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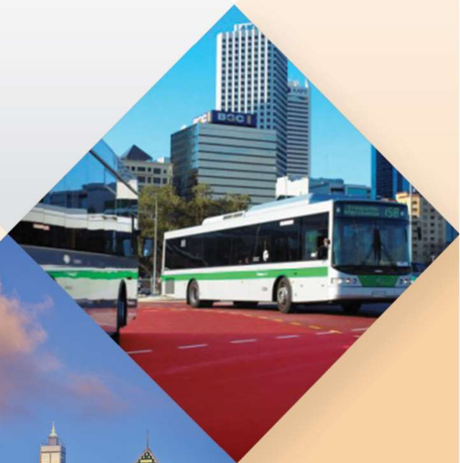

Prepared for

Australian Government
Infrastructure Australia

Transport Planning for the Australian Infrastructure Audit

Transport Modelling Report for Perth

March 2019


AXA AUSTRALIA

Transport Planning for the Australian Infrastructure Audit

FINAL

Transport Modelling Report for Perth

Project No. 18-025

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21/09/2018	B	H Smithers / L Walker	D Veryard	D Veryard	Draft Report
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Contents

List of Figures

List of Tables

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 Perth. Specifically, it evaluates the performance of Greater Perth's transport network in 2031 based on an evaluation framework that includes transport, economic, environmental and social indicators.

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

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

All tables and figures which quote numbers have been rounded to reflect that these forecasts are subject to considerable uncertainty. Where a numerical or percentage change has been quoted, it has been calculated using the unrounded data.

2. Perth in the future

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

2.1 People and jobs

The number of people living and working in Perth, as well as the locations in which they live and work, are the main determinants of the nature and scale of the city's transport task. In 2016, just over 2 million people resided in the Perth Greater Capital City Statistical Area (GCCSA). Figure 2-1 describes the city's population in more geographic detail using two metrics – total population by Level 3 Statistical Area (SA3) and gross population density by travel zone.

The highest population densities are seen in inner SA3s, particularly Perth City and South Perth. Other inner SA3s, such as Stirling, Melville and Bayswater-Bassendean, have relatively high densities. Conversely, outer SA3 populations are less dense. Almost 20 per cent of Perth residents lived in the Stirling SA3. The other two largest SA3s are also north of the Swan River – Wanneroo (195,000 residents) and Joondalup (161,000 residents). Rockingham is the most populous SA3 south of the Swan River, with 129,000 residents in 2016.

By 2031, WA Government projections indicate that Perth GCCSA's population will increase by 30 per cent to just over 2.6 million, an increase of over 600,000 from 2016 (Figure 2-2). Existing high population densities in Perth City and Stirling are further reinforced by strong growth (Figure 2-3). Other inner areas are projected to have more modest population growth. The inner eastern SA3s of Bayswater-Bassendean, Belmont-Victoria Park and Canning are predicted to add between 16,000 to 26,000 extra residents. In the inner west the number of people residing in Cottesloe, Fremantle and Melville is assumed to stay relatively stable. In contrast, Perth's fringe areas are expected to accommodate most of the city's population growth. For instance, the SA3 with the largest population growth is Wanneroo, at the metropolitan area's northern edge. Wanneroo is forecast to house an extra 145,000 residents between 2016 and 2031. The significant increase in population in the outer areas is important for this study, as trips made by these new and dispersed residents are likely to put pressure on both the infrastructure in outer areas but also the corridors connecting Perth's major activity centres.

The WA Government has identified achieving higher densities of both infill and greenfield residential development as a key target for Perth[1]. The demographics used in this study reflect this goal with increased population density expected in concentrated pockets.

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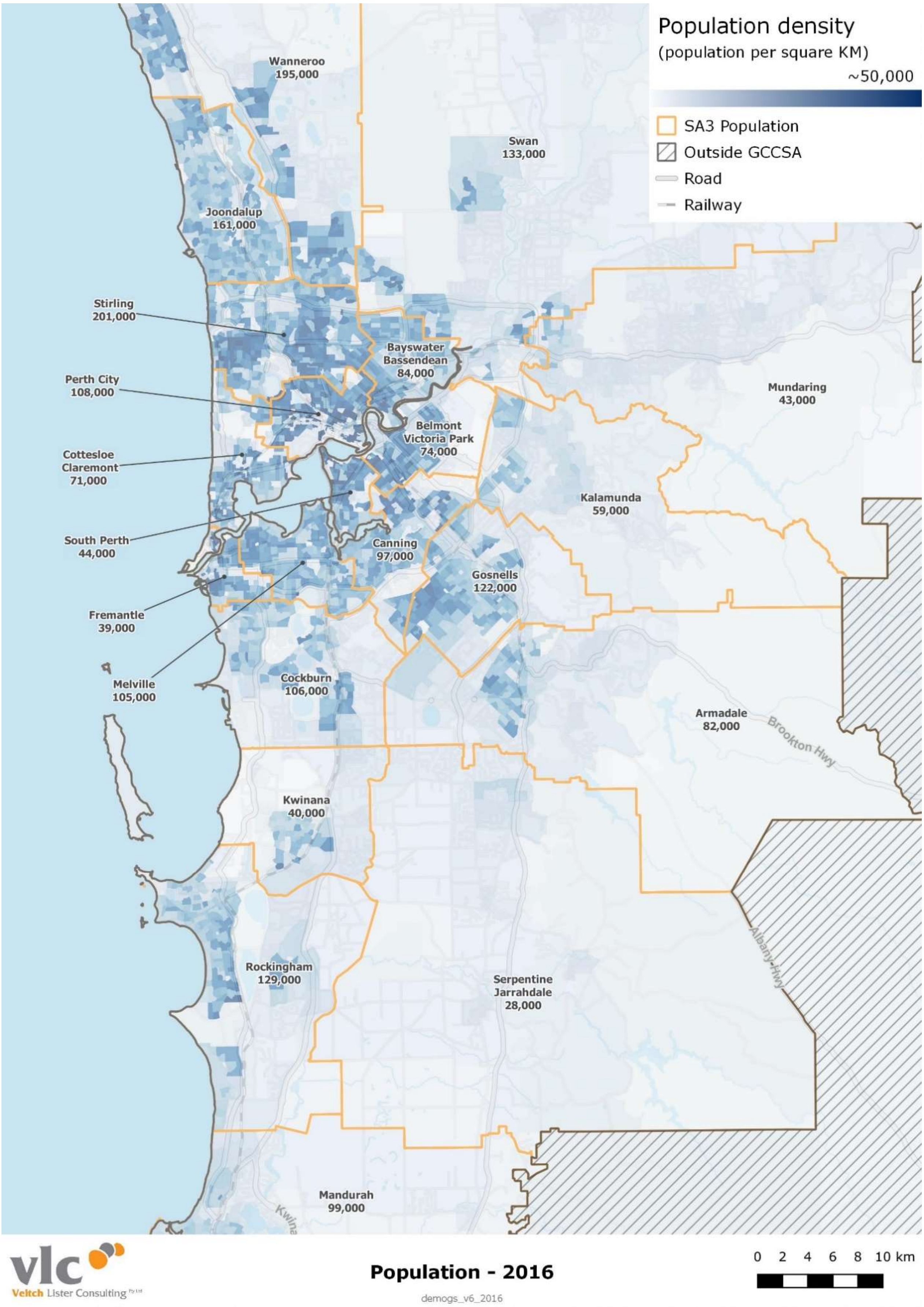
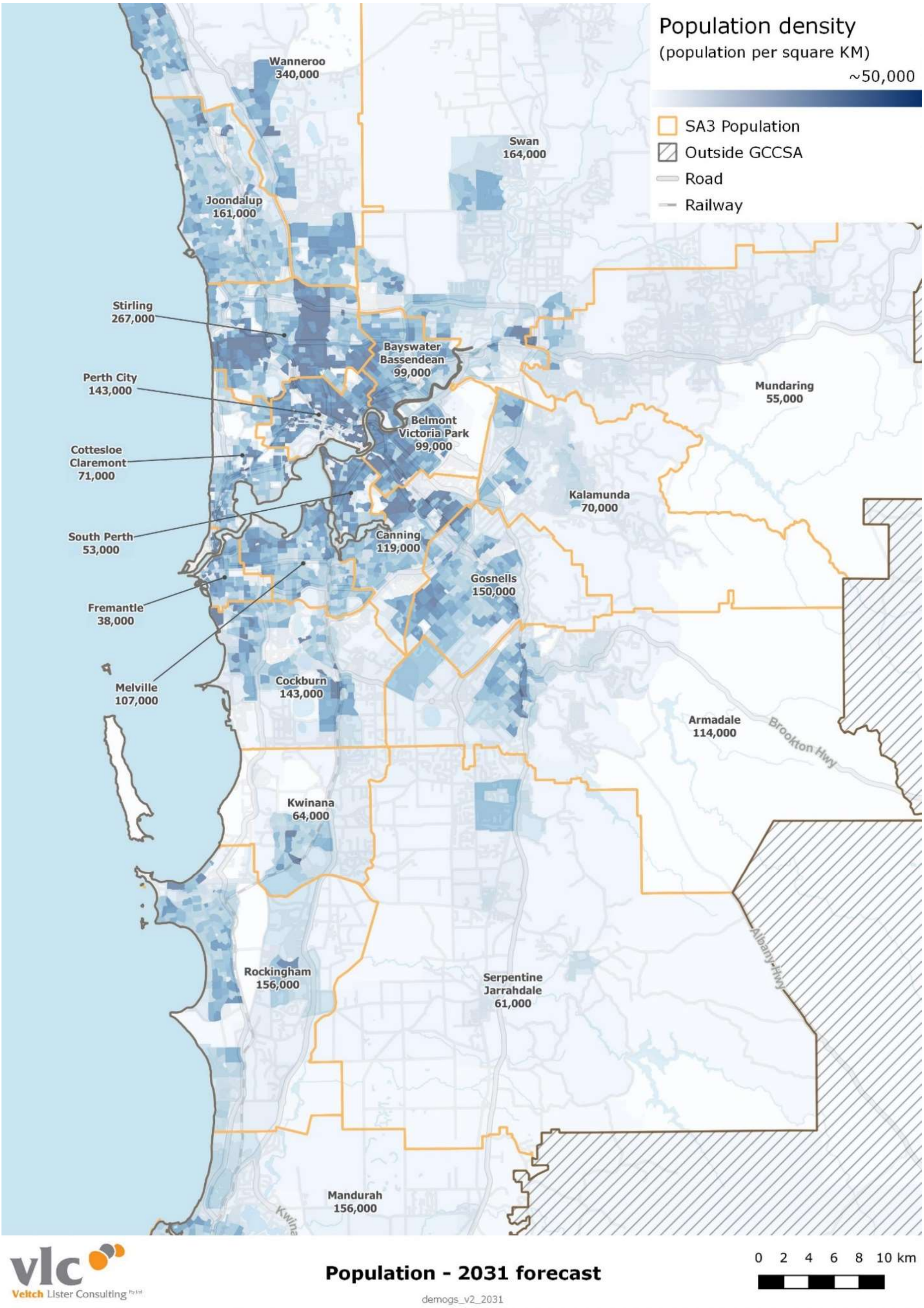
[1] Western Australian Planning Commission. (2010). *Directions 2031 and beyond.* Retrieved from https://www.planning.wa.gov.au/dop_pub_pdf/plan_directions2031_Part1.pdf

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



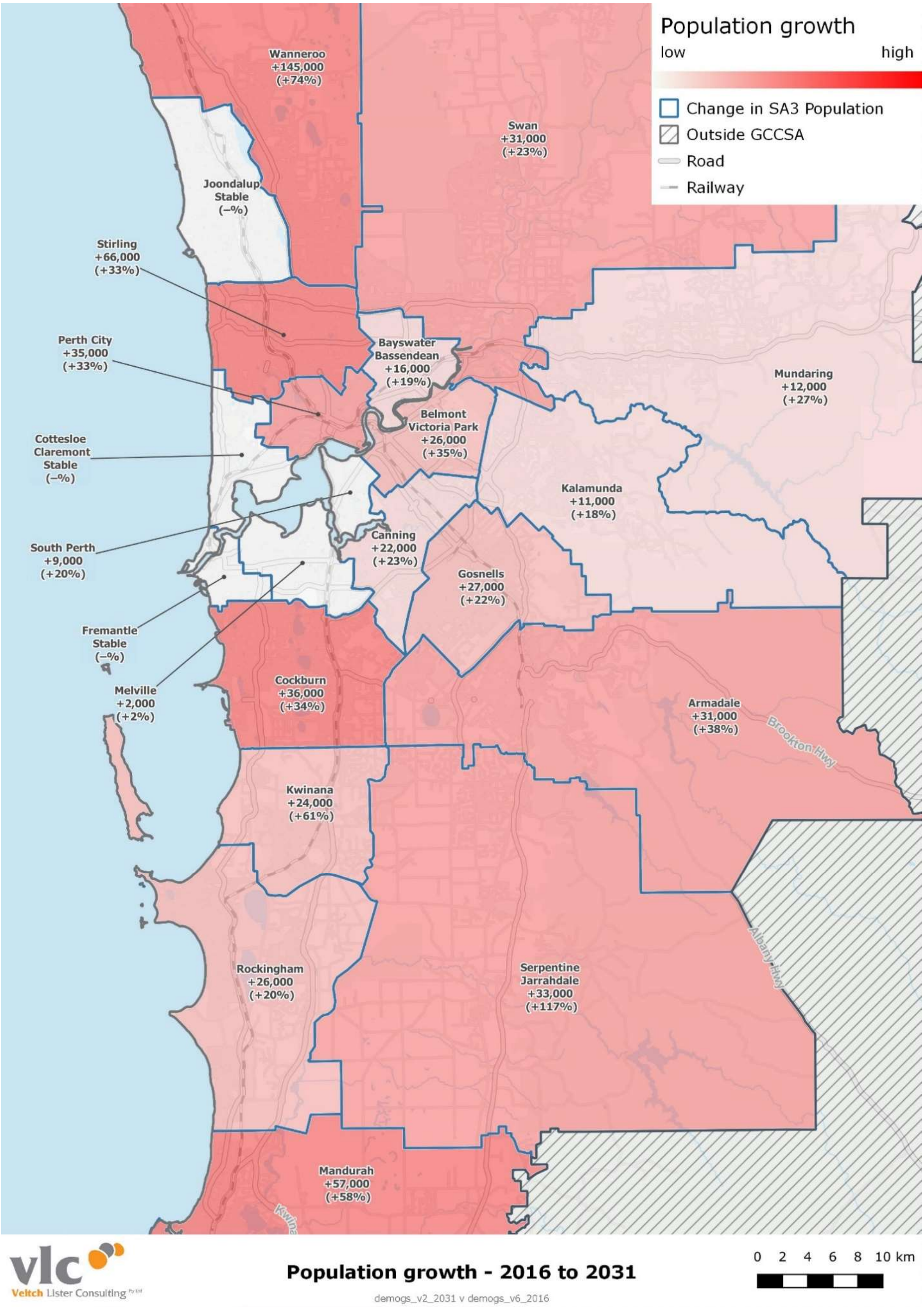
Source: ABS 2016 Census, disaggregated to Zenith travel zones

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



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

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



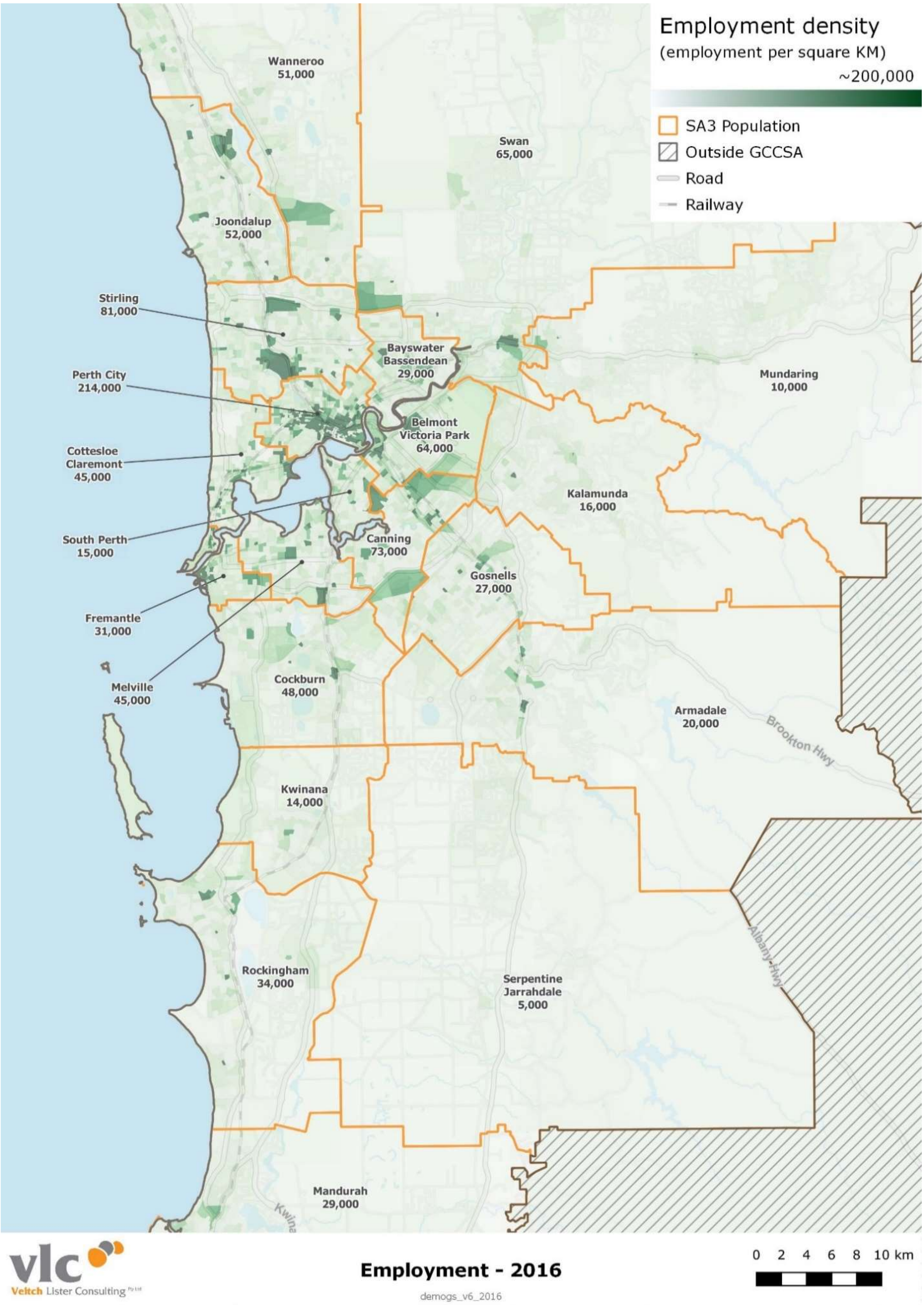
Source: WA Government population forecasts, disaggregated to Zenith travel zones

In addition to location of residence, the location of employment is a further determinant of travel choices. In 2016, just under 1 million jobs were located in the Perth GCCSA. Figure 2-4 describes both the total number of jobs by SA3 and density of jobs at a travel zone level. While population is relatively dispersed across the city, employment is much more concentrated into distinct hubs. The most significant employment hub is the Perth CBD, with the Perth City SA3 accommodating the largest number of jobs and over twice as the many jobs as the next highest, Stirling. There are additional employment clusters in outer areas (such as Joondalup in the north), however most of Perth's employment hubs are located in the inner urban areas around the Swan and Canning Rivers.

By 2031, it is expected that nearly 1.3 million jobs will be located in the Perth GCCSA (an increase of 323,000 jobs or approximately 30%). Employment is projected to increasingly consolidate within a small number of hubs in Perth's inner areas (Figure 2-5). At an SA3 level, the Perth City SA3 is forecast to have the strongest growth with the addition of 77,000 jobs (Figure 2-6). This would represent a reversal of recent trends of slow employment growth in the city. The number of jobs in other inner areas is also projected to grow. In most outer areas, weaker employment growth is expected. The exception to this is Wanneroo, which is predicted to experience the second largest increase in jobs (an additional 39,000 jobs).

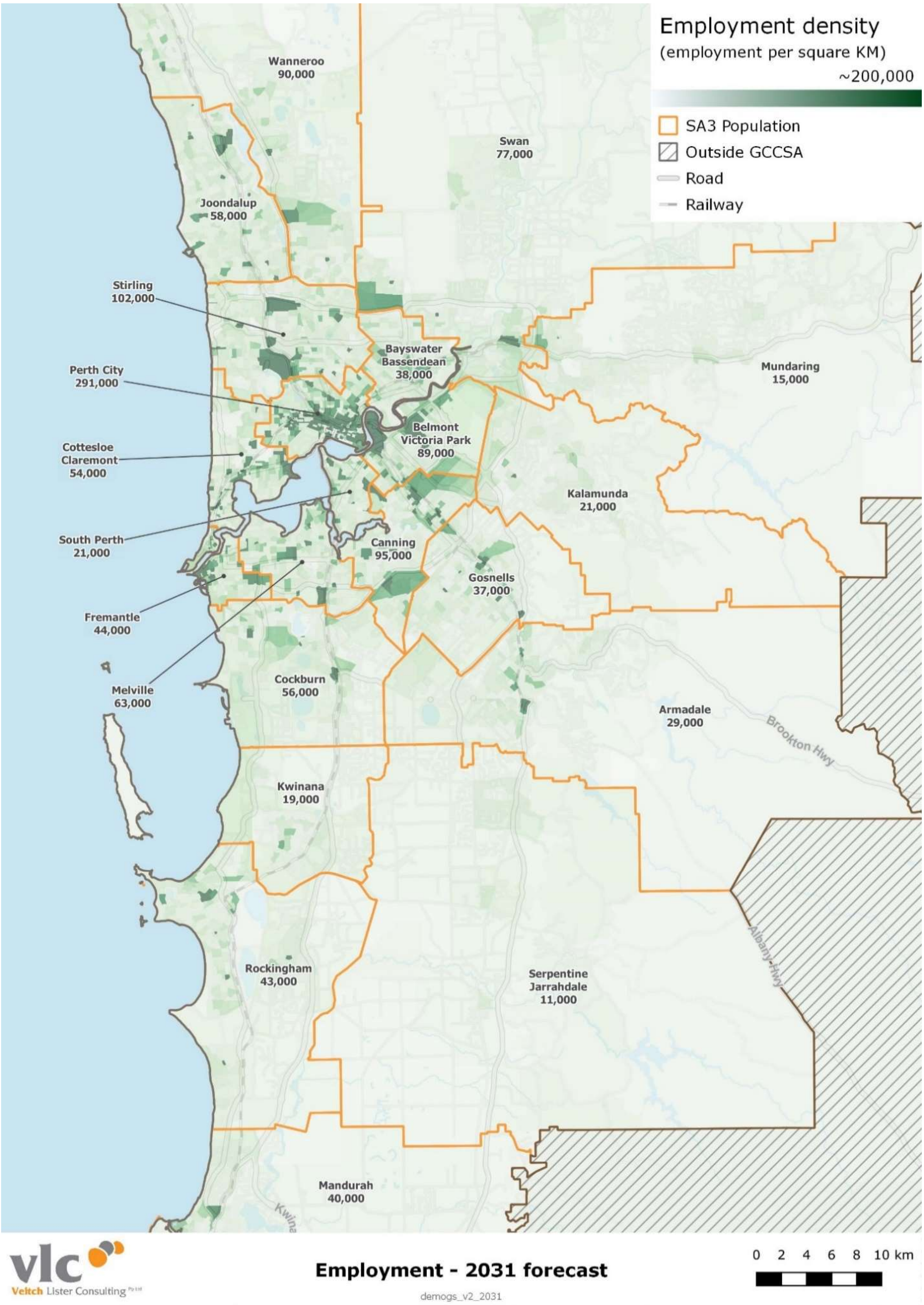
The trend towards increasing employment concentration is likely to increase demand for travel to inner areas. When compounded by an increasingly dispersed population, Perth's infrastructure will face a large challenge to support adequate access to jobs for the city's growing population.

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



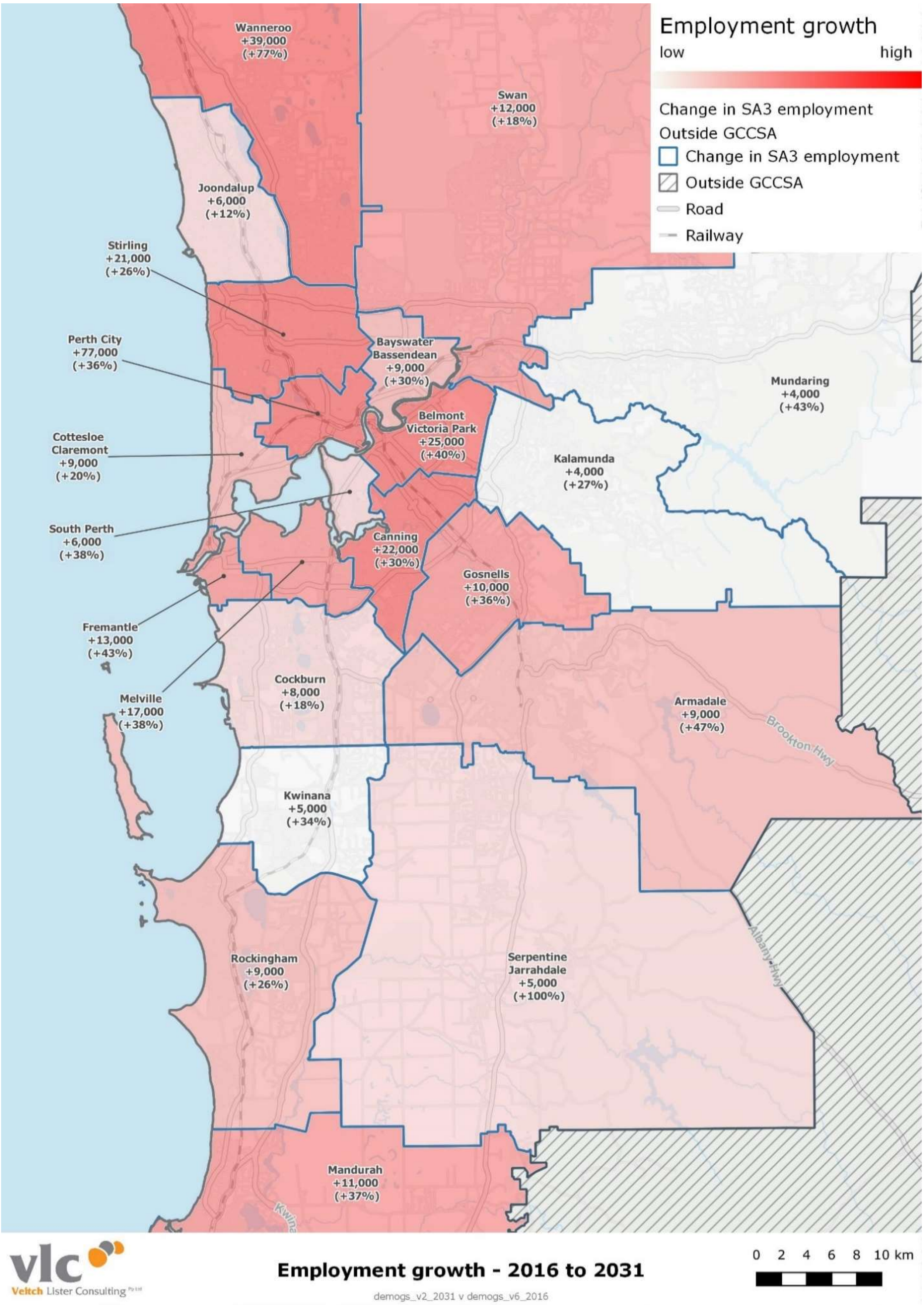
Source: ABS 2016 Place of Work, disaggregated to Zenith travel zones

Figure 2-5 – Perth GCCSA employment density and SA3 totals in 2031 forecast



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

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



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

2.2 Transport networks

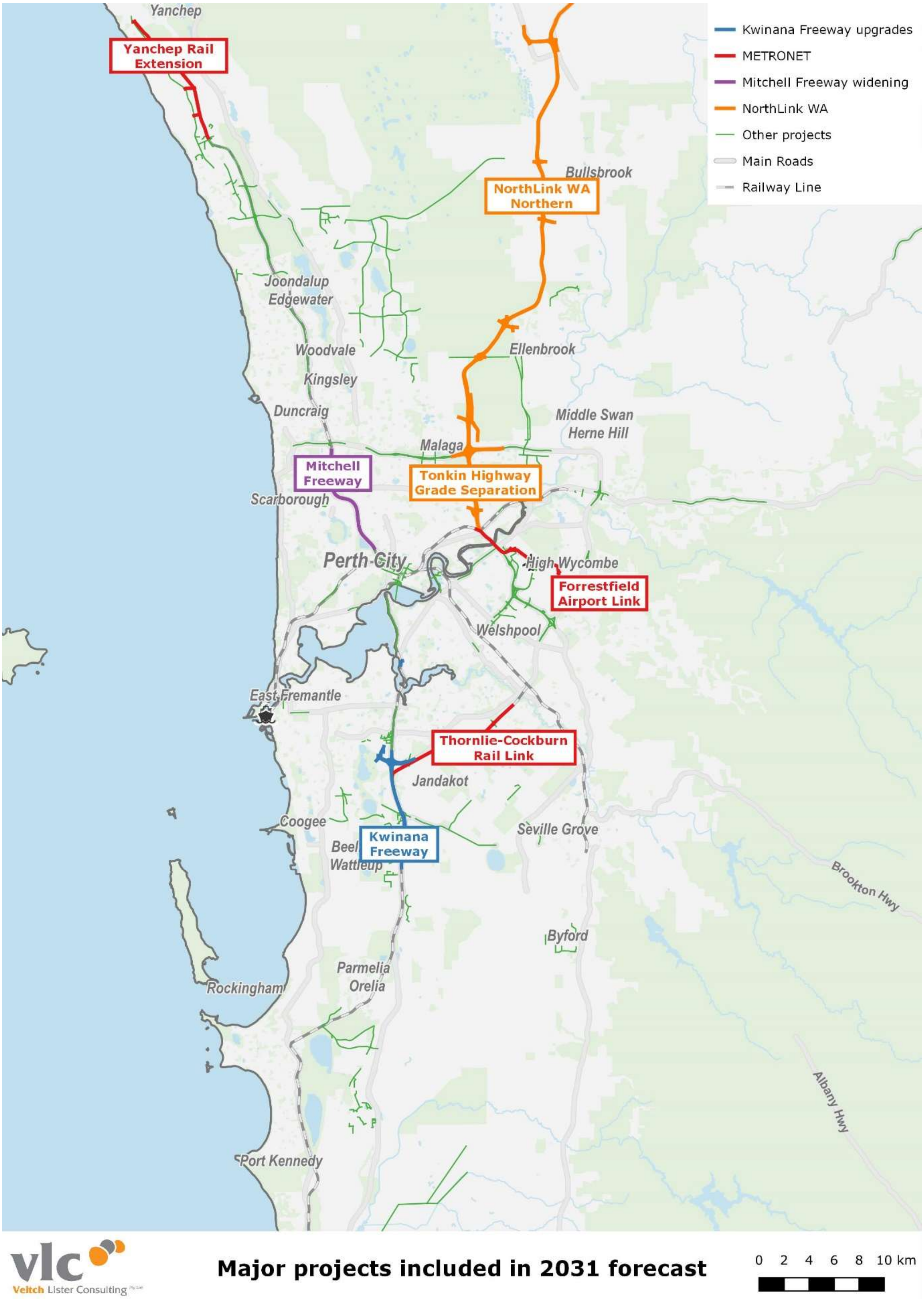
The transport network assumed in any given year will determine how (and how easily) populations will get between their homes, jobs, schools, shops and other activity areas. The 2031 transport network for Perth has been developed using a minimal-intervention approach. Included projects were (at the time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

NorthLink WA is a major road project that has been jointly funded by Federal and State Governments. It is currently under construction, with completion expected in 2019. The road links Muchea in the north to Guildford Road in the south, providing an alternative route to the heavily trafficked Greater Northern Highway. The road is being built in three separate sections, and all three have been included in the modelling. The **Tonkin Highway Grade Separation** is a related project that is also represented in the 2031 network.

METRONET is a program of projects, comprising several major rail network extensions and upgrades. Components of METRONET that have been included in the modelling for 2031 include the **Forrestfield Airport Link**, the **Thornlie-Cockburn Link** and the **Yanchep Rail Extension**. The Federal Government has indicated potential funding for each of these rail projects, with the Airport Link already under construction. METRONET projects that do not have sufficient commitment to be included in the modelling are the Morley-Ellenbrook Rail line, the Midland Line to Bellevue extension and the Byford extension.

Perth's north-south freeway spine is due to be upgraded with the **widening of Mitchell and Kwinana Freeways**. The Kwinana Freeway in the southbound direction is currently being upgraded between Armadale and Russell Roads, with the northbound direction fully funded with completion expected in 2020. The Mitchell Freeway southbound widening is planned for 2019. These upgrades are all reflected in the modelling.

Figure 2-7 – Major projects included in 2031 forecast



By 2031 bus services are assumed to improve incrementally through increased service frequencies and the extension of routes into growth areas. Rail in-service kilometres are assumed to increase by 18 per cent, this is a result of the extensions to the network (Forestfield Airport Link, Yanchep Rail Extension and the Thornlie-Cockburn Rail Link), rather than increases in frequency. In the context of Perth's 30 per cent population growth, a 24 per cent increase in total public transport in-service kilometres reflects a continuation of a 'business as usual' paradigm (Table 2-1).

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

Metric	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	5,000	6,000	+1,000	+15%
	Inter-peak (9AM-4PM)	13,000	16,000	+3,000	+20%
	PM peak (4-6PM)	5,000	6,000	+1,000	+16%
	Off-peak (6PM-7AM)	11,000	13,000	+2,000	+17%
	Daily total	**35,000**	**41,000**	**+6,000**	**+18%**
Bus	AM peak (7-9AM)	39,000	48,000	+9,000	+23%
	Inter-peak (9AM-4PM)	91,000	114,000	+23,000	+25%
	PM peak (4-6PM)	40,000	49,000	+9,000	+24%
	Off-peak (6PM-7AM)	54,000	69,000	+15,000	+29%
	Daily total	**224,000**	**280,000**	**+57,000**	**+25%**
Total PT	AM peak (7-9AM)	45,000	54,000	+10,000	+22%
	Inter-peak (9AM-4PM)	104,000	130,000	+26,000	+25%
	PM peak (4-6PM)	45,000	55,000	+10,000	+23%
	Off-peak (6PM-7AM)	65,000	82,000	+17,000	+27%
	Daily total	**259,000**	**322,000**	**+63,000**	**+24%**

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

3. Travel demands

Given the 30 per cent population and employment growth projected for Perth between 2016 and 2031, the transport task is expected to grow. This section provides 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.

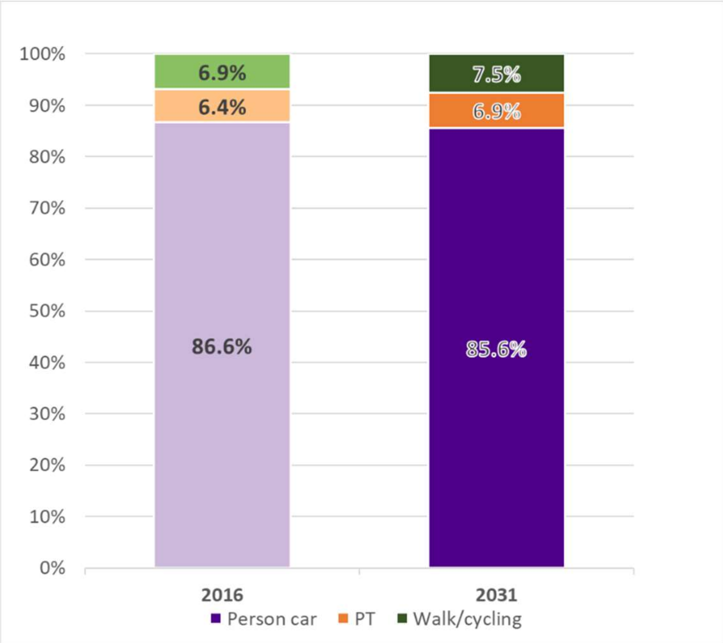
3.1 Growth in person travel

Between 2016 and 2031 the total number of trips made each day in Perth is forecast to increase by a third. Growth in person car trips closely matches Perth's population growth (30%) with almost 1.5 million extra daily trips, representing a 32 per cent increase, implying an approximately stable trip rate (Figure 3-2 and Table 3-1). Car travel retains its dominance over other modes with person car's mode share falling only very slightly from 87 per cent in 2016 to 86 per cent in 2031 (Figure 3-1). The increased congestion forecast on the road network in 2031 is likely to be the main driver of this decline. The small magnitude of the decline reflects that despite increased delays, residents of Perth will still find driving to be the most convenient option for most of their travel.

Table 3-1 – Perth GCCSA person trips by mode

Mode	Time period	2016	2031	Change	% change
Car	AM peak (7-9AM)	770,000	1,000,000	+230,000	+30%
	Inter-peak (9AM-4PM)	2,189,000	2,901,000	+712,000	+33%
	PM peak (4-6PM)	727,000	950,000	+224,000	+31%
	Off-peak (6PM-7AM)	971,000	1,284,000	+313,000	+32%
	Daily total	**4,657,000**	**6,136,000**	**+1,479,000**	**+32%**
Public transport	AM peak (7-9AM)	89,000	129,000	+39,000	+44%
	Inter-peak (9AM-4PM)	113,000	162,000	+49,000	+44%
	PM peak (4-6PM)	79,000	112,000	+33,000	+41%
	Off-peak (6PM-7AM)	65,000	90,000	+25,000	+39%
	Daily total	**346,000**	**494,000**	**+147,000**	**+42%**
Walk and cycle	AM peak (7-9AM)	59,000	82,000	+23,000	+38%
	Inter-peak (9AM-4PM)	183,000	274,000	+91,000	+50%
	PM peak (4-6PM)	52,000	75,000	+23,000	+43%
	Off-peak (6PM-7AM)	76,000	106,000	+30,000	+39%
	Daily total	**371,000**	**537,000**	**+166,000**	**+45%**
Total	AM peak (7-9AM)	919,000	1,211,000	+292,000	+32%
	Inter-peak (9AM-4PM)	2,485,000	3,338,000	+852,000	+34%
	PM peak (4-6PM)	858,000	1,137,000	+279,000	+33%
	Off-peak (6PM-7AM)	1,113,000	1,481,000	+368,000	+33%
	Daily total	**5,375,000**	**7,167,000**	**+1,792,000**	**+33%**

Figure 3-1 – Perth GCCSA mode share of daily trips

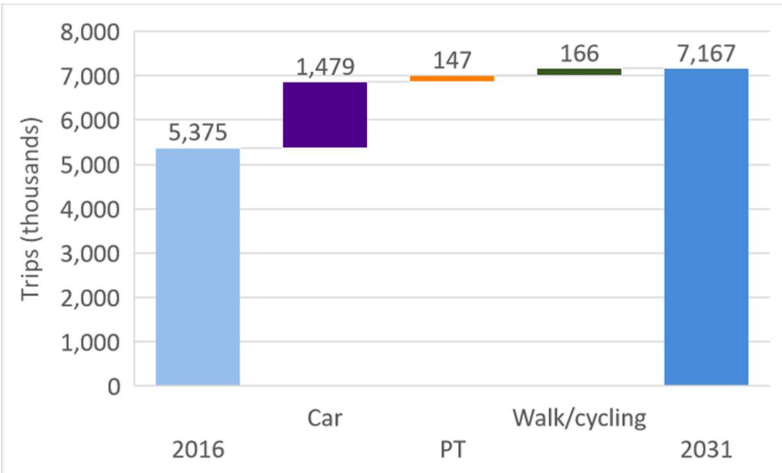


Public transport trips grow by 42 per cent across the day with an additional 147,000 trips. As a result, public transport's share of daily trips grows slightly, from 6 per cent in 2016 to 7 per cent in 2031 (with higher shares in the AM and PM peak periods). The main reason public transport is likely to become more popular in 2031 is the prevailing level of road congestion; congested roads make public transport more competitive. The relative cost to car travel is also a factor: in 2031, public transport travel is assumed to have become slightly cheaper relative to car travel (public transport fares are assumed to grow at CPI while parking charges for cars grow at 1.5 per cent per annum above CPI – see Appendix E).

While the share of trips made using public transport is expected to increase, this represents a relatively small number of additional public transport trips (around 147,000 per weekday, Figure 3-2).

Walking and cycling trips are forecast to grow by around 45 per cent, a result of the increased time and monetary costs of car travel to 2031. A real increase in parking charges is particularly relevant for walking and cycling trips as parking charges are applied mostly in Perth's inner areas, where closely clustered population and employment makes the active modes most viable.

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



3.2 Growth in vehicle travel

Traffic on the road network is split between car (93%) and commercial vehicle travel (7%).[3] Significant trip growth is forecast for both vehicle types, growing by 32 and 35 per cent respectively (Table 3-2 and Table 3-3).

Table 3-2 – Perth GCCSA weekday car traffic statistics

Metric	Time period	2016	2031	Change	% change
Trips	AM peak (7-9AM)	548,000	709,000	+162,000	+30%
	Inter-peak (9AM-4PM)	1,628,000	2,156,000	+528,000	+32%
	PM peak (4-6PM)	564,000	734,000	+170,000	+30%
	Off-peak (6PM-7AM)	745,000	984,000	+239,000	+32%
	Daily total	**3,485,000**	**4,583,000**	**+1,099,000**	**+32%**
Kilometres	AM peak (7-9AM)	7,390,000	9,802,000	+2,412,000	+33%
	Inter-peak (9AM-4PM)	21,386,000	28,774,000	+7,388,000	+35%
	PM peak (4-6PM)	7,765,000	10,316,000	+2,552,000	+33%
	Off-peak (6PM-7AM)	11,494,000	15,592,000	+4,098,000	+36%
	Daily total	**48,035,000**	**64,484,000**	**+16,449,000**	**+34%**
Hours	AM peak (7-9AM)	159,000	253,000	+93,000	+58%
	Inter-peak (9AM-4PM)	378,000	562,000	+183,000	+48%
	PM peak (4-6PM)	161,000	255,000	+94,000	+58%
	Off-peak (6PM-7AM)	179,000	245,000	+66,000	+37%
	Daily total	**878,000**	**1,314,000**	**+436,000**	**+50%**
Average assigned speed (kph)	AM peak (7-9AM)	46	39	-8	-16%
	Inter-peak (9AM-4PM)	57	51	-5	-9%
	PM peak (4-6PM)	48	40	-8	-16%
	Off-peak (6PM-7AM)	64	64	-1	-1%
	Daily total	**55**	**49**	**-6**	**-10%**

[3] See section A.2 for VLC's commercial vehicle definitions.

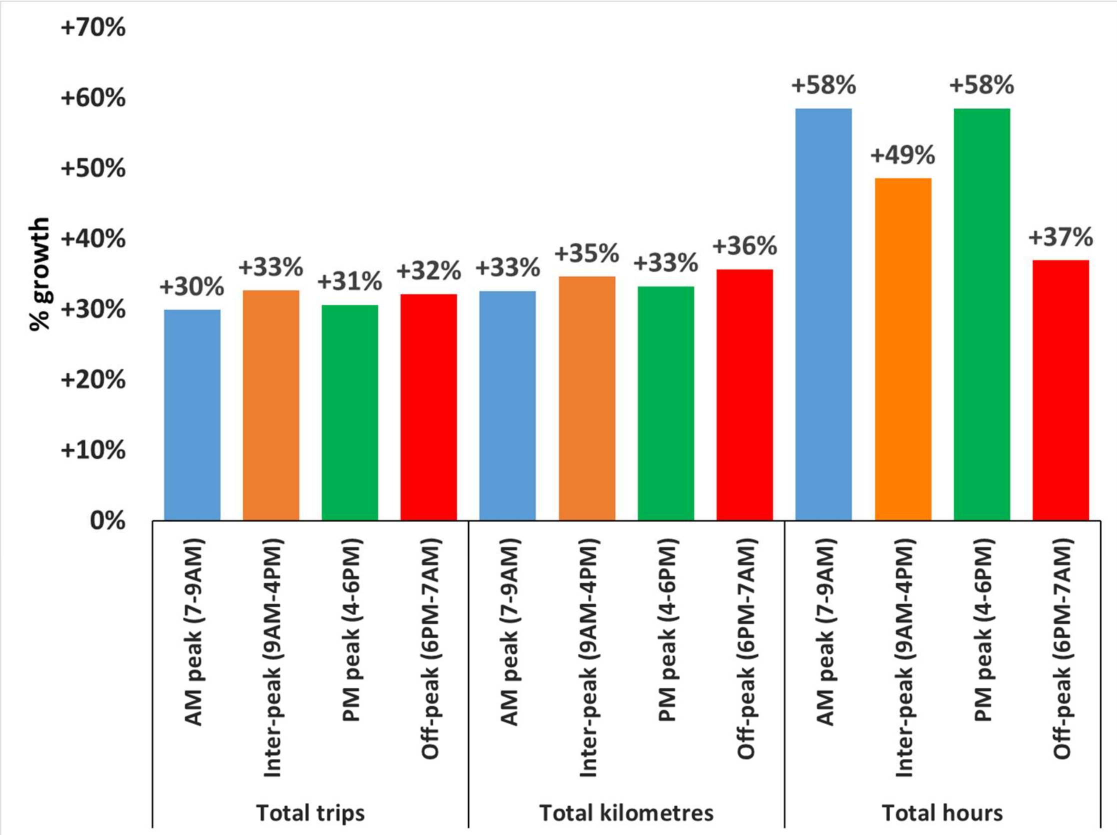
Table 3-3 – Perth GCCSA weekday commercial vehicle traffic statistics

Metric	Time period	2016	2031	Change	% change
Trips	AM peak (7-9AM)	37,000	50,000	+13,000	+35%
	Inter-peak (9AM-4PM)	121,000	164,000	+43,000	+35%
	PM peak (4-6PM)	42,000	57,000	+15,000	+36%
	Off-peak (6PM-7AM)	59,000	78,000	+20,000	+33%
	Daily total	**259,000**	**349,000**	**+90,000**	**+35%**
Kilometres	AM peak (7-9AM)	506,000	667,000	+161,000	+32%
	Inter-peak (9AM-4PM)	1,617,000	2,184,000	+567,000	+35%
	PM peak (4-6PM)	549,000	762,000	+212,000	+39%
	Off-peak (6PM-7AM)	907,000	1,230,000	+323,000	+36%
	Daily total	**3,579,000**	**4,843,000**	**+1,263,000**	**+35%**
Hours	AM peak (7-9AM)	10,000	16,000	+6,000	+59%
	Inter-peak (9AM-4PM)	28,000	42,000	+14,000	+49%
	PM peak (4-6PM)	11,000	18,000	+7,000	+64%
	Off-peak (6PM-7AM)	14,000	19,000	+5,000	+38%
	Daily total	**63,000**	**95,000**	**+32,000**	**+51%**

Total vehicle kilometres grow quite uniformly across the day and slightly above total trip growth (Figure 3-3). This indicates that the average trip length will increase slightly – a result of population growth in outer areas and employment concentration (section 2.1).

In contrast, the growth rates for total hours travelled are much more extreme in peak periods with total vehicle hours forecast to increase by almost 60 per cent in the AM and PM peak periods. This is a result of the underlying dynamics of traffic flow (when additional traffic is added to an already congested road, the resultant delay is disproportionately higher than in less congested conditions). Total vehicle hours in the interpeak time period are also predicted to grow significantly, indicating emerging and worsening congestion in the middle of the day. The off-peak is expected to remain relatively uncongested with the increase in the amount of time spent driving (37%) closer to the increase in trips (32%). The increased congestion is driven by population and employment growth, the peak periods are most affected, although congestion in the interpeak is also expected to worsen.

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



3.3 Growth in public transport ridership

By 2031 the demand placed on the public transport system is expected to increase substantially with both in-vehicle passenger kilometres and in-vehicle passenger hours doubling from 2016 (Table 3-4). Public transport boardings are also forecast to grow strongly.

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 – Perth GCCSA weekday public transport metrics

Metric	Time period	2016	2031	Change	% change
Boardings	AM peak (7-9AM)	119,000	180,000	+61,000	+51%
	Inter-peak (9AM-4PM)	160,000	236,000	+76,000	+48%
	PM peak (4-6PM)	106,000	157,000	+51,000	+48%
	Off-peak (6PM-7AM)	79,000	112,000	+33,000	+42%
	Daily total	**464,000**	**685,000**	**+222,000**	**+48%**
In-vehicle passenger kilometres	AM peak (7-9AM)	1,554,000	2,560,000	+1,006,000	+65%
	Inter-peak (9AM-4PM)	1,614,000	2,605,000	+991,000	+61%
	PM peak (4-6PM)	1,344,000	2,149,000	+805,000	+60%
	Off-peak (6PM-7AM)	978,000	1,475,000	+496,000	+51%
	Daily total	**5,490,000**	**8,789,000**	**+3,298,000**	**+60%**
In-vehicle passenger hours	AM peak (7-9AM)	38,000	63,000	+25,000	+65%
	Inter-peak (9AM-4PM)	43,000	68,000	+25,000	+58%
	PM peak (4-6PM)	32,000	52,000	+20,000	+62%
	Off-peak (6PM-7AM)	22,000	33,000	+11,000	+51%
	Daily total	**135,000**	**216,000**	**+81,000**	**+60%**

While overall public transport boardings increase strongly – by 95 per cent for rail and 80 per cent for buses – the bus network has a higher number of boardings, emphasising the significant role of buses in Perth's public transport network (Table 3-5). In contrast in both 2016 and 2031 the modelling predicts more in-vehicle passenger kilometres travelled on trains than on buses (Table 3-6). The reason for this is that Perth's suburban rail network facilitates long distance travel by providing commuters in outer areas with a direct service to the city's central employment hubs. Despite fewer kilometres being travelled by bus passengers, the total time spent on buses is greater than is spent on trains (as buses travel more slowly than trains) (Table 3-7). Overall, these metrics indicate that buses and trains play significant and complementary roles, with the rail network enabling long trips and the bus network providing for shorter ones.

Table 3-5 – Perth GCCSA weekday public transport boardings

Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	55,000	88,000	+34,000	+61%
	Inter-peak (9AM-4PM)	53,000	86,000	+33,000	+63%
	PM peak (4-6PM)	49,000	78,000	+28,000	+58%
	Off-peak (6PM-7AM)	38,000	52,000	+14,000	+37%
	Daily total	**195,000**	**305,000**	**+110,000**	**+56%**
Bus	AM peak (7-9AM)	64,000	92,000	+27,000	+43%
	Inter-peak (9AM-4PM)	107,000	150,000	+43,000	+40%
	PM peak (4-6PM)	57,000	79,000	+23,000	+40%
	Off-peak (6PM-7AM)	41,000	60,000	+19,000	+47%
	Daily total	**269,000**	**381,000**	**+112,000**	**+42%**

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

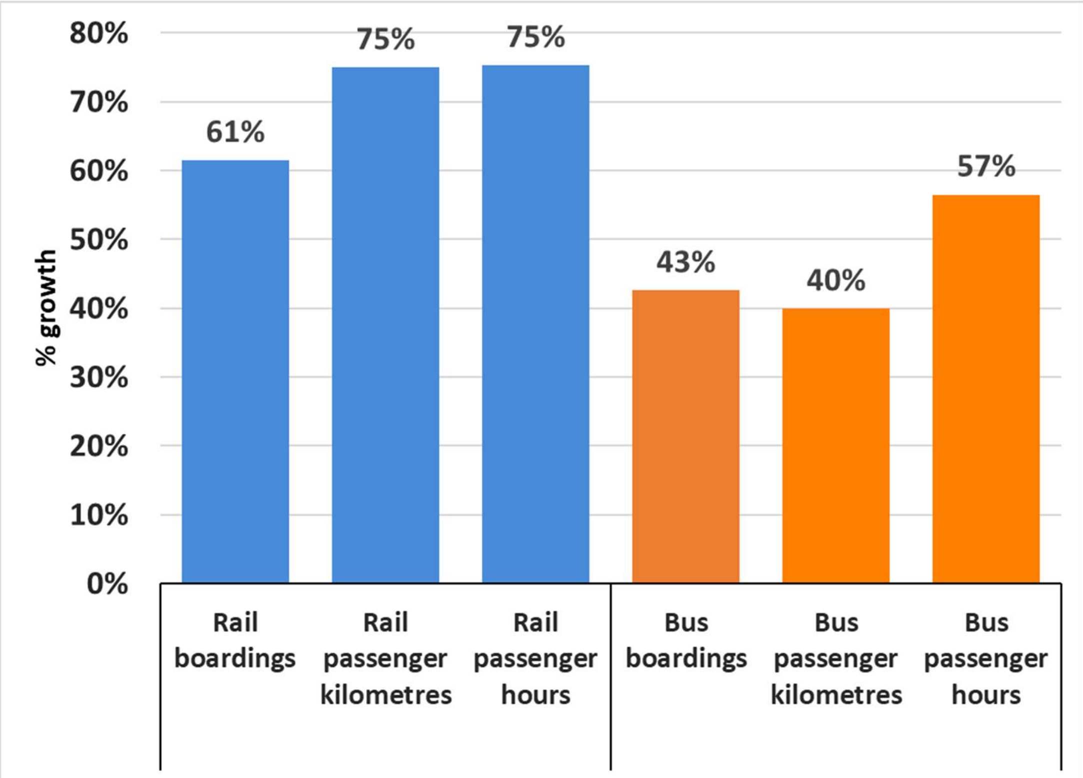
Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	1,099,000	1,923,000	+824,000	+75%
	Inter-peak (9AM-4PM)	907,000	1,617,000	+710,000	+78%
	PM peak (4-6PM)	969,000	1,635,000	+665,000	+69%
	Off-peak (6PM-7AM)	701,000	1,068,000	+367,000	+52%
	Daily total	**3,677,000**	**6,243,000**	**+2,567,000**	**+70%**
Bus	AM peak (7-9AM)	455,000	637,000	+182,000	+40%
	Inter-peak (9AM-4PM)	707,000	988,000	+281,000	+40%
	PM peak (4-6PM)	375,000	514,000	+140,000	+37%
	Off-peak (6PM-7AM)	277,000	406,000	+129,000	+47%
	Daily total	**1,814,000**	**2,545,000**	**+731,000**	**+40%**

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

Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	18,000	32,000	+14,000	+75%
	Inter-peak (9AM-4PM)	15,000	27,000	+12,000	+79%
	PM peak (4-6PM)	16,000	27,000	+11,000	+70%
	Off-peak (6PM-7AM)	12,000	18,000	+6,000	+53%
	Daily total	**61,000**	**104,000**	**+43,000**	**+70%**
Bus	AM peak (7-9AM)	20,000	31,000	+11,000	+57%
	Inter-peak (9AM-4PM)	28,000	41,000	+13,000	+47%
	PM peak (4-6PM)	16,000	25,000	+9,000	+54%
	Off-peak (6PM-7AM)	10,000	15,000	+5,000	+48%
	Daily total	**74,000**	**112,000**	**+38,000**	**+51%**

Perth's public transport network will be more heavily utilised by 2031 than in 2016. While AM peak boardings on the rail network will double, passenger kilometres and hours are expected to grow even more (Figure 3-4). This trend reflects lengthening rail trips; a result of strong population growth on Perth's fringe. Conversely, while bus boardings and passenger kilometres grow at about the same rate, the amount of time spent in buses is expected to grow more strongly (108% growth in bus passenger hours). This reflects the degree to which buses are affected by road congestion in the peak periods.

Figure 3-4 – Perth GCCSA growth in key AM peak (7-9AM) weekday public transport metrics - 2016 to 2031



4. Road network performance

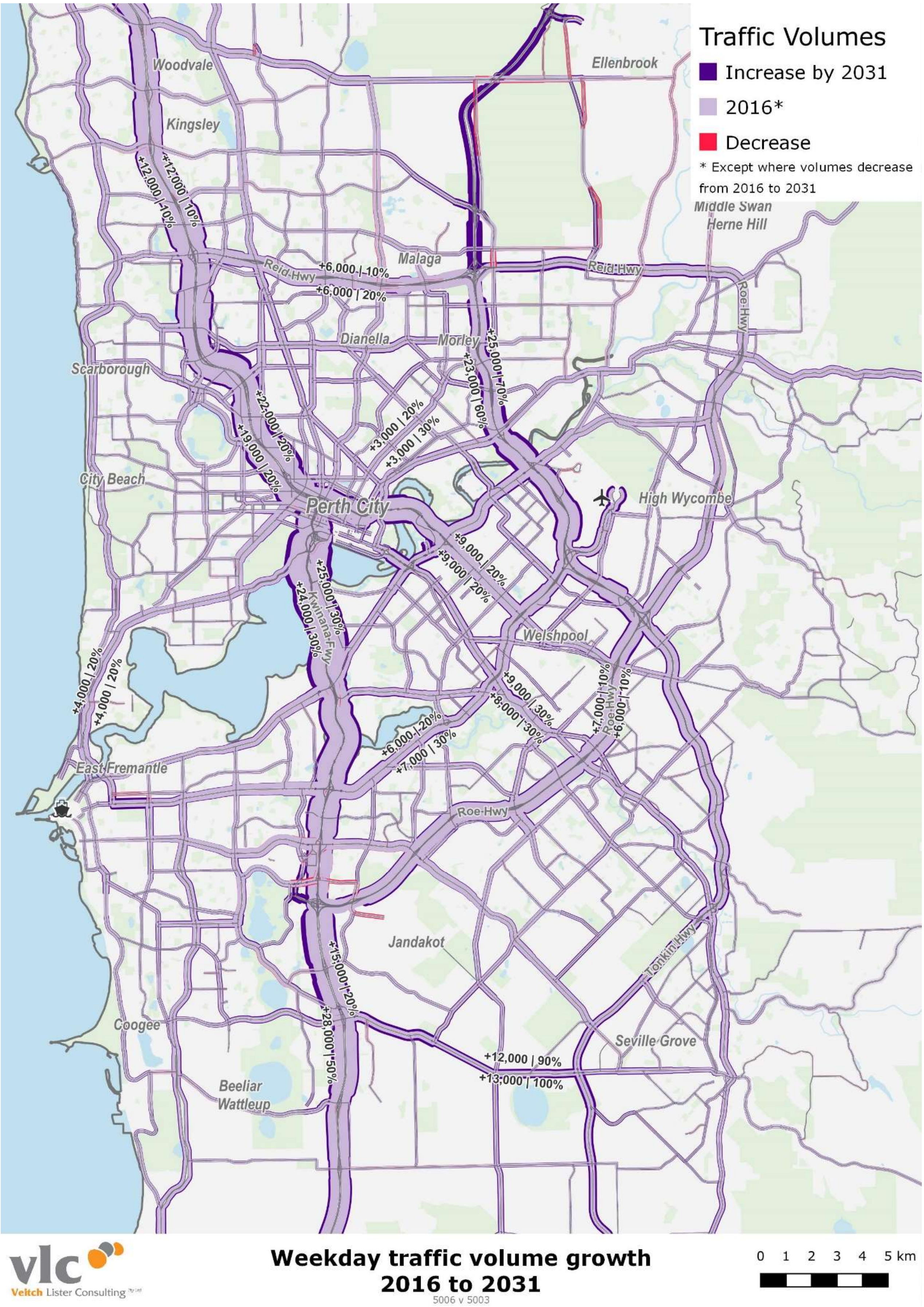
The previous section demonstrated that travel demand in Perth is expected to increase significantly by 2031, and gave some indications of deteriorating road network performance. This section analyses this performance in more detail using the following metrics:

- *Volume capacity (V/C) ratio*. The V/C ratio for a section of road is a useful metric to gauge its level of congestion 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.

Perth's major freeways are expected to accommodate a large share of the projected increase in road demand (Figure 4-1). In particular, the Mitchell and Kwinana Freeways attract large volumes of additional traffic. The NorthLink WA package, including the new section in the north connecting into the Tonkin Highway, draws traffic from parallel routes. By 2031 both NorthLink and the Roe Highway play vital roles in facilitating north-south vehicle travel. Traffic growth on the Reid Highway and other east-west corridors is more modest, reflecting the concentration of population growth on the coastal axis from Mandurah to Yanchep (section 2.1).

The arterial road network is also subject to additional demands in 2031. There is strong demand for the river crossings at Fremantle and north-east of the CBD, while arterials in the inner eastern suburbs also experience high growth rates. In outer areas, the arterials are expected to experience strong growth in both percentage and absolute terms, playing an increasing role in supporting the road transport task. For example, the arterials around Jandakot in the south not only experience large increases in volume, but acts as feeders to the Kwinana Freeway.

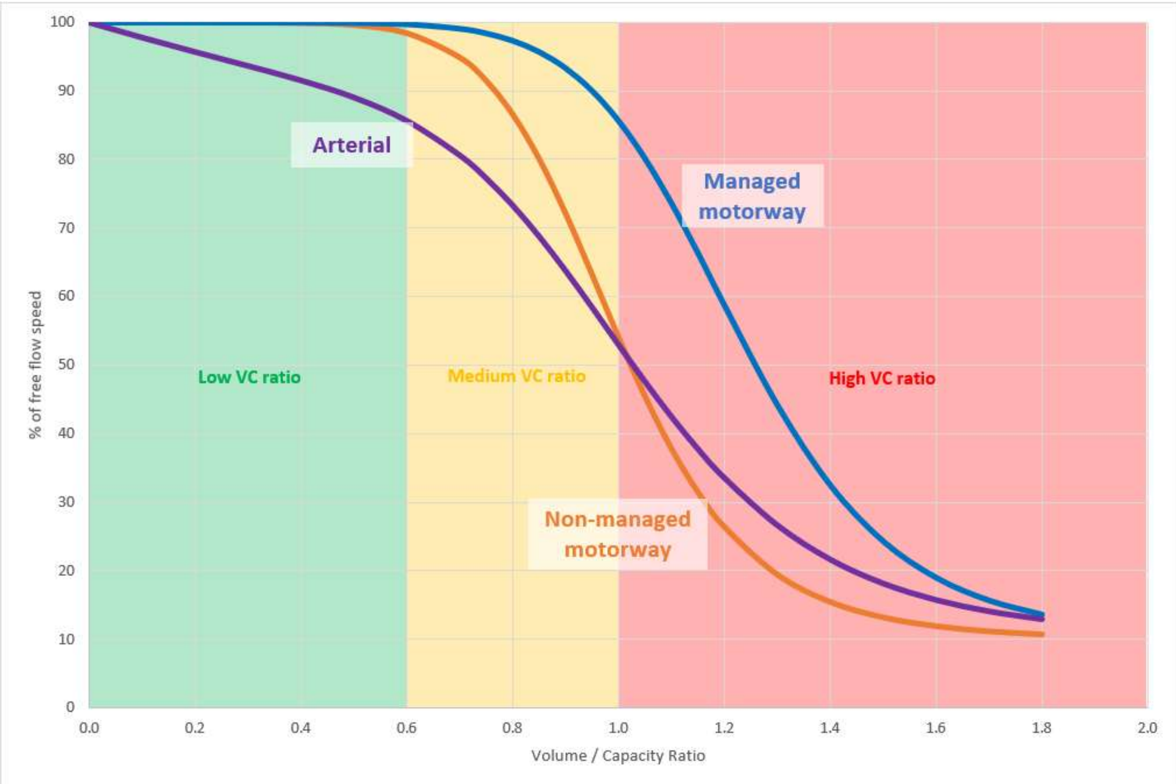
Figure 4-1 – Perth GCCSA weekday traffic volume growth - 2016 to 2031



The following traffic volume / road capacity (V/C) images illustrate the levels of congestion observed in 2016 and in 2031. The V/C ratios are shown as the worst hour in the 2-hour peak. This peak one hour is assumed to be 56 per cent of the AM peak, and 52 per cent in the PM peak, an assumption developed based on observed travel data from various Australian cities. The colour of the bandwidth indicates the level of congestion, and the width is proportional to the volume of traffic using this link. (Minor 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 (though there are no managed motorways in the 2031 forecast for Perth).

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



In 2016, the major freeways, the arterial roads feeding those freeways and the river crossings are the parts of Perth's road network that have the highest levels of congestion. The modelled V/C ratios in the AM peak are described in Figure 4-2. In this period there is high demand for travel to inner areas with substantial congestion on the approaches to the CBD. Volumes on the Mitchell Freeway are close to capacity from Woodvale in the north right through to Perth CBD. Similarly, the Kwinana Freeway is also heavily congested in the northbound direction, particularly as it approaches the CBD. Notably high demand is also observed on the Kwinana Freeway in the counter peak direction from the city southbound.

While these high capacity sections are the most heavily trafficked parts of the network in terms of volume, lower capacity sections of freeway also experience comparable levels of congestion. For instance, the Mitchell Freeway through Woodvale and Kingsley is heavily congested in the southbound direction. The parallel arterials are also congested, indicating a strong demand for this north to south movement. In general, the levels of congestion on the arterial roads are less severe. However, high volumes are seen on the sections that feed the freeways. Perth’s river crossings also constrain movements, an example being the Causeway which crosses the Swan River at the south eastern edge of the CBD.

In the PM peak a very similar pattern of congestion can be seen in the opposite direction (Figure 4-4). The Kwinana Freeway is most heavily congested in the southbound direction and the Mitchell Freeway in the northbound direction from the city to the northern suburbs.

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

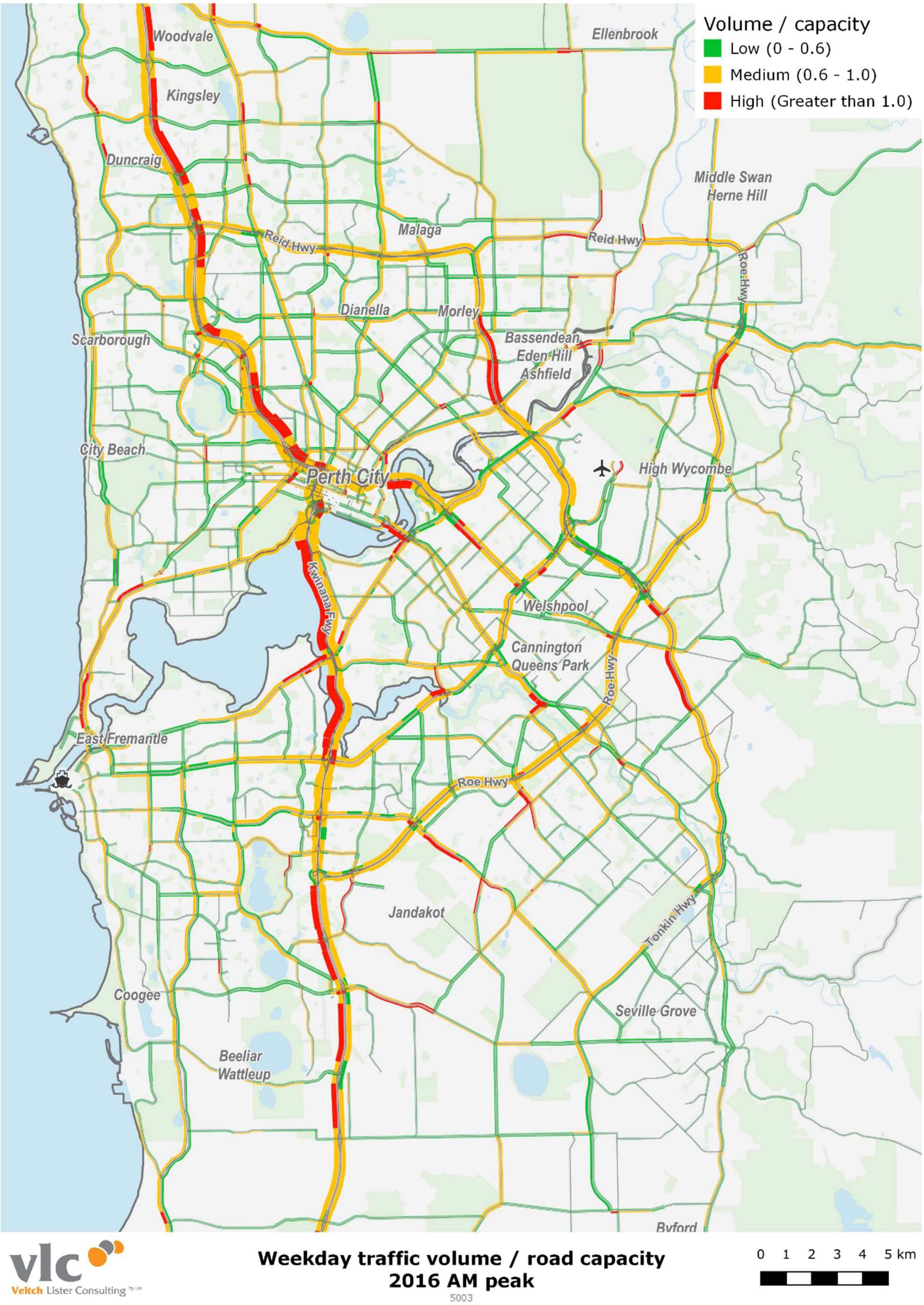
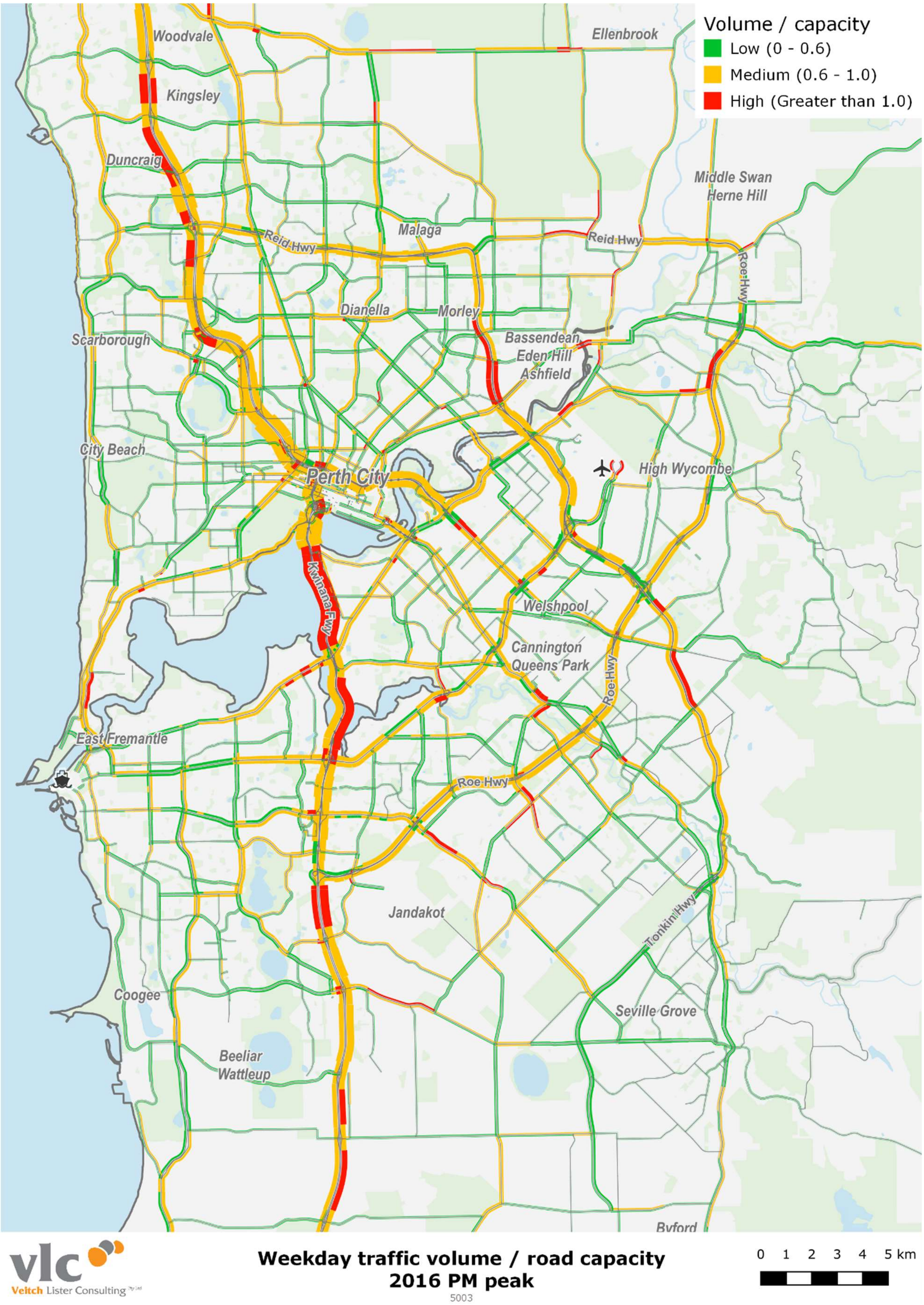


Figure 4-4 – Perth GCCSA weekday traffic volume / road capacity - 2016 1-hour PM peak



Between 2016 and 2031 congestion is expected to worsen substantially, particularly on Perth's major north-south corridor: the Mitchell and Kwinana Freeways (Figure 4-5 and Figure 4-6). In the 2031 AM peak period, very severe congestion is expected in the city-bound direction on most of this corridor (with the reverse expected in the PM peak). There is also predicted to be major congestion in the counter-peak direction, most notably on the Kwinana Freeway. A similar trend is expected on the other major freeways, meaning that by 2031 motorists traveling from outer areas to inner areas can expect to encounter congestion earlier on the morning commute and for longer on their way home.

The Roe Highway is expected to be the most affected of the orbital freeways by increased traffic. Although the grade separation of the Tonkin Highway has improved the traffic conditions on some of sections of this corridor, the Swan River crossing at its southern extent remains a major constraint. Congestion on the other major river crossings is also predicted to worsen. By 2031, the impact of this congestion also seems to be contributing to congestion in the corridors they connect. Examples of this are the heavy delays forecast near the crossings at Fremantle and in the inner south-eastern suburbs.

Arterial roads in outer areas are also predicted to come under significant pressure by 2031. Desired access to the major freeways in southern suburbs (such as Jandakot) continues to result in heavy traffic delays on the feeder arterials. By 2031 this congestion has both intensified and spread. In the north, the Mitchell Freeway is not able to meet the demand for north-south travel. Some of the excess traffic is borne by the parallel arterials, resulting in high volume / capacity ratios. This delay will not only impact on travel time for motorists but also on the buses using these roads.

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

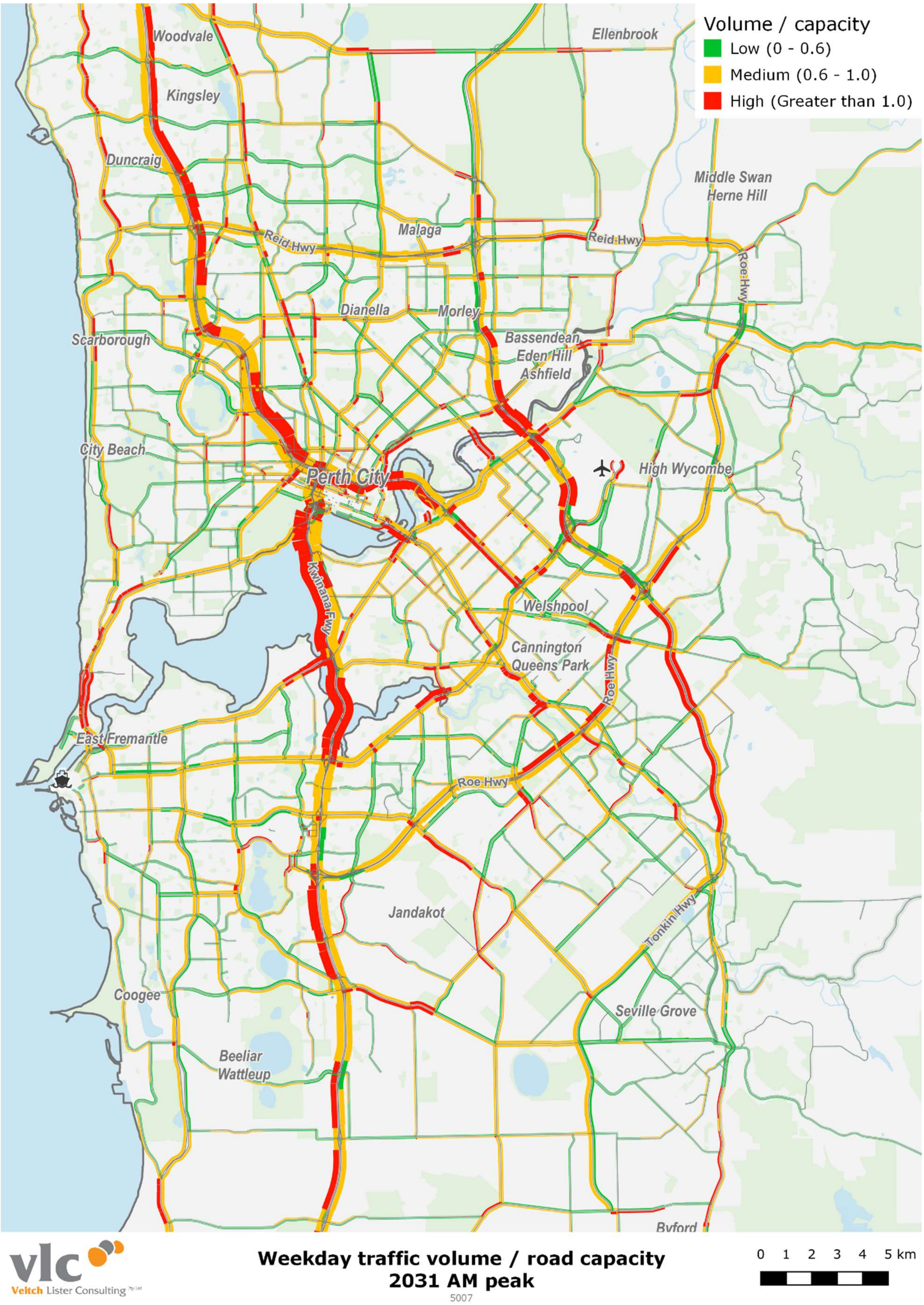
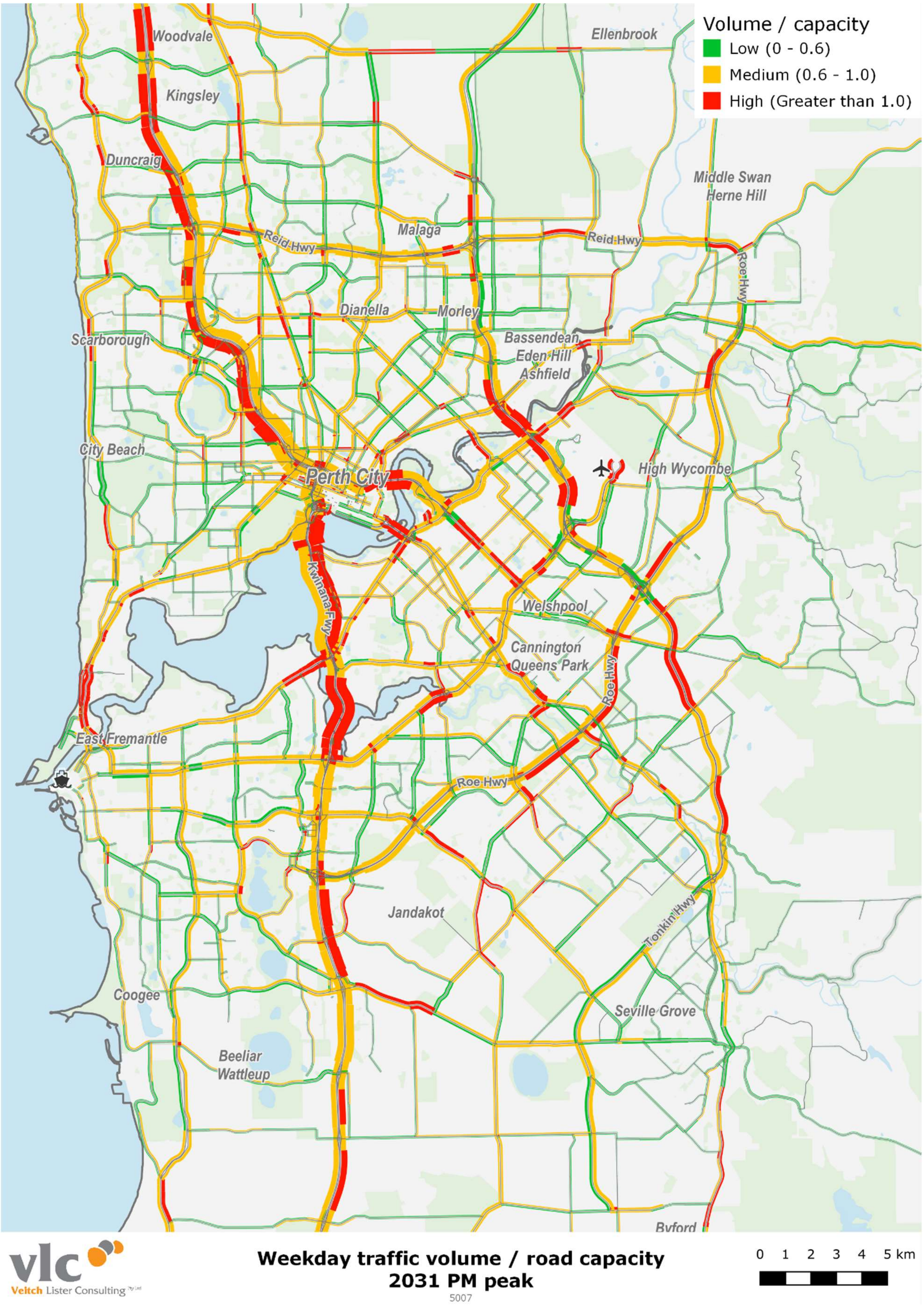
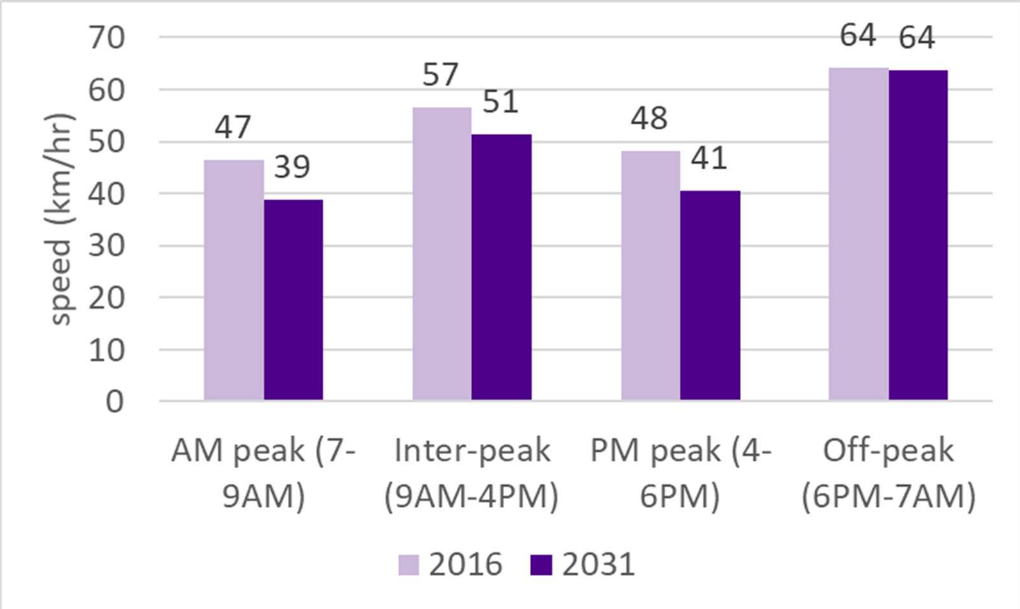


Figure 4-6 – Perth GCCSA weekday traffic volume / road capacity - 2031 1-hour PM peak



The most significant declines in network speeds are in the AM and PM peaks (8km and 7km per hour respectively), but future congestion also slows traffic materially in the middle of the day (Figure 4-6). The off-peak time period offers an indication of vehicle speeds on a relatively uncongested network.

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



Congestion causes substantial delay hours for vehicles on the road network (Table 4-1). Delays are most intense in the peak periods, but cumulatively there is more delay forecast over the seven hour inter-peak period. A small amount of delay is predicted in the relatively uncongested off-peak. Traffic delay is forecast to more than double, increasing by about 141 per cent across the day.

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

Time period	2016	2031	Change	% change
AM peak (7-9AM)	43,000	100,000	+56,000	+130%
Inter-peak (9AM-4PM)	49,000	126,000	+76,000	+154%
PM peak (4-6PM)	40,000	97,000	+56,000	+140%
Off-peak (6PM-7AM)	8,000	18,000	+10,000	+119%
Daily total	**141,000**	**340,000**	**+199,000**	**+141%**

5. Public transport system performance

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

Perth's public transport network is mostly radial and CBD-centric. In areas serviced by rail, the rail corridor forms the spine and is fed by buses. Outside the rail catchments, buses perform a line-haul role to the city. Use of public transport for travel in the counter-peak directions or for orbital movements is limited.

Patronage on the Joondalup line is forecast to grow the most of all of Perth's rail lines, with approximately 12,000 additional weekday passengers in each direction between 2016 and 2031 (Figure 5-1). Most of this growth is a result of the extension to Yanchep which expands the line's catchment into the fast growing far northern suburbs. A similar outcome is expected on the Midland line, where both an extension and the addition of the airport spur result in around 8,000 extra weekday passengers in each direction.

The addition of the Thornlie-Cockburn Rail Link further expands the rail catchment and attracts extra patronage. Demand on the Armadale line is also fed by population growth in Perth's south-east, contributing to a patronage growth of around 7,000 weekday passengers. Patronage growth on the Mandurah and Fremantle lines is expected to be more modest, growing by around 30 per cent, in line with Perth's overall population growth.

Rail investments that expand service catchments, coupled with strong population growth, are the main drivers of the increase in demand for rail services. However, the congestion identified on the road network in the previous section is also likely to promote mode shift from private vehicle to rail.

Perth's bus network is also forecast to experience widespread patronage growth (Figure 5-2). The largest number of additional passengers are expected on the main radial corridors serving central Perth. Buses accessing the city from the south, south east and north are forecast to accommodate large volumes of extra passengers.

As with rail, population growth in both emerging and established areas is the key driver of bus patronage growth.

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

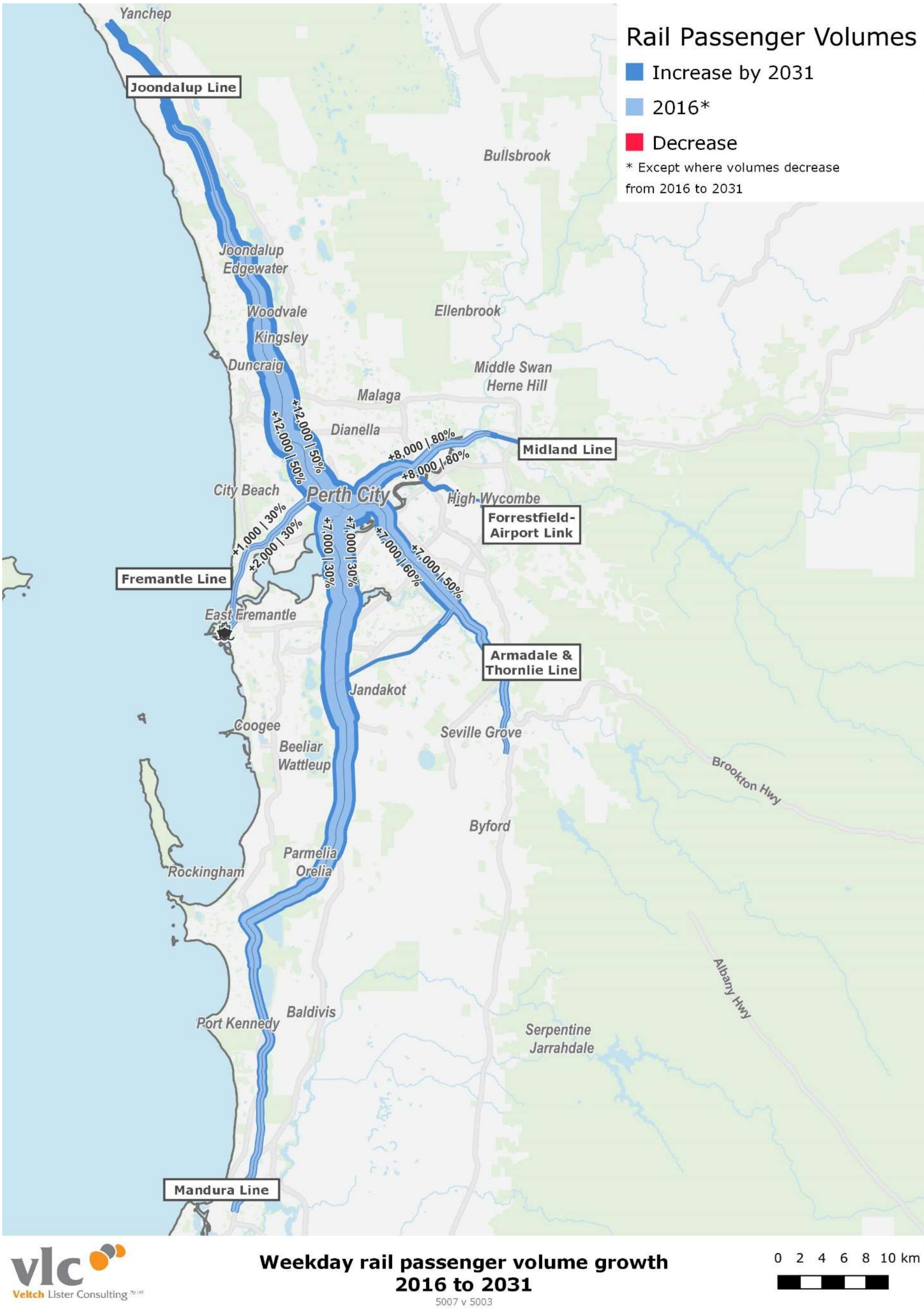
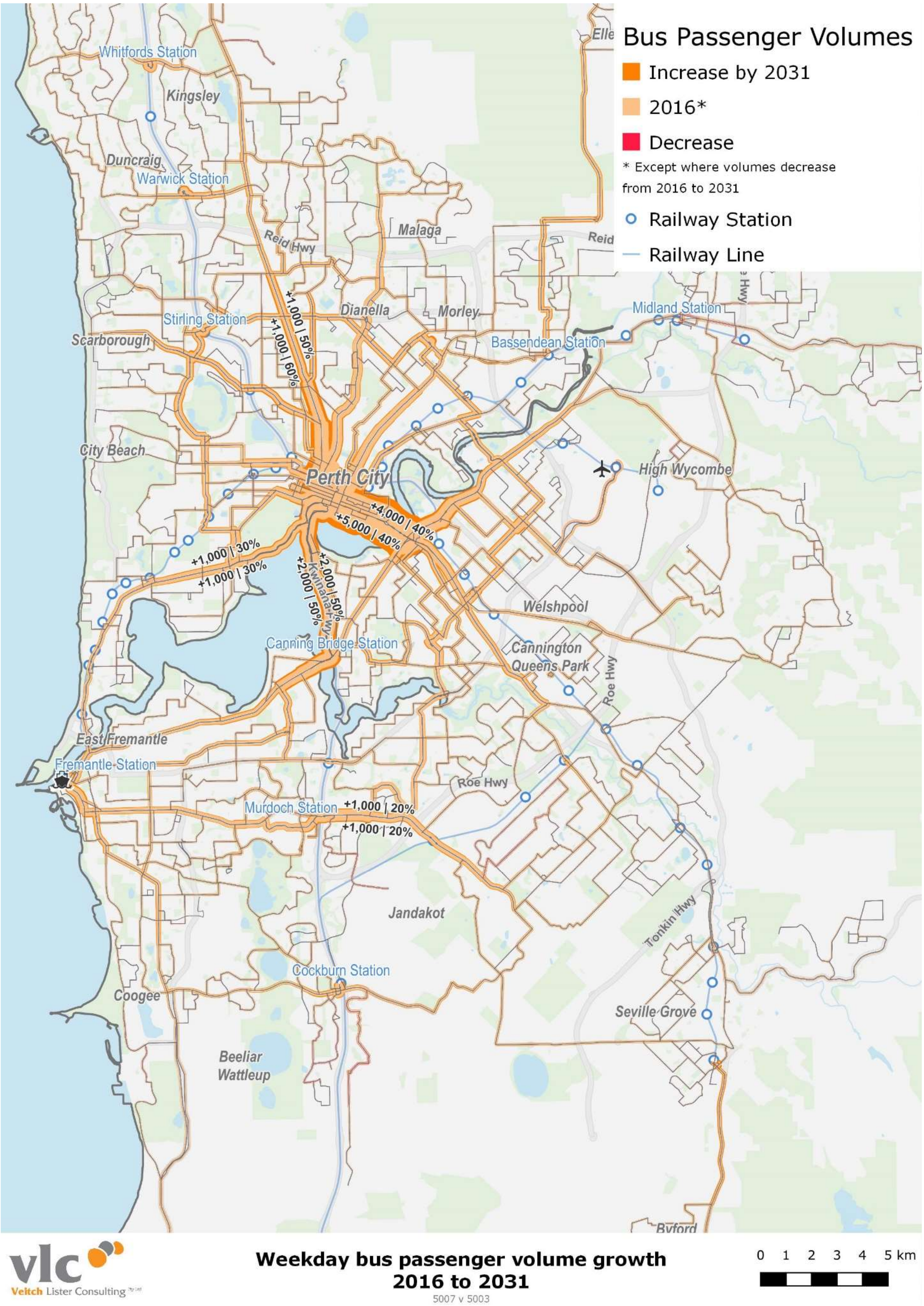


Figure 5-2 – Perth GCCSA weekday bus passenger volume growth - 2016 to 2031



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 travel demand in that period, an assumption developed based on observed travel data from various Australian cities.

High and increasing passenger volumes on peak-direction public transport services increase the levels of crowding expected on rail and bus services. By 2031, the north-south public transport routes are under the most pressure, while the east-west corridors remain relatively uncrowded.

In the morning, rail services become more crowded as they approach the Perth CBD. (This can be measured using a V/C ratio, i.e. the number of passengers on a service relative to the crush capacity of the bus or rolling stock allocated to that service). The opposite pattern occurs in the evening, with services becoming less crowded as they get further from the city. Patronage in the counter-peak direction is relatively low, suggesting that most rail commuters use the system to travel to and from the inner city.

In 2016, the levels of crowding on Perth’s rail network in both AM and PM peaks are expected to approach, but not exceed, crush capacity (Figure 5-3 and Figure 5-4). The Joondalup and Mandurah lines carry the highest of number of passengers and experience mostly moderate levels of crowding, though the southern approach to Perth reaches an average of 90 per cent of crush capacity in the AM peak. The Fremantle, Midland and Armadale Lines carry fewer passengers and do not experience significant crowding.

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

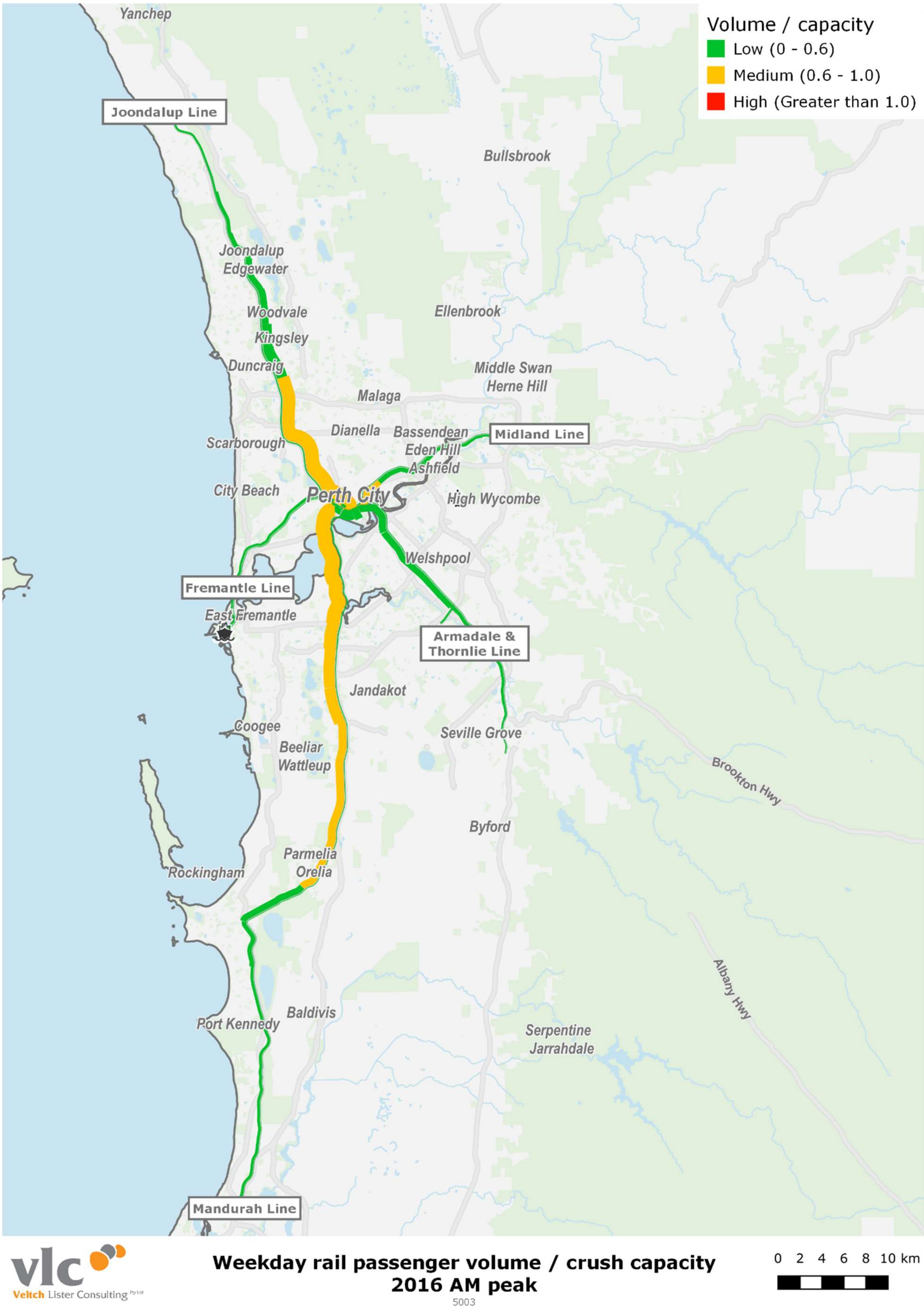
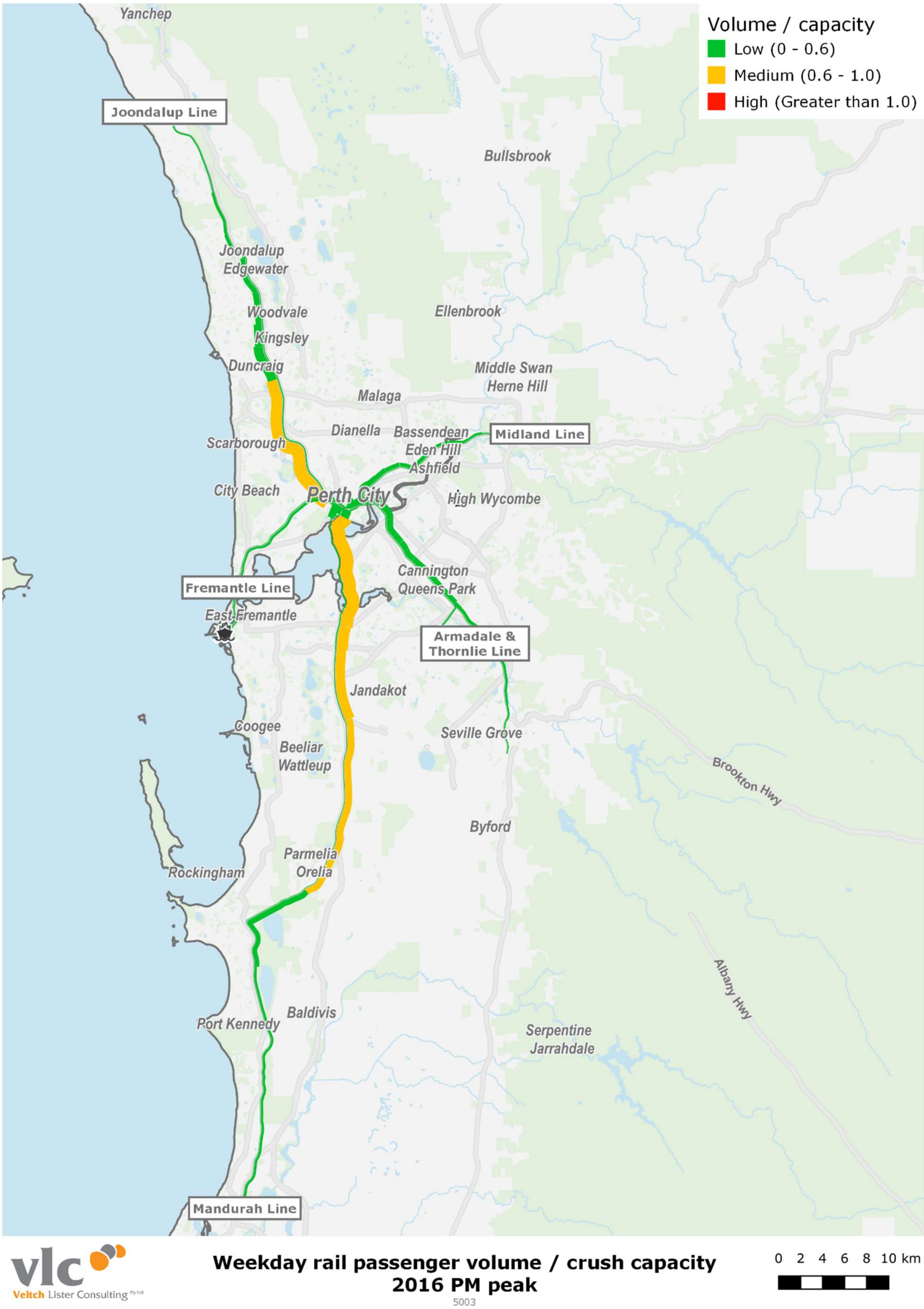


Figure 5-4 – Perth GCCSA weekday rail passenger volume / crush capacity - 2016 1-hour PM peak



Perth's suburban rail network is expected to come under considerable pressure in the 2031 peak periods. Most notably the high levels of travel demand from the outer north and south result in services on the Joondalup and Mandurah lines reaching crush capacity (Figure 5-5 and Figure 5-6). On the Joondalup line, services are expected to be very crowded between Woodvale and the city. A similar outcome is predicted on the Mandurah line. On the southern section of Mandurah line (shown on the map as between Parmelia and Jandakot) service frequencies assumed in the modelling are not able to meet the forecast demand, resulting in high levels of crowding. Services on the Armadale line are predicted to be crowded, however they are not expected to reach crush capacity. Perth's east-west running lines are not expected to experience significant crowding.

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

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

Buses perform multiple functions in Perth's public transport network. The first of these is complementing the rail network: stations at which there are significant numbers of bus to rail transfers are labelled in Figure 5-7 and Figure 5-8. As per the approach with rail, levels of crowding on the bus network are examined through the use of V/C ratios (i.e. the number of passengers on a service relative to the crush capacity of the bus). In general, there are low levels of crowding on these bus routes.

Buses also provide a line haul function in the areas which are relatively close to the city but are not serviced by rail. The most heavily patronised bus corridors provide commuters from the north, south and east with access to Perth CBD[4]. These services are crowded in the peak directions, with low patronage in the counter peak direction. Rail feeder bus routes are much more balanced, with substantial numbers of users travelling on buses *from* train stations in the morning and *to* stations in the evening.

[4] In Figure 5-7 the passenger volume / crush capacity ratio on the inbound section of the Kwinana Freeway between the Canning Highway and the CBD is shown to be 'Medium', indicating a ratio of between 0.6 and 1.0 for buses travelling on this link in the AM peak (7-9AM). Figure 5-8 shows that in the PM peak (4-6PM) the adjacent outbound section of freeway has a 'High' ratio (indicating passenger volumes that are above crush capacity). In 2016, the forecast passenger volumes are balanced (around 1,800 inbound in the AM peak and around 1,800 outbound in the PM peak). However, public transport timetables from Transperth indicate that there are fewer buses scheduled to travel outbound on this section of the Kwinana Freeway in the evening than travel inbound in the morning. The lower outbound capacity means that even with about the same number of passengers, the PM peak volume capacity ratio is greater than the AM peak inbound ratio.

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

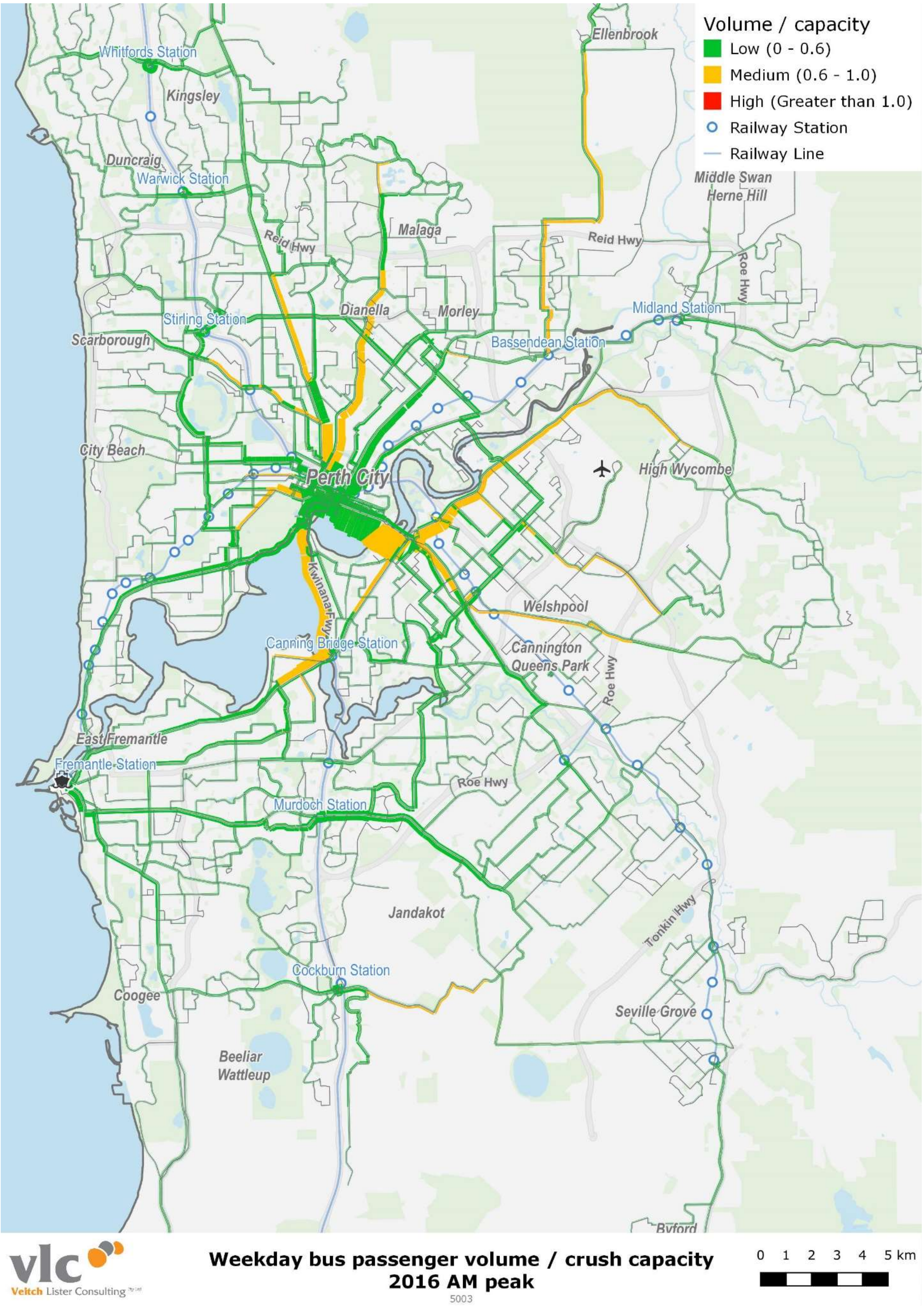
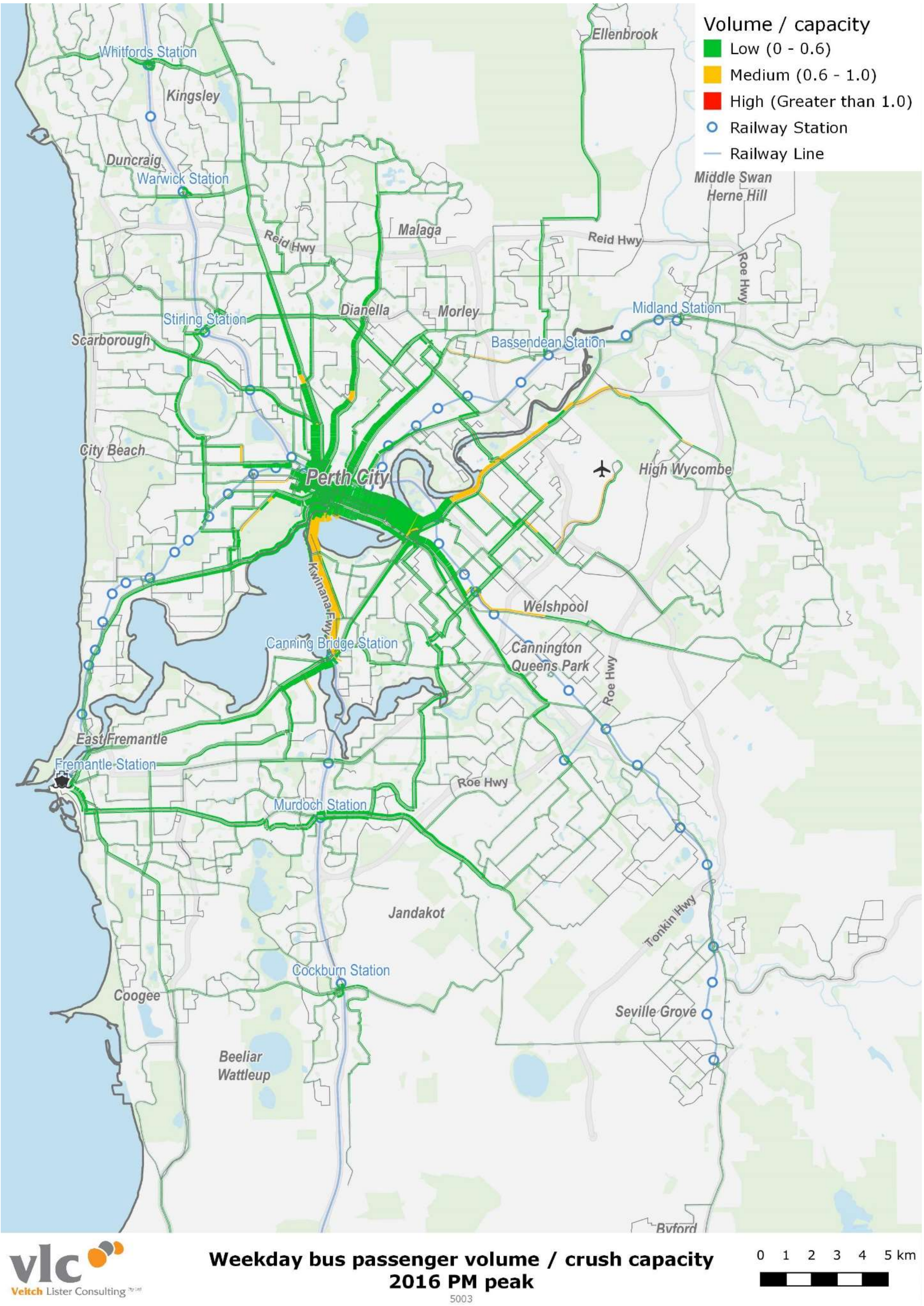


Figure 5-8 – Perth GCCSA weekday bus passenger volume / crush capacity - 2016 1-hour PM peak



Crowding on Perth's buses is also projected to worsen by 2031 (Figure 5-9 and Figure 5-10). In particular, the radial routes which serve areas beyond rail catchments are likely to be increasingly crowded. Examples of this are the routes serving the inner and middle northern suburbs. However, a worsening of crowding on sections of bus routes which run parallel to rail lines is also evident. This is likely to be a result of peak-period crowding on the rail lines diverting people onto buses. The rationale for this behaviour is that a less crowded bus – potentially with the option to sit – is more appealing than boarding a crowded train.

Crowding on most rail feeder services is forecast to remain at low levels in 2031. The exceptions to this are a subset of routes serving Bassendean and Cockburn stations which are predicted to have demand approaching or exceeding vehicle capacities. The high levels of crowding the users of these services are willing to tolerate may indicate that there are few viable alternatives. Overall, many key routes in Perth's bus network are expected to become very crowded by 2031. As was the case for rail, the crowded corridors are mostly city-serving and north-south, due to strengthening north-south commuting patterns.

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

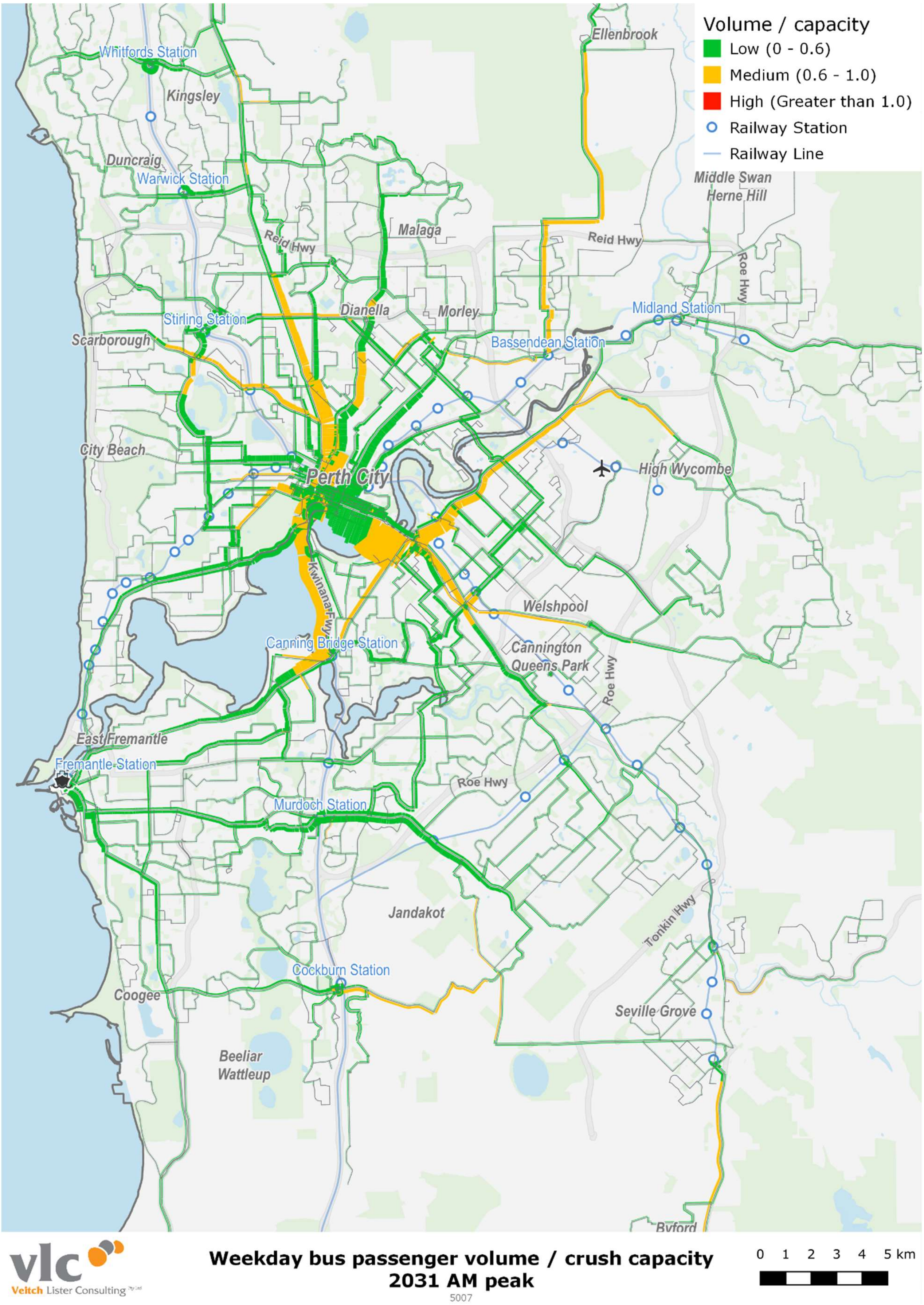
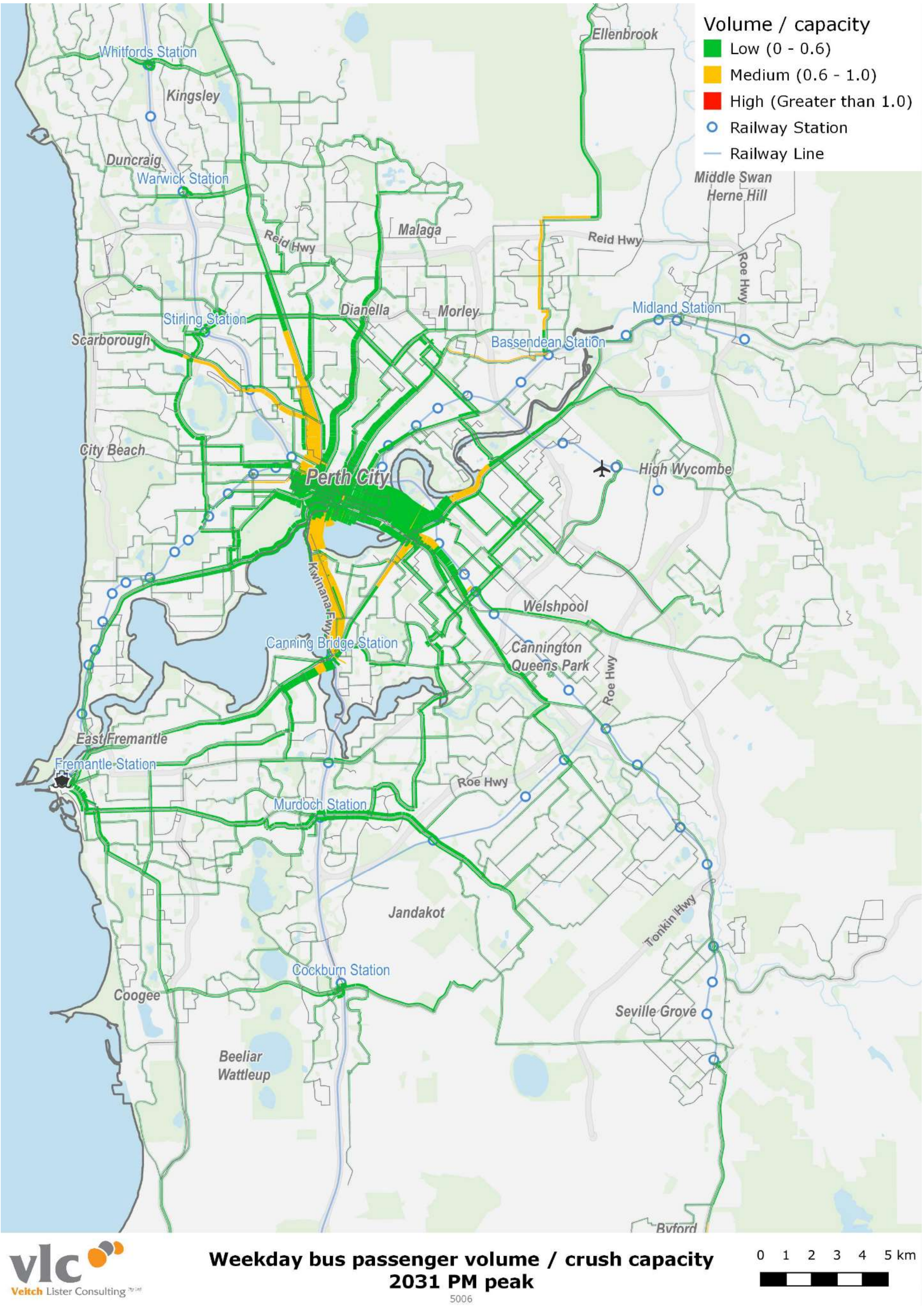
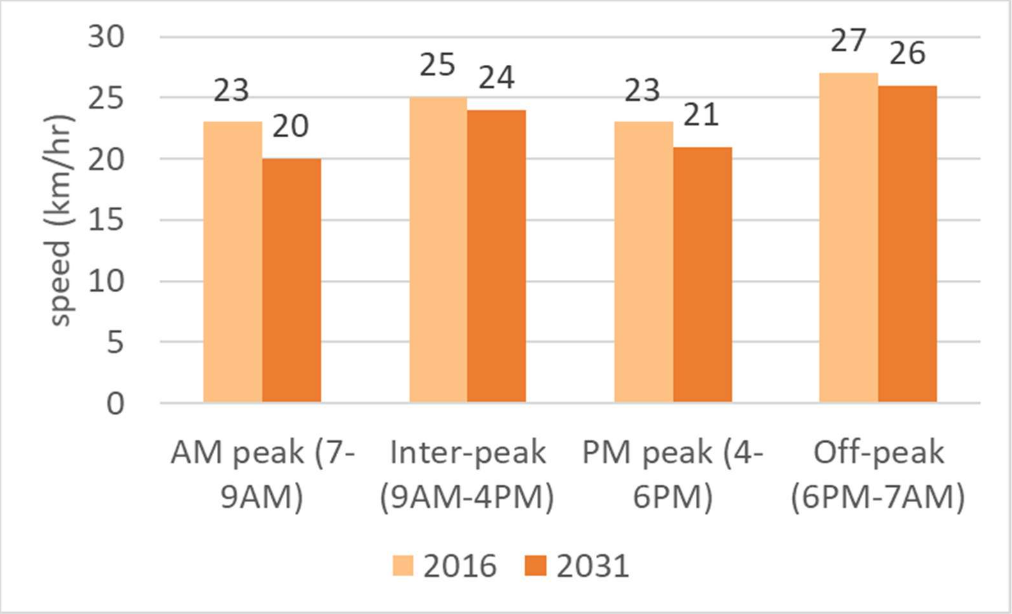


Figure 5-10 – Perth GCCSA weekday bus passenger volumes / crush capacity - 2031 1-hour PM peak



Buses are the most affected by traffic during the AM and PM peak periods, with less delay expected for the middle of the day (Figure 5-11). In the off-peak period, buses are likely operate with very little delay and thus it can be assumed that speeds of around 26 km/hr constitute largely unimpeded operating conditions. By 2031, average bus speeds in the AM and PM peaks are forecast to decrease to around 20 km/hr, mostly because of increased traffic congestion.[5]

Figure 5-11 – Perth GCCSA average bus speeds



[5] The 2016 and 2031 bus networks are not identical, so some of the change in speed can be attributed to new routes, higher frequencies and different route alignments. Nevertheless, the similarity between the 2031 and 2016 off-peak speeds suggests that network changes only account for a limited portion of the deterioration observed in the other time periods.

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

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

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

Limitations of strategic accessibility modelling:

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

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

Table 6-1 – Social infrastructure services

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

6.1 Accessibility in 2016 and 2031

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

The modelling indicates that for the average Perth resident with access to a car, child care and public schools are within a five-minute trip in 2016 and a seven-minute trip in 2031 (Table 6-2). For residents dependent on public transport, travel times are much longer – generally averaging 20 to 30 minutes for all services, with times worsening between 2016 and 2031.

Table 6-2 – Perth 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	4.2	6.2	25.6	29.1
Public primary school	2.9	3.8	18.0	20.3
Public secondary school	5.2	7.1	30.8	34.4

Most parts of Perth are expected to be able to reach a range of child care centres within a five to 10-minute drive from home in 2031, which is consistent with the city-wide average travel time of about six minutes (Figure 6-1). The main exception is in growth areas to the north, specifically those within the Wanneroo SA3 (see Table 6-3). The modelling indicates that in 2031 the average Wanneroo resident trying to reach a child care centre by car will have to travel approximately 17 minutes from home, compared to 4.5 minutes in 2016. This considerable reduction in accessibility is a function of significant population growth projections coupled with the limited existing supply of both transport and social infrastructure in greenfield areas. However, to some extent the high forecast journey times are likely to be to driven by the limitations noted above (large travel zones and an absence of projected childcare centres). The analysis does, however, highlight the importance of ensuring that social and transport infrastructure is carefully planned for greenfield development. Similar patterns are seen for access to public primary schools (Figure 6-3) and public secondary schools (Figure 6-5).

The much longer average travel times required for residents dependent on public transport is clearly evident in Figure 6-2 (child care centres), Figure 6-4 (public primary schools) and Figure 6-6 (public secondary schools). In some established parts of Perth public transport may offer a realistic alternative to car as a means of accessing child care centres, with travel times between 15 and 25 minutes. In populated areas on the urban fringe or locations not adjacent to heavy rail services, travel times in excess of 25 minutes are forecast. In contrast to car accessibility, in many areas across Perth the public transport accessibility of local social infrastructure is forecast to improve slightly to 2031, reflecting improved bus frequencies and an expansion of the rail network (Table 6-3). In other cases, the growth in population in more fringe areas of the SA3s more than offsets the public transport service improvements, resulting in increases in average journey times (e.g. Rockingham).

To a large extent, this is a function of the radial nature of Perth's public transport network (Section 5). The network is not as effective at catering for localised travel needs as it is at transporting large numbers of people into the city centre.

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

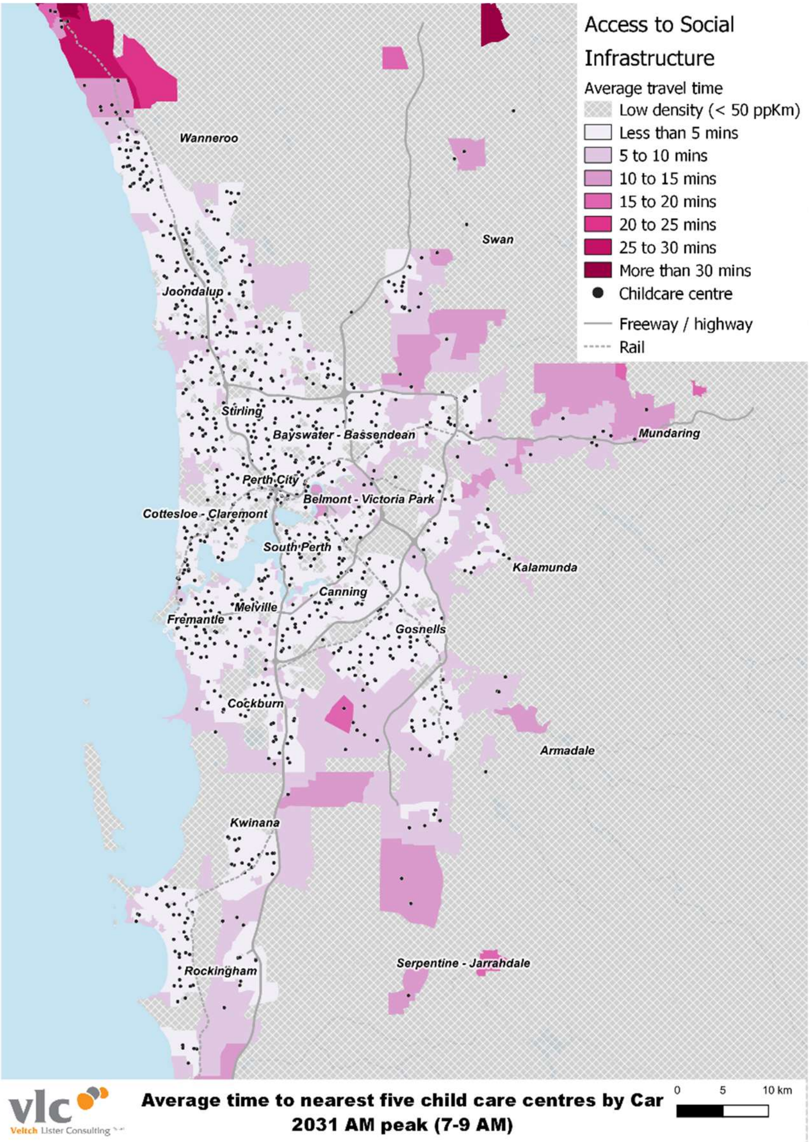


Figure 6-2 – Perth GCCSA average time to nearest five child care centres by PT - 2031 AM peak (7-9AM)

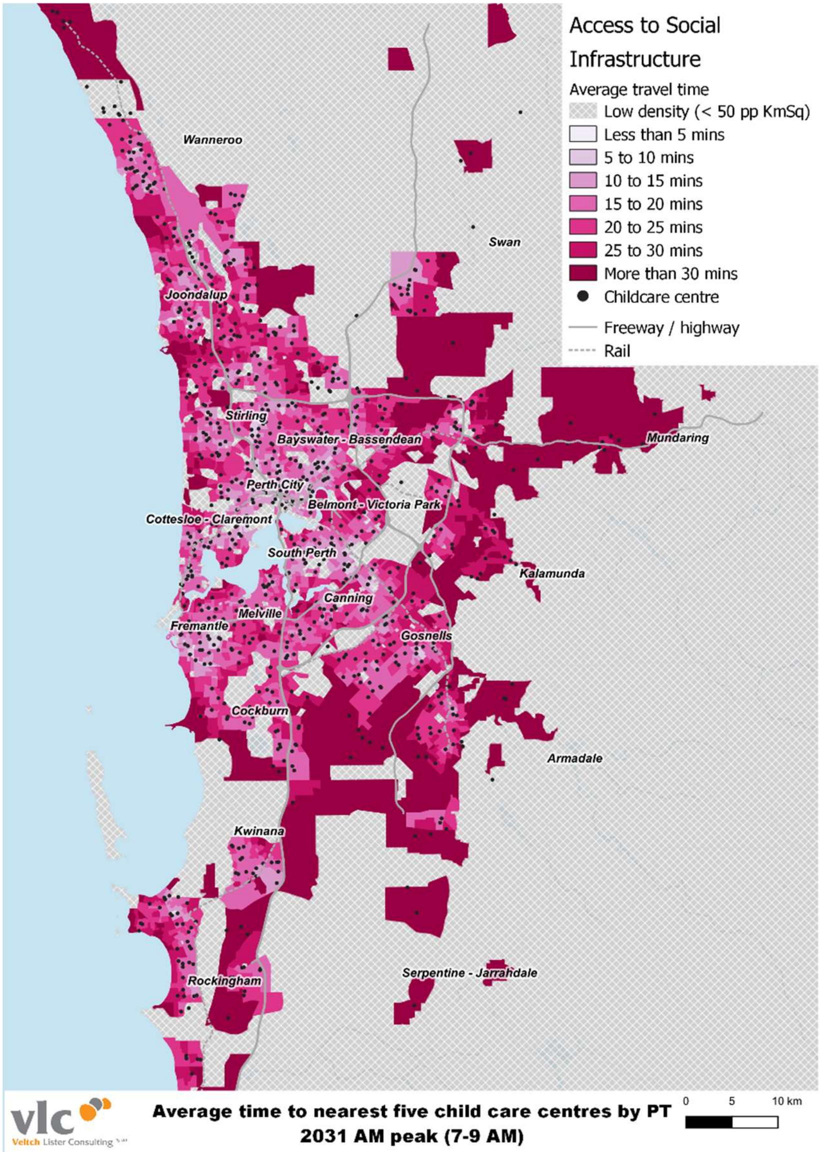


Figure 6-3 – Perth GCCSA average time to nearest public primary school by Car - 2031 AM peak (7-9AM)

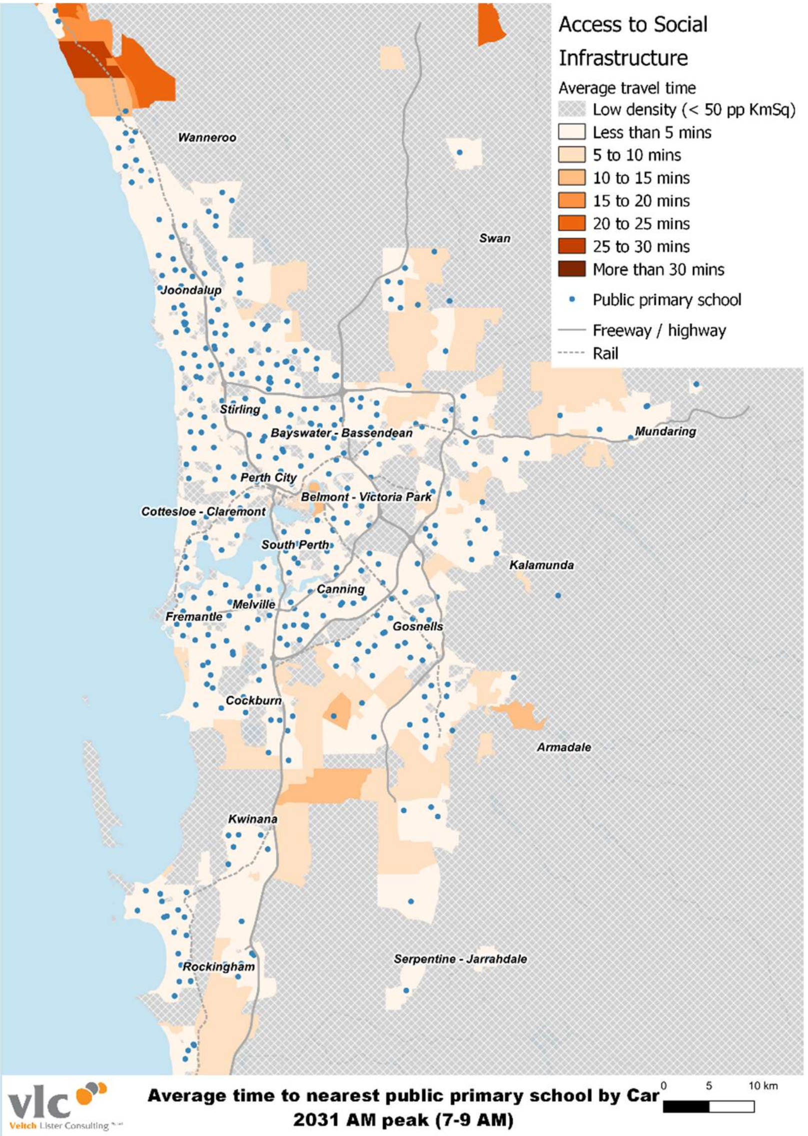


Figure 6-4 – Perth GCCSA average time to nearest public primary school by PT - 2031 AM peak (7-9AM)

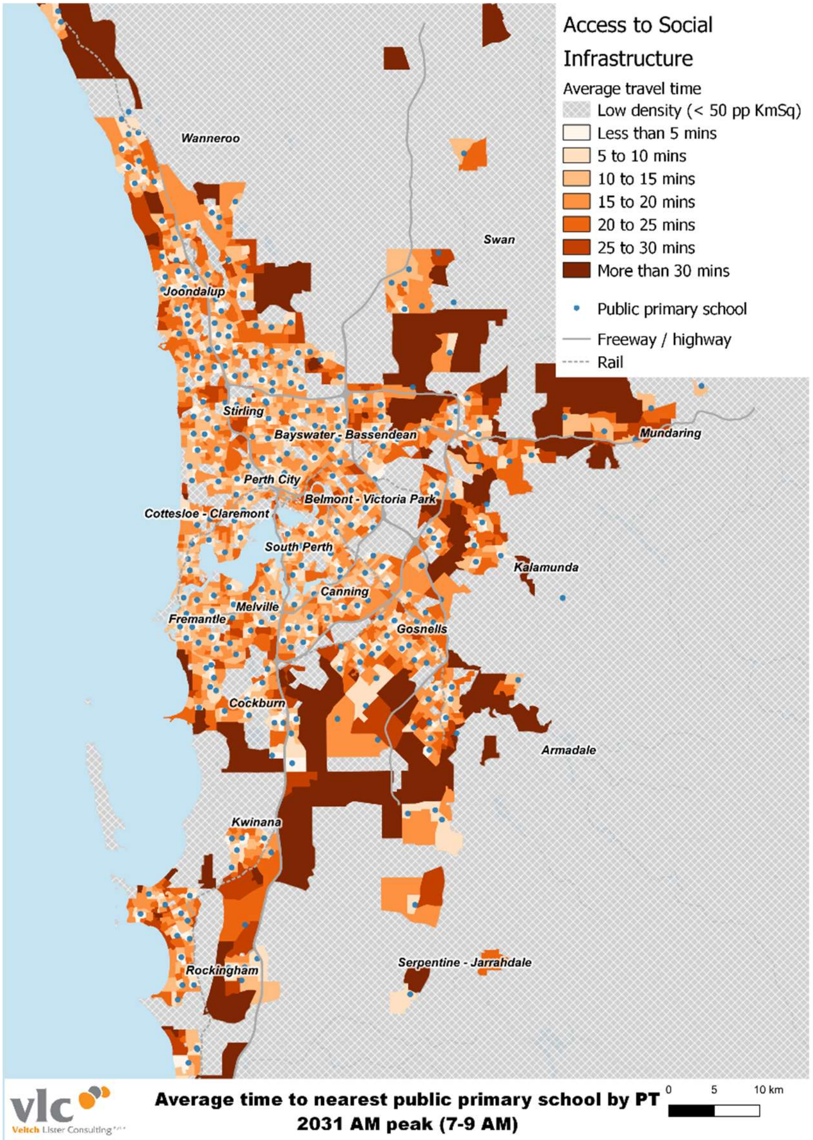


Figure 6-5 – Perth GCCSA average time to nearest public secondary school by Car - 2031 AM peak (7-9AM)

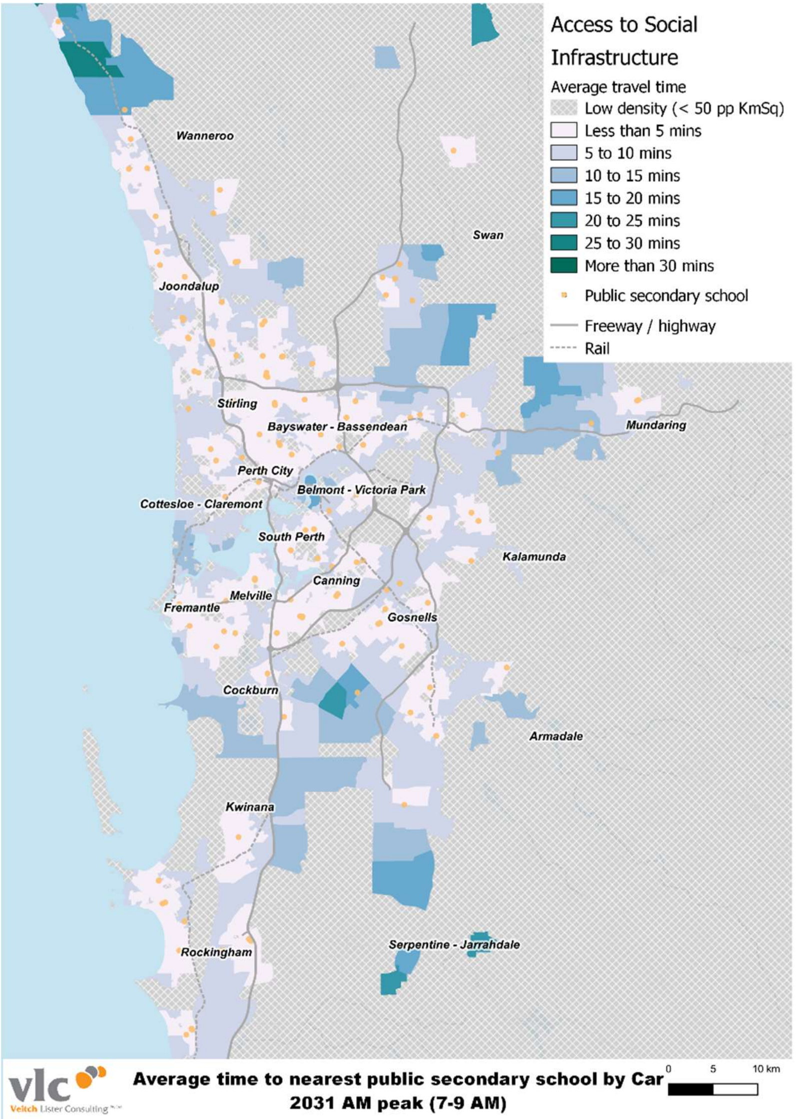


Figure 6-6 – Perth GCCSA average time to nearest public secondary school by PT - 2031 AM peak (7-9AM)

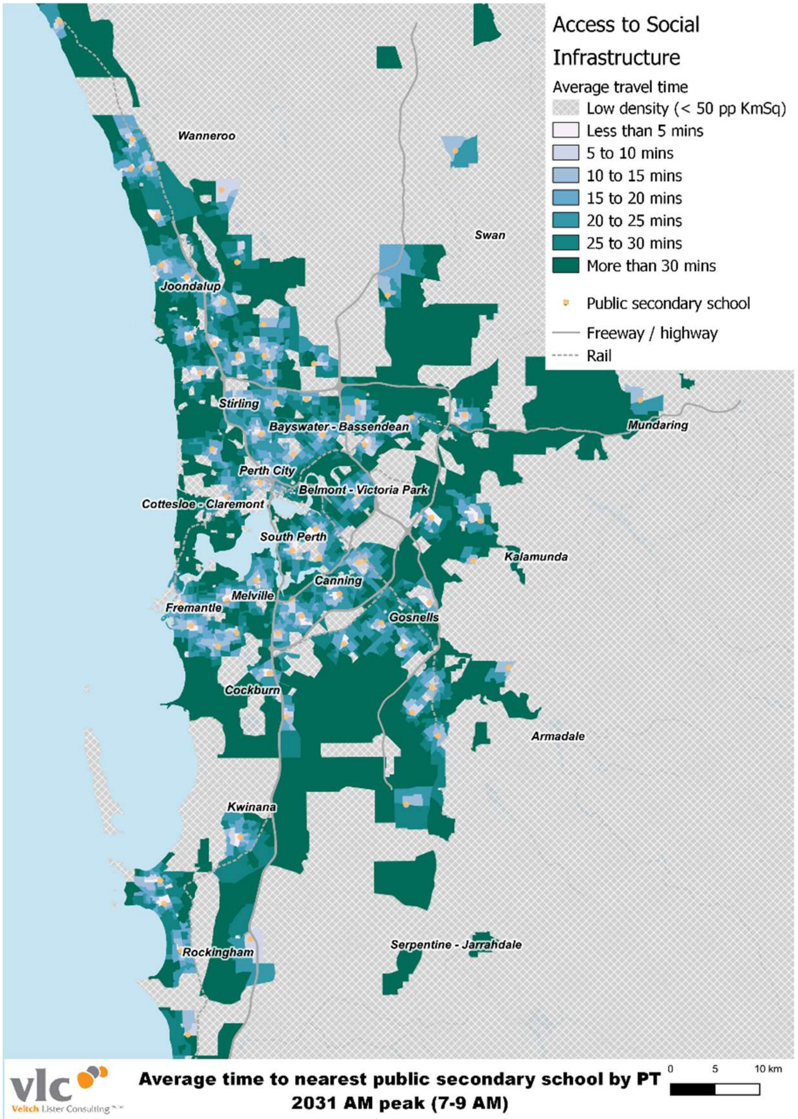


Table 6-3 – Perth GCCSA population-weighted average travel times* to child care and public schools by SA3 - AM peak (7-9AM)

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
Armadale	5.5	6.7	+1.2	31.8	31.5	-0.3	3.7	4.7	+1.0	21.0	21.7	+0.7	6.6	8.4	+1.8	36.7	38.7	+1.9
Bayswater - Bassendean	3.2	3.3	+0.1	19.9	19.4	-0.5	2.3	2.4	+0.1	15.3	15.4	+0.1	4.2	4.4	+0.2	26.3	26.6	+0.3
Belmont - Victoria Park	3.7	5.0	+1.3	20.3	21.0	+0.7	2.3	3.4	+1.1	13.6	14.6	+1.0	4.4	5.8	+1.5	25.0	25.6	+0.7
Canning	3.3	3.3	+0.0	20.4	19.7	-0.8	2.3	2.3	+0.0	14.4	14.0	-0.4	3.8	4.1	+0.3	23.5	23.2	-0.4
Cockburn	4.0	4.4	+0.4	22.7	22.7	-0.1	2.7	2.9	+0.2	16.4	16.5	+0.1	6.1	7.0	+0.9	33.9	34.0	+0.1
Cottesloe - Claremont	3.2	3.3	+0.1	19.0	18.8	-0.2	2.2	2.3	+0.1	13.8	13.8	+0.0	7.6	8.3	+0.7	35.6	36.0	+0.4
Fremantle	4.5	3.8	-0.7	18.4	17.8	-0.6	2.8	2.4	-0.5	12.3	12.1	-0.2	4.7	3.9	-0.8	20.9	19.3	-1.6
Gosnells	3.5	3.9	+0.4	22.9	23.3	+0.3	2.6	2.9	+0.3	16.6	17.6	+1.0	4.6	5.2	+0.6	27.9	29.1	+1.2
Joondalup	3.9	4.1	+0.1	24.1	23.5	-0.6	2.6	2.7	+0.1	15.9	16.1	+0.1	4.4	4.6	+0.2	27.9	27.4	-0.5
Kalamunda	5.0	5.0	-0.1	32.6	30.3	-2.2	3.2	3.2	+0.0	20.6	19.9	-0.7	5.9	6.1	+0.2	36.5	34.4	-2.0
Kwinana	3.7	4.2	+0.5	25.4	25.3	-0.1	3.4	4.1	+0.7	23.2	24.7	+1.5	4.9	5.5	+0.5	31.7	31.3	-0.4
Mandurah	5.2	6.0	+0.8	35.4	40.3	+4.9	4.2	4.9	+0.6	30.7	35.0	+4.3	6.3	7.3	+1.0	40.0	43.7	+3.7
Melville	3.4	3.5	+0.1	20.8	20.1	-0.7	2.3	2.4	+0.0	14.5	14.3	-0.2	4.0	4.1	+0.1	24.8	24.4	-0.4
Mundaring	8.9	8.9	+0.0	59.5	55.1	-4.4	3.5	3.8	+0.2	23.6	25.1	+1.6	8.6	8.5	-0.1	57.3	54.5	-2.7
Perth City	2.5	2.7	+0.2	13.8	13.7	-0.1	2.5	3.0	+0.5	13.5	14.2	+0.8	4.3	4.9	+0.6	22.6	22.8	+0.2
Rockingham	4.1	4.5	+0.3	26.7	28.9	+2.2	2.9	3.1	+0.2	18.4	18.6	+0.3	4.4	4.6	+0.2	28.5	30.5	+2.0
Serpentine – Jarrahdale^	8.4	10.0	+1.5	67.2	60.3	-6.9	4.6	3.7	-0.9	36.2	24.4	-11.8	8.6	10.3	+1.7	71.9	64.0	-7.9
South Perth	3.5	3.6	+0.1	18.9	18.6	-0.3	2.2	2.3	+0.1	13.9	13.7	-0.2	4.7	4.8	+0.1	26.2	25.7	-0.5
Stirling	3.2	3.3	+0.0	19.7	18.8	-1.0	2.3	2.4	+0.1	14.0	14.0	+0.0	4.2	4.5	+0.3	26.4	26.0	-0.4
Swan	6.0	6.6	+0.6	35.9	35.8	-0.1	4.2	4.5	+0.3	25.6	25.6	-0.0	7.0	7.8	+0.8	39.9	39.7	-0.1
Wanneroo	4.5	16.8	+12.3	25.8	48.4	+22.6	3.1	8.3	+5.2	19.1	31.9	+12.8	4.9	16.0	+11.2	28.9	50.7	+21.8
Perth GCCSA	**4.2**	**6.2**	**+2.0**	**25.6**	**29.1**	**+3.5**	**2.9**	**3.8**	**+1.0**	**18.0**	**20.3**	**+2.3**	**5.2**	**7.1**	**+2.0**	**30.8**	**34.4**	**+3.5**

*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).

^The apparent improvement in Serpentine-Jarrahdale is a result of the small population in that area and projected population growth being concentrated in the most 'accessible' travel zones in that SA3. Because the metric is population-weighted, this considerably improves average travel times.

Most Perth residents have good access to green space. In 2016, 97 per cent of the Greater Perth population could reach green space within 10 minutes in 2016, which is expected to continue to 2031. This measure excludes population in large travel zones (mostly on the urban fringe or rural areas). Applying a similar filter at an SA3 level constrains the analysis largely to established areas – nearly all of which are assessed as having very good walking access to green space of some kind. Cottesloe – Claremont, Stirling and Melville in Perth's west have below average access to green space (Figure 6-7).[6]

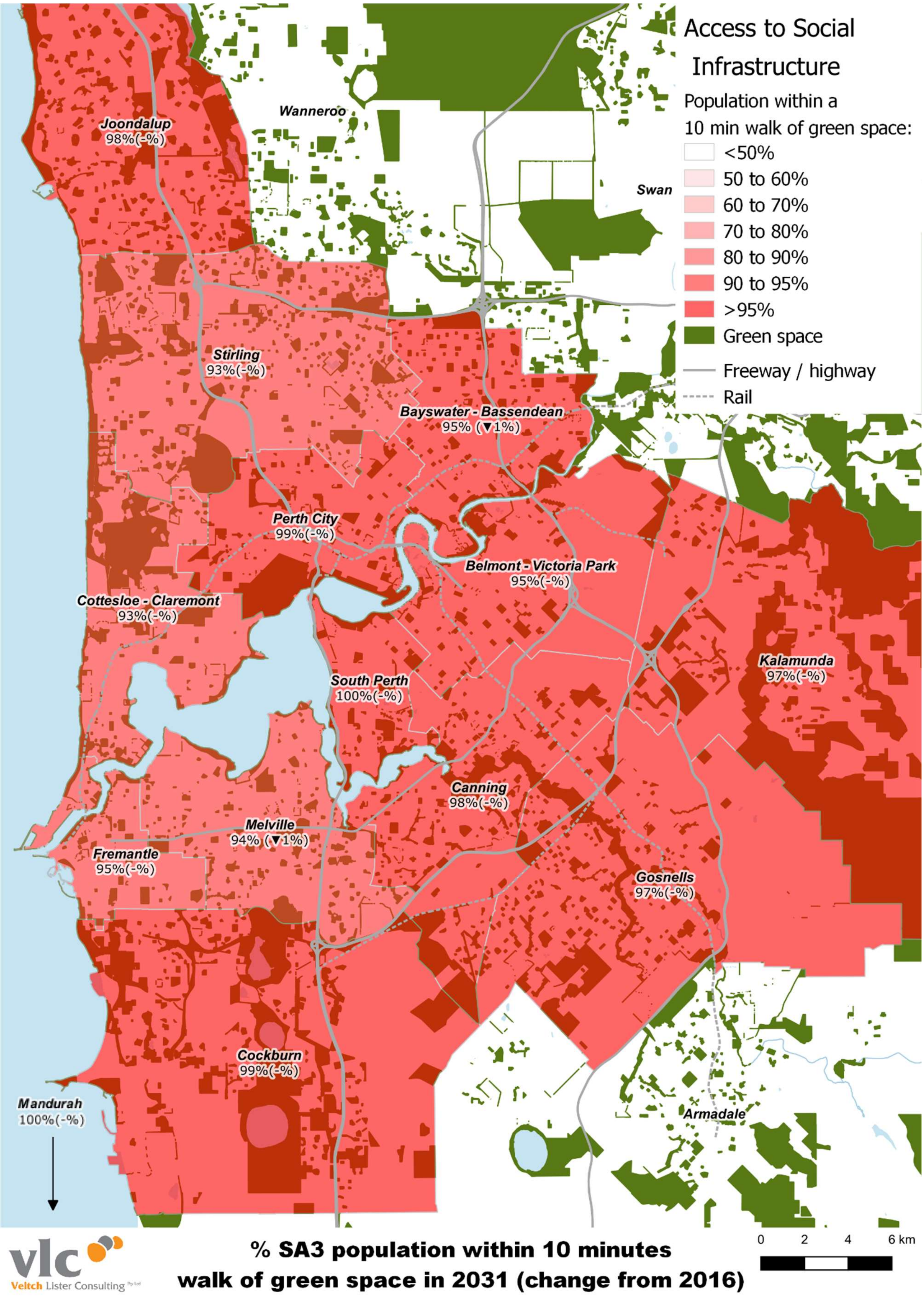
Limitations to measuring green space access:

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.

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

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



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

The high current and future concentration of jobs within the central areas of Greater Perth mean that the ease of access to the CBD is the main driver of employment accessibility. Areas close to the city or near infrastructure that directly links to the CBD have the highest level of access by car and by public transport.

Job accessibility by car generally reduces into the future, with many parts of Perth being able to access a smaller percentage of available jobs in 2031 compared with 2016 (Figure 6-8 and Figure 6-9). This is particularly pronounced in areas to the south of the Swan River. This suggests that congestion on river crossings including the Causeway, Kwinana and Graham Farmer Freeways is having a material impact on travel times to job opportunities in the north of Perth, and that job growth south of the Swan River is insufficient to mitigate the reduction in accessibility associated with this growing congestion.

Job accessibility by public transport is relatively stable between 2016 and 2031 (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. It also highlights that current development plans for the public transport system keep pace with the spread of the population. Given the increasing dispersal of the population this reflects more intensive use of rail compared to the slower bus mode in the public transport task (section 5).

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

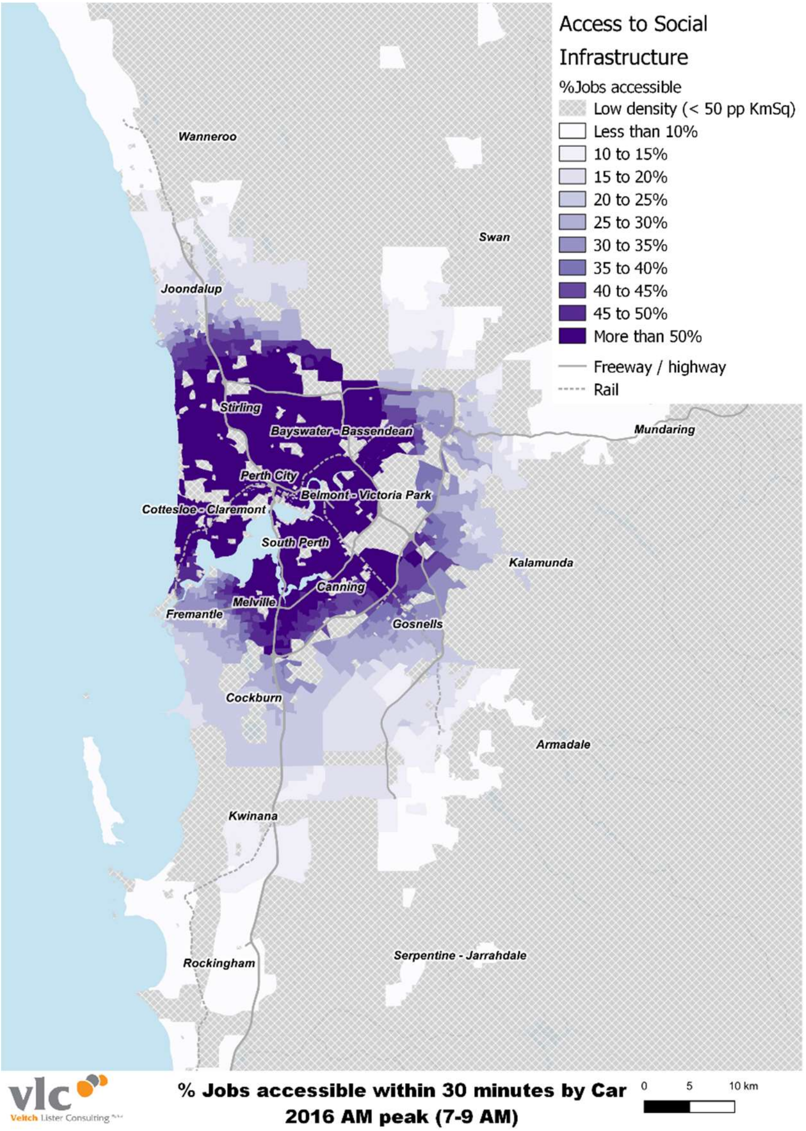


Figure 6-9 – Perth GCCSA access to jobs by Car - 2031 AM peak (7-9AM)

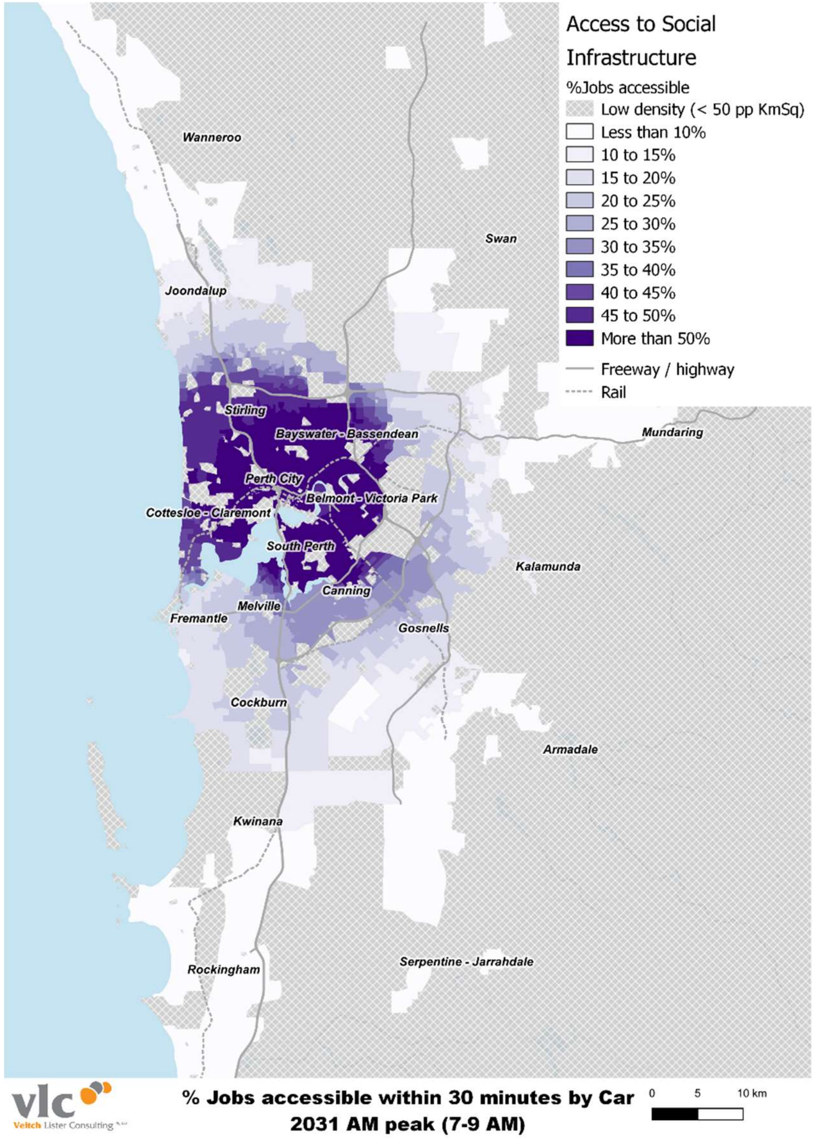


Figure 6-10 – Perth GCCSA access to jobs by PT - 2016 AM peak (7-9AM)

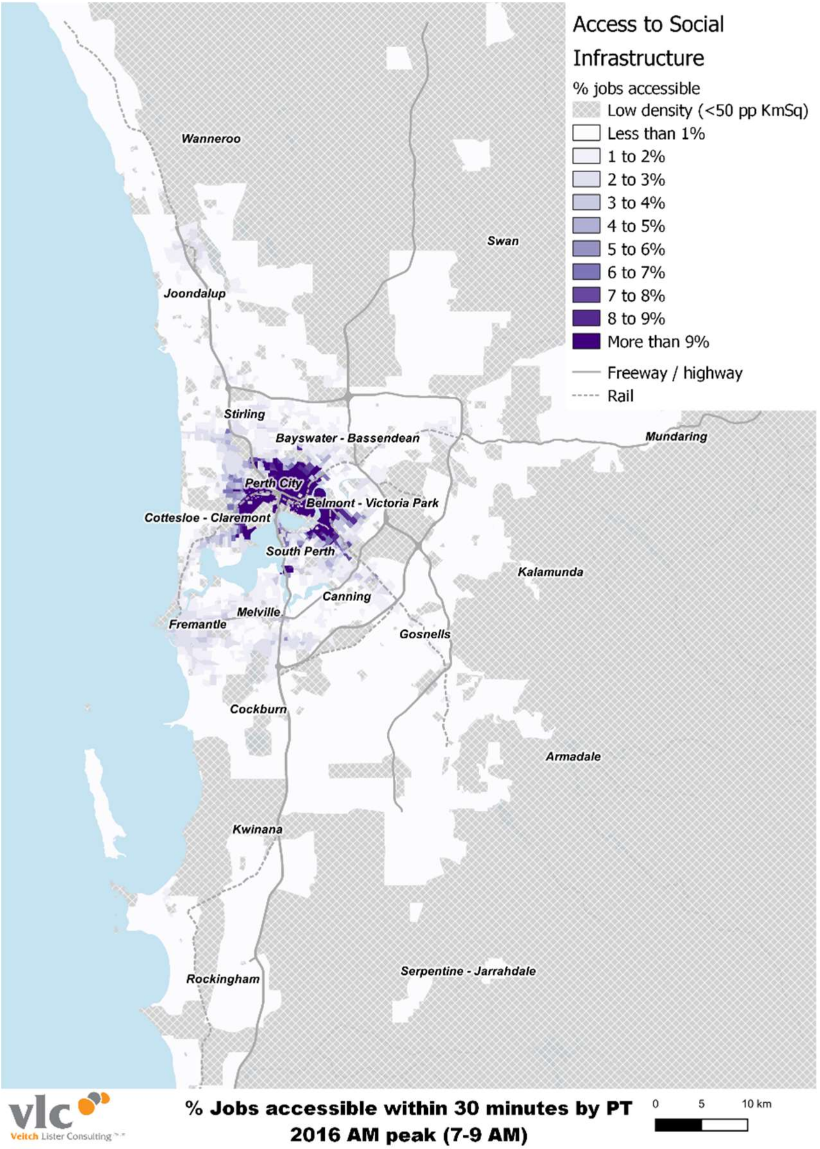
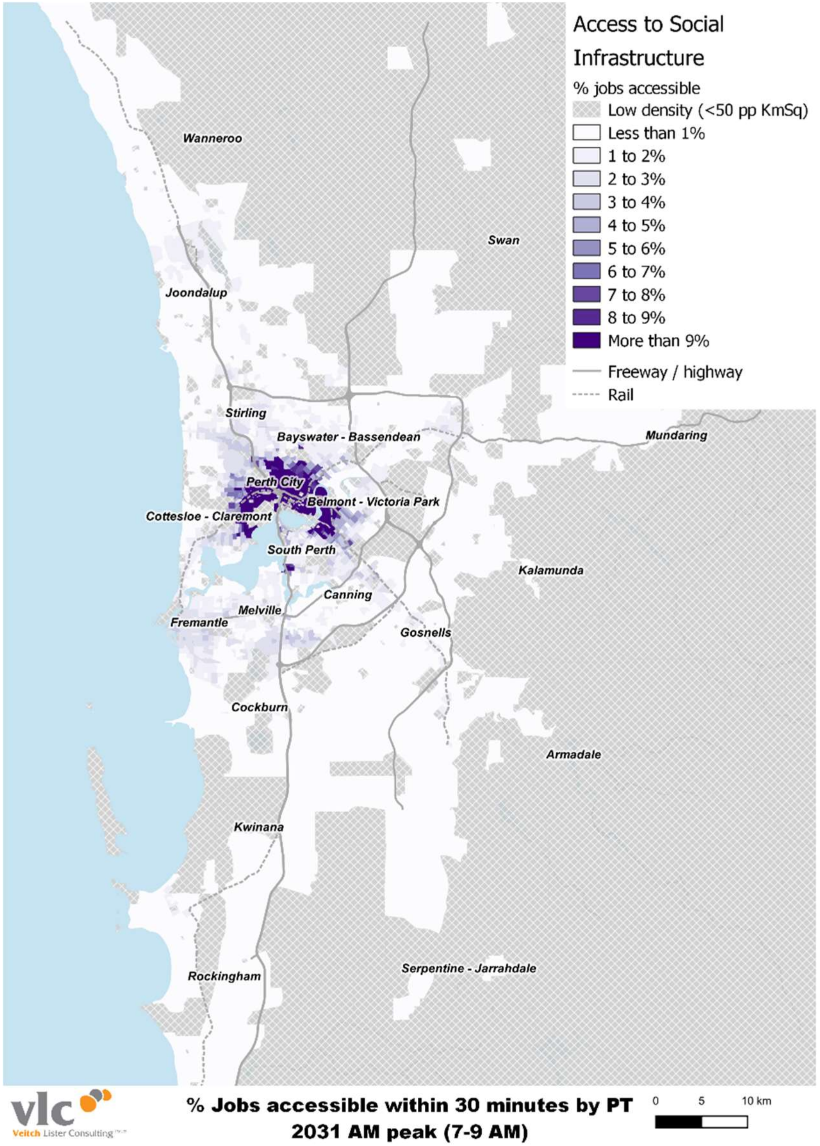


Figure 6-11 – Perth GCCSA access to jobs by PT - 2031 AM peak (7-9AM)



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 respectively). Although all but one of Greater Perth's 19 public hospitals is near a rail line (the exception being Kalamunda Hospital to the east of Perth Airport), car accessibility to hospitals is far superior to public transport. This is reinforced by Table 6-4, showing that only residents of Perth City and Fremantle will, on average, be able to reach the nearest public hospital within 30 minutes by public transport, and most Greater Perth residents needing to travel for more than 45 minutes.

Table 6-4 – Perth 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*
Armadale	10.1	11.5	*+1.4*	52.9	52.3	*-0.6*
Bayswater - Bassendean	9.4	10.8	*+1.4*	46.3	45.0	*-1.4*
Belmont - Victoria Park	9.2	11.6	*+2.5*	37.1	37.5	*+0.3*
Canning	9.2	9.7	*+0.5*	39.5	38.6	*-0.9*
Cockburn	15.2	17.1	*+1.9*	44.0	43.5	*-0.5*
Cottesloe - Claremont	5.3	5.7	*+0.5*	32.1	31.9	*-0.3*
Fremantle	6.3	5.9	*-0.4*	25.7	24.7	*-0.9*
Gosnells	14.4	15.5	*+1.0*	54.1	55.3	*+1.1*
Joondalup	7.7	7.9	*+0.3*	46.9	45.4	*-1.6*
Kalamunda	10.3	10.8	*+0.5*	57.2	55.7	*-1.5*
Kwinana	14.1	15.0	*+0.9*	55.3	52.4	*-2.9*
Mandurah	9.6	10.7	*+1.1*	57.7	60.3	*+2.6*
Melville	5.3	5.6	*+0.3*	38.5	38.4	*-0.2*
Mundaring	17.9	18.4	*+0.5*	82.1	72.2	*-10.0*
Perth City	2.8	3.2	*+0.3*	21.9	20.9	*-1.1*
Rockingham	8.4	9.1	*+0.7*	57.3	59.0	*+1.6*
Serpentine - Jarrahdale	18.4	24.5	*+6.1*	104.6	99.5	*-5.1*
South Perth	4.9	5.1	*+0.1*	38.2	38.8	*+0.6*
Stirling	6.2	6.5	*+0.3*	38.8	38.3	*-0.5*
Swan	19.7	20.8	*+1.1*	78.9	75.1	*-3.7*
Wanneroo	16.9	39.1	*+22.2*	59.3	80.9	*+21.7*
Perth GCCSA	**11.9**	**16.1**	***+4.2***	**49.6**	**52.9**	***+3.3***

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

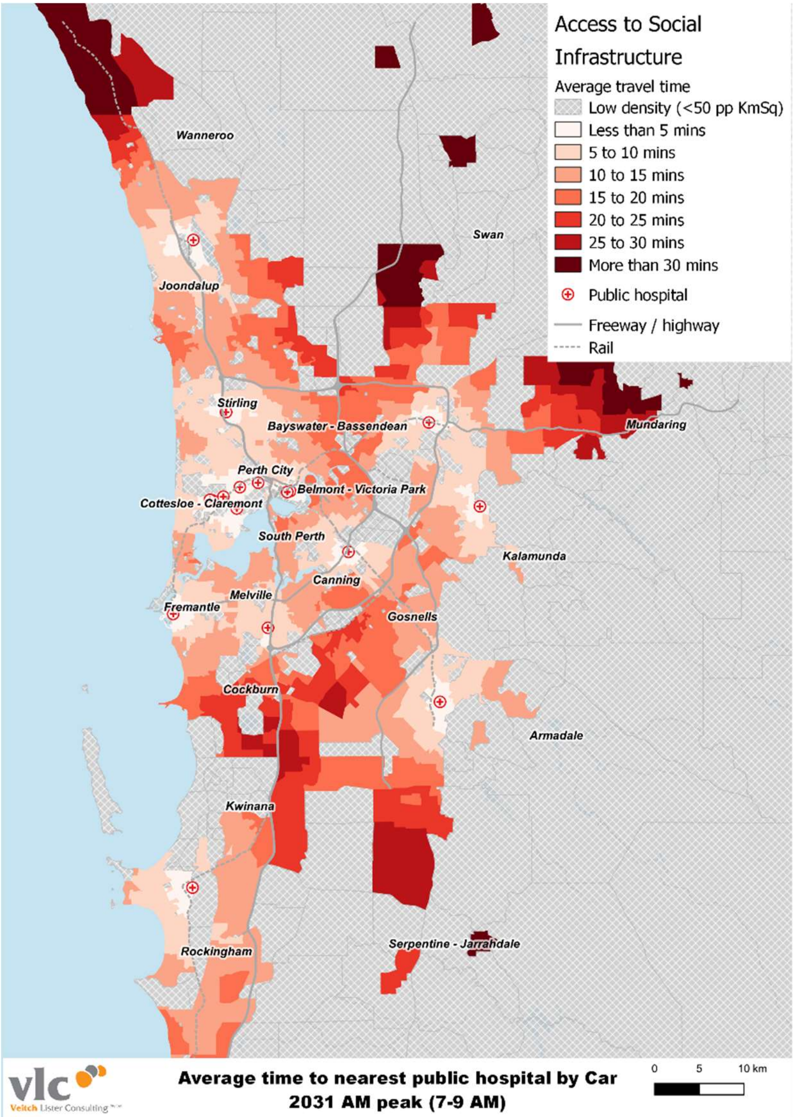
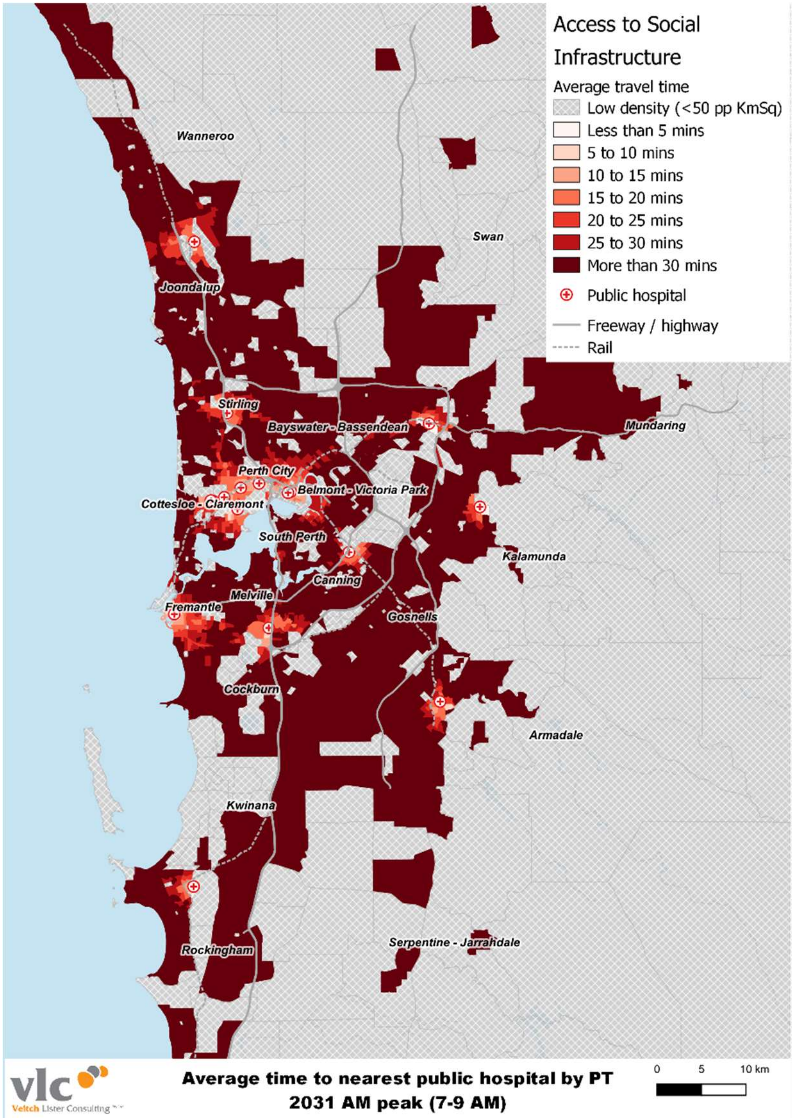


Figure 6-13 – Perth GCCSA average time to nearest public/emergency hospital by PT - 2031 AM peak (7-9AM)



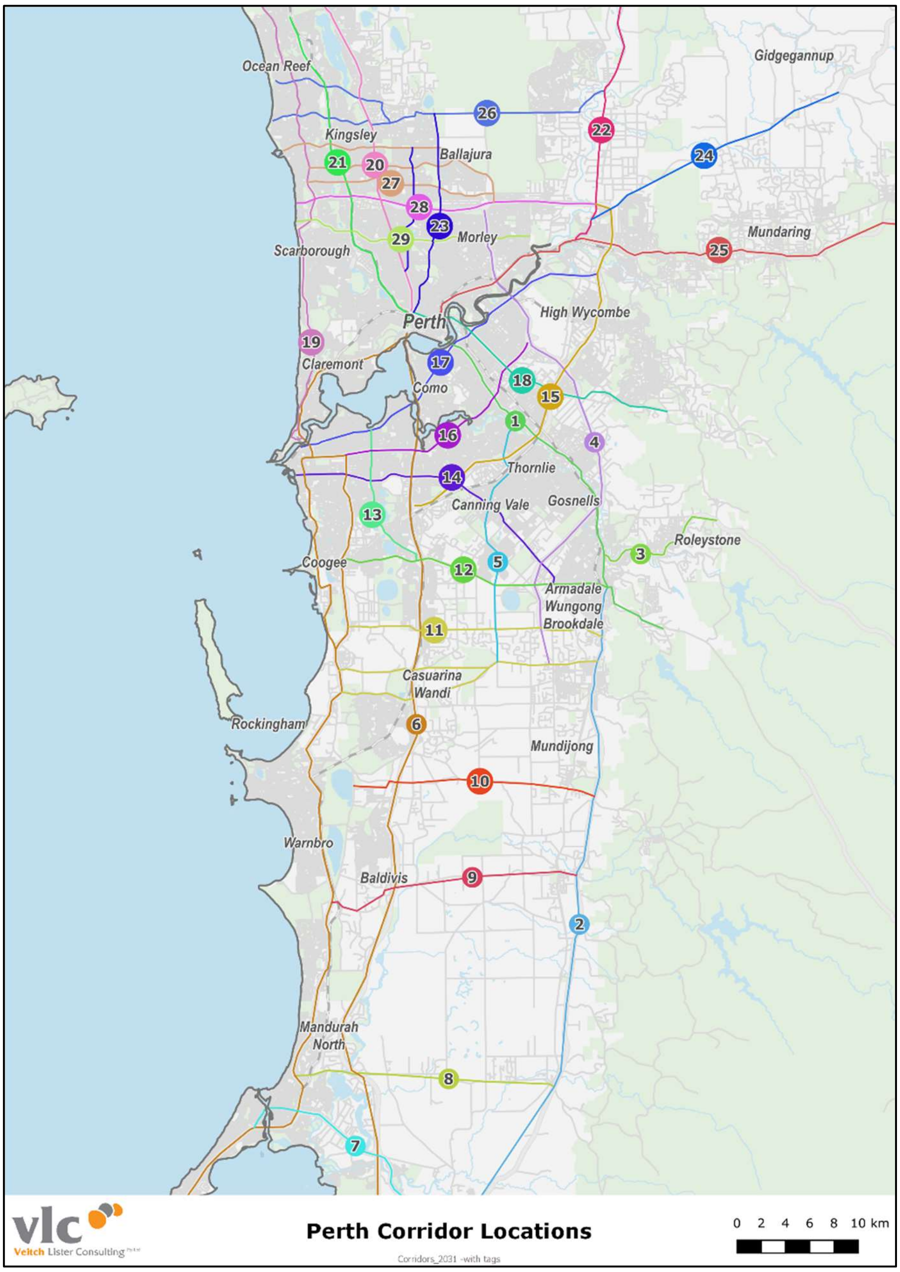
7. Assessment

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

Perth's radial corridors are expected to come under significant pressure by 2031. The continued agglomeration of employment in central Perth and relatively dispersed population growth drives strong demand for these movements. As a result, key road and rail corridor performance is expected to deteriorate significantly to 2031. In this section we measure network performance for road, rail and bus corridors in 2016 and 2031 using 30 key multi-modal corridors that were identified with Infrastructure Australia (Figure 7-1 and Appendix Table C-1).

Figure 7-1 – Perth 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).

The Mitchell Freeway and Kwinana Freeway have the longest total delays in 2016 (Table 7-1). These corridors are also forecast to be the worst performing road corridors in 2031, with peak period delay hours increasing to around 5,000 and 8,000 respectively (Table 7-2). The poor performance of these corridors contributes to increased delay on second-order arterials:

- The congestion on the Mitchell Freeway – coupled with strong population growth in the far north – diverts traffic onto the Marmion Avenue/West Coast corridor. As a result, the performance of the Marmion Avenue/West Coast corridor is expected to deteriorate significantly, becoming with the corridor third highest total delay.
- The Old Coast/Mandurah/Stock/Stirling Hwy Corridor in the south provides a north-south alternative to the Kwinana Freeway and is also predicted to become a major contributor to delay hours.

Congestion on other city-serving corridors such as the Albany Highway and the Graham Farmer Freeway/Orrong Road/Welshpool Road East corridor are also projected to contribute to delay on the road network. While most of the deficient road corridors are radial, the Roe Highway and the Tonkin Highway facilitate orbital movements. Significant delays occur on these roads in both directions in the peak periods. For instance, the Tonkin Highway is a major cause of delay in both the northbound and southbound directions.

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

	Corridor name	Number	Direction	Delay Hours
	AM peak (7-9AM)			
1	Kwinana Fwy Corridor	6	NB	4,600
2	Mitchell Fwy Corridor	21	SB	3,000
3	Old Coast/Mandurah/Stock/Stirling Hwy Corridor	6	NB	1,500
4	Tonkin Hwy Corridor	4	NB	1,400
5	Marmion Ave/West Coast Hwy Corridor	19	SB	1,300
6	Wanneroo Rd Corridor	20	SB	1,100
7	Graham Farmer Fwy/Orrong Rd/Welshpool Rd East Corridor	18	WB	1,100
8	Kwinana Fwy Corridor	6	SB	1,000
9	Albany Hwy Corridor	1	NB	900
10	Roe Hwy Corridor	15	SB	900
	PM peak (4-6PM)			
1	Kwinana Fwy Corridor	6	SB	4,000
2	Mitchell Fwy Corridor	21	NB	2,400
3	Kwinana Fwy Corridor	6	NB	1,700
4	Old Coast/Mandurah/Stock/Stirling Hwy Corridor	6	SB	1,300
5	Tonkin Hwy Corridor	4	SB	1,200
6	Marmion Ave/West Coast Hwy Corridor	19	NB	1,000
7	Tonkin Hwy Corridor	4	NB	900
8	Roe Hwy Corridor	15	NB	900
9	Wanneroo Rd Corridor	20	NB	800
10	Mitchell Fwy Corridor	21	SB	800

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

	Corridor Name	Number	Direction	Delay Hours
	AM peak (7-9AM)			
1	Kwinana Fwy Corridor	6	NB	8,600
2	Mitchell Fwy Corridor	21	SB	5,200
3	Marmion Ave/West Coast Hwy Corridor	19	SB	4,100
4	Old Coast/Mandurah/Stock/Stirling Hwy Corridor	6	NB	3,200
5	Tonkin Hwy Corridor	4	NB	3,100
6	Wanneroo Rd Corridor	20	SB	2,500
7	Kwinana Fwy Corridor	6	SB	2,300
8	Tonkin Hwy Corridor	4	SB	2,200
9	Graham Farmer Fwy/Orrong Rd/Welshpool Rd East Corridor	18	WB	2,100
10	Albany Hwy Corridor	1	NB	1,900
	PM peak (4-6PM)			
1	Kwinana Fwy Corridor	6	SB	7,500
2	Mitchell Fwy Corridor	21	NB	4,700
3	Marmion Ave/West Coast Hwy Corridor	19	NB	3,500
4	Kwinana Fwy Corridor	6	NB	3,300
5	Old Coast/Mandurah/Stock/Stirling Hwy Corridor	6	SB	2,900
6	Tonkin Hwy Corridor	4	SB	2,900
7	Tonkin Hwy Corridor	4	NB	2,400
8	Wanneroo Rd Corridor	20	NB	2,200
9	Roe Hwy Corridor	15	NB	1,800
10	Canning Hwy/Great Eastern Hwy (west) Corridor	17	EB	1,600

When considering delays from an individual user's perspective, many of the same corridors perform worst (Table 7-3 and Table 7-4). By 2031 users on these corridors can expect to spend approximately 40 to 60 per cent of their travel time stuck in traffic. This is considerably worse than the situation in 2016, where only the Mitchell Freeway corridor had a percentage delay of over 40 per cent.

On this user measure the major freeways are forecast to perform poorly (the Mitchell and Kwinana Freeways) in 2031. However the user perspective analysis also highlights long delays on key arterial corridors. Users travelling the length of the Graham Farmer Fwy/Orrong Rd/Welshpool Rd East Corridor can expect travel times of approximately 43 minutes in the AM peak. Nearly half of this time is a result of congestion delays, particularly at the Swan River Crossing (Figure 4-5 shows a volume-capacity ratio above 1 at the Windan Bridge). The Canning Hwy/Great Eastern Hwy (west) Corridor is one of the few east-west corridors that is forecast to come under pressure. Users of this corridor are most heavily delayed where it provides access to the major freeways.

In outer areas, significant population growth to 2031 drives congestion on the arterial roads. While congestion on these roads affects fewer users than congestion on the high capacity freeways and highways, the amount of delay incurred by individual users is significant and is a major impediment to their travel. In the far north the Marmion Ave/West Coast Hwy Corridor and Wanneroo Rd Corridors perform poorly. In the south a similar outcome is expected on the Nicholson Rd Corridor. By 2031, it is expected that travelling the length of these corridors in peak periods will take approximately twice as long as travel in uncongested conditions. The delay on corridors in outer areas emphasises the importance of expanding infrastructure to cater for rapid population growth.

Table 7-3 – Perth 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	Mitchell Fwy Corridor	21	SB	29	51%	20	39
2	Nicholson Rd Corridor	5	NB	22	40%	12	30
3	Kwinana Fwy Corridor	6	NB	80	40%	32	80
4	Tonkin Hwy Corridor	4	NB	44	36%	17	47
5	Wanneroo Rd Corridor	20	SB	47	35%	22	65
6	Marmion Ave/West Coast Hwy Corridor	19	SB	61	34%	28	82
7	Graham Farmer Fwy/Orrong Rd/Welshpool Rd East Corridor	18	WB	24	34%	12	35
8	Leach Hwy Corridor	16	EB	19	33%	9	27
9	South St/Ranford Rd Corridor	14	WB	26	33%	13	39
10	Reid Hwy Corridor	28	WB	25	33%	10	30
	PM peak (4-6PM)						
1	Mitchell Fwy Corridor	21	NB	29	41%	13	32
2	Nicholson Rd Corridor	5	SB	22	34%	9	27
3	Kwinana Fwy Corridor	6	SB	80	34%	25	73
4	Tonkin Hwy Corridor	4	SB	44	31%	14	44
5	Leach Hwy Corridor	16	WB	19	31%	8	26
6	Roe Hwy Corridor	15	NB	34	31%	10	33
7	Reid Hwy Corridor	28	EB	25	30%	9	29
8	Canning Hwy/Great Eastern Hwy (west) Corridor	17	WB	30	29%	13	44
9	South St/Ranford Rd Corridor	14	EB	26	29%	11	37
10	Marmion Ave/West Coast Hwy Corridor	19	NB	61	29%	22	76

Table 7-4 – Perth 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	Mitchell Fwy Corridor	21	SB	29	62%	31	50
2	Marmion Ave/West Coast Hwy Corridor	19	SB	61	54%	64	118
3	Wanneroo Rd Corridor	20	SB	47	53%	48	91
4	Nicholson Rd Corridor	5	NB	22	52%	19	37
5	Tonkin Hwy Corridor	4	NB	44	51%	30	60
6	Kwinana Fwy Corridor	6	NB	80	51%	50	98
7	Graham Farmer Fwy/Orrong Rd/Welshpool Rd East Corridor	18	WB	24	47%	20	43
8	Roe Hwy Corridor	15	SB	34	44%	18	40
9	Albany Hwy Corridor	1	NB	33	43%	24	57
10	Leach Hwy Corridor	16	EB	19	42%	13	31
	PM peak (4-6PM)						
1	Mitchell Fwy Corridor	21	NB	29	56%	25	43
2	Marmion Ave/West Coast Hwy Corridor	19	NB	61	50%	53	107
3	Wanneroo Rd Corridor	20	NB	47	48%	40	83
4	Nicholson Rd Corridor	5	SB	22	48%	17	35
5	Tonkin Hwy Corridor	4	SB	44	47%	27	56
6	Kwinana Fwy Corridor	6	SB	80	46%	42	90
7	Roe Hwy Corridor	15	NB	34	44%	18	41
8	Leach Hwy Corridor	16	WB	19	41%	13	31
9	Canning Hwy/Great Eastern Hwy (west) Corridor	17	EB	30	41%	21	52
10	Tonkin Hwy Corridor	4	NB	44	40%	20	49

The additional demand placed on Perth's public transport system to 2031 is expected to result in a deterioration in network performance. 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.)

By 2031 the crowding expected on the Joondalup and Mandurah lines is expected to have worsened significantly, particularly during the AM peak (Table 7-5 and Table 7-6). As was identified previously in Section 5, services are most crowded on the sections just outside the CBD. Users of these sections of network in peak periods are predicted to experience uncomfortable levels of crowding, with loadings at or above vehicle capacities.

Table 7-5 – Perth GCCSA top three most crowded 2016 rail corridors

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Mandurah line south of Perth CBD	NB	3.3	0.8
Joondalup line north of Perth CBD	SB	2.8	0.7
Midland line east of Perth CBD	EB	2.5	0.6
PM peak (4-6PM)			
Mandurah line south of Perth CBD	SB	2.8	0.7
Joondalup line north of Perth CBD	NB	2.7	0.7
Midland line east of Perth CBD	WB	2.3	0.6

Table 7-6 – Perth GCCSA top three most crowded 2031 rail corridors

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Mandurah line south of Perth CBD	NB	4.2	1.1
Joondalup line north of Perth CBD	SB	4.4	1.2
Midland line east of Perth CBD	EB	2.8	0.7
PM peak (4-6PM)			
Mandurah line south of Perth CBD	SB	3.6	0.9
Joondalup line north of Perth CBD	NB	4.1	1.1
Midland line east of Perth CBD	WB	2.4	0.6

Some of Perth's major bus routes are also likely to perform poorly as passenger demand increases to 2031 and is not matched by assumed supply expansions. The worst crowding is expected on the sections just outside the CBD (again, see Section 5). Crowding on buses on the Kwinana Freeway is forecast to worsen significantly, particularly in the evening peak period (Table 7-7 and Table 7-8).

By 2031 the modelling indicates that users will experience uncomfortable levels of crowding on key sections of Perth's bus network; bus loadings on these sections are forecast to be near or above vehicle capacities.

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

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Kwinana Freeway south of Perth CBD	NB	1.0	0.7
Great Eastern Highway east of Perth CBD	WB	1.0	0.8
Alexander Drive north of Perth CBD	SB	0.9	0.6
Wanneroo Road north of Perth CBD	SB	0.9	0.7
Causeway at the Swan River	WB	0.9	0.6
PM peak (4-6PM)			
Kwinana Freeway south of Perth CBD	SB	1.2	0.8
Great Eastern Highway east of Perth CBD	EB	1.0	0.7
Alexander Drive north of Perth CBD	NB	0.8	0.6
Wanneroo Road north of Perth CBD	NB	0.8	0.6
Causeway at the Swan River	EB	0.7	0.5

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

Corridor	Direction	Indicative volume / seated capacity	Indicative volume / crush capacity
AM peak (7-9AM)			
Kwinana Freeway south of Perth CBD	NB	1.1	0.7
Causeway at the Swan River	WB	1.1	0.7
Great Eastern Highway east of Perth CBD	WB	1.0	0.7
Wanneroo Road north of Perth CBD	SB	1.0	0.7
Alexander Drive north of Perth CBD	SB	0.9	0.6
PM peak (4-6PM)			
Kwinana Freeway south of Perth CBD	SB	1.4	0.9
Great Eastern Highway east of Perth CBD	EB	0.9	0.6
Alexander Drive north of Perth CBD	NB	0.9	0.6
Wanneroo Road north of Perth CBD	NB	0.9	0.6
Causeway at the Swan River	EB	0.8	0.6

7.2 Regional deficiencies

Despite growth in road congestion to 2031, residents across Greater Perth are generally well-served by local social infrastructure, providing they have access to a car. In 2031, the average resident in SA3s in the Perth GCCSA can reach the nearest five child care centres, nearest public primary school and nearest public secondary school within a ten-minute drive in the morning peak, with one exception – Wanneroo. This is a result of modelled growth in congestion around this SA3, that partly reflects limitations in the knowledge of the future networks (section 6.1). The future congestion forecast by the model is therefore likely to be overstated. 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 Perth residents without regular car access is considerably poorer, particularly those living in outer suburbs. Students in Mandurah, Mundaring or Wanneroo would need to spend around 40 minutes to an hour on public transport to high school, and similarly for adults to accompany their young child to care or primary school. This is largely due to lower walkability of these areas, coupled with the limited ability of Perth's radial public transport system to cater for local trips.

Growing congestion on the freeway and arterial network has more pronounced impacts on the ease with which residents in fringe suburbs can reach regional services, including jobs and hospitals. Again, Wanneroo is forecast to have the largest decrease in accessibility, with the average resident able to access 144,000 fewer jobs within 45 minutes in 2031 compared with 2016. Travel to the nearest public hospital by car also increases by over 20 minutes.

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 Perth 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 more than double from $4.4 million in 2016 to $10.5 million in 2031 (Figure 7-2). This is consistent with the deteriorating network performance described in the preceding chapters. Each modelled time-period contributes a different amount to the total daily congestion cost. The highest costs are accrued in the inter-peak, given that this time-period accounts for the highest volume of daily travel (approximately 37% of vehicle trips in both years) as this period covers seven hours. While the two-hour AM and PM peaks each represent around 16 per cent of daily vehicle trips, they make up 30 and 27 per cent of daily congestion costs respectively.

The hourly cost incurred in the AM peak is triple that of the inter-peak – around $0.7 million compared to $0.2 million in 2016, and $1.5 million compared to $0.6 million in 2031 (Figure 7-3). The PM peak has a slightly lower hourly cost of congestion than the AM peak in both years. This is a function of the lower hours of delay on key corridors described earlier in this chapter, as well as the concentration of 'higher value' trips (i.e. business travel and freight trips) in the AM peak compared with the PM peak.

Annually, the estimated cost of congestion in Perth GCCSA is $1.5 billion in 2016, growing to $3.6 billion in 2031.

Figure 7-2 – Perth GCCSA average weekday cost of congestion

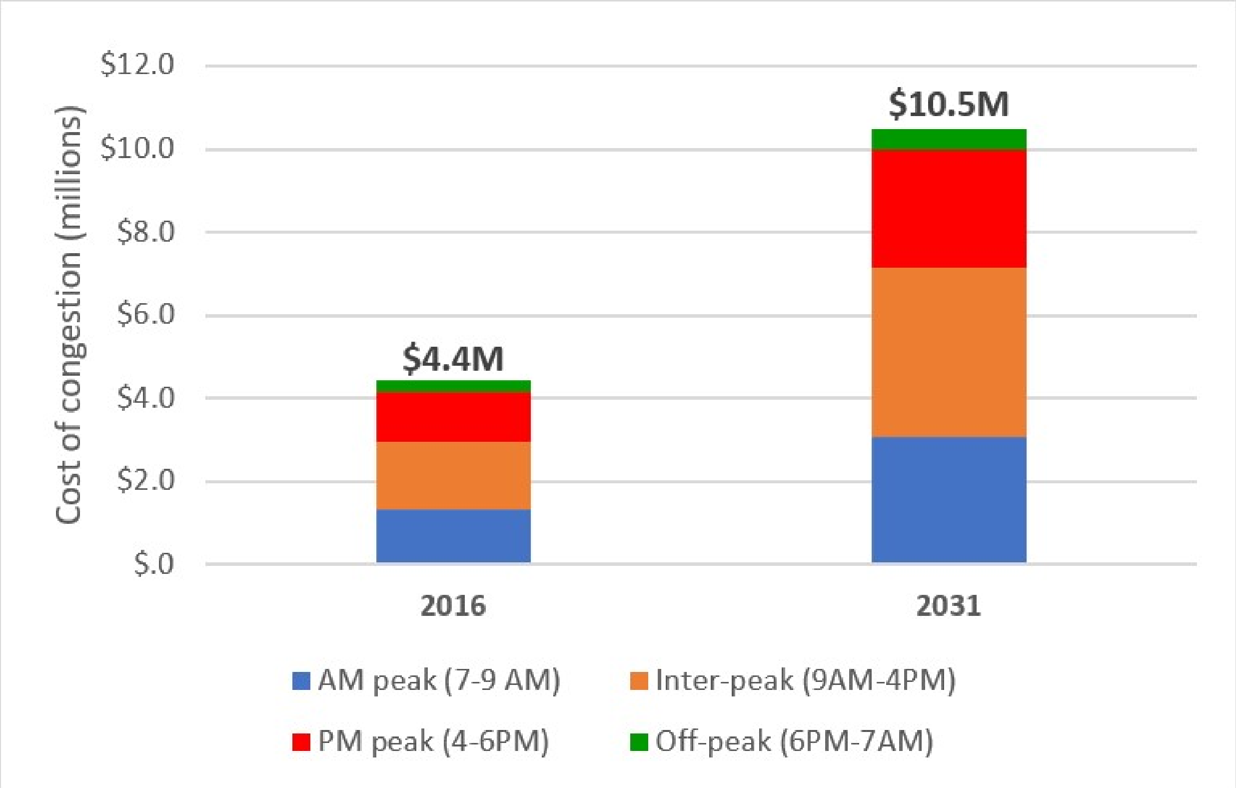
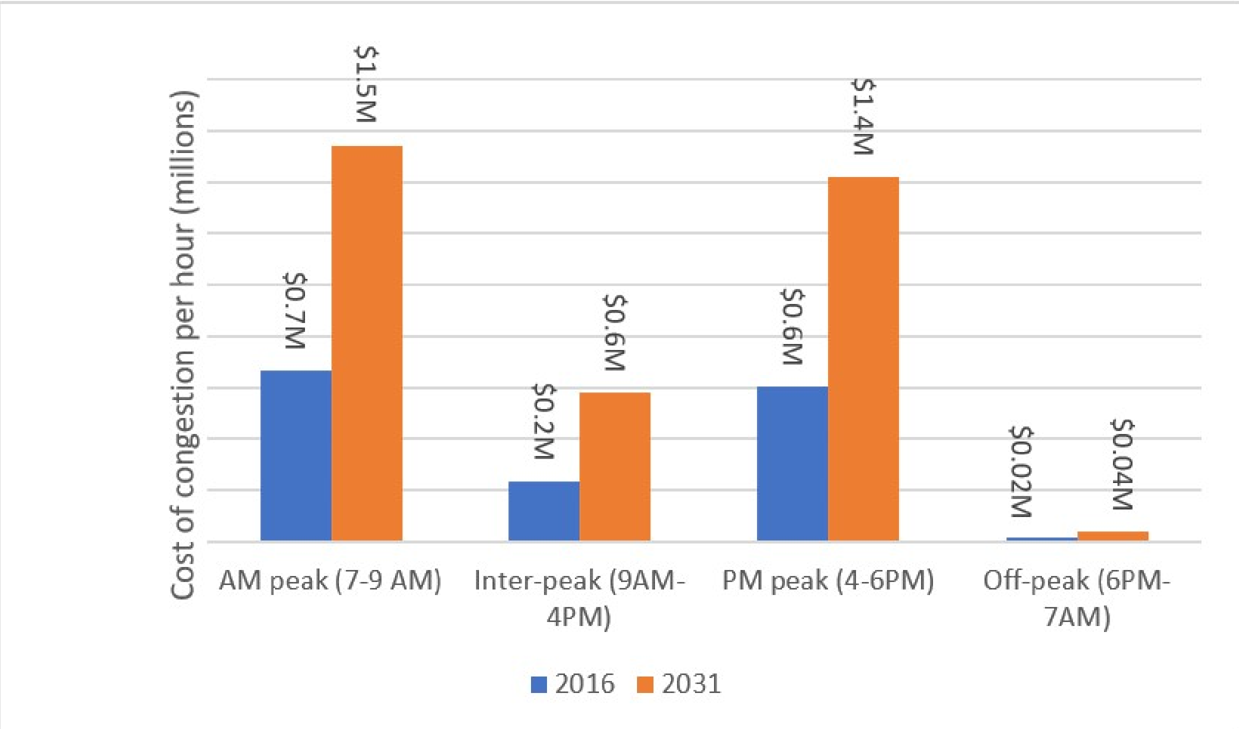


Figure 7-3 – Perth GCCSA average weekday hourly cost of congestion by time-period



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 small compared to the road congestion costs and are contained to the peak periods (Table 7-9). When travelling outside of the AM and PM peaks, passengers are generally able to travel in a seat.

During the peak periods, crowding costs increase considerably for both rail and bus users between 2016 and 2031. This is the result of increases in passenger kilometres outpacing the increase in in-service kilometres. While rail users incur the highest costs in 2016, by 2031 the cost of crowding for bus users increases dramatically. Buses are typically the main public transport option in growth areas and, as they offer much lower capacity services, can accommodate far fewer passengers before becoming crowded. Annually, the estimated cost of crowding in Perth GCCSA is $17.4 million in 2016, growing to $159 million in 2031.

Table 7-9 – Perth GCCSA average weekday cost of public transport crowding

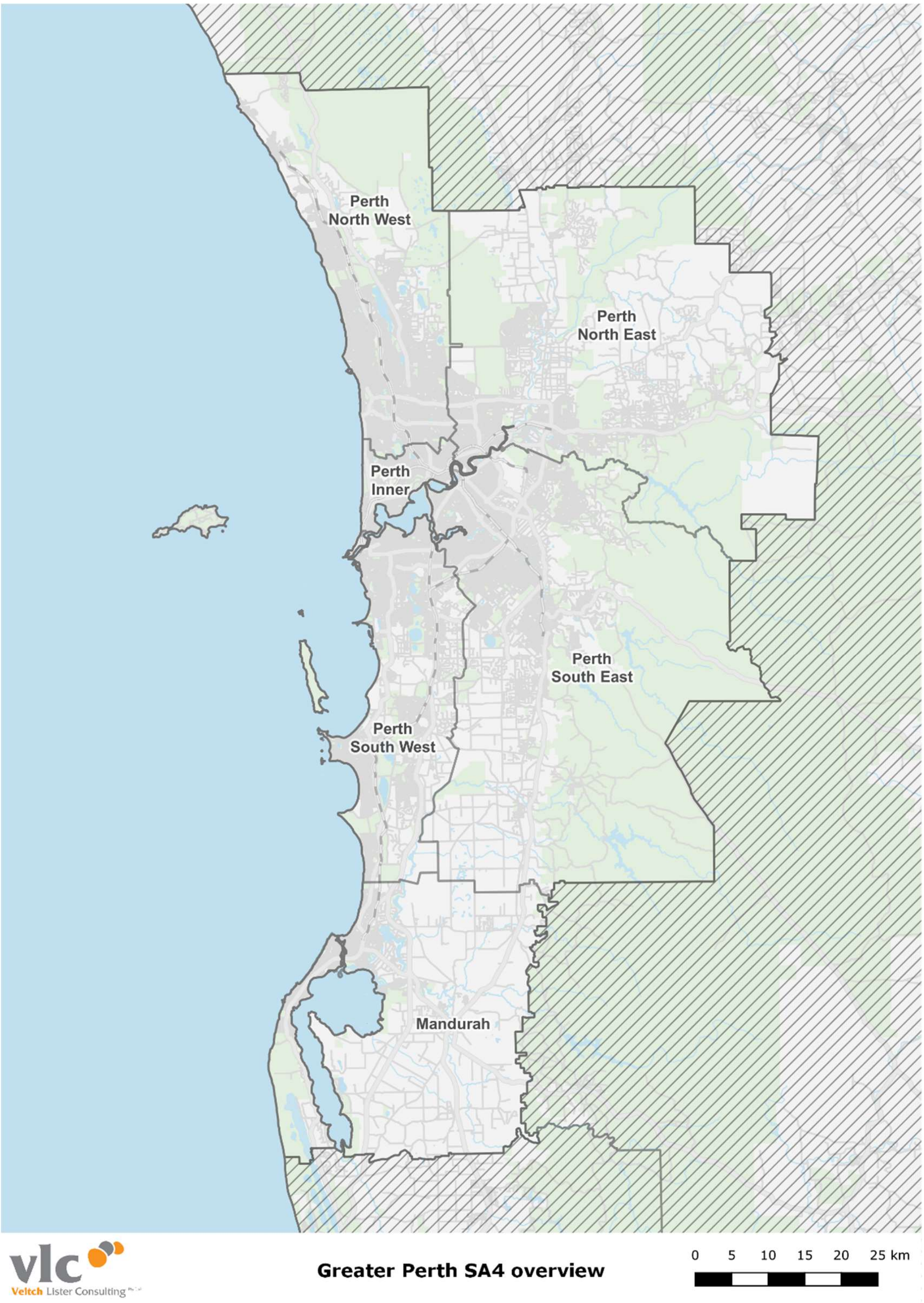
Mode	Time period	2016	2031	Change	% change
Rail	AM peak (7-9AM)	$31,000	$178,000	+$147,000	+474%
	PM peak (4-6PM)	$23,000	$85,000	+$62,000	+270%
Bus	AM peak (7-9AM)	$5,000	$140,000	+$135,000	+2,700%
	PM peak (4-6PM)	$2,000	$153,000	+$151,000	+7,550%

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.

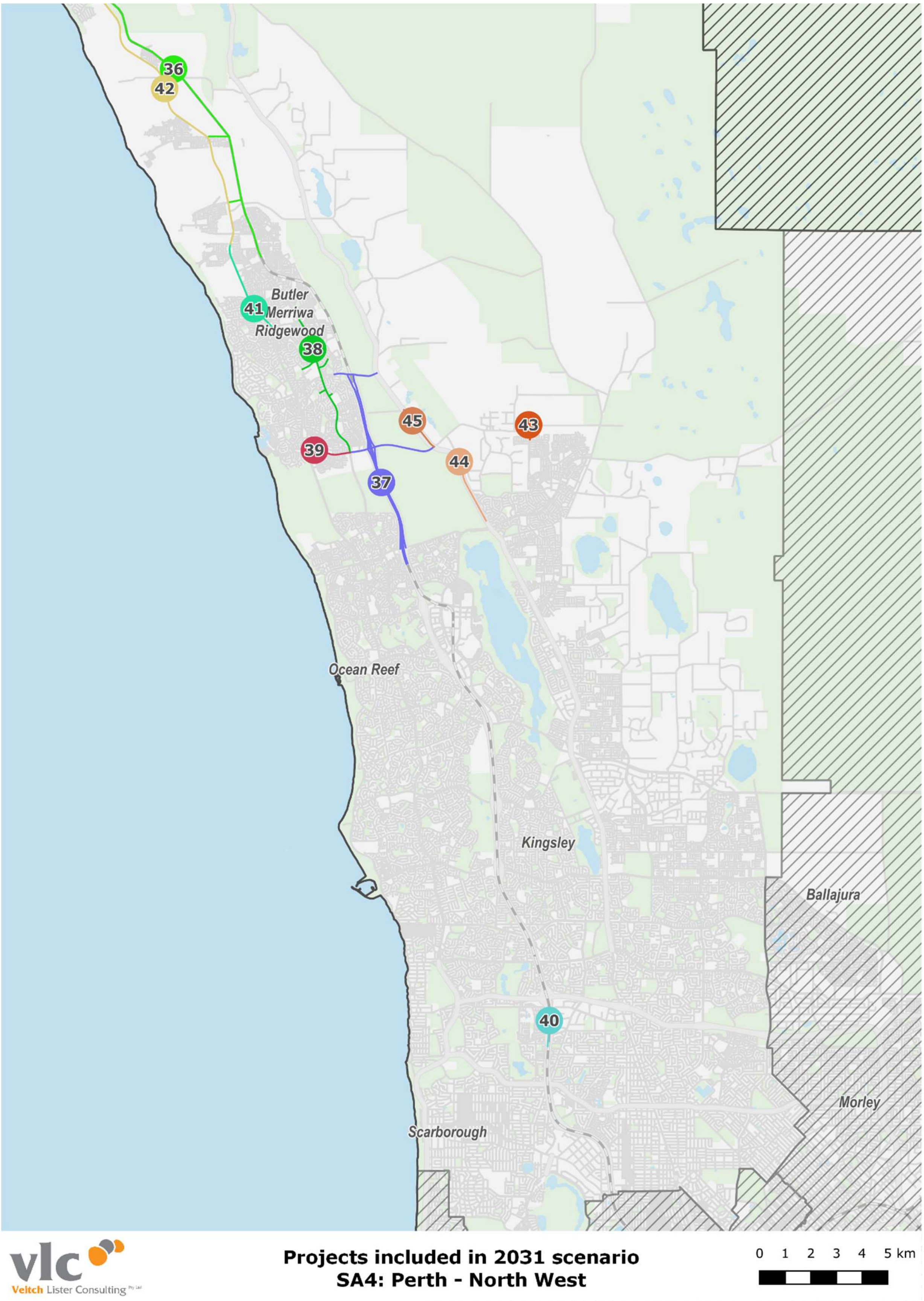
Appendix A: Projects included in modelling

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.

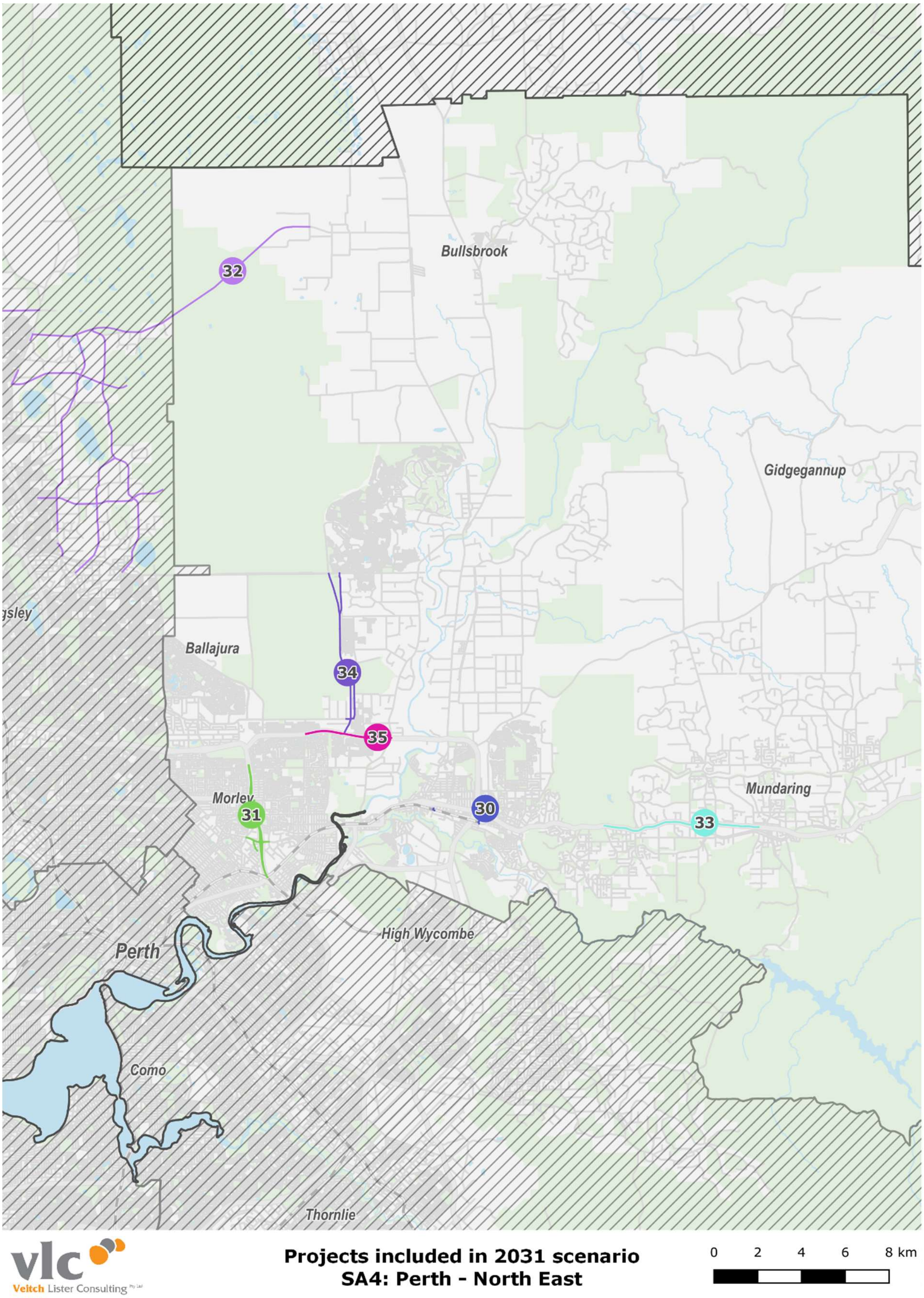
Appendix Figure A-1 – Greater Perth SA4 overview



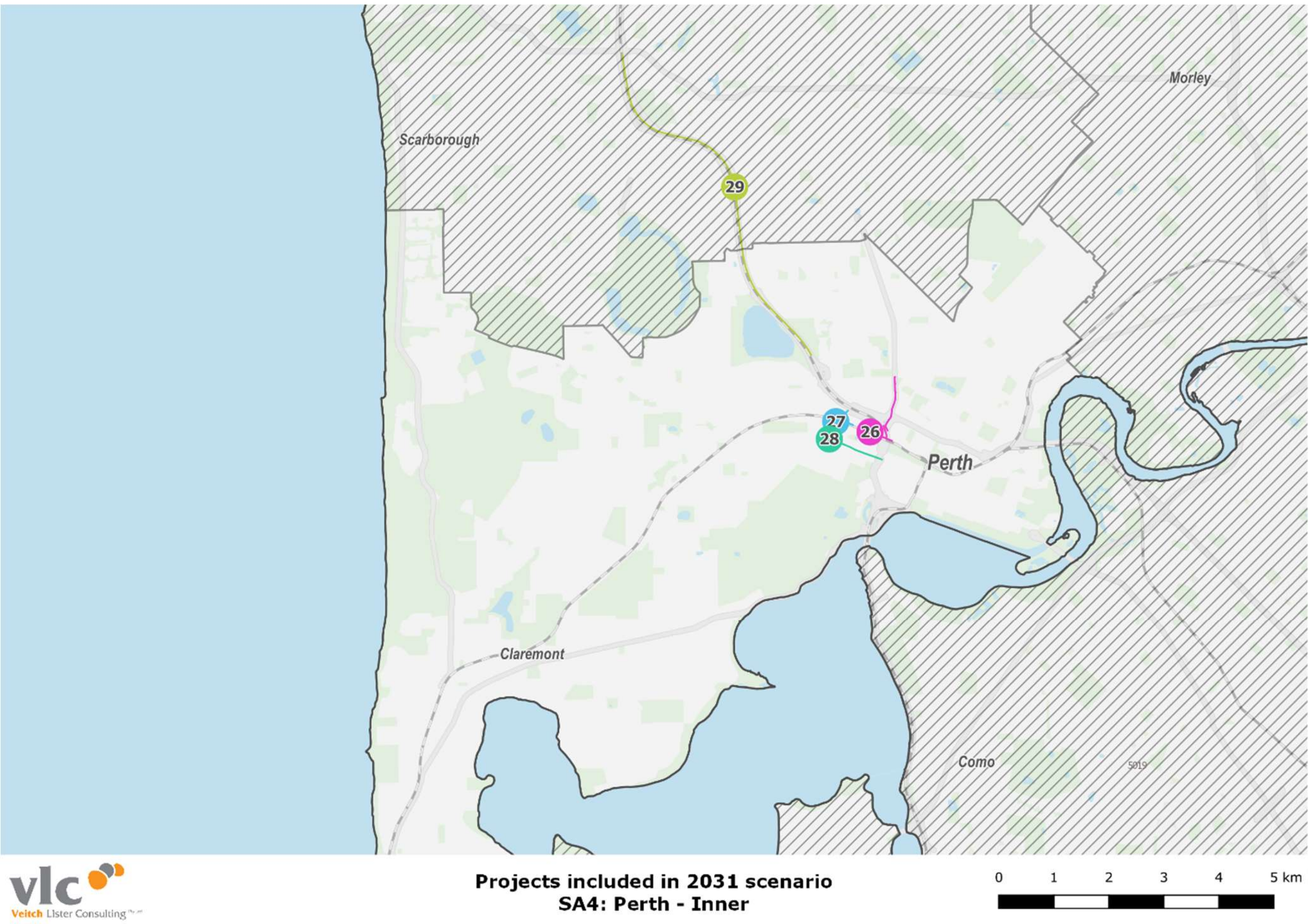
Appendix Figure A-2 – Projects included in the 2031 forecast SA4: Perth – North West



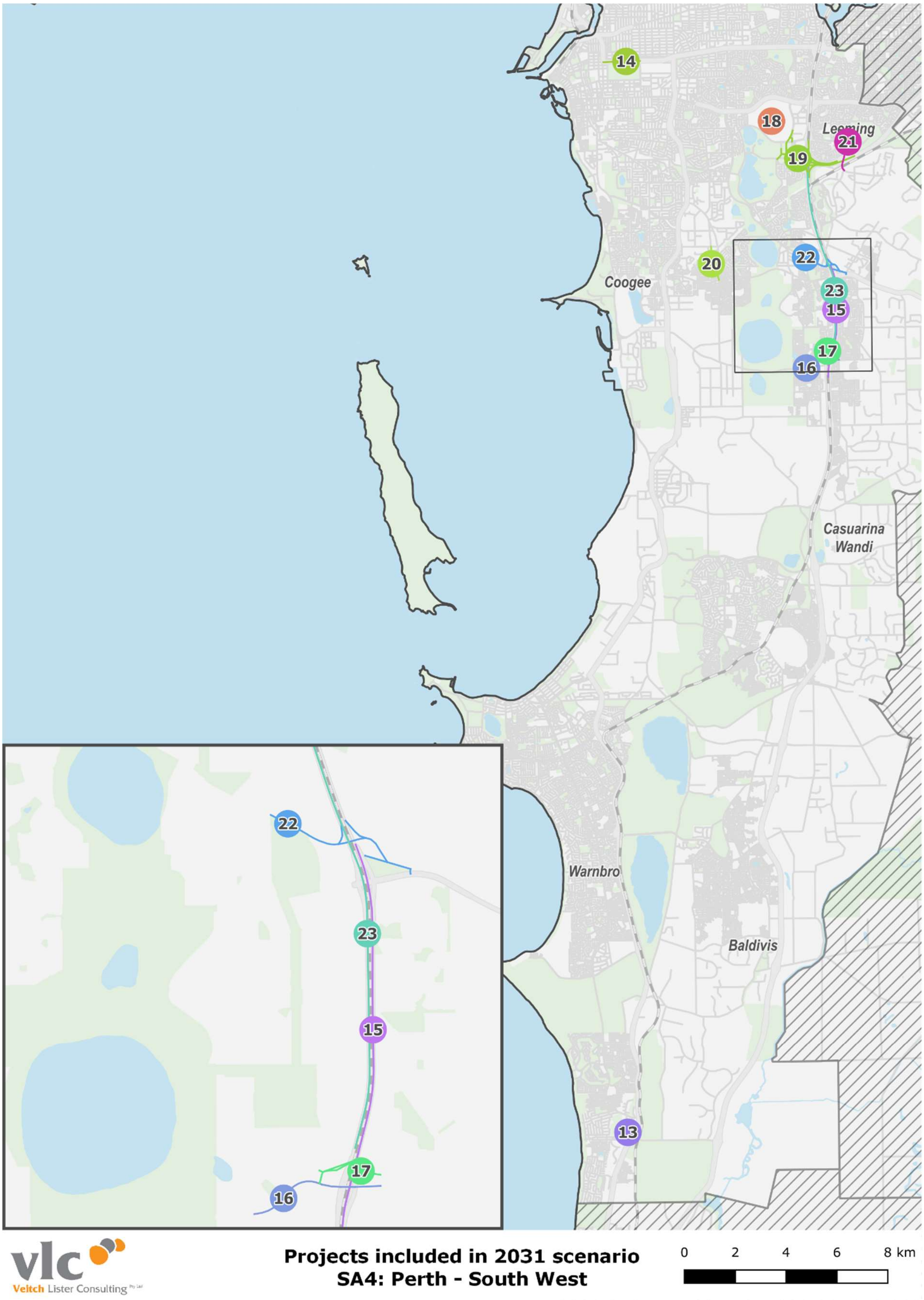
Appendix Figure A-3 – Projects included in the 2031 forecast SA4: Perth – North East



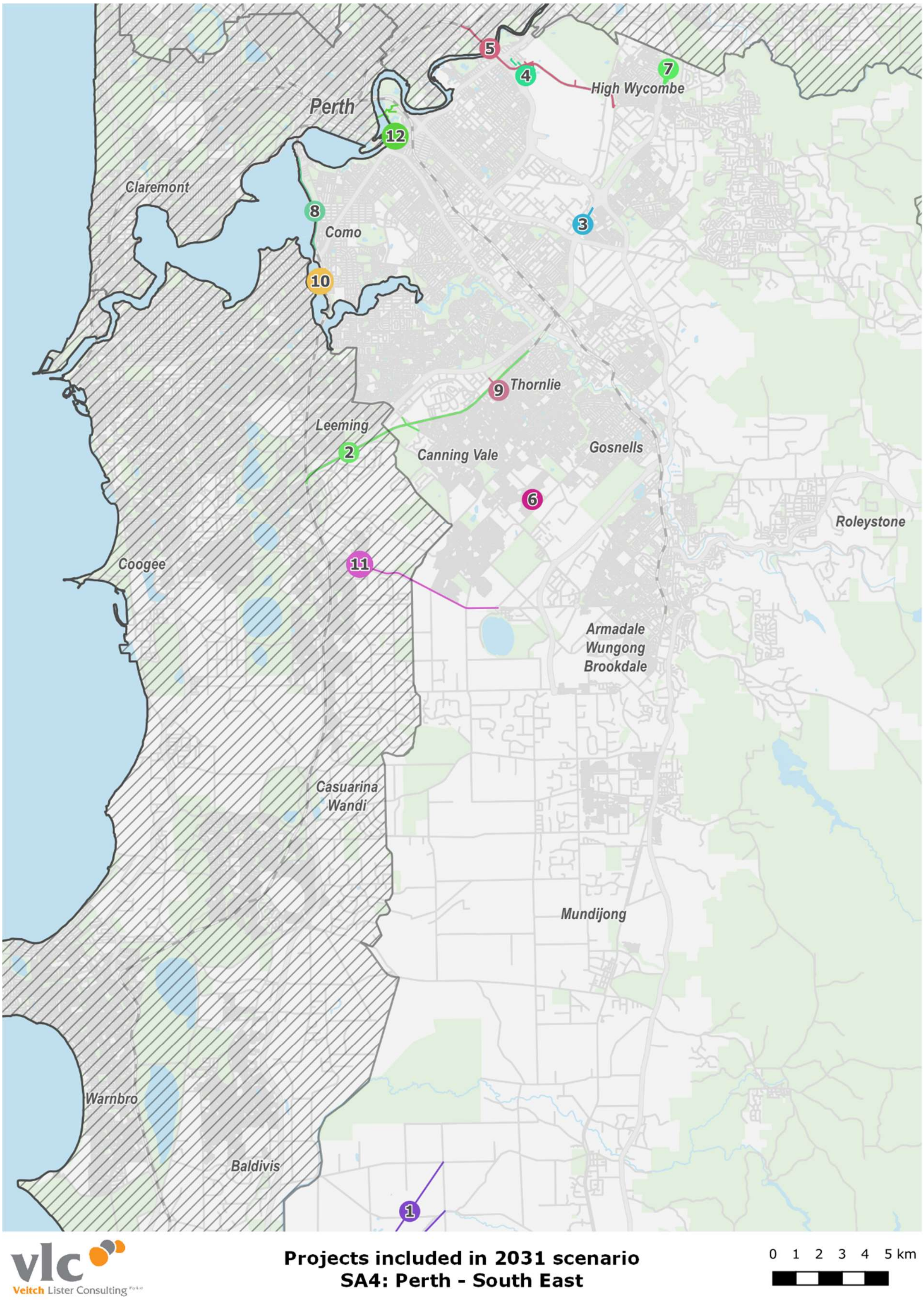
Appendix Figure A-4 – Projects included in the 2031 forecast SA4: Perth – Inner



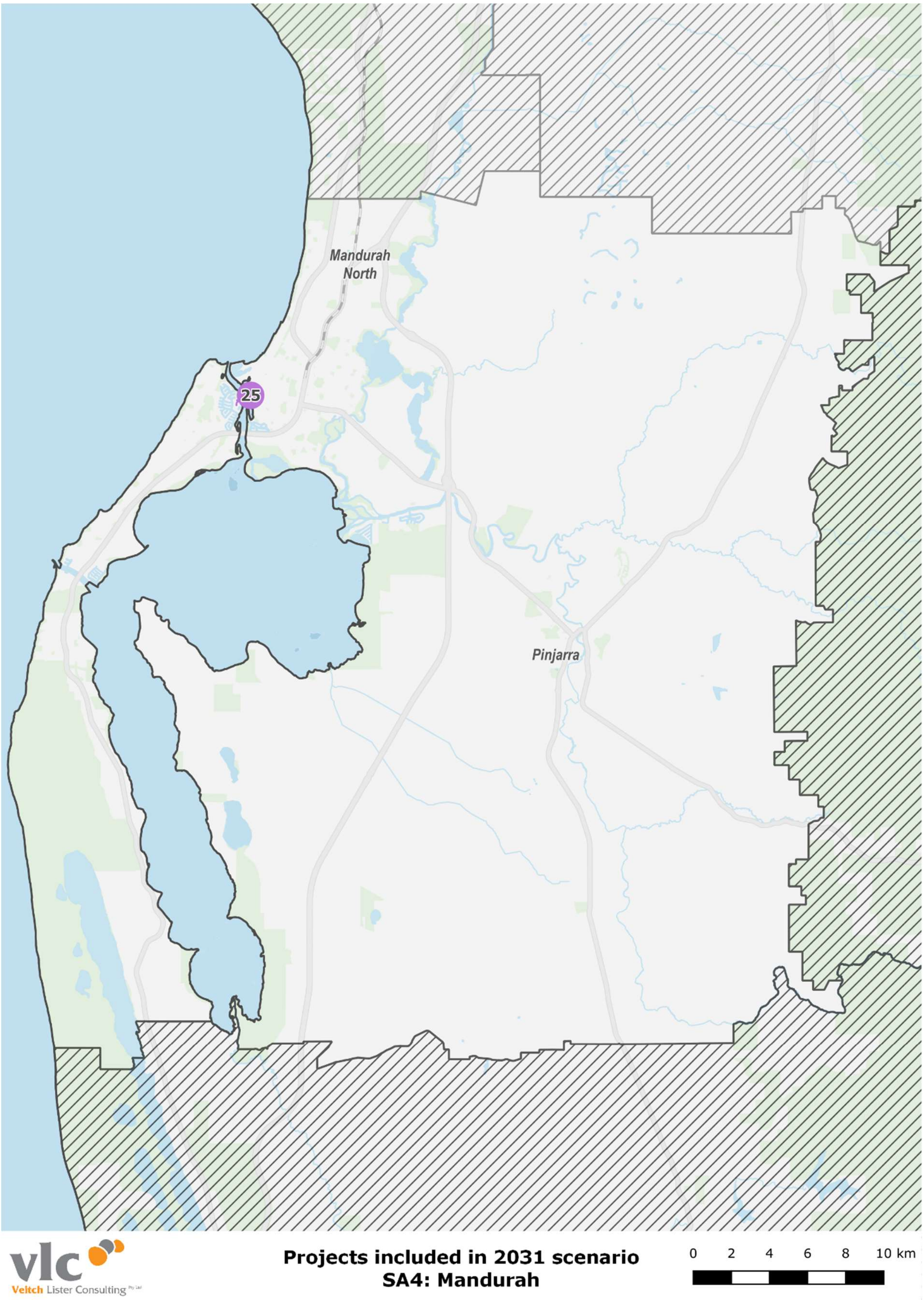
Appendix Figure A-5 – Projects included in the 2031 forecast SA4: Perth – South West



Appendix Figure A-6 – Projects included in the 2031 forecast SA4: Perth – South East



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



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

Project no.	Name
1	Addition of local roads in Keralup for future PT infrastructure. *Since the modelling was undertaken, the significant Keralup urban development is now no longer proposed, and therefore some of these roads are no longer likely to be committed.*
2	Extension of the Thornlie line to link with the Mandurah line.
3	Roe Highway - Between Orrong Road and Tonkin Highway, upgrade to 6 Lanes.
4	Brearly Ave Closure and Central Ave construction - Between First Street and Dunreath Drive, new road of 2 Lanes.
5	Forrestfield Airport Link, new rail line including 3 new stations.
6	Various new local road infrastructure in South East Perth.
7	Roe Highway and Kalamunda Road Interchange upgrade - Between Roe Hwy and Kalamunda Rd.
8	Kwinana Smart Freeways - Between Roe Highway and Narrows Bridge.
9	Nicholson Road level crossing grade separation - Between Yale Rd and Bannister Rd.
10	Kwinana Freeway southbound on-ramp construction at Manning Road
11	Armadale Road Duplication to 4 lanes- Between Anstey Road and Tapper Road.
12	Perth Stadium to Swan River Pedestrian Bridge.
13	Karnup Station construction. *This is part of the WA Government's METRONET program, but did not meet the technical Base Case definition as of July – September 2018.*
14	Leach Highway (High Street) Fremantle Project.
15	Kwinana Freeway Southbound widening - Between Armadale Rd and Russell Rd. Expected upgrade in 2017. 3 Lanes.
16	Russel Road Upgrade - Between Lamar Court and Lyon Road.
17	New Station at Aubin Grove.
18	Construction of additional Murdoch Activity Centre Roads.
19	Murdoch Drive Connection to Kwinana Freeway and Roe Highway – Upgrade to 2 lanes between Murdock Dve and Roe Hwy.
20	Spearwood Avenue Duplication to 4 lanes - Between Beeliar Dr and Yangebup Rd.
21	Karel Avenue Upgrade to 4 lanes - Between Farrington Rd and Berrigan Dve.
22	Armadale Road to North Lake Road Bridge construction – 4 lanes between Soloman Rd and Midgegooroo Ave.
23	Kwinana Freeway Northbound Widening to 3 lanes - Between Russell Road and Roe Highway.
24	NorthLink WA (Central and Northern sections) - Construction of a dual carriageway highway between Ellenbrook and Muchea, new interchange at the Reid / Tonkin Hwy intersection.
25	Old Mandurah Bridge Replacement.
26	Charles Street Busway and Bridge construction.

Project no.	Name
27	Grade Separation at Railway Street/ Thomas Street.
28	Murray Street 2-way conversion stage 2.
29	Mitchell Freeway widening (Southbound) - Between Cedric St and Vincent St. Funded upgrade in 2019. 4 Lanes.
30	Midland Station Project. Funded upgrade / new route in 2031. *Midland Station relocation and an extension to Bellevue is part of the WA Government's METRONET program, but did not meet the technical Base Case definition as of July – September 2018.*
31	Northlink WA (Southern Section) - Between Guildford Rd and Benara Rd.
32	East Wanneroo local roads – construction of additional access roads.
33	Great Eastern Highway upgrade – upgrade to 4 lanes between Mann Street and Bilgoman Road.
34	New Lord St – new 4 lanes road between Gnangars Rd and Reid Hwy
35	Reid Highway dual carriageway – upgrade to 4 lanes total from Altone Road to West Swan Road.
36	Yanchep rail extension, including three new stations at Alkimos, Eglinton and Yanchep.
37	Mitchell Freeway Extension from Burns Beach Road too Hester Avenue.
38	Connolly Drive upgrade to 4 lanes - Between Neerabup Rd and Lukin Drive.
39	Neerabup Rd upgrade to 4 lanes - Between Marmion Ave and Connolley Dr.
40	Mitchell Freeway Northbound - Between Erindale Raod and Reid Highway. Expected upgrade in 2017. 4 Lanes.
41	Marmion Avenue upgrade to 4 lanes - Between Lukin Drive and Camborne Parkway.
42	Marmion Avenue upgrade to 4 lanes - Between Camborne Parkway and Yanchep Beach Rd.
43	Various new local roads in Perth's north west.
44	Wanneroo Road and Joondalup Drive intersection upgrade - Between Joondalup Dr and Flynn Dr.
45	Wanneroo Road Upgrade - Between Flynn Drive and Hall Road.

Appendix B: Public Transport Network Assumptions

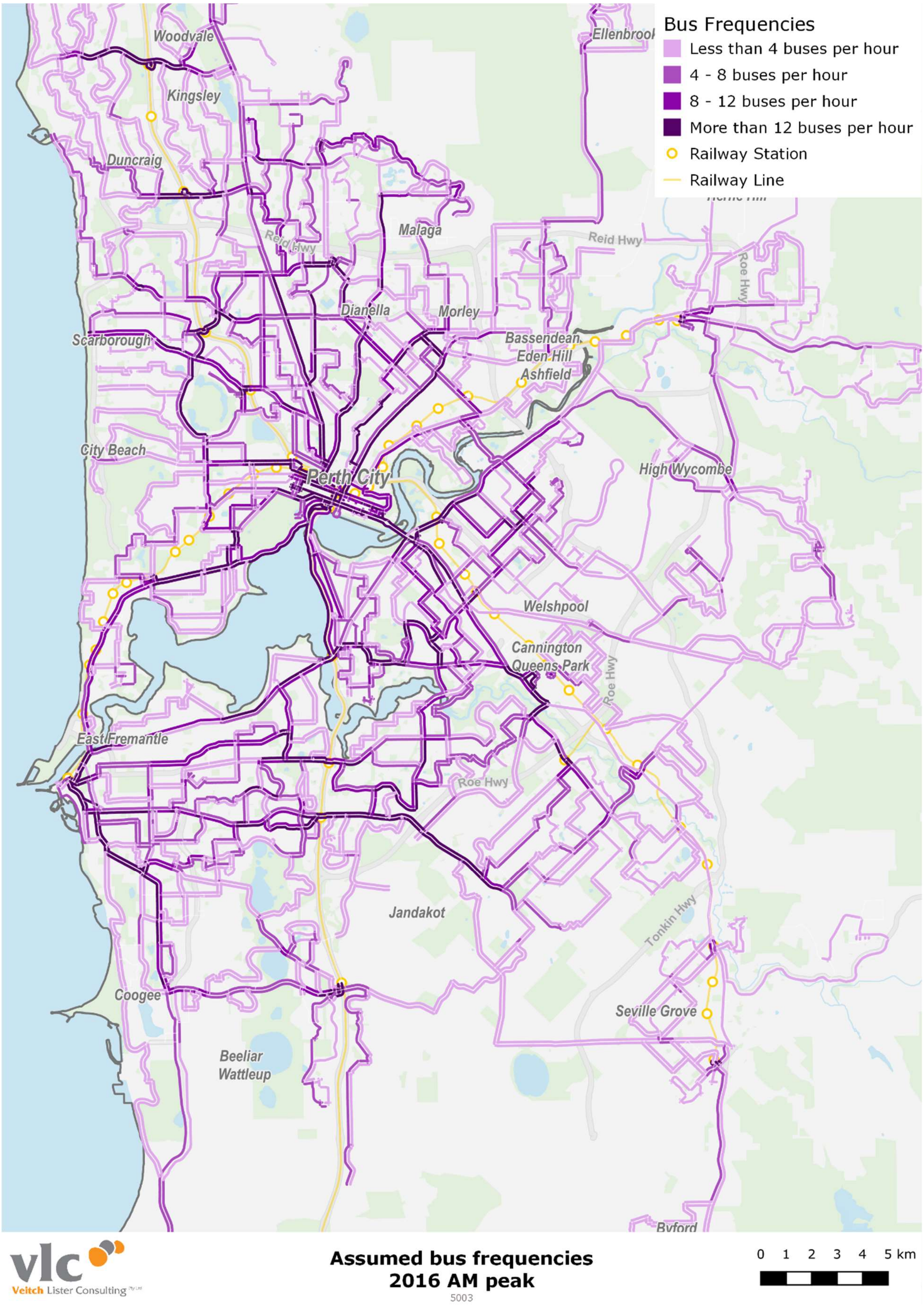
This section provides a high level overview of the public transport networks used in the modelling.

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

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

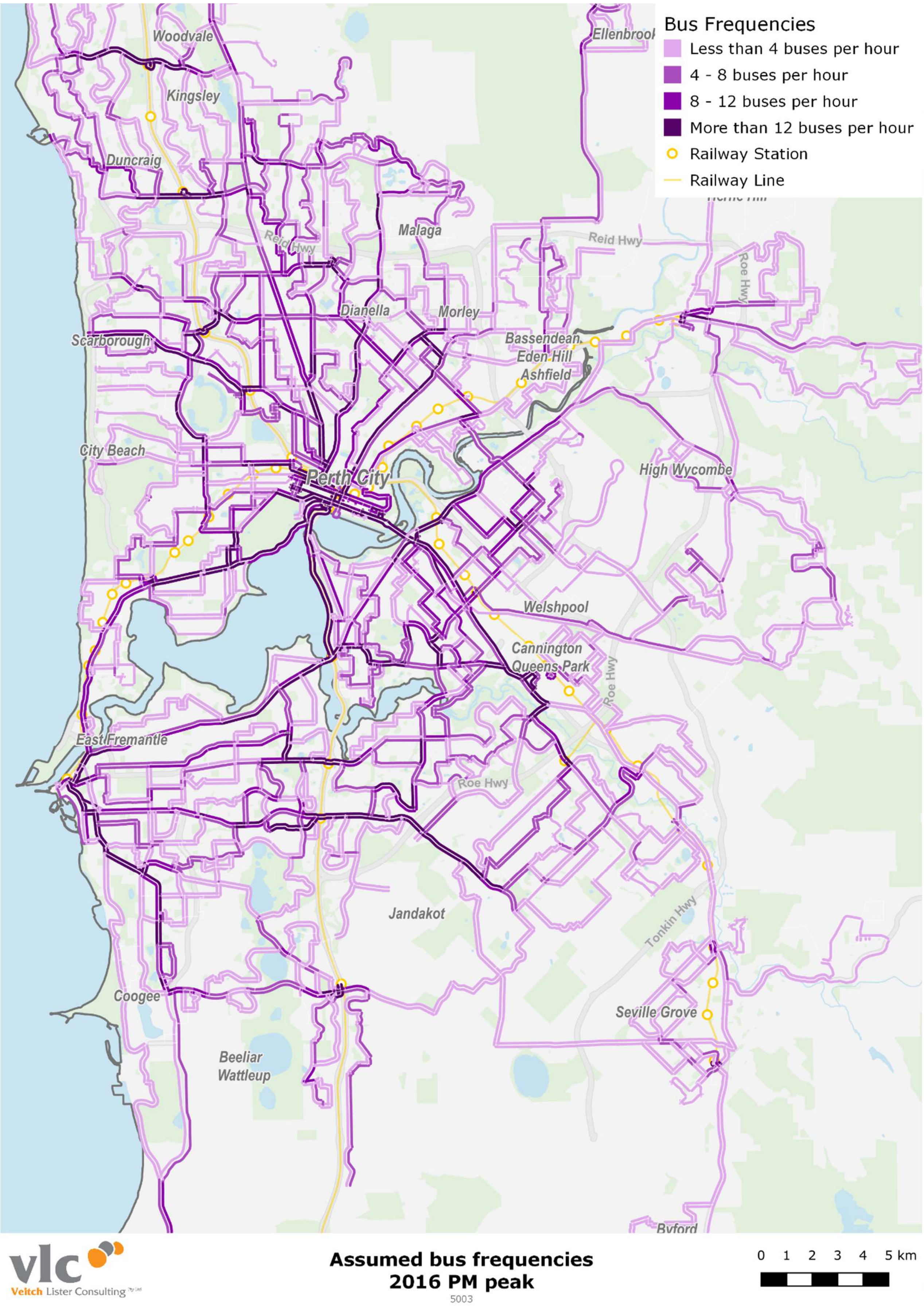
The 2016 routes and frequencies used in modelling were obtained from Transperth. Details of how the 2031 network were developed can be found in Appendix D: Model Assumptions.

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



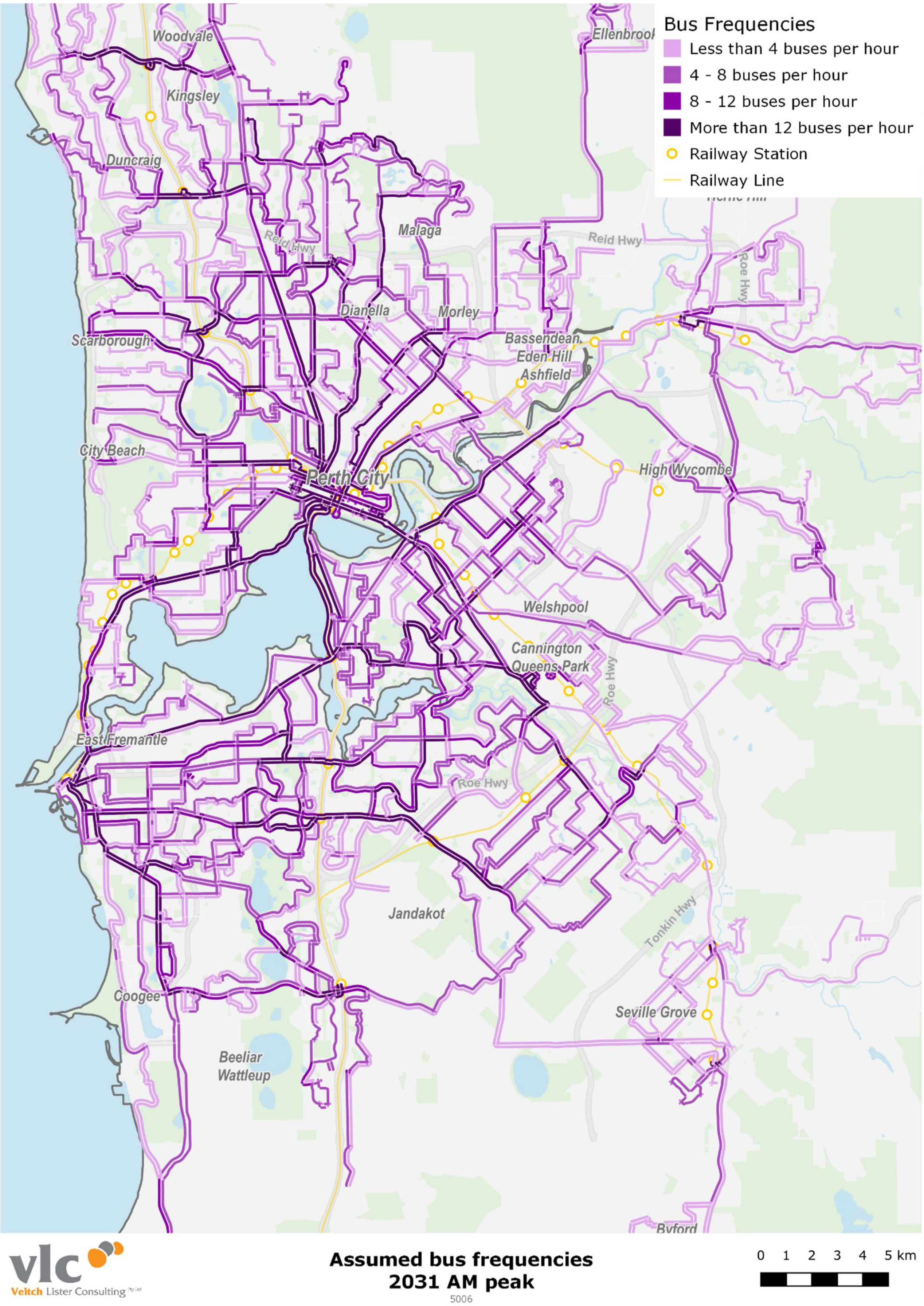
Source: Transperth

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

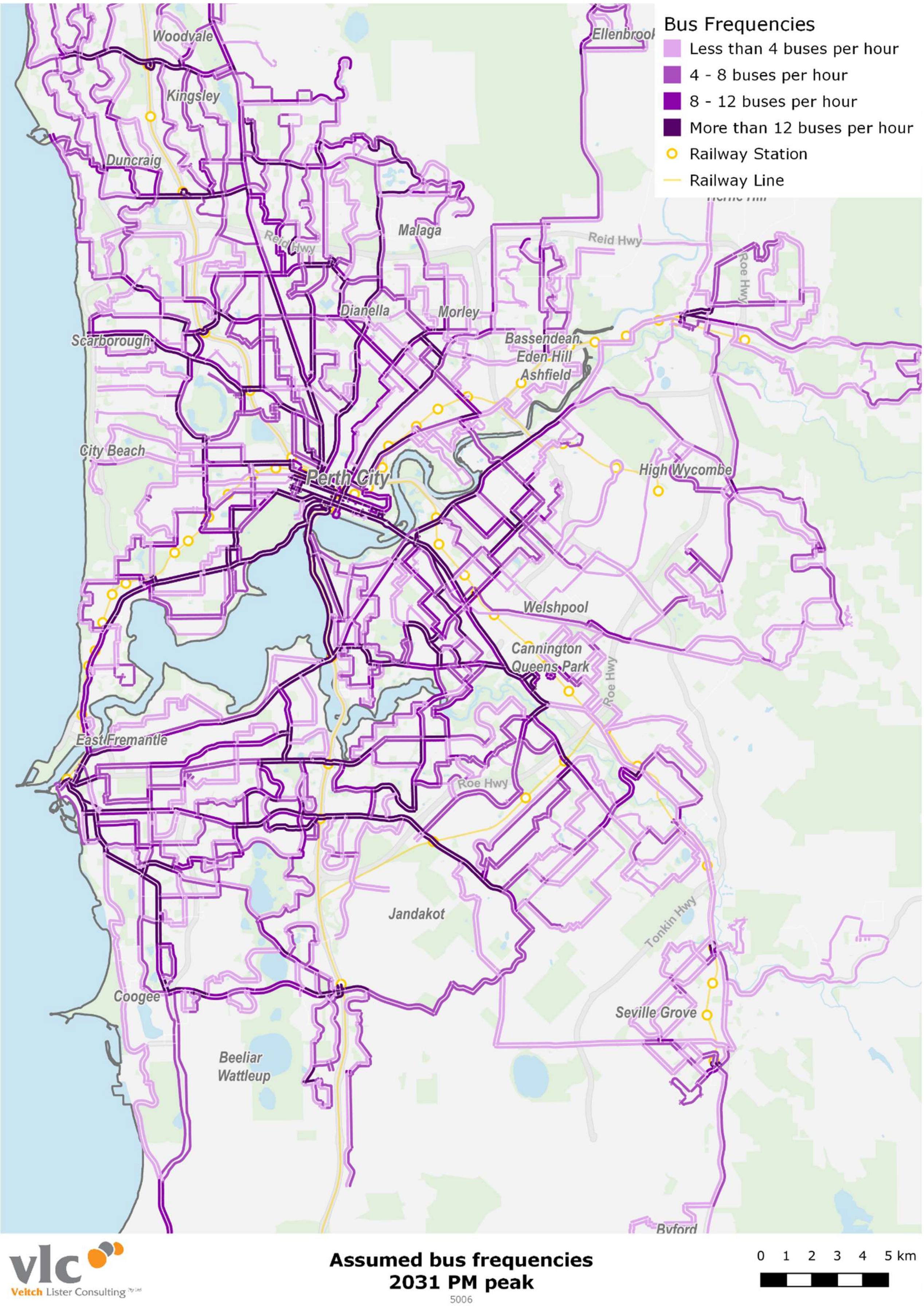


Source: Transperth

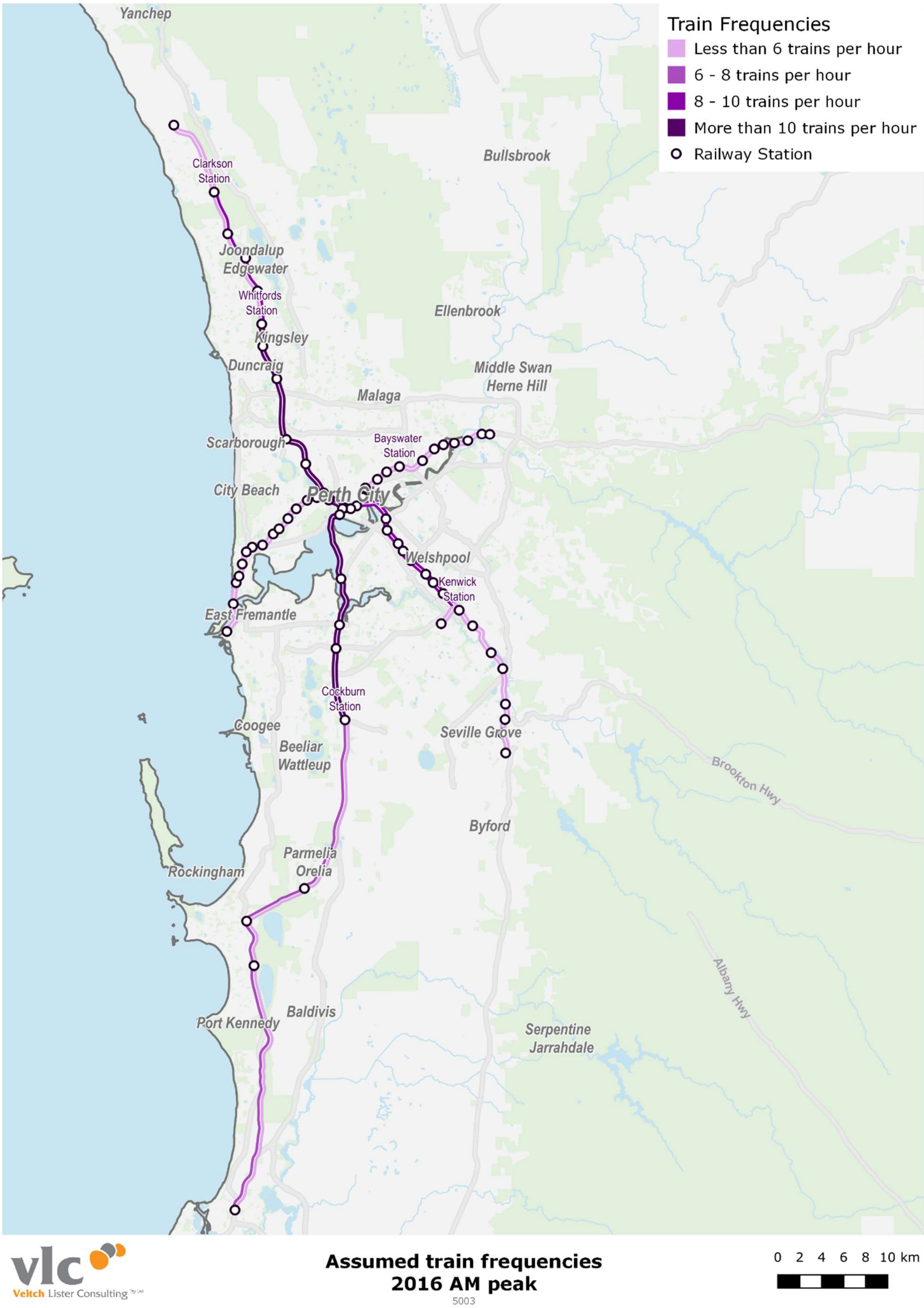
Appendix Figure B-3 – Assumed bus frequencies - 2031 AM peak (7-9AM)



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

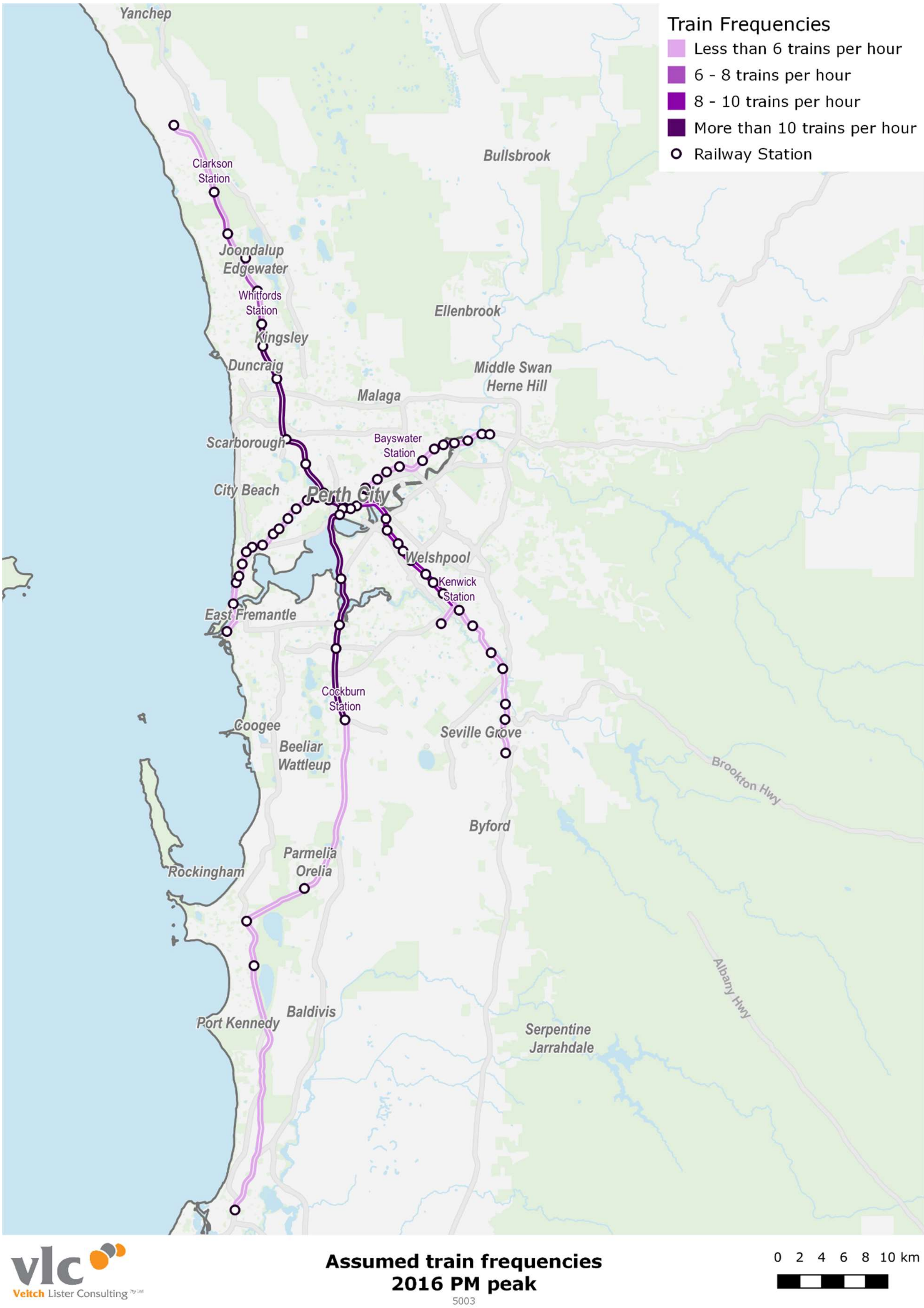


Appendix Figure B-5 – Assumed train frequencies - 2016 AM peak (7-9AM)



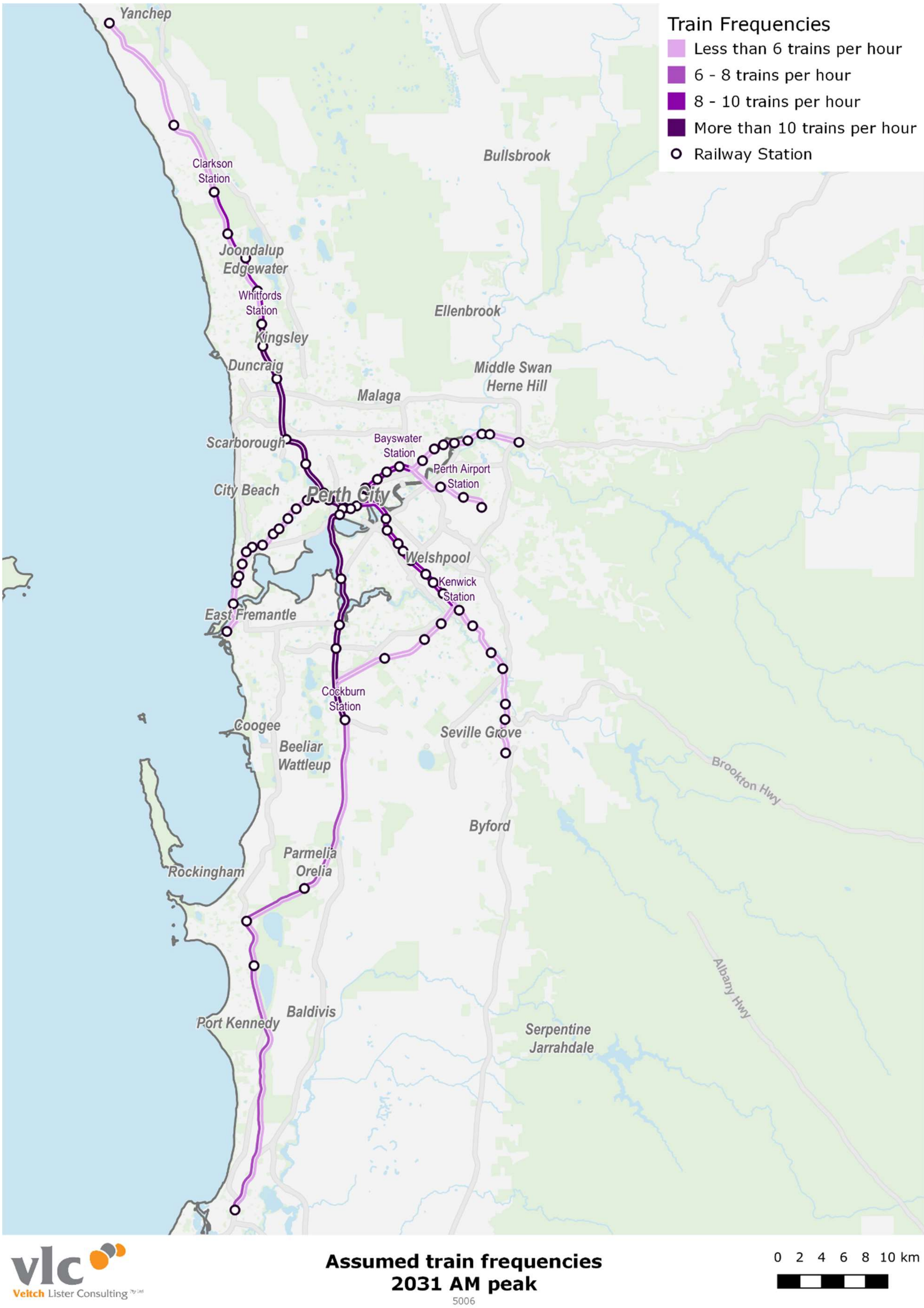
Source: Transperth

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

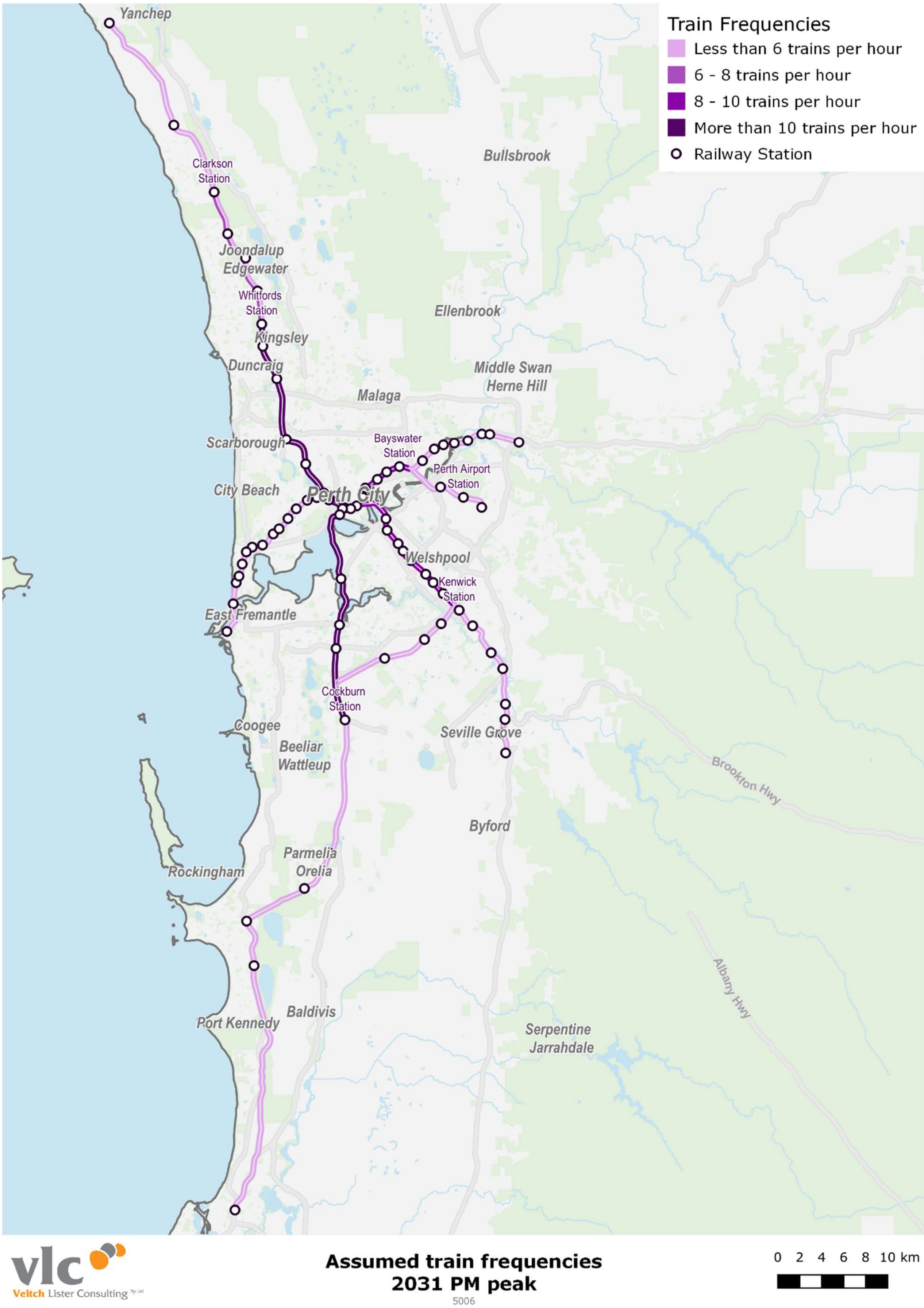


Source: Transperth

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 C: Perth Road Corridors

Appendix Table C-1 – Perth road corridors

Number	Corridor name
1	Albany Hwy Corridor
2	South Western Hwy Corridor
3	Brookton Hwy Corridor
4	Tonkin Hwy Corridor
5	Nicholson Rd Corridor
6	Kwinana Fwy Corridor
6	Old Coast/Mandurah/Stock/Stirling Hwy Corridor
6	Cockburn Rd/Hampton Rd Corridor
7	Pinjarra Rd Corridor
8	Lakes Rd/Gordon Rd Corridor
9	Karnup Rd/Stakehill Rd Corridor
10	Mundijong Rd Corridor
11	Thomas Rd Corridor
11	Wattleup Rd/Rowley Rd Corridor
11	Anketell Rd Corridor
12	Beeliar Dr/Armadale Rd Corridor
13	North Lake Rd Corridor
14	South St/Ranford Rd Corridor
15	Roe Hwy Corridor
16	Leach Hwy Corridor
17	Canning Hwy/Great Eastern Hwy (west) Corridor
18	Graham Farmer Fwy/Orrong Rd/Welshpool Rd East Corridor
19	Marmion Ave/West Coast Hwy Corridor
20	Wanneroo Rd Corridor
21	Mitchell Fwy Corridor
22	Great Northern Hwy Corridor
23	Alexander Dr Corridor
23	Mirrabooka Ave Corridor
24	Toodyay Rd Corridor
25	Great Eastern Hwy (east)/Guildford Rd Corridor
26	Gnangara Rd/Whitfords Ave Corridor
26	Ocean Reef Rd Corridor
27	Hepburn Ave Corridor
27	Beach Rd Corridor
27	Marangaroo Dr/Warwick Rd Corridor
28	Reid Hwy Corridor
29	Morley Dr/Karrinyup Rd Corrridor
30	Scarborough Beach Rd 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.

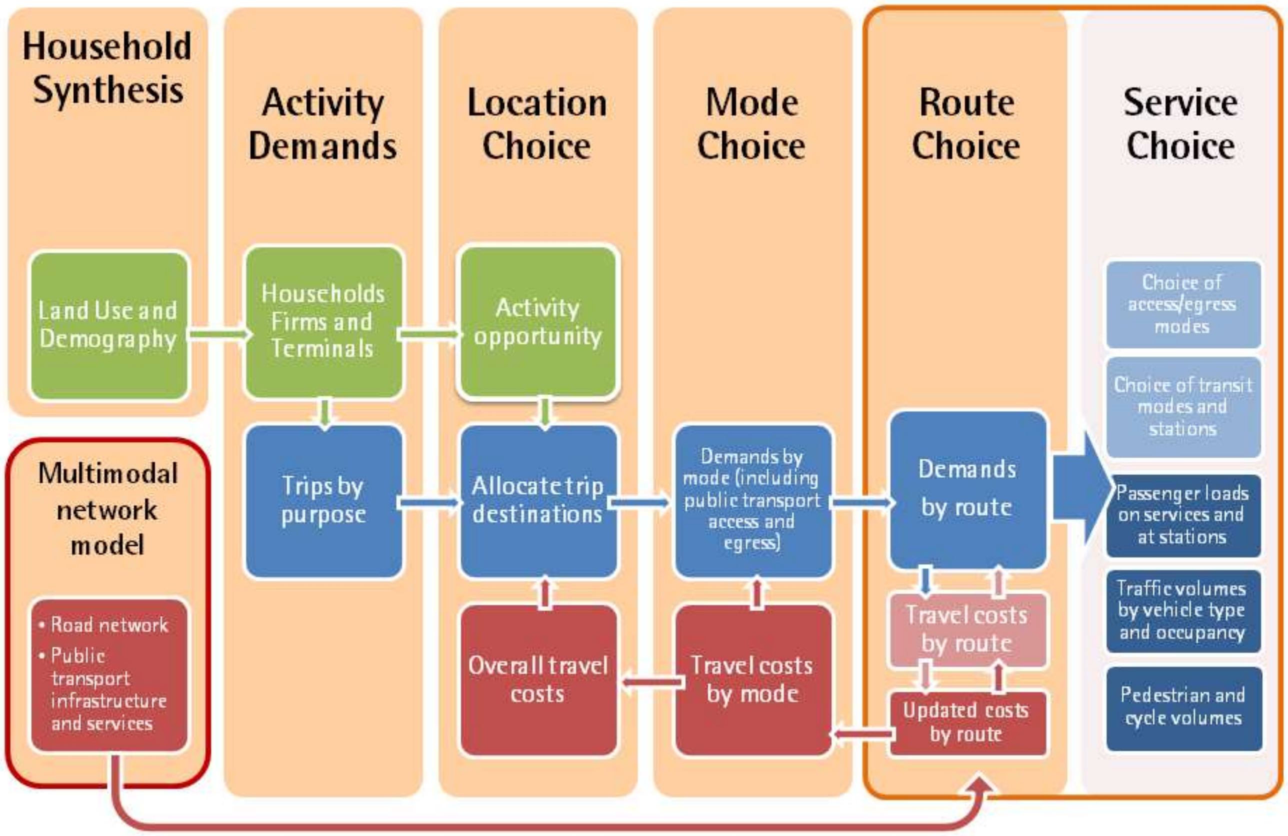
D.2.2 Model Architecture

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.

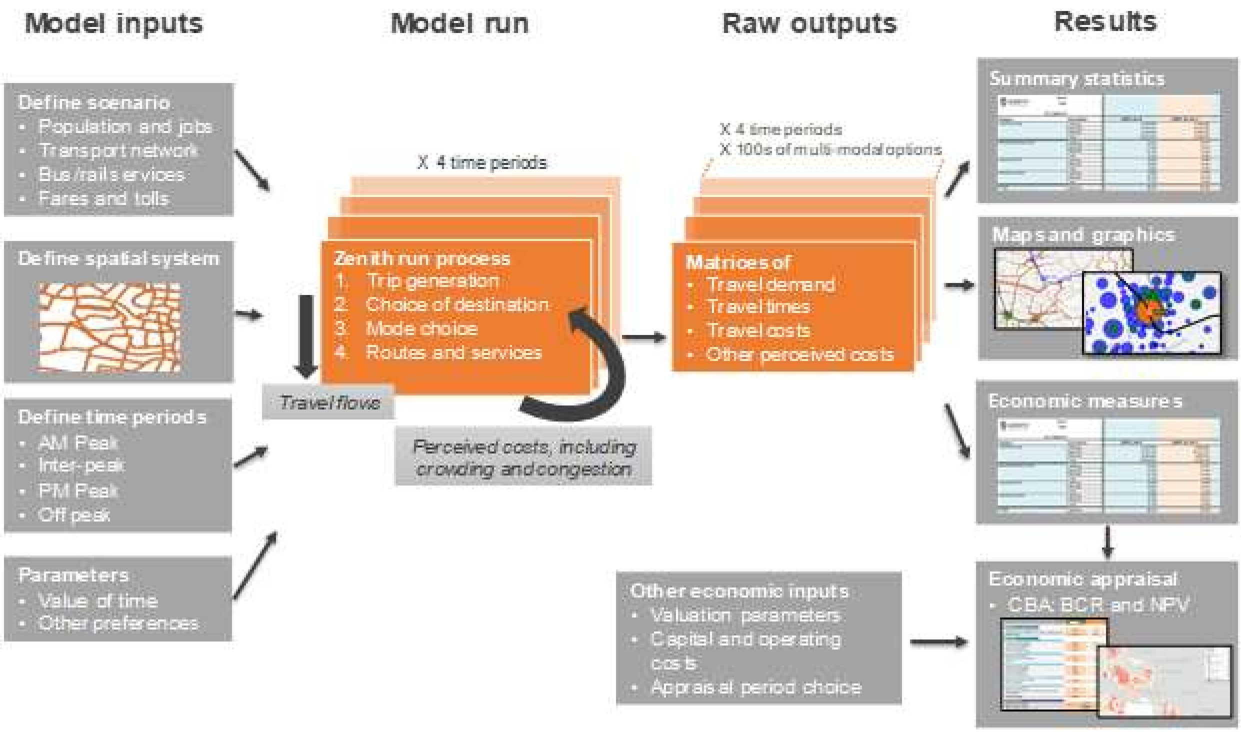
Having determined the destination and mode of travel, the model then reflects the choice of route for trips by private or commercial vehicle, public transport and active travel modes such as cycling and walking.

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:

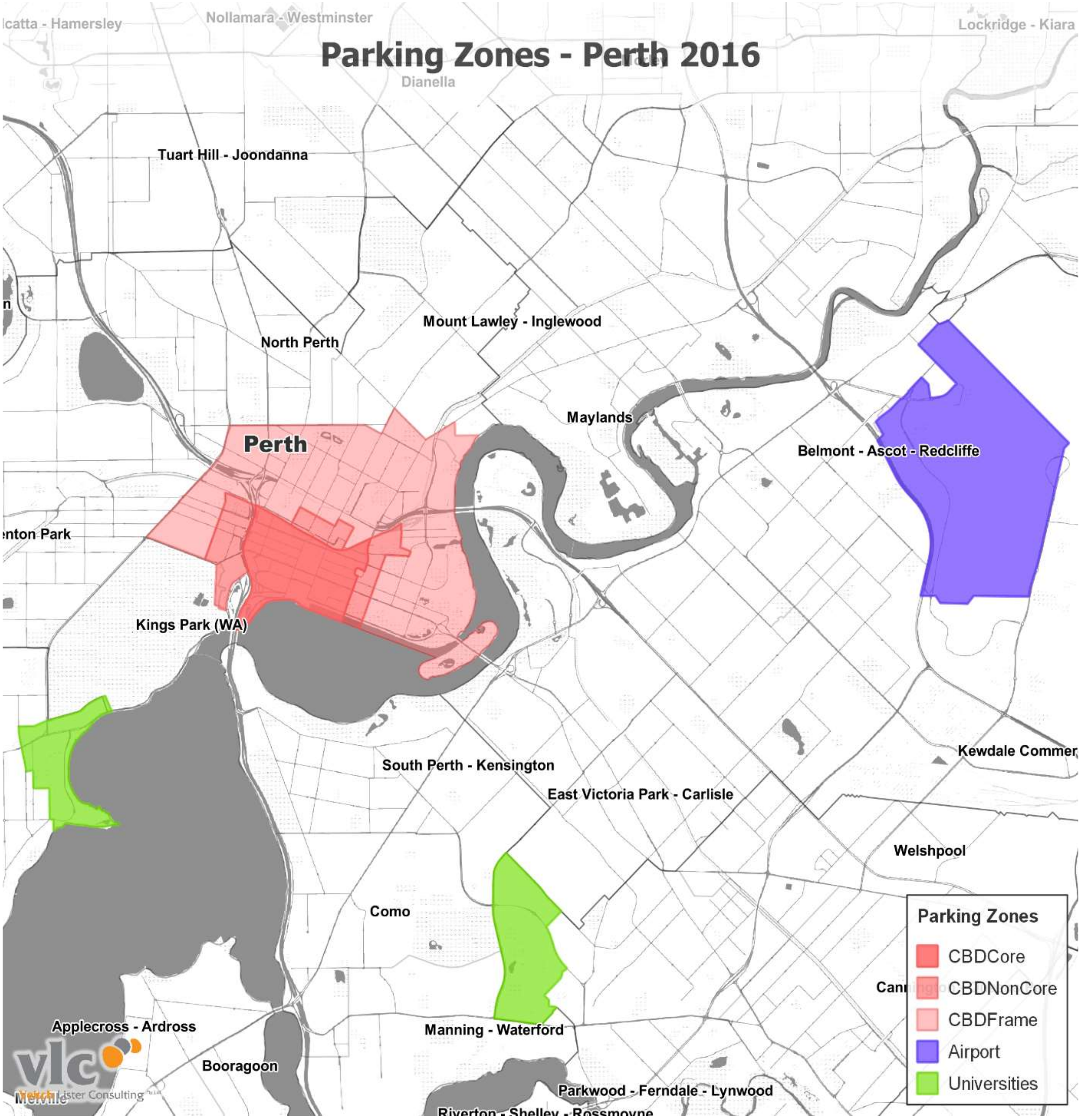
- real increases in the price of transport fuels; and
- reduction in the rate of fuel consumption due to improved vehicle efficiency and increased use of more efficient fuels within the vehicle fleet.

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 – Perth parking zones



Tolls

Perth 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. The fare zones are illustrated in Appendix Figure D-4.

Appendix Table D-1 – Public transport costs and fares

Public Transport Cost Parameters	Year	Zenith
Public Transport VOT, 2016 (AUD 2011)		$12 / hour
Public Transport Fares (AUD 2011) Same values apply both directions. Free bus only applies to buses in the CBD, rail stations in this area will have applied zone 1 values. From transperth website	2016 and 2018	

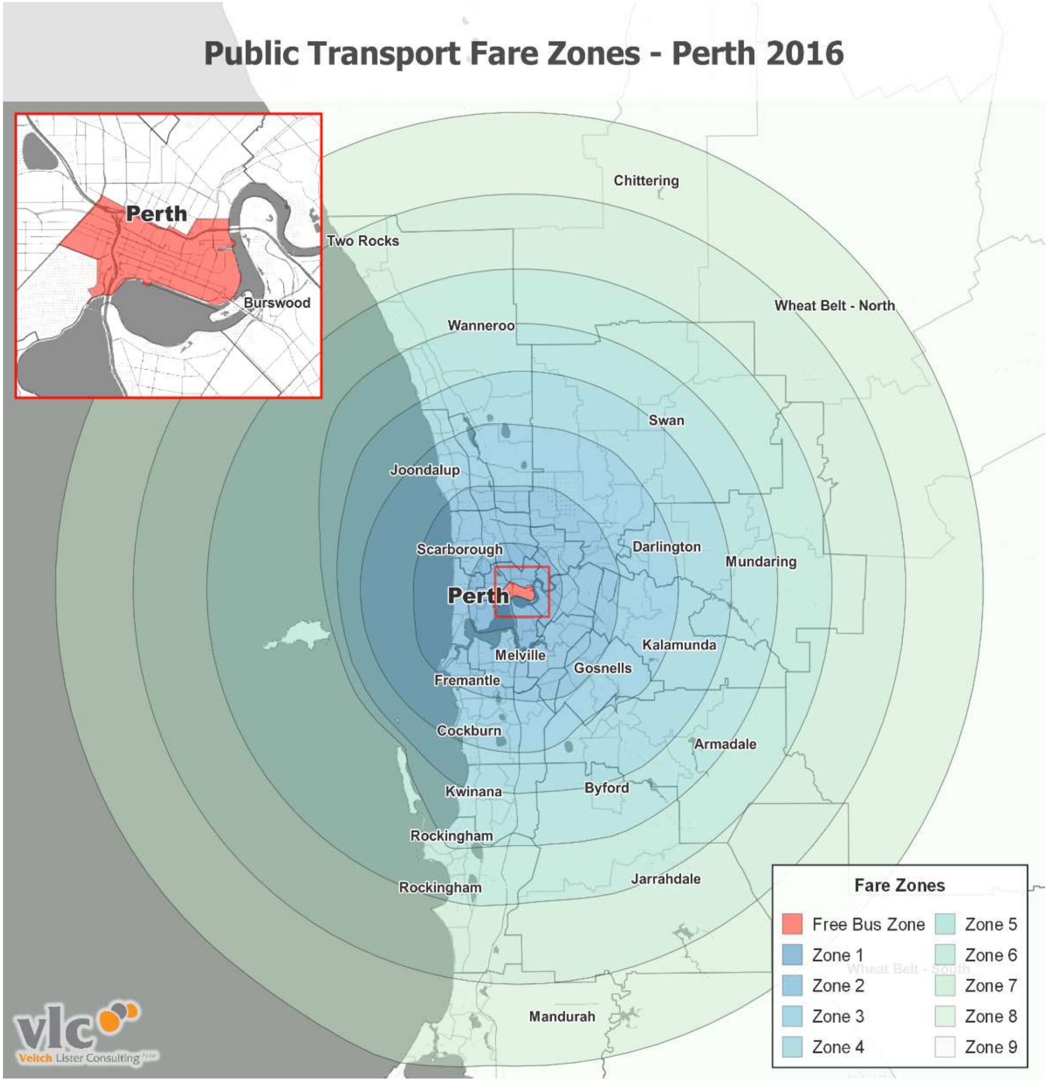
	Free Bus	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Free Bus	0.00	1.88	2.82	3.31	3.98	4.95	5.58	6.57	7.06	7.56
Zone 1		1.88	2.82	3.31	3.98	4.95	5.58	6.57	7.06	7.56
Zone 2			1.88	2.82	3.31	3.98	4.95	5.58	6.57	7.06
Zone 3				1.88	2.82	3.31	3.98	4.95	5.58	6.57
Zone 4					1.88	2.82	3.31	3.98	4.95	5.58
Zone 5						1.88	2.82	3.31	3.98	4.95
Zone 6							1.88	2.82	3.31	3.98
Zone 7								1.88	2.82	3.31
Zone 8									1.88	2.82
Zone 9										1.88

2018 in 2011 Dollars - Taking into account % SmartRider Ticketing

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
Zone 1	0.00	1.91	2.95	3.46	4.12	5.16	5.80	6.84	7.32	7.88
Zone 2		1.91	2.95	3.46	4.12	5.16	5.80	6.84	7.32	7.88
Zone 3			1.91	2.95	3.46	4.12	5.16	5.80	6.84	7.32
Zone 4				1.91	2.95	3.46	4.12	5.16	5.80	6.84
Zone 5					1.91	2.95	3.46	4.12	5.16	5.80
Zone 6						1.91	2.95	3.46	4.12	5.16
Zone 7							1.91	2.95	3.46	4.12
Zone 8								1.91	2.95	3.46
Zone 9									1.91	2.95
Zone 10										1.91

Fare growth	Beyond 2018	cpi

Appendix Figure D-4 – Public transport fare zones



D.3.2 Technology uptake

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

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

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

D.3.3 Value of travel time

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

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

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

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

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

D.3.4 Public transport frequencies

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

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

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

D.3.5 Commercial vehicle definitions

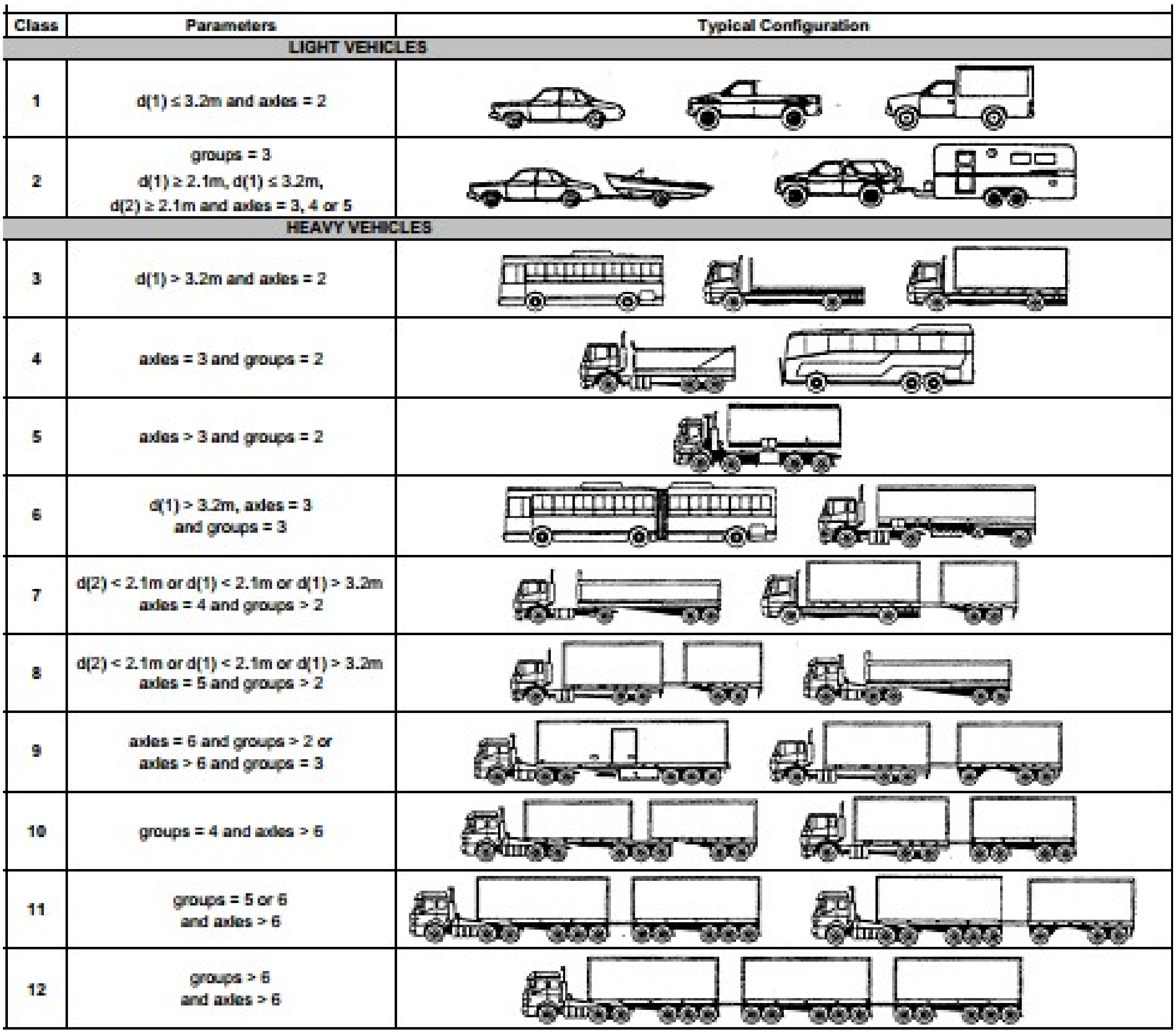
In the Zenith model private vehicle traffic is split into cars and commercial vehicles. Commercial vehicles are further split into sub-categories of light commercial vehicles and heavy commercial vehicles.

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

Appendix Figure D-5 – 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).[7]

Method to quantify

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

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

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

D.4.2 Cost of public transport crowding

Modelling approach to estimate impacts

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

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

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

Measures of service capacity

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

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

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

Appendix Table D-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

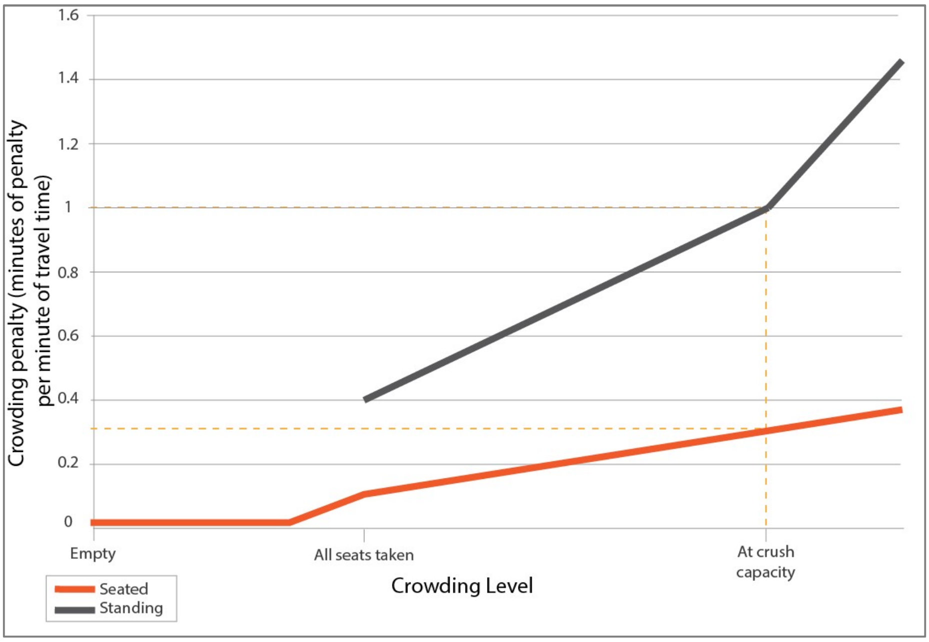
Vehicle	Seated Capacity	Crush capacity
Bus	45	65
Train	200	800

Crowding cost function

The crowding cost function is an estimate of the level of discomfort experienced by passengers at different levels of crowding, depending on whether passengers are seated or standing. The function is based on parameters provided in Australian Transport Council (ATC) guidelines and is shown in Appendix Figure D-6.[8] 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.

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

Appendix Figure D-6 – Crowding cost function



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

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

Linking of outward and return journeys

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

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

Method to quantify

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

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

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

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

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

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

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

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

For national consistency we follow ATAP (2018) guidelines by applying an annualisation factor of 286 to scale up the weekday average estimates, reflecting the perspective that crowding is primarily a weekday phenomenon.[9] 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.

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

Appendix E: Differences between 2015 and current modelling

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

E.1 Changes to the models

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

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

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

E.2 Changes to model inputs and assumptions

E.2.1 Population and land use

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

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

	2014-15 Audit	2018-19 Audit	Difference
Perth GCCSA population	3.3 million	2.6 million	-19%

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

- The largest differences between Audits are apparent in the outer SA3s.
- In the south, Rockingham has 107,000 fewer residents in 2018-19 than in 2014-15, Mandurah has 87,800 fewer residents
- In the north, Wanneroo has 101,500 fewer residents in 2018-19 than in 2014-15, Swan has 75,900 fewer residents, Joondalup has 50,200 fewer residents.
- Perth City shows the next largest reduction (43,000 fewer residents).
- Middle ring SA3s show a lower magnitude of change. Stirling and Bayswater Bassendean are the only SA3s where more population is forecast in the 2018-19 Audit than in the 2014-15.

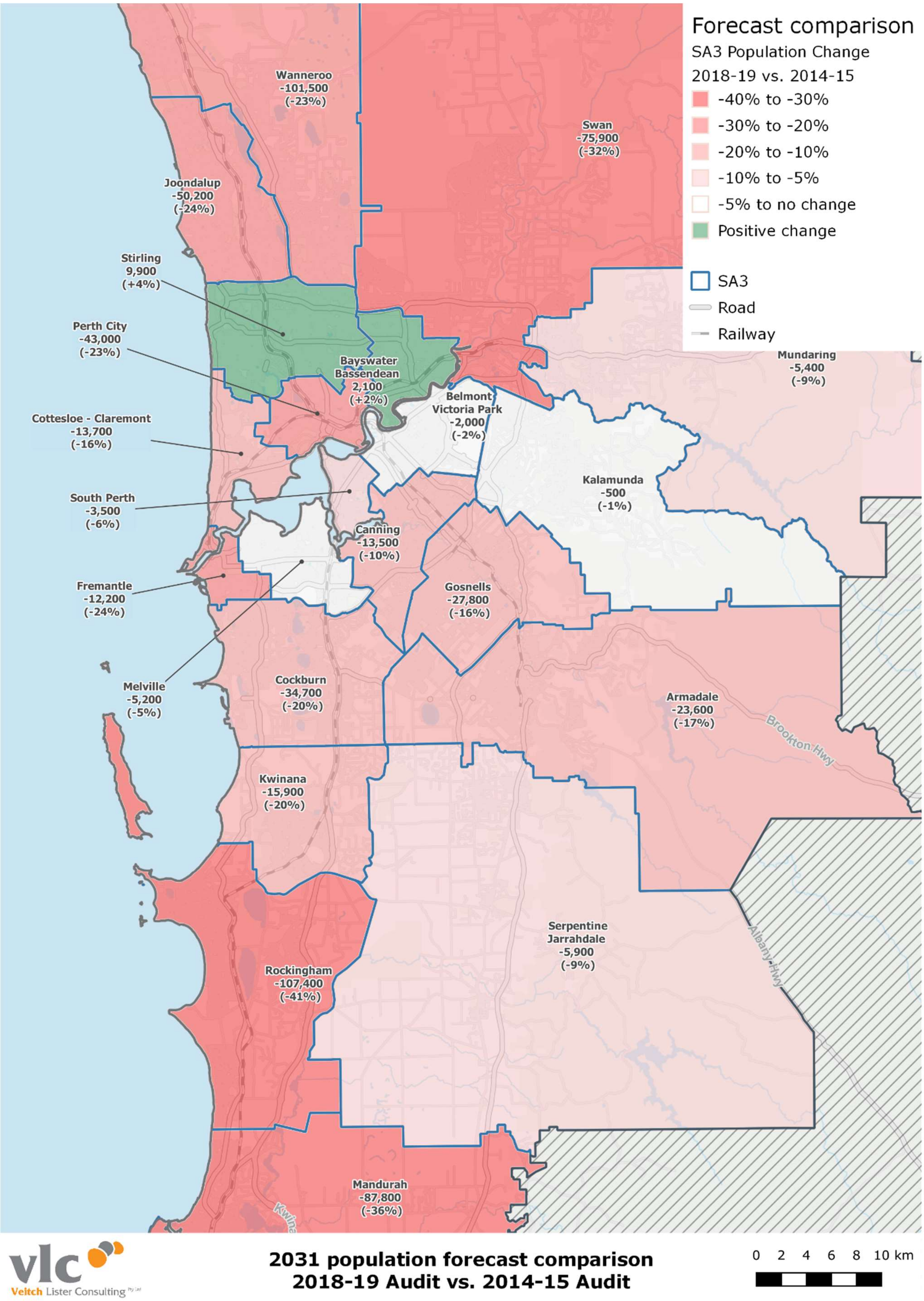
In the 2014-15 Audit, VLC has prepared forecasts for employment, consistent with the population projections constrained to the ABS B series forecast. The employment forecasts are based on projected levels of employment self-containment within each LGA, which recognise the structure planning of local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

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

	2014-15 Audit	2018-19 Audit	Difference
Perth GCCSA employment	1.7 million	1.3 million	-22%
Proportion of employment in Perth City SA3	23%	23%	-%

The way in which jobs are distributed across a city is a key determinant of trip destination, and as such mode choice (more jobs in the CBD encourages more PT travel). In strategic modelling, a gravity model is used to distribute trip destinations, with features such as jobs attracting trips. As such the attractiveness of an area is determined by its **share** of total employment rather than the actual **number** of jobs it contains. Thus, having 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 Perth, key differences in network assumptions are as follows:

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

Major projects in 2014-15 NOT in 2018-19	Major projects in 2018-19 NOT in 2014-15
• Roe Highway extension	• METRONET (Forrestfield Airport Link, Thornlie-Cockburn Rail link) • Tokin Highway grade separation

E.2.3 Cost assumptions

Cost assumptions in Perth (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.

The 2018-19 modelling forecasts lower 2031 travel demand across all four metrics. Details are provided in Appendix Table E-5, however the main driver of this is the considerably lower 2031 population forecast.

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. As is expected, given the large reduction in population forecasts, traffic volumes and delays have decreased. The worst-performing corridors are largely consistent between the Audits with the same four corridors topping the list in both year (the only difference being a small change in ordering at second and third place).

In general, shows that vehicle delays are forecast to decrease by more than the corresponding change in traffic volumes. This is a function of the underlying dynamics of traffic flow (when additional traffic is added to an already congested road, the resultant delay is disproportionately higher than in less congested conditions). 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 have reduced (-19%)**	⇩ **Employment forecasts have reduced (-22%), however the proportion of jobs in Perth City SA3 remains stable**	⇧ **More investment in the road network (+5% network lane km)**	⇧ **More investment in the PT network (~+30% 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 (-40%)	⇩ Lower total population reduces total modelled trips	- Total trips are generated by population assumptions and model parameters only.							• Changes to the model calibration have impacted the number of trips produced in the model. • Trip numbers are generally lower in the re-calibrated models. However, due to a change in balance between trip lengths and trip numbers, the reduction in network volumes can be largely attributed to the lower population forecasts.
	Car trips (-37%)	⇩ Lower total population reduces total modelled car trips	- The distribution of employment is similar between the audits, as such a decline in overall employment does not substantially alter the balance between car and PT travel	⇧ Better roads encourage car travel	⇩ Better PT can encourage more PT travel and fewer car trips	⇧ Lower fuel prices encourage car travel	- No change = no impact			• Changes to the model calibration results in fewer trips in the model. By extension, there are fewer car trips.
	Car vehicle kms travelled (-20%)	⇩ An overall reduction in population reduces car kilometres. Lower population growth at the urban fringe also causes a reduction in this metric	- The distribution of employment is similar between the audits, as such a decline in overall employment does not substantially alter the balance between car and PT travel	⇧ Better roads encourage car travel	⇩ Better PT can encourage more PT travel and fewer car kms	⇧ Lower fuel prices encourage car travel	- No change = no impact			• Changes to the model calibration results in fewer trips in the model, but slightly longer trip lengths. Both factors impact on car vehicle kilometres travelled.
	Public transport trips (-18%)	⇩ Lower total population reduces total modelled PT trips	- The distribution of employment is similar between the audits, as such a decline in overall employment does not substantially alter the balance between car and PT travel	⇩ Better roads encourage car travel and fewer PT trips	⇧ Better PT can encourage more PT travel	⇩ Lower fuel prices encourage car travel and reduce PT travel	- No change = no impact			• Capacity constraining public transport networks would reduce demand for services where crowding occurs. • Analysis of observed public transport behavioural data suggested that PT usage has been declining in Perth. 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 Perth GCCSA AM peak (ranked by total delay)

Rank IA Audit 2018-19	Direction	Corridor Name	Corridor	Average Peak Hour Traffic 2031 forecasts			Total Delay Hours 2031 forecasts			Rank IA Audit 2014-15
				IA Audit 2014-15	IA Audit 2018-19	% Diff	IA Audit 2014-15	IA Audit 2018-19	% Diff	
1	NB	Kwinana Fwy Corridor	6	3,700	3,500	-6%	12,800	8,600	-32%	1
2	SB	Mitchell Fwy Corridor	21	6,200	5,700	-9%	8,400	5,200	-38%	3
3	SB	Marmion Ave/West Coast Hwy Corridor	19	2,100	1,800	-13%	9,900	4,100	-59%	2
4	NB	Old Coast/Mandurah/Stock/Stirling Hwy Corridor	6	2,600	1,800	-29%	8,200	3,200	-60%	4
5	NB	Tonkin Hwy Corridor	4	3,700	3,200	-14%	6,200	3,100	-49%	6
6	SB	Wanneroo Rd Corridor	20	2,100	1,700	-20%	7,800	2,500	-68%	5
7	SB	Kwinana Fwy Corridor	6	2,600	2,500	-3%	1,100	2,300	111%	25
8	SB	Tonkin Hwy Corridor	4	2,500	2,500	3%	2,800	2,200	-23%	11
9	WB	Graham Farmer Fwy/Orrong Rd/Welshpool Rd East Corridor	18	3,100	2,600	-16%	4,100	2,100	-49%	8
10	NB	Albany Hwy Corridor	1	2,200	1,700	-21%	4,400	1,900	-56%	7
11	SB	Roe Hwy Corridor	15	3,400	2,900	-14%	3,000	1,700	-43%	10
12	WB	Canning Hwy/Great Eastern Hwy (west) Corridor	17	2,300	2,000	-9%	2,600	1,600	-38%	13
13	EB	Canning Hwy/Great Eastern Hwy (west) Corridor	17	2,000	1,800	-10%	2,000	1,500	-26%	18
14	NB	Roe Hwy Corridor	15	3,100	2,700	-12%	2,100	1,400	-32%	17
15	WB	Great Eastern Hwy (east)/Guildford Rd Corridor	25	1,800	1,400	-23%	3,400	1,300	-62%	9

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