Veitch Lister Consulting Pty Ltd

Prepared for

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Transport Planning for the Australian Infrastructure Audit

Transport Modelling Report for Adelaide

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Transport Planning for the Australian Infrastructure Audit

FINAL

Transport Modelling Report for Adelaide

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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 Adelaide. Specifically, it evaluates the performance of Greater Adelaide’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 per centage change has been quoted, it has been calculated using the unrounded data.

2. Adelaide in the future

Understanding how Adelaide'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 Adelaide. More detailed assumptions can be found in the appendices.

2.1 People and jobs

The number of people residing in Adelaide, as well as the spatial distribution of where they live and work are key drivers of the city's transport patterns. In 2016, the Adelaide Greater Capital City Statistical Area (GCCSA) accommodated around 1.3 million residents. 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.

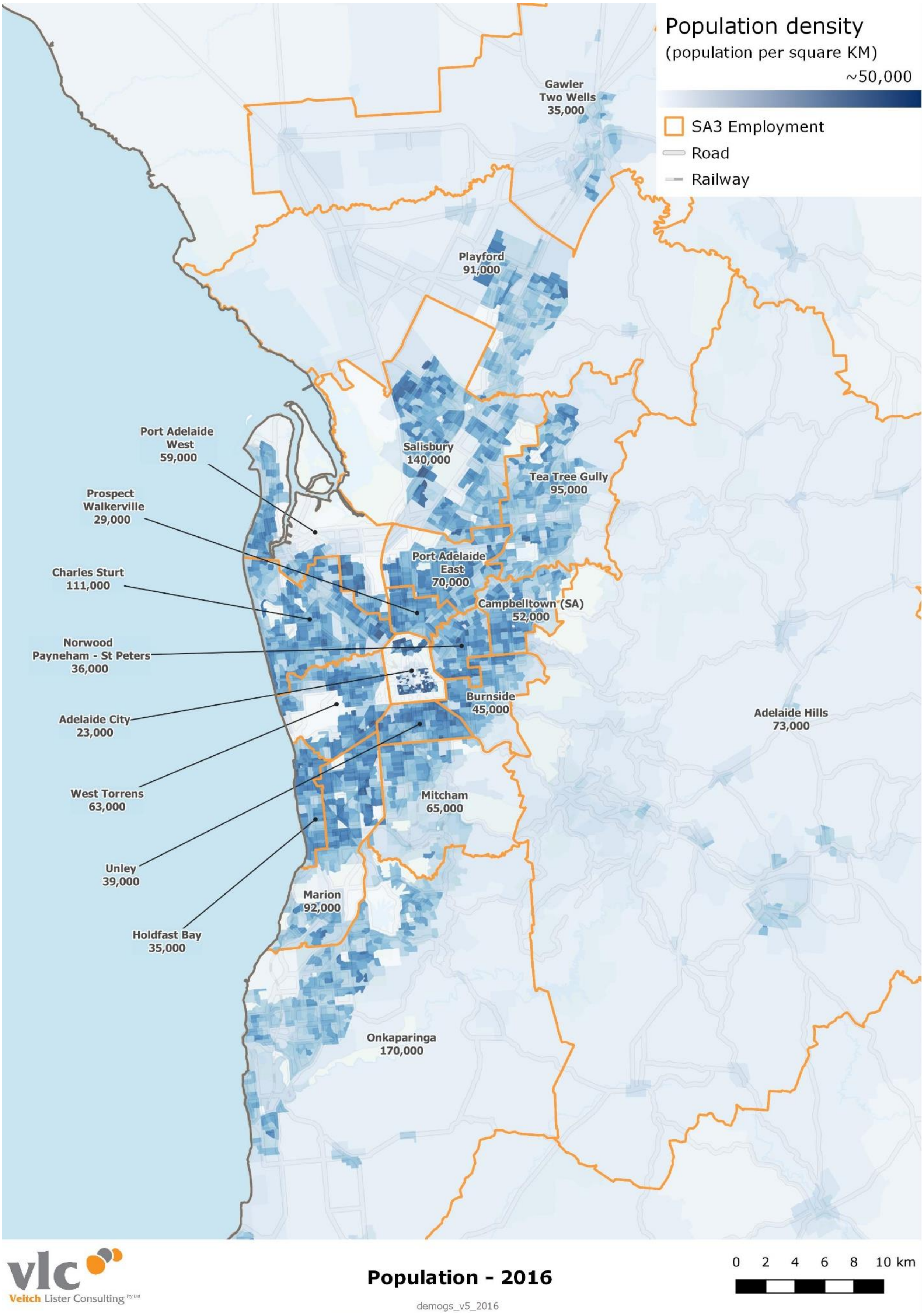
Adelaide's urban areas sit between the coast in the west and the Adelaide Hills to the city's east. In 2016 most of Adelaide's residential development was low or medium density, with the most densely populated areas clustered around the city's core (Figure 2-1).

By 2031, the South Australian (SA) Government's demographic projections suggest a total population of 1.6 million people will live in the Adelaide GCCSA (an increase of around 240,000 or 18% compared to 2016). The future distribution of Adelaide's population is expected to remain similar to that of 2016, with higher densities in inner areas and lower densities in outer areas (Figure 2-1 and Figure 2-2). Adelaide's CBD and western shoreline will accommodate more residents, with strong population growth forecast for Adelaide City, Charles Sturt, Port Adelaide – West, West Torrens, and Marion (Figure 2-3). Slower population growth is expected along Adelaide's central axis, with the areas from Salisbury in the north to Mitcham in the south all forecast to house relatively few additional residents.

Adelaide's urban footprint is expected to expand into greenfield areas by 2031; the strongest growth is projected for the far north and south. Of Adelaide's SA3s, Playford is predicted to accumulate the highest number of additional residents, growing by around 64,000 people. Immediately north of Playford, the population of Gawler-Two Wells is forecast to increase substantially, growing by around 22,000 residents. In the south, Onkaparinga is projected to add the second highest number of new residents (an extra 28,000 people). To the city's east, Tea Tree Gully and the Adelaide Hills are expected to grow moderately.

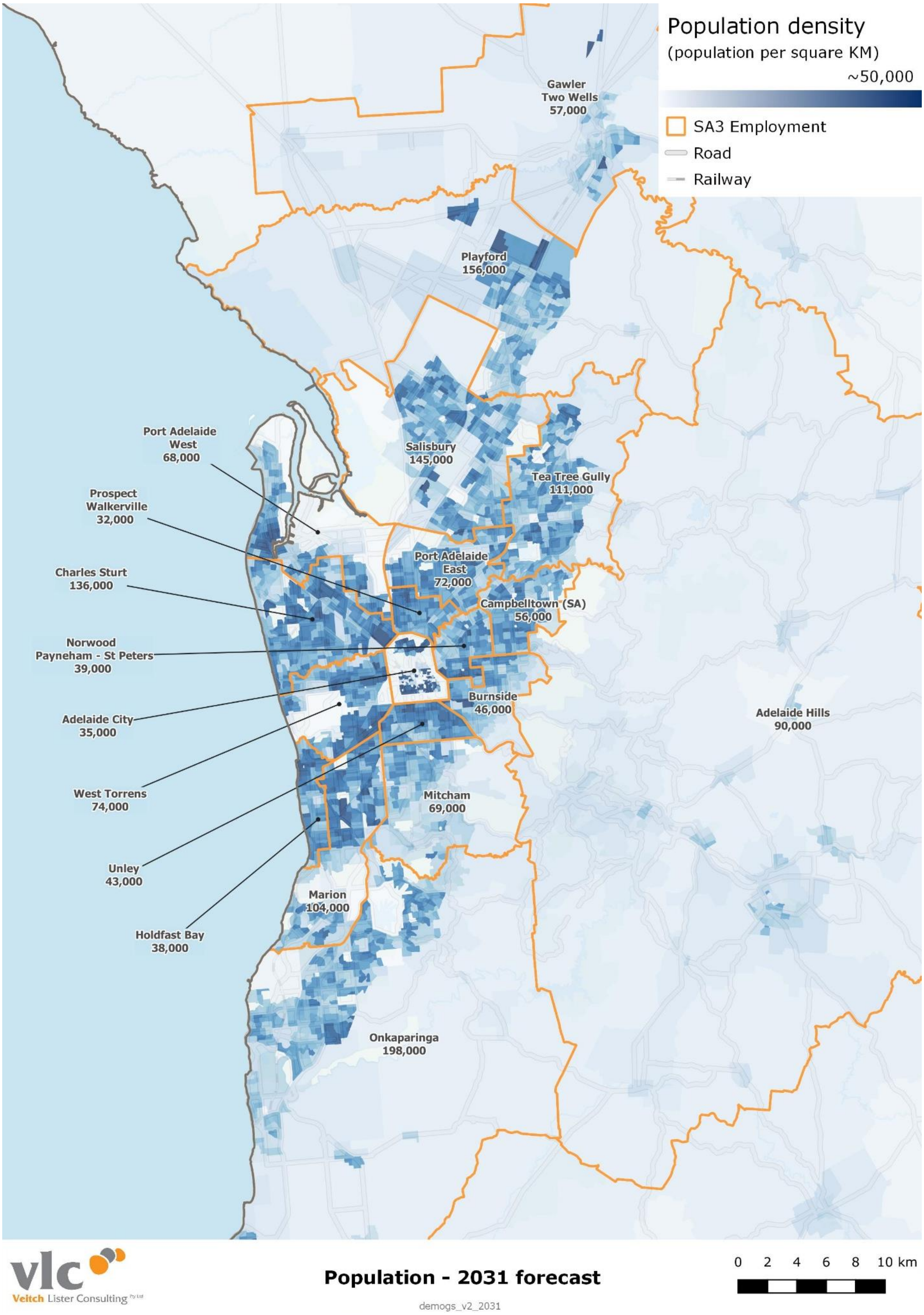
Adelaide's outer areas are projected to accommodate over 60 per cent of the population growth. The significant increase in population in these growth areas is an important consideration in this study, as it is likely to put pressure not only on the infrastructure in these areas but also the corridors connecting Adelaide's major activity centres.

Figure 2-1 – Adelaide GCCSA population density and SA3 totals in 2016



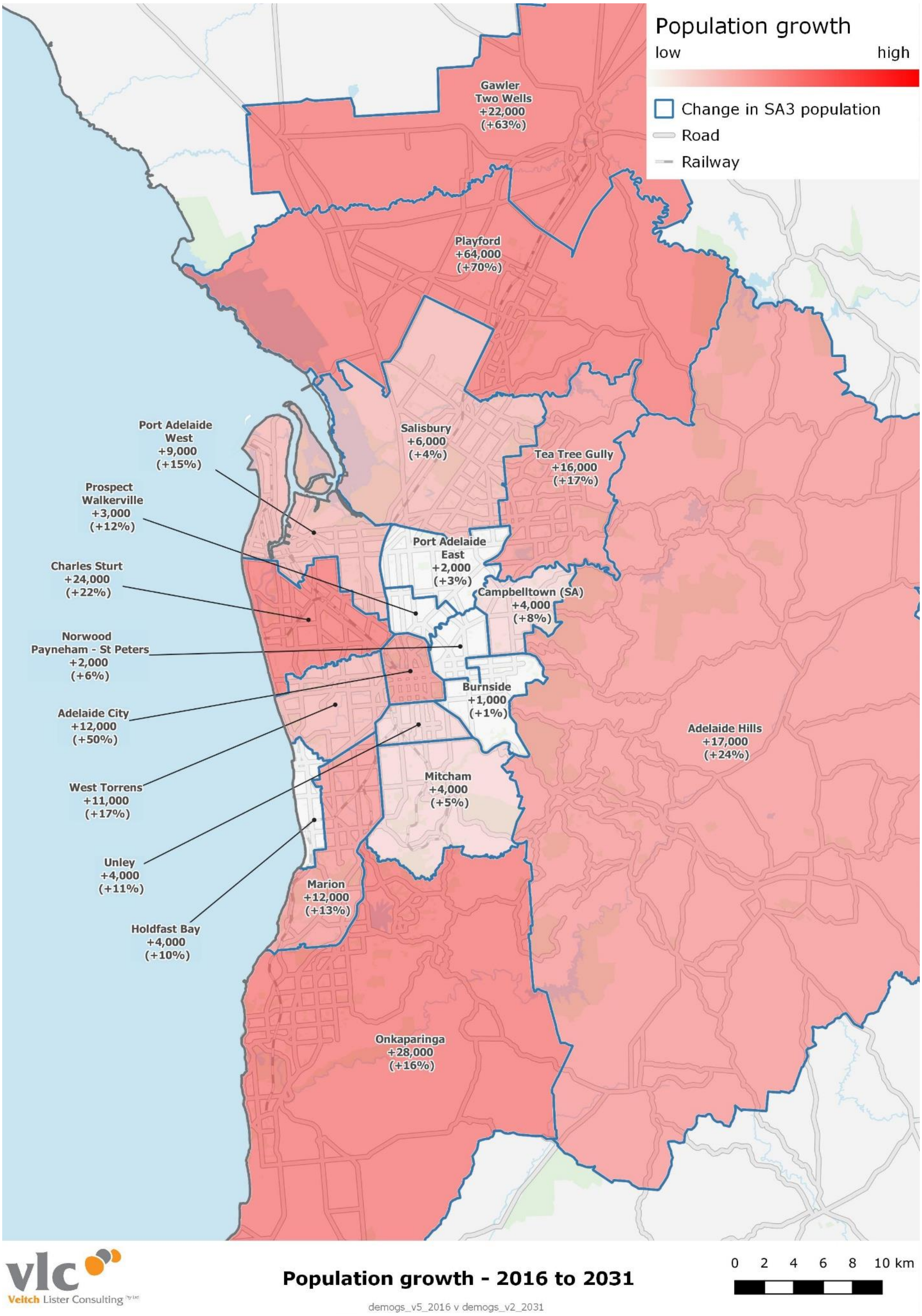
Source: ABS 2016 Census, disaggregated to Zenith travel zones

Figure 2-2 – Adelaide GCCSA population density and SA3 totals in 2031



Source: SA Government, via Infrastructure Australia, disaggregated to Zenith travel zones

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



Source: SA Government, via Infrastructure Australia, disaggregated to Zenith travel zones

In addition to where people live, the location of where they work is a further determinant of travel choices. In 2016 there were approximately 600,000 jobs located in Adelaide's metropolitan area. Most of these jobs were clustered around central Adelaide, with very high levels of employment in or just outside the CBD. As a result, the Adelaide City SA3 contained around 20 per cent of the city's employment (approximately 130,000 jobs), with more jobs located just outside the boundary of this SA3. Outside the central core jobs were fairly evenly spread across the city. While other employment hubs exist, for example at the port and Darlington, they are much smaller than the CBD (Figure 2-4).

By 2031 Adelaide is projected to experience a net increase of around 110,000 jobs (Figure 2-5). Significant employment agglomeration is expected, particularly in Adelaide City where an additional 30,000 jobs are forecast (Figure 2-6). Of the other employment hubs, the Marion/Mitcham hub grows strongly, and there is also increased employment forecast for Playford. In other parts of the city, employment is expected to grow more slowly or to decline slightly. The SA Government forecasts that employment will decline in the areas around the port.

Although people travel for a variety of purposes, the journey between home and work is a key driver of travel demand at peak times. Demographic projections indicate that most of Adelaide's population growth will occur in outer areas. The CBD is expected to strengthen its role as the city's principal employment centre and is likely to attract and generate significant numbers of trips. Emerging employments hubs in the north and south will dampen some of this travel demand, however overall the disconnect between where people live and work is expected to widen, increasing the magnitude of the transport task.

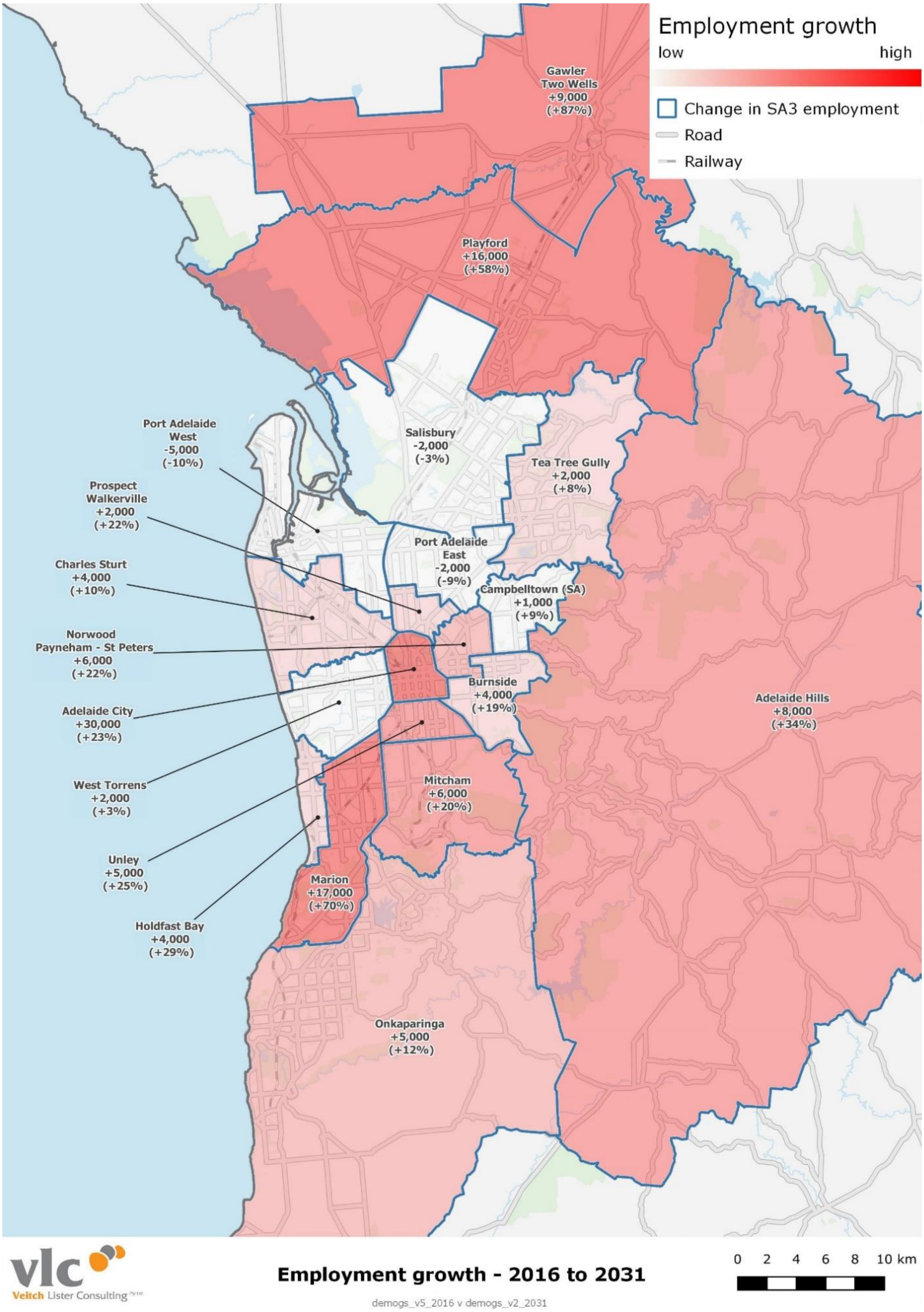
Figure 2-4 – Adelaide GCCSA employment density and SA3 totals in 2016

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

Figure 2-5 – Adelaide GCCSA employment density and SA3 totals in 2031 scenario

Source: SA Government, via Infrastructure Australia, disaggregated to Zenith travel zones

Figure 2-6 – Adelaide GCCSA employment growth by SA3 2016 to 2031 forecast



Source: South Australian Government, via Infrastructure Australia, disaggregated to Zenith travel zones

2.2 Transport networks

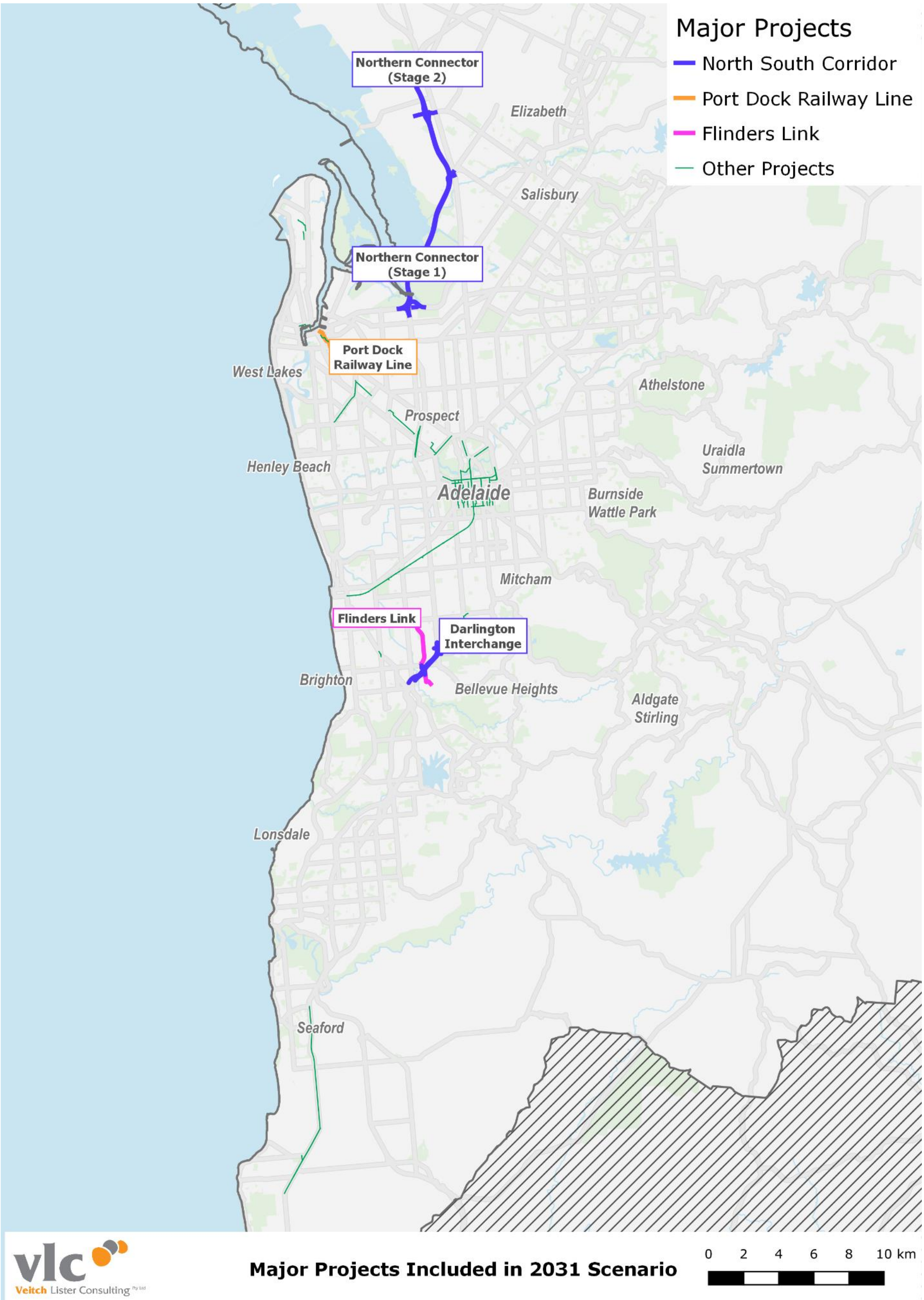
The transport network assumed in transport modelling determines how (and how easily) people will get between their homes, jobs, schools, shops and other activity areas. The 2031 transport network for Adelaide has been developed using a minimal-intervention approach. Included projects were (at the time 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. Some of the most significant projects are described in more detail below and can be referenced in Figure 2-7. A full list of network assumptions can be found in Appendix A.

Northern Connector *is a new 15.5 kilometre section of freeway connecting the North-South Motorway and Port River Expressway from Wingfield in the south to the Northern Expressway at Waterloo Corner in the north. This project forms part of the North-South Corridor running from Old Noarlunga to Gawler. This is one of Adelaide's most important corridors, and the Northern Connector will help link Adelaide's growing northern suburbs to the city's centre. In the south, another part of the North-South Corridor is the* ***Darlington Upgrade Project.*** *This project will upgrade the connection between Main South Road and the Southern Expressway, removing major intersections.*

Flinders Link *extends the Tonsley rail line to the health, innovation and education precincts at Flinders Medical Centre and Flinders University.*

An additional spur will be added to the Outer Harbour rail line with the ***Port Dock Railway Line*** *connecting Port Adelaide to Adelaide's metropolitan rail network.*

Figure 2-7 – Major projects included in 2031 forecast



Public transport services are assumed to improve to 2031 (Table 2-1). Buses provide the largest share of in-service kilometres in Adelaide, and by 2031 bus service kilometres are assumed to increase by around 25 per cent, largely to service the expanded residential areas. Rail plays a relatively minor role in both the 2016 and 2031 networks. Rail service frequencies are assumed to stay constant in most time periods with the growth in rail service kilometres driven by extensions to the rail network (Port Dock and Flinders Link extensions). The exception to this is the off-peak time period, in which rail service kilometres more than double by 2031, this is a result of the more services in the evenings (announced in the 2017 State Budget). With only one route, trams play a small part in the network. Nevertheless, tram service kilometres are expected to grow strongly, driven by increased frequencies and a recently completed extension in the CBD. While the overall provision of public transport increases in Adelaide, the network improvements assumed in this study are incremental.

Table 2-1 – Adelaide GCCSA weekday public transport service kilometres[1]

Metric	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	2,300	2,500	+200	+7%
	Inter-peak (9AM-4PM)	6,300	6,600	+400	+6%
	PM peak (4-6PM)	2,200	2,300	+200	+7%
	Off-peak (6PM-7AM)	4,000	9,000	+5,100	+128%
	Daily total	**14,700**	**20,500**	**+5,700**	**+39%**
Bus	AM peak (7-9AM)	28,000	35,000	+6,900	+25%
	Inter-peak (9AM-4PM)	67,600	85,400	+17,800	+26%
	PM peak (4-6PM)	27,300	33,900	+6,600	+24%
	Off-peak (6PM-7AM)	35,100	43,700	+8,600	+25%
	Daily total	**158,100**	**198,000**	**+39,900**	**+25%**
Tram	AM peak (7-9AM)	500	700	+200	+44%
	Inter-peak (9AM-4PM)	1,300	1,900	+500	+38%
	PM peak (4-6PM)	500	700	+200	+39%
	Off-peak (6PM-7AM)	900	1,500	+700	+76%
	Daily total	**3,200**	**4,800**	**+1,600**	**+50%**
Total	AM peak (7-9AM)	30,800	38,100	+7,300	+24%
	Inter-peak (9AM-4PM)	75,200	93,900	+18,700	+25%
	PM peak (4-6PM)	30,000	37,000	+7,000	+23%
	Off-peak (6PM-7AM)	40,000	54,300	+14,300	+36%
	Daily total	**176,000**	**223,300**	**+47,300**	**+27%**

[1] Note that service kilometres include all public transport lines servicing the Adelaide GCCSA (and not exclusively kilometres operating within the Adelaide GCCSA).

3. Travel demands

The population growth projected for Adelaide is likely to increase the transport task by 2031. 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 is expected to increase by just under a quarter (24%, Table 3-1). This is somewhat above the population growth of around 18 per cent. This reflects the way the Zenith model responds to a decrease in average household size into the future within the SA 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.

In 2031 car travel is predicted to retain its dominance, making up around 86 per cent of total trips. This is a very slight decrease from its 2016 share (87%). Public transport trips grow faster than both car and active (walk and cycle) trips, growing by 31 per cent between 2016 and 2031. As a result, public transport's share of trips increases slightly to 5 per cent (up from 4% in 2016, Figure 3-1). This is a result of the increased time and monetary costs of car travel (congestion and a real increase in parking charges) which makes public transport more competitive (for detailed model assumptions see Appendix D:).

At a network level the net increase in public transport trips is relatively small (around 47,000 trips) compared to the increase in car trips (around 732,000, Figure 3-2). The very slight increase in public transport's share of trips (and the corresponding decrease in car's share) reflects that despite increased delays, residents of Adelaide will still find driving to be the most convenient option for most of their travel.

Table 3-1 – Adelaide GCCSA person trips by mode

Mode	Time period	2016	2031	Change	% change
Car	AM peak (7-9AM)	504,000	617,000	+113,000	+22%
	Inter-peak (9AM-4PM)	1,388,000	1,724,000	+336,000	+24%
	PM peak (4-6PM)	532,000	655,000	+123,000	+23%
	Off-peak (6PM-7AM)	661,000	820,000	+159,000	+24%
	Daily total	**3,084,000**	**3,816,000**	**+732,000**	**+24%**
Public transport	AM peak (7-9AM)	34,000	43,000	+10,000	+29%
	Inter-peak (9AM-4PM)	63,000	82,000	+19,000	+30%
	PM peak (4-6PM)	32,000	42,000	+10,000	+30%
	Off-peak (6PM-7AM)	24,000	33,000	+9,000	+36%
	Daily total	**153,000**	**199,000**	**+47,000**	**+31%**
Walk and cycle	AM peak (7-9AM)	49,000	59,000	+11,000	+22%
	Inter-peak (9AM-4PM)	162,000	201,000	+40,000	+25%
	PM peak (4-6PM)	50,000	62,000	+12,000	+23%
	Off-peak (6PM-7AM)	71,000	89,000	+18,000	+26%
	Daily total	**331,000**	**412,000**	**+80,000**	**+24%**
Total	AM peak (7-9AM)	586,000	719,000	+133,000	+23%
	Inter-peak (9AM-4PM)	1,612,000	2,007,000	+395,000	+24%
	PM peak (4-6PM)	614,000	759,000	+145,000	+24%
	Off-peak (6PM-7AM)	756,000	942,000	+186,000	+25%
	Daily total	**3,568,000**	**4,427,000**	**+859,000**	**+24%**

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

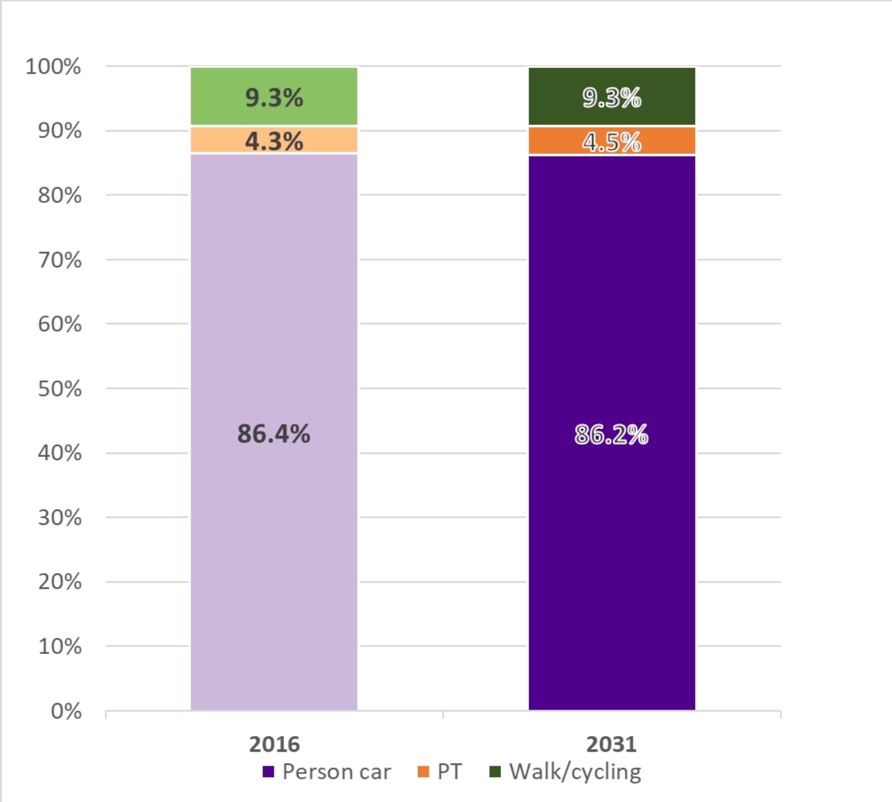
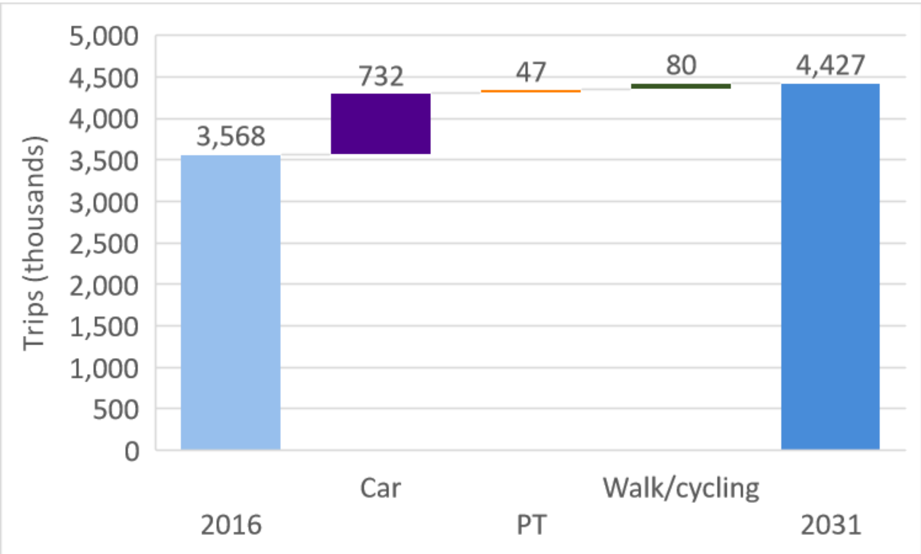


Figure 3-2 – Adelaide GCCSA growth in weekday person trips, 2016 to 2031



3.2 Growth in vehicle travel

Traffic on the road network is split between car (95%) and commercial vehicles (5%). Significant growth is forecast for both types of vehicles (23% for cars and 21% for commercial vehicles) (Table 3-2 and Table 3-3).[2]

Table 3-2 – Adelaide GCCSA weekday car traffic statistics

Mode	Time period	2016	2031	Change	% change
Trips	AM peak (7-9AM)	460,000	561,000	+101,000	+22%
	Inter-peak (9AM-4PM)	1,257,000	1,556,000	+299,000	+24%
	PM peak (4-6PM)	497,000	611,000	+113,000	+23%
	Off-peak (6PM-7AM)	628,000	777,000	+148,000	+24%
	Daily total	**2,843,000**	**3,505,000**	**+662,000**	**+23%**
Kilometres	AM peak (7-9AM)	5,066,000	6,468,000	+1,402,000	+28%
	Inter-peak (9AM-4PM)	12,907,000	16,612,000	+3,705,000	+29%
	PM peak (4-6PM)	5,556,000	7,116,000	+1,560,000	+28%
	Off-peak (6PM-7AM)	7,352,000	9,365,000	+2,013,000	+27%
	Daily total	**30,881,000**	**39,560,000**	**+8,680,000**	**+28%**
Hours	AM peak (7-9AM)	135,000	194,000	+60,000	+44%
	Inter-peak (9AM-4PM)	264,000	353,000	+89,000	+34%
	PM peak (4-6PM)	145,000	209,000	+65,000	+45%
	Off-peak (6PM-7AM)	136,000	171,000	+35,000	+26%
	Daily total	**679,000**	**928,000**	**+249,000**	**+37%**
Average assigned speed (kph)	AM peak (7-9AM)	38	33	-4	-12%
	Inter-peak (9AM-4PM)	49	47	-2	-4%
	PM peak (4-6PM)	38	34	-4	-11%
	Off-peak (6PM-7AM)	54	55	+1	+1%
	Daily total	**45**	**43**	**-3**	**-6%**

[2] See section Appendix D: for VLC's commercial vehicle definitions.

Table 3-3 – Adelaide GCCSA weekday commercial vehicle traffic statistics

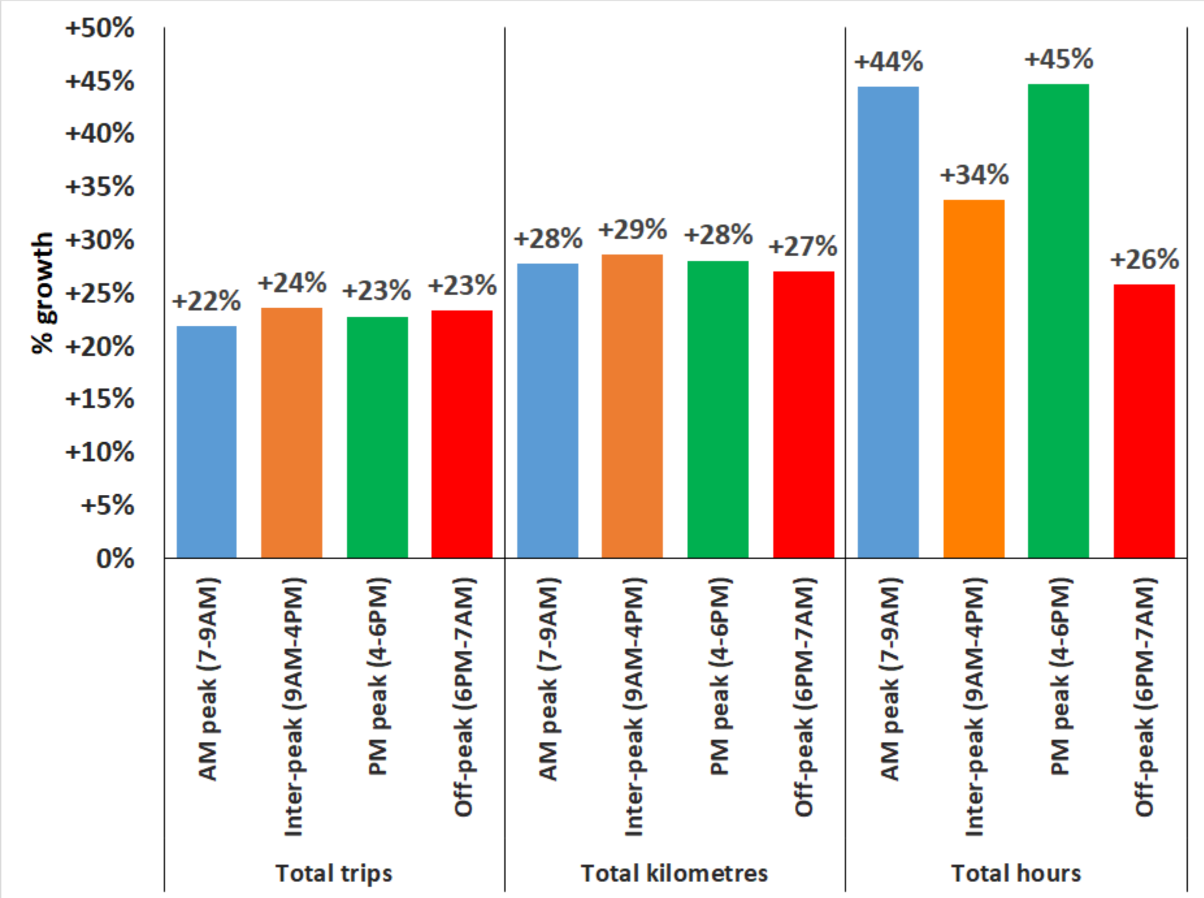
Metric	Time period	2016	2031	Change	% change
Trips	AM peak (7-9AM)	23,000	27,000	+5,000	+20%
	Inter-peak (9AM-4PM)	74,000	90,000	+16,000	+22%
	PM peak (4-6PM)	26,000	32,000	+6,000	+23%
	Off-peak (6PM-7AM)	34,000	41,000	+6,000	+19%
	Daily total	**158,000**	**191,000**	**+33,000**	**+21%**
Kilometres	AM peak (7-9AM)	242,000	313,000	+71,000	+29%
	Inter-peak (9AM-4PM)	798,000	1,017,000	+218,000	+27%
	PM peak (4-6PM)	276,000	354,000	+77,000	+28%
	Off-peak (6PM-7AM)	421,000	513,000	+92,000	+22%
	Daily total	**1,738,000**	**2,197,000**	**+459,000**	**+26%**
Hours	AM peak (7-9AM)	6,000	9,000	+3,000	+45%
	Inter-peak (9AM-4PM)	16,000	20,000	+5,000	+31%
	PM peak (4-6PM)	7,000	10,000	+3,000	+44%
	Off-peak (6PM-7AM)	7,000	9,000	+2,000	+21%
	Daily total	**36,000**	**48,000**	**+12,000**	**+34%**

Total vehicle kilometres are forecast to grow by around 28 per cent across an average day between 2016 and 2031, slightly above overall trip growth (around 23%, Figure 3-3). This indicates a slight increase in trip lengths – a result of the population growth in outer areas and employment concentration in the central area.

Substantial increases in vehicle hours are forecast in the AM and PM periods (44% and 45% respectively). 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). In contrast, vehicle hours are forecast to grow more slowly in the inter-peak (34%) and off-peak (26%). This profile highlights how congestion is forecast to affect road network performance:

- The worst deterioration is expected in peak periods – a result of higher levels of congestion,
- A moderate deterioration is forecast in the inter-peak, when congestion is more limited, and
- Marginal delays are forecast for the off-peak, when the road network is relatively uncongested.

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



3.3 Growth in public transport ridership

By 2031 the demand placed on the public transport network is expected to increase. This is reflected in the key public transport metrics, with public transport boardings, in-vehicle passenger kilometres and in-vehicle passenger hours predicted to grow by at least a third (Table 3-4).

The increased popularity of public transport is a result of mode shift from cars, a response to both increased road congestion and higher levels of public transport service provision. In the peak periods, road congestion accounts for most of this growth. In contrast, the increased ridership in the off-peak (6PM-7AM) is primarily driven by the significant increase in public transport service levels (particularly extra rail services). Overall, the growth rates set out in Table 3-4 indicate that public transport is expected to play a slightly more important role in Adelaide's transport network in 2031 than it does today.

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 – Adelaide GCCSA weekday public transport metrics

Metric	Time period	2016	2031	Change	% change
Boardings	AM peak (7-9AM)	54,000	73,000	+19,000	+34%
	Inter-peak (9AM-4PM)	102,000	136,000	+35,000	+34%
	PM peak (4-6PM)	53,000	73,000	+19,000	+37%
	Off-peak (6PM-7AM)	33,000	48,000	+14,000	+42%
	Daily total	**242,000**	**329,000**	**+87,000**	**+36%**
In-vehicle passenger kilometres	AM peak (7-9AM)	462,000	644,000	+182,000	+39%
	Inter-peak (9AM-4PM)	764,000	1,051,000	+287,000	+38%
	PM peak (4-6PM)	426,000	587,000	+161,000	+38%
	Off-peak (6PM-7AM)	264,000	379,000	+114,000	+43%
	Daily total	**1,916,000**	**2,661,000**	**+745,000**	**+39%**
In-vehicle passenger hours	AM peak (7-9AM)	16,000	23,000	+7,000	+47%
	Inter-peak (9AM-4PM)	24,000	33,000	+9,000	+39%
	PM peak (4-6PM)	15,000	21,000	+6,000	+44%
	Off-peak (6PM-7AM)	9,000	12,000	+3,000	+38%
	Daily total	**63,000**	**89,000**	**+26,000**	**+42%**

Rail boardings are forecast to increase across the day (Table 3-5). The strongest growth is in the off-peak (rail boardings are forecast to double) and is driven by more services during this period (section

2.2). In the other periods boardings are still forecast to grow substantially. Rather than increased levels of service provision, this growth largely reflects that rail is expected to become more competitive with car travel, particularly in the peak periods where road congestion is at its highest level. Boardings on buses are forecast to grow more moderately (by 29% across the day), broadly in line with the increased level of service provision.

Boardings on Adelaide's tram network are expected to grow strongly by 2031. Increasing road congestion in areas in which the tram operates, coupled with the tram priority infrastructure that makes the service more immune to congestion, likely encourages some users to switch from car. The tram network also undergoes a short extension which further increases the number of boardings.

Table 3-5 – Adelaide GCCSA weekday public transport boardings

Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	11,000	18,000	+6,000	+53%
	Inter-peak (9AM-4PM)	19,000	28,000	+9,000	+45%
	PM peak (4-6PM)	11,000	17,000	+6,000	+57%
	Off-peak (6PM-7AM)	6,000	13,000	+7,000	+105%
	Daily total	**48,000**	**76,000**	**+28,000**	**+58%**
Bus	AM peak (7-9AM)	42,000	53,000	+12,000	+28%
	Inter-peak (9AM-4PM)	80,000	104,000	+24,000	+30%
	PM peak (4-6PM)	40,000	51,000	+12,000	+29%
	Off-peak (6PM-7AM)	25,000	31,000	+6,000	+23%
	Daily total	**186,000**	**240,000**	**+53,000**	**+29%**
Tram	AM peak (7-9AM)	900	1,900	+900	+100%
	Inter-peak (9AM-4PM)	2,700	4,400	+1,700	+63%
	PM peak (4-6PM)	2,500	4,200	+1,700	+66%
	Off-peak (6PM-7AM)	1,500	2,900	+1,500	+100%
	Daily total	**7,600**	**13,300**	**+5,700**	**+76%**

The distance travelled by passengers on the rail network increases substantially between 2016 and 2031 (57% in the AM peak and 56% in the PM peak), a reflection of population growth in outer areas (Table 3-6).

The increase in bus passenger kilometres is more modest (26% across the day), indicating that bus trips are forecast to remain shorter than rail trips.

By 2031 the tram network has been extended, as such tram passenger kilometres are also expected to increase.

Table 3-6 – Adelaide GCCSA weekday in-vehicle passenger kilometres

Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	176,000	277,000	+101,000	+57%
	Inter-peak (9AM-4PM)	273,000	411,000	+138,000	+51%
	PM peak (4-6PM)	164,000	256,000	+92,000	+56%
	Off-peak (6PM-7AM)	84,000	167,000	+83,000	+98%
	Daily total	**698,000**	**1,112,000**	**+414,000**	**+59%**
Bus	AM peak (7-9AM)	282,000	360,000	+77,000	+27%
	Inter-peak (9AM-4PM)	486,000	631,000	+145,000	+30%
	PM peak (4-6PM)	257,000	321,000	+65,000	+25%
	Off-peak (6PM-7AM)	175,000	205,000	+30,000	+17%
	Daily total	**1,200,000**	**1,517,000**	**+317,000**	**+26%**
Tram	AM peak (7-9AM)	3,500	7,000	+3,500	+100%
	Inter-peak (9AM-4PM)	5,200	8,400	+3,300	+64%
	PM peak (4-6PM)	5,200	9,800	+4,600	+90%
	Off-peak (6PM-7AM)	4,700	6,400	+1,700	+36%
	Daily total	**18,600**	**31,700**	**+13,200**	**+71%**

Growth in rail passenger hours (Table 3-7) closely mirrors the growth rates for passenger kilometres (Table 3-6). In contrast, bus passenger hours grow faster than bus passenger kilometres – particularly in peak periods – a result of delay imposed by road congestion on buses in mixed traffic (Chapter 5).

Table 3-7 – Adelaide GCCSA weekday in-vehicle passenger hours

Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	4,000	6,000	+2,000	+60%
	Inter-peak (9AM-4PM)	6,000	9,000	+3,000	+51%
	PM peak (4-6PM)	4,000	6,000	+2,000	+59%
	Off-peak (6PM-7AM)	2,000	4,000	+2,000	+102%
	Daily total	**16,000**	**25,000**	**+10,000**	**+62%**
Bus	AM peak (7-9AM)	12,000	17,000	+5,000	+41%
	Inter-peak (9AM-4PM)	18,000	24,000	+6,000	+34%
	PM peak (4-6PM)	11,000	15,000	+4,000	+38%
	Off-peak (6PM-7AM)	6,000	7,000	+1,000	+18%
	Daily total	**46,000**	**62,000**	**+16,000**	**+35%**
Tram	AM peak (7-9AM)	200	400	+200	+109%
	Inter-peak (9AM-4PM)	300	500	+200	+51%
	PM peak (4-6PM)	300	500	+200	+71%
	Off-peak (6PM-7AM)	300	400	+100	+39%
	Daily total	**1,100**	**1,800**	**+700**	**+64%**

4. Road network performance

The previous section demonstrated that travel demand across Adelaide is expected to increase significantly by 2031. This section analyses the likely impacts of increased demand on the performance of the road network 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 during a period of the day. 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.

By 2031, traffic is forecast to grow substantially on Adelaide's road network (Figure 4-1). Traffic volumes on the North-South Motorway are expected to grow very strongly. The new Northern Connector – which feeds the North-South Motorway at its northern end – provides additional capacity to Adelaide's growing northern suburbs (section 2.1). The Northern Connector is predicted to redirect some traffic from the Port Wakefield Road and Salisbury Highway corridor. Sections of the North-South Corridor (made up of the North-South Motorway, South Rd and Main South Road), also benefit from an upgrade to motorway standard, relieving traffic on the remaining surface road sections (such as the section crossing Port Road). These improvements, along with the Darlington Upgrade near Bellevue Heights, strengthen the North-South Corridor as Adelaide's primary road spine. This corridor is also fed by the strong population growth in the city's south, which is evident in the substantial increase in traffic forecast on the Southern Expressway.

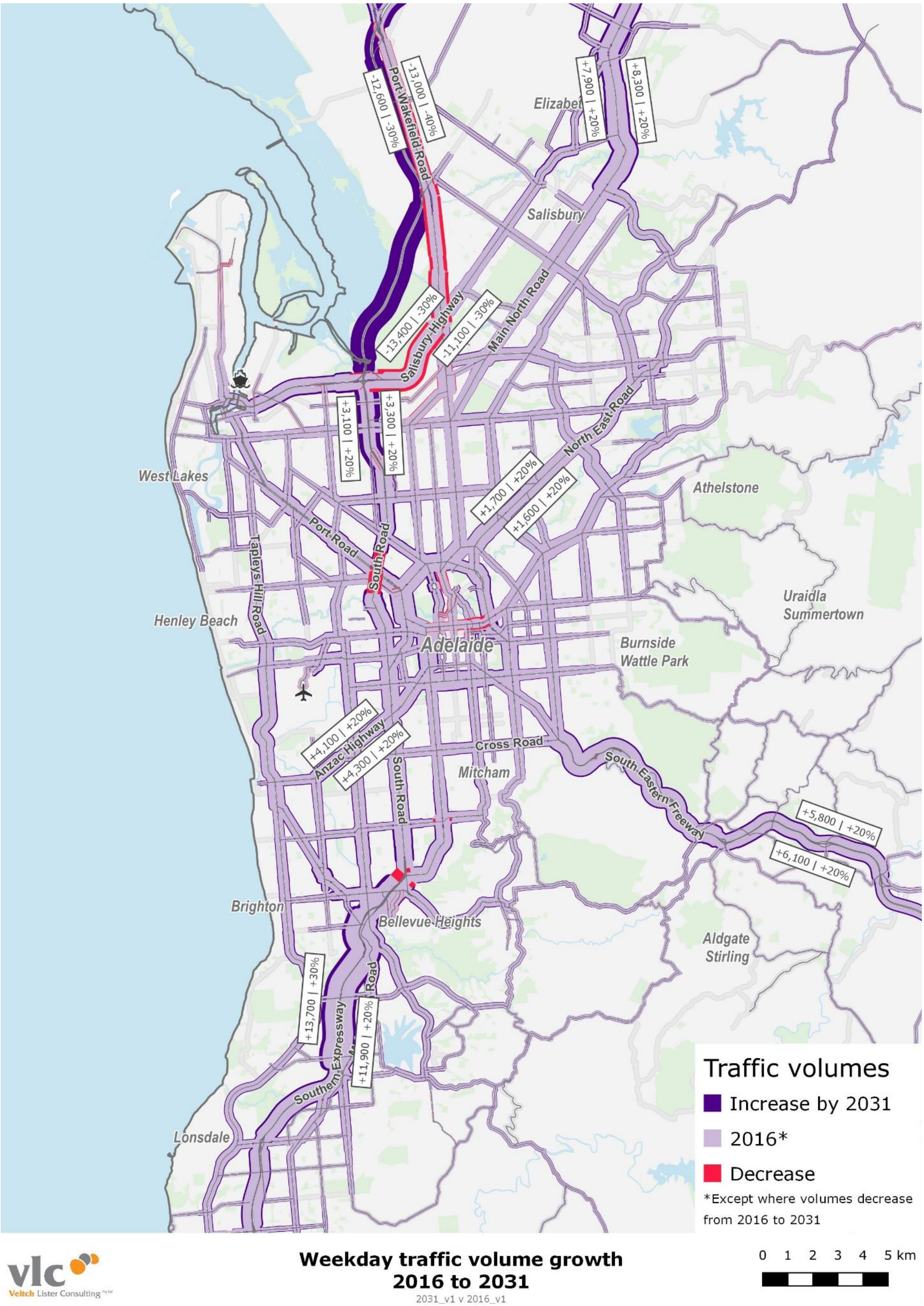
Strong traffic growth is forecast on the arterial roads serving both Elizabeth and the areas south of Bellevue Heights. These areas are Adelaide's emerging employment hubs (section 2.1). A significant portion of this traffic growth is a driven by increased activity in these areas.

In terms of demand from the south east, traffic on the South Eastern Freeway is predicted to increase. This is likely a reflection of both the projected population growth in Adelaide Hills as well as the fact that it is the only major highway providing passage through the region.

North-south travel is the movement for which there is expected to be the strongest demand. This demand is relatively evenly distributed across Adelaide's north-south arterial network. Evidence of this can be seen just south of the CBD, where relatively similar traffic volumes are forecast for roads running perpendicular to Cross Road.

Although the highest concentration of heavily utilised roads is on the routes surrounding the CBD, the Tapleys Hill corridor – which runs north-south along the coast – is also forecast to carry substantial additional traffic. This emphasises that although the CBD is a strong attractor, it is north-south travel movements (as opposed to CBD-bound movements) that dominate. As such, some of the demand on the radial corridors such as Port Road, North East Road and Anzac Highway is driven by cross-city as well as CBD-bound travel.

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



The following images illustrate the levels of congestion observed in 2016 and in 2031 (Figure 4-3 to Figure 4-6). The colour of the bandwidth indicates the level of congestion, and the width is proportional to the volume of traffic using this link. (Minor roads have been excluded for clarity, as these links generally 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 (there are some short sections of the road network that are managed in the 2031 forecast for Adelaide).

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

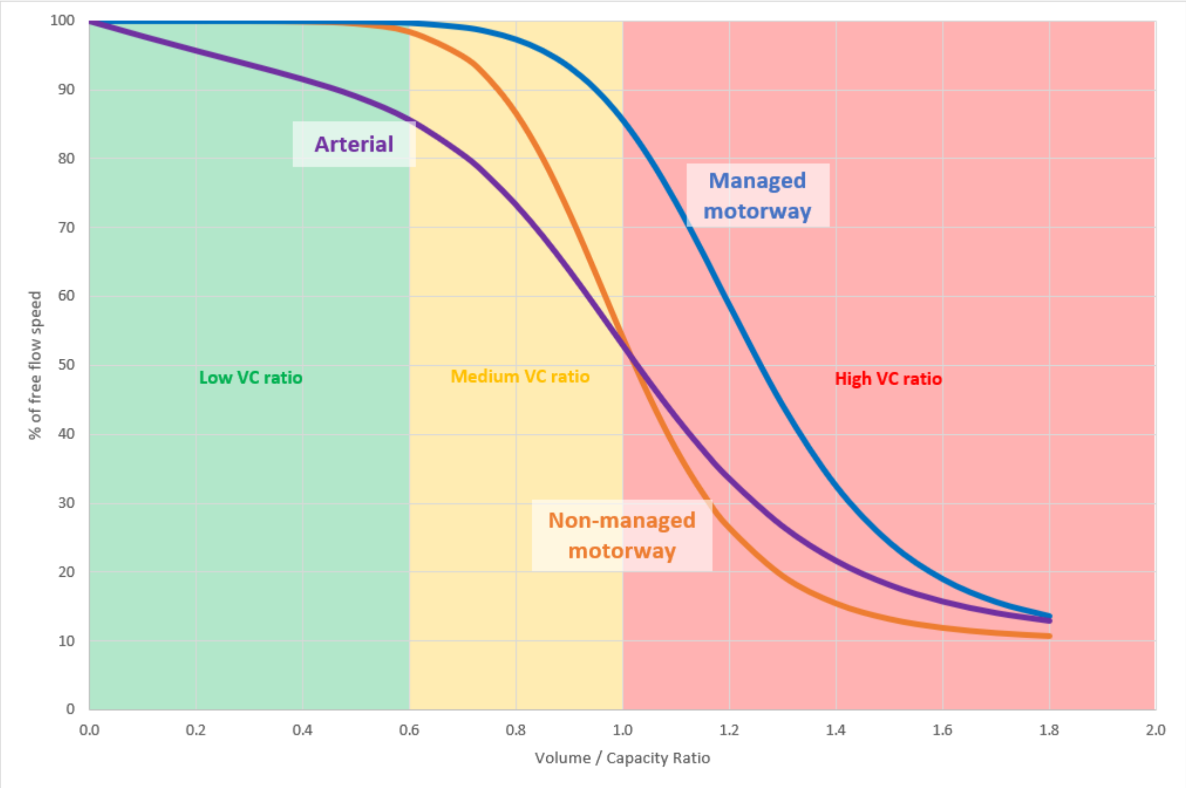


Figure 4-3 and Figure 4-4 indicate high levels of congestion on north-south routes in the peak periods. The highest concentration of congested links appears to be just south of the CBD where demand for travel in the peak direction results in traffic volumes approaching or exceeding road capacity. Most prominently, the Main South Road/South Road corridor carries high volumes of traffic and is congested for most of its length. This corridor is also relatively busy in the counter peak direction. Other heavily utilised links are the South Eastern Freeway and Tapleys Hill Road from Glenelg north.

The highest levels of congestion are predicted for the key links immediately north of the CBD. Modelling also indicates congestion on the radial corridors in the inner north east, with demand on corridors such as North-East Road approaching capacity. In contrast, Port Road and the major connections to Port Adelaide seem relatively uncongested.

In the city’s north, the major links to Adelaide’s outer northern suburbs come under significant pressure, with congestion on Port Wakefield Road and Main North Road.

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

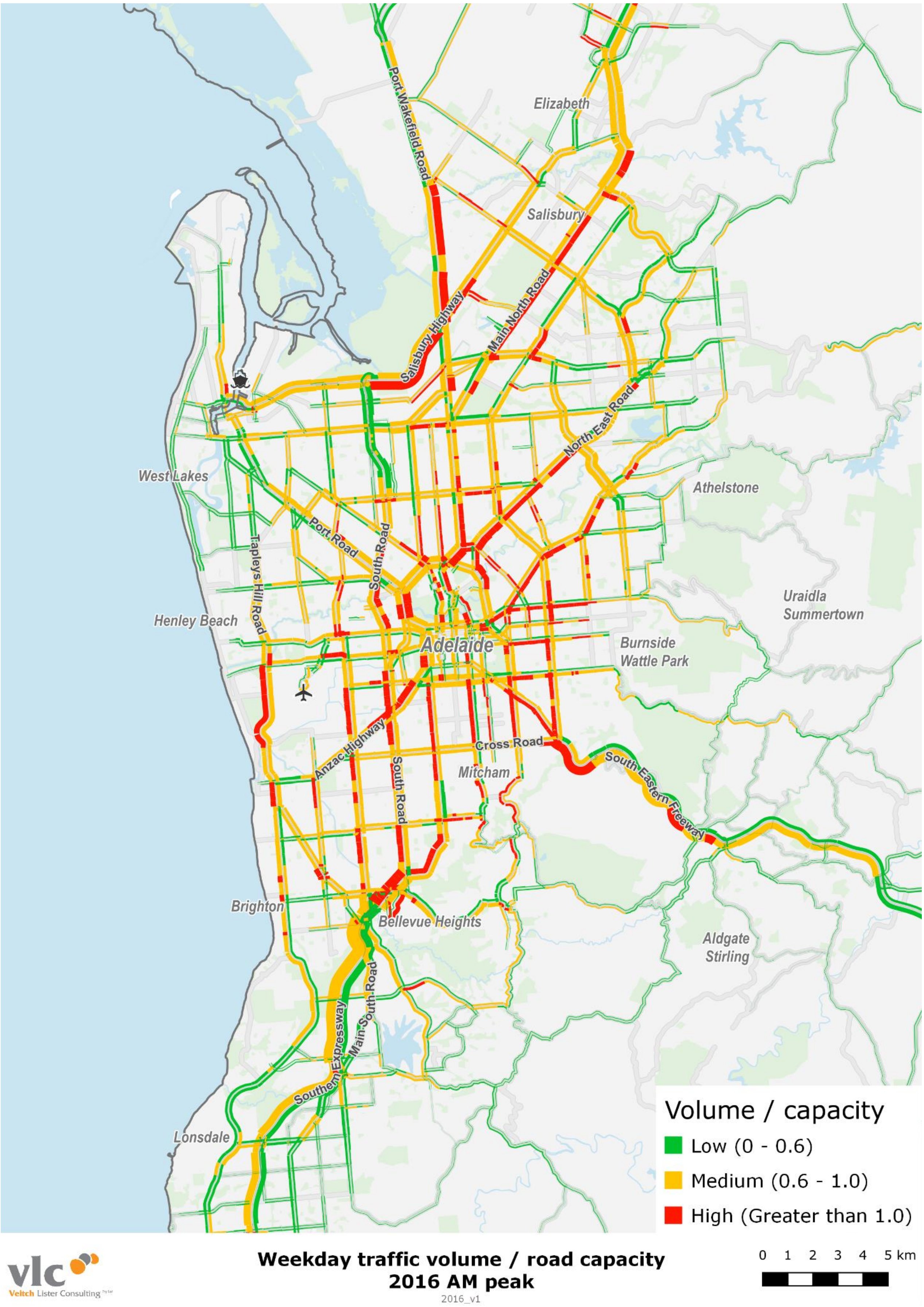
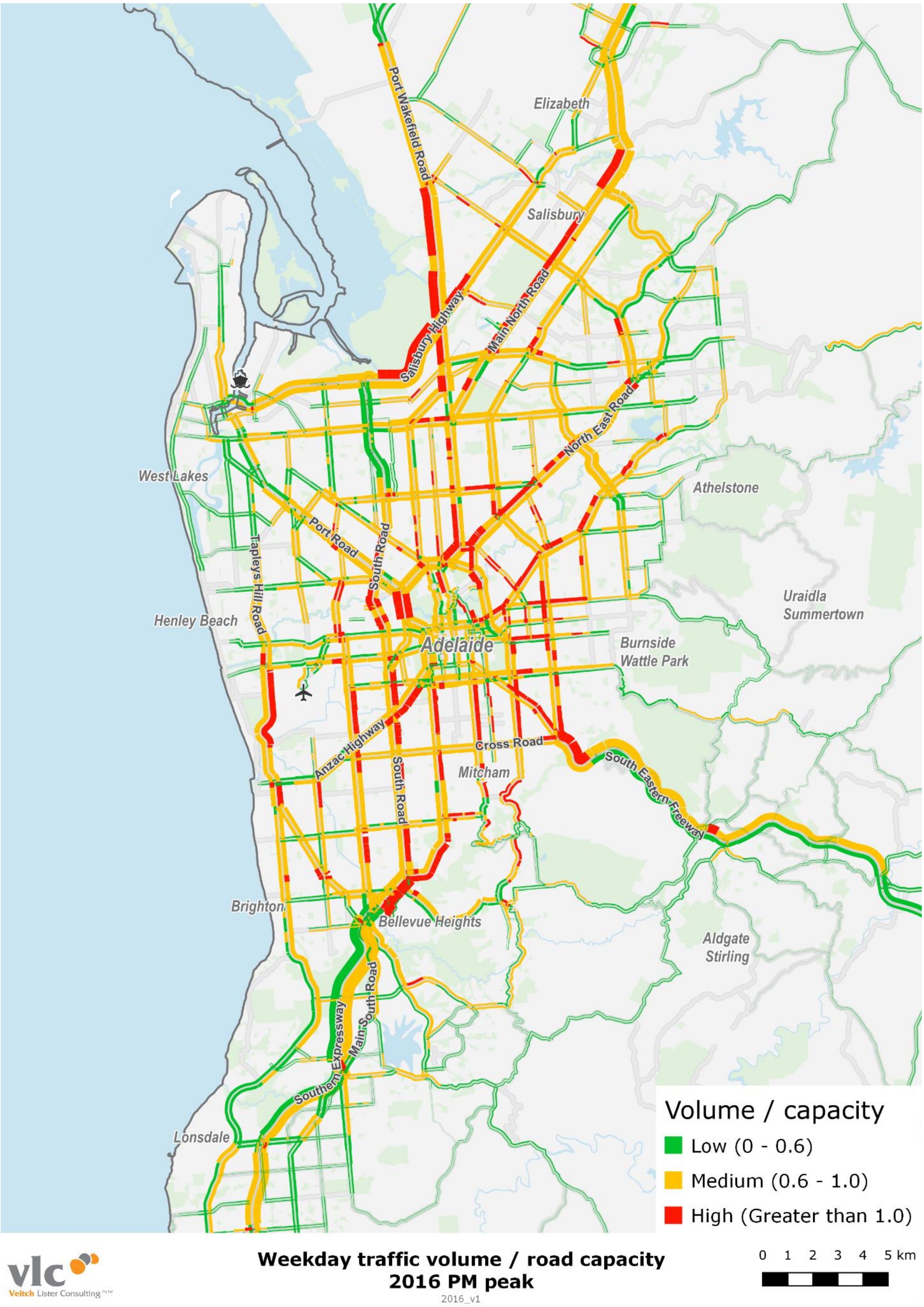


Figure 4-4 – Adelaide GCCSA weekday traffic volume / road capacity - 2016 1-hour PM peak



By 2031, peak period congestion on Adelaide's road network is forecast to increase significantly (Figure 4-5 and Figure 4-6). In general, the worst congestion is expected to occur within about five kilometres of the CBD. As in 2016, the north-south routes are much more congested than the east-west corridors. On the major north-south roads, severe congestion is predicted be more prevalent around and south of the CBD than is forecast further north. This is likely a reflection of the lack of a high standard motorway serving the southern half of the city by 2031 (i.e. prior to the assumed completion of the full North-South Corridor, which is ultimately planned to convert Main South Rd to non-stop motorway). In the morning peak, high volumes of traffic pass through Sturt on the Southern Expressway and are fed onto the north-south arterials.

Roads in Adelaide's south are expected to struggle to cater for north bound demand in the morning (Figure 4-5) and south bound in the evening (Figure 4-6). In a similar way, heavy congestion is forecast both on the South Eastern Freeway itself as well as onto the arterials it connects with.

Along Adelaide's eastern shore, congestion is forecast for the Tapleys Hill Road corridor in both directions in the peak periods. This is likely to be a result of substantial population growth in the inner north eastern suburbs (as was identified in section 2.1).

In the north, the addition of the Northern Connector is expected to relieve congestion on the Port Wakefield Road and Salisbury Highway corridor. The increased importance of the northern activity centres can be seen in the form of increased traffic through Elizabeth and Salisbury. There is also evidence of high levels of demand outstripping supply on local links in the northern growth areas. Nevertheless, the infrastructure provided in the northern suburbs is expected to perform better than in the south.

Traffic congestion in Adelaide is forecast to increase, and by 2031 the performance of many north-south routes will deteriorate significantly. In general, the worst congestion is expected in the inner city and on the arterials serving the southern suburbs. This indicates that the level of demand placed on the road network is likely to exceed its ability to provide reasonable levels of service to motorists.

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

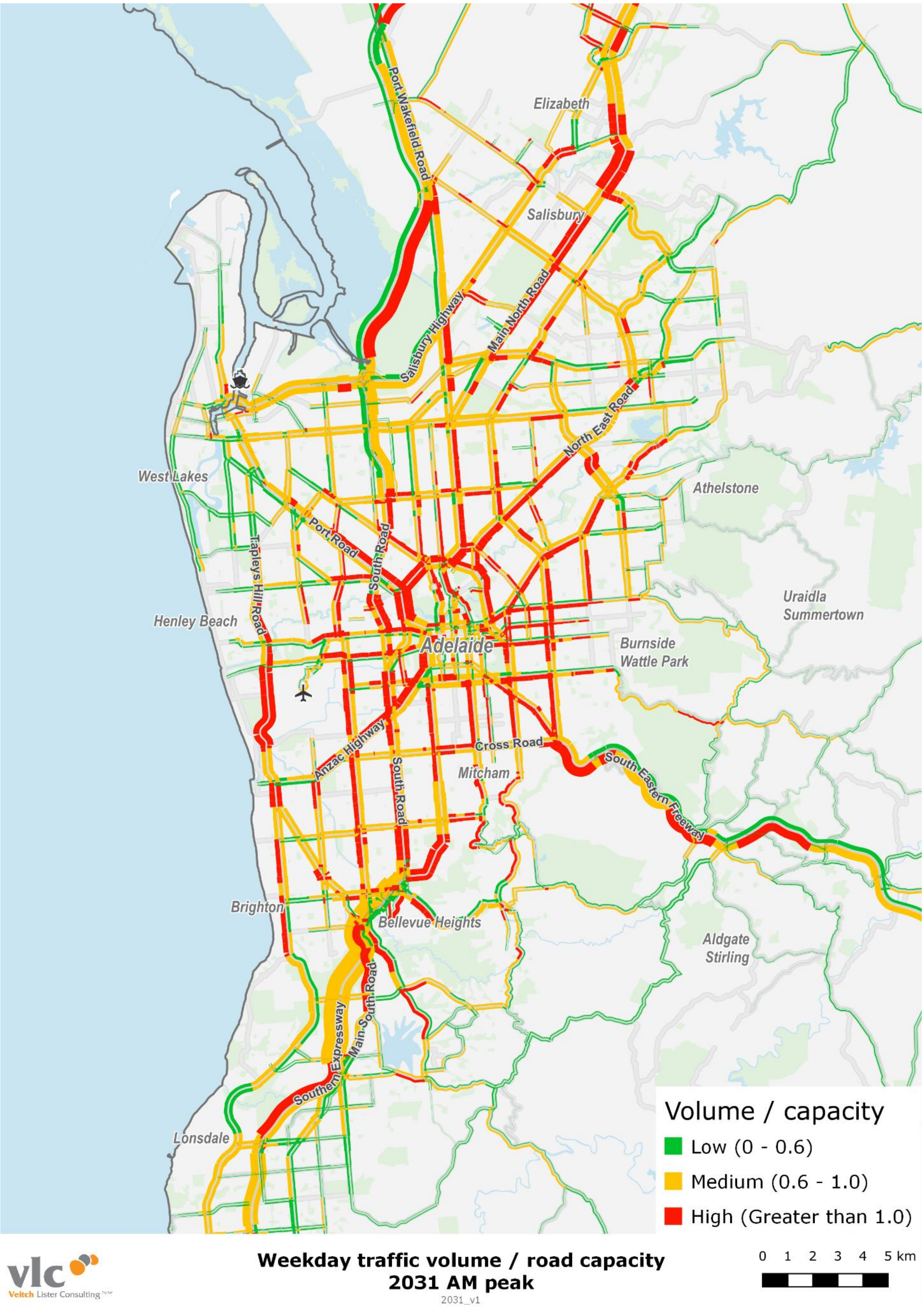
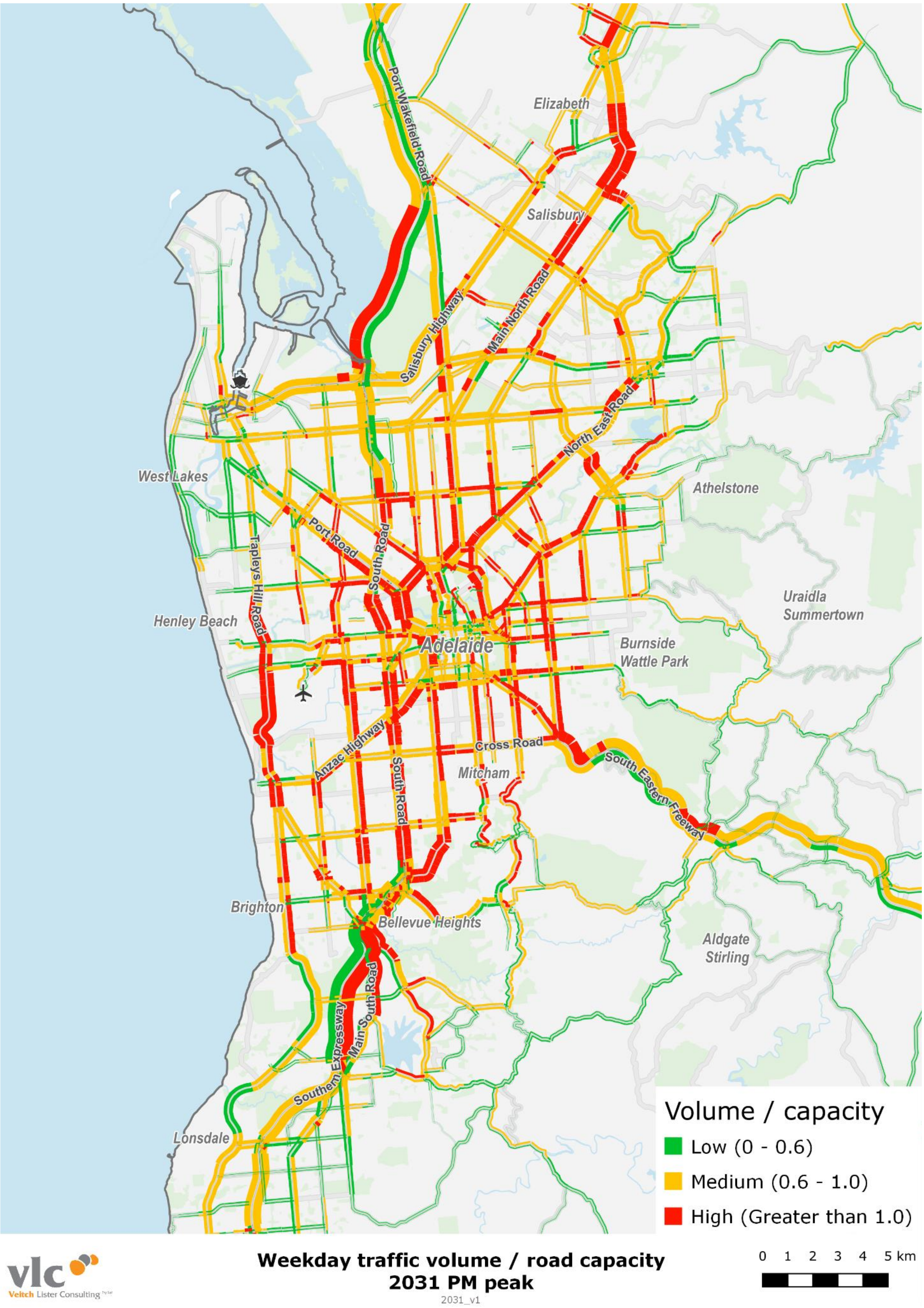
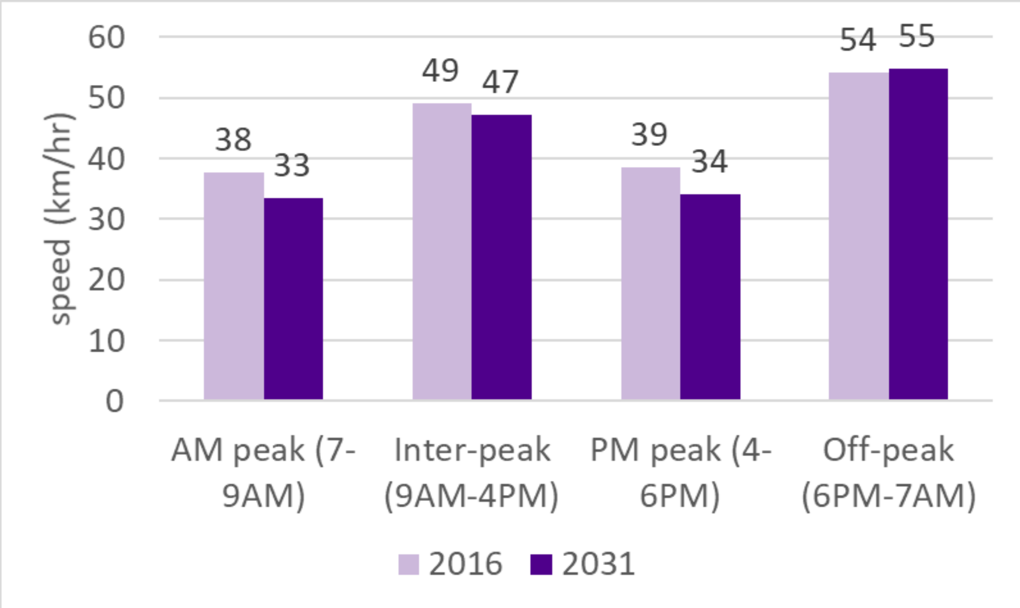


Figure 4-6 – Adelaide GCCSA weekday traffic volume / road capacity - 2031 1-hour PM peak



Average vehicle speeds on the road network are expected to decline by approximately five kilometres per hour in the AM and PM peak periods. In the middle of day, average speed is forecast to decline slightly (about 2km/h), reflecting the worsening congestion occurring on the network. During the off-peak time period the network is relatively uncongested, the slight increase in speed is a function of the small expansion of high-speed freeway network kilometres in the overall network.

Figure 4-7 – Adelaide GCCSA total average assigned speed



Congestion causes substantial delay hours for vehicles on the road network (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. Traffic delay is forecast to increase substantially by 2031 (by around 82% across the day).

Table 4-1 – Adelaide GCCSA road network total delay hours

Time period	2016	2031	Change	% change
AM peak (7-9AM)	45,000	83,000	+38,000	+84%
Inter-peak (9AM-4PM)	37,000	67,000	+30,000	+83%
PM peak (4-6PM)	47,000	87,000	+40,000	+86%
Off-peak (6PM-7AM)	9,000	14,000	+5,000	+53%
Daily total	**137,000**	**250,000**	**+113,000**	**+82%**

5. Public transport system performance

This section analyses the impact of passenger demand on Adelaide's public transport network.

Adelaide's public transport system is largely radial, with most train, bus and tram routes providing access to central areas either directly, or in the case of bus feeder routes, through interchanges. As a result, peak direction city-centric movements dominate. Unlike other cities, buses perform the majority of Adelaide's public transport task and have the greatest number of passenger kilometres, passenger hours and boardings (see section 3.3). Rail travel is also prominent, serving the far north and south. The role of Adelaide's tram route is restricted to the corridors in which it operates, however patronage is expected to grow to into the future in part due to the city extension.

Usage of Adelaide's rail system is expected to increase to 2031, particularly on the rail lines linking outer suburbs in the north and south. The Gawler line is expected to carry nearly 3,000 extra passengers in and out of the city each day (Figure 5-1). Much of the patronage increase occurs on the outer section of the line, with around 2,500 extra passengers just north of Elizabeth. High levels of population growth in outer areas are likely to drive this growth. The outer section of the Seaford line – which serves Adelaide's growing south – is also forecast to experience substantial patronage growth.

In the inner west, the Outer Harbour and Grange lines are projected to carry approximately 2,300-2,500 extra daily passengers in each direction by 2031. Overall, the modelling indicates that by 2031, the rail system will deliver around 25,000 passengers to Adelaide Railway Station each weekday - an increase of roughly 9,000 passengers - with a similar number using the station to travel out bound.

Adelaide's bus network includes high capacity corridors, feeder services and local services (Figure 5-2). The strongest patronage growth is expected on the O-Bahn, which serves the city's north-east, attracting approximately 2,000 extra passengers per direction each day. The O-Bahn is forecast to be one of Adelaide's most important public transport corridors, delivering around 7,000 passengers into and out of the city each day. Patronage growth is also expected for Adelaide's other prominent bus corridors such as the south eastern bus corridor from the Adelaide Hills and the Main South Road corridor in the south.

In addition to a line haul function, buses also feed the rail lines. Stations at which significant numbers of bus-rail transfers can be observed are labelled in Figure 5-2. Patronage on these routes is forecast to grow, especially on the routes serving outer areas. Evidence of this can be seen at Elizabeth Station in the north.

Adelaide currently has a single tram corridor connecting Gawler and the city. In 2031, extensions and extra services in the city have been modelled and are forecast to attract additional patronage (Figure 5-3). Passenger loads between Gawler and the city are also predicted to increase.

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

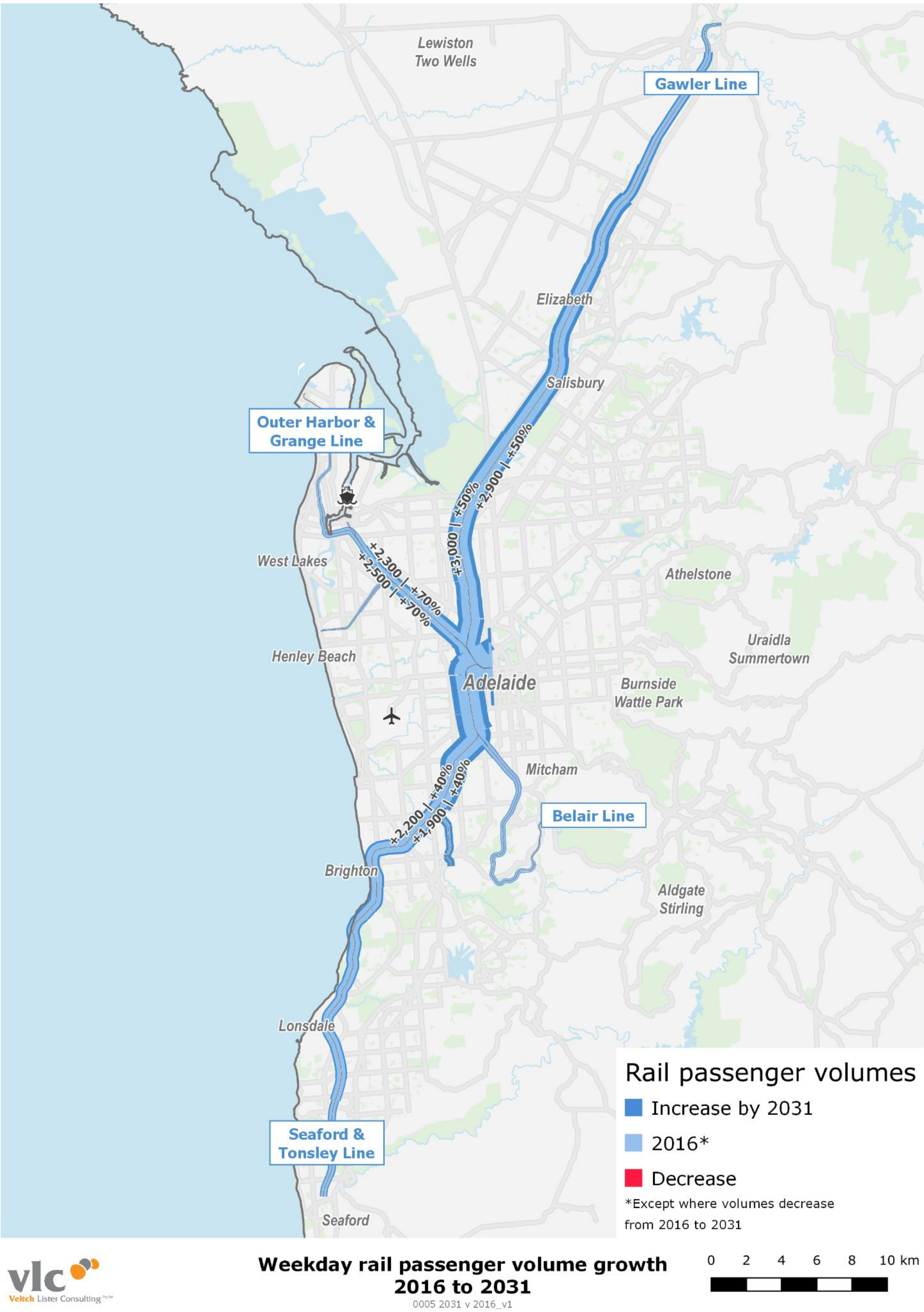


Figure 5-2 – Adelaide GCCSA weekday bus passenger volume growth - 2016 to 2031

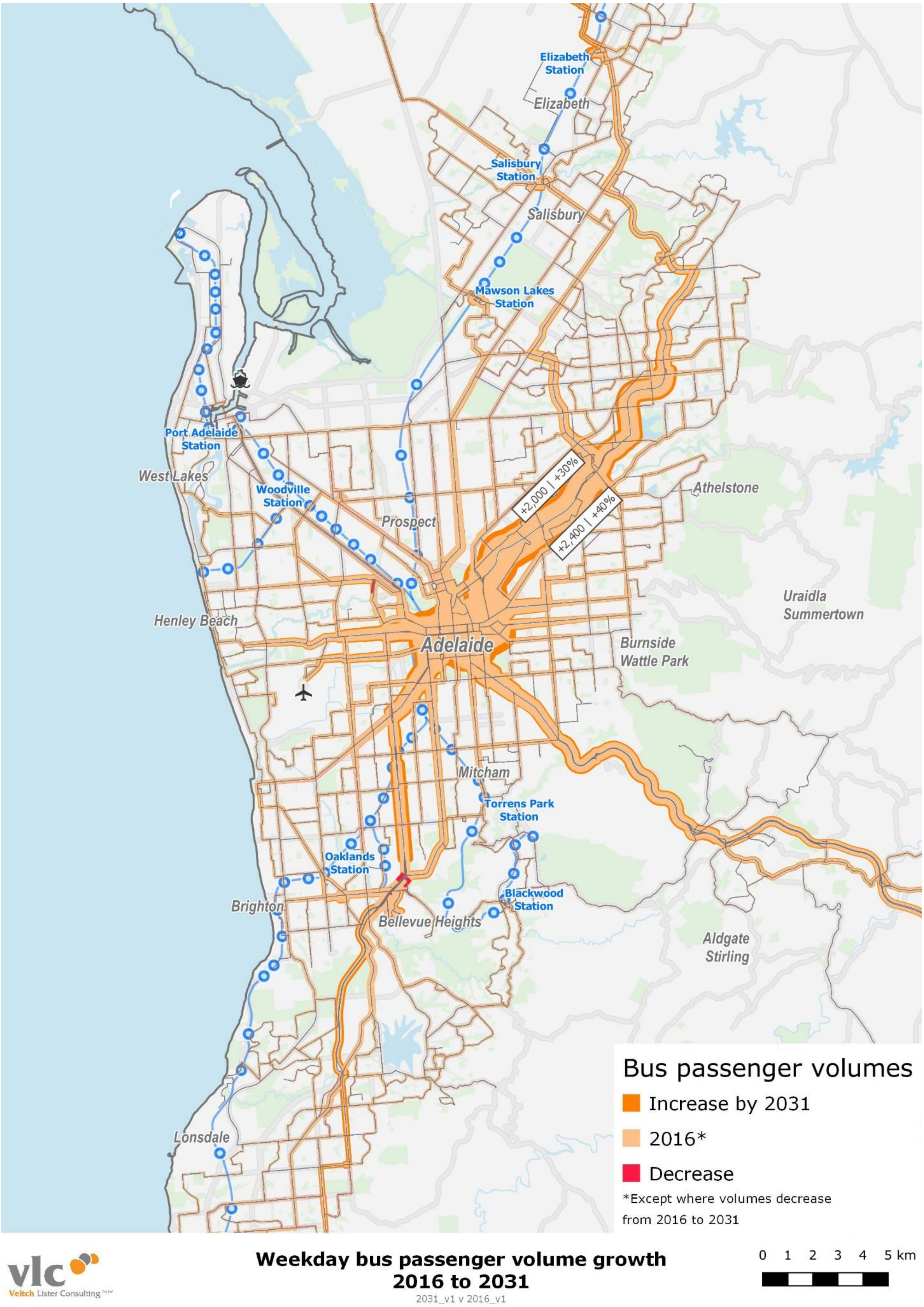
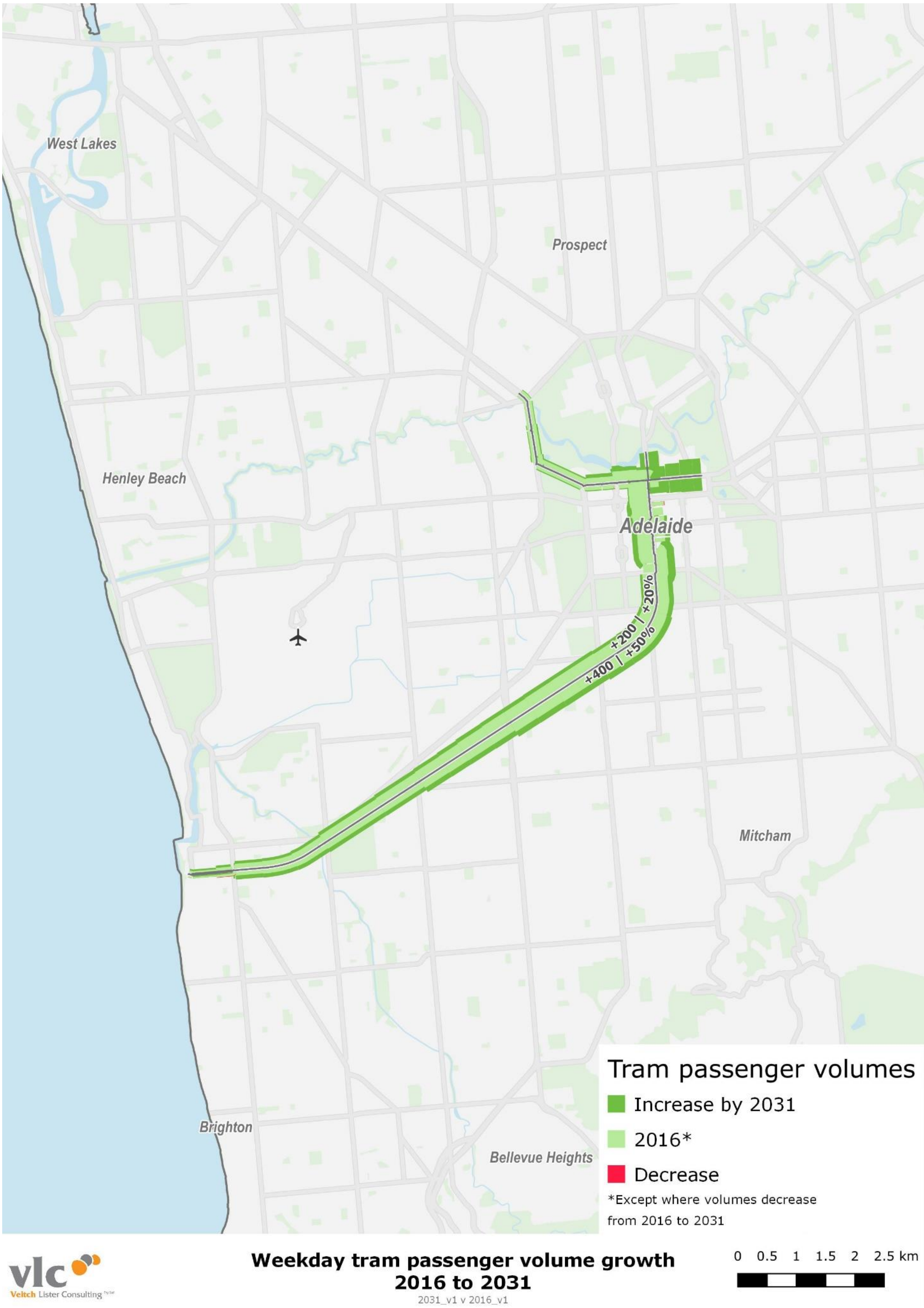


Figure 5-3 – Adelaide GCCSA weekday tram passenger volume growth - 2016 to 2031



The rest of this chapter focuses on crowding on the public transport network. 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.

In the morning, suburban rail services become more crowded as they approach the Adelaide CBD (Figure 5-4). The reverse can be observed in Figure 5-5, as commuters return home. In 2016, crowding in peak periods was not widespread.

By 2031, increased rail patronage is expected to lead to moderate levels of crowding in the peak periods on the southern and northern approaches to the CBD (Figure 5-6 and Figure 5-7). Crowding along the Gawler line is expected to occur further north than was observed in 2016. The worst levels of crowding expected on the rail network are forecast to the south of Salisbury, however passenger numbers are not expected to exceed train crush capacities. On the other sections of the network crowding is projected to remain relatively light.

Adelaide’s rail network is expected to remain relatively underutilised by 2031. Crowding levels are generally low and there is the potential for increased ridership, especially as the rail network connects the major growth areas in the north and south.

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).

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

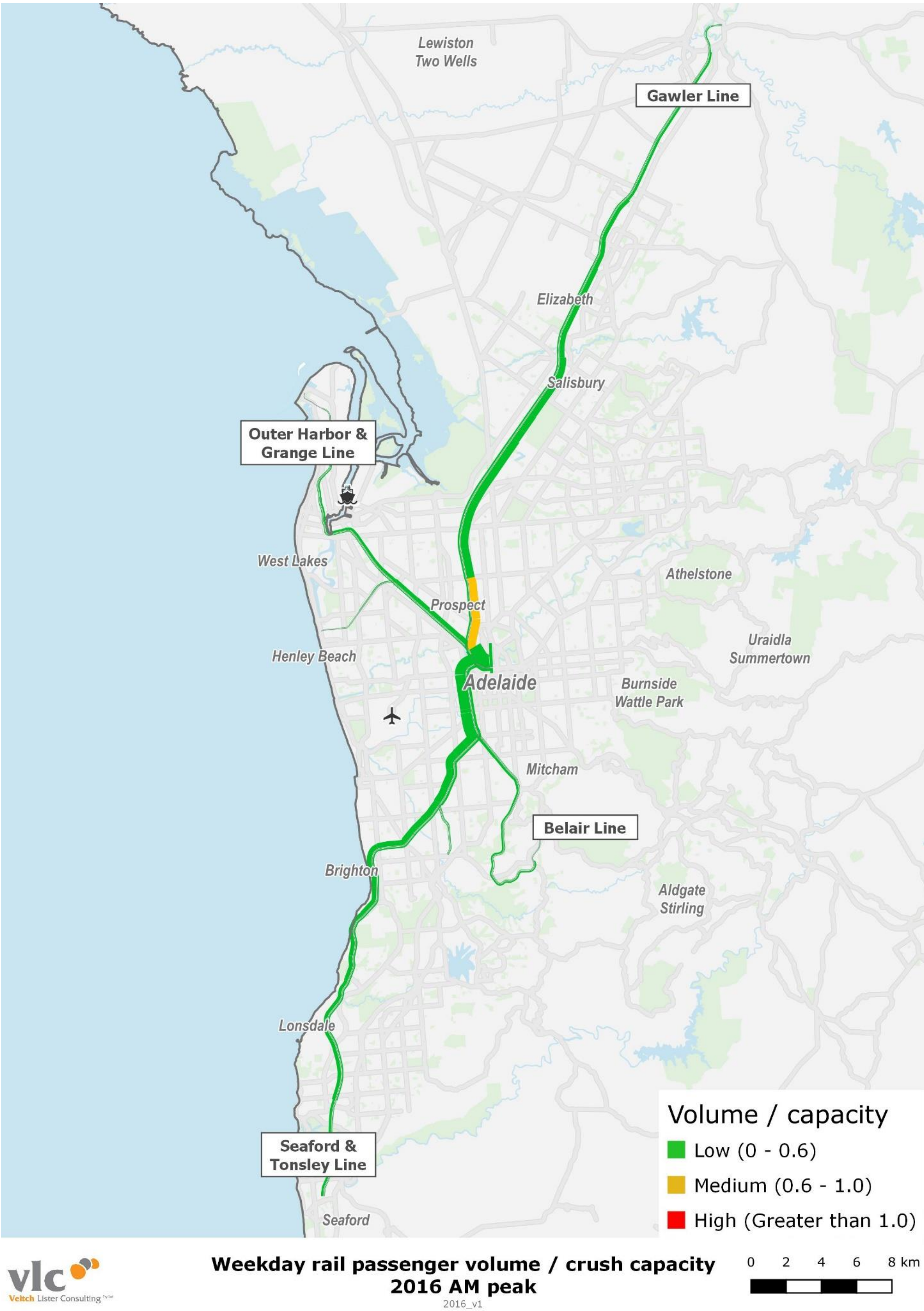


Figure 5-5 – Adelaide GCCSA weekday rail passenger volume / crush capacity - 2016 1-hour PM peak

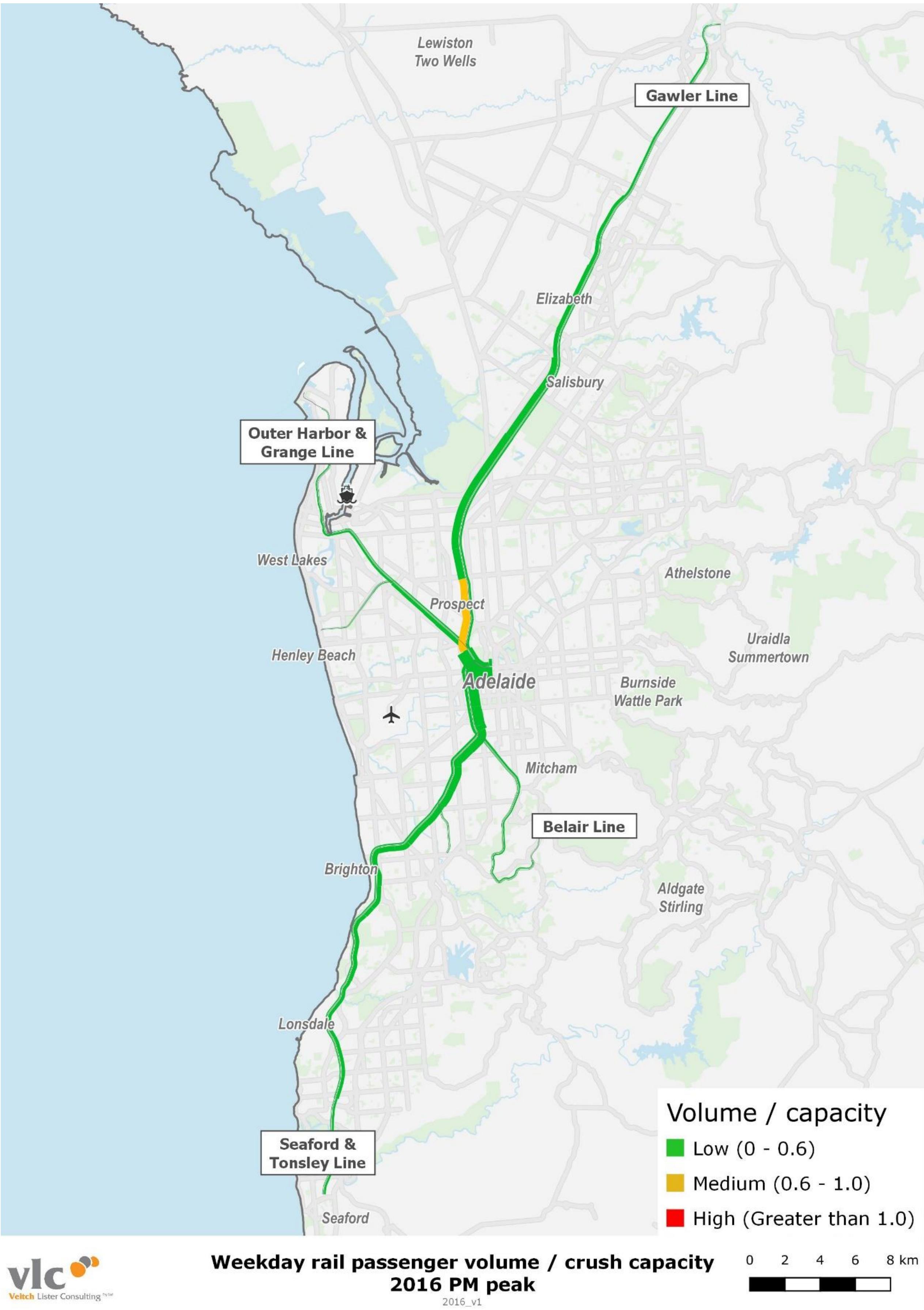


Figure 5-6 – Adelaide GCCSA weekday rail passenger volume / crush capacity - 2031 1-hour AM peak

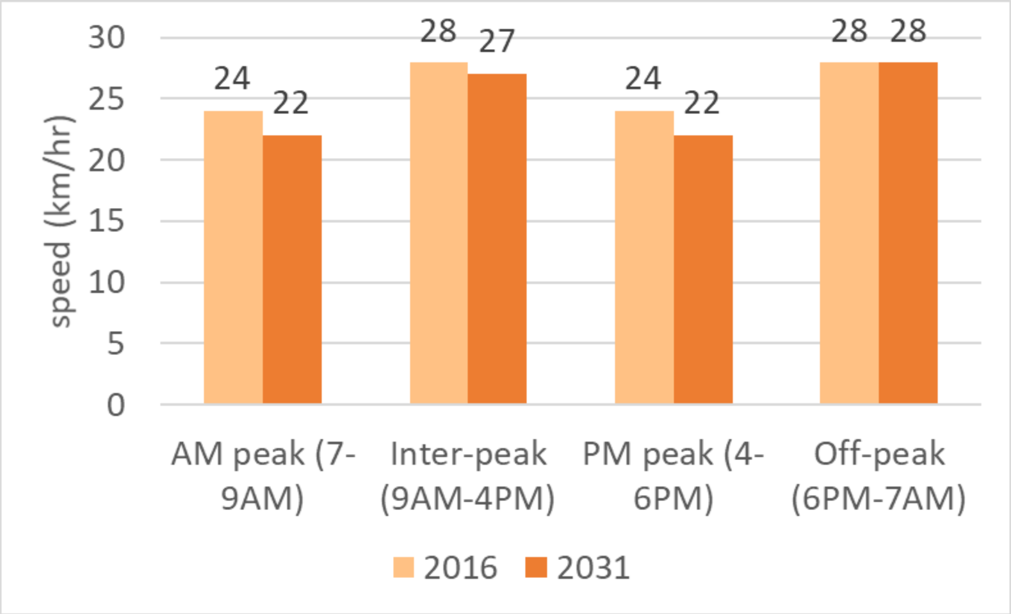
Figure 5-7 – Adelaide GCCSA weekday rail passenger volume / crush capacity - 2031 1-hour PM peak

Users of Adelaide's bus network in the 2016 peak periods would generally experience low levels of crowding (Figure 5-9 and Figure 5-10). The busiest buses are on the south eastern corridor, particularly beyond Stirling where high volume capacity ratios probably reflect low levels of service provision and limited alternative public transport options.

At a network level, crowding on Adelaide's bus network remains relatively minor in 2031 (Figure 5-11 and Figure 5-12). Nevertheless, some routes are expected to become busy, particularly in growth areas such as between Elizabeth and Salisbury in the north.

Bus speeds are most affected by traffic congestion in the AM and PM peak periods. Average speeds are expected to decline by approximately two kilometres per hour during these periods (Figure 5-8). There is a very small increase in inter-peak bus delay in 2031 and negligible delay in the off-peak. The relatively minor impact of congestion at a network level demonstrates the benefit of bus separation from general traffic on key corridors such as the O-Bahn.

Figure 5-8 – Adelaide GCCSA average bus speeds



Reasonably low levels of crowding and existing high-quality bus infrastructure mean that Adelaide's bus network is well-positioned to attract new users. The strong demand from the south eastern hills presents an opportunity to further increase ridership, as buses can most easily serve these areas. New and more frequent bus services also have the potential both to reinforce the success of existing corridors and to further complement the rail system.

Figure 5-9 – Adelaide GCCSA weekday bus passenger volume / crush capacity - 2016 1-hour AM peak

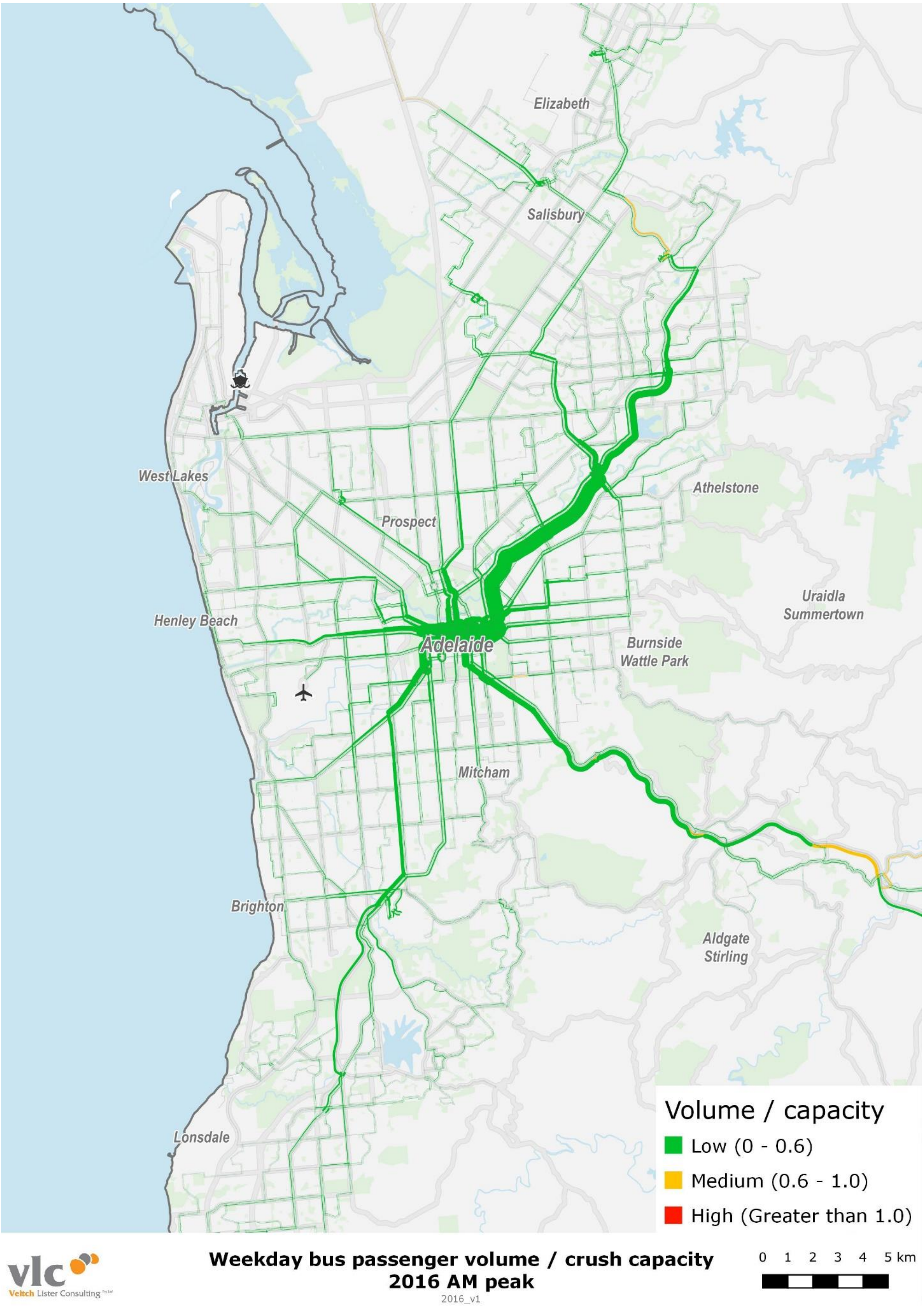


Figure 5-10 – Adelaide GCCSA weekday bus passenger volume / crush capacity - 2016 1-hour PM peak

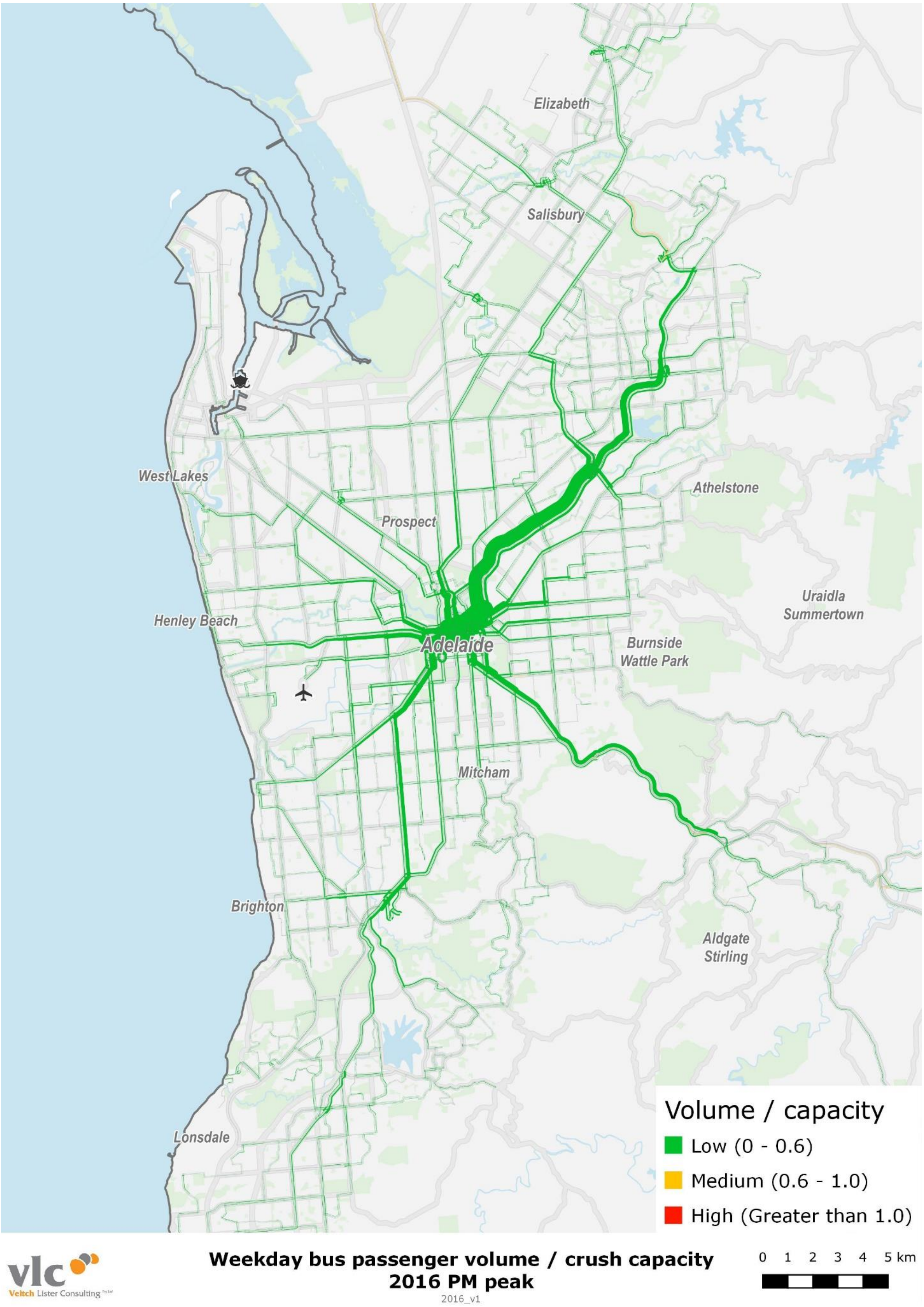


Figure 5-11 – Adelaide GCCSA weekday bus passenger volume / crush capacity - 2031 1-hour AM peak

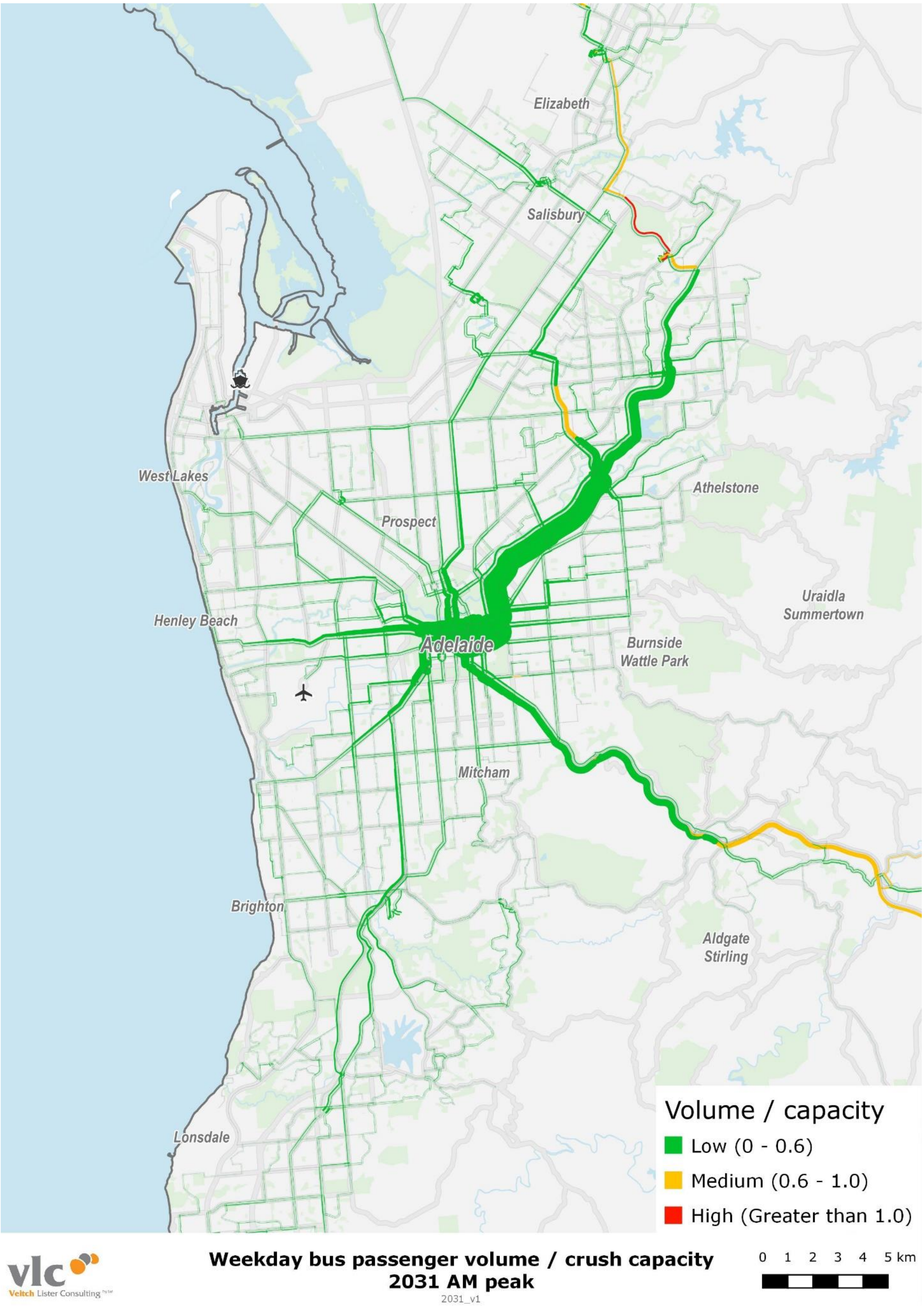
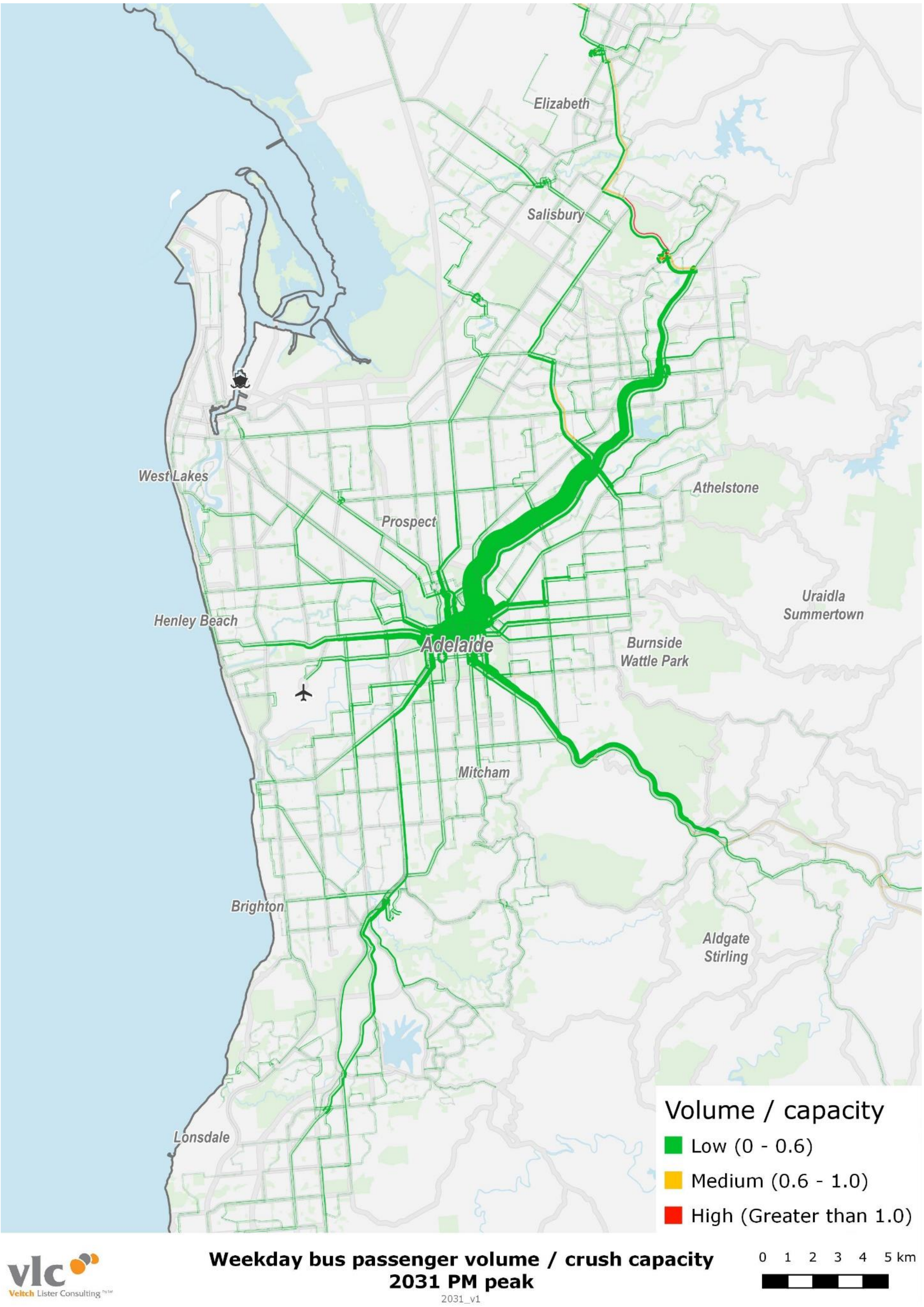
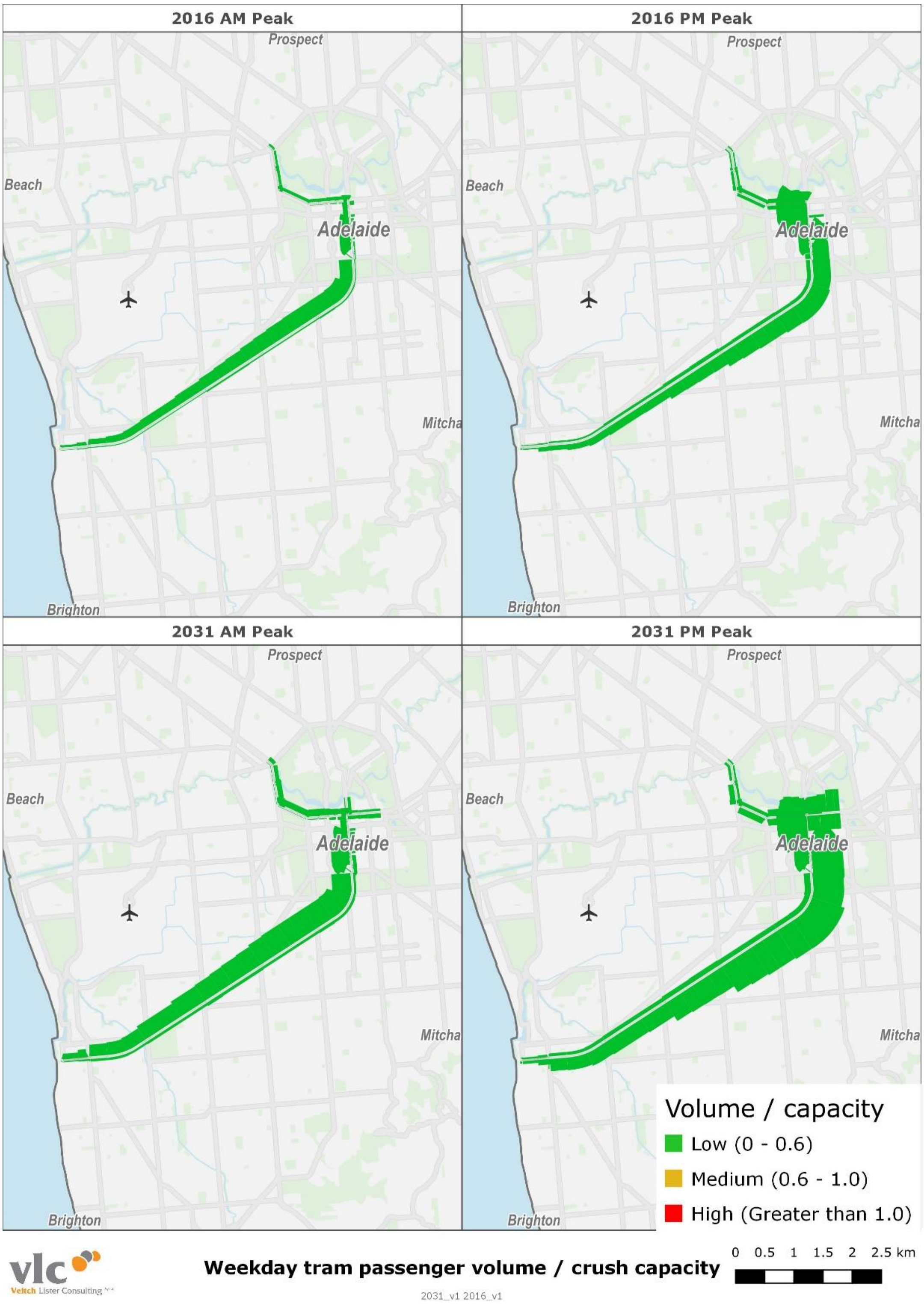


Figure 5-12 – Adelaide GCCSA weekday bus passenger volume / crush capacity - 2031 1-hour PM peak



Crowding is currently light on Adelaide's Glenelg tram (Figure 5-13). This low crowding is expected to continue to 2031, suggesting there is an opportunity to grow ridership on the network. Because it serves both the dense CBD and areas with high amounts of recreational activity (beaches and parks), the tram network is uniquely positioned to integrate well with active transport. For instance, improved cycling infrastructure around the light rail corridor could increase its catchment and encourage higher ridership.

Figure 5-13 – Adelaide GCCSA weekday tram passenger volume / crush capacity - 2016 and 2031 AM and PM peaks (1-hour)



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 Adelaide 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.

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Table 6-1 – Accessibility to 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 SA 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 average Adelaide resident with access to a car is within 5 minutes of schools and childcare services in the 2016 AM peak (Table 6-2). By 2031, this is forecast to increase slightly with these services within a six-minute car trip. Those dependent on public transport are likely to have to travel for longer, generally within 25 minutes, with public secondary schools averaging 31 minutes. Between 2016 and 2031 public transport trip times are forecast to decrease slightly, reflecting the modest modelled improvements in service frequencies and the limited impact of future road congestion on bus travel times even in the peak periods. In high growth SA3s (Playford, Adelaide Hills and Gawler-Two Wells) the population is added in areas that are comparatively well connected to public transport. The result is a substantial decrease in population weighted travel times for these SA3s (Table 6-3).

Table 6-2 – Adelaide 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	3.9	4.5	23.4	23.4
Public primary school	3.1	3.5	18.3	18.5
Public secondary school	5.5	6.5	31.6	31.4

In the 2031 AM peak, residents of most of Adelaide's suburbs are forecast to be able to reach a range childcare centres within a 5-minute drive (Figure 6-1). Similar travel times are predicted for access to public primary schools with slightly longer travel times to public secondary schools (Figure 6-3 and Figure 6-5). While most areas have relatively good accessibility, longer travel times are estimated in outer areas, particularly Adelaide's north. In part, these longer times in outer areas reflect a limitation of the model's resolution (i.e. larger travel zones in these areas, so population-weighted measures are subject to greater uncertainty).

The lower measured car accessibility in most areas in 2031 is simply due to gradually increasing congestion. The largest decreases in car accessibility is in outer growth areas, and in these cases the measured deterioration is more likely to be a function of significant population growth and limited supply of both transport and social infrastructure in greenfield areas. Additionally, the modelling limitations noted above (large travel zones and an absence of projected childcare centres) also lengthen modelled journey times. Nevertheless, the analysis highlights the importance of ensuring that social and transport infrastructure is carefully planned for greenfield development.

Access to education infrastructure is likely to be more difficult without access to a car. Travel times to access childcare services (Figure 6-2) and public primary schools (Figure 6-4) in the 2031 AM peak using public transport are likely to take up to 25 minutes from most parts of the city, with those living within the catchments of major rail and bus corridors able to travel to these facilities within around 15 minutes. Secondary school students are likely to have slightly longer travel times (Figure 6-6).

The radial nature of Adelaide's public transport network means that it is not as effective at catering for localised travel needs as it is at transporting large numbers of people into the city centre.

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

SA3	Child care centres (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*
Adelaide City	2.7	2.8	*+0.1*	13.5	12.1	*-1.3*	2.7	3.0	*+0.2*	13.7	13.0	*-0.7*	5.4	5.4	*-0.0*	23.8	22.2	*-1.6*
Adelaide Hills	8.1	8.0	*-0.1*	57.8	52.9	*-4.9*	4.4	4.7	*+0.2*	31.5	30.7	*-0.8*	9.8	9.9	*+0.1*	68.0	64.2	*-3.9*
Burnside	3.5	3.8	*+0.3*	18.5	18.2	*-0.3*	3.2	3.4	*+0.2*	16.9	16.6	*-0.3*	4.5	5.1	*+0.6*	21.5	21.3	*-0.3*
Campbelltown	3.4	3.6	*+0.2*	19.0	18.5	*-0.5*	2.7	2.8	*+0.1*	16.3	15.9	*-0.4*	5.7	6.0	*+0.4*	28.6	27.9	*-0.7*
Charles Sturt	3.4	3.8	*+0.4*	19.9	19.9	*+0.0*	2.7	3.1	*+0.4*	16.0	16.6	*+0.5*	4.0	4.3	*+0.4*	23.6	22.9	*-0.7*
Gawler-Two Wells	5.7	8.3	*+2.6*	43.6	41.2	*-2.4*	4.2	4.7	*+0.6*	31.7	27.0	*-4.7*	9.0	12.8	*+3.8*	72.6	60.3	*-12.3*
Holdfast Bay	3.0	3.3	*+0.3*	17.9	17.7	*-0.2*	2.6	2.8	*+0.2*	15.3	15.1	*-0.1*	4.9	5.4	*+0.5*	26.0	25.9	*-0.1*
Marion	3.3	3.7	*+0.3*	19.0	19.0	*+0.0*	2.8	3.1	*+0.3*	15.8	16.0	*+0.2*	4.8	5.1	*+0.4*	27.2	27.0	*-0.2*
Mitcham	3.8	4.2	*+0.4*	21.5	21.5	*+0.0*	3.3	3.6	*+0.3*	18.8	19.0	*+0.2*	5.0	5.5	*+0.5*	27.8	27.2	*-0.5*
Norwood-Payneham-St Peters	3.2	3.4	*+0.3*	14.9	14.7	*-0.1*	2.8	3.0	*+0.2*	13.7	13.6	*-0.0*	4.8	5.2	*+0.4*	23.6	23.1	*-0.5*
Onkaparinga	4.2	4.4	*+0.2*	26.5	25.7	*-0.8*	3.1	3.3	*+0.2*	20.3	20.3	*-0.1*	6.2	6.6	*+0.4*	37.1	36.0	*-1.1*
Playford	4.3	6.7	*+2.5*	27.0	27.5	*+0.5*	3.2	5.1	*+1.9*	20.0	22.2	*+2.2*	5.5	10.6	*+5.1*	34.7	37.2	*+2.5*
Port Adelaide-East	3.6	3.7	*+0.2*	18.8	18.8	*-0.0*	3.0	3.2	*+0.1*	16.5	16.6	*+0.1*	6.1	6.5	*+0.3*	31.6	30.7	*-0.9*
Port Adelaide-West	3.2	3.4	*+0.2*	20.9	21.1	*+0.1*	3.1	3.2	*+0.1*	18.2	17.9	*-0.3*	4.5	4.7	*+0.2*	25.2	25.2	*-0.0*
Prospect-Walkerville	3.0	3.2	*+0.2*	14.9	14.7	*-0.2*	2.6	2.8	*+0.1*	12.9	12.7	*-0.2*	7.1	8.1	*+1.0*	34.1	34.0	*-0.1*
Salisbury	3.7	3.9	*+0.2*	20.7	20.4	*-0.3*	3.0	3.2	*+0.1*	16.7	16.5	*-0.2*	4.6	4.9	*+0.3*	24.7	24.4	*-0.4*
Tea Tree Gully	3.4	3.6	*+0.2*	20.9	20.6	*-0.3*	2.6	2.7	*+0.1*	16.5	16.3	*-0.2*	4.6	5.0	*+0.4*	26.8	26.3	*-0.5*
Unley	3.2	3.4	*+0.2*	15.9	15.6	*-0.3*	2.7	2.9	*+0.2*	14.2	14.1	*-0.2*	5.0	5.5	*+0.5*	23.9	23.9	*+0.0*
West Torrens	3.2	3.5	*+0.3*	17.4	17.1	*-0.3*	3.1	3.5	*+0.4*	16.9	16.8	*-0.1*	4.7	5.1	*+0.4*	23.3	22.4	*-0.8*
Adelaide GCCSA	**3.9**	**4.5**	***+0.6***	**23.4**	**23.4**	***-0.0***	**3.1**	**3.5**	***+0.4***	**18.3**	**18.5**	***+0.2***	**5.5**	**6.5**	***+1.0***	**31.6**	**31.4**	***-0.1***

*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).

Figure 6-1 – Adelaide GCCSA average time to nearest five child care centres by Car - 2031 AM peak (7-9AM)

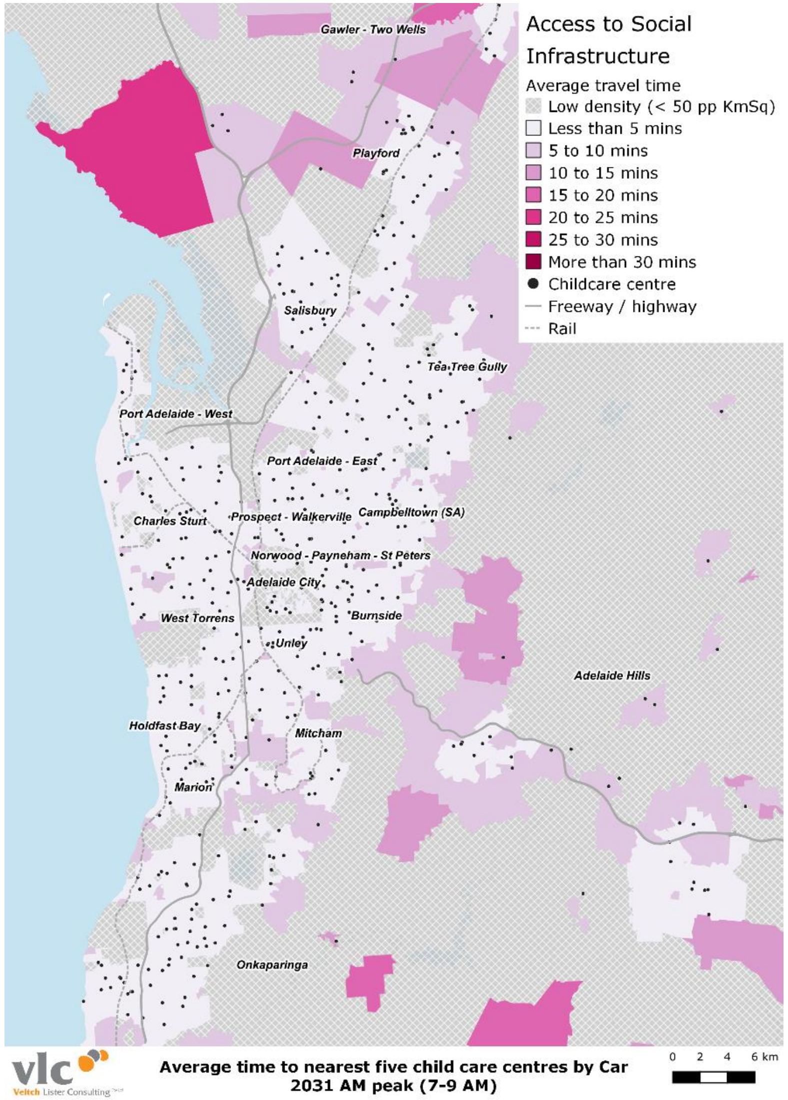


Figure 6-2 – Adelaide GCCSA average time to nearest five child care centres by PT - 2031 AM peak (7-9AM)

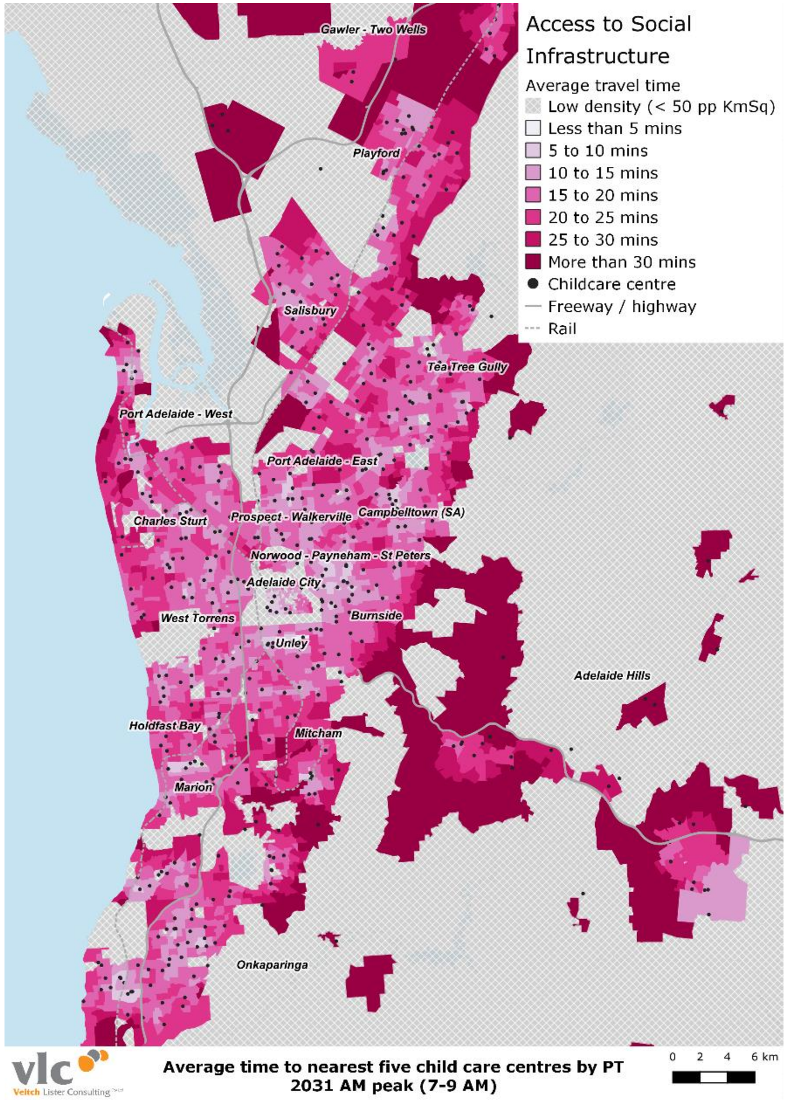


Figure 6-3 – Adelaide GCCSA average time to nearest public primary school by Car - 2031 AM peak (7-9AM)

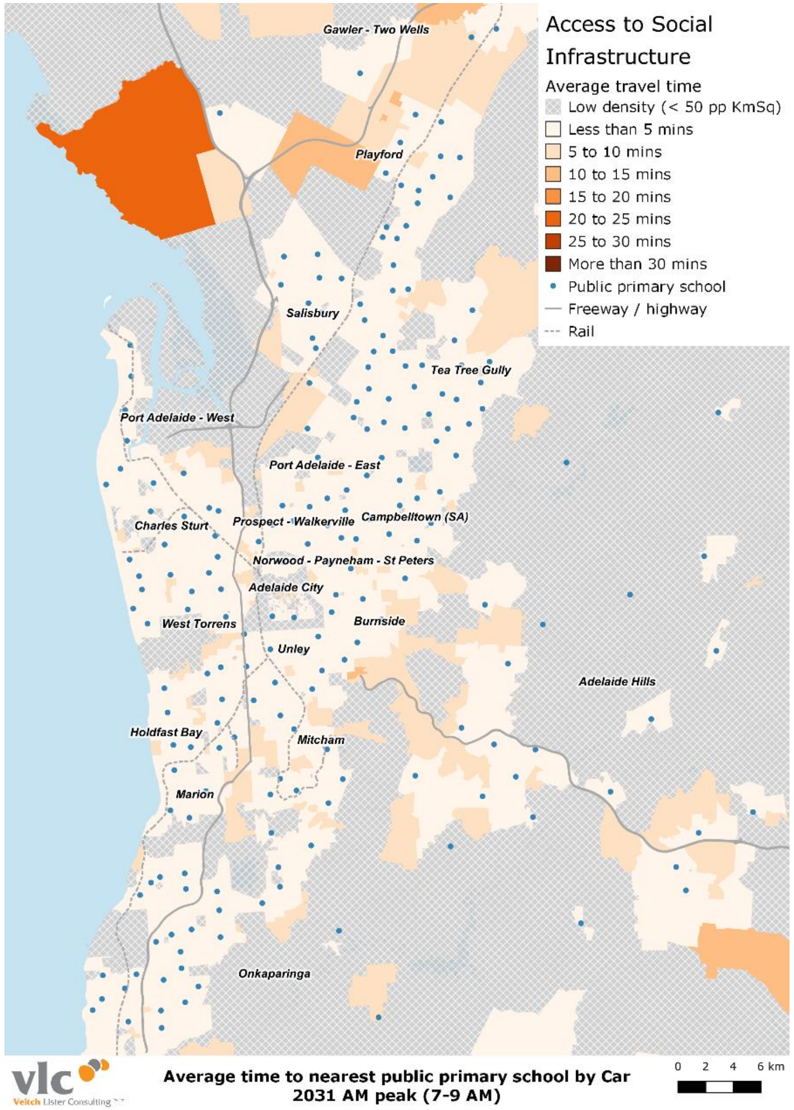


Figure 6-4 – Adelaide GCCSA average time to nearest public primary school by PT - 2031 AM peak (7-9AM)

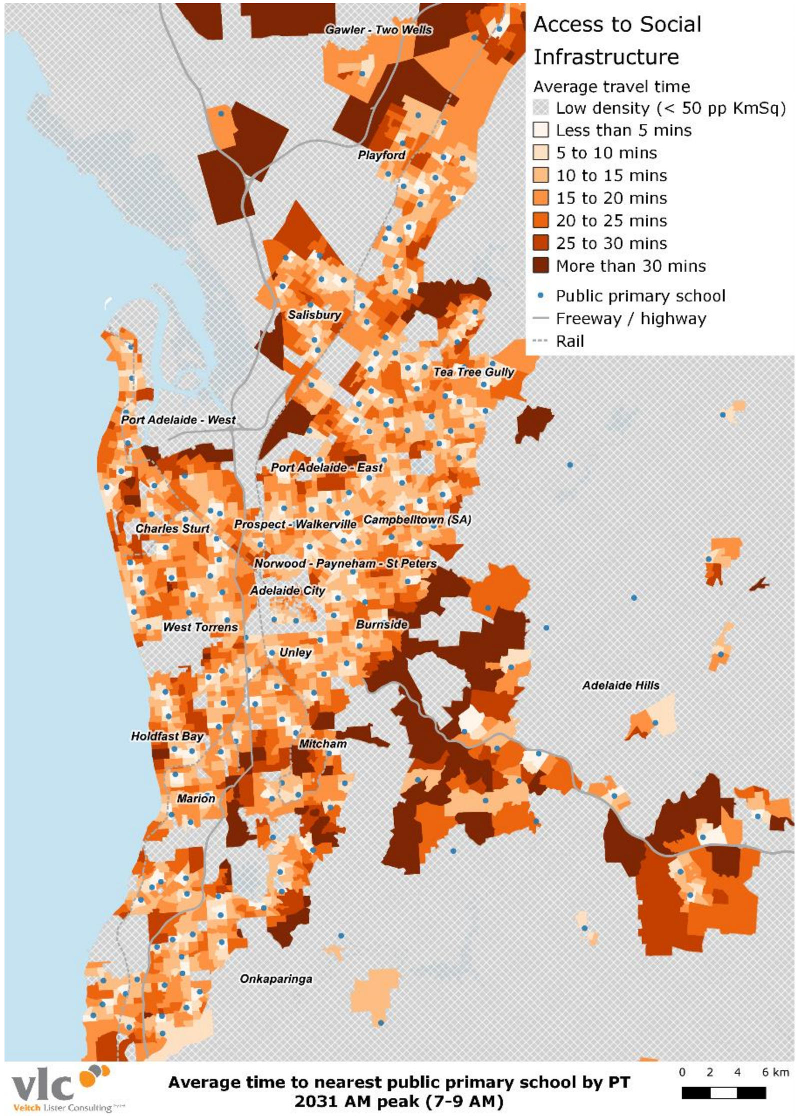


Figure 6-5 – Adelaide GCCSA average time to nearest public secondary school by Car - 2031 AM peak (7-9AM)

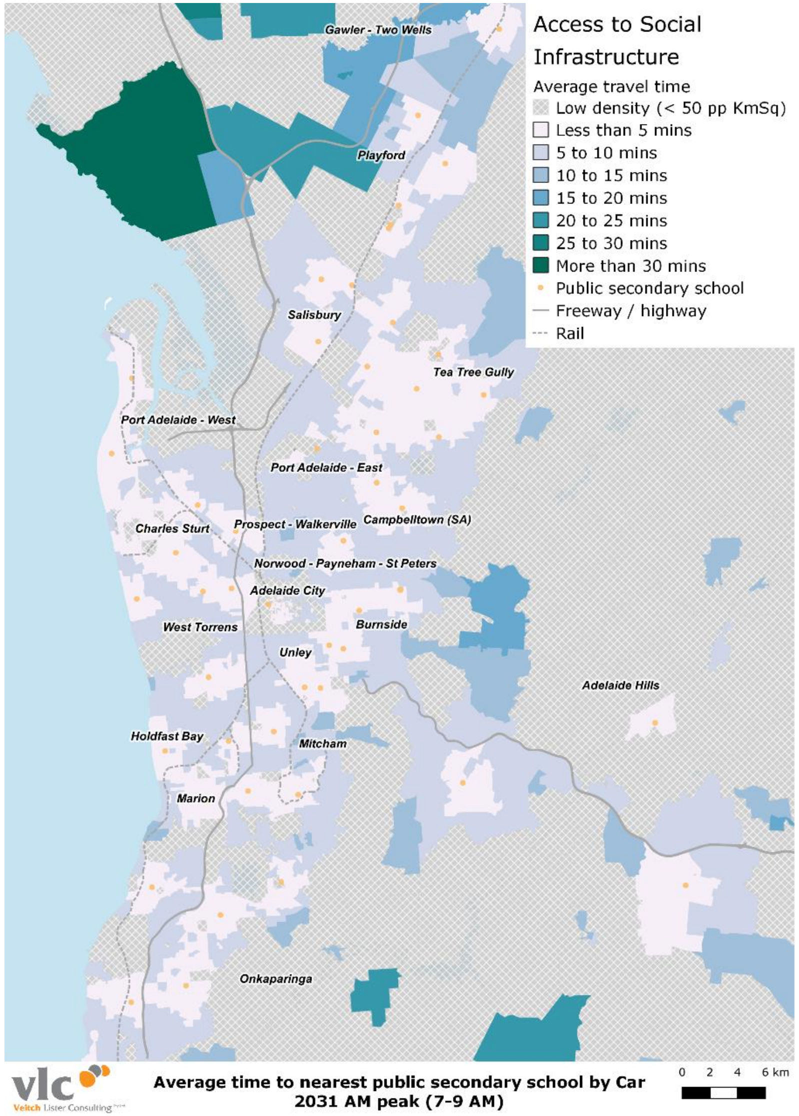
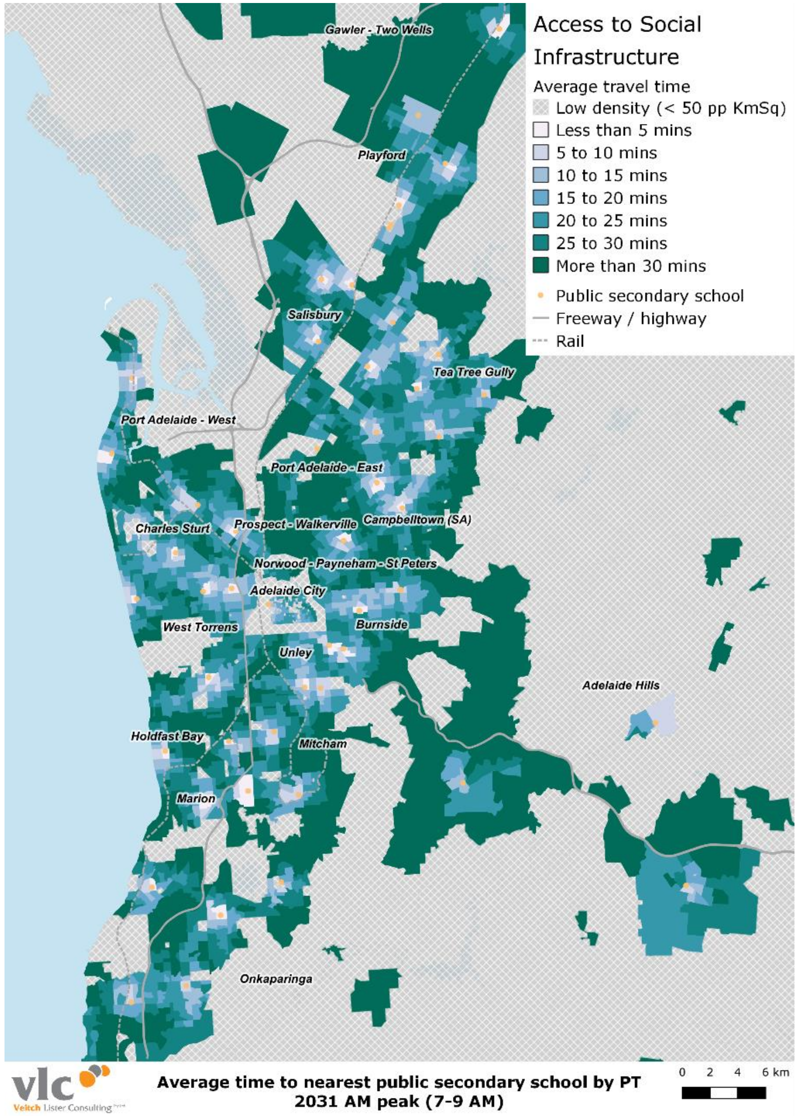


Figure 6-6 – Adelaide GCCSA average time to nearest public secondary school by PT - 2031 AM peak (7-9AM)



Most of Adelaide's residents are likely to have good access to green space. In 2016, 67 per cent of the population was within a 10-minute walk of green space, decreasing slightly to 66 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. Residents of Adelaide City are assessed as having excellent access to greenspace, a reflection of the various parks surrounding the CBD (Figure 6-7). By contrast, less than half of the residents of the inner-ring areas of Prospect-Walkerville, Norwood-Payneham-St Peters and Unley are assessed to have access to green space within a short walk. This reflects that with only limited greenspace within these SA3s, residents of these areas may have to walk to the Adelaide City SA3 to access greenspace.[3]

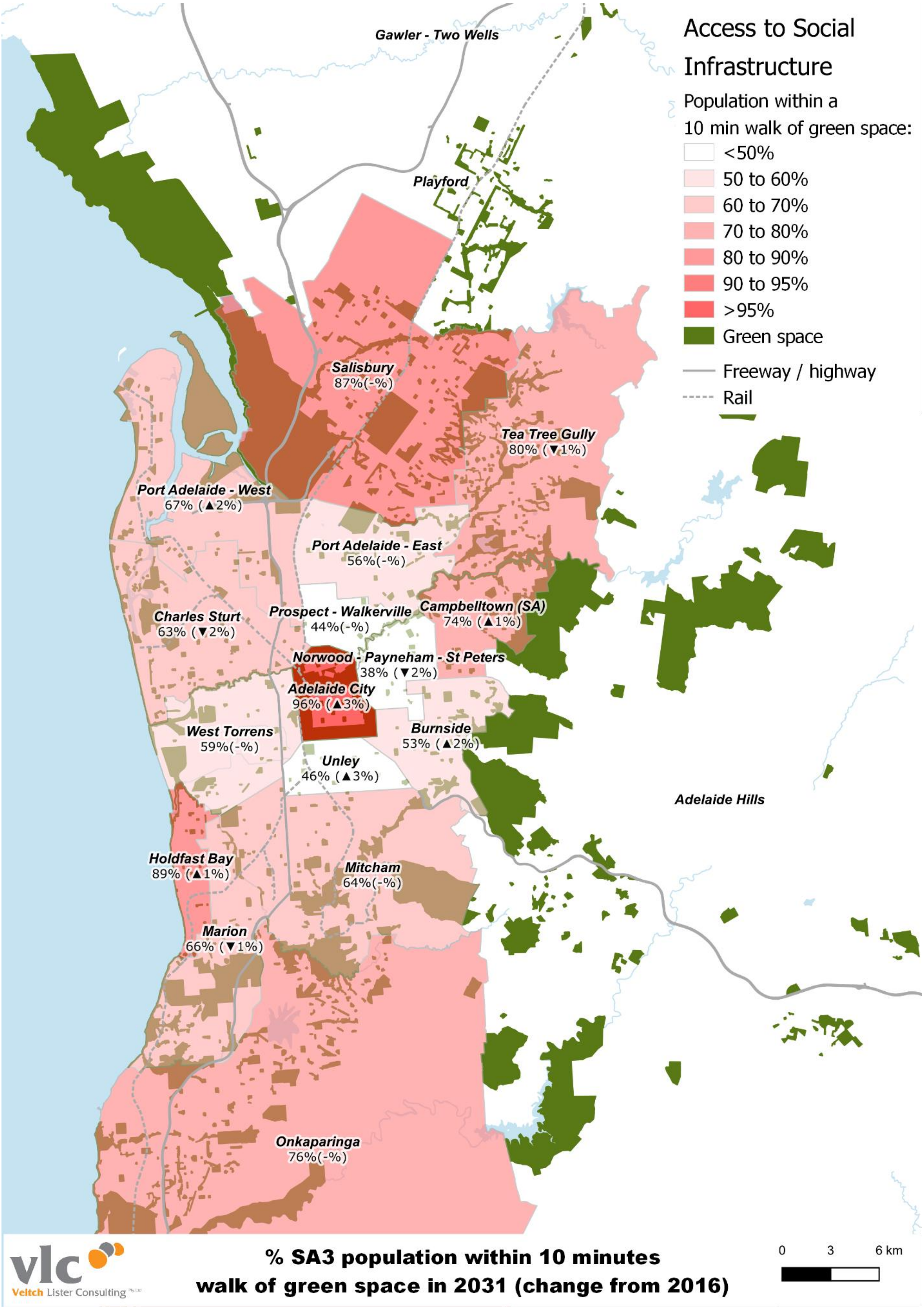
Limitations to measuring green space access:

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.

[3] While not mapped, growth areas such as Gawler-Two Wells; Playford and Adelaide Hills are assessed to experience relatively poor green space accessibility in 2016 and 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.

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



Car travel gives Adelaide’s residents access to a much higher proportion of jobs than public transport (in both 2016 and the 2031 forecast). This is a result of the higher level of flexibility that car travel affords. Much of Adelaide’s current and forecast employment is concentrated in the areas around Adelaide’s urban core, which means that the ease of access to this area is the main driver of employment accessibility. The urban core and the areas near infrastructure that directly links to the CBD have the highest level of access by both car and public transport.

The proportion of jobs accessible by car in the AM peak decreases substantially between 2016 and 2031 (Figure 6-8 and Figure 6-9) – a result of increased congestion on the road network. Spatially, the contraction in the proportion of labour market opportunities available is relatively symmetrical. This is reflective of the way in which traffic in Adelaide is relatively evenly spread across the major and arterial roads (section 4). In terms of access to jobs, this phenomenon will reinforce the advantage enjoyed by residents of inner areas.

The proportion of jobs available to those using public transport is forecast to remain fairly stable (Figure 6-10 and Figure 6-11). This is partly reflective of the relative consistency of the spatial distribution of projected growth in employment into the future, meaning that areas with good job accessibility by public transport in 2016 will likely continue to experience good job accessibility going forward. While population grows significantly in the north, the Gawler rail line helps mitigate decreases in accessibility by providing a connection to central Adelaide. In the small number of areas that are forecast to see a decline in job accessibility, this is driven by delays imposed on buses by traffic congestion.

Figure 6-8 – Adelaide GCCSA access to jobs by Car - 2016 AM Peak (7-9AM)

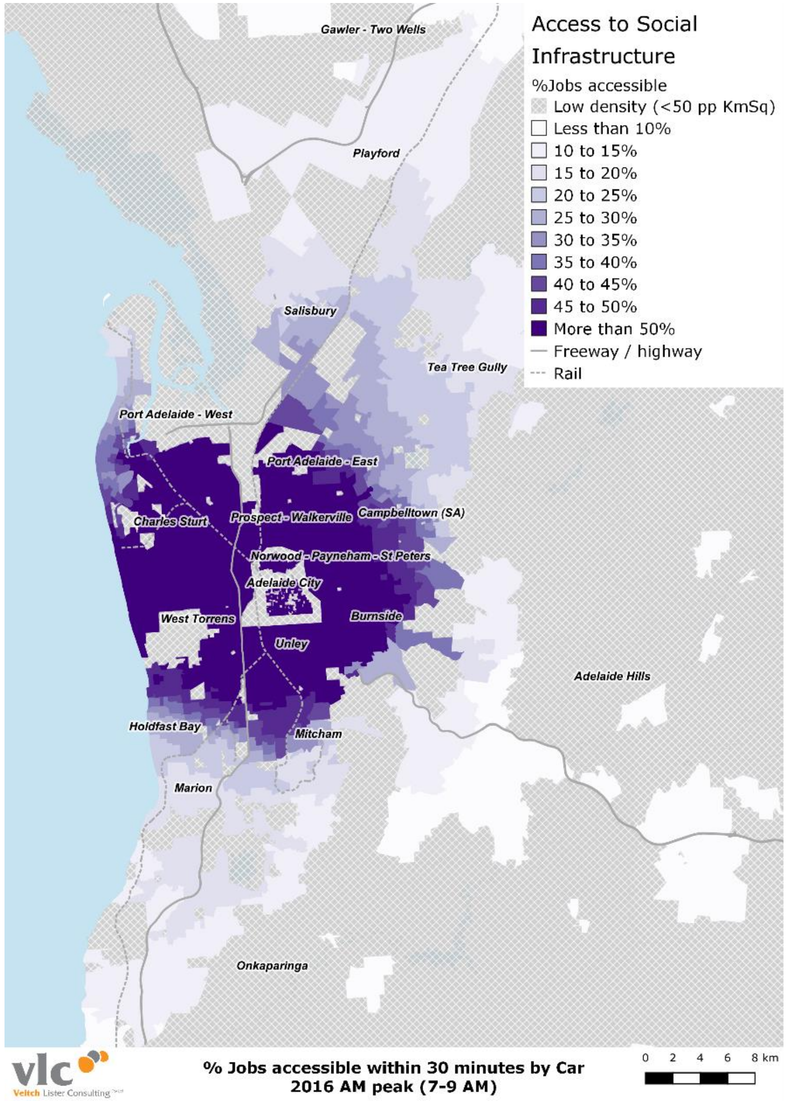


Figure 6-9 – Adelaide GCCSA access to jobs by Car - 2031 AM Peak (7-9AM)

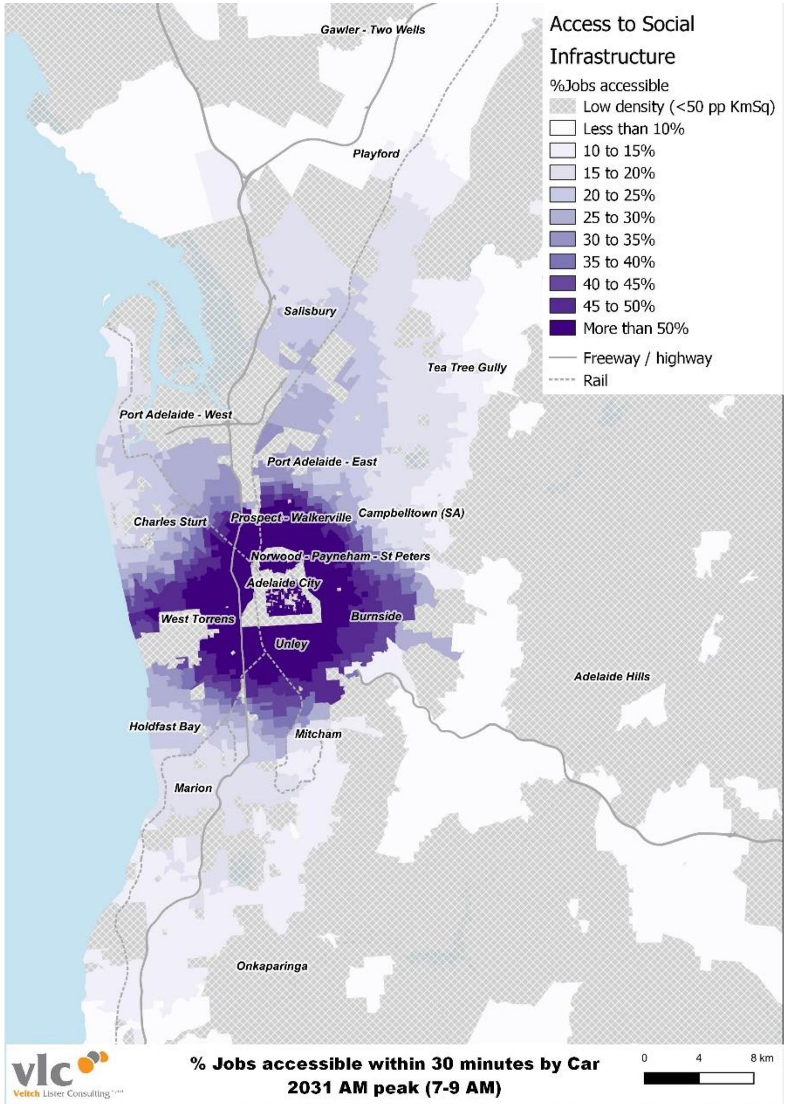


Figure 6-10 – Adelaide GCCSA access to jobs by PT - 2016 AM Peak (7-9AM)

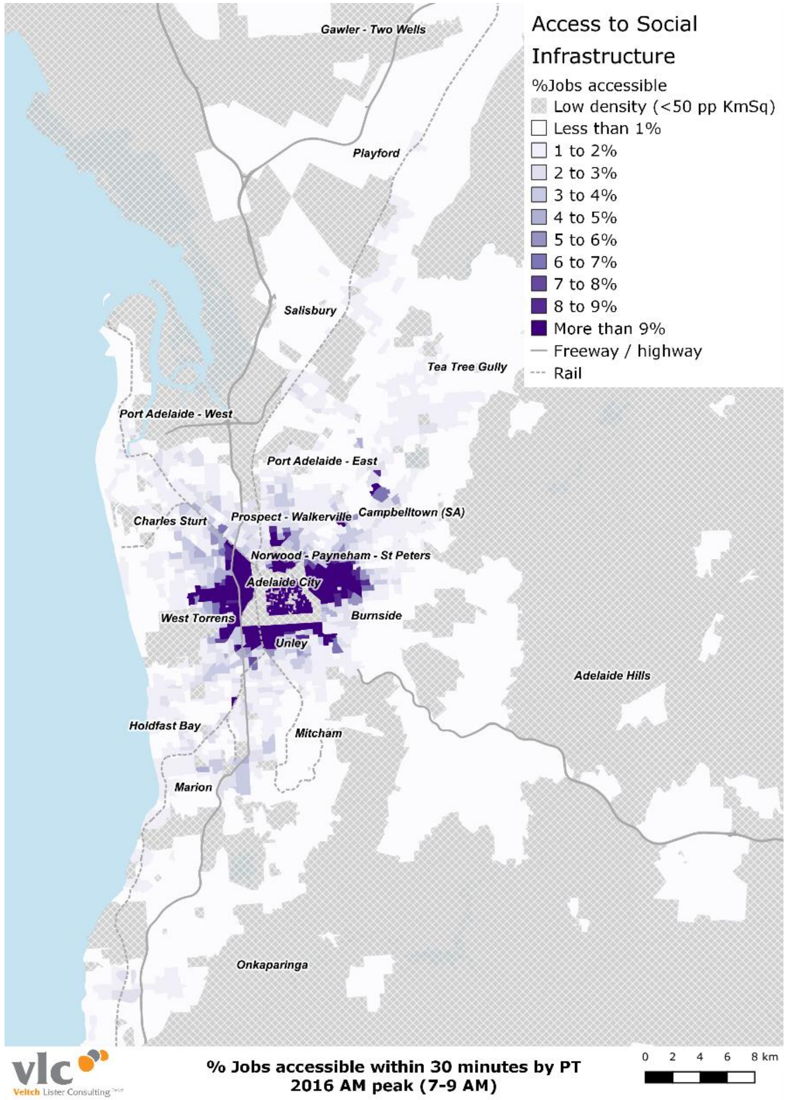
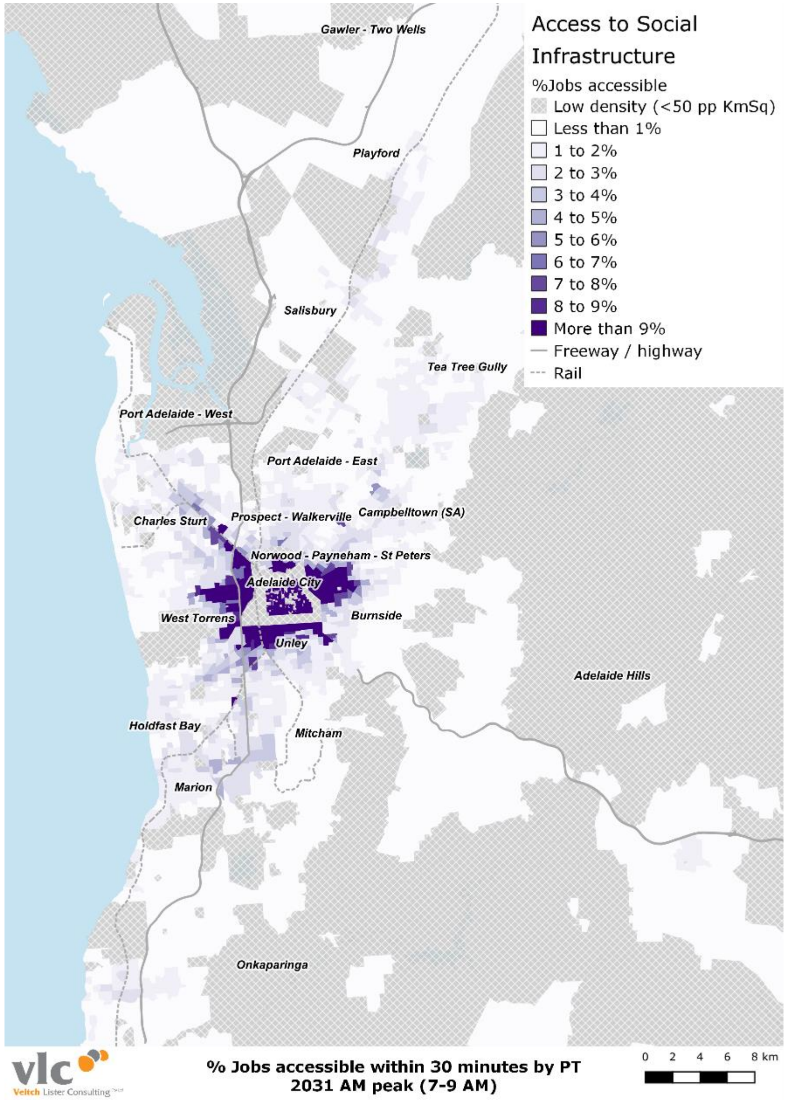


Figure 6-11 – Adelaide GCCSA access to jobs by PT - 2031 AM Peak (7-9AM)



Access to critical healthcare is measured by the travel time to the nearest public hospital/hospital with an emergency department by car and public transport (Figure 6-12 and Figure 6-13). AM peak travel times to access hospitals are much better by car than by public transport. Only the areas in rail corridors or directly around hospitals are forecast to be able to access a hospital within 30 minutes by public transport (Figure 6-13). In the rest of the city, those who don't have access to a car can expect to travel for at least half an hour (with a city-wide average of approximately 46 minutes) to access a public hospital, compared to a little over 10 minutes by car.

For both car and public transport users, travel times to the nearest public hospital are short for residents of inner areas (such as Adelaide City) and much longer for those in outer areas (Gawler-Two Wells and Playford) (Table 6-4).

Table 6-4 – Adelaide GCCSA 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
Adelaide City	4.3	5.2	*+0.9*	19.4	20.9	*+1.5*
Adelaide Hills	14.2	13.7	*-0.5*	91.2	84.3	*-6.9*
Burnside	9.8	11.5	*+1.7*	37.2	37.8	*+0.5*
Campbelltown	15.3	16.9	*+1.6*	44.2	42.9	*-1.2*
Charles Sturt	7.0	7.4	*+0.4*	32.1	31.3	*-0.8*
Gawler-Two Wells	10.1	12.7	*+2.6*	76.3	61.7	*-14.6*
Holdfast Bay	19.4	21.8	*+2.4*	51.9	52.2	*+0.3*
Marion	15.9	17.3	*+1.3*	45.0	44.3	*-0.7*
Mitcham	16.5	18.2	*+1.8*	49.6	48.9	*-0.7*
Norwood-Payneham-St Peters	11.2	12.2	*+1.0*	37.9	39.8	*+1.9*
Onkaparinga	14.3	15.6	*+1.3*	49.1	50.4	*+1.3*
Playford	13.1	19.0	*+5.9*	56.2	60.5	*+4.3*
Port Adelaide-East	6.2	6.4	*+0.2*	31.8	32.3	*+0.5*
Port Adelaide-West	6.2	6.4	*+0.2*	34.9	34.5	*-0.4*
Prospect-Walkerville	9.3	10.4	*+1.0*	28.8	32.7	*+3.9*
Salisbury	11.3	13.9	*+2.6*	44.9	45.8	*+0.9*
Tea Tree Gully	8.3	8.9	*+0.7*	35.8	34.6	*-1.2*
Unley	10.7	12.1	*+1.4*	36.5	37.1	*+0.6*
West Torrens	13.4	15.3	*+1.9*	40.9	42.4	*+1.5*
Adelaide GCCSA	**11.7**	**13.3**	***+1.7***	**45.4**	**46.0**	***+0.5***

*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 – Adelaide GCCSA average time to nearest public/emergency hospital by Car - 2031 AM peak (7-9AM)

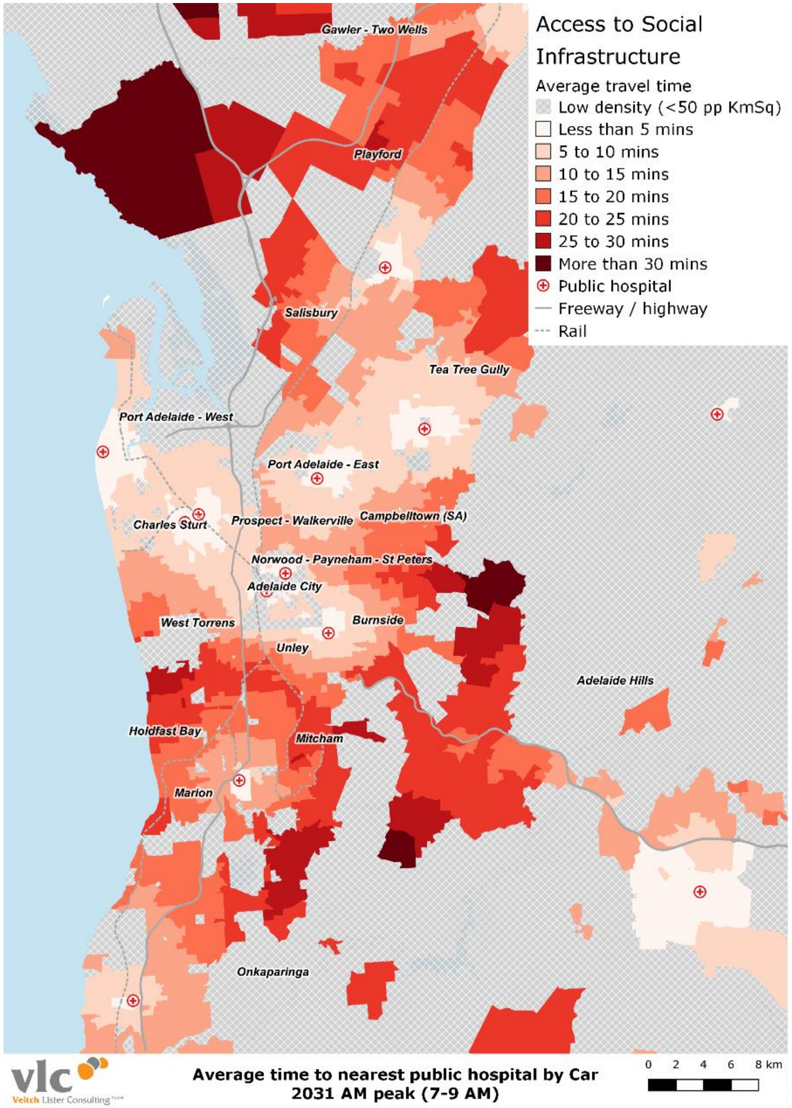
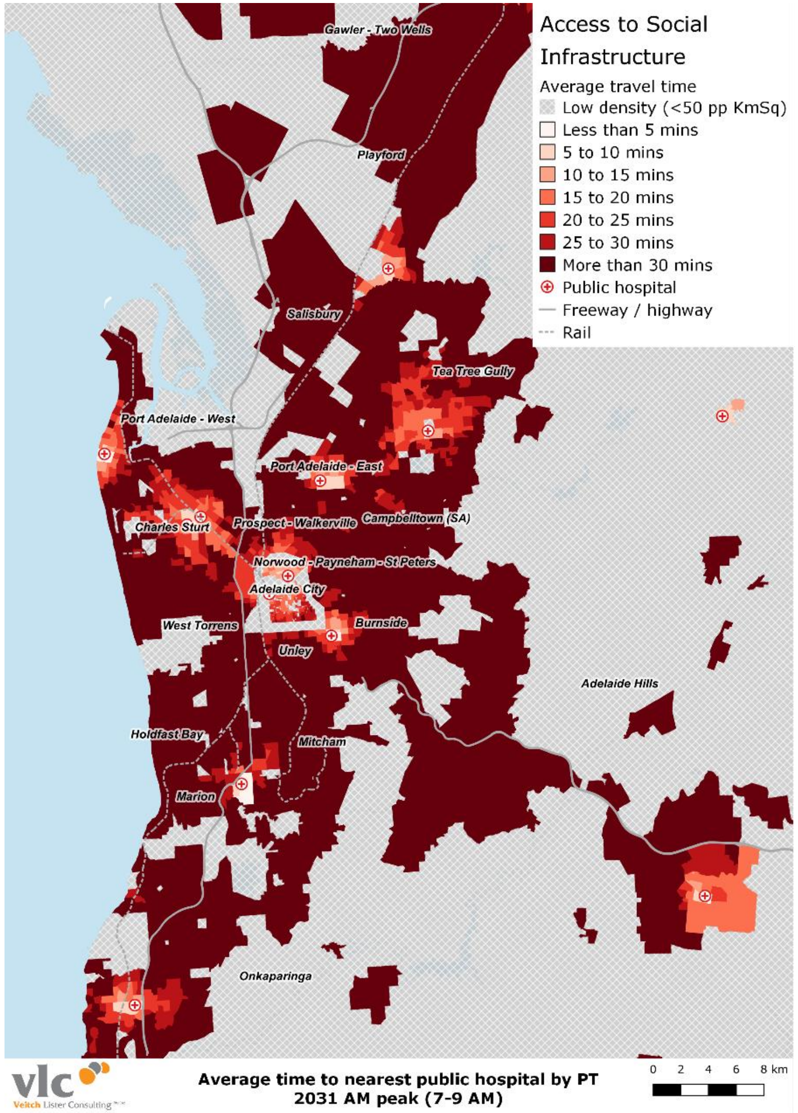


Figure 6-13 – Adelaide GCCSA average time to nearest public/emergency hospital by PT - 2031 AM peak (7-9AM)



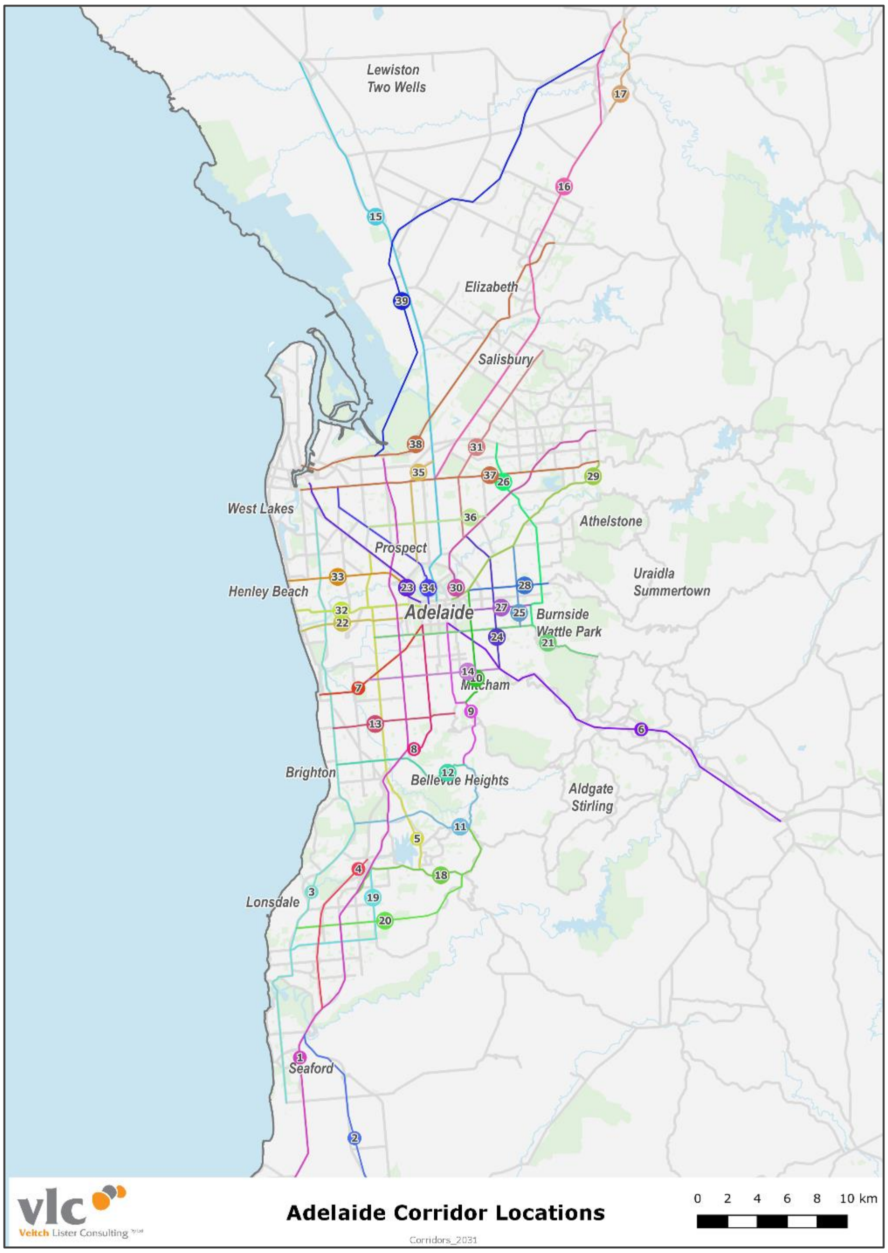
7. Assessment

This section draws together the analysis of the preceding chapters 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 Adelaide'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 39 key multi-modal corridors that were identified with Infrastructure Australia (Figure 7-1).

Figure 7-1 – Adelaide 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).

Adelaide's most congested road corridor in 2016 is forecast to be the South Rd/Main South Rd Corridor (Table 7-1), it is also expected to top the list in 2031 with around 3,600 delay hours predicted for a weekday AM peak (7-9AM) and around 3,800 for the PM peak (4-6PM) (Table 7-2). The modelling indicates that in peak periods the South Rd/Main South Rd Corridor is likely to be congested along most of its length.

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

	Corridor Name	Number	Direction	Delay Hours
	AM peak (7-9AM)			
1	South Rd/Main South Rd Corridor	1	NB	2,300
2	Port Wakefield Rd/Main North Rd Corridor	15	SB	2,200
3	Princess Hwy (M1)/Glen Osmond Rd Corridor	6	NB	1,400
4	Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor	3	NB	1,400
5	North East Road Corridor	30	SB	1,300
6	Outer Main North Rd Corridor	16	SB	1,300
7	Marion Rd Corridor	5	NB	1,300
8	Lower North East Rd/Payneham Rd Corridor	29	WB	1,100
9	Salisbury Hwy/Philip Hwy Corridor	38	SB	1,100
10	South Rd/Main South Rd Corridor	1	SB	1,000
	PM peak (4-6PM)			
1	South Rd/Main South Rd Corridor	1	SB	2,500
2	Port Wakefield Rd/Main North Rd Corridor	15	NB	2,200
3	Outer Main North Rd Corridor	16	NB	1,500
4	Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor	3	SB	1,400
5	Princess Hwy (M1)/Glen Osmond Rd Corridor	6	SB	1,300
6	Marion Rd Corridor	5	SB	1,300
7	North East Road Corridor	30	NB	1,300
8	Salisbury Hwy/Philip Hwy Corridor	38	NB	1,100
9	South Rd/Main South Rd Corridor	1	NB	1,100
10	Lower North East Rd/Payneham Rd Corridor	29	EB	1,100

High levels of population growth and the limited number of major roads mean that the Outer Main North Rd and the Port Wakefield Rd/Main North Rd Corridor are also among the city's most deficient in the 2031 forecast.

The Princess Hwy (M1)/Glen Osmond Rd Corridor is forecast to be one of the worst-performing in Adelaide. The problem emerges as the Princess Hwy connects with Glen Osmond Rd. The Princess Highway attracts high volumes of traffic, but as a motorway standard road it can accommodate these demands. Where the traffic using the highway is fed onto the lower-capacity Glen Osmond Rd, the corridor's performance deteriorates, and substantial delays are expected.

While most of the poorly performing corridors facilitate CBD-bound movements, the Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor – which runs north-south along the coast – is also a cause of substantial delay. This reinforces that although there is substantial demand for radial movements, the main travel pattern in Adelaide is along the city's north-south axis. As such the demand for north-south travel is the primary driver of delays on Adelaide's road network.

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

	Corridor Name	Number	Direction	Delay Hours
	AM peak (7-9AM)			
1	South Rd/Main South Rd Corridor	1	NB	3,600
2	Outer Main North Rd Corridor	16	SB	2,800
3	Port Wakefield Rd/Main North Rd Corridor	15	SB	2,400
4	Princess Hwy (M1)/Glen Osmond Rd Corridor	6	NB	2,300
5	South Rd/Main South Rd Corridor	1	SB	2,300
6	North East Road Corridor	30	SB	2,200
7	Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor	3	NB	2,100
8	Marion Rd Corridor	5	NB	1,900
9	Port Road Corridor	23	EB	1,800
10	Lower North East Rd/Payneham Rd Corridor	29	WB	1,800
	PM peak (4-6PM)			
1	South Rd/Main South Rd Corridor	1	SB	3,800
2	Outer Main North Rd Corridor	16	NB	2,800
3	South Rd/Main South Rd Corridor	1	NB	2,600
4	Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor	3	SB	2,400
5	North East Road Corridor	30	NB	2,100
6	Port Wakefield Rd/Main North Rd Corridor	15	NB	2,100
7	Marion Rd Corridor	5	SB	2,100
8	Princess Hwy (M1)/Glen Osmond Rd Corridor	6	SB	2,100
9	Port Road Corridor	23	WB	1,800
10	Lower North East Rd/Payneham Rd Corridor	29	EB	1,700

By 2031 Adelaide's motorists can expect longer traffic delays, with Table 7-4 highlighting that users will spend a higher proportion of their journeys stuck in traffic compared with 2016 (Table 7-3). From an individual user's perspective, the worst performers in both 2016 and 2031 are the Fullarton Rd and the Goodwood Road Corridors. These corridors are relatively short (under 10 kilometres in length) with most of the corridor forecast to be congested (Figure 4-3 and Figure 4-5). Motorists travelling the length of these corridors in peak times are forecast to spend around two-thirds of their travel time stuck in traffic. For example, congestion on the Goodwood Rd Corridor causes approximately 20 minutes delay in 2031, up from 15 minutes in 2016 (with journey times increasing from approximately 25 minutes to 30 minutes). Similar outcomes are expected on the Glynburn Road, Unley Rd/Belair Rd and Magill Road Corridors with at least half of the travel time on these corridors a result of congestion.

Some of the corridors that were identified in Table 7-1 and Table 7-2 as performing poorly at an aggregate level also cause substantial delays for individual users. For instance, the delay of up to 30 minutes on the Lower North East Rd/Payneham Rd and North East Road Corridors is predicted to affect large numbers of people.

Many of the worst performing corridors identified in both the aggregate and user focused analysis are designated as National Key Freight Routes by the Federal Government[4]. Delays on these links can disproportionately impact on a city's function by reducing the productivity of the commercial vehicles. In particular, peak period delays of at least 17 minutes on the Port Road Corridor will reduce the productivity of freight movements in Adelaide.

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[4] Transport and Infrastructure Council. (2018). *National Key Freight Route Maps*. Retrieved from: http://transportinfrastructurecouncil.gov.au/publications/files/freight_route_maps/SA_Adelaide_Urban_Map_A3_ROAD.pdf

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

	Corridor name	Number	Direction	Corridor length (km)	% of journey time accounted for by congestion	Delay per vehicle (mins)	Congested travel time for corridor (mins)
	AM peak (7-9AM)						
1	Fullarton Rd Corridor	10	NB	8	60%	13	23
2	Goodwood Rd Corridor	8	NB	9	59%	15	26
3	Magill Road Corridor	28	WB	5	55%	8	14
4	Lower North East Rd/Payneham Rd Corridor	29	WB	14	55%	20	37
5	Glynburn Road Corridor	25	SB	5	55%	8	14
6	Unley Rd/Belair Rd Corridor	9	NB	11	54%	17	31
7	North East Road Corridor	30	SB	16	50%	19	38
8	Anzac Hwy Corridor	7	EB	9	49%	11	22
9	Port Wakefield Rd/Main North Rd Corridor	15	SB	39	48%	28	59
10	Kensington Road Corridor	27	WB	5	47%	6	12
	PM peak (4-6PM)						
1	Fullarton Rd Corridor	10	SB	8	57%	12	21
2	Goodwood Rd Corridor	8	SB	9	56%	14	24
3	Lower North East Rd/Payneham Rd Corridor	29	EB	14	52%	18	35
4	Unley Rd/Belair Rd Corridor	9	SB	11	51%	15	29
5	Glynburn Road Corridor	25	NB	5	51%	7	13
6	Magill Road Corridor	28	EB	5	50%	6	13
7	North East Road Corridor	30	NB	16	48%	18	37
8	Marion Rd Corridor	5	SB	23	47%	22	47
9	Anzac Hwy Corridor	7	WB	9	46%	10	21
10	Port Wakefield Rd/Main North Rd Corridor	15	NB	39	45%	26	57

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

	Corridor name	Number	Direction	Corridor length (km)	% of journey time accounted for by congestion	Delay per vehicle (mins)	Congested travel time for corridor (mins)
	AM peak (7-9AM)						
1	Fullarton Rd Corridor	10	NB	8	67%	18	27
2	Goodwood Rd Corridor	8	NB	9	66%	20	31
3	Glynburn Road Corridor	25	SB	5	66%	12	18
4	Magill Road Corridor	28	WB	5	66%	12	18
5	Lower North East Rd/Payneham Rd Corridor	29	WB	14	64%	30	47
6	Unley Rd/Belair Rd Corridor	9	NB	11	63%	24	38
7	North East Road Corridor	30	SB	16	60%	29	48
8	Torrens Road Corridor	34	EB	11	59%	20	34
9	Kensington Road Corridor	27	WB	5	59%	9	15
10	Port Road Corridor	23	EB	11	57%	19	32
	PM peak (4-6PM)						
1	Fullarton Rd Corridor	10	SB	8	65%	17	26
2	Goodwood Rd Corridor	8	SB	9	65%	20	30
3	Glynburn Road Corridor	25	NB	5	63%	11	17
4	Lower North East Rd/Payneham Rd Corridor	29	EB	14	62%	27	44
5	Unley Rd/Belair Rd Corridor	9	SB	11	61%	22	36
6	Magill Road Corridor	28	EB	5	60%	10	16
7	North East Road Corridor	30	NB	16	58%	26	46
8	Marion Rd Corridor	5	SB	23	57%	33	58
9	Torrens Road Corridor	34	WB	11	56%	18	32
10	Port Road Corridor	23	WB	11	56%	17	31

By 2031, the level of demand placed on Adelaide's public transport system is expected to increase. In this study, high levels of crowding are taken as an indicator of poor network performance. (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.)

The demand placed on Adelaide's north-south rail and bus corridors is expected to increase significantly due to population growth in Adelaide's northern suburbs. By 2031 crowding on the Gawler Line is forecast to worsen substantially with passenger volumes near the capacity of trains

(Table 7-5 and Table 7-6). Crowding on the O-bahn is also expected to increase, but is not forecast to approach crush levels.

Table 7-5 – Adelaide GCCSA crowding on 2016 public transport corridors

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Gawler Line, north of Adelaide CBD	SB	1.1	0.6
O-Bahn, east of Adelaide CBD	SB	0.6	0.4
PM peak (4-6PM)			
Gawler Line, north of Adelaide CBD	NB	1	0.6
O-Bahn, east of Adelaide CBD	NB	0.6	0.4

Table 7-6 – Adelaide GCCSA crowding on 2031 public transport corridors

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Gawler Line, north of Adelaide CBD	SB	1.5	0.9
O-Bahn, east of Adelaide CBD	SB	0.7	0.5
PM peak (4-6PM)			
Gawler Line, north of Adelaide CBD	NB	1.4	0.9
O-Bahn, east of Adelaide CBD	NB	0.7	0.5

7.2 Regional deficiencies

Most of Adelaide's residents will be able to reach a range of childcare centres, a primary school and a secondary school within a ten-minute drive in the morning peak. However, residents living in fast growing areas (Playford, Gawler-Two Wells and Adelaide Hills) are likely to have to travel for longer. This is a result of modelled growth in congestion around these SA3, 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 Adelaide's residents without regular car access is poorer, particularly those living in outer suburbs. For instance, the average resident of Playford, would to spend 20 to 30 minutes on public transport to accompany their young child to care or primary school, with secondary students in these areas expected to travel for longer. This is largely due to lower walkability of these areas, coupled with the limited ability of Adelaide's radial public transport system to cater for local trips.

Increasing congestion on Adelaide's key roads will affect access to jobs. Residents of the outer areas highlighted above (such as Gawler – Two Wells and Playford) will have access to less than 10% of the city's jobs. As a result, it is likely that many residents in these areas will travel south to access employment. The increased congestion on the north-south corridors identified in section 4 mean that these trips are likely to take significantly longer. Increased congestion will also affect residents of 'middle' suburbs. For example, in 2016 residents of Port Adelaide were able to access approximately 50 per cent of Adelaide's jobs in the AM peak by car. By 2031, this proportion is forecast to decrease to approximately 30 per cent.

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 Adelaide 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 cost of congestion is estimated to increase considerably from $4.2 million in 2016 to $7.6 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 (33.0% in 2016, growing to 33.7% in 2031). This is closely followed by the AM peak, at 32.2 per cent and 32.5 per cent in 2016 and 2031 respectively. By extension, the hourly cost incurred is comparable between the AM and PM peaks in both years ($0.7 million in 2016 and $1.3 million in 2031 – Figure 7-3). This suggests similar levels of congestion in both peak periods.

Annually, the estimated cost of congestion in Adelaide is $1.4 billion in 2016, increasing to $2.6 billion in 2031.

Figure 7-2 – Adelaide GCCSA average weekday cost of congestion - 2016 and 2031

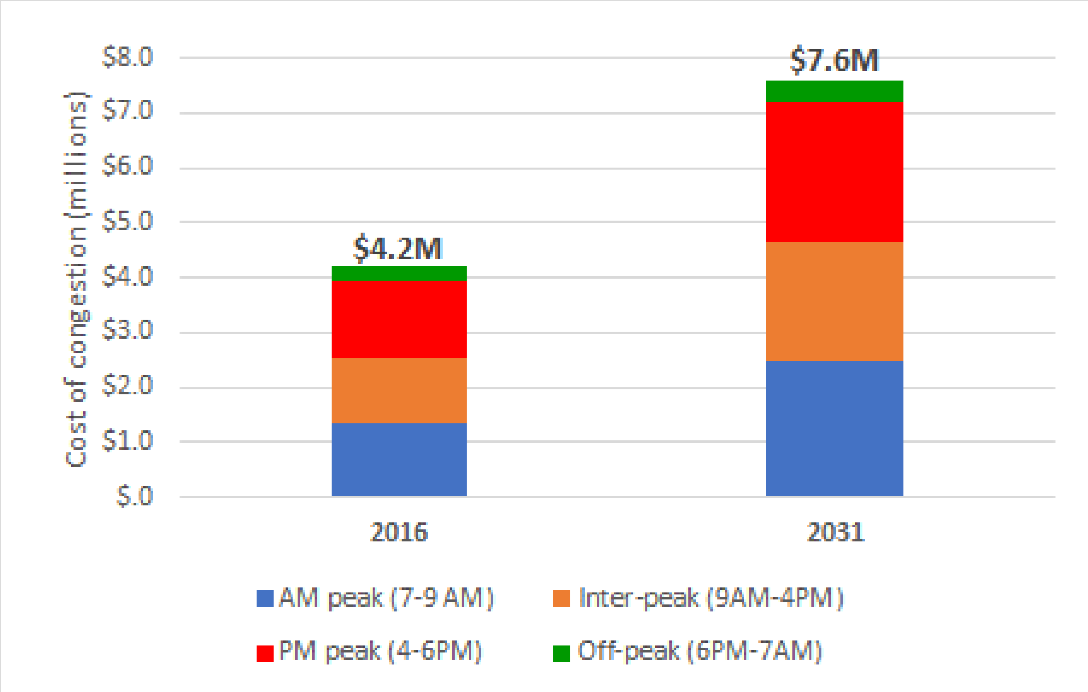
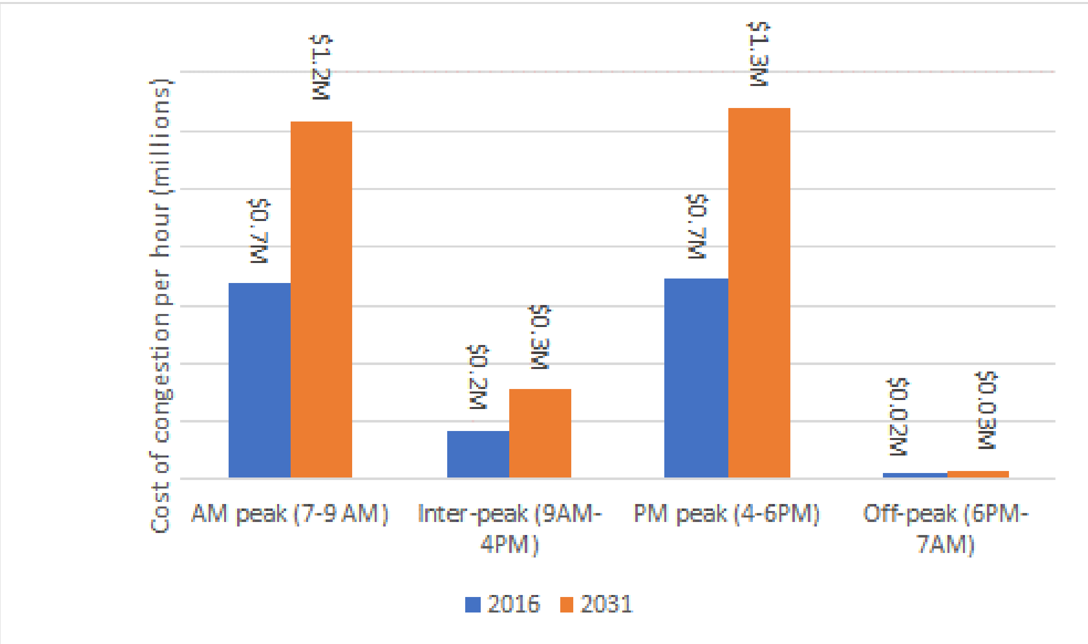


Figure 7-3 – Adelaide GCCSA average weekday hourly cost of congestion by time-period - 2016 and 2031



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 on a train or bus, and particularly where vehicles are very full (again, see Appendix D.4 for a detailed calculation methodology). Crowding costs are immaterial compared to the road congestion costs and are contained to the peak periods (Table 7-7). When travelling outside of the AM and PM peaks, passengers are generally able to travel in a seat.

While crowding costs increase in the peak periods into the future, these costs are still minor in 2031. This reflects the significant residual capacity available on Adelaide's public transport network. Annually, the estimated cost of crowding in Adelaide GCCSA is $970,000 in 2016, growing to $4.4 million in 2031.

Table 7-7 – Adelaide GCCSA average weekday cost of public transport crowding - 2016 and 2031

Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	$1,200	$6,100	$4,900	408%
	PM peak (4-6PM)	$1,200	$5,200	$4,000	333%
Bus	AM peak (7-9AM)	$700	$2,700	$2,000	286%
	PM peak (4-6PM)	$300	$1,300	$1,000	333%

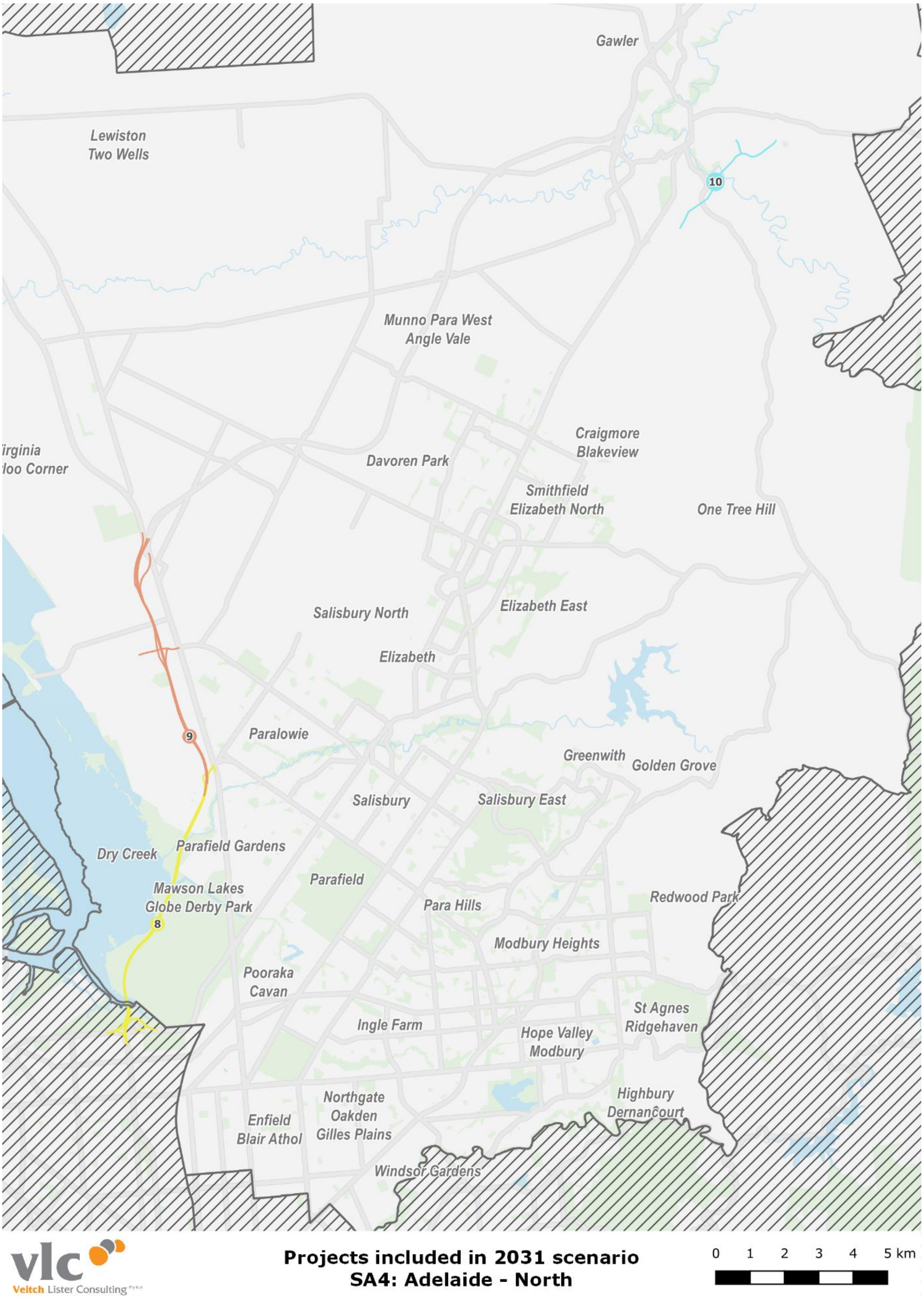
Crowding costs are based on the average crowding of services in each two-hour peak period (similar to chapter 5). As such, the cost of crowding would underestimate costs where there is high variability in crowding levels across services within this peak period.

Appendix A: Projects included in modelling

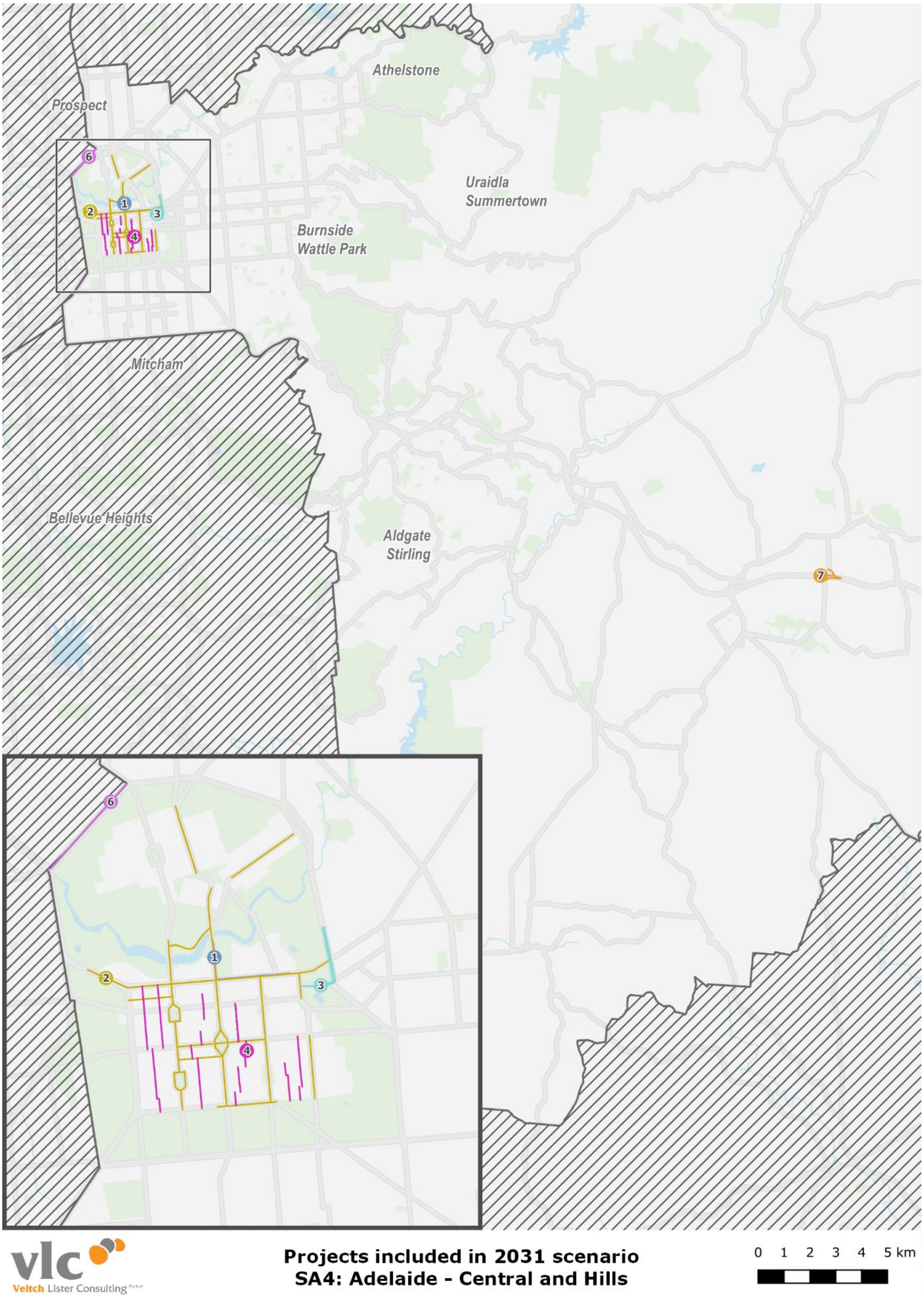
This section details the projects included in the modelling. A map for each SA4 has been included (Appendix Figure A-1 gives an overview of the relevant SA4s). The numbers referenced in maps are linked to project names in Appendix Table A-1.

Appendix Figure A-1 – Greater Adelaide SA4 overview

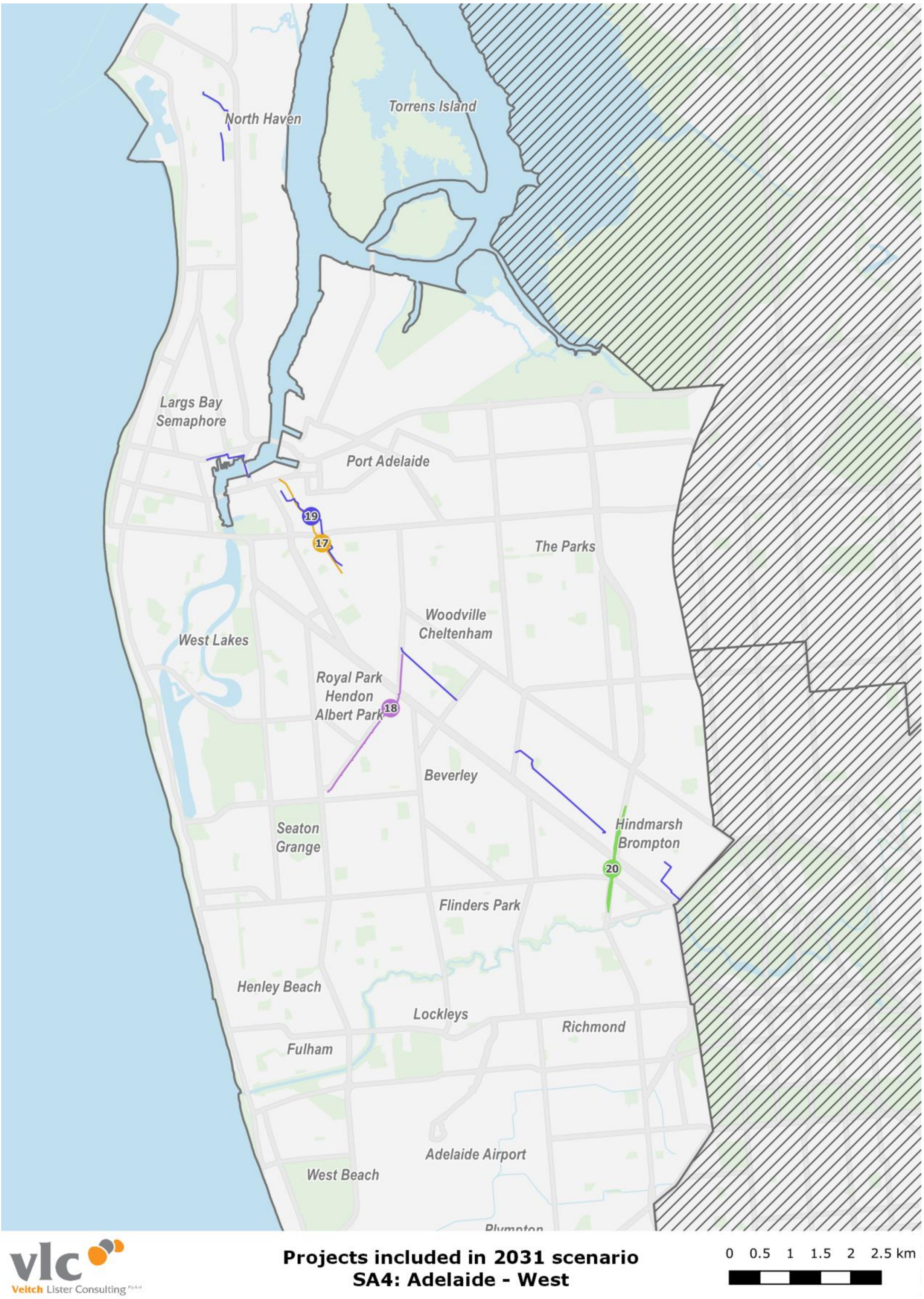
Appendix Figure A-2 – Projects included in the 2031 scenario SA4: Adelaide – North



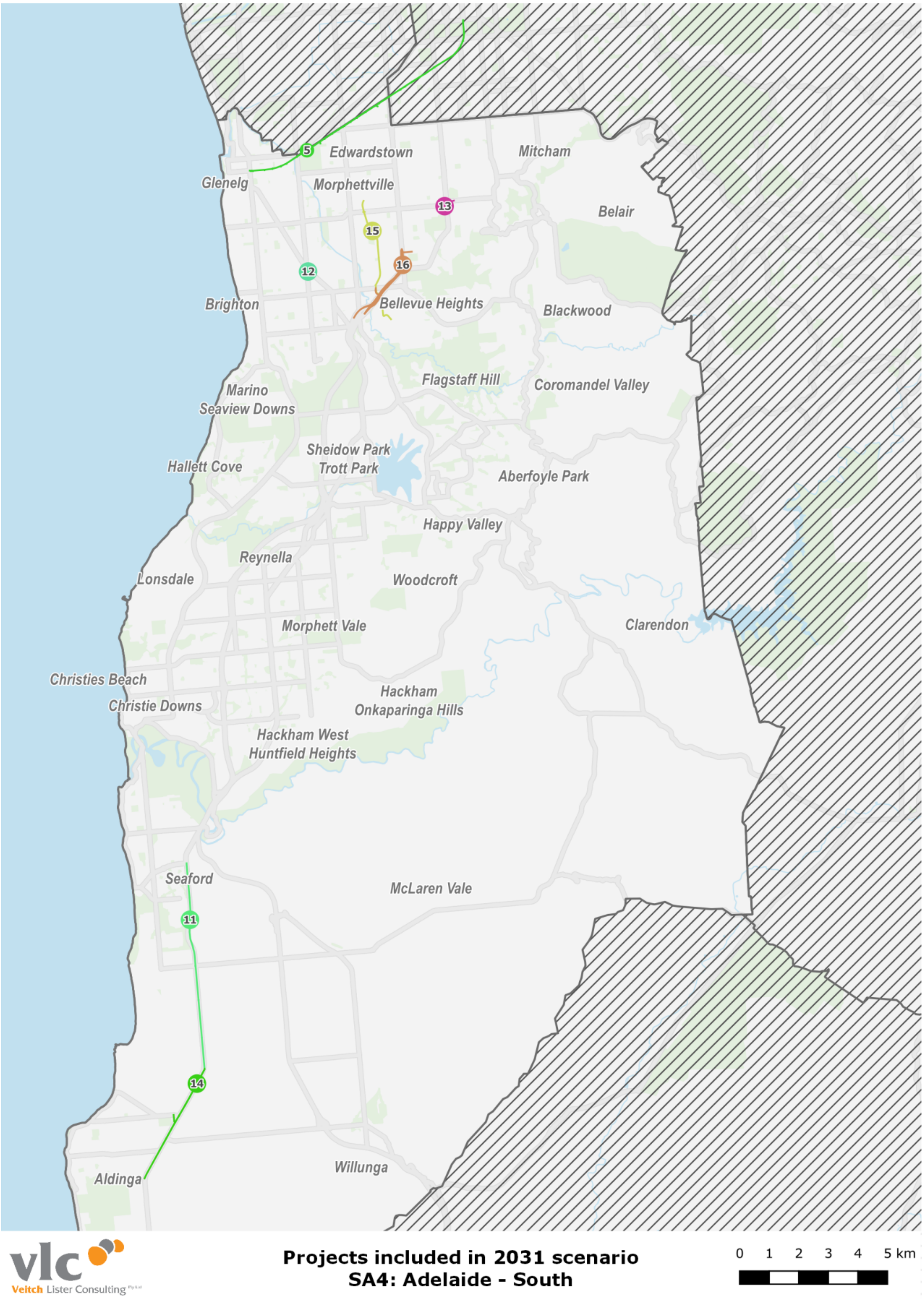
Appendix Figure A-3 – Projects included in the 2031 scenario SA4: Adelaide – Central and Hills



Appendix Figure A-4 – Projects included in the 2031 scenario SA4: Adelaide – West



Appendix Figure A-5 – Projects included in the 2031 scenario SA4: Adelaide – South



Appendix Table A-1 – Projects included in modelling

Project no.	Name
1	City Tram extension - Between North Terrace and Victoria Drive. Expected new route in 2018.
2	Design for traffic speeds below 30km/h in Significant City Places and local streets. Candidate upgrade in 2022.
3	Improve O-Bahn access to Adelaide city centre. Expected upgrade in 2018.
4	Complete at least 80% of north-south 'active' cross-city links by 2022. Candidate upgrade in 2022.
5	Mike Turtur Bikeway. Expected upgrade/new route in 2018.
6	Torrens Rail Junction Project - Between Park Terrace and Park Terrace. Expected upgrade in 2018.
7	New Interchange on the South Eastern Freeway. Expected new route in 2017.
8	Northern Connector Stage 1. Funded new route in 2020.
9	Northern Connector Stage 2. Funded new route in 2019.
10	Gawler East local link road. Expected new route in 2019.
11	Duplication of Main South Road (Seaford to Aldinga). Candidate upgrade in 2046.
12	Oaklands Crossing Grade separation. Funded upgrade in 2019.
13	Goodwood, Springbank and Daws Road intersection upgrade. Funded upgrade in 2021.
14	Main South Road Upgrade - Old Coach Road to Malpas Road. Expected upgrade in 2018.
15	Flinders Link. Funded new route in 2018.
16	Darlington Interchange. Funded new route in 2018.
17	Port Dock Railway Line - Between Alberton Station and National Railway Mudeum. Funded new route in 2019.
18	Grange Greenway - Woodville to Seaton - Between Outer Harbour Greenway and Seaton Park Railway Station. Funded new route in 2019.
19	Outer Harbour Greenway - Between North Haven and North Adelaide. Expected new route in 2017.
20	South Road Upgrade: Torrens to Torrens. Expected upgrade in 2018.
Not shown on map	Advanced Traffic Management System / Managed Motorways - South Eastern Freeway
	Rail service frequency improvements. Funded service improvement in 2017. Additional services run on Gawler, Outer Harbour, Tonsley and Seaford lines, as per the public transport timetable.
	Gawler Train Line electrification. Funded upgrade in 2019. Electrification and grade separation removals allow additional service frequencies along the corridor.

Appendix B: Public Transport Network Assumptions

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

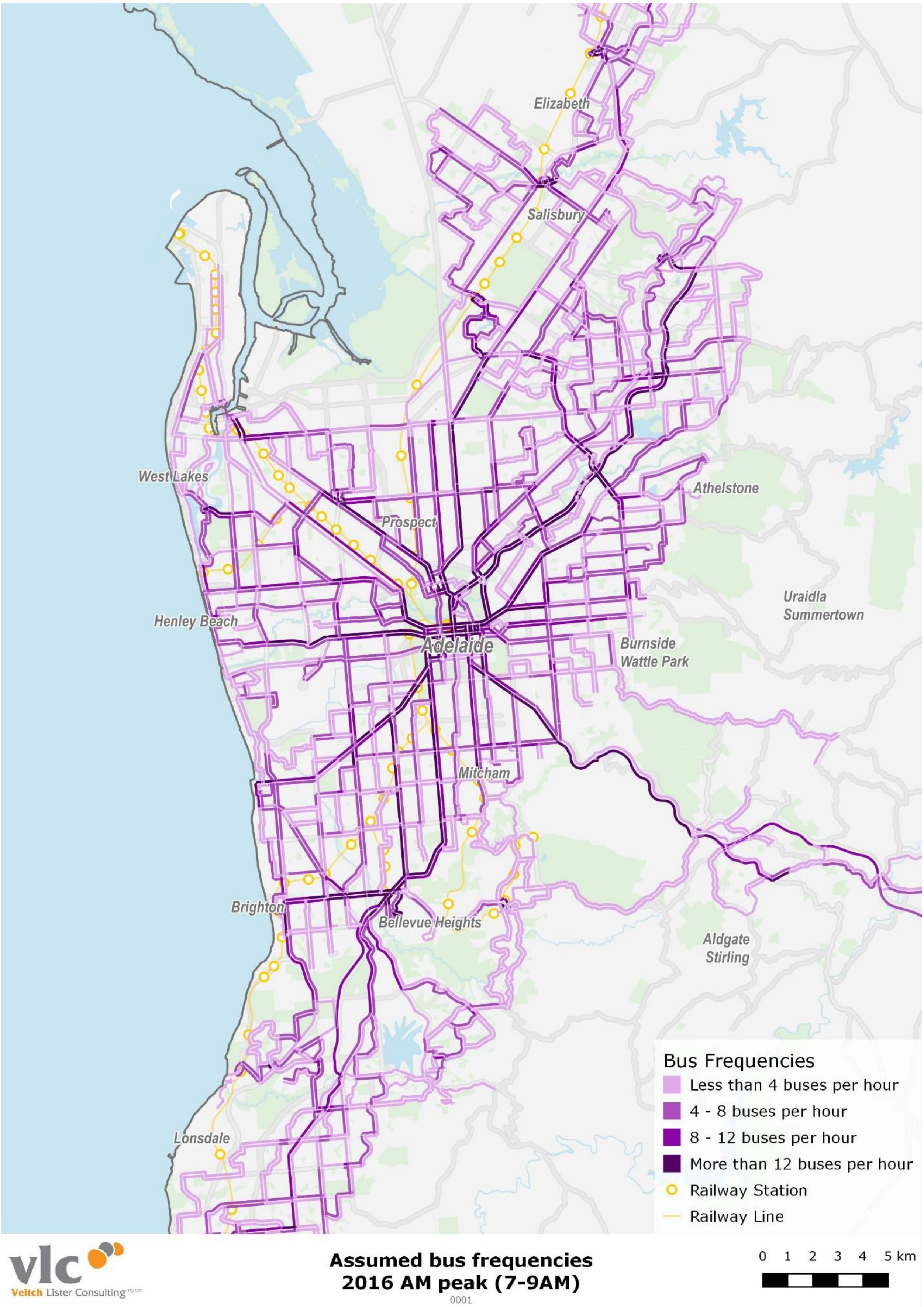
Appendix Figure B-1 through to Appendix Figure B-4 illustrate the frequencies assumed on Adelaide's bus network.

Appendix Figure B-5 through to Appendix Figure B-8 illustrate the frequencies assumed on Adelaide's rail network.

Appendix Figure B-9 through to Appendix Figure B-12 illustrate the frequencies assumed on Adelaide's tram network.

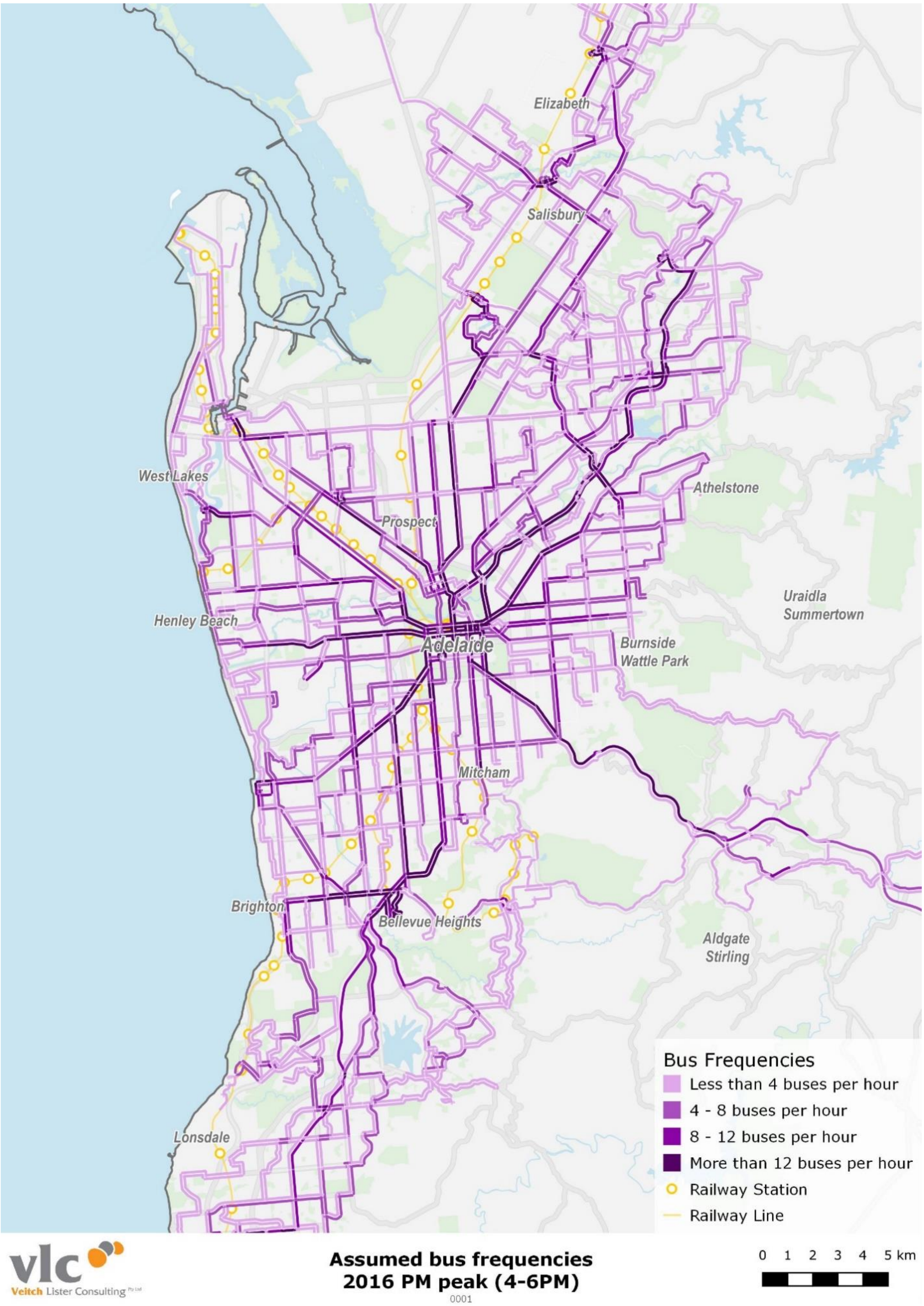
The 2016 routes and frequencies used in modelling were obtained from Adelaide Metro. Details of how the 2031 network were developed can be found in Model Assumptions.

Appendix Figure B-1 – Assumed bus frequencies - 2016 AM peak (7-9AM)



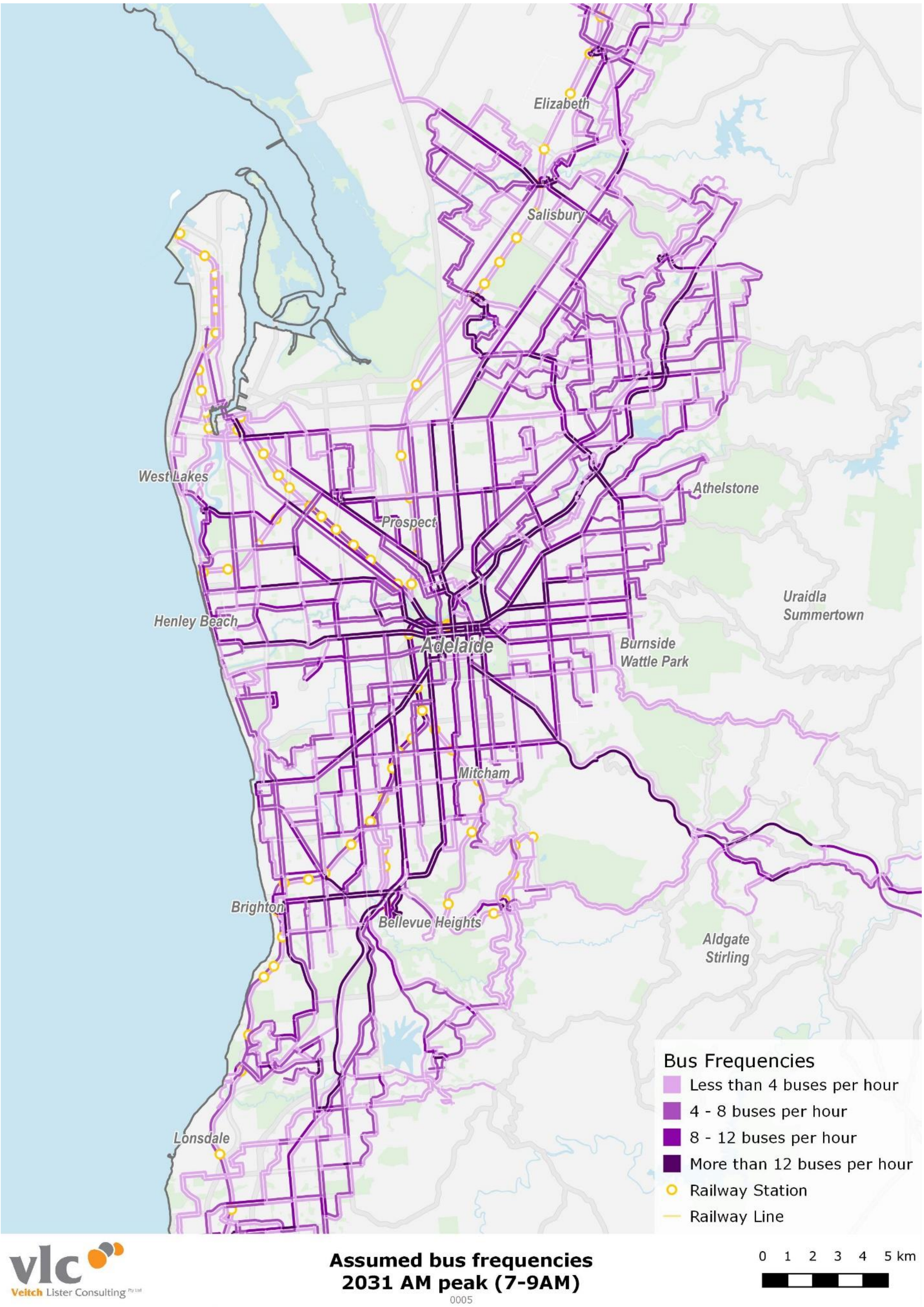
Source: Adelaide Metro

Appendix Figure B-2 – Assumed bus frequencies - 2016 PM peak (4-6PM)

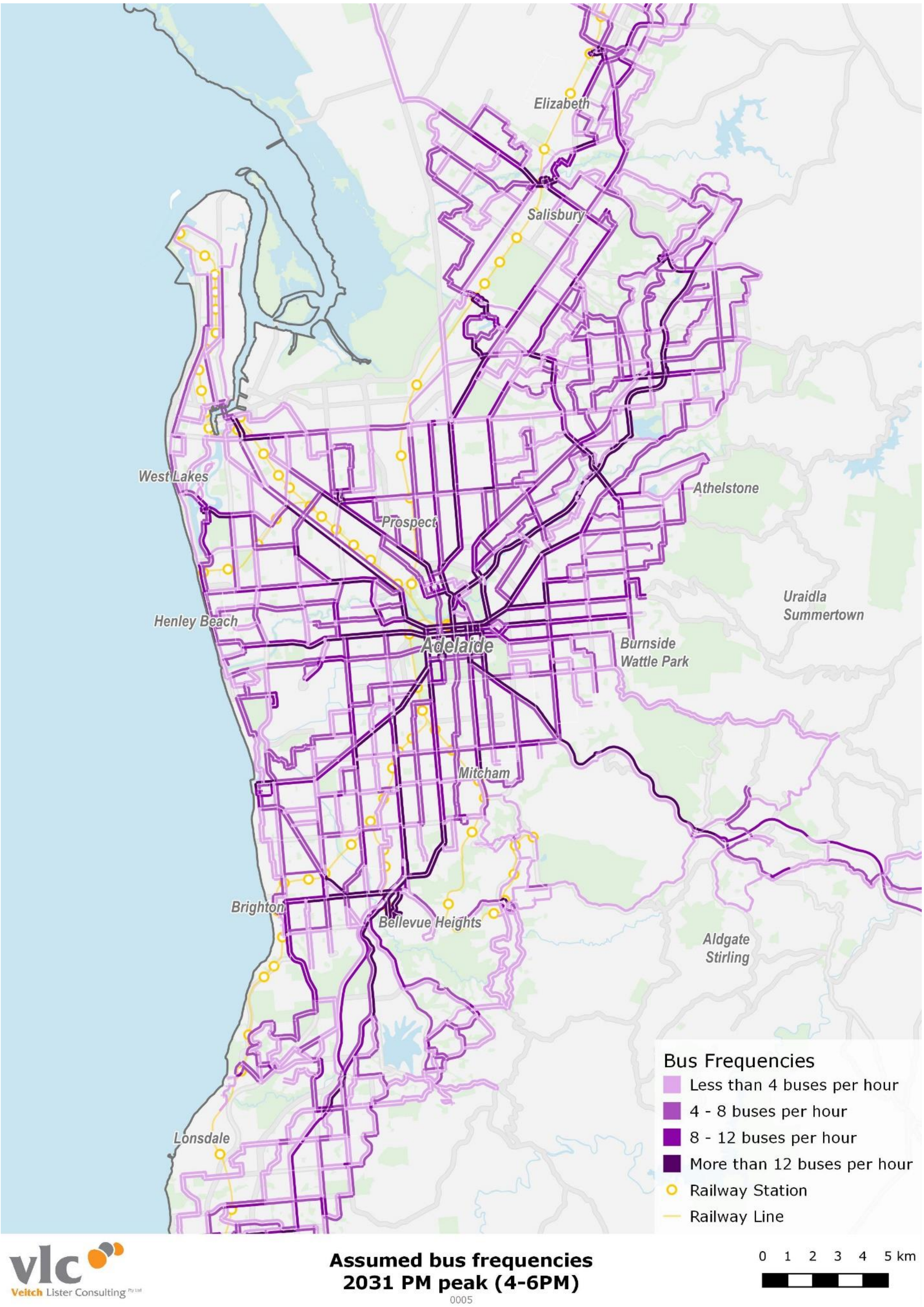


Source: Adelaide Metro

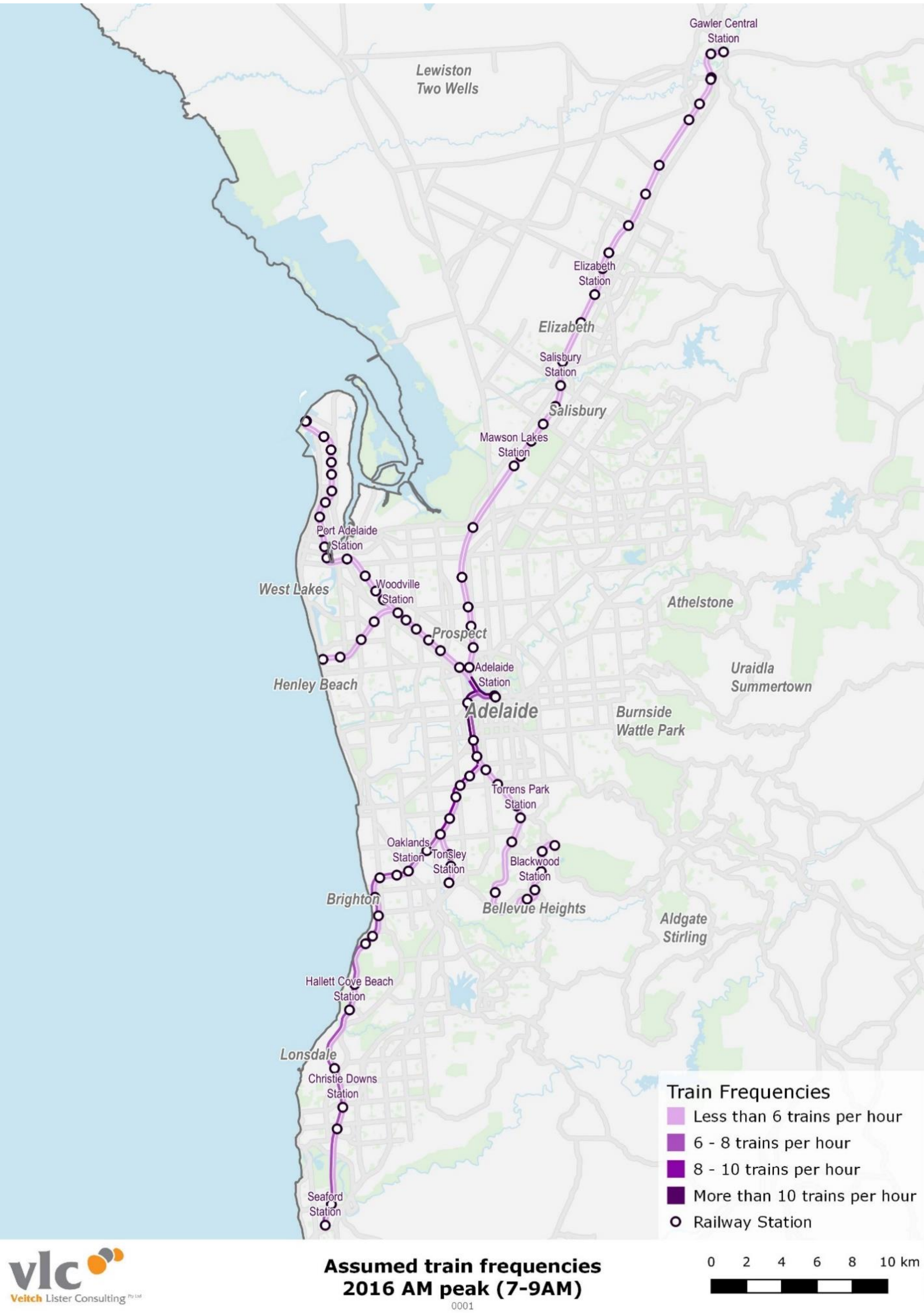
Appendix Figure B-3 – Assumed bus frequencies - 2031 AM peak (7-9AM)



Appendix Figure B-4 – Assumed bus frequencies - 2031 PM peak (4-6PM)

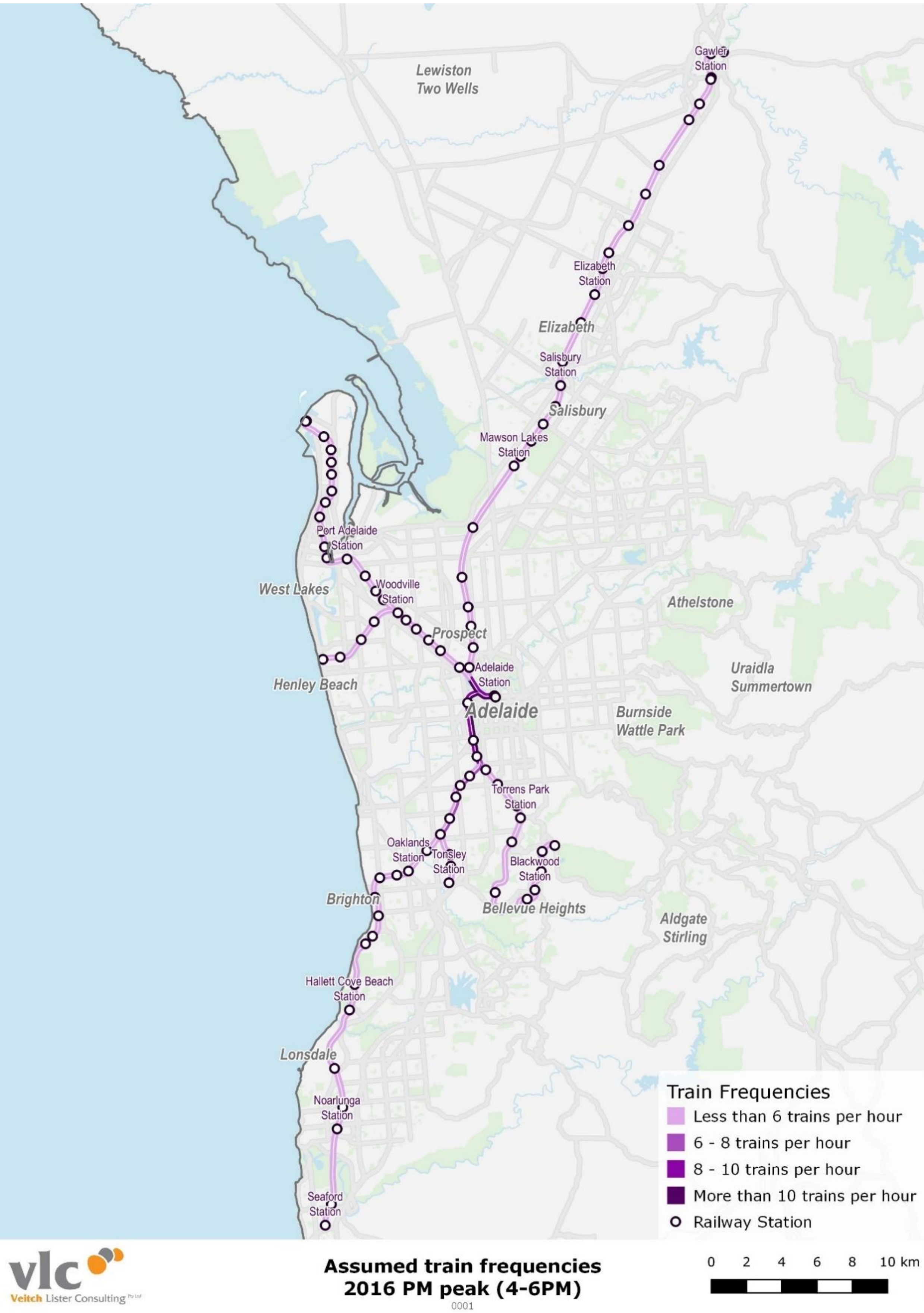


Appendix Figure B-5 – Assumed train frequencies - 2016 AM peak (7-9AM)



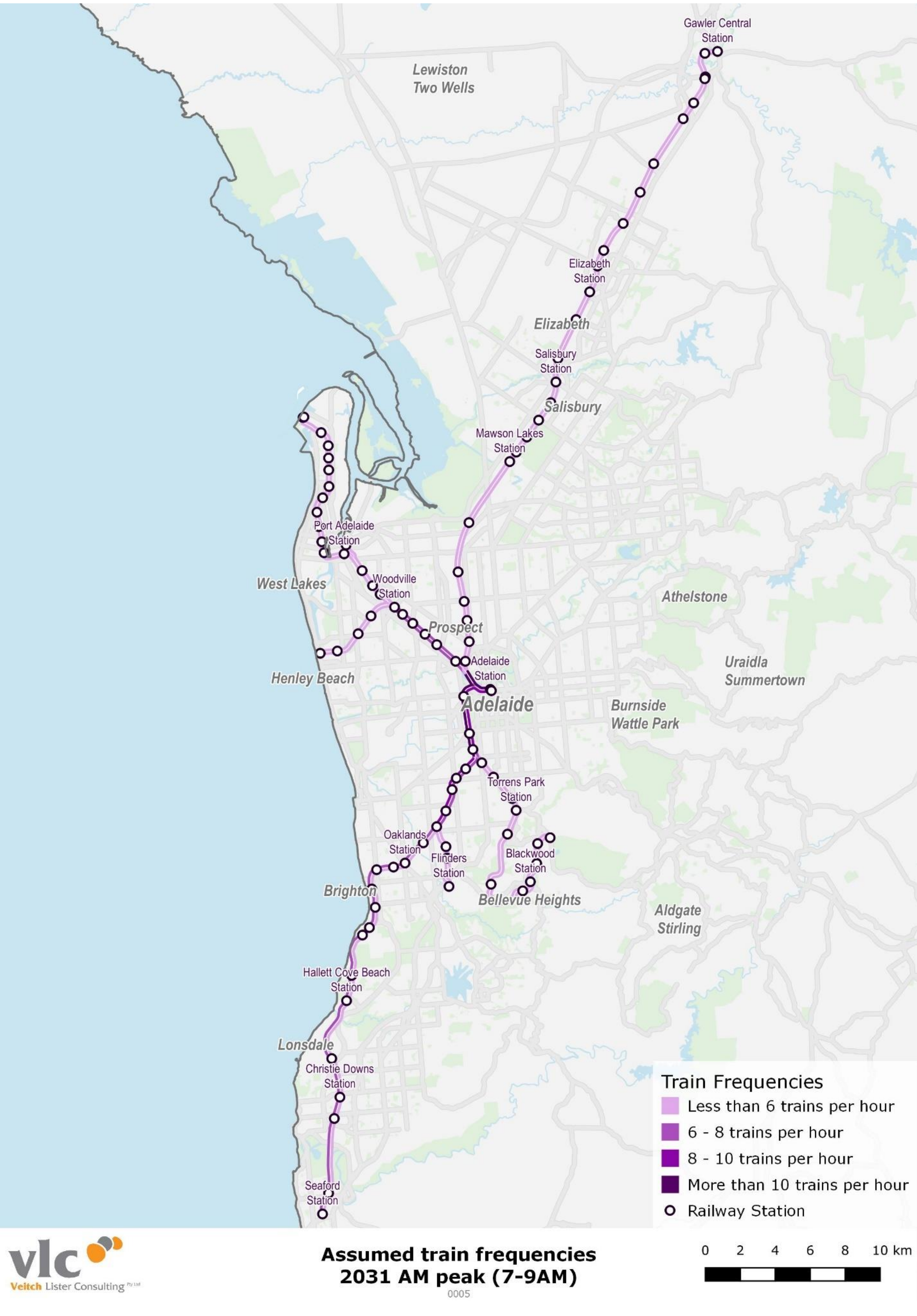
Source: Adelaide Metro

Appendix Figure B-6 – Assumed train frequencies - 2016 PM peak (4-6PM)

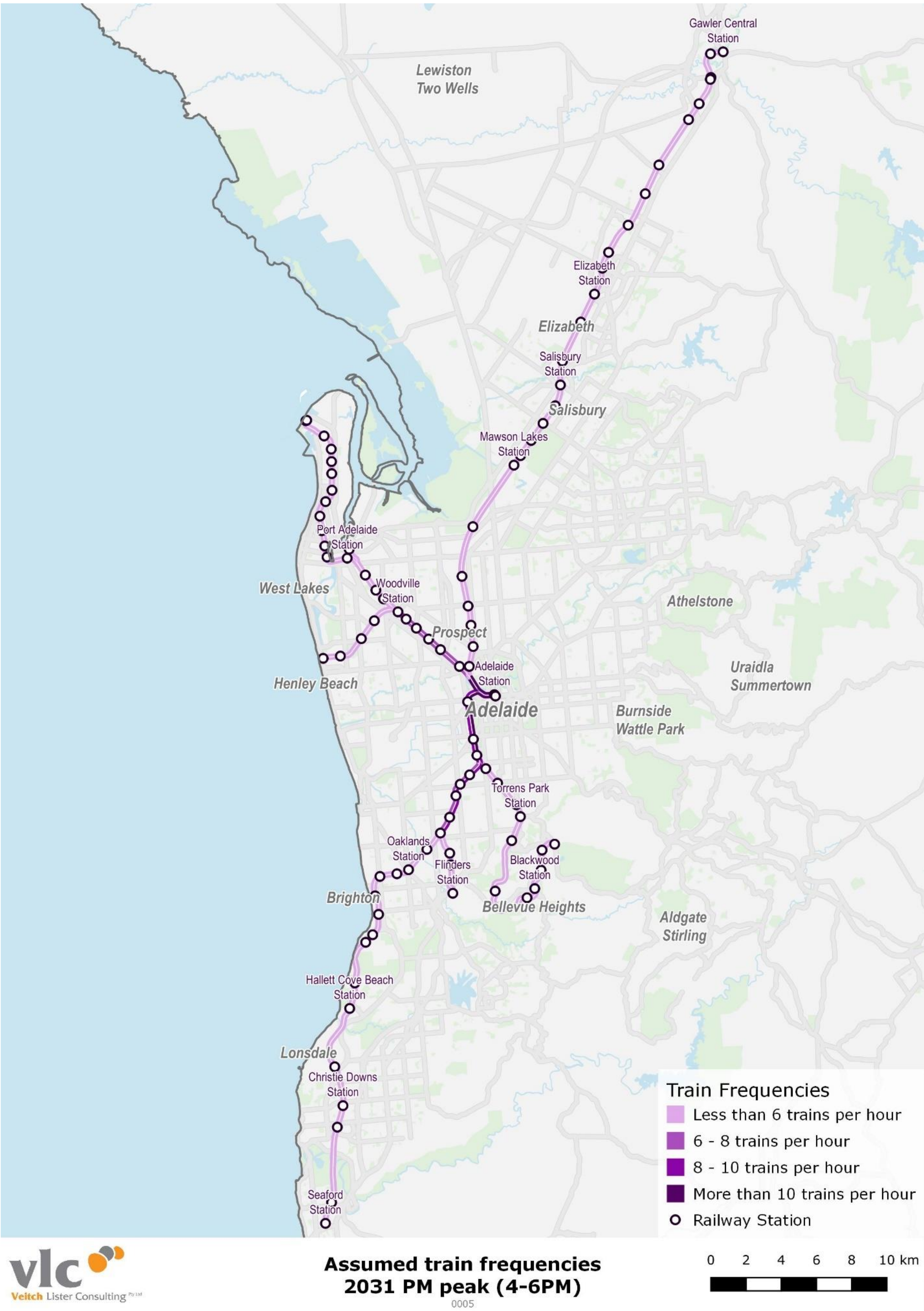


Source: Adelaide Metro

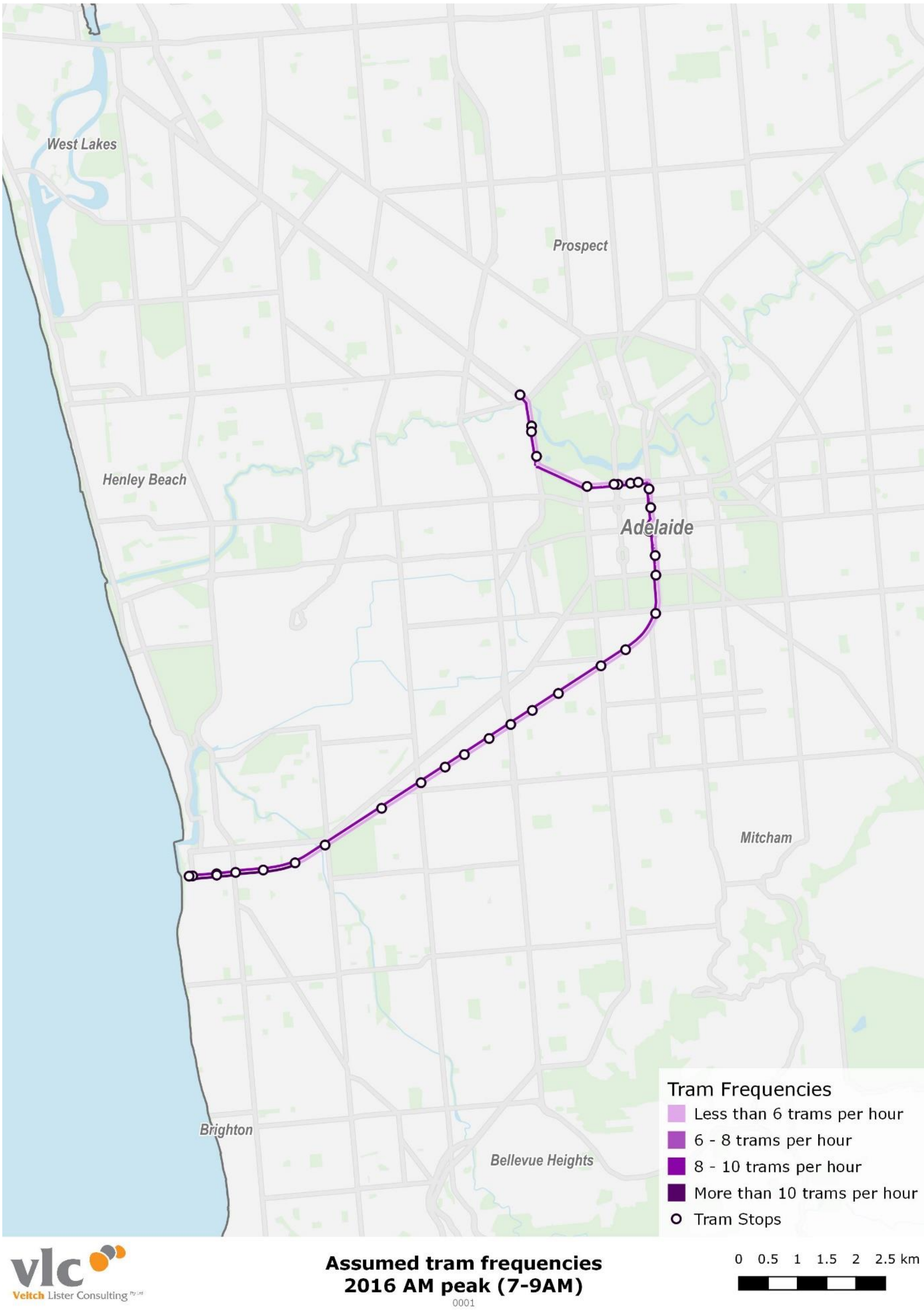
Appendix Figure B-7 – Assumed train frequencies - 2031 AM peak (7-9AM)



Appendix Figure B-8 – Assumed train frequencies - 2031 PM peak (4-6PM)

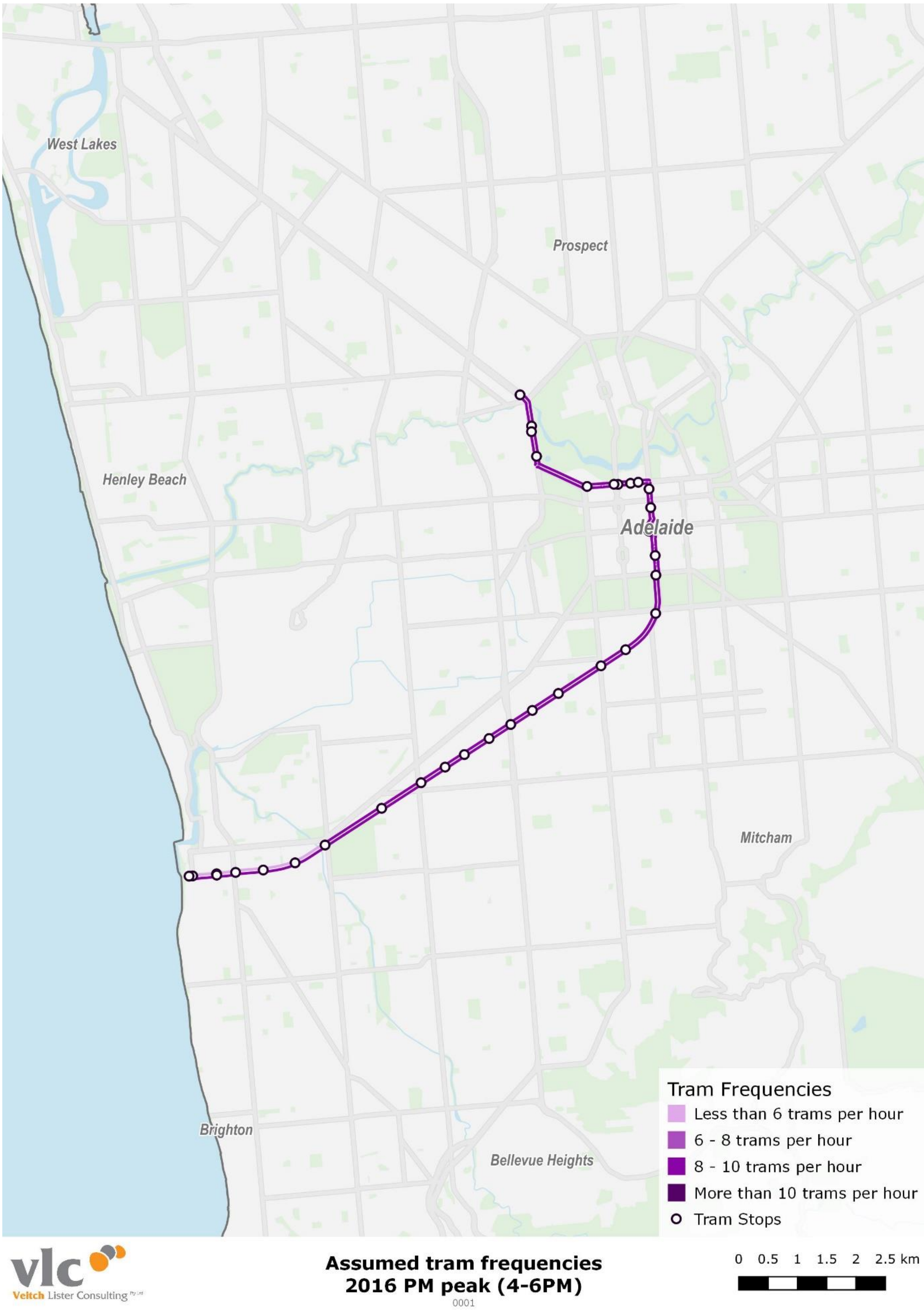


Appendix Figure B-9 – Assumed tram frequencies - 2016 AM peak (7-9AM)



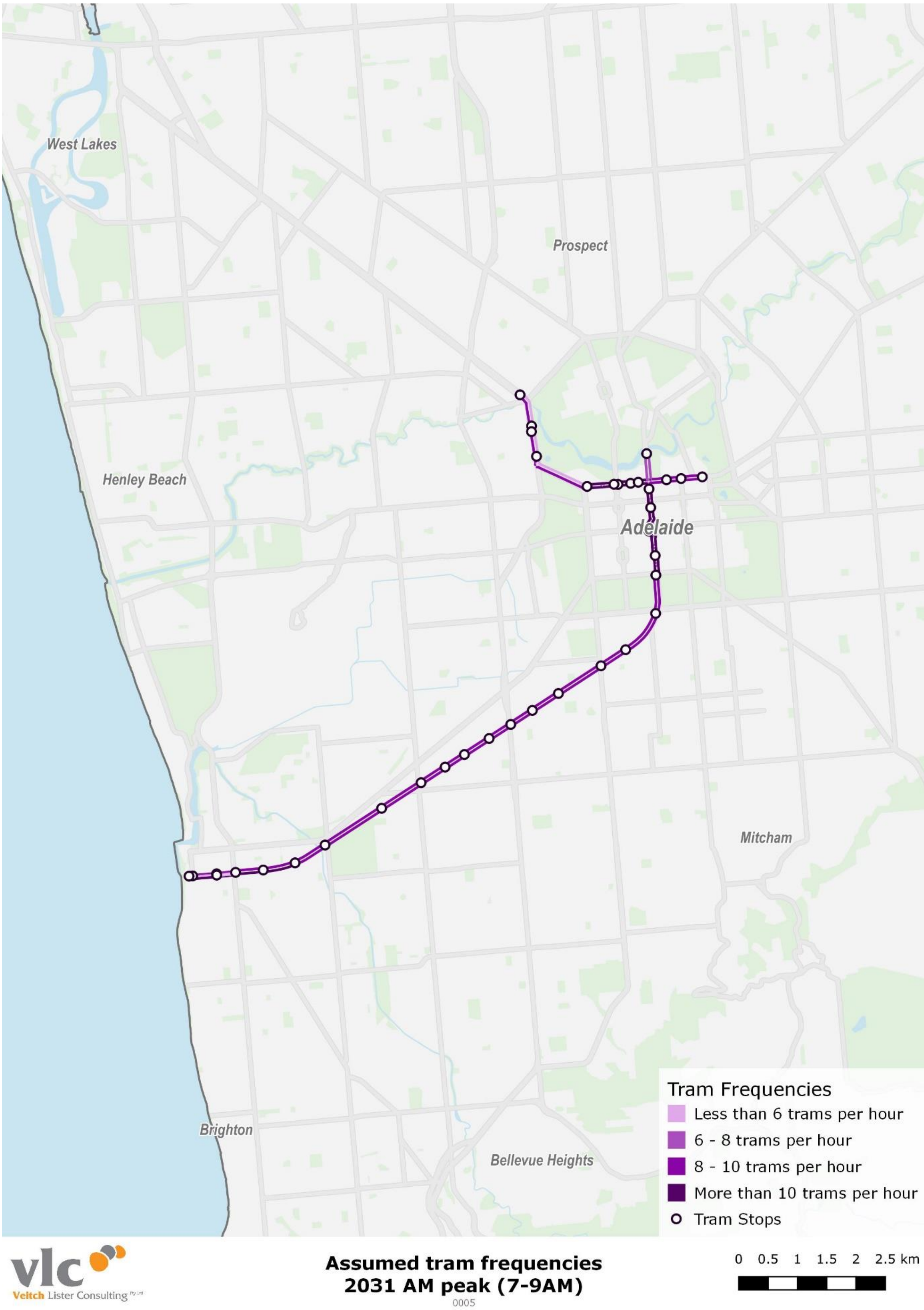
Source: Adelaide Metro

Appendix Figure B-10 – Assumed tram frequencies - 2016 PM peak (4-6PM)

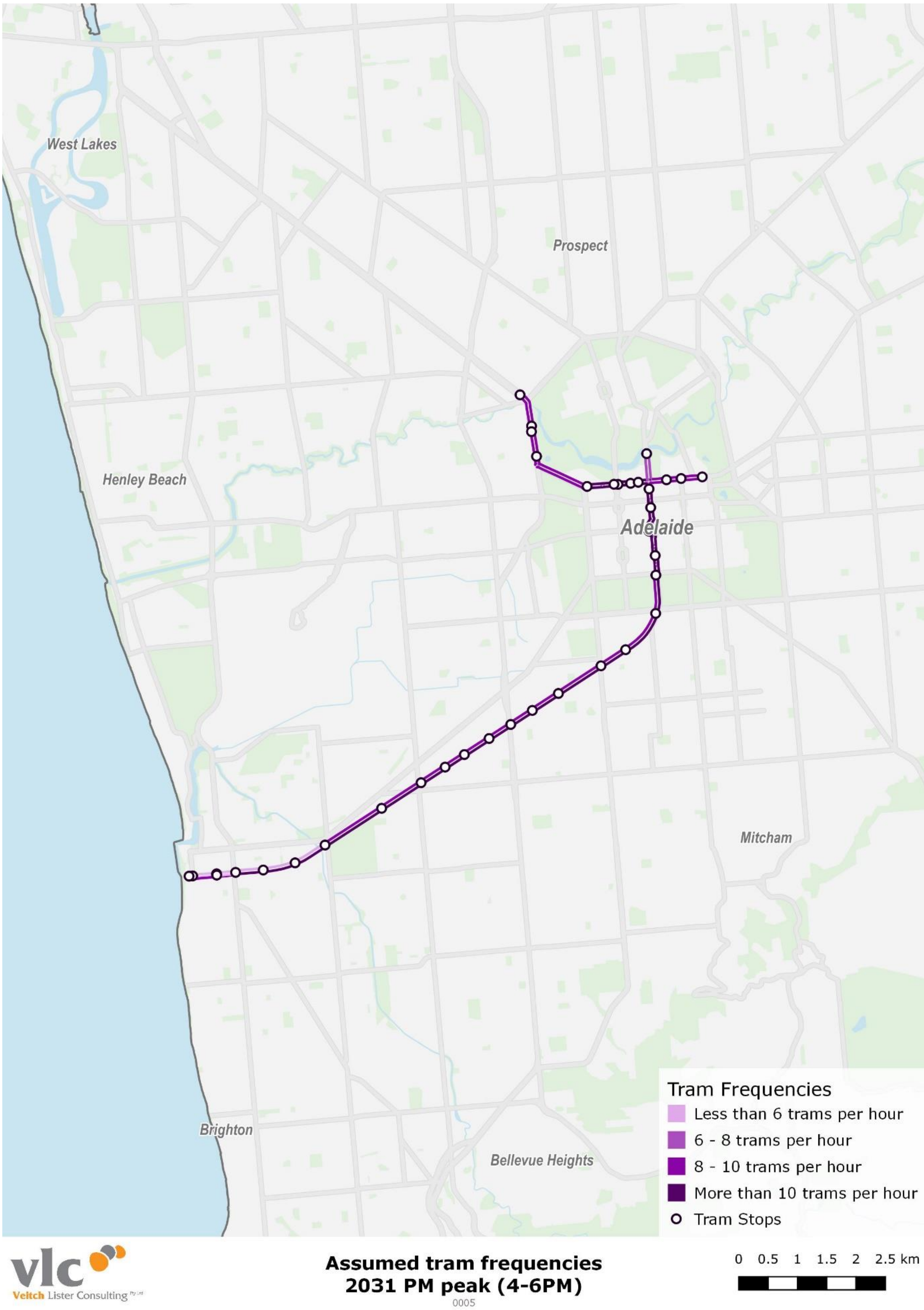


Source: Adelaide Metro

Appendix Figure B-11 – Assumed tram frequencies - 2031 AM peak (7-9AM)



Appendix Figure B-12 – Assumed tram frequencies - 2031 PM peak (4-6PM)



Appendix C: Adelaide Transport Corridors

Appendix Table C-1 – Adelaide Transport Corridors

Corridor number	Corridor name
1	South Rd/Main South Rd Corridor
2	Victor Harbor Rd Corridor
3	Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor
4	Southern Expressway Corridor
5	Marion Rd Corridor
6	Princess Hwy (M1)/Glen Osmond Rd Corridor
7	Anzac Hwy Corridor
8	Goodwood Rd Corridor
9	Unley Rd/Belair Rd Corridor
10	Fullarton Rd Corridor
11	Majors/Black/Main Rd Corridor
12	Sturt/Shepherds Hill Rd Corridor
13	Oaklands/Daws/Springbank Rd Corriddor
14	Cross Rd Corridor
15	Port Wakefield Rd/Main North Rd Corridor
16	Outer Main North Rd Corridor
17	Gawler Township Corridor
18	Kenihans Rd/Chandlers Hill Rd/Main Rd Corridor
19	Flaxmill/Wheatsheaf/Panalatinga Rd Corridor
20	O'Sullivan Beach/Bains/Piggott Range Rd Corridor
21	Richmond Rd/Greenhill Rd Corridor
22	Sir Donald Bradman Dve Corridor
23	Port Road Corridor
24	Portrush Road Corridor
25	Glynburn Road Corridor
26	Outer Eastern Arterial Bypass Corridor
27	Kensington Road Corridor
28	Magill Road Corridor
29	Lower North East Rd/Payneham Rd Corridor
30	North East Road Corridor
31	Bridge Road/Hampstead Rd Corridor
32	Henley Beach Road Corridor
33	Grange Road Corridor

34	Torrens Road Corridor
35	Churchill Road Corridor
36	Regency Road Corridor
37	Grand Junction Road Corridor
38	Salisbury Hwy/Philip Hwy Corridor
39	Northern Expressway Corridor

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.

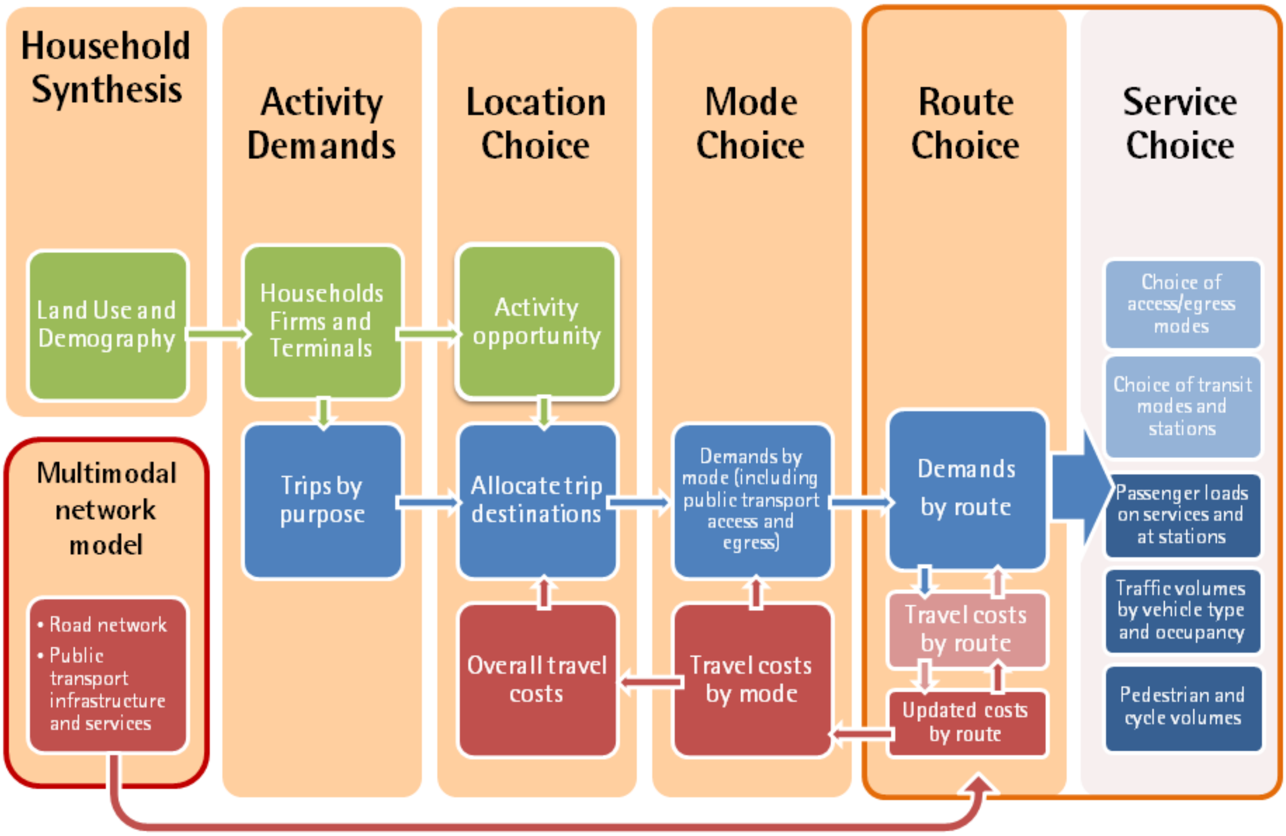
D.2.2 Model Architecture

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.

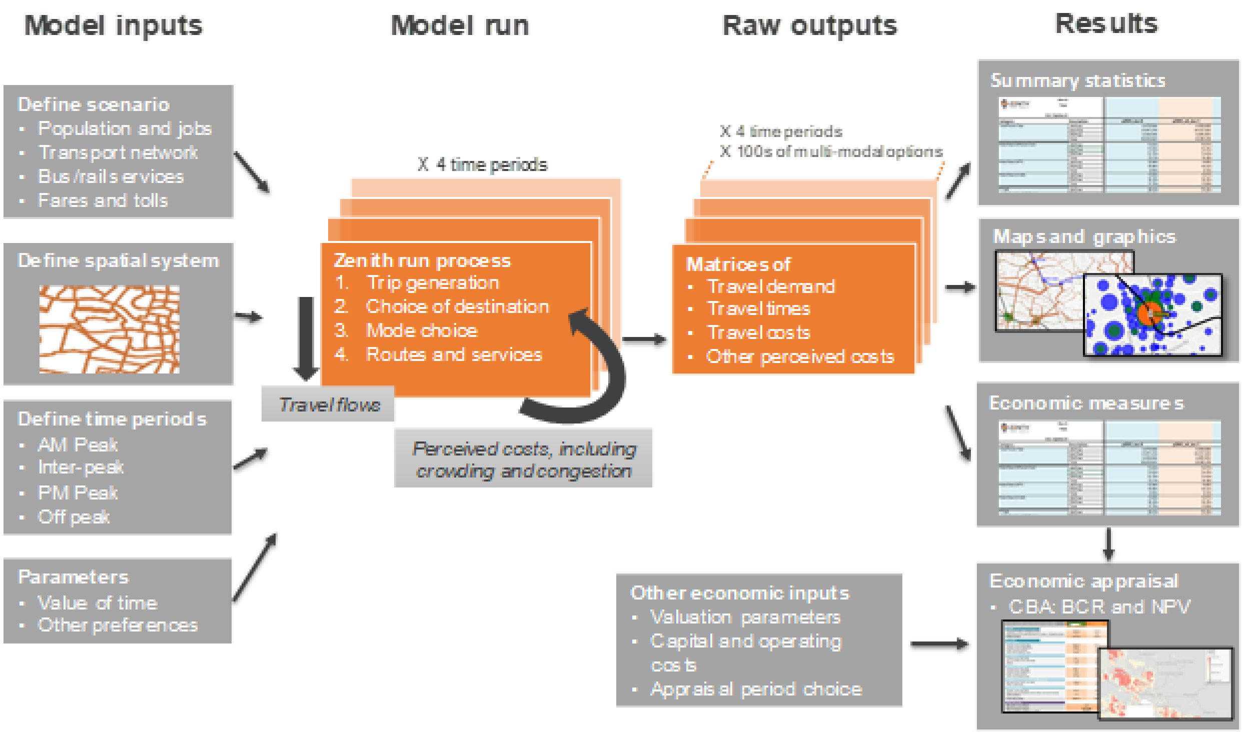
Having determined the destination and mode of travel, the model then reflects the choice of route for trips by private or commercial vehicle, public transport and active travel modes such as cycling and walking.

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:

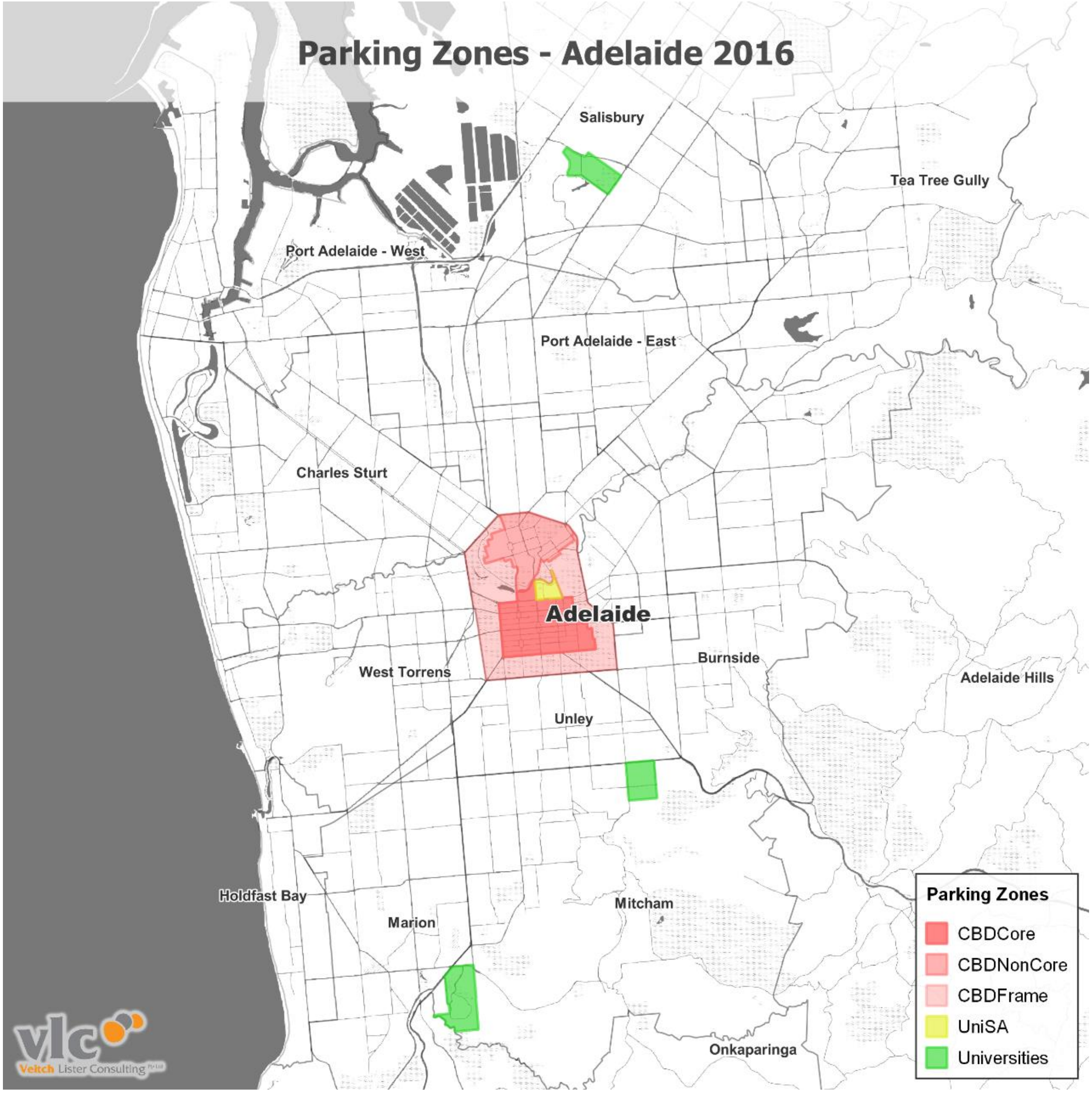
- real increases in the price of transport fuels; and
- reduction in the rate of fuel consumption due to improved vehicle efficiency and increased use of more efficient fuels within the vehicle fleet.

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 per cent (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 – Adelaide parking zones



Tolls

Adelaide does not currently have any existing or planned toll roads.

Public transport fares

While any observed 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-1 – Public transport costs and fares. Adelaide does not have a distance based fare system.

Appendix Table D-1 – Public transport costs and fares

Public Transport Cost Parameters		Zenith
Public Transport VOT, 2016 (AUD 2011)		$12 / hour
Public Transport Fares, 2016 (AUD 2011)	Interpeak (Zenith MD)	1.64
	Peak (Zenith AM, PM, OP)	2.99

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.

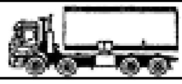
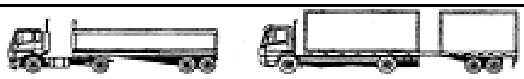
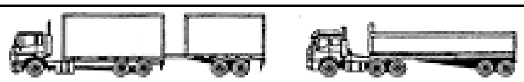
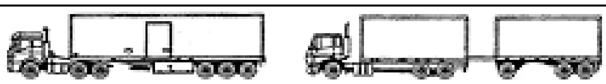
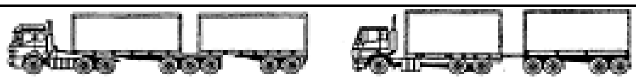
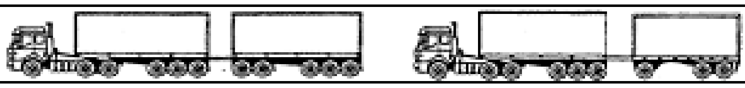
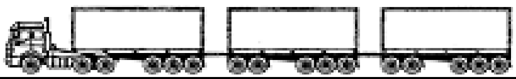
Vehicles are classified according to the Austroads Vehicle Classification System (Appendix Figure D-4). Appendix Table D-2 details how the VLC vehicle types equate to Austroads vehicle classes.

Appendix Table D-2 – 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

Source: Austroads

Appendix Figure D-4 – Austroads Vehicle Classification System

Class	Parameters	Typical Configuration
LIGHT VEHICLES		
1	d(1) ≤ 3.2m and axles = 2	
2	groups = 3 d(1) ≥ 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
HEAVY VEHICLES		
3	d(1) > 3.2m and axles = 2	
4	axles = 3 and groups = 2	
5	axles > 3 and groups = 2	
6	d(1) > 3.2m, axles = 3 and groups = 3	
7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
9	axles = 6 and groups > 2 or axles > 6 and groups = 3	
10	groups = 4 and axles > 6	
11	groups = 5 or 6 and axles > 6	
12	groups > 6 and axles > 6	

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).[5]

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

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

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

- Measures of service capacity
- Crowding cost function, and
- Linking of outward and return journeys.

<u>Measures of service capacity</u>

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-1 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-3 – Public transport vehicle capacities

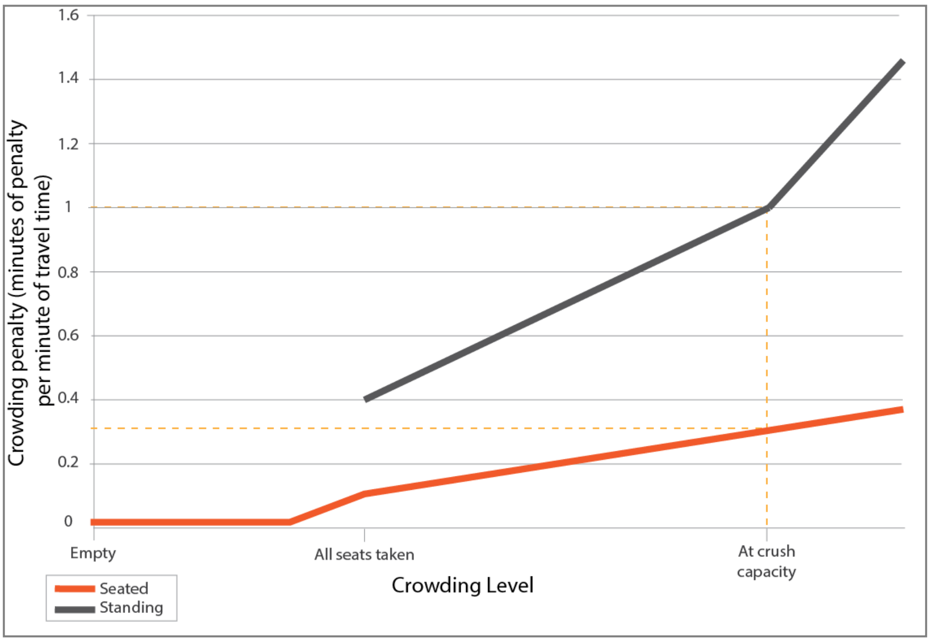
Vehicle	Seated Capacity	Crush capacity
Bus	45	65
Train	205	336
Light Rail	60	140

<u>Crowding cost function</u>

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-5.[6] 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.

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

Appendix Figure D-5 – 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-5).

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.[7] 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.

[7] 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 number 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 Adelaide, the impact is as follows:

Appendix Table E-2 – Comparison of Adelaide GCCSA 2031 forecast population

	2014-15 Audit	2018-19 Audit	Difference
Adelaide GCCSA population	1.6 million	1.6 million	-

Overall the demographic forecasts used in the 2018-19 Audit were fairly similar to those used in the 2014-15 Audit. Both sets of work forecast approximately 1.6 million people will live in the Adelaide GCCSA in 2031. Appendix Figure E-1 shows very minor differences in the way in which Adelaide's population was distributed the 2031 forecasts used in the 2014-15 and 2018-19 Audits. These are unlikely to result in significant changes to modelling results.

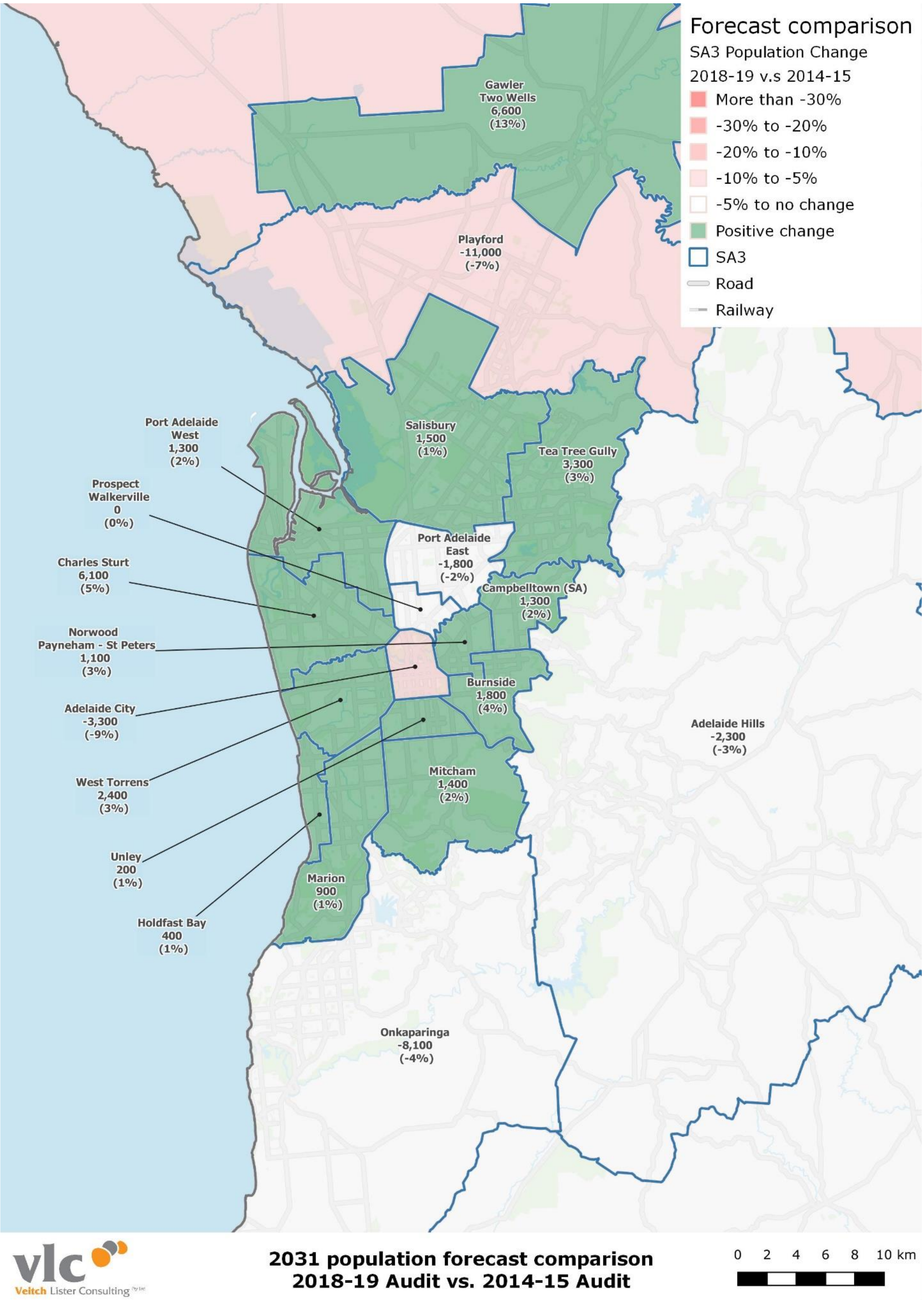
In the 2014-15 Audit, VLC prepared forecasts for employment, consistent with the population projections constrained to the ABS B series forecast. The employment forecasts are based on projected levels of employment self-containment within each LGA, which recognise the structure planning of local authorities 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 Adelaide, the impact is as follows:

Appendix Table E-3 – Comparison of Adelaide GCCSA 2031 forecast employment and centralisation

	2014-15 Audit	2018-19 Audit	Difference
Adelaide modelled area employment	0.8 million	0.7 million	-13%
Proportion of employment in Adelaide City SA3	23%	22%	-%

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. As such the attractiveness of a location is determined by the **proportion** of total attractors (jobs) in that location (rather than the actual **number** of jobs). Thus, having fewer 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 – 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 Adelaide, key differences in network assumptions are as follows:

Appendix Table E-4 – Comparison of Adelaide 2031 major project assumptions

Major projects in 2014-15 NOT in 2018-19	Major projects in 2018-19 NOT in 2014-15
• Many major projects included in the previous modelling were completed by 2016 and are therefore in the base year network for the current Audit	• City Tram extension • Port Dock Railway Line

E.2.3 Cost assumptions

Cost assumptions in Adelaide (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-5 compares the following high-level outputs:

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

Details of how 2018-19 modelling forecasts different from the 2014-15 Audit are provided in Appendix Table E-5.

Appendix Table E-6 compares corridor-level average traffic and delay hours for the AM peak for the 15 most delayed corridors in the 2018-19 Audit. It also shows the corridor ranking from the 2014-15 Audit. Traffic volumes on the most delayed corridors are broadly consistent. Also, the same corridors make up the top 4 in both audits (with a change to the ordering). Results for the PM peak showed a similar outcome.

Appendix Table E-5 – 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 are similar (-%)**	**⇩** **Employment forecasts have reduced (-12%), however the proportion of jobs in Adelaide City SA3 remains stable**	**⇧** **More investment in the road network (+10% network lane km)**	**⇧** **More investment in the PT network (+27% 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 (-41%)	**-** As population forecasts are similar, this would have minimal impact on model results	- 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-6).
	Car trips (-17%)	**-** As population forecasts are similar, this would have minimal impact on model results	**-** 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, this results in fewer car trips.
	Car vehicle kms travelled (-%)	**-** As population forecasts are similar, this would have minimal impact on model results	**-** 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 (-35%)	**-** As population forecasts are similar, this would have minimal impact on model results	**-** 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 crowing occurs • Analysis of observed public transport behavioural data suggested that PT usage has been declining in Adelaide. This is reflected in the updated 2016 base model, and could result in lower PT demand forecasts • The model recalibration will also affect the number of public transport trips.

Appendix Table E-6 – 2031 top ten most delayed road corridors for Adelaide - AM peak (ranked by total delay)

Rank IA Audit 2018-19	Direction	Corridor Name	Corridor	Average Peak Hour Traffic for 2031 forecasts			Total Delay Hours for 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	NB	South Rd/Main South Rd Corridor	1	1,800	2,000	8.6%	4,000	3,600	-10.0%	2
2	SB	Outer Main North Rd Corridor	16	2,800	2,600	-5.4%	3,800	2,800	-27.8%	3
3	SB	Port Wakefield Rd/Main North Rd Corridor	15	2,500	2,100	-17.7%	6,600	2,400	-63.4%	1
4	NB	Princess Hwy (M1)/Glen Osmond Rd Corridor	6	3,200	3,200	1.4%	2,900	2,300	-18.0%	4
5	SB	South Rd/Main South Rd Corridor	1	1,200	1,400	22.6%	1,200	2,300	93.6%	17
6	SB	North East Road Corridor	30	2,400	2,300	-1.9%	2,300	2,200	-3.9%	8
7	NB	Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor	3	1,700	1,700	3.9%	2,400	2,100	-14.0%	7
8	NB	Marion Rd Corridor	5	2,000	1,900	-6.4%	2,400	1,900	-22.8%	6
9	EB	Port Road Corridor	23	2,700	2,700	-0.9%	1,700	1,800	7.3%	11
10	WB	Lower North East Rd/Payneham Rd Corridor	29	1,900	1,800	-4.8%	2,100	1,800	-14.9%	9
11	SB	Northern Expressway Corridor	39	1,400	3,400	140.0%	100	1,600	2588.7%	68
12	NB	Outer Main North Rd Corridor	16	1,800	2,200	27.2%	600	1,500	165.3%	31
13	SB	Tapleys Hill/Brighton/Lonsdale/Dyson/Commercial Rd Corridor	3	1,200	1,400	14.8%	800	1,400	88.2%	23
14	NB	Goodwood Rd Corridor	8	2,400	2,200	-7.3%	1,800	1,300	-26.8%	10
15	EB	Anzac Hwy Corridor	7	3,000	2,300	-23.3%	1,500	1,200	-23.0%	12

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