Veitch Lister Consulting Pty Ltd

Greater Sydney Travel Modelling Report

October 2014

PREPARED FOR
Infrastructure Australia

www.veitchlister.com.au

Greater Sydney – Travel modelling report

Project No. 14-011

Date	Revision	Prepared By	Checked By	Approved By	Description
16/10/2014	B	MV/MJ	JM	MV	Final Draft Report
13/11/2014	C	MV/MJ	MV	MV	Final Report

Contents

List of Figures

List of Tables

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 Sydney 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 of the Greater Sydney Region, Newcastle and Wollongong.

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 Greater Sydney 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 Greater Sydney 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 Sydney, Newcastle and Wollongong 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 Sydney, 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 larger Sydney metropolitan area including the Hunter and Illawarra 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 information, and New South Wales Department of Planning and Environment to confirm growth expectations in the larger Sydney 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 Sydney GCCSA dataset have been developed using the ABS Series B population projections. The population dataset is constrained to Department of Planning and Environment 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. The Hunter and Illawarra regions are constrained to ACIL Allen's demographic projections for 2031 at SA4 level.

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 Tourism New South Wales.

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 Sydney 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 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 Sydney, 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 Sydney. 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 Sydney by SA3.

2.3 Population

2.3.1 Population characteristics and projections for the Greater Sydney Capital Area

The Greater Sydney Capital Area is comprised of 47 SA3's. These areas vary widely in nature, from inner city urban areas with very high population densities (around 4,500 people per square kilometre is typical in inner-Sydney SA3s) 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 Sydney.

Table 2-1 provides population estimates for the Greater Sydney Capital Area SA3's for 2011 and 2031.

The table also shows the absolute growth in population and the equivalent average annual growth rate.

Table 2-1: Population estimates and projection for the Sydney GCCSA by SA3

SA3	2011	2031	Growth	%	AAGR
Sydney Inner City	189,000	294,100	+105,100	+56%	2.2%
Eastern Suburbs - North	130,900	157,700	+26,700	+20%	0.9%
Marrickville - Sydenham - Petersham	55,900	67,300	+11,500	+21%	0.9%
Leichhardt	55,700	65,500	+9,900	+18%	0.8%
Strathfield - Burwood - Ashfield	142,700	193,500	+50,800	+36%	1.5%
Botany	41,700	58,900	+17,300	+41%	1.7%
Eastern Suburbs - South	137,700	171,700	+34,000	+25%	1.1%
Kogarah - Rockdale	128,900	167,300	+38,400	+30%	1.3%
Canterbury	132,100	162,700	+30,600	+23%	1.0%
Hurstville	122,900	155,800	+33,000	+27%	1.2%
Cronulla - Miranda - Caringbah	104,600	124,800	+20,300	+19%	0.9%
Sutherland - Menai - Heathcote	112,100	134,600	+22,400	+20%	0.9%
Liverpool	108,800	169,700	+60,900	+56%	2.2%
Campbelltown	154,900	238,700	+83,800	+54%	2.2%
Bankstown	167,200	195,900	+28,700	+17%	0.8%
Merrylands - Guildford	142,700	186,300	+43,600	+31%	1.3%
Auburn	78,800	121,500	+42,700	+54%	2.2%
Fairfield	183,500	223,300	+39,800	+22%	1.0%
Bringelly - Green Valley	84,400	138,500	+54,100	+64%	2.5%
Penrith	128,900	188,700	+59,800	+46%	1.9%
Camden	51,600	130,000	+78,400	+152%	4.7%
Blue Mountains - South	3,500	4,700	+1,200	+34%	1.5%
Wollondilly	36,800	51,200	+14,500	+39%	1.7%
Canada Bay	78,200	105,800	+27,600	+35%	1.5%
Pennant Hills - Epping	44,800	56,800	+12,000	+27%	1.2%
Carlingford	62,400	91,800	+29,400	+47%	2.0%
Ryde - Hunters Hill	125,800	166,800	+41,000	+33%	1.4%
Parramatta	130,100	186,100	+56,000	+43%	1.8%
Blacktown	128,400	188,400	+60,000	+47%	1.9%

SA3	2011	2031	Growth	%	AAGR
Richmond - Windsor	35,800	46,700	+10,900	+30%	1.3%
St Marys	54,000	79,200	+25,200	+47%	1.9%
Hawkesbury	25,900	33,300	+7,400	+29%	1.3%
Blue Mountains	77,200	91,600	+14,300	+19%	0.9%
Rouse Hill - McGraths Hill	28,700	42,000	+13,300	+46%	1.9%
Mount Druitt	107,800	158,300	+50,500	+47%	1.9%
Blacktown - North	77,300	114,100	+36,700	+47%	2.0%
North Sydney - Mosman	95,000	115,400	+20,300	+21%	1.0%
Chatswood - Lane Cove	106,300	135,900	+29,600	+28%	1.2%
Ku-ring-gai	114,700	147,500	+32,700	+29%	1.3%
Hornsby	79,900	97,900	+18,000	+23%	1.0%
Dural - Wisemans Ferry	25,800	36,100	+10,300	+40%	1.7%
Baulkham Hills	140,400	209,700	+69,300	+49%	2.0%
Manly	42,600	52,200	+9,600	+23%	1.0%
Warringah	147,500	174,200	+26,700	+18%	0.8%
Wyong	154,000	200,800	+46,800	+30%	1.3%
Pittwater	60,200	82,100	+21,900	+36%	1.6%
Gosford	167,700	190,600	+22,900	+14%	0.6%
Total Greater Sydney (Sydney GCCSA)	***4,605,800***	***6,205,700***	**+1,599,900**	**+35%**	**1.5%**

In 2011, the population within the Greater Sydney Capital Area was approximately 4.6 million. By 2031 the population is forecast to reach just over 6 million.

The New South Wales Regional Growth Plan for Metropolitan Sydney and each of the local authority plans envisage a shift in the pattern of growth towards the outer municipalities of Greater Sydney, which are forecast to attract an increasing share of population growth to 2031. The North West and South West Growth Centres take up a high portion of this growth. The Bringelly & Green Valley and Camden SA3's grow by more than 130,000 residents in the period between 2011 to 2031 with capacity to spare.

Figure 2-1 shows how State and Local Government planning intentions translate into population growth across the Sydney region in the period 2011-2031, by presenting a spatial representation of growth by small areas.

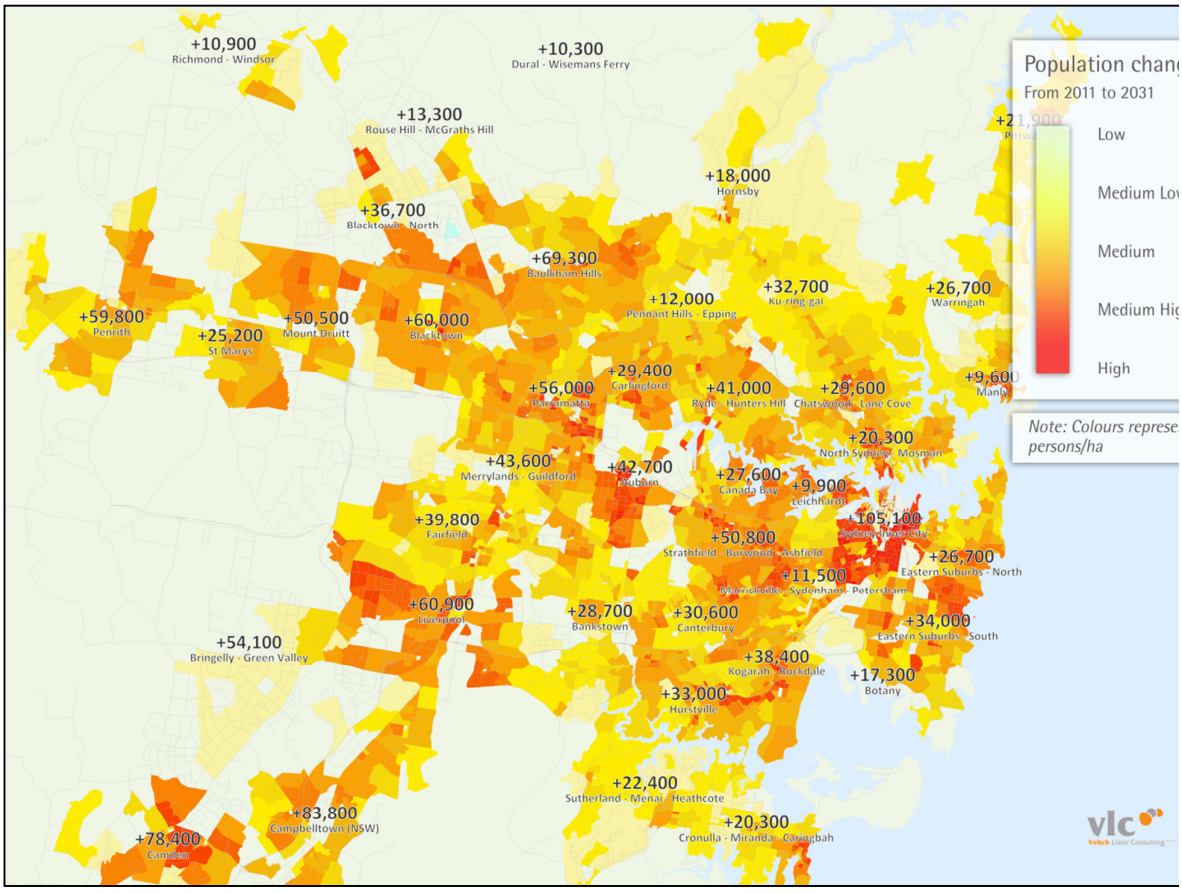


Figure 2-1: Projected population growth in the Greater Sydney Region (2011 – 2031)

2.3.2 Population characteristics and projections for the Hunter and Illawarra regions

The Hunter region includes the Newcastle and Lake Macquarie SA4 and the Hunter Valley excluding Newcastle SA4. A total of 7 SA3's are included in this area. The Illawarra region comprises 4 SA3's.

The following sections summarise the population characteristics and projections for SA3's in the Hunter and Illawarra regions.

Table 2-2 provides population estimates for the Hunter and Illawarra SA3's for 2011 and 2031.

The table also shows the absolute growth in population and the equivalent average annual growth rate.

Table 2-2: Population estimates and projection for Hunter and Illawarra by SA3

SA3	2011	2031	Growth	%	AAGR
Newcastle	158,100	208,700	+50,600	+32%	1.4%
Lake Macquarie - East	123,200	143,900	+20,700	+17%	0.8%
Lake Macquarie - West	72,700	84,300	+11,600	+16%	0.7%
Maitland	66,300	99,100	+32,700	+49%	2.0%
Port Stephens	71,800	100,500	+28,700	+40%	1.7%
Lower Hunter	84,500	107,300	+22,900	+27%	1.2%
Upper Hunter	30,500	36,000	+5,500	+18%	0.8%
Total Hunter Region	***607,100***	***779,800***	***+172,700***	***+28%***	***1.3%***
Wollongong	126,000	139,700	+13,700	+11%	0.5%
Dapto - Port Kembla	72,200	83,700	+8,500	+11%	0.5%
Illawarra Catchment Reserve	160	180	+20	+11%	0.5%
Kiama - Shellharbour	86,900	117,100	+30,200	+35%	1.5%
Total Illawarra Region	***288,300***	***340,700***	***+72,600***	***+18%***	***0.8%***

The Hunter and Illawarra regions grow slightly slower than the Sydney area at 1.3% and 0.8% per annum respectively (versus the Sydney GCCSA at 1.5% per annum). The highest growth is expected in the Maitland SA3 in the Hunter Valley which will grow to just under 100,000 residents by 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 NSW State government.

2.4.1 Employment characteristics and projections for the Greater Sydney Capital Area

The Zenith model projects employment across a range of industries and occupations for Sydney. 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.

The New South Wales Regional Growth Plan aims to achieve extension and consolidation of the Global Economic Corridor (Port Botany, Sydney CBD, North Sydney, Macquarie Park, Northwest Business Park and Parramatta) to maintain its position as the strongest cluster of specialised service sector jobs in Australia. The plan also aims to boost the regional cities of Parramatta, Liverpool and Penrith as major employment and service hubs.

As seen in table 2-3, strong employment growth is expected to occur across the Sydney region. In particular, strong growth is expected in the Bringelly - Green Valley SA3 as part of the South West Growth Centre and the Western Sydney Employment Area. Strong growth is also expected in the Sydney CBD with an additional 185,000 jobs anticipated over the 20 year period to 2031.

Other areas of strong growth are Parramatta, Blacktown, Kogarah and Fairfield that all grow at around 2% per annum. Over the whole of Sydney the average annual growth rate is 1.7%.

Table 2-3: Employment estimates and projection for the Sydney GCCSA by SA3

SA3	2011	2031	Growth	%	AAGR
Sydney Inner City	475,800	660,800	+185,100	+39%	1.7%
Eastern Suburbs - North	48,900	60,700	+11,800	+24%	1.1%
Marrickville - Sydenham - Petersham	23,400	28,200	+4,800	+21%	0.9%
Leichhardt	23,000	31,500	+8,500	+37%	1.6%
Strathfield - Burwood - Ashfield	56,600	79,000	+22,400	+40%	1.7%
Botany	65,000	87,500	+22,500	+35%	1.5%
Eastern Suburbs - South	43,400	58,600	+15,200	+35%	1.5%
Kogarah - Rockdale	33,300	53,800	+20,500	+61%	2.4%
Canterbury	28,200	37,600	+9,300	+33%	1.4%
Hurstville	28,300	35,900	+7,600	+27%	1.2%
Cronulla - Miranda - Caringbah	40,600	46,600	+6,000	+15%	0.7%
Sutherland - Menai - Heathcote	27,300	33,800	+6,500	+24%	1.1%
Liverpool	53,000	80,200	+27,200	+51%	2.1%
Campbelltown (NSW)	48,000	73,400	+25,400	+53%	2.1%
Bankstown	61,000	91,300	+30,200	+49%	2.0%
Merrylands - Guildford	49,600	79,400	+29,800	+60%	2.4%
Auburn	56,100	74,200	+18,100	+32%	1.4%
Fairfield	52,300	81,100	+28,900	+55%	2.2%
Bringelly - Green Valley	12,500	36,100	+23,600	+188%	5.4%
Penrith	47,400	68,900	+21,500	+45%	1.9%
Camden	17,400	28,800	+11,400	+66%	2.6%
Blue Mountains - South	900	2,100	+1,200	+146%	4.6%
Wollondilly	10,200	16,400	+6,200	+61%	2.4%
Canada Bay	32,400	40,200	+7,700	+24%	1.1%
Pennant Hills - Epping	12,100	16,400	+4,300	+35%	1.5%
Carlingford	20,700	31,300	+10,500	+51%	2.1%
Ryde - Hunters Hill	87,600	93,000	+5,400	+6%	0.3%
Parramatta	93,100	138,900	+45,800	+49%	2.0%

SA3	2011	2031	Growth	%	AAGR
Blacktown	45,800	67,600	+21,900	+48%	2.0%
Richmond - Windsor	18,100	27,000	+8,900	+49%	2.0%
St Marys	16,500	20,200	+3,700	+22%	1.0%
Hawkesbury	4,700	8,200	+3,500	+74%	2.8%
Blue Mountains	19,200	23,800	+4,600	+24%	1.1%
Rouse Hill - McGraths Hill	9,700	19,600	+9,900	+103%	3.6%
Mount Druitt	42,000	58,100	+16,100	+38%	1.6%
Blacktown - North	11,900	26,000	+14,000	+118%	4.0%
North Sydney - Mosman	81,100	102,500	+21,400	+26%	1.2%
Chatswood - Lane Cove	83,400	115,000	+31,600	+38%	1.6%
Ku-ring-gai	32,500	41,500	+9,000	+28%	1.2%
Hornsby	29,000	36,600	+7,600	+26%	1.2%
Dural - Wisemans Ferry	10,500	13,400	+2,900	+27%	1.2%
Baulkham Hills	54,900	72,500	+17,600	+32%	1.4%
Manly	13,600	17,600	+4,000	+30%	1.3%
Warringah	56,200	73,200	+17,000	+30%	1.3%
Wyong	46,400	65,200	+18,800	+41%	1.7%
Pittwater	22,500	28,800	+6,300	+28%	1.2%
Gosford	60,100	81,400	+21,300	+35%	1.5%
Greater Sydney (Sydney GCCSA)	***2,206,200***	***3,063,900***	**+857,700**	**+39%**	**1.7%**

Figure 2-2 shows how State and Local Government planning intentions translate into employment growth across the Sydney region during the period 2011-2031, by presenting the data spatially by small areas.

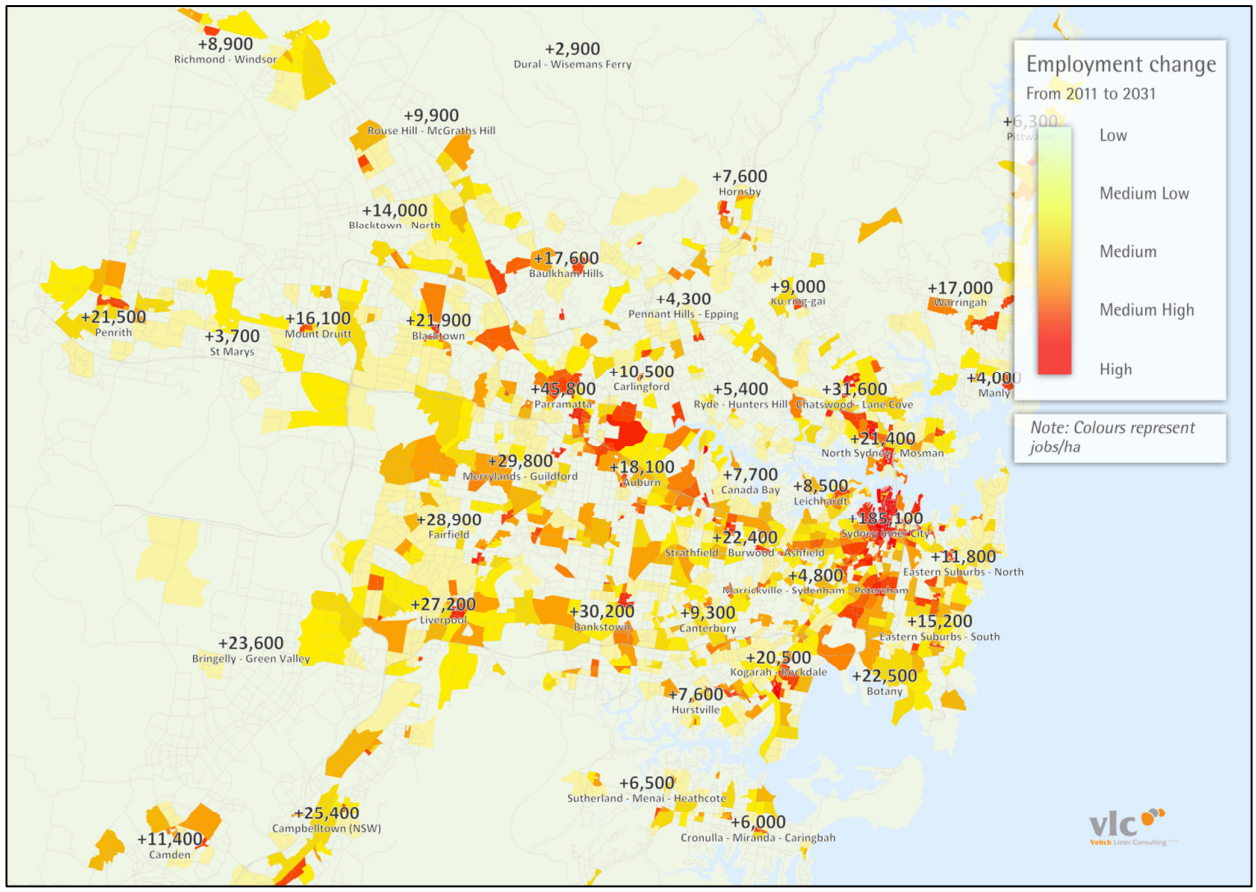


Figure 2-2: Projected employment growth in Sydney between 2011 and 2031

2.4.2 Employment characteristics and projections for the Hunter and Illawarra regions

Employment levels in the Hunter and Illawarra areas are expected to increase by 95,000 jobs during the 20 years to 2031, with both areas maintaining their current levels of self-containment.

Table 2-4 shows the employment projections for the Hunter and Illawarra areas.

Table 2-4: Employment estimates and projection for Hunter and Illawarra by SA3

SA3	2011	2031	Growth	%	AAGR
Newcastle	*102,900*	*131,600*	+28,700	+28%	1.2%
Lake Macquarie - East	*42,100*	*51,500*	+9,400	+22%	1.0%
Lake Macquarie - West	*19,500*	*23,200*	+3,600	+19%	0.9%
Maitland	*26,300*	*34,600*	+8,400	+32%	1.4%
Port Stephens	*27,500*	*33,200*	+5,800	+21%	1.0%
Lower Hunter	*36,600*	*49,000*	+12,400	+34%	1.5%
Upper Hunter	*16,400*	*19,500*	+3,000	+18%	0.8%
Total Hunter region	***271,300***	***342,600***	**+71,300**	**+26%**	**1.2%**
Wollongong	*51,300*	*62,300*	+11,000	+21%	1.0%
Dapto - Port Kembla	*33,000*	*42,800*	+9,800	+30%	1.3%
Illawarra Catchment Reserve	*100*	*110*	+20	+18%	0.8%
Kiama - Shellharbour	*21,700*	*25,800*	+4,000	+18%	0.9%
Total Illawarra region	***106,100***	***131,010***	**+24,910**	**+23%**	**1.1%**

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.

In relation to State controlled transport infrastructure and services, only funded or committed works have been included in the base case future networks. However, some additional road network initiatives and expansion of public transport routes and services have been added to the 2031 base case networks to meet the needs of the growth centres in the North West and the South West.

3.1 Road network assumptions

The locations of new transport infrastructure projects included in the 2031 base case network are shown in Figure 3-1 on the next page. The nature of each major infrastructure project is more fully described in Table 3-1 below.

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

Item	Description	Standard
1	WestConnex Stage 1	6-8 lane motorway
2	WestConnex Stage 2	4-8 lane motorway
3	NorthConnex	4 lane motorway
4	M2 Motorway	6 lane motorway
5	M4 Motorway	6 lane motorway
6	M5 West Motorway	6 lane motorway
7	New motorway to South West Growth Centre and Western Sydney Airport	4 lane motorway
8	Northern Road (Narellan to Bringelly)	4-6 lane divided arterial
9	Moorebank Avenue	4 lane arterial
10	Alfords Point Road	6 lane arterial
11	Richmond Road	4 lane divided arterial
12	Erskine Park Link Road	4 lane divided arterial
13	Central Coast Highway upgrade	4 lane divided arterial
14	Hunter Expressway	4 lane expressway
15	Newcastle Inner City Bypass	4 lane divided arterial

Note: The full list of projects, including minor works in Council PIPs, is included as Appendix A.

The following sections describe the major transport infrastructure improvements in more detail. A full list of projects, including minor works in Council PIP's, is included as appendix A.

3.1.1 NorthConnex

The NorthConnex project involves a new road tunnel connection between the M2 at Pennant Hills West and the M1 at Wahroonga. The M1 motorway connects to the Central Coast, Newcastle and the north coast of NSW, and interstate to Queensland. As planning and funding commitments for the project are well advanced, it has been included in the base case network assumptions for the AIA.

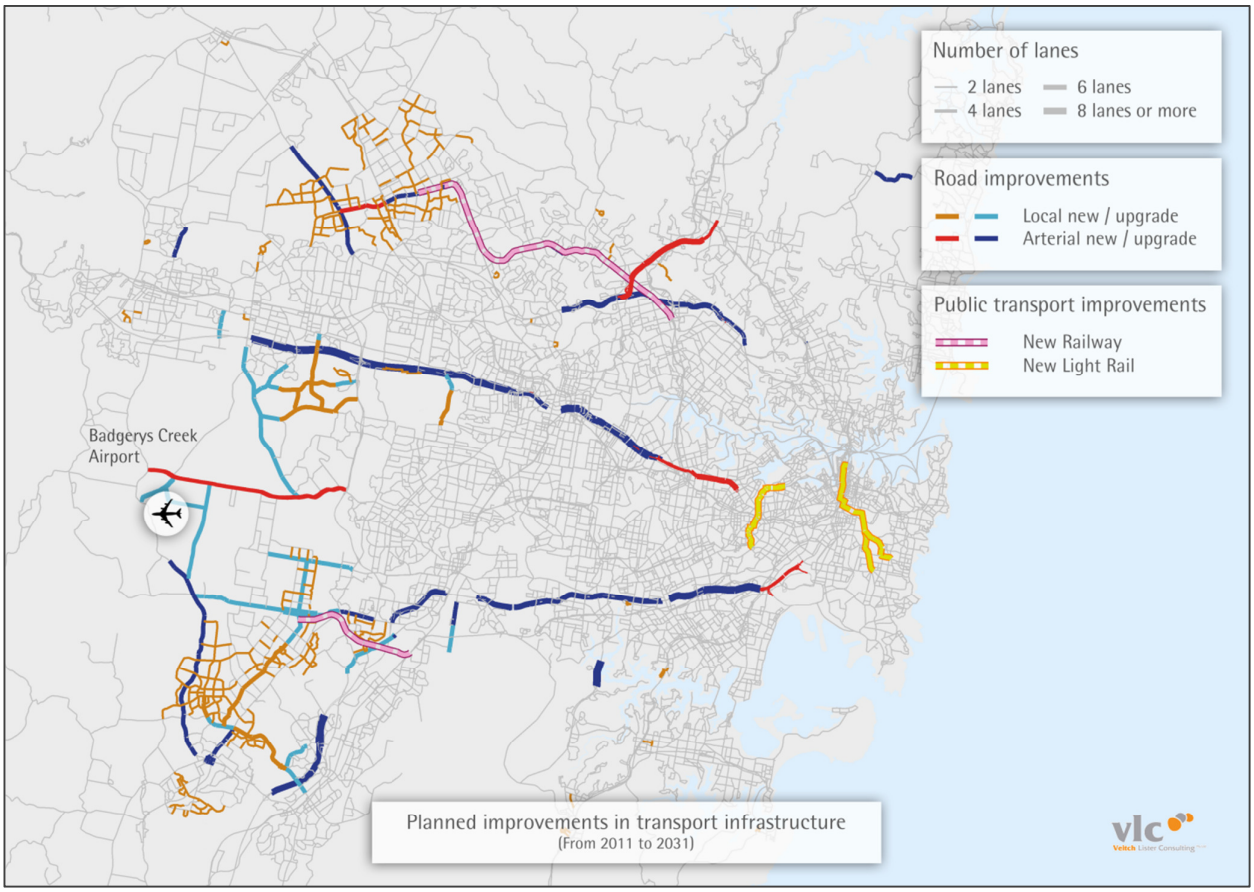


Figure 3-1: New transport infrastructure included in 2031 base case network

3.1.2 WestConnex

The WestConnex project involves widening and extension of the M4 and M5 motorways to the east, and eventually linking the two, providing improved access to the Airport, Port and central suburbs, and relieving congestion on key arterials across the inner-west and central regions of Sydney.

The first stage concerns the widening of the M4 to eight lanes between Parramatta and Strathfield due for completion in 2017, and extension east to City Link Road at Haberfield via a six-lane tunnel, due to open in 2019.

The second stage concerns the duplication of the M5 east of King Georges Road and a new four-lane connection to St Peters and the Airport precinct via tunnel, due for completion by 2019.

Both of these stages are well advanced in planning and project development, and have committed funding to proceed. For these reasons they have been assumed in the base case network improvements for the AIA. Progress on the third stage is earlier in the planning process, with project development and community consultation anticipated by 2015, and completion by 2023. This stage has not been assumed within the base case.

3.1.3 M2 motorway

The M2 motorway runs from the Hills District in the north west of Sydney to the Pacific Highway at Lane Cove via the Lane Cove Tunnel and to North Sydney and the Sydney Harbour crossings via the Gore Hill Freeway. The motorway was upgraded to six lanes between Windsor Road in Baulkham Hills and Lane Cove Road in North Ryde, with additional transit lanes. The upgrades were completed in 2013.

3.1.4 M4 motorway

The M4 motorway runs from Penrith at the foot of the Blue Mountains to Parramatta and east to Concord in the inner west of Sydney. The motorway is generally six lanes over this 40km length, and has a connection to the M7 orbital motorway at Eastern Creek. It is planned to introduce a range of operational measures to improve the reliability of travel on the motorway.

3.1.5 M5 west motorway

The M5 transport corridor is the main route for passengers, commerce and freight between south-western Sydney and Sydney Airport, Port Botany and the Sydney CBD. Widening of the M5 west from four to six lanes between Camden Valley Way and King Georges Road commenced in 2012 and is expected to be complete by 2015. The estimated cost of the project is $400m, most of which is to be funded by the private operator.

3.1.6 New motorway to South West Growth Centre and Western Sydney Airport

This involves a new four-lane motorway between the M7 and The Northern Road (14km), to support development of the South West Growth Centre and Western Sydney Airport. The new motorway would be located adjacent to the alignment of Elizabeth Drive, which would continue to service local traffic. Cost estimate is $1.25b.

3.1.7 Arterial roads

The base case network improvements also include upgrades (among others) to the following major arterial roads:

- Northern Road (Narellan to Bringelly)
- Moorebank Avenue connection from M5 to Moorebank Intermodal Terminal to be upgraded
- Alfords Point Road between Georges River and Brushwood Drive
- Richmond Road (M7 to Richmond)
- Erskine Park Link Road completed in 2013

3.1.8 Road upgrades in Hunter, Central Coast and Illawarra

- Central Coast Highway upgrade
- Hunter Expressway (now completed with estimated cost of $1.7b)
- Newcastle Inner City Bypass (Shortland to Sandgate) (now completed at cost of $143m)
- Princes Highway, Gerringong upgrade at cost of $329m

3.1.9 Clearways

The Sydney Clearways Strategy identifies five priority routes for implementation or expansion of Clearways on Sydney's most constrained corridors. These routes are:

- Victoria Road (Iron Cove Bridge to Rozelle)
- Lane Cove Road (North Ryde to Macquarie Park)
- Mona Vale Road (Pacific Highway to St Ives)
- King Georges Road (M5 to Hume Highway)
- Princes Highway (Kirrawee to Blakehurst)

3.2 Public transport network assumptions

Four major public transport infrastructure investments have been assumed when creating the 2031 low investment transport strategy for Sydney, as listed in Table 3-2 together with their assumed peak and off-peak operating frequencies.. The alignments of the four rail and light projects are shown in Figure 3-2.

Table 3-2: Major new public transport infrastructure included in 2031 base case network

Item	Description	Frequency per hour	
		Peak	Off-peak
1	North West Rail Link	10	5
2	South West Rail Link	6	3
3	Inner West Light Rail	8	5
4	CBD and South East Light Rail	8	4

The North West Rail Link is a new 23 kilometre rail line running from Epping to Cudgegong Road at Rouse Hill. It is planned to have 8 stations. It has been assumed to operate every 6 minutes in the peaks, and every 12 minutes in the off-peak.

The South West Rail Link is a new 11.4 kilometre rail line from Glenfield to Leppington, with two new stations at Edmondson Park and Leppington. It has been assumed in the modelling to operate every 12 minutes in the peaks, and every 20 minutes off-peak.

The Inner West Light Rail project is a 5.6 kilometre extension of the previous IWLR project. It runs along the former Rozelle rail freight corridor between Lilyfield and Dulwich Hill. It adds nine new light rail stops and it opened in March 2014. In 2031 it has been assumed to operate every seven and a half minutes in the peaks, and every 12 minutes off-peak.

The CBD and South East Light Rail project runs through the heart of the Sydney CBD and extends to the Moore Park sporting and entertainment precinct, the University of NSW and the Prince of Wales Hospital. It is expected to commence operating in 2019/20. It has been assumed to operate every seven and a half minutes in the peaks and every 15 minutes off-peak.

As can be seen in Figure 3-2, the 2031 low investment strategy assumes a significant expansion of the bus network in Western Sydney (the extended bus route network is shown in green).

All existing bus routes have been retained in the 2031 modelling, and they have been assumed to operate at their current frequencies.

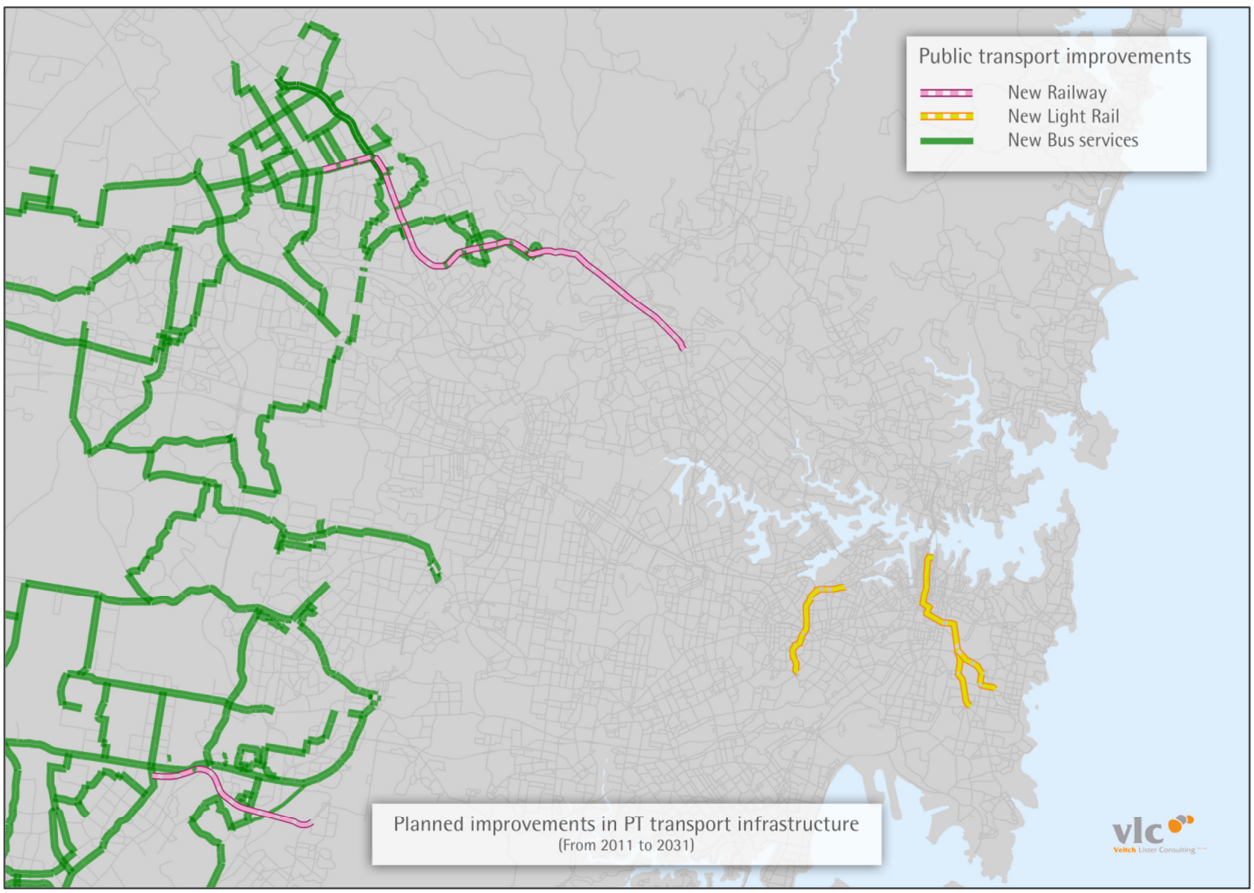


Figure 3-2: New public transport services included in 2031 base case network

Table 3-3 that follows shows the degree to which the in-service public transport vehicle-kilometres increases between 2011 and 2031. Clearly the biggest percentage increases occur on the light rail network, but this is building off a low base. In-service rail kilometres increase by 11% in the low investment strategy, while in-service bus kilometres increase by 13%.

No changes have been assumed in the operations of the ferry network.

Table 3-3: Service kilometres in 2011 and 2031

Mode	Period	Service kilometres 2011	2031	Change
Rail	AM peak	17,062	19,625	+15%
	Off-peak	88,529	96,953	+10%
	PM peak	18,254	20,818	+14%
	24 hours	123,845	137,396	+11%
Light Rail	AM peak	190	1,439	+650%
	Off-peak	945	4,828	+400%
	PM peak	190	1,439	+650%
	24 hours	1,325	7,706	+500%
Bus	AM peak	94,232	109,067	+16%
	Off-peak	349,507	386,783	+11%
	PM peak	89,910	104,750	+17%
	24 hours	533,649	600,600	+13%
Ferry	AM peak	1,259	1,259	-
	Off-peak	5,312	5,312	-
	PM peak	1,199	1,199	-
	24 hours	7,770	7,770	-

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 Sydney 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. The one exception is in relation to peoples' increased willingness to pay tolls in the future, as a result of increasing real average weekly earnings. In this case (i.e. predicting whether people will choose a tolled or untolled route) we have adopted the UK Department for Transport recommendation that an elasticity of 0.8 be used between the value of time and increases in real average weekly earnings. In other words, if real average weekly earnings go up by 10% then it should be assumed that the value of time will go up by 8%.

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.

State governments in NSW, Victoria and Western Australia have introduced parking space levies within the CBD of their capital cities to encourage more sustainable travel choices. Although there may be a case for it, the base case has assumed no real increase in these levies, nor expansion of coverage.

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

The Long Term Transport Master Plan for Sydney reflects policies that constrain the growth in supply of parking in centres in order to encourage a shift to public transport, while local council development controls are encouraging a lower rate of provision of non-residential parking in close proximity to activity centres with good public transport access.

CBD employment continues to grow quickly. In the past 5 years, the average annual increase in the workforce within the Sydney CBD was 1.7%, while all other capitals had increases of between 2.1% and 2.8%.

With increasing demand and constrained supply of parking spaces, it is reasonable to expect that parking costs within Sydney 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 Toll prices

It has been assumed that road tolls in the future will increase in line with CPI, so in a modelling sense there will be no effective (or real) toll increases in the future.

4.6 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 Sydney 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
Sydney Domestic	2011	40,700	10,500	12,300	**63,500**
	2031	76,500	18,100	19,700	**114,300**
	(% increase)	84%	85%	85%	**85%**
Sydney International	2011	6,500	7,900	14,900	**29,300**
	2031	15,700	19,100	35,900	**70,700**
	(% increase)	151%	151%	150%	**151%**
Newcastle	2011	300	1,600	1,300	**3,200**
	2031	600	2,900	2,300	**5,800**
	(% increase)	100%	81%	77%	**81%**
Western Sydney Airport (proposed)	2011	-	-	-	**-**
	2031	1,800	2,100	4,000	**7,900**
	(% increase)	-	-	-	**-**

5. Methodology

The use of VLC's Zenith Travel model provides insight 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
- CityRail 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 on 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 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 result in the Hours of Delay metric. Passenger Hours Travelled is a similar metric which takes 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.

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 C.

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 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. A visual representation of the SA3 sectors is provided in Appendix C. 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 Sydney GCCSA and the Hunter and Illawarra regions are available together with a grand total for the modelled area.

Table 5-4: Example of Metrics by SA3 to SA3 (weekday person trips)

To SA3 sector

From SA3 sector	Sydney Inner City				Eastern Suburbs - North			
	2011	2031	Diff	%Diff	2011	2031	Diff	%Diff
SydneyInnerCity	513,604	746,222	+232,618	+45%	245,751	320,084	+74,332	+30%
EasternSuburbs-North	245,123	319,561	+74,437	+30%	381,776	447,028	+65,252	+17%
Marrickville-Sydenham-Petersham	122,258	152,456	+30,198	+25%	29,395	33,172	+3,776	+13%
Leichhardt	127,595	171,612	+44,017	+34%	33,539	39,702	+6,163	+18%
Strathfield-Burwood-Ashfield	145,621	207,478	+61,856	+42%	37,787	47,613	+9,826	+26%
Botany	224,835	344,390	+119,555	+53%	79,450	111,380	+31,930	+40%
EasternSuburbs-South	224,666	304,381	+79,715	+35%	175,123	222,533	+47,410	+27%
Kogarah-Rockdale	135,176	194,502	+59,325	+44%	48,792	66,273	+17,481	+36%
Canterbury	94,563	121,045	+26,481	+28%	26,224	30,244	+4,020	+15%
Hurstville	78,967	102,014	+23,047	+29%	29,575	35,444	+5,869	+20%
Cronulla-Miranda-Caringbah	79,297	102,229	+22,932	+29%	31,756	39,061	+7,305	+23%
Sutherland-Menai-Heathcote	66,923	86,213	+19,291	+29%	27,541	31,931	+4,389	+16%
Liverpool	37,576	58,403	+20,827	+55%	14,671	20,468	+5,797	+40%
Campbelltown(NSW)	38,642	56,782	+18,140	+47%	15,353	20,489	+5,136	+33%
Bankstown	79,815	98,028	+18,213	+23%	26,385	29,581	+3,195	+12%
Merrylands-Guildford	36,979	47,484	+10,505	+28%	12,750	14,926	+2,176	+17%

* 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 Tranport, Active Transport
Hours of Delay	Work, Business, Other, Total	Car
	Total	Commercial Vehicles
Fuel **Green House Gas Emissions**	Total	Car, Commercial Vehicles

5.3 Corridor Analysis

All of the more major road corridors in Sydney 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, the M2/Lane Cove Tunnel toll roads and the untolled Epping Road.

A total of 32 important road corridors were identified, as shown in Figure 5-1.

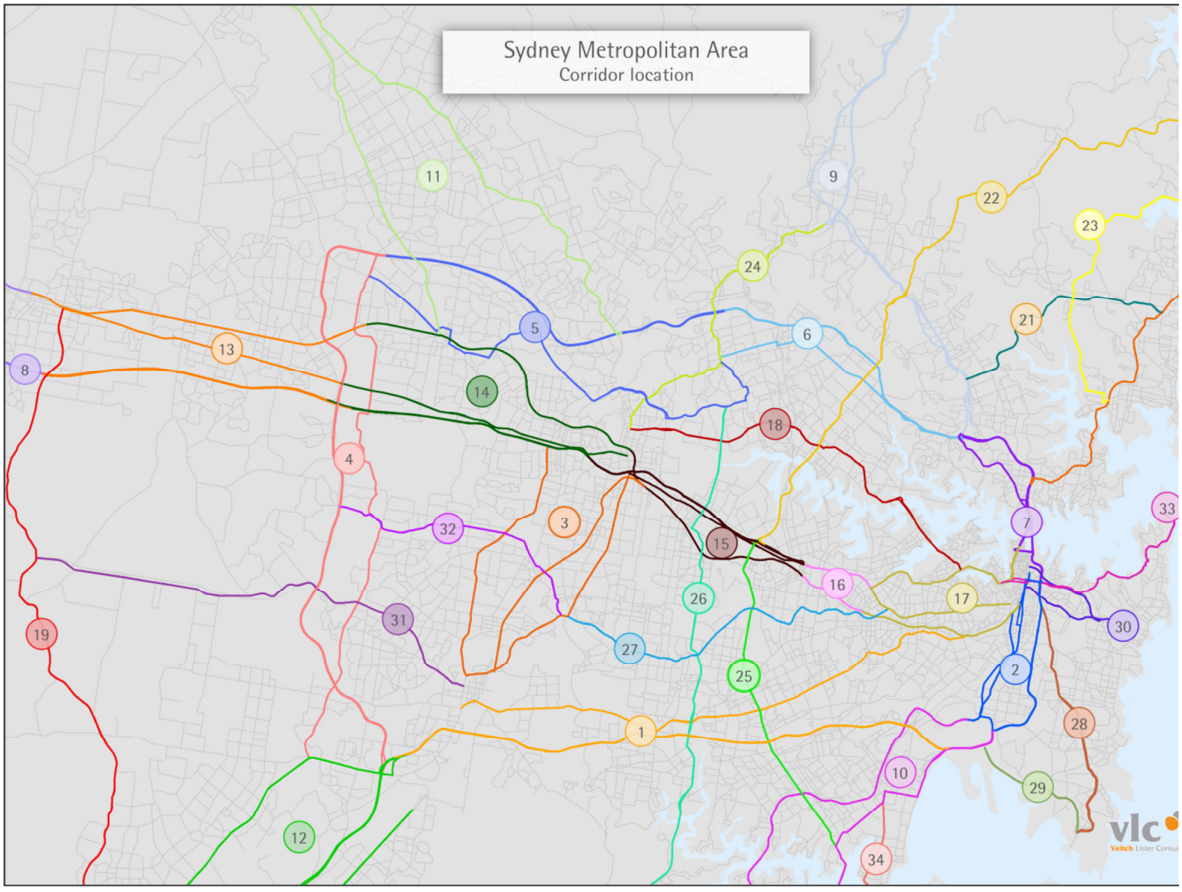


Figure 5-1: Major road corridors in Sydney

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 1 (the M5 South Western Motorway and the A34 Milperra Road/Canterbury Road arterial) 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 Sydney'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 Sydney is titled **vlc_yymmdd_02_SYD_Corridor Analysis.xlsx**

Figure 5-2: Subsections in Corridor 1 - The M5 Motorway and Milperra/Canterbury Road

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 Average Peak Hour CV Volumes % Average Peak Hour CV Volumes
Traffic speeds under freeflow (modelled) and congested conditions	Average Speed Freeflow (kph) Average Speed Congested (kph)
Travel Times under freeflow (modelled) and congested conditions	Total Travel Time Freeflow (min) Total Travel Time Congested (min)
Network performance daily	Total Vehicle Kilometers Travelled (km) Total Vehicle Hours Travelled Congested (hrs) Total Vehicle Hours Travelled Freeflow (hrs) Total hours of delay (hrs)
Level of Service (Traffic) (busiest peak hour)	Minimum Level of Service Average Level of Service Maximum Level of Service
Traffic V/C (busiest peak hour)	Weighted V/C Traffic

5.4 CityRail analysis

Based on the seating capacity and crush capacity of Sydney'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 Northern Line are presented in Figures 5-3 and 5-4.

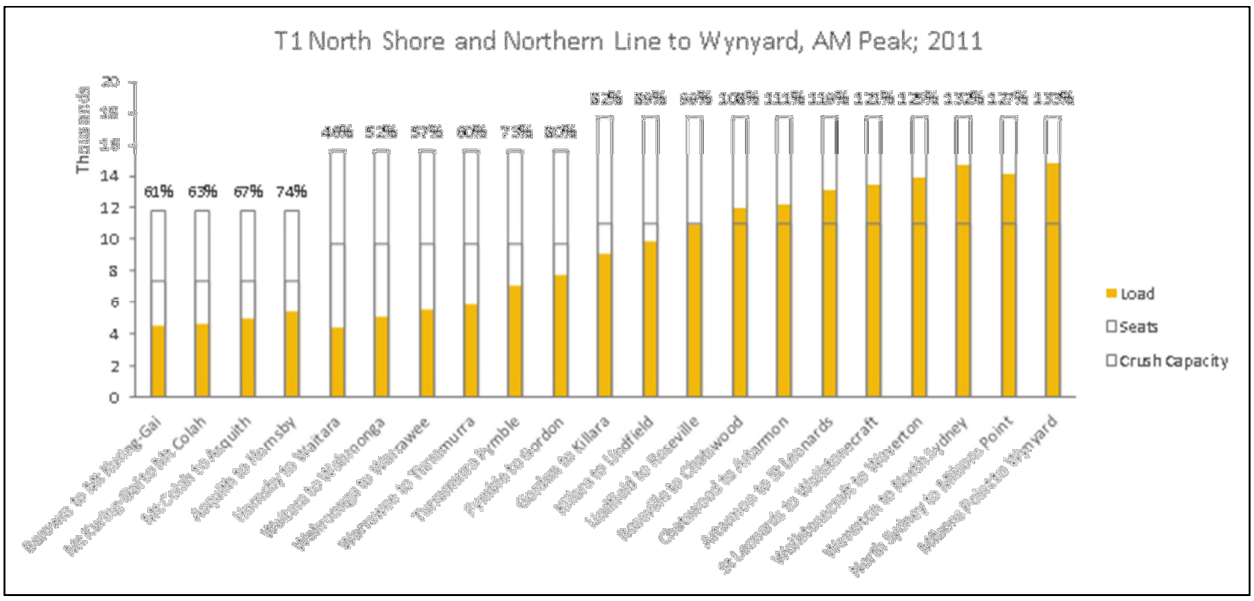


Figure 5-3: Passenger loading profile - Northern Line in the AM peak (2011)

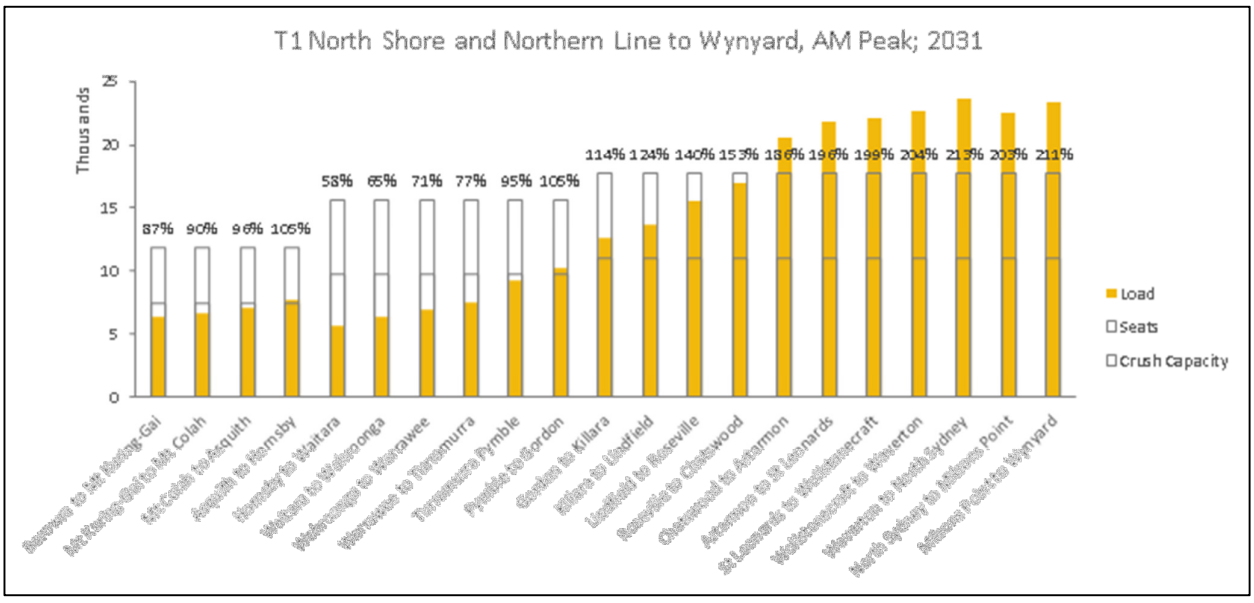


Figure 5-4: Passenger loading profile - Northern Line in the AM peak (2031)

6. Travel demand increase in Sydney, Newcastle and Wollongong between 2011 and 2031

6.1 Introduction

This section of the report provides the Zenith model's travel estimates and forecasts for 2011 and 2031for the Greater Sydney Metropolitan Area (GSMA) - which includes the Sydney, Illawara and Newcastle Statistical Divisions - 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 below shows the Zenith model's forecast growth in person trips between 2011 and 2031. Total person trips made each weekday in the region is forecast to increase from approximately 23.5 million each weekday in 2011 to 31.5 million in 2031 - a 34% increase. As might be expected, the total amount of travel within the region is forecast to increase in line with the projected increase in population.

Under the *low transport network investment* scenario travel by car is forecast to remain the dominant mode in the region, accounting for over 70% of all travel. However, the percentage of trips made by car is forecast to decline slightly, from 72.7% of all travel to 71.9%, while public transport's share of the travel market is forecast to increase from 10.0% to 10.7%.

Table 6-1: Growth in person travel in the Greater Sydney Metropolitan Area (2011-2031)

Modal statistics, trips and mode shares		2011*		2031*		% change
Person car trips	AM	2,501,991	*72.4%*	3,283,847	*71.2%*	*+31%*
	OP	12,149,210	*72.8%*	16,144,470	*72.2%*	*+33%*
	PM	2,426,956	*72.3%*	3,189,446	*71.2%*	*+31%*
	24h	17,078,157	*72.7%*	22,617,763	*71.9%*	*+32%*
PT trips	AM	509,495	*14.7%*	728,478	*15.8%*	*+43%*
	OP	1,419,781	*8.5%*	2,034,260	*9.1%*	*+43%*
	PM	416,746	*12.4%*	598,627	*13.4%*	*+44%*
	24h	2,346,022	*10.0%*	3,361,365	*10.7%*	*+43%*
Walk / cycling trips	AM	443,634	*12.8%*	600,436	*13.0%*	*+35%*
	OP	3,108,407	*18.6%*	4,191,440	*18.7%*	*+35%*
	PM	513,906	*15.3%*	693,657	*15.5%*	*+35%*
	24h	4,065,947	*17.3%*	5,485,533	*17.4%*	*+35%*
Total trips	AM	3,455,120	*100.0%*	4,612,761	*100.0%*	*+34%*
	OP	16,677,398	*100.0%*	22,370,170	*100.0%*	*+34%*
	PM	3,357,608	*100.0%*	4,481,730	*100.0%*	*+33%*
	24h	23,490,126	*100.0%*	31,464,661	*100.0%*	*+34%*

** the model statistics are extracted for the modelled area that includes (but is not limited to) GCCSA, Hunter, Illawarra*

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

Table 6-2 that follows provides the Zenith models' forecast growth in vehicular travel in the region between 2011 and 2031.

Points to note from this table include:

a) Car trips made each weekday in the region increases from approximately 12.5 million in 2011to 16.6 million in 2031 - an increase of 33%, which again is closely aligned with the projected increase in population.

b) Car-kilometres of travel increase by a similar amount (32%); however, car-hours of travel is predicted to increase by a far larger amount (52%), which is the result of increasing congestion delays on the road network under the assumed *low road network investment* scenario.

c) This has the effect of reducing the average car travel speed on the road network from 43.0 kilometres an hour (kph) in 2011 to 37.1 kph in 2031.

d) Commercial vehicle trips in the region are forecast to increase by slightly more than the increase in population (by 37% versus 34%).

e) Average commercial vehicle speeds are forecast to reduce from 46.9 kph in 2011 to 41.3 kph in 2031 under the *low road network investment* scenario.

Table 6-2: Growth in vehicular travel in the Greater Sydney Metropolitan Region (2011-2031)

Traffic statistics		2011*	2031*	% change
Car trips	AM	1,743,764	2,290,894	*+31%*
	OP	8,984,205	11,959,701	*+33%*
	PM	1,790,295	2,353,576	*+31%*
	24h	12,518,264	16,604,171	*+33%*
Car kilometres	AM	17,211,575	22,281,712	*+29%*
	OP	86,392,037	114,380,301	*+32%*
	PM	18,778,261	24,424,608	*+30%*
	24h	122,381,873	161,086,621	*+32%*
Car hours	AM	449,187	694,643	*+55%*
	OP	1,928,371	2,920,220	*+51%*
	PM	470,198	722,971	*+54%*
	24h	2,847,756	4,337,834	*+52%*
Car Average assigned speed (kph)	AM	38.3	32.1	*-16%*
	OP	44.8	39.2	*-13%*
	PM	39.9	33.8	*-15%*
	24h	43.0	37.1	*-14%*
Commercial Vehicle trips	AM	103,868	141,679	*+36%*
	OP	555,121	758,226	*+37%*
	PM	91,369	124,723	*+37%*
	24h	750,358	1,024,628	*+37%*
Commercial Vehicle kilometres	AM	2,237,085	3,034,137	*+36%*
	OP	12,818,622	17,278,933	*+35%*
	PM	2,049,296	2,768,838	*+35%*
	24h	17,105,003	23,081,908	*+35%*
Commercial Vehicle hours	AM	52,228	81,851	*+57%*
	OP	265,875	403,799	*+52%*
	PM	46,725	72,749	*+56%*
	24h	364,828	558,399	*+53%*

Traffic statistics		2011*	2031*	% change
Commercial Vehicle Average assigned speed (kph)	AM	42.8	37.1	*-13%*
	OP	48.2	42.8	*-11%*
	PM	43.9	38.1	*-13%*
	24h	46.9	41.3	*-12%*
Total trips	AM	1,847,632	2,432,573	*+32%*
	OP	9,539,326	12,717,927	*+33%*
	PM	1,881,664	2,478,299	*+32%*
	24h	13,268,622	17,628,799	*+33%*
Total kilometres	AM	19,448,660	25,315,849	*+30%*
	OP	99,210,658	131,659,234	*+33%*
	PM	20,827,557	27,193,446	*+31%*
	24h	139,486,875	184,168,529	*+32%*
Total hours	AM	501,415	776,494	*+55%*
	OP	2,194,247	3,324,019	*+51%*
	PM	516,923	795,721	*+54%*
	24h	3,212,585	4,896,234	*+52%*
Total Average assigned speed (kph)	AM	38.8	32.6	*-16%*
	OP	45.2	39.6	*-12%*
	PM	40.3	34.2	*-15%*
	24h	43.4	37.6	*-13%*

** the traffic statistics are extracted for the modelled area that includes (but is not limited to) GCCSA, Hunter, Illawarra*

6.4 Growth in public transport ridership (2011-2031)

Table 6-3 below shows the Zenith model's predicted growth in public transport ridership between 2011 and 2031 under the *low transport network investment* scenario.

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

Public transport statistics		2011*	2031*	% change
Total PT boardings	AM	633,700	943,349	*+49%*
	OP	1,682,818	2,472,225	*+47%*
	PM	535,720	803,428	*+50%*
	24h	2,852,238	4,219,002	*+48%*
In vehicle passenger kilometres	AM	7,356,045	11,233,297	*+53%*
	OP	15,605,105	24,393,709	*+56%*
	PM	6,276,091	9,693,692	*+54%*
	24h	29,237,241	45,320,698	*+55%*
In vehicle passenger hours	AM	205,909	332,830	*+62%*
	OP	440,406	715,377	*+62%*
	PM	170,870	277,452	*+62%*
	24h	817,185	1,325,659	*+62%*
Total Rail boardings	AM	320,838	502,405	*+57%*
	OP	802,461	1,215,046	*+51%*
	PM	284,771	446,333	*+57%*
	24h	1,408,070	2,163,784	*+54%*
Total Bus boardings	AM	301,691	405,581	*+34%*
	OP	847,420	1,151,947	*+36%*
	PM	240,657	325,469	*+35%*
	24h	1,389,768	1,882,997	*+35%*
Total Ferry boardings	AM	9,022	16,893	*+87%*
	OP	22,923	33,433	*+46%*
	PM	8,104	13,260	*+64%*
	24h	40,049	63,586	*+59%*
Total Light Rail boardings	AM	2,149	18,470	*+759%*
	OP	10,014	71,798	*+617%*
	PM	2,188	18,366	*+739%*
	24h	14,351	108,634	*+657%*

** the public transport statistics are extracted for the modelled area that includes (but is not limited to) GCCSA, Hunter, Illawarra*

It should be appreciated that, under the *low transport network investment* scenario, the existing frequencies of currently operating public services have been retained in the 2031 model run. It has not been assumed that frequencies will be increased in the future.

However, in-service public transport vehicle kilometres are higher in 2031 due to committed extensions of the rail network, expansion of the LRT network and expansion of bus services in the growth areas, as described in Section 3 of this report.

Table 6-4 that follows shows the extent to which in-service public transport vehicle-kilometres have been increased when performing the 2031 Zenith model run.

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	17,062	19,625	*+15%*
	OP	88,529	96,953	*+10%*
	PM	18,254	20,818	*+14%*
	24h	123,845	137,396	*+11%*
In-Service Kilometres by Bus	AM	94,232	109,067	*+16%*
	OP	349,507	386,783	*+11%*
	PM	89,910	104,750	*+17%*
	24h	533,649	600,600	*+13%*
In-Service Kilometres by Ferry	AM	1,259	1,259	*+0%*
	OP	5,312	5,312	*+0%*
	PM	1,199	1,199	*+0%*
	24h	7,770	7,770	*+0%*
In-Service Kilometres by LRT	AM	190	1,439	*+657%*
	OP	945	4,828	*+411%*
	PM	190	1,439	*+657%*
	24h	1,325	7,706	*+482%*

Points to note from Tables 6-3 and 6-4 are as follows:

a) Total weekday rail and bus in-service vehicle kilometres have been increased (in percentage terms) by far less that the projected increase in population in the region under the *low transport network investment* scenario. Rail in-service vehicle-kilometres are increased by 11%, while bus in-service vehicle-kilometres increase by 13%, whereas the population is projected to increase by 34%.

b) There is a large percentage increase in LRT in-service kilometres (482%), but building off a low base in 2011.

c) No increase in ferry services has been assumed in the *low transport network investment* scenario.

d) The rate of increase in usage of the public transport system is predicted to be higher than the projected increase in population. This is particularly the case for CityRail and the ferries.

e) Bus usage increases in line with the projected increase in population.

f) There is a very large increase in LRT usage (657%) as a result of the planned expansion of the network and the large increase in LRT vehicle-kilometres.

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 Sydney 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 Sydney (shown in dark green) between 2011 and 2031.

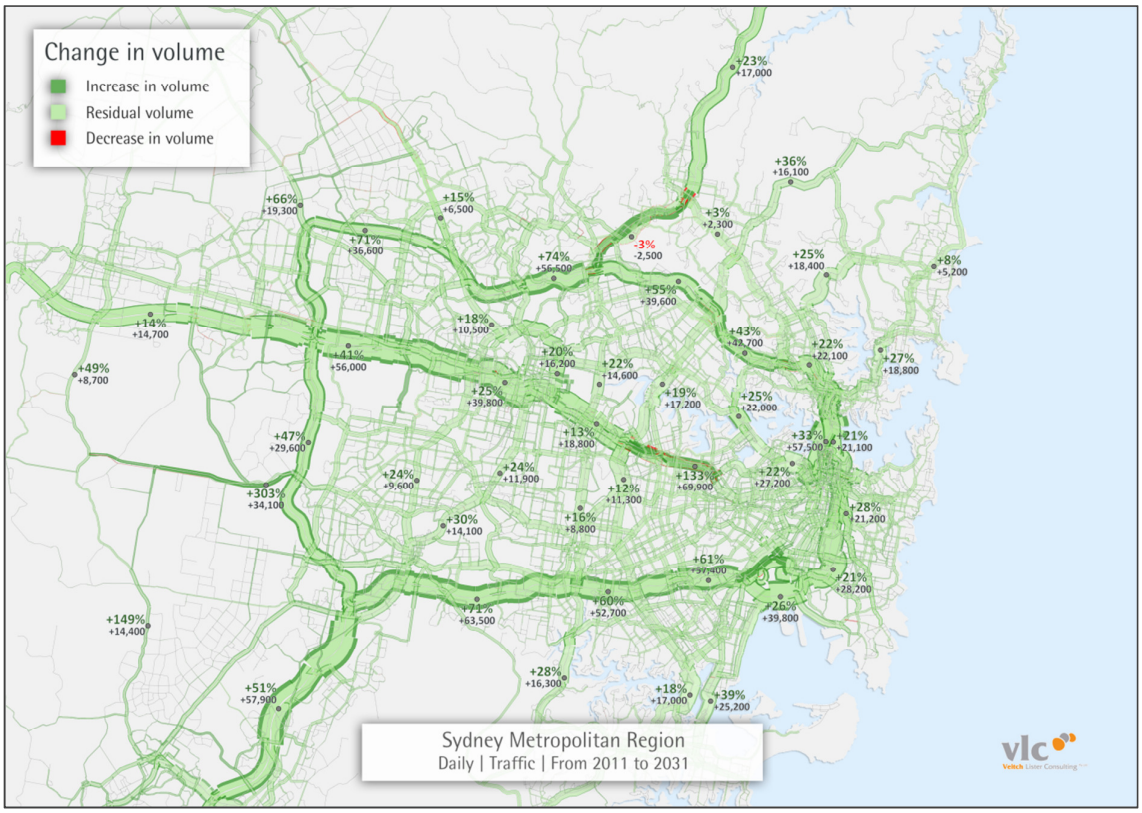


Figure 7-1: Predicted increase in Sydney weekday traffic (2011-2031)

Daily (weekday) traffic demand is forecast to increase significantly (2011-2031) on the orbital motorway network (South Western Motorway, WestLink M7, Hills Motorway/Lane Cove Tunnel, Gore Hill/Warringah Freeway, the Harbour Bridge and Tunnel).

Traffic is also predicted to increase significantly on the Western Motorway, the Hume Highway south of Liverpool, the Sydney-Newcastle Freeway and Southern Cross Drive/Eastern Distributor.

The predicted changes in traffic volume (2011-2031) in Sydney in the AM and PM peaks are shown in Figures 7-2 and 7-3.

The predicted changes in weekday traffic volumes (2011 – 2031) in the Hunter and Illawarra Regions is shown in Figures 7-4 and 7-5.

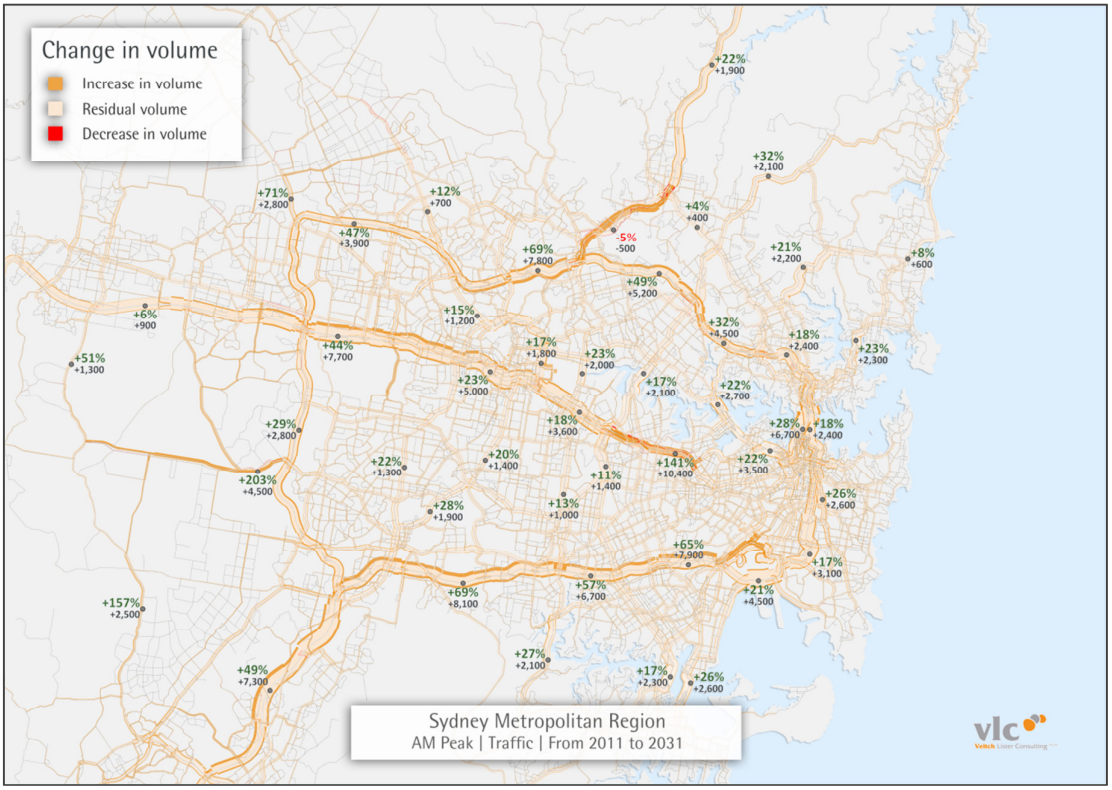


Figure 7-2: Predicted increase in Sydney weekday AM peak traffic (2011-2031)

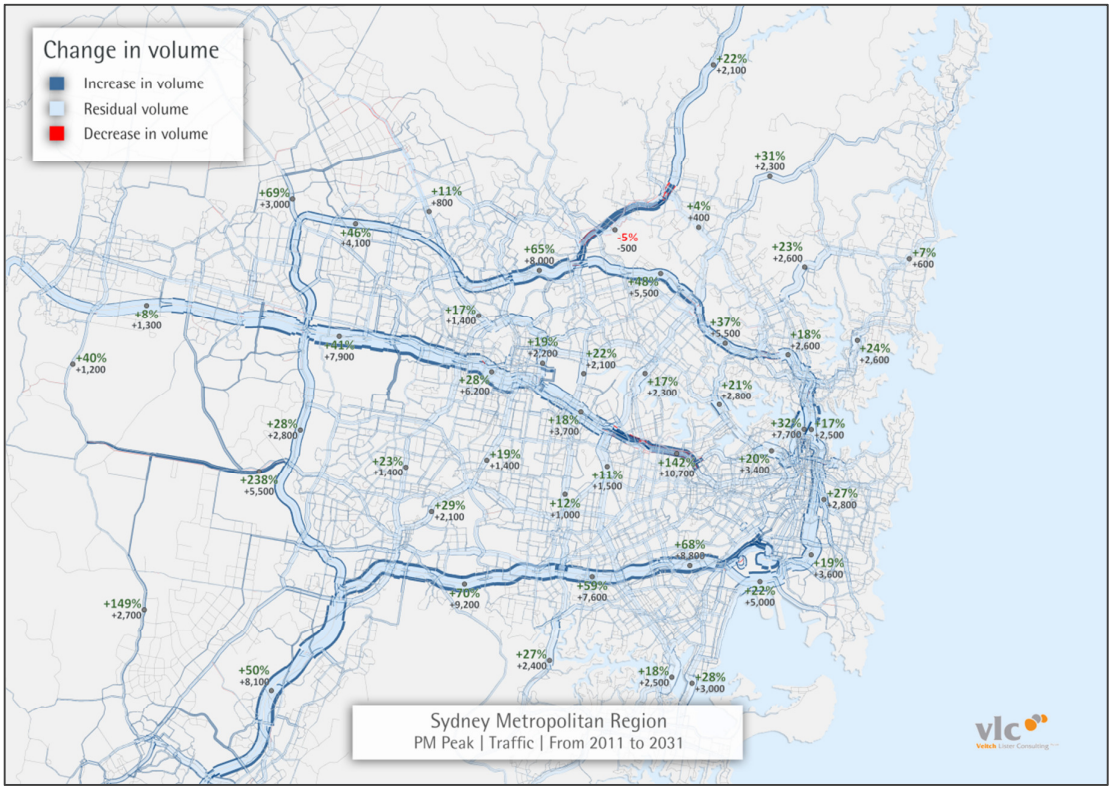


Figure 7-3: Predicted increase in Sydney weekday PM peak traffic (2011-2031)

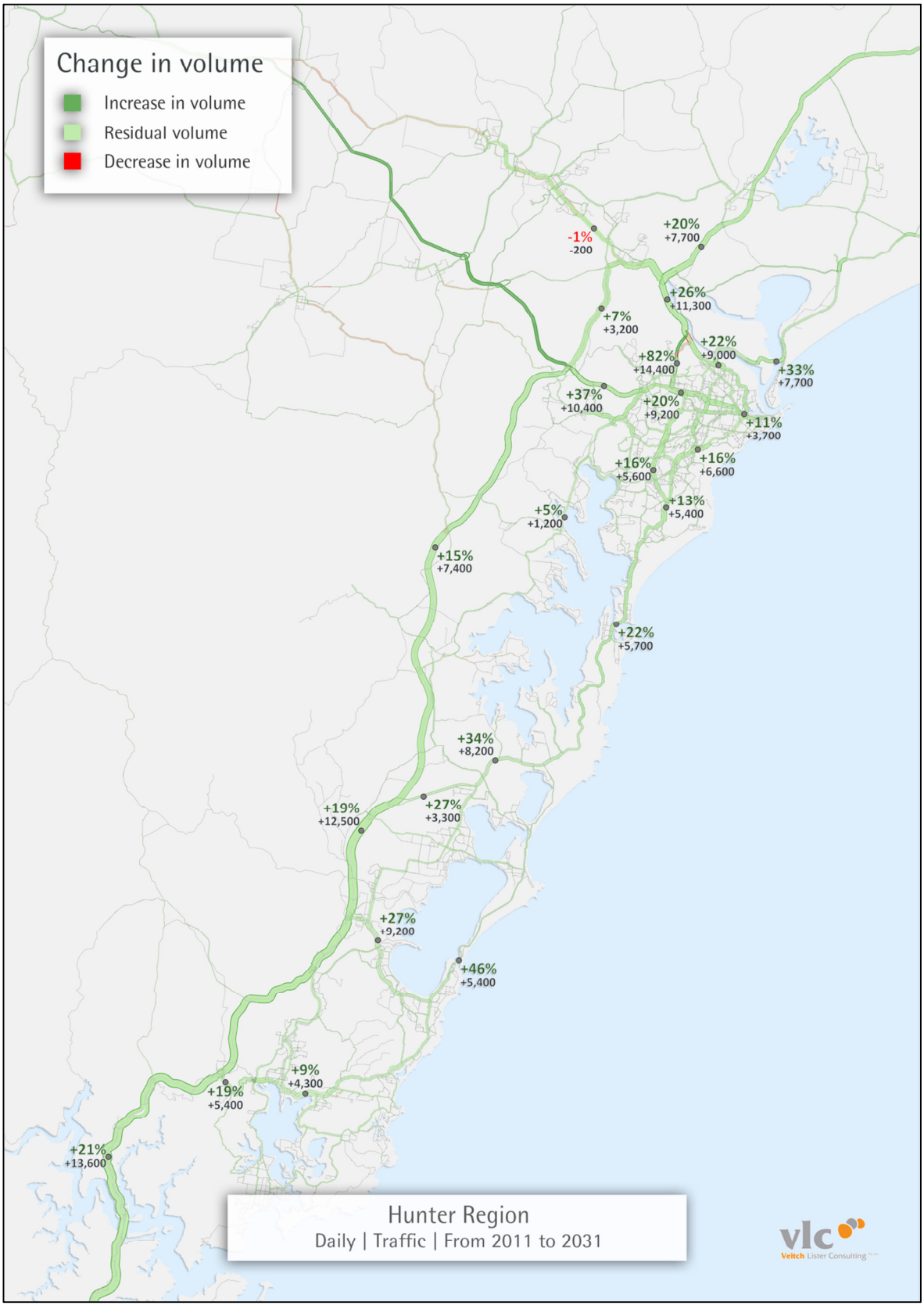


Figure 7-4: Predicted increase in Hunter Region weekday daily traffic (2011-2031)

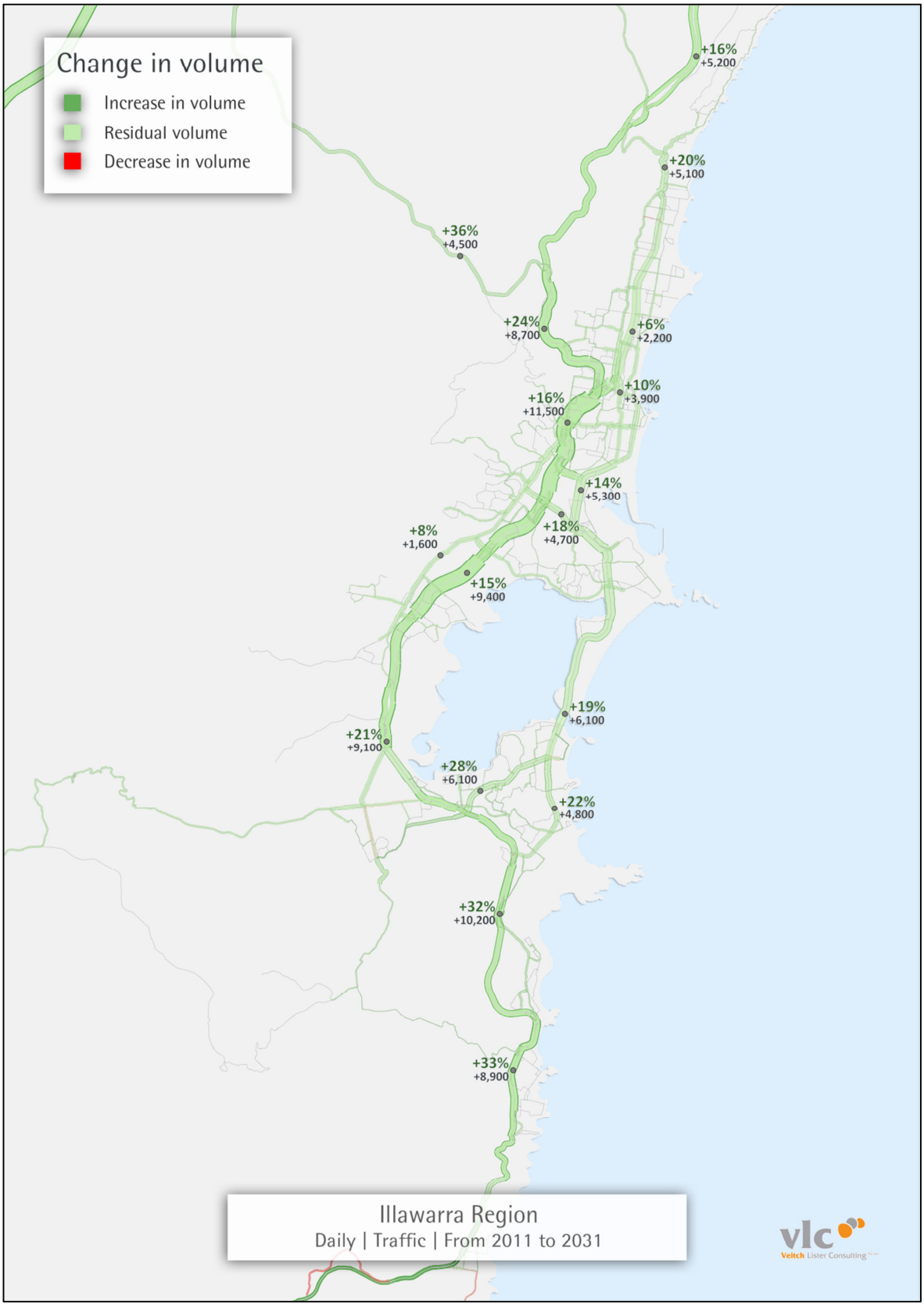


Figure 7-5: Predicted increase in Illawarra Region average daily traffic (2011-2031)

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 Sydney's more major roads are already operating at or close to capacity in both peak periods.

While most of WestLink operates well within its practical capacity (V/C typically in the range 0.5-0.7 in the peaks), key major sections Sydney's road network were operating at, or extremely close to, capacity in 2011, including:

- almost the entirety of the South West Motorway (M5);
- the whole of the Western Motorway (M4) and Parramatta Road;
- the Hills Motorway (M2);
- the Pacific Highway south of Wahroonga;
- the Gore Hill Freeway and Warringah Freeway;
- the two harbour crossings (both bridge and tunnel);
- Southern Cross Drive;
- the Victoria Road corridor from Parramatta to the CBD;
- most of the important A3 north-south corridor from the Princes Highway (at Blakehurst) to the Pacific Highway (at Pymble) (via King Georges Road, Centenary Drive, Homebush Bay Drive and Lane Cove Road);
- most of the north-south A6 corridor from the Princes Highway (at Heathcote) to the Pacific Highway (at Pymble) (particularly in the northern Pennant Hills Road/Hills Road section of the corridor);
- the Windsor Road/Old Windsor Road corridor and James Ruse Drive; and
- roads accessing the North Shore and Northern Beaches (Spit Road/Military Road and Warringah Road).

Figure 7-5 shows the 2011 situation during a typical hour in the midday off-peak. Most of the Sydney major road network operates at well below its practical capacity. However, several key sections of the network can been seen to have only 20-30% spare capacity in the off-peak, including:

- most of the South West Motorway (M5);
- the Western Motorway (M5);
- the Pacific Highway south of Wahroonga and the Warringah Freeway;
- Pennant Hills road between the Pacific Highway and the Hills Motorway (M2);
- the North Shore and Northern Beaches access roads; and
- the middle sections of the A3, north and south of Homebush Bay.

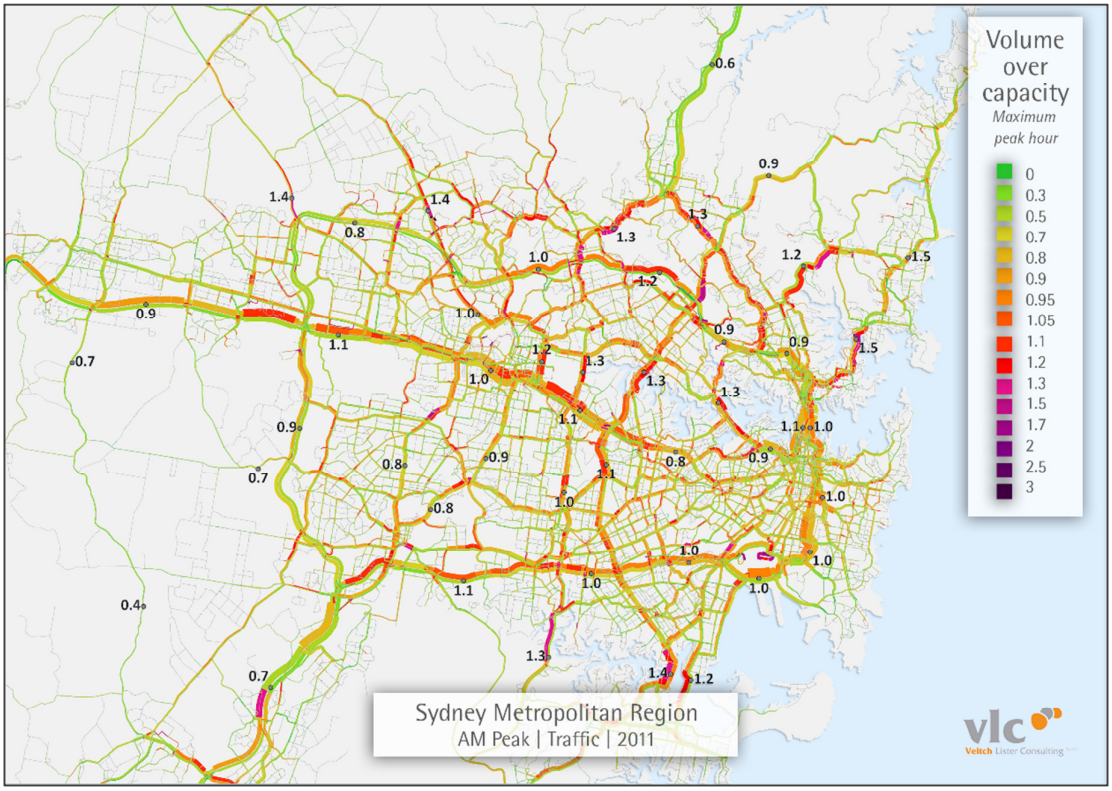


Figure 7-6: Road network volume/capacity ratios in 2011 - AM maximum peak hour

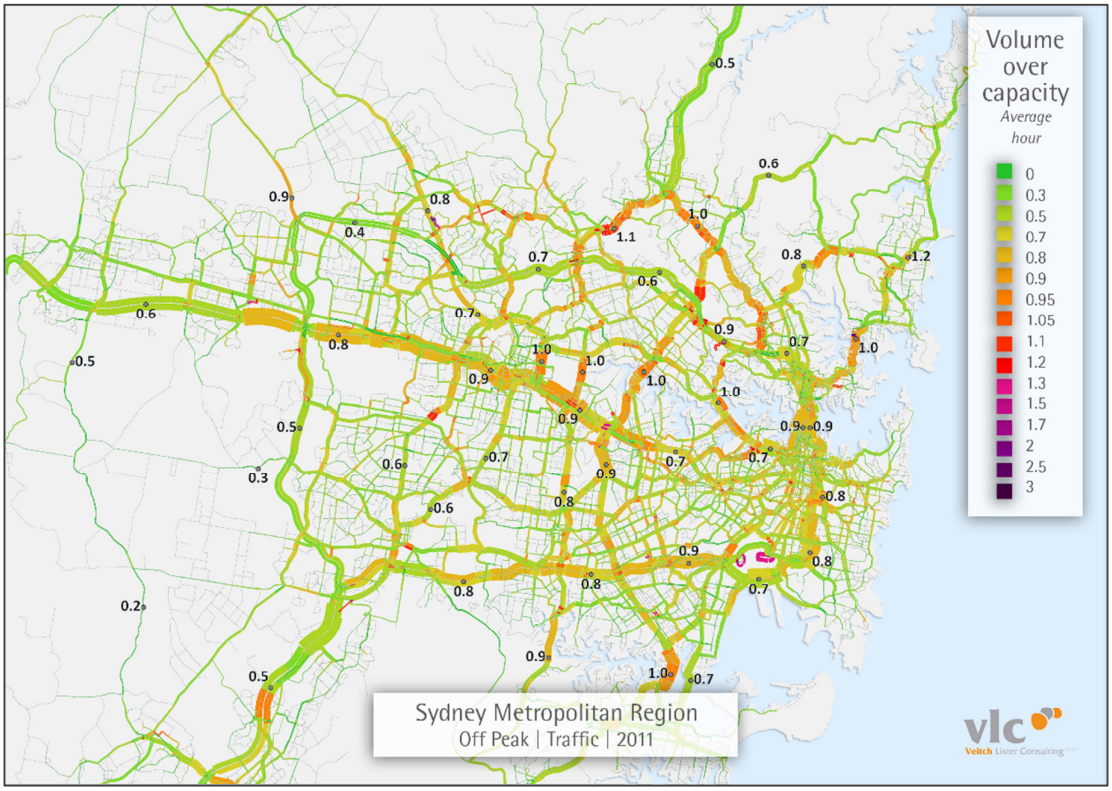


Figure 7-7: Road network volume/capacity ratios in 2011 - daytime off-peak

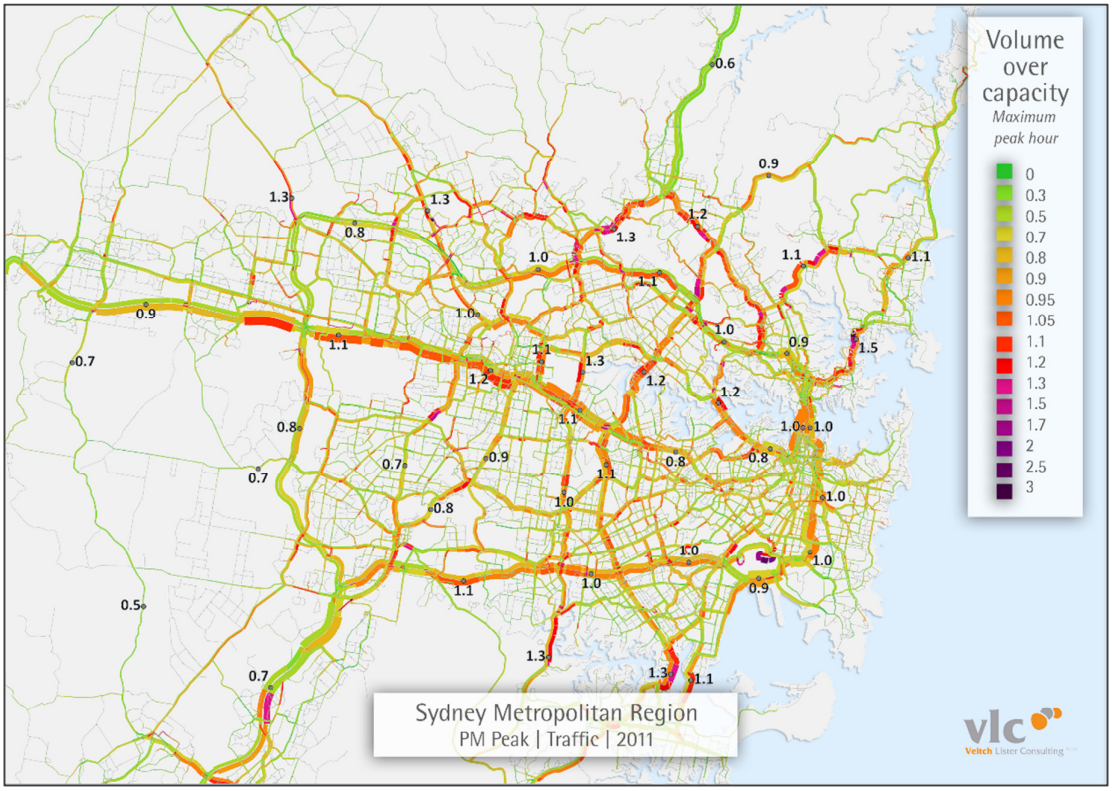


Figure 7-8: Road network volume/capacity ratios in 2011 - PM maximum peak hour

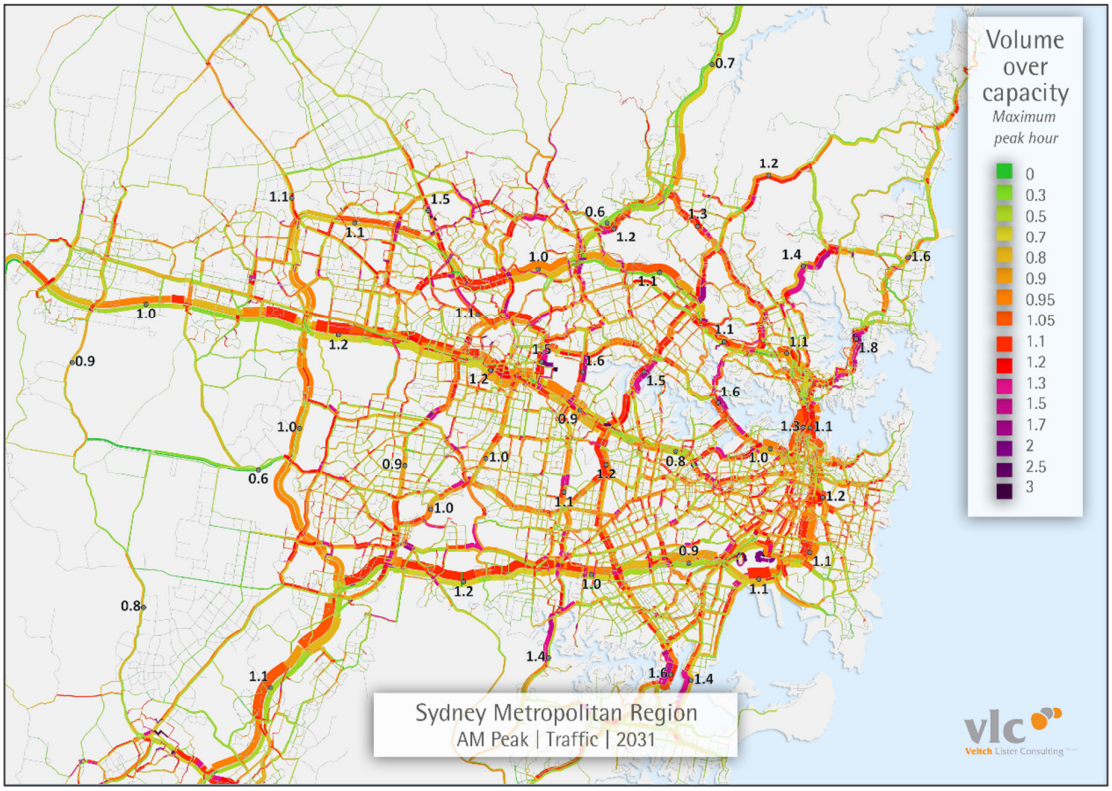


Figure 7-9: Road network volume/capacity ratios in 2031 - AM maximum peak hour

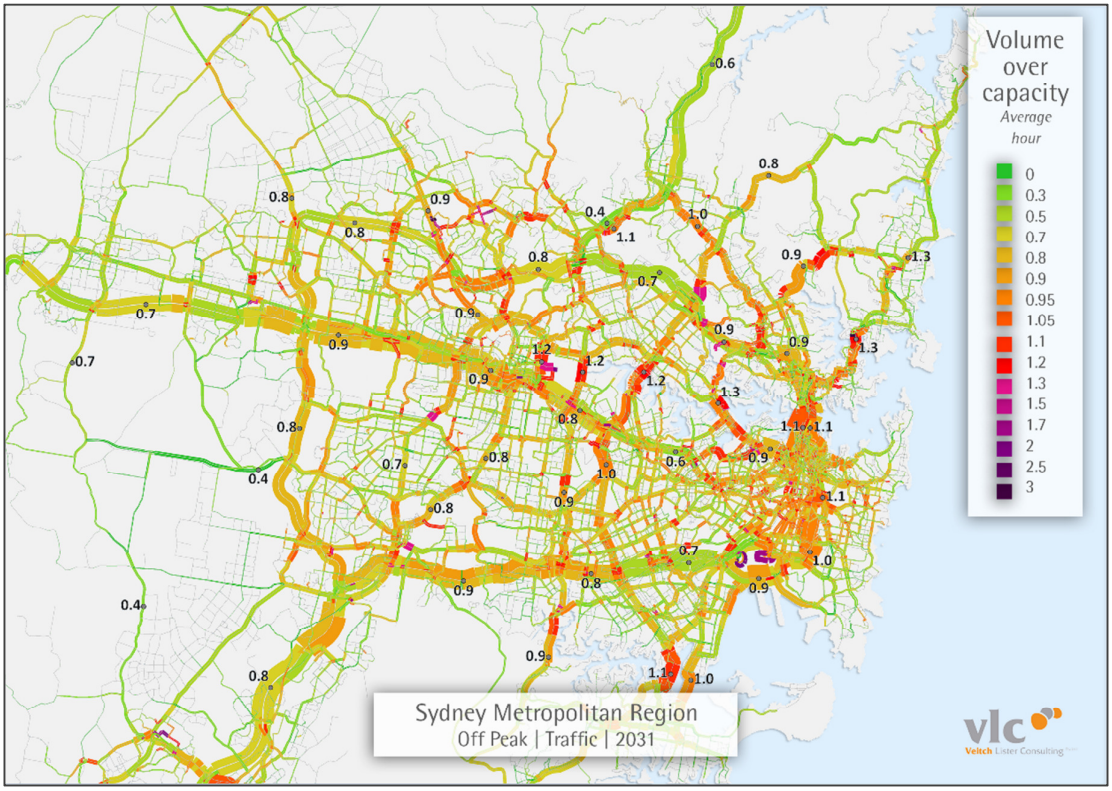


Figure 7-10: Road network volume/capacity ratios in 2031 - daytime off-peak

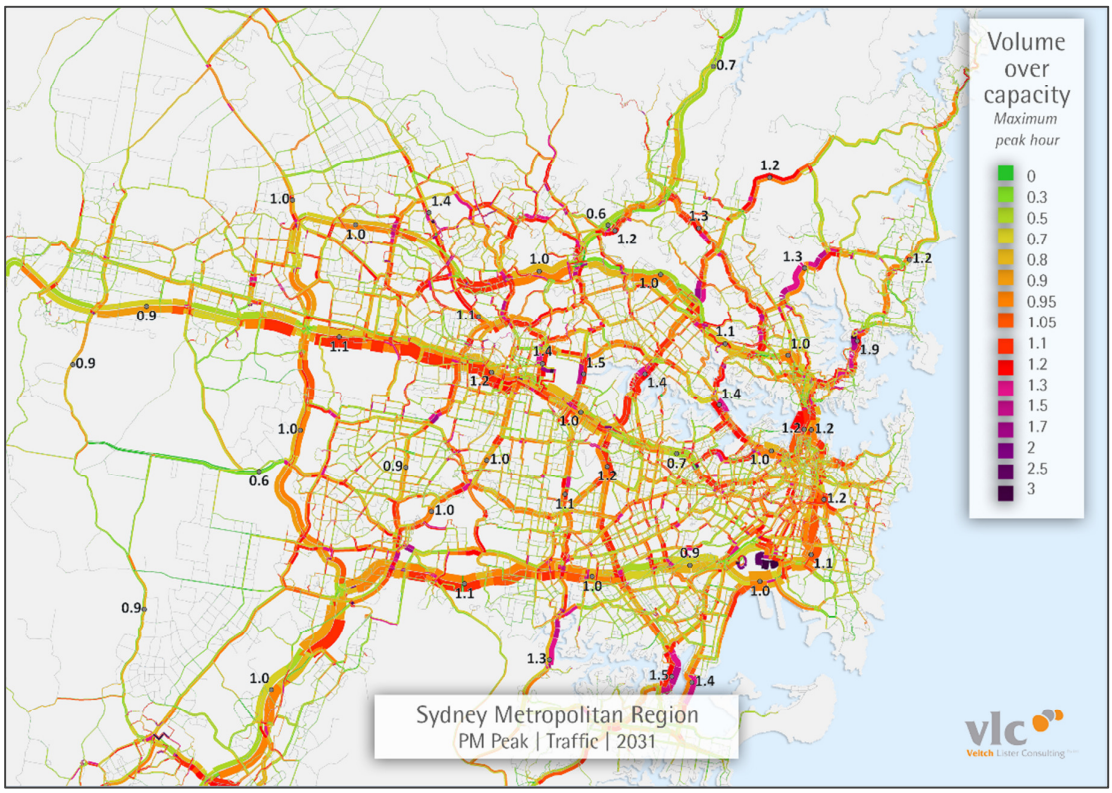


Figure 7-11: Road network volume/capacity ratios in 2031 - PM maximum peak hour

Figure 7-9 (previous) presents V/C ratios across the Sydney road network using the Zenith model's 2031 AM peak traffic forecasts for a *low road network investment* scenario.

It is clearly evident from Figure 7-9 that, if the Zenith model's forecasts are correct, then a significant proportion of Sydney's orbital motorway network will be unable to accommodate the predicted demand. Even widened sections of the South Western Motorway (M5) will be under pressure. The only way such levels of travel demand can be accommodated is by traffic diverting to the shoulders of the peak (peak spreading), or by travellers changing their travel behaviour (mode of travel, destination, etc.).

Figure 7-11 suggests that a similar scale of problem will emerge in the PM peak.

In the daytime off-peak in 2031 (refer Figure 7-10) the Zenith model predicts that most of the major road network will still have spare capacity. However, the model suggests that there will be little spare off-peak capacity on the South Western and Western Motorways, roads connecting the airport with the CBD, the Pacific Highway south of Wahroonga and the roads accessing the North Shore and Northern Beaches.

7.4 Change in travel times (2011-2031)

This section of the report translates the forecast increase in levels of congestion in Sydney in 2031 (as described in Section 7.3), into the likely implications for AM peak car travel times to key destinations. Three key destinations are considered:

- The Sydney CBD
- Sydney Airport; and
- The Parramatta business centre.

Figures 7-12 through 7-17 provide 2011 and 2031 travel time contours for car travel to these three destinations in the AM peak, under a *low investment road network* scenario.

Referring to Figures 7-12 and 7-13, it is evident that the Zenith model predicts significant contraction of the travel time contours for car around the Sydney CBD by 2031. For example, the journey time by car from Mona Vale (on the Northern Beaches) to the CBD will increase from 50-55 minutes to 65-70 minutes due heavy congestion on Pittwater Road, Military Road, Warringah Road and the Pacific Highway. Similarly AM peak car travel times are forecast to increase for travel between Liverpool and the CBD from 45-50 minutes to 55-60 minutes. AM peak car travel times from Parramatta to the CBD are also expected to increase from 40-45 minutes in 2011 to 50-55 minutes in 2031.

Figures 7-14 and 7-15 also show a significant contraction of the radius of the AM peak travel time contours for car around Sydney Airport by 2031. Generally speaking, longer distance car travel times to the Airport increase by about 10 minutes. The travel time for travelling to the Airport from the Sydney CBD by car are forecast to increase from 15-20 minutes in 2011 to 25-30 minutes in 2031.

Figures 7-16 and 7-17 show the contraction in the travel time contours for car for the Parramatta Business Centre by 2031; however, the degree of contraction is far less pronounce than for the other two key destinations (CBD and Airport). This is largely due to a significant proportion of drivers accessing Parramatta in the AM peak are travelling in the counter-peak direction where lower levels of traffic congestion will be experienced.

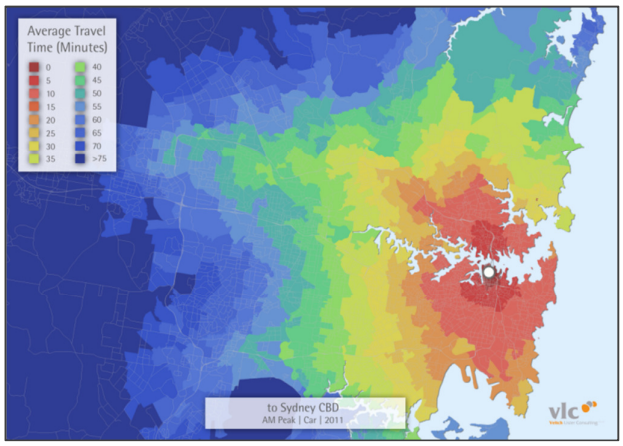


Figure 7-12: Sydney CBD | Road | AM Peak | 2011

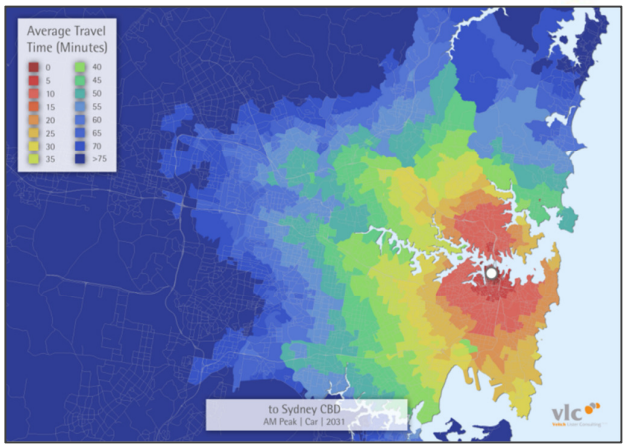


Figure 7-13: Sydney CBD | Road | AM Peak | 2031

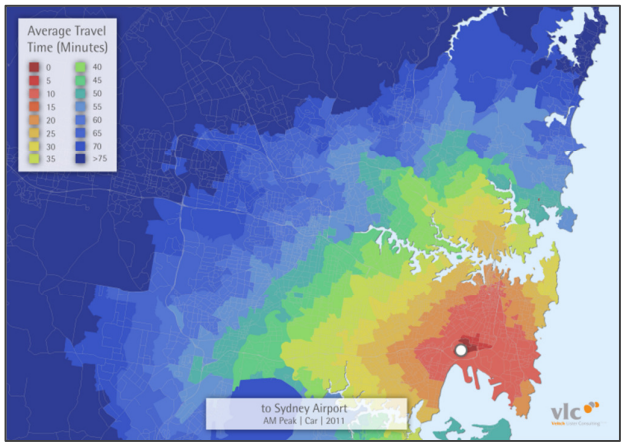


Figure 7-14: Sydney Airport | Road | AM Peak | 2011

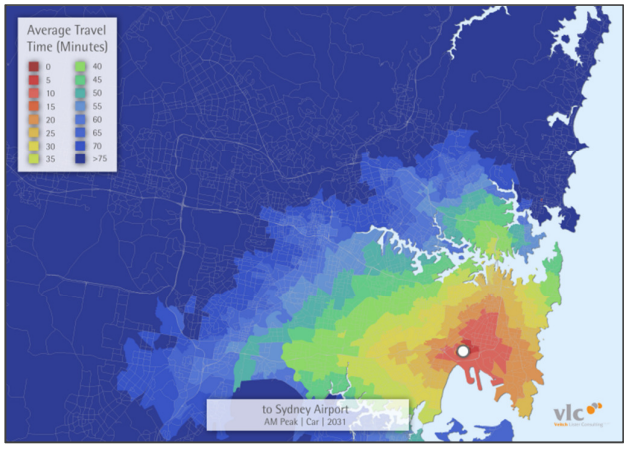


Figure 7-15: Sydney Airport | Road | AM Peak | 2031

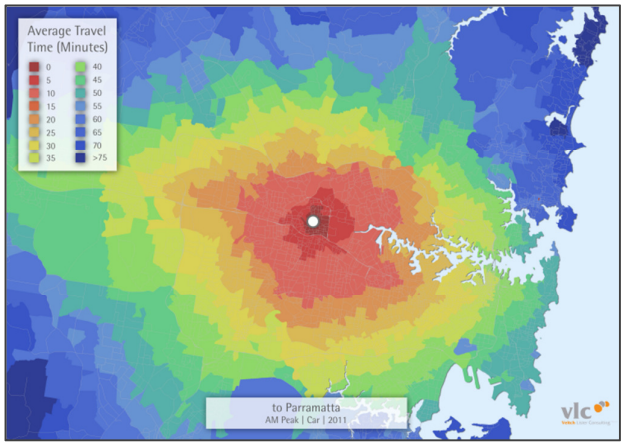


Figure 7-16: Parramatta | Road | AM Peak | 2011

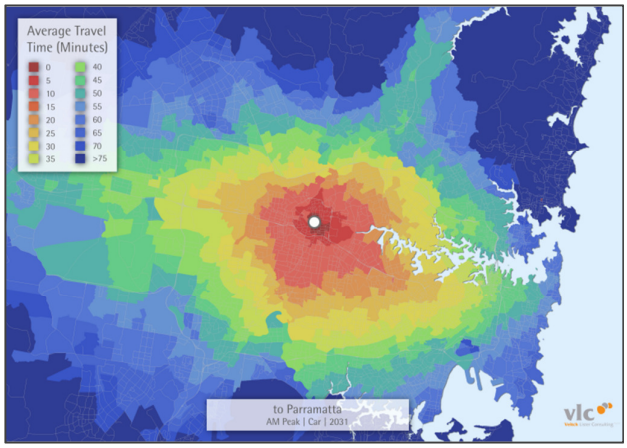


Figure 7-17: Parramatta | Road | AM Peak | 2031

8. Public transport system performance

8.1 Introduction

This section of the report presents the Zenith model's predictions as to extent that public transport ridership will increase in the future in Sydney 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. While some sections of new rail line have been added to the 2031 CityRail network, the current frequency of existing rail services have not been increased. For buses, new bus routes have been added to the public transport network to service the growth areas and Western Sydney Airport, but 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)

Figure 8-1 shows the Zenith model's forecast increase in daily passenger loading on the CityRail network between 2011 and 2031.

The largest increase in daily rail line loading by 2031 is forecast for the rail services approaching the CBD from the west - the Inner West, Western, Southern and Northern lines - particularly east of Strathfield. Large increases in passenger loading are also forecast for the Illawarra line that approaches the CBD from the south west - as well as the lines serving the North Shore (the Northern and North Shore lines) south of Chatswood.

Figure 8-2 shows where the Zenith model forecasts changes in weekday bus passenger loading by 2031. The model forecasts a large increase in usage of services operating between the North Shore/Northern Beaches and the Sydney CBD. Significant increases in passenger loading are also predicted for the bus routes serving the inner western suburbs.

Significant increases patronage are evident on the bus routes operating in the north west and south west growth area, while only modest increases in bus passenger loading are predicted for the balance of the bus network.

Reduced passenger loading is predicted on the bus services operating to the immediate south east of the Sydney CBD as a result of the introduction of LRT services. Passenger demand is also forecast to reducing on bus services operating on the M2 as a result of the North West Rail Link project.

Figure 8-3 shows the predicted increase in weekday passenger loading for both the ferry and LRT network by 2031. It shows healthy loading on the new LRT network operating to the south east of the CBD, and a healthy increase on the LRT line operating to the west of the CBD - largely due to its extension from Lilyfield to Dulwich Hill.

While there are increases in patronage predicted broadly across the ferry network, there is a significant jump in patronage on the Manly Ferry, most probably the result of increasing traffic congestion making it more difficult to cross the harbour from the beach suburbs on the North Shore.

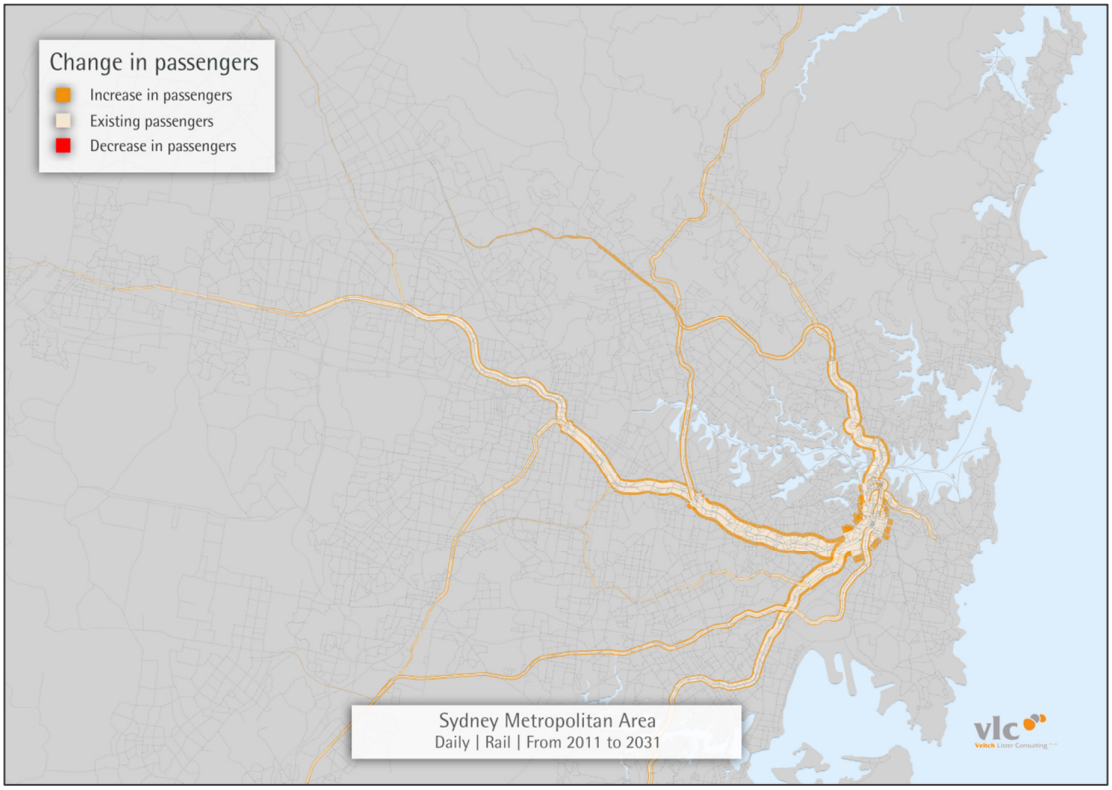


Figure 8-1: Increase in weekday CityRail passenger loading (2011-2031)

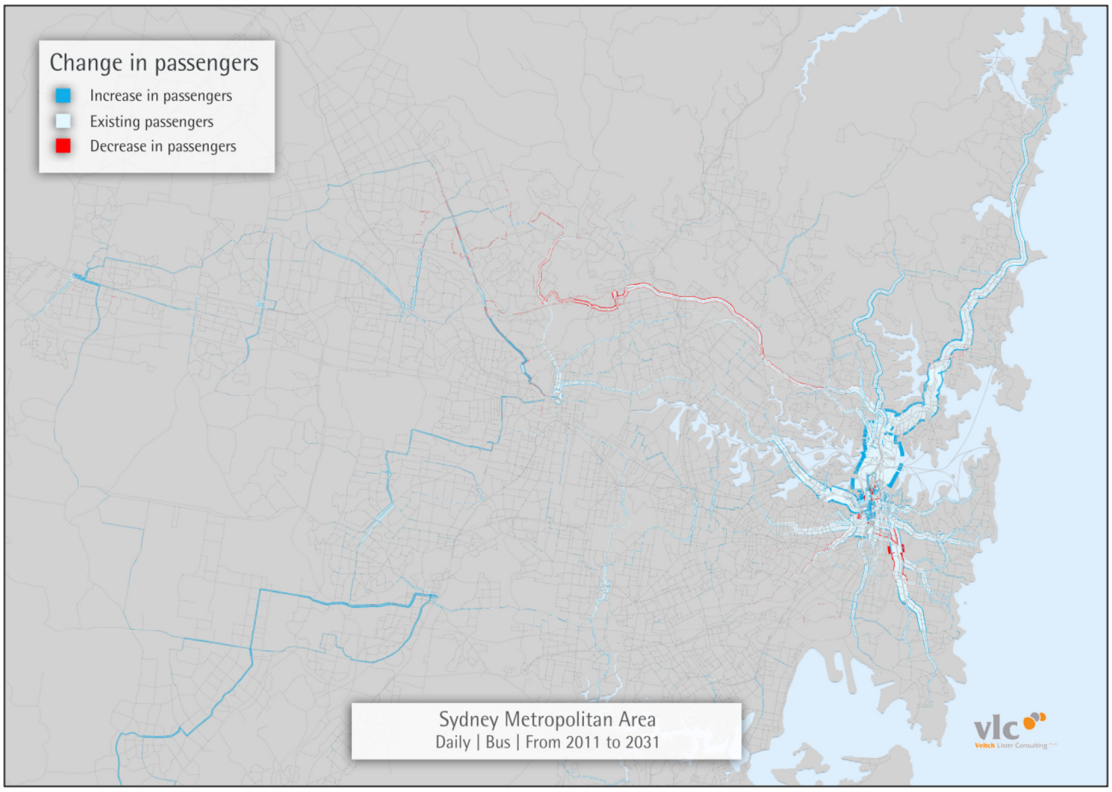


Figure 8-2: Increase in weekday bus passenger loading (2011-2031)

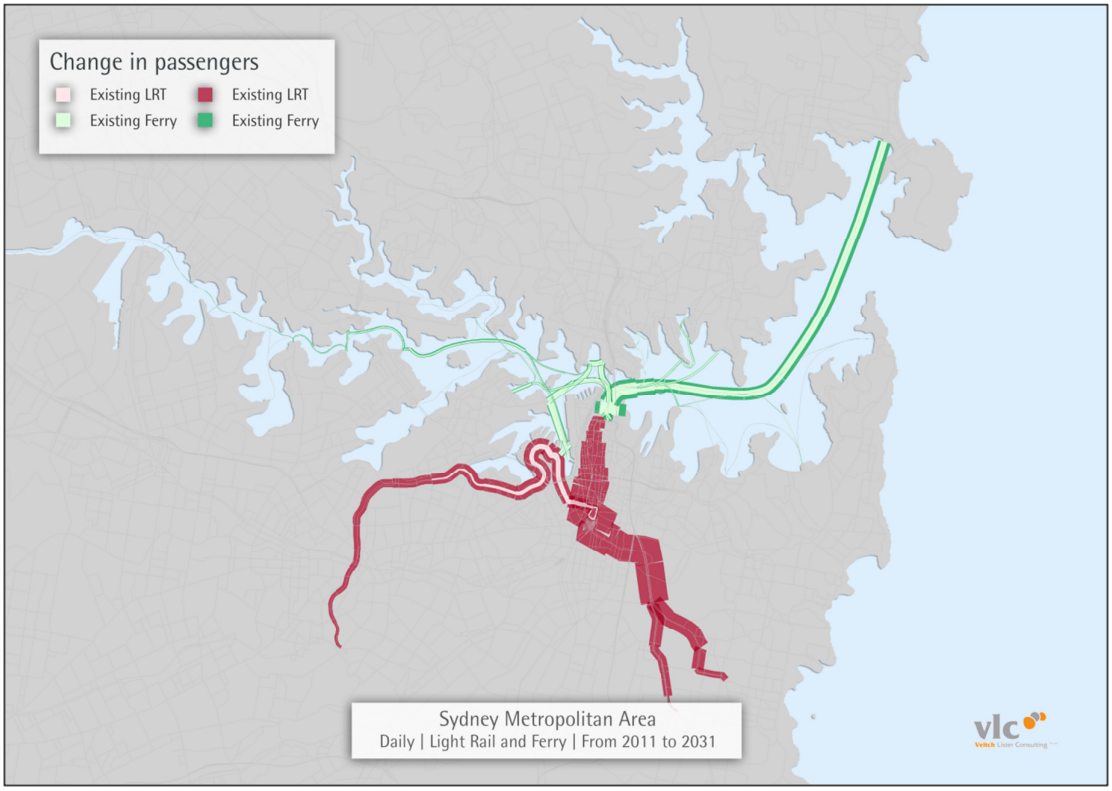


Figure 8-3: Increase in ferry and LRT weekday passenger loading (2011-2031)

8.3 CityRail line loadings relative to seating and crush capacity

Figure 8-4 that follows shows the Zenith model's weekday AM peak (one hour) passenger load on the CityRail network relative to the available seating capacity in 2011 and 2031, while Figure 8.5 plots the weekday passenger load relative to the "crush" capacity, the latter being assumed to be 60% above the seating capacity.

Referring to Figure 8-4, it shows that the Zenith model's estimated 2011 passenger demand on the rail network exceeds the seating capacity of the trains on all lines as they approach the Sydney CBD - the exception being the Eastern Suburbs line. This figure suggests that in 2011 the passenger demand on inbound trains in the morning peak hour exceeded the seating capacity of the trains for a considerable distance from the Sydney CBD, resulting in some passengers having to stand for a considerable period of time.

For example, passengers boarding trains operating from the North Shore (the North Shore and Northern lines) between Chatswood and the CBD would most likely have to stand. On the Western and South lines seats were at a premium between Ashfield and the CBD. On the Illawarra line, the Zenith model suggest that the passenger load on the line exceeds the seating capacity as far out as Penshurst Station.

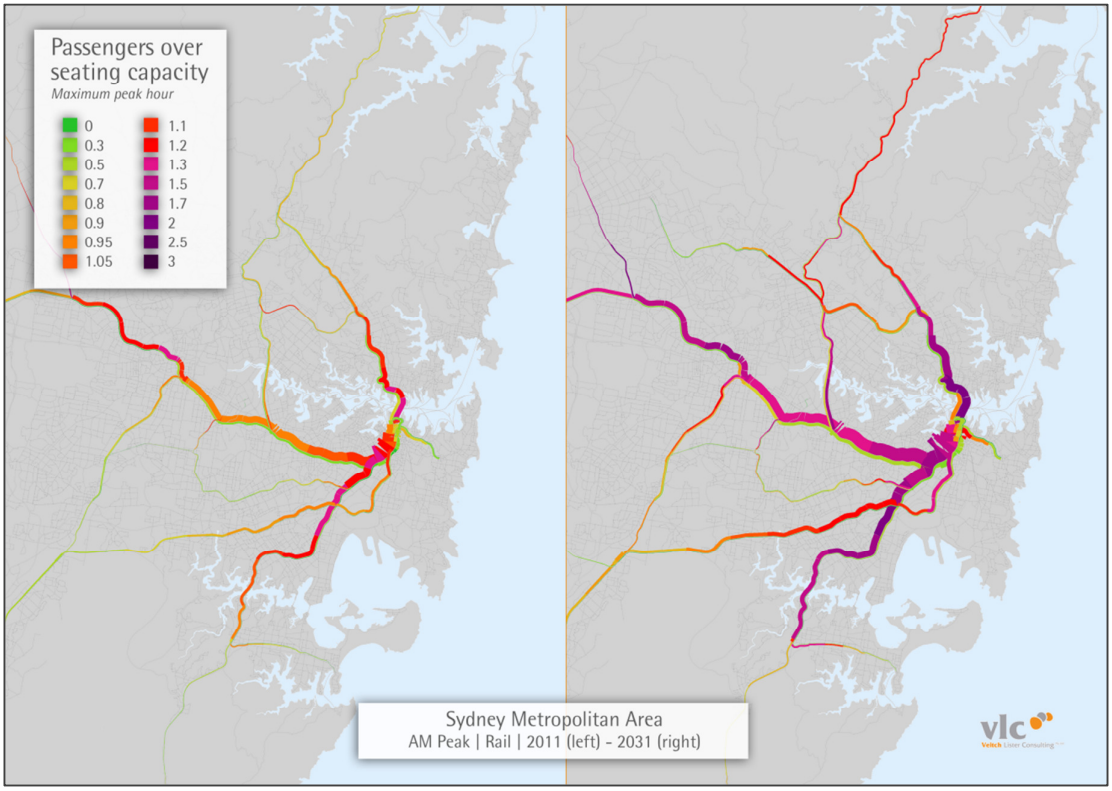


Figure 8-4: CityRail weekday passenger demand relative to seating capacity (2011 and 2021)

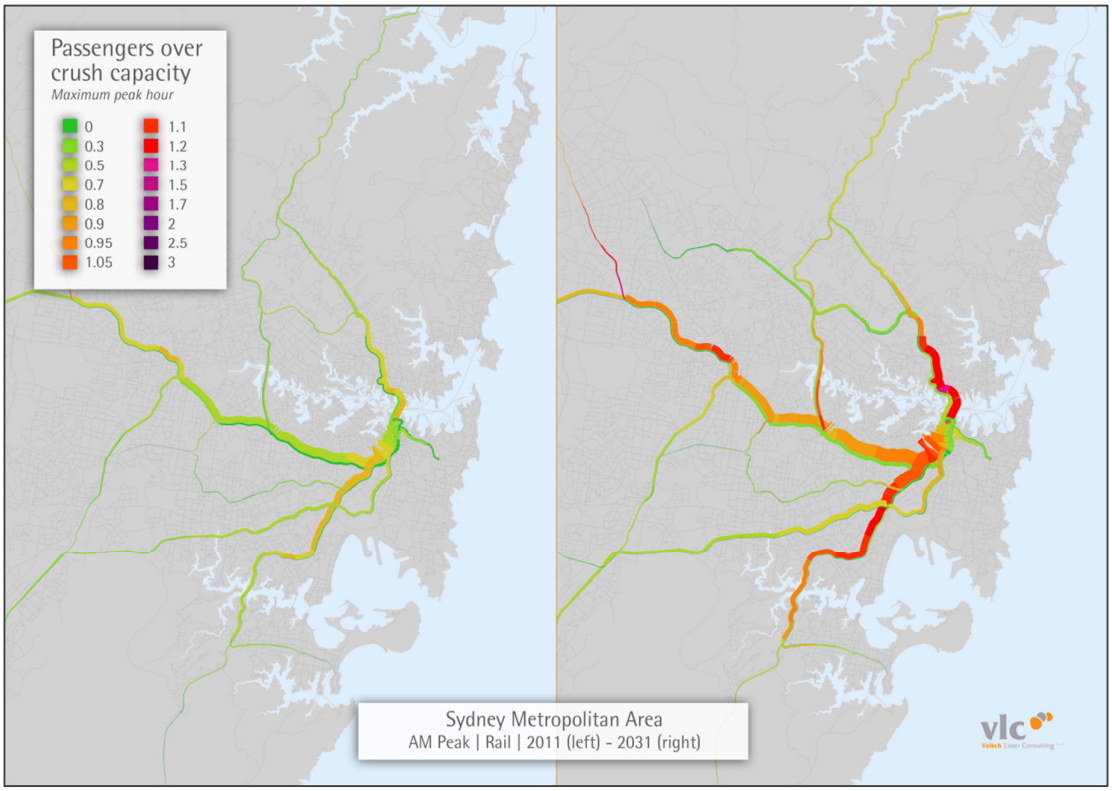


Figure 8-5: CityRail weekday passenger demand relative to crush capacity (2011 and 2031)

By 2031 the Zenith model suggests that, if train frequencies are not increased in the AM peak then the duration that passengers would have to stand increases considerably, as shown in Figure 8-4, particularly on the Western, South and Illawarra lines.

Figure 8-5 shows that average train passenger loads across the AM peak (one hour) in 2011 were below the defined crush capacity. This does not mean that individual trains are not operating at, or above, the defined crush capacity at the peak of the peak.

Figure 8-5 shows that by 2031, if train frequencies are not increased, then extensive sections of the CityRail network will experience demand in the AM peak in excess of, or close to crush capacity. The North Shore and Illawarra lines are predicted to be the most over-loaded.

Appendix A:
Transport Infrastructure Improvements
2031 Base Case Network

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

Item	Road
1	Improved exit ramp to Campbelltown Road
2	F5 Freeway - Stage 3 - Widen to 3 lanes in each direction between Raby Road and Narellan Road, completed in March 2012
3	Pedestrian and bike bridge between Claymore and Woodbine
4	Permanent closure of Jones Street to Broadway
5	The Ponds supporting infrastructure (including The Ponds Boulevard)
6	Boundary Street upgrade – April 2012, replaced rail bridge over Boundary Road
7	Great Western Hwy - Station Rd to Tableland Rd (Wentworth)
8	Camden Valley Way upgrade between Cobbitty Road and Narellan Road
9	South West Growth Centre - Oran Park 2012
10	Camden Valley Way upgrade
11	Wallarah Creek, Pacific Highway Upgrade
12	Hoxton Park Rd
13	F5 Freeway Widening - Stage 2
14	M2 Upgrade Project - Windsor Rd west facing ramps and Herring Road west bound off ramp
15	M2 Upgrade Project - Christie Rd east facing ramp
16	Cumberland Highway and M4 intersection. Lane number edits
17	Eagle Vale Drive Upgrade to 4 lanes North of Epping Rd
18	Improving traffic flow on Marsden Road, Eastwood
19	The Ponds - Greenview Parade
20	Extra minor Roads for 2013 PT network
21	South West Growth Centre - Oran Park 2013
22	South West Growth Centre - Turner Rd 2013
23	Upgrade of central coast highway between carlton road and matcham rd
24	Pedestrian underpass across central coast hwy, kariong
25	The Ponds - Ridgeline Drive
26	Powers Road extra lane
27	Reconciliation Road, Pemulwuy
28	The Northern Road, Cranebrook
29	Taren Point Rd sth to hold & nrth to toorak- increasing length of slip turning lanes by 110m.
30	South West Growth Centre - Oran Park 2014
31	Erskine Park Link Road
32	M2 Upgrade Project
33	Upgrade of central coast highway between matcham rd and ocean view drive
34	Princes Highway Upgrade - South Nowra. 2 to 4 lanes
35	The Hunter Expressway - new 40km highway
36	Great Western Hwy Upgrade at Bullaburra
37	M2 Upgrade Project - Lane Cove Road East-bound on-Ramp and Lane widening
38	Richmond Road Upgrade - Stage 1
39	Schofields Road Corridor Upgrade - Stage 1
40	Brisbane Water Drive and Manns Road at West Gosford Intersection upgrade
41	Nelson Bay Road Upgrade, Bob's Farm to Annay Bay
42	M5 West Widening
43	Richmond Road Upgrade - Stage 2
44	Western Sydney Employment Area - Old Wallgrove Road upgrade
45	Fullers Road, Chatswood
46	Boundary Street Upgrade, Roseville
47	North West Growth Centre - Alex Avenue Precinct
48	North West Growth Centre - Marsden Park Precinct
49	North West Growth Centre - Colebee
50	Spring Farm Road Infrastructure Stage 1
51	Elderslie Road Infrastructure
52	South West Growth Centre - Oran Park 2016
53	South West Growth Centre - Turner Rd 2016
54	Eagle Vale Drive Upgrade to 4 lanes South of Epping Rd

55	South West Growth Centre - Edmondson Park 2016
56	Camden Valley Way upgrade between Oran Park Drive, Harrington Park and Bringelly Road, Leppington - upgrade from 2 to 4 lanes with 80km/hr speed limit
57	Schofields Road Upgrade and Extension - Stage 2
58	Werrington Arterial Road - Stage 1, Claremont Meadows
59	Showground Road Upgrade, Castle Hill
60	South West Growth Centre - Oran Park 2018
61	NorthConnex (M2 to F3 Corridor)
62	Prospect Highway upgrade
63	North West Growth Centre - Schofields Precinct
64	Western Sydney Employment Area - Southern Link Road
65	Schofields Rd Upgrade and Extension - Stage 3
66	Narellan Road Upgrade
67	Mona Vale Road Upgrade
68	Alford's Point Road Southern Approach
69	North West Growth Centre - Area 20 Precinct
70	North West Growth Centre - Riverstone Precinct
71	North West Growth Centre - Riverstone West Precinct
72	North West Growth Centre - Box Hill Precinct
73	North West Growth Centre - North Kellyville Precinct
74	North West Growth Centre - Riverstone East Precinct
75	Spring Farm Road Infrastructure Stage 2
76	South West Growth Centre - Catherine Fields (Part) 2021
77	South West Growth Centre - Turner Rd 2021
78	South West Growth Centre - Austral & Leppington 2021
79	South West Growth Centre - Edmondson Park 2021
80	South West Growth Centre - Marylands - 2021
81	South West Growth Centre - East Leppington - 2021
82	M4 widening
83	Upgrade of Campbelltown Road
84	South West Growth Centre - Leppington - 2026
85	South West Growth Centre - Marylands - 2026
86	Upgrade of Denham Court Rd
87	Archbold Road
88	Western Sydney Employment Area - Long-term Improvements
89	Richmond Road Upgrade - Stage 3
90	Bringelly Road Upgrade
91	The Northern Road upgrade, Bringelly
92	North West Growth Centre - Schofields West Precinct
93	North West Growth Centre - Vineyard
94	South West Growth Centre - Catherine Fields North - 2031
95	South West Growth Centre - Catherine Fields - 2031
96	WestConnex Stage 1
97	WestConnex Stage 2

Appendix B:
Public transport capacity assumptions

CityRail Capacity Coding

General

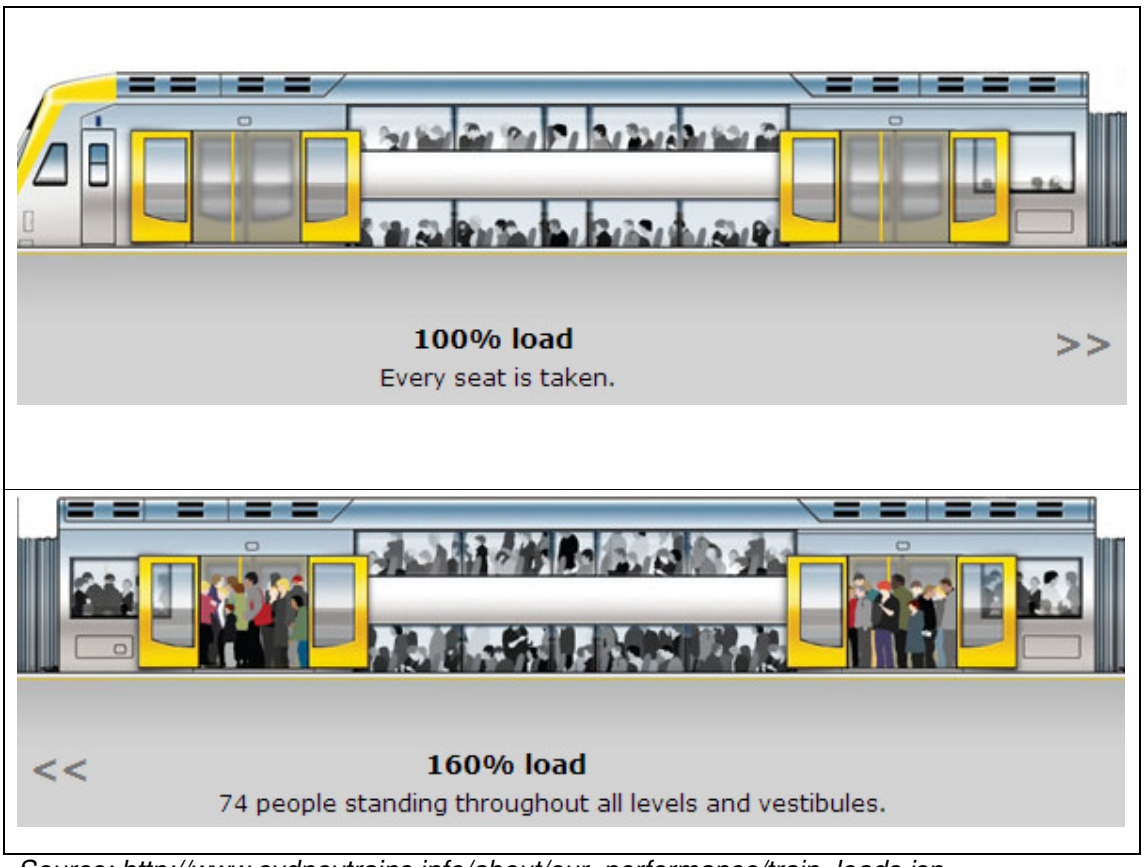
Coding of CityRail fleet capacities was based on information provided on the Sydney Trains website. Information for each class of train in the fleet was sourced from;

http://www.sydneytrains.info/about/fleet/

In the reporting of performance figures, Sydney Trains provides a guide to the meaning of certain percentage loads, for instance, that “100% load” means “Every seat is taken”. Refer to;

http://www.sydneytrains.info/about/our_performance/train_loads.jsp

At this website, the guide provided by Sydney Trains has its maximum at 160% load, with a corresponding diagram that is suggestive of maximum seating and standing capacity. Thus, for every class of train, we have assumed that 160% of seating capacity is the crush capacity.



Source: http://www.sydneytrains.info/about/our_performance/train_loads.jsp

For each class of train, the following information was noted;

- Seating capacity of each type of carriage (e.g. trailer, motor)
- Number in service
- Whether it primarily serves suburban or intercity routes

This information is used to calculate the seating (and therefore crush) capacity of a typical 8-car set of that class of train. Note that;

- Operationally, most rail services in Sydney are 8 car sets. There are three exceptions: the Carlingford line, intercity services on the Southern Highlands line, and services on the North-West Rail Link in 2031 scenarios.
- These two exceptions are addressed later in this document.

Coding of Suburban service capacities

For all classes categorised as “suburban”, a weighted average capacity for an 8-car set is calculated across all these classes. This weighted average is used across all suburban services. The classes categorised as “suburban” are;

- Waratah, Millennium, Tangara; C-, S- and K-Sets

The suburban weighted average 8-car capacity is directly applied to all services that begin *and* terminate within the following boundary;

- South of Berowra
- East of Richmond or Emu Plains
- North of Macarthur or Waterfall

This is consistent with Sydney Trains’ definition of their suburban network at;

http://www.sydneytrains.info/stations/pdf/suburban_map.pdf

Source: http://www.sydneytrains.info/stations/pdf/suburban_map.pdf

The one exception within this area is the Carlingford Line, which operates using 4-car sets. The capacities applied to the Carlingford Line are *half* the suburban weighted average 8-car capacity.

Coding of Intercity service capacities

Based on the information provided at http://www.sydneytrains.info/about/fleet/, we can infer the following;

- *Oscar*-class trains operate on the Central Coast Line only as far as Wyong, and along the South Coast Line to Kiama
- *Endeavour*-class trains operate exclusively on the Southern Highlands Line
- *V*-Set trains operate on the full extent of the Newcastle Line (to Newcastle), and are the only class operating on the Blue Mountains Line

Note that "intercity" services must terminate (when outbound) or begin (when inbound to central) outside the suburban boundary defined previously. For these intercity services, we code the capacities, assuming 8-car sets, as follows:

- On the Newcastle Line, all services terminating/beginning south of Wyong are assumed to be operated by *Oscar*-class trains. Operationally, this includes Gosford and Wyong services

- On the Newcastle Line, remaining services (terminate/begin north of Wyong) are assumed to be operated by *V*-Set trains.
- All Blue Mountains Line services are assumed to be operated by *V*-Set trains
- All South Coast Line services are assumed to be operated by *Oscar*-class trains
- All Southern Highlands services are assumed to be operated by *Endeavour*-class trains
    - *However*, the *Endeavour* class trains run as only 2- or 4-car sets, and the capacities are coded as such (i.e. not as 8-car sets).
    - It is assumed that Southern Highlands services beginning or terminating at Macarthur are operated as 2-car sets
    - In each peak, there are several Southern Highlands services that continue to or start from Central. These are coded as 4-car sets.

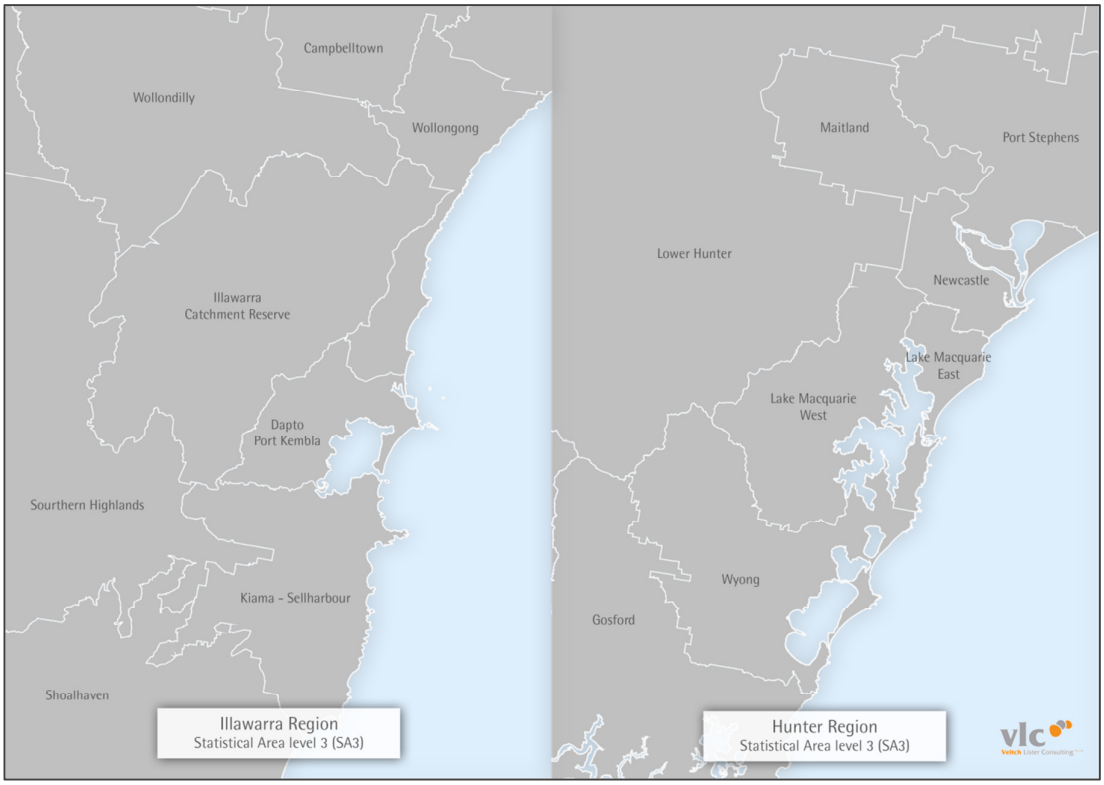
North-West Rail Link

At present, it is understood that the North-West Rail Link (NWRL) will make use of *single-deck* trains (source: http://nwrail.transport.nsw.gov.au/The-Project/Trains), in contrast to double-deck trains used across the rest of the Sydney suburban network. To infer a capacity for these trains, we have used the single-deck trains in Melbourne as a template;

- VLC assumes that each 6-car train set in Melbourne has seating capacity of 500, with crush capacity of 1250.
- We have assumed that services on the NWRL will follow the Sydney convention of using 8-car sets, thus, we scale up the Melbourne capacities by 4/3
- This results in seating capacity of 667, and crush capacity of 1667, on the NWRL.
- For comparison, information provided on the NWRL website states "*each train will be capable of moving up to 1,300 people*", although it does not say at what percentage of seating capacity this would apply.
    - It is logical to assume that this capacity of 1,300 must include some element of standing, as is the case with any other single-deck suburban train worldwide.
    - Furthermore, it is logical to assume that "crush" capacity is somewhat higher than normal operational capacity.

Appendix C:
ABS Statistical Areas level 3

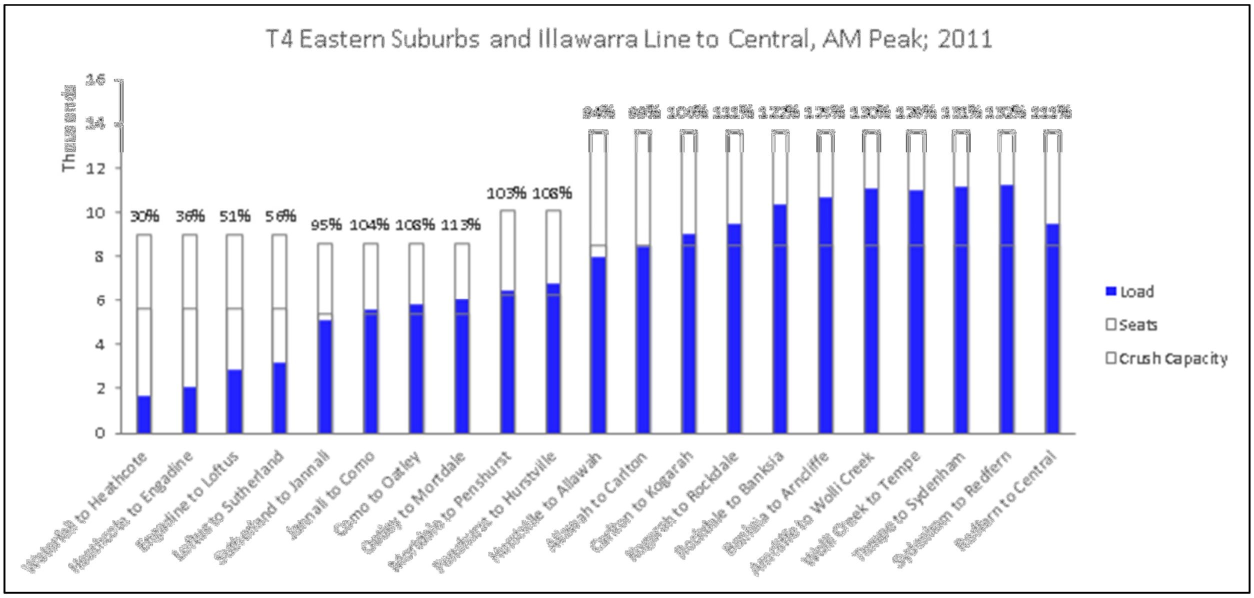
Sydney Metropolitan Area SA3s

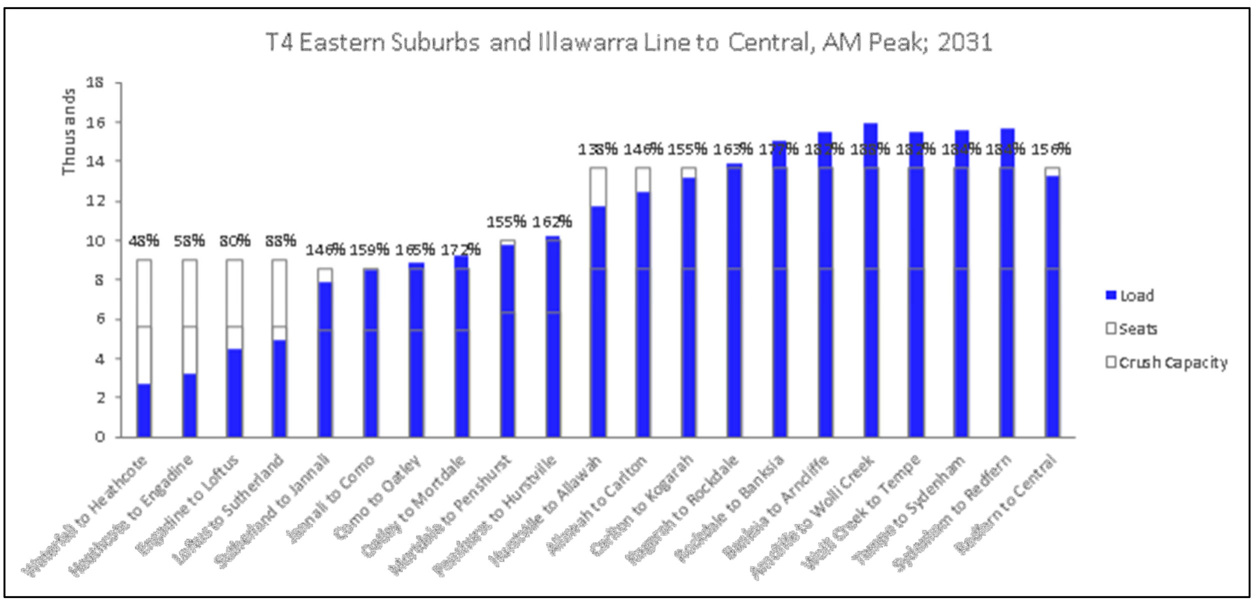


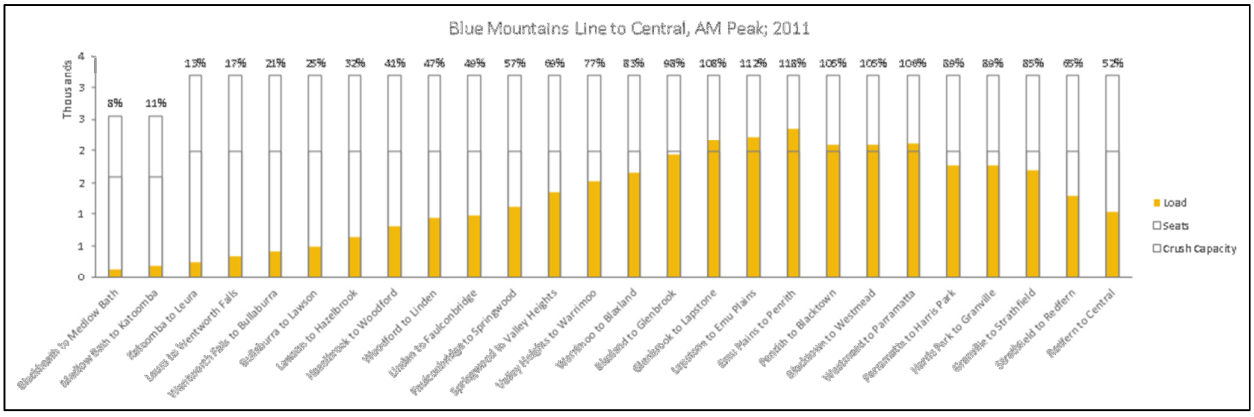
SA3s in Illawarra and Hunter Regions

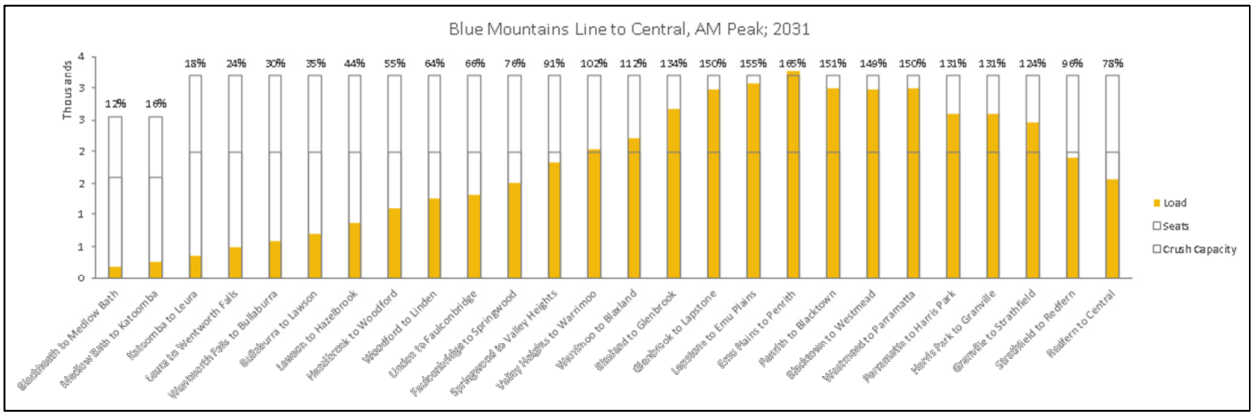
Appendix D:
Selection of CityRail supply and demand charts by line

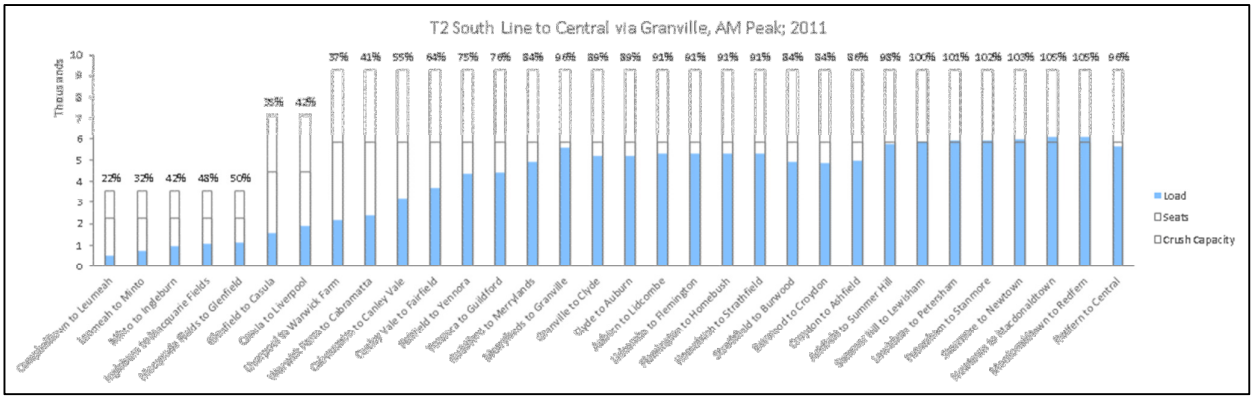
Equivalent information is available for all rail lines, as well as all bus, light rail, and ferry routes.

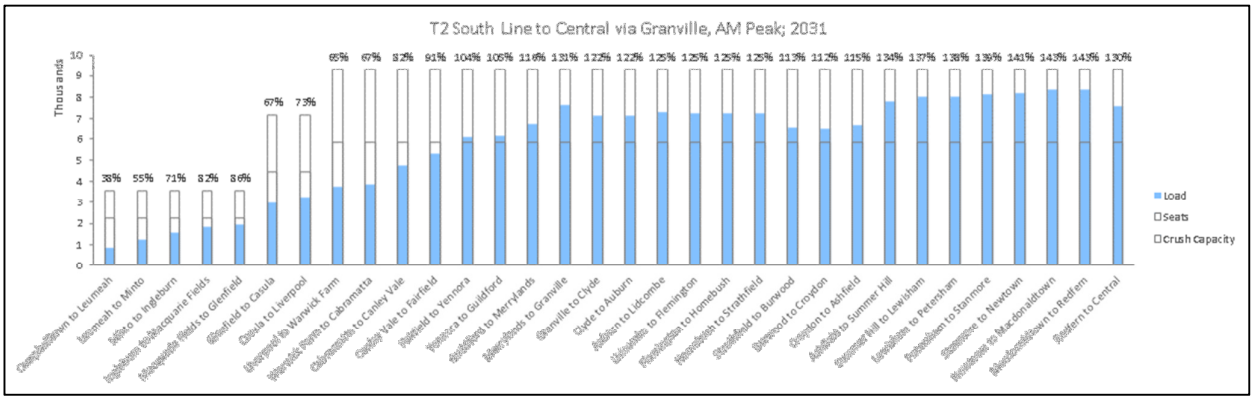

T4 Eastern Suburbs and Illawarra Line to Central, AM Peak; 2011
Thousands
Load
Seats
Crush Capacity
Waterfall to Heathcote
Heathcote to Engadine
Engadine to Loftus
Loftus to Sutherland
Sutherland to Jannali
Jannali to Como
Como to Oatley
Oatley to Mortdale
Mortdale to Penshurst
Penshurst to Hurstville
Hurstville to Allawah
Allawah to Carlton
Carlton to Kogarah
Kogarah to Rockdale
Rockdale to Banksia
Banksia to Arncliffe
Arncliffe to Wolli Creek
Wolli Creek to Tempe
Tempe to Sydenham
Sydenham to Redfern
Redfern to Central

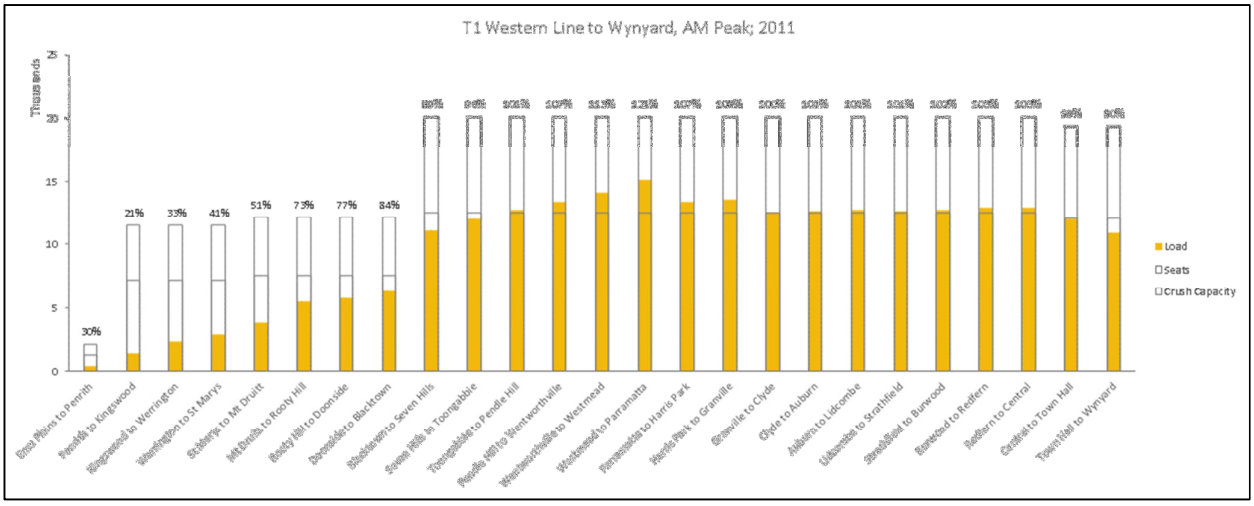

T4 Eastern Suburbs and Illawarra Line to Central, AM Peak; 2031
Thousands
Load
Seats
Crush Capacity
48% 58% 80% 88% 146% 159% 165% 172% 155% 162% 138% 146% 155% 163% 156%
Waterfall to Heathcote
Heathcote to Engadine
Engadine to Loftus
Loftus to Sutherland
Sutherland to Jannali
Jannali to Como
Como to Oatley
Oatley to Mortdale
Mortdale to Penshurst
Penshurst to Hurstville
Hurstville to Allawah
Allawah to Carlton
Carlton to Kogarah
Kogarah to Rockdale
Rockdale to Banksia
Banksia to Arncliffe
Arncliffe to Wolli Creek
Wolli Creek to Tempe
Tempe to Sydenham
Sydenham to Redfern
Redfern to Central

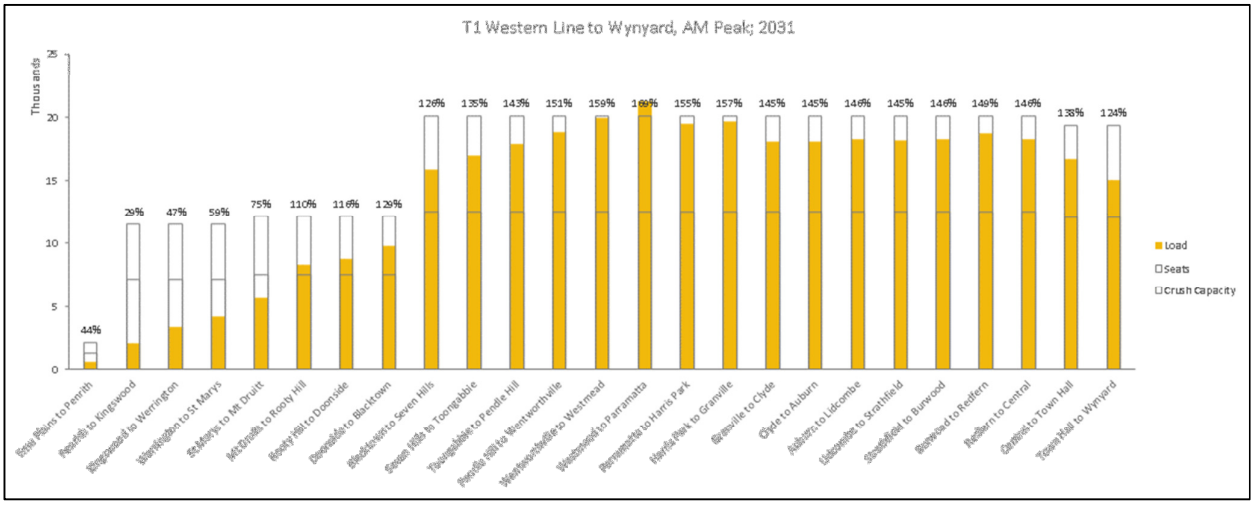

Blue Mountains Line to Central, AM Peak; 2011
Thousands
0
1
2
3
4
8%
11%
13%
17%
21%
25%
32%
41%
47%
49%
57%
69%
77%
83%
98%
108%
112%
118%
105%
105%
106%
89%
89%
85%
65%
52%
Load
Seats
Crush Capacity
Blackheath to Medlow Bath
Medlow Bath to Katoomba
Katoomba to Leura
Leura to Wentworth Falls
Wentworth Falls to Bullaburra
Bullaburra to Lawson
Lawson to Hazelbrook
Hazelbrook to Woodford
Woodford to Linden
Linden to Faulconbridge
Faulconbridge to Springwood
Springwood to Valley Heights
Valley Heights to Warrimoo
Warrimoo to Blaxland
Blaxland to Glenbrook
Glenbrook to Lapstone
Lapstone to Emu Plains
Emu Plains to Penrith
Penrith to Blacktown
Blacktown to Westmead
Westmead to Parramatta
Parramatta to Harris Park
Harris Park to Granville
Granville to Strathfield
Strathfield to Redfern
Redfern to Central


Blue Mountains Line to Central, AM Peak; 2031
Thousands
0
1
2
3
4
12%
16%
18%
24%
30%
35%
44%
55%
64%
66%
76%
91%
102%
112%
134%
150%
155%
165%
151%
149%
150%
131%
131%
124%
96%
78%
Load
Seats
Crush Capacity
Blackheath to Medlow Bath
Medlow Bath to Katoomba
Katoomba to Leura
Leura to Wentworth Falls
Wentworth Falls to Bullaburra
Bullaburra to Lawson
Lawson to Hazelbrook
Hazelbrook to Woodford
Woodford to Linden
Linden to Faulconbridge
Faulconbridge to Springwood
Springwood to Valley Heights
Valley Heights to Warrimoo
Warrimoo to Blaxland
Blaxland to Glenbrook
Glenbrook to Lapstone
Lapstone to Emu Plains
Emu Plains to Penrith
Penrith to Blacktown
Blacktown to Westmead
Westmead to Parramatta
Parramatta to Harris Park
Harris Park to Granville
Granville to Strathfield
Strathfield to Redfern
Redfern to Central


T2 South Line to Central via Granville, AM Peak; 2011
Thousands
Load
Seats
Crush Capacity
Campbelltown to Leumeah
Leumeah to Minto
Minto to Ingleburn
Ingleburn to Macquarie Fields
Macquarie Fields to Glenfield
Glenfield to Casula
Casula to Liverpool
Liverpool to Warwick Farm
Warwick Farm to Cabramatta
Cabramatta to Canley Vale
Canley Vale to Fairfield
Fairfield to Yennora
Yennora to Guildford
Guildford to Merrylands
Merrylands to Granville
Granville to Clyde
Clyde to Auburn
Auburn to Lidcombe
Lidcombe to Flemington
Flemington to Homebush
Homebush to Strathfield
Strathfield to Burwood
Burwood to Croydon
Croydon to Ashfield
Ashfield to Summer Hill
Summer Hill to Lewisham
Lewisham to Petersham
Petersham to Stanmore
Stanmore to Newtown
Newtown to Macdonaldtown
Macdonaldtown to Redfern
Redfern to Central


T2 South Line to Central via Granville, AM Peak; 2031
Thousands
Load
Seats
Crush Capacity
Campbelltown to Leumeah
Leumeah to Minto
Minto to Ingleburn
Ingleburn to Macquarie Fields
Macquarie Fields to Glenfield
Glenfield to Casula
Casula to Liverpool
Liverpool to Warwick Farm
Warwick Farm to Cabramatta
Cabramatta to Canley Vale
Canley Vale to Fairfield
Fairfield to Yennora
Yennora to Guildford
Guildford to Merrylands
Merrylands to Granville
Granville to Clyde
Clyde to Auburn
Auburn to Lidcombe
Lidcombe to Flemington
Flemington to Homebush
Homebush to Strathfield
Strathfield to Burwood
Burwood to Croydon
Croydon to Ashfield
Ashfield to Summer Hill
Summer Hill to Lewisham
Lewisham to Petersham
Petersham to Stanmore
Stanmore to Newtown
Newtown to Macdonaldtown
Macdonaldtown to Redfern
Redfern to Central


T1 Western Line to Wynyard, AM Peak; 2011
Thousands
25
20
15
10
5
0
30%
21%
33%
41%
51%
73%
77%
84%
Load
Seats
Crush Capacity
Emu Plains to Penrith
Penrith to Kingswood
Kingswood to Werrington
Werrington to St Marys
St Marys to Mt Druitt
Mt Druitt to Rooty Hill
Rooty Hill to Doonside
Doonside to Blacktown
Blacktown to Seven Hills
Seven Hills to Toongabbie
Toongabbie to Pendle Hill
Pendle Hill to Wentworthville
Wentworthville to Westmead
Westmead to Parramatta
Parramatta to Harris Park
Harris Park to Granville
Granville to Clyde
Clyde to Auburn
Auburn to Lidcombe
Lidcombe to Strathfield
Strathfield to Burwood
Burwood to Redfern
Redfern to Central
Central to Town Hall
Town Hall to Wynyard


T1 Western Line to Wynyard, AM Peak; 2031
Thousands
25
20
15
10
5
0
44%
29%
47%
59%
75%
110%
116%
129%
126%
135%
143%
151%
159%
160%
155%
157%
145%
145%
146%
145%
146%
149%
146%
138%
124%
Load
Seats
Crush Capacity
Emu Plains to Penrith
Penrith to Kingswood
Kingswood to Werrington
Werrington to St Marys
St Marys to Mt Druitt
Mt Druitt to Rooty Hill
Rooty Hill to Doonside
Doonside to Blacktown
Blacktown to Seven Hills
Seven Hills to Toongabbie
Toongabbie to Pendle Hill
Pendle Hill to Wentworthville
Wentworthville to Westmead
Westmead to Parramatta
Parramatta to Harris Park
Harris Park to Granville
Granville to Clyde
Clyde to Auburn
Auburn to Lidcombe
Lidcombe to Strathfield
Strathfield to Burwood
Burwood to Redfern
Redfern to Central
Central to Town Hall
Town Hall to Wynyard