,800**	**+11%**
Total	AM peak (7-9AM)	107,000	132,000	+26,000	+24%
	Inter-peak (9AM-4PM)	232,000	291,000	+59,000	+26%
	PM peak (4-6PM)	100,000	125,000	+25,000	+25%
	Off-peak (6PM-7AM)	199,000	270,000	+70,000	+35%
	Daily total	**638,000**	**819,000**	**+181,000**	**+28%**
Hunter Region					
Rail	AM peak (7-9AM)	1,900	2,100	+200	+10%
	Inter-peak (9AM-4PM)	7,900	7,400	-500	-7%
	PM peak (4-6PM)	2,400	2,600	+200	+10%
	Off-peak (6PM-7AM)	7,300	7,500	+200	+3%
	Daily total	19,500	19,600	+100	**+1%**
Light rail	AM peak (7-9AM)	0	100	+100	-
	Inter-peak (9AM-4PM)	0	100	+100	-
	PM peak (4-6PM)	0	100	+100	-
	Off-peak (6PM-7AM)	0	300	+300	-
	Daily total	0	600	+600	**-**
Bus	AM peak (7-9AM)	8,400	10,200	+1,800	+21%
	Inter-peak (9AM-4PM)	22,500	27,900	+5,400	+24%
	PM peak (4-6PM)	8,600	9,800	+1,200	+14%
	Off-peak (6PM-7AM)	10,600	15,300	+4,700	+44%
	Daily total	50,100	63,200	+13,100	**+26%**
Ferry	AM peak (7-9AM)	0	0	+0	+45%
	Inter-peak (9AM-4PM)	0	0	+0	+57%
	PM peak (4-6PM)	0	0	+0	+33%
	Off-peak (6PM-7AM)	0	0	+0	-12%
	Daily total	100	100	+0	**+25%**
Total	AM peak (7-9AM)	10,300	12,400	+2,000	+20%
	Inter-peak (9AM-4PM)	30,400	35,400	+5,000	+17%
	PM peak (4-6PM)	10,900	12,500	+1,500	+14%
	Off-peak (6PM-7AM)	18,000	23,100	+5,200	+29%
	Daily total	69,700	83,400	+13,800	**+20%**
Illawarra Region					
Rail	AM peak (7-9AM)	2,400	2,300	-100	-5%
	Inter-peak (9AM-4PM)	4,800	4,700	-100	-2%
	PM peak (4-6PM)	1,700	1,600	-100	-6%
	Off-peak (6PM-7AM)	7,200	7,200	0	-0%
	Daily total	16,100	15,800	-300	-2%
Light rail	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	0	0	0	**-**
Bus	AM peak (7-9AM)	3,300	4,500	+1,200	+38%
	Inter-peak (9AM-4PM)	10,100	13,900	+3,800	+37%
	PM peak (4-6PM)	3,300	4,400	+1,000	+31%
	Off-peak (6PM-7AM)	4,800	6,800	+2,000	+42%
	Daily total	21,500	29,600	+8,100	+38%
Ferry	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	0	0	0	**-**
Total	AM peak (7-9AM)	5,700	6,800	+1,100	+20%
	Inter-peak (9AM-4PM)	14,900	18,600	+3,700	+25%
	PM peak (4-6PM)	5,100	6,000	+900	+18%
	Off-peak (6PM-7AM)	12,000	14,000	+2,000	+17%
	Daily total	37,600	45,400	+7,800	+21%
Total Region*					
	AM peak (7-9AM)	17,700	22,500	+4,800	+27%

Rail	Inter-peak (9AM-4PM)	42,400	49,500	+7,100	+17%
	PM peak (4-6PM)	16,300	21,600	+5,300	+32%
	Off-peak (6PM-7AM)	51,000	65,500	+14,500	+28%
	Daily total	127,400	159,100	+31,700	**+25%**
Light rail	AM peak (7-9AM)	300	1,300	+1,000	+281%
	Inter-peak (9AM-4PM)	800	3,200	+2,400	+284%
	PM peak (4-6PM)	400	1,300	+1,000	+256%
	Off-peak (6PM-7AM)	900	3,900	+3,100	+349%
	Daily total	2,400	9,800	+7,400	**+303%**
Bus	AM peak (7-9AM)	99,200	121,600	+22,400	+23%
	Inter-peak (9AM-4PM)	218,200	276,300	+58,100	+27%
	PM peak (4-6PM)	94,300	115,400	+21,100	+22%
	Off-peak (6PM-7AM)	163,200	222,300	+59,100	+36%
	Daily total	574,700	735,500	+160,800	**+28%**
Ferry	AM peak (7-9AM)	1,200	1,400	+200	+16%
	Inter-peak (9AM-4PM)	3,100	3,400	+300	+9%
	PM peak (4-6PM)	1,000	1,200	+200	+17%
	Off-peak (6PM-7AM)	2,100	2,200	+200	+8%
	Daily total	7,500	8,300	+800	**+11%**
Total	AM peak (7-9AM)	118,400	146,800	+28,400	+24%
	Inter-peak (9AM-4PM)	264,500	332,400	+67,900	+26%
	PM peak (4-6PM)	112,000	139,500	+27,500	+25%
	Off-peak (6PM-7AM)	217,100	293,900	+76,800	+35%
	Daily total	712,100	912,700	+200,600	**+28%**

* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. ‘Total Region’ measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

Appendix Table F-2 – Sydney GCCSA, Hunter and Illawarra person trips by mode

Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Person car trips	AM peak (7-9AM)	1,586,000	1,968,000	+381,000	+24%
	Inter-peak (9AM-4PM)	4,758,000	6,061,000	+1,304,000	+27%
	PM peak (4-6PM)	1,705,000	2,131,000	+426,000	+25%
	Off-peak (6PM-7AM)	2,802,000	3,549,000	+747,000	+27%
	Daily total	**10,851,000**	**13,709,000**	**+2,858,000**	+26%
Public transport trips	AM peak (7-9AM)	410,000	573,000	+163,000	+40%
	Inter-peak (9AM-4PM)	712,000	977,000	+265,000	+37%
	PM peak (4-6PM)	355,000	499,000	+145,000	+41%
	Off-peak (6PM-7AM)	376,000	517,000	+141,000	+37%
	Daily total	**1,852,000**	**2,566,000**	**+714,000**	+39%
Walk/cycling trips	AM peak (7-9AM)	368,000	468,000	+100,000	+27%
	Inter-peak (9AM-4PM)	1,862,000	2,355,000	+493,000	+26%
	PM peak (4-6PM)	498,000	636,000	+138,000	+28%
	Off-peak (6PM-7AM)	785,000	997,000	+211,000	+27%
	Daily total	**3,512,000**	**4,455,000**	**+943,000**	+27%
Total trips	AM peak (7-9AM)	2,363,000	3,008,000	+645,000	+27%
	Inter-peak (9AM-4PM)	7,332,000	9,393,000	+2,062,000	+28%
	PM peak (4-6PM)	2,557,000	3,266,000	+709,000	+28%
	Off-peak (6PM-7AM)	3,963,000	5,062,000	+1,099,000	+28%
	Daily total	**16,215,000**	**20,730,000**	**+4,515,000**	+28%
Hunter Region					
Person car trips	AM peak (7-9AM)	246,000	290,000	+44,000	+18%
	Inter-peak (9AM-4PM)	795,000	967,000	+172,000	+22%
	PM peak (4-6PM)	275,000	328,000	+53,000	+19%
	Off-peak (6PM-7AM)	458,000	550,000	+92,000	+20%
	Daily total	**1,774,000**	**2,135,000**	**+360,000**	**+20%**
Public transport trips	AM peak (7-9AM)	14,000	20,000	+6,000	+40%
	Inter-peak (9AM-4PM)	27,000	37,000	+10,000	+38%
	PM peak (4-6PM)	9,000	14,000	+5,000	+50%
	Off-peak (6PM-7AM)	9,000	14,000	+5,000	+53%
	Daily total	**59,000**	**85,000**	**+25,000**	**+43%**
Walk/cycling trips	AM peak (7-9AM)	35,000	42,000	+7,000	+21%
	Inter-peak (9AM-4PM)	167,000	207,000	+40,000	+24%
	PM peak (4-6PM)	47,000	58,000	+11,000	+23%
	Off-peak (6PM-7AM)	85,000	102,000	+17,000	+19%
	Daily total	**335,000**	**410,000**	**+75,000**	**+22%**
Total trips	AM peak (7-9AM)	296,000	353,000	+57,000	+19%
	Inter-peak (9AM-4PM)	990,000	1,212,000	+222,000	+22%
	PM peak (4-6PM)	331,000	400,000	+68,000	+21%
	Off-peak (6PM-7AM)	553,000	665,000	+113,000	+20%
	Daily total	**2,169,000**	**2,629,000**	**+460,000**	**+21%**
Illawarra Region					
Person car trips	AM peak (7-9AM)	110,000	130,000	+19,000	+17%
	Inter-peak (9AM-4PM)	348,000	419,000	+71,000	+20%
	PM peak (4-6PM)	124,000	147,000	+23,000	+19%
	Off-peak (6PM-7AM)	205,000	245,000	+39,000	+19%
	Daily total	**788,000**	**940,000**	**+153,000**	**+19%**
Public transport trips	AM peak (7-9AM)	10,000	13,000	+3,000	+32%
	Inter-peak (9AM-4PM)	15,000	20,000	+4,000	+29%
	PM peak (4-6PM)	7,000	10,000	+3,000	+35%
	Off-peak (6PM-7AM)	6,000	8,000	+2,000	+24%
	Daily total	**39,000**	**51,000**	**+12,000**	**+30%**
Walk/cycling trips	AM peak (7-9AM)	20,000	23,000	+4,000	+18%
	Inter-peak (9AM-4PM)	95,000	115,000	+20,000	+21%
	PM peak (4-6PM)	27,000	32,000	+5,000	+19%
	Off-peak (6PM-7AM)	49,000	58,000	+9,000	+19%
	Daily total	**191,000**	**229,000**	**+38,000**	**+20%**
Total trips	AM peak (7-9AM)	140,000	166,000	+26,000	+19%
	Inter-peak (9AM-4PM)	458,000	554,000	+96,000	+21%
	PM peak (4-6PM)	158,000	189,000	+31,000	+19%
	Off-peak (6PM-7AM)	261,000	311,000	+50,000	+19%
	Daily total	**1,018,000**	**1,220,000**	**+202,000**	**+20%**
Total Region*					
Person car trips	AM peak (7-9AM)	1,922,000	2,362,000	+440,000	+23%
	Inter-peak (9AM-4PM)	5,846,000	7,381,000	+1,535,000	+26%
	PM peak (4-6PM)	2,079,000	2,577,000	+498,000	+24%
	Off-peak (6PM-7AM)	3,429,000	4,297,000	+868,000	+25%
	Daily total	**13,276,000**	**16,618,000**	**+3,341,000**	**+25%**
Public transport trips	AM peak (7-9AM)	427,000	596,000	+170,000	+40%
	Inter-peak (9AM-4PM)	745,000	1,023,000	+277,000	+37%
	PM peak (4-6PM)	365,000	515,000	+150,000	+41%
	Off-peak (6PM-7AM)	387,000	533,000	+146,000	+38%
	Daily total	**1,924,000**	**2,666,000**	**+742,000**	**+39%**
Walk/cycling trips	AM peak (7-9AM)	422,000	534,000	+111,000	+26%
	Inter-peak (9AM-4PM)	2,124,000	2,677,000	+553,000	+26%
	PM peak (4-6PM)	572,000	726,000	+154,000	+27%
	Off-peak (6PM-7AM)	920,000	1,157,000	+237,000	+26%
	Daily total	**4,038,000**	**5,094,000**	**+1,055,000**	**+26%**
Total trips	AM peak (7-9AM)	2,771,000	3,492,000	+721,000	+26%
	Inter-peak (9AM-4PM)	8,716,000	11,080,000	+2,364,000	+27%
	PM peak (4-6PM)	3,016,000	3,818,000	+802,000	+27%
	Off-peak (6PM-7AM)	4,736,000	5,987,000	+1,251,000	+26%
	Daily total	**19,239,000**	**24,378,000**	**+5,139,000**	**+27%**

* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. 'Total Region' measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

Appendix Table F-3 – Sydney GCCSA, Hunter and Illawarra car traffic statistics

Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Car trips	AM peak (7-9AM)	1,141,000	1,414,000	+273,000	+24%
	Inter-peak (9AM-4PM)	3,432,000	4,373,000	+940,000	+27%
	PM peak (4-6PM)	1,265,000	1,578,000	+313,000	+25%
	Off-peak (6PM-7AM)	1,985,000	2,511,000	+526,000	+27%
	Daily total	**7,824,000**	**9,877,000**	**+2,053,000**	**+26%**
Car kilometres	AM peak (7-9AM)	13,508,000	17,168,000	+3,660,000	+27%
	Inter-peak (9AM-4PM)	36,392,000	48,047,000	+11,655,000	+32%
	PM peak (4-6PM)	14,769,000	18,918,000	+4,149,000	+28%
	Off-peak (6PM-7AM)	24,497,000	32,018,000	+7,521,000	+31%
	Daily total	**89,166,000**	**116,151,000**	**+26,984,000**	**+30%**
Car hours	AM peak (7-9AM)	428,000	657,000	+229,000	+54%
	Inter-peak (9AM-4PM)	781,000	1,144,000	+363,000	+46%
	PM peak (4-6PM)	449,000	705,000	+256,000	+57%
	Off-peak (6PM-7AM)	457,000	618,000	+161,000	+35%
	Daily total	**2,115,000**	**3,124,000**	**+1,009,000**	**+48%**
Car Average assigned speed (kph)	AM peak (7-9AM)	32	26	-5	-17%
	Inter-peak (9AM-4PM)	47	42	-5	-10%
	PM peak (4-6PM)	33	27	-6	-18%
	Off-peak (6PM-7AM)	54	52	-2	-3%
	Daily total	**42**	**37**	**-5**	**-12%**
Hunter Region					
Car trips	AM peak (7-9AM)	174,000	205,000	+31,000	+18%
	Inter-peak (9AM-4PM)	564,000	687,000	+123,000	+22%
	PM peak (4-6PM)	199,000	238,000	+39,000	+19%
	Off-peak (6PM-7AM)	318,000	382,000	+64,000	+20%
	Daily total	**1,255,000**	**1,511,000**	**+256,000**	**+20%**
Car kilometres	AM peak (7-9AM)	2,659,000	3,196,000	+537,000	+20%
	Inter-peak (9AM-4PM)	9,046,000	11,200,000	+2,154,000	+24%
	PM peak (4-6PM)	2,988,000	3,614,000	+626,000	+21%
	Off-peak (6PM-7AM)	6,390,000	7,803,000	+1,413,000	+22%
	Daily total	**21,084,000**	**25,814,000**	**+4,730,000**	**+22%**
Car hours	AM peak (7-9AM)	58,000	81,000	+23,000	+40%
	Inter-peak (9AM-4PM)	153,000	211,000	+58,000	+38%
	PM peak (4-6PM)	65,000	93,000	+28,000	+44%
	Off-peak (6PM-7AM)	94,000	121,000	+26,000	+28%
	Daily total	**370,000**	**505,000**	**+136,000**	**+37%**
Car Average assigned speed (kph)	AM peak (7-9AM)	46	39	-7	-14%
	Inter-peak (9AM-4PM)	59	53	-6	-10%
	PM peak (4-6PM)	46	39	-7	-16%
	Off-peak (6PM-7AM)	68	65	-3	-4%
	Daily total	**57**	**51**	**-6**	**-10%**
Illawarra Region					
Car trips	AM peak (7-9AM)	78,000	92,000	+13,000	+17%
	Inter-peak (9AM-4PM)	248,000	299,000	+52,000	+21%
	PM peak (4-6PM)	90,000	107,000	+17,000	+18%
	Off-peak (6PM-7AM)	142,000	169,000	+27,000	+19%
	Daily total	**558,000**	**667,000**	**+109,000**	**+19%**
Car kilometres	AM peak (7-9AM)	1,017,000	1,212,000	+195,000	+19%
	Inter-peak (9AM-4PM)	2,935,000	3,557,000	+622,000	+21%
	PM peak (4-6PM)	1,145,000	1,364,000	+219,000	+19%
	Off-peak (6PM-7AM)	1,968,000	2,411,000	+444,000	+23%
	Daily total	**7,064,000**	**8,544,000**	**+1,481,000**	**+21%**
Car hours	AM peak (7-9AM)	19,000	28,000	+9,000	+49%
	Inter-peak (9AM-4PM)	46,000	60,000	+14,000	+31%
	PM peak (4-6PM)	22,000	31,000	+10,000	+44%
	Off-peak (6PM-7AM)	28,000	35,000	+7,000	+24%
	Daily total	**114,000**	**153,000**	**+39,000**	**+35%**
Car Average assigned speed (kph)	AM peak (7-9AM)	54	43	-11	-20%
	Inter-peak (9AM-4PM)	64	60	-5	-7%
	PM peak (4-6PM)	53	44	-9	-17%
	Off-peak (6PM-7AM)	71	70	-1	-2%
	Daily total	**62**	**56**	**-6**	**-10%**
Total Region*					
Car trips	AM peak (7-9AM)	1,377,000	1,691,000	+314,000	+23%
	Inter-peak (9AM-4PM)	4,202,000	5,308,000	+1,106,000	+26%
	PM peak (4-6PM)	1,536,000	1,901,000	+365,000	+24%
	Off-peak (6PM-7AM)	2,417,000	3,028,000	+610,000	+25%
	Daily total	**9,532,000**	**11,927,000**	**+2,395,000**	**+25%**
Car kilometres	AM peak (7-9AM)	17,067,000	21,441,000	+4,374,000	+26%
	Inter-peak (9AM-4PM)	47,946,000	62,300,000	+14,354,000	+30%
	PM peak (4-6PM)	18,767,000	23,736,000	+4,968,000	+26%
	Off-peak (6PM-7AM)	32,564,000	41,858,000	+9,293,000	+29%
	Daily total	**116,345,000**	**149,334,000**	**+32,989,000**	**+28%**
Car hours	AM peak (7-9AM)	502,000	762,000	+260,000	+52%
	Inter-peak (9AM-4PM)	973,000	1,405,000	+432,000	+44%
	PM peak (4-6PM)	533,000	825,000	+292,000	+55%
	Off-peak (6PM-7AM)	576,000	768,000	+192,000	+33%
	Daily total	**2,583,000**	**3,760,000**	**+1,177,000**	**+46%**
Car Average assigned speed (kph)	AM peak (7-9AM)	34	28	-6	-17%
	Inter-peak (9AM-4PM)	49	44	-5	-10%
	PM peak (4-6PM)	35	29	-6	-18%
	Off-peak (6PM-7AM)	57	55	-2	-4%
	Daily total	**45**	**40**	**-5**	**-12%**

* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. 'Total Region' measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

Appendix Table F-4 – Sydney GCCSA, Hunter and Illawarra commercial vehicle traffic statistics

Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Commercial Vehicle trips	AM peak (7-9AM)	85,000	107,000	+22,000	+25%
	Inter-peak (9AM-4PM)	276,000	343,000	+67,000	+24%
	PM peak (4-6PM)	99,000	123,000	+24,000	+24%
	Off-peak (6PM-7AM)	144,000	179,000	+34,000	+24%
	Daily total	**605,000**	**752,000**	**+147,000**	**+24%**
Commercial Vehicle kilometres	AM peak (7-9AM)	1,325,000	1,669,000	+344,000	+26%
	Inter-peak (9AM-4PM)	4,145,000	5,182,000	+1,037,000	+25%
	PM peak (4-6PM)	1,496,000	1,842,000	+346,000	+23%
	Off-peak (6PM-7AM)	2,651,000	3,288,000	+637,000	+24%
	Daily total	**9,617,000**	**11,981,000**	**+2,364,000**	**+25%**
Commercial Vehicle hours	AM peak (7-9AM)	37,000	57,000	+20,000	+54%
	Inter-peak (9AM-4PM)	82,000	115,000	+33,000	+41%
	PM peak (4-6PM)	41,000	64,000	+23,000	+54%
	Off-peak (6PM-7AM)	45,000	58,000	+13,000	+29%
	Daily total	**205,000**	**294,000**	**+89,000**	**+43%**
Hunter Region					
Commercial Vehicle trips	AM peak (7-9AM)	21,000	25,000	+5,000	+22%
	Inter-peak (9AM-4PM)	66,000	80,000	+14,000	+22%
	PM peak (4-6PM)	24,000	28,000	+5,000	+20%
	Off-peak (6PM-7AM)	44,000	53,000	+9,000	+21%
	Daily total	**154,000**	**187,000**	**+33,000**	**+21%**
Commercial Vehicle kilometres	AM peak (7-9AM)	570,000	680,000	+109,000	+19%
	Inter-peak (9AM-4PM)	1,789,000	2,129,000	+339,000	+19%
	PM peak (4-6PM)	671,000	803,000	+132,000	+20%
	Off-peak (6PM-7AM)	1,388,000	1,675,000	+286,000	+21%
	Daily total	**4,419,000**	**5,286,000**	**+867,000**	**+20%**
Commercial Vehicle hours	AM peak (7-9AM)	11,000	16,000	+4,000	+40%
	Inter-peak (9AM-4PM)	28,000	38,000	+10,000	+35%
	PM peak (4-6PM)	13,000	19,000	+6,000	+45%
	Off-peak (6PM-7AM)	19,000	25,000	+6,000	+29%
	Daily total	**72,000**	**98,000**	**+26,000**	**+36%**
Illawarra Region					
Commercial Vehicle trips	AM peak (7-9AM)	6,000	8,000	+2,000	+32%
	Inter-peak (9AM-4PM)	19,000	25,000	+6,000	+33%
	PM peak (4-6PM)	7,000	9,000	+2,000	+34%
	Off-peak (6PM-7AM)	12,000	16,000	+4,000	+37%
	Daily total	**43,000**	**58,000**	**+15,000**	**+34%**
Commercial Vehicle kilometres	AM peak (7-9AM)	134,000	182,000	+48,000	+36%
	Inter-peak (9AM-4PM)	432,000	567,000	+135,000	+31%
	PM peak (4-6PM)	152,000	190,000	+39,000	+26%
	Off-peak (6PM-7AM)	325,000	423,000	+98,000	+30%
	Daily total	**1,043,000**	**1,363,000**	**+320,000**	**+31%**
Commercial Vehicle hours	AM peak (7-9AM)	2,000	4,000	+1,000	+65%
	Inter-peak (9AM-4PM)	6,000	9,000	+3,000	+44%
	PM peak (4-6PM)	3,000	4,000	+1,000	+53%
	Off-peak (6PM-7AM)	4,000	6,000	+1,000	+35%
	Daily total	**15,000**	**22,000**	**+7,000**	**+46%**
Total Region*					
Commercial Vehicle trips	AM peak (7-9AM)	109,000	136,000	+27,000	+25%
	Inter-peak (9AM-4PM)	351,000	435,000	+84,000	+24%
	PM peak (4-6PM)	126,000	156,000	+30,000	+24%
	Off-peak (6PM-7AM)	192,000	237,000	+45,000	+24%
	Daily total	**778,000**	**965,000**	**+187,000**	**+24%**
Commercial Vehicle kilometres	AM peak (7-9AM)	1,991,000	2,485,000	+494,000	+25%
	Inter-peak (9AM-4PM)	6,261,000	7,758,000	+1,497,000	+24%
	PM peak (4-6PM)	2,277,000	2,788,000	+511,000	+22%
	Off-peak (6PM-7AM)	4,287,000	5,293,000	+1,006,000	+23%
	Daily total	**14,816,000**	**18,324,000**	**+3,508,000**	**+24%**
Commercial Vehicle hours	AM peak (7-9AM)	49,000	75,000	+25,000	+51%
	Inter-peak (9AM-4PM)	115,000	160,000	+45,000	+39%
	PM peak (4-6PM)	56,000	86,000	+29,000	+52%
	Off-peak (6PM-7AM)	67,000	87,000	+20,000	+30%
	Daily total	**288,000**	**408,000**	**+120,000**	**+42%**

* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. 'Total Region' measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

Appendix Table F-5 – Sydney GCCSA, Hunter and Illawarra total public transport, key metrics

Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Total PT boardings	AM peak (7-9AM)	522,000	768,000	+247,000	+47%
	Inter-peak (9AM-4PM)	896,000	1,276,000	+381,000	+43%
	PM peak (4-6PM)	452,000	686,000	+233,000	+52%
	Off-peak (6PM-7AM)	457,000	653,000	+196,000	+43%
	Daily total	**2,326,000**	**3,383,000**	**+1,057,000**	**+45%**
Total in vehicle passenger kilometres	AM peak (7-9AM)	7,983,000	11,903,000	+3,920,000	+49%
	Inter-peak (9AM-4PM)	10,950,000	15,542,000	+4,592,000	+42%
	PM peak (4-6PM)	6,814,000	10,239,000	+3,425,000	+50%
	Off-peak (6PM-7AM)	5,942,000	8,436,000	+2,494,000	+42%
	Daily total	**31,690,000**	**46,120,000**	**+14,431,000**	**+46%**
Total in vehicle passenger hours	AM peak (7-9AM)	206,000	300,000	+94,000	+45%
	Inter-peak (9AM-4PM)	273,000	386,000	+112,000	+41%
	PM peak (4-6PM)	177,000	260,000	+83,000	+47%
	Off-peak (6PM-7AM)	143,000	199,000	+56,000	+39%
	Daily total	**799,000**	**1,144,000**	**+345,000**	**+43%**
Hunter Region					
Total PT boardings	AM peak (7-9AM)	23,000	33,000	+11,000	+47%
	Inter-peak (9AM-4PM)	45,000	61,000	+16,000	+35%
	PM peak (4-6PM)	16,000	24,000	+8,000	+49%
	Off-peak (6PM-7AM)	16,000	22,000	+6,000	+40%
	Daily total	**99,000**	**140,000**	**+40,000**	**+41%**
Total in vehicle passenger kilometres	AM peak (7-9AM)	713,000	967,000	+255,000	+36%
	Inter-peak (9AM-4PM)	1,397,000	1,708,000	+310,000	+22%
	PM peak (4-6PM)	552,000	726,000	+174,000	+31%
	Off-peak (6PM-7AM)	502,000	613,000	+111,000	+22%
	Daily total	**3,165,000**	**4,014,000**	**+849,000**	**+27%**
Total in vehicle passenger hours	AM peak (7-9AM)	13,000	19,000	+6,000	+42%
	Inter-peak (9AM-4PM)	25,000	32,000	+7,000	+27%
	PM peak (4-6PM)	10,000	14,000	+4,000	+37%
	Off-peak (6PM-7AM)	9,000	11,000	+2,000	+23%
	Daily total	**58,000**	**76,000**	**+18,000**	**+31%**
Illawarra Region					
Total PT boardings	AM peak (7-9AM)	20,000	26,000	+6,000	+29%
	Inter-peak (9AM-4PM)	26,000	33,000	+7,000	+29%
	PM peak (4-6PM)	14,000	18,000	+4,000	+30%
	Off-peak (6PM-7AM)	12,000	15,000	+3,000	+25%
	Daily total	**71,000**	**92,000**	**+20,000**	**+29%**
Total in vehicle passenger kilometres	AM peak (7-9AM)	704,000	926,000	+222,000	+31%
	Inter-peak (9AM-4PM)	774,000	998,000	+224,000	+29%
	PM peak (4-6PM)	527,000	727,000	+199,000	+38%
	Off-peak (6PM-7AM)	372,000	473,000	+101,000	+27%
	Daily total	**2,377,000**	**3,123,000**	**+745,000**	**+31%**
Total in vehicle passenger hours	AM peak (7-9AM)	14,000	18,000	+4,000	+33%
	Inter-peak (9AM-4PM)	14,000	19,000	+4,000	+31%
	PM peak (4-6PM)	10,000	14,000	+4,000	+40%
	Off-peak (6PM-7AM)	7,000	9,000	+2,000	+28%
	Daily total	**44,000**	**59,000**	**+15,000**	**+33%**
Total Region*					
Total PT boardings	AM peak (7-9AM)	538,000	792,000	+254,000	+47%
	Inter-peak (9AM-4PM)	926,000	1,321,000	+395,000	+43%
	PM peak (4-6PM)	463,000	702,000	+239,000	+52%
	Off-peak (6PM-7AM)	466,000	668,000	+202,000	+43%
	Daily total	**2,393,000**	**3,484,000**	**+1,091,000**	**+46%**
Total in vehicle passenger kilometres	AM peak (7-9AM)	8,246,000	12,256,000	+4,010,000	+49%
	Inter-peak (9AM-4PM)	11,273,000	16,029,000	+4,757,000	+42%
	PM peak (4-6PM)	6,971,000	10,468,000	+3,497,000	+50%
	Off-peak (6PM-7AM)	6,061,000	8,607,000	+2,546,000	+42%
	Daily total	**32,550,000**	**47,360,000**	**+14,810,000**	**+45%**
Total in vehicle passenger hours	AM peak (7-9AM)	213,000	309,000	+97,000	+45%
	Inter-peak (9AM-4PM)	282,000	399,000	+117,000	+41%
	PM peak (4-6PM)	180,000	266,000	+85,000	+47%
	Off-peak (6PM-7AM)	145,000	203,000	+57,000	+39%
	Daily total	**820,000**	**1,176,000**	**+356,000**	**+43%**

* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. 'Total Region' measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

Appendix Table F-6 – Sydney GCCSA, Hunter and Illawarra in-vehicle passenger kilometres

Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Rail passenger kilometres	AM peak (7-9AM)	6,618,000	10,002,000	+3,385,000	+51%
	Inter-peak (9AM-4PM)	8,710,000	12,456,000	+3,746,000	+43%
	PM peak (4-6PM)	5,663,000	8,656,000	+2,994,000	+53%
	Off-peak (6PM-7AM)	4,922,000	7,054,000	+2,132,000	+43%
	Daily total	**25,912,000**	**38,168,000**	**+12,257,000**	**+47%**
Light rail passenger kilometres	AM peak (7-9AM)	19,000	119,000	+100,000	+535%
	Inter-peak (9AM-4PM)	38,000	206,000	+168,000	+447%
	PM peak (4-6PM)	20,000	119,000	+99,000	+497%
	Off-peak (6PM-7AM)	22,000	111,000	+89,000	+414%
	Daily total	**98,000**	**555,000**	**+457,000**	**+466%**
Bus passenger kilometres	AM peak (7-9AM)	1,249,000	1,695,000	+447,000	+36%
	Inter-peak (9AM-4PM)	2,135,000	2,798,000	+663,000	+31%
	PM peak (4-6PM)	1,051,000	1,381,000	+330,000	+31%
	Off-peak (6PM-7AM)	974,000	1,253,000	+278,000	+29%
	Daily total	**5,409,000**	**7,127,000**	**+1,718,000**	**+32%**
Ferry passenger kilometres	AM peak (7-9AM)	98,000	87,000	-11,000	-12%
	Inter-peak (9AM-4PM)	68,000	82,000	+14,000	+21%
	PM peak (4-6PM)	80,000	82,000	+2,000	+2%
	Off-peak (6PM-7AM)	24,000	19,000	-5,000	-22%
	Daily total	**271,000**	**270,000**	**-1,000**	**-0%**
Hunter Region					
Rail passenger kilometres	AM peak (7-9AM)	615,000	832,000	+217,000	+35%
	Inter-peak (9AM-4PM)	1,230,000	1,470,000	+241,000	+20%
	PM peak (4-6PM)	489,000	637,000	+148,000	+30%
	Off-peak (6PM-7AM)	471,000	560,000	+89,000	+19%
	Daily total	**2,806,000**	**3,501,000**	**+695,000**	**+25%**
Light rail passenger kilometres	AM peak (7-9AM)	0	2,000	+2,000	-
	Inter-peak (9AM-4PM)	0	4,000	+4,000	-
	PM peak (4-6PM)	0	2,000	+2,000	-
	Off-peak (6PM-7AM)	0	3,000	+3,000	-
	Daily total	**0**	**10,000**	**+10,000**	**-**
Bus passenger kilometres	AM peak (7-9AM)	97,000	133,000	+35,000	+36%
	Inter-peak (9AM-4PM)	167,000	233,000	+66,000	+39%
	PM peak (4-6PM)	63,000	86,000	+24,000	+38%
	Off-peak (6PM-7AM)	31,000	50,000	+19,000	+63%
	Daily total	**358,000**	**502,000**	**+144,000**	**+40%**
Ferry passenger kilometres	AM peak (7-9AM)	100	100	0	+19%
	Inter-peak (9AM-4PM)	200	300	+100	+44%
	PM peak (4-6PM)	100	100	0	+22%
	Off-peak (6PM-7AM)	100	100	0	-2%
	Daily total	**500**	**600**	**+100**	**+24%**
Illawarra Region					
Rail passenger kilometres	AM peak (7-9AM)	680,000	882,000	+203,000	+30%
	Inter-peak (9AM-4PM)	722,000	908,000	+186,000	+26%
	PM peak (4-6PM)	510,000	695,000	+185,000	+36%
	Off-peak (6PM-7AM)	365,000	458,000	+92,000	+25%
	Daily total	**2,277,000**	**2,943,000**	**+666,000**	**+29%**
Light rail passenger kilometres	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	**0**	**0**	**0**	**-**
Bus passenger kilometres	AM peak (7-9AM)	25,000	43,000	+19,000	+76%
	Inter-peak (9AM-4PM)	52,000	90,000	+38,000	+72%
	PM peak (4-6PM)	17,000	32,000	+14,000	+82%
	Off-peak (6PM-7AM)	6,000	15,000	+8,000	+133%
	Daily total	**101,000**	**180,000**	**+79,000**	**+79%**
Ferry passenger kilometres	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	**0**	**0**	**0**	**-**
Total Region*					
Rail passenger kilometres	AM peak (7-9AM)	6,763,000	10,192,000	+3,429,000	+51%
	Inter-peak (9AM-4PM)	8,825,000	12,648,000	+3,823,000	+43%
	PM peak (4-6PM)	5,744,000	8,776,000	+3,032,000	+53%
	Off-peak (6PM-7AM)	5,004,000	7,160,000	+2,156,000	+43%
	Daily total	**26,337,000**	**38,776,000**	**+12,440,000**	**+47%**
Light rail passenger kilometres	AM peak (7-9AM)	19,000	121,000	+102,000	+546%
	Inter-peak (9AM-4PM)	38,000	210,000	+172,000	+456%
	PM peak (4-6PM)	20,000	121,000	+101,000	+507%
	Off-peak (6PM-7AM)	22,000	113,000	+92,000	+425%
	Daily total	**98,000**	**565,000**	**+467,000**	+477%
Bus passenger kilometres	AM peak (7-9AM)	1,365,000	1,856,000	+491,000	+36%
	Inter-peak (9AM-4PM)	2,342,000	3,089,000	+747,000	+32%
	PM peak (4-6PM)	1,126,000	1,489,000	+362,000	+32%
	Off-peak (6PM-7AM)	1,011,000	1,315,000	+304,000	+30%
	Daily total	**5,844,000**	**7,748,000**	**+1,904,000**	**+33%**
Ferry passenger kilometres	AM peak (7-9AM)	98,200	86,800	-11,400	-12%
	Inter-peak (9AM-4PM)	68,300	82,600	+14,400	+21%
	PM peak (4-6PM)	80,500	82,300	+1,800	+2%
	Off-peak (6PM-7AM)	24,500	19,100	-5,400	-22%
	Daily total	271,500	270,800	-600	**-0%**

* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. 'Total Region' measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

Appendix Table F-7 – Sydney GCCSA, Hunter and Illawarra in-vehicle passenger hours

Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Rail passenger hours	AM peak (7-9AM)	144,000	215,000	+71,000	+49%
	Inter-peak (9AM-4PM)	190,000	268,000	+78,000	+41%
	PM peak (4-6PM)	124,000	187,000	+63,000	+51%
	Off-peak (6PM-7AM)	111,000	154,000	+43,000	+39%
	Daily total	**569,000**	**824,000**	**+256,000**	**+45%**
Light rail passenger hours	AM peak (7-9AM)	1,000	5,000	+4,000	+446%
	Inter-peak (9AM-4PM)	2,000	10,000	+7,000	+352%
	PM peak (4-6PM)	1,000	6,000	+4,000	+380%
	Off-peak (6PM-7AM)	1,000	5,000	+4,000	+320%
	Daily total	**6,000**	**26,000**	**+20,000**	**+368%**
Bus passenger hours	AM peak (7-9AM)	58,000	76,000	+18,000	+32%
	Inter-peak (9AM-4PM)	79,000	105,000	+26,000	+33%
	PM peak (4-6PM)	49,000	64,000	+16,000	+33%
	Off-peak (6PM-7AM)	30,000	39,000	+9,000	+29%
	Daily total	**216,000**	**285,000**	**+69,000**	**+32%**
Ferry passenger hours	AM peak (7-9AM)	3,200	2,900	-300	-10%
	Inter-peak (9AM-4PM)	2,400	2,600	+300	+11%
	PM peak (4-6PM)	2,800	2,900	+100	+2%
	Off-peak (6PM-7AM)	600	500	-200	-24%
	Daily total	**9,000**	**8,900**	**-100**	**-1%**
Hunter Region					
Rail passenger hours	AM peak (7-9AM)	10,000	14,000	+4,000	+38%
	Inter-peak (9AM-4PM)	20,000	24,000	+4,000	+21%
	PM peak (4-6PM)	8,000	10,000	+2,000	+31%
	Off-peak (6PM-7AM)	8,000	9,000	+1,000	+18%
	Daily total	**46,000**	**58,000**	**+12,000**	**+26%**
Light rail passenger hours	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	**0**	**0**	**0**	**-**
Bus passenger hours	AM peak (7-9AM)	3,000	5,000	+2,000	+50%
	Inter-peak (9AM-4PM)	5,000	8,000	+2,000	+45%
	PM peak (4-6PM)	2,000	3,000	+1,000	+55%
	Off-peak (6PM-7AM)	1,000	2,000	+1,000	+60%
	Daily total	**12,000**	**17,000**	**+6,000**	**+50%**
Ferry passenger hours	AM peak (7-9AM)	0	0	+0	+19%
	Inter-peak (9AM-4PM)	0	0	+0	+44%
	PM peak (4-6PM)	0	0	+0	+22%
	Off-peak (6PM-7AM)	0	0	+0	-2%
	Daily total	**0**	**100**	**+0**	**+24%**
Illawarra Region					
Rail passenger hours	AM peak (7-9AM)	13,000	16,000	+4,000	+29%
	Inter-peak (9AM-4PM)	13,000	16,000	+3,000	+25%
	PM peak (4-6PM)	9,000	12,000	+3,000	+35%
	Off-peak (6PM-7AM)	7,000	8,000	+2,000	+25%
	Daily total	**41,000**	**53,000**	**+12,000**	**+29%**
Light rail passenger hours	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	**0**	**0**	**0**	**-**
Bus passenger hours	AM peak (7-9AM)	800	1,600	+800	+97%
	Inter-peak (9AM-4PM)	1,800	3,000	+1,300	+71%
	PM peak (4-6PM)	600	1,300	+700	+104%
	Off-peak (6PM-7AM)	200	400	+200	+110%
	Daily total	**3,400**	**6,300**	**+3,000**	**+86%**
Ferry passenger hours	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	**0**	**0**	**0**	**-**
Total Region*					
Rail passenger hours	AM peak (7-9AM)	146,000	218,000	+72,000	+49%
	Inter-peak (9AM-4PM)	192,000	271,000	+80,000	+42%
	PM peak (4-6PM)	125,000	189,000	+63,000	+51%
	Off-peak (6PM-7AM)	112,000	156,000	+44,000	+39%
	Daily total	**575,000**	**834,000**	**+259,000**	**+45%**
Light rail passenger hours	AM peak (7-9AM)	1,000	6,000	+5,000	+454%
	Inter-peak (9AM-4PM)	2,000	10,000	+8,000	+358%
	PM peak (4-6PM)	1,000	6,000	+4,000	+387%
	Off-peak (6PM-7AM)	1,000	5,000	+4,000	+328%
	Daily total	**6,000**	**26,000**	**+21,000**	+375%
Bus passenger hours	AM peak (7-9AM)	62,000	83,000	+20,000	+33%
	Inter-peak (9AM-4PM)	86,000	115,000	+29,000	+34%
	PM peak (4-6PM)	51,000	68,000	+17,000	+34%
	Off-peak (6PM-7AM)	32,000	41,000	+10,000	+30%
	Daily total	**231,000**	**307,000**	**+76,000**	**+33%**
Ferry passenger hours	AM peak (7-9AM)	3,200	2,900	-300	-10%
	Inter-peak (9AM-4PM)	2,400	2,700	+300	+12%
	PM peak (4-6PM)	2,900	2,900	+100	+2%
	Off-peak (6PM-7AM)	600	500	-200	-24%
	Daily total	9,100	9,000	-100	**-1%**

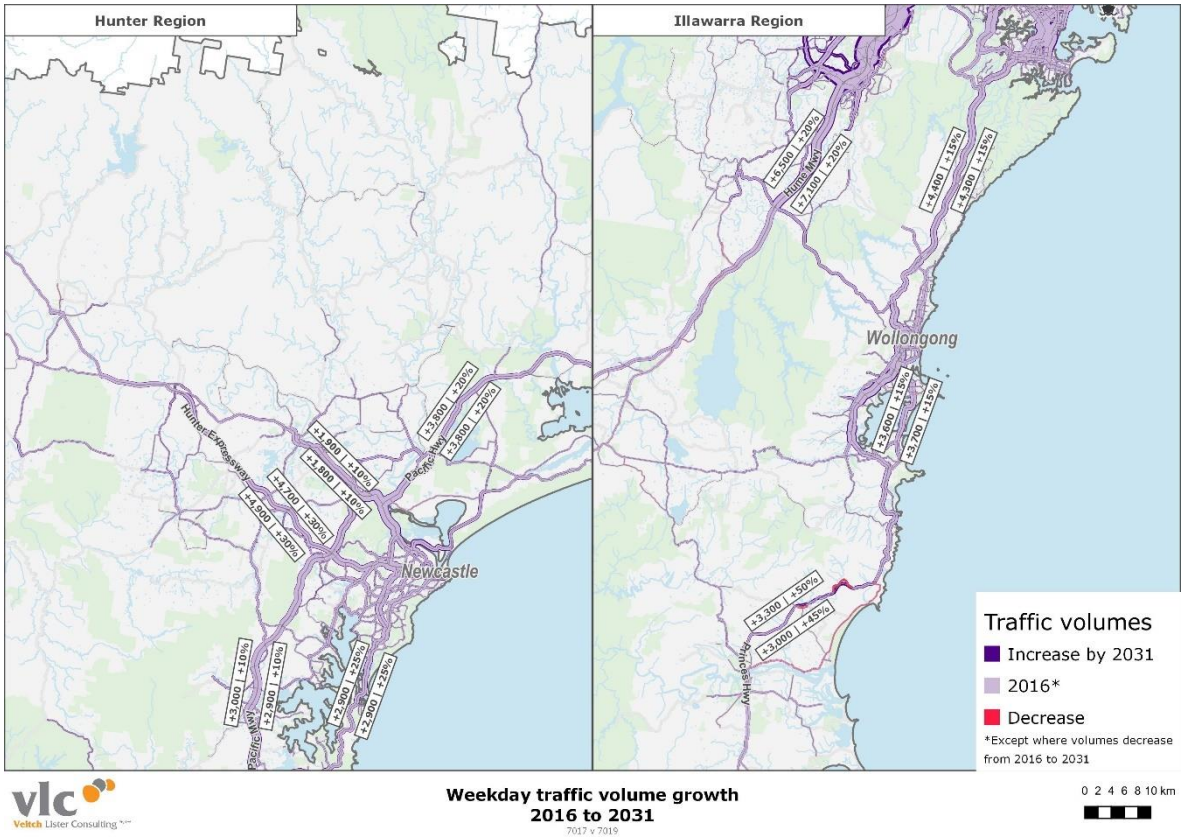
* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. 'Total Region' measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

Appendix Table F-8 – Sydney GCCSA, Hunter and Illawarra public transport boardings

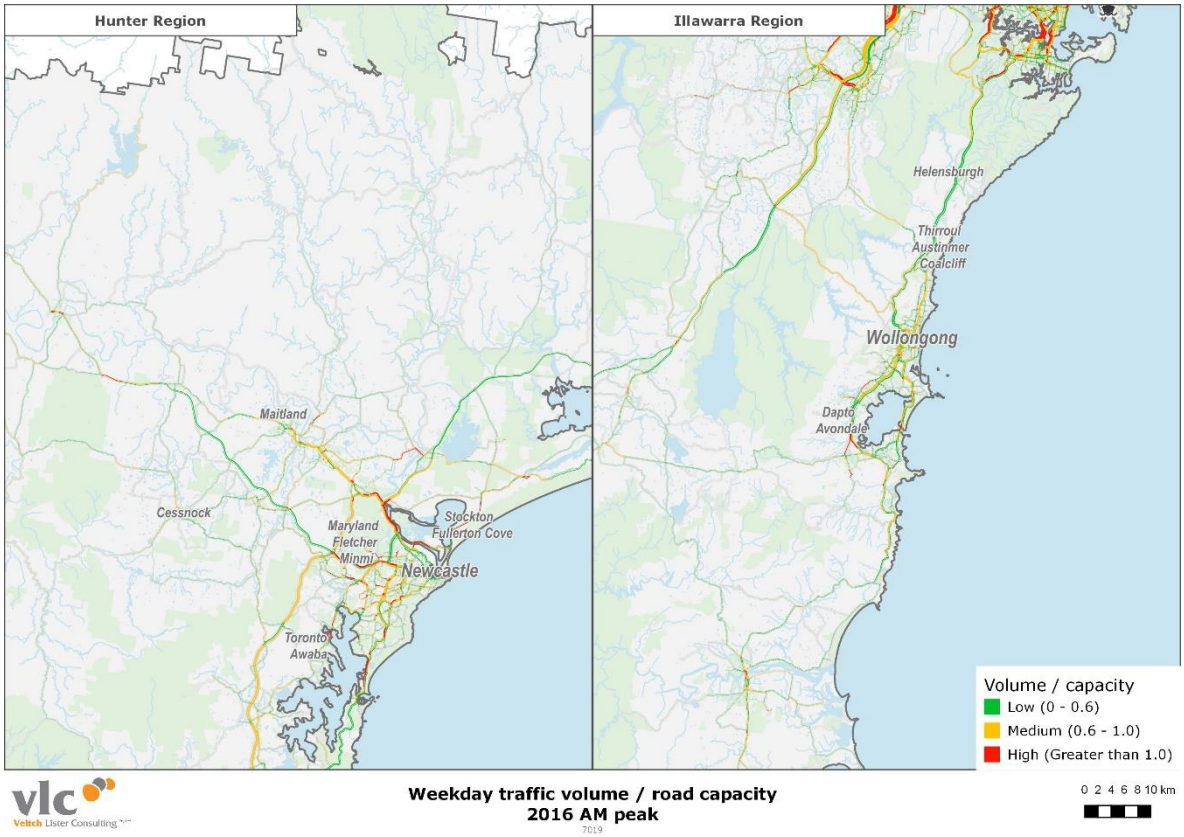
Metric	Time period	2016	2031	Change	% change
Sydney GCCSA					
Rail boardings	AM peak (7-9AM)	348,000	519,000	+171,000	+49%
	Inter-peak (9AM-4PM)	563,000	794,000	+231,000	+41%
	PM peak (4-6PM)	303,000	455,000	+153,000	+50%
	Off-peak (6PM-7AM)	323,000	449,000	+125,000	+39%
	Daily total	**1,537,000**	**2,217,000**	**+680,000**	**+44%**
Light rail boardings	AM peak (7-9AM)	6,000	32,000	+26,000	+470%
	Inter-peak (9AM-4PM)	15,000	74,000	+60,000	+408%
	PM peak (4-6PM)	8,000	46,000	+39,000	+496%
	Off-peak (6PM-7AM)	8,000	43,000	+35,000	+442%
	Daily total	**36,000**	**196,000**	**+160,000**	**+444%**
Bus boardings	AM peak (7-9AM)	157,000	207,000	+50,000	+32%
	Inter-peak (9AM-4PM)	307,000	396,000	+89,000	+29%
	PM peak (4-6PM)	132,000	173,000	+42,000	+32%
	Off-peak (6PM-7AM)	123,000	159,000	+36,000	+30%
	Daily total	**719,000**	**935,000**	**+216,000**	**+30%**
Ferry boardings	AM peak (7-9AM)	11,300	10,500	-800	-7%
	Inter-peak (9AM-4PM)	10,100	12,100	+2,000	+20%
	PM peak (4-6PM)	9,800	10,300	+400	+4%
	Off-peak (6PM-7AM)	2,800	2,100	-700	-25%
	Daily total	**34,000**	**35,000**	**+1,000**	**+3%**
Hunter Region					
Rail boardings	AM peak (7-9AM)	14,000	21,000	+7,000	+48%
	Inter-peak (9AM-4PM)	29,000	36,000	+8,000	+27%
	PM peak (4-6PM)	11,000	15,000	+5,000	+44%
	Off-peak (6PM-7AM)	12,000	15,000	+3,000	+25%
	Daily total	**65,000**	**87,000**	**+22,000**	**+34%**
Light rail boardings	AM peak (7-9AM)	0	1,000	+1,000	-
	Inter-peak (9AM-4PM)	0	3,000	+3,000	-
	PM peak (4-6PM)	0	1,000	+1,000	-
	Off-peak (6PM-7AM)	0	2,000	+2,000	-
	Daily total	**0**	**7,000**	**+7,000**	**-**
Bus boardings	AM peak (7-9AM)	8,000	11,000	+3,000	+30%
	Inter-peak (9AM-4PM)	16,000	22,000	+5,000	+33%
	PM peak (4-6PM)	5,000	7,000	+2,000	+36%
	Off-peak (6PM-7AM)	4,000	5,000	+2,000	+47%
	Daily total	**34,000**	**45,000**	**+12,000**	**+34%**
Ferry boardings	AM peak (7-9AM)	100	200	+0	+19%
	Inter-peak (9AM-4PM)	300	400	+100	+44%
	PM peak (4-6PM)	100	200	+0	+22%
	Off-peak (6PM-7AM)	200	200	-0	-2%
	Daily total	**1,000**	**1,000**	**+0**	**+24%**
Illawarra Region					
Rail boardings	AM peak (7-9AM)	17,000	21,000	+4,000	+25%
	Inter-peak (9AM-4PM)	19,000	23,000	+4,000	+22%
	PM peak (4-6PM)	11,000	14,000	+3,000	+25%
	Off-peak (6PM-7AM)	11,000	13,000	+2,000	+20%
	Daily total	**58,000**	**71,000**	**+13,000**	**+23%**
Light rail boardings	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	**0**	**0**	**0**	**-**
Bus boardings	AM peak (7-9AM)	3,000	5,000	+2,000	+49%
	Inter-peak (9AM-4PM)	7,000	10,000	+3,000	+48%
	PM peak (4-6PM)	2,000	3,000	+1,000	+56%
	Off-peak (6PM-7AM)	1,000	2,000	+1,000	+75%
	Daily total	**13,000**	**20,000**	**+7,000**	**+52%**
Ferry boardings	AM peak (7-9AM)	0	0	0	-
	Inter-peak (9AM-4PM)	0	0	0	-
	PM peak (4-6PM)	0	0	0	-
	Off-peak (6PM-7AM)	0	0	0	-
	Daily total	**0**	**0**	**0**	**-**
Total Region*					
Rail boardings	AM peak (7-9AM)	353,000	526,000	+174,000	+49%
	Inter-peak (9AM-4PM)	571,000	806,000	+235,000	+41%
	PM peak (4-6PM)	306,000	461,000	+154,000	+50%
	Off-peak (6PM-7AM)	328,000	454,000	+127,000	+39%
	Daily total	**1,557,000**	**2,247,000**	**+690,000**	**+44%**
Light rail boardings	AM peak (7-9AM)	6,000	33,000	+28,000	+494%
	Inter-peak (9AM-4PM)	15,000	77,000	+62,000	+426%
	PM peak (4-6PM)	8,000	48,000	+40,000	+512%
	Off-peak (6PM-7AM)	8,000	45,000	+37,000	+463%
	Daily total	**36,000**	**203,000**	**+167,000**	+463%
Bus boardings	AM peak (7-9AM)	168,000	221,000	+53,000	+32%
	Inter-peak (9AM-4PM)	330,000	427,000	+97,000	+29%
	PM peak (4-6PM)	139,000	184,000	+44,000	+32%
	Off-peak (6PM-7AM)	128,000	167,000	+39,000	+30%
	Daily total	**765,000**	**998,000**	**+233,000**	**+31%**
Ferry boardings	AM peak (7-9AM)	11,400	10,700	-800	-7%
	Inter-peak (9AM-4PM)	10,400	12,500	+2,100	+21%
	PM peak (4-6PM)	10,000	10,400	+500	+5%
	Off-peak (6PM-7AM)	3,000	2,300	-700	-23%
	Daily total	**35,000**	**36,000**	**+1,000**	**+3%**

* Total values do not sum due to cross-regional trips (e.g. Sydney to Hunter Valley) being counted once in each Sydney GCCSA and Hunter Region. 'Total Region' measures unique trips made within the three combined regions, i.e. without double counting of cross-region trips.

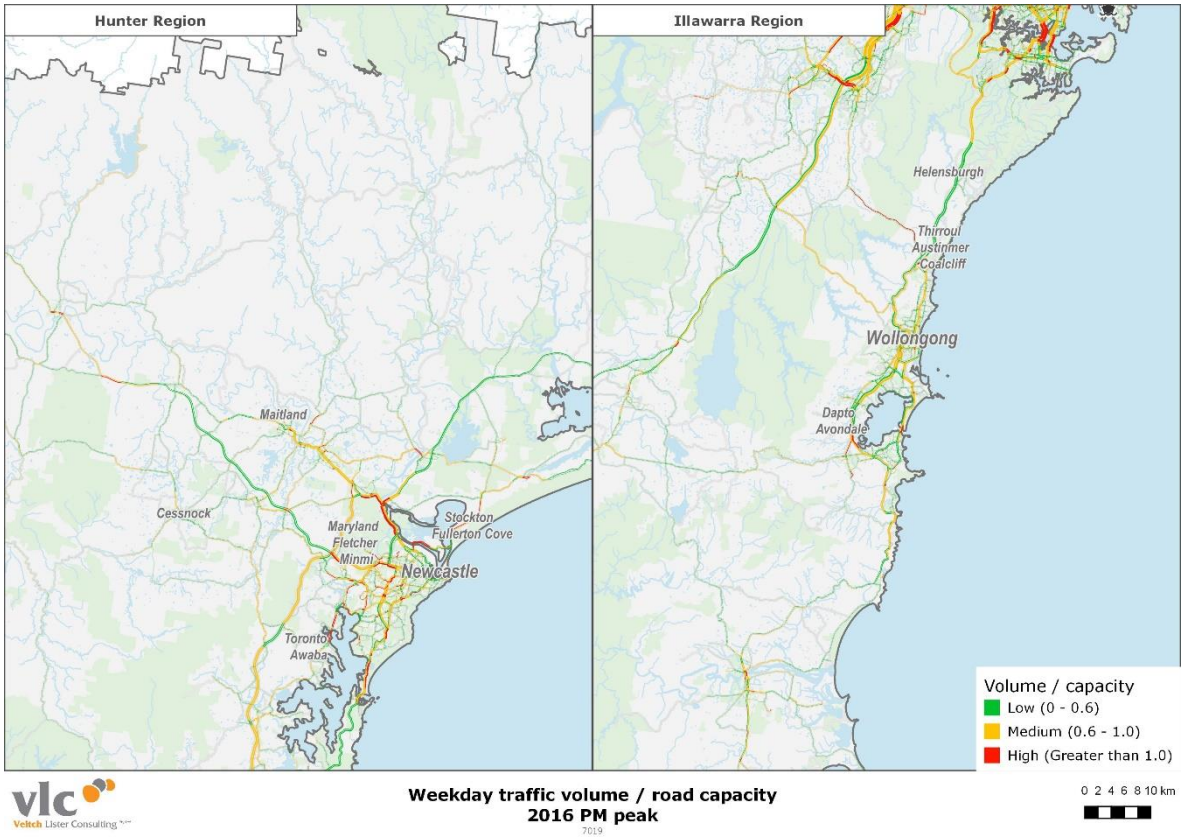
Appendix Figure F-1 – Hunter and Illawarra weekday traffic volume growth - 2016 to 2031



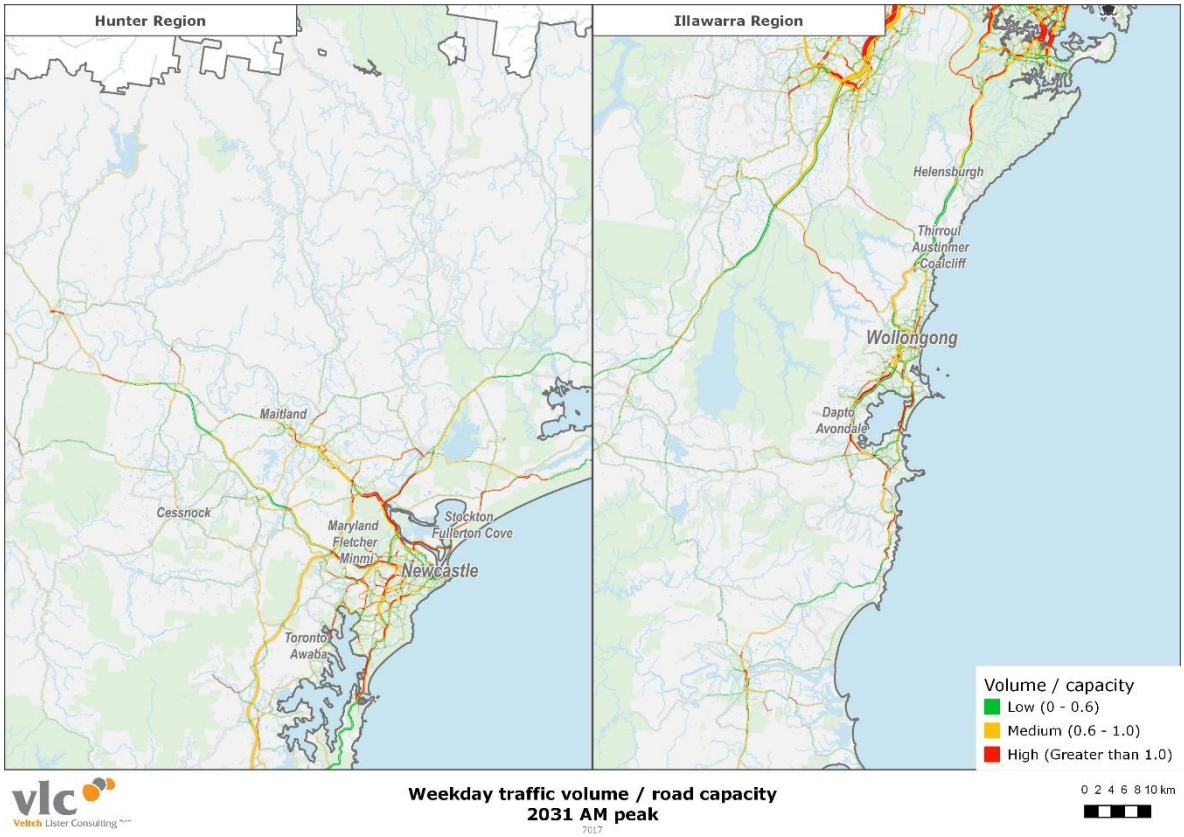
Appendix Figure F-2 – Hunter and Illawarra weekday traffic volume / road capacity - 2016 AM peak (7-9AM)



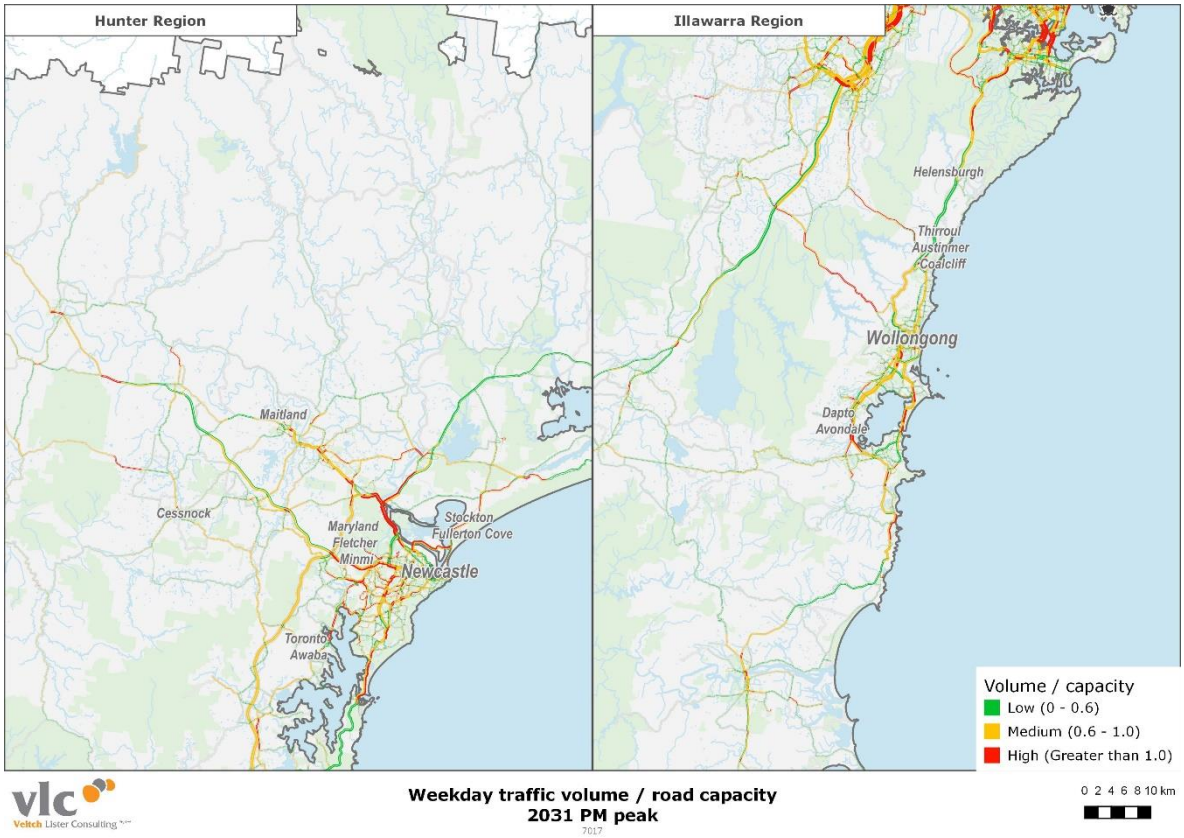
Appendix Figure F-3 – Hunter and Illawarra weekday traffic volume / road capacity - 2016 PM peak (4-6PM)



Appendix Figure F-4 – Hunter and Illawarra weekday traffic volume / road capacity - 2031 AM peak (7-9AM)



Appendix Figure F-5 – Hunter and Illawarra weekday traffic volume / road capacity - 2031 PM peak (4-6PM)

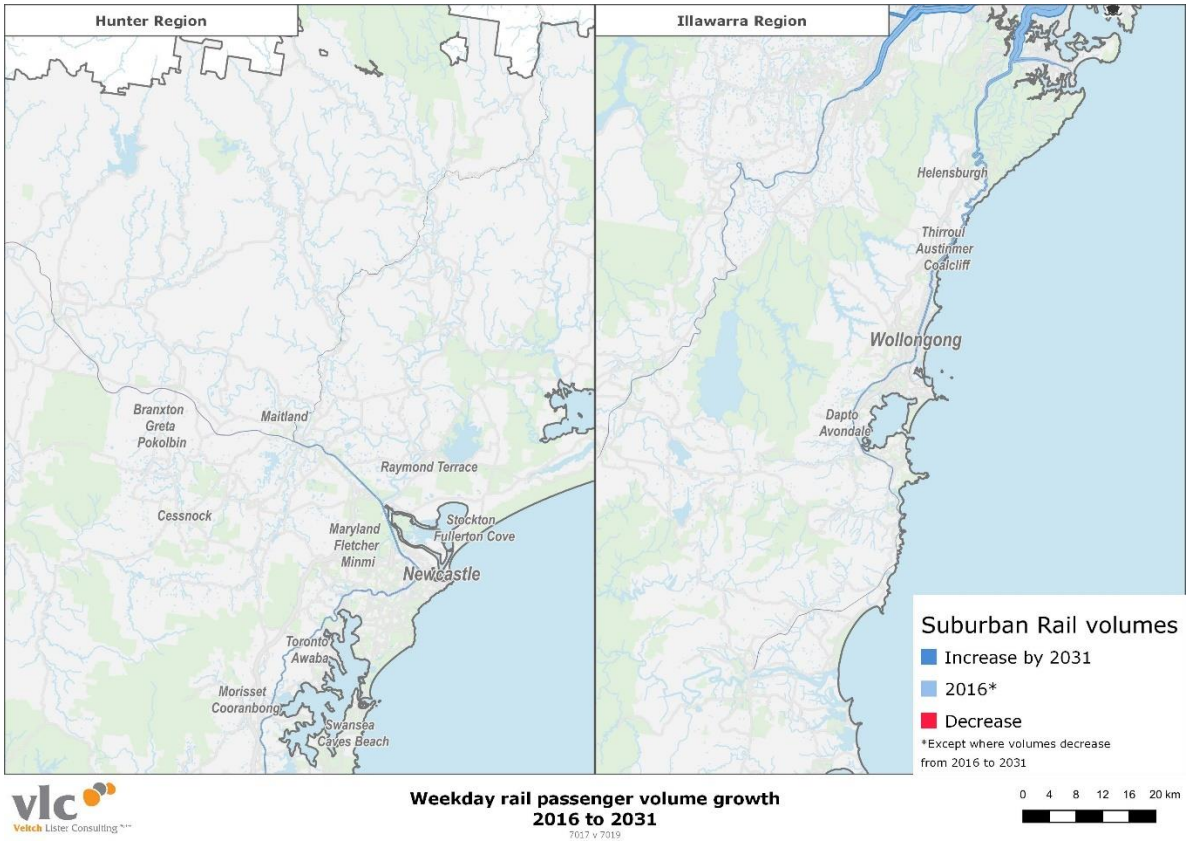


In the Hunter region, significant levels of congestion are observed on roads towards Newcastle's city centre in 2016 are expected to persist in 2031 (Appendix Figure F-2 to Appendix Figure F-5).

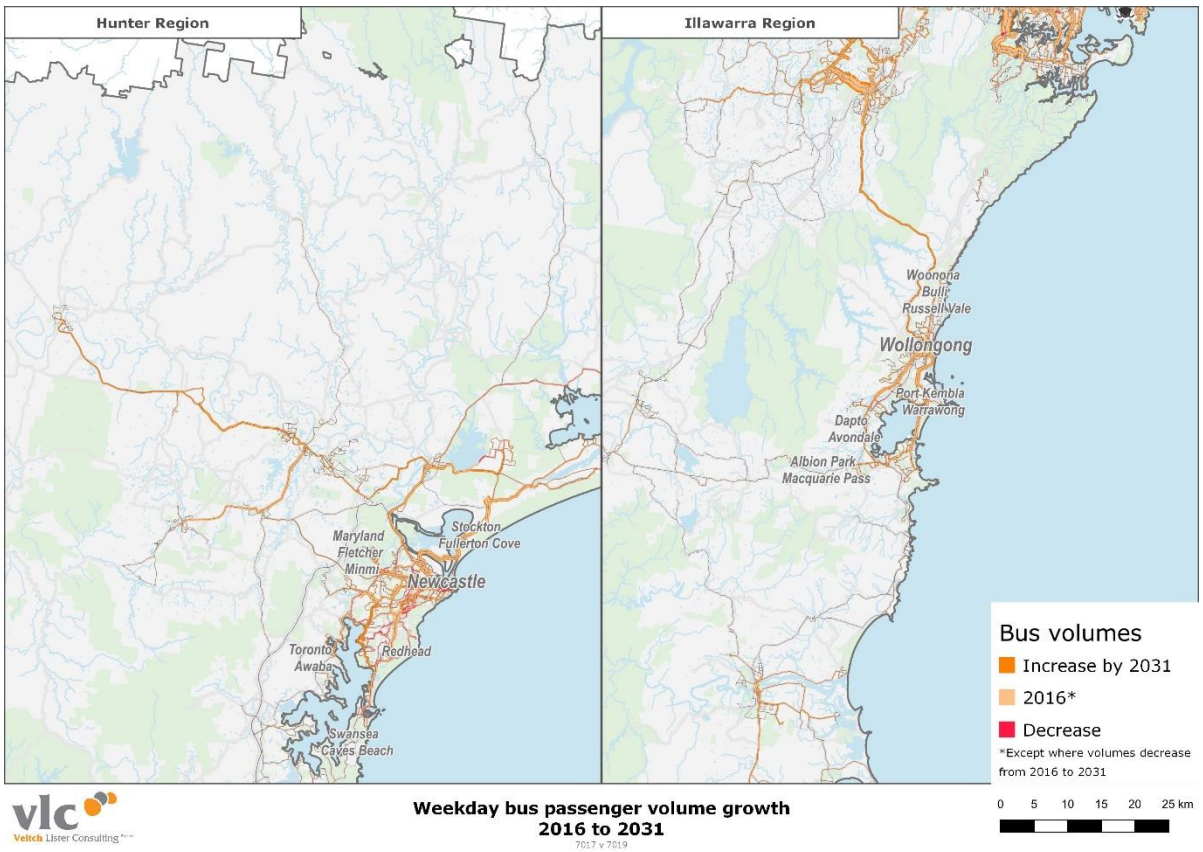
In the Illawarra region, note that VLC has not included the Albion Park Bypass in 2031, which may alleviate some of the congestion forecasted to the east on Windang Road. However, this is not expected to reduce congestion on the Princes Motorway in Dapto.

Rail in the Hunter and Illawarra largely services trips into the Sydney GCCSA (Appendix Figure F-6), with crowding generally worsening as services approach Greater Sydney in both 2016 and 2031 (Appendix Figure F-8 to Appendix Figure F-11). Buses service local trips, with some capacity constraints apparent on services in both regions by 2031 (Appendix Figure F-12 through Appendix Figure F-15).

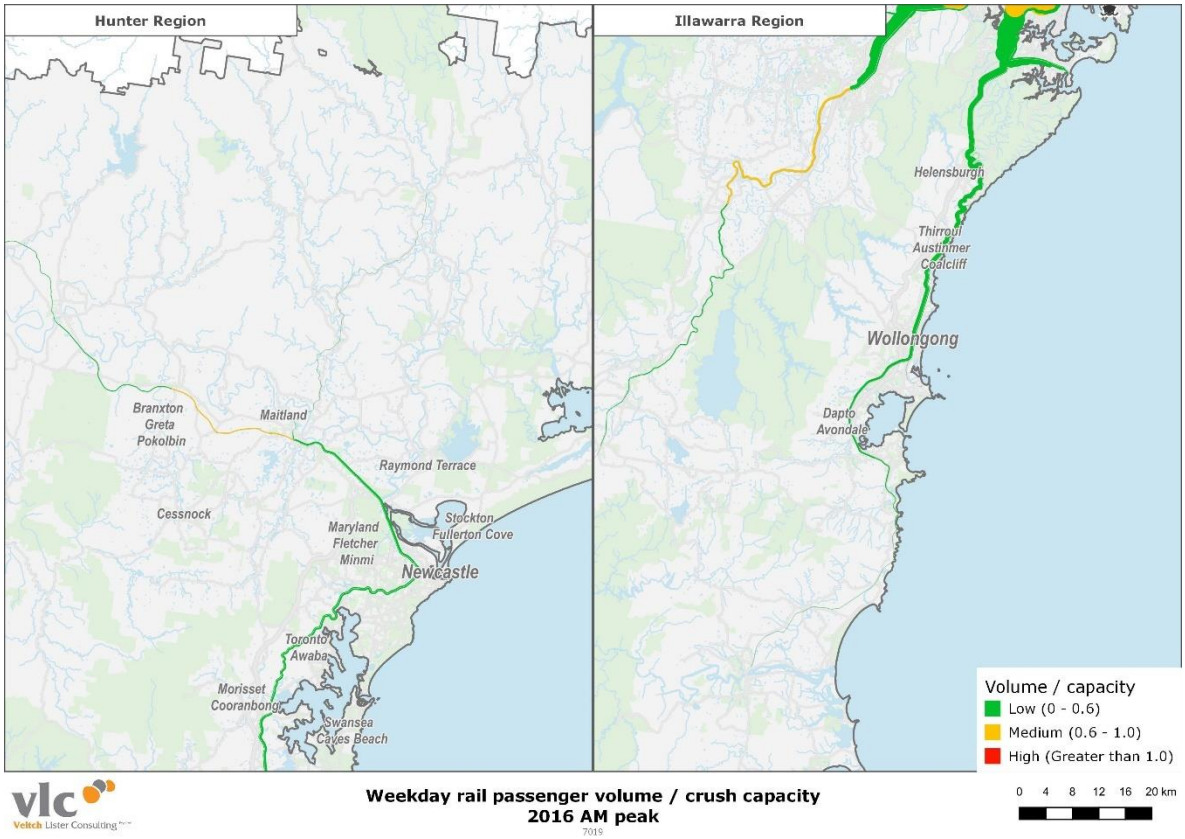
Appendix Figure F-6 – Hunter and Illawarra weekday rail passenger volume growth 2016 to 2031



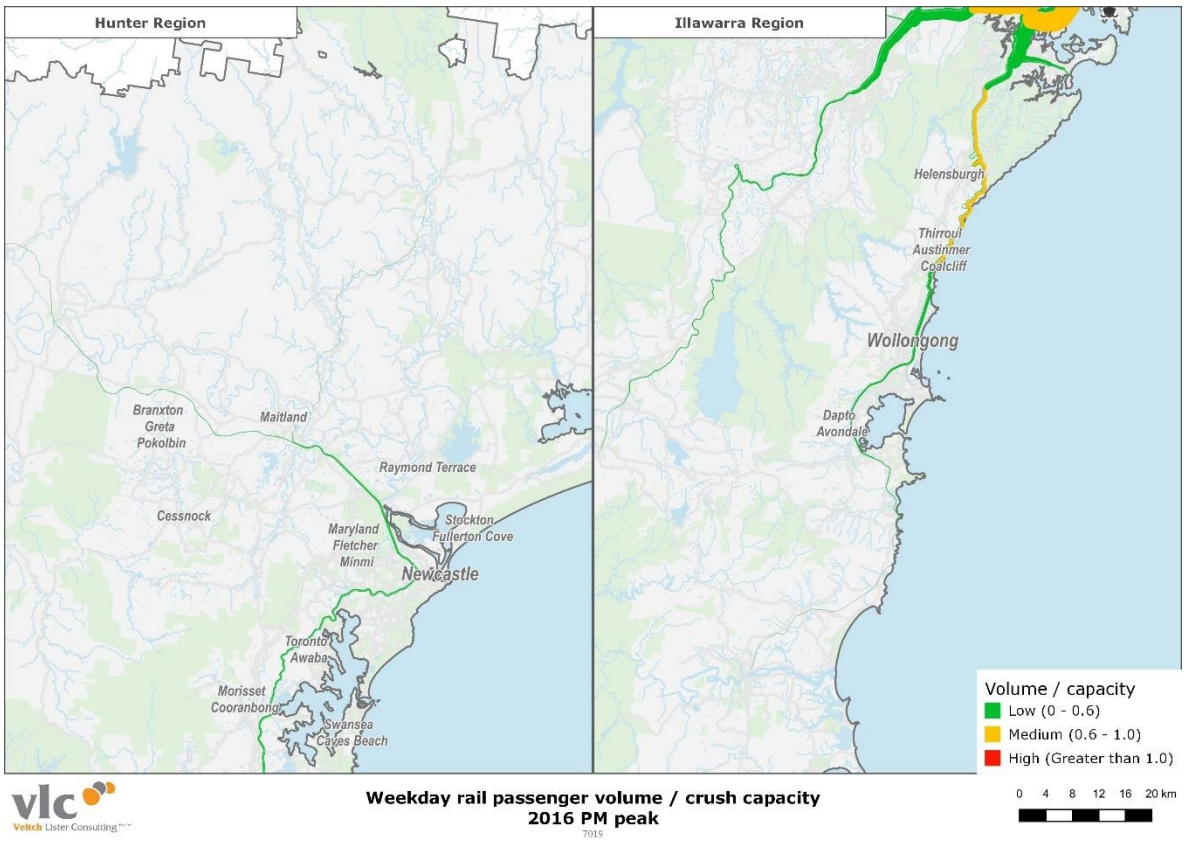
Appendix Figure F-7 – Hunter and Illawarra weekday bus passenger volume growth 2016 to 2031



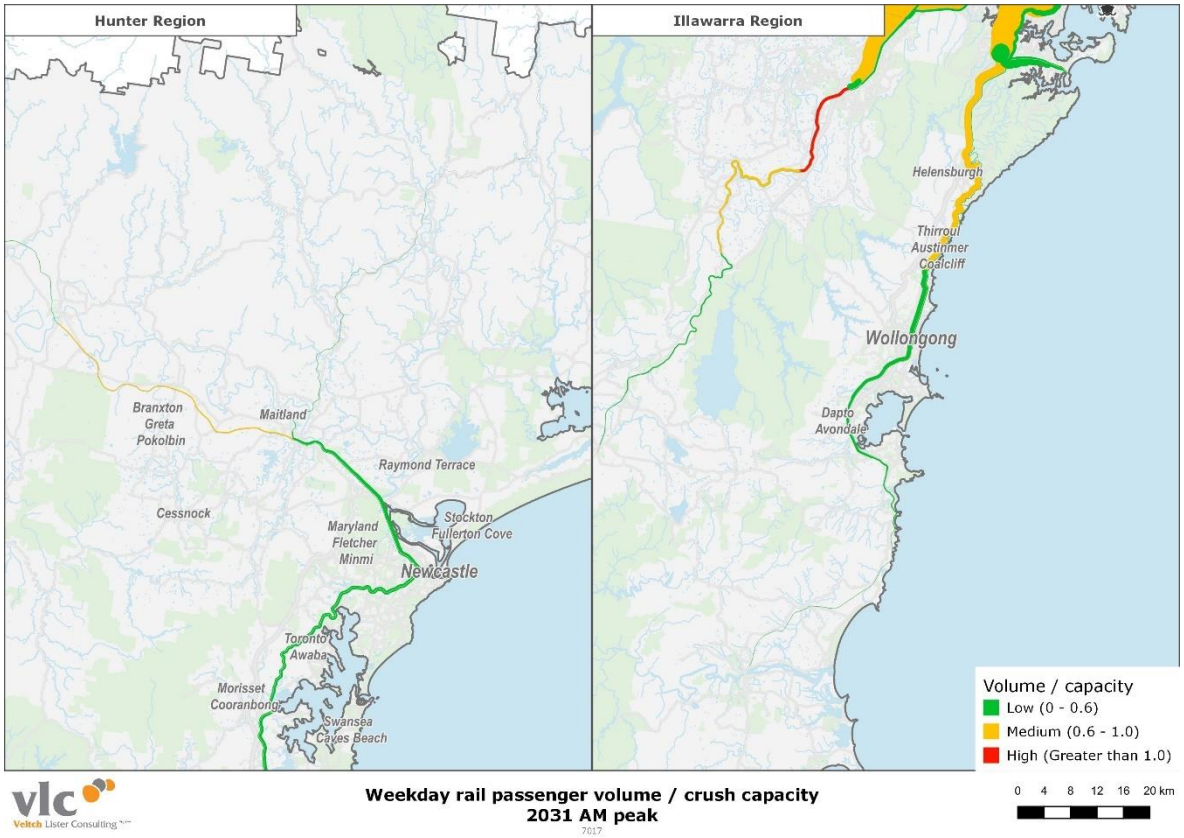
Appendix Figure F-8 – Hunter and Illawarra weekday rail passenger volume / crush capacity 2016 1-hour AM peak



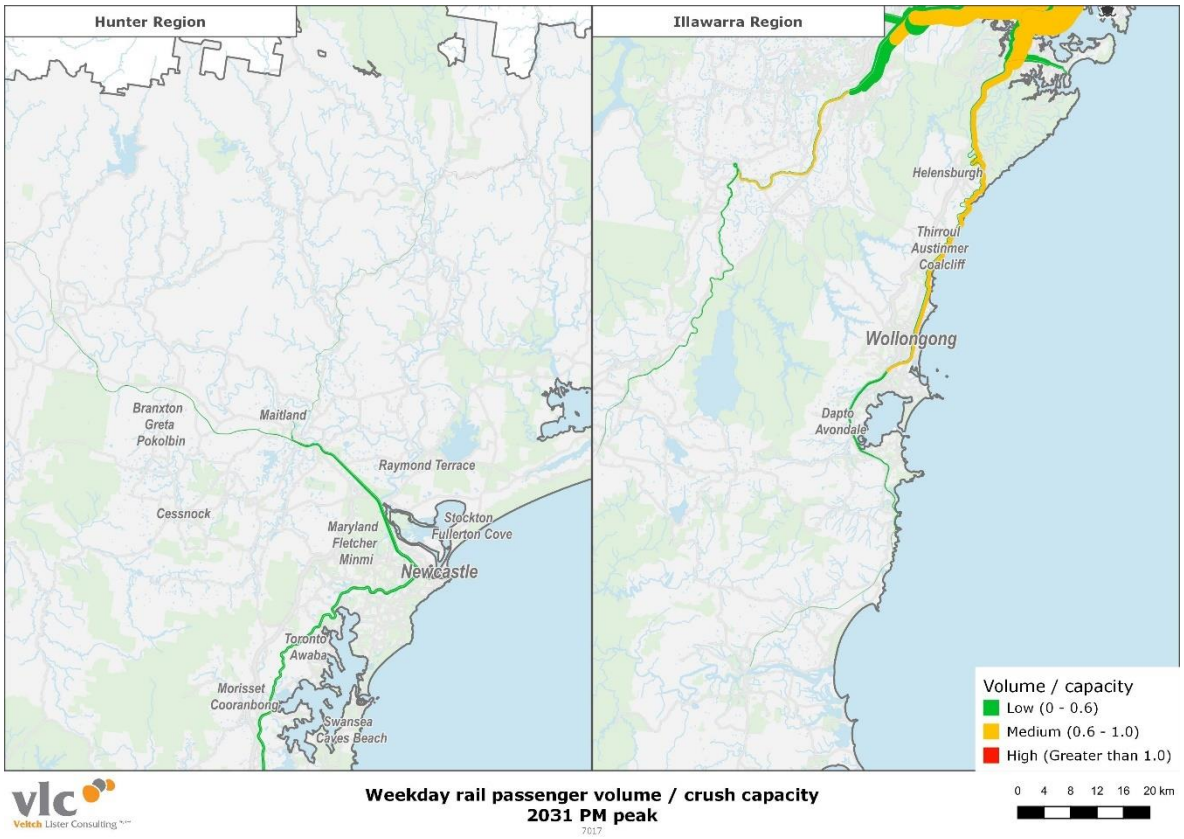
Appendix Figure F-9 – Hunter and Illawarra weekday rail passenger volume / crush capacity 2016 1-hour PM peak



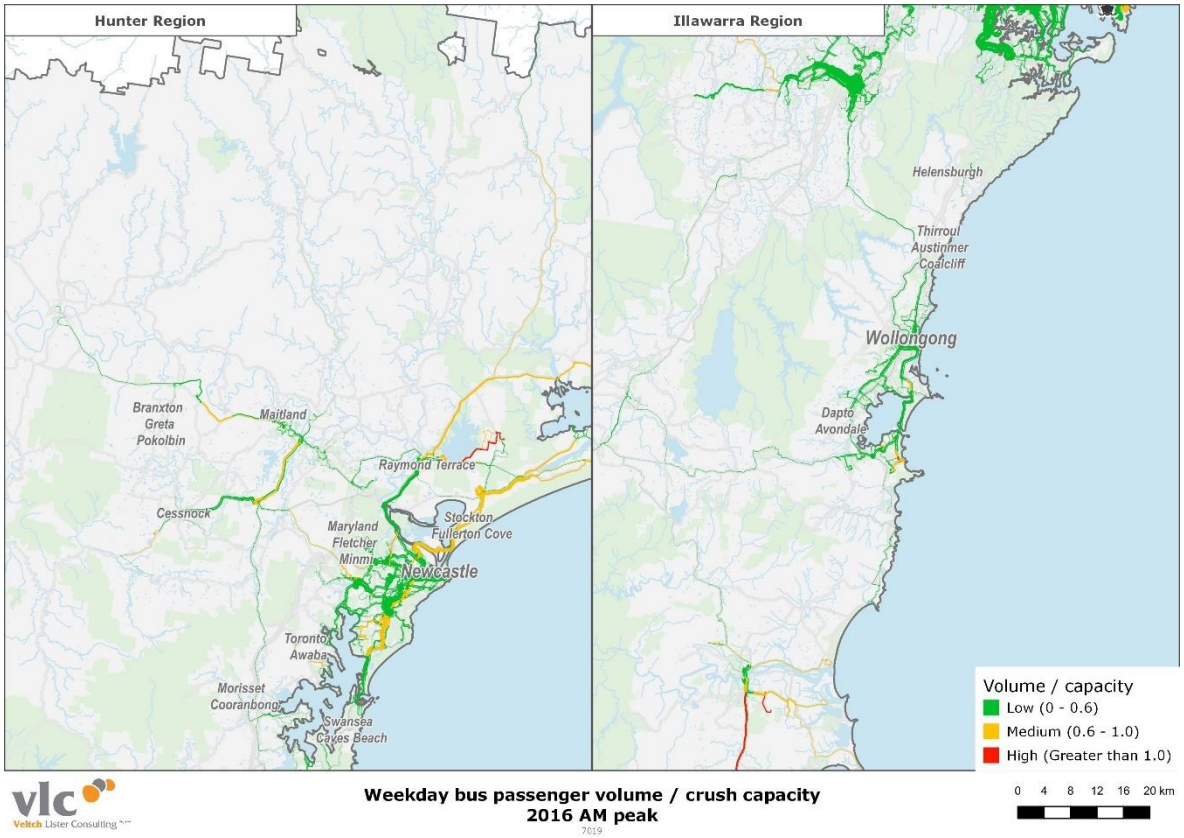
Appendix Figure F-10 – Hunter and Illawarra weekday rail passenger volume / crush capacity 2031 1-hour AM peak



Appendix Figure F-11 – Hunter and Illawarra weekday rail passenger volume / crush capacity 2031 1-hour PM peak

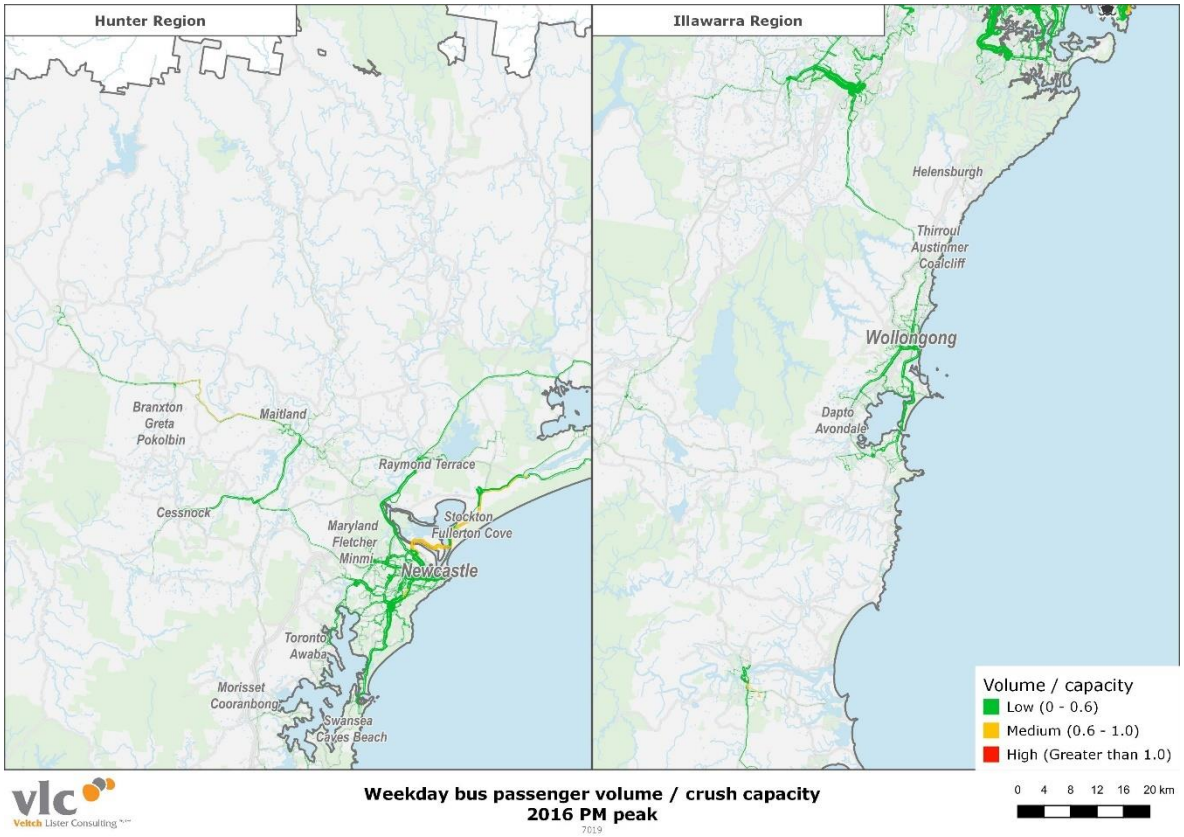


Appendix Figure F-12 – Hunter and Illawarra weekday bus passenger volume / crush capacity 2016 1-hour AM peak



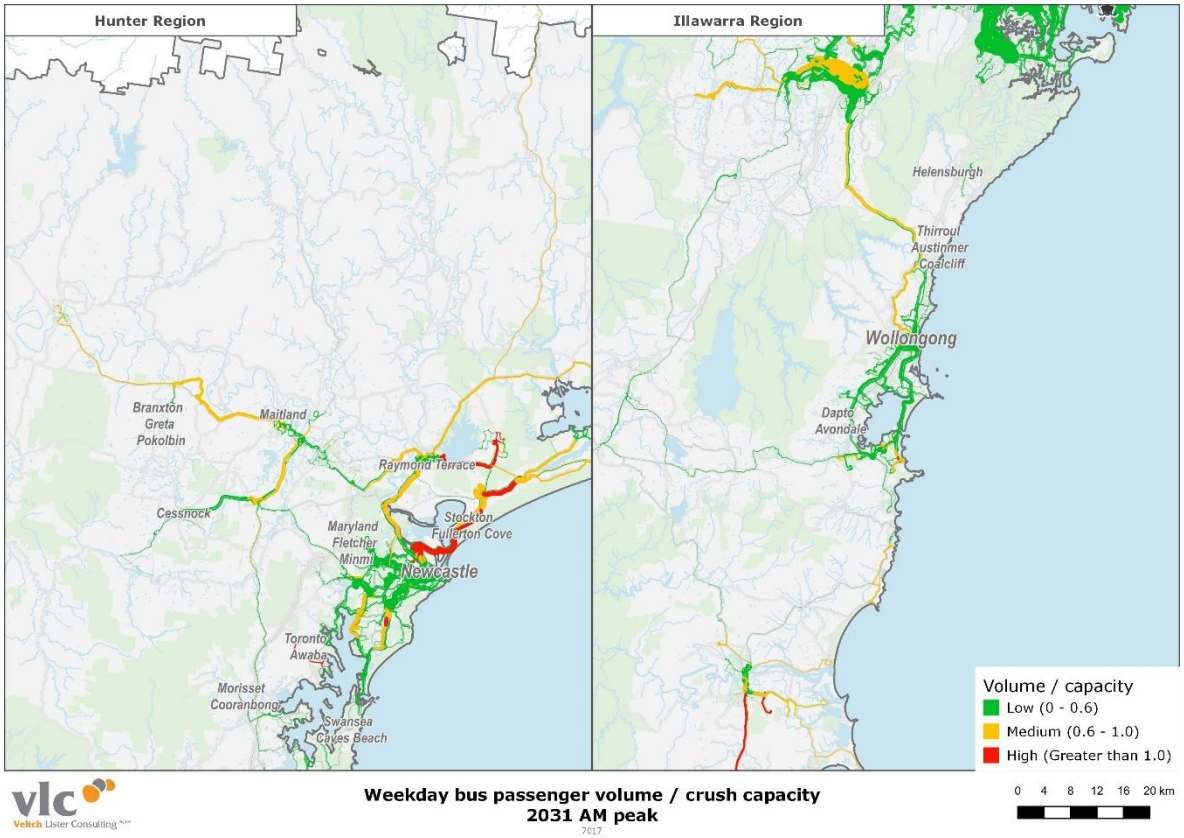
Weekday bus passenger volume / crush capacity
2016 AM peak

Appendix Figure F-13 – Hunter and Illawarra weekday bus passenger volume / crush capacity 2016 1-hour PM peak



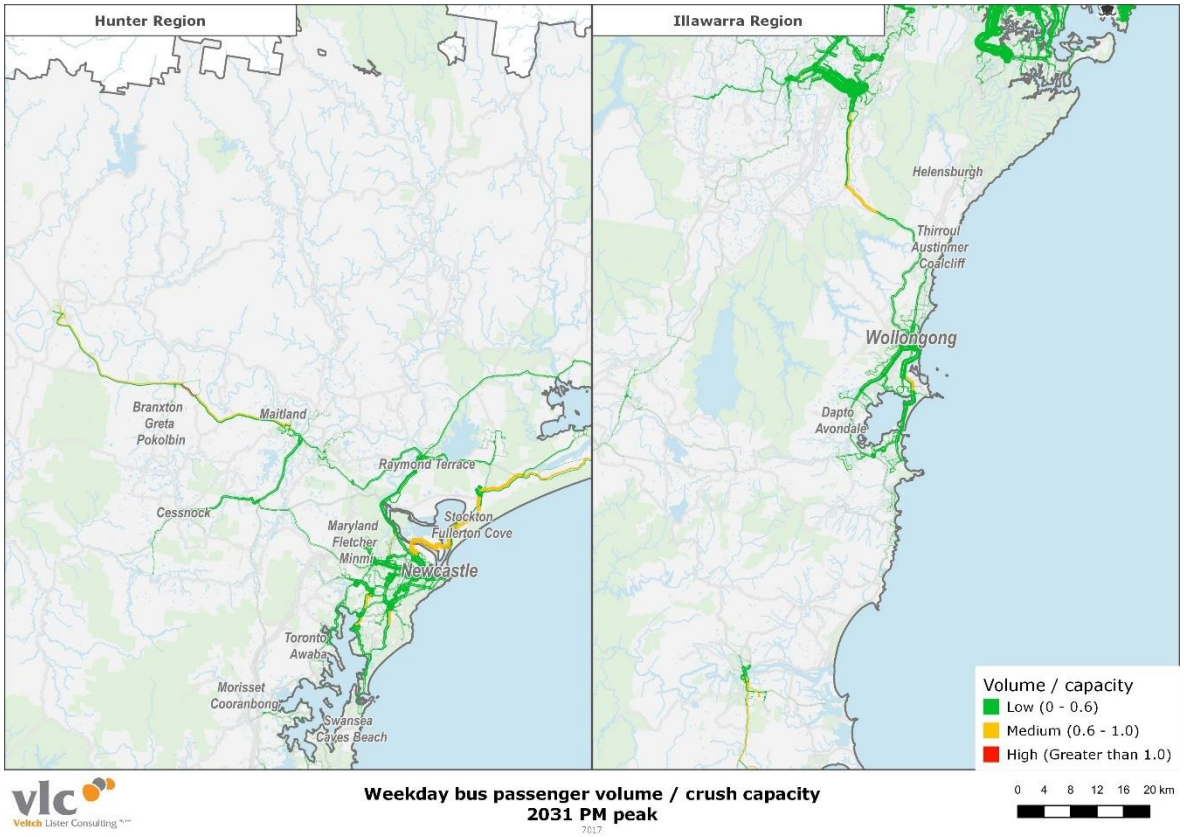
Weekday bus passenger volume / crush capacity
2016 PM peak

Appendix Figure F-14 – Hunter and Illawarra weekday bus passenger volume / crush capacity 2031 1-hour AM peak



Weekday bus passenger volume / crush capacity
2031 AM peak

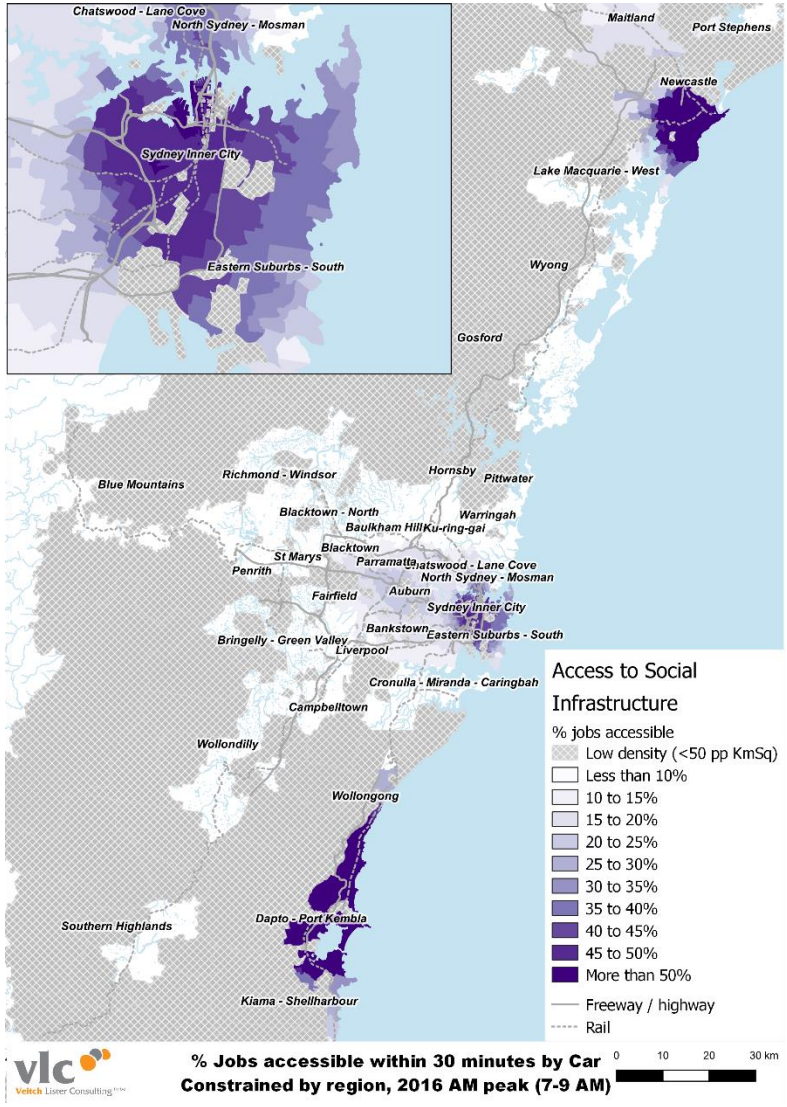
Appendix Figure F-15 – Hunter and Illawarra weekday bus passenger volume / crush capacity 2031 1-hour PM peak



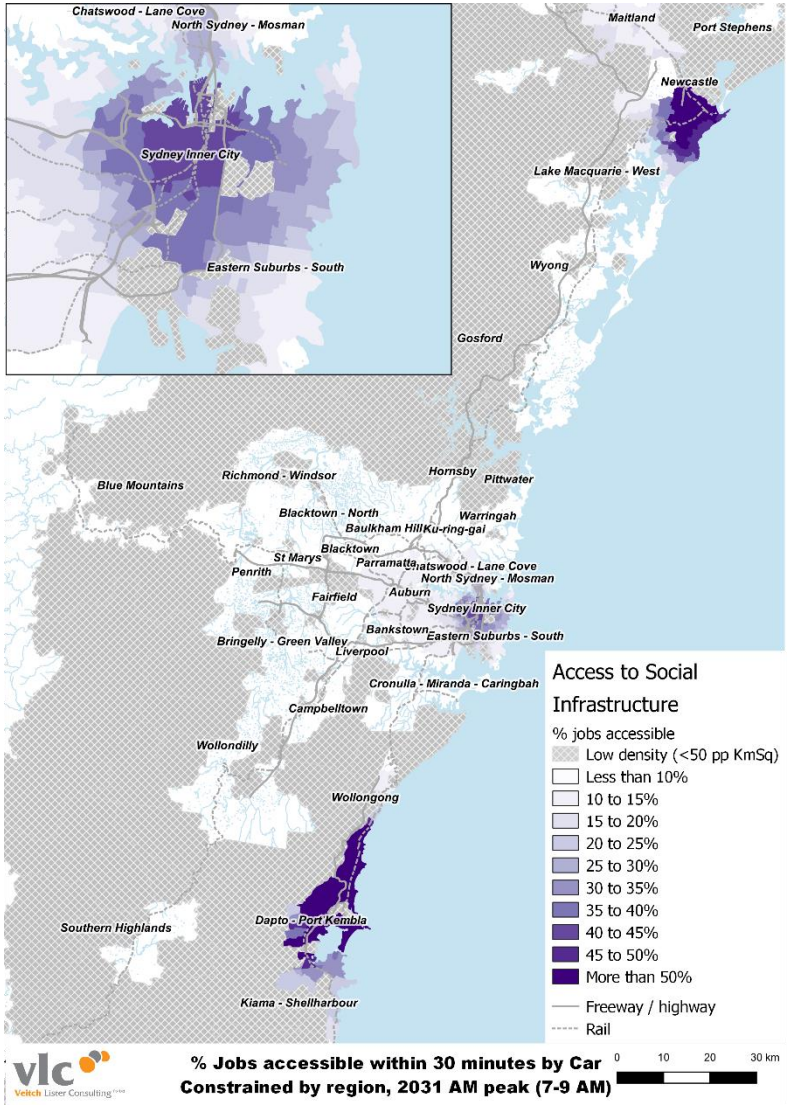
Weekday bus passenger volume / crush capacity
2031 PM peak

Figure 6-8 and Figure 6-9 showed that residents of the Hunter and Illawarra had access to a very limited proportion of the region's jobs (i.e. the proportion of jobs in Sydney, Newcastle and the Illawarra). However, when a level of self-containment is assumed, and accessibility is constrained to the percentage of jobs available within each individual sub-region, the picture changes. For example residents of Newcastle with access to a car have good access to the city's jobs (with the a similar outcome for the Illawarra, Appendix Figure F-16). By 2031 some reduction in accessibility is seen in both Newcastle and the Illawarra (Appendix Figure F-17). Nevertheless, both these sub-regions retain good access to jobs by car. Access to jobs by public transport is limited (Appendix Figure F-18 and Appendix Figure F-19).

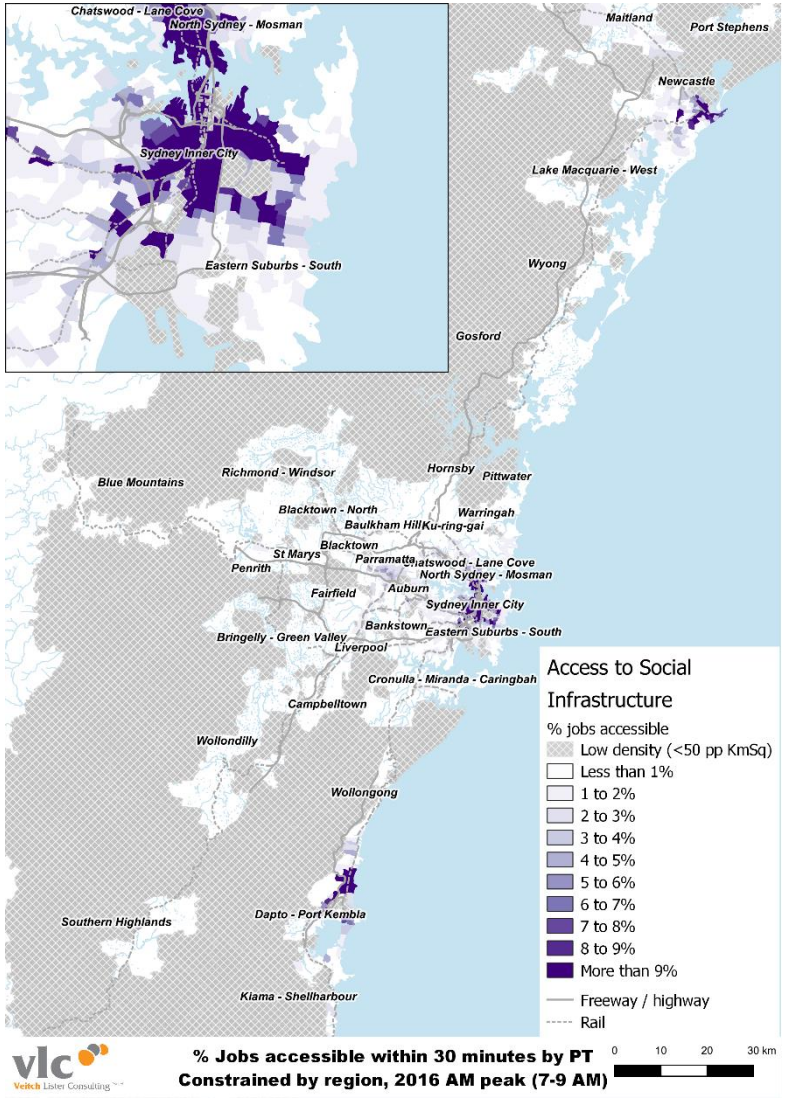
Appendix Figure F-16 – Access to jobs by Car contained by sub-region - 2016 AM Peak (7-9AM)



Appendix Figure F-17 – Access to jobs by Car contained by sub-region - 2031 AM Peak (7-9AM)



Appendix Figure F-18 – Access to jobs by PT contained by sub-region - 2016 AM Peak (7-9AM)



Appendix Figure F-19 – Access to jobs by PT contained by sub-region - 2031 AM Peak (7-9AM)