Veitch Lister Consulting Pty Ltd


# Greater Perth Travel Modelling Report

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**PREPARED FOR**
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# Greater Perth – Travel modelling report

## Project No. 14-011



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| | | | | | |

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# 1. Introduction

## 1.1 Background

In April 2014 Veitch Lister Consulting (VLC) was commissioned by Infrastructure Australia (IA) to produce travel demand forecasts and transport network performance assessments for Perth and its associated regions for 2011 and 2031. This document presents the results of this work.

The 2031 travel predictions and transport network performance assessments have been produced for a low transport investment scenario - i.e. the transport networks (road and public transport) used in the modelling only included current transport network infrastructure and services, supplemented by committed and "highly likely" transport network enhancements.

The travel predictions and transport system performance measures presented in this report have been generated using VLC's Zenith model - a four-step multimodal model encompassing the entire region. The area modelled encompasses both the Greater Perth region and the Outer Perth Region.

## 1.2 Purpose of this investigation

The primary purpose of this consulting commission is to provide input to the Australian Infrastructure Audit (AIA) being conducted by Infrastructure Australia, by:

a) robustly predicting the scale of travel increase in the entire region, where it is likely to occur and the modes of travel that will be chosen;
b) assessing the degree to which the performance of the transport network will deteriorate by 2031 under a *low transport investment* scenario - including identification of those elements of the road network that will, by 2031, be generating large economic costs due to congestion, and sections of the rail network that will be subject to severe over-crowding; and
c) providing travel and transport system performance data suitable for input to the ACIL Allen Tasman economic model of the region.

## 1.3 Structure of report

The balance of the report is structured as follows:

Section 2: Land use assumptions used in the modelling

Section 3: Assumed 2031 base case transport networks

Section 4: Other modelling assumptions

Section 5: Methodology

Section 6: Travel demand increase in Perth and associated regions 2011-2031

Section 7: Road network performance

Section 8: Public transport system performance

# 2. Land use assumptions

Land use and transport system operation are linked by complex, yet identifiable relationships which are investigated through transport modelling activities. It is crucial therefore to utilise the most current, rigorous land use dataset available to underpin the traffic modelling.

In this section, we outline the land use and demographic variables underpinning travel behaviour within the Perth region, and describe the application of land use projections developed by VLC for the purpose of forecasting travel and the performance of the transport network within the regions.

## 2.1 Demographic dataset development

VLC has developed a current baseline demographic dataset to underpin traffic forecasting for this project. This dataset contains population, employment, education enrolment and visitor data for a base year of 2011 and future year 2031 appropriate for input into VLC's Zenith model. This demographic dataset developed as a result of this project contains the most current and rigorous small area demographic projections which form an essential input into transport modelling and traffic forecasting.

Datasets used as inputs in the development of the baseline demographic dataset include, but are not limited to:

- 2011 Australian Bureau of Statistics (ABS) Census of Population and Housing
- ABS Series B population projections and associated age structure data
- State Government household projections
- ABS Estimated Resident Population
- Local government land use data
- Enrolment data for primary, secondary and tertiary institutions
- Planning scheme data
- Tourism forecast data

Development has also included advice from local governments in relation to current planning intentions and expectations in the region.

### 2.1.1 Base year (2011) data development

Base year data has been derived from the 2011 Census of Population and Housing. Population variables have been derived from Estimated Resident Population data, rebased to the 2011 Census. Base year employment has been derived from Place of Work DZN data, with adjustments made to account for Census under-reporting, and "Not Stated" responses.

Enrolment data has been obtained from The Australian Curriculum, Assessment and Reporting Authority (ACARA), as well as contact with various primary, secondary and tertiary institutions to confirm enrolment figures, and associated employment. Visitor data, both domestic and international, has been obtained from the 2011 Census of Population and Housing.

### 2.1.2 Baseline dataset future year land use projection development

Future year projections for the baseline demographic in the various regions' datasets have been developed using the ABS Series B population projections. The population dataset is constrained to State Government projections at 2031. Base 2031 population projections are adjusted to match ABS Series B 2031 population. ABS population projections are provided at Greater Capital City Statistical Area, therefore the difference between base 2031 projected population and ABS Series B 2031 projected population is apportioned to small areas according to their share of growth between 2011 and 2031.

Future year employment has been based on the 2011 Journey to Work statistical relationships. Employment growth is distributed based on knowledge of known future developments and information obtained from local and regional planning instruments.

The ratio of domestic and international visitors to the number of usual residents at the small area level is assumed to be the same in future years and is applied to future years' total residents to forecast the number of domestic and international visitors. These figures are validated at aggregate levels to figures provided by relevant Government authorities.

For future enrolments, an age-cohort model has been used to allocate additional students to existing institutions based on notional capacities of institutions in the future. Any surplus students were then allocated to schools with additional capacity in neighbouring Small Areas at level 2 (SA2s), or new schools allocated to areas of high growth and/or where planning information is available.

Tertiary education centres are expected to experience a capped growth per year.

## 2.2 The Zenith model and small area demographics

The Zenith model for the regions takes into account information describing the location and scale of various land uses, activities and demographics across the region in reflecting the travel choices of households and firms.

When applying the model, the region is divided into a number of zones whose size depends on the scope of impacts being investigated and the resolution of information available. Forecasts of demographic variables for each zone used in the model include:

- Population – number of persons whose usual place of residence is within a zone
- Households – number of households including occupied private dwellings and group households
- White Collar Workers – persons employed in occupations classified as 'white-collar'
- Blue Collar Workers – persons employed in occupations classified as 'blue-collar'
- Dependants (0-17) – number of non-workers aged up to 17 years
- Dependants (18-64) – number of non-workers aged 18 to 64 years
- Dependants (65+) – number of non-workers aged 65 and over
- Cars – number of private motor vehicles garaged at occupied private dwellings

The model uses this information to generate profiles of households of different structure, the members of which would each make different choices regarding the frequency, purpose, location, period, mode and route of travel.

The model also defines a number of activities for which travel is undertaken. A number of socioeconomic and land use variables are used to determine the level of participation or attraction for each activity in each zone, which influences the number of trips undertaken for a range of purposes.

These activity variables include:

- Employment by industry (14 custom categories based on 1-digit ANZSIC industry divisions)
- Educational enrolment by 3 levels
- Demand information for special generators:
  - Airport passengers (3 categories)
  - Tourism and recreation visitation rates (4 categories)
  - Freight and logistics terminals demand forecasts

VLC have defined a small area cadastre for the region, for which data for all of the land use and demographic variables is maintained for the forecast horizon. This is aggregated as needed to provide an efficient zoning system for application of the Zenith model.

VLC has undertaken extensive data acquisition, research and fieldwork to ensure the accuracy of the demographic and socioeconomic data that underpins the forecasting of travel demand in the region. For the small area cadastre, the data for 2011 is developed from and validated against the Australian Bureau of Statistics Census of Population and Housing.

VLC maintains its own scenarios of land use projections, integrating planning information from various local, state and federal government bureaux, supplemented with its knowledge of proposed developments.

The following sections summarise the population and employment characteristics and forecasts for the region by SA3.

## 2.3 Population

### 2.3.1 Population projections for the region

The region as a whole is comprised of 24 SA3's. These areas vary widely in nature, from inner city urban areas with very high population densities to rural-fringe areas characterised by small local centres interspersed with open space and agricultural production areas.

The following sections summarise the population characteristics and projections for SA3's in the region.

Table 2-1 provides population estimates for the region by SA3 for 2011 and 2031.

These tables also show the absolute growth in population and the equivalent average annual growth rate.

In the region as a whole (that is the area incorporating the Greater and Outer Perth regions), the population was 1.87m in 2011 rising to 3.30m in 2031 an average annual growth rate of 2.9%.

Within Greater Perth the AAGR is 2.8 percent with peaks occurring in Perth City (3.2 percent), Swan (4.0 percent), Wanneroo (5.2 percent), Armadale (3.8 percent), Serpentine – Jarrahdale (6.6 percent), Kwinana (4.9 percent), and Rockingham (4.5 percent).

In the Outer Perth region, Mandurah with an AAGR of 5.3 percent accounts for approximately 90 percent of the population growth in the region.

This pattern of growth is depicted in Figure 2-1.

### Table 2-1: Existing and Projected Populations in the Region

| SA3 | 2011 | 2031 | Growth | % | AAGR |
|---|---|---|---|---|---|
| **Cottesloe - Claremont** | 69,000 | 84,600 | +15,600 | +23% | 1.0% |
| **Perth City** | 99,600 | 186,000 | +86,400 | +87% | 3.2% |
| **Bayswater - Bassendean** | 80,700 | 97,200 | +16,500 | +20% | 0.9% |
| **Mundaring** | 42,200 | 60,000 | +17,800 | +42% | 1.8% |
| **Swan** | 108,900 | 240,300 | +131,400 | +121% | 4.0% |
| **Joondalup** | 161,700 | 210,800 | +49,100 | +30% | 1.3% |
| **Stirling** | 189,900 | 257,300 | +67,400 | +35% | 1.5% |
| **Wanneroo** | 160,300 | 441,500 | +281,300 | +176% | 5.2% |
| **Armadale** | 65,300 | 137,400 | +72,100 | +110% | 3.8% |
| **Belmont - Victoria Park** | 67,700 | 101,500 | +33,700 | +50% | 2.0% |
| **Canning** | 94,200 | 132,500 | +38,300 | +41% | 1.7% |
| **Gosnells** | 112,300 | 177,300 | +65,000 | +58% | 2.3% |
| **Kalamunda** | 56,400 | 70,400 | +14,000 | +25% | 1.1% |
| **Serpentine - Jarrahdale** | 18,500 | 66,600 | +48,100 | +260% | 6.6% |
| **South Perth** | 44,000 | 56,400 | +12,400 | +28% | 1.2% |
| **Cockburn** | 92,900 | 177,300 | +84,400 | +91% | 3.3% |
| **Fremantle** | 36,200 | 50,500 | +14,300 | +39% | 1.7% |
| **Kwinana** | 30,600 | 80,200 | +49,600 | +162% | 4.9% |
| **Melville** | 104,600 | 112,200 | +7,600 | +7% | 0.4% |
| **Rockingham** | 109,100 | 263,000 | +153,900 | +141% | 4.5% |
| ***Greater Perth region*** | ***1,744,100*** | ***3,003,000*** | ***+1,258,900*** | ***+72%*** | ***2.8%*** |
| **Bunbury** | 3,600 | 4,400 | +800 | +22% | 1.0% |
| **Mandurah** | 87,100 | 244,100 | +157,000 | +180% | 5.3% |
| **Wheat Belt - South** | 6,000 | 7,800 | +1,700 | +29% | 1.3% |
| **Wheat Belt - North** | 29,700 | 44,300 | +14,600 | +49% | 2.0% |
| ***Outer Perth region*** | ***126,400*** | ***300,600*** | ***+174,200*** | ***+138%*** | ***4.4%*** |
| ***Total to SA3*** | ***1,870,500*** | ***3,303,600*** | ***+1,433,100*** | ***+77%*** | ***2.9%*** |

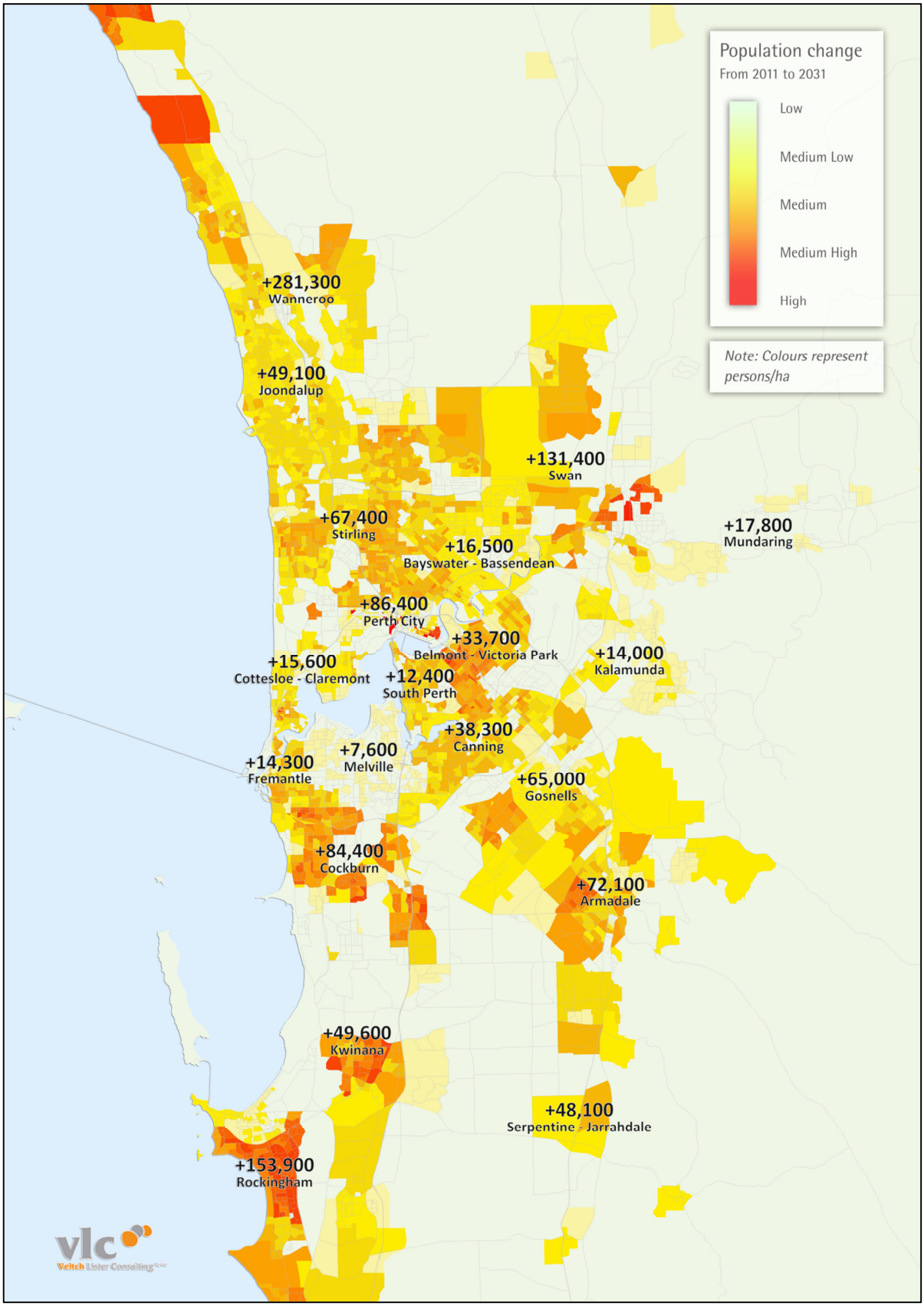



*Figure 2-1: Projected population growth in the Perth Region (2011 – 2031)*

## 2.4 Employment

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 the state government.

### 2.4.1 Employment characteristics and projections for the region

The Zenith model requires employment estimates and projection across a range of industries and occupations for the region. As well as indicating the number of jobs, this is also indicative of the opportunities to participate in a range of commercial and social activities, such as education, business, shopping, dining and entertainment, health and recreation, as well as activities generating freight.

Table 2-2 summarises existing and projected employment in the region as a whole.

Total employment in the region is predicted to increase from 1.01m in 2011 to 1.68m in 2031, an increase of 66 percent at an AAGR of 2.6 percent (see Table 2-2).

Approximately 90 percent of this growth is expected to occur in the Greater Perth region with most of this growth occurring in Perth City, Swan, Wanneroo, and Stirling.

In the Outer Perth region, Mandurah accounts for over 80 percent of that region's growth. Figure 2-2 depicts the spatial pattern of employment growth.

### Table 2-2: Existing and Projected Employment in the Region

| SA3 | 2011 | 2031 | Growth | % | AAGR |
|---|---|---|---|---|---|
| **Cottesloe - Claremont** | 43,500 | 60,200 | +16,700 | +38% | 1.6% |
| **Perth City** | 240,800 | 391,200 | +150,400 | +62% | 2.5% |
| **Bayswater - Bassendean** | 31,300 | 43,000 | +11,800 | +38% | 1.6% |
| **Mundaring** | 10,700 | 16,500 | +5,800 | +54% | 2.2% |
| **Swan** | 62,100 | 127,800 | +65,700 | +106% | 3.7% |
| **Joondalup** | 50,900 | 73,800 | +23,000 | +45% | 1.9% |
| **Stirling** | 85,800 | 127,600 | +41,800 | +49% | 2.0% |
| **Wanneroo** | 43,200 | 102,400 | +59,200 | +137% | 4.4% |
| **Armadale** | 16,900 | 33,700 | +16,900 | +100% | 3.5% |
| **Belmont - Victoria Park** | 69,100 | 104,900 | +35,800 | +52% | 2.1% |
| **Canning** | 81,000 | 119,600 | +38,600 | +48% | 2.0% |
| **Gosnells** | 27,800 | 51,200 | +23,400 | +84% | 3.1% |
| **Kalamunda** | 17,900 | 25,200 | +7,400 | +41% | 1.7% |
| **Serpentine - Jarrahdale** | 4,200 | 12,600 | +8,500 | +203% | 5.7% |
| **South Perth** | 15,400 | 22,200 | +6,700 | +44% | 1.8% |
| **Cockburn** | 37,900 | 71,100 | +33,200 | +87% | 3.2% |
| **Fremantle** | 36,900 | 56,300 | +19,300 | +52% | 2.1% |
| **Kwinana** | 15,100 | 35,500 | +20,400 | +135% | 4.4% |
| **Melville** | 42,000 | 54,000 | +12,000 | +29% | 1.3% |
| **Rockingham** | 30,800 | 58,000 | +27,200 | +88% | 3.2% |
| ***Greater Perth region*** | *963,300* | *1,586,800* | *+623,500* | *+65%* | *2.5%* |
| **Bunbury** | 2,800 | 3,400 | +600 | +22% | 1.0% |
| **Mandurah** | 26,700 | 65,300 | +38,600 | +144% | 4.6% |
| **Wheat Belt - South** | 6,400 | 8,800 | +2,400 | +38% | 1.6% |
| **Wheat Belt - North** | 11,200 | 16,400 | +5,200 | +47% | 1.9% |
| ***Outer Perth region*** | *47,100* | *93,900* | *+46,800* | *+99%* | *3.5%* |
| ***Total to SA3*** | ***1,010,400*** | ***1,680,700*** | ***+670,300*** | ***+66%*** | ***2.6%*** |

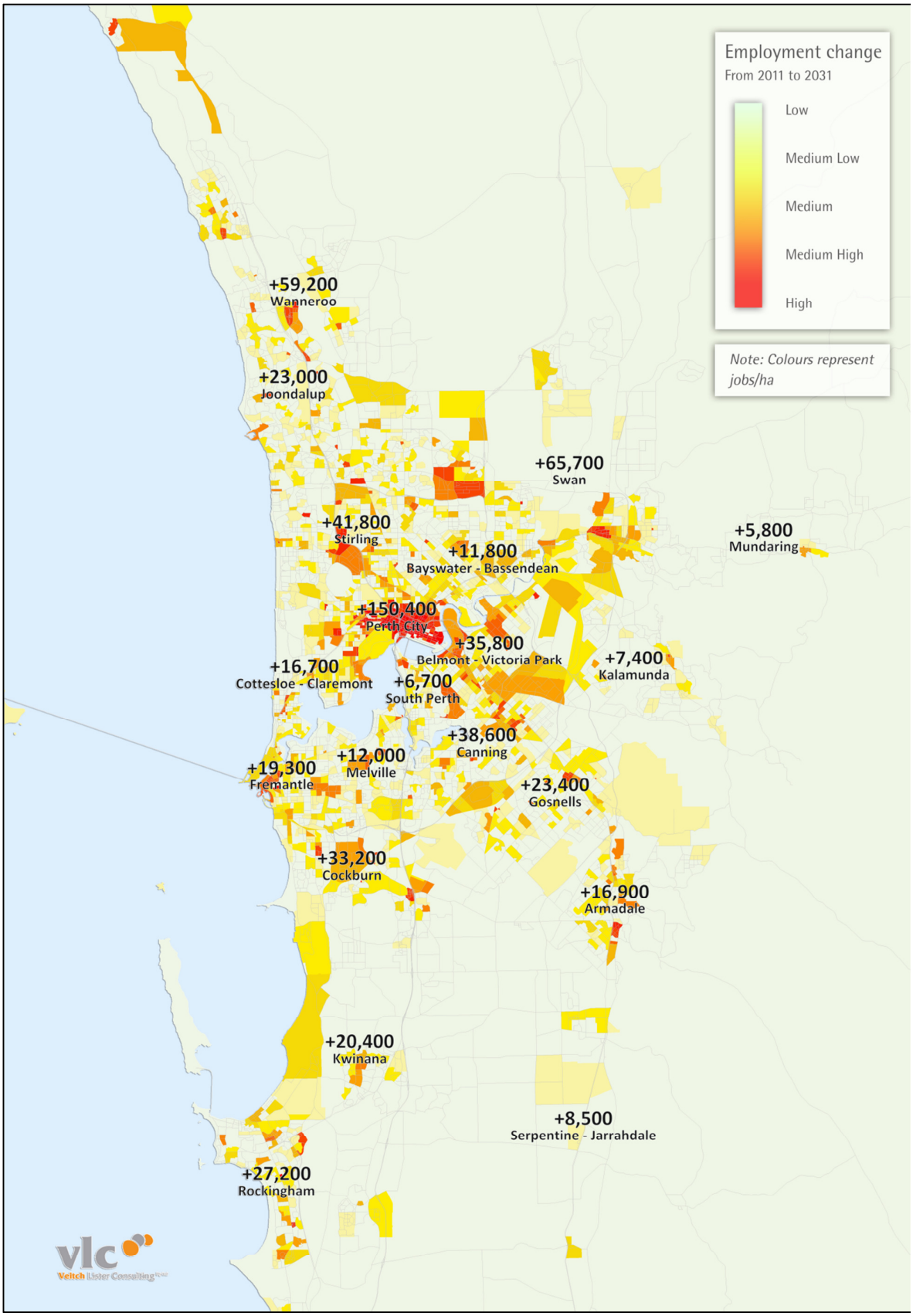



*Figure 2-2: Projected employment growth in the Perth region between 2011 and 2031*

# 3. Assumed base case transport networks

This section of the report describes the transport network improvements that have been assumed for the AIA base case networks. In order to assess properly the priorities for development of the transport network under the planned strategies for urban growth, the base case assumes a balance of committed future works, as well as those that are required to support the development of urban growth centres.

Table 3-1 summarises the major funded and committed works across the region. A full listing of all works (i.e. including minor projects) is provided in Appendix A of the report. Figure 3-1 indicates the location of each of the proposed projects.

***Table 3-1: Major new transport infrastructure included in 2031 base case network***

| Project Nr | Project Description |
|---|---|
| **1** | Perth City Link (sinking of Fremantle line) |
| **2** | Perth City Link (construction of Perth Busport) |
| **3** | Perth Stadium Transport Project (Swan River Pedestrian bridge, bus terminal, internal roads) |
| **4** | Joondalup Line extension to Butler |
| **5** | Aubin Grove station construction |
| **7** | Gateway WA - Perth Airport and Freight Access |
| **8** | Kwinana Fwy - addition of third lane (SB only) btn Roe Hwy and Armadale Rd |
| **9** | Mitchell Freeway extension btn Burns Beach Rd and Hester Ave |
| **10** | NorthLink WA - Swan Valley Section |
| **11** | Reid Hwy - Duffy Road to Erindale Road Dual Carriageway |
| **12** | Reid Hwy - Malaga Dr grade separation |
| **13** | Graham Farmer Fwy - Tunnel Conversion to 3L |
| **14** | Great Eastern Hwy - Kooyong Rd to Tonkin Hwy Stage 1 - Construct Dual Carriageway (6L) |
| **15** | Great Eastern Hwy - construction of interchange with Roe Hwy |
| **16** | Kwinana Fwy - addition of third lane btn Leach Hwy and Roe Hwy |
| **17** | Mitchell Fwy - addition of third lane (NB only) btn Hepburn Ave and Hodges Dr |

## 3.1 Road network assumptions

The major roadworks included in the base case network are:

- Gateway W.A.
- Kwinana Fwy upgrade
- Mitchell Fwy extension
- Northlink W.A.
- Reid Hwy upgrade
- Graham Farmer Fwy tunnel upgrade
- Great Eastern Hwy upgrade
- Roe Highway extension

A full list of projects included in the low investment 2031 transport network is enclosed in Appendix A.

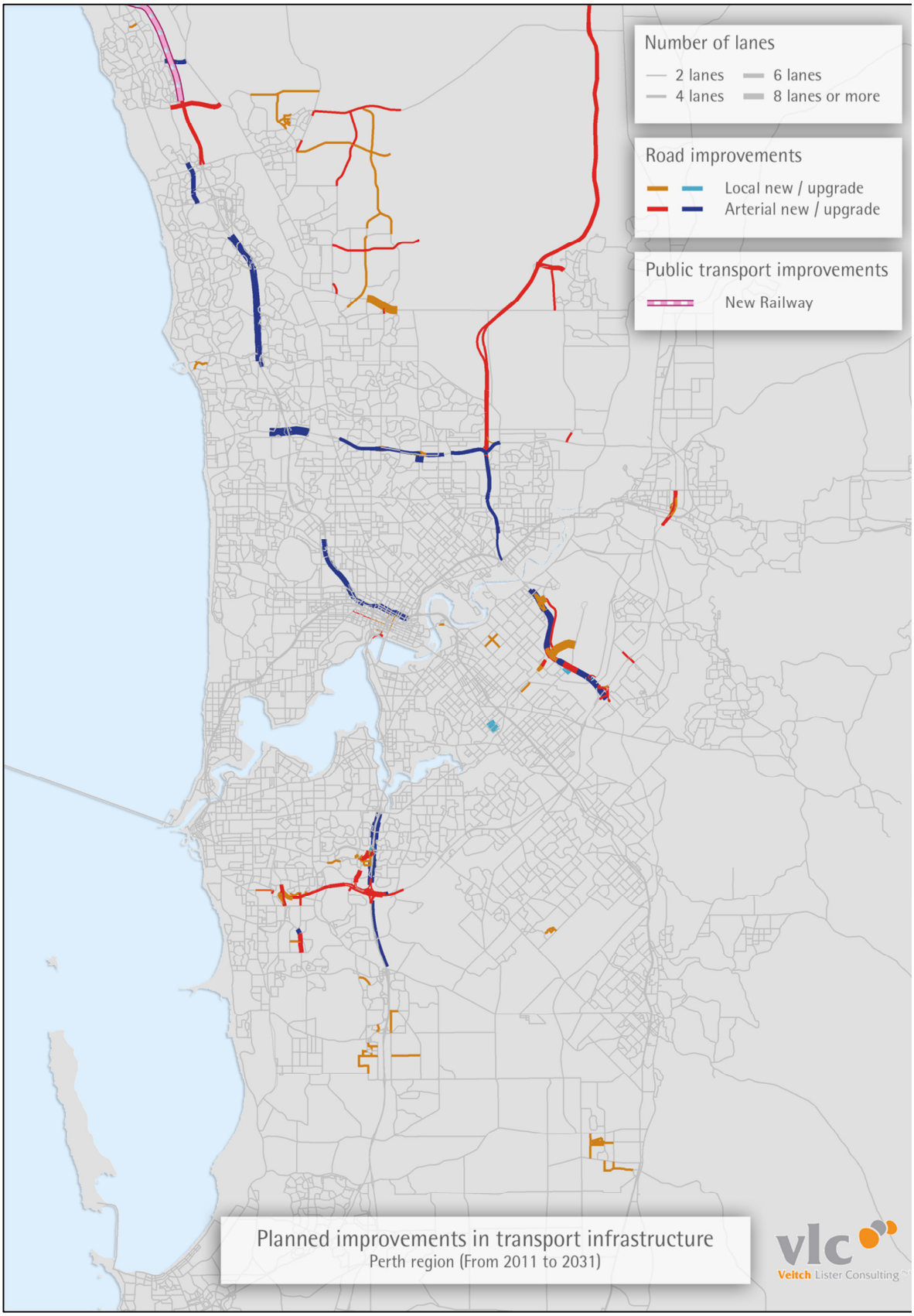



***Figure 3-1: New transport infrastructure included in 2031 base case network***

## 3.2 Public transport network assumptions

Significant public transport enhancements as previously listed in Table 3-1 are:

- The Perth City Link project
- Perth Stadium Transport project
- Joondalup line extension to Butler
- Aubin Grover station construction

# 4. Pricing and behavioural assumptions

When individuals make choices regarding how, when and where to travel, they take into account the costs and convenience of each of the options available. These considerations may include the value of time spent travelling, the cost of fuel, public transport fares, parking charges and tolls, as well as longer term costs associated with vehicle ownership and use. Likewise firms that schedule commercial travel take into account the costs associated with operation and maintenance of the vehicle and labour costs of the driver or crew, as well as the efficiency of travel on each route and the cost of tolls.

The modelling of future travel in the region for the Australian Infrastructure Audit makes certain assumptions about how these costs will change, and how preferences affecting travel behaviour may evolve over time. These assumptions are based on available evidence and are intended to reflect the current policies of all levels of government.

## 4.1 Value of travel time

The 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.

There is a significant volume of behavioural research that suggests values of travel time increase with increasing 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.

## 4.2 Fuel costs

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
- 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. The base case for the AIA has therefore assumed no real change in the unit of costs of fuel in future.

## 4.3 Public transport fares

While there have been real increases in public transport fares during recent years, there is a growing concern to maintain prices and provide off-peak discounts to encourage greater use of public transport. In order to maintain a neutral position on pricing, the base case for the AIA has assumed no real change in public transport fares.

## 4.4 Parking charges and supply

The availability and cost of parking can have a strong influence on the choice of destination or mode used for travel, particularly to CBD destinations, where high parking costs and a high level of public transport accessibility contribute to public transport being relatively attractive.

There are however, strong pressures on price arising from increasing demand and constrained supply of parking in the CBD and major activity centres.

With increasing demand and constrained supply of parking spaces, it is reasonable to expect that parking costs within the CBD and at major activity centres in the metropolitan area will experience real increases of 1-2% per annum. The base case modelling for the AIA has assumed a real annual increase of 1.5% in parking charges.

## 4.5 Airport passenger demands

Travel demands associated with the region's airports are based upon forecasts of passenger demand by BITRE, categorised according to whether travel is for business, and for non-business travel, whether by residents of the region, or visitors.

The passenger demand estimates and forecasts assumed within the base case are provided in Table 4-1.

***Table 4-1: Air passenger demand estimates and forecasts (average weekday)***

| Terminal | Year | Business | Local | Visitors | Total |
|---|---|---|---|---|---|
| **Perth International** | 2011 | 2,500 | 2,800 | 4,000 | 9,300 |
| | 2031 | 6,900 | 7,800 | 11,200 | 25,900 |
| | (% increase) | +176% | +179% | +180% | +178% |
| **Perth Domestic** | 2011 | 8,200 | 2,200 | 11,300 | 21,700 |
| | 2031 | 18,000 | 4,700 | 24,800 | 47,500 |
| | (% increase) | +120% | +114% | +119% | +119% |

All of the segments of the travel demands market are expected to increase significantly, most particularly the international market segment.

# 5. Methodology

The use of VLC's Zenith Travel model provides insights into urban transport at a high level of granularity. In order to allow for detailed analyses of the vast amount of data a number of spreadsheets have been created to inform the National Audit of Urban Infrastructure at different levels of data aggregation:

- Metrics from SA3 to SA3
- Key Model Statistics
- Corridor analysis
- Rail demand and supply analysis

This chapter describes the methodology.

## 5.1 Description of metrics

The Zenith model contains a wealth of information. This section describes the metrics and where applicable the calculations to generate these metrics.

### 5.1.1 Network (lane) kilometres

The Zenith model describes travel demands on individual links (sections of road) for roads generally carrying over 3,000 vehicles per day. The total number of kilometres this network encompasses is described in this metric. A link that can be travelled in both directions will be accounted for in each direction. Network lane kilometres describe a similar metric but also take into account the number of lanes for each link and direction.

### 5.1.2 Demand

Demand is measured in trips. Depending on the mode of travel these trips can be either vehicular trips (car, light or heavy goods vehicles) or person trips (car driver or car passenger, public transport and active transport).

### 5.1.3 Speeds

Speeds can either be reported under free-flow or under congested conditions. The free-flow speeds are the input speeds to the travel model whereas the congested speeds are a result of traffic impeding other traffic.

### 5.1.4 Vehicle Kilometres Travelled (VKT), Passenger Kilometres Travelled (PKT)

The number of vehicle kilometres travelled is a key part of the network performance indicators. This metric is calculated by multiplying the demand on a link by the length of this link. In a similar way passenger kilometres travelled can be calculated.

### 5.1.5 Vehicle Hours Travelled (VHT), Passenger Hours Travelled (PHT) and Hours of Delay

The number of Vehicle Hours Travelled is calculated by multiplying the vehicle demand on a link by the time to traverse that link in the network. This metric can be reported either under free-flow or congested conditions. The difference between the Vehicle Hours Travelled under free-flow and congested conditions results in the Hours of Delay metric. Passenger Hours Travelled is a similar metric which is based on the passenger demand on a link.

### 5.1.6 Traffic Volume over Capacity Ratios

Volume over Capacity ratios or V/C ratios in short are calculated by dividing the vehicular demands by the capacity of a link. For peak periods the maximum peak hour demand is used to calculate the V/C ratios. In the off-peak situation the average demand is used. It is worth noting that goods vehicles are weighted the same as cars. This might cause lower than actual V/C ratio's on roads with high

volumes of goods vehicles. However the weighting of goods vehicles would also be included the capacity of a road, the magnitude of difference therefore is expected to be generally limited. A public transport trip that utilises a car to access a stop is excluded from the vehicular demands. Buses are also excluded from the vehicular demands. This could potentially result in understated V/C ratios around stations and bus corridors but generally not to any significant degree.

### 5.1.7 Public Transport Volume over Capacity Ratios

Determining V/C ratios for public transport take into account the number of passengers on a particular service and the capacity of the vehicle used for that service. This capacity can either be expressed as seated or crush capacity. The seated capacity is total number of seats in a vehicle. The absolute maximum number of passengers a vehicle can (legally) carry is the crush capacity. Depending on the metric either the seated or crush capacity is used. The method to determine seated and crush capacities is described in Appendix B.

### 5.1.8 LOS

An LOS analysis provides an indication of where the road network would fail to meet desired standards of service under the travel demands and traffic volumes forecast. By extension, it illustrates where such behavioural changes are likely to impact on forecasts to some degree, if these levels of congestion result in a change in travel behaviour.

The ability of a road to maintain high levels of service under increasing traffic levels depends upon its design standard and access controls, junction operation and coordination, degree of separation of conflicting movements, as well as its local environment and relation to connecting roads. Higher standards of roads, junctions and network management are able to provide better performance under similar levels of congestion (ratio of volume to capacity) than those of a lower standard. Austroads defines six threshold levels for standardised performance assessment, for which we describe how this affects driver behaviour, and provide typical threshold levels of congestion for three standards of roads.

***Table 5-1: AustRoads Level of Service (LOS) definitions***

| Level of service | | Threshold ratio of volume to capacity | | |
|---|---|---|---|---|
| | | Motorway | Arterial | Local |
| A | Drivers may travel at desired speed, and manoeuvre freely, experiencing no delay due to other traffic | 0.50 | 0.40 | 0.35 |
| B | Drivers will incur occasional minor delays and restrictions to manoeuvre due to other traffic | 0.65 | 0.60 | 0.50 |
| C | Drivers will experience interrupted travel, with minor delays and stops, but with the network operating efficiently providing predictable travel times | 0.85 | 0.75 | 0.65 |
| D | Drivers will experience occasional major delays, with variable travel times due to conflicting traffic and volumes approaching capacity | 1.00 | 0.90 | 0.80 |
| E | Drivers will experience frequent major delays, with volumes at or exceeding capacity for short periods, unpredictable travel times | 1.15 | 1.05 | 0.95 |
| F | Drivers will experience severe congestion and delays, with volumes exceeding capacity for long periods, strong influence on route choice | | | |

### 5.1.9 Fuel Consumption and Greenhouse Gas Emissions

Vehicle fleet mix can be expected to change reflecting the entry of hybrid, plug in hybrids and electric vehicles challenging the dominant market position of vehicles powered by an internal combustion engine (ICE). Most evidence available today is about hybrid vehicles. Hybrid cars use an ICE engine as well as electrical generators and motors. They are very fuel efficient using around 50 per less fuel in normal use than ICE powered cars and a similar amount less in GHG emissions, with performance differing by make.

The fuel efficiency and fleet mix assumptions used when estimating Greenhouse Gas Emissions in 2011 and 2031 are presented in Tables 5-2 and 5-3.

***Table 5-2: Relative fuel intensity assumptions***

| Year | Mode | ICE | Hybrid | PHEV | Electric |
|---|---|---|---|---|---|
| **2011** | Cars | 94.9% | 87.1% | 42.8% | 0.0% |
| | Commercial vehicles | 94.9% | 88.4% | 42.8% | 0.0% |
| **2031** | Cars | 76.9% | 61.4% | 22.8% | 0.0% |
| | Commercial vehicles | 76.9% | 66.3% | 22.8% | 0.0% |

***Table 5-3: Fleet mix composition assumptions***

| Year | ICE | Hybrid | PHEV | Electric |
|---|---|---|---|---|
| **2011** | 100.0% | 0.0% | 0.0% | 0.0% |
| **2031** | 80.5% | 18.0% | 1.5% | 0.0% |

## 5.2 Metrics by SA3 to SA3

This analysis disaggregated urban transport activity according to the origin and destination of trips to and from a pair of SA3s (ABS level 3 statistical areas).

Table 5-4 shows an example of the format of the data provided. Metrics are presented in matrix format where the horizontal rows contain the origin SA3 sectors and the vertical columns contain the destination SA3 sectors. For each origin & destination pair metrics are provided for 2011 and 2031 together with the absolute and relative growth between 2011 and 2031. Subtotals for the region are available together with a grand total for the modelled area.

The full matrix is available at:

**vlc_yymmdd_01_PER_Tables by SA3.xlsx**

### *Table 5-4: Example of Metrics by SA3 to SA3*

To SA3 sector

| From SA3 sector | Cottesloe - Claremont | | | | Perth City | | | |
|---|---|---|---|---|---|---|---|---|
| | 2011 | 2031 | Diff | %Diff | 2011 | 2031 | Diff | %Diff |
| Cottesloe - Claremont | 183,836 | 217,388 | +33,551 | +18% | 64,257 | 93,068 | +28,811 | +45% |
| Perth City | 64,254 | 93,065 | +28,811 | +45% | 701,665 | 1,278,964 | +577,299 | +82% |
| Bayswater - Bassendean | 3,535 | 4,053 | +519 | +15% | 49,049 | 65,910 | +16,861 | +34% |
| Mundaring | 684 | 863 | +179 | +26% | 5,036 | 7,638 | +2,602 | +52% |
| Swan | 2,675 | 5,049 | +2,374 | +89% | 21,871 | 48,533 | +26,661 | +122% |
| Joondalup | 6,302 | 7,859 | +1,557 | +25% | 26,961 | 39,871 | +12,909 | +48% |
| Stirling | 30,892 | 38,936 | +8,044 | +26% | 120,521 | 176,135 | +55,613 | +46% |
| Wanneroo | 3,268 | 6,343 | +3,075 | +94% | 18,653 | 42,148 | +23,496 | +126% |
| Armadale | 763 | 1,425 | +662 | +87% | 4,700 | 10,131 | +5,430 | +116% |
| Belmont - Victoria Park | 6,178 | 8,436 | +2,258 | +37% | 51,158 | 91,279 | +40,121 | +78% |
| Canning | 4,237 | 5,435 | +1,198 | +28% | 23,698 | 37,789 | +14,091 | +59% |
| Gosnells | 1,752 | 2,517 | +765 | +44% | 11,584 | 20,025 | +8,441 | +73% |
| Kalamunda | 1,040 | 1,197 | +157 | +15% | 7,854 | 11,018 | +3,164 | +40% |
| Serpentine - Jarrahdale | 226 | 658 | +432 | +191% | 1,209 | 3,839 | +2,630 | +217% |
| South Perth | 4,389 | 5,098 | +709 | +16% | 27,031 | 39,240 | +12,208 | +45% |
| Cockburn | 4,439 | 7,209 | +2,769 | +62% | 10,889 | 22,267 | +11,378 | +104% |

* Full table continues down and to the right

All metrics are available for the morning peak (7-9am), the evening peak (4-6pm), off peak and daily. Certain metrics are only available for certain activity and mode combinations. Table 5-5 below details the availability of metrics by activity and mode combination.

### *Table 5-5: Availability of metrics by activity and mode combination*

| Metric | Activity | Modes |
|---|---|---|
| **Demand, VKT, VHT** | Work, Business, Other, Total | Car, Person Car, (Light, Heavy) Commercial Vehicles, Public Transport, Active Transport |
| **Hours of Delay** | Work, Business, Other, Total | Car, Commercial Vehicles |
| **Fuel, Green House Gas Emissions** | Total | Car, Commercial Vehicles |

## 5.3 Corridor Analysis

All of the more major road corridors in Perth were identified and subjected to more detailed analysis in terms of how they perform in 2011 and 2031. Some corridors include more than one road route when routes are competing. For example, Wattleup Rd/Rowley Rd, Anketell Rd and Thomas Rd.

A total of 30 mportant road corridors were identified, as shown in Figure 5-1.

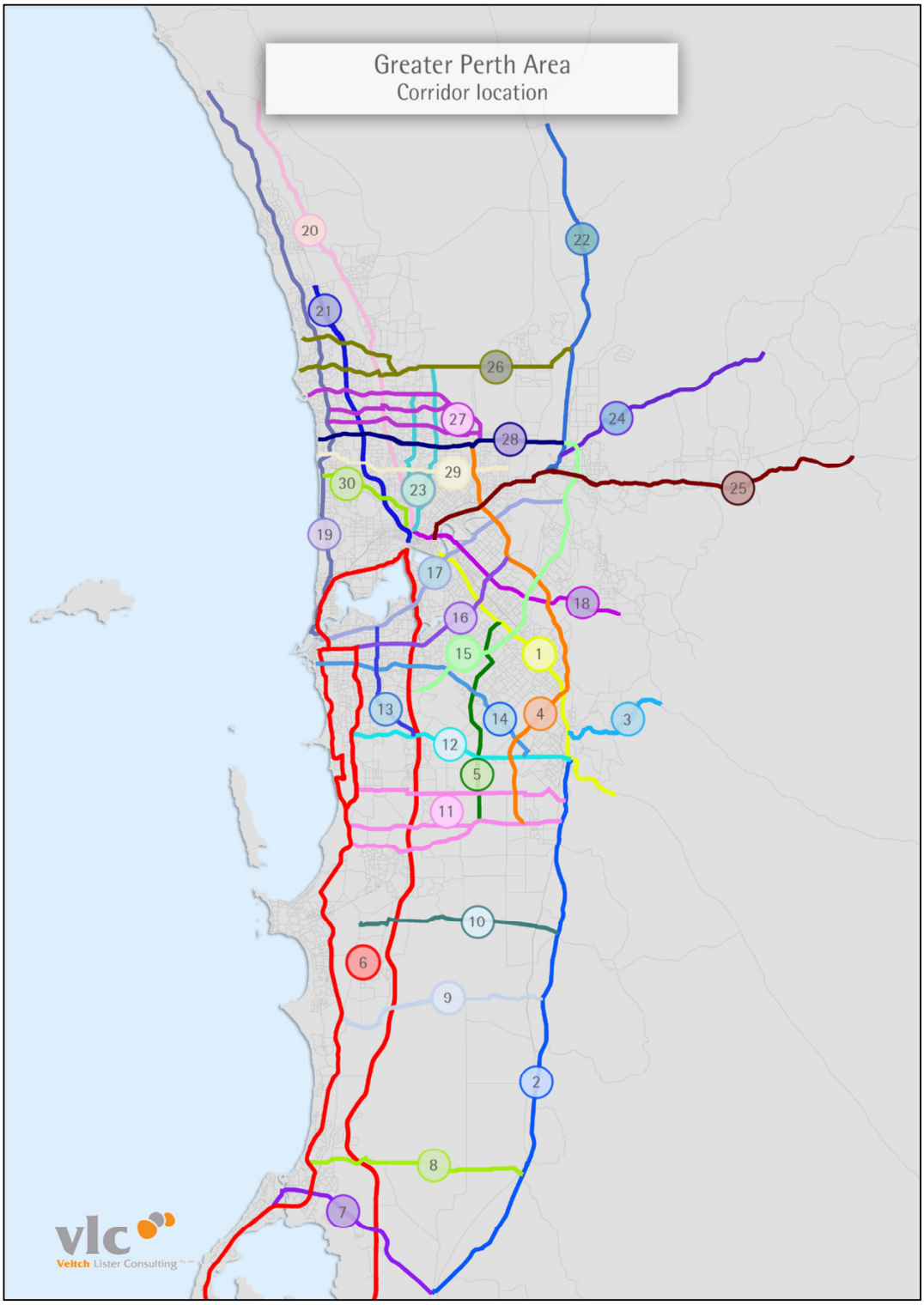



*Figure 5-1: Corridor Locations: Perth Region*

Each of the major roads in each corridor was then divided up into subsections, based on variations in the road's characteristics - such as the number of traffic lanes, posted speed and likely changes in traffic demand. How the roads in Corridor 11 (Wattleup Rd/Rowley Rd, Anketell Rd, and Thomas Rd) were split into subsections is shown in Figure 5-2.

The Zenith model has then been used to produce a number of metrics that, in combination, help define the importance of the various section of Perth's higher order road network, their economic contribution and how efficiently they perform in 2011 and 2031. Such information is important, as it guides transport planners to those portions of the road network that will in the future be generating large economic cost due to congestion, yet still be making a large economic contribution as a result of the number of vehicle-kilometres of travel they accommodate each weekday.

The full set of metrics produced for each subsection of road in each corridor are listed in Table 5-6.

The spreadsheet containing the metrics by road subsection for all the identified corridors in Perth is titled **vlc_yymmdd_02_PER_Corridor Analysis.xlsx**

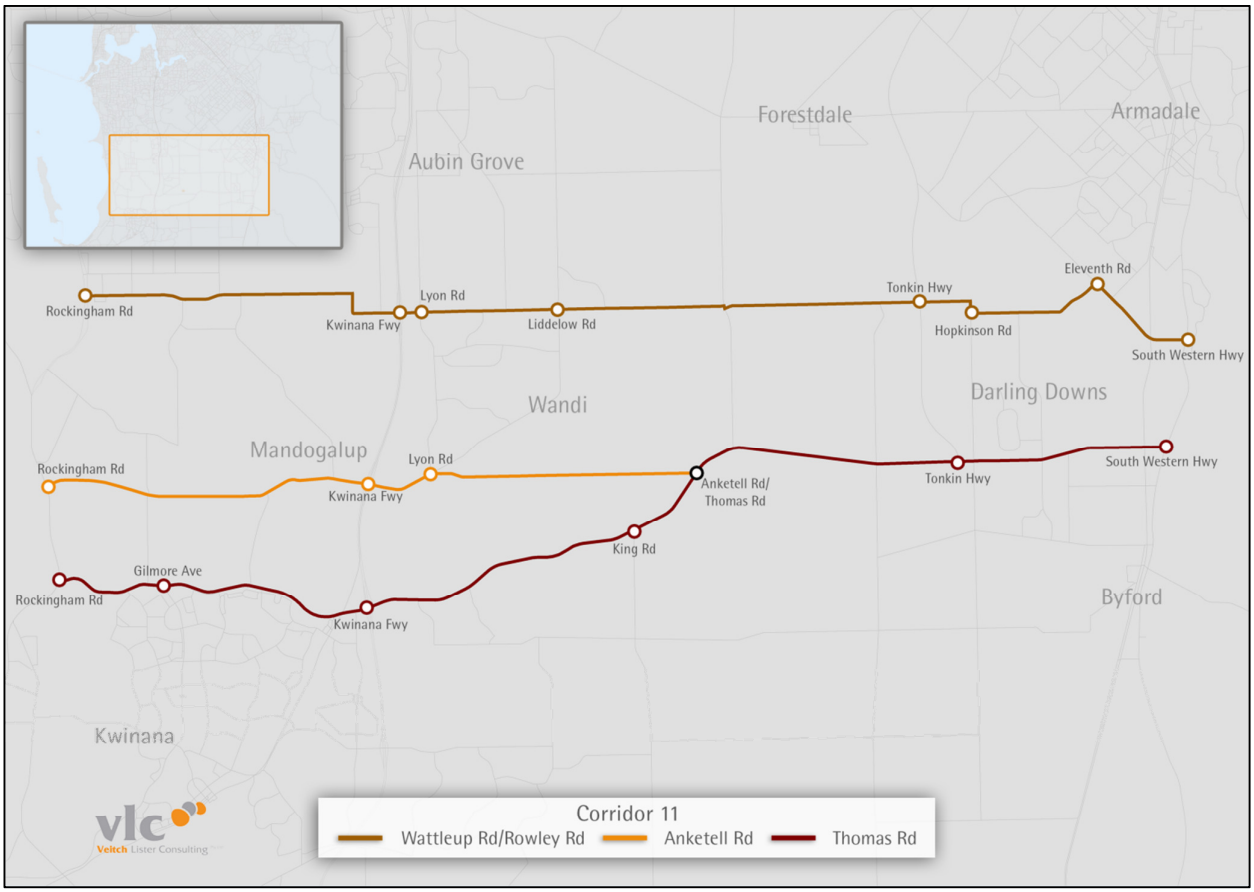



***Figure 5-2: Subsections in Corridor 11 - Wattleup Rd/Rowley Rd, Anketell Rd, Thomas Rd***

### Table 5-6: Metrics reported for major road subsections

| Type | Metric |
|---|---|
| Corridor Type | Corridor Type |
| Length | Total Length (km) |
| Capacities (veh/hr) | Average Hourly Capacity per km |
| Traffic volumes weighted by vehicle kilometers (busiest peak hour) | Average Peak Hour Traffic Volumes<br>Average Peak Hour CV Volumes<br>% Average Peak Hour CV Volumes |
| Traffic speeds under freeflow (modelled) and congested conditions | Average Speed Freeflow (kph)<br>Average Speed Congested (kph) |
| Travel Times under freeflow (modelled) and congested conditions | Total Travel Time Freeflow (min)<br>Total Travel Time Congested (min) |
| Network performance daily | Total Vehicle Kilometers Travelled (km)<br>Total Vehicle Hours Travelled Congested (hrs)<br>Total Vehicle Hours Travelled Freeflow (hrs)<br>Total hours of delay (hrs) |
| Level of Service (Traffic) (busiest peak hour) | Minimum Level of Service<br>Average Level of Service<br>Maximum Level of Service |
| Traffic V/C (busiest peak hour) | Weighted V/C Traffic |

## 5.4 Rail analysis

Based on the seating capacity and crush capacity of Perth's trains (as described in Appendix B), the Zenith model has been used to assess the degree of crowding and overcrowding across the entire rail network.

Passenger loading profiles have been produced for all lines in both the AM and PM peaks for both 2011 and 2031. Examples for the Mandurah Line are presented in Figures 5-3 and 5-4.

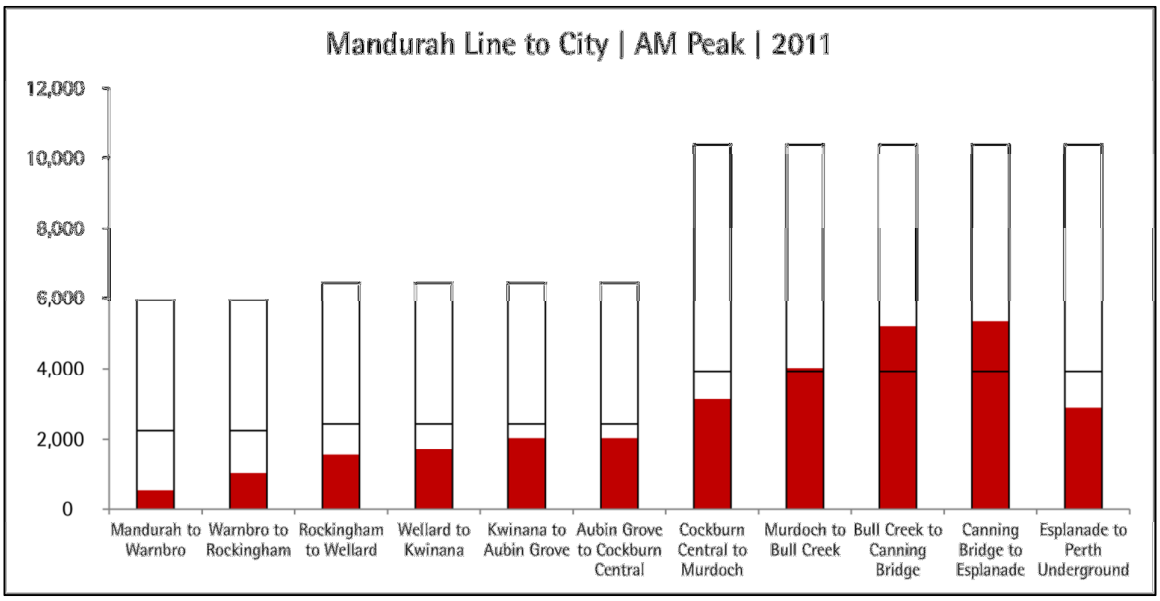



*Figure 5-3: Passenger loading profile - Mandurah Line in the AM peak (2011)*

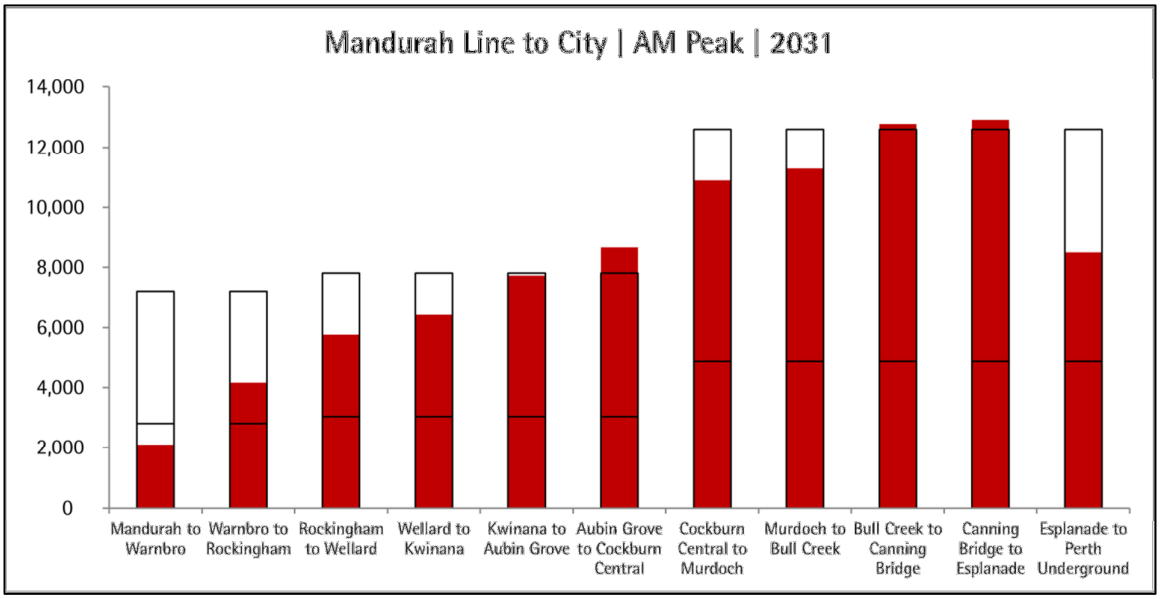



*Figure 5-4: Passenger loading profile - Mandurah Line in the AM peak (2031)*

Passenger load profiles are available for all rail lines, bus routes, and ferry services.

# 6. Changes in travel demand

## 6.1 Introduction

This section of the report provides the Zenith model's travel estimates and forecasts for 2011 and 2031 for the modelled area in aggregate, as well as the model's high level assessment of the performance of the transport network for these two time horizons under a *low transport network investment* scenario. More detailed information on travel demands and network performance at specific locations in the road and public transport networks is provided in Sections 7 and 8 of the report.

## 6.2 Forecast growth in person travel by mode (2011-2031)

Table 6-1 summarises the model's estimates of person trips by mode and by time of day for the modelled area.

***Table 6-1: Change in person travel in the modelled area (2011-2031)***

| Model Statistics | | 2011 | 2031 | Change | % change |
|---|---|---|---|---|---|
| **Person car trips** | AM | 957,497 | 1,649,067 | +691,571 | +72% |
| | OP | 4,795,685 | 8,305,433 | +3,509,748 | +73% |
| | PM | 994,614 | 1,712,961 | +718,347 | +72% |
| | 24H | 6,747,795 | 11,667,461 | +4,919,666 | +73% |
| **PT trips** | AM | 83,209 | 159,965 | +76,755 | +92% |
| | OP | 248,348 | 456,228 | +207,880 | +84% |
| | PM | 66,622 | 131,164 | +64,542 | +97% |
| | 24H | 398,180 | 747,356 | +349,176 | +88% |
| **Walk/cycling trips** | AM | 207,499 | 347,587 | +140,088 | +68% |
| | OP | 1,285,207 | 2,152,910 | +867,703 | +68% |
| | PM | 233,301 | 394,282 | +160,982 | +69% |
| | 24H | 1,726,006 | 2,894,779 | +1,168,773 | +68% |
| **Total trips** | AM | 1,248,205 | 2,156,619 | +908,414 | +73% |
| | OP | 6,329,239 | 10,914,570 | +4,585,331 | +72% |
| | PM | 1,294,537 | 2,238,407 | +943,871 | +73% |
| | 24H | 8,871,980 | 15,309,596 | +6,437,615 | +73% |

As would be expected, motorised travel is dominated by person car trips and relatively stable (approximately 76 percent of person trips are undertaken by car in both 2011 and 2031). Not surprisingly, therefore, the mode split to public transport is relatively stable though rising marginally over this period (from 4.5 to 4.9 percent). Peak period mode share is higher at about 7.0 percent though rising marginally over the period. Walk/cycling trips, in terms of market share, diminish marginally over the period.

## 6.3 Growth in vehicular travel and road network performance in 2011 and 2031

Table 6-2 summarises the major road network performance indicators.

Results in the table indicate:

a) Overall daily vehicular trips increase from approximately 4.8m trips per day in 2011 to 8.3m in 2031 (73 percent)

b) This level of growth is very similar across each of the time periods (that is, by time of day)

c) Car kilometres increase disproportionately (by 92 percent) implying that there is a higher incidence of longer trips (consistent with the demographic forecasts)

d) Vehicle hours also increases disproportionately (by approximately 206 percent) reflecting a significant decline in average network speeds across the network (almost 18 kms/hr)

***Table 6-2: Growth in vehicular travel in the Modelled Area***

| Traffic statistics | | 2011 | 2031 | % change |
|---|---|---|---|---|
| **Car trips** | AM | 667,703 | 1,142,958 | +71% |
| | OP | 3,391,765 | 5,872,852 | +73% |
| | PM | 737,126 | 1,267,773 | +72% |
| | 24h | 4,796,594 | 8,283,582 | +73% |
| **Car kilometres** | AM | 7,014,787 | 13,041,459 | +86% |
| | OP | 32,874,086 | 63,643,794 | +94% |
| | PM | 7,929,779 | 14,958,964 | +89% |
| | 24h | 47,818,653 | 91,644,217 | +92% |
| **Car hours** | AM | 147,318 | 421,745 | +186% |
| | OP | 677,650 | 2,098,648 | +210% |
| | PM | 173,288 | 529,573 | +206% |
| | 24h | 998,256 | 3,049,966 | +206% |
| **Car Average assigned speed (kph)** | AM | 47.6 | 30.9 | -35% |
| | OP | 48.5 | 30.3 | -37% |
| | PM | 45.8 | 28.2 | -38% |
| | 24h | 47.9 | 30.0 | -37% |

| Traffic statistics | | 2011 | 2031 | % change |
|---|---|---|---|---|
| **Commercial Vehicle trips** | AM | 20,777 | 35,563 | +71% |
| | OP | 216,769 | 372,528 | +72% |
| | PM | 24,140 | 41,357 | +71% |
| | 24h | 261,687 | 449,449 | +72% |
| **Commercial Vehicle kilometres** | AM | 339,247 | 627,997 | +85% |
| | OP | 3,518,974 | 6,608,459 | +88% |
| | PM | 393,529 | 733,363 | +86% |
| | 24h | 4,251,750 | 7,969,818 | +87% |
| **Commercial Vehicle hours** | AM | 6,182 | 16,534 | +167% |
| | OP | 65,666 | 197,448 | +201% |
| | PM | 7,581 | 21,914 | +189% |
| | 24h | 79,428 | 235,895 | +197% |
| **Commercial Vehicle Average assigned speed (kph)** | **AM** | 54.9 | 38.0 | -31% |
| | OP | 53.6 | 33.5 | -38% |
| | PM | 51.9 | 33.5 | -36% |
| | 24h | 53.5 | 33.8 | -37% |
| **Total trips** | AM | 688,480 | 1,178,521 | +71% |
| | OP | 3,608,535 | 6,245,380 | +73% |
| | PM | 761,266 | 1,309,130 | +72% |
| | 24h | 5,058,281 | 8,733,031 | +73% |
| **Total kilometres** | AM | 7,354,035 | 13,669,456 | +86% |
| | OP | 36,393,060 | 70,252,253 | +93% |
| | PM | 8,323,308 | 15,692,327 | +89% |
| | 24h | 52,070,403 | 99,614,036 | +91% |
| **Total hours** | AM | 153,499 | 438,279 | *+186%* |
| | OP | 743,316 | 2,296,096 | *+209%* |
| | PM | 180,869 | 551,487 | *+205%* |
| | 24h | 1,077,684 | 3,285,861 | *+205%* |
| **Total Average assigned speed (kph)** | AM | 47.9 | 31.2 | *-35%* |
| | OP | 49.0 | 30.6 | *-38%* |
| | PM | 46.0 | 28.5 | *-38%* |
| | 24h | 48.3 | 30.3 | *-37%* |

## 6.4 Growth in public transport ridership (2011-2031)

Table 6-3 below summarises the modelled base year and the 2031 forecasts for the modelled area in terms of patronage and network supply indicators by mode and by time of day.

The following points are notable:

a) Total PT boardings increase by almost 100 percent over the period; this is in contrast to the 88 percent increase in PT trips (implying a higher level of interchanging is expected to occur).

b) The rate of growth is highest on the rail system (at about 140 percent) which is presumably mainly a function of the fact that the rail system is largely insulated from the effects of congestion as will the rail network extension to Butler.

c) This conclusion is reinforced by the fact that the assumed level of service parameters are changed only moderately.

d) However other contributing factors would include parking charges which have been assumed to increase at an annual rate of 1.5 percent in real terms.

### Table 6-3: Predicted growth in public transport ridership (2011-2031)

| Public transport statistics | | 2011 | 2031 | % change |
|---|---|---|---|---|
| **Total PT boardings** | AM | 97,774 | 199,297 | +104% |
| | OP | 282,351 | 542,969 | +92% |
| | PM | 79,316 | 170,556 | +115% |
| | 24h | 459,441 | 912,822 | +99% |
| **In vehicle passenger kilometres** | AM | 158,595 | 341,010 | +115% |
| | OP | 918,672 | 1,825,094 | +99% |
| | PM | 97,774 | 199,297 | +104% |
| | 24h | 282,351 | 542,969 | +92% |
| **In vehicle passenger hours** | AM | 703,815 | 1,310,203 | +86% |
| | OP | 97,774 | 199,297 | +104% |
| | PM | 282,351 | 542,969 | +92% |
| | 24h | 79,316 | 170,556 | +115% |
| **Total Rail boardings** | AM | 44,057 | 106,382 | +141% |
| | OP | 129,259 | 300,646 | +133% |
| | PM | 41,331 | 107,313 | +160% |
| | 24h | 214,647 | 514,341 | +140% |
| **Total Bus boardings** | AM | 53,652 | 92,766 | +73% |
| | OP | 152,812 | 241,576 | +58% |
| | PM | 37,911 | 63,040 | +66% |
| | 24h | 244,375 | 397,382 | +63% |
| **Total Ferry boardings** | AM | 33 | 74 | +128% |
| | OP | 140 | 373 | +167% |
| | PM | 37 | 102 | +176% |
| | 24h | 209 | 549 | +162% |

Table 6-4 that follows shows the extent to which in-service public transport vehicle-kilometres have been increased in the 2031 network (i.e. marginally).

***Table 6-4: Increase in in-service public transport vehicle-kilometres (2011-2031)***

| Public transport statistics | | 2011 | 2031 | % change |
|---|---|---|---|---|
| **In-Service Kilometres by Rail** | AM | 5,115 | 5,343 | +4% |
| | OP | 21,976 | 22,948 | +4% |
| | PM | 5,196 | 5,401 | +4% |
| | 24h | 32,288 | 33,692 | +4% |
| **In-Service Kilometres by Bus** | AM | 35,726 | 35,875 | - |
| | OP | 133,275 | 133,824 | - |
| | PM | 36,468 | 36,619 | - |
| | 24h | 205,469 | 206,318 | - |
| **In-Service Kilometres by Ferry** | AM | 14 | 14 | - |
| | OP | 54 | 54 | - |
| | PM | 14 | 14 | - |
| | 24h | 82 | 82 | - |

Points to note from Tables 6-4 are as follows:

a) The only measurable increase in service provision is on the rail system associated with the extension to Butler
b) Elsewhere the system has been held virtually constant reflecting the underlying minimalist investment strategy.

# 7. Road network performance

## 7.1 Introduction

This section of the report presents the Zenith model's predictions as to how traffic demand in the Greater Perth Region will increase between 2011 and 2031, and how these predicted increases will affect the performance of the road network under a *low road network investment* scenario that assumes only committed and "highly likely" road projects will be initiated in the future.

## 7.2 Increase in traffic (2011-2031)

Figure 7-1 shows the Zenith model's predicted increases in weekday traffic flows in Perth (shown in dark green) between 2011 and 2031.

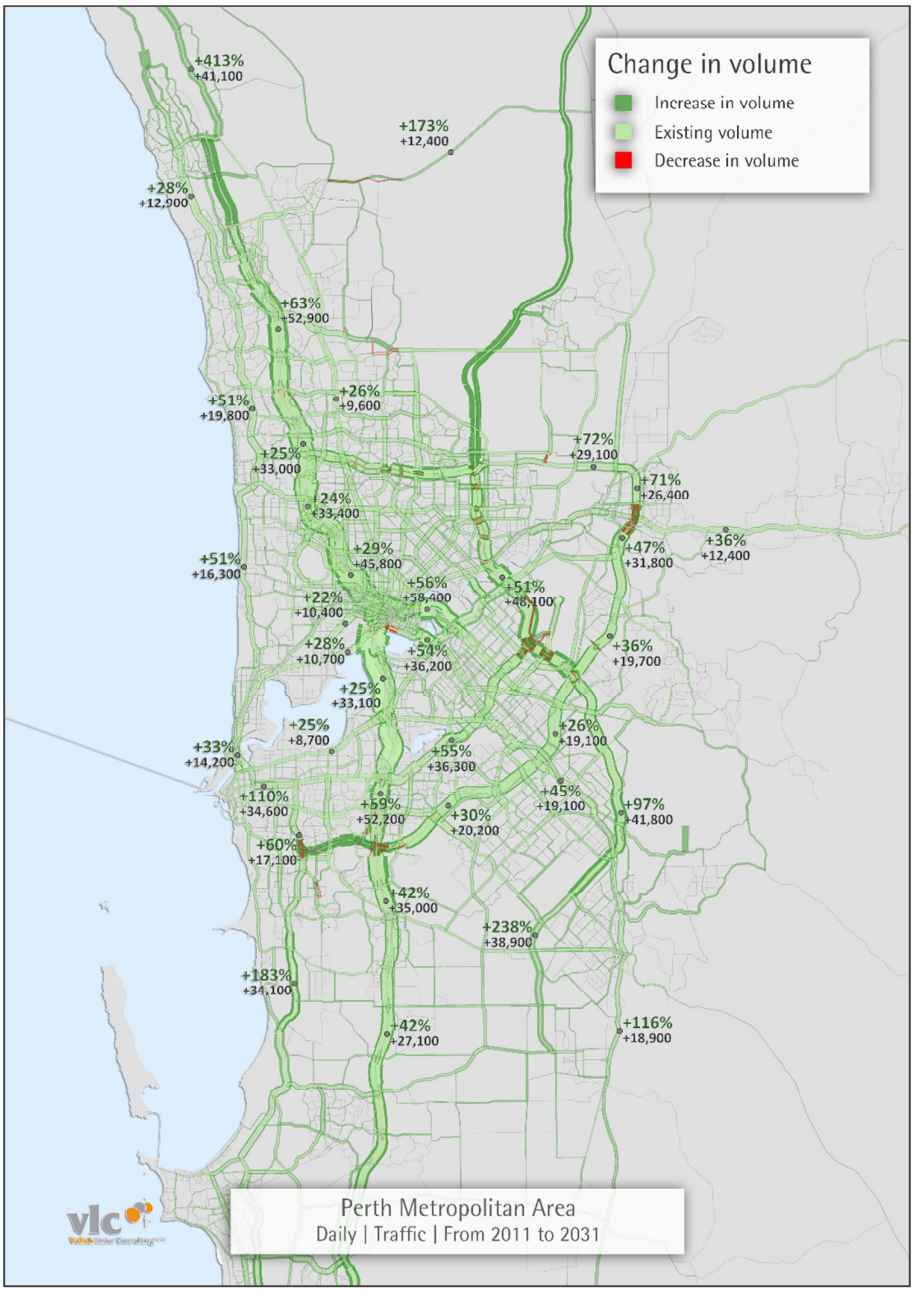



***Figure 7-1: Predicted increase in Perth weekday traffic (2011-2031)***

Weekday traffic levels are expected to increase significantly over current levels between 2011 and 2031 and this is expected to occur throughout the metropolitan area.

Figures 7-2 and 7-3, which relate to the AM and PM peaks respectively, similarly indicate significant increases in peak traffic (the estimates refer to the peak hour).

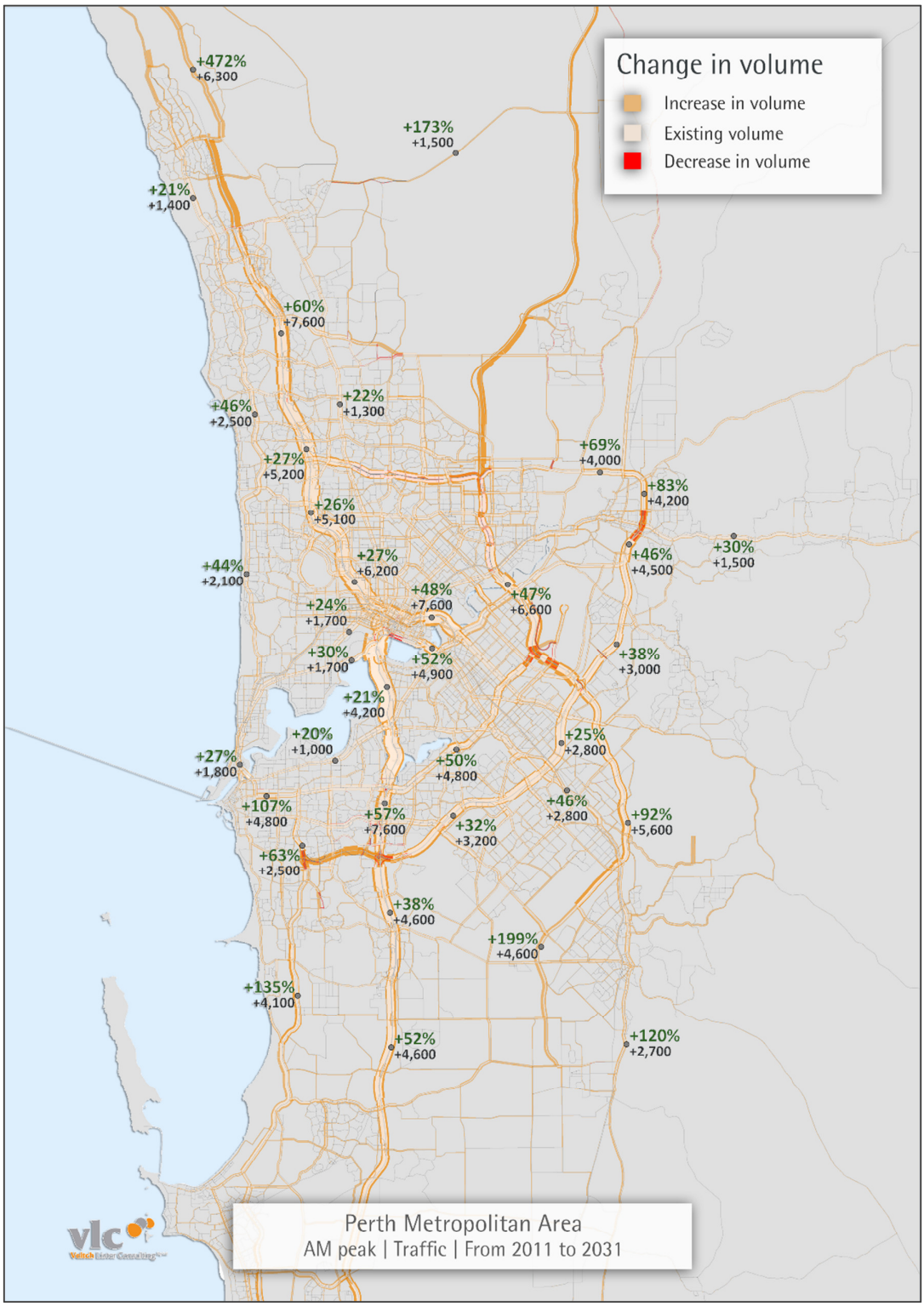



***Figure 7-2: Predicted increase in Perth weekday AM peak traffic (2011-2031)***

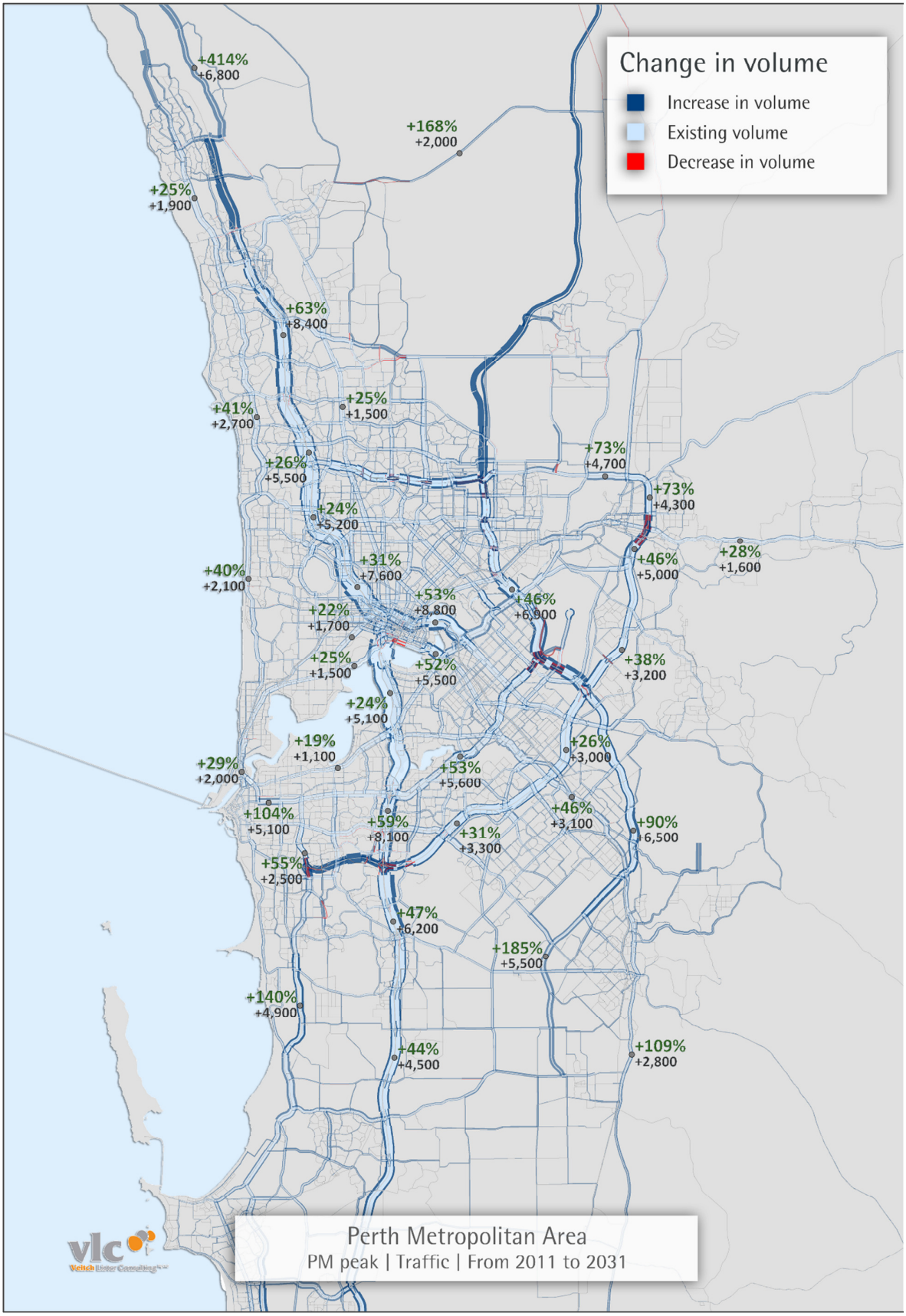



*Figure 7-3: Predicted increase in Perth weekday PM peak traffic (2011-2031)*

## 7.3 Volume/capacity ratios (V/C)

The Zenith model's assessment of the performance of the road network in 2011 and 2031 can be gauged from volume/capacity ratio plots (V/C).

Figure 7-4, 7-5 and 7-6 show the Zenith model's estimates of V/C for the road network in 2011 for the maximum AM peak hour, typical off-peak hour and maximum PM peak hour respectively.

Figures 7-7, 7-8 and 7-9 present the same information for 2031 based on the Zenith model's traffic forecasts.

V/C ratios are used to gauge the level of congestion in the road network. Significant congestion and delays occur at the V/C ratio approaches unity. Should the V/C ratio exceed unity then the excess demand can only be accommodated by drivers choosing to switch to the shoulders of the peak thereby extending the duration of the peak, changing their destination, changing mode, or not making the journey at all.

Referring to Figures 7-4 and 7-6 it is evident that a significant part of Perth's more major roads are already operating at or close to capacity in both peak periods.

The most heavily trafficked road is the Kwinana Fwy which is currently estimated to be operating beyond capacity as are parts of the Albany Hwy. This general observation applies to both the AM and PM peaks.

The position in 2031 (see Figures 7-7, 7-8, and 7-9) is significantly worse in the absence of significant additional road investment. In both the AM and PM peaks most of the network is at or above capacity and would generally be thought of as unsustainable for any period of time.

In 2011, off-peak traffic levels are at an acceptable level but by 2031 the estimates suggest parts of the network would be unacceptably loaded given community expectations of off-peak traffic levels.

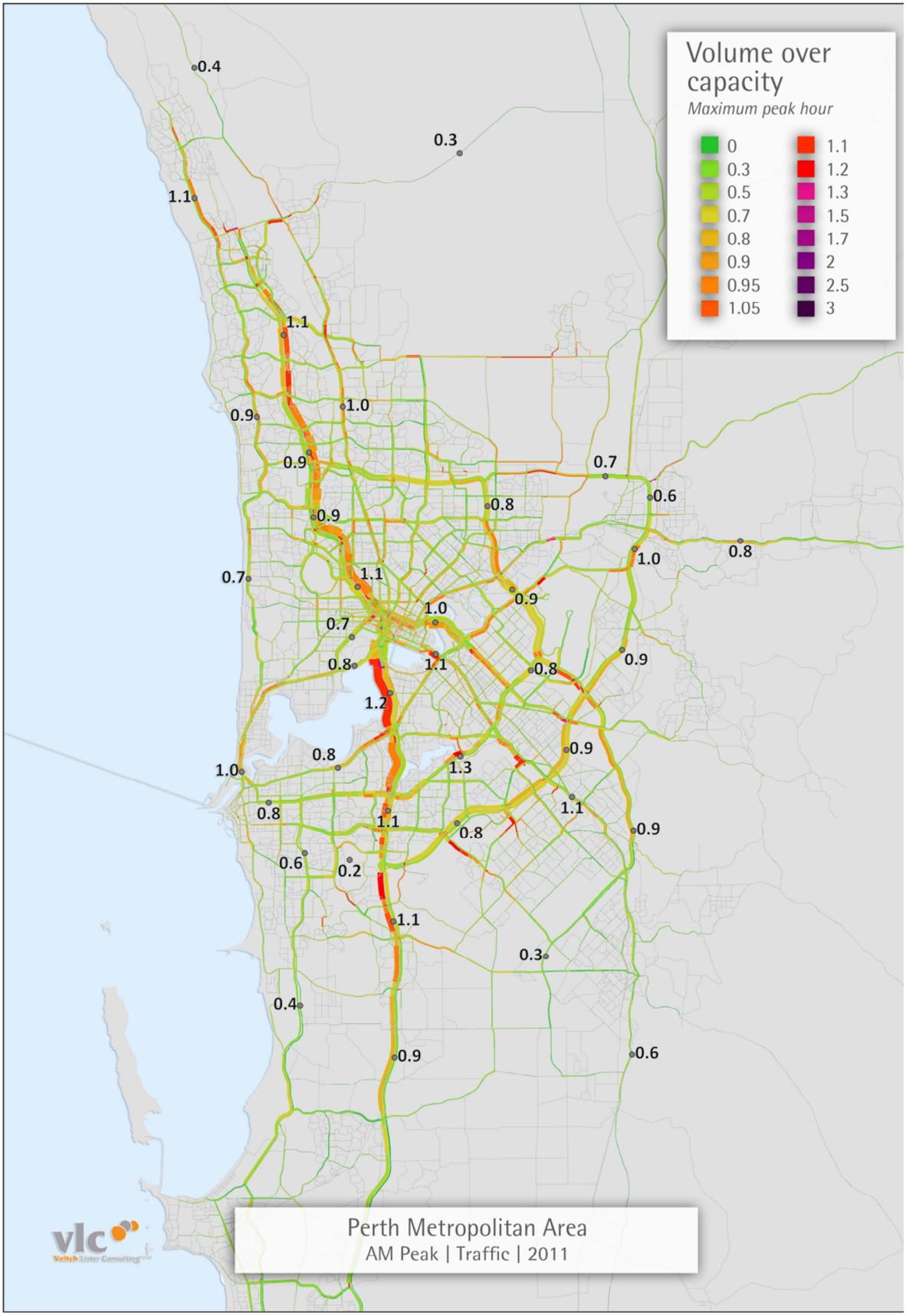



*Figure 7-4: Road network volume/capacity ratios in 2011 - AM maximum peak hour*

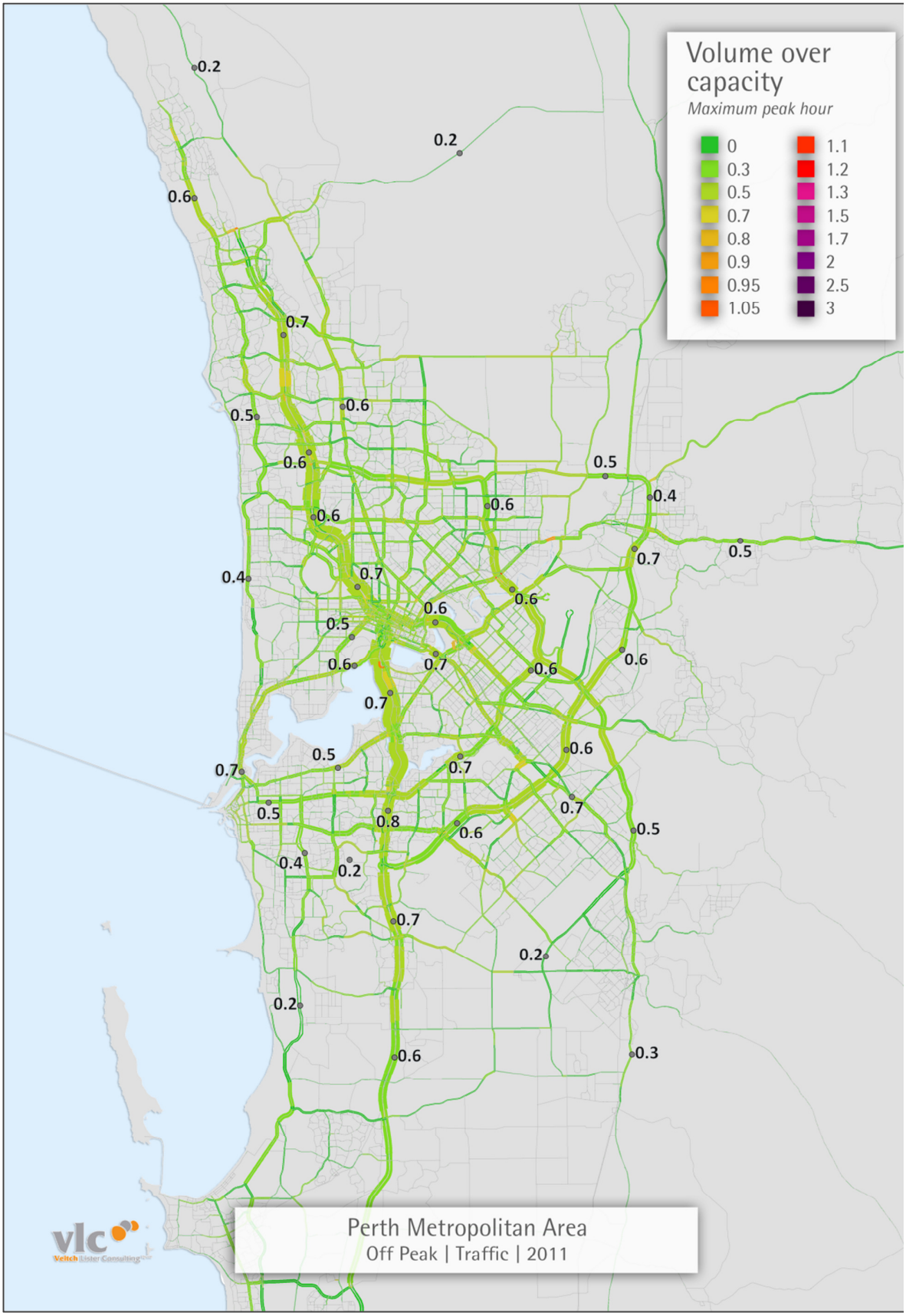



*Figure 7-5: Road network volume/capacity ratios in 2011 - daytime off-peak*

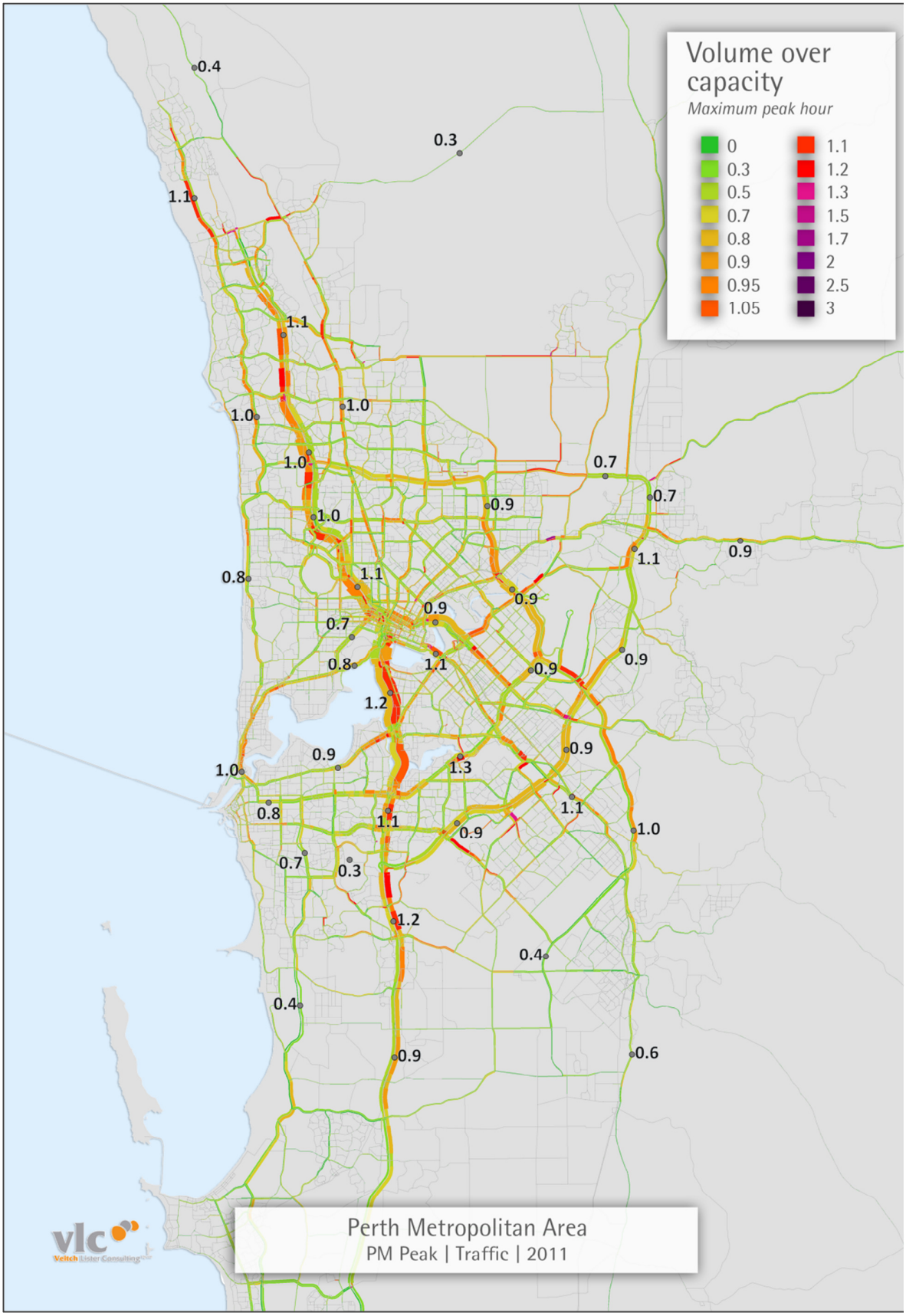



*Figure 7-6: Road network volume/capacity ratios in 2011 - PM maximum peak hour*

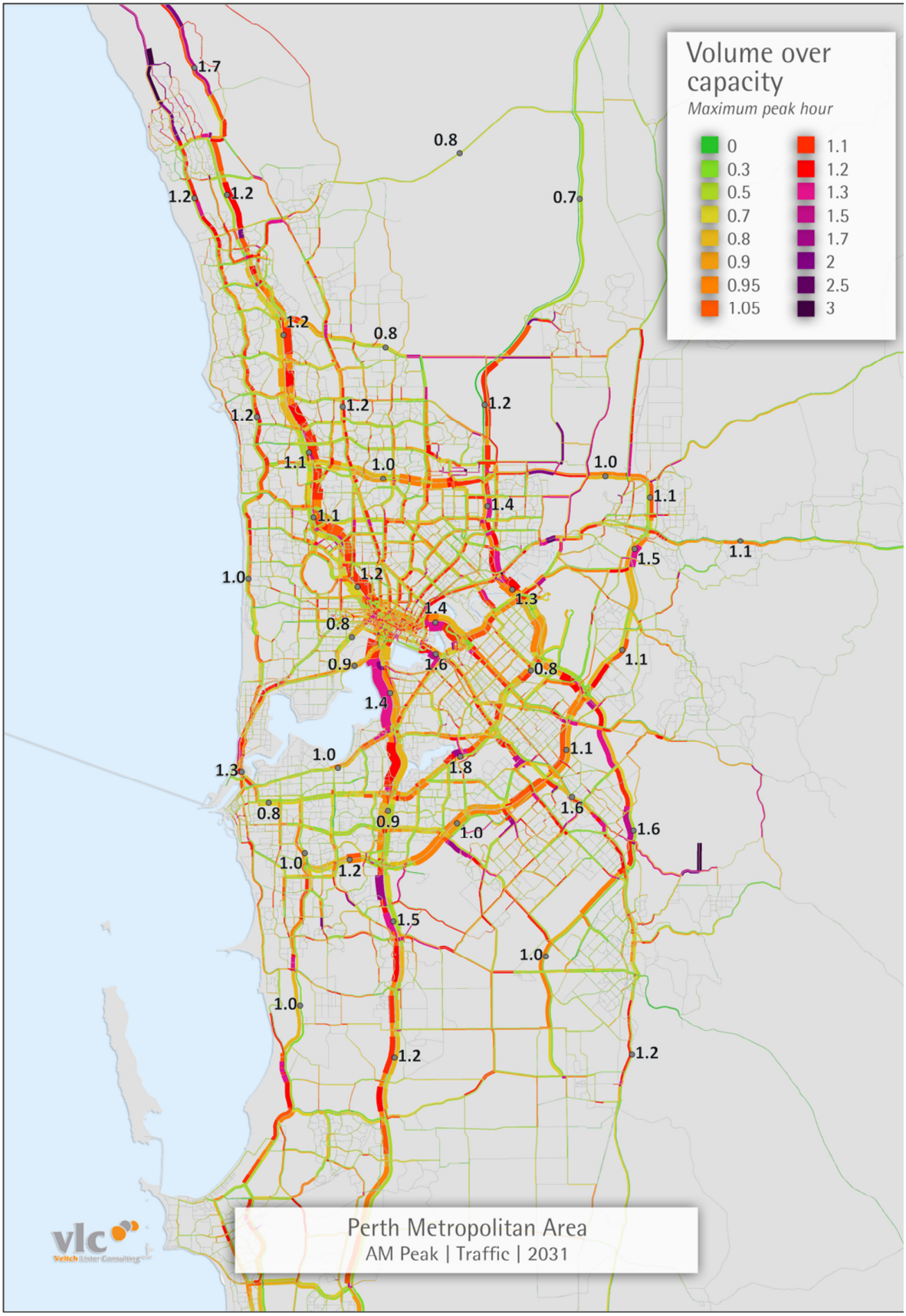



*Figure 7-7: Road network volume/capacity ratios in 2031 - AM maximum peak hour*

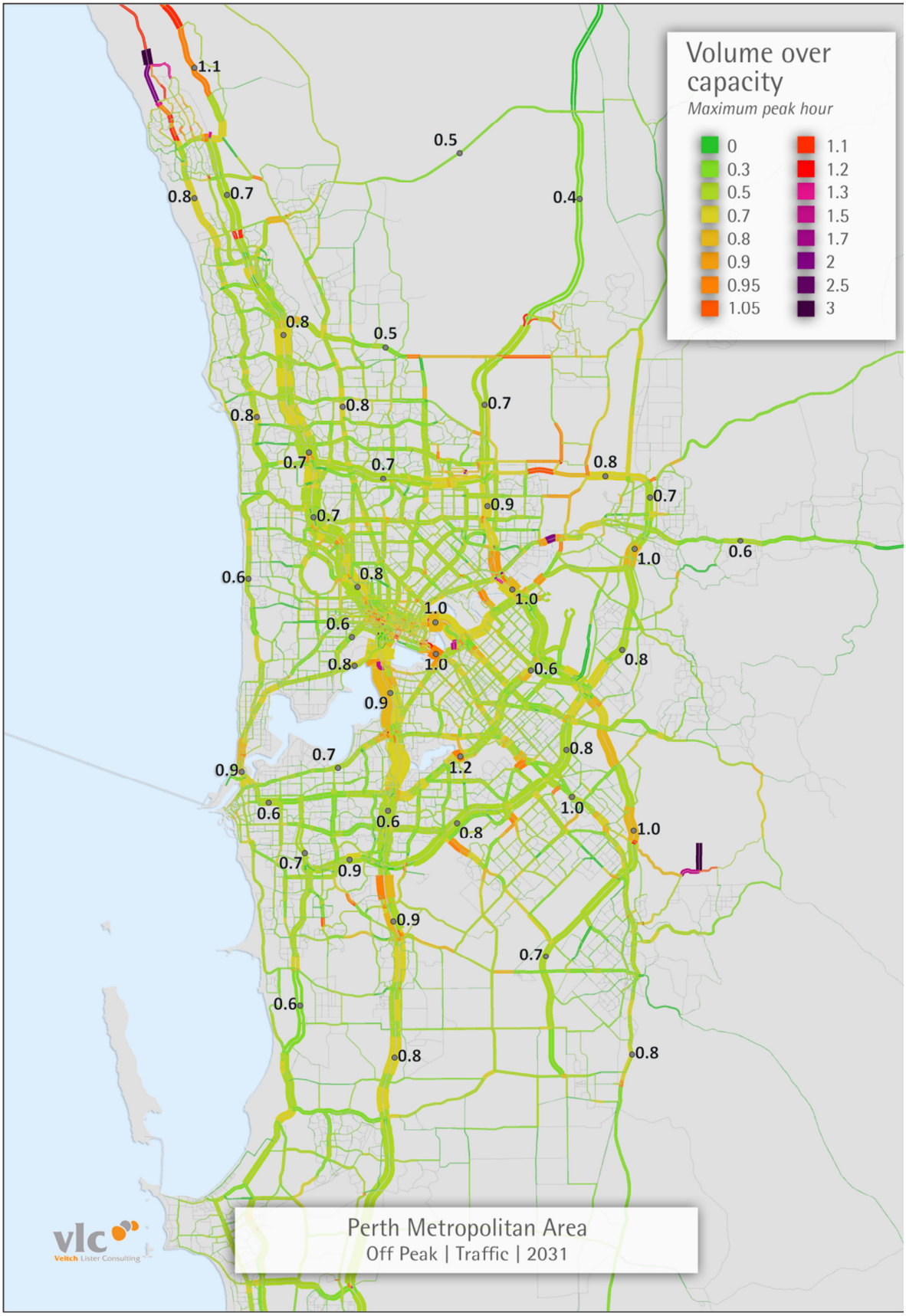



*Figure 7-8: Road network volume/capacity ratios in 2031 - daytime off-peak*

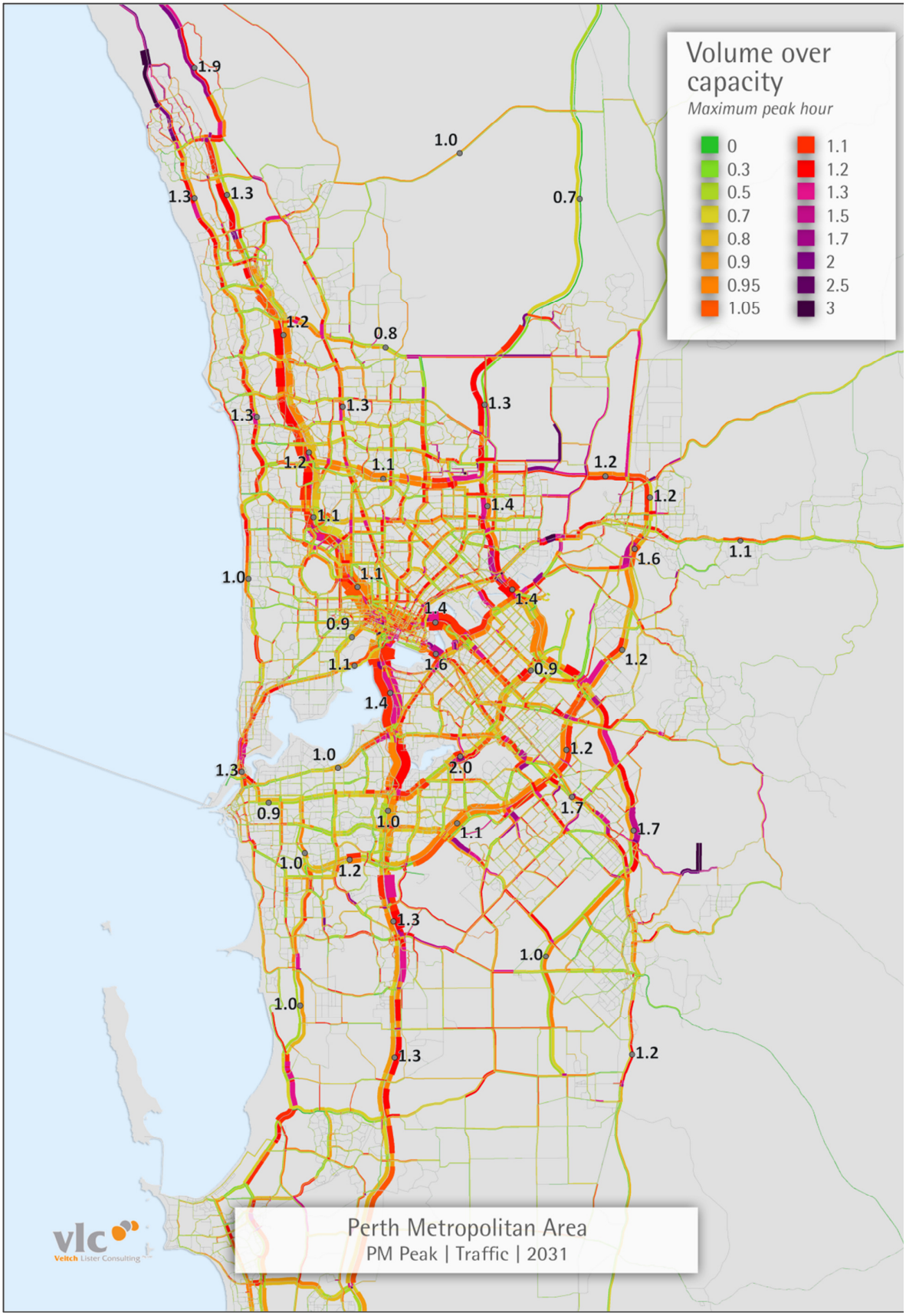



*Figure 7-9: Road network volume/capacity ratios in 2031 - PM maximum peak hour*

## 7.4 Change in travel times (2011-2031)

The analysis of predicted travel time changes are depicted in the following graphics:

- Figures 7-10 and 7-11 for travel to the CBD in 2011 and 2031 respectively.
- Figures 7-12 and 7-13 for travel to the airport
- Figures 7-14 and 7-15 for travel to Fremantle
- These are in reference to the AM peak hour.

All of these figures suggest a significant deterioration in average travel speeds by car to those destinations with the infrastructure investment strategy modelled.

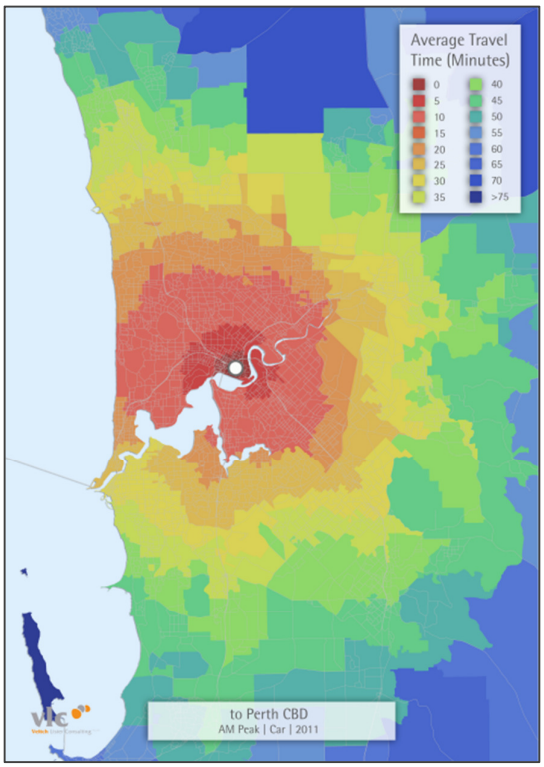



Figure 7-10: To CBD | Road | AM Peak | 2011

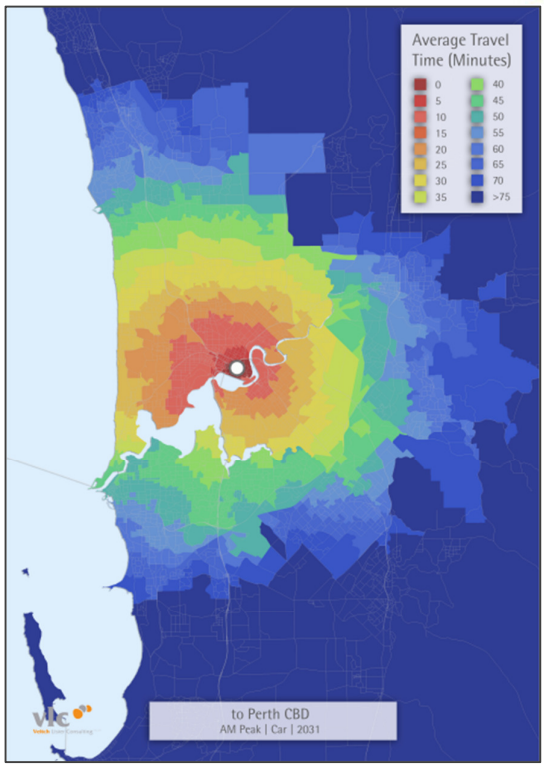



Figure 7-11: To CBD | Road | AM Peak | 2031

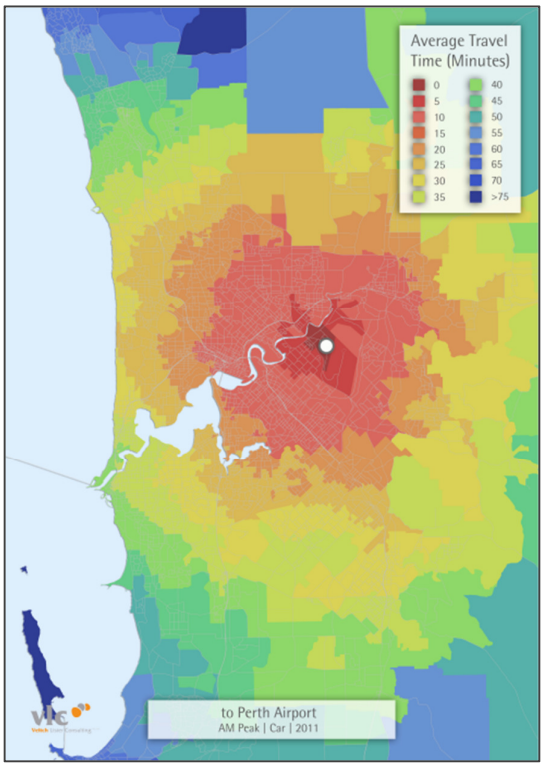



Figure 7-12: To Airport | Road | AM Peak | 2011

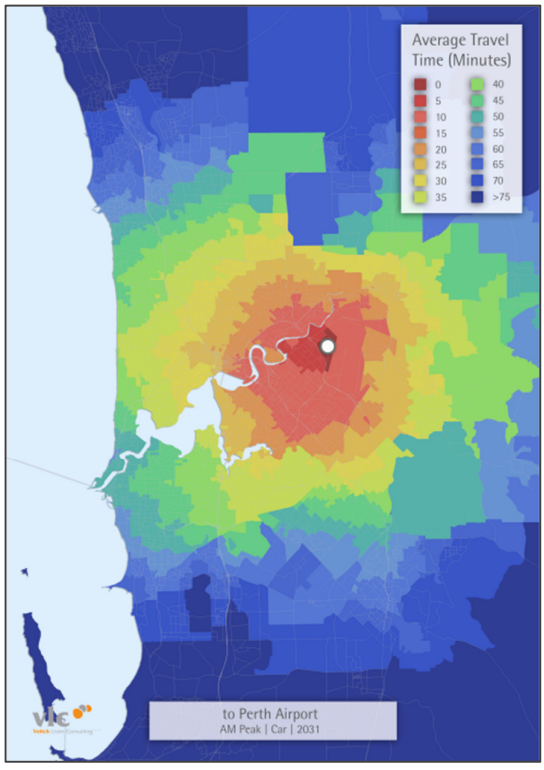



Figure 7-13: To Airport | Road | AM Peak | 2031

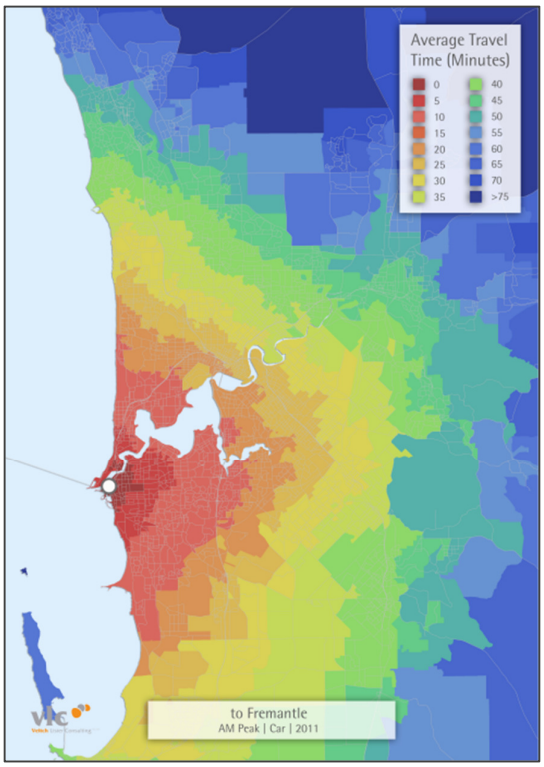



Figure 7-14: To Fremantle | Road | AM Peak | 2011

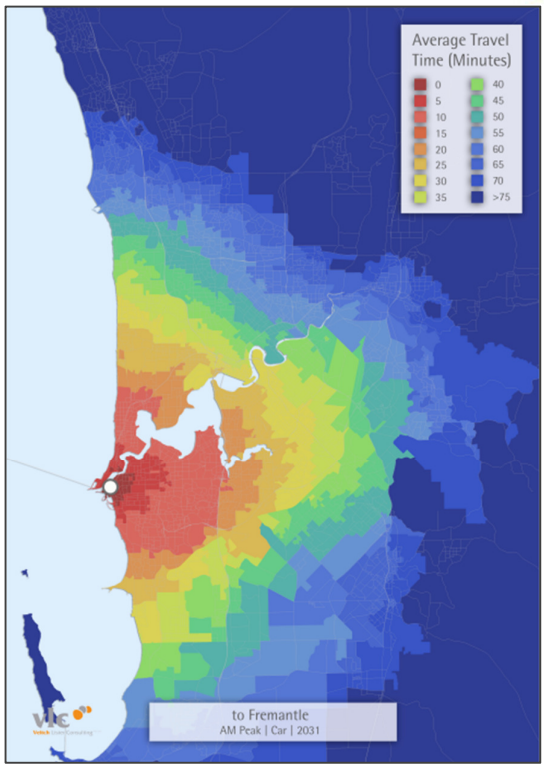



Figure 7-15: To Fremantle | Road | AM Peak | 2031

# 8. Public transport system performance

## 8.1 Introduction

This section of the report presents the Zenith model's predictions as to the extent that public transport ridership will increase in the future in Perth between 2011 and 2031, and how these predicted increases will affect the performance of the public transport system under a *low public transport investment* strategy, that only includes committed and "highly likely" public transport projects.

A conservative assumption has also been adopted regarding public transport service frequencies in that the current frequency of rail services has not been increased. Similarly, the current frequencies of existing bus services have been retained in the 2031 model run.

## 8.2 Forecast increase in demand on the public transport system (2011-2031)

### 8.2.1 Transperth Rail Services

The largest increases in patronage, in absolute terms, are expected to occur on the Joondalup line to the north end and on the Mondurah line to the south. While growth rates on the Armadale, Fremantle and Midland lines are also significant, the biggest call for additional operating capacity will occur on the Joondalup and Mandurah lines. Refer to Figure 8-1.

This is confirmed in the rail capacity analysis (see Section 8.3).

### 8.2.2 Metropolitan Bus Services

Figure 8-2 depicts the forecast changes in weekday bus passenger loadings between 2001 and 2031.

In general terms there is significant growth in bus patronage but not to the same extent as was estimated on the rail system. We believe this would be due, in part, to the effect of very high levels of congestion on the road network. The rail system is largely insulated from the effects of road congestion which directly affects bus operations. This would tip the competitive edge further in the rail direction.

This is most particularly the case on the Kwinana Fwy crossing of the Swan River.

The model's estimates for this section of road are shown in Table 8-1.

| Kwinana Bridge Northbound | 2011 | 2031 | % change |
|---|---|---|---|
| **Bus passengers (Daily)** | 2,020 | 759 | -62% |
| **Rail passengers (Daily)** | 19,167 | 49,176 | +157% |
| **Bus passengers (AM)** | 761 | 269 | -65% |
| **Rail passengers (AM)** | 7,737 | 18,709 | +142% |

Again we believe this would be due to the particularly high level of congestion on the bridge in 2031 (together with the general deterioration in traffic congestion on the network as a whole).

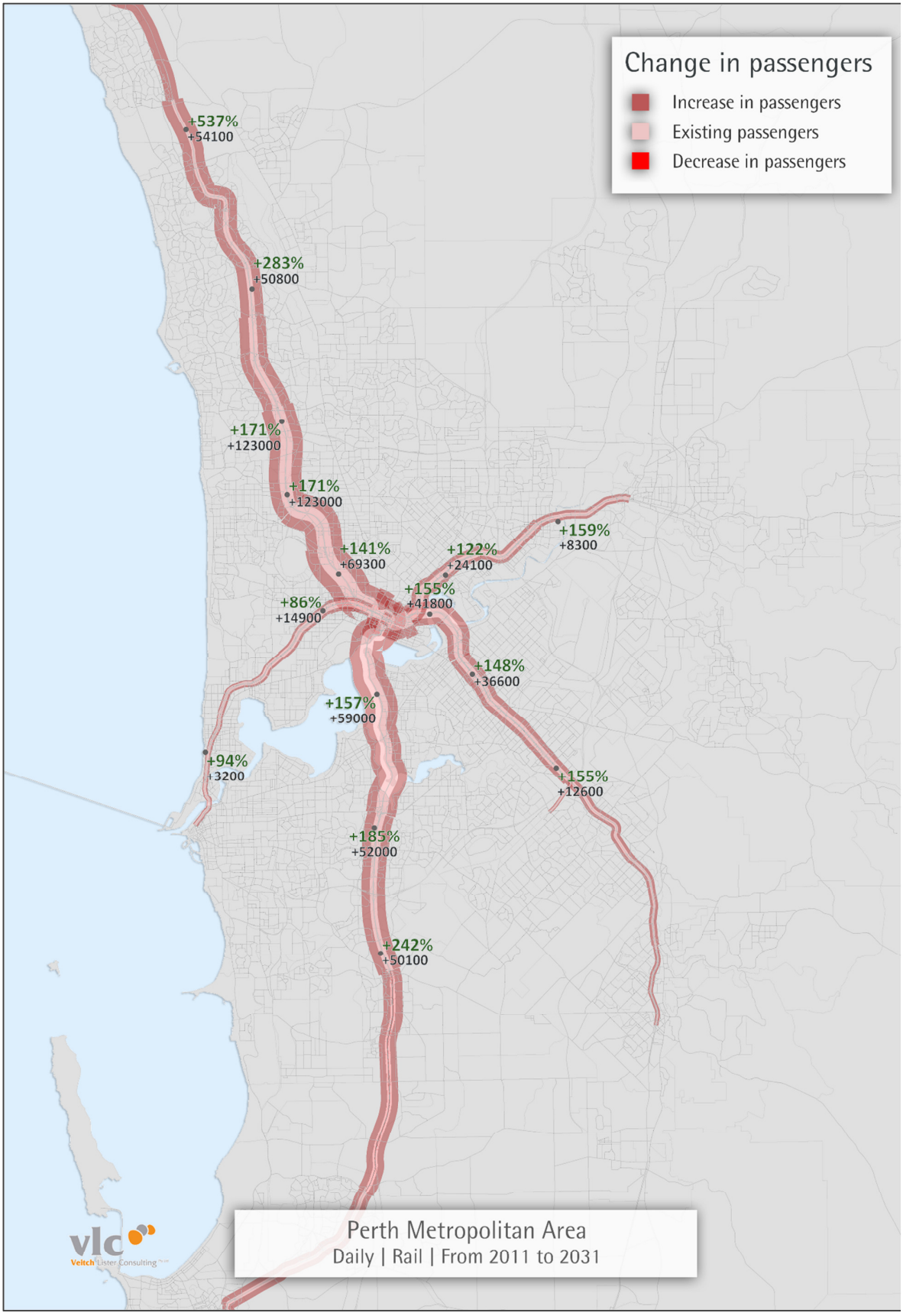



*Figure 8-1: Increase in weekday rail passenger loading (2011-2031)*

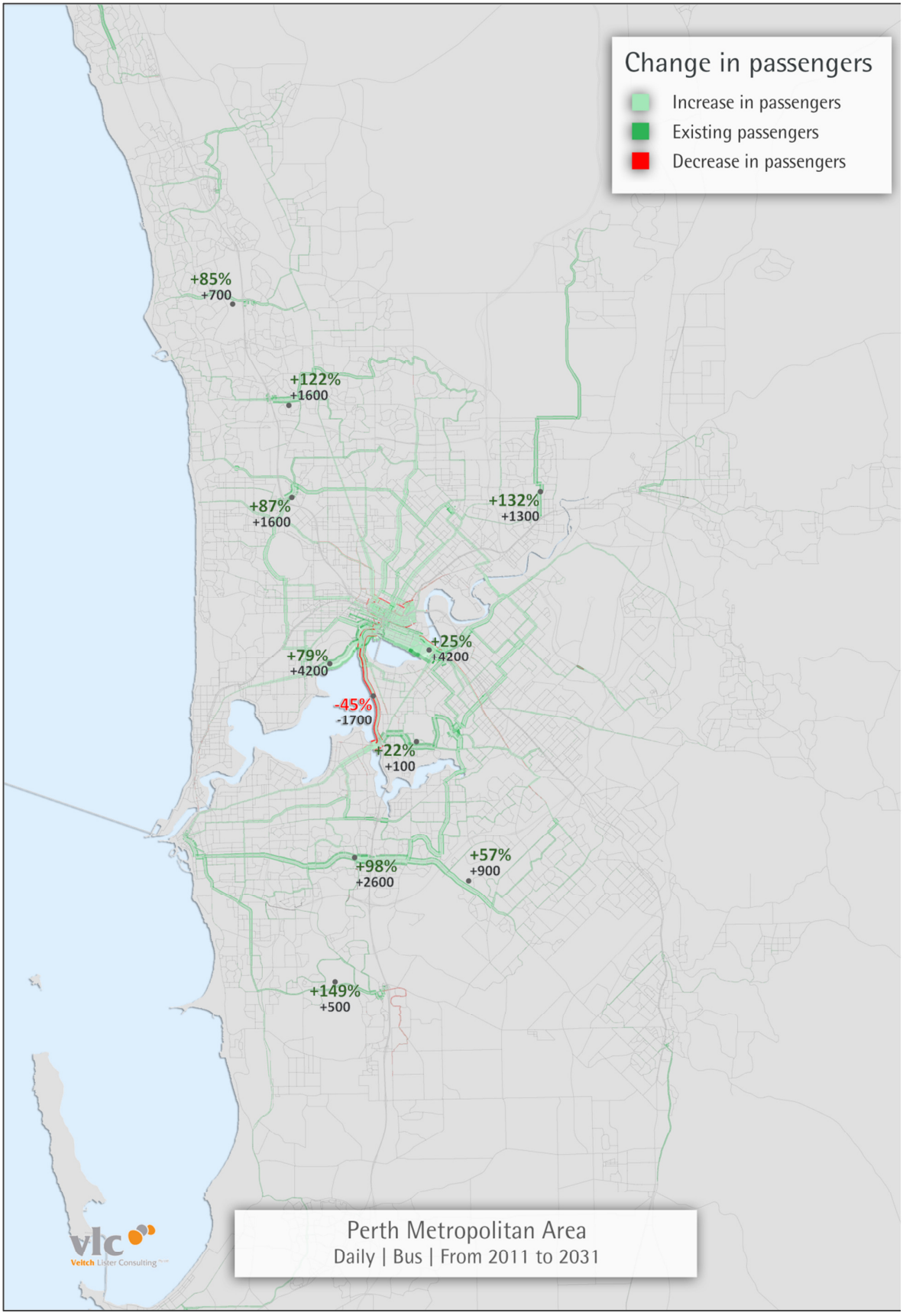



*Figure 8-2: Increase in weekday bus passenger loading (2011-2031)*

## 8.3 Transperth Rail line loadings relative to seating and crush capacity

Figures 8-3 and 8-4 summarise the estimated levels of passenger demand relative to seating capacity and crush capacity in 2011 and 2031.

Expressed in either terms (seating or crush), the estimated loading levels in 2031 would not be acceptable. These estimates refer to the average over the peak hour. There is of course, a peak within the peak, which under these conditions would spread but we would not expect that of itself would result in an operationally sustainable loading condition.

Again the obvious comment would be that maintenance of existing services frequencies in 2031 is not a feasible policy position.

## 8.4 Bus loadings relative to seating and crush capacity

Figures 8-5 and 8-6 present the corresponding estimates for the bus system in Perth.

In terms of seating capacity, the estimates indicate a relatively comfortable position in 2011. In 2031, conditions generally deteriorate somewhat but not to an unacceptable level with the possible exception of Lord St services.

In terms of crush capacity the network is well within the limits (again with the exception of Lord St services) but crush service capacity would not be generally accepted as an appropriate scheduling standard as it leaves no leeway for managing unusual circumstances (e.g. late running, service cancellations etc).

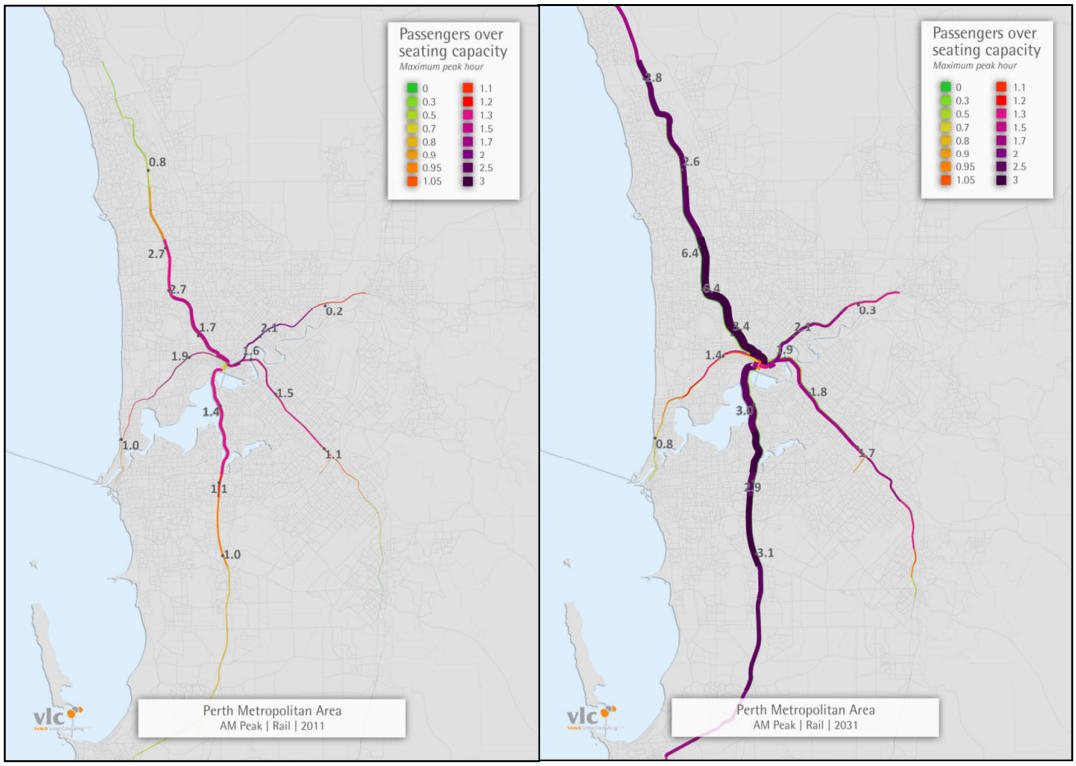



*Figure 8-3: Rail weekday passenger demand relative to seating capacity (2011 and 2031)*

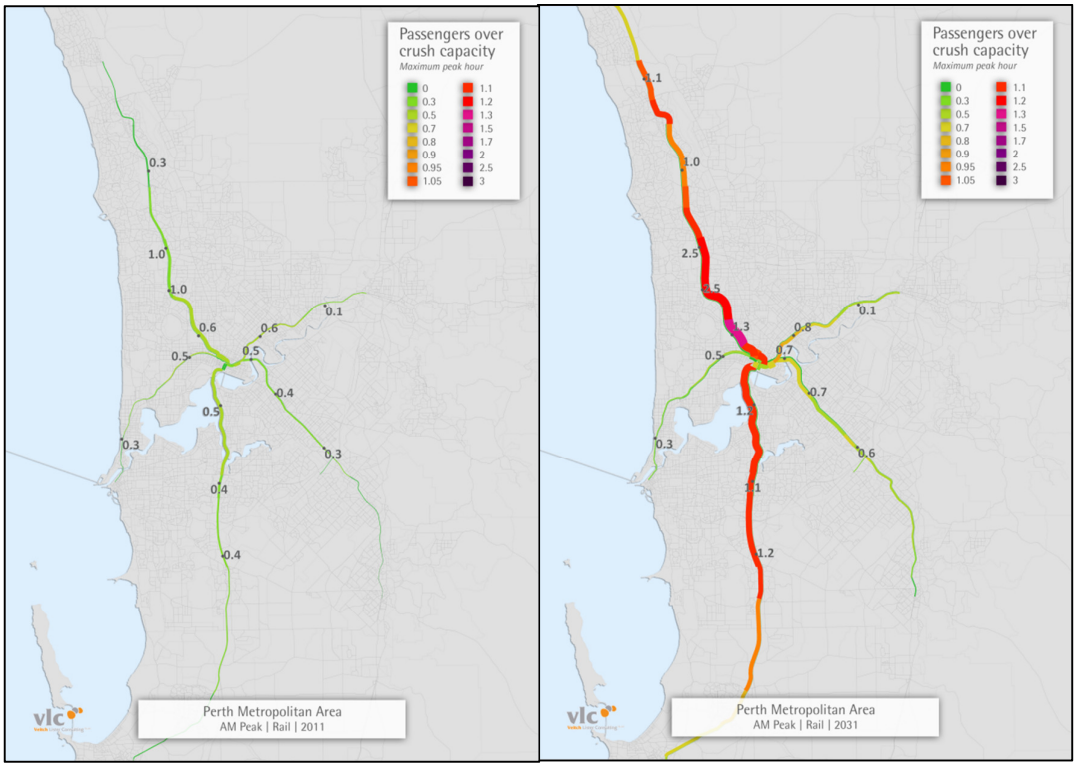



*Figure 8-4: Rail weekday passenger demand relative to crush capacity (2011 and 2031)*

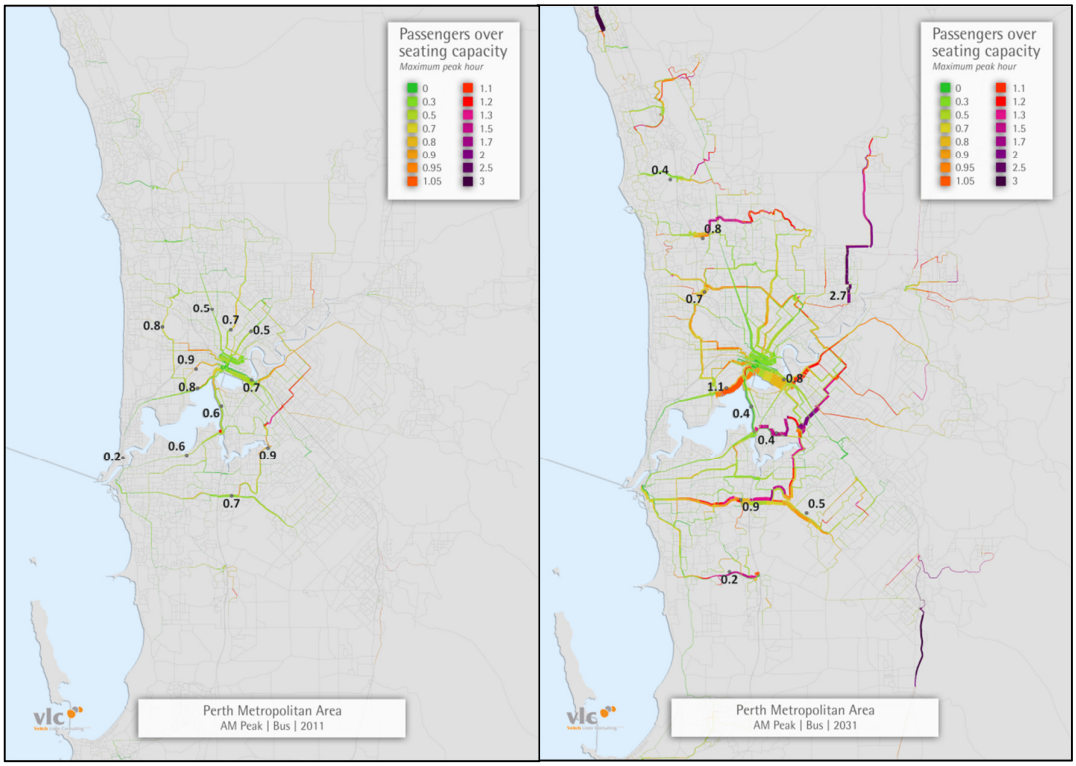



***Figure 8-5: Bus weekday passenger demand relative to seating capacity (2011 and 2031)***

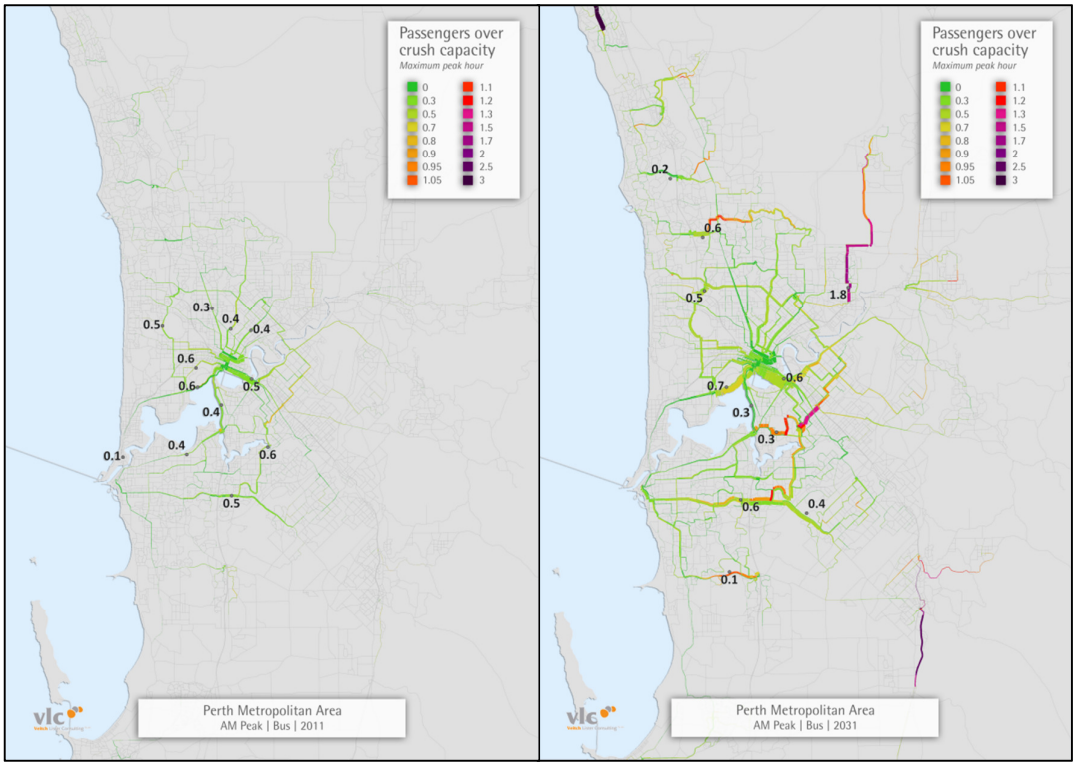



***Figure 8-6: Bus weekday passenger demand relative to crush capacity (2011 and 2031)***

# Appendix A:
# Transport Infrastructure Improvements
# 2031 Base Case Network

## Full list of transport infrastructure improvements included in the 2031 base case network

| Project Nr | Project Description |
|---|---|
| 1 | Great Eastern Highway Upgrade - Kooyong Road to Tonkin Highway<br>Widened from 2 to 3 lanes per direction, with central median for the full length of the upgrade |
| 2 | Spearwood Avenue Upgrade<br>Upgrades to Spearwood Avenue from Barrington Street to Sundlow Road |
| 3 | Great Eastern Highway Upgrade - Great Eastern Highway to Roe Highway Interchange<br>Upgrades to interchange at Great Eastern Highway and Roe Highway |
| 4 | Reid Highway/Mirrabooka Avenue Overpass<br>Grade separation of two intersections between the existing traffic signals on Mirabooka Avenue, allowing higher vehicle capacity assumptions |
| 5 | Kwinana Freeway Widening between Leach and Roe Highways<br>Widening and upgrades to a 4.5 kilometre section of the Kwinana Freeway, allowing higher vehicle capacity assumptions |
| 6 | Murdoch Activity Centre Roads<br>Construction of several local roads in Murdoch as per Murdoch Activity Centre Structure Plan Murdoch Area Roads (University-Hospital-Industrial Area) |
| 7 | Albany Highway Upgrade - John Street to Leach Highway<br>Widening to allow right turns at major intersections |
| 8 | GatewayWA - Roe Highway and Tonkin Highway interchange upgrade<br>Grade separation of intersection at Roe Highway and Tonkin Highway |
| 9 | GatewayWA - Tonkin Highway and Kewdale Road interchange upgrade<br>Grade separation of intersection at Tonkin Highway and Kewdale Road |
| 10 | GatewayWA - Leach Highway and Tonkin Highway interchange upgrade<br>Grade separation of intersection at Tonkin Highway and Leach Highway |
| 11 | GatewayWA - Connection from Tonkin Highway to Perth Airport<br>Construction of a connection from Tonkin Highway to Dunreath Drive, providing Highway access to Perth Airport |
| 12 | Roe Highway Extension<br>Extension from Kartel Avenue to Bibra Drive |
| 13 | Roe Highway Extension<br>Extension from Bibra Drive to North Lake Road |
| 14 | Roe Highway Extension<br>Extension from North Lake Road to Stock Road |
| 15 | Tonkin Hwy on ramp from Abernethy Rd<br>Constrution of a new on ramp to the Tonkin Highway at Abernethy Road |
| 16 | Graham Farmer Freeway Tunnel Upgrade<br>Additional lanes in the Graham Farmer Freeway tunnel between Fitzgerald Street and Lord Street |
| 17 | Mitchell Freeway Widening (Northbound)<br>Hepburn Ave to Hodges Dr widened from 2 to 3 lanes (Northbound Direction Only) |
| 18 | Connolly Drive upgrade as part of Mitchell Freeway Widening<br>Widened from Shenton Avenue to Neerabup Road from 1 to 2 lanes |
| 28 | Mitchell Freeway Widening (Southbound)<br>Hepburn Ave to Hodges Dr widened from 2 to 3 lanes (Southbound Direction Only) |
| 29 | Great Eastern Highway localised improvements<br>Localised improvements from Stoneville Road to Mann Street |
| 30 | Reid Highway Principal Shared Path<br>Construction of a pedestrian/cyclist shared pathway from Mirrabooka Avenue to Camboon Road |
| 31 | Mitchell Freeway Widening (Northbound)<br>Additional lane on Mitchell Freeway northbound from Graham Farmer Freeway to Hutton Street |
| 32 | Guildford Road Principal Shared Path<br>Construction of a pedestrian/cyclist shared pathway from Tonkin Highway to Bassendean Station |
| 33 | Kwinana Freeway Northbound exit ramp realignment<br>Realignment of northbound exit ramp to South Road |
| 34 | Various local roads<br>Construction of various local roads to accommodate additional PT network in 2013 |
| 35 | Perth Stadium to Swan River Pedestrian Bridge<br>Construction of a pedestrian bridge connecting the Perth CBD with the new Perth Stadium |

| | |
|---|---|
| **36** | Hepburn Avenue Extension<br>Extension to Marshall Road |
| **37** | NorthLink WA<br>Construction of a new freeway grade road from the Brand Highway to the Reid/Tonkin Highway interchange |
| **39** | East Wanneroo local access roads<br>Consturction of local roads propose in the East Wanneroo growth area |
| **41** | Leach Highway (High Street) Fremantle Project<br>Upgrade the section of High Street between Carrington Street and Stirling Highway to a 4 lane dual carriageway standard; Realignment of the intersection of High Street and Stirling Highway, creating a continuous route at the eastern leg of the new Leach Highway and Stirling Highway; Upgraded pedestrian and cyclist access from Marmion Street to Carrington Street along the route and including at the major intersections. |
| **42** | Mitchell Freeway Extension - Burns Beach Road to Hester Avenue<br>Extension of the Mitchell Freeway to Hester Avenue; Extension of Neerabup Road to Wanneroo Road; Upgrades to Hester Avenue from Wanneroo Road to Hidden Valley Retreat |
| **43** | Reid Highway Duplication<br>Duplication of Reid Highway from Erindale Road to Duffy Road |
| **44** | Beaufort Street 2-way conversion<br>Beaufort Street converted to 2-way operation from Roe Street to Newcastle Street |
| **45** | William Street 2-way conversion<br>William Street converted to 2-way operation from Roe Street to Newcastle Street |
| **46** | Murray Street 2-way conversion stage 1<br>Murray Street converted to 2-way operation - Stage 1 from Barrack Street to Pier Street |
| **47** | Murray Street 2-way conversion stage 2<br>Murray Street converted to 2-way operation - Stage 2 from William Street to Elder Street |
| **48** | Murray Street 2-way conversion stage 3<br>Murray Street converted to 2-way operation - Stage 3 from Elder Street to Thomas Street |
| **49** | Mounts Bay Road 2-way conversion<br>Mounts Bay Road converted to 2-way operation from Mill Street to William Street |
| **50** | Barrack St 2-way conversion<br>Barrack St converted to 2-way operation from St Georges Terrace to Wellington Street |
| **51** | Roe Highway Extension<br>Widening of the Kwinana Freeway in the southbound from Roe Highway to Armadale Road, part of the Roe Highway extension package |
| **52** | Reid Highway - Lord Street Intersection Upgrade |
| **53** | Greenslands Road Realignment<br>Greenslands Road realigned to connect with new South Western Highway roundabout |
| **54** | GatewayWA - Roe Highway and Berkshire Road interchange upgrade<br>Interchange at Berkshire and Roe Highway converted to a diamond interchange |
| **56** | Riverside Dr Closure<br>Permanent closure of Riverside Dr between Barrack St and William St |

# Appendix B:
# Public transport capacity assumptions

# Transperth Capacity Coding

The coding of Transperth fleet seating capacities was based on manual counts of seats from online photos and videos of the interiors of both the A-Series and B-Series trains.

Crush capacities were derived from a State Government of Western Australia media statement; http://www.mediastatements.wa.gov.au/pages/StatementDetails.aspx?listName=StatementsBarnett&StatId=7675. This provided an estimated crush capacity of 200 passengers per carriage, regardless of the rolling stock. For A-Series trains, this equates to a crush-to-seating-capacity ratio of around 360% - a number largely achievable through the exclusive use of longitudinal seating on these trains.

The Transperth August 2012 railcar allocation timetables were used to determine which services were operated by which rolling stock. While this website made it clear that railcar allocations in 2012 were different to those in 2011, VLC felt that in the absence of more relevant information, it would provide a reasonable indication of supply on each line.

From the railcar allocation, the proportion of each type of service (two, three, four or six-car sets) could be determined for each line, direction (inbound or outbound) and time period. This allowed the proportional combination of seating and crush capacities to find a typical service for each of these combinations.

In the 2031 model, A-Series trains were assumed to have been retired from service. Services which were operated by two-car sets in 2011 were assumed to be operated by three-car B-Series sets in 2031; likewise, four-car sets in 2011 were operated by six-car sets in 2031.

Line loading graphs (see section 5.4) were used to determine where demand exceeded crush capacity (the Joondalup, Mandurah and, to a lesser extent, Midland lines) when averaged across each peak period. In these cases, three-car sets were replaced with six-car services incrementally. Consequently, the Joondalup and Mandurah lines' passenger capacities were outstripped by demand even assuming 100% of peak-hour services were operated by six-car sets. The Midland line required one additional six-car service in the AM peak in order to avoid overcrowding issues.

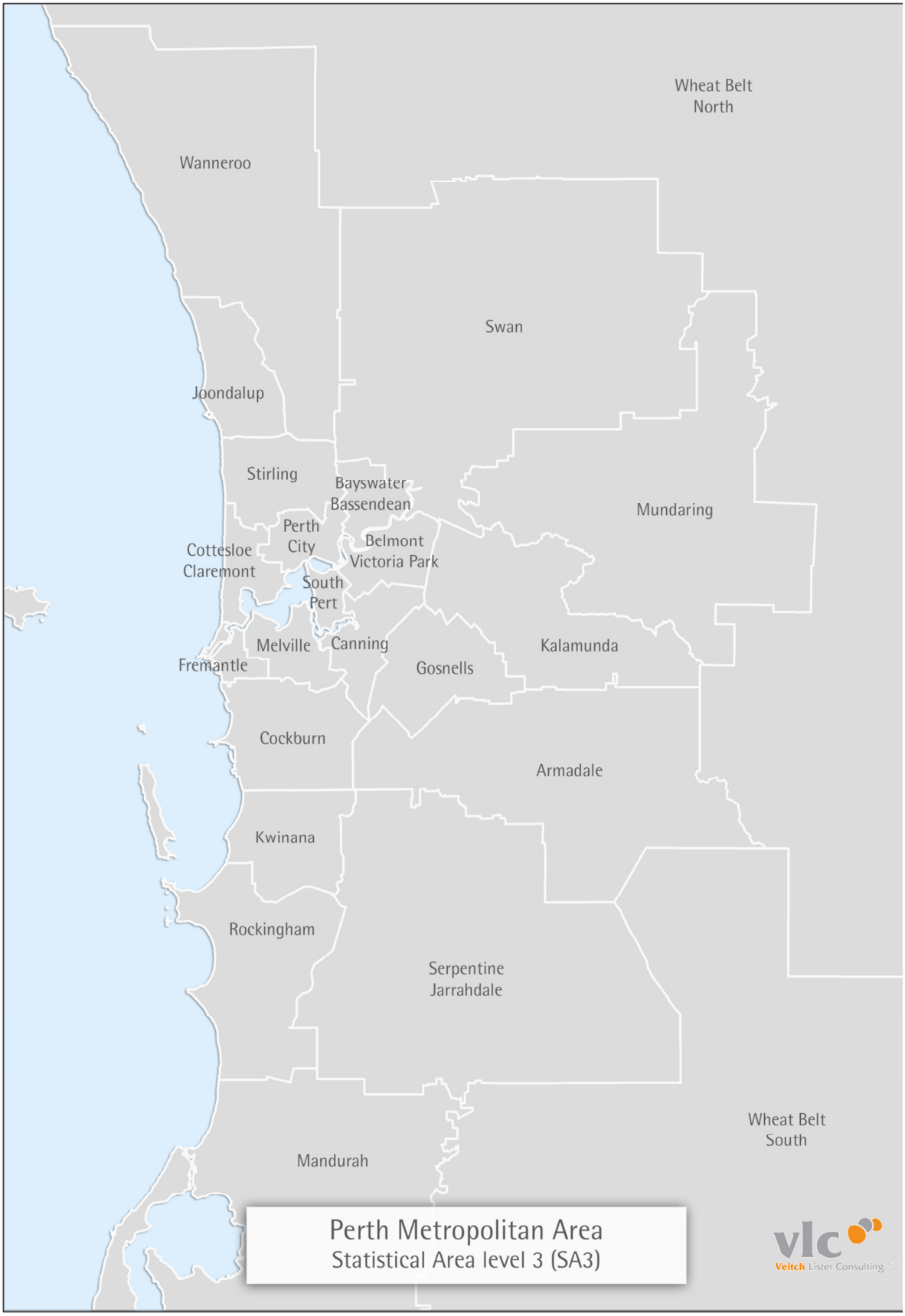
## Passenger Capacity by Line (Seating/Crush)

| | | Perth-Armadale | Armadale-Perth | Perth-Clarkson | Clarkson-Perth | Perth-Fremantle | Fremantle-Perth | Perth-Mandurah | Mandurah-Perth | Perth-Midland | Midland-Perth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | AM | 186 / 635 | 186 / 640 | 374 / 991 | 377 / 1008 | 160 / 571 | 164 / 585 | 373 / 1000 | 374 / 991 | 205 / 733 | 205 / 733 |
| | Off Peak | 172 / 607 | 176 / 618 | 337 / 884 | 335 / 878 | 168 / 600 | 168 / 600 | 338 / 886 | 337 / 890 | 224 / 800 | 220 / 786 |
| | PM | 165 / 589 | 175 / 625 | 378 / 992 | 368 / 967 | 157 / 560 | 157 / 560 | 368 / 967 | 378 / 992 | 224 / 800 | 224 / 800 |
| **2031** | AM | 356 / 918 | 361 / 930 | 466 / 1200 | 466 / 1200 | 333 / 857 | 341 / 877 | 415 / 1070 | 466 / 1200 | 427 / 1100 | 447 / 1150 |
| | Off Peak | 350 / 900 | 354 / 911 | 356 / 916 | 352 / 907 | 350 / 900 | 350 / 900 | 355 / 914 | 361 / 930 | 466 / 1200 | 458 / 1179 |
| | PM | 356 / 916 | 364 / 938 | 466 / 1200 | 388 / 1000 | 326 / 840 | 326 / 840 | 466 / 1200 | 398 / 1025 | 466 / 1200 | 466 / 1200 |

## Bus System Capacity Coding

The levels of capacity adopted were a seated load of 45 passengers with a crush capacity of 65 passengers.

# Appendix C:
# ABS Statistical Areas level 3




***Perth Metropolitan Area SA3s***