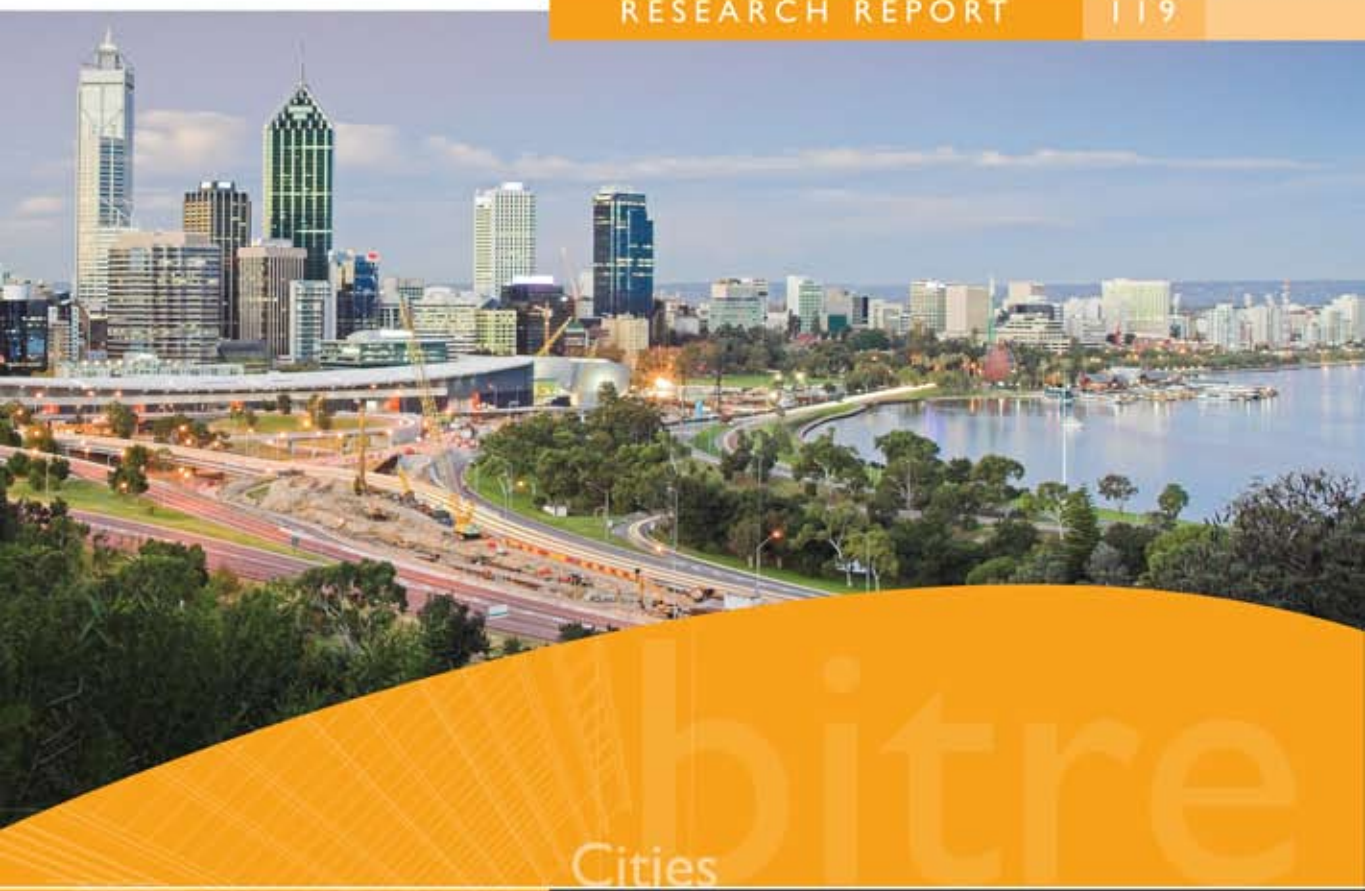
Australian Government
Department of Infrastructure and Transport
Bureau of Infrastructure, Transport and Regional Economics

RESEARCH REPORT 119



bitre

Cities

Population growth, jobs growth and commuting flows in Perth

Bureau of Infrastructure, Transport and Regional Economics

Population growth, jobs growth and commuting flows in Perth

Department of Infrastructure and Transport
Canberra, Australia

ISSN 1440–9585

ISBN 978–1–921260–44–5

September 2010 / INFRASTRUCTURE07179

This publication is available in hard copy or PDF format from the Bureau of Infrastructure, Transport and Regional Economics website at www.bitre.gov.au—if you require part or all of this publication in a different format, please contact BITRE.

An appropriate citation for this report is:

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2010, *Population growth, jobs growth and commuting flows in Perth*, Canberra ACT.

Indemnity statement

The Bureau of Infrastructure, Transport and Regional Economics has taken due care in preparing the analyses contained in this report. However, noting that data used for the analyses have been provided by third parties, the Commonwealth gives no warranty to the accuracy, reliability, fitness for purpose, or otherwise of the information.

Published by

Bureau of Infrastructure, Transport and Regional Economics

GPO Box 501, Canberra ACT 2601, Australia
Telephone (international) +61 2 6274 7210
Fax +61 2 6274 6816
Email: bitre@infrastructure.gov.au
Internet: http://www.bitre.gov.au

Desktop publishing by Kerry Rose

Foreword

This report identifies recent spatial changes in employment and the residential population within Perth, and investigates how commuting behaviour has responded to these changes. It also explores the extent to which metropolitan plans have been successful in attempting to mould the city's spatial distribution of population, employment and commuting.

The paper represents the first publication from BITRE's new Cities Research team. It will be the first in a series of reports covering population, employment and commuting in Australia's five largest cities—Sydney, Melbourne, Brisbane, Perth and Adelaide.

This research project was led by Leanne Johnson, with Dennis Byles and Dr Jan Anderson Muir also making important contributions to the report. Dr Gary Dolman provided executive supervision.

Gary Dolman
Head of Bureau
Bureau of Infrastructure, Transport and Regional Economics
September 2010

Acknowledgements

The authors would like to acknowledge the assistance of a number of individuals and organisations who contributed to this Perth study through provision of data and advice. The authors recognise the contribution made by the Australian Bureau of Statistics in preparing special tabulations of census and demographic data, particularly the assistance provided by Barb Dehne and Joseph Kaspar. The Western Australian Department of Planning, particularly John Patterson and Janusz Pradzynski, provided BITRE with some very useful datasets and advice. We also wish to acknowledge valuable comments and suggestions provided by participants at conferences and seminars and by the Major Cities Unit.

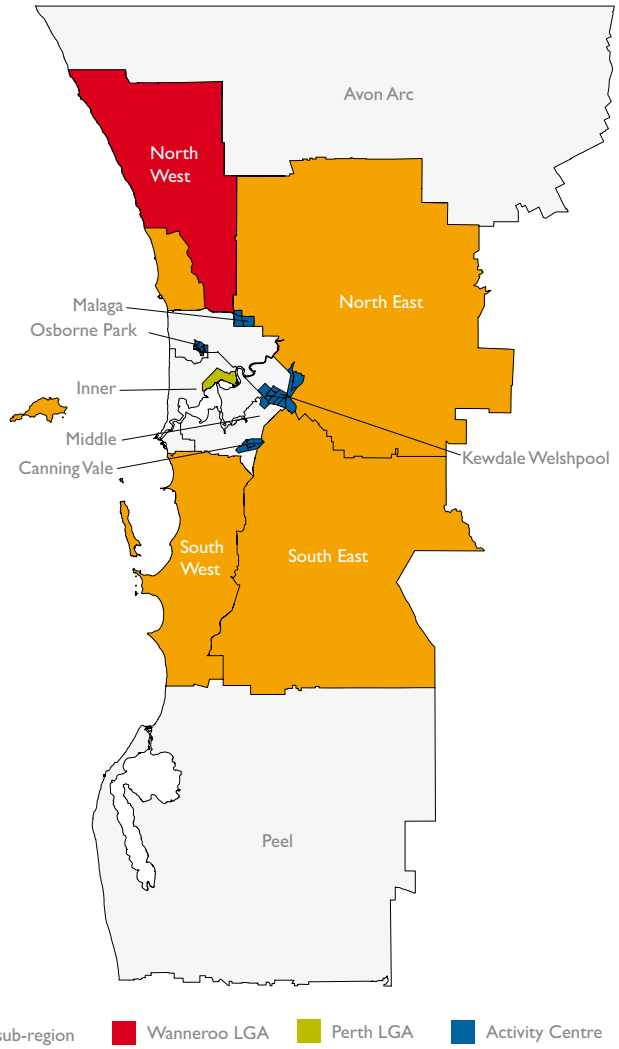
The authors would also like to acknowledge the contributions made by Dr Catharina Williams, Dr Karen Wade, Jo Whiddon and Hirut Yigezu, and the advice provided by Phil Potterton, David Mitchell and Pearl Louis.

While BITRE is grateful for the assistance provided by these individuals and organisations, the views expressed in this report are those of BITRE and should not be attributed to any other organisation.

At a glance

- This is the first of a series of reports analysing spatial trends in population, employment and commuting in our five largest cities.
- Perth's population increased by 139 200 between 2001 and 2006 to reach 1.61 million, representing 1.8 per cent growth per annum. Sixty-four per cent of this growth occurred in the Outer subregions and a further 8 per cent in Peel (the following map presents subregional boundaries). The increased population was accommodated largely through residential development on the urban fringe but also through inner city redevelopment. The City of Wanneroo, on Perth's northern fringe, accounted for 23 per cent of Perth's population increase.
- Perth is a low density city, with comparatively few high population density suburbs. However, two-thirds of Perth's suburbs increased their population densities between 2001 and 2006, often substantially.
- Population is concentrated in the outer suburbs, while employment is concentrated in the inner and middle suburbs. In 2006, the Outer subregions had 50 per cent of the population, but just 30 per cent of jobs. A lack of jobs, relative to population, is most evident in the South-East and North-West subregions.
- The major job concentrations occur in the City of Perth, which has 17 per cent of employment, and in the Kewdale-Welshpool, Malaga, Osborne Park and Canning Vale industrial centres.
- Employment in Outer subregions grew by 3.7 per cent per annum from 2001 to 2006, much higher than the Perth average of 2.3 per cent. Industrial and specialised centres recorded very strong jobs growth.
- The major industry drivers of jobs growth were construction, health and community services and government administration and defence.
- Trips to work in an inward direction dominate those in an outward direction (43 and 9 per cent, respectively), while commuting within the home subregion is also important (44 per cent). More complex forms of commuting, such as journeys between Outer subregions grew most rapidly.
- Commuting times and distances remained stable from 2001 to 2006.
- Gravity model regression analysis reveals that the current pattern of commuting flows in Perth is largely driven by the spatial distribution of population and jobs throughout the city. The spatial growth in employed residents and jobs also plays an important role in explaining changes in commuting flows between 2001 and 2006.
- Some incremental progress has been made against urban planning objectives between 2001 and 2006, particularly regarding outer suburban jobs growth and boosting public transport use.

A map displaying sections of Perth's planning subregions, selected local government areas and industrial centres



Note: Only a limited number of activity centres are displayed based on their discussion in the At a Glance.

Source: BITRE analysis of WAPC planning subregions and selected industrial centres and local government areas.

Contents

Figures

Tables

Maps

Executive summary

This paper represents the first case study of a broader research project which will identify recent spatial changes in employment and residential population within Australia's five largest cities and investigate how commuting behaviour has responded to those changes. Understanding changes in the spatial patterns of major city land uses will assist in the development of urban, infrastructure and local government policy.

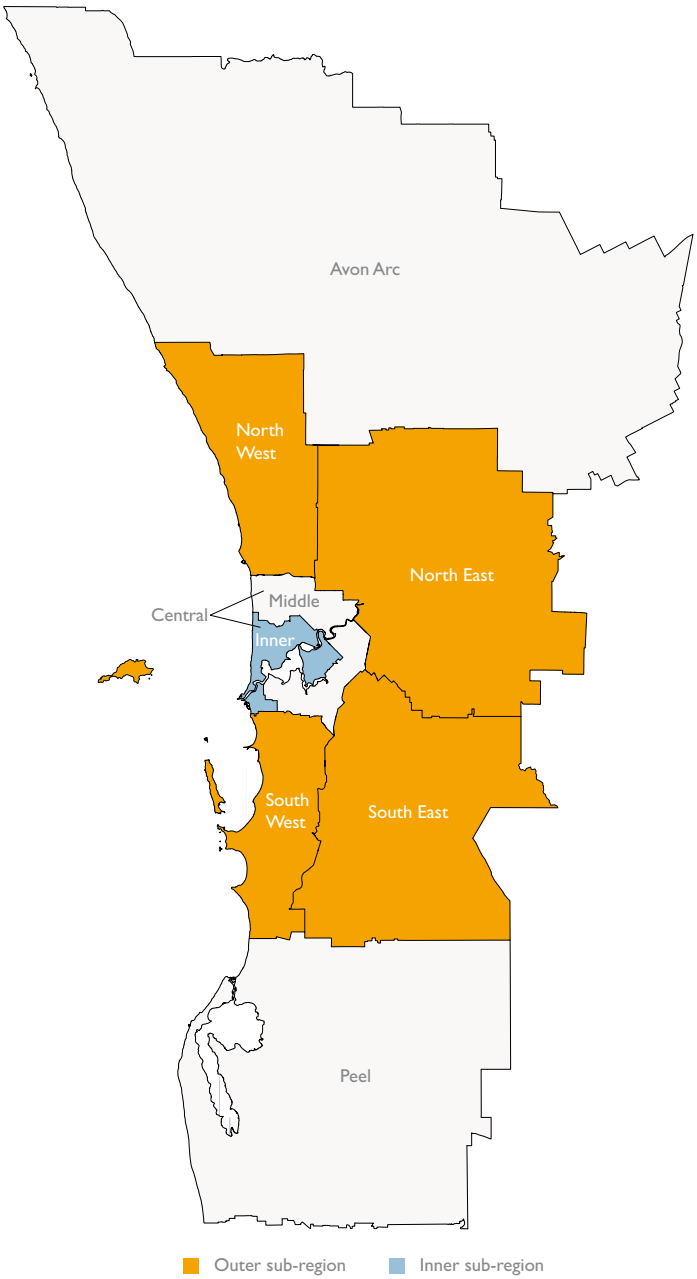
The primary aim of this study is to identify spatial changes in population, employment and commuting in Perth, with a view to providing a solid evidence base about the reality of the trends that have been shaping the city in recent years. A secondary aim is to investigate the extent to which metropolitan plans have been successful in attempting to mould the city's spatial distribution of population, employment and commuting.

The study focuses primarily on the 2001 to 2006 period, but wherever possible incorporates information on longer-term trends to put current changes into their historical context. The key data sources are the ABS *Census of Population and Housing* for 2001 and 2006 and ABS Estimated Resident Population time series data.[1]

The analysis is based on BITRE's Perth working zone, which includes the Perth statistical division, as well as the Mandurah, Murray and Waroona Statistical Local Areas (SLAs) in the Peel region and the Gingin, Chittering and Toodyay SLAs in the Avon Arc region. The map on the next page shows the Perth working zone and its planning subregions. In June 2009, the *Directions 2031: Draft Spatial Framework for Perth and Peel* adopted a different set of planning regions, in that the Inner and Middle subregions were combined into a single 'Central' subregion, while the Eastern sector was renamed the North-East subregion (WAPC 2009a). The analysis undertaken in this report will use the North-East terminology. However, we will keep separate the 'Central' subregion with Inner and Middle subregions to provide a more disaggregated spatial analysis. The spatial analysis is presented at a range of different levels of disaggregation—including the Perth working zone as a whole, planning subregions, SLAs, destination zones, suburbs and census collection districts—to convey an understanding of both the overarching patterns and some of the finer detail.

1 The data presented in the Executive Summary were largely derived by BITRE through analysis of these two primary data sources and a range of secondary data sources. Details of data sources are provided in the relevant chapters.

Map of Perth working zone and planning subregions



Note: The North-West, North-East, South-East and South-West subregions together make up the Outer subregion of Perth. The Inner and Middle subregions combine to create the Central subregion, with the Peel subregion making up the final planning subregion in *Directions 2031*.

Source: BITRE analysis of WAPC planning subregions.

Residential patterns and trends

The population of the Perth and Peel region grew from 175 000 in 1921 to 715 000 in 1971 (WAPC 2003b), and has more than doubled since then to reach 1.6 million in 2006 (ABS 2008a).[2] The average annual rate of population growth was 1.8 per cent between 1971 and 1981 and 2.7 per cent in the following decade, but has been lower than this in recent years, with growth averaging 1.7 per cent between 1991 and 2001 and 1.8 per cent between 2001 and 2006.

Historically, Perth's development pattern has been based on linear corridors stretching out from the city's core, with large non-urban wedges between each of these corridors (Hill 2005). More recently, Perth has been divided into subregional areas, rather than corridors for planning purposes. The two coastal subregions (i.e. the North-West and South-West) have consistently achieved higher rates of population growth than the two inland subregions. The Outer subregions (namely the North-East, North-West, South-West and South-East subregions) have grown rapidly since 1971, and account for 74 per cent of Perth and Peel's total population increase of 879 000 between 1971 and 2006. However, Peel has grown more rapidly than Outer Perth since 1981.

As of 2006, roughly half of the city's population lives in the Outer subregional area, 29 per cent in the Middle subregion, 15 per cent in the Inner subregion[3] and 5 per cent in Peel. Between 2001 and 2006, Perth's population increased by 139 200 persons (ABS 2008a). The annual rate of population growth was greatest for Peel (3.4 per cent) and the South-West (2.9 per cent), and lowest in the Middle subregion (0.9 per cent).

The areas experiencing the most rapid rate of population growth were Wanneroo North-East and Wanneroo North-West (on the city's northern fringe) and Perth Inner and Perth Remainder (which together comprise the City of Perth). The Outer SLAs of Rockingham, Wanneroo North-East, Wanneroo North-West, Gosnells and Swan were the major contributors to growth, each adding between 12 000 and 14 000 residents between 2001 and 2006.

Perth is a low density city, with 'spreading suburbs predicated on a cultural preference for owner-occupied detached houses on large lots and the use of private cars' (WAPC 2003b p.7). The urban centre of Perth is less densely populated than Sydney, Melbourne or Adelaide, but of comparable density to Brisbane. High population density areas are scarce within the Perth metropolitan area—those that do exist are concentrated in the inner and middle suburbs. Despite these generally low densities, two-thirds of Perth's suburbs raised their population density between 2001 and 2006, sometimes by a very substantial amount.

The rate of population growth has increased for Perth since 2006, with population growing by 2.7 per cent for the year ended June 2007 and 2.9 per cent for the year ended June 2008 (ABS 2009b).[4] Growth continues to be concentrated in essentially the same set of urban fringe locations, with Wanneroo, Rockingham, Swan, Cockburn and Mandurah recording the largest population increases. The City of Perth local government area (LGA) is continuing to experience very rapid population growth, growing by 21 per cent between June 2006 and

2 ABS ERP figures for 2006 are preliminary.
3 The Middle and Inner subregions can be combined to create the Central planning subregion with 44 per cent of the city's population.
4 The 2008 ABS ERP figures remain preliminary.

June 2008, while the City of Wanneroo grew by 16 per cent (ibid). Serpentine-Jarrahdale has recently emerged as an area experiencing very rapid residential growth.

Official population projections (ABS 2008b) indicate that Perth will continue to be one of the fastest growing capitals (alongside Brisbane), although growth is expected to moderate from the current, historically high rates. WAPC (2009a) notes that the Perth region will need to accommodate over half a million new residents by 2031, but claims there is sufficient available land to comfortably meet these growth demands. Reflecting the urban consolidation goals of recent strategic plans, the WA Government projects that the Central (i.e. Inner plus Middle) and North-West subregions will face the greatest increase in the size of their population through to 2031 (WAPC 2009a). However, Peel is projected to face the most rapid rate of population growth (ibid).

Employment and industry

Employment patterns and trends

Since 1961 there has been considerable dispersal of employment away from Perth's central business district and towards the middle and outer suburbs. In 1961, 72 per cent of jobs were located in the Inner subregion, but this fell to 38 per cent in 2006. The Outer subregion has grown strongly over the last few decades, more than doubling its share of employment between 1971 and 2006. While the employment share of the City of Perth and the Inner subregion continue to decline, and the Outer subregion continues to increase in importance, the employment share of the Middle subregion peaked in 1991.

Jobs are widely distributed across the Perth working zone, but compared to population, jobs are more heavily clustered in particular parts of the city. As of 2006, the City of Perth accounts for 17 per cent of Perth's employment. Other important employment clusters include the industrial centres of Kewdale-Welshpool, Malaga, Osborne Park and Canning Vale. These and other industrial centres accounted for 17 per cent of Perth's employment in 2006.

Employment is concentrated in the inner and middle suburbs, while population is concentrated in the outer suburbs. In 2006, the Inner and Middle subregions together had 66 per cent of jobs, but just 44 per cent of employed residents. The Outer subregion has 50 per cent of population, but only 30 per cent of jobs. A lack of jobs, relative to population, is most evident in the South-East and North-West Outer subregions.

Between 2001 and 2006, employment participation surged across Perth. The number of people employed in Perth grew more rapidly than the city's population, with an average annual growth rate of 2.3 per cent, compared to 1.8 per cent for population. Jobs growth was strongest in the South-West, North-West, North-East and Peel subregions, which all had a growth rate exceeding 3.5 per cent per annum. Jobs growth was lowest in the Inner and Middle subregions, but was still reasonably strong, at 1.8 and 1.4 per cent per annum, respectively.

The City of Perth LGA added 11 000 jobs between 2001 and 2006, Swan added 6600 jobs and Rockingham added 5100 jobs. The rate of jobs growth was highest for the Wanneroo, Rockingham and Mandurah LGAs.

Industrial centres and specialised centres (such as airports, universities and hospitals) had very strong jobs growth between 2001 and 2006. Centres experiencing particularly rapid jobs growth include the Perth airport, Murdoch University and the Malaga industrial area.

Strong employment growth continued between 2006 and 2008, with the number of employed residents growing by 4.9 per cent in the year ended June 2007 and by 3.3 per cent for the year ended June 2008 (ABS 2009c). However, between October 2008 and June 2009 there was a 3.7 per cent decline in employed residents (ibid).

The WA Government projects 353 000 additional jobs for Perth and Peel by 2031, reflecting average annual growth of 1.9 per cent (WAPC 2009a). The strongest jobs growth is projected for the North-West and Peel subregions, and the employment share of the Outer subregions is expected to increase from 30 per cent in 2008 to 38 per cent in 2031 (ibid).

Industry patterns and trends

In 2006, the major employing industries in Perth were *retail trade* (15.4 per cent of employment); *property and business services* (12.5 per cent); *health and community services* (11.5 per cent); and *manufacturing* (11.0 per cent). Jobs in *finance and insurance, government administration and defence* and *property and business services* were all heavily concentrated in the Inner subregion. Perth's SLAs each had their own distinctive mix of industries. Some were specialised in *education* (e.g. Melville, Joondalup North), and others in *transport and storage* (e.g. Belmont, Fremantle Remainder) or *Manufacturing* (e.g. Kwinana).

The long-term trend towards increased service industry dominance of employment has halted, at least temporarily, for Perth. From 2001 to 2006, the most rapid jobs growth occurred in the non-service industries of *mining* (11 per cent average annual growth) and *construction* (7 per cent), although the *government administration* and *defence* industry also recorded rapid jobs growth (7 per cent).

The industry drivers of jobs growth vary across Perth—industries which have grown strongly in one place can be stagnant in another. For example, *retail trade* employment tended to decline in the Inner subregion but increased rapidly on the urban fringe. *Government administration and defence* was the largest contributor to jobs growth in Inner Perth; *manufacturing* was the largest contributor in the South-West and North-East subregions; *retail trade* in Peel and the North-West; and *health and community services* in the South-East and Middle subregions. *Mining* jobs growth was highly concentrated in the City of Perth, but most SLAs shared in the jobs growth of the construction and *Health and community services* industries.

The main industry drivers of jobs growth in Perth have remained reasonably consistent between the intercensus period and the post-2006 period. The key changes are the recent emergence of *transport, postal and warehousing* as a driver of jobs growth and a loss of *mining* employment following the global financial crisis.

Transport mode usage: patterns and trends

Perth is a car dependent city, with 70 per cent of employed residents travelling to work by private vehicle in 2006. Car dependence was highest for people living in the South-West subregion (74 per cent) and for those working in the Middle (78 per cent), South-West (78 per cent) and North-East subregions (77 per cent). It was lowest for those living in the Inner subregion or working in the Inner or Avon Arc subregions (61 per cent).

Levels of commuter use of public transport are highest for residents of Inner Perth and, more generally, for residents who live in the immediate vicinity of railway stations. The Inner subregion also had the highest proportion of employed residents travelling to work by bicycle or on foot. Public transport usage was least prevalent amongst employed residents of the outlying Peel and Avon Arc subregions.

While only 17 per cent of Perth's employment was located in the City of Perth, 67 per cent of commuter public transport usage involved travel to a workplace in the City of Perth and 81 per cent involved travel to a workplace in the Inner subregion. Less than 8 per cent of usage was to a workplace in an Outer subregion.

Over the last two decades, public transport use has risen in Perth, supported by expansion of existing infrastructure. Strong growth in rail usage occurred following the opening of the Joondalup line in 1992 and the Mandurah line in 2007. Between 2001 and 2006, the proportion of employed Perth residents using public transport to get to work rose from 7.5 to 8.4 per cent.

Commuting patterns and trends

Commuter flows in an outward direction from the Perth working zone to other parts of Australia are much greater than the inflows to Perth. Perth attracts relatively few commuters from surrounding regions, because of the small population of the surrounding areas. However, the rapid growth of WA's mining industry in recent years and a shift to fly in fly out operations, has resulted in significant commuter flows from Perth to remote mine sites.

Turning to commuting flows *within* the Perth working zone, we find that 42 per cent of employed residents work in their home subregion. Self-containment is highest for the Inner subregion (65 per cent) and very low for the South-East and North-West subregions (29 and 33 per cent, respectively). There has been no progress in improving the self-containment of Perth's Outer subregions between 2001 and 2006. In both years, 35 per cent of the employed residents of Perth's Outer subregions had a place of work within their home Outer subregion.

Trips to work in an inward direction greatly outweigh trips in an outward direction (43 and 9 per cent of Perth trips, respectively). A particularly common form of inward commuting is commuting to a workplace located in the central business district (CBD). The probability of commuting to the CBD is highest for residents of nearby areas (e.g. Vincent) and less than 5 per cent for many of the more distant SLAs (e.g. Rockingham, Kwinana, Armadale).

Nine of the ten most common commuter trips were trips within the home SLA (e.g. 14 194 Rockingham residents travelled to a workplace in Rockingham). While inward commuting and commutes within the home SLA are the two most important forms of commuting, both recorded a below-average rate of growth between 2001 and 2006. More complex forms of commuting, such as journeys between Outer subregions, grew most rapidly, but can be hard to service by public transport.

The North-East Outer subregion attracted a higher proportion of its workers from other subregions in 2006, than in 2001. An expanded employment base in Swan and Kalamunda, driven by the transport, manufacturing and construction industries, generated rapid growth in the number of people commuting into the North-East subregion from other parts of Perth. The largest increases occurred for residents of the Middle and North-West subregions. The South-East Outer subregion also attracted a higher proportion of its workers from other subregions in 2006, than in 2001, with residents of the Middle subregion being the primary source of that growth. Another source of change was the rapid population growth in Wanneroo North-East and Rockingham, which generated increased commuting to nearby areas.

Average commuting distances are relatively low for Inner and Middle subregions residents, higher for the Outer subregions and highest for Peel and the Avon Arc. There is less variation in average commuting distance by place of work. Commuting travel times and distances appear to have remained quite stable in Perth in recent years. Very short trips and very long trips have both risen in importance, with minimal net effect on the average distance travelled to work. Residents of the North-West subregion have a slightly lower average commuting distance in 2006 than in 2001. The average distance travelled to a workplace in the North-East or South-East subregions has risen, reflecting their increased drawing power as places of work.

Some drivers of commuting flows

As well as describing spatial patterns and trends in commuting, this project set out to explore how commuting behaviour has responded to recent spatial changes in population and employment. Regression analysis was used to investigate this issue. A simple gravity model of commuter flows was successful in explaining about 80 per cent of all variation in origin–destination flows within Perth. The fundamental drivers of commuter flows, identified through this gravity model, remained very stable for Perth between 2001 and 2006.

The number of people commuting between an origin–destination pair tends to increase with the number of employed residents of the origin SLA and the number of jobs in the destination SLA, but declines as the distance between the two SLAs widens. This distance penalty is lower when there is a direct rail connection between the origin–destination pair. Skills also have an important influence—the greater the alignment between the skills available in the origin SLA and the skills demanded in the destination SLA, the greater the predicted commuting flows between those two places.

Growth in employed residents and jobs both play a very important role in explaining changes in commuting flows in Perth between 2001 and 2006. These two factors alone explain just over half of the variation in commuting growth rates for origin–destination pairs with non-trivial commuter flows. The rate of jobs growth in the destination SLA is the most powerful predictor of spatial change in commuter flows in Perth.

The current pattern of commuting flows in Perth is, to a large extent, driven by the spatial distribution of population and jobs throughout the city. The spatial distribution of population and jobs which we see today reflects the accumulated pattern of development over many decades, and continues to be shaped by demographic trends, economic forces, cultural preferences and government intervention.

Scenario modelling suggests that the WA Government's spatial projections of residential and jobs growth to 2031 (which reflect urban consolidation and outer suburban jobs growth objectives) are likely to be associated with increased self-sufficiency in the Outer subregion and a shift away from inward commutes towards commutes within the home SLA. The results highlight some tensions between these spatial projections and the planning goals of reducing commuting distances and encouraging public transport over private transport.

Urban planning in Perth

The core elements of the planning system for Perth are the Minister, the Western Australian Planning Commission, the Department of Planning and local government. The structure of the planning system has remained very stable over time, with its most enduring element being 'the use of boards and committees to subject policies, plans and approvals to a degree of independent scrutiny' (WAPC 2008 p.4). Recent planning initiatives have emphasised community involvement processes and, in comparison to other states, there is a relatively high degree of state control over planning (Stokes 2006).

The most recent strategic plans for Perth are *Metroplan 1990, Network City 2004* and the 2009 draft strategic plan, *Directions 2031*, which is to be released as *Directions 2031* and *Beyond* in July 2010. All the plans aim to improve urban containment and urban consolidation, encourage employment growth in centres and the outer suburbs, encourage use of public transport and reduce commuting times and distances. BITRE has analysed the extent to which progress has been achieved against these common goals between 2001 and 2006 and the findings are summarised in the table on the next page.

Progress against urban planning goals for Perth, 2001 to 2006

Objective	Extent of progress	Comments
Limiting urban sprawl	Limited	Perth continued its outward expansion, with the majority of population growth occurring in new growth areas on the urban fringe. While only 27 per cent of population growth was in the Inner and Middle subregions, several established suburbs grew rapidly (e.g. Perth, East Perth, Subiaco, Stirling).
Raising population density	Some	Perth remains a low density city, but has had some success with raising population densities in both the inner city and outer suburbs. Although small lot sizes have become more common for newly released land, 85 per cent of new dwellings were detached houses.
Employment in centres	Some	About half of Perth's employment is located in activity centres (under the new draft activity centres hierarchy). Centred employment has grown slightly more rapidly than non-centred employment, with specialised and industrial centres experiencing the most rapid jobs growth. Retail-focused activity centres generally recorded below-average jobs growth.
Transit oriented development (TOD)	Some	TOD is a comparatively recent initiative in Perth and lead times are long. Up to 2006, there had been limited achievement of land use change around rail stations. Important exceptions include the Subiaco and East Perth TODs which have high and growing density, following redevelopment. Numerous TOD projects are underway.
Outer suburban employment growth	Good	Outer subregion employment grew by 3.7 per cent per annum, which was much higher than the Perth average of 2.3 per cent, but similar to growth in Outer subregion employed residents (3.5 per cent). The Outer subregion had 30 per cent of Perth's jobs in 2006, but was home to 50 per cent of the population, with many outer suburbs offering limited job opportunities for local residents. Manufacturing and Construction both added more than 5000 Outer subregion jobs.
Encouraging public transport use	Good	Public transport patronage increased by 3.3 per cent per annum and the proportion of employed Perth residents using public transport to get to work rose from 7.5 to 8.4 per cent. However, Perth remains a very car dependent city, with 70 per cent of employed residents travelling to work by private vehicle in 2006.
Reducing average commuting times and distances	No change	Commuting travel times and distances have remained quite stable in Perth. Very short trips and very long trips have both risen in importance, with no net effect on average commuting distances.

Source: BITRE analysis

Where progress has been made against these urban planning objectives, it has been incremental in nature—longstanding consumer preferences and the accumulated effects of decades of residential and industry development do not reverse in a period as short as five years.

How does Perth compare?

This paper is the first of a series of reports covering Australia's five largest cities. The full value of the Perth study will not be evident until the analysis is replicated for the remaining cities and results are compared. The final comparative report will provide an overview of relevant statistics for the five cities, highlight commonalities and differences in the ways our cities are evolving over time and draw out the implications for urban development, infrastructure and local government policy.

CHAPTER 1
Introduction

Key points

- This Perth report is the first case study of a broader BITRE research project which aims to identify the spatial changes in major capital city employment and residential patterns and how commuting behaviour has responded.
- ABS *Census of Population and Housing* and *Estimated Resident Population* data are the two primary information sources used in the analysis, which is focused on the 2001 to 2006 period.
- The analysis is presented at a range of geographic scales, including the Perth working zone as a whole, planning subregions, Statistical Local Areas, destination zones, suburbs and census collection districts.

Context

This document represents the first case study of a broader BITRE research project which aims to identify the spatial changes in major capital city employment and residential patterns and how commuting behaviour has responded to these changes. Reports will also be prepared for Sydney, Melbourne, Brisbane and Adelaide as the project progresses.

It is intended that the in-depth case studies of these five cities will provide the basis for a final comparative report, which provides an:

- overview of relevant statistics for the five cities
- pulls out some of the common themes which emerge from the individual city studies, as well as the differences, and
- highlights the implications of the analysis.

Understanding changes in the spatial patterns of major city land uses can assist in the development of urban, infrastructure and local government policy. The aim of this paper is to provide stakeholders with an evidence base on the spatial nature of changes in population, jobs growth and commuting flows in Perth. As the first city case study to be completed, feedback on this paper should also help to clarify requirements for the project as a whole.

Information sources

The basic approach of this project is to use official population counts and detailed data from the ABS *Census of Population and Housing* and to answer the following research question:

> What are the recent spatial changes in major capital city employment and residential patterns and how has commuting behaviour responded?

The study focuses primarily on the 2001 to 2006 period, but wherever possible incorporates information on longer term trends to put current changes into their historical context. Where possible, information on post-2006 changes and longer term projections are also presented.

The datasets analysed in this study represent a combination of published and unpublished data:

- Data on Estimated Resident Population (ERP) was obtained directly from ABS Cat. 3218.0 *Regional Population Growth, Australia*.
- Some census data on employed residents and transport mode was accessed from the ABS' *Basic Community Profile* (ABS Cat. 2069.0.30.001) and CDATA 2001.
- Detailed unpublished census data was purchased from ABS on employment, industry and commuting flows.
- Due to quality issues with the ABS provided data for 2001, a corrected journey to work matrix provided by the (then) Western Australian Department for Planning and Infrastructure (DPI)[5] was used to assess changes in employment and commuting flows over time.

Many of the capital city central business district (CBD) councils and WA Governments have undertaken similar, and sometimes more in-depth, analysis of patterns of residential and jobs growth for their own city, but this is by no means universal. For example, the publicly-available material for Perth relates to the 2001 census, and more recent analysis has not yet been released. BITRE's study will add value by bringing together the five cities on to a comparable basis and highlighting commonalities and differences in the ways the cities are evolving over time.

While the *Census of Population and Housing* and ERP data are the two primary information sources, BITRE's study also draws on a range of government and academic literature.

- An overview of the planning system and key strategic plans for Perth is provided in Chapter Two. BITRE's analysis includes reference to the goals of recent strategic plans and compares the actual outcomes in terms of population and jobs growth to the expressed goals. The paper also makes reference to academic analyses of planning in Perth.
- Some academics are quite critical of capital city strategic plans for ignoring the reality of economic forces and trends shaping our cities. This study will identify those economic trends and their spatial implications, which should be of benefit for future planning initiatives.
- Published material on past and projected population growth, jobs growth, commuting flows and transport usage is incorporated, where relevant.

5 From 1 July 2009, the Department has since been split into two: the Department of Planning and the Department of Transport.

Geography

Several different geographic boundaries are of relevance when considering planning for the city of Perth:

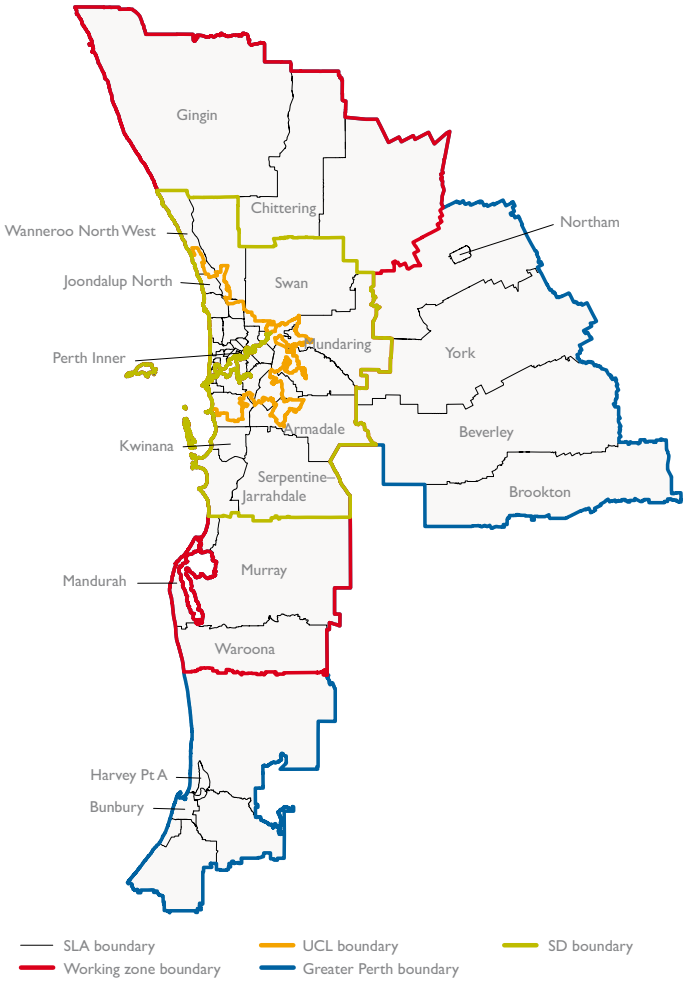
- *Perth metropolitan region (or Metropolitan Perth)*: This corresponds to the Perth Statistical Division (SD) as defined in the Australian Standard Geographical Classification (ASGC) (ABS 2006).
- *Perth and Peel*: This corresponds to the aggregation of the Perth Statistical Division and the Peel region, which comprises the Mandurah, Murray and Waroona Local Government Areas (LGAs). The *Network City* and *Directions 2031 and Beyond* strategic plans relate to the Perth and Peel region.
- *Greater Perth*: This is a more expansive region, which includes Greater Bunbury (the LGAs of Bunbury, Harvey, Dardanup and Capel) and the Avon Arc (the LGAs of Beverley, Brookton, Chittering, Gingin, Northam shire, Northam town, Toodyay and York), as well as the Perth and Peel region (WAPC 2003b).

BITRE's analysis will be based on the *Perth working zone* boundary, except where otherwise noted. BITRE has defined a set of approximately 400 working zones (WZ) based on the commuting patterns revealed in the 2006 ABS *Census of Population and Housing* (BITRE 2009c). The Perth working zone corresponds to the Perth and Peel region, as defined above, plus the Chittering, Gingin and Toodyay LGAs from the Avon Arc, which each have a significant proportion of employed residents commuting to Perth. As of 2006, the Greater Bunbury region and the remainder of the Avon Arc had limited commuting flows to Perth and so they have been excluded from BITRE's Perth working zone.

BITRE's analysis of commuting flows will consider all significant commuting flows into or out of the Perth working zone, and so will capture long-distance commuting such as flows from Perth to the Pilbara or from Bunbury to Perth.

Map 1.1 illustrates the different geographic boundaries.

M1.1 Map of selected geographic boundaries, Perth



Note: 'UCL Boundary' refers to the ABS urban centre boundary for Perth.

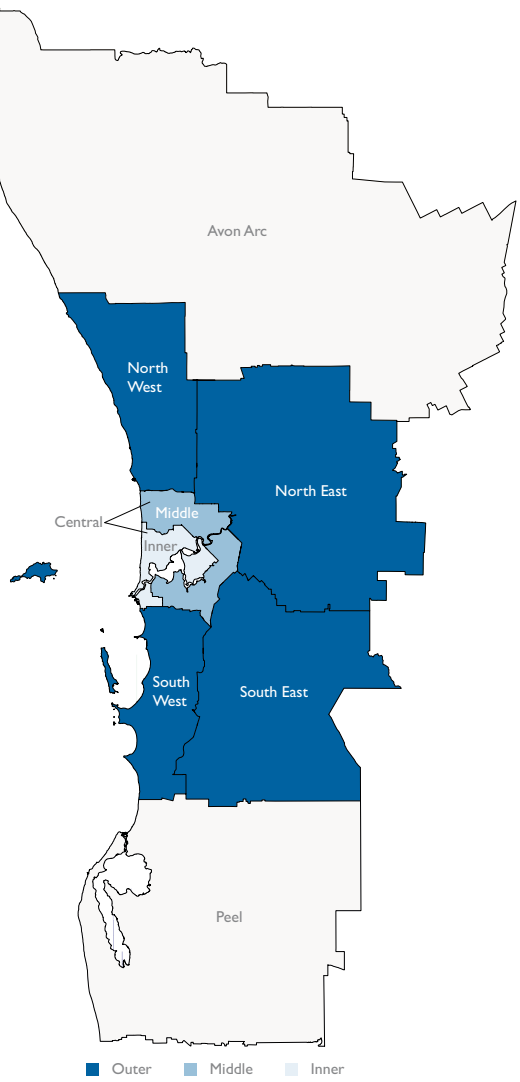
Source: BITRE analysis.

For planning purposes, Perth is broken down into several subregions, which are mapped in Map 1.2:

- Central subregion (For this report, Central subregion has been disaggregated further into Inner and Middle subregions.)
- Outer subregional areas: North-West, North-East, South-East, and South-West
- Peel subregion (In Perth planning it is classified as Outer but for this analysis it is treated separately.)
- Other parts of Greater Perth: Avon Arc and Greater Bunbury

This document will occasionally disaggregate Perth into these subregions. A list of local government areas, and their corresponding planning subregions, can be found within Appendix A.

M1.2 Subregional boundaries for Perth



Note: The North-West, North-East, South-East and South-West subregions together make up the Outer subregion of Perth. The Inner and Middle subregions combine to create the Central subregion, with the Peel subregion making up the final planning subregion in *Directions 2031*.

Source: BITRE analysis of WAPC planning subregions.

This study adopts 2006 ASGC boundaries (2006) and the majority of the analysis is undertaken at the Statistical Local Area (SLA) scale. There was no major SLA boundary changes for Perth between 2001 and 2006, although there were some minor changes, such as the transfer of part of Stirling Central SLA to Cambridge and of part of Cockburn SLA to Melville. No boundary change occurred which involved a transfer of more than 1 per cent of an SLA's population or area.

Some of the analysis is also presented at a more spatially disaggregated scale, namely:

- *for population*: suburbs or census collection districts (CCDs) as defined in the 2006 ASGC.
- *for employment*: 2001 and 2006 destination zones as defined by the Western Australian Department of Planning.

Thus, the spatial analysis in this report is presented at a range of different levels of disaggregation, to convey an understanding of both the overarching patterns and some of the finer detail. Appendix A contains further information about the geographic boundaries used in this study.

Structure of report

This paper commences with an overview of the urban planning system for Perth. Chapter 3 presents a spatial analysis of residential growth between 2001 and 2006, and includes consideration of population, urban expansion, households and employed residents. Chapter 4 focuses on the spatial dimensions of employment within Perth, while the location and growth of different industries is examined in Chapter 5. Spatial differences in car and public transport usage are then considered in Chapter 6. This is followed by an investigation of existing commuting flows and changes in these commuter flows. Chapter 8 considers the relationship of commuting flows to population and jobs growth, while Chapter 9 provides an overview of the main findings.

CHAPTER 2
Planning

Key points

- The core elements of the planning system for Perth are the Minister, the Western Australian Planning Commission, the Department of Planning and local government.
- There is a relatively high degree of state control over planning in Perth.
- The most recent strategic plans for Perth are *Metroplan 1190, Network City 2004* and the 2009 draft strategic plan, *Directions 2031*, which will be finalised as *Directions 2031 and Beyond* in July 2010.
- All three plans aim to improve urban containment, urban consolidation and urban renewal, encourage employment growth in centres and encourage usage of public transport.
- Previous reviews have criticised Perth's planning for limited progress against the stated goals, poor follow through, inadequate foresight and taking insufficient account of the economic trends, forces and preferences that shape the city.
- Recent planning initiatives in Perth have emphasised community involvement processes.

The planning system

The WA planning system is administered at several levels:

- The Minister for Planning, as the executive head of planning in the state, 'sets the priorities, directs the portfolio agencies, administers and updates the planning legislation, makes planning instruments, nominates and approves appointments to WAPC and its committees and as a member of the executive government, makes policy and allocates resources' (WAPC 2008 p.5).
- The Western Australian Planning Commission (WAPC) is a statutory authority with statewide responsibility for land use planning, land development and strategic planning. Its responsibilities include: administration of the Metropolitan Region Scheme (MRS), which zones broad categories of land use; the Urban Development Program (UDP)[6], which identifies land and infrastructure needs for urban development over the next five years, and development of strategic plans for *Directions 2031 and Beyond*. WAPC responds to the strategic direction of the WA Government and operates with the support and resources of the Department of Planning[7] (Hill 2005 p.142, WAPC 2008 p.5).

6 The Urban Development Program replaced the Metropolitan Development Program in 2006.
7 From June 2009 the Department for Planning and Infrastructure was separated into three departments: the Department of Planning, the Department of Transport and the Department of Regional Development and Lands.

- The Department of Planning advises the Minister, which has the 'statewide responsibility for the planning for future communities' (DP 2010). It supports WAPC through provision of human resources, professional and technical advice and implementation of WAPC decisions.
- Local government is responsible for developing detailed town planning schemes for their local government area (LGA). These local planning schemes must be consistent with the MRS.

The structure of the WA planning system has remained very stable over time, with its most enduring element being 'the use of boards and committees to subject policies, plans and approvals to a degree of independent scrutiny' (WAPC 2008 p.4). Other core elements are the statutory region schemes (i.e. MRS, Peel Region Scheme, Greater Bunbury Region Scheme) and the Metropolitan Region Improvement Tax (MRIT), which generates around $45 million of revenue per year and 'has been a key factor in the success of the MRS by enabling land to be acquired in advance for regional planning purposes' (Stokes 2006 p.5).

In comparison to other states, 'WA has retained a strong degree of state control over planning' (Stokes 2006 p.1). While in other states the subdivision process is typically the responsibility of individual LGAs, in WA the WAPC is responsible for the determination of subdivision applications, although input is sought from the relevant LGA and a range of WA Government agencies (ibid). The high degree of state control is also evident in the planning appeals process, which differs from processes operating in other states in that the 'Minister for Planning has the power to make a submission to the tribunal or to call-in and determine an appeal' (ibid p.9).

Strategic plans

The WA Government has adopted four plans for the Perth metropolitan region:

- *Stephenson and Hepburn's 1955* report was a plan for guiding future growth in the Perth metropolitan area. It called for greater controls of housing densities and recommended a radial suburban railway system be established to relieve congestion (Hill 2005).
- *The Corridor Plan 1970* proposed that the urban development of Perth should be based around corridors. This involved 'arms of urban expansion, approximately five miles wide, pushing out from the urban core along strong linear routes' (Hill 2005 p.129) with large non-urban wedges between each corridor. It was argued that each new urban corridor would be largely self-contained in terms of employment and that benefits would include more efficient public transport.
- *Metroplan 1990* had an increased emphasis on urban containment and suburban renewal, while retaining the corridor-based development pattern (WAPC 2003a). There was a focus on providing 'new homes closer to jobs and amenities' (Hill 2005 p.133) by encouraging employment growth in the outer suburbs, nominated regional centres and the CBD, while constraining commercial development in the inner suburbs.

- The *Network City 2004* strategic plan aimed to 'integrate transport and land use in a network of places connected by corridors that allow for the movement of freight and people. These places of exchange are activity centres, and are connected by activity corridors' (WAPC 2005a p.1). Areas of focus include the containment of urban sprawl, renewal of existing urban areas, encouragement of public transport and ensuring employment is created in the nominated activity centres. The consultation approach which fed into the development of *Network City* involved 'unprecedented community involvement' (WAPC 2006 p.1).

Following the change of government in 2008, a new draft plan has been released (WAPC 2009a). When the report is finalised in July 2010, *Directions 2031 and Beyond*, will replace all previous strategic plans for the Perth and Peel region, and supersede the draft *Network City* policy. *Directions 2031 and Beyond* is a 'high level strategic plan that establishes a vision for future growth of the Perth and Peel region, and provides a framework to guide the detailed planning and delivery of housing, infrastructure and services necessary to accommodate that growth' (ibid p.1).

While *Directions 2031 and Beyond* aims to achieve a more compact city, it recognises that 'we must work with the city we have' (ibid p.2) and the urban consolidation target is less ambitious than that in *Network City*. The spatial framework details population, housing and jobs targets for subregions and develops the activity centre concept as a way of achieving a more balanced distribution of jobs, services and amenity throughout the city.

Reviews of planning in Perth have highlighted several issues with respect to these strategic plans:

- The nominated regional centres in the Outer subregions may not have been well chosen and have not developed in the way originally envisaged. There has been insufficient jobs growth to achieve the aim of 60 per cent employment self-containment within corridors (State Planning Commission 1987, Curtis 2005, WAPC 2003c).
- Not recognising until 1987 that services rather than manufacturing would be the major driver of Perth's employment growth 'resulted in some unfortunate decisions' (WAPC 2003c p.36). There was excess land allocated for industrial purposes, such as the large amount of premium coastal land allocated to heavy manufacturing in the South-West Outer subregion, while growth of the services sector was not adequately planned.
- There has been considerable unplanned employment growth in inner and middle suburbs (within the Central subregion) in locations that are difficult to access by public transport (Curtis 2006, WAPC 2003c).
- The average distance travelled to work has increased, despite previous plans aiming to reduce travel distances (Hill 2005).
- Previous plans have mispredicted where people will choose to live (Hill 2005).
- Suburban infill has been resisted by many LGAs due to community opposition (Curtis 2005).
- Forces outside the formal planning system have been 'more influential than the spatial plans in determining outer area development outcomes' (Adams 2007 p.61).

- '[P]lanning strategies have consistently referred to employment and employment location but may not have accorded this critical component the same level of consideration as residential land supply and the suite of policies designed to support residential issues' (WAPC 2003a p.37).
- The consultation process was managed to serve the government's interests (Albrechts 2006, Maginn 2007).

The WA Government's recent *Blueprint for planning reform* identifies priorities for planning reform, including achieving simpler approvals processes, reduced timelines, major project facilitation and a more integrated infrastructure and land use planning framework (WAPC 2009c).

The WA Government's planning objectives are sufficiently transparent to provide a basis for evaluation of progress. The WA Government has also shown a willingness to critically evaluate past Perth planning efforts in a series of discussion papers published in 2003 (e.g. WAPC 2003b, 2003c, 2003d, 2003e). This reflective and open approach has helped build understanding of what has and has not worked previously in Perth and potentially provides a basis for improving the effectiveness of planning policy.

These strategic plans and the associated literature provide important context for the remainder of the Perth case study. BITRE's spatial analysis of population growth, jobs growth and changes in commuting flows will investigate the extent to which the population, employment and commuting objectives of the more recent strategic plans have been achieved.

The analysis focuses on the 2001 to 2006 period, so these comparisons are not intended to evaluate the success of any specific strategic plan. However, the three most recent plans have a number of goals in common:

- containment of urban sprawl and urban consolidation
- encouraging employment in centres and in the outer suburbs
- encouraging public transport
- reducing average commuting times and distances.

BITRE's analysis will assess the extent to which progress has been achieved against these common goals between 2001 and 2006. It will also provide evidence about the reality of the trends that have been shaping the city of Perth, which can be used to inform future planning initiatives.

CHAPTER 3
Residential patterns and trends

Key points

- Half of Perth's population lives in the Outer subregion, 29 per cent in the Middle subregion, 15 per cent in the Inner subregion and 5 per cent in Peel.
- The population of Perth increased by 139 200 persons to reach 1.61 million in 2006—an average annual increase of 1.8 per cent from 2001. The growth rate was greatest for Peel (3.4 per cent) and the South-West (2.9 per cent) and lowest in the Middle subregion (0.9 per cent).
- The Outer subregion accounted for 74 per cent of Perth and Peel's total population increase of 879 000 between 1971 and 2006.
- Rockingham, Wanneroo North-East, Wanneroo North-West, Gosnells and Swan each added 12 000 to 14 000 people between 2001 and 2006.
- Wanneroo North-East and Perth Remainder both experienced average annual population growth of 10 per cent between 2001 and 2006.
- Areas of population loss were most evident in the outer suburbs, but were interspersed with areas of strong population growth.
- Between 2001 and 2006, 61 per cent of growth was in new growth areas rather than existing urban areas. This exceeds the *Network City* target of 40 per cent and the *Directions 2031* target of 53 per cent.
- Perth's rate of population growth has risen steadily between 2000 and 2008, exceeding 2.5 per cent for the years ended June 2007 and 2008. Continued strong population growth is projected through to 2031, with projections ranging from 1.3 to 2.0 per cent growth per annum. Dwelling demand is projected to outpace population growth.
- Perth has lower population density than Sydney, Melbourne or Adelaide, but is comparable to Brisbane in terms of density. Areas with a population density of more than 4000 persons per square kilometre are scarce within the Perth metropolitan area.
- Population density increased between 2001 and 2006, with the largest increases occurring in the Inner subregion.
- Relatively small lot sizes have become much more common for newly released land but there has not been a shift towards higher density forms of housing. Of the 54 000 dwellings added between 2001 and 2006, 85 per cent were separate houses.

- Eighty four per cent of Perth's population find the idea of living in a high population density area unattractive. Thus, community opposition is likely to continue to pose a challenge to planners' attempts to raise densities in existing suburbs.
- Employment participation surged across Perth from 2001 to 2006. Growth in employed residents exceeded the national growth rate for all subregions, but was particularly strong for Peel and the South-West.

Population

2006 snapshot

Population location

ABS Estimated Resident Population (ERP) figures indicate that the population of the Perth working zone was 1.61 million in 2006,[8] up from 1.47 million in 2001. The Perth working zone, while not as heavily populated as Sydney, Melbourne or Brisbane, encompasses a fairly large geographic area, made up of numerous local governments.

The working zone extends about 170 kilometres from Gingin in the north to Waroona in the south, but is relatively narrow with roughly 60 kilometres between the coastline and the North-East border of the Mundaring LGA. According to WAPC (2003b p.8), '[t]wo elongated coastal corridors to the North-West and the South-West have emerged as an expression of community preferences for coastal living environments'.

Table 3.1 provides a summary of how the total population of the Perth working zone was distributed across planning subregions in 2006. Roughly half of Perth's population lives in the Outer subregion, while 29 per cent live in the Middle subregion and 15 per cent in the Inner subregion. Within the Outer subregions, the North-West contains the greatest population, while the other three subregions each contribute between 10 and 12 per cent of the working zone's total population. Peel and the Avon Arc contribute relatively small shares of Perth's population.

Map 3.1 shows the raw numbers of people living within each Statistical Local Area (SLA). The largest populations are in the Outer subregion's SLAs such as Rockingham, Joondalup South and Gosnells. The most populous SLA in 2006 was Joondalup South with 105 190 residents, while Inner Fremantle had just 879 residents. The average population size across the 43 SLAs in Perth was 37 400 persons and the median was 28 500. Inner SLAs typically have lower populations, as do some of the more peripheral SLAs, such as Serpentine-Jarrahdale, Murray, Waroona, Chittering, Toodyay and Gingin. This reflects areas which remain largely rural in nature, with relatively few housing developments.

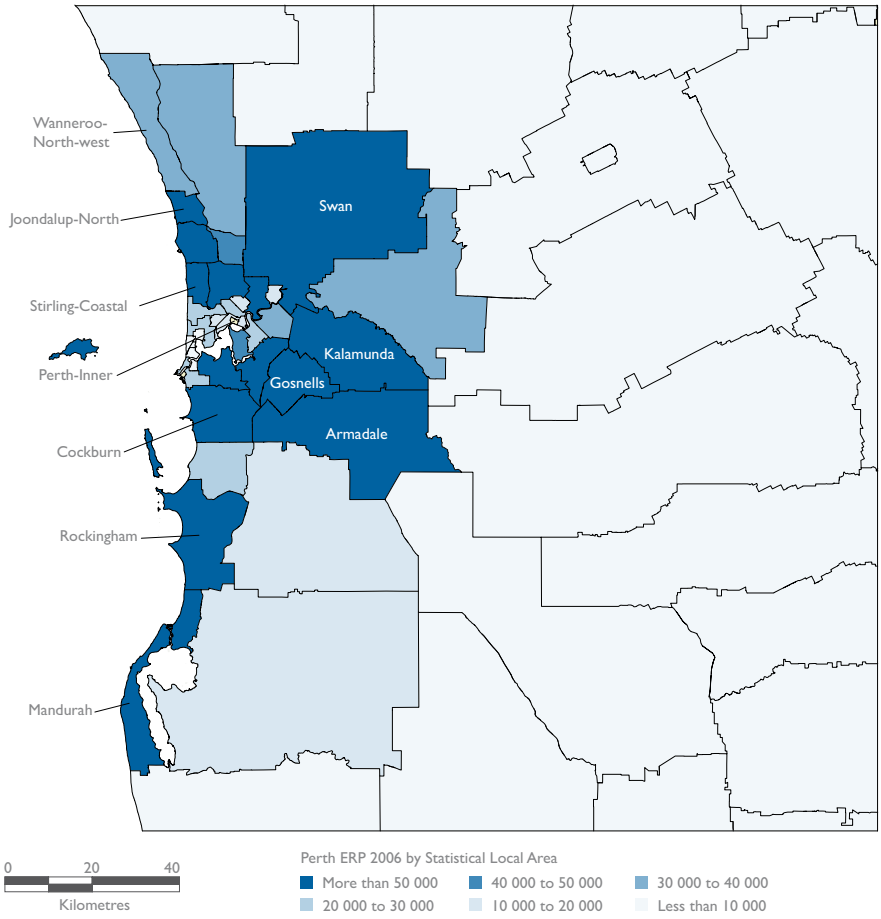
8 ABS ERP figures for 2006 are preliminary.

T3.1 Estimated resident population by subregion, Perth working zone, 2006

Subregion	Estimated resident population 2006	Share of Working Zone population (per cent)
Inner	237 224	14.8
Middle	471 749	29.4
Outer	810 540	50.4
North-West	272 881	17.0
North-East	185 849	11.6
South-East	161 819	10.1
South-West	189 991	11.8
Peel (Mandurah, Murray and Waroona)	74 650	4.6
Avon Arc (Chittering, Toodyay and Gingin)	12 576	0.8
Perth working zone	1 606 739	100.0

Source: BITRE analysis of ABS Cat. 3218.0 Regional Population Growth, 2006–07.

M3.1 Distribution of Estimated Residential Population across Statistical Local Areas in Perth working zone, 2006



Note: The high apparent population at Rottnest and Garden Islands is due to these islands being part of the Cockburn and Rockingham SLAs respectively.

Source: ABS Cat. 3218.0 Regional Population Growth, 2006–07.

Other geographies are available that are a little less variable in terms of population size, namely suburbs and census collection districts (CCDs). These are briefly considered, in turn, below.

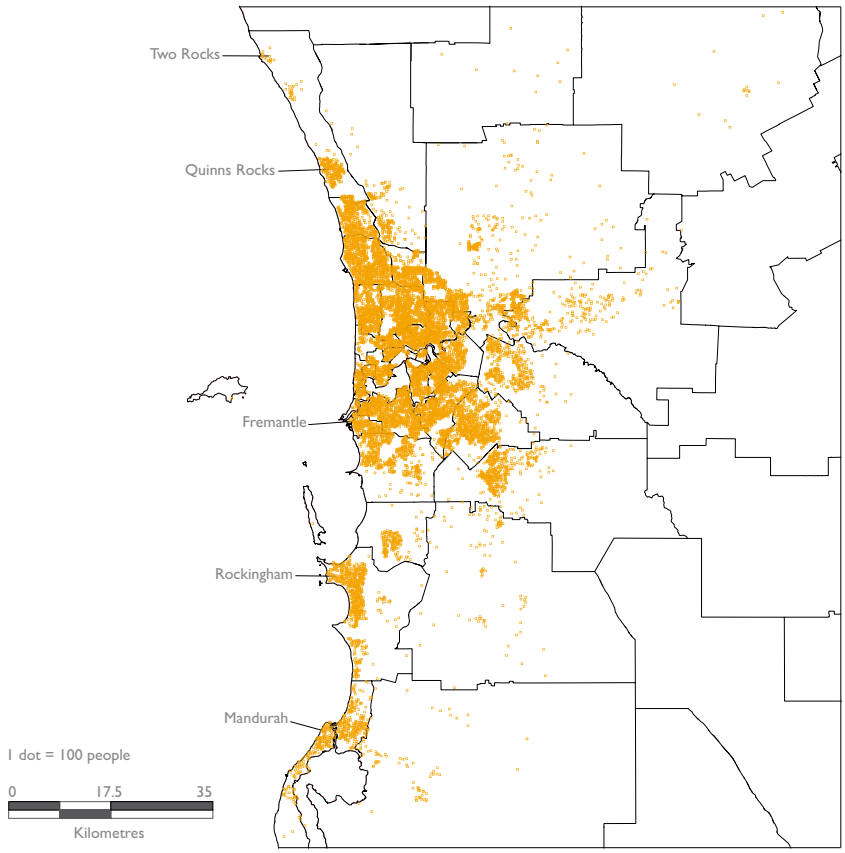
The average Perth suburb had a population of 3820 in 2006, while the median population was 2740. Some of Perth's suburbs have zero populations, such as Alkimos, a yet to be developed suburb in the North-West Outer subregion. The most populous suburbs in 2006 were:

- Canning Vale with 23 278 persons, which cuts across the Canning and Gosnells LGAs
- Thornlie with 22 262 persons which is part of the Gosnells SLA
- Dianella with 21 540 persons which is part of the Stirling Central SLA.

The CCDs are more homogenous, ranging from zero to 1892 persons. The average and median population of CCDs was about 490 across the Perth working zone in 2006.

Map 3.2 uses the CCD data to show the distribution of the population throughout the Perth working zone in 2006. Perth's development pattern is based on linear corridors reaching out from the city's core, with large non-urban wedges between each of these corridors (Hill 2005). Map 3.2 shows that the North-West corridor contains an almost continual stretch of residential development extending to Quinns Rocks in Wanneroo North-West. In contrast, the South-West corridor SLAs of Cockburn, Kwinana and Rockingham contain large areas of land with low population density—some of these are industrial areas, while others are undeveloped bushland and wetlands. The non-urban wedges between the corridors are not immediately obvious in Map 3.2, although an area of undeveloped land can be discerned between the South-East and South-West corridors. The North-East corridor's population does not appear to be focused along a strong linear route. Rather, population is clustered in several relatively central locations such as Ballajura, Beechboro, Midland, Midvale, Stratton, High Wycombe and Forrestfield (see Map A.5), and population densities are quite low in most other parts of the Swan, Mundaring and Kalamunda SLAs.

M3.2 Dot density map of population distribution for Perth working zone, 2006



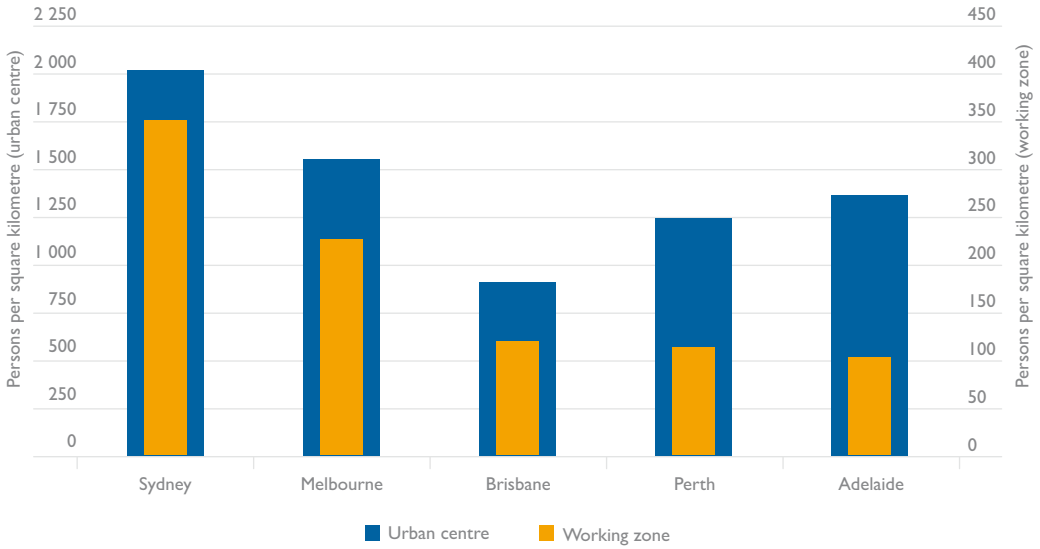
Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data at CCD scale.

Population density

According to WAPC (2003b p.7), 'Perth's existing urban form is characterised by low-density, spreading suburbs predicated on a cultural preference for owner-occupied detached houses on large lots and the use of private cars to access activity centres'.

The Perth working zone is a very broad geographic area which includes large areas of non-residential land, including industrial and rural land and nature reserves. If the focus is restricted to just the urban centre of Perth, it has a population density of 1258 persons per square kilometre (Figure 3.1). When attention is restricted to just the urban centre, as defined by ABS, Perth has much lower population density than Sydney or Melbourne, but is considerably more densely populated then Brisbane.

F3.1 Population density of Australia's capitals, 2006



Source: ABS Cat. 3218.0 Regional Population Growth, 2006-07 and Census of Population and Housing 2006.

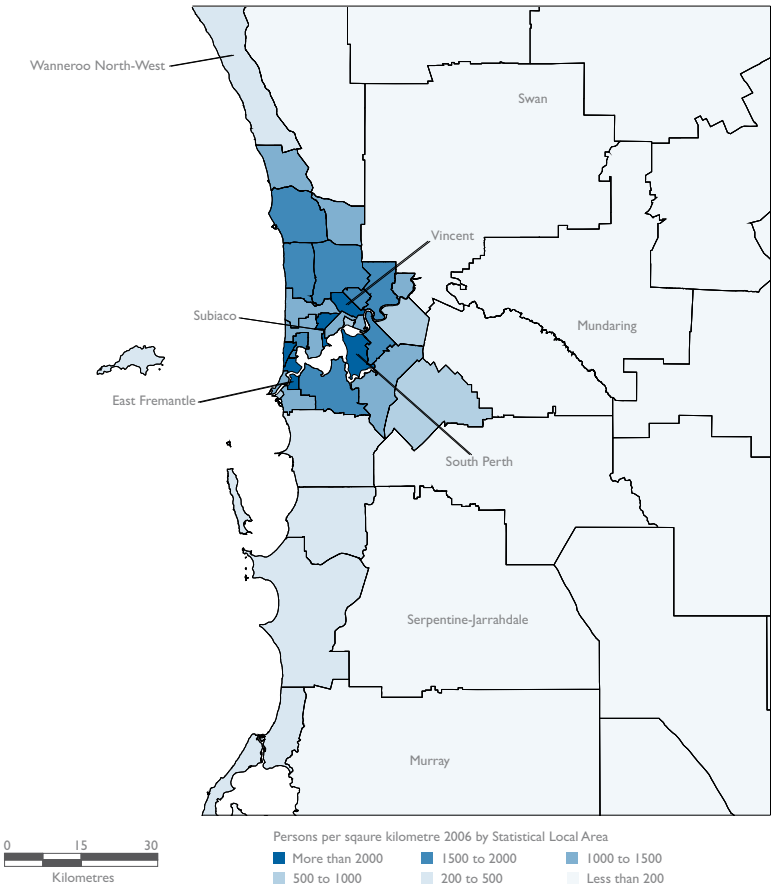
High density residential and commercial developments in certain 'activity centres' are being encouraged in order to combat Perth's urban sprawl and foster sustainability. The focus on provision of additional housing within existing urban areas should also raise densities. *Directions 2031* argues that the average density of residential development on the urban fringe must be increased from 10 to 15 dwellings per zoned hectare (WAPC 2009a).

The underlying research for *Network City* found that living in a high population density area was 'very attractive' to only 3 per cent of the population, while to 84 per cent this was a 'not at all attractive' or 'not very attractive' option (Colmar Brunton n.d.). The appeal of high population density areas was greatest for 18 to 29 year olds (ibid).

Research undertaken in the early 1990s found that 'intense anti-consolidation attitudes prevail in the outer suburbs, where the only favoured housing type was the single detached house' (WAPC 2003b p.15). Curtis (2006) acknowledges there has been community opposition to planners' attempts to raise densities and planning authorities face the challenge of convincing local residents of the appropriateness of higher density developments. According to WAPC (2003b), there are recent signs that preferences for high density living are changing in Perth and *Network City* will use the 'development of underused and vacant public land to demonstrate the potential of redevelopment in established areas' (WAPC 2004c). With respect to the Inner and Middle subregions, *Directions 2031* states that '[b]lanket redevelopment or redensification of these traditional suburbs will not be considered unless these initiatives are supported by the local communities' (WAPC 2009a p.36).

The SLAs within Perth have varying densities (see Map 3.3). The population density of an area is dependent on housing density, average household size and the amount of non-residential land in an area. Unsurprisingly, the densest parts of Perth are located within inner SLAs such as Vincent and Subiaco. Both of these SLAs adjoin the City of Perth, and have traditionally been high density, with many of the older apartments and townhouses still being used today, but now accompanied by newly built or gentrified housing. The other areas of especially high density include East Fremantle, South Perth, Mosman Park and Cottesloe. While Vincent is the most densely populated SLA in Perth with about 2700 residents per square kilometre, there are SLAs within Sydney, Melbourne and Brisbane which have a population density two to three times as high.

M3.3 Population density by statistical local area, Perth working zone, 2006



Source: ABS Cat. 3218.0 Regional Population Growth, 2006-07. Estimates of population density were derived by BITRE.

Surprisingly, the Perth Inner and Perth Remainder SLAs do not have a particularly high population density, despite the fact that there has been a rapid increase in ERP in the area, and a push from both local and the WA Governments to make the CBD more attractive to live in with new apartment blocks. The population of the City of Perth rose by 4700 persons between 2001 and 2006 to top 12 500 and its population density increased by 60 per cent. However, the 2006 population density of just under 1000 persons per square kilometre is less than half the population density of the City of Melbourne and about one-sixth that of the City of Sydney.

While six SLAs fit into the highest density class of more than 2000 people per square kilometre, several others fit into the second highest density class. These include the Inner subregion SLAs of Claremont, Victoria Park and Peppermint Grove, and the Middle subregion SLAs of Melville, Bayswater, Stirling Central, Stirling Coastal and Stirling South-East and the North-West Outer subregion's SLA of Joondalup South.

The lowest population densities within Perth occur in the Avon Arc, Murray and Waroona, which all contain less than 10 persons per square kilometre. These areas are on the outer edges of Perth and are peri-urban in nature. Other SLAs with low population densities of less than 100 persons per square kilometre include Armadale, Mundaring, Swan and Serpentine-Jarrahdale in the outer east and Wanneroo North-East in the outer north.

Using census estimates of population, rather than the official ERP data, can provide a more disaggregated perspective. Table 3.2 lists the ten suburbs with the highest population density within Perth in 2006. With the sole exception of Victoria Park, all are located to the north of the river. Highgate and West Leederville are high density inner suburbs which border the City of Perth. Further north, there is a cluster of four adjoining suburbs with high population density—Mount Hawthorne, Glendalough, Joondanna and Tuart Hill. Further west, Scarborough and Doubleview form another high density cluster. Flats, units, townhouses and semi-detached dwellings make up more than half of the dwelling stock in Glendalough, Scarborough, Joondanna, Highgate and Tuart Hill, contributing to the high population density of these SLAs. In contrast, separate houses dominate the dwelling stock in Mount Hawthorn, Doubleview and West Leederville.

While the previously mentioned suburbs are all well established, Kinross is a more recently developed residential area about 30 kilometres to the north of the CBD. The housing stock is almost entirely separate houses, but Kinross has a much greater average household size than the remainder of the top ten, with substantial population concentrations in the 5 to 14 and 35 to 44 age groups. These demographic factors are an important contributor to its high population density. A further contributor is planning policy which has encouraged smaller block sizes in new developments (WAPC 2003b).

T3.2 Perth suburbs with the highest population density, 2006

Suburbs	Statistical Local Area	Subregion	Persons per square kilometre 2006
Highgate	Vincent	Inner	4261
Joondanna	Stirling Central	Middle	2810
Mount Hawthorn	Vincent	Inner	2754
Victoria Park	Victoria Park	Inner	2749
West Leederville	Cambridge	Inner	2702
Doubleview	Stirling Coastal	Middle	2702
Tuart Hill	Stirling Central	Middle	2608
Glendalough	Stirling Central	Middle	2603
Scarborough	Stirling Coastal	Middle	2579
Kinross	Joondalup North	North-West	2549

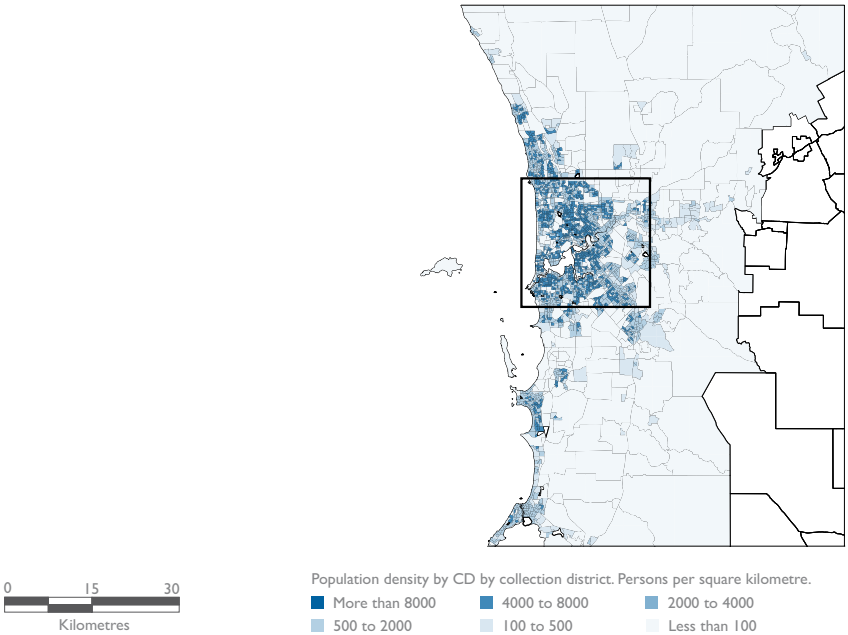
Source: BITRE analysis of ABS Census of Population and Housing 2006.

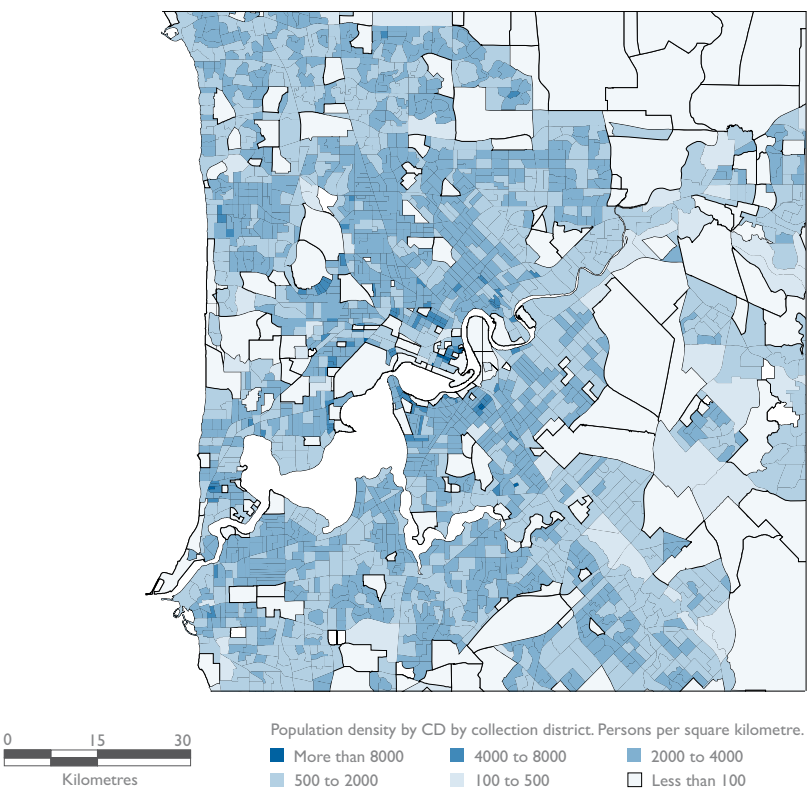
At the CCD scale, there are some pockets of very high population density (more than 10 000 persons per square kilometre) located within the suburbs of East Perth, South Perth, Victoria Park and Bentley (in the Canning SLA). Map 3.4 shows population density at the CCD scale. Areas with a population density of more than 4000 persons per square kilometre are scarce within the Perth metropolitan area, and are concentrated in the inner and middle suburbs. Most of the CCDs in Perth's established residential areas have population densities of between 500 and 4000 persons, but there are substantial areas scattered throughout the metropolitan area with population densities of less than 100 persons per square kilometre. Some of these are industrial areas, special purpose facilities (e.g. airports, educational institutions, defence facilities) or recreational areas (e.g. parks, golf courses).

Population density has implications for public transport viability. Academic research (e.g. Newman and Kenworthy 1989, 2006) has suggested there is a critical density threshold of around 30 to 40 persons per hectare below which public transport does not attract sufficient riders to support frequent services. This equates to a threshold of 3000 to 4000 persons per square kilometre. There was only one Perth suburb which exceeded this population density threshold in 2006,[9] although at the more disaggregated CCD scale, about 10 per cent of CCDs passed the 3000 persons per square kilometre threshold. However, other authors have suggested that much lower densities are capable of supporting an unsubsidised rail service with feeder buses, where the rail system serves a strong CBD (Thomson 1977, Mees 2009).

9 The data presented in the Executive Summary were largely derived by BITRE through analysis of these two primary data sources and a range of secondary data sources. Details of data sources are provided in the relevant chapters.

M3.4 Population density by CCD, Perth working zone, 2006





Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data at CCD scale.

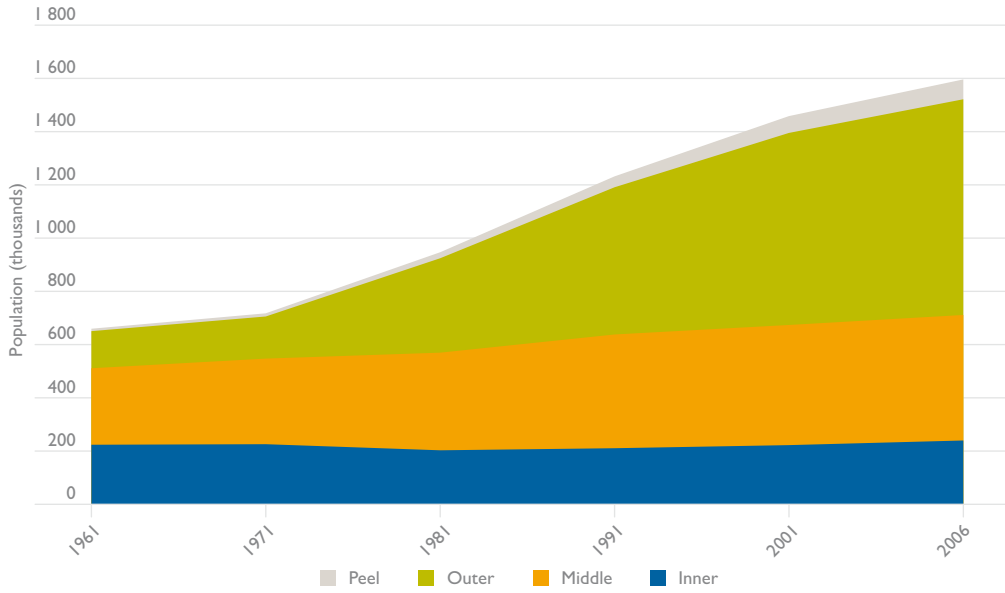
Population growth

Historic population growth

The population of the Perth and Peel region grew from 175 000 in 1921 to 715 000 in 1971 (WAPC 2003b), and has more than doubled since then to reach nearly 1.6 million in 2006 (ABS 2008a). The Stephenson-Hepburn report in 1955 allowed for 1.4 million residents of the Perth metropolitan region in 2000 and this turned out to be almost exactly on target (Hill 2005).

Figure 3.2 shows the population contribution of each subregion. The population of the Inner subregion has remained quite stable since 1961 while the Middle subregion's population has shown some growth. Perth's Outer subregion has grown rapidly since 1971 and accounts for 74 per cent of Perth and Peel's total population increase of 879 000 over that period.

F3.2 Population of Perth and Peel, 1961 to 2006

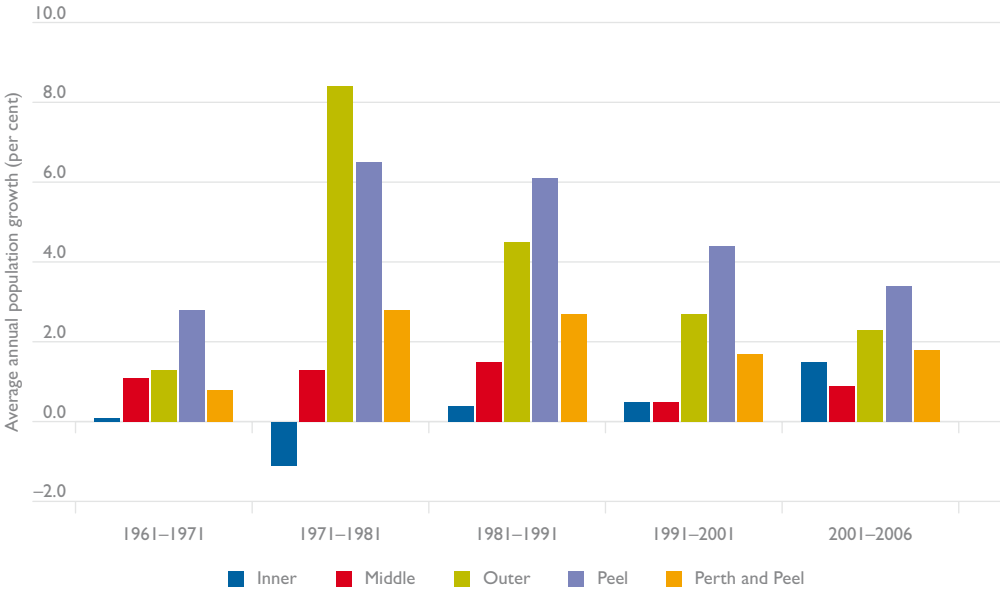


Note: The chart maps data for 1961, 1971, 1981, 1991, 2001 and 2006, and not for any of the intervening years.

Source: 2001 and 2006 population data were sourced from ABS ERP publication (ABS 2008a). Earlier years are BITRE estimates based on WAPC (2003b) and WAPC (2003c).

Figure 3.3 shows the average annual growth rate of population across these subregions. The average annual rate of population growth for Perth and Peel was 1.8 per cent between 1971 and 1981 and 2.7 per cent in the following decade, but has been lower than this in recent years, with growth averaging 1.7 per cent between 1991 and 2001 and 1.8 per cent between 2001 and 2006. The Inner subregion experienced population decline in the 1970s, but experienced historically strong growth between 2001 and 2006. The Middle subregion's rate of population growth was modest throughout the entire period. The Outer subregion experienced extraordinarily rapid population growth in the 1970s, but growth has averaged 2.6 per cent between 1991 and 2006. Peel has grown more rapidly than Outer Perth since 1981 but its growth rate has also slowed since 1991.

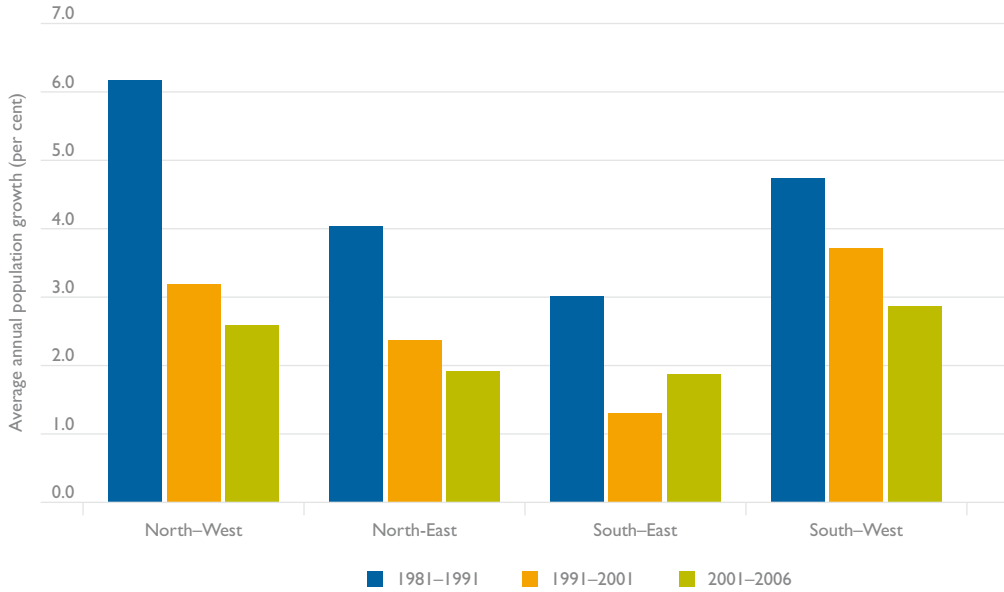
F3.3 Average annual population growth, Perth and Peel, 1961 to 2006



Source: 2001 and 2006 population data were sourced from ABS ERP publication (ABS 2008a). Earlier years are BITRE estimates based on WAPC (2003b) and WAPC (2003c).

Figure 3.4 illustrates the population growth rates achieved within the four Outer subregions. All four Outer subregions have experienced declines over time in their population growth rate. The two coastal Outer subregions (i.e. the North-West and South-West) have consistently achieved higher rates of population growth than the two inland Outer subregions. Growth has not occurred uniformly throughout these Outer subregions, but has instead been concentrated on the urban fringe. WAPC (2003b) identifies Wanneroo in the North-West Outer subregion and Rockingham in the South-West Outer subregion as being the first and third most rapidly growing local government areas between 1991 and 2001. The City of Perth was the second most rapidly growing council in Perth over this period.

F3.4 Average annual population growth by Outer subregions, 1981 to 2006



Source: 2001 and 2006 population data were sourced from ABS ERP publication (ABS 2008a). Earlier years are BITRE estimates based on WAPC (2003b) and WAPC (2003c).

Changes from 2001 to 2006

Changes in estimated residential population

This section provides an in-depth analysis of population growth between 2001 and 2006. The Perth working zone's population grew by 139 200 persons or 9.5 per cent over this period. This represents an average annual increase of 1.8 per cent, making Perth the second most rapidly growing capital city, after Brisbane. By contrast, total ERP growth for Australia was 1.3 per cent per annum, while the ERP growth for Australia's most populous city, Sydney, was only 0.7 per cent.

As can be seen from Figures 3.3 and 3.4, the rate of average annual population growth was greatest for Peel (3.4 per cent), the South-West (2.9 per cent) and the North-West (2.6 per cent) subregions. Population grew most slowly in the Middle subregion (0.9 per cent) and the Inner subregion (1.5 per cent). The Outer subregion accounted for about 64 per cent of total population growth in the Perth working zone.

Table 3.3 shows the SLAs which contributed most to the total increase in population of 139 200 persons. The SLAs which grew the most were the outer SLAs of Wanneroo North-East and Wanneroo North-West in the North-West Outer subregion, Rockingham in the South-West Outer subregion, Swan in the North-East Outer subregion and Gosnells in the South-Eastern Outer subregion. Some of the more heavily populated SLAs in the Middle subregion, such as Stirling Central and Canning, also made an important contribution to Perth's growth.

T3.3 Change in population by SLA, Perth working zone, 2001 to 2006

Greatest growth		Least growth	
SLA name	Resident Growth (Number)	SLA name	Resident Growth (Number)
Rockingham	13 523	Joondalup South	–3 098
Wanneroo North-West	12 634	Peppermint Grove	34
Wanneroo North-East	12 602	Fremantle Inner	81
Gosnells	12 206	Waroona	115
Swan	12 157	Bassendean	143
Mandurah	9 580	Nedlands	226
Cockburn	9 001	Toodyay	241
Wanneroo South	6 145	Stirling South-East	318
Stirling Central	5 376	Gingin	327
Canning	4 412	East Fremantle	329

Source: ABS Cat. 3218.0 Regional Population Growth, 2006–07

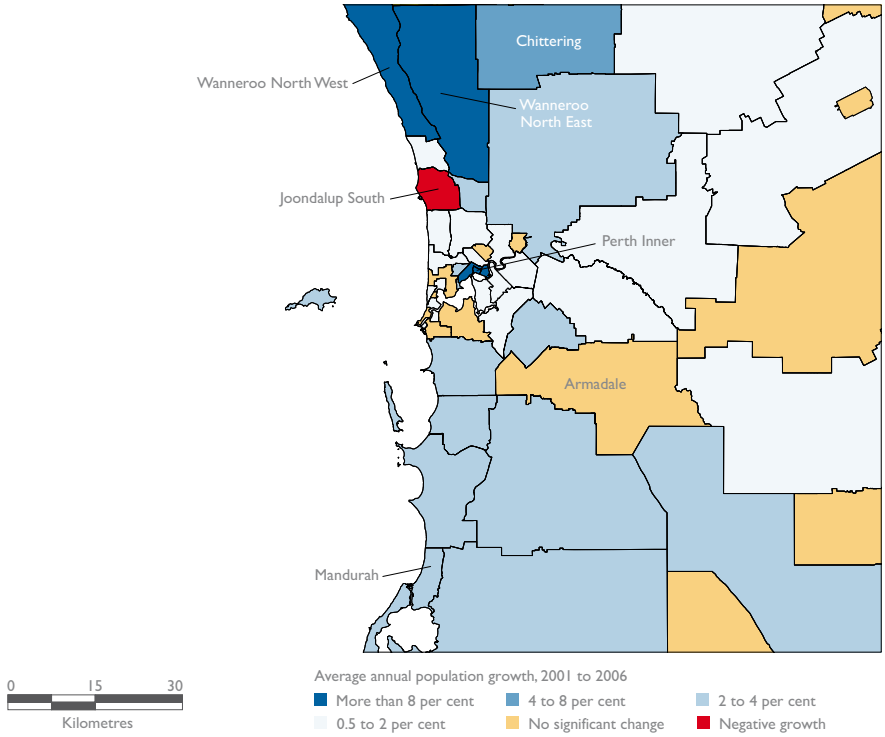
The ten slowest growing SLAs are a bit more heterogenous, featuring a combination of outer (e.g. Joondalup South), middle (e.g. Bassendean, Stirling South-Eastern), inner (e.g. Peppermint Grove, Nedlands, Fremantle) and rural SLAs (e.g. Waroona, Toodyay and Gingin).

Joondalup South was the only SLA to experience a decrease in population, although, due to its high population base, it remains one of the more populated areas of Perth. Census data for 2001 and 2006 indicate that the loss was concentrated in residents aged 0 to 54, while the 55 and over population had increased. However, the growth in the 55 and over age group stemmed from ageing in place rather than migration.

The above table displays population growth in terms of raw numbers. An alternative way to view population growth is to examine the growth as a percentage of the existing resident population, which paints a slightly different picture (Map 3.5).

The fastest growing SLAs (Table 3.4) are Wanneroo North-East and Wanneroo North-West on the city's northern fringe, and the two City of Perth SLAs. While the City of Perth grew its population by 9.8 per cent per annum between 2001 and 2006, it did not feature in Table 3.2 as that growth was coming off a low population base. A number of other outer SLAs also experienced well above average rates of population growth, including Chittering, Mandurah, Murray, Rockingham, Wanneroo South and Gosnells. Generally, SLAs in the Inner subregion recorded lower rates of growth—the exceptions being Perth Inner, Perth Remainder and Subiaco.

M3.5 Percentage growth in Estimated Resident Population by SLA, Perth working zone, 2001 to 2006



Note: Rottnest and Garden Islands form part of the Cockburn and Rockingham SLAs, respectively.

Source: ABS Cat. 3218.0 Regional Population Growth, 2006–07.

T3.4 Growth rate of population by SLA, Perth working zone, 2001 to 2006

Fastest growth		Slowest growth	
SLA name	Average annual growth (per cent)	SLA name	Average annual growth (per cent)
Wanneroo North-East	10.1	Joondalup South	–0.6
Perth Remainder	10.0	Armadale	0.2
Perth Inner	8.4	Bassendean	0.2
Wanneroo North-West	8.1	Nedlands	0.2
Chittering	4.6	Melville	0.4
Mandurah	3.6	Stirling South-Eastern	0.4
Rockingham	3.4	Peppermint Grove	0.4
Wanneroo South	3.1	Fremantle Remainder	0.4
Murray	2.9	Cambridge	0.6
Gosnells	2.8	Bayswater	0.6

Source: ABS Cat. 3218.0 Regional Population Growth, 2006–07.

The SLAs with the lowest growth rates include the outer SLAs of Joondalup South and Armadale, the middle SLAs of Bassendean, Stirling South-Eastern and Bayswater (which are all located to the east of the CBD), and the inner SLAs of Nedlands, Melville, Peppermint Grove and Fremantle Remainder.

Table 3.5 lists the Perth suburbs which experienced the most rapid population growth and decline during this period. Wanneroo North-East is particularly well represented in the list, with seven suburbs having average annual growth rates of 10 per cent or more. Most of the very strong growth suburbs are located in either the North-West (10 of 27 suburbs), South-West (6) or North-East (4) Outer subregions, while 4 are located in Peel. The Inner subregion has only one rapidly growing suburb on the list, which is Northbridge to the immediate north of the CBD. Canning Vale straddles the Canning SLA in the Middle subregion and the South-East Outer subregion SLA of Gosnells and is the most populous suburb in Perth.

At the same time, some Perth suburbs were experiencing population declines. Most of the declining suburbs listed in Table 3.5 are also located in the Outer subregion. The previously noted population loss within the Joondalup South SLA is reflected in the population loss of the suburb of Craigie. The SLAs of Wanneroo South, Rockingham and Gosnells contain suburbs with rapid population growth as well as declining suburbs. These SLAs are quite large geographic areas which contain considerable internal variation.

Map 3.6 uses the CCD data to show how population change was distributed throughout the Perth working zone. It shows that population loss was widespread throughout Joondalup South, along the border between Stirling Central and Wanneroo South, and in the more established parts of Rockingham. Areas of population loss are most evident in the outer suburbs, but are interspersed with areas of strong population growth. Many of the growth suburbs listed in Table 3.5 are visible as concentrations of green dots on the map. The major concentrations of population growth include:

- Butler in Wanneroo North-West
- Carramar, Tapping, Ashby, Sinagra and Pearsall in Wanneroo North-East
- Ellenbrook in Swan
- Canning Vale (primarily the Gosnells part)
- Success and Hammond Park in Cockburn
- Port Kennedy and Secret Harbour to the south of Rockingham town centre.

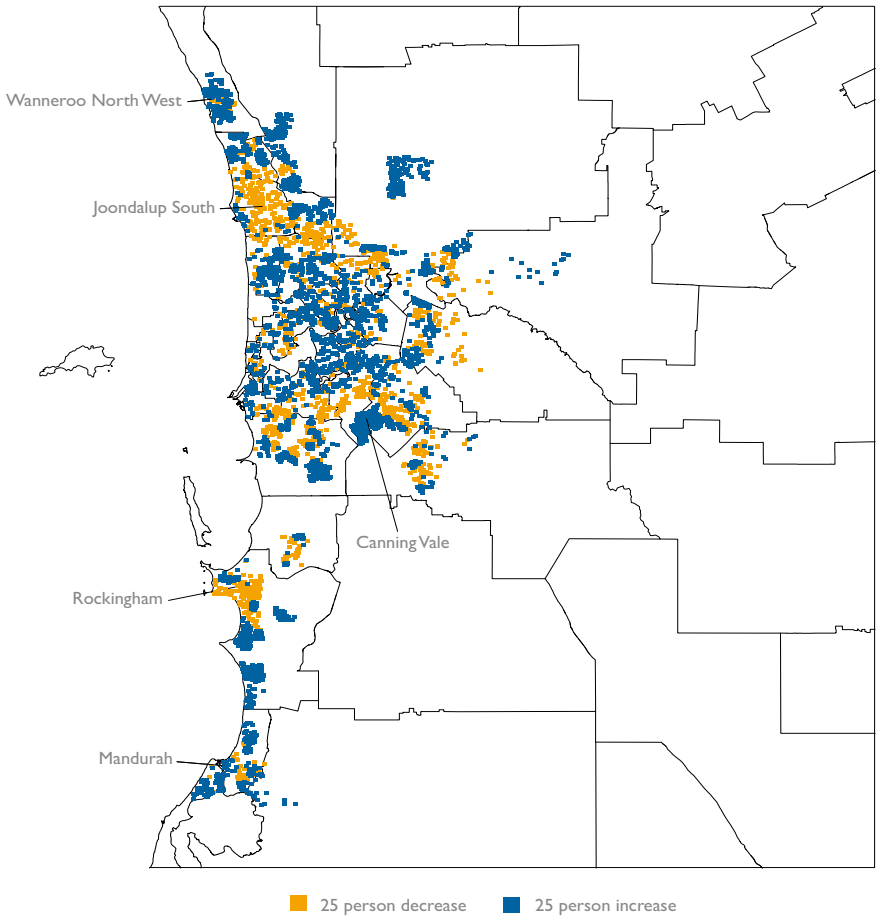
T3.5 Perth suburbs with rapid population change, 2001 to 2006

Suburb name	SLA name	Subregion	2006 population	2001 population	Average annual growth (per cent)
Most rapidly growing suburbs					
Lakelands	Mandurah	Peel	433	0	na
Butler	Wanneroo North-West	North-West	5 051	7	273
Bertram	Kwinana	South-West	2 316	56	111
Southern River	Gosnells	South-East	2 357	266	55
Darch	Wanneroo South	North-West	3 180	379	53
Ashby	Wanneroo North-East	North-West	1 661	216	50
Madeley	Wanneroo South	North-West	2 782	386	48
Tapping	Wanneroo North-East	North-West	3 113	514	43
Wattle Grove	Kalamunda	North-East	1 694	397	34
Henley Brook	Swan	North-East	1 730	477	29
Hammond Park	Cockburn	South-West	1 021	372	22
Baldivis	Rockingham	South-West	3 736	1 409	22
Pearsall	Wanneroo North-East	North-West	1 594	608	21
Success	Cockburn	South-West	4 845	1 950	20
Sinagra	Wanneroo North-East	North-West	684	302	18
Secret Harbour	Rockingham	South-West	5 651	2 613	17
Carramar	Wanneroo North-East	North-West	4 429	2 057	17
Hocking	Wanneroo North-East	North-West	3 765	1 872	15
Wannanup	Mandurah	Peel	1 963	1 040	14
Port Kennedy	Rockingham	South-West	12 799	6 847	13
Ellenbrook	Swan	North-East	10 088	5 502	13
Canning Vale	Gosnells	South-East	22 846	12 537	13
Dawesville	Mandurah	Peel	3 036	1 704	12
Banksia Grove	Wanneroo North-East	North-West	1 941	1 121	12
Northbridge	Perth Remainder	Inner	677	413	10
Jane Brook	Swan	North-East	3 122	1 919	10
Ravenswood	Murray	Peel	482	779	10
Most rapidly declining suburbs					
Safety Bay	Rockingham	South-West	7 304	7 957	–2
Craigie	Joondalup South	North-West	5 563	6 068	–2
Samson	Fremantle Remainder	Middle	1 981	2 166	–2
Girrawheen	Wanneroo South	North-West	7 991	8 780	–2
Cooloongup	Rockingham	South-West	6 811	7 523	–2
Martin	Gosnells	South-East	406	454	–2
Bellevue	Swan	North-East	1 667	1 867	–2
West Swan	Swan	North-East	131	197	–8

Note: Where suburbs are split across more than one SLA (e.g. Canning Vale), they have been allocated to the SLA that accounts for the largest population share.

Source: BITRE analysis of ABS 2001 and 2006 Census of Population and Housing data. Excludes suburbs with populations of less than 100 in 2006.

M3.6 Dot density map of population change for Perth working zone, 2001 to 2006



Source: BITRE analysis of ABS 2001 and 2006 Census of Population and Housing data.

Sources of population growth

Population growth can occur as a result of natural increase (i.e. births exceeding deaths), internal migration or overseas migration. Historically, overseas migration has been a more important contributor to Perth's population growth, than either interstate or intrastate migration (WAPC 2003b).

Official population data (ABS 2009a) shows that the ERP of Western Australia as a whole grew by 158 200 between the June quarters of 2001 and 2006. Thus, about 88 per cent of the state's population increase was attributable to the Perth working zone. ABS (2009a) decomposes Western Australia's population growth to the following three sources:

- natural increase—43 per cent
- net interstate migration—2 per cent
- net overseas migration—53 per cent.

Unfortunately, ABS does not publish an equivalent decomposition for Perth. However, given the extent to which Perth dominates Western Australia's population growth, the pattern is likely to be similar. The Perth working zone also attracts a net inflow of people from the remainder of Western Australia, estimated at 7600 for the 2001 to 2006 period.[10]

The sources of population growth will vary for different parts of Perth. For example, census data reveals:

- The arrival of almost 90 000 new migrants from overseas between 2001 and 2006 substantially boosted Perth's population (by about 6 per cent). The boost to the existing population base exceeded 12 per cent for the City of Perth, Subiaco, Wanneroo North-East and Wanneroo North-West.
- Wanneroo North-East, Wanneroo North-West, Chittering and Perth Remainder all received significant net inflows of residents from other parts of Perth between 2001 and 2006, amounting to more than 10 per cent of each SLA's 2001 population.
- Twelve per cent of the population of Wanneroo North-East and West are aged between zero and four, compared to 6 per cent for the Perth working zone as a whole—this suggests that natural increase has also played an important role in the rapid population growth experienced by these two SLAs.

Changes in population densities

The Perth working zone's overall population density increased from 103 to 113 persons per square kilometre between 2001 and 2006. The additional population was accommodated through expanded residential development on the urban fringe and redevelopment of some existing suburbs, particularly in the Inner subregion. Relatively small lot sizes have become increasingly common for newly released land in Perth and Peel, with lots of less than 500 square metres making up 33 per cent of residential lot approvals in 2005–06 (WAPC 2007), compared to 8 per cent in 1991–92 (WAPC 2003b).

There has not, however, been a shift towards higher density forms of housing. Instead, Perth continues to be dominated by detached dwellings, which rose from 77.8 per cent of dwellings in 2001 to 78.4 per cent in 2006. Of the 54 000 additional dwellings added to the Perth working zone between 2001 and 2006, 85 per cent were separate houses. This pattern was particularly pronounced in outer metropolitan and fringe areas. For example, 89 per cent of the 4700 dwellings added in Peel between 2001 and 2006 were separate houses.

Population density increased from 1503 to 1623 persons per square kilometre in the Inner subregion and from 1476 to 1542 persons per square kilometre in the Middle subregion. The increases in population density were more modest in the Outer subregion, Peel and the Avon Arc.

10 BITRE analysis of unpublished 2006 ABS Census of Population and Housing data on SLA migration flows over the previous five years. The 2008 ABS ERP figures remain preliminary.

Table 3.6 lists the regions which experienced the greatest absolute increase in persons per square kilometre between 2001 and 2006. The SLAs with the greatest increase in density mainly comprised central and inner SLAs (Perth Inner and Remainder, Subiaco, South Perth, Cottesloe, Mosman Park and Vincent). Three SLAs in the northern suburbs also had a substantial increase in population density, namely Wanneroo South, Stirling Coastal and Joondalup North. While Perth Inner and Perth Remainder achieved their increases off a relatively low population density in 2001, Subiaco and Vincent both experienced substantial increases in density despite beginning the period with a relatively high population density. Joondalup South was the only SLA which experienced a decline in population density.

T3.6 Greatest increases in population density by SLA for Perth, 2001 to 2006

SLA Name	Persons per square kilometre 2001	Persons per square kilometre 2006	Increase in density
Perth Remainder	654	1052	397
Subiaco	2236	2506	271
Vincent	2505	2736	230
Perth Inner	427	638	212
South Perth	1892	2067	175
Wanneroo South	993	1157	164
Stirling Coastal	1663	1778	114
Joondalup North	1218	1330	112
Mosman Park	1917	2028	111
Cottesloe	1910	2016	106

Source: ABS Cat. 3218.0 Regional Population Growth, 2006–07.

There were several Perth suburbs which experienced a substantial decline in population density over the period. Highgate remains the most densely populated Perth suburb, despite its population density dropping by 198 persons per square kilometre over the period. The suburbs of Girrawheen in Wanneroo South, Samson in Fremantle Remainder, Safety Bay in Rockingham and Parkwood in Canning all experienced declines of between 140 and 170 persons per square kilometre.

Two-thirds of Perth's suburbs raised their population density between 2001 and 2006, sometimes by a very substantial amount. Table 3.7 lists the suburbs which experienced an increase in population density of more than 300 persons per square kilometre. The majority of these are recently developed suburbs in the Outer subregion, which started the period with a relatively low population density. However, the outer northern suburbs of Kinross, Merriwa and Quinns Rocks all had a population density that was well above average in 2001, but further increased their density between 2001 and 2006. These increases reflected a combination of high birth rates and continued residential development.

T3.7 Suburbs which increased population density by more than 300 persons per square kilometre between 2001 and 2006, by subregion

Subregion	Suburb	Statistical Local Area	Persons per square kilometre 2001	Persons per square kilometre 2006	Change in density
Inner^	East Perth	Perth Remainder	1202	1807	605
	Northbridge	Perth Remainder	860	1410	550
	Karawara	South Perth	1423	1949	526
	West Perth	Perth Remainder	1299	1794	495
	Subiaco	Cambridge	2020	2396	376
Middle	Gwelup	Stirling Coastal	792	1108	316
	Innaloo	Stirling Coastal	1828	2137	309
Outer	Ashby	Wanneroo North-East	148	1138	990
	Butler	Wanneroo North-West	1	949	948
	Darch	Wanneroo South	125	1053	927
	Hocking	Wanneroo North-East	774	1556	782
	Madeley	Wanneroo South	125	903	778
	Tapping	Wanneroo North-East	149	905	756
	Bertram	Kwinana	18	747	729
	Pearsall	Wanneroo North-East	403	1056	653
	Atwell	Cockburn	1303	1879	576
	Success	Cockburn	338	840	502
	Merriwa	Wanneroo North-West	1807	2279	472
	Quinns Rocks	Wanneroo North-West	1489	1947	458
	Secret Harbour	Rockingham	385	833	448
	Hammond Park	Cockburn	248	681	433
	Iluka	Joondalup North	1119	1524	405
	Canning Vale	Gosnells	493	898	405
	Kinross	Joondalup North	2144	2546	402
	Carramar	Wanneroo North-East	306	658	352

Note: Where suburbs are split across more than one SLA (e.g. Canning Vale), they have been allocated to the SLA that accounts for the largest population share.

^ The South Perth suburb of Manning was excluded from the table due to concerns about data quality.

Source: BITRE analysis of ABS 2001 and 2006 Census of Population and Housing data.

Only two Middle subregion SLAs appear in Table 3.7, as having an increase in population density of more than 300 persons per square kilometre. Innaloo achieved increased density through increases in the number of flats and semi-detached dwellings in established residential areas. Gwelup achieved increased density through the building of nearly 300 new houses in previously undeveloped areas of the suburb and through a high birth rate.

There were some substantial increases in density in Inner SLAs, particularly in the three City of Perth suburbs of East Perth, West Perth and Northbridge. These increases were due to large scale building of apartment-style accommodation, which included the conversion of commercial buildings into apartments (WAPC 2003b). Subiaco already had a high population density in 2001, but ongoing development and construction of more than 500 additional dwellings led to further increases in density. The South Perth suburb of Karawara achieved increased density by redevelopment which added about 180 dwellings (a 40 per cent increase) and through increased household size.

Expansion of residential areas

Management of population growth and the city's outward expansion is central to Perth's strategic plans. *Network City* aimed to 'contain urban sprawl and enhance opportunities for urban regeneration and renewal within the existing urban area' (WAPC 2005a). More specifically, 60 per cent of required dwellings were to be accommodated in existing urban areas and 40 per cent in new growth areas (WAPC 2004c). However, the preferred 'connected city' scenario in the draft *Directions 2031* spatial framework is less ambitious, requiring only 47 per cent of new dwellings to be accommodated within existing developed areas (WAPC 2009a).

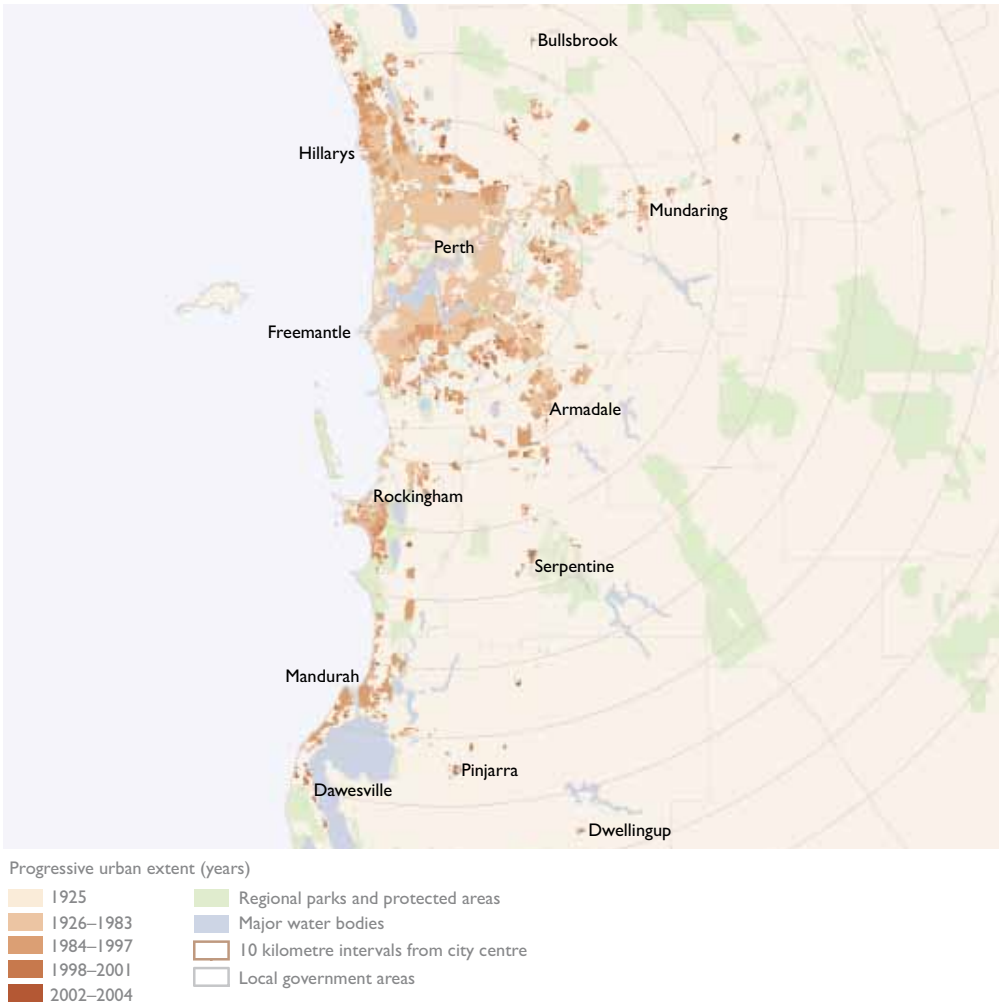
Strong population and economic growth meant that Perth's physical extent expanded between 2001 and 2006:

- The land area of the Perth urban centre, as defined by the ABS Urban Centres and Localities classification, expanded between 2001 and 2006 by 35 square kilometres or 3.6 per cent. The expansion reflects the development of new suburbs on the fringe, including Butler, Banksia Grove, Darch, Wattle Grove, Southern River and Hammond Park.
- Other urban centres within the Perth working zone have also expanded in terms of land area. For example, Mandurah expanded by 16 per cent between 2001 and 2006, Ellenbrook by 8 per cent, Kwinana by 3 per cent and Rockingham[11] by 3 per cent.
- BITRE first developed its working zone boundaries based on 2001 commuting patterns (BTRE 2004) and has since updated the working zones to ensure they reflect commuting behaviour in 2006 (BITRE 2009). This update led to the expansion of the Perth working zone boundary to include the Gingin SLA to the north-west, the Toodyay SLA to the north-east and the Waroona SLA to the south. These SLAs became more economically integrated with the rest of Perth between 2001 and 2006.

11 Baldivis is located within the Rockingham LGA but is classified by ABS as a separate urban centre. The ABS urban centre of Baldivis expanded its land area from 1.5 to 10.2 square kilometres between 2001 and 2006.

Map 3.7 illustrates how the Perth urban area has expanded over time.

M3.7 Expansion of Perth's urban extent between 1925 and 2004

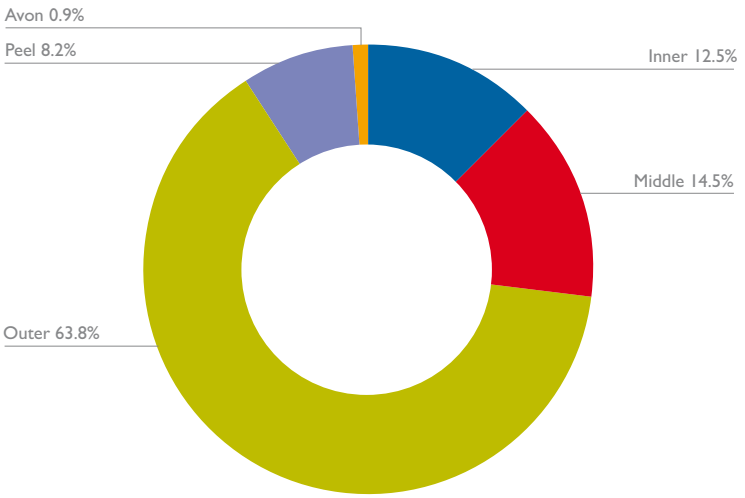


Source: Adapted from Figure HS1.1 in State of the Environment Report, Western Australia, 2007 (Environmental Protection Authority 2007)

To what extent was Perth's population growth accommodated in existing urban areas between 2001 and 2006? Figure 3.5 shows that the Inner and Middle subregions together accounted for just 27 per cent of Perth's total population growth. Sixty-four per cent of Perth's population growth occurred in the Outer subregion, and the peripheral areas of Peel and Avon Arc accounted for a further 9 per cent of growth.

Further investigation is required to distinguish whether this outer suburban population growth is predominantly occurring in established urban areas or in newly developed areas. This distinction is not always clearcut, as there can be delays of many years between an initial land release and a suburb being fully populated, and significant new land releases can occur within existing urban areas.

F3.5 Proportion of population growth attributable to each subregion, Perth working zone, 2001 to 2006



Source: BITRE analysis of ABS Cat. 3218.0 Regional Population Growth, 2006-07.

In setting its population growth targets, WAPC (2004c) does not clearly define what is considered a 'new growth area' or an 'existing urban area'. Some suburbs, such as Butler, Atwell, Ashby and Southern River, had tiny populations in 2001 and experienced very rapid population growth over the following five years. These clearly qualify as 'new growth areas'. For many other suburbs, the situation is less clearcut. An established residential area existed in the late 1990s in the outer suburbs of Landsdale, Canning Vale, Quinns Rocks, Mindarie, Atwell and Beechboro, but significant parts of these suburbs remained undeveloped (or in progress) until the current decade. The suburb of Canning Vale alone accounted for more than 7 per cent of Perth's population growth between 2001 and 2006. During the study period, substantial new residential land was made available and large numbers of new dwellings were constructed in Canning Vale (WAPC 2004d).

In 2006, there were 357 suburbs designated by the ABS in Perth, Mandurah and Murray. In order to identify the extent to which population growth is being accommodated in existing urban areas, BITRE has classified each of these suburbs as either an existing urban area or a new growth area. BITRE classified a suburb as a new growth area for the 2001 to 2006 period if it experienced very rapid and substantive growth in dwellings over the period. Specifically, a new growth area needed to meet one of the following criteria:

1. A suburb located in Peel or the Outer subregion in which the number of occupied private dwellings increased by more than 50 per cent over the period *and* this involved an increase of at least 100 dwellings.

2. A suburb located in Peel or the Outer subregion in which the number of occupied private dwellings increased by between 30 and 50 per cent over the period and this involved at least 100 additional dwellings and at least one CD within the suburb more than doubled its number of dwellings *and* the growth related to fringe development, not urban infill.

Criterion one captures newly developing suburbs which were experiencing very rapid growth off a very low base. This criterion is quite restrictive, as only suburbs which have experienced dwellings growth more than five times the Perth-wide average (9.5 per cent) qualify as new growth areas. A total of 29 suburbs qualify as new growth areas under this criterion.

Criterion two loosens this a little to ensure the definition is able to capture suburbs which contain some established residential areas, but in which substantial new land releases occurred during or just prior to the period of interest. Six additional suburbs qualify under this criterion, including Atwell, Landsdale and Meadow Springs.

In total, BITRE has classified 33 suburbs, or 9 per cent of suburbs, as new growth areas for the 2001 to 2006 period. These suburbs are listed in Table 3.8.

T3.8 Suburbs classified as new growth areas for the 2001 to 2006 period

The following suburbs were classified by BITRE as new growth suburbs	
Ashby	Lakelands
Atwell	Landsdale
Banksia Grove	Pearsall
Beeliar	Port Kennedy
Bertram	Quinns Rocks
Butler	Ravenswood
Canning Vale	Ridgewood
Carramar	Secret Harbour
Baldivis	Sinagra
Darch	Southern River
Dawesville	Success
Ellenbrook	Tapping
Erskine	Madeley
Hammond Park	Meadow Springs
Henley Brook	Wannanup
Hocking	Wattle Grove
Jane Brook	

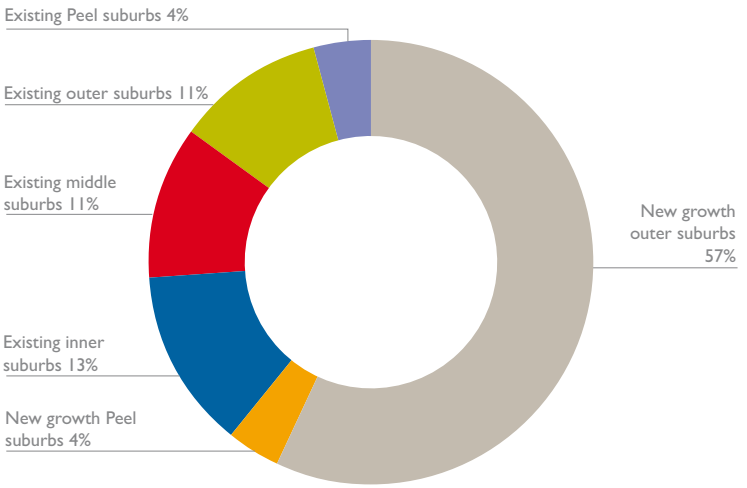
Source: BITRE analysis of ABS Census of Population and Housing suburb data for 2001 and 2006.

Some outer suburbs experienced quite rapid growth over the period, but did not qualify as new growth areas. Examples include Joondalup, Mindarie, Merriwa and The Vines. All increased the number of dwellings by between 30 and 40 per cent, but did not meet the criteria, either because the growth was urban infill (e.g. Joondalup) or because the growth was spread across the suburb, rather than being concentrated in a new land release area (e.g. The Vines).

Between 2001 and 2006, the usual resident population of Perth, Mandurah and Murray increased by about 116 000 persons, according to census data. Figure 3.6 shows how much of that population growth occurred in new growth areas and existing urban areas. In total, 61 per cent of population growth was attributable to new growth areas and 39 per cent was attributable to existing urban areas. This is essentially the opposite of the longer term goal set out in *Network City* which aimed to accommodate 60 per cent of growth in existing urban areas.[12] However, it is much closer to the 47 per cent target in *Directions 2031*.

12 Note that the WA government is focused on the extent to which additional dwellings are located in existing urban areas or new growth areas. This differs from BITRE's analysis, which instead focuses on population.

F3.6 Proportion of population growth attributable to new growth areas and existing urban areas, 2001 to 2006



Note: The analysis relates to Perth, Mandurah and Murray.
The data differs from that presented in Figure 3.5 which was based on ERP counts for SLAs in the Perth working zone, rather than census population counts for suburbs in Perth, Mandurah and Murray.

Source: BITRE analysis of ABS Census of Population and Housing suburb data for 2001 and 2006.

Between 2001 and 2006, the majority of Perth's population growth has been accommodated by new growth areas which are almost entirely concentrated in the Outer subregion, with Peel making a relatively minor contribution. The population growth in existing urban areas is roughly evenly split across each of the Inner, Middle and Outer subregions. However, Perth has had notable success with urban consolidation in specific established suburbs, such as:

- East Perth (which increased population by 1930 or 50 per cent)
- Perth city (increase of 1628 or 34 per cent)
- Joondalup (increase of 1609 or 24 per cent)
- Stirling (increase of 1219 persons or 21 per cent)
- Subiaco (increase of 1196 persons or 19 per cent).

Survey research undertaken as part of *Dialogue with the City* revealed a disconnect between planning objectives and expected outcomes. While 65 per cent of Perth residents would like to ensure 'growth is encouraged to be in existing areas of development, and undeveloped land remains that way', only 23 per cent expect this to happen (Colmar Brunton n.d.). This was the lowest expectation across all the surveyed trends.

Adams (2007) pointed to a significant disjuncture between the WA Government's past spatial plans and actual residential development outcomes in Perth between 1971 and 2005.

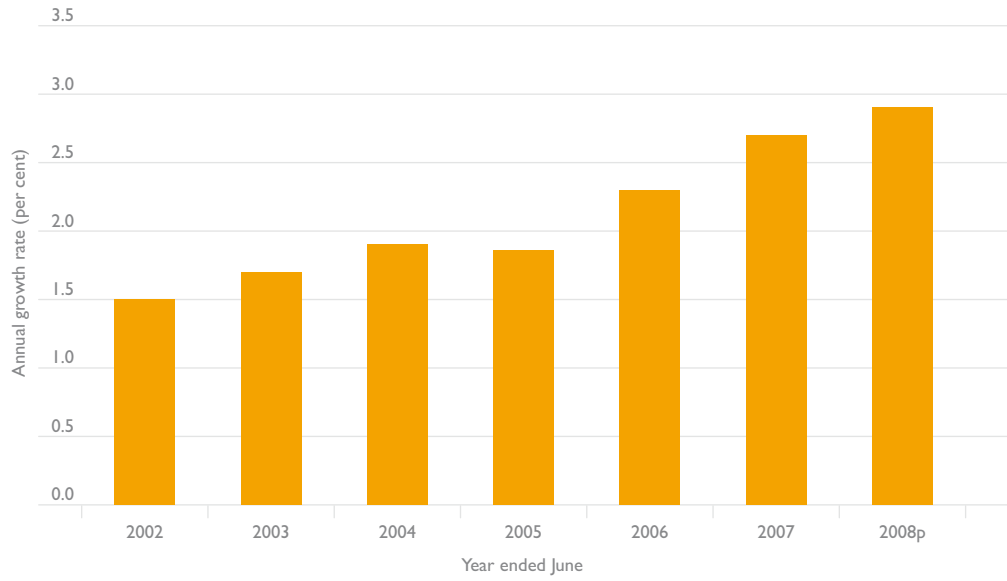
> 'Despite the generous quantum of urban expansion potential earmarked within each growth corridor . . . there has indeed been substantial and potentially systematic departures from the desired urban development outcomes envisaged for both The Corridor Plan and Metroplan' (ibid p.71).

Adams (2007) argues that the spatial plans have 'been relatively impotent in determining the location and timing of urban expansion patterns' (ibid p1) and that the land development and real estate industries have had more influence than the spatial plans on outer area development outcomes.

Recent population growth

This study focuses on the 2001 to 2006 period, but more recent ERP data is also available for Perth. Between 2001 and 2006, ERP grew at an average annual rate of 1.8 per cent. However, Figure 3.7 shows that the rate of growth was initially lower and steadily increased during the period. The rate of population growth has continued to rise since 2006, with population growing by 2.7 per cent for the year ended June 2007 and 2.9 per cent for the year ended June 2008.[13] Perth and Darwin recorded the most rapid population growth of the capital cities in the year ended June 2008 (ABS 2009b).

F3.7 Annual rate of growth in Estimated Resident Population, Perth working zone, 2001 to 2008



Note: 2008 data is preliminary.

Source: BITRE analysis of ABS Cat. 3218.0 Regional Population Growth, 2006–07.

Between June 2006 and June 2008, eight different SLAs have increased population by between 5000 and 9000 residents. The eight growth SLAs are (in descending order): Rockingham, Swan, Wanneroo North-West, Wanneroo North-East, Cockburn, Mandurah, Stirling Central and Gosnells. Peppermint Grove was the only SLA to record a population decline between 2006 and 2008.

13 The 2008 ABS ERP figures remain preliminary.

The population grew by 20–22 per cent between June 2006 and June 2008 in Perth Remainder, Wanneroo North-East, Perth Inner and Wanneroo North-West. It also grew strongly in Serpentine-Jarrahdale (14 per cent growth) and Chittering (10 per cent growth). Apart from Serpentine-Jarrahdale, all were in the top five rapid growth SLAs for the 2001 to 2006 period (see Table 3.4).

Thus, while the overall rate of population growth has ramped up for Perth since 2006, the growth continues to be concentrated in essentially the same set of locations. One notable change is the recent emergence of Serpentine-Jarrahdale as an area experiencing very rapid residential growth.

Projected Population Growth

ABS (2008b) projections of population indicate that Perth will continue to be one of the fastest growing capitals into the future (Table 3.9), having an average annual growth rate on par with Brisbane between 2006 and 2056. Both Brisbane and Perth are expected to grow at significantly faster rates than Melbourne, the next fastest growing city. Projection Series B was chosen for display as it 'largely reflects current trends in fertility, life expectancy at birth, net overseas migration and net interstate migration' (ABS 2008a p.3).

In relative terms, the projections also indicate that, by 2056, each of the cities will retain their current rankings in terms of total residential populations.

T3.9 Population projections for Australia's major capital cities, 2006 to 2056

Year	Perth	Sydney	Melbourne	Brisbane	Adelaide
2006	1 518 748	4 281 988	3 743 015	1 819 762	1 145 812
2010	1 661 785	4 496 597	3 998 175	1 980 650	1 194 151
2026	2 267 589	5 426 260	5 038 113	2 681 135	1 384 544
2056	3 358 367	6 976 827	6 789 215	3 979 293	1 651 836
Average annual growth rate (per cent)	1.6	1.0	1.2	1.6	0.7

Source: ABS Cat. 3222.0 Population Projections Australia, 2006 to 2101 (Series B projections)

WAPC (2009a) recognises that the Perth region will need to accommodate over half a million new residents by 2031, but if the available land 'is planned and used effectively and efficiently, it is expected that it will be sufficient to comfortably meet growth demands to 2031' (ibid p.6).

But what about population projections within different parts of Perth? The Australian Government Department of Health and Ageing (DHA) has released small area population projections, which are summarised in Table 3.10. These projections were prepared by ABS and are consistent with the projections summarised in Table 3.9. Population growth is projected to be greatest in the South-West and North-West Outer subregions, and lowest in the Middle and Inner subregions.

The WAPC also prepares population projections for Greater Perth, by planning subregion. The projections for Perth and Peel as a whole were produced in 2005 (WAPC 2005b), but in 2009 updated projections were produced at the subregional scale based on the original totals for Perth and Peel (WAPC 2009b). The updated subregional projections reflect the urban consolidation goals of *Directions 2031*.

From Table 3.11 it is evident that the average annual growth rate to 2031 in the WAPC projections is much lower than that projected for Perth and Peel by the federal government. It is also a little lower than the population growth rate achieved between 1991 and 2001 or 2001 and 2006 (see Figure 3.3).

T3.10 Federal government population projections by subregion, Perth and Peel, 2007 to 2027

	Population projections (thousands)				
Subregion	2007	2011	2021	2027	Average annual growth rate (per cent)
Inner	241	252	287	311	1.3
Middle	477	494	546	581	1.0
Outer	836	916	1205	1414	2.7
North-West	283	312	415	490	2.8
North-East	190	203	250	284	2.0
South-East	165	179	232	271	2.5
South-West	198	222	307	369	3.2
Perth	1 554	1 662	2 038	2 306	2.0
Peel	78	86	110	124	2.3
Perth and Peel	1 632	1 748	2 147	2 430	2.0

Source: Department of Health and Ageing (2009).

T3.11 WA Government population projections by subregion, Perth and Peel, 2008 to 2031

Subregion	Population 2008 (thousands)	Projected population 2031 (thousands)	Change (thousands)	Average annual growth rate (per cent)
Central (Inner and Middle)	705	910	205	1.1
Outer	852	1159	307	1.3
North-West	285	395	110	1.4
North-East	189	258	69	1.4
South-East	170	228	58	1.3
South-West	208	278	70	1.3
Perth Statistical Division	1 557	2 069	512	1.2
Peel	88	133	45	1.8
Perth and Peel	1 645	2 202	557	1.3

Source: WAPC (2009a).

Why are the WAPC projections lower than the Australian Government projections? This is partly because the original WAPC projections were released several years prior to the ABS projections (WAPC 2005b). Since 2005, the annual rate of population growth has increased for both Perth and Australia.

The WAPC projections indicate that the Peel planning subregion, despite having the lowest population, has the highest average annual growth rate. All four Outer subregions are projected to have average annual growth rates of between 1.2 and 1.5 per cent between 2008 and 2031. The Central subregion is projected to experience slightly lower population growth over the period. The projected growth rates for Peel and the four Outer subregions all lie below their actual growth rates between 2001 and 2006, but the projected growth rate for Central Perth matches the actual rate of population growth achieved between 2001 and 2006 (1.1 per cent). The projected population growth in the Central subregion is dependent on increased rates of urban infill residential development (WAPC 2009a).

The WAPC projections predict lower growth than the DHA for all subregions, apart from the Central subregion where the two sets of projections are broadly consistent. A key difference is that while Peel is the standout growth subregion in WAPC's projections, in the DHA projections Peel's growth rate is only slightly above average. The DHA (2008) projections are based entirely on demographic considerations, and it is likely that the WA Government projections better reflect local economic intelligence and land supply constraints (WAPC 2005b).

In summary, the available projections of Perth's future population and its subregional distribution vary considerably and highlight the uncertainty about the magnitude of the city's future growth. The WAPC projections are more conservative than current ABS projections. Nevertheless, all sets of projections anticipate continued strong population growth for Perth and Peel.

Households

The analysis underlying the *Network City* strategic plan was based on an understanding that due to declining household size, the number of dwellings would increase at a more rapid rate than the projected population (WAPC 2003e). The spatial patterns highlighted so far relate to population, but these patterns may be somewhat different for households. This section presents a brief overview of spatial differences in average household size and the rate of growth of households, focusing on similarities and differences with the population results presented in the previous section. This analysis has been included to provide some understanding of the connection between spatial change in population, households and demand for dwellings.

Table 3.12 summarises household growth and household size at the subregional scale for the 2001 to 2006 period. For the Perth working zone as a whole, households grew at an average annual rate of 1.7 per cent, which was marginally lower than the population growth rate. The lowest household growth rate occurred for the Middle subregion, followed by the Inner subregion, and this is the same as the pattern observed for ERP. The number of households grew most rapidly in the North-West Outer subregion, followed by the South-West Outer subregion and Peel. For population growth the ordering was a little different, with Peel recording the most rapid rate of growth, followed by the South-West and North-West Outer subregions. In Peel and the Inner subregion, growth in population considerably outstripped growth in the number of households.

The average household size in the Perth working zone did not change significantly between 2001 and 2006. In 2006, average household size ranged from 2.2 persons per household in the Inner subregion to 2.9 persons per household in the North-West Outer subregion. The average number of persons per household remained quite stable at the subregional scale between 2001 and 2006, apart from Peel which increased household size.

At the SLA scale, growth in households was dominated by five Outer subregion SLAs which together contributed 48 per cent of the total increase in households in the Perth working zone between 2001 and 2006. The five SLAs were Rockingham (which increased by 4508 households), Wanneroo North-East (4412), Gosnells (4336), Swan (4130) and Wanneroo North-West (4092). The same five SLAs also experienced the greatest absolute increase in ERP between 2001 and 2006, contributing 46 per cent of Perth's total increase in population.

T3.12 Household growth and household size by subregion, Perth working zone, 2001 to 2006

Subregion	Average annual growth in households, 2001 to 2006 (per cent)	Average annual growth in estimated resident population, 2001 to 2006 (per cent)	Average household size 2001	Average household size 2006	Change in household size, 2001 to 2006
Inner	0.9	1.6	2.18	2.25	0.07
Middle	0.7	0.8	2.42	2.43	0.01
Outer	2.5	2.3	2.83	2.80	–0.02
North-West	3.0	2.6	2.94	2.89	–0.05
North-East	2.0	1.9	2.83	2.81	–0.02
South-East	2.0	1.8	2.80	2.77	–0.03
South-West	2.8	2.9	2.70	2.71	0.01
Peel	2.5	3.5	2.38	2.50	0.12
Avon Arc	2.2	2.5	2.57	2.61	0.04
Perth working zone	1.7	1.8	2.56	2.58	0.02

Note: The estimated resident population data used for this calculation is based on residents of occupied private dwellings, to enable valid comparison with household data.

Source: BITRE analysis of ABS data on request.

There were, however, some differences between household and population growth rates at the SLA scale. The number of households grew much less rapidly than population for Mandurah, Murray and Waroona (which together comprise Peel) as well as Chittering and the Inner subregion SLAs of Perth Remainder, Cottesloe, East Fremantle and South Perth—all eight SLAs experienced a notable increase in average household size. The number of households in Gingin, Joondalup South, Inner Fremantle and Inner Perth grew more rapidly than population, as average household size declined. However, average household size was fairly stable for most SLAs between 2001 and 2006.

In 2006, the average number of persons per household ranged from 1.6 for Inner Perth to 3.0 in Serpentine-Jarrahdale.

The spatial distribution of household growth is fairly well aligned with the spatial distribution of population growth within Perth. However, some areas of Perth are experiencing significant demographic changes which are impacting on household size and generating a gap between the rate of household growth and the rate of population growth.

Employed residents

Up until this point the focus has been on the spatial distribution of the residential population and how this has changed in recent years. The next chapter shifts focus to the spatial distribution of employment on a place of work basis. The current section connects the two by discussing the spatial distribution of employment on a place of residence basis.

Only 46 per cent of people who live in the Perth working zone were employed on either a full-time or a part-time basis in 2006, reflecting an increase from 44 per cent in 2001. As less than half of the population of most areas within Perth are employed, strong growth in population within an area will not necessarily translate into strong growth in employed residents or commuters, particularly where the population growth is concentrated in the under 15 or over 65 age groups.

The number of employed residents of the Perth working zone increased from 640 600 to 736 500 between 2001 and 2006, representing an increase of 95 900 residents. Table 3.13 summarises growth in the number of employed residents and the ratio of employed residents to ERP at the subregional scale. The key point is that the number of employed residents grew much more rapidly between 2001 and 2006 (averaging 2.8 per cent per annum across the Perth working zone) than did population (1.8 per cent per annum).

All subregions experienced much stronger growth in employed residents than ERP. Growth in employed residents was strongest for Peel (5.2 per cent per annum) and the neighbouring South-West (4.5 per cent), and these two subregions also experienced the greatest population growth. The Inner and Middle subregions experienced the slowest growth in both employed residents and population. However, the rate of employment growth in the Inner and Middle subregions still marginally exceeded the national rate of growth in employed residents. Thus, above-average employment growth occurred across all of Perth's planning subregions, reflecting the impact of the mining boom and the very strong growth of the Western Australian economy between 2001 and 2006.

T3.13 Change in employed residents and proportion of estimated resident population (ERP) participating in employment by subregion, Perth working zone, 2001 to 2006

Subregion	Average annual growth in employed residents, 2001 to 2006 (per cent)	Average annual growth in ERP, 2001 to 2006 (per cent)	Ratio of employed residents to ERP 2001	Ratio of employed residents to ERP 2006	Change in ratio, 2001 to 2006
Inner	2.0	1.5	0.45	0.46	0.01
Middle	1.9	0.9	0.44	0.47	0.02
Outer	3.5	2.3	0.44	0.46	0.02
North-West	3.5	2.6	0.46	0.49	0.02
North-East	3.0	1.9	0.44	0.47	0.02
South-East	2.9	1.9	0.43	0.45	0.02
South-West	4.5	2.9	0.40	0.43	0.03
Peel	5.2	3.4	0.33	0.37	0.03
Avon Arc	3.5	2.2	0.38	0.42	0.02
Perth working zone	2.8	1.8	0.44	0.46	0.02

Note: The estimated resident population data used for this calculation is based on residents of occupied private dwellings.

Source: BITRE analysis of ABS ERP data on request and ABS Census of Population and Housing place of usual residence data on employment for 2001 and 2006.

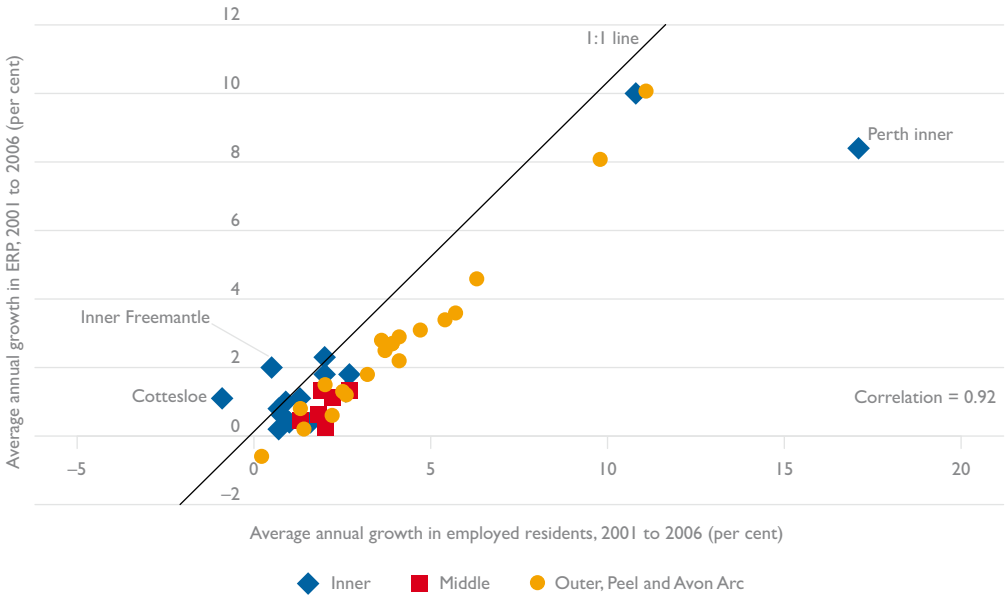
In 2006, the ratio of employed residents to ERP was 0.46, but there was considerable variation in this ratio across Outer subregions. The ratio ranged from a low of 0.37 in Peel to a high of 0.49 in the North-West subregion. All subregions experienced an increase in this ratio between 2001 and 2006, as the strong economic conditions encouraged people to enter the labour market. Peel and the South-West Outer subregion recorded the largest increase in employment participation.

While less than half of each subregion's population is employed, the subregions with the most rapid growth in population have experienced the most rapid growth in employed residents (and vice versa). Is a similar pattern evident at the SLA scale?

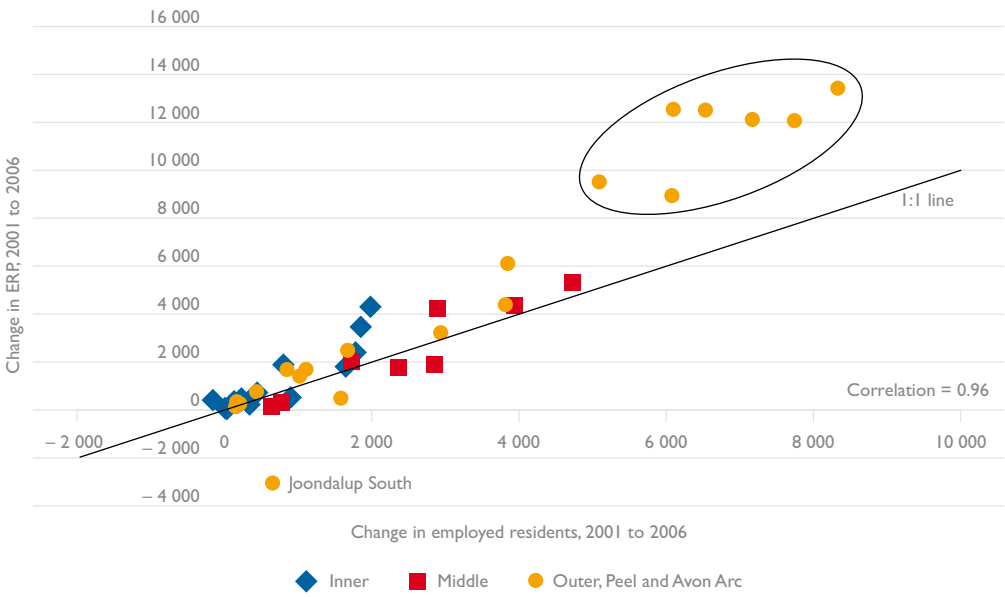
Figure 3.8 illustrates the association between growth of employed residents and growth in population across Perth's SLAs. The first panel compares average annual growth rates, and shows that the growth rates of ERP and employed residents for SLAs are very highly correlated with a correlation statistic of 0.92. The strength of this association is predominantly driven by SLAs in the Outer subregion, Peel and Avon Arc as well as the two City of Perth SLAs (although the Inner Perth SLA diverges from the overall pattern). There is a much weaker connection for the remaining Inner and Middle subregions SLAs. Nearly all observations lie below the 1:1 line, indicating that for most SLAs the growth rate of employed residents exceeded the ERP growth rate. Cottesloe and Inner Fremantle, both part of the Inner subregion, were the only three SLAs where growth in ERP significantly exceeded growth in employed residents.

F3.8 Growth in population and employed residents by SLA, Perth working zone, 2001 to 2006

(a) Average annual rate of growth



(b) Change in the number of persons



Note: The estimated resident population data used for this calculation is based on residents of occupied private dwellings.

Source: BITRE analysis of ABS ERP data on request and ABS Census of Population and Housing place of usual residence data on employment for 2001 and 2006.

The second panel of Figure 3.8 compares the difference in population and employed residents for SLAs between 2001 and 2006. Again the correlation is very strong, with a correlation statistic of 0.96. Moreover, the correlation statistic is 0.90 or more for the Inner subregion, the Middle subregion and the combined Outer, Peel and Avon Arc subregions. The change in population exceeds the change in employed residents for most SLAs, although Joondalup South is a notable exception to the overall pattern.

A cluster of seven high growth SLAs has been highlighted in panel (b) of Figure 3.8. These were ranked as the top seven SLAs in the Perth working zone according to both the increase in ERP and the increase in employed residents between 2001 and 2006. All are located in the Outer subregion or Peel. Together these seven SLAs accounted for 59 per cent of growth in population between 2001 and 2006 and 49 per cent of growth in employed residents. The seven SLAs are (in order of the absolute increase in employed residents): Rockingham, Swan, Gosnells, Wanneroo North-East, Cockburn, Wanneroo North-West and Mandurah.

There was some variation in the ratio of employed residents to ERP across SLAs. In 2006, the ratio varied from a low of 0.36 for Mandurah and Inner Perth to a high of 0.52 for Joondalup South. Between 2001 and 2006, the ratio increased in all but five SLAs—the Inner subregion SLAs of Cottesloe, Inner Fremantle, Subiaco, Claremont and East Fremantle. The most substantial increases in employment participation were evident in Inner Perth, Chittering, Stirling South-Eastern, Bassendean, Rockingham and Mandurah.

The overall message from this analysis is that the spatial patterns of population growth and employed residents growth have been very closely related over the period. The areas which experienced the greatest absolute increase in population also tended to experience a very large absolute increase in employed residents and the areas which experienced the most rapid rate of population growth also tended to experience a very rapid rate of growth in employed residents. So while strong population growth need not necessarily translate into strong growth in employed residents, in practice it has within Perth. The connection has been particularly strong for outer and fringe areas.

Another key message is that Perth's employment grew much more rapidly than its population between 2001 and 2006, and this pattern was reflected in nearly all SLAs. About 70 per cent of Perth's population increase over the period was attributable to employed residents, rather than those outside the labour force or the unemployed. Employment participation surged across the Perth working zone.

CHAPTER 4

Employment location and trends

Key points

- Perth's strategic plans have aimed to improve self-sufficiency and encourage jobs growth in the outer suburbs and in centres, but have had limited success in directing jobs growth to specific locations.
- In 2006, the Inner subregion accounted for 15 per cent of Perth's population, but 36 per cent of employment. The Outer subregion had 50 per cent of population and only 30 per cent of employment.
- The City of Perth alone accounted for 17 per cent of Perth's employment. While the employment share remained stable between 2001 and 2006, the City of Perth added 11 000 jobs.
- Outside the City of Perth, the four largest contributors to employment in 2006 were the industrial centres of Kewdale-Welshpool, Malaga, Osborne Park and Canning Vale. These and other industrial centres account for 17 per cent of Perth's employment.
- Dormitory suburbs, offering few job opportunities for local residents, are clustered to the north-west and east of the city centre (e.g. Wanneroo North-West, Joondalup South, Gosnells). Perth Inner, Perth Remainder and Canning are the only areas that contain more jobs than employed residents.
- Between 2001 and 2006, self-sufficiency ratios fell in the South-West and Peel, while only the North-East Outer subregion significantly improved its self-sufficiency. The North-West and South-East Outer subregions have very low and stable self-sufficiency ratios, despite strong jobs growth since 2001.
- Between 1961 and 2006, there has been considerable dispersal of employment away from the CBD and the inner suburbs, towards the middle suburbs (until 1991) and the outer suburbs.
- Outer subregion employment grew by 3.7 per cent per annum between 2001 and 2006, much higher than the Perth average of 2.3 per cent. Jobs growth was strongest in the South-West, North-West, North-East and Peel subregions, and at its lowest in the Inner and Middle subregions.
- The most rapid jobs growth locations include Rockingham, Wanneroo, Mandurah, Murdoch University, Malaga and Perth airport.
- Industrial and specialised centres had strong jobs growth between 2001 and 2006, while retail-focused centres did not fare as well.

- In 2006, 3.6 per cent of employed residents worked at home, down from 4.2 per cent in 2001.
- The WA Government projects 350 000 additional jobs by 2031, with the Outer subregion increasing its share from 30 to 38 per cent.
- Government regulation of land use has both benefits and costs, and can impact on business decisions about jobs and investment.

Introduction

The distribution of employment throughout the city impacts on 'the nature and character of suburbs, transport requirements and environmental quality' (Frewer 2001 p.97). While residential land supply and population growth have been the focus of metropolitan planning, Perth's strategic plans have also aimed to influence the location of employment within the city.

For example, a core aim of *The Corridor Plan 1970* was that that each urban corridor would be largely self-contained in terms of employment, requiring large numbers of jobs to be created in the outer suburbs (Hill 2005). *Metroplan 1990* aimed to further develop the CBD as the region's largest employment centre, while containing the spillover of employment into nearby inner suburbs. It also encouraged employment growth in the outer suburbs and in nominated strategic regional centres (ibid).

One of the ten key objectives of *Network City* was to 'ensure employment is created in centres' (WAPC 2006 p2). The motivations for increased employment in activity centres are 'to support public transport' (WAPC 2004a p.16) and to reduce commuting distances and times (ibid p.53). Increased centre-based employment is to be achieved through a new requirement to prepare employment strategies at regional, subregional and local levels, and through implementation of 'regulatory policies that restrain developments from locating outside activity centres and corridors, when they should be in them' (ibid p.55). This represents a more directive approach than occurred in the past.

The more recent *Directions 2031* statement establishes a new hierarchy of activity centres (WAPC 2009a). The draft activity centres policy aims to 'concentrate commercial activity in centres and consequently regulate the extent to which various types of retail and commercial development should be permitted outside centres' (WAPC 2009b p.3). *Directions 2031* also aims to improve the relationship between where people live and work, reduce commuting time, and achieve 'greater levels of employment self-sufficiency in middle and outer urban areas' (WAPC 2009a, p.17). Activity centres are the core element of the strategy to support employment growth and a more equitable distribution of jobs (ibid).

Land use and planning regulation can constrain employment growth by preventing a firm from pursuing a particular opportunity or by increasing the costs of development. Costa (2009) argues that the economic costs are significant:

> 'Most state and local government planning agencies have been captured by planning zealots who are hostile to market-driven economic development. These planners believe the market is the fundamental problem in urban land use allocation. Rather than harnessing the power of the market to produce economically sensible land allocation outcomes they try to fit these decisions within the current cookie-cutter ideological fashion'.

However, as the Productivity Commission (1993, p.173) points out '[g]overnment regulation of land use and development is warranted in many instances—the goal is to ensure that worthwhile outcomes are achieved without unnecessary costs'.

Until now the planning authorities have not had a great deal of success in directing employment growth to specific locations. 'Employment has not suburbanised in pace with the residential population' so that many outer suburbs offer little in the way of job opportunities for local residents (WAPC 2003d p.13). The CBD's strong employment growth has spilled over into the adjacent inner suburbs of West Perth, Northbridge and South Perth (ibid p16). According to Curtis (2005 p.430), 'the "regional centre" strategy has failed'. Some of the strategic regional centres have stagnated in terms of jobs growth, with rapid employment growth occurring in other areas which do not have regional centre designation, such as the Albany Highway in Victoria Park (WAPC 2003d p.59). According to *Directions 2031*, the 'inadequacy of existing implementation levers has made it difficult to deliver many of the policy's objectives' (WAPC 2009a p.1). Market forces, particularly the locational decisions of private sector firms, have been rather more influential than government plans in shaping the spatial distribution of employment within Perth.

This chapter begins with a snapshot of the spatial distribution of employment within Perth in 2006, before discussing changes in the location of employment and future prospects.

Place of work—2006 snapshot

There were 736 500 employed people living in the Perth working zone at the time of the 2006 census. Information on place of work was available for 95 per cent of employed residents. The great majority of employed Perth residents who provided place of work information worked at a location within the Perth working zone (640 000 persons). However, 20 700 worked in regional WA and 3000 worked interstate, while a further 36 000 individuals (representing 5 per cent of employed residents) had no fixed work address. This category includes many taxi drivers, couriers, tradespeople, labourers and mobile sales workers, of whom most would probably be based in the Perth working zone.

The analysis in this section is based on the 646 400 people who reported a fixed place of work within the Perth working zone in 2006.[14] Of this group, 99 per cent (640 000) were Perth residents, 4300 were residents of regional WA and 2100 were interstate residents.

14 The 2006 place of work analysis is based only on persons who reported a fixed place of work within the Perth working zone, and therefore excludes those who reported no fixed work address, a place of work in 'Undefined WA' or did not respond. Due to issues of non-response, undercount and inadequately described place of work, the actual number of people employed within Perth is likely to be significantly higher than the figure reported here.

Subregional overview

Table 4.1 summarises place of work information by subregion. About 36 per cent of employment is located in the Inner subregion of Perth, although the Inner subregion contains only 15 per cent of the city's population. The Middle subregion accounts for 29 per cent of employment and population.[15] The North-West, North-East and South-West Outer subregions each employ between 52 000 and 57 000 people, but employment is lower in the South-East Outer subregion. The Outer subregion account for 50 per cent of Perth's population, but just 30 per cent of its employment.

T4.1 Place of work data by Perth subregion, 2006

Subregion	People who work in subregion	Proportion of Perth WZ employment (per cent)	Proportion of Perth WZ ERP (per cent)	Employment density (jobs per square kilometre)	Self-sufficiency ratio
Inner	235 379	36.4	14.8	1610.0	2.14
Middle	188 083	29.1	29.4	614.8	0.86
Outer	196 538	30.4	50.4	39.8	0.52
North-West	56 303	8.7	17.0	71.8	0.42
North-East	56 163	8.7	11.6	27.9	0.65
South-East	31 919	4.9	10.1	20.0	0.44
South-West	52 153	8.1	11.8	95.8	0.63
Peel	21 471	3.3	4.6	7.9	0.79
Avon Arc	3 233	0.5	0.8	0.5	0.63
Unknown address	1 693	0.3	na	na	na
Perth working zone	646 397	100.0	100.0	48.0	0.88

Note: The self-sufficiency ratio is the ratio of people who work in the subregion to the number of employed people who live in the subregion. The ratio for the Perth WZ is less than one due to non-response, no fixed place of work and residents who work outside the Perth WZ.

Source: BITRE analysis of ABS Census of Population and Housing 2006 and ABS Cat. 3218.0 Regional Population Growth, 2006–07.

Only the Inner subregion has many more jobs than employed residents. The North-West and South-East Outer subregions have very low self-sufficiency ratios. This suggests that the opportunities for residents to work close to home are quite limited in these two Outer subregions.

While there are more than 1600 jobs per square kilometre in the Inner subregion and 615 in the Middle subregion, all other subregions have less than 100 jobs per square kilometre. Peel and the Avon Arc cover a large land area and have a very low employment density.

Statistical Local Areas

Table 4.2 lists the ten SLAs containing the largest number of jobs in 2006. The Inner Perth SLA is the place of work for nearly 62 000 people, representing almost 10 per cent of Perth's employment. The Inner Perth SLA corresponds to the Perth CBD (narrowly defined), and is bordered by the 'railway line to the north, the Swan River in the south, Spring and Milligan

15 Population calculations are based on 2006 ERP figures, which are preliminary.

streets in the west and Victoria Avenue and Lord Street in the east' (WAPC 2003b). There are nearly 150 times as many jobs as there are employed residents of this SLA, reflecting the CBD's very strong employment orientation. Employment density is extremely high at nearly 34 000 jobs per square kilometre.

The SLA with the second highest number of jobs is the Perth Remainder SLA (i.e. the Perth LGA minus the CBD). It includes Northbridge, East Perth, West Perth and part of the University of Western Australia at Crawley. It contains nearly 48 000 jobs, representing 7.4 per cent of the city's employment. Two other inner SLAs also appear in the top ten, namely Subiaco and Victoria Park.

T4.2 Top employing Statistical Local Areas in Perth, 2006

SLA	Subregion	People who work in SLA	Proportion of Perth WZ employment (per cent)	Proportion of Perth WZ ERP (per cent)	Employment density (jobs per square kilometre)	Self-sufficiency ratio
Perth Inner	Inner	61 787	9.6	0.1	33 949	147.11
Perth Remainder	Inner	47 905	7.4	0.7	4 423	9.67
Canning	Middle	47 344	7.3	5.1	731	1.23
Stirling Central	Middle	43 503	6.7	6.5	730	0.94
Swan	North-East	37 817	5.9	6.1	36	0.86
Melville	Middle	28 597	4.4	6.2	539	0.62
Belmont	Middle	27 943	4.3	2.0	702	1.99
Cockburn	South-West	21 757	3.4	4.9	130	0.59
Subiaco	Inner	19 980	3.1	1.1	2 862	2.32
Victoria Park	Inner	19 656	3.0	1.8	1 096	1.45

Note: The self-sufficiency ratio is the ratio of people who work in the SLA to the number of employed people who live in the SLA.

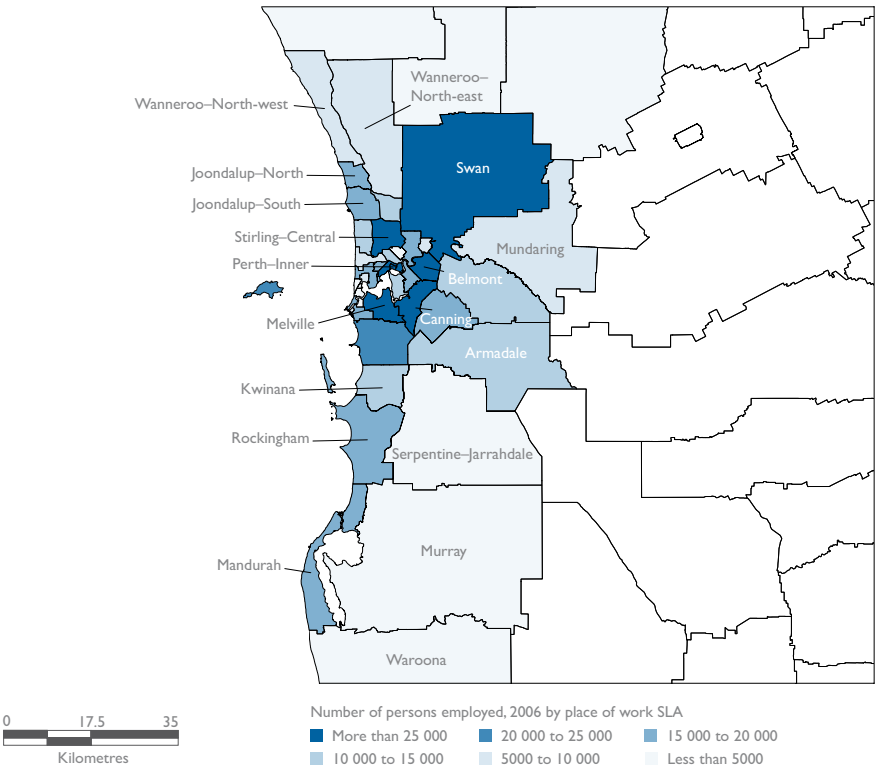
Source: BITRE analysis of ABS Census of Population and Housing 2006 and ABS Cat, 3218.0 Regional Population Growth, 2006-07.

The Middle subregion contains a number of SLAs which have more than 20 000 jobs, namely Canning, Stirling Central, Melville and Belmont. Only two of the top ten SLAs are located in the Outer subregions, with Swan forming part of the North-East subregion and Cockburn forming part of the South-West subregion.

Map 4.1 shows the number of people working in each SLA for 2006. It highlights the large number of jobs available in the City of Perth and several Middle subregion SLAs. The largely rural SLAs of the Avon Arc, Serpentine-Jarrahdale and Murray contain few jobs, but also have a relatively small population base.

Within Perth, employment density is at its greatest in Perth Inner (33 900 jobs per square kilometre), Fremantle Inner (6400), Perth Remainder (4400) and Subiaco (2900). Employment density is less than five jobs per square kilometre for Chittering, Gingin, Toodyay (all in the Avon Arc), Murray and Waroona (in Peel) and Serpentine-Jarrahdale.

M4.1 People working in each Statistical Local Area in Perth, 2006



Source: BITRE analysis of ABS Census of Population and Housing 2006

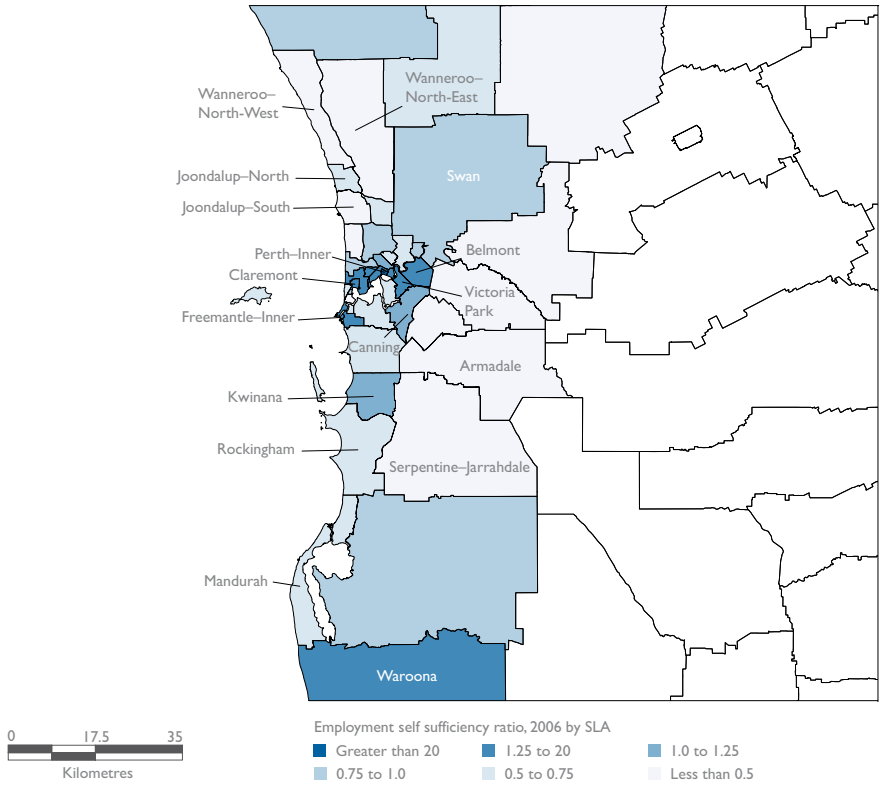
The number of jobs is more than double the number of employed residents in just four SLAs: Perth Inner, Fremantle Inner, Perth Remainder and Subiaco. These are the same four SLAs that had the highest employment density and are important focal points for employment within Perth. Fremantle Inner employs only 6500 people, but with just 879 residents it is clearly employment oriented. Other SLAs which are self-sufficient in terms of employment are Belmont, Nedlands, Fremantle Remainder, Victoria Park, Waroona, Claremont, Canning, Kwinana and Vincent.

Map 4.2 maps the self-sufficiency ratio for each SLA for 2006. The areas where there are more jobs than employed residents are concentrated within the Inner subregion.

There are quite a few SLAs where the self-sufficiency ratio lies below 0.5 (i.e. there is less than one job for every two employed residents). These are Perth's dormitory suburbs, offering few employment opportunities for local residents. These SLAs are largely clustered to the north-west and east of the city centre:

- Wanneroo North-West, Joondalup South, Wanneroo North-East and Stirling Coastal to the north-west
- Serpentine-Jarrahdale, Gosnells, Mundaring, Kalamunda and Armadale to the east.

M4.2 Self-sufficiency ratio in each Statistical Local Area in Perth, 2006



Note: The self-sufficiency ratio is the ratio of jobs located in the SLA to the number of employed residents of the SLA.
Source: BITRE analysis of ABS Census of Population and Housing 2006.

While most of the SLAs with low self-sufficiency ratios are located within an Outer subregion, Mosman Park is in the Inner subregion, Stirling Coastal is in the Middle subregion and Toodyay is on Perth's rural fringe. Wanneroo North-West and Joondalup South have the lowest self-sufficiency ratios, offering less than one job for every three employed residents.

In 2006, 3.6 per cent of Perth residents worked at home. The proportion of residents working from home was greatest in fringe areas with a substantial number of owner-operator farmers (e.g. Gingin, Chittering, Toodyay, Serpentine-Jarrahdale). It was also high for some wealthy western suburbs such as Peppermint Grove (9.4 per cent), Cottesloe (6.9 per cent) and Nedlands (6.8 per cent). A much smaller proportion of residents worked from home in Wanneroo South (2.2 per cent) and Kwinana (2.3 per cent). According to census data, the proportion of Perth residents working from home has declined from 4.2 per cent in 2001 to 3.6 per cent in 2006.

Destination zones

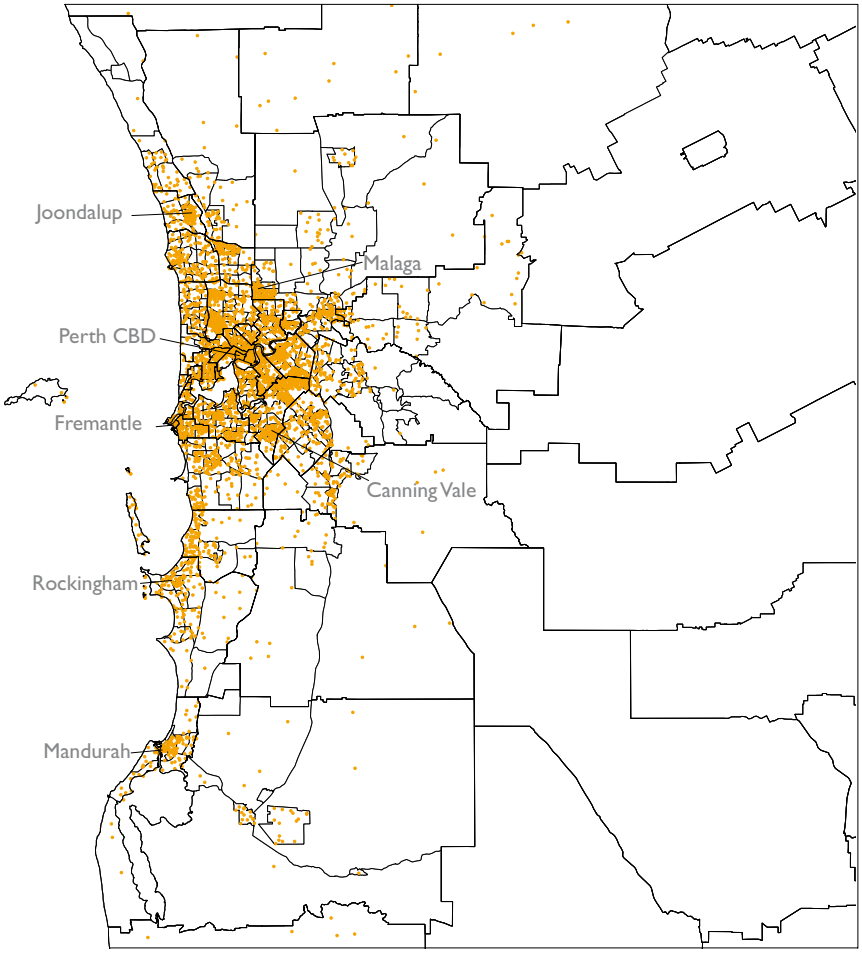
The place of work data can also be disaggregated to a more detailed scale—destination zones. The spatial information on destination zones was obtained from the Western Australian Department of Planning and Infrastructure. Map 4.3 plots the distribution of jobs across Perth, based on the destination zone data. Employment is more obviously clustered than the population distribution shown in Map 3.2. Employment is very heavily clustered in and around the CBD. Other important employment clusters are evident at Fremantle, the airport, Canning Vale, Kewdale-Welshpool (along the border of Belmont and Canning), Balcatta and Osborne Park (in Stirling Central), Malaga (in Swan) and around Joondalup town centre.

Map 4.4 maps the number of people who work in each of the 2006 destination zones in Perth. The destination zones in Perth's Inner and Middle subregions often cover a very small geographic area, sometimes as small as a city block. Many destination zones which employ more than 1250 people are scattered throughout the Inner and Middle subregions. The destination zones in the Outer subregions and peripheral areas are geographically much larger, but few employ more than 1250 people.

In Map 4.4, there are several clusters of adjoining destination zones with substantial employment, including major clusters in:

- the City of Perth
- Stirling Central, stretching along its border with Stirling Coastal
- Eastern Belmont stretching into the northern part of Canning
- Subiaco
- in the north-west of Cockburn
- coastal Kwinana, stretching in to both Cockburn and Rockingham.

M4.3 Dot density map of job distribution for Perth working zone 2006

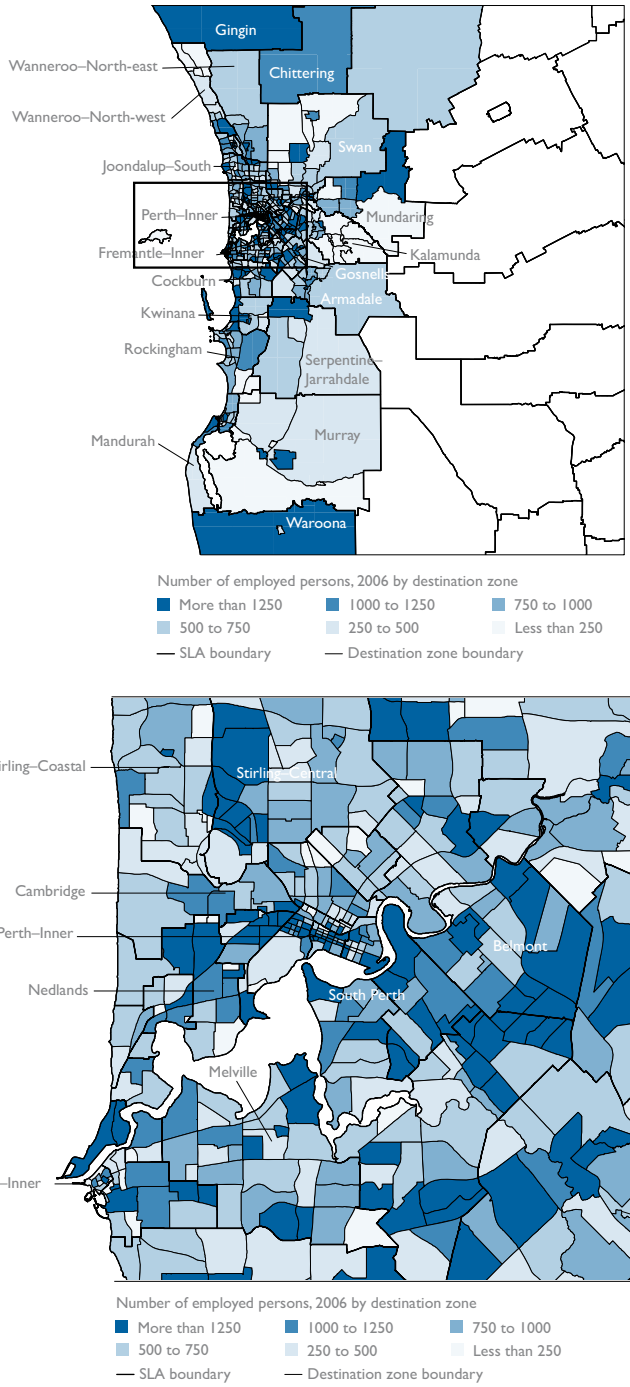


Employment distribution, 2006 by destination zone

● 100 employees

Source: BITRE analysis of ABS Census of Population and Housing 2006.

M4.4 People working in each destination zone in Perth, 2006



Source: BITRE analysis of ABS Census of Population and Housing 2006

The twenty highest employing destination zones in 2006 are listed in Table 4.3. Seven of these are located in the City of Perth, typically in the CBD. Most of the other destination zones listed in the table contain either a significant industrial estate or a major shopping centre. However, some of the destination zones have a less typical employment base, with two of the top employing destination zones (1081 in the CBD and 1116 in Nedlands) including large hospitals, while destination zone 1028 is based around the Burswood Entertainment Complex.

T4.3 Top twenty employing destination zones in Perth, 2006

Destination zone	SLA	People who work in destination zone	Description of destination zone
1206	Stirling Central	8 202	Balcatta Industrial Estate
1089	Perth Inner	7 945	Block in CBD bordered by Hay St, William St, St Georges Terrace and King St
1081	Perth Inner	6 603	CBD area bordered by railway line, Lord St, Victoria Square, Murray St and Barrack St. Includes Royal Perth Hospital.
1097	Perth Inner	6 390	CBD area bordered by St Georges Terrace, Barrack St, Swan River and William St
1116	Nedlands	6 327	Includes Queen Elizabeth II Medical Centre and Hollywood Private Hospital
1292	Belmont	6 291	Belmont Industrial Area
1693	Swan	6 159	Includes Midland Gate Shopping Centre
1083	Perth Inner	5 869	Block in CBD bordered by Hay St, King St, St Georges Terrace and Milligan St
1345	Canning	5 854	Includes a large part of Canning Vale Industrial Estate
1681	Swan	5 472	Malaga Industrial Estate (west of Malaga Road only)
1789	Kwinana	5 253	Part of Kwinana Industrial Area. Includes BP Oil Refinery.
1074	Perth Inner	5 250	CBD area bordered by Murray St, Milligan St, St Georges Terrace and Mitchell Freeway
1093	Perth Inner	5 247	Block of CBD bordered by St Georges Terrace, William St, Mounts Bay Road and Mill St
1683	Swan	4 840	Malaga Industrial Estate (east of Malaga Road only)
1028	Victoria Park	4 706	Includes Burswood Entertainment Complex
1652	Joondalup South	4 331	Includes Whitford City shopping centre and Hillary's
1245	Stirling Central	4 307	Most of Osborne Park Industrial Estate
1107	Perth Remainder	3 921	Area bordered by Adelaide Terrace, Hill St, Swan River and Victoria Avenue in the city
1644	Wanneroo South	3 889	Most of Wangara Industrial Estate
1316	Canning	3 860	Includes Westfield Carousel shopping centre

Note: Based on 2006 destination zone boundaries.

Source: BITRE analysis of ABS Census of Population and Housing 2006.

Map 4.5 maps the employment density (jobs per square kilometre) of the destination zones for 2006 and shows the low employment densities through most of the metropolitan area. The highest job densities are in the CBD. Most of the other destination zones with particularly high job densities are located in the Inner subregion, including parts of Inner Fremantle, Vincent, Nedlands and Cambridge. Some destination zones contain a large concentration of employment, but have low job densities—an example is destination zone 1789 in the Kwinana Industrial Estate.

Map 4.6 maps the self-sufficiency ratio for each destination zone in 2006, which is calculated as the ratio of jobs to employed residents of the destination zone. Very employment oriented clusters (in blue) stand out in coastal Kwinana, the City of Perth, Inner Fremantle and the Osborne Park area of Stirling Central. The employment-oriented cluster in Belmont extends south into Canning, east into Kalamunda and north into Swan. Most of Perth's destination zones have a residential orientation, in that there are considerably more employed residents than jobs located in the destination zone. Residentially oriented destination zones dominate the coastal northern suburbs of Perth.

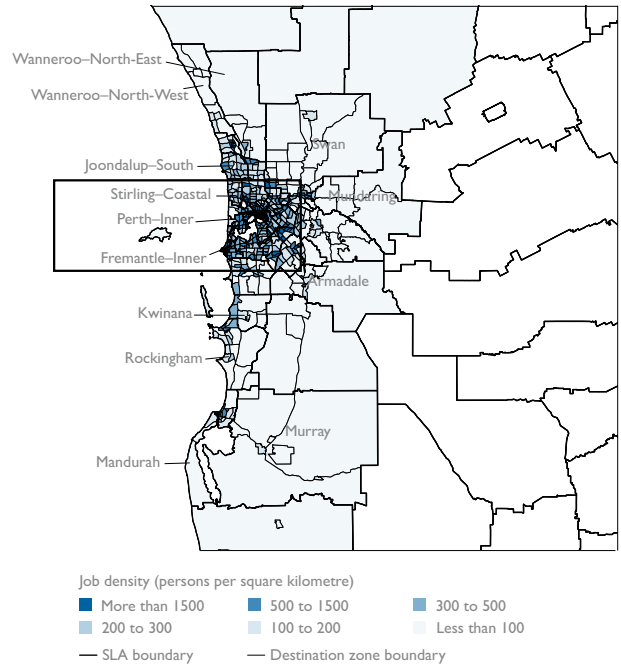
The self-sufficiency ratios can be used to understand the extent to which Perth's employment is heavily concentrated in employment focused areas or more dispersed throughout the suburbs. Employment can be split as follows:

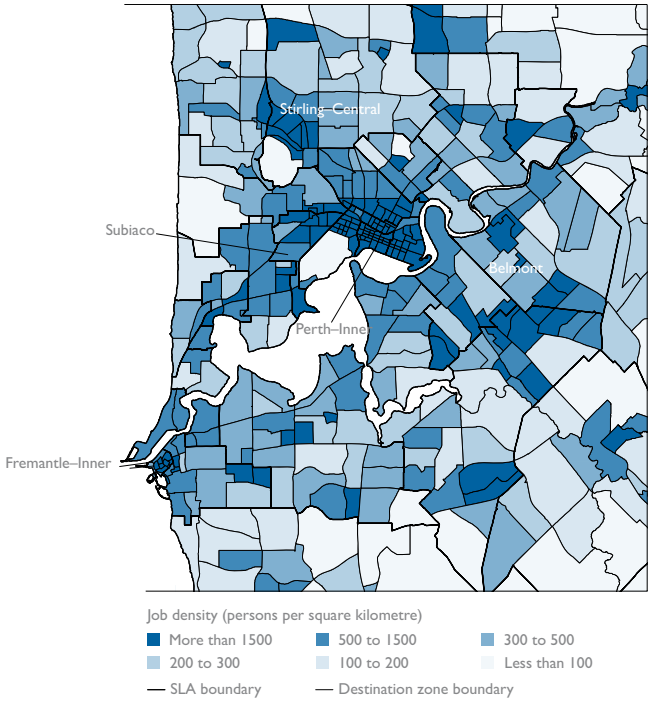
- 30 per cent of workers have a job in an employment focused destination zone, which has at least twice as many workers as employed residents (i.e. the self-sufficiency ratio exceeds two)
- 12 per cent of workers have a place of work in a residentially focused destination zone, which has at least twice as many employed residents as workers (i.e. the self-sufficiency ratio is less than 0.5)
- The remaining 58 per cent of Perth's employment is located in destination zones which are 'mixed use' containing more of a balance of residential areas and employing businesses.

Employment in the two City of Perth SLAs is dominated by employment focused destination zones, which is also the case for Fremantle Inner, Subiaco and Belmont. The three top employing SLAs outside the City of Perth are considered, in turn, below.

- Three-quarters of Canning's employment is concentrated in employment focused destination zones, particularly the Canning Vale and Welshpool industrial areas and Westfield Carousel and its surrounds. The largest industries are *manufacturing* (21 per cent of employment) and the *retail trade* (19 per cent).
- Two-thirds of Stirling Central's employment is concentrated in employment focused destination zones, particularly the Osborne Park and Balcatta industrial areas. The largest industries are the *retail trade* (19 per cent) and *manufacturing* (17 per cent). The SLAs largest employer is West Australian Newspapers (City of Stirling 2008).

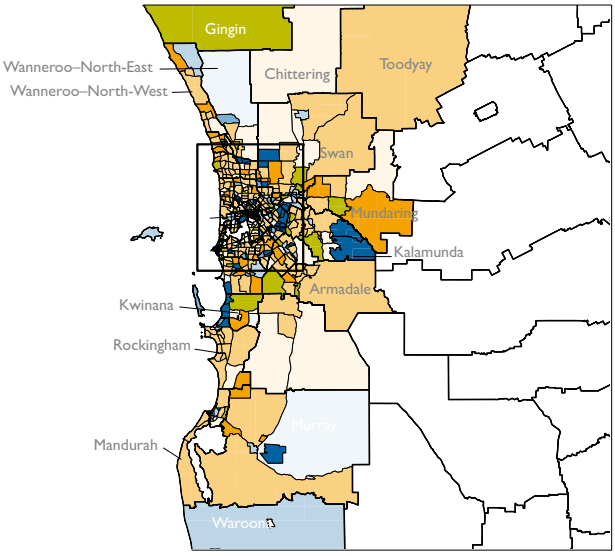
M4.5 Employment density of each destination zone in Perth, 2006





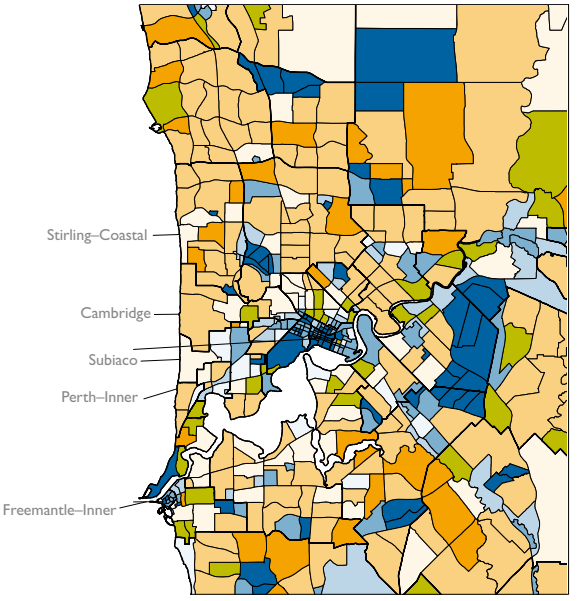
Source: BITRE analysis of ABS Census of Population and Housing 2006

M4.6 Self-sufficiency ratio of each destination zone in Perth, 2006



Self sufficiency category, 2006 by destination zone

- Very residentially orientated
- Mainly residentially orientated
- Somewhat residentially orientated
- In approximate balance
- Somewhat employment orientated
- Mainly employment orientated
- Very employment orientated
- Almost entirely employment orientated
- SLA boundary
- Destination zone boundary



Self sufficiency category, 2006 by destination zone

- Very residentially orientated
- Mainly residentially orientated
- Somewhat residentially orientated
- In approximate balance
- Somewhat employment orientated
- Mainly employment orientated
- Very employment orientated
- Almost entirely employment orientated
- SLA boundary
- Destination zone boundary

Note: BITRE assigned the self-sufficiency categories based on the ratio of employed residents to jobs in each destination zone.

Source: BITRE analysis of ABS Census of Population and Housing 2006.

- Fifty-eight per cent of Swan's employment is concentrated in employment focused destination zones, particularly the Malaga industrial area and in and around the Midland Gate shopping centre. *Manufacturing* is the largest industry with 20 per cent of employment, followed by retail (16 per cent). Employment in Swan is more dispersed than in the previous two SLAs. For example, the fifth top employing destination zone in Swan contains the recently developed suburbs of Ellenbrook and The Vines and is very residentially focused, with 6000 employed residents but only 1600 workers.

All three SLAs contain substantial concentrations of employment in their industrial areas. While *manufacturing* is an important industry in all three SLAs it typically only contributes about 20 per cent of employment. Perth's industrial areas contain a diversity of industries, and have become sites for trade centres, warehouses, showrooms and business parks (WAPC 2003c).

With respect to the Outer subregional areas, WAPC (2003d) notes that the North-East subregion[16] has several strong employment nodes (particularly in Swan), the South-West subregion has a string of employment nodes located along the coast and the South-East subregion has an employment corridor that roughly aligns with the rail line and the Albany Highway. In contrast, employment in the North-West subregion is highly dispersed (ibid). For example, the Joondalup South SLA employs over 17 000 people, of which more than two-thirds work in a residentially focused destination zone and only 6 per cent work in an employment focused destination zone. The top employing destination zone in Joondalup South includes employment nodes such as Hillary's Boat Harbour and the Whitford City shopping centre, but is otherwise largely residential in nature.

The destination zones also allow us to get a handle on the extent to which employment is concentrated within centres in Perth. The Metropolitan Centres Policy (WAPC 2000) specified a number of centres, namely the Perth Central Area, eight strategic regional centres (e.g. Cannington, Fremantle, Morley, Innaloo) and 14 other regional centres (e.g. Subiaco, Booragoon, Belmont and Ellenbrook). There are also a range of district, neighbourhood and local centres.

In 2006, the City of Perth accounted for 17 per cent of employment in the Perth working zone. About 27 per cent of employment in the Perth working zone was located in a 'centre',[17] with the remaining 73 per cent of jobs situated in a wide range of dispersed locations around the city. While strategic regional centres lie near the top of the urban hierarchy, some (e.g. Armadale, Innaloo) contribute only a very small share of Perth's employment (less than 0.5 per cent). Many of the industrial zones make a more substantial contribution to employment.

In 2009, a new draft activity centres policy was released (WAPC 2009b). This broadens the definition of activity centres to include specialised and mixed use centres, not just retail centres. The new hierarchy consists of:

16 Referred to by WAPC(2003d) as the Eastern sub-region.

17 Defining a centre as one of the first three levels of the metropolitan hierarchy, namely the Perth Central Area, a strategic regional centre or a regional centre (see WAPC 2003a). As official boundaries for these centres were not available, BITRE used judgement to define the centre boundaries based on 2006 destination zones. In practice, this involved adopting relatively encompassing definitions which often extended beyond the retail precinct.

- Perth central area
- the primary centres of Joondalup and Rockingham
- strategic centres, including city centres (e.g. Fremantle, Midland), specialised centres (e.g. Curtin, Perth airport) and industrial centres (e.g. Kwinana, Kewdale-Welshpool)
- regional centres, including town centres (e.g. Subiaco, Whitfords), specialised centres (e.g. Jandakot airport) and industrial centres (e.g. Canning Vale, Osborne Park)
- district centres
- neighbourhood centres
- local centres (WAPC 2009a).

Restricting the focus to the top four levels of the hierarchy (i.e. regional centres and above) results in 55 nominated activity centres, compared to just 23 under the previous *Metropolitan Centres Policy*. Based on this new and much more encompassing definition of centred employment,[18] BITRE estimates that about 52 per cent of Perth's employment was located in activity centres in 2006, with the remaining jobs situated in a wide range of dispersed locations around the city. Table 4.4 summarises the results.

The newly defined industrial centres accounted for about 17 per cent of Perth's employment in 2006, while the new specialised centres (e.g. airports, universities, hospitals) contributed 5 per cent of employment. Outside the Perth central area, the four largest contributors to Perth's employment were the industrial centres of Kewdale-Welshpool (including Forrestfield), Osborne Park, Canning Vale and Malaga. Together, those four industrial centres contribute 11 per cent of Perth's employment.

T4.4 Proportion of employment in centres, Perth working zone, 2006

Type of location	Metropolitan Centres Policy (2000) definition of centres	*Directions 2031* statement (2009) definition of centres
	(per cent)	
Perth central area	17	17
Other centres	10	35
All centres	27	52
Other locations	73	48
Perth working zone	100	100

Notes: 'Other centres' include strategic regional centres and regional centres in WAPC (2000) and primary centres, strategic centres and regional centres in WAPC (2009a).

Centres were defined by BITRE using 2006 destination zones, which are more spatially disaggregated than 2001 destination zones and so can provide a more precise measure of centred employment in 2006.

Source: BITRE analysis of ABS Census of Population and Housing data, WAPC (2009a) and WAPC (2000).

18 Official boundaries for these activity centres are not yet available. BITRE used judgement to define the centre boundaries based on 2006 destination zones, which in practice involved adopting fairly encompassing definitions. The estimates are therefore approximate in nature.

In terms of the new hierarchy, employment is split as follows:

- Perth central area (17 per cent of employment)
- primary centres (2 per cent)
- strategic centres (13 per cent)
- regional centres (20 per cent).

The new expanded definition of centres has roughly doubled the proportion of employment considered to be located in a centre within Perth. It has also expanded the government's potential to influence employment outcomes in Perth through activity centres policy.

Long term trends in place of work

Table 4.5 summarises the location of employment in metropolitan Perth between 1961 and 2006. There has been considerable dispersal of employment away from the CBD and towards the middle and outer suburbs. In 1961, 72 per cent of jobs were located in the Inner subregion, but this fell to 38 per cent in 2006. The pace of change was particularly rapid in the 1960s and 1970s. While the employment share of the City of Perth LGA and the Inner subregion continues to decline, and the Outer subregion continue to increase in importance, the employment share of the Middle subregion peaked in 1991.

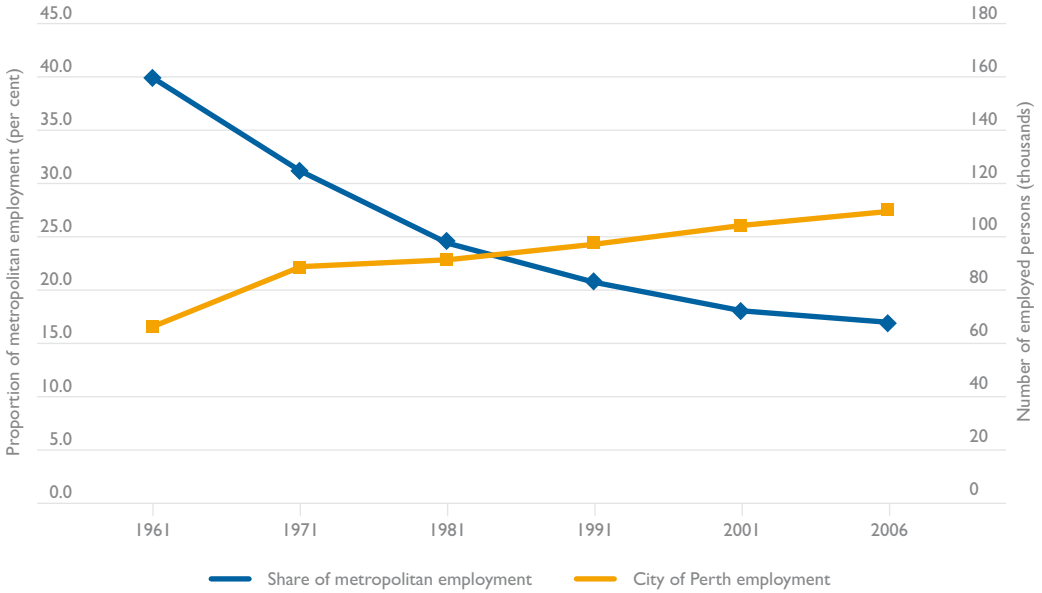
Employment in the CBD can be quite cyclical. For example, during the early 1990s' recession, employment in the City of Perth LGA fell by 7800 persons from 1990 to 1993 (WAPC 2004b). Employment has since recovered, adding 12 650 jobs between 1993 and 2001 (ibid). Despite these fluctuations, the City of Perth's employment share has halved since 1961. The total number of persons employed in the City of Perth has continued to increase, but at a declining rate (Figure 4.1).

T4.5 Employment shares in metropolitan Perth, 1961 to 2006

Subregion	1961	1971	1981	1991	2001	2006
City of Perth	39.9	31.2	24.4	20.7	18.1	17.6
Inner (excluding city)	31.6	29.6	25.2	22.8	20.6	20.2
Middle	16.2	26.1	32.0	33.1	31.8	30.3
Outer	12.2	14.1	18.4	23.4	29.4	31.6
Metropolitan Perth	100.0	100.0	100.0	100.0	100.0	100.0

Source: WAPC 2003c, except for 2006 data which was derived by BITRE from ABS Census of Population and Housing data.

F4.1 Employed persons in the City of Perth, 1961 to 2006



Source: WAPC 2003c, except for 2006 data which was derived by BITRE from ABS Census of Population and Housing data.

Employment in the Outer subregion has grown strongly over the last few decades, but the outer suburbs continue to account for a much greater proportion of population than employment. Outer suburban employment increased from 14 to 32 per cent of employment between 1971 and 2006, while outer suburban population increased from 23 to 53 per cent of Metropolitan Perth's population. A lack of jobs, relative to population, is particularly evident in the South-East and North-West Outer subregions.

Changes in place of work between 2001 and 2006

The original plan was for BITRE's analysis of changes in the place of work data to be based directly on comparison of the ABS' 2001 and 2006 journey to work matrices. However, the 2001 ABS journey to work data contains coding errors for Western Australia, which if taken at face value would lead to misleading conclusions being drawn about the location of jobs growth within the Perth metropolitan area. For example, the ABS data suggests 4460 people worked in the Kwinana SLA in 2001, while the corrected 2001 journey to work matrix provided to BITRE by the WA Government indicates that about 9800 people worked in Kwinana in 2001. The corrected figure is much closer to the 2006 ABS figure of about 11 200 people working in Kwinana. This coding issue affects only the 2001 ABS journey to work data, not the 2006 data.

Due to these known problems with the unadjusted ABS dataset for 2001, the analysis in this section is instead based on the corrected data provided by the WA Government. However, the 2001 dataset provided by the Western Australian government has been rescaled to adjust for census under-enumeration, meaning that it cannot be directly compared to the ABS 2006 dataset or to the 2001 data for other cities. BITRE has therefore attempted to undo this rescaling so that such comparisons can be undertaken. This has introduced a degree of approximation into the analysis and to reflect this imprecision, all numbers presented in this section have been rounded to the nearest 100 persons. The WA Government dataset does not separately identify the peripheral SLAs of Waroona, Gingin, Chittering and Toodyay, and so BITRE's analysis of change focuses only on the Perth metropolitan region, plus the Murray and Mandurah SLAs.

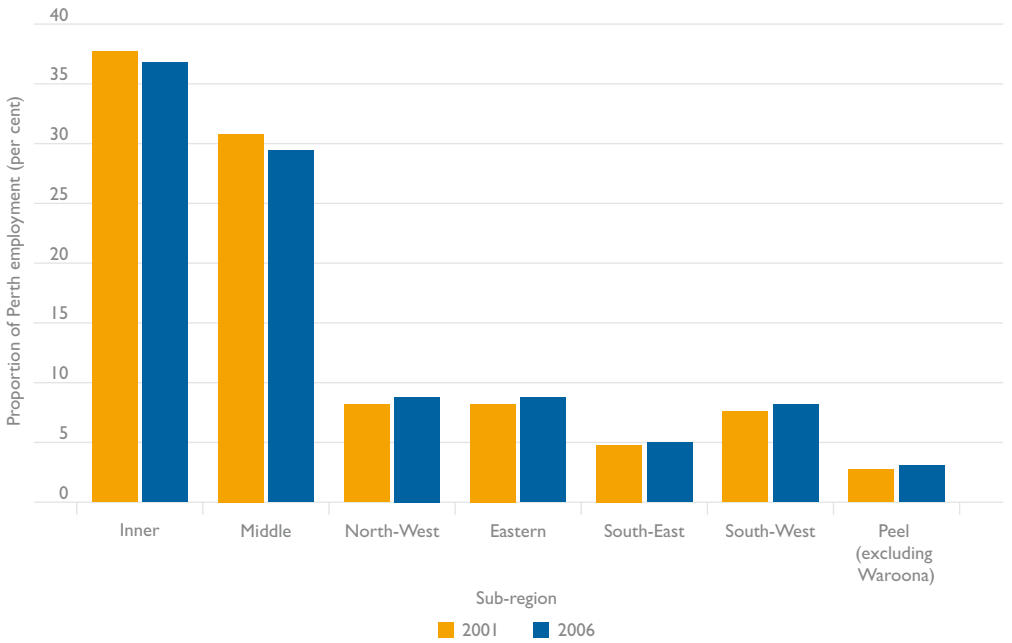
The number of people who reported a fixed place of work[19] within Perth, Mandurah or Murray grew by 12.2 per cent (or 2.3 per cent average annual growth) between 2001 and 2006. This is lower than the 2.9 per cent annual growth in employed residents, due to rapid growth in Perth residents working elsewhere in WA (4.4 per cent per annum) and rapid growth in workers with no fixed address. The number of employed residents of Perth, Mandurah and Murray with no fixed place of work increased by 30 per cent during the period, representing 5.3 per cent average annual growth).

Subregional overview

Figure 4.2 summarises the subregional distribution of employment in Perth over the period. The overall picture is one of stability. The single largest change was the decline in the importance of the Middle subregion, from 30.8 per cent of employment in 2001 to 29.4 per cent of employment in 2006. The Inner subregion's employment share also declined, from 37.7 per cent to 36.8 per cent. The North-West, South-West and North-East Outer subregions each increased their employment share by 0.5–0.7 percentage points.

19 The 2001 place of work analysis is based only on persons who reported a fixed place of work within the Perth metropolitan region, Murray or Mandurah, and therefore excludes those who reported no fixed work address or a place of work in 'Undefined WA'. Due to issues of non-response, undercount and inadequately described place of work, the actual number of people employed within Perth is likely to be considerably higher than the figure reported here.

F4.2 Contribution of subregions to total employment, 2001 and 2006



Note: Excludes Avon Arc SLAs and Waroona.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Table 4.6 summarises changes in place of work by subregion between 2001 and 2006. About 70 000 additional people were employed in 2006, compared to 2001, and nearly 30 per cent of those new jobs were located in the Inner subregion. Employment grew most rapidly in the North-West, South-West and North-East Outer subregions and Peel. Employment growth was relatively modest in the Middle subregion at just 1.4 per cent annual average growth, but the Middle subregion still accounted for 18 per cent of the growth in employment.

The strong employment growth in the North-West and South-West Outer subregions and Peel can be connected to their high rates of population growth. However, jobs growth in the North-East Outer subregion is high despite its population growth being similar to the Perth average. The North-East Outer subregion SLAs of Kalamunda and Swan both experienced strong growth in employment in the transport, wholesale, construction and manufacturing industries between 2001 and 2006, associated with development of the industrial estates at Malaga and Forrestfield.

T4.6 Changes in place of work data by subregion, 2001 to 2006

Subregion	Change in employment	Average annual employment growth (per cent)	Subregion's share of Perth employment growth (per cent)	Average annual population growth (per cent)
Inner	20 400	1.8	29	1.5
Middle	12 300	1.4	18	0.9
Outer	32 600	3.7	47	2.3
North-West	9 800	3.9	14	2.6
North-East	9 300	3.7	13	1.9
South-East	4 600	3.2	7	1.9
South-West	8 800	3.8	13	2.9
Peel (excl. Waroona)	4 100	4.8	6	3.5
Perth, Mandurah and Murray	69 300	2.3	100	1.8

Source: BITRE analysis of ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WA DPI and ABS Cat. 3218.0 Regional Population Growth, 2006-07.

The Outer subregions accounted for nearly half of all employment growth between 2001 and 2006. Outer subregion employment grew at an average annual rate of 3.7 per cent, much higher than the Perth average of 2.3 per cent, reflecting a trend towards greater decentralisation of employment. Growth in Outer subregion employment easily exceeded growth in Outer subregion population (2.3 per cent), but that employment growth is occurring off a low base and the Outer subregions continue to account for a much lower share of employment than of population (30 per cent vs 50 per cent in 2006).

Directions 2031 aims to increase the levels of employment self-sufficiency within Perth's subregions and identifies target self-sufficiency ratios for 2031 (WAPC 2009a). Table 4.7 compares these targets to the actual rate of employment self-sufficiency in each subregion in 2001 and 2006. Despite the rapid growth in employment over the period, there were only modest changes in the self-sufficiency ratios. The change was greatest for the Central and South-West subregions—both recorded a decline in their self-sufficiency ratio. Only the North-East Outer subregion recorded a notable increase in its self-sufficiency ratio between 2001 and 2006.

While Peel and South-West have self-sufficiency ratios that are only marginally below the target ratio, both recorded declines in their self-sufficiency ratios between 2001 and 2006, because growth in employed residents outpaced growth in jobs in both subregions. Towns such as Rockingham and Mandurah have become increasingly interconnected with the rest of Perth in recent years, and the completion of the Mandurah rail line at the end of 2007 may well exacerbate this trend, making the target harder to achieve.

The South-East and North-West Outer subregions have very low self-sufficiency ratios which remained fairly stable between 2001 and 2006. To achieve the *Directions 2031* targets, employment will need to double in the South-East and to increase by 123 per cent in the North-West between 2008 and 2031 (WAPC 2009a). For these two Outer subregions, the employment self-sufficiency targets appear ambitious.

T4.7 Employment self-sufficiency ratio by subregion, 2001 to 2006

Subregion	2001	2006	2031 target
Central (Inner and Middle)	1.31	1.28	1.21
North-West	0.42	0.42	0.60
North-East	0.63	0.65	0.75
South-East	0.43	0.44	0.55
South-West	0.66	0.63	0.70
Peel^	0.78	0.76	0.80

Notes: The self-sufficiency ratio is the ratio of jobs located in the subregion to the number of employed residents of the subregion.

^ The 2001 and 2006 self-sufficiency ratios are for Murray and Mandurah only, while the 2031 target encompasses Waroona.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI. 2031 target is from WAPC (2009a).

Statistical Local Areas

Employment became a little less spatially concentrated at the SLA scale between 2001 and 2006. The top five employing SLAs accounted for 38 per cent of employment in 2001, which dropped to 37 per cent in 2006, while the employment share of the top ten SLAs declined from 57 per cent to 56 per cent.

At the SLA scale, 2001 employment was highest for Perth Remainder (50 800), followed by Perth Inner (47 900), Canning (43 800) and Stirling Central (43 700). By 2006, Inner Perth had surpassed the remainder of the Perth LGA in terms of employment (see Table 4.2).

Table 4.8 highlights the SLAs that experienced an absolute change in the place of work data involving more than 3000 employed persons between 2001 and 2006. Inner Perth alone contributed 20 per cent of Perth's growth in employment, with an additional 13 900 jobs. The concentration of employment in Perth Inner increased from 8.4 per cent in 2001 to 9.7 per cent in 2006. However, due to reduced employment in the Perth Remainder SLA, the employment share of the City of Perth LGA declined marginally between 2001 and 2006. There were, however, about 11 000 more jobs located in the City of Perth in 2006 than in 2001.

Swan and Rockingham both experienced employment growth of more than 5000 jobs. Mandurah and the Outer subregion locations of Swan, Rockingham and Gosnells all experienced a rapid rate of growth in both population and employment. However, the Middle subregion SLAs of Belmont, Canning and Melville experienced a large absolute increase in employment, despite their moderate employment growth rates and relatively low population growth rates.

In 2006, there were about 2900 fewer employed persons in the Perth Remainder SLA than in 2001. This SLA experienced a 65 per cent increase in its population between 2001 and 2006 due to large scale building of apartment-style accommodation, which included the conversion of commercial buildings into apartments (WAPC 2003b). The reduction in employment suggests that the rapid residential development may have squeezed out employment to some extent. The reduction in Perth Remainder employment occurred at the same time as rapid employment growth in Perth Inner, with the employment density of the Perth Inner SLA increasing from 26 300 to 33 900 persons per square kilometre between 2001 and 2006.

T4.8 Changes in place of work data by Statistical Local Area, 2001 to 2006

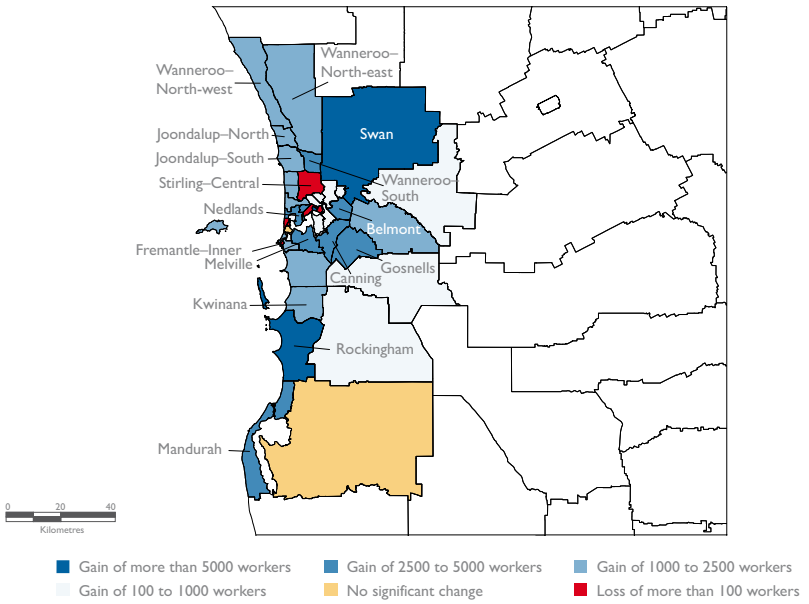
SLA	Subregion	2001 People who work in SLA	Change in employment, 2001 to 2006	Average annual employment growth (per cent)	Share of employment growth in Perth (per cent)	Average annual population growth (per cent)
Perth Inner	Inner	47 900	+ 13 900	5.2	20	8.4
Swan	North-East	31 200	+ 6 600	3.9	10	2.7
Rockingham	South-West	14 100	+ 5 100	6.4	7	3.4
Mandurah	Peel	11 100	+ 4 000	6.3	6	3.6
Canning	Middle	43 800	+ 3 500	1.5	5	1.1
Belmont	Middle	24 500	+ 3 400	2.7	5	1.3
Gosnells	South-East	15 000	+ 3 400	4.2	5	2.8
Melville	Middle	25 400	+ 3 200	2.4	5	0.4

Source: BITRE analysis of ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WA DPI and ABS Cat. 3218.0 Regional Population Growth, 2006-07.

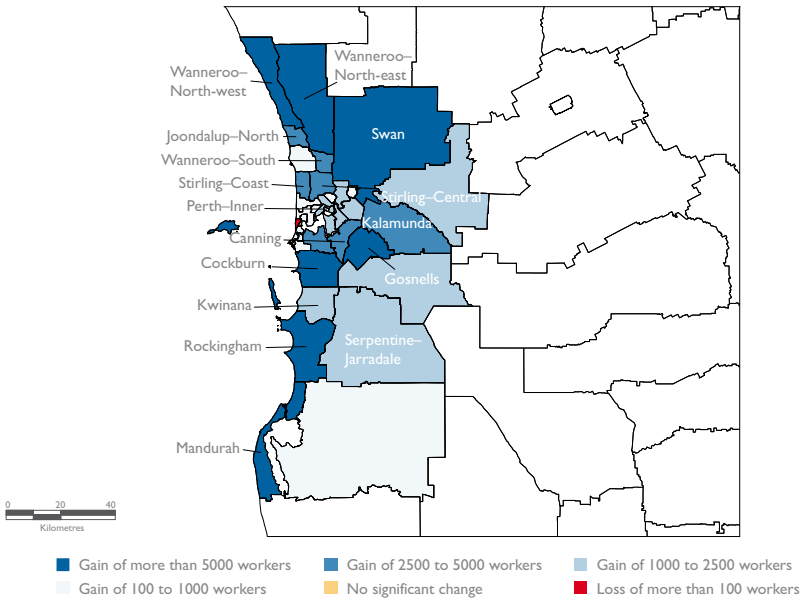
Map 4.7 shows the change in the place of work data between 2001 and 2006 for SLAs and compares it to the changes in the number of employed residents in each SLA over the same period. Swan, Rockingham and Perth Inner experienced very large increases in both jobs and employed residents. Cockburn, Wanneroo North-East and Wanneroo North-West experienced a job increase of between 1000 and 2500, while the number of employed residents increased by more than 5000. While all SLAs apart from Cottesloe recorded an increase in the number of employed residents, several SLAs experienced a loss of jobs over the period.

M4.7 Changes in number of employed people working and living in Statistical Local Areas, 2001 to 2006

a) Change in number of workers



b) Change in number of employed residents



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Between 2001 and 2006, the rate of employment growth was greatest for:

- Wanneroo North-West (average annual employment growth of 8 per cent);
- Rockingham (6 per cent)
- Mandurah (6 per cent)
- Wanneroo North-East (6 per cent)
- Wanneroo South (5 per cent)
- Perth Inner (5 per cent).

The highest rates of jobs growth were concentrated in the urban fringe SLAs in the north-west and south-west of Perth (see Map 4.8). While employment grew most rapidly in the CBD and on the urban fringe, the Inner subregion SLAs of Subiaco, Cambridge and Nedlands all grew employment by about 3 per cent per annum. Belmont showed the most rapid employment growth in the Middle subregion at 3 per cent per annum.

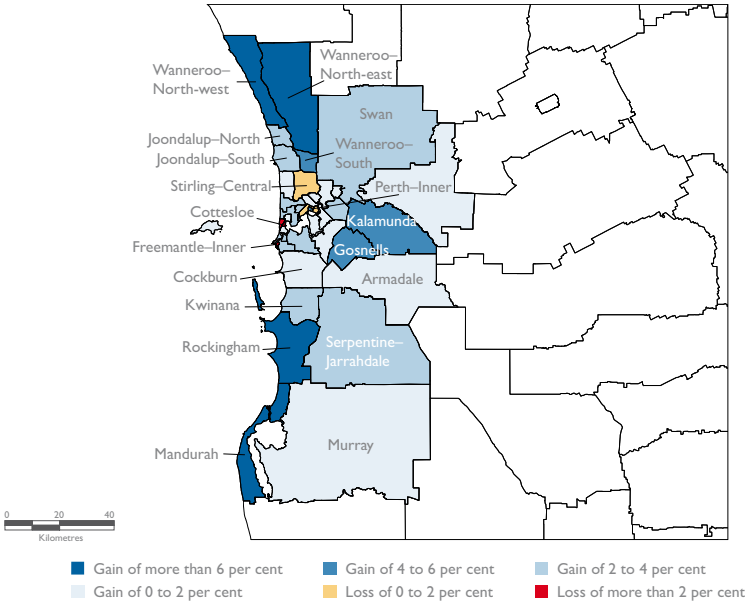
Only five SLAs experienced employment declines:

- Fremantle Inner (average annual change of –4 per cent)
- Cottesloe (–3 per cent)
- Peppermint Grove (–3 per cent)
- Perth Remainder (–1 per cent)
- Stirling Central (–0.1 per cent).

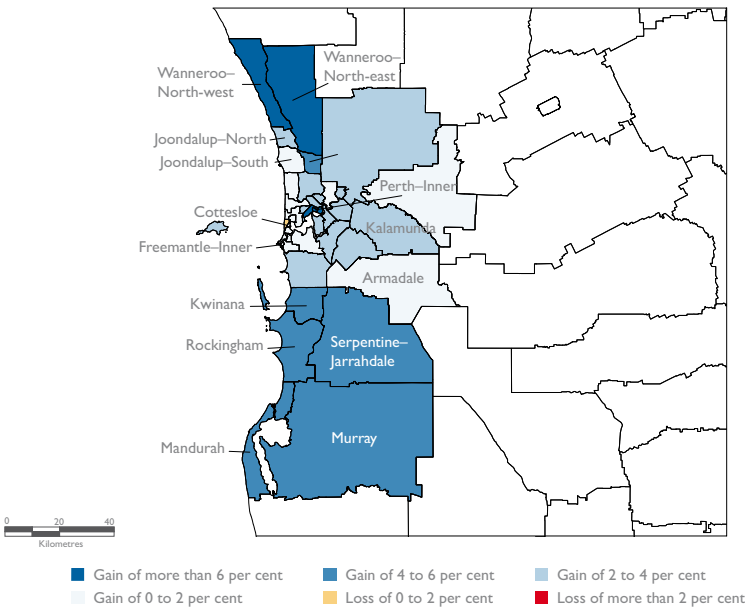
All but Cottesloe showed positive growth in population and in the number of employed residents. While Cottesloe experienced modest population growth, the number of employed residents declined.

M4.8 Average annual percentage changes in workers and employed residents by Statistical Local Area, 2001 to 2006

a) Change in number of workers



b) Change in number of employed residents



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

In Rockingham and Mandurah, growth in jobs outpaced growth in employed residents and population between 2001 and 2006. However, in the neighbouring inland SLAs of Murray and Serpentine-Jarrahdale, the rate of jobs growth fell well behind the strong growth in the number of employed residents.

For Perth Inner, the rate of jobs growth (5 per cent per annum) was well below the very rapid growth in population and employed residents (8 and 16 per cent respectively). A similar result was evident for Wanneroo North-East.

In the North-East Outer subregion SLA of Kalamunda jobs growth averaged 4 per cent per annum while population growth averaged just 1 per cent per annum. Kalamunda's employment growth was very much driven by the *transport and storage* industry, which doubled its employment between 2001 and 2006. This was supported by strong growth in *manufacturing and construction* jobs. The strong jobs growth is linked to the development of the former Forrestfield Marshalling Yards into a new transport-oriented industrial estate called Access Park, which includes the Forrestfield rail terminal. The South-East Outer subregion SLA of Gosnells also experienced strong jobs growth, but this was supported by solid growth in the local population and in employed residents.

Overall, Map 4.8 suggests there is a positive association between the rate of jobs growth and the rate of growth of employed residents in an SLA. This is borne out by the correlation statistic of 0.51, indicating the relationship is of moderate strength. The growth rates of population and employed residents are extremely closely linked at the SLA scale (correlation = 0.91).

Destination zones

Some further insights into the location of employment growth can be gained from analysing data for destination zones. As destination zone boundaries changed between 2001 and 2006, and were generally more disaggregated in the later period, BITRE has analysed patterns of change by aggregating the 2006 destination zone data so it corresponds to the 2001 destination zone boundaries, and then estimating change for the WA government's 2001 destination zones.

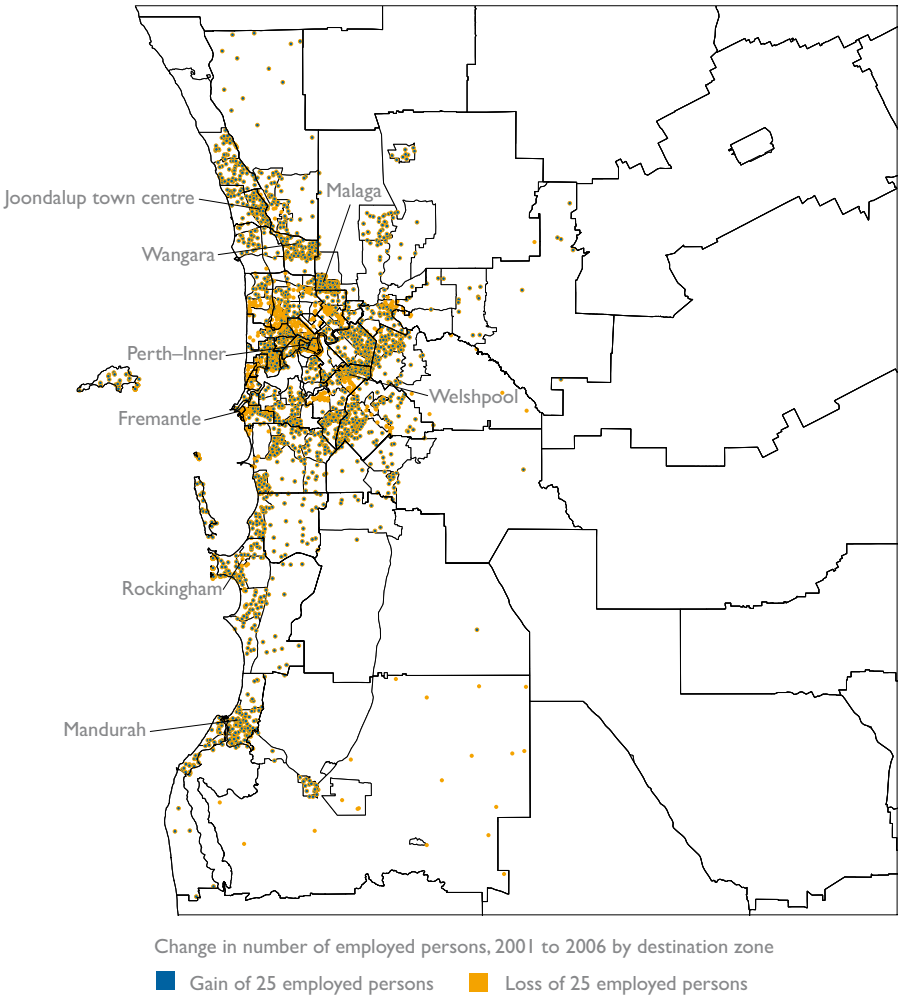
Between 2001 and 2006, there were three destination zones which experienced employment growth of more than 3000 persons:

- Destination zone 1040[20] added about 4500 employed persons, representing a 1.8 per cent average annual increase. This destination zone corresponds to the entire Perth Inner SLA.
- Destination zone 1042 added about 4100 employed persons, growing at 6.2 per cent per annum. This destination zone covers the CBD end of West Perth and includes Parliament House and the Mount Hospital.
- Destination zone 1095 added about 3500 employed persons representing a 6.7 per cent average annual increase. This destination zone includes all of the Malaga Industrial Estate.

Map 4.9 uses the destination zone data to show how employment change was distributed throughout Perth. While population loss was largely concentrated in the outer suburbs (see Map 3.6), job loss is largely concentrated in the inner and middle suburbs. With few exceptions, Perth's outer suburban destination zones experienced growth in the number of jobs available between 2001 and 2006.

20 These are 2001 destination zone codes, which differ from 2006 codes.

M4.9 Dot density map of employment change, 2001 to 2006



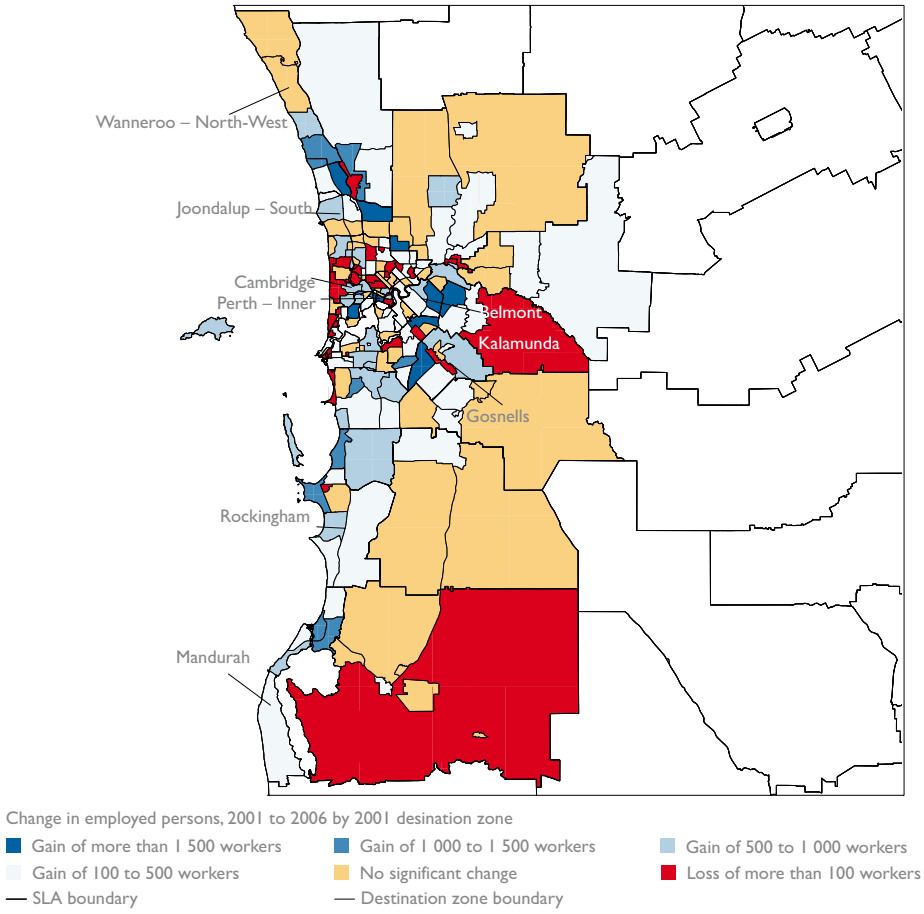
Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Map 4.10 maps the change in the number of people who work in each destination zone between 2001 and 2006, while Map 4.11 maps the percentage change. In addition to the previously mentioned jobs growth in the City of Perth and the Malaga Industrial Estate, growth of more than 1500 jobs was also evident in several other SLAs including:

- Destination zone 1169 in Wanneroo South, which includes the Wangara Industrial Area.
- Destination zone 1075 in Gosnells, which includes the suburbs of Thornlie, Langford and part of Canning Vale.
- Destination zone 1100 in Joondalup North contains the Lakeside Shopping Centre as well as several educational institutions (e.g. Edith Cowan University campus, Joondalup College of TAFE, WA Police Academy).
- Destination zone 1064 in Canning contains the Welshpool Industrial Area.

- Destination zone 1273 in Kalamunda includes the Forrestfield Industrial Area and rail terminal.
- The adjacent destination zone 1062 in Belmont contains Perth's international and domestic airports.
- Destination zone 1008 in Nedlands contains the Queen Elizabeth II Medical Centre and Hollywood Private Hospital.

M4.10 Changes in number of employed people working in destination zones, 2001 to 2006

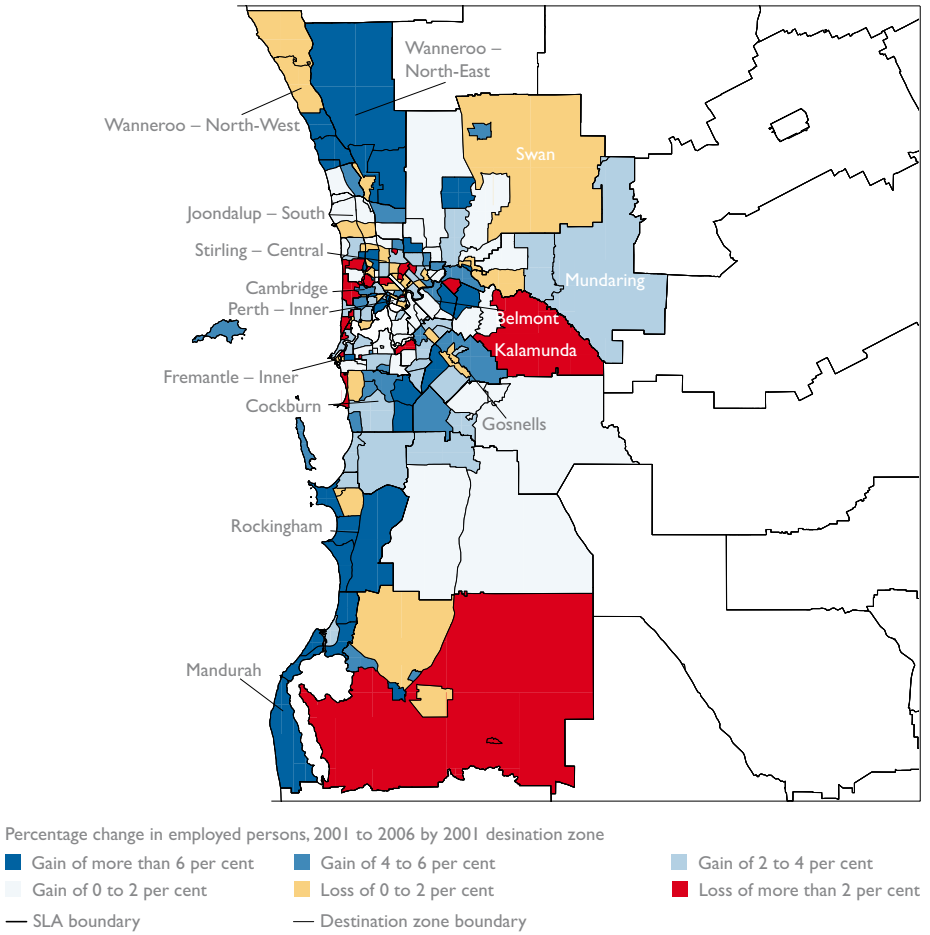


Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Industrial estates are very prominent amongst the areas with the most substantial jobs growth in Perth between 2001 and 2006. Retail focused destination zones do not feature strongly. Areas of job loss are scattered around the city, but occur more frequently in the Inner and Middle subregions than in the Outer subregions.

Large parts of Wanneroo North-East, Wanneroo North-West, Rockingham and Mandurah stand out in Map 4.11 as having high rates of jobs growth, but these SLAs did not feature prominently in Map 4.10. Wanneroo North-East and Wanneroo North-West are experiencing rapid jobs growth off a small existing employment base.

M4.11 Percentage changes in employed people working in destination zones, 2001 to 2006



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

As previously noted, the more recent strategic plans for Perth have aimed to concentrate employment growth within nominated centres. It was expected that jobs in the service industries would flow to these centres and this was a key strategy for improving employment self-containment in the Outer subregions. Past reviews identified a lack of success in encouraging employment to concentrate in these centres (State Planning Commission 1987, Hill 2005). '[S]trategic and regional centres were supposed to be employment centres but in practice they turned out to be no more than shopping centres' (WAPC 2003c p.37).

The *Metropolitan Centres Policy* identified the hierarchy of centres within Perth (WAPC 2000). WAPC (2003d) points out that the focus of the Metropolitan Centres Policy on retail centres captures only a fraction of total employment. Moreover, it 'lacks the implementation mechanisms to have a significant impact on land use' (ibid p.40).

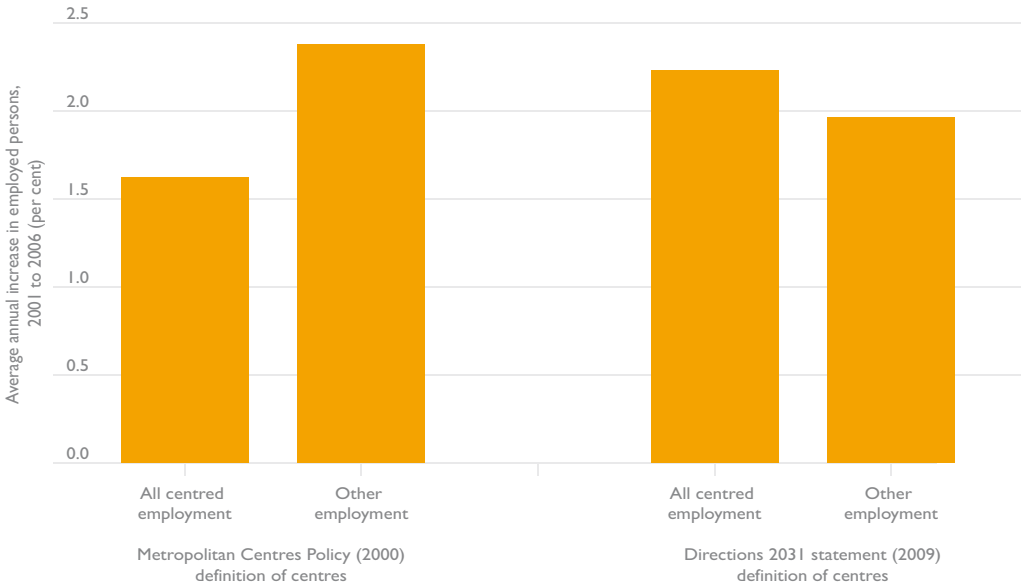
The new draft strategic framework for Perth, *Directions 2031*, defines activity centres much more broadly to encompass universities, hospitals, airports and industrial estates, as well as shopping centres (WAPC 2009a).

BITRE has analysed employment growth rates for the 2001 to 2006 period, based on both the new (WAPC 2009a) and old (WAPC 2000) definition of centres. The results are summarised in Figure 4.3 and are discussed, in turn, below:

- The *Metropolitan Centres Policy* was in existence throughout the 2001 to 2006 study period, and aimed to encourage a more balanced distribution of jobs across Perth, with employment growth being concentrated in centres. However, the centres nominated in this policy account for a relatively small share of Perth's employment and have been growing at a less rapid pace than non-centred employment in recent years. These results are contrary to the aims of state planning policy and point to market forces and business location decisions as having a more important influence on changes in the spatial distribution of jobs within Perth.
- The draft *Directions 2031* statement was released in 2009 and defines activity centres much more broadly. Under this new definition, the nominated activity centres account for roughly half of Perth's employment and grew at a slightly more rapid pace than non-centred employment between 2001 and 2006. The different result is partly attributable to the strong jobs growth experienced by industrial centres and specialised centres, as can be seen from Figure 4.4. For example, the Perth airport, Murdoch University and the Malaga, Henderson and Bibra Lake industrial centres all recorded average annual jobs growth of at least 5 per cent between 2001 and 2006. The more retail focused centres did not fare as well—the strategic city centres (e.g. Armadale, Cannington, Fremantle, Morley) recorded little jobs growth between 2001 and 2006. However, Joondalup, Stirling/Innaloo and Mandurah recorded above-average jobs growth.

Activity centres policy is fundamental to the WA Government's aim to influence the spatial distribution of employment within Perth and improve employment self-sufficiency. The shift to a more encompassing definition of centres is a step which will increase the potential influence over employment outcomes. Whether authorities are actually able to shape the future spatial distribution of employment will depend on the implementation mechanisms. The effectiveness of implementation should not be solely assessed in terms of the degree of control provided over land use and employment outcomes. The potential economic costs of land use regulation—such as reduced competition, higher prices and impediments to structural adjustment (Costa 2009, PC 1993)—also need to be taken into account.

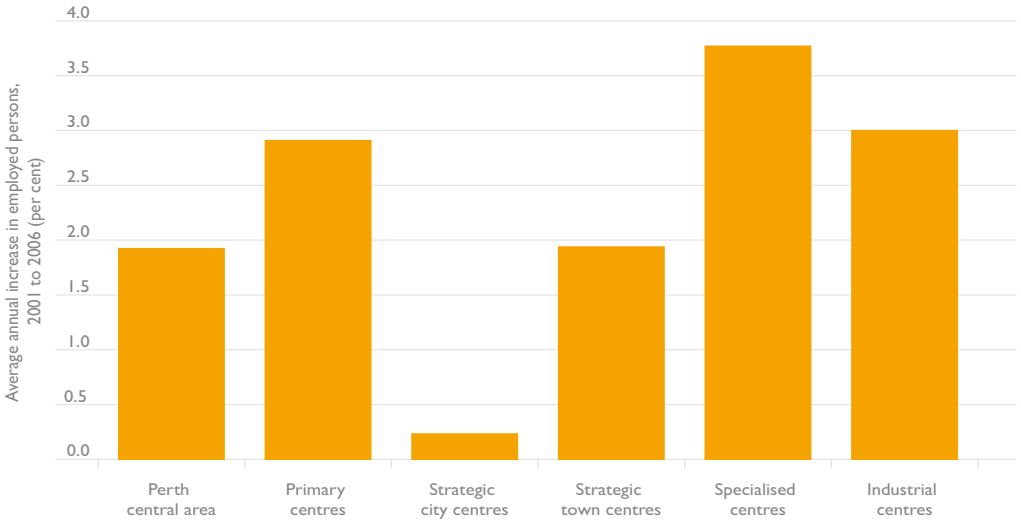
F4.3 Percentage change in people working in centres in Perth, 2001 to 2006



Note: Derived by BITRE using 2001 destination zone boundaries, which may encompass a larger geographic area than just the centre.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI. Centres defined based on the top three levels of the hierarchy in WAPC (2000) and the top four levels of the hierarchy in WAPC (2009a).

F4.4 Percentage change in people working in different types of centres in Perth, 2001 to 2006



Note: Derived by BITRE using 2001 destination zone boundaries, which may encompass a larger geographic area than just the centre. Specialised (industrial) centres includes both strategic and regional specialized (industrial) centres.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI. Centres defined based on the top four levels of the hierarchy in WAPC (2009a).

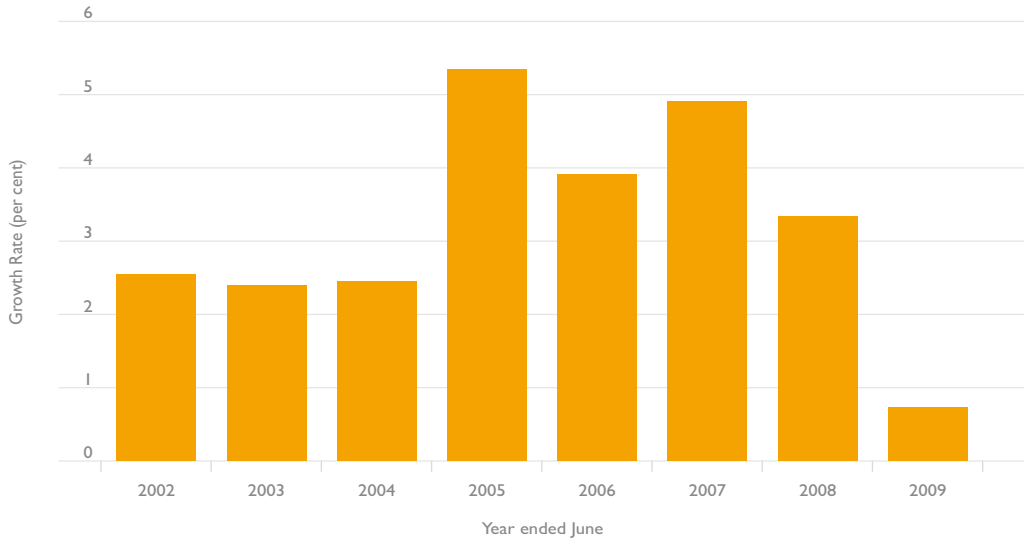
Recent changes in employment

Census data reveals that the number of jobs in the Perth metropolitan region grew at an average annual rate of 2.3 per cent between 2001 and 2006, while the number of employed residents grew at a more rapid pace (2.7 per cent).

Has much changed since then? The ABS *Labour Force Survey* provides up-to-date information on the number of employed residents in the Perth metropolitan region, but does not provide information on the location of jobs. Figure 4.5 plots annual growth in employed residents for Perth, showing steady growth between 2001 and 2004, followed by a period of very rapid growth between 2004 and 2008 and a marked slowdown in growth in the year ended June 2009. Employment fell from 902 400 in October 2008 to 868 700 in June 2009, representing a 3.7 per cent decline (ABS 2009c).

The ABS *Labour Force Survey* reports more rapid growth than census data for the 2001 to 2006 period, with employed residents growing at 3.3 per cent per annum. The average annual growth rate since June 2006 is slightly lower at 3.0 per cent.

F4.5 Growth in employed residents of Perth metropolitan region, 2001 to 2009



Note: Excludes Peel and Avon Arc.
Source: BITRE analysis of ABS Cat. 6291.0.55.001.

Thus, Perth appears to have continued its strong employment growth through to October 2008, but the effects of the global financial crisis have meant that there has been a significant decline in employment since then.

Unfortunately, there is currently little post-2006 information available on changes in the spatial distribution of jobs within Perth. The most recent *Land Use and Employment Survey* was completed by the Western Australian Department of Planning in June 2009 and provides useful insights about new jobs growth locations. These surveys are conducted over an extended period, for example the most recent survey commenced in March 2007 and concluded in June 2009, as such the results cover a wide time frame. Also, the most

recent estimates for 2007 to 2009 are preliminary data extractions and will be subject to change. The year 2008 is selected as the reference year, essentially the midpoint of the 2007 to 2009 survey years. The regions covered are Local Government Areas (LGA) within the ABS' Perth Statistical Division. Also, the total number of persons in the survey is roughly 73 per cent of the total number of employed persons in Perth's Statistical Division for 2006.

In 2002, employment was classified into four land use zones. Commercial (58 per cent) and Industrial (28 per cent) are the two largest components, followed by 13 per cent for Public Use and only 1 per cent for Recreational. The most recent survey (2007 to 2009) does not yet have data available for Public Use and Recreational. However, as these zones only account for 14 per cent of the total employment in 2002, the use of only the Industrial and Commercial employment can still be very valuable. Table 4.9 presents the total employment for the land use zones, with the inclusion of Commercial and Industrial employment for 2008. It shows that Industrial employment has grown twice as fast as Commercial employment.

T4.9 Employment by Land Use Zones for metropolitan Perth, 2008 to 2008

Employment	2002	2008	Percentage change	Average annual growth (per cent)
Commercial	247 766	290 648	17	3
Industrial	116 792	162 013	39	6
Commercial and Industrial	364 558	452 661	24	4
Public purpose	55 598	Unavailable		
Recreational and Open space	3 686	Unavailable		
Total	423 842	Unavailable		

Note: Estimates for 2008 are preliminary and subject to change.

Source: BITRE analysis of WA's Department for Planning *Land Use and Employment Survey.*

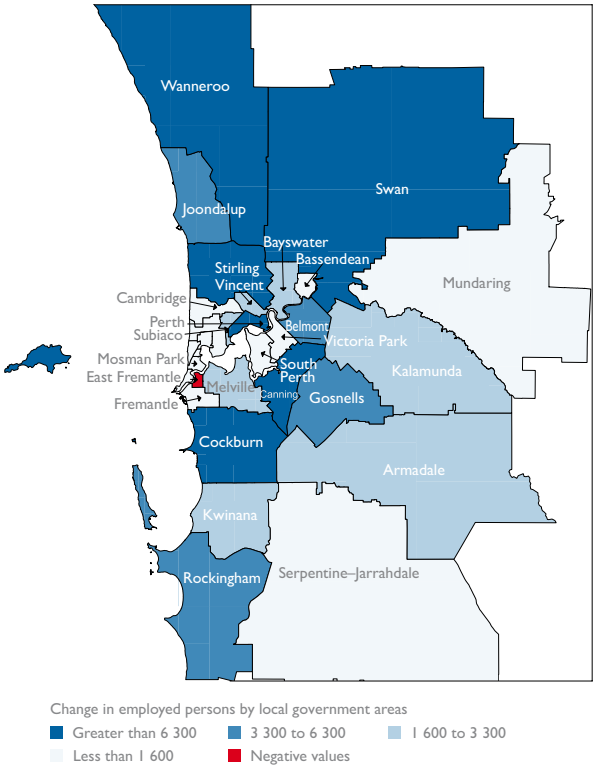
Using the census data from 2001 to 2006, jobs growth was concentrated in the Outer subregion, with the largest share at 47 per cent, followed by the Inner subregion at 29 per cent and the Middle subregion at 18 per cent. The survey data from 2002 to 2008 also shows that the Commercial and Industrial jobs growth is in the Outer subregion, representing over 50 per cent. In regards to the employment growth for the other subregions, the survey suggests higher growth in the Middle subregion (27 per cent) than the Inner by 5 percentage points.

The average annual rate of jobs growth for the survey data was also slightly higher in the Middle (3 per cent) and Inner (2 per cent) subregions than the census data show for the 2001 to 2006 period, but both experienced slower growth than the Outer subregion (7 per cent). This strong growth for the Outer subregion suggests further expansion in employment since 2006.

Map 4.12 presents the strong growing LGAs from the survey data through change in the number of persons employed from 2002 to 2008. Some of the LGAs with strong employment growth are (in descending order) Swan, Perth, Canning, Stirling, Cockburn and Wanneroo.

East Fremantle is the only LGA with declining employment. The intercensal analysis similarly found that the Perth and Swan LGAs added the most jobs between 2001 and 2006.

M4.12 Change in employment by person for metropolitan Perth by LGAs, 2002 to 2008



Note: Estimates for 2008 are preliminary and subject to change.

Source: BITRE analysis WA's Department for Planning and Infrastructure Land Use and Employment Survey.

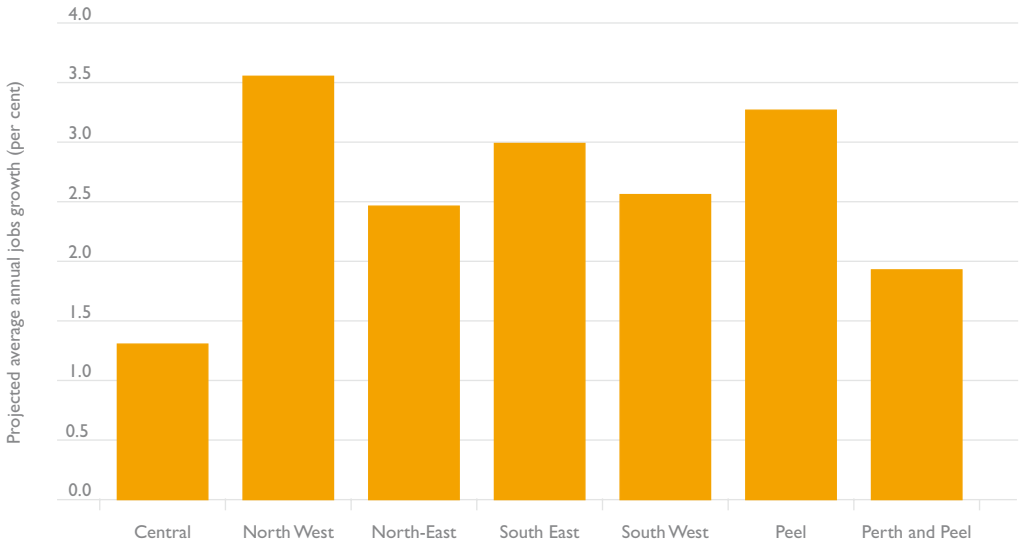
In terms of the average annual growth rate for employment by LGAs from the *Land Use and Employment Survey*, the strongest growth in employment is evident in the Outer subregion with 10 LGAs in the top 12, from 2002 to 2008. For example, LGAs with strong employment growth are Serpentine-Jarrahdale (13 per cent from a low base), Wanneroo (10 per cent), Cockburn (9 per cent) and Kalamunda (9 per cent). Overall the Inner subregion experienced slow rates of growth, with the City of Perth growing at 2 per cent per year.

The more recent data from the ABS' Labour Force Survey and the *Land Use and Employment survey* illustrate that the employment patterns in Perth have continued with much stronger growth in the Outer subregion, than in the Inner or Middle subregions.

Projected changes in place of work, 2008 to 2031

The WA Government projects 353 000 additional jobs for Perth and Peel by 2031. The projections are summarised in Figure 4.6 by subregions. Employment growth is projected to slow from its average annual growth rate of 2.3 per cent between 2001 and 2006, to average 1.9 per cent growth between 2008 and 2031.

F4.6 Employment projections by subregion for Perth and Peel, 2008 to 2031



Note: Central includes the Inner and Middle subregions.
Source: BITRE analysis of WAPC (2009a)

The strongest jobs growth is projected for the North-West subregion, representing a 123 per cent total increase in employment between 2008 and 2031. Peel is also projected to more than double employment by 2031. Employment growth is projected to exceed the metropolitan average for the South-East, South-West and North-East Outer subregions. The employment share of Outer subregions is expected to increase from 30 per cent in 2008 to 38 per cent in 2031. Employment growth is projected to be much lower for the Central subregion, with its employment share projected to decline from 66 per cent in 2008 to 59 per cent in 2031.

Earlier unpublished projections prepared by WA's DPI in 2006 include more spatially disaggregated information. Inner Perth is projected to exceed 95 000 employed persons in 2031, but this reflects a projected growth rate roughly half the metropolitan average. According to these projections, the CBD will remain Perth's main place of work in 2031, followed by Canning (72 300 employed persons), Swan (69 300), Perth Remainder (59 800) and Stirling Central (56 400).

CHAPTER 5
Industry

Key points

- Perth's major employing industries in 2006 were the *retail trade* (15.4 per cent), *property and business services* (12.5 per cent), *health and community services* (11.5 per cent) and *manufacturing* (11.0 per cent).
- Retail is the major employing industry in the Middle, North-West, South-West and Peel subregions. *Manufacturing* is the major employer in the North-East and South-West Outer subregions, while the *property and business services* industry is the major employer in the Inner subregion.
- The spatial concentration of industries has implications for commuting, particularly where workers have specialised skills that tie them closely to specific industries.
- *Finance and insurance, government administration and defence* and *property and business services* all have over 55 per cent of employment concentrated in the Inner subregion.
- Employment in *education, construction, retail trade* and *accommodation, cafes and restaurants* is well dispersed across statistical local areas.
- Perth's statistical local areas (SLAs) each have their own distinctive mix of industries. Some are specialised in *education* (e.g. Melville, Joondalup North), and others in transport (e.g. Belmont, Fremantle Remainder) or *manufacturing* (e.g. Kwinana).
- From 2001 to 2006, jobs growth was greatest for *construction* (which added 19 000 jobs), *health and community services* (14 900), *government administration and defence* (10 100) and *mining* (9400).
- Between 2001 and 2006, the trend towards increased service industry dominance of employment has halted, at least temporarily.
- The industry drivers of jobs growth vary across Perth—industries which have grown strongly in one place can be stagnant in another.
- *Government administration and defence* was the largest contributor to jobs growth in Inner Perth; *manufacturing* was the largest contributor in the South-West and North-East Outer subregions; retail in Peel and the North-West; and *health and community services* in the South-East and Middle subregions.
- Retail employment tended to decline in the Inner subregion and increased most rapidly on the urban fringe.
- *Mining* jobs growth was highly concentrated in the City of Perth.

- Most SLAs shared in the jobs growth of the *construction* and *health and community services* industries.
- Key post-2006 developments include the emergence of transport and warehousing as a growth industry and a loss of mining employment following the global financial crisis.

Introduction

This chapter considers the location of different industries within Perth and how that has changed between 2001 and 2006. The analysis is based on employment data for different industries from the *Census of Population and Housing*.

Employment by industry in 2006

This section investigates the spatial distribution of industries within the Perth working zone in 2006 using census data on employment by industry. The data is analysed using the ANZSIC 1993 classification at the 1 digit level, which involves 17 different industries. The analysis is undertaken on a place of work basis, except where otherwise noted.

For the Perth working zone, the largest employing industries were *retail trade* (15.4 per cent), *property and business services* (12.5 per cent), *health and community services* (11.5 per cent) and *manufacturing* (11.0 per cent).

Table 5.1 shows the major employing industries for each subregion, as well as each subregion's main industry of specialisation. A place can have a very high degree of specialisation in an industry which does not contribute a large proportion of the region's total employment. For example, the *mining* industry accounts for only 3.8 per cent of employment in Inner Perth. This is more than three times the industry's national employment share of 1.2 per cent, and consequently Inner Perth can be described as being very specialised in *mining*. The top specialisation for each subregion was identified using location quotients, which in the above example would equal 3.1 (i.e. 3.8 divided by 1.2).

T5.1 Main employing industries and specialisations by subregion, Perth working zone, 2006

Subregion of work	Major employing industry	Employment share (per cent)	Main specialisation	Employment share (per cent)
Inner	Property and business services	19.7	Mining	3.8
Middle	Retail trade	19.8	Wholesale trade	8.9
North-West	Retail trade	23.2	Education	13.2
North-East	Manufacturing	17.3	Manufacturing	17.3
South-East	Retail trade	20.7	Personal and other services	5.7
South-West	Manufacturing	23.2	Electricity, gas and water	1.7
Peel	Retail trade	21.1	Mining	2.2
Avon Arc	Agriculture, forestry and fishing	31.4	Agriculture, forestry and fishing	31.4

Source: BITRE analysis of ABS Census of Population and Housing 2006

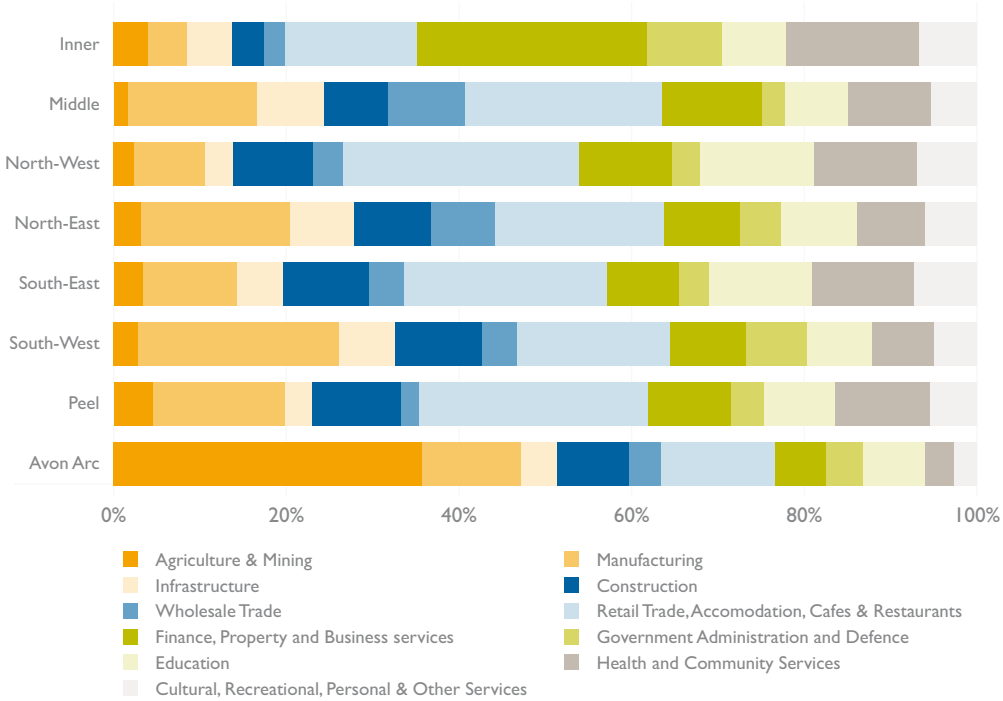
Retail is the major employing industry in the Middle, North-West, South-East and Peel subregions. *Manufacturing* employs the most people within the North-East and South-West Outer subregions, while the *property and business services* industry is the major employer in the Inner subregion and agriculture is the major employer in the Avon Arc. The top industry specialisation is the same as the major employing industry for the North-East corridor and the Avon Arc. Both Peel and the Inner subregion have specialisations in the *mining* industry.

Figure 5.1 compares the industry mix of employment across the different subregions. For presentation purposes, the 17 industries have been collapsed into 11 industries. Key features of the chart include:

- *Manufacturing* is relatively unimportant to the Inner subregion, but accounts for a significant proportion of employment in the Middle, South-West, North-East and Peel subregions.
- *Construction* employs relatively few people in the Inner subregion.
- *Wholesale trade* is a relatively important employer in the Middle and North-East subregions.
- *Retail trade* and *accommodation, cafes and restaurants* account for a comparatively small share of employment in the Inner and Avon Arc subregions.
- *Finance and insurance* and *property and business services* account for a much greater share of employment in the Inner subregion than in the other subregions.
- *Government administration and defence* employment is relatively high in the Inner and South-West subregions.
- *Education* is a particularly important source of employment in the North-West Outer subregion.
- *Health and community services* employment is most prominent in the Inner subregion, while this industry employs relatively few people in the Avon Arc.

Within Perth, the industries which are most centralised are *finance and insurance* (69 per cent in the Inner subregion), *mining* (64 per cent), *property and business services* (57 per cent) and *government administration and defence* (57 per cent). The industries which are most decentralised in that they have the highest proportion of employment in the Outer subregions, Peel and the Avon Arc are *agriculture* (81 per cent), *construction* (48 per cent) and *manufacturing* (46 per cent).

F5.1 Employment by industry in each subregion of Perth, 2006



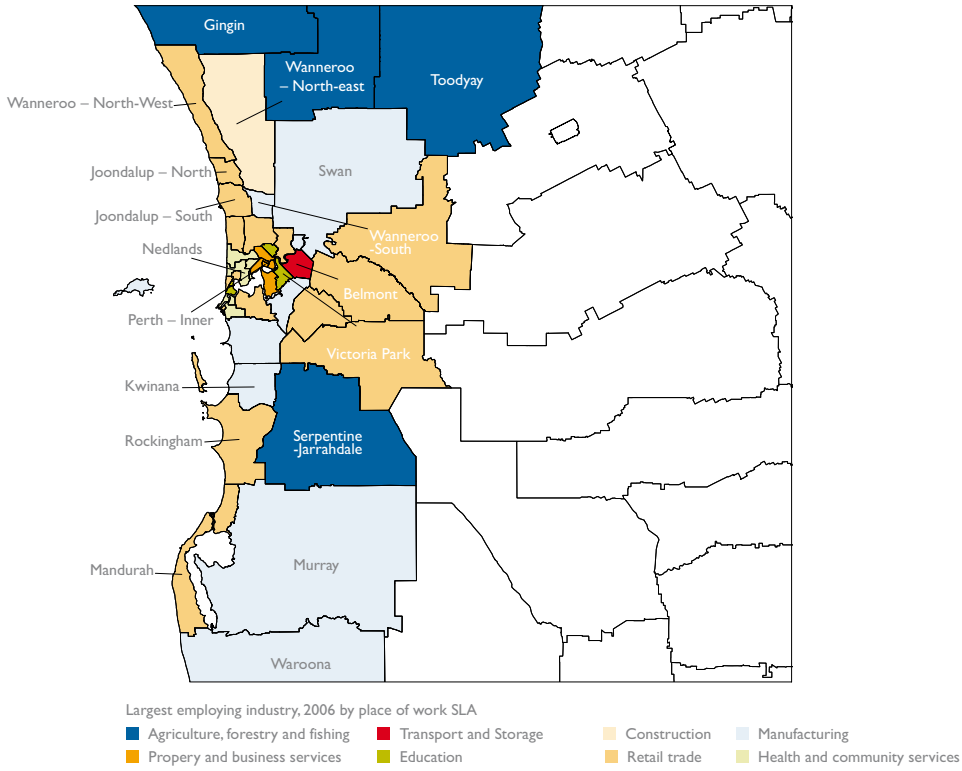
Note: Infrastructure includes communications, Transport and storage, Electricity, gas and water supply.

Source: BITRE analysis of ABS Census of Population and Housing 2006.

There is a greater degree of variation in the major employing industries at a small area scale. Map 5.1 indicates the largest employing industry for each SLA in 2006. Eight industries feature as the largest employer in at least one SLA:

- The *retail* industry is most dominant being the largest employer in 16 Perth SLAs.
- *Manufacturing* is the largest industry in eight SLAs, none of which are part of the Inner subregion.
- *Health and community services* is the largest industry in five SLAs, all of which are part of the Inner subregion.
- *Agriculture* features as the largest employer in the Avon Arc SLAs and Serpentine-Jarrahdale.
- Four Inner subregion SLAs have *property and business services* as the main employer.
- *Education* is also the major source of employment in four SLAs.
- The Belmont SLA contains the domestic and international airports and employment is concentrated in the *transport and storage* industry.
- The urban fringe SLA of Wanneroo North-East is the only place where the *construction* industry is the major employer.

M5.1 Largest employing industry in each Statistical Local Area, Perth working zone, 2006



Source: BITRE analysis of ABS Census of Population and Housing 2006.

Table 5.2 lists the main employing industry and the top industry specialisation for the twenty SLAs containing the largest number of workers. The industry base of Perth's employment hubs is highly variable. Employment in the City of Perth is largely in the *property and business services, finance and insurance* and *government administration* industries, while there is also a concentration of office-based employment with mining companies. Perth's suburban SLAs each have their own distinctive mix of industries.

There are only a few SLAs where the top industry specialisation is also the largest source of employment. The *retail* industry is the top specialisation and the top employer within Bayswater, Joondalup South, Mandurah and Stirling Coastal. The Belmont SLA has the *transport and storage* industry as both its top specialisation and its top employer. *Health and community services* is the top specialisation and the top employer in both Subiaco and Nedlands, due to the location of several large hospitals in these SLAs.

Some of the specialisations in this table result from a single major enterprise being located within the SLA. For example, Rockingham's top industry specialisation arises from the location of a naval base within its boundaries, while Fremantle Remainder is specialised in *transport and storage* because it contains the Port of Fremantle. *Education* is the top specialisation for Melville (which contains Murdoch University) and Joondalup North (which contains an Edith Cowan University campus). Victoria Park is specialised in *cultural and recreational services* because it contains the Burswood Entertainment Complex.

T5.2 Main employing industries and specialisations by place of work, Perth working zone, 2006

Place of work SLA	People working in SLA	Main employing industry	Main industry's employment share (per cent)	Top specialisation
Perth Inner	61 787	Property and business services	26	Mining
Perth Remainder	47 905	Property and business services	24	Mining
Canning	47 344	Manufacturing	21	Wholesale trade
Stirling Central	43 503	Retail trade	18	Wholesale trade
Swan	37 817	Manufacturing	19	Wholesale trade
Melville	28 597	Retail trade	23	Education
Belmont	27 943	Transport and storage	18	Transport and storage
Cockburn	21 757	Manufacturing	30	Electricity, gas and water supply
Subiaco	19 980	Health and community services	23	Health and community services
Victoria Park	19 656	Education	19	Cultural and recreational services
Rockingham	19 211	Retail trade	22	Government administration and defence
Gosnells	18 340	Retail trade	21	Personal and other services
Bayswater	17 823	Retail trade	25	Retail trade
Joondalup South	17 506	Retail trade	28	Retail trade
Fremantle Remainder	17 307	Health and community services	21	Transport and storage
Nedlands	16 101	Health and community services	51	Health and community services
Joondalup North	15 282	Retail trade	21	Education
Mandurah	15 029	Retail trade	27	Retail trade
Vincent	14 727	Property and business services	22	Electricity, gas and water supply
Stirling Coastal	13 001	Retail trade	32	Retail trade

Source: BITRE analysis of ABS Census of Population and Housing 2006.

There is a great deal of diversity in the industry mix of jobs available in different parts of the city. However, the *retail* industry is one of the top three employing industries in three-quarters of Perth's SLAs. There are also some specific combinations of industries that occur in more than one SLA:

- Swan, Wanneroo South and Cockburn each have *manufacturing* as the major employer, followed by *retail* and *construction*.
- Melville, Joondalup South, Joondalup North and Armadale have service-based economies, with *retail* as the major employer, followed by *health and community services* and *education*.
- Subiaco and Nedlands are neighbouring SLAs that both have *health and community services* as the major employer, followed by *property and business services* and *education*.

While most Perth SLAs have a reasonably diverse mix of industries, several SLAs are extremely specialised in terms of the mix of jobs that are available. The most extreme example is Nedlands, where half of all employment is in *health and community services*. Further examples are Peppermint Grove, where 38 per cent of jobs are in *education*, and Kwinana, where 38 per cent of jobs are in *manufacturing*.

In some parts of Perth, there is a poor match between the jobs available and the industries in which local residents are employed. Figure 5.2 shows the substantial mismatch between the industry mix of jobs available in Peppermint Grove and the industries in which employed residents of this SLA work. While the number of jobs available in Peppermint Grove is sufficient to employ 89 per cent of employed residents, the substantial industry mismatch means that 38 per cent of employed residents would need to change industry to replicate the industry mix of jobs available in the SLA.[21] Other places with substantial industry mismatch include Nedlands and Inner Fremantle.

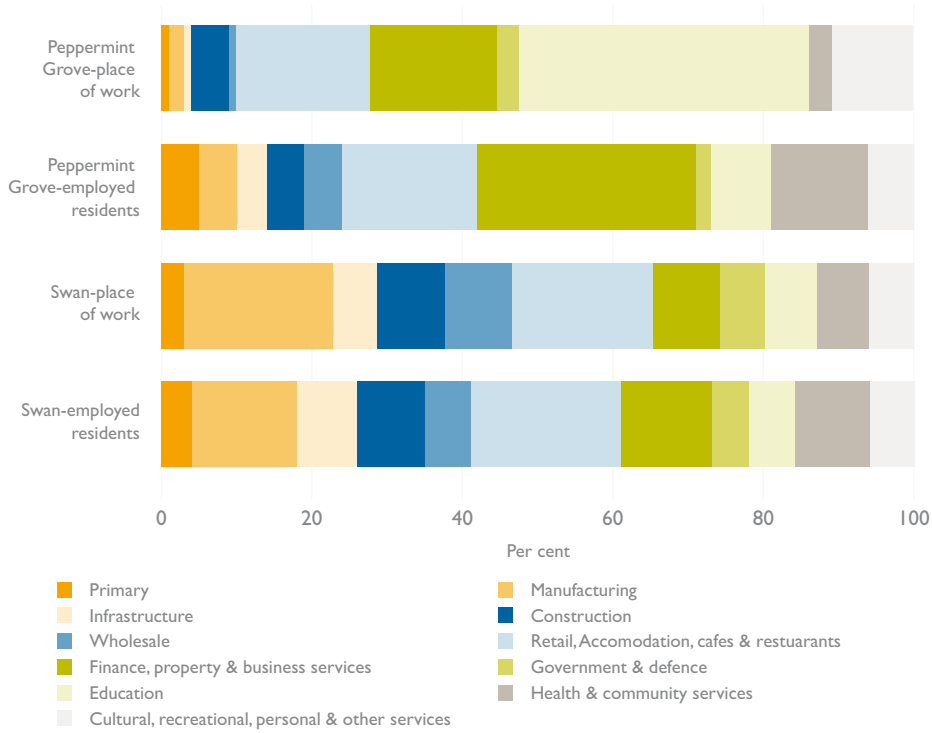
Other parts of Perth have a high degree of alignment between the industry mix of jobs available in the SLA and the industries in which local residents are employed. Examples include Swan, Mundaring and Gingin. The number of jobs available in Swan is sufficient to employ 86 per cent of employed residents and only 11 per cent of employed residents would need to change industry to replicate the industry mix of jobs available in the SLA.

Within the Perth metropolitan region, Swan has the third highest proportion of employed residents who work within the SLA (i.e. self-containment rate) after the CBD and Rockingham, suggesting that the good match between local employment opportunities and the skills of employed residents may have boosted self-containment. In contrast, Peppermint Grove has poor employment self-containment.

This pattern can be generalised in that there is a significant correlation of –0.35 between the self-containment rate of an SLA and the measure of industry mismatch. The greater the degree of mismatch between the industry mix of jobs available in the SLA and the industries in which residents are employed, the less self-contained the SLA tends to be and the higher the proportion of residents who commute to a place of work outside the SLA. A high degree of industry mismatch can generate commuting, but the strength of this relationship should not be overstated. There are several SLAs, such as Vincent, that have very poor self-containment of employment despite little industry mismatch. Even though the industry mix of jobs available in Swan seems to be a very close match to the industries in which its residents work, 71 per cent of employed residents of Swan still commute to a place of work outside the SLA. This is a lower rate than most other suburban SLAs, but illustrates the complexity and interconnection of the metropolitan system.

21 The industry mismatch measure was calculated using a variant of the Structural Change Index, which compares the industry mix across the place of work and place of residence datasets, rather than across two separate points in time. See BITRE (2004) for more detail.

F5.2 Industry mismatch in Swan and Peppermint Grove, 2006



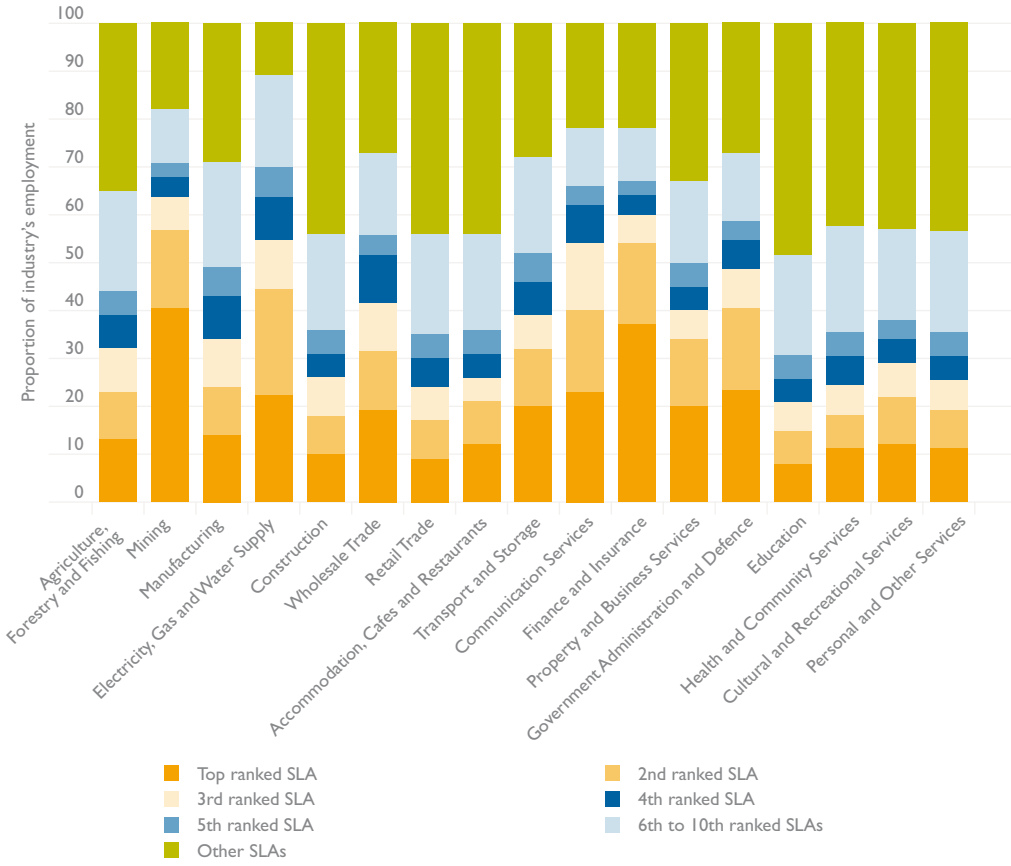
Source: BITRE analysis of ABS Census of Population and Housing 2006

While some industries are widely dispersed across the whole city, for other industries employment is more spatially concentrated. WAPC (2003c) distinguishes three different types of industries in terms of location preferences:

- High order services (e.g. *finance, government, business services*) favour central locations.
- Other services (e.g. *retail, education, personal services*) are more dispersed and tend to follow the distribution of the population.
- Some industries (e.g. *manufacturing, transport, wholesale*) locate in places that meet their specific infrastructure and land use requirements.

Figure 5.3 illustrates the extent to which employment in each industry is concentrated in a relatively small number of SLAs. *Finance and insurance* employment is most heavily concentrated in a single SLA, with the CBD containing 37 per cent of Perth's employment in this industry. More than 80 per cent of employment in the *electricity, gas and water* and *mining* industries is concentrated in the top ten SLAs. Industries in which employment is much more evenly distributed across SLAs include *Education, construction, retail* and *accommodation, cafes and restaurants*.

F5.3 Spatial concentration of each industry's employment within Perth working zone, 2006



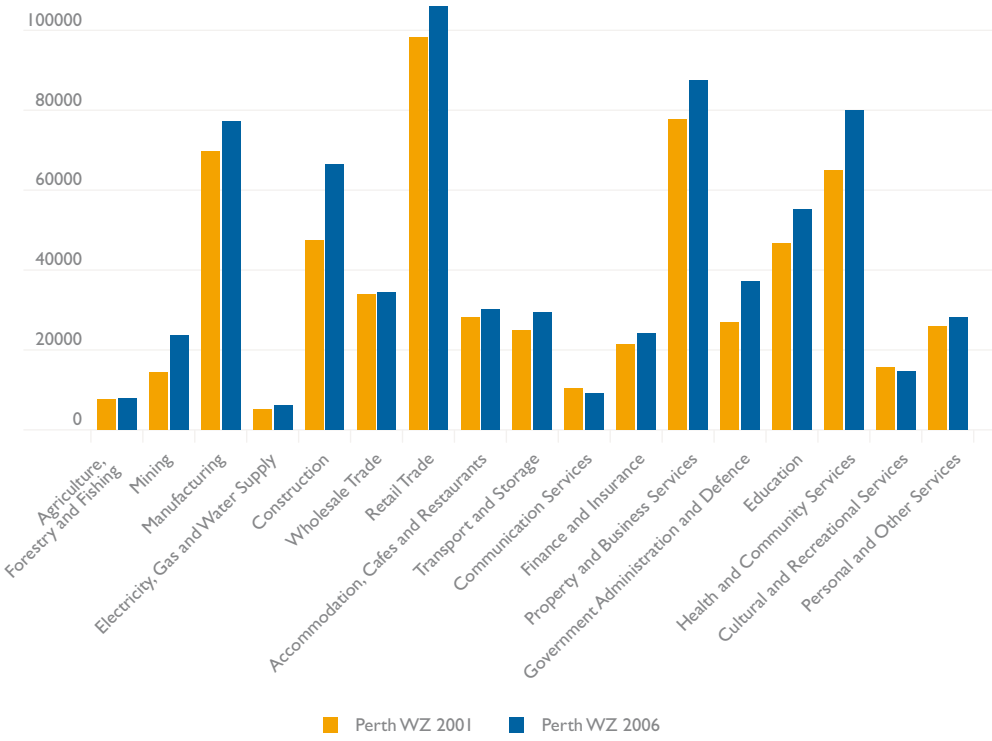
Source: BITRE analysis of ABS Census of Population and Housing 2006.

The spatial concentration of the different industries has implications for commuting, particularly where workers have specialised skillsets which closely tie them to specific industries. Employees of the *finance and insurance* industry have a very high probability of commuting to the City of Perth for work. While 45 per cent of *finance and insurance* employees live in the Outer subregions, only 17 per cent of the industry's jobs are located in the Outer subregions. In contrast, jobs for teachers and construction workers are widely distributed throughout the city, so we would expect such workers to be more likely to have a place of work in close proximity to their place of residence.

Industry changes, 2001 to 2006

There were some notable changes in the industry composition of Perth's employment between 2001 and 2006. Figure 5.4 shows employment by industry for residents of the Perth working zone in the two years. *Retail trade* was the major employing industry in both periods, followed by *property and business services*. However, the *construction* industry was the major source of jobs growth, adding nearly 19 000 jobs between 2001 and 2006 and growing at about 7 per cent per annum. The *health and community services* and *government administration and defence* industries also added more than 10 000 jobs. An additional 9 400 Perth residents were employed in the *mining* industry, but this represented a very rapid average annual growth rate of 11 per cent. Significant job losses were evident in *communication services* (–1200) and *cultural and recreational services* (–900).

F5.4 Employment by industry for residents of Perth working zone, 2001 and 2006



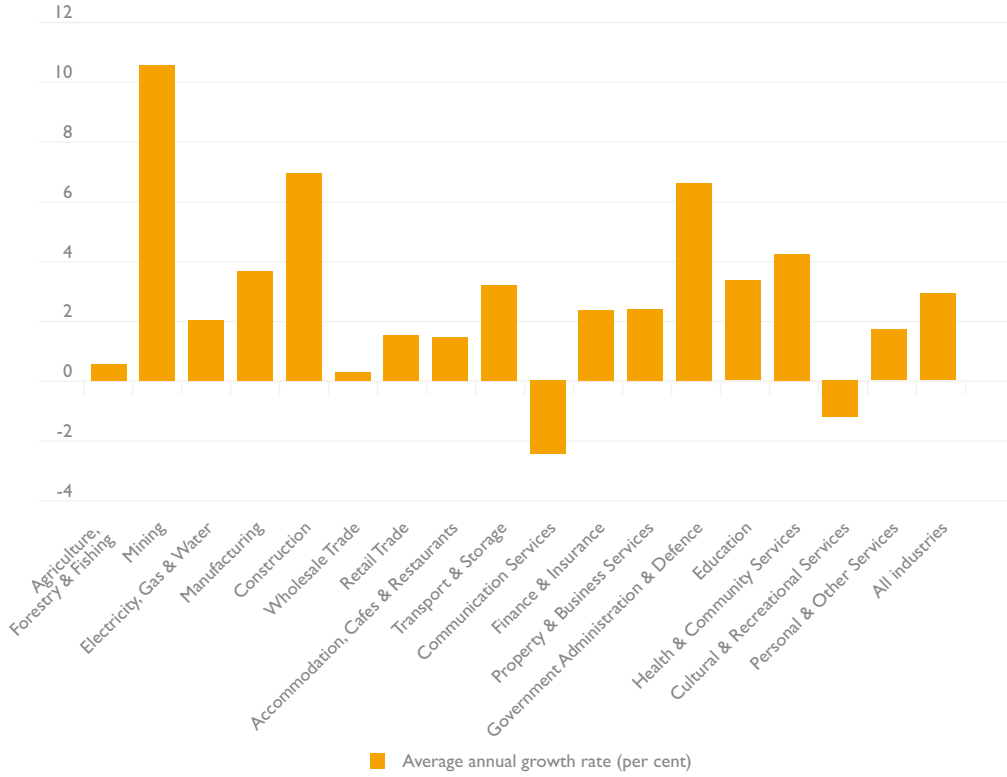
Source: BITRE analysis of ABS Census of Population and Housing 2006 and 2001.

WAPC (2003c) argues that Perth's employment growth will continue to be concentrated in the service industries.

> '[L]ike other modern cities, Perth's industrial composition has been changing in favour of the service industries for over 50 years, with finance and business services, public administration, community services and trade and entertainment growing at the expense of manufacturing, transport and construction and other non-service industries. These trends are likely to continue in the future.' (WAPC 2003c, p.5)

The latest census data, shown in Figure 5.5, reveals that several non-service industries experienced strong employment growth between 2001 and 2006, particularly *construction* and *mining*. Some service industries grew very strongly, such as *government administration and defence*, while others grew slowly (e.g. *retail trade*) or declined (e.g. *cultural and recreational services*). Adopting the WAPC (2003c) definition[22], the employment share of the Perth working zone's services sector actually declined slightly from 70.4 per cent in 2001 to 69.4 per cent in 2006. The trend towards increased service industry dominance of employment has halted, at least temporarily.

F5.5 Employment growth rate by industry, Perth working zone residents, 2001 to 2006



Source: BITRE analysis of ABS Census of Population and Housing 2006 and 2001.

Earlier sections highlighted the strong jobs growth in Peel and the South-West, North-East and North-West Outer subregions of Perth between 2001 and 2006 and the comparatively slow jobs growth of the Inner and Middle subregions. Table 5.3 summarises the largest industry contributors to jobs growth in each subregion. In the North-East and South-West Outer subregions, the main contributor to jobs growth was the *manufacturing* industry, supporting the finding of WAPC (2003c) that manufacturing jobs were increasingly being located in the Outer subregion. For Peel and the North-West, the *retail* industry added the most jobs. In the South-East and Middle subregions, the *health and community services* industry added the most jobs. *Government administration and defence* was the largest contributor to jobs growth in the

22 Agriculture, forestry and fishing, Mining, Manufacturing, Transport and storage, Communication services, Electricity, gas and water and Construction are considered non-service industries.

Inner subregion of Perth, adding more than 5700 jobs between 2001 and 2006, which was the largest employment increase by a single industry in any of the subregions.

The largest job loss was experienced by the *retail* industry in the Inner subregion, which lost nearly 900 jobs over the period. The *retail* industry showed positive growth in all other subregions, although the rate of growth was less than 1 per cent per annum in the Middle subregion. Clearly, the industry drivers of jobs growth differ considerably across Perth's subregions—industries which have grown very strongly in one subregion may be stagnating or declining in another.

The long-term trend towards greater employment in consumer services is likely to make the distribution of jobs more decentralised (WAPC 2003c). Overall, Perth's employment did become a little more decentralised between 2001 and 2006, with the Inner and Middle subregions' employment share dropping slightly from 68.5 per cent to 66.2 per cent. Greater decentralisation was evident across most industries, but the pattern was particularly evident for the *manufacturing, transport and storage, construction* and *retail trade* industries, where employment growth generally grew more strongly in the Outer subregion and Peel, than in the Inner and Middle subregions. In contrast, the already highly centralised *mining* industry became even more centralised over the period, a result which was influenced by reduced mining employment within Peel.

T5.3 Main industry contributors to employment growth between 2001 and 2006 by subregion of work, Perth

Subregion	Largest source of growth	2nd largest source of growth	3rd largest source of growth
Inner	Government administration and defence	Health and community services	Property and business services
Middle	Health and community services	Construction	Transport and storage
North-West	Retail trade	Health and community services	Education
North-East	Manufacturing	Health and community services	Education
South-East	Health and community services	Education	Construction
South-West	Manufacturing	Construction	Government administration and defence
Peel*	Retail trade	Construction	Health and community services

Note: * Excludes Waroona.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Table 4.8 previously identified the eight SLAs that added more than 3000 jobs between 2001 and 2006. Table 5.4 identifies the main industry contributors to jobs growth within each of those eight growth areas. Again, the main industry drivers of jobs growth vary considerably by place. In the CBD, the employment growth is occurring particularly in *property and business services*, but also in *mining* and *government administration*. However, *property and business services* does not emerge as an important source of growth in the other listed SLAs.

T5.4 Main industry contributors to employment growth between 2001 and 2006 for Statistical Local Areas that added more than 3000 jobs, Perth

SLA	Largest source of growth	2nd largest source of growth	3rd largest source of growth
Perth Inner	Property and business services	Mining	Government administration and defence
Swan	Manufacturing	Construction	Wholesale trade
Rockingham	Government administration and defence	Retail trade	Health and community services
Mandurah	Retail trade	Health and community services	Construction
Canning	Transport and storage	Wholesale trade	Construction
Belmont	Transport and storage	Manufacturing	Construction
Gosnells	Retail trade	Education	Construction
Melville	Health and community services	Education	Retail trade

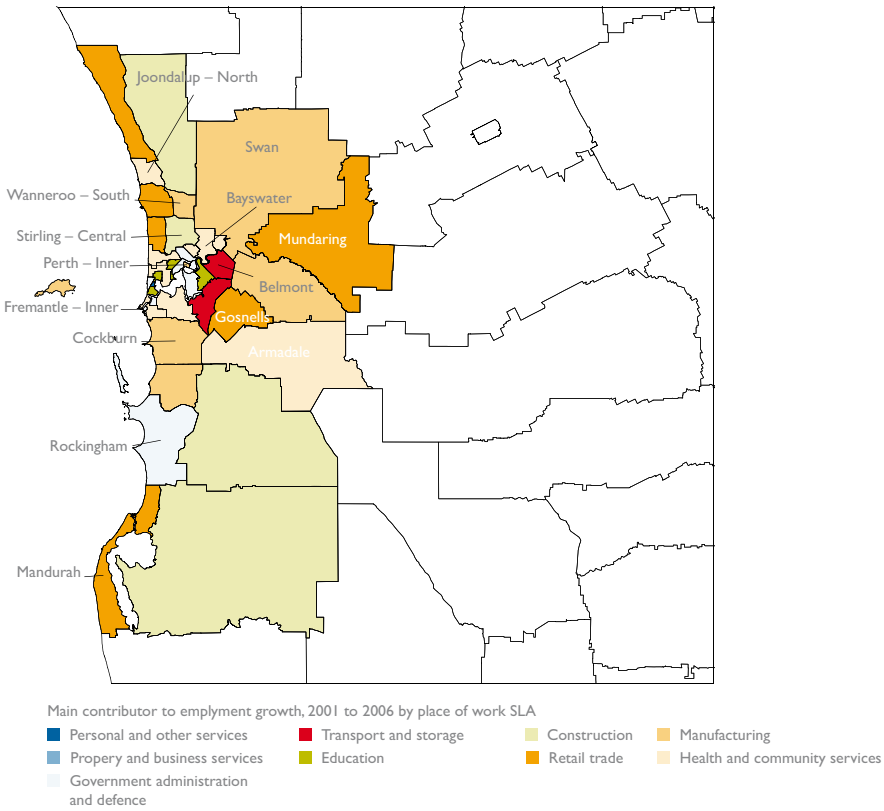
Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

The Middle subregion SLAs of Canning and Belmont both have the *transport and storage* industry as the largest contributor to growth, while in Mandurah and Gosnells the retail industry is the major contributor. *Manufacturing* is an important source of growth in Swan, which reflects the large increase in people working at the Malaga Industrial Estate between 2001 and 2006. Rockingham's employment growth is being driven largely by *government administration and defence*, which probably reflects an expansion in employment at Fleet Base West (previously HMAS Stirling). Melville's major source of employment growth is the *health and community services* industry.

Map 5.2 shows the largest industry contributor to employment growth for each SLA between 2001 and 2006. Nine different industries feature as the largest contributor to employment growth for at least one SLA, with the *health and community services* industry being most prominent.

In the Inner subregion, there are several SLAs which have *education* as the major source of jobs growth, as well as several which have *government administration and defence* as the major source. None of the six SLAs with the *retail trade* as the largest source of jobs growth are located in the Inner subregion. There are five SLAs in the Outer subregions which have *manufacturing* as the largest source of jobs growth. *Construction* is also an important driver of growth in several urban fringe SLAs.

M5.2 Main industry contributor to employment growth between 2001 and 2006, Statistical Local Areas, Perth



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Jobs growth within Perth is arising from a diverse range of industries and the remainder of this section focuses on the industries which have experienced the largest growth in employment between 2001 and 2006. To set the context, Table 5.5 summarises the primary location of jobs growth within Perth for each industry. The City of Perth (either Perth Inner or Perth Remainder) is the largest contributor to jobs growth for numerous industries. Swan is the largest contributor for the *wholesale trade* and *accommodation, cafes and restaurants* industries, Kwinana for *manufacturing*, Belmont for *transport and storage* and Subiaco for *education*. Belmont contains the domestic and international airports and the Kewdale Intermodal Terminal, while Subiaco contains most of the University of Western Australia's Crawley campus.

The *construction* industry was the major source of employment growth in Perth between 2001 and 2006. While it commonly features as the second or third largest source of jobs growth in Table 5.4, it does not feature as the largest source of jobs growth for any of the listed SLAs.[23] However, there was a substantial increase in the number of *construction* industry employees who reported a place of work in Perth Inner and Swan (both increased by 1100 between 2001 and 2006). Map 5.3 shows the main locations of *construction* industry jobs growth within Perth.

T5.5 Statistical Local Areas which had largest increase in employed persons for each industry, Perth, 2001 to 2006

Industry	SLA which had largest jobs growth for industry
Agriculture, forestry and fishing	Wanneroo North-East
Mining	Perth Inner
Manufacturing	Kwinana
Electricity, gas and water supply	Perth Inner
Construction	Perth Inner
Wholesale trade	Swan
Retail trade	Mandurah
Accommodation, cafes and restaurants	Swan
Transport and storage	Belmont
Communication services	Perth Inner
Finance and insurance	Perth Remainder
Property and business services	Perth Inner
Government administration and defence	Rockingham
Education	Subiaco
Health and community services	Nedlands
Cultural and recreational services	*
Personal and other services	Gosnells

Note: Table relates to Perth, Mandurah and Murray only: excludes Avon Arc and Waroona

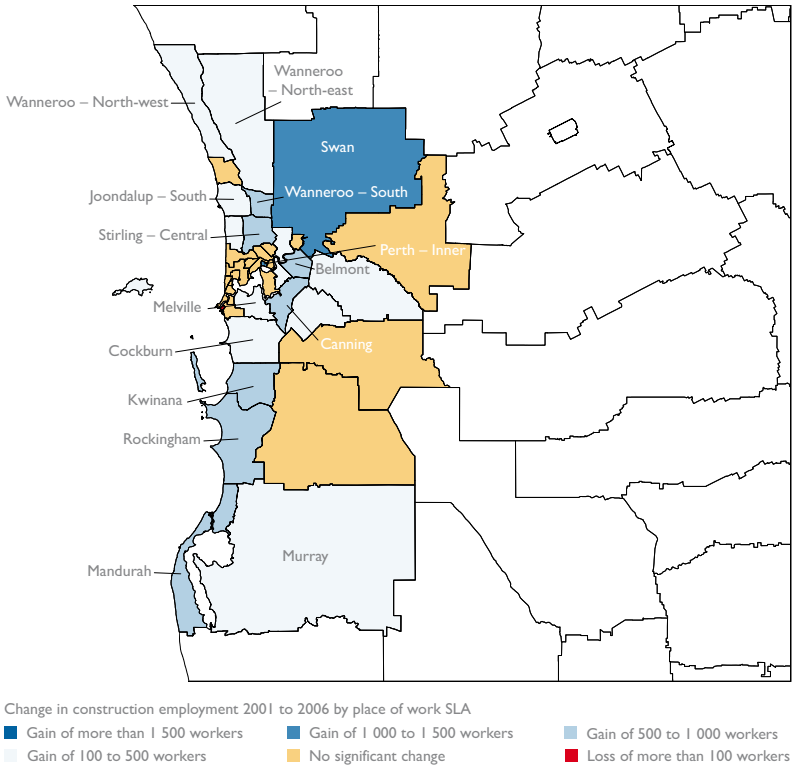
* No SLA had jobs growth of more than 100 persons for this industry.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

The *health and community services* industry was the second largest source of employment growth in Perth during this period. This industry grew very strongly in Nedlands, which added 2400 jobs between 2001 and 2006, increasing the industry's employment share from 43 to 52 per cent. Nedlands contains the Queen Elizabeth II Medical Centre and Hollywood Private Hospital. Perth Inner and Melville both added about 1000 additional *health and community services* jobs during this period. Map 5.4 maps the main areas of *health and community services* jobs growth within Perth and shows that numerous SLAs experienced gains of more than 500 persons employed in this industry.

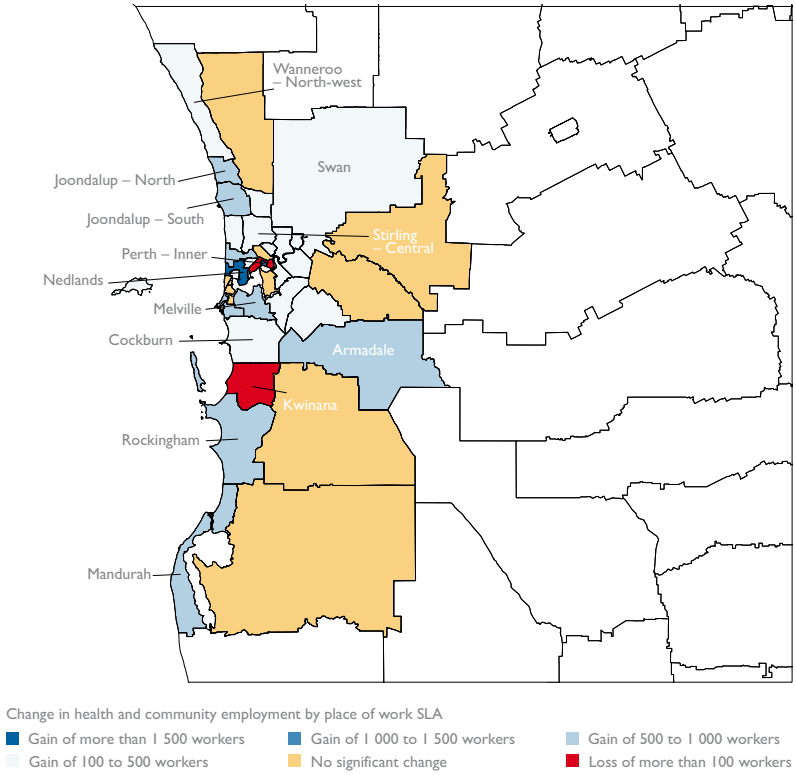
23 This is partly attributable to the high proportion of construction workers who have no fixed place of work. In 2006, about one quarter of those employed in construction throughout Australia reported no fixed place of work.

M5.3 Change in the number of employed persons in Construction for Statistical Local Areas, Perth, 2001 to 2006



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

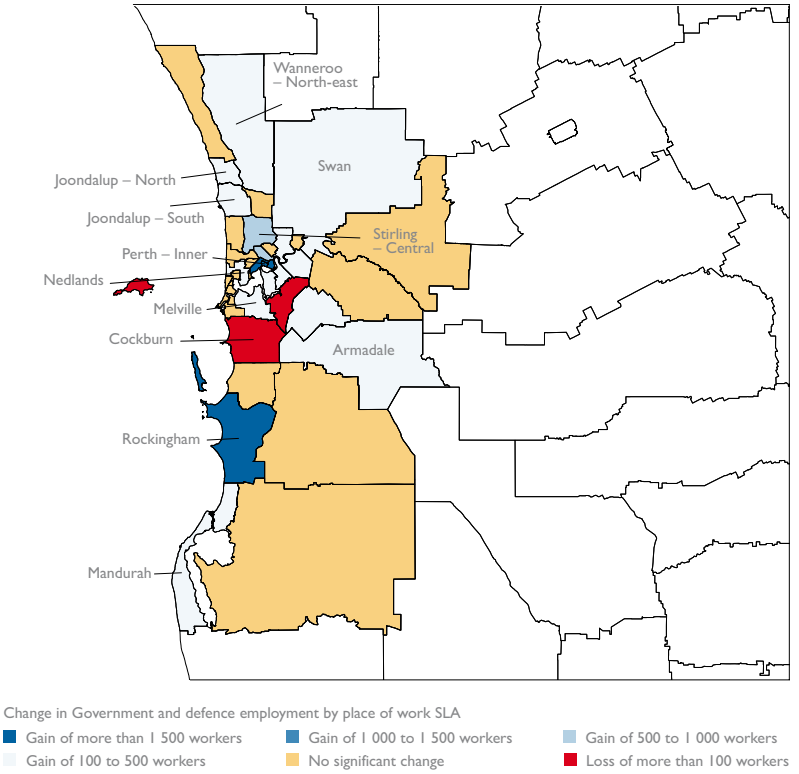
M5.4 Change in the number of employed persons in Health and community services for Statistical Local Areas, Perth, 2001 to 2006



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

The third largest industry source of employment growth in Perth between 2001 and 2006 was *government administration and defence*. Perth Inner, Perth Remainder and Rockingham all added more than 1500 jobs in *government administration and defence*. Map 5.5 indicates the main areas of *government administration and defence* jobs growth within Perth. Employment growth was more spatially concentrated than it was for *health and community services*, with only a handful of SLAs showing growth of more than 500 *Government administration* and *defence* jobs.

M5.5 Change in the number of employed persons in Government administration and defence for Statistical Local Areas, Perth, 2001 to 2006

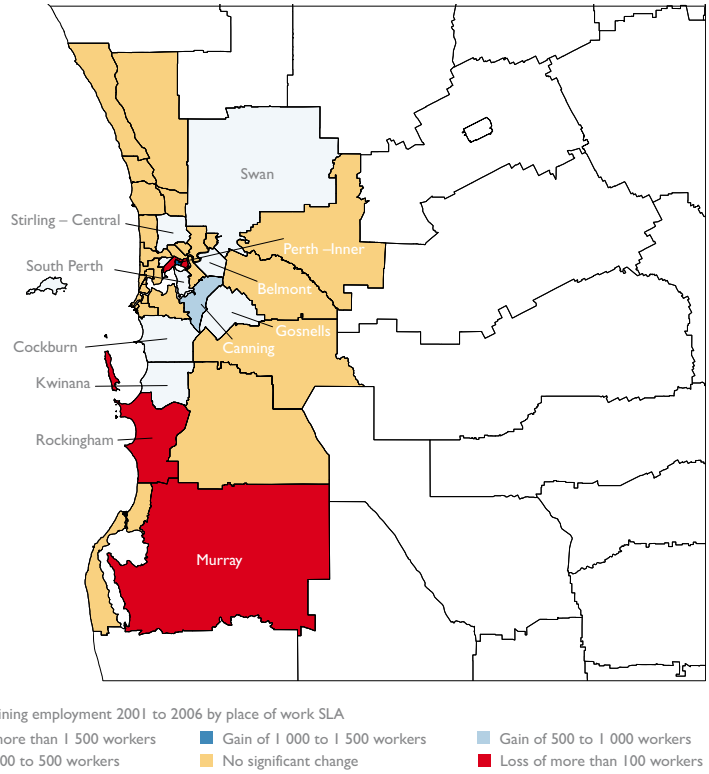


Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Mining was the industry which experienced the highest rate of jobs growth in Perth between 2001 and 2006. Map 5.6 maps the main areas of *Mining* jobs growth within Perth. Jobs growth in this industry was highly centralised, with Perth Inner SLA adding 3800 jobs and no other SLA adding more than 600 *Mining* jobs.

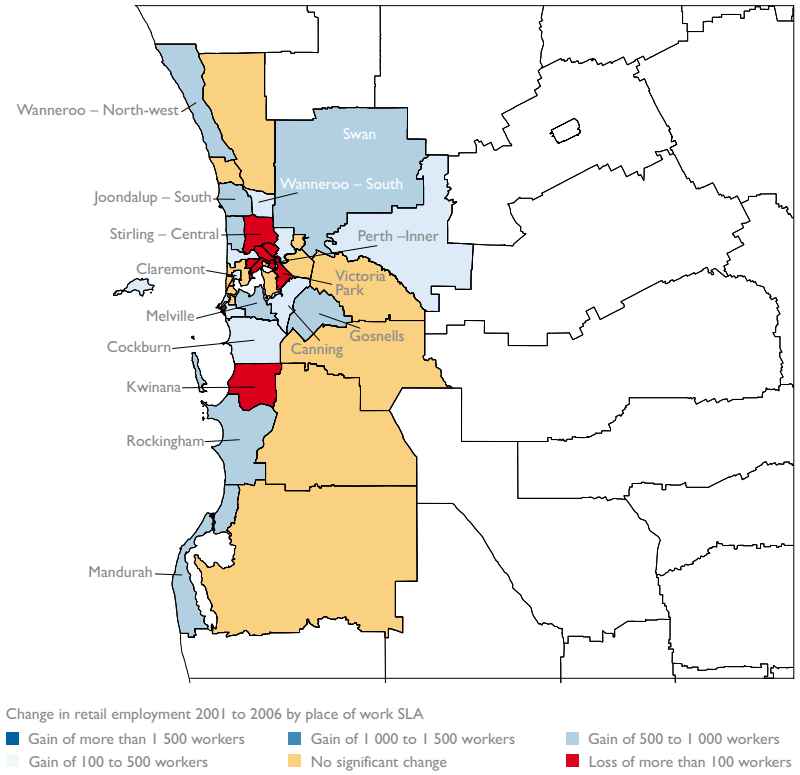
The final industry to be examined is *retail trade*, which is the single largest employing industry in Perth, but experienced fairly modest growth between 2001 and 2006. Map 5.7 maps the main areas of *retail* jobs growth and decline within Perth. It reveals a mixed picture, with many SLAs recording solid growth in *retail* employment, while Kwinana, Stirling Central and a cluster of Inner subregion SLAs all experienced employment declines.

M5.6 Change in the number of employed persons in mining for Statistical Local Areas, Perth, 2001 to 2006



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

M5.7 Change in the number of employed persons in the retail trade for Statistical Local Areas, Perth, 2001 to 2006



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

The State Planning Commission (1987) identified a trend for retail developments and employment to increasingly move away from the inner city to the middle suburbs. Between 2001 and 2006, most of the SLAs experiencing a decline in *retail trade* employment were located in the Inner subregion, while most of the large increases in *retail trade* employment were in the outer suburbs or urban fringe (e.g. Mandurah, Rockingham, Joondalup South). The middle suburbs experienced mixed fortunes. For example, while Stirling Coastal experienced strong jobs growth, Stirling Central experienced a decline in retail employment.

Recent industry changes

The ABS' *Labour Force Survey* provides some insight into the industry drivers of employment change in Perth since the last census. The following industries recorded substantial change in the number of employed residents for the Perth metropolitan region between the August quarter of 2006 and the August quarter of 2009 (ABS 2009d):

- *transport, postal and warehousing* (+20 000)
- *health care and social assistance* (+20 000)
- *construction* (+13 000)
- *retail trade* (+8000)
- *accommodation and food services* (+6000)
- *public administration and safety* (+4000)
- *information, media and telecommunications* (–6000)
- *professional, scientific and technical services* (–10 000).

The recent loss of jobs in the telecommunications industry appears to represent a continuation of the previous trend (see Figure 5.5). The *health care and social assistance, public administration and safety, retail trade* and *construction* industries all featured amongst the main sources of employment growth for the 2001 to 2006 period as well as the 2006 to 2009 period (ABS 2009d).[24] However, the strong jobs growth in the *transport, postal and warehousing* industry is a more recent development. The Labour Force Survey also indicates that the rapid rate of growth in Perth *mining* employment from 2001 continued until the November quarter in 2008, and fell just over 15 000 people in the following two quarters. It returned to positive growth in August 2009 quarter, but remained well below the 2008 employment peak.

Another source for understanding employment changes by industry is through the *Land Use and Employment Survey* completed by the Western Australian Department of Planning. These surveys are conducted over an extended period of time with the latest concluding in June 2009 but beginning in March 2007. The current estimates are preliminary only,[25] but a comparison with the employment estimates from 2002 reveals that office/business employment grew by 51 350 employed persons, far and away the highest increase, representing 58 per cent of the employment growth in commercial and industrial zones. The office/business category represents a range of different industries, which may include *government administration, business services* and *mining* headquarters. The second and third largest employment increases were in shop/retail (11 245) and manufacturing/processing/fabrication (9530). These three categories alone account for 82 per cent of the overall growth between 2002 and 2008.

The main industry drivers of jobs growth in Perth seem to have remained reasonably consistent between the intercensus period and the post-2006 period. The key differences are the recent emergence of transport and warehousing as a driver of jobs growth and a loss of mining employment following the global financial crisis.

24 The Labour Force Survey shows a considerably higher rate of growth in retail trade employment than the Census of Population and Housing for Perth between 2001 and 2006.

25 Caution should be exercised with the Land Use and Employment survey because findings are based on preliminary estimates only.

CHAPTER 6
Transport mode

Key points

- WA Government policies aim to encourage a shift towards public transport usage and reduce car dependence.
- Perth is a car dependent city, with 70 per cent of employed residents travelling to work by private vehicle in 2006. Residents of the South-West Outer subregion were the most car dependent.
- Bus use was slightly more prevalent than train use for the journey to work in 2006.
- Inner Perth had the highest proportions of employed residents travelling to work by public transport, bicycle and foot. Public transport usage was least prevalent amongst employed residents of the outlying Peel and Avon Arc subregions.
- Levels of commuter use of public transport are highest for residents who live in the immediate vicinity of railway stations.
- Strong growth in rail usage occurred following the opening of the Joondalup line in 1992 and the Mandurah line in 2007.
- Between 2001 and 2006, the proportion of employed Perth residents using public transport to get to work rose from 7.5 to 8.4 per cent.
- Public transport's mode share increased significantly in the Inner, Middle and North-West subregions between 2001 and 2006. This was due to increased rail use in the North-West, increased bus use in the Inner subregion and growth in both modes in the Middle subregion.
- The private vehicle mode share declined in the Inner and Middle subregions, but rose throughout the rest of Perth between 2001 and 2006.
- While only 17 per cent of Perth working zone employment was located in the City of Perth in 2006, 67 per cent of commuter public transport usage involved travel to a workplace in the City of Perth. Less than 8 per cent of usage was to a workplace in an Outer subregion.
- Car dependence was very high for people working in the Middle or South-West subregions and lowest for those working in the Inner subregion.
- People who work in Belmont, Canning, Kwinana, Cockburn, Stirling Central and Swan are amongst the most car dependent. These places contain large numbers of jobs, but many are located in industrial estates, which are not well served by public transport.

- In 2006, 87 per cent of Perth's jobs and employed residents were within one kilometre of a frequently serviced rail or bus stop.
- Two per cent of Perth households had no private vehicle and did not live near a frequent public transport service.
- The WA Government has a proactive approach to promoting transit-oriented development, but with a few exceptions in the Inner subregion, there has been limited achievement of land use change to date.

Introduction

This chapter considers usage of different transport modes within Perth, concentrating on the journey to work information available from the ABS *Census of Population and Housing*. The chapter begins with some contextual information, before analysing transport mode by place of residence, and then by place of work. The chapter concludes with a discussion of transit-oriented development (TOD) and access to transport within Perth.

Context

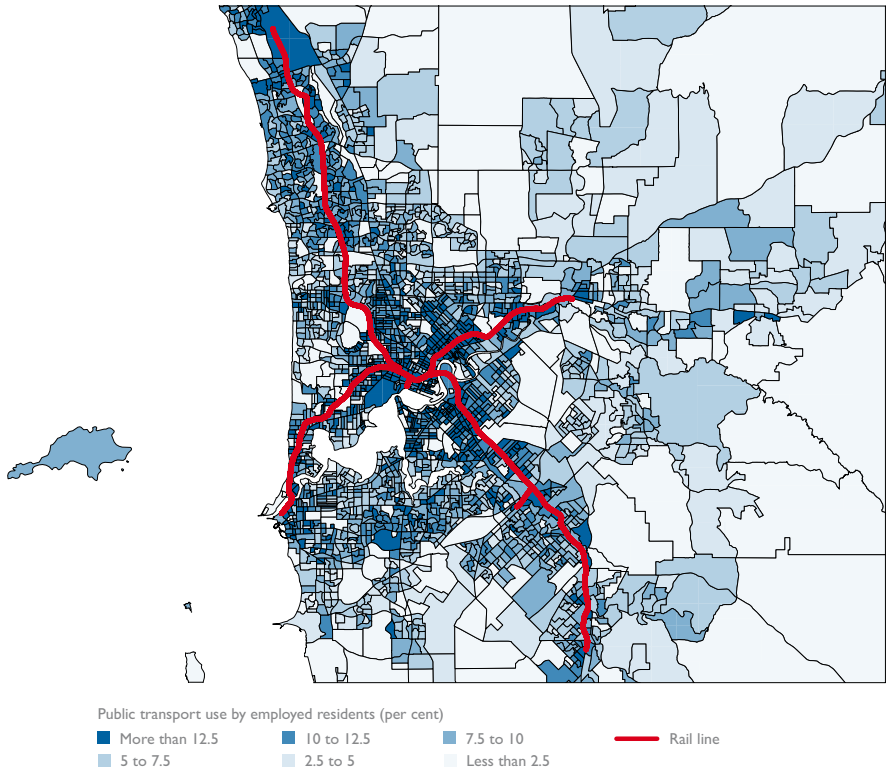
The *Network City* strategic plan aimed to encourage a shift towards public transport usage and reduce car dependence. It specifically aimed to 'encourage public transport over private transport' (WAPC 2006, p.2).

Key features relating to transport modes in Perth include:

- Perth residents and commuters are largely dependent on car transport. In particular, the city's major employment centres have spread in recent years from the central business district into Inner and Middle subregion suburbs. Many of these newer employment centres are not well served by public transport, and relatively difficult to access (WAPC 2003d, Curtis 2005).
- Perth is a geographically dispersed city, with one of the lowest population densities of Australia's capital cities (other than Canberra and Brisbane) (WAPC 2003d).
- Population growth has well exceeded employment growth in many outer suburban areas (WAPC 2003d). This means that many outer suburban residents also commute relatively long distances by car to employment centres outside their home suburbs.
- Despite this dependence upon cars, public transport use in Perth has increased in recent years. Between 2001 and 2006, the proportion of employed people who resided in the Perth working zone and used public transport to get to work increased from 7.5 to 8.4 per cent.
- In terms of transport mode share, bus use was still slightly more prevalent than train use amongst employed Perth people in their journeys to work in 2006.
- Meanwhile, the percentage of Perth working zone residents travelling to work by private vehicle remained steady at 70.4 per cent.

Map 6.1 shows that levels of commuter use of public transport in Perth are often highest in those census collection districts (CCDs) surrounding urban rail lines, and that rail plays a central role in the Perth public transport network.

M6.1 Percentage of employed persons commuting by public transport by CCD of residence, Perth, 2006

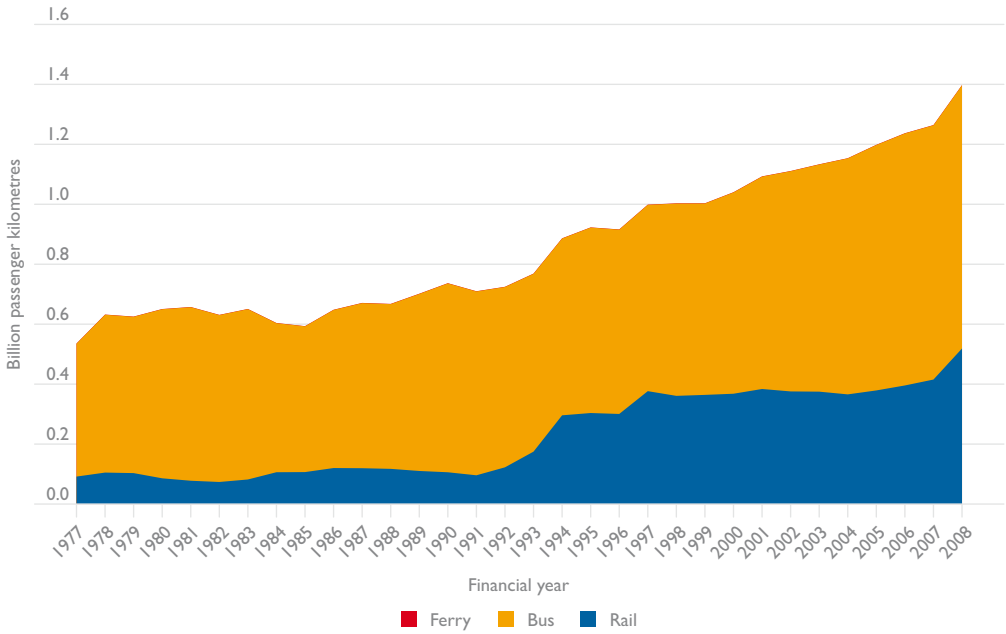


Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001) and Public Transport Authority stops and services data.

Recent growth in public transport use has been supported by the construction and extension of the north-west and south-west rail lines. Between 1976–77 and 2007–08, total annual urban passenger transport kilometres travelled increased from 0.54 billion to 1.4 billion. Notably, between the 1991–92 and 1993–94 financial years, total annual heavy rail urban passenger kilometres rose by 150 per cent, from 0.12 to 0.30 billion in Perth (BITRE 2009a, p.10). The Joondalup Line (linking the north-west to the central business district) was opened in 1992, and extended to Currambine in 1993 (Public Transport Authority 2008b). The line was extended again to Clarkson and Nowergup in 2004 (Public Transport Authority 2008c).

Further, the Mandurah Line (linking the south-west to the central business district) was opened on 23 December 2007 (Public Transport Authority 2008a). Although the line was only open for half of the 2007–08 financial year, total annual heavy rail urban passenger kilometres rose by a further 24 per cent from 0.42 to 0.52 billion during that time (BITRE 2009a, p.10). Figure 6.1 shows increases in rail and bus passenger kilometres over time in the city.

F6.1 Public transport historical trend, Perth, 1977 to 2007



Source: BITRE 2009a.

Place of residence

2006 snapshot

This section discusses modes of transport used by employed people journeying to work, based on their usual place of residence, in 2006. All data provided here has been drawn from the 2006 *Census of Population and Housing*. Spatially, it first considers transport trends across the Perth working zone as a whole. Second, it considers transport use across Perth planning subregions. Third, it considers transport use amongst residents at the Statistical Local Area (SLA) scale, and finally, at the CCD and associated suburban level.

It should be noted that many commuters used more than one mode of transport to get to work. In order to assign each person's census response to one key mode of transport for analysis, a hierarchy has been applied to the data. The hierarchy follows that outlined in the New South Wales Ministry of Transport's (2008) *Transfigures* report. It is as follows:

- train
- bus
- ferry
- tram/light rail
- taxi
- vehicle driver

- vehicle passenger
- truck
- motorbike
- bicycle
- other mode (not specified)
- walk only.

The hierarchy was created in such a way so that it 'gives priority to public transport over other modes' (ibid, p.14). This means that, for example, if a person used the train, a car and the bus to get to work, their journey to work was classified as a 'train' journey, because train is highest in the hierarchy. Similarly, if a person used the bus and a bicycle, their journey was classed as a 'bus' journey.

Perth working zone

In 2006, Perth working zone residents were largely dependent upon private vehicle transport for commuting to work, particularly cars. Table 6.1 shows that in 2006, 69.8 per cent of Perth working zone residents travelled by private vehicle (car, truck or motorbike) to work. Most of these (68.2 per cent of employed people living in the Perth working zone) travelled by car. By comparison, 8.6 per cent of the resident working population used public transport on their journey to work (bus, train, taxi, tram/light rail or ferry). Relatively few employed people walked (2.2 per cent) or cycled (0.9 per cent) to work. Similarly, few (3.6 per cent) stated that they worked from home, and hence did not commute at all.

T6.1 Employed residents by mode of transport, Perth working zone, 2006

Transport mode	Employed usual residents (per cent)	Employed usual residents (number)
Car	68.2	502 189
Private vehicle (includes cars)	69.8	514 223
Public transport	8.6	63 095
Bicycle	0.9	6 979
Walk only	2.2	16 433
Other	1.4	9 988
Mode unstated	1.7	12 577
Worked from home	3.6	26 705
Did not go to work	11.7	86 489
Total	100.0	736 489

Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001)

Table 6.2 shows that the most commonly used mode of public transport in Perth was via bus, with 4.3 per cent of residents travelling to work this way.

T6.2 Employed residents by mode of public transport, Perth working zone, 2006

Transport mode	Usually resident working people (per cent)
Bus	4.3
Train	4.0
Taxi	0.2
Other (includes ferry)	0.0
Total	8.6

Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001)

Subregions

This section discusses modes of transport used by employed persons, by subregion of residence, in 2006. Table 6.3 shows that the most heavily car dependent subregion of Perth was the South-West subregion, with 72.2 per cent of resident workers driving or travelling as a passenger. It should be noted that these 2006 figures pre-date the completion of the Mandurah rail line in the South-West. Dependence on car transport was lowest in the Inner region.

T6.3 Employed residents by mode of transport and subregion, Perth working zone, 2006

Subregion	Car	Private vehicle (includes cars)	Public transport	Bicycle	Walked	Other mode	Worked at home	Did not go to work	Method of travel not stated
	Mode share (per cent)								
Inner	59.6	60.6	12.2	2.2	5.5	1.1	4.8	12.1	1.4
Middle	68.6	70.0	9.6	1.2	1.8	1.2	3.3	11.3	1.6
Outer	70.5	72.4	7.4	0.5	1.5	1.5	3.3	11.6	1.8
North-West	69.2	71.0	9.3	0.4	1.3	1.3	3.3	11.6	1.8
North-East	70.8	72.9	6.1	0.5	1.7	1.3	3.9	11.6	1.8
South-East	70.4	72.6	7.7	0.6	1.4	1.2	3.2	11.3	1.9
South-West	72.2	73.9	5.4	0.5	1.7	2.1	2.6	12.0	1.8
Peel	69.4	71.2	2.5	0.6	2.4	1.9	4.5	14.9	2.1
Avon Arc	60.2	63.6	2.4	0.4	4.9	2.6	12.0	12.9	1.3
Perth total	68.2	69.8	8.6	0.9	2.2	1.4	3.6	11.7	1.7

Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001)

Inner Perth had the highest proportions of resident workers travelling to work by public transport (12.2 per cent), by foot (5.5 per cent) and by bicycle (2.2 per cent). Residents of the Avon Arc and Peel had the lowest levels of public transport use (2.4 per cent and 2.5 per cent respectively). Notably, however, the Avon Arc had a relatively high proportion of workers travelling to work by foot (4.9 per cent). Given the industry structure of employment in the Avon Arc region, it is possible that many of these people were agricultural business owners who nominated 'walking' as a way of getting to work on their own farms.

Table 6.4 shows public transport use by mode. The figures demonstrate that the level of train use was highest in the North-West subregion, with 7.8 per cent of resident workers travelling this way to their employment. On the other hand, train use was lowest in Peel (0.2 per cent) and the South-West (0.5 per cent). These 2006 figures pre-date the completion of the Mandurah rail line.

Bus use was highest for residents of Inner Perth (7.7 per cent) and Middle Perth (5.9 per cent). It was lowest in the North-West subregion (1.3 per cent) and the Avon Arc (1.4 per cent).

T6.4 Employed residents by mode of public transport and subregion, Perth working zone, 2006

Subregion	Train	Bus	Other (includes ferry)	Taxi
	Mode share (per cent)			
Inner	4.1	7.7	0.1	0.3
Middle	3.5	5.9	0.0	0.2
Outer	4.7	2.6	0.0	0.1
North-West	7.8	1.3	0.0	0.1
North-East	3.1	2.9	0.0	0.1
South-East	5.5	2.1	0.0	0.1
South-West	0.5	4.7	0.0	0.1
Peel	0.2	2.2	0.0	0.1
Avon Arc	1.0	1.4	0.0	0.1
Perth working zone	4.0	4.3	0.0	0.2

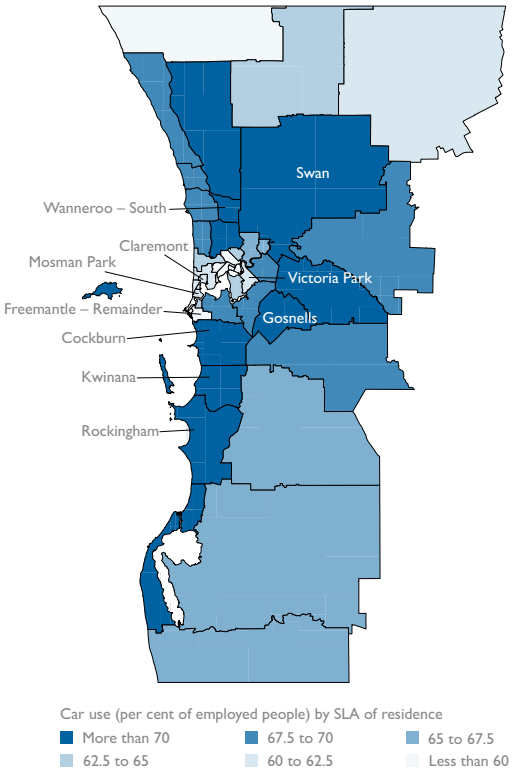
Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001)

Statistical Local Areas

This section discusses modes of transport used by employed persons, by SLA of residence, in 2006.

Map 6.2 shows that at the SLA level, car use was highest amongst residents of Rockingham, Kwinana and Cockburn in the South-West, Gosnells in the South-East and Swan in the North-East subregion. Wanneroo South in the Middle subregion also featured in this group. Car use was lowest amongst residents of a number of SLAs in the Inner subregion, including Claremont, Mosman Park, Fremantle Remainder and Victoria Park.

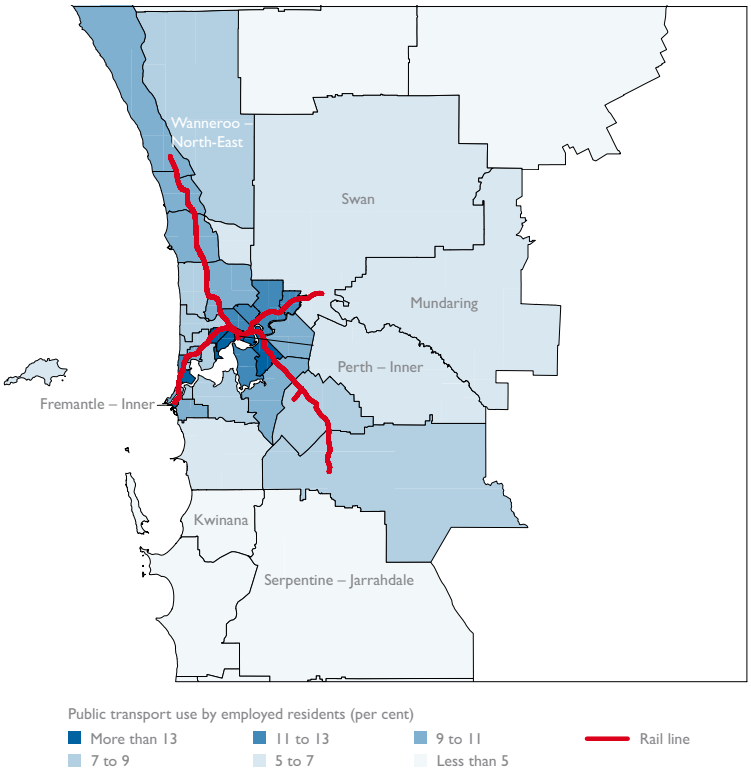
M6.2 Percentage of employed persons commuting by car by SLA of residence, Perth working zone, 2006



Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001)

Map 6.3 shows that in 2006, public transport use levels were highest amongst residents of SLAs close to the main urban rail corridors or close to the city centre. Use of public transport was lowest in outlying areas away from regular urban passenger train services. These trends are depicted in greater detail in the section on transport use at the CCD and suburb level to follow.

M6.3 Percentage of employed persons commuting by public transport, by SLA of residence, Perth 2006



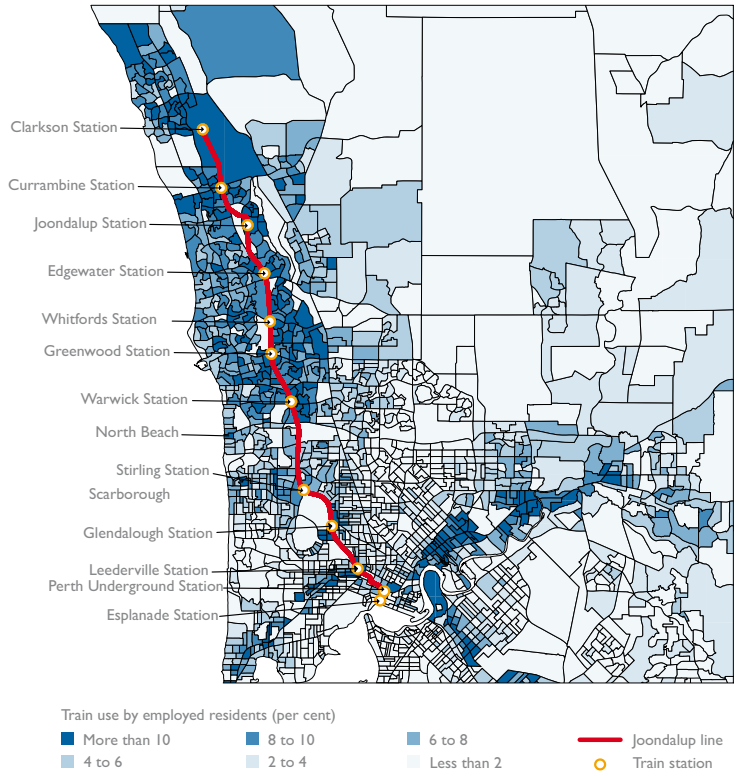
Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001) and WA Public Transport Authority stops and services data.

Collection districts and suburbs

This section discusses modes of transport used by employed persons, by CCD and suburb of residence, in 2006. As discussed earlier, car use dominated commuter transport across the whole of the Perth working zone. This is also reflected at the CCD and suburban level.

Maps 6.4 to 6.7 show that train use was highest amongst residents of those suburbs along a railway line, and particularly high in the immediate vicinity of a railway station. Map 6.4, for example, shows that those suburbs adjacent to railway stations had the highest levels of train use along the Joondalup train line in the North-West subregion. Train use was also high in parts of Scarborough, which is connected to Stirling Station by regular bus services (Transperth 2009a and 2009b). Similarly North Beach, which is connected to Warwick and Stirling Stations by bus (Transperth 2009c), had high levels of train use. Like many major Perth railway stations, both Stirling and Warwick also have park and ride facilities (Transperth, n.d.), which increase their accessibility for people who rely on car transport to reach the train station.

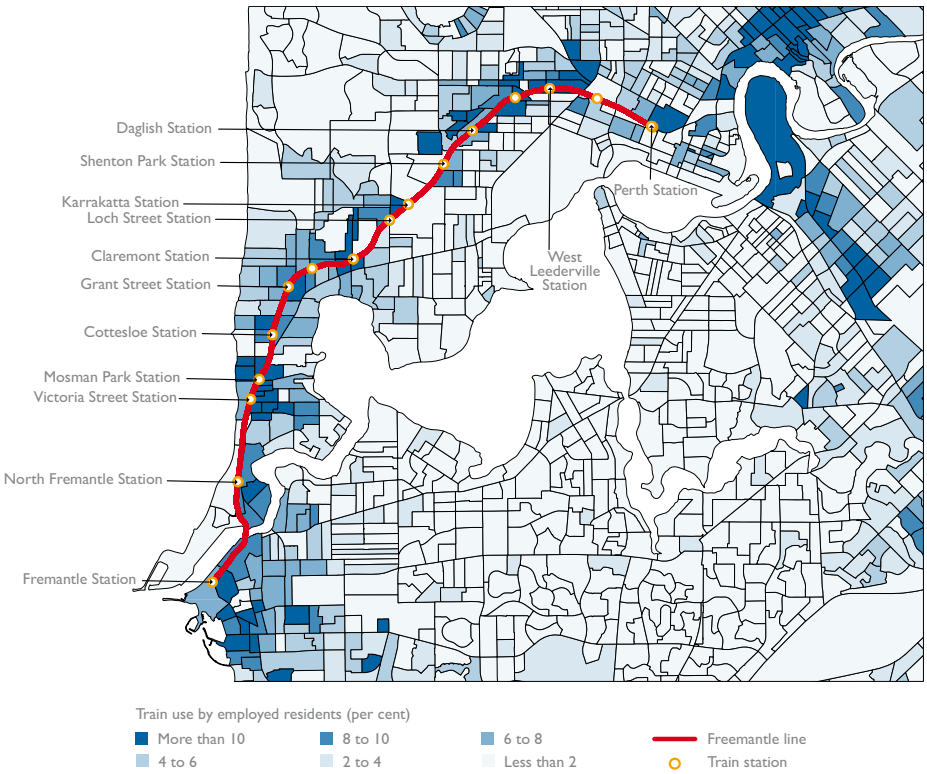
M6.4 Percentage of employed people using the train on the Joondalup Line by CCD of residence, 2006



Note: Esplanade station was not operational in 2006.

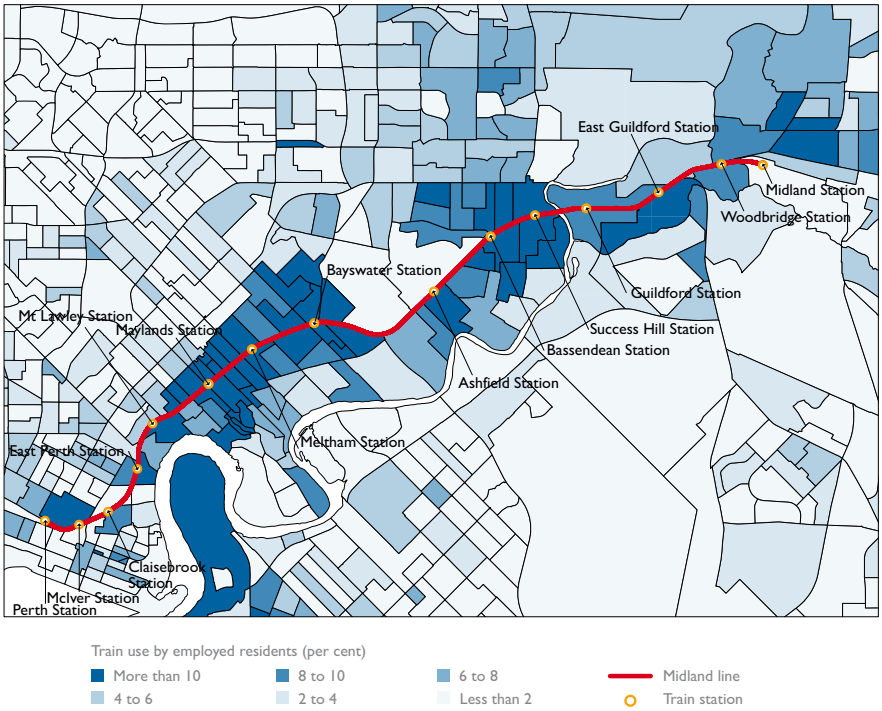
Source: BITRE analysis of ABS 2006 Census basic community profile release 2 (Cat. 2069.0.30.001) and WA Public Transport Authority stops and services data.

M6.5 Percentage of employed people using the train on the Fremantle Line by CCD of residence, 2006



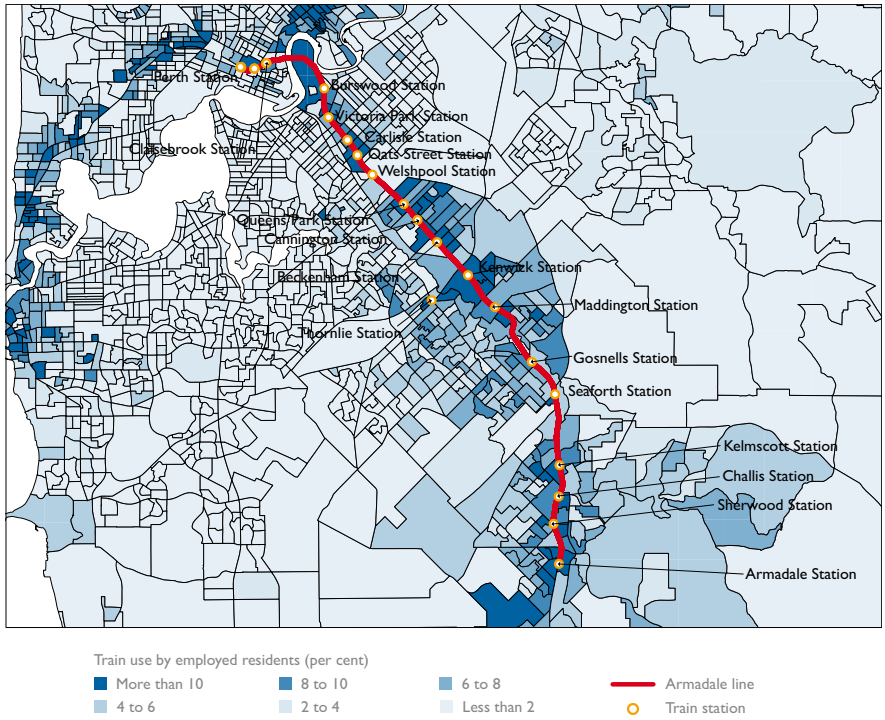
Source: BITRE analysis of ABS 2006 Census basic community profile release 2 (Cat. 2069.0.30.001) and WA Public Transport Authority stops and services data.

M6.6 Percentage of employed people using the train on the Midland Line by CCD of residence, 2006



Source: BITRE analysis of ABS 2006 Census basic community profile release 2 (Cat. 2069.0.30.001) and WA Public Transport Authority stops and services data.

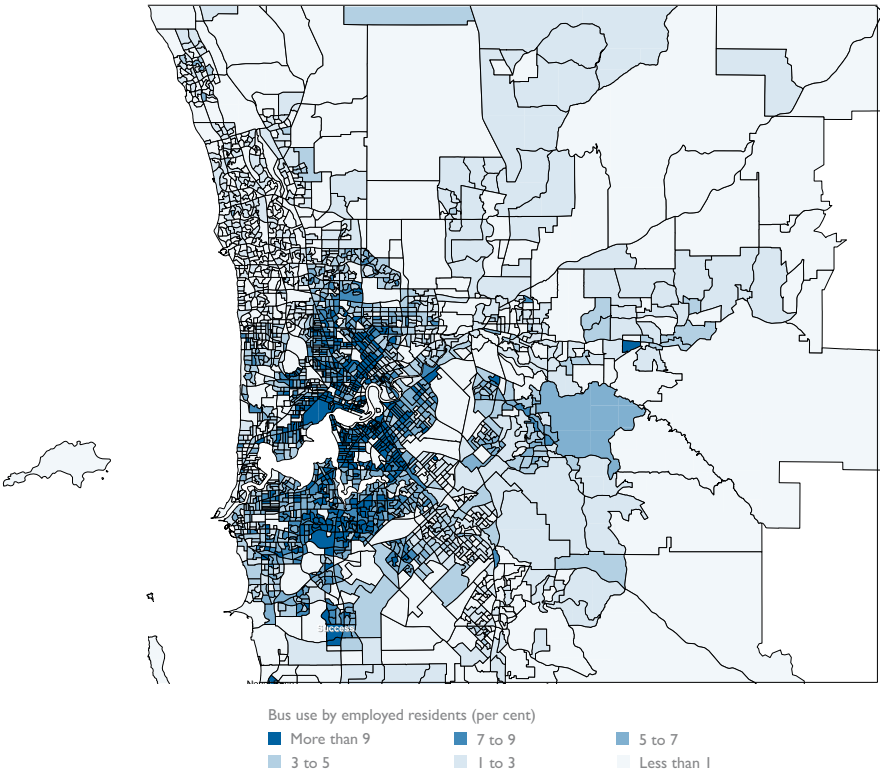
M6.7 Percentage of employed people using the train on the Armadale Line by CCD of residence, 2006



Source: BITRE analysis of ABS 2006 Census basic community profile release 2 (Cat. 2069.0.30.001) and WA Public Transport Authority stops and services data.

With respect to bus use, people who lived in the suburbs surrounding the central business district were most likely to use this mode of transport (see Map 6.8). Residents of the suburbs of Success and Attwell in Cockburn (neighbouring suburbs in the South-West subregion) also used the bus relatively often to get to work.

M6.8 Percentage of employed people using the bus in Perth by CCD of residence, 2006

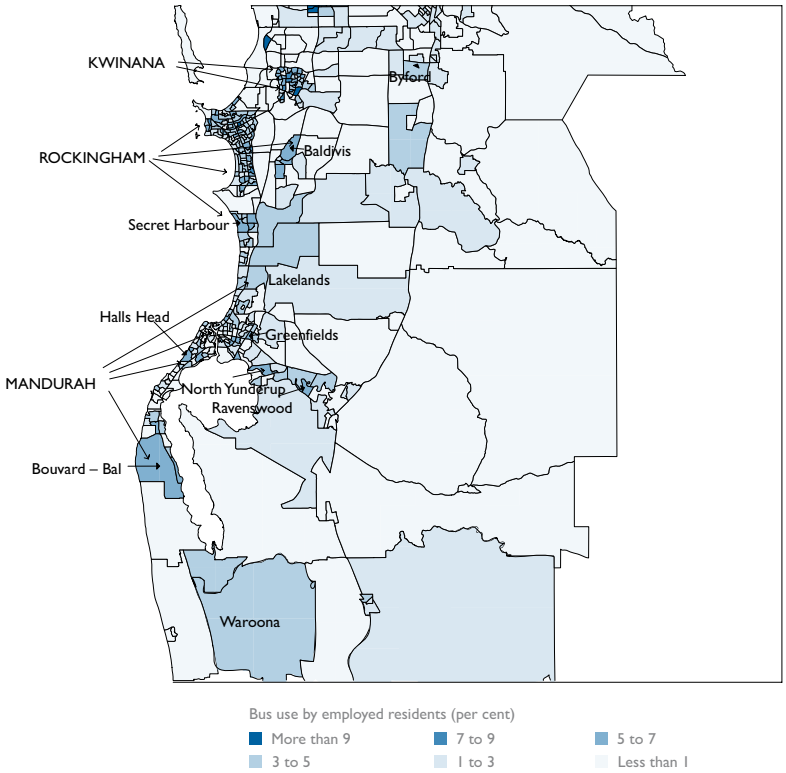


Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001)

Map 6.9 shows that higher than average levels of bus use were also evident in the inner suburbs of the town centres of Rockingham and Kwinana to Perth's south. In the city of Mandurah, areas with high bus use were more dispersed, including parts of Halls Head, Erskine, Coodanup, Dudley Park, Mandurah, Greenfields, Silver Sands and Lakelands. At the time of the census, more than 4 per cent of workers from Waroona also used bus transport. Regular public bus services were offered between Waroona, Pinjarra and Mandurah during that period (Department for Planning and Infrastructure 2006).

Meanwhile, bus use levels outside these areas were generally low. As Hill (2005) points out, bus transit services do serve more remote locations, but face the challenge of catering to a widely dispersed population, whose needs vary. He asserts that as a result, '[t]ravelling between major regional centres, or attempting intra-suburban travel, can be frustrating at best' (Hill 2005 p.146).

M6.9 Percentage of employed people using the bus in south-western Perth and Peel by CCD of residence, 2006



Source: BITRE analysis of ABS 2006 Census DataPacks: basic community profile release 2 (Cat. 2069.0.30.001)

With respect to those people who walked to work, it is difficult to draw out clear spatial patterns from the available data. The CCDs which had high proportions of people walking to work are widely dispersed. Almost all of the peri-urban and rural regions surrounding Perth show high numbers of people walking to work. One of the reasons for this could be a tendency amongst people who live in rural areas to nominate walking as the method of getting to work on their own farms. This said, the 2006 CCD level data does show a concentration of people walking to work in and around the central business district, north of the Swan River. These people lived in Perth, North Perth, West Perth, East Perth and Mount Lawley.

Changes from 2001 to 2006

This section discusses changes in the modes of transport used by employed people journeying to work, based on their place of residence, between 2001 and 2006. Importantly, this section is not based on people's usual place of residence in August 2006, but upon the place where they were staying on census night (place of enumeration). This is because BITRE was most readily able to access reliable, comparable, disaggregated transport mode data for the years 2001 and 2006 according to place of enumeration. Across a range of geographical classifications within Perth, at least in 2006, the transport mode share figures were relatively similar between place of usual residence and place of enumeration census counts, so the place of enumeration data is useful here.

Perth working zone and city subregions

Table 6.5 shows that amongst people staying in the Perth working zone (Perth total) on census night, car and private vehicle mode share remained stable between 2001 and 2006. Meanwhile, the public transport mode share increased by 0.9 per cent. At the same time, there was a decline in the share of people working from home, by –0.5 per cent.

With respect to city subregions, car mode share declined in the Inner and Middle subregions, whilst public transport mode share increased. Car mode share increased in all of the other subregions (most notably amongst people living in the Avon Arc). At the same time, public transport mode share increased across all of the Perth working zone except the Avon Arc. It increased most in the Inner, Middle and North-West subregions. Table 6.5 shows that in the North-West, almost all of the public transport mode share growth was due to increases in train use, probably linked to the extension of the Joondalup railway in 2004. Bus mode share growth was strongest in the Inner subregion. At the other end of the spectrum, it declined in the South-East.

T6.5 Change in transport mode share amongst employed people enumerated in the Perth working zone, by subregion, 2001 to 2006

Subregion	Train	Bus	Public transport total	Car	Private vehicle total	Bicycle	Other mode	Walked	Worked at home	Did not go to work	Method of travel to work not stated
					(percentage point change in mode share)						
Inner	0.4	1.5	1.9	–2.4	–2.3	0.3	–0.4	1.0	–0.3	–0.3	0.0
Middle	0.6	0.7	1.3	–0.6	–0.7	0.1	–0.3	0.2	–0.4	–0.4	0.1
Outer	0.4	0.1	0.6	0.9	0.7	0.0	–0.2	0.0	–0.6	–0.8	0.3
North-West	0.9	0.1	1.0	0.3	0.3	0.0	–0.3	0.1	–0.5	–0.9	0.3
North-East	0.1	0.3	0.4	1.1	0.8	–0.1	–0.3	0.0	–0.8	–0.5	0.4
South-East	0.7	–0.3	0.4	1.4	1.2	0.0	–0.5	–0.1	–0.6	–0.8	0.3
South-West	–0.1	0.3	0.2	0.9	0.7	–0.1	0.5	0.1	–0.5	–1.1	0.2
Peel	0.0	0.3	0.3	1.8	1.7	–0.1	–0.5	0.0	–0.5	–1.0	0.1
Avon Arc	–0.1	0.1	0.0	5.8	5.8	0.0	–0.2	–0.7	–3.0	–0.3	–1.6
Perth total	0.5	0.4	0.9	0.0	0.0	0.0	–0.3	0.2	–0.5	–0.6	0.2

Source: BITRE derived data from ABS 2006 Census DataPacks: place of enumeration profile release 2 (Cat. 2069.0.30.004); ABS CData 2001.

Walking and bicycle mode shares both increased most in the Inner subregion of the city. Walking (along with working from home) declined most in the Avon Arc.

Whilst both car and public transport mode shares were increasing in most subregions, there were corresponding decreases in the share of employed people using other modes of transport to get to work that day,[26] in the share of people working from home, and in the share of employed people who did not go to work on the day of the census.

Statistical Local Areas

Map 6.10 shows that between 2001 and 2006, car use increased its transport mode share most amongst residents of the peri-urban and rural SLAs of Gingin, Wanneroo North-East, Toodyay and Chittering. This could relate to broader economic restructuring processes in these peri-urban areas occurring during the same period. ABS industry of employment data from the 2001 and 2006 censuses shows a decline in the number of (often locally based) agricultural jobs in Toodyay (–8.9 per cent), Chittering (–2.7 per cent) and Wanneroo North-East (–0.5 per cent), for example. At the same time employment in a range of other industry sectors, such as +mining and construction, grew significantly.

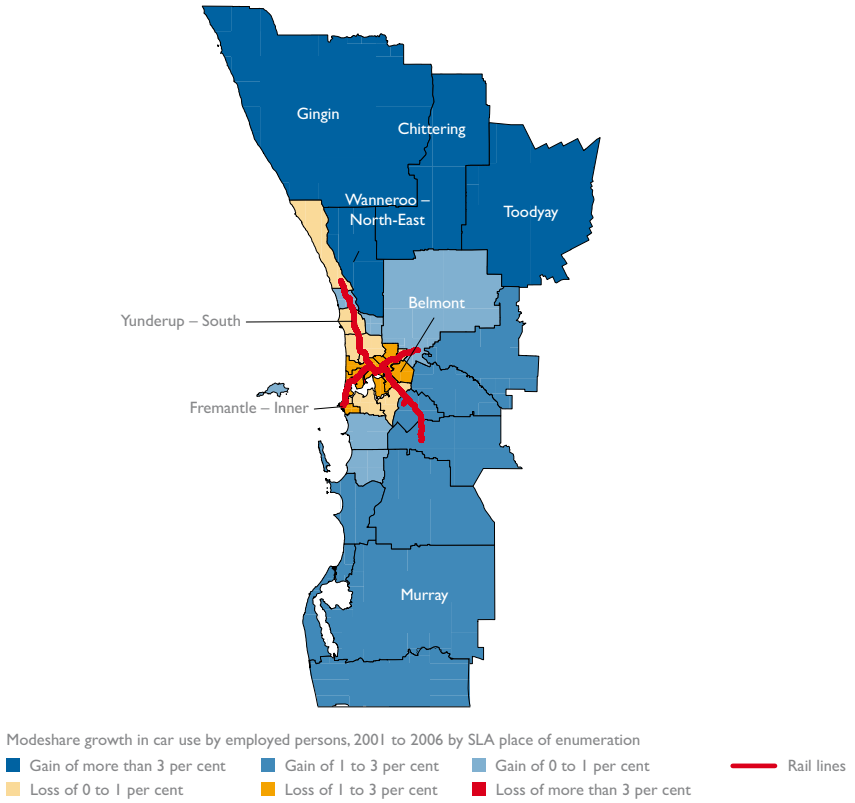
Meanwhile, car mode share has decreased most in many Inner SLAs, where a corresponding rise in the public transport mode share has been evident.

Map 6.11 shows that between 2001 and 2006, public transport as a share of all transport modes used by commuters increased most in the SLAs of Wanneroo North-West, Claremont, Mosman Park, South Perth, Victoria Park, Bassendean and Bayswater.

The increase in public transport mode share in some of these SLAs was chiefly due to higher levels of train use. This was most apparent in Wanneroo North-West (Joondalup rail line), Bayswater and Bassendean (Midland rail line) and Claremont and Mosman Park (Fremantle rail line). In 2004, the Joondalup rail line was extended from Currambine to Clarkson in Wanneroo. This probably accounts for much of the public transport mode share increase in the Wanneroo SLAs. Public transport mode share increases in South Perth and Victoria Park, however, were largely due to an increase in bus transport mode share (up by 2.4 and 2.5 per cent respectively).

26 Method of travel to work data was collected in 2006 and 2001 based on the method of travel to work used on the day of the census (ABS 2006d:108; ABS 2001b:104).

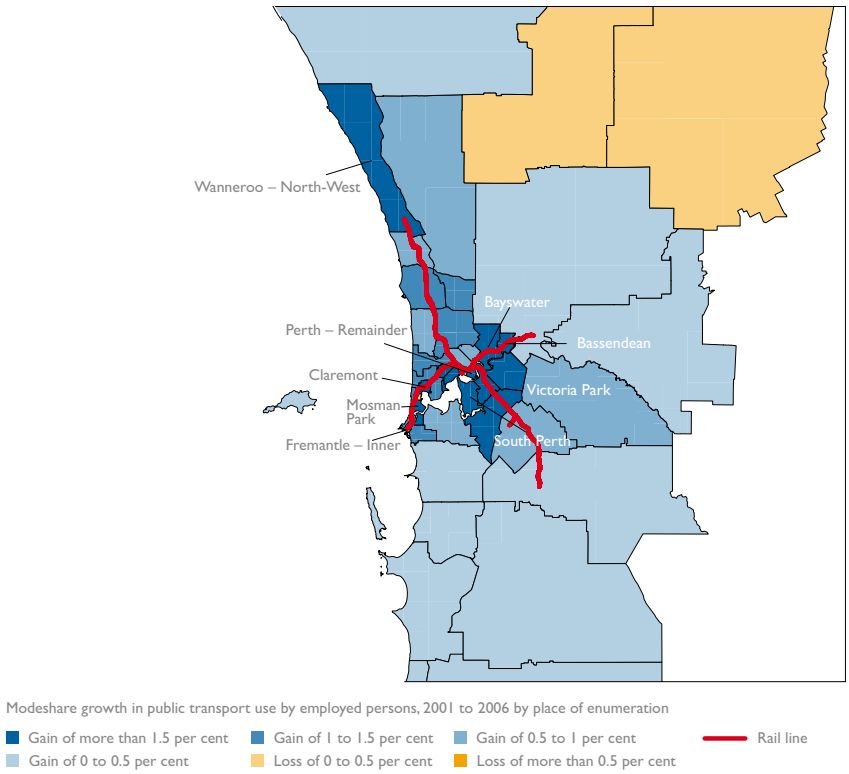
M6.10 Percentage point change in car mode share amongst employed people enumerated in the Perth working zone, by SLA, 2001 to 2006



Source: BITRE derived data from ABS 2006 Census DataPacks: place of enumeration profile release 2 (Cat. 2069.0.30.004); ABS CData 2001 and WA Public Transport Authority stops and services data.

Between 2001 and 2006, public transport mode share decreased in the SLA of Fremantle Inner by 6.3 per cent, whilst private vehicle transport increased by five per cent. Importantly, however, only 454 employed people lived in this SLA on census night in 2006, so the mode share change does not represent a large number of people shifting between transport modes.

M6.11 Percentage point change in public transport mode share amongst employed people enumerated in the Perth working zone, by SLA, 2001 to 2006



Source: BITRE derived data from ABS 2006 Census DataPacks: place of enumeration profile release 2 (Cat. 2069.0.30.004); ABS CData 2001; WA Public Transport Authority stops and services data.

Place of work

This section discusses modes of transport used by employed people journeying to work, based on their place of work (regardless of whether they lived in the Perth working zone) in 2006. All data provided here has been drawn from the 2006 *Census of Population and Housing*.

Spatially, this section first considers transport trends across the Perth working zone as a whole. Second, it considers transport use across subregions. Third, it considers transport use at the Journey to Work Statistical Local Area (JWSLA) level. [27]

27 BITRE does not hold statistics on journey-to-work transport modes at the CCD or Destination Zone level, where these statistics are based on place of work (as opposed to place of residence).

Perth working zone

In 2006, the transport mode share was almost identical between those people who lived in the Perth working zone (see Table 6.1), and those people who worked in the Perth working zone (see Table 6.6). People who worked in the Perth working zone were largely dependent upon private vehicle transport in their journey to work.

Table 6.7 shows that with respect to public transport, people who worked in the Perth working zone reported using the train marginally more than the bus. This is slightly different from people who lived in the Perth working zone (see Table 6.2), more of whom used the bus (4.3 per cent) than the train (4.0 per cent).

T6.6 Mode of transport used by employed people to travel to a place of work in the Perth working zone, 2006

Transport mode	Employed persons working within the Perth w orking zone (per cent)	Employed persons working within the Perth working zone (number)
Car total	69.3	446 962
Private vehicle (includes cars)	70.7	455 589
Public transport	8.7	56 280
Bicycle	1.0	6 455
Walk only	2.2	14 100
Other	0.9	5 988
Mode unstated	1.1	6 785
Worked from home	3.9	25 444
Did not go to work	11.5	74 045
Total	100.0	644 686

Source: BITRE analysis of ABS 2006 Census DataPacks: working population profile release 2 (Cat. 2069.0.30.006)

T6.7 Mode of public transport used by employed people to travel to a place of work in the Perth working zone, 2006

Transport mode	Employed persons working within the Perth working zone (per cent)	Employed persons working within the Perth working zone (number)
Bus	4.2	27 151
Train	4.3	27 811
Taxi	0.2	1 137
Other (includes ferry)	0.0	181
Total	8.7	56 280

Source: BITRE analysis of ABS 2006 Census DataPacks: working population profile release 2 (Cat. 2069.0.30.006)

Subregion

This section discusses modes of transport used by employed persons, by workplace subregion, in 2006. Table 6.8 shows that car dependence was highest amongst people working in the Middle and South-West subregions (it should be noted that these figures were collected before the opening of the Mandurah rail line). It was lowest amongst people working in the Inner subregion and the Avon Arc. Table 6.8 also shows that people working in the Inner subregion were most likely to use public transport to get to work in 2006. Almost one-fifth of people who worked in the Inner subregion used public transport. Bicycle use was also strongest amongst people working in the Inner subregion.

T6.8 Mode of transport used by employed people to travel to a place of work subregion, Perth working zone, 2006

Subregion of work	Car	Private vehicle (includes cars)	Public transport	Bicycle	Other mode	Walked	Worked at home	Did not go to work	Method of travel to work not stated
	Mode share (per cent)								
Inner	59.9	60.8	19.4	1.5	0.8	2.7	2.4	11.5	0.9
Middle	76.5	78.0	3.3	0.8	0.8	1.6	3.7	10.9	1.1
Outer	73.7	75.4	2.1	0.6	1.2	2.1	5.7	11.7	1.2
North-West	71.2	72.8	2.5	0.5	0.8	2.0	7.1	13.0	1.2
North-East	74.9	76.8	2.0	0.6	0.9	2.1	5.6	10.9	1.1
South-East	71.6	73.6	2.3	0.8	0.9	2.3	6.7	12.1	1.3
South-West	76.2	77.9	1.8	0.6	2.1	2.0	3.7	10.8	1.1
Peel	72.3	73.7	0.7	0.6	1.2	2.3	5.3	15.0	1.3
Avon Arc	57.2	60.6	0.3	0.4	2.4	6.6	17.5	11.2	1.1
Perth total	69.3	70.7	8.7	1.0	0.9	2.2	3.9	11.5	1.1

Source: BITRE analysis of ABS 2006 Census DataPacks: working population profile release 2 (Cat. 2069.0.30.006)

In fact, more than 81 per cent of all Perth working zone employees who used public transport (45 741 people from a total of 56 280) worked in the Inner subregion (see Table 6.9). The Middle subregion of Perth also had a small concentration of public transport users, but there were over seven times as many public transport users working in and around the central business district. Relatively few people used public transport to access a place of work in one of the Outer subregions.

In keeping with observations made earlier in this chapter about people working in agricultural industries, walking to work was most common amongst those people working in the Avon Arc. Notably, many people working in the Avon Arc described themselves as working from home.

T6.9 Percentage of all employed public transport users by subregion of work, Perth, 2006

Subregion of work	Proportion of all employed public transport users in Perth working zone (per cent)
Inner	81.3
Middle	11.0
North-West	2.5
North-East	2.0
South-East	1.3
South-West	1.7
Peel	0.3
Avon Arc	0.0
Perth total	100.0

Source: BITRE analysis of ABS 2006 Census DataPacks: working population profile release 2 (Cat. 2069.0.30.006)

Table 6.10 shows that even within the Inner subregion of Perth, much of the public transport use was concentrated in the two SLAs of Perth Inner and Perth Remainder. It also shows that train use was even more concentrated amongst people who worked in the Inner subregion. More than 84 per cent of train commuters journeyed daily to workplaces here. Bus use was similarly concentrated, with more than 79 per cent of bus users working in the Inner subregion of Perth.

T6.10 Percentage of all employed public transport, rail and bus users by place of work, Perth, 2006

Subregion of work	Proportion of all users of that mode within Perth working zone (per cent)		
	Employed public transport users	Employed train users	Employed bus users
City of Perth (Inner Perth and Perth Remainder)	67.4	69.4	67.0
Inner subregion (Remainder)	13.9	15.1	12.3
Middle	11.0	9.1	12.3
North-West	2.5	2.8	2.1
North-East	2.0	1.7	2.0
South-East	1.3	1.6	0.9
South-West	1.7	0.3	2.8
Peel	0.3	0.0	0.4
Avon Arc	0.0	0.0	0.0
Perth total	100.0	100.0	100.0

Source: BITRE analysis of ABS 2006 Census DataPacks: working population profile release 2 (Cat. 2069.0.30.006)

By comparison, Table 6.3, which was based on people's place of residence, showed that public transport use was not as heavily concentrated amongst residents of inner city suburbs, instead being much more widely distributed across subregions. This would suggest that many of the public transport users were people living outside the Inner subregion and travelling to inner city workplaces, where 36.4 per cent of Perth jobs were located (see Table 4.1). This can be contrasted with current city planning models which espouse the goal of self-containment—namely people living and working within the same subregion (Curtis 2005).

Census statistics also show that more than 60 per cent of people working in the Inner subregion still travelled to work by private vehicle in 2006. The current situation could pose challenges to Perth planning authorities' plans to gradually eliminate central area car parking spaces, and to encourage commuters to use public transport instead (Hill 2005).

The large scale movement of public transport passengers from outlying areas to inner city workplaces may also be contrasted with the WAPC's goal of anchoring major Perth public transport routes at both ends to major employment hubs or activity centres, in order to 'create more balanced passenger demand in both directions and make ... more efficient use of available public transport capacity' (WAPC 2004a). The minimal usage of public transport to access workplaces in the Outer subregions suggests that public transport ridership remains very unbalanced in peak periods.

The second largest concentration of jobs (29.1 per cent) was in Perth's Middle subregion. However, Table 6.8 has shown that only 3.3 per cent of people who worked there used public transport, whilst 78 per cent travelled by private vehicle. As a place of work, Perth's Middle subregion was the most dependent upon private vehicle transport. This is commensurate with the fact that, as recognised by the WAPC, many of the newer workplaces emerging outside Perth's central business district are not well served by public transport (WAPC 2003d). High trip generating developments continue to be permitted in locations that are not accessible by public transport, with WAPC (2003d) citing examples of an office park redevelopment and a TAFE relocation.

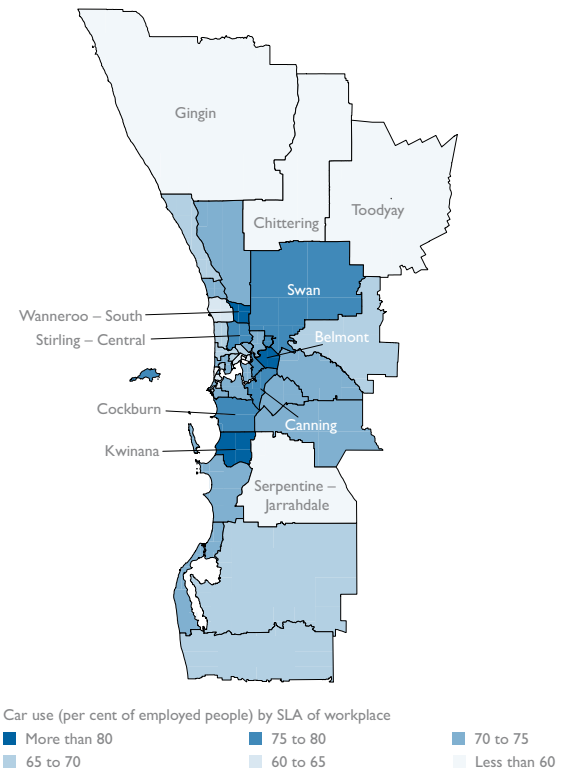
This situation can be contrasted with Curtis' (2005 p.171) concern that the continued viability of Perth's public transport system depends on '[a] balance between maintaining a strong CBD and achieving growth at the centres within activity corridors'. She argues that both CBD and non-CDB employment centres need to continue to be located around public transport nodes, and that there is more potential for this, particularly in middle ring areas of the city such as Osborne Park, Cannington and Murdoch (Curtis 2005 p.171–72).

Journey to work statistical local area

This section discusses modes of transport used by employed persons, by SLA of work, in 2006.

Levels of car use were highest amongst people working in the Middle subregion SLAs of Belmont, Canning and Stirling Central; and amongst people working in the South-West subregion SLAs of Kwinana, Cockburn and Rockingham (see Map 6.12). In Belmont and Canning, a significant proportion of employment was dispersed across a number of industrial estates, rather than being focused in any particular central area which could easily be reached by public transport. In Stirling, workplaces were also widely dispersed, but with a broader range of employing industries. The car transport mode share was high amongst people working in the North-East subregion SLA of Swan, with a similarly dispersed range of workplaces, and a broad range of employing industries.

M6.12 Percentage of employed persons commuting by car, by SLA of work, Perth, 2006

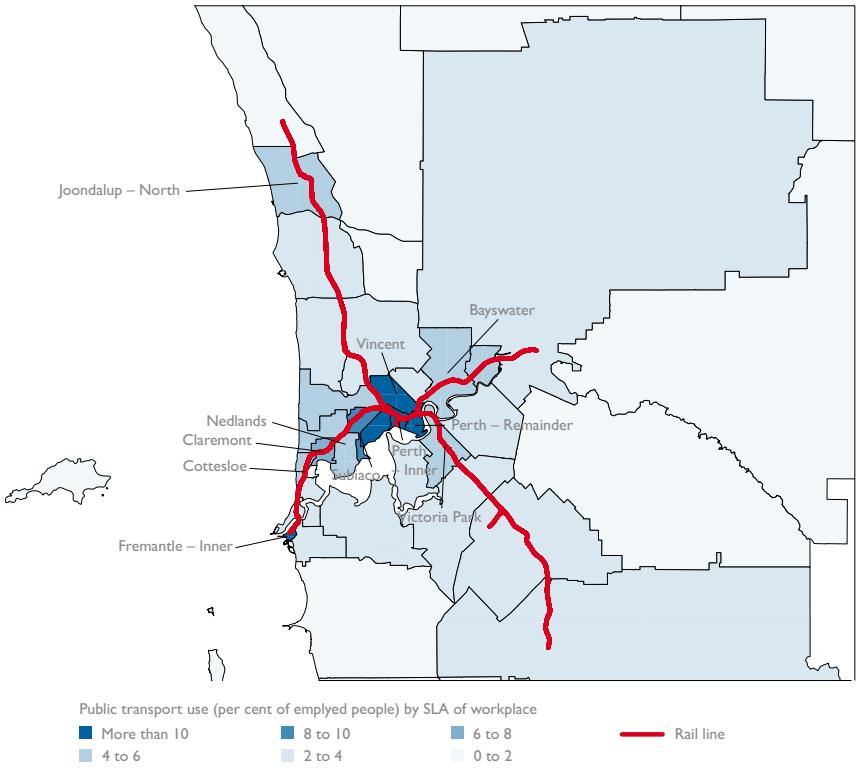


Source: BITRE analysis of ABS 2006 Census DataPacks: working population profile release 2 (Cat. 2069.0.30.006)

Car use levels were lower amongst people working in inner city SLAs. They were also lower in Gingin, Chittering and Toodyay of the Avon Arc. As shown in Table 6.8, a high proportion of people working in the Avon Arc either worked from home (often in an agricultural business) or walked to work (again, probably in an agricultural business).

At the SLA level, Map 6.13 provides more detail on the way in which public transport commuters work in places concentrated around the central business district of Perth. Almost all of the workplace SLAs where public transport mode share was highest were located in the Inner subregion of Perth. They were also located in close proximity to an urban rail line (in addition to being service by bus routes).

M6.13 Percentage of employed persons commuting by public transport, by SLA of work, Perth, 2006



Source: BITRE analysis of ABS 2006 Census DataPacks: working population profile release 2 (Cat. 2069.0.30.006) and WA Public Transport Authority stops and services data.

Despite the high levels of car dependence outside the Inner subregion discussed earlier, Joondalup North in the North-West subregion is something of an exception. This SLA's public transport mode share was 4.2 per cent, which was significantly higher than in other outer suburban areas. Many of those people working in Joondalup North and using public transport, travelled to work by train (2.8 per cent transport mode share).

Joondalup North can be highlighted here as an example of Perth's more successful linkages between public transport networks, public transport nodes and emergent employment hubs outside the inner city. As Hill (2005 p.126–127,144–145) points out, Joondalup has been identified as a strategic regional centre for employment development since the introduction of corridor planning in Perth in the late 1960s. The centre of Joondalup is located adjacent to the Joondalup train station and is serviced by regular train arrivals and departures throughout the day, making it accessible to work commuters.

Transport access issues

The literature provides evidence that a lack of access to transport can be an important barrier to participation in work and education and to accessing a range of services (Hurni 2006). For example, a lack of transport access on the urban fringe has been linked to limited employment opportunities for young residents (Currie 2009). According to Currie (2009), the links between social disadvantage and transport are particularly significant in urban Australia.

This section provides some evidence about how transport access varies for residents of different parts of Perth. It also investigates the extent to which jobs in Perth can be readily accessed by the rail and bus systems.

Transport access by place of residence in 2006

Private vehicle is by far the most commonly used transport mode within Perth. However, not everyone has access to a vehicle or can drive. Those without a vehicle may face access difficulties if other options (such as public transport) are not available. In the context of outer suburban Melbourne, Currie (2009) points out that 83 per cent of zero car ownership households reported access difficulties.

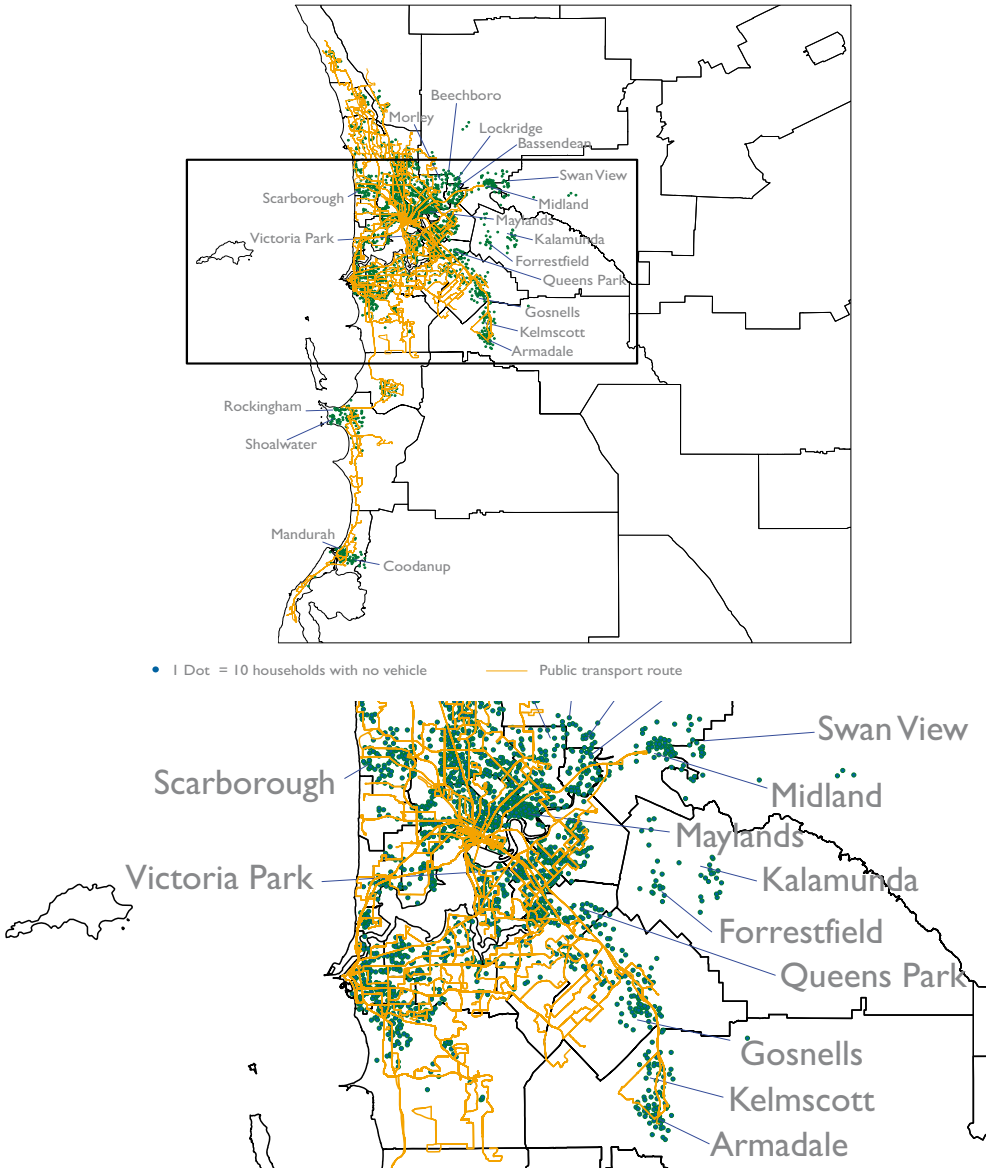
The ABS' 2006 *Census of Population and Housing* provides information on the number of dwellings that do not have a motor vehicle for each CCD. Only 7 per cent of Perth dwellings did not have a vehicle. The proportion of dwellings with no vehicle is highest in the Inner subregion (12 per cent), followed by the Middle subregion (9 per cent). It is relatively low for the Outer subregion (5 per cent), Peel (6 per cent) and the Avon Arc (3 per cent). At the LGA scale, the proportion of dwellings without a vehicle was highest for the City of Perth (24 per cent) and Victoria Park (16 per cent).

Map 6.14 shows the spatial distribution of dwellings without a vehicle, and overlays this with public transport routes which have services at least every 15 minutes during the morning peak period.[28] Data on public transport routes and frequency was obtained from Transperth, and is freely available from <www.transperth.wa.gov.au>. The Transperth data relates to the public transport timetable in operation in August 2009, while the population data relates to August 2006. New stations on the Mandurah line have been excluded from BITRE's analysis of accessibility, but no further attempt has been made to adjust for changes in public transport services between 2006 and 2009.

Map 6.14 shows that the north-western suburbs of Perth tend to have relatively few households without a vehicle. These suburbs also have many frequent public transport routes. The households without a vehicle are concentrated to the north and east of the city, particularly in the inner and middle suburbs. Some of these areas have access to frequent public transport services, while others do not. Some of the suburbs that stand out as having a concentration of households without a vehicle and a relative absence of frequent public transport services are Maylands, Kalamunda, Swan View, Forrestfield, Gosnells, Scarborough, Shoalwater and Coodanup. This does not mean there is no frequent bus or train service to the suburb, but just that there are parts of the suburb that are distant from any such service.

28 The focus on peak periods reflects this study's focus on commuter travel.

M6.14 Dot density map showing distribution of households who do not own a motor vehicle, Perth working zone, 2006



Note: Public transport routes with at least 15 minute frequency in morning peak are shown. Mandurah railway excluded as it was not operational in 2006.

Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data at CCD scale and WA Public Transport Authority stops and services data for 2008.

Areas with and without public transport services of at least 15 minutes frequency during the weekday morning peak period were identified based on 2006 CCD boundaries. Table 6.11 divides each subregion into the portions with and without frequent public transport, showing the number and percentage of zero vehicle households living in each area. Three-quarters of households who do not own a vehicle live in close proximity to frequent public transport options. This difference is also bourne out for the individual subregions—the majority of the subregion's households who do not own a vehicle live in a CCD with frequent public transport services. The North-East subregion is the only exception to this rule, having more households without vehicles being located in areas without frequent public transport (2139) than areas with frequent public transport (314).

The Middle and North-East subregions have the largest number of households who do not have access to either a private vehicle or to frequent public transport services. Few households in the North-West subregion face this situation.

T6.11 Distribution of households without vehicles, by subregion and availability of public transport, 2006

Subregion	Number of households without private vehicles	Percentage of Perth, Mandurah and Murray's zero vehicle households (per cent)
Has access to public transport of at least 15 minute frequency during morning peak period		
Inner	8 889	23.2
Middle	11 443	29.9
Outer	7 554	19.8
North-West	2 897	7.6
North-East	314	0.8
South-West	2 675	7.0
South-East	1 668	4.4
Mandurah and Murray	817	2.1
Perth, Mandurah and Murray	28 703	75.1
Does not have access to public transport of at least 15 minute frequency during morning peak period		
Inner	1 272	3.3
Middle	3 384	8.8
Outer	4 414	11.5
North-West	162	0.4
North-East	2 139	5.6
South-West	992	2.6
South-East	1 121	2.9
Mandurah and Murray	467	1.2
Perth, Mandurah and Murray	9 537	24.9

Note: Public transport routes assumes Mandurah railway not operational.

Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data and WA Public Transport Authority stops and services data for 2008.

Table 6.12 lists the top ten suburbs in Perth, according to their percentage contribution of zero vehicle households for the Perth, Mandurah and Murray area, for both areas that have and do not have access to frequent public transport. For each listed suburb, the national decile on the SEIFA Index of Relative Socio-economic Disadvantage (IRSD) is also listed. The SEIFA IRSD 'is a general socio-economic index that summarises a wide range of information about the

economic and social resources of people and households within an area' (ABS 2008d p.11). It is important to note that 'SEIFA provides summary information about the people in an area, not information about an individual person in an area' (ibid p.15) with lower deciles indicating relatively more disadvantage than higher deciles.

Table 6.12 shows that there are some differences between the top ten suburbs where households with zero vehicles have access to public transport and the suburbs where they do not have access to public transport. The top ten suburbs with access to public transport tend to be either located in Inner or Middle suburbs, and overall account for a larger percentage of zero vehicle households. They also have a large decile range (1–10) for the SEIFA IRSD, indicating that that this category consists of suburbs with both very low and very high degrees of disadvantage.

T6.12 Top ten Perth suburbs for households without vehicles, with and without access to frequent public transport, 2006

Suburb	Subregion	Number of households who do not own a vehicle	Percentage of zero vehicle households (per cent)	SEIFA IRSD decile
Has access to public transport of at least 15 minute frequency during morning peak period				
Bentley	Middle	786	2.1	1
Fremantle	Inner	541	1.4	5
Dianella	Middle	530	1.4	7
Como	Inner	505	1.3	10
Bayswater	Middle	503	1.3	5
Perth	Inner	454	1.2	6
East Perth	Inner	447	1.2	7
Mosman Park	Inner	435	1.1	8
South Perth	Inner	430	1.1	9
Balga	Middle	427	1.1	1
Perth, Mandurah and Murray		28 703	75.1	na
Does not have access to public transport of at least 15 minute frequency during morning peak period				
Maylands	Middle	598	1.6	4
Gosnells	South-East	480	1.3	3
Rockingham	South-West	330	0.9	3
Bassendean	Middle	296	0.8	5
Midland	North-East	268	0.7	1
Osborne Park	Middle	243	0.6	3
Victoria Park	Inner	227	0.6	6
Dianella	Middle	227	0.6	7
Forrestfield	North-East	214	0.6	5
Armadale	South-East	183	0.5	1
Perth, Mandurah and Murray		9 537	24.9	na

Notes: Public transport routes assumes Mandurah railway not yet operational.

Data on number of households without private vehicles for each suburb is split between parts of the suburb with and without public transport access of at least 15 minute frequencies within the weekday morning peak period. Data on SEIFA decile is based on the whole suburb.

Where a suburb is split across two or more subregions, it is assigned to a subregion which takes up the largest amount of area for that suburb.

Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data at CCD scale and WA Public Transport Authority stops and services data for 2008.

The top ten suburbs without access to public transport are located in a wider variety of subregions, including the Inner, Middle and Outer subregions.

The range of deciles for the SEIFA IRSD was also fairly large (1–7) although its upper limit is lower than for the top ten suburbs with access to public transport.

The suburbs listed in this second part of Table 6.12 essentially correspond to the suburbs highlighted in the discussion of Map 6.14. Areas such as these, where many households do not have a private vehicle and public transport services are infrequent, are particularly likely to face transport access difficulties, but are not necessarily disadvantaged in other ways.

The preceding analysis has considered all households, irrespective of whether residents of those households are actively engaged in the labour market. In some of the highlighted suburbs, such as Midland and Rockingham, less than 40 per cent of residents are employed. The next section concentrates on employed residents, in line with this study's focus on commuters.

Public transport access of employed residents in 2006

This section presents information about the proportion of employed residents of the Perth Working Zone who are located within a buffer of 0.5, 1 or 2 kilometres from a frequently serviced rail or bus stop. To be considered as 'frequently serviced' an individual rail or bus stop must have services stopping there at least every 15 minutes during weekday morning peak times. The analysis is based on usual residence counts by collection districts from the 2006 Census.

Table 6.13 presents results for the set of frequently serviced rail and bus stops that were in operation in 2006, as well as for an expanded set of rail stations which includes the newly opened Mandurah line. About two-thirds of employed residents in Perth were within 0.5 kilometres of a frequently serviced public transport stop and just over 90 per cent of employed residents were within 2 kilometres. This indicates that the majority of employed residents are able to obtain access to frequent public transport. It does not say anything about the range of destinations that can be accessed by those frequent public transport services, whether a person's workplace can be accessed by public transport from their place of residence, or whether the public transport service is in fact used. The exclusion of the Mandurah rail stations did not affect these results significantly.

Table 6.14 shows the percentage of employed residents in each Perth planning subregion which fall within 0.5, 1 or 2 kilometres of a frequently serviced public transport stop, including stations on the Mandurah line. The great majority of employed residents within the Inner and Middle subregions are within 0.5 kilometres of frequent public transport stops, and almost 100 per cent are within 1 kilometre. Employed residents in the Outer subregions had a moderate degree of access to frequent public transport stops, with both the North-West and South-West subregions having more than 60 per cent of employed residents within 0.5 kilometres, while the North-East and South-East subregions had less than 50 per cent of employed residents within 0.5 kilometres. The Avon Arc is the worst served for public transport.

T6.13 Percentage of employed residents within 0.5, 1 and 2 kilometres of a frequently serviced rail or bus stop, 2006

	Proportion of Perth's employed residents within 0.5km (per cent)	Proportion of Perth's employed residents within 1km (per cent)	Proportion of Perth's employed residents within 2km (per cent)
With Mandurah rail line	66.4	86.9	93.7
Without Mandurah rail line	66.3	86.9	93.6

Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data at CCD scale and WA Public Transport Authority stops and services data for 2008.

T6.14 Percentages of employed residents in each subregion falling within 0.5, 1 and 2 km of a regularly serviced rail or bus stop (includes Mandurah line stations), 2006

Subregion	0.5 km	1 km	2 km
Inner	91.8	99.7	100.0
Middle	82.1	99.0	100.0
Outer	53.0	79.5	90.9
North-West	63.1	90.2	97.4
North-East	40.7	65.7	83.2
South-East	36.8	68.7	82.4
South-West	64.2	86.2	95.9
Peel	33.5	56.2	73.4
Avon Arc	0.0	0.0	0.0
Perth working zone	66.4	86.9	93.7

Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data at CCD scale and WA Public Transport Authority stops and services data for 2008.

Overall, just 13 per cent of employed residents of the Perth working zone do not live within one kilometre of at least one frequent public transport service. Table 6.15 shows the top five SLAs that have the largest numbers of employed residents falling outside the range of each rail and bus stop buffer. Unsurprisingly, the locations listed are all within various parts of the Outer subregion, which accords with the findings of the table above, indicating that lower proportions of Outer subregion employed residents are within 0.5, 1 or 2 kilometres of a regularly serviced bus or rail stop, in comparison to the Inner and Middle subregions of Perth. The North-East and South-Eastern subregions are prominent in the table (i.e. Swan, Mundaring, Armadale, Gosnells).

It should also be noted that none of the SLAs listed in Table 6.15 are considered to have high degrees of disadvantage, as defined by the SEIFA IRSD. The SLAs of Armadale and Murray, have the lowest deciles of five on the SEIFA IRSD, of all the listed SLAs, indicating average levels of disadvantage. On the other hand, the SLA of Joondalup South has a decile of 10 on the SEIFA Index, indicating very low levels of disadvantage. Thus, there remains no clear link between high levels of socioeconomic disadvantage in an area, and the inability of employed residents to access frequent public transport.

T6.15 Top five SLAs in terms of the number of employed residents which fall outside each buffer, 2006

Rank	0.5 km	1 km	2 km
1	Swan	Swan	Swan
2	Gosnells	Mundaring	Mundaring
3	Rockingham	Armadale	Serpentine-Jarrahdale
4	Armadale	Rockingham	Armadale
5	Joondalup South	Gosnells	Murray

Note: Includes Mandurah railway in buffers

Source: BITRE analysis of ABS Census of Population and Housing 2006 usual residence data at CCD scale and WA Public Transport Authority stops and services data for 2008.

Public transport access to jobs in 2006

This section repeats the analysis presented above, but now using the location of employment, based on 2006 census place of work data at the destination zone scale. Analysis is still based on the number and percentage of jobs falling within 0.5, 1 and 2 kilometres of a frequently serviced train or bus stop. To be defined as frequently serviced, each bus or railway stop must have a service at a minimum of every 15 minutes during the weekday morning peak period.

Table 6.16 presents results for the set of rail and bus stops that were in operation in 2006 as well as for an expanded set of railway stations which includes stations on the newly opened Mandurah line. It is revealed that excluding the Mandurah rail line does not make a significant difference to the percentage of jobs located inside any of the buffers. This is likely due to bus stations that existed prior to the opening of the Mandurah rail, which serviced a similar catchment area. Table 6.16 reveals that almost 70 per cent of Perth's jobs are located within half a kilometre of a frequently serviced public transport stop and almost 95 per cent are within two kilometres. These results are very similar to the results for employed residents that were presented in Table 6.13.

T6.16 Percentage of jobs within 0.5, 1 and 2 kilometres of a frequently serviced rail or bus stops, 2006

	Proportion of Perth jobs within 0.5km (per cent)	Proportion of Perth jobs within 1km (per cent)	Proportion of Perth jobs within 2km (per cent)
With Mandurah rail line	69.3	86.5	94.1
Without Mandurah rail line	69.3	86.5	94.1

Source: BITRE analysis of ABS customised census data at destination zone scale for 2006 and WA Public Transport Authority stops and services data for 2008.

Table 6.17 shows the percentage of jobs in each Perth planning subregion which fall within 0.5, 1 or 2 kilometres of a frequently serviced rail or bus stop, including stations on the new Mandurah line. More than 90 per cent of all Inner subregion jobs are within 0.5 kilometres of a rail or bus stop, as are 70 per cent of Middle subregion jobs. A lower percentage of Outer subregion, Peel and Avon jobs tended to be within 0.5 kilometres of frequently serviced stops in comparison, although the percentage of jobs considerably improves at a 1 kilometre radius. Of the Outer subregion's, the North-West consistently has the highest percentage of jobs near a frequently serviced public transport stop.

While employed residents of the South-West subregion had better access to public transport than employed residents of the North-East and South-East subregions (see Table 6.14), the South-West, North-East and South-East subregions all have similar levels of public transport access to jobs. In the South-West subregion, public transport appears to serve residential areas considerably better than employment-oriented areas.

T6.17 Percentages of jobs in each subregion falling within 0.5, 1 and 2 km of frequently serviced rail or bus stops (includes Mandurah line stations), 2006

Subregion	0.5 km	1 km	2 km
Inner	93.6	99.2	100.0
Middle	71.3	94.2	99.5
Outer	42.5	68.7	86.5
North-West	53.7	78.7	94.4
North-East	38.8	65.6	84.2
South-East	35.8	62.3	79.1
South-West	38.6	65.2	85.0
Peel	39.0	55.8	66.1
Avon Arc	0.0	0.0	0.0
Perth working zone	69.3	86.5	94.1

Source: BITRE analysis of ABS customised census data at destination zone scale for 2006 and WA Public Transport Authority stops and services data for 2008.

Roughly 6 per cent of Perth's jobs lie more than 2 kilometres from a frequently serviced rail or bus stop. Table 6.18 shows the five SLAs in Perth with the largest number of jobs outside the range of each buffer. Swan and Cockburn appear in all three lists. The top five lists are also dominated by SLAs in the Outer subregion, although two SLAs within the Middle subregion (Canning and Belmont) appear in the 0.5 kilometres list. Apart from Murray, all of the SLAs contain some frequent public transport services, but a significant proportion of jobs tend to be concentrated in areas which are not easily accessible.

Swan stands out as an area where a large number of employed residents live more than one or two kilometres from a frequently serviced rail or bus stop and a large number of jobs are located more than one or two kilometres from a frequently serviced rail or bus stop. The Murray and Mundaring SLAs share these characteristics. However, there are notable differences between the SLAs in Tables 6.14 and 6.17. The South-West subregion SLAs of Cockburn and Kwinana feature as places where a large number of jobs are not easily accessible by public transport, while residential access to frequent public transport was less of an issue in these areas.

T6.18 Top five SLAs in terms of the number of jobs which fall outside each buffer, 2006

Rank	0.5 km buffer	1 km buffer	2 km buffer
1	Swan	Swan	Swan
2	Canning	Cockburn	Murray
3	Cockburn	Kwinana	Mundaring
4	Belmont	Gosnells	Cockburn
5	Gosnells	Rockingham	Kwinana

Note: Includes Mandurah railway in buffers

Source: BITRE analysis of ABS customised census data at destination zone scale for 2006 and WA Public Transport Authority stops and services data for 2008.

Summary

A lack of access to transport is a potential barrier to participation in the labour force. In Perth, only 7 per cent of households do not have a vehicle, while 13 per cent of employed residents live more than one kilometre from a frequently serviced rail or bus stop. About 2 per cent of Perth households do not have access to either a private vehicle or a nearby frequent public transport service.

Transport access varies spatially across Perth. More than 99 per cent of employed residents of the Inner and Middle subregions live within one kilometre of a frequent public transport service. Employed residents of the Avon Arc, Peel, North-East and South-East subregions are much less likely to live within one kilometre of a frequent public transport service, while a relatively high proportion of jobs in these four subregions and the South-West subregion are located more than one kilometre from a frequently serviced rail or bus stop. Households without a vehicle are concentrated in the Inner and Middle subregions, primarily in areas with good public transport access. However, some Perth suburbs have many non-vehicle owning households as well as a lack of frequent public transport—examples include Victoria Park in the Inner subregion, Maylands and Dianella in the Middle subregion and Gosnells, Midland, Forrestfield and Rockingham in the Outer subregion. Transport access difficulties would appear to be greatest in these Perth suburbs.

Transit oriented development (TOD)

> 'TOD seeks to maximise access to mass transit and non-motorised transportation with centrally located rail or bus stations surrounded by relatively high-density commercial and residential development' (Planning Institute of Australia (PIA) 2005, p.3)

TODs are intended as 'compact, mixed-use, pedestrian-friendly precincts around major public transport stations' (Renne, Chandra, Tippett and Kolapalli 2007, p.1). An important aspect of TOD design is to encourage public transport usage and reduce automobile dependence (Holling 2008).

Network City aimed to prioritise TOD development and creation of jobs at major activity centres connected by public transport (WAPC 2004c). The latest plan, *Directions 2031*, also 'supports the principles of transit orientated development in the planning and re-planning of activity centres to achieve better integration of land use and transport services' (WAPC 2009, p.11).

In particular, the WA Government aims to redevelop land around some Perth train stations into TODs (HURIWA 2007). These TODs would extend roughly 800 metres from the station, with the first 400 metres comprising of medium-to-high density residential blocks and commercial buildings (e.g. shops and offices), while the remaining 400 metres would comprise of low-to-medium density residential areas and open space (ibid). TODs are one of the proposed tools by which *Network City* intended to fulfil its goal of having 60 per cent of future development in the form of infill, without generating additional traffic congestion (Renne et al 2007).

The WA Government has a relatively proactive approach to promoting TODs involving forward planning to identify TOD opportunities as well as planning of individual transit places (Renne 2008, PIA 2005). TODs are a comparatively recent initiative in Perth, with the TOD Coordinating Committee being set up in 2001. Given the long lead times involved, it is not surprising that studies (i.e. Curtis 2005, PIA 2005) have concluded that there has been limited achievement of land use change around rail stations in Perth. An important exception is Subiaco, where patronage has rapidly increased following the area's redevelopment (PIA 2005). With respect to the more recently built rail lines, Curtis (2005, p.447) notes that:

> 'Most stations sit within the freeway reserve, their spacing predicated on car-based catchments, making pedestrian scale transit-oriented development difficult'.

Survey research has indicated that 61 per cent of surveyed Perth residents would consider living in a TOD, with more affordable housing being the main factor encouraging households to consider TOD (Housing and Urban Research Institute 2007). However, proximity to rail stations tends to drive up house prices, posing a challenge for provision of affordable housing within TODs (ibid). While survey participants were favourably disposed towards TODs, the majority of respondents wanted their TOD home to have a backyard, two bathrooms and at least three bedrooms, while half wanted their dwelling to have parking for two cars (ibid). Thus, the demand for TOD is not generally for high density dwellings. The continued preference of households for low density living and '[t]he dispersed nature of Perth's employment and activity centres, reinforced by a pervasive car-oriented urban form, may therefore continue to inhibit the development of TOD' (ibid p.11).

Research has also identified a 'large chasm between planner's visions for what TOD can do in terms of retail and commercial activity, and business perception of train stations and their commercial value' (Holling and Haslam McKenzie 2009 p19). For small and medium businesses operating in Subiaco, Leederville and Maylands, the train and bus stations have not been a widespread driver of location selection (ibid).

As of 2006, the Perth metropolitan area had 70 public transport hubs comprising 33 railway stations, 13 major bus interchanges and 24 combined rail and bus stations. This number is slightly higher in 2009, due to the opening of the Mandurah railway line, and its associated stations. It should be noted that '[t]he building of a new railway line does not automatically create TODs around stations' (Renne et al 2007, p6), so not every station in this analysis can be necessarily declared a TOD. Instead, the following analysis examines the residential and employment growth around each rail and major bus station, as each of these have at least the public transport facilities available to be potential future TODs. Examples of TODs existing, or planned to exist, include Subiaco and East Perth in the Inner subregion, Bassendean in the Middle subregion and Clarkson, Armadale and Guildford in the Outer subregions (PIA 2005). In addition, the Mandurah line is expected to contain some TODs, particularly in stations such as Cockburn Central and Wellard (ibid).

The area 800 metres around each station that existed in 2006 was examined in terms of usual resident population and employment density for the 2001 to 2006 time period. The distance of 800 metres was chosen as this seems to be the suggested distance around transport hubs at which TOD precincts are intended to be developed (HURIWA 2007). Additionally, survey research conducted on TOD-related issues in Perth focused on collecting data from the households and businesses within 800 metres of railway stations (e.g. Renne et al 2007, Holling 2008).

Population and employment density

The concept of TOD is focused on developing mixed use residential and employment centres closely linked to public transport (e.g. Holling 2008). Thus, both population and employment factors will have to be considered together in order to assess the status of Perth's rail and major bus station precincts between 2001 and 2006. One way of doing this is to calculate a combined population and employment density per hectare threshold, as done in previous studies (e.g. Newman and Kenworthy 2006, Renne et al 2007).

Data sources

In order to obtain estimates of resident population, BITRE constructed 800 metre buffers around each railway station and major bus interchange. Every CCD which fell inside these buffers was incorporated into the calculations. Where a CCD fell partly in and partly out of the buffer zone, the proportion of the CCD's area which fell inside the buffer was used to estimate the number of residents living within 800m of the station. Population data was sourced from customised census counts of usual residents provided by the ABS.

Employment levels were estimated in a similar way to residential populations: by using buffers radiating 800 metres from every rail and major bus interchange station that existed in Perth during 2006 and capturing every destination zone (DZ) that fell inside these buffers. The proportion of each DZ's area that was inside each buffer was used to estimate the number of workers with a place of work within 800m of a station. Because DZs for 2001 and 2006 differ considerably, a concordance was constructed to convert 2006 DZs into their equivalent 2001 versions. Due to a lack of comparable data between these two time periods, DZ's within the Avon Arc and Waroona were excluded from the analysis.

Densities for each area's resident population and employment were calculated by dividing the numbers of each variable by the area in hectares, to obtain individual population and employment densities. Combined population and employment densities for each area were then obtained by summing the individual population and employment densities together.

Changes in population and employment density

Table 6.19 displays the population and employment densities within 800 metres of each station by subregion for 2001 and 2006. Areas within 800 metres of rail or major bus stations have a higher population and employment density than areas outside 800 meters. However, there is still considerable variation between subregions in terms of their density around stations. Stations in the Inner subregion had the highest population and jobs density within 800 metres, followed by the Middle subregion, while stations further away from the CBD had lower densities.

Another interesting aspect of Table 6.19 is the growth rates in the population and employment densities. Overall, areas outside 800 metres of train or major bus stations experienced the second highest average annual growth in population and employment density, from a very low density in 2001, being beaten by only areas inside 800 metres of stations within the Inner subregion. In terms of areas falling inside the 800 metres, the Inner subregion had the highest average annual growth, with the North-East subregion as the second highest. The South-Eastern subregion showed little growth in densities around bus and rail stations.

T6.19 Population and employment densities within 800 metres of rail stations and major bus interchanges by subregion, 2001 to 2006

Subregion	Population and employment density 2001	Population and employment density 2006	Average annual growth rate (per cent)
Inner	47.5	52.2	1.9
Middle	24.4	25.7	1.0
Outer	12.9	13.3	0.7
North-West	13.9	14.7	1.1
North-East	11.8	12.5	1.2
South-East	13.5	13.6	0.2
South-West	4.5	4.7	0.7
Peel	14.7	15.3	0.8
Perth, Mandurah and Murray: areas within 800 metres	27.5	29.6	1.5
Perth, Mandurah and Murray: areas beyond 800 metres	2.3	2.5	1.8

Note: Both South-West and Peel have only one bus interchange each in 2006 that still continues to exist today. It is conceivable that other bus interchanges existed in these subregions but have since been discontinued—any such interchanges have not been included in the analysis.

Source: BITRE analysis of ABS customized census data, corrected 2001 commuting matrix provided by WAPC and WA Public Transport Authority stops and services data.

Table 6.20 examines specific stations, listing the top five in terms of their 2006 population and employment density, as well as the top five stations with the highest average annual growth rates in density between 2001 and 2006, provided they have a minimum population and employment density of 15 per hectare in 2001. The 15 residents and jobs per hectare cut-off was used to focus attention on stations with moderate or high densities (i.e. potential TODs). It shows that the top five stations in terms of 2006 population and employment density are all within the City of Perth. This result reflects the CBDs status as the biggest employment centre in Perth. It is also interesting to note that only one of the five stations on this list (City West) also appeared in the top five list of fastest average annual growth in density, indicating that the remaining four have relatively slow growth rates compared to stations outside the City of Perth.

The top five stations with the highest average annual growth rates (and minimum population and employment density of 15 per hectare) are also concentrated within the Inner subregion, with only one (Stirling station) being located in the Middle subregion. This list indicates that the stations with some of the highest growth rates tend to be located in the Inner subregion, albeit not necessarily in the CBD.

T6.20 Top five bus and railway stations by 2006 density and average annual growth rates between 2001 and 2006

Station name	Main SLA	Population and employment density 2001	Population and employment density 2006	Average annual growth rate (per cent)
Top five: Population and employment density 2006				
Esplanade Busport	Perth Inner	258.8	292.5	2.5
Perth Stn	Perth Inner	206.3	223.6	1.6
Wellington Street Bus Stn	Perth Inner	191.8	210.5	1.9
McIver Stn	Perth Remainder	128.6	139.4	1.6
City West Stn	Perth Remainder	90.7	108.5	3.7
Top five: Average annual growth rate 2001 to 2006*				
Karrakatta Stn	Nedlands	15.6	19.1	4.2
City West Stn	Perth Remainder	90.7	108.5	3.7
Subiaco Stn	Subiaco	47.1	56.0	3.5
Stirling Stn	Stirling Central	23.0	27.3	3.5
Loch Street Stn	Nedlands	23.7	27.4	2.9

Note: Some railway stations incorporate two or more SLA's within 800 meters. Only the SLA that comprises the most area within 800 meters of the station is listed.

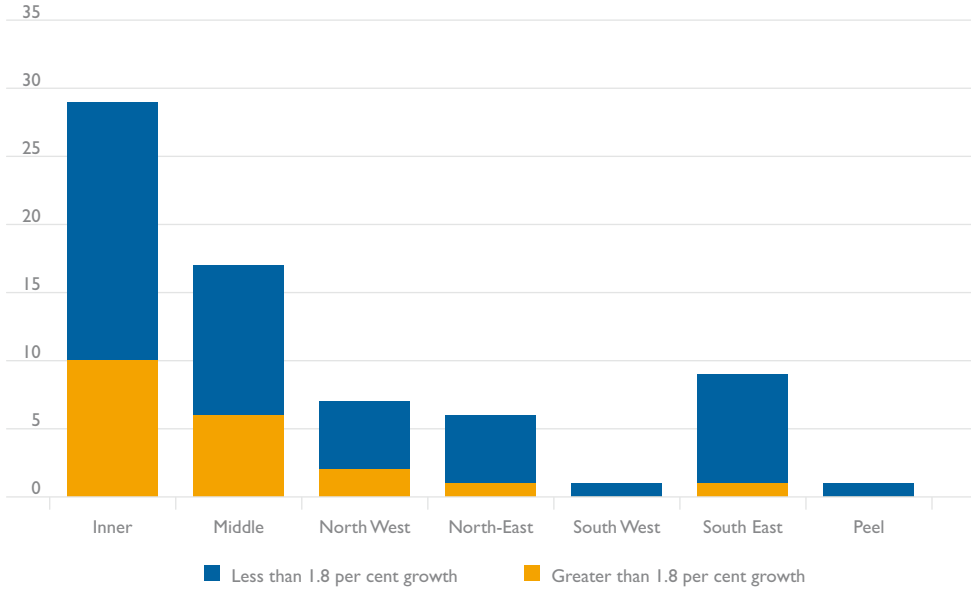
* Top growth rates for stations with a density of at least 15 jobs and residents per hectare in 2001.

Source: BITRE analysis of ABS customized census data, corrected 2001 commuting matrix provided by WAPC and WA Public Transport Authority stops and services data.

Figure 6.2 displays the number of stations in each subregion where the population and employment density growth within 800 metres exceeds 1.8 per cent (the Perth-wide average annual density growth rate for areas more than 800 metres from a rail station or bus interchange).

It shows that most of the stations with density growth exceeding 1.8 per cent per annum are located in the Inner and Middle subregions. The Outer subregions and Peel showed a fairly low number of stations that had density growth exceeding 1.8 per cent. Of note, is that the North-West subregion, whose rail line was fairly recently built (compared to the North-East and South-East subregions), has the highest number of stations in the Outer subregion exceeding 1.8 per cent density growth between 2001 and 2006. It should also be noted that, although the South-West and Peel had no public transport stations growing more than 1.8 per cent in terms of density, the situation may have since changed with the opening of the Mandurah rail line. This rail line has TOD planned for stations such as Wellard and Cockburn Central and more may be investigated (PIA 2005).

F6.2 Number of stations in each subregion exceeding or not exceeding 1.8 per cent average annual density growth, 2001 to 2006



Note: Stations are assigned to planning subregions according to which subregion comprises the most area within 800 metres of the station.

Source: BITRE analysis of ABS customized census data, corrected 2001 commuting matrix provided by WAPC and WA Public Transport Authority stops and services data.

Applying a population and employment density threshold

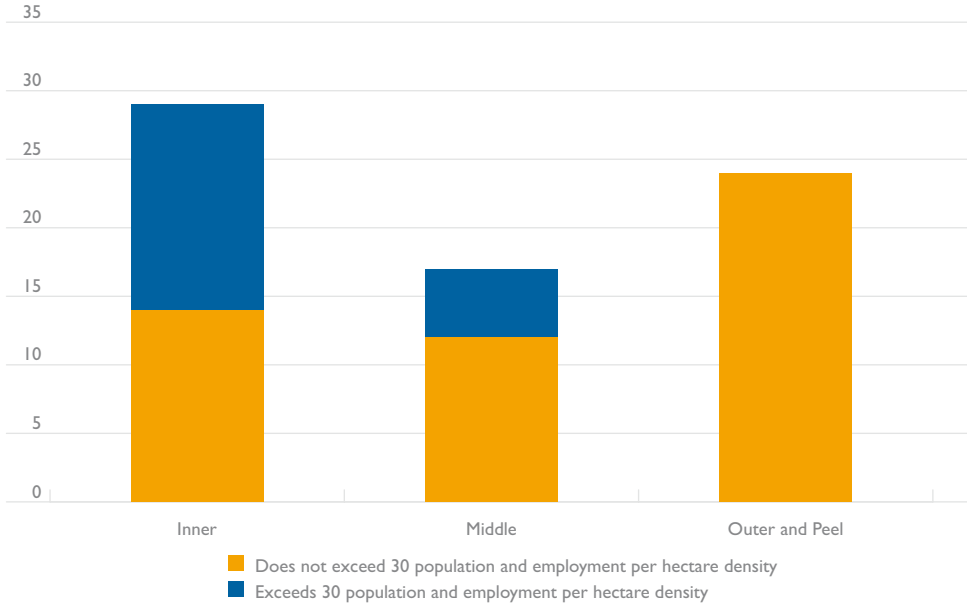
Newman and Kenworthy (2006) suggest that a minimum of 30 to 40 jobs and residents per hectare is required to create viable town centres with high levels of amenity and strong links to public transport. Newman and Kenworthy (2006) cite the suburbs of Fremantle and Subiaco as centres which exceed the 35 residents and jobs per hectare density, stating that 'the commercial reality of running a public transport service or locating in a center (sic) depends on this kind of activity intensity' (ibid p.46). Not all Perth stations have achieved this minimum activity threshold per hectare—a survey of five rail stations in Perth (Mosman Park, Subiaco, Maylands, Glendalough and Joondalup), conducted by Renne et al (2007), found that only Subiaco had managed to achieve this density.

This study contributes to this area of research by examining the combined population and employment densities in an 800 metre radius for each rail station and major bus station that existed in 2006, to see what range of densities exist and whether they have changed over time. Our calculation of area differs from that of Newman and Kenworthy (2006) in that they only include urbanised land in their calculations, whereas BITRE uses both developed and undeveloped land in an 800 metre radius from each train and major bus station. This may lead to our density estimates being more conservative, hence we will use the lower bounds of 30 jobs and residents per hectare to determine whether stations have met the minimum threshold or not.

Table 6.19 previously showed a subregion based analysis of population and employment densities within 800 metres of existing train and bus stations, along with the average annual growth rate between 2001 and 2006. Overall, areas within 800 metres of a Perth rail or major bus station fell just below the 30 jobs and residents per hectare required to make a viable centre. Only the Inner subregion exceeded this minimum threshold, with subregions progressively further away from the city centre having lower densities.

Figure 6.3 explores this theme further, displaying the number of individual stations in 2006 for each subregion that meet a minimum density threshold of 30 jobs and residents per hectare. Data for 2001 was not displayed because the list of stations that met the threshold in 2001 were identical to the list of stations that met the threshold in 2006. Figure 6.3 indicates that only the Inner and Middle subregions have stations that meet the minimum density while stations in Peel and the Outer subregion have yet to reach this threshold.

F6.3 Number of stations in each subregion exceeding, or not exceeding, the 30 resident population and jobs per hectare threshold, 2006



Note: Stations are assigned to planning subregions according to which subregion comprises the most area within 800 meters of the station.

Source: BITRE analysis of ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WAPC and WA Public Transport Authority stops and services data.

Table 6.21 lists the stations in both years that have managed to pass Newman and Kenworthy's (2006) 30 population and employment per hectare minimum density, along with their densities for 2001 and 2006. The greatest growth in density was achieved in the areas surrounding the City West, Subiaco and Daglish rail stations and the Curtin University bus station. In contrast, the area surrounding the Fremantle rail and Morley bus stations experienced a significant decline in density between 2001 and 2006.

T6.21 List of rail and bus stations that meet density threshold of 30 residents and jobs per hectare in 2001 and 2006

Station name	Main SLA	Population and employment density 2001	Population and employment density 2006	Average annual growth rate (per cent)
Esplanade Busport	Perth Inner	258.8	292.5	2.5
Perth Stn	Perth Inner	206.3	223.6	1.6
Wellington St Bus Stn	Perth Inner	191.8	210.5	1.9
McIver Stn	Perth Remainder	128.6	139.4	1.6
City West Stn	Perth Remainder	90.7	108.5	3.7
Claisebrook Stn	Perth Remainder	68.2	77.9	2.7
West Leederville Stn	Cambridge	57.9	62.5	1.5
Subiaco Stn	Subiaco	47.1	56.0	3.5
Leederville Stn	Vincent	50.5	54.8	1.6
Fremantle Stn	Fremantle Inner	58.8	54.3	–1.6
Glendalough Stn	Stirling Central	37.9	41.3	1.7
Daglish Stn	Subiaco	34.4	39.5	2.8
Booragoon Bus Stn	Melville	35.6	37.3	1.0
East Perth Stn	Vincent	34.8	36.3	0.9
Curtin University Bus Stn	Victoria Park	30.3	34.9	2.9
Mt. Lawley Stn	Stirling South-Eastern	35.3	34.8	–0.3
Maylands Stn	Bayswater	33.5	34.3	0.5
Morley Bus Stn	Bayswater	34.5	32.7	–1.1
Victoria St. Stn	Mosman Park	30.2	30.5	0.2
Swanbourne Stn	Claremont	30.0	30.1	0.1

Note: Some railway stations incorporate two or more SLAs within 800 meters. Only the SLA that comprises the most area within 800 metres of the station is listed.

Source: BITRE analysis of ABS customized census data, corrected 2001 commuting matrix provided by WAPC and WA Public Transport Authority stops and services data.

What are the differences between stations that manage to meet the 30 jobs and residents per hectare threshold and those that do not? Table 6.22 compares the resident to employment ratio of stations that succeed in meeting this threshold compared to stations that do not, by subregion. The ratio is calculated by dividing the residential density by the employment density of each station, such that a ratio of one indicates a 50/50 residential and employment balance within 800 metres of a station.

The train and bus stations meeting the threshold density tend to be stations where employment numbers are much higher than residential numbers within 800 metres of the station. This difference is especially pronounced between the Inner stations that meet the minimum threshold density and those Inner stations that do not.

T6.22 Residents to jobs ratio of stations which did and did not meet the density threshold, by subregion, 2001 and 2006

	Residents to jobs ratio 2001	Residents to jobs ratio 2006
All stations that met threshold	0.3	0.3
All stations that did not meet threshold	1.9	1.9
All Inner stations that met threshold	0.2	0.2
All Inner stations that did not meet threshold	2.0	2.0
All Middle stations that met threshold	1.2	1.2
All Middle stations that did not meet threshold	1.4	1.4
All stations in Outer subregion and Peel that did not meet threshold	2.4	2.2

Source: BITRE analysis of ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WAPC and WA Public Transport Authority stops and services data.

Interestingly, it also seems that average annual growth in employment numbers 800 metres around each station is greater (at 1.6 per cent), than population growth (1.3 per cent). Examining gains in population and employment numbers between 2001 and 2006 indicates that 15 223 additional jobs were added to areas within 800 metres of stations, which was a larger quantity compared to the 9729 new residents. Comparing these growth figures against overall jobs and resident growth in the region indicates that the new jobs within 800 metres of stations account for about 24 per cent of total jobs growth, while residential growth within 800 metres only accounts for about 8 per cent of total residential growth.

TODs have been proposed as a mechanism for achieving 60 per cent of future development as urban infill (Renne et al 2007). However, given the high projected population growth and the current 11 per cent share of Perth's population living within 800 metres of a bus or rail station, a marked increase in population densities around many Perth stations would be required for TOD to make a significant contribution to this goal.

Since 31 per cent of Perth's employment was located within 800 metres of a bus or rail station in 2006, a widespread and significant increase in employment density in TODs could potentially have an important influence on Perth's overall spatial distribution of employment.

Summary

TODs make up an important aspect of the WA Government's *Network City* and *Directions 2031* urban plans as a way to provide compact mixed-use residential, employment and service centres linked to public transport. However, the data on population and employment shows that railway and major bus precincts in Perth have experienced varying degrees of success being formed into TODs.

In terms of population and employment densities per hectare, each subregion's stations had varying densities, ranging from the fairly dense Inner subregion to the low density South-West subregion. Moreover, each subregion shows differences in the average annual growth in densification, with stations in the Inner subregion growing fastest and stations in the South-East showing little change between 2001 and 2006.

The top five stations that had the highest densities in 2006 were all concentrated in the City of Perth. In contrast, stations that experienced relatively high density growth (greater than 1.8 per cent) between 2001 and 2006 were more dispersed throughout Perth, including the Inner, Middle, North-West, North-East and South-East subregions. Two stations in the North-West subregion actually had the highest average annual growth in density, although they also started from a low base.

In terms of meeting a minimum density of 30 jobs and residents per hectare, it can be seen that stations that meet this criteria are located in the Inner and Middle subregions. Interestingly, when comparing stations that meet this threshold to stations that do not, it was found that stations that met this threshold mainly did so by having higher contributions of employment density rather than residential density. This fact, along with the higher growth rate in employment numbers within 800 metres of each station indicates that more success has been achieved in concentrating jobs around public transport hubs compared to residential developments.

Research on small to medium enterprises in TODs found that '[t]he continuing dominance of Perth CBD as the business hub … is likely to continue the desirability of inner suburb TOD for office development at the expense of middle suburb and outer suburban TODs in the foreseeable future' (Holling 2008 p.iv-v). Other problems arise in trying to promote residential growth in rail or major bus station precincts, with research by HURIWA (2007) finding that survey respondents considered affordable housing as the prime factor to encourage residential growth in TODs. HURIWA (2007 p.10) comments that '[i]n contrast to this perception, the reality is that TOD locations or locations with transport interchanges, objectively attract an 'accessibility premium''.

Looking forward

It is likely that the public transport mode share will show an increase in future census data, particularly in relation to the South-West subregion, since the completion of the Mandurah railway line in 2007.

The Australian Government has identified improved multimodal links at the Perth airport (including upgrades to arterial roads and the possible provision of a dedicated public transport link) as one of 28 nationally significant infrastructure projects in its priority pipeline, requiring further project development (Infrastructure Australia 2009). The Northbridge Rail Link project, which will sink the Northbridge railway station and create a revamped cultural and recreational precinct, is also part of the priority pipeline (ibid).

Research has been conducted into the likelihood of more Perth residents adopting public transport or environmentally friendly modes of transport, such as walking and cycling, in future (e.g. Socialdata 2000; Colmar Brunton n.d.). Notably, whilst there is public interest in increasing public transport usage, survey responses also show that a number of factors constrain potential transport mode shifts. For example, Colmar Brunton researchers found that nearly 90 per cent of Perth residents surveyed believed it was important to make it easy for people to use public transport, cycling or walking as alternatives to their cars. However, 87 per cent of respondents also felt that it was important to ensure people could travel freely and efficiently by car. In other words, people also wished to continue using cars (Colmar Brunton n.d. p.23–24).

Socialdata (2000) surveyed residents of Perth about their potential use of environmentally friendly modes of transport (for all journeys, including work) between 1998 and 2000.[29] On the basis of their research, the authors claimed that in principle, car transport mode share could be reduced by up to 22 per cent through replacement with public transport, up to 26 per cent through replacement with cycling, and up to 21 per cent through replacement with walking (Socialdata 2000 p.3).

However, some of the key impediments which survey respondents listed against using public transport were:

- no public transport connection available
- public transport connection times not reasonable
- public transport usually too slow
- public transport usually too uncomfortable
- distance too far to walk or cycle
- walking or cycling is too slow (Socialdata 2000 p.11–14).

At the same time, Socialdata (2000 p10) researchers also claimed that 41 per cent of private vehicle trips were made because of 'subjective reasons' such as lack of awareness and perception of alternative modes, and choosing freely to use a car whilst not having any particular reason for avoiding environmentally friendly modes. With little change to public transport infrastructure and routes, people in this category could perhaps be encouraged to use public transport through awareness and education campaigns (Socialdata 2000 p.2).

29 It should be noted that all of the regions included in the Socialdata survey already had relatively high public transport mode share compared with other parts of Perth. Data was collected from South Perth, Subiaco, Victoria Park, Melville and parts of Joondalup.

CHAPTER 7
Commuting flows

Key points

- In 2006, 1 per cent of Perth's workforce lived outside Perth, while 3 per cent of residents worked outside the Perth working zone, typically on remote mine sites.
- About 42 per cent of employed Perth residents work in their home subregion. Self-containment is highest for the Inner subregion (65 per cent) and very low for the South-East and North-West subregions (29 and 33 per cent, respectively). There has been no progress in improving self-containment in the Outer subregions between 2001 and 2006.
- The Inner and Middle subregions draw more than half their workforce from beyond their boundaries. Only 20 per cent of Peel and North-West subregion workers are sourced from further afield.
- About 17 per cent of employed people commute to a workplace in the City of Perth. The probability of commuting to the CBD is highest for residents of nearby areas (e.g. Vincent) and less than 5 per cent for many of the more distant SLAs (e.g. Rockingham, Kwinana, Armadale).
- Average commuting distances are low for Inner and Middle subregion residents, higher for the Outer subregions and highest for Peel and the Avon Arc. Those with jobs in the North-West and South-East subregions travel short distances to work, particularly compared to Avon Arc workers.
- Trips to work in an inward direction dominate those in an outward direction (43 and 9 per cent of Perth trips, respectively).
- More complex forms of commuting, such as journeys between Outer subregions, grew most rapidly from 2001 to 2006. Inward commuting and commutes within the home SLA grew much less rapidly. Trips between Outer subregions are hard to service by public transport.
- Nine of the ten most common commuter trips were intra-SLA trips (e.g. 14 194 Rockingham residents travelled to a workplace in Rockingham). The most common inter-SLA flows were Gosnells to Canning and Joondalup South to Stirling Central or Perth Inner.
- The 2001 to 2006 increase in commuting was greatest for intra-SLA flows in Rockingham (+3700 persons), Mandurah (+2900) and Swan (+2200). Commuting from Gosnells to Canning and from Stirling Coastal or Joondalup South to the CBD increased by 1000 persons.

- Rapid population growth in Wanneroo North-East and Rockingham generated increased commuter flows to nearby areas.
- Swan and Kalamunda's strong jobs growth generated rapid growth in commuting into the North-East subregion from other parts of Perth.
- Metropolitan plans have long aimed to reduce average commuting times and distances, but both remained stable for Perth over the study period.

Introduction

This chapter connects the population and employed residents analysis of Chapter 3 with the job location analysis of Chapter 4. The term 'commuting flow' is used to refer to the number of people who travel from a particular place of residence to a particular place of work. This chapter identifies the main commuting flows within Perth as well as spatial differences in the average distance travelled to work. It also highlights the main changes that occurred between 2001 and 2006.

The analysis is based on the ABS' journey to work matrix from the 2001 and 2006 censuses, as well as a corrected 2001 matrix provided by the WA Government. BITRE's analysis is undertaken at the subregional and statistical local area (SLA) scales, not at the more disaggregated destination zone or census collection district (CCD) scale. As a consequence, BITRE's distance estimates are less precise than any estimates derived from a more disaggregated matrix of commuting flows.

2006 snapshot

Long distance commutes

In 2006, there were 6349 people employed in the Perth working zone (WZ) who lived outside of the region, representing just 1 per cent of the workforce. One-third of this group lived interstate. Table 7.1 summarises the main regions of residence for these long distance commuters.

Daily commuting to Perth is really only feasible for the working zones centred on Bunbury, Busselton and Northam-York. The towns of Northam and York are both located about 100 km east of Perth. Several hundred residents of the Northam-York working zone commute to a workplace in the eastern SLAs of Mundaring and Swan. Bunbury and Busselton are located 185 km and 225 km south of Perth, respectively. The majority of Bunbury residents who commute to Perth work in the Peel region. However, the Busselton residents are much more likely to work in the City of Perth LGA.

The residents of the more distant places listed in the table (e.g. Sydney, Melbourne, Geraldton) are presumably commuting to Perth on a less frequent basis, such as weekly.

About 3 per cent of residents of the Perth working zone had a workplace outside the region in 2006. This amounts to 23 717 employed persons, of which 87 per cent had a workplace elsewhere in WA. Table 7.2 summarises the main places of work for these long distance commuters.

T7.1 Main regions of residence for people employed at a fixed work address in Perth working zone, 2006

Working zone	Number of residents employed in Perth working zone
Perth & surrounds	640 048
Bunbury & surrounds	818
Northam-York & surrounds	720
Melbourne & surrounds	418
Sydney & surrounds	358
Brisbane & surrounds	231
Busselton	189
Adelaide & surrounds	151
Kalgoorlie-Boulder	138
Geraldton & surrounds	108

Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

T7.2 Main non-Perth places of work for employed residents of Perth working zone, 2006

Working zone	Number of Perth residents employed in working zone
Laverton, Leonora & Menzies	2 257
East Pilbara	1 756
Ashburton	1 525
Roebourne	1 036
Wiluna	918
Northam-York & surrounds	627
Bunbury & surrounds	616
Sydney & surrounds	506
Ravensthorpe	499
Melbourne & surrounds	486

Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

Only two of the ten listed regions are within daily commuting distance (Bunbury, Northam-York). Perth residents are presumably commuting to the more distant places on a less frequent basis, such as weekly or based around shifts.

The first five listed working zones, plus Ravensthorpe, are mining regions which have a significant Perth-based workforce and contain large mines operating on a fly-in, fly-out basis. Residents of outlying areas of the Perth working zone such as Peel, the Avon Arc and Wanneroo North-West, are most likely to work in one of these mining regions.

Commuter flows in an outward direction from the Perth working zone are much greater than the inflows to Perth. Perth attracts relatively few commuters from surrounding regions, because of the small population of the surrounding areas. However, the rapid growth of WA's mining industry in recent years and a shift to fly-in, fly-out operations, has resulted in significant commuter flows from Perth to remote mine sites.

Subregional overview

The remainder of the analysis of commuting flows for 2006 focuses only on the flows that occur *within* the Perth working zone.

The concept of employment self-containment has been central to corridor development in Perth, but '[s]elf-containment of corridors is still elusive' (WAPC 2003c p.37). Employment self-containment is typically measured as the proportion of employed residents who work in their home subregion.

Table 7.3 summarises each subregion's degree of employment self-containment and the extent to which each subregion is able to attract workers who reside in other subregions of the city. Self-containment is relatively high in the Inner subregion and in the Peel region, with more than 60 per cent of employed residents working in the same subregion in which they live. The degree of self-containment is extremely low for the South-East and North-West subregions. However, as Curtis (2005) points out, none of the corridors have come close to achieving the planned self-containment rate of 60 per cent. According to WAPC (2003c p.64):

> 'The main problem with moderate self-sufficiency rates in corridors lies in the magnitude of future work trips to the middle and inner areas of metropolitan Perth. Work trips will at least double by 2031 as most of the population and resident employment growth will occur in corridors. This will put additional pressure on the road network and transport system.
>
> To alleviate this problem, it will be necessary to alter the current location pattern of employment and double corridors' employment self-containment. This task is not easy. Metropolitan strategy policies since 1970 have tried with little success.'

While past Perth plans are based on the notion that people will choose to live and work locally in self-contained communities, 'it is widely acknowledged that both individual travel patterns and the activities of business are more complex and diverse, having a much wider 'spatial reach'' (Curtis 2006 p.163). Despite the Inner subregion's high degree of self-containment, nearly 70 per cent of its workers live in other subregions. The majority of the workforce of the Middle subregion also resides outside the subregion. Of the Outer subregions, the North-East subregion attracts the greatest proportion of its workforce from outside its boundaries. Only 20 per cent of workers in the Peel and North-West subregions are sourced from further afield. While Peel attracts few workers from elsewhere it is able to retain a high proportion of its employed residents. However, the North-West subregion (and to a lesser extent the South-East subregion) attracts few workers from elsewhere and does a poor job of retaining its employed residents.

T7.3 Self-containment and proportion who commute from outside by subregion, Perth working zone, 2006

Subregion	Workers	Employed residents	Work in home subregion	Self-containment rate (per cent)	Proportion who commute from outside subregion (per cent)
Inner	235 379	109 822	71 862	65	69
Middle	188 083	219 847	85 483	39	55
North-West	56 303	132 496	44 200	33	21
North-East	56 163	86 419	30 806	36	45
South-East	31 919	73 357	21 328	29	33
South-West	52 153	82 181	34 916	42	33
Peel	21 471	27 271	17 238	63	20
Avon Arc	3 233	5 106	2 397	47	26
Perth working zone	646 397	736 499	308 230	42	52

Note: The place of work total is substantially less than the number of employed residents, due to non-response and no fixed work address.

Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

Table 7.4 summarises commuting flows at the subregional level for 2006. For the Inner subregion, more workers are drawn from the Middle subregion (79 987) than the Inner subregion (71 862). For all other subregions, the main source of workers is those residing within the subregion. Excluding commuter flows within a single subregion, the commuter flows which exceeded 20 000 persons all involved a place of work in the Inner or Middle subregions:

- to the Inner subregion from the Middle and North-West subregions
- to the Middle subregion from the North-West, North-East and South-East subregions.

Of the more than 330 000 Perth residents who commuted to a workplace located outside the subregion in which they live, the great majority of those commuter flows involve a workplace in either the inner suburbs (49 per cent) or middle suburbs (31 per cent) of Perth. The most substantial commuter flows involving a place of work outside the Inner and Middle subregions was the flow of 10 552 residents of the Middle subregion to a place of work in the North-East subregion.

T7.4 Subregional commuting flows in the Perth working zone, 2006

Subregion of residence	Subregion of work								
	Inner	Middle	North-West	North-East	South-East	South-West	Peel	Avon Arc	Perth WZ
Inner	71 862	18 470	1 648	2 353	1 264	3 115	189	40	98 941
Middle	79 987	85 483	6 858	10 552	4 396	6 114	321	124	193 835
North-West	32 263	27 243	44 200	7 304	548	1 030	84	318	112 990
North-East	16 310	21 581	2 477	30 806	2 022	830	66	221	74 313
South-East	14 072	20 337	313	2 921	21 328	3 398	393	18	62 780
South-West	17 085	12 331	234	867	1 877	34 916	2 602	15	69 927
Peel	1 142	874	53	128	277	2 211	17 238	3	21 926
Avon Arc	261	360	253	520	35	24	0	2 397	3 850
Perth working zone	232 982	186 679	56 036	55 451	31 747	51 638	20 893	3 136	638 562

Note: The total is less than the workers total in Table 7.3, due to the exclusion of those who work in an undefined part of Perth.

Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

Another way of looking at the cross-subregional commuting flows is by considering the probability that an employed resident of one subregion will commute to a workplace in another subregion. The probabilities which exceeded 10 per cent are outlined below:

- The probability of working in the Inner subregion is highest for residents of the Middle subregion (36 per cent), followed by the North-West (24 per cent), South-West (21 per cent), North-East (19 per cent) and South-Eastern (19 per cent) Outer subregions.
- The probability of working in the Middle subregion is highest for residents of the South-East (28 per cent), North-East (25 per cent) and North-West (21 per cent) subregions. Residents of the South-West subregion had a 15 per cent probability of working in the Middle subregion.
- Residents of the Inner subregion have a 17 per cent probability of working in the Middle subregion, but the probability of working in each of the other subregions lies below 5 per cent. Similarly, the probability of Middle subregion residents working in each of the other subregions (apart from the Inner subregion) lies below 5 per cent.
- Residents of the Avon Arc have a 10 per cent probability of working in the North-East subregion.

These results indicate that commuting across subregions in Perth is dominated by commuting flows operating in an inward direction, whether from the middle suburbs and Outer subregions to a workplace in the inner city, from the Outer subregions to the middle suburbs or from the rural fringe to the adjacent Outer subregions.

Table 7.5 reveals the three top places of work for residents of each of the subregions. Typically all three are located within the subregion of interest. However, for residents of the Middle subregion, the Perth Inner SLA is the main place of work. For residents of the South-East subregion, the Middle subregion SLA of Canning is the main place of work. This reflects the very low rate of employment self-containment in the South-East subregion. For residents of the North-West subregion, only one of the top three places of work is located within the North-West subregion (Joondalup South), again reflecting low self-containment.

T7.5 Main places of work for residents of each subregion, 2006

Subregion of residence	Main SLA of work	2nd main SLA of work	3rd main SLA of work
Inner	Perth Inner	Perth Remainder	Subiaco
Middle	Perth Inner	Stirling Central	Canning
North-West	Joondalup South	Stirling Central	Perth Inner
North-East	Swan	Kalamunda	Mundaring
South-East	Canning	Gosnells	Armadale
South-West	Rockingham	Cockburn	Kwinana
Peel	Mandurah	Murray	Waroona
Avon Arc	Gingin	Chittering	Toodyay

Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

Table 7.6 shows the public transport mode share for each subregion of residence/subregion of work combination. Public transport mode share is highest for commutes from the North-West and South-East subregions to the Inner subregion, but all categories of commute to the Inner subregion have a relatively high public transport mode share. In contrast, commutes to a place of work in the North-East, South-East or South-West subregions very rarely rely on public transport. Public transport usage is dominated by trips involving a place of work in either the Inner or Middle subregion (93 per cent). While one-quarter of all commutes involve an origin and destination within the Outer subregion, only 2 per cent of these trips make use of public transport.

Residents of the Inner, Middle and North-West subregions are most likely to use public transport to get to work. Residents of the North-East and South-West subregion are considerably less likely to use public transport, but the public transport mode share has probably risen substantially in the South-West subregion since the opening of the Mandurah line.

T7.6 Public transport mode share by subregion of residence and subregion of work, Perth statistical division, 2006

Subregion of residence	Subregion of work						
	Inner	Middle	North-West	North-East	South-East	South-West	Perth SD
Inner	15	5	6	4	6	3	13
Middle	19	3	3	3	3	1	10
North-West	28	3	2	1	7	2	10
North-East	21	3	1	2	0	0	6
South-East	26	3	9	2	2	1	8
South-West	16	2	5	2	1	2	5
Perth SD	19	3	3	2	2	2	9

Source: BITRE analysis of ABS Census of Population and Housing 2006 data, extracted from TableBuilder

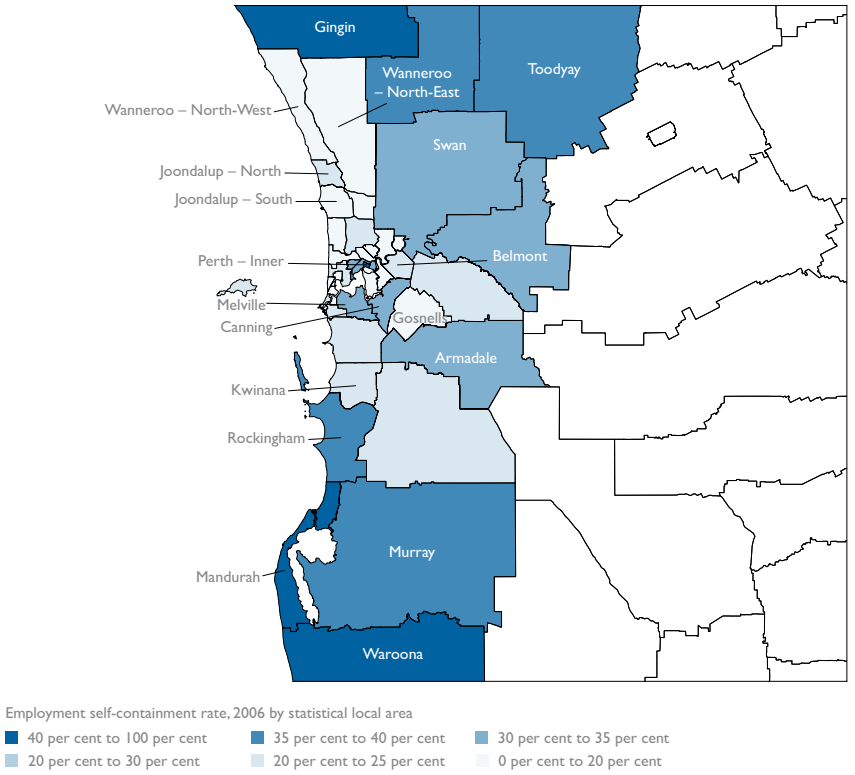
Commuting flows between SLAs

This section analyses commuting flows between Perth SLAs in 2006.

About one-quarter of all employed Perth residents worked in the same SLA in which they lived. Map 7.1 maps the self-containment rate for all Perth SLAs. It shows that employment self-containment is highest in the more peripheral areas of the Perth working zone, particularly Peel, Rockingham and the Avon Arc. For example, 60 per cent of employed Gingin residents work in Gingin, while 53 per cent of employed Mandurah residents work in Mandurah. Self-containment is also high for the Perth Inner SLA.

The SLAs to the north-west of the city centre consistently have less than one quarter of residents working within the home SLA. Stirling South-Eastern has the lowest self-containment rate with only 12 per cent of employed residents working in their home SLA. East Fremantle, Wanneroo South and Bassendean also perform very poorly on this measure, while Gosnells stands out as having a much lower rate of employment self-containment than its neighbours.

M7.1 Self-containment rate in each Statistical Local Area in Perth, 2006



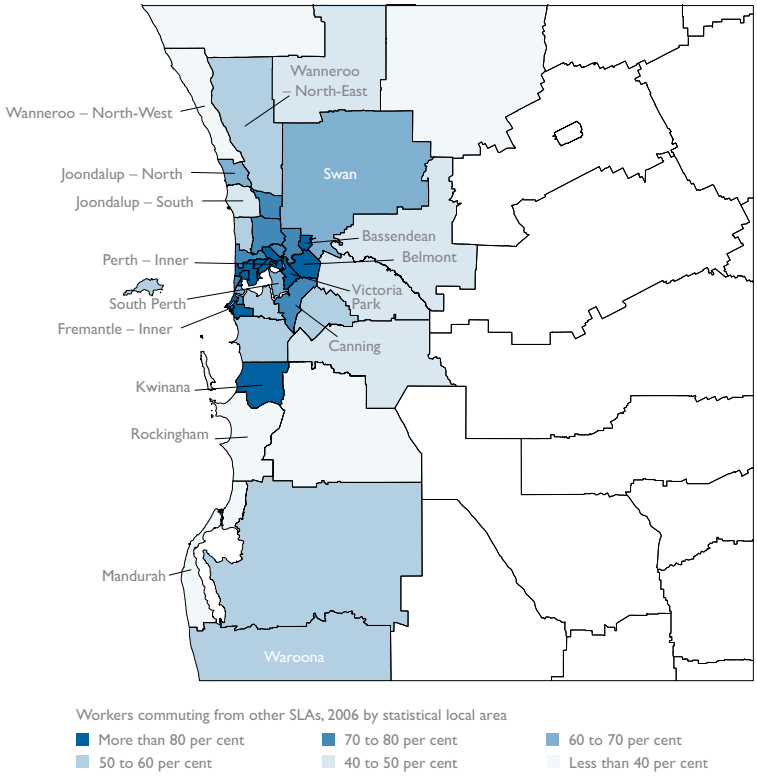
Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

The proportion of an SLA's workers who commute from a residence located outside the SLA provides a different perspective (see Map 7.2). Close to 100 per cent of those who work in Perth Inner, Fremantle Inner and Perth Remainder commute from outside the SLA. Many other inner suburbs also attract more than 80 per cent of their workers from outside the SLA, as does the Kwinana SLA in the South-West subregion.

The Wanneroo North-West, Rockingham, Mandurah, Toodyay, Gingin and Serpentine-Jarrahdale SLAs are much more reliant on the local population to provide their workforce. For example, only 15 per cent of those who work in Toodyay have a place of residence in another SLA.

While the peripheral areas of Mandurah, Rockingham, Toodyay and Gingin are able to provide jobs for a relatively high proportion of their employed residents, this is combined with a very limited ability to attract workers from further afield. This is in contrast to Wanneroo North-West and Serpentine-Jarrahdale which have low employment self-containment and a very limited ability to attract workers from further afield. Perth Inner, Perth Remainder, Subiaco and Canning combine an above-average degree of self-containment with a relatively high ability to attract workers from other SLAs.

M7.2 Proportion of workers who commute from outside the Statistical Local Area of work, 2006



Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

Of total commuting flows in 2006, only 17 per cent involved commuting to a place of work located in the City of Perth. This is considerably smaller in magnitude than the commuting flows that involve a place of work located within the home SLA.

Total commuting flows can be categorised according to the approximate direction of the commute:

- 43 per cent commuted in an inward direction, including the
  - 17 per cent commuting to a place of work in the City of Perth
  - 13 per cent commuting to a place of work elsewhere in the Inner subregion from a Middle or Outer subregion or peripheral SLA
  - 13 per cent commuting to a place of work in the Middle subregion from an Outer subregion or peripheral[30] SLA
- 9 per cent commuted in an outward direction
- the direction of commute was less clear for the remaining 48 per cent of commuting flows, which included
  - 27 per cent commuting within the home SLA
  - 7 per cent commuting to a different SLA within the Outer subregion or peripheral subregion of residence
  - 6 per cent commuting from one SLA in the Middle subregion to another.

Trips to work in an inward direction clearly dominate those in an outward direction for Perth. However, cross-suburban commutes, including both short distance commutes within the home SLA and commutes to nearby SLAs, also make up a large share of total commuting flows.

Table 7.7 lists the major commuting flows within Perth. The single largest flow is the 14 194 employed residents of Rockingham who have a place of work within the Rockingham SLA. Nine of the top ten listed flows involve the same SLA of work and SLA of residence.

The second part of the table lists the major commuting flows which involve an SLA of work which is different to the SLA of residence. The single largest inter-SLA commuting flow is the movement of 8496 residents of Gosnells to a place of work in the Canning SLA. Three of the top ten listed flows relate to a place of work in the CBD, two relate to a place of work in Perth Remainder and two relate to a place of work in Stirling Central.

Table 7.8 lists all SLA pairs which have a commuting flow involving more than 2000 employed persons, excluding flows within the home SLA. The CBD attracts more than 2000 workers from 11 different SLAs. These span the inner and middle suburbs as well as the North-West, North-East and South-East corridors. Other SLAs which draw substantial flows of workers from multiple SLAs include Perth Remainder (8 SLAs), Stirling Central (5), Canning (5), Swan (4), Belmont (3), Fremantle Remainder (2), Melville (2) and Cockburn (2). While the main commuter flows to Stirling Central are coming predominantly from the suburbs to its north, the main commuter flows to Canning are coming from the east and south. Swan presents a more complex picture, with substantial commuting flows from the east, the adjoining middle suburbs and the North-West corridor. The main commuter flows into the Belmont SLA come from the east.

30 The term peripheral subregion is used to refer to the Peel and Avon Arc subregions.

Interestingly no place of work in the South-East subregion features in the table, reflecting the limited number of jobs in the subregion. Of the employment hubs located in an Outer subregion, only Swan in the North-East subregion and Cockburn in the South-West are able to attract substantial flows of workers from SLAs in other subregions.

T7.7 Major commuting flows between Statistical Local Areas, Perth working zone, 2006

SLA of residence	SLA of work	Number of people
Top commuting flows		
Rockingham	Rockingham	14 194
Swan	Swan	12 723
Melville	Melville	11 533
Mandurah	Mandurah	11 137
Canning	Canning	10 385
Joondalup South	Joondalup South	10 211
Stirling Central	Stirling Central	10 195
Cockburn	Cockburn	8 734
Gosnells	Gosnells	8 698
Gosnells	Canning	8 496
Top commuting flows between different SLAs 2006		
Gosnells	Canning	8 496
Joondalup South	Stirling Central	5 665
Joondalup South	Perth Inner	5 069
Stirling Central	Perth Inner	4 656
Melville	Perth Inner	4 420
Joondalup South	Perth Remainder	3 918
Stirling Central	Perth Remainder	3 839
Cockburn	Melville	3 721
Stirling Coastal	Stirling Central	3 702
Rockingham	Kwinana	3 593

Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

All of the top ten employing SLAs in Perth listed in Table 4.2 appear in Table 7.8, except for Subiaco. While nearly 20 000 people work in Subiaco, it does not attract 2000 workers from any single SLA. This suggests its workforce is drawn from a relatively diverse range of locations.

This can be assessed by constructing a simple measure of residential diversity, which calculates the share of an SLA's workers accounted for by (for example) the top five SLAs of residence. The SLAs which draw their workforce from the most diverse mix of residential SLAs are Perth Inner, Perth Remainder, Subiaco and Nedlands. All are located in the Inner subregion. In each case the top five SLAs of origin contribute less than 45 per cent of the SLA's workers, while the top ten SLAs contribute less than 65 per cent of workers. In contrast, Mandurah workers are drawn from a very narrow range of SLAs, with the Mandurah, Murray and Rockingham SLAs making up 93 per cent of Mandurah workers. Wanneroo North-West and Toodyay also draw their workers from a very narrow range of SLAs. These three SLAs are all located on Perth's fringe.

T7.8 Commuting flows between different Statistical Local Areas that involve more than 2000 persons, Perth working zone, 2006

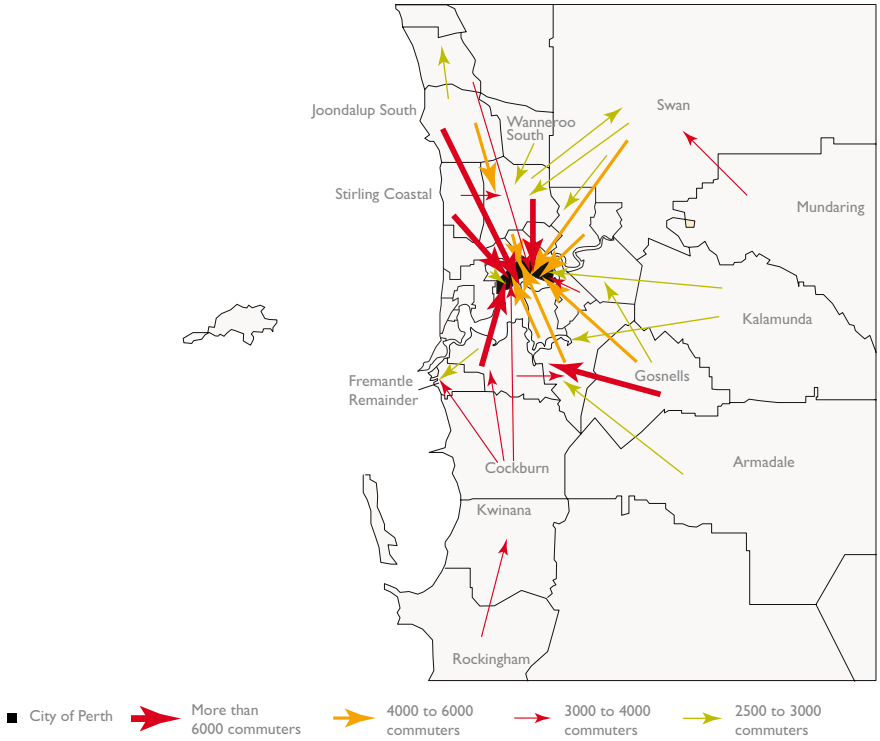
Subregion	Employment hub	Attracts more than 2000 workers from
Inner	Perth Inner	Joondalup South, Stirling Central, Melville, Stirling Coastal, Canning, Bayswater, South Perth, Gosnells, Swan, Vincent, Joondalup North
	Perth Remainder	Joondalup South, Stirling Central, Melville, Stirling Coastal, Bayswater, Canning, Swan, Gosnells
	Fremantle Remainder	Cockburn, Melville
	Victoria Park	Canning
Middle	Canning	Gosnells, Melville, Armadale, Kalamunda, Cockburn
	Stirling Central	Joondalup South, Stirling Coastal, Swan, Wanneroo South, Joondalup North
	Melville	Cockburn, Canning
	Bayswater	Swan
	Belmont	Gosnells, Swan, Kalamunda
	Stirling Coastal	Joondalup South
North-East	Swan	Mundaring, Stirling Central, Joondalup South, Bayswater
South-West	Kwinana	Rockingham
	Cockburn	Rockingham, Melville
North-West	Joondalup North	Joondalup South
	Wanneroo South	Joondalup South

Note: Excludes commutes within the SLA of residence.
Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

Map 7.3 presents this information visually, but for reasons of visual clarity focuses on flows of more than 2500 persons (rather than 2000 persons as in Table 7.8). To make the map more readable, all flows into and out of the Perth Inner and Perth Remainder SLAs have been aggregated and the map shows total flows for the City of Perth LGA. The map is dominated by commuting flows into the City of Perth. The Middle subregion SLAs of Canning and Stirling Central also feature as common destinations for commuters.

Most of the origin–destination flows involving more than 2500 persons operate in an inward direction. Some noteworthy exceptions are the outward flows from Joondalup South to Joondalup North, from Stirling Central to Swan, and from Melville to Fremantle Remainder

M7.3 Inter-SLA commuting flows involving 2500 or more persons, Perth working zone, 2006



Note: To make the map more readable, all flows into and out of the Perth Inner and Perth Remainder SLAs have been aggregated—the map shows total flows for the City of Perth LGA.

There were no inter-SLA commuter flows of more than 2500 persons for the SLAs not shown on this map (i.e. Mandurah, Murray, Waroona, Gingin, Toodyay and Chittering).

Commuting flows within the home SLA are not shown.

Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

The previous two tables are dominated by the more heavily populated SLAs such as Joondalup South and Stirling Central. Another way of looking at the inter-SLA commuting flows is by considering the probability that an employed resident of one SLA will commute to a workplace in another SLA.

The probability of commuting to the CBD is relatively high for many SLAs. Table 7.9 lists the SLAs which have the highest probability of commuting to the CBD as well as the highest probabilities of commuting which do not involve the CBD as the destination. The highest probabilities occur for residents of Perth Remainder commuting to the CBD (25 per cent) and for residents of Murray commuting to a place of work in Mandurah (23 per cent).

T7.9 Highest probabilities of commuting between Statistical Local Areas, Perth working zone, 2006

SLA of residence	SLA of work	Probability residents will commute to this place of work (per cent)
Top ten probabilities of commuting to CBD		
Perth Remainder	Perth Inner	25
Peppermint Grove	Perth Inner	18
Vincent	Perth Inner	18
Subiaco	Perth Inner	17
Stirling South-Eastern	Perth Inner	16
Cottesloe	Perth Inner	16
Nedlands	Perth Inner	15
South Perth	Perth Inner	15
Cambridge	Perth Inner	15
Claremont	Perth Inner	14
Top ten probabilities of commuting to a place of work outside the CBD		
Murray	Mandurah	23
Gosnells	Canning	19
Mundaring	Swan	19
Chittering	Swan	15
Fremantle Inner	Fremantle Remainder	14
Wanneroo South	Stirling Central	14
Vincent	Perth Remainder	13
Stirling South-Eastern	Perth Remainder	13
East Fremantle	Fremantle Remainder	12
Armadale	Canning	12

Note: Excludes commutes within the SLA of residence.

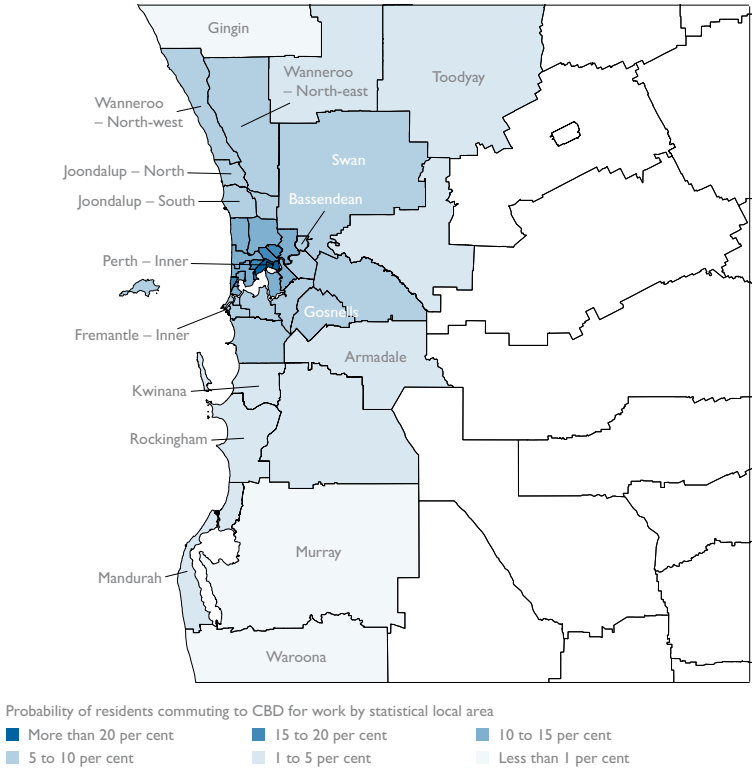
Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

The SLAs of residence which have the highest probability of commuting to a CBD workplace are all located in the Inner subregion, apart from Stirling South-Eastern, which belongs to the Middle subregion. While residents of Perth Remainder and Peppermint Grove are most likely to commute to the CBD for work, neither features amongst the SLAs which have the largest absolute flows of workers into the CBD. Joondalup South, Stirling Central and Melville each provide more than 4000 workers to the CBD, but they feature because of their large population base, not because residents have a high probability of working in the CBD.

Map 7.4 shows the probability of commuting to Inner Perth for residents of each SLA. Residents of Peel and the Avon Arc SLAs all have a less than 2 per cent probability of commuting to a workplace in the CBD, while the probability of commuting to the CBD is also very low for residents of Rockingham, Kwinana, Serpentine-Jarrahdale and Armadale. The probability of commuting to Inner Perth exceeds 10 per cent for all Inner subregion SLAs, apart from Inner Fremantle, Fremantle Remainder and East Fremantle.

The SLAs in the North-West subregion all have a probability of commuting to Perth Inner of between 5 and 10 per cent. However, two of the three SLAs in the South-East and South-West subregions have a probability of less than 5 per cent. The lower commuting to the CBD from the South-West subregion may reflect the absence of a rail connection in 2006, but Armadale in the South-East is connected to the CBD by rail.

M7.4 Probabilities of residents of each Statistical Local Area commuting to the Perth CBD, 2006



Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

Returning to the bottom half of Table 7.9, the highest probabilities typically occur for neighbouring SLAs. Many involve a commute in an inward direction (e.g. from Chittering to Swan, or from Wanneroo South to Stirling Central). Some of the other SLA combinations with high probabilities involve cross-suburban commutes between SLAs which are roughly equidistant from the CBD (e.g. Murray to Mandurah, Fremantle Inner to Fremantle Remainder).

Commuting in an outward direction is less common, but there are some SLA pairs for which this is evident. Residents of the Middle subregion SLAs of Bassendean, Bayswater and Stirling Central have a reasonable probability of commuting to the North-East subregion SLA of Swan (11 per cent, 8 per cent and 6 per cent, respectively). Residents of the inner SLAs of East Fremantle and Fremantle Inner both have 5–7 per cent probabilities of commuting to the Cockburn SLA in the South-West subregion. Residents of Rockingham have a 5 per cent probability of commuting to the more southerly Mandurah SLA, and this exceeds the 4 per cent probability of Mandurah residents commuting to a workplace in Rockingham.

The *Network City Action Plan* (WAPC 2004c) aimed to improve the public transport system's viability by encouraging balanced ridership. While the journey to work origin–destination dataset doesn't separate out the different transport modes, it does show that relatively few of the SLA pairs with a commuting flow of more than 1000 persons achieve a balanced flow in both directions. Commuting between Stirling Central and Swan is well balanced, with 2800 persons commuting from Stirling Central to Swan and 2900 commuting in the opposite direction. Commuting between Stirling Central and Bayswater is also well balanced with about 1900 people commuting in each direction. The SLA pairs with the most unbalanced commuting flows include:

- Gosnells–Canning: 8500 people commuted from Gosnells to Canning, but only 1700 commuted in the opposite direction.
- Joondalup South–Stirling Central: 5700 people commuted from Joondalup South to Stirling Central, but only 900 commuted in the opposite direction.
- The SLA pairs involving the two City of Perth SLAs: for example, while 4400 Melville residents commute to a place of work in Perth Inner, only a handful of people make the reverse commute. Similarly, about 3900 people commute from Joondalup South to Perth Remainder, but only 25 make the reverse commute. These results reflect the City of Perth's low residential population.
- Cockburn–Fremantle Remainder: 3500 people commuted from Cockburn to Fremantle Remainder, but less than 800 commuted in the opposite direction.
- Rockingham–Kwinana: 3600 people commuted from Rockingham to Kwinana, with just over 1000 making the reverse commute.

The remainder of this section focuses on commuting patterns for selected SLAs. Map 7.5 compares the major commuting flows for four different places of work:

- Perth Inner
- Canning
- Swan
- Subiaco.

Perth Inner draws more than 1000 workers from a wide range of inner, middle and outer SLAs. The Middle subregion SLA of Canning draws more than 1000 workers from a range of outer suburban SLAs (Swan, Kalamunda, Armadale, Gosnells, Cockburn) and the neighbouring Melville SLA. The flows from Inner subregion SLAs and the northern suburbs of Perth into Canning are more modest. The North-East subregion SLA of Swan is more connected with the northern suburbs, attracting over 1000 commuters from the adjacent Mundaring, Kalamunda, Bayswater, Stirling Central and Wanneroo South SLAs, as well as from Joondalup North and Joondalup South. The Inner subregion SLA of Subiaco attracts smaller commuting flows than the other three SLAs pictured in Map 7.5, with its largest flows being drawn from the northern suburbs (Stirling Central, Stirling Coastal and Joondalup South).

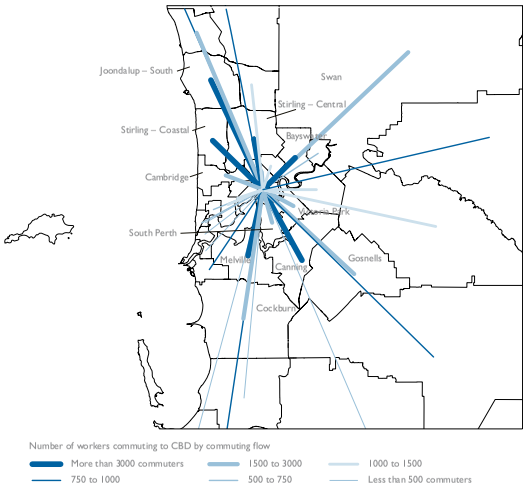
Map 7.6 compares the major commuting flows for four different SLAs of residence:

- Joondalup South
- Melville
- Kalamunda
- Cottesloe.

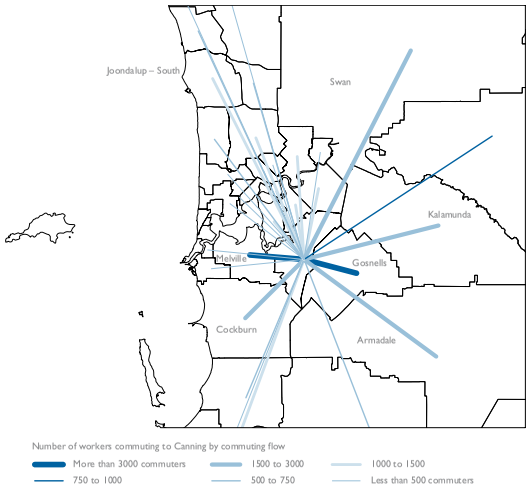
Joondalup South is the most heavily populated SLA in Perth. Large numbers of residents of Joondalup South commute to a place of work in the City of Perth. Other important work destinations include Swan and the neighbouring SLAs of Stirling Central, Wanneroo South and Joondalup North. Large numbers of Melville residents also worked in the City of Perth, with the neighbouring SLAs of Fremantle Remainder, Canning and Cockburn also receiving large commuter flows from Melville. The North-East subregion SLA of Kalamunda generated large commuter flows to Swan and Canning and more modest flows into the City of Perth. The Inner subregion SLA of Cottesloe has a relatively small population base in comparison to the other three SLAs in Map 7.6, and so generated relatively modest commuter flows. The main work destinations were located within a relatively short distance of Cottesloe, and included the City of Perth, Subiaco, Fremantle Remainder and Stirling Central.

M7.5 Main commuting flows to selected places of work, Perth working zone, 2006

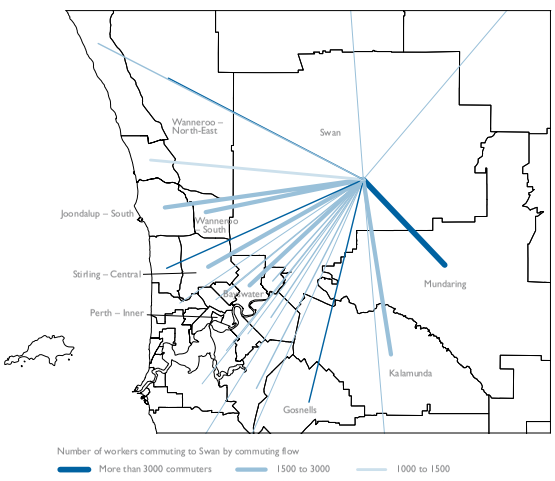
(a) Perth Inner



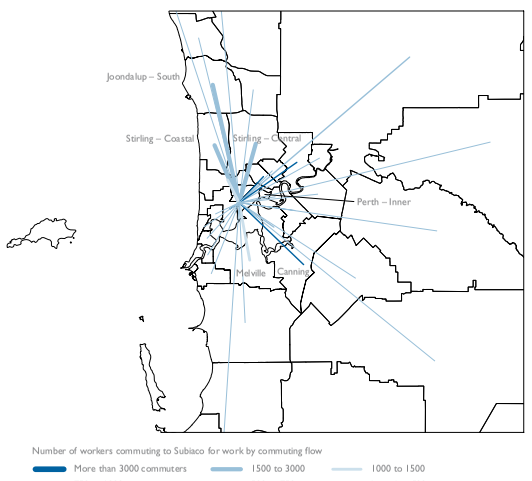
(b) Canning



(c) Swan



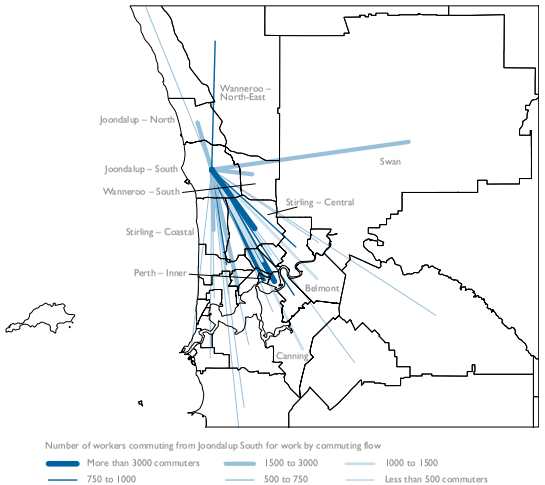
(d) Subiaco



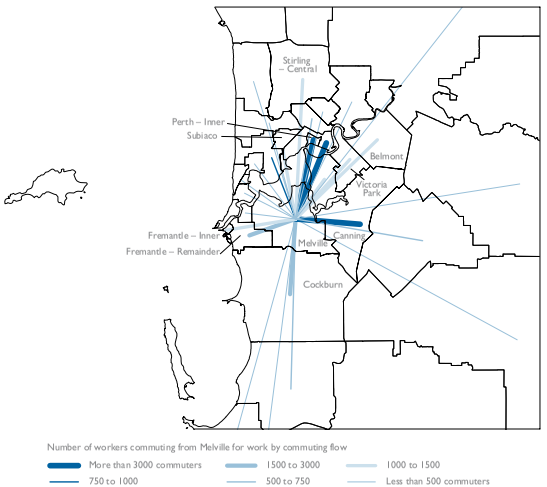
Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

M7.6 Commuting flows from selected Statistical Local Areas of residence, Perth working zone, 2006

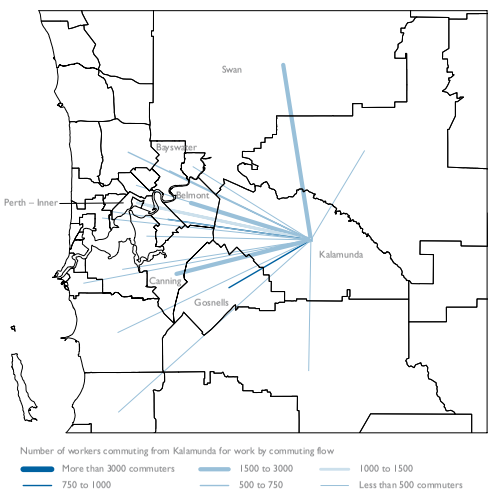
(a) Joondalup South



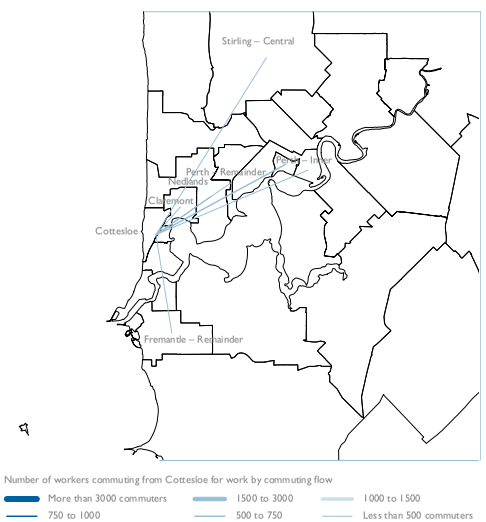
(b) Melville



(c) Kalamunda



(d) Cottesloe



Source: BITRE analysis of ABS Census of Population and Housing 2006 unpublished data.

This detailed series of maps reinforces the importance of commuting flows from the Inner, Middle and North-West subregions into the City of Perth and nearby employment centres such as Subiaco. It also highlights the complex mix of cross-suburban commuter flows that occur within Perth—from one Middle subregion SLA to another, from the Outer subregions to the Middle subregion (and vice versa), within Outer subregions and between Outer subregions.

Commuting distances

Travel times and travel distances have been an ongoing concern of strategic plans for Perth (Hill 2005, WAPC 2009a). According to the HILDA survey, Perth residents who were employed full-time spent about 4.4 hours commuting to work each week in 2006 (Melbourne Institute 2009). This is similar to the average commuting time for Adelaide residents, but well below the average commuting times in Sydney, Melbourne and Brisbane (ibid). The study also finds that, nationally, commuting time is highest for professionals and lowest for elementary clerical, sales and service workers.

This section presents an analysis of spatial variation in the average distance travelled to work within Perth. The analysis is based solely on Perth residents who work within the Perth working zone (i.e. it excludes long distance commuting).

BITRE has estimated average distances based on commuting flows between SLAs, and so the distance estimates will be less accurate than calculations based on more spatially disaggregated data such as destination zones. The BITRE estimates are derived straight line distances and so are likely to be systematically lower than average distance calculations that reflect actual or simulated travel routes.

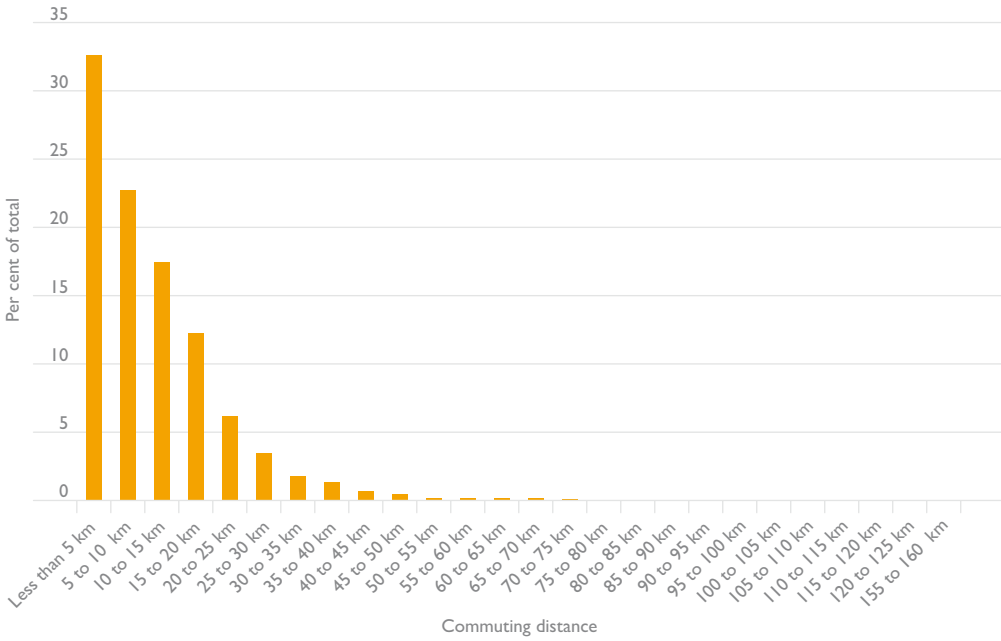
Distance for each origin–destination pair was calculated using MapInfo as the straight line distance between the population-weighted centroid of the origin SLA (calculated using 2006 data for CCDs) and the job-weighted centroid of the destination SLA (calculating using 2006 data for destination zones). People who work at home are assigned a distance of zero, while people who work elsewhere in their home SLA are assigned the straight-line distance between the population-weighted centroid and the job-weighted centroid of the home SLA. The distance between each origin–destination pair was fixed for 2001 and 2006.

A range of different methods for calculating distance were experimented with, prior to settling on this method. The average distance figure for SLAs proved most sensitive to the estimate of the distance travelled within the home SLA, particularly for peripheral SLAs such as Chittering, Gingin, Toodyay and Murray, where self-containment rates were high and the SLAs were physically large.

Figure 7.1 shows the distribution of journey to work travel distances within Perth. While 33 per cent of workers travel less than 5 kilometres to get to work and 55 per cent travel less than 10 kilometres, about 5 per cent of workers travel more than 30 kilometres to their workplace.

A significant minority of Perth residents live within 30 minutes walk of their workplace—14 per cent travel less than 1 kilometre and 21 per cent travel less than 2 kilometres to their place of work. Just under 4 per cent of employed Perth residents work from home.

F7.1 Distribution of workers by journey to work travel distance, 2006



Source: BITRE analysis of ABS Census of Population and Housing 2006 data and WA DPI and ABS ASGC digital boundary files.

The average distance travelled to work was 11.0 km in 2006. Coupled with the HILDA average travel time figure reported earlier for full-time workers of 4.4 hours per week, which is equivalent to 26.4 minutes per trip, this equates to an average speed of roughly 25 km per hour while commuting. This is an average speed from door-to-door, and so may include time spent walking as well as time in a vehicle.

Table 7.10 shows that average commuting distances are relatively low for the Inner and Middle subregion, which together housed 46 per cent of employed residents. Average distances are higher for residents of the four Outer subregions and a little higher again for Peel. Residents of the Avon Arc had the farthest to travel with an average commuting distance of 28 kilometres, although this area housed a relatively small proportion of the of the total Perth population at 0.6 per cent. On average, residents of the Outer subregion travelled roughly double the distance that Inner subregion residents travelled to get to work. This is consistent with Western Australian Government (2008) which reports that while the average time spent travelling is similar across the Perth metropolitan region, the average distance travelled per day is greater for residents of outer suburbs than for inner city residents.

T7.10 Average commuting distance for journey to work, by subregion, 2006

Subregion	Average commuting distance for residents of subregion (km)	Average commuting distance to a workplace in this subregion (km)
Inner	6.6	11.8
Middle	8.2	10.6
Outer	13.5	10.0
North-West	14.4	7.8
North-East	12.4	11.0
South-East	12.2	8.5
South-West	14.3	12.1
Peel	15.6	11.7
Avon Arc	27.5	21.5
Perth working zone	11.0	11.0

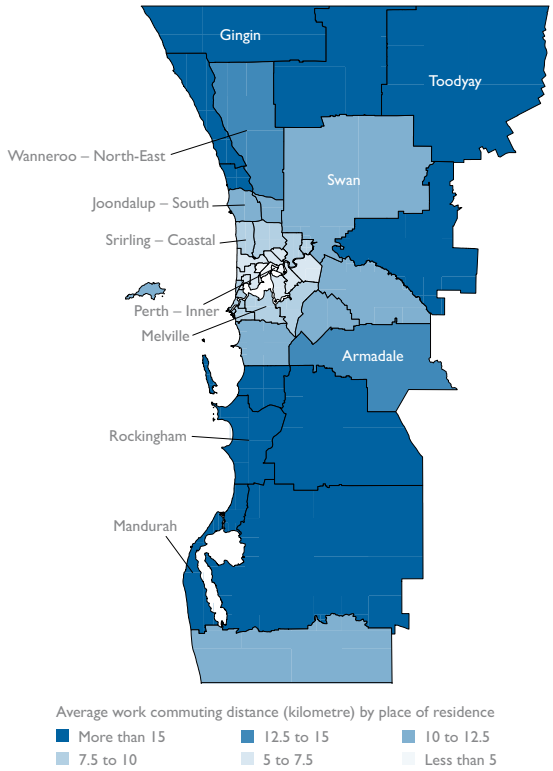
Source: BITRE analysis of ABS Census of Population and Housing 2006 data and WA DPI and ABS ASGC digital boundary files.

The SLA data in Map 7.7 shows a similar pattern—residents of the City of Perth commute the least average distance to work, followed by residents of SLAs close to the city centre, middle ring SLAs, outer suburban SLAs, etc.

Table 7.11 lists the SLAs of residence which have the highest and lowest average commuting distances. Perth Inner residents travel just 2.7 kilometres to work on average, while Chittering residents have an average travel distance of 31 kilometres. Overall, the table shows that residents of the Avon Arc and other urban fringe SLAs have the longest average commutes to work, while residents of SLAs adjacent to the CBD tend to have shorter average commutes to work.

Table 7.10 also shows that average commuting distances travelled to a workplace in the Outer subregion are somewhat less than average commuting distances travelled to workplaces in the Inner and Middle subregions. Commuting distances are lowest for people who work in the North-West and South-East subregions—these are the two subregions that have the lowest employment self-sufficiency (see Table 4.1). Avon Arc workers travel considerable distances, and workers in the South-West, Peel and Inner subregions also have average travel distances which exceed the Perth-wide average.

M7.7 Average commuting distance to place of work, by SLA of residence, 2006



Note: SLA boundaries as at 2006 ASGC.

Source: BITRE analysis of ABS Census of Population and Housing 2006 data and WA DPI and ABS ASGC digital boundary files.

T7.11 Five longest and shortest average distances travelled to work by SLA of residence, 2006

SLA of residence	Average travel distance (km)	SLA of residence	Average travel distance (km)
Chittering	31.0	Perth Inner	2.7
Toodyay	30.2	Perth Remainder	4.0
Wanneroo North-West	22.4	Subiaco	4.8
Gingin	21.9	Vincent	5.5
Serpentine-Jarrahdale	19.8	Stirling South-Eastern	5.8

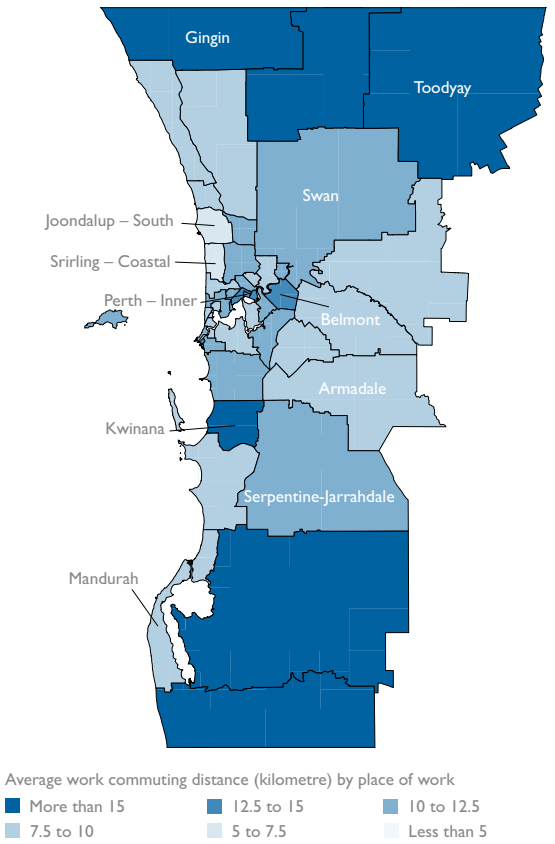
Source: BITRE analysis of ABS Census of Population and Housing 2006 data and WA DPI and ABS ASGC digital boundary files.

Map 7.8 maps average commuting distance for each SLA of work, but unlike Map 7.7, no clear pattern emerges. No place of work SLA has an average travel distance of less than 5 kilometres and only two SLAs (Joondalup South and Stirling Coastal) have an average travel distance of between 5 and 7.5 kilometres. The SLAs which attracted workers from furthest afield were in the Avon Arc and Peel subregions (see Table 7.12).

Kwinana, Belmont, Perth Inner, Perth Remainder and Fremantle Inner stand out as having much higher average commuting distances than the SLAs surrounding them. This appears to reflect the nature of the work available in these areas. The City of Perth is largely devoted to office blocks and retailing, while Fremantle Inner is an important retail and tourism centre. Belmont is a transport hub, which contains the Perth international and domestic airports and Kewdale freight terminal. Kwinana is Perth's major manufacturing area.

Wanneroo North-West and Mandurah are interesting in that both have a relatively high average travel distance for residents but a very low average distance travelled to workplaces within the SLA. These are both predominantly residential SLAs a substantial distance from the city centre. A very large proportion of people who work in the SLA are drawn from within the SLA itself.

M7.8 Average commuting distance to each SLA of work, 2006



Note: SLA boundaries as at 2006 ASGC.

Source: BITRE analysis of ABS Census of Population and Housing 2006 data and WA DPI and ABS ASGC digital boundary files.

T7.12 Five longest and shortest average distances travelled to work by SLA of work, 2006

SLA of work	Average travel distance (km)	SLA of work	Average travel distance (km)
Chittering	26.8	Joondalup South	5.3
Gingin	22.0	Stirling Coastal	7.0
Waroona	20.9	Mandurah	8.0
Murray	20.6	Wanneroo North-West	8.1
Kwinana	17.3	Armadale	8.1

Source: BITRE analysis of ABS Census of Population and Housing 2006 data and WA DPI and ABS ASGC digital boundary files.

Changes between 2001 and 2006

Change in long distance commutes

Due to the previously mentioned coding problems in the 2001 ABS commuting matrix, and the absence of detailed data on long distance commuting flows in the WA Government's corrected matrix, BITRE was not able to undertake any detailed analysis of changes in long distance commuting flows.

The data that is available suggests that between 2001 and 2006:

- There was a large absolute increase in the number of people who were employed in the Perth working zone but lived outside it.
- Residents of the 'Bunbury and surrounds' and 'Northam-York and surrounds' working zones recorded the largest absolute increase in commuting to a workplace in Perth.
- There was also a large absolute increase in the number of Perth residents who commuted to a workplace outside of Perth.
- The increases were largest for Perth residents commuting to East Pilbara, Ashburton and Roebourne, but were also substantial for Wiluna and Ravensthorpe.
- There was a large absolute decline in the number of Perth residents commuting to a workplace in Bunbury and surrounds.

Perth attracts relatively few commuters from surrounding regions, but as Perth expands an increasing number of Bunbury residents are commuting to Peel for work and an increasing number of Northam and York residents are commuting to a workplace in Perth's eastern suburbs. The rapid growth of WA's mining industry in recent years and a shift to fly in fly out operations, has resulted in a marked increase in commuter flows from Perth to remote mine sites, such as those in the Pilbara.

Subregional overview of change

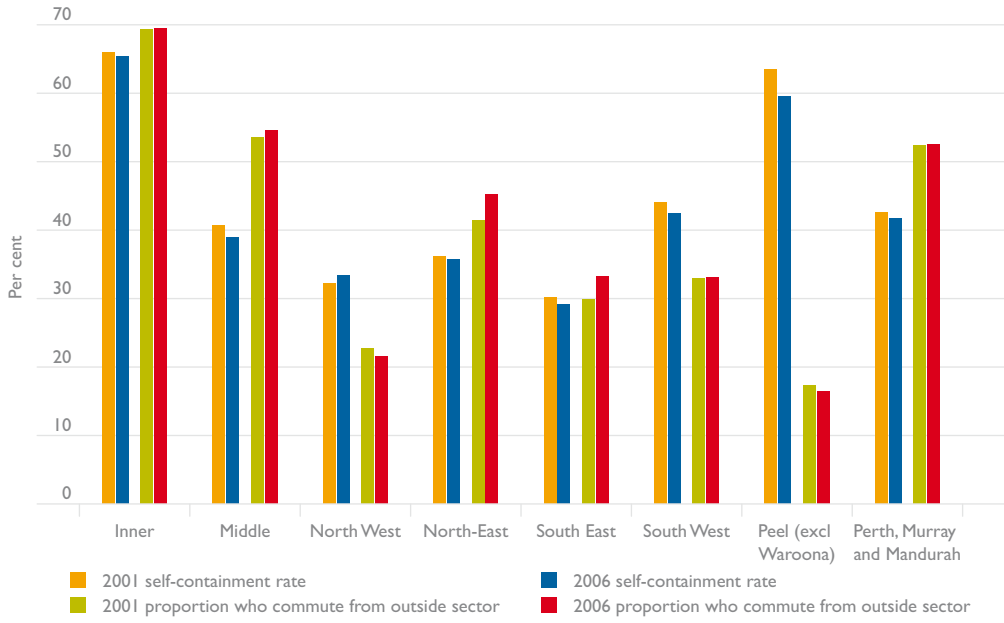
The remainder of the analysis of changes in commuting flows between 2001 and 2006 focuses only on the flows that occur within Perth, Mandurah and Murray.

Figure 7.2 summarises the change in each subregion's degree of employment self-containment (i.e. the proportion of employed residents who work in their home subregion) and the change in the extent to which each subregion is able to attract workers who reside in other subregions of the city. Neither measure has changed significantly for the Perth, Mandurah and Murray region as a whole. However, noteworthy changes have occurred for three of the subregions:

- The North-East subregion attracted a higher proportion of its workers from other subregions in 2006, than in 2001. As previously noted, Swan and Kalamunda experienced very strong jobs growth, which outpaced growth in the local population. The expanded employment base generated rapid growth in the number of people commuting into the North-East subregion from other parts of Perth. The number of Middle subregion residents working in the North-East subregion increased by about 2000 between 2001 and 2006, while the increase was 1900 for the North-West subregion.
- The South-Eastern subregion also attracted a higher proportion of its workers from other subregions in 2006 than in 2001. Of most significance was the increase of 1700 in the number of Middle subregion residents working in the South-East subregion.
- Peel (excluding Waroona) had a lower employment self-containment rate in 2006 than in 2001. The number of Peel residents commuting to other parts of Perth grew much more rapidly than the number of Peel residents who worked in Peel.

Little progress has been made towards improving employment self-containment within Perth's Outer subregions during this period. In both 2001 and 2006, 35 per cent of the employed residents of Perth's Outer subregions had a place of work within their home subregion. The North-West, North-East and South-West subregions experienced very rapid jobs growth, but only the North-West subregion recorded an improvement in employment self-containment (and the increase was marginal).

F7.2 Self-containment and proportion who commute from outside by subregion, 2001 and 2006



Source: BITRE analysis of ABS Census of Population and Housing unpublished data and corrected 2001 commuting matrix provided by WA DPI.

Between 2001 and 2006, commuter flows either grew or remained stable for all subregion pairs, with no subregion pair experiencing a decline of more than 100 people. The largest absolute increases between 2001 and 2006 occurred for the within subregion flows, such as the increase of 8800 North-West subregion residents working in the North-West subregion. The largest increases in flows between subregions were:

- an additional 6800 Middle subregion residents working in the Inner subregion, representing an average annual increase of 2 per cent.
- an additional 3500 North-West subregion residents working in the Inner subregion, representing an average annual increase of 2 per cent.

Other between subregion flows showed a more rapid rate of growth—for example, an additional 1900 North-West subregion residents worked in the North-East subregion in 2006, representing an average annual increase of 6 per cent. The between subregion flows in which Peel was either the origin or destination typically showed very rapid growth rates.

Change in commuting flows between SLAs

Between 2001 and 2006, the proportion of total Perth, Mandurah and Murray commuting flows which involved a place of work located within the SLA of residence declined marginally from 23.8 per cent to 23.3 per cent.

Table 7.13 provides an overview of the main types of commuting flows observed *within* Perth, Mandurah and Murray. There have been some subtle shifts in the relative prominence of different types of flows *between* 2001 and 2006:

- Commuting flows operating in an outward direction have maintained their share of total flows.
- Commuting flows operating in an inward direction have experienced a relative decline. This applies to inward flows to a place of work in the CBD, as well as inward flows to workplaces elsewhere in the Inner subregion or in the Middle subregion.
- Commutes within the home SLA have declined in relative terms.
- Commuting flows where the place of residence and place of work are within the same subregion, but not the same SLA, have increased in prominence.
- Commutes from one Outer subregion to another have also become more prominent.

T7.13 Proportion of total commuting flows within Perth, Mandurah and Murray by type, 2001 and 2006

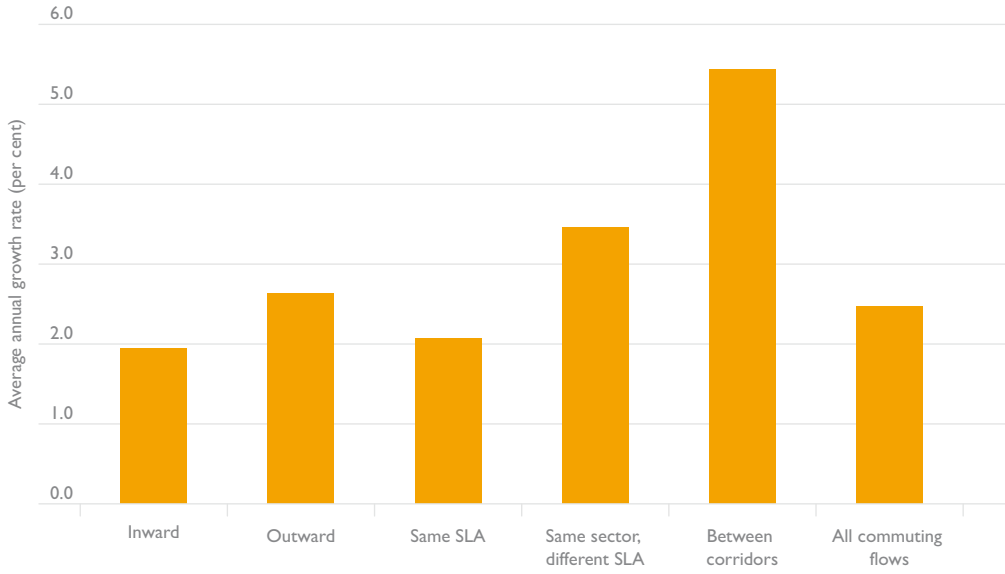
Type of commuter flow	2001 (per cent)	2006 (per cent)
Inward direction	44.0	42.9
To the City of Perth	17.0	16.6
To an SLA elsewhere in Inner subregion from Middle, Outer subregion or peripheral location	13.2	12.8
To a Middle subregion SLA from an Outer subregion or peripheral location	13.5	13.0
Outward direction (e.g. from Middle subregion to an Outer subregion)	9.3	9.3
Other flows: direction unclear	46.7	47.8
Within home SLA	23.8	23.3
Within home subregion, but different SLA	19.7	20.7
From one Outer subregion to another	3.2	3.7

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

As the two most common types of commuting flows (i.e. commuting to the CBD and commuting within the home SLA) become less prominent, the spatial dimensions of commuting patterns within Perth are becoming more diverse and complex. There appears to have been considerable growth in cross-suburban commuting, particularly from one Outer subregion location to another (outside the home SLA). This reflects the strong jobs growth in the Outer subregions and Peel in recent years. This is confirmed in Figure 7.3, which shows that inward commuting and commuting within the home SLA experienced below average growth between 2001 and 2006. By contrast, commuting between Outer subregions experienced very rapid growth.

WAPC (2003d p.60) argues that '[t]he new geography of employment is generating commuting patterns that are further undermining the effectiveness of public transport'. Between 2001 and 2006, Perth managed to achieve growth in its public transport mode share, despite the continued decline in the City of Perth's employment share and the shift towards a more diverse mix of cross-suburban commuting flows.

F7.3 Growth in different types of commuting flows within Perth, Mandurah and Murray, 2001 to 2006



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Table 7.14 lists the commuting flows which experienced the greatest change in the number of commuters between 2001 and 2006. The single largest change was the increase in the number of Rockingham residents who worked in Rockingham from 10 500 to 14 200 between 2001 and 2006. Eight of the top ten greatest changes involved the same SLA of work and SLA of residence.

T7.14 Greatest change in commuting flows between 2001 and 2006 for Perth, Mandurah and Murray

SLA of residence	SLA of work	Change in number of people	Average annual growth rate (per cent)
Greatest change			
Rockingham	Rockingham	+ 3 700	6
Mandurah	Mandurah	+ 2 900	6
Swan	Swan	+ 2 200	4
Joondalup South	Joondalup South	+ 1 400	3
Cockburn	Cockburn	+ 1 300	3
Gosnells	Gosnells	+ 1 300	3
Melville	Melville	+ 1 200	2
Stirling Coastal	Perth Inner	+ 1 000	7
Joondalup South	Perth Inner	+ 1 000	5
Wanneroo North-West	Wanneroo North-West	+ 1 000	8
Greatest change for commuting flows between different SLAs			
Stirling Coastal	Perth Inner	+ 1 000	7
Joondalup South	Perth Inner	+ 1 000	5
Gosnells	Canning	+ 1 000	2
Melville	Perth Inner	+ 900	5
Canning	Perth Inner	+ 800	6
Rockingham	Kwinana	+ 800	5
Bayswater	Perth Inner	+ 700	5
Wanneroo North-East	Joondalup North	+ 700	15
Rockingham	Mandurah	+ 700	10
South Perth	Perth Inner	+ 600	5

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

The second part of the table focuses on the greatest absolute change where the SLA of work was different to the SLA of residence. The single largest inter-SLA increase related to the 1000 person increase in commuting from Stirling Coastal to Perth Inner. Six of the ten listed SLA pairs involve Perth Inner as the place of work.

Some of the SLA pairs featured in Table 7.14 have modest average annual growth rates (e.g. Melville to Melville, Gosnells to Canning). Growth rates were typically much higher for SLA pairs where the origin region was an urban fringe area experiencing rapid population growth (e.g. Wanneroo North-East, Rockingham, Mandurah).

Some commuting flows reduced in magnitude between 2001 and 2006. The largest absolute decline occurred for commuting from Stirling Central to Perth Remainder—it fell by 600 people between 2001 and 2006.

The remainder of this section focuses on changes in commuting patterns for selected SLAs. Map 7.9 compares the changes in commuting flows for four different places of work:

- Perth Inner
- Canning
- Swan
- Subiaco.

Perth Inner recorded substantial increases in commuter flows from a wide range of SLAs, including the quite distant (but rapidly growing) SLAs of Wanneroo North-East and Rockingham. For Canning, the largest gains in commuter flows occurred from Gosnells in the South-East subregion and Cockburn in the South-West subregion. Fewer Armadale residents commuted to a place of work in Canning in 2006 than in 2001. The pattern for Swan is quite striking, with the largest gains occurring for Perth's northern suburbs, particularly Wanneroo South and Joondalup South. Subiaco recorded a smaller overall gain in employment over the period than the other pictured SLAs, but experienced an increase in commuters from a range of SLAs across the Inner, Middle, North-West and North-East subregions.

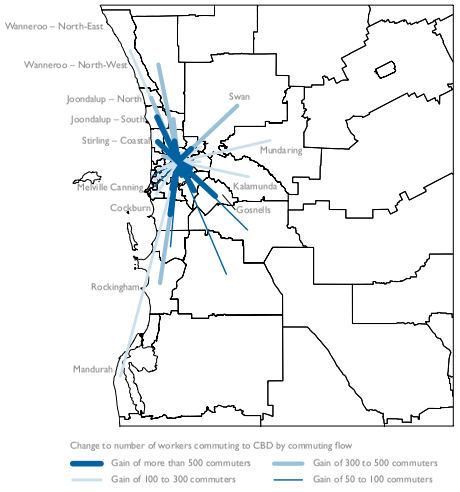
Map 7.10 compares the changes in commuting flows for four different SLAs of residence:

- Wanneroo North-East
- Melville
- Stirling Coastal
- Vincent.

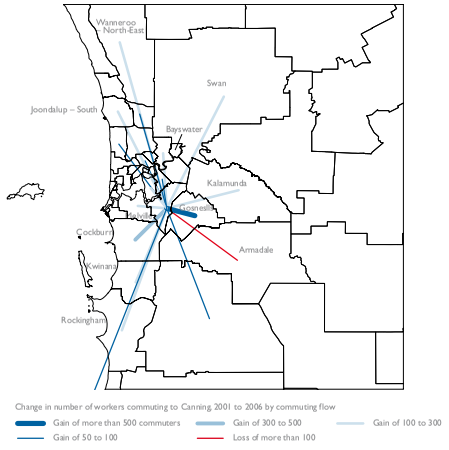
Wanneroo North-East experienced very rapid growth in population and employed residents between 2001 and 2006, and this growth was associated with much higher commuting flows to Swan, Wanneroo South and Joondalup North. Melville is a much more established residential area, and while an increased number of Melville residents commuted to Perth Inner, there were declines in commuting to Perth Remainder, Stirling Central and Fremantle Inner over the period. Perth Inner also received increased commuter inflows from the Stirling Coastal and Vincent SLAs. While commuting to the CBD recorded the greatest growth, Stirling Coastal provided increased numbers of workers to Swan, Stirling Central and Nedlands, while Vincent provided more workers to Subiaco and Cambridge in 2006 than it did in 2001.

M7.9 Changes in commuting flows to selected places of work in Perth, 2001 to 2006

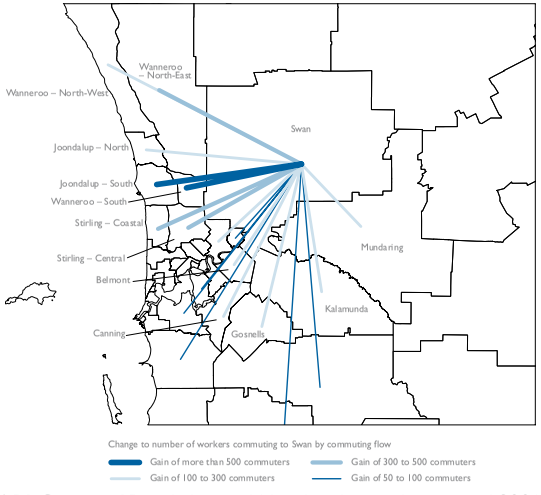
(a) Perth Inner



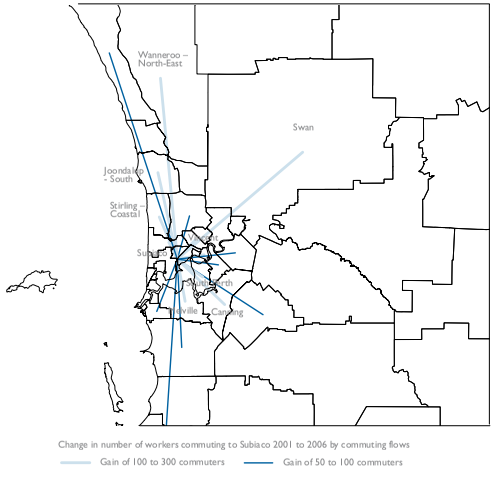
(b) Canning



(c) Swan



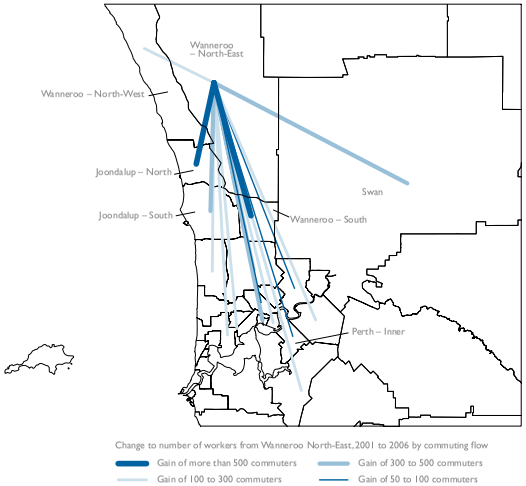
(d) Subiaco



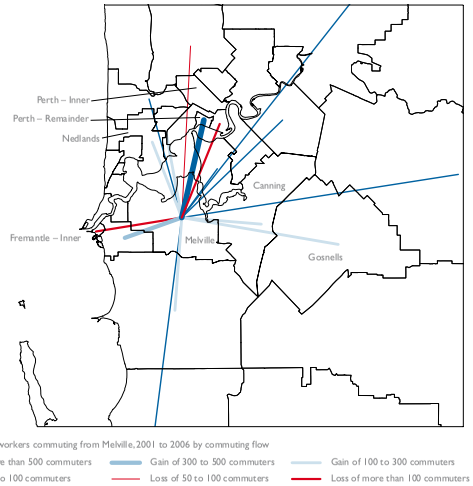
Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

M7.10 Changes in commuting flows from selected Statistical Local Areas of residence in Perth, 2001 to 2006

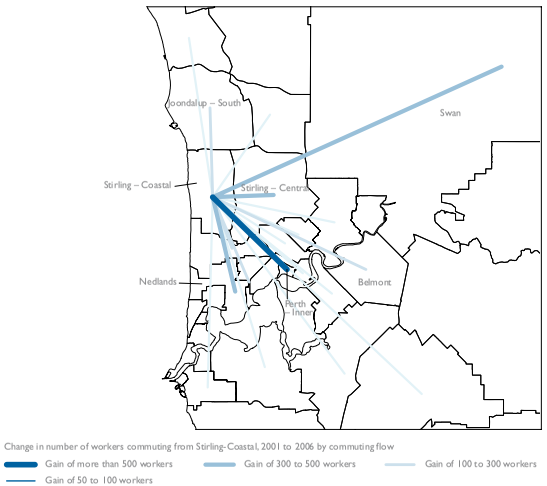
(a) Wanneroo North-East



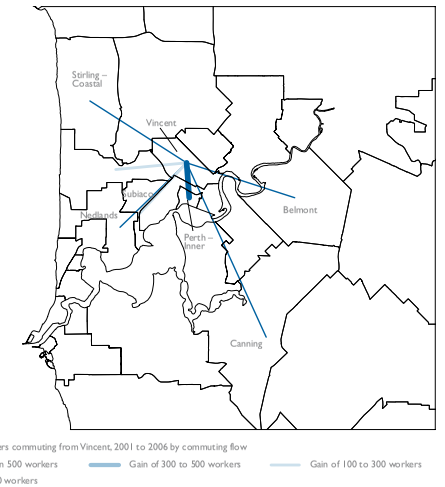
(b) Melville



(c) Stirling Coastal



(d) Vincent



Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

The preceding two sets of maps highlight the important role of the Perth Inner and Swan SLAs with respect to changes in commuter flows between 2001 and 2006. Perth Inner accounted for 20 per cent of Perth's jobs growth over the period, while Swan contributed 10 per cent of jobs growth. This jobs growth was reflected in two main changes in commuting flows within Perth:

- growing commuter flows from a wide range of different residential SLAs to the CBD
- large increases in commuting from the North-West subregion and the Middle subregion (north of the river) to Swan.

The rapid population and labour force growth in the Wanneroo North-East and Rockingham SLAs was a further contributor to change, generating increased commuter flows to nearby SLAs (e.g. from Rockingham to Kwinana and Mandurah, from Wanneroo North-East to Joondalup North).

Change in distance travelled

Metropolitan plans for Perth have long aimed to achieve reductions in commuting times and distances. For example, *Metroplan* aimed to encourage jobs growth in the outer suburbs to 'allow people to work closer to their homes, reducing peak hour commuter travel' (Hill 2005 p.134). Similarly, *Directions 2031* aims to promote 'higher levels of employment self-sufficiency in subregional areas, thereby reducing commuting distances and times' (WAPC 2009a).

According to the HILDA survey, average commuting times for full-time Perth workers have remained stable between 2002 and 2006, oscillating between 4.2 and 4.4 hours per week. In contrast, the national average increased by 9 per cent between 2002 and 2006 (Melbourne Institute 2009). An interesting finding of the HILDA analysis is that those who moved house but not job increased commuting time by 0.13 hours, while those who moved job but not house reduced commuting time by 0.35 hours (ibid). This implies that people may choose to shift jobs in order to reduce travel time, but shift house for other reasons.

BITRE has calculated average travel distances using the method outlined earlier in the chapter. The key point to note is that the following analysis is based only on people who both work and live in Perth, Mandurah and Murray, while the 2006 analysis was based on the Perth working zone as a whole (which includes the additional SLAs of Chittering, Toodyay, Gingin and Waroona). Using this approach, BITRE has estimated the average commuting distance for Perth, Mandurah and Murray at 10.7 kilometres in 2001 and 10.8 kilometres in 2006.

The HILDA time estimates and BITRE's distance estimates therefore suggest minimal change has occurred between 2001 and 2006. Based on household travel survey data, Lawrence (2005) concludes that the median trip distance across all Perth trips (not just commutes) did not change significantly between 1976 and 2003. Other studies have suggested that average commuting distances rose considerably for Perth in the 1970s and 1980s (State Planning Commission 1986, Hill 2005)

Table 7.15 shows how the frequency distribution of trips of different lengths has changed. Between 2001 and 2006, very short trips of less than 5 kilometres increased from 32.2 to 32.7 per cent of all trips, but very long trips of more than 30 kilometres also rose from 4.4 to 4.8 per cent of trips. Trips of between 5 and 10 kilometres declined from 23.3 to 22.8 per cent of all trips. The net effect was a very small increase in average commuting distance over the period.

T7.15 Distribution of workers by journey to work travel distance, 2001 and 2006

Distance range	2001 percentage share	2006 percentage share	Percentage point difference
< 2km	20.7	20.9	0.2
2 to 5km	11.5	11.8	0.3
5 to 10km	23.3	22.8	–0.5
10 to 15km	17.5	17.6	0.0
15 to 20km	12.6	12.4	–0.2
20 to 25km	6.2	6.2	0.0
25 to 30km	3.7	3.5	–0.2
30+ km	4.4	4.8	0.4
All trips	100.0	100.0	0.0

Note: Relates to Perth, Mandurah and Murray only.

Source: BITRE analysis of ABS Census of Population and Housing 2006 and 2001 data, corrected 2001 commuting matrix provided by WA DPI and DPI and ABS ASGC digital boundary files.

Table 7.16 examines how average commuting distances have changed at the subregional scale. Most of the changes by subregion of residence were fairly modest. More substantial changes were evident in terms of distance travelled to the workplace subregion, with the North-East and South-East subregions recording increases in commuting distance between 2001 and 2006, and Peel (i.e. Murray and Mandurah) recording a fall in commuting distance.

Table 7.17 summarises the changes in average commuting distance at the SLA scale. For most SLAs, the average distance travelled to work remained very stable between 2001 and 2006. Residents of Perth Inner and Wanneroo North-West travelled a shorter average distance to work in 2006 than in 2001, while for residents of Murray, Kwinana and Inner Fremantle the average commuting distance increased substantially. The average distance travelled to work increased notably for nine place-of-work SLAs, but declined notably for just three. Kalamunda recorded the greatest change, with the average distance travelled to a workplace in the SLA rising from 6.6 to 8.0 km between 2001 and 2006. Kalamunda experienced strong jobs growth over the period, driven by the *transport and storage*, *manufacturing* and *construction* industries.

T7.16 Average journey to work travel distance by subregion of residence and subregion of work, 2001 and 2006

	Average distance from subregion of residence (kilometres)			Average distance to subregion of work (kilometres)		
Subregion	2001	2006	Change	2001	2006	Change
Inner	6.6	6.5	–0.1	11.7	11.8	0.1
Middle	8.1	8.2	0.1	10.4	10.5	0.2
Outer	13.4	13.5	0.0	9.6	10.0	0.3
North-West	14.5	14.2	–0.3	7.9	7.6	–0.3
North-East	12.3	12.2	–0.1	10.3	10.7	0.4
South-East	12.3	12.2	–0.1	7.9	8.5	0.6
South-West	14.1	14.2	0.1	12.0	12.1	0.1
Peel (excl Waroona)	15.0	15.2	0.2	11.3	10.7	–0.6
Perth, Mandurah and Murray	10.7	10.8	0.1	10.7	10.8	0.1

Source: BITRE analysis of ABS Census of Population and Housing 2006 and 2001 data, corrected 2001 commuting matrix provided by WA DPI and DPI and ABS ASGC digital boundary files.

T7.17 Distribution of workers by journey to work travel distance, 2001 and 2006

Change in average commuting distance (kilometres)	SLA of residence		SLA of work	
	Number of SLAs	Examples	Number of SLAs	Examples
Declined by more than 1km	2	Perth Inner, Wanneroo North-West	0	None
Declined by 0.3 to 1km	3	Joondalup North, Rockingham, Mundaring	3	Joondalup North, Claremont, Wanneroo North-East
Change of between –0.3 and 0.3 km	29	Wanneroo South, Bassendean, Perth Remainder, Claremont	27	Stirling Central, Bayswater, Perth Inner, Mandurah
Increased by 0.3 to 1km	2	Wanneroo North-East, Serpentine-Jarrahdale	8	Kwinana, Gosnells, Serpentine-Jarrahdale
Increased by more than 1km	3	Murray, Kwinana, Fremantle Inner	1	Kalamunda

Source: BITRE analysis of ABS Census of Population and Housing 2006 and 2001 data, corrected 2001 commuting matrix provided by WA DPI and DPI and ABS ASGC digital boundary files.

The available evidence suggests that commuting travel times and distances have remained quite stable in Perth in recent years. Very short trips and very long trips have both risen in importance. While some parts of the city have experienced a reduction in average commuting distances for residents (e.g. the North-West subregion), residents of other places are travelling greater average distances than before.

CHAPTER 8
Some drivers of these changes

Key points

- Residents of areas experiencing rapid population growth predominantly find work within the home area or neighbouring areas. Similarly, areas experiencing rapid jobs growth predominantly draw their additional workers from amongst local residents.
- Areas with strong jobs growth generally tend to draw their workers from a similar set of places as they did previously. An exception is Kalamunda, where the rapid jobs growth between 2001 and 2006 meant workers were increasingly drawn from further afield.
- A simple gravity model of commuter flows can explain about 80 per cent of all variation in origin–destination flows in Perth.
- The amount of people commuting between an origin–destination pair tends to increase with the number of employed residents of the origin SLA and the number of jobs in the destination SLA, but declines as the distance between the two SLAs widens. This distance penalty is lower when there is a direct rail connection between the origin–destination pair.
- The greater the alignment between the skills available in the origin SLA and the skills demanded in the destination SLA, the greater the predicted commuting flows between those two SLAs.
- The fundamental drivers of commuter flows remained very stable for Perth between 2001 and 2006.
- Growth in employed residents and jobs play a very important role in explaining changes in commuting flows in Perth between 2001 and 2006. These two factors alone explain just over half of the variation in commuting growth rates for origin–destination pairs with non-trivial commuter flows.
- The rate of jobs growth in the destination SLA is the most powerful predictor of spatial change in commuter flows in Perth.
- Regression analysis does not support the proposition that expansions of Perth's road and rail networks between 2001 and 2006 have significantly altered spatial commuting patterns.
- Scenario modelling suggests the WA Government's spatial projections of residential and jobs growth to 2031 (which reflect urban consolidation and outer suburban jobs growth objectives) are likely to involve increased self-sufficiency in the Outer subregion and a shift away from inward commutes towards commutes within the home SLA. The analysis also highlights some tensions between these spatial projections and the planning goals of reducing commuting distances and encouraging public transport over private transport.

Introduction

This chapter explores how the observed changes in commuting flows relate back to the observed patterns of residential growth and jobs growth and explores other potential drivers, such as distance, transport infrastructure and industry structure. This chapter also presents gravity model results for Perth—gravity models provide a means of explaining growth in commuting flows in terms of residential and jobs growth.

Residential and jobs growth

Growth in the commuting flow between an origin and destination pair is expected to be related to the growth occurring in those two regions. At the point of origin, it is growth in the number of employed residents which is of primary interest—this is, in turn, influenced by population growth and changes in labour force participation and the unemployment rate. At the destination, it is the growth in the number of available jobs which is of primary interest.

Correlation analysis was undertaken across the 1521 possible origin–destination combinations within Perth, Mandurah and Murray. The correlation analysis shows that the 2001 to 2006 change in the number of persons commuting between any two SLAs was:

- significantly positively associated with the change in the number of employed residents in the origin SLA (correlation = 0.20)
- significantly positively associated with the change in the number of jobs available in the destination SLA (correlation = 0.35).

Thus, strong growth in the origin and destination regions does tend to translate into strong growth in commuting flows between the two regions. Of the two, jobs growth in the destination SLA appears to be rather more closely linked to growth in commuting flows. The correlations are not overly strong, suggesting other factors may also play an important role in driving growth in commuter flows.

To see how this plays out in practice, a closer look will be taken at the SLAs which experienced substantial growth in employed residents or substantial growth in jobs.

Focusing first on the places with particularly strong growth in employed residents, where are the residents finding work? Table 8.1 shows that the employed residents growth in Wanneroo North-East, Wanneroo North-West, Wanneroo South, Mandurah and Rockingham is primarily generating increased commuting flows within the home SLA. Residential growth in Kwinana is generating increased commuting flows to neighbouring Rockingham, while residential growth in Murray is generating increased commuting flows to neighbouring Mandurah. Residential growth in Perth Remainder is generating additional short-distance commuting flows to the Perth Inner SLA.

Typically, the residents of areas experiencing rapid residential growth are finding work within the home SLA or neighbouring SLAs. The CBD is also receiving increasing commuter flows from some of these growth areas (e.g. Wanneroo North-East, Wanneroo South, Rockingham).

T8.1 Areas in which residents of rapid residential growth SLAs are finding work, Perth, 2001 to 2006

SLAs with rapid growth in employed residents	Average annual growth (per cent)	Increase in employed residents, 2001 to 2006	More than 300 additional residents commuted to a place of work in the following SLAs (in descending order of importance)
Perth Inner	17	229	None
Wanneroo North-East	11	6551	Wanneroo North-East, Joondalup North, Wanneroo South, Stirling Central, Swan, Perth Inner, Joondalup South
Perth Remainder	11	1983	Perth Inner
Wanneroo North-West*	10	6114	Wanneroo North-West
Mandurah	6	5104	Mandurah
Rockingham	5	8355	Rockingham, Kwinana, Mandurah, Perth Inner
Wanneroo South	5	3857	Wanneroo South, Swan, Perth Inner
Murray	4	850	Mandurah
Kwinana	4	1677	Rockingham

Note: *This SLA had a high rate of non-response to the place of work question, as well as significant numbers with no fixed place of work or a place of work outside of Perth in 2006.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

The rapid growth SLA of Wanneroo North-East is generating substantial additional commuter flows to a wide range of areas to the north of the Swan River. Even though Stirling Central experienced a decline in jobs between 2001 and 2006, it still managed to attract a much increased flow of workers from Wanneroo North-East. Strong residential growth in Wanneroo North-East was associated with a reduced concentration of employment within the home SLA, with the self-containment rate falling from 20 to 17 per cent between 2001 and 2006.[31] Rockingham and Mandurah experienced similarly large increases in the number of employed residents, but managed to maintain the level of employment self-containment.

Did new residents of growth areas have to increasingly look further afield to find work? Of the areas experiencing strong residential growth, listed in Table 8.1:

- Residents of Inner Perth, Rockingham and Wanneroo North-West experienced a decline in the average distance travelled to work between 2001 and 2006.
- Residents of Perth Remainder, Mandurah and Wanneroo South experienced no significant change in the average distance travelled to work.
- Residents of Murray, Kwinana and Wanneroo North-East experienced an increase in the average distance travelled.

Thus, while the increased commuting flows generated by residential growth areas tend to be concentrated within the origin SLA and adjoining areas, for some growth areas (e.g. Murray, Kwinana, Wanneroo North-East), residents are tending to travel greater distances to work in 2006 than they were in 2001.

31 For Perth as a whole, the proportion of employed residents working in the home SLA fell from 23.8 to 23.3 per cent.

Turning attention to the place of work, from where did the places with strong jobs growth draw their additional workers? Table 8.2 summarises the SLAs which are supplying considerably more workers to these rapid jobs growth SLAs in 2006 than they were in 2001.

Perth Inner is distinctly different from the other SLAs in the table, experiencing good growth in commuters from a wide range of different SLAs of residence, but not from within its own boundaries. For all of the other SLAs with rapid jobs growth, the single largest source of additional workers was residents of the same SLA. Some of the jobs growth SLAs also managed to attract substantial additional flows of workers from neighbouring SLAs, with Mandurah drawing additional workers from Murray and Rockingham and Wanneroo South drawing additional workers from Wanneroo North-East and Joondalup South.

The jobs growth in Swan had a fairly wide influence, drawing additional workers from a range of SLAs to the north of the city in both the Middle and North-West subregions. A major focal point of Swan's job growth was the Malaga Industrial Estate which borders Stirling Central.

Do the residential growth areas form a major source of the additional workers required in the jobs growth areas? They do, because the largest source of additional workers for any place of work is typically from within the same SLA, and there is considerable overlap between the residential growth SLAs (in Table 8.1) and the jobs growth SLAs. However, very distant SLAs experiencing rapid residential growth do not generally form an important source of additional workers for job growth SLAs. The exception is the CBD which is drawing additional workers from a wide range of SLAs—close and distant, growing and declining.

T8.2 Areas which rapid jobs growth SLAs are drawing their additional workers from, Perth, 2006

Statistical Local Area experiencing rapid jobs growth	Average annual rate of jobs growth (per cent)	Job increase	Origin SLAs which increased commuting to jobs growth SLA by more than 300 persons (in descending order)
Wanneroo North-West	8	1 700	Wanneroo North-West
Rockingham	6	5 100	Rockingham, Kwinana
Mandurah	6	4 000	Mandurah, Rockingham, Murray
Wanneroo North-East	6	1 600	Wanneroo North-East
Wanneroo South	5	2 800	Wanneroo South, Wanneroo North-East, Joondalup South
Perth Inner	5	13 900	Stirling Coastal, Joondalup South, Melville, Canning, Bayswater, South Perth, Stirling Central, Vincent, Perth Remainder, Cockburn, Victoria Park, Gosnells, Subiaco, Swan, Wanneroo North-East, Wanneroo South, Joondalup North, Rockingham, Cambridge
Kalamunda	4	2 200	Kalamunda
Gosnells	4	3 400	Gosnells, Canning
Swan	4	6 600	Swan, Joondalup South, Wanneroo South, Stirling Central, Wanneroo North-East, Stirling Coastal

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Do areas with strong jobs growth draw additional workers from the same set of places as previously, or do they draw workers from an expanded range of places? The mix of regions from which workers were drawn was generally fairly stable between 2001 and 2006 for the SLAs listed in Table 8.2.

However, Kalamunda is one SLA which drew workers from a much more diverse mix of residential SLAs in 2006, than it did in 2001. Kalamunda increasingly drew workers from Canning, Bayswater and Swan and this is reflected in the increase in the average distance travelled to work from 9.1 kilometres in 2001 to 10.2 kilometres in 2006, the largest increase of any place of work SLA.[32] The strong jobs growth in Kalamunda is linked to the development of the Forrestfield rail terminal and Access Park.

Gosnells and Swan also drew their workers from an increasingly diverse mix of SLAs between 2001 and 2006. However, Wanneroo North-East's workforce was drawn from a less diverse mix of regions in 2006 than in 2001 and the average distance travelled to a workplace in that SLA fell from 8.4 to 8.0 kilometres.

Travel cost

The cost of travel between areas is another potentially important driver of commuting flows. The cost of travel between two regions is dependent on the time spent undertaking the journey, the opportunity cost of that time, and direct costs such as fuel, rail and bus tickets, tolls and parking fees. The time spent undertaking a journey depends on the distance between the two regions and average speed, which in turn depends on the type and quality of transport infrastructure and the level of congestion.

BITRE does not have spatially-disaggregated travel time information for Perth. However, estimates of the distance between all origin–destination pairs should serve as a useful proxy for both time spent travelling and some of the direct costs, such as fuel. That is, the greater the distance between any origin–destination pair, the greater the travel costs, and the greater the impediment to travel between those two regions.

The results of a simple correlation analysis across the 1521 possible origin–destination combinations within Perth, Mandurah and Murray are presented in Table 8.3. The results show that distance is significantly negatively correlated with commuting flows and with the change in the number of persons commuting between any two SLAs. As the distance between any two SLAs is fixed for 2001 and 2006, the latter result implies that the extent to which distance impedes travel may have increased over the period. This would be consistent with the sharp increase of 55 per cent in automotive fuel prices between the September quarters of 2001 and 2006 (ABS 2009e). However, the observed correlations, while statistically significant, are not particularly strong.

32 For Perth, Mandurah and Murray, the average distance travelled to work was 10.7 kilometres in 2001 and 10.8 kilometres in 2006.

The distance penalty may differ by mode of travel. According to WAPC (2009a p.42), '[a]verage peak hour travel times between Joondalup and Perth are 26 minutes by rail and 60 minutes by car'. This suggests that the impact of distance may be less for origin–destination pairs which have a direct rail connection than for those that are reliant on the road network. This is supported by correlation analysis which finds that the negative correlation between commuting flows and distance was a little weaker for Perth origin–destination pairs that have a direct rail connection.[33] This relationship will be investigated further through estimation of a gravity model of commuting flows, to be presented later in the chapter.

T8.3 Correlation analysis of relationships between commuting flows and distance, 2001 to 2006

Commuting flow variable	Distance
Number of persons commuting between origin and destination region, 2006	–0.28
Number of persons commuting between origin and destination region, 2001	–0.28
Change in number of persons commuting between origin and destination region, 2001 to 2006	–0.18

Note: Correlation based on sample of non-zero origin–destination commuter flows.

Source: BITRE analysis of ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WA DPI, and DPI and ABS ASGC digital boundary files.

Transport infrastructure

The impact of transport infrastructure can be explored using available information on major rail and road infrastructure investments. Between 2001 and 2006, the main expansions of Perth's passenger rail system were the extension of the northern rail line from Currambine to Clarkson in 2004 and the opening of the Thornlie spur line in 2005.

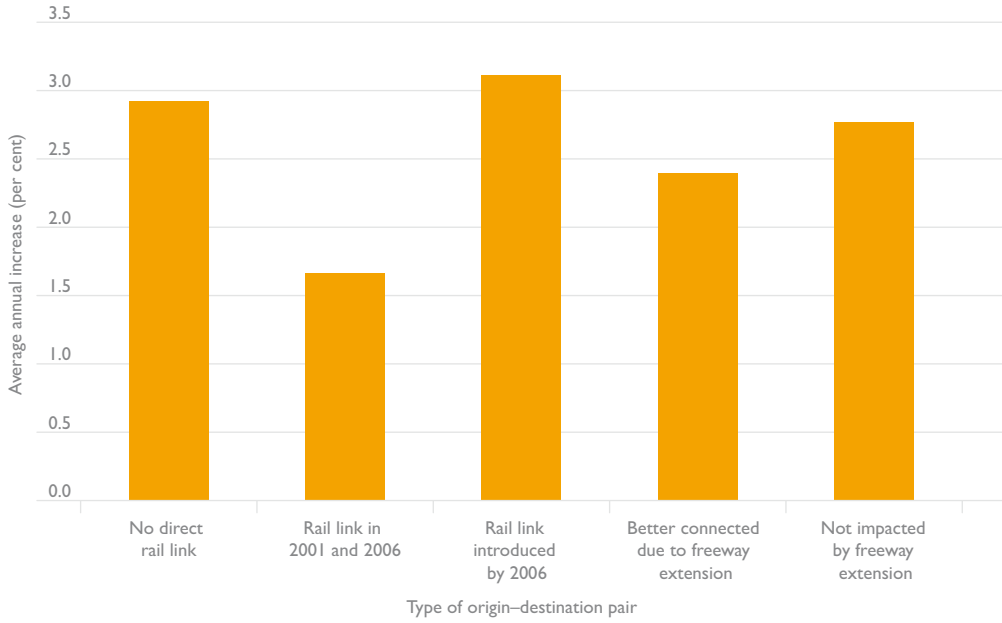
Improvements in bus transport and road infrastructure also potentially have an impact on changes in commuter flows. Changes in bus routes or timetables have not been investigated in this study. Important road infrastructure projects completed between 2001 and 2006 include:

- The Kwinana Freeway extension to Safety Bay Road (including bus transitway) was completed in 2002: this would be expected to improve connectivity from Rockingham to places further north (and vice versa).
- The Roe Highway stage six and seven extensions were completed in 2004 and early 2006 respectively: these extensions would be expected to improve east-west connectivity in the suburbs south of the Swan River (e.g. between Cockburn and the airport, Canning and Kalamunda, Melville and Gosnells).
- The Tonkin Highway extension to Thomas Road was completed in 2005: this would be expected to improve connectivity between the south-eastern SLAs of Serpentine-Jarrahdale and Armadale and other parts of Perth, especially Canning, Belmont and Kalamunda.

33 All SLA pairs in Perth were categorised by BITRE as either having a direct rail link (one which does not involve changing trains) or not having a direct rail link. This assessment was based on the location of a regularly serviced train station within the SLA and published timetables. The categorisation varied slightly between 2001 and 2006, due to expansion of rail services.

Figure 8.1 shows that the origin–destination pairs that gained a rail link between 2001 and 2006 did experience comparatively strong growth in commuting flows between 2001 and 2006. However, the origin–destination pairs without a direct rail link grew more strongly than the origin–destination pairs with an existing rail link. This is consistent with the earlier finding that the traditional inward commuting flows are declining in importance and more complex commuting flows (e.g. between subregions) that are difficult to service by public transport are growing most rapidly.

F8.1 Growth in commuting flows and transport infrastructure upgrades, Perth, 2001 to 2006



Note: Only the Kwinana, Tonkin and Roe highway extensions are considered.

Source: BITRE analysis of ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WA DPI, Perth rail timetables and maps of the road network.

While the three major road infrastructure investments detailed above might be expected to have improved connectivity and boosted commuter flows for selected origin–destination pairs, no such effect is apparent in Figure 8.1. Origin-destination pairs which were not directly impacted by these three highway extensions[34] actually grew at a slightly more rapid pace than those that were directly affected.

34 All SLA pairs in Perth were categorised by BITRE as either having been directly impacted by at least one of the three freeway extensions or not impacted. A summary of the SLA pairs judged to have been impacted by each freeway extension was provided on the previous page.

The gravity model analysis later in this chapter will attempt to assess whether these major extensions of Perth's road and rail infrastructure had a statistically significant impact on spatial change in commuting flows in Perth.

Industry and skills

The literature suggests that industry and skills related factors play an important role in shaping commuting flows between different parts of the city and how they change over time. For example, human capital theory predicts that distance has less of a deterrent effect in the commuting decision for more educated workers (Trendle and Siu 2005). BITRE does not have access to commuting matrices which are disaggregated by industry or education, and this limits the extent to which such effects can be empirically investigated. However, some exploration of potential impacts is possible.

For many places of work, insufficient workers with the relevant skills reside within the local area and workers instead need to be drawn from further afield. Other things equal, commuting flows are likely to be greater for origin–destination pairs which have good alignment between the industry (skills) mix of employed residents in the origin SLA and the industry (skills) mix of jobs in the destination SLA.

To investigate this issue, BITRE has developed a measure of industry mismatch and a measure of skill mismatch. These identify the proportion of employed residents of the origin SLA who would need to change industries (skill categories) to match the industry (skill) mix of the destination SLA.

The **industry mismatch index** was calculated based on the single digit ANZSIC 1993 industry classification for both 2001 and 2006. While the industry mismatch index can theoretically take values between 0 and 1, in practice, no Perth origin–destination pair has an industry mismatch index over 0.6 and the median index value is 0.29. Industry mismatch was lowest for the origin–destination pair of Kwinana and Swan, as both Kwinana residents and Swan jobs have a manufacturing specialisation. Industry mismatch is greatest for the SLA pair of Murray and Nedlands. Even though Kwinana and Swan are relatively distant, the high degree of industry alignment could potentially result in significant commuting flows. Commuting flows from Murray to Nedlands, however, would be expected to be minimal.

The **skills mismatch index** was calculated for 2006 in a parallel manner to the industry mismatch index. It was based on three qualifications categories: no post school qualifications, certificate level qualification and higher qualification.[35] Skills mismatch was lowest for the origin–destination pair of Bassendean and Stirling Central and greatest for the pairing of Nedlands and Murray. Other things constant, it is expected that SLA pairs with a high score on the skills mismatch index will have lower commuting flows. While the skills mismatch index can theoretically take values between 0 and 1, in practice, no Perth origin–destination pair has a skills mismatch index over 0.5 for 2006 and the median index value is 0.14.

35 Constraints on data availability meant a slightly different classification was used to construct the 2001 index: no post-school qualifications above Certificate Level II; Certificate III or IV qualification; higher qualification.

Table 8.4 presents the results of correlation analysis. As expected, the greater the degree of industry or skills mismatch, the lower the observed commuting flow. The industry and skill mismatch correlation coefficients are of similar magnitude in both 2001 and 2006. The correlations also suggest that a high degree of industry or skills mismatch may negatively affect the change in commuting flows.

The gravity model analysis in the following section will assess whether industry and skill mismatch have a statistically significant influence on commuting flows in Perth.

T8.4 Correlation analysis of relationships between commuting flows and industry mismatch, 2001 to 2006

Commuting flow variable	Industry mismatch index	Skill mismatch index
Number of persons commuting between origin and destination region, 2006	–0.18	–0.19
Number of persons commuting between origin and destination region, 2001	–0.19	–0.19
Change in number of persons commuting between origin and destination region, 2001 to 2006	–0.12	–0.15

Note: Correlation based on sample of non-zero origin–destination commuter flows. Change correlations based on 2001 version of industry and skills mismatch indices.

Source: BITRE analysis of ABS Census of Population and Housing data and corrected 2001 commuting matrix provided by WA DPI.

Some major industry-specific employment changes occurred between 2001 and 2006 in Perth. These provide an opportunity for investigating the impact of industry shocks on commuting flows.

Between 2001 and 2006, there was a substantial increase in defence industry employment in Rockingham at the naval base. About 76 per cent of Rockingham jobs were filled by Rockingham residents in 2001, and 72 per cent of the increase in jobs in Rockingham was filled by local residents. The number of residents of Kwinana, Cockburn and Mandurah who commuted to Rockingham also increased. This positive shock to employment in Rockingham does not appear to have generated much in the way of longer distance commuting flows, with most of the additional workers living in the local area, and some living on the defence base itself.

There was also a substantial increase in health industry employment in Nedlands, which contains the Queen Elizabeth II Medical Centre, Hollywood Private Hospital, a Royal Perth Hospital campus and Graylands Hospital. About 15 per cent of all Nedlands jobs were filled by Nedlands residents in 2001, while 11 per cent of the increase in jobs in Nedlands was filled by local residents. The largest proportion (12 per cent) was filled by residents of Stirling Coastal, while the number of residents of Joondalup South, Wanneroo North-East, Bayswater, Stirling Central, Swan and Melville who worked in Nedlands also increased notably between 2001 and 2006. In contrast to the Rockingham experience, this positive shock to employment in Nedlands appears to have generated increased commuting flows from a wide range of places, including quite distant places such as Wanneroo North-East and Swan.

These two examples show very different commuting responses to strong jobs growth in a particular industry. Neither shock appeared to cause much change to the mix of SLAs from which workers were drawn. Nedlands continued to draw its workers from a diverse mix of SLAs, while Rockingham continued to draw the majority of its workers from within its own borders.

A gravity model of commuting

The preceding discussion has identified a number of factors which are likely to be important drivers of spatial commuting flows in Perth. There are many other factors that are also likely to have an influence, such as age, home ownership, occupation, income and gender (Trendle and Siu 2005).

This section estimates a gravity model for origin–destination commuting flows in Perth. The model is not intended to be comprehensive. Its role is threefold:

- to quantify the influence that residential growth and jobs growth have on spatial patterns of commuting in Perth
- to investigate the impact of transport infrastructure on spatial patterns of commuting in Perth
- to enable comparisons across Australia's five major cities through adoption of a single model specification across all cities.

The modelling results have also been used to undertake some scenario modelling based on the available spatial projections of population and jobs growth in Perth.

Explaining origin–destination commuter flows

Gravity models are commonly used to explain spatial variation in commuter flows. Gravity models relate passenger flows between origin and destination zones to the relevant population total in the origin and destination zones and to distance. The basic structure of a gravity model of commuting is as follows:

$$C_{ij} = \alpha R_i^{\beta} W_j^{\gamma} / D_{ij}^{\delta}$$

C_{ij} = commuting flow from zone i to zone j

R_i = the number of employed residents of zone i

W_j = the number of people working in zone j

D_{ij} = the distance or commuting time between zones i and j

$\alpha, \beta, \gamma, \delta$ are the model parameters to be estimated

Trendle and Siu (2005 p.9) note that 'the underlying assumption to this model is that every worker is equally attracted to any type of job and they also have the equal amount of chance to obtain any job'. In practice, employees are not homogenous—they have different skills and educational attainment and vary in their suitability for employment in different industries. Some authors have addressed this issue by estimating separate gravity models for different skill categories (Harsman and Quigley 1998, Trendle and Siu 2005). In the absence of a journey to work matrix disaggregated by skill category, BITRE has attempted to capture this heterogeneity through inclusion of the industry mismatch and skill mismatch variables, which were described in the previous section, in the regression analysis.

Several state transport departments have developed far more sophisticated models of spatial commuting flows, which reflect more disaggregated flow data and more detailed information on transport infrastructure and mode usage. Such models have been progressively improved over many years and have the capability of addressing a much broader set of questions. The relatively simple gravity model presented in this paper nevertheless provides a useful introduction to some of the principal drivers of spatial differences in commuter flows within Perth.

The gravity model is traditionally estimated in logarithmic form using ordinary least squares (OLS) estimation. The following model was estimated for each time period (t).

$$\ln C_{ijt} = \alpha + \beta \ln R_{it} + \gamma \ln W_{jt} - \delta \ln D_{ijt}$$

The analysis is based on the 37 SLAs in the Perth Statistical Division plus the Murray and Mandurah SLAs. With 39 SLAs, there is a potential sample of 1521 origin–destination pairs (i.e. 39 X 39), but all sample observations which took a value of either zero or three were excluded from the analysis.[36] This resulted in a sample of 1308 observations for 2001 and 1359 for 2006.

Initial testing of the model identified some issues with heteroskedasticity and non-normality of errors. Following Chen et al (2003), robust standard errors were derived and the resulting robust t-values have been presented throughout this chapter. As a rule of thumb, robust t-values which have an absolute value of more than two should be considered statistically significant. Using robust standard errors had minimal impact as all variables remained highly significant and the robust standard errors remained low.

Table 8.5 summarises the base gravity model results for 2001 and 2006. Some key points to note include:

- The gravity model has very high explanatory power, with the three independent variables explaining about 80 per cent of all variation in origin–destination commuter flows. Other studies have had similarly high explanatory power (e.g. Trendle and Siu 2005, Harsman and Quigley 1998).
- All three explanatory variables are highly significant and have the expected signs. The amount of people commuting between an origin–destination pair tends to increase with the number of employed residents in the origin SLA and the number of jobs in the destination SLA. Greater distance between an origin–destination pair is associated with smaller commuting flows.

36 Values of three and zero are generated by randomisation techniques applied by ABS to protect confidentiality, and should not be relied upon.

- The model results are very similar for 2001 and 2006. The 2001 model has slightly lower explanatory power, perhaps because of the known data quality problems with the 2001 journey to work matrix. While some minor changes in the parameter estimates are evident between 2001 and 2006, these changes are not statistically significant at the 5 per cent probability level.
- The 2006 parameter estimate for employed residents is a little higher than that for jobs, but the difference is not statistically significant at the 5 per cent probability level.

T8.5 Estimation of base gravity model of origin–destination commuter flows, Perth, 2001 and 2006

	2001	2006
Sample	1308	1359
Adjusted R-squared (per cent)	79.2	81.5
Parameter estimates		
Constant	–10.70	–11.48
Log of number of employed residents in origin SLA	0.98	1.04
Log of number of jobs in destination SLA	0.97	0.99
Log of distance between origin and destination SLA	–1.05	–1.11
Robust t-value		
Constant	–33.85	–38.49
Log of number of employed residents in origin SLA	41.07	46.42
Log of number of jobs in destination SLA	45.43	49.71
Log of distance between origin and destination SLA	–31.86	–32.95

Note: The dependent variable is the log of the number of persons commuting from the origin SLA to the destination SLA in the given year.

Sources: Estimated by BITRE using SAS OLS estimation and robust standard errors. Based on ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WA DPI and BITRE-derived estimates of distance between SLAs.

The largest commuting flows are predicted to occur for origin–destination pairs which have a very large number of employed residents in the origin SLA, a very large number of jobs in the destination SLA and a very short distance between the two SLAs.

To see how the model works in practice, some examples are provided below based on the 2006 parameter estimates:[37]

- For an origin–destination pair which is located 5 kilometres apart, where each has 10 000 employed residents and jobs, commuting flows are predicted to be 228 persons.
- A doubling of the size of the two SLAs to 20 000 employed residents and jobs (leaving distance unchanged) results in predicted commuting flows of 932 persons.
- If the two SLAs with 20 000 employed residents and jobs are located 10 kilometres apart, the predicted commuting flow is 432 persons. It is 200 persons if they are located 20 kilometres apart.

37 Calculated as exp [–11.48+ 1.04 lnRi +0.99 lnWj □1.11 lnDij]

Table 8.6 presents an extended gravity model of commuting flows, which allows for the following two additional influences:

- Heterogeneity of workers is captured through inclusion of a 'skill mismatch' variable. An industry mismatch variable was also trialled, but it was omitted as it was sufficiently closely correlated with the skill mismatch variable (correlation = 0.7 in 2006) to pose multicollinearity risks, but had lower explanatory power.

An additional 'rail distance' variable has been included to identify whether the distance penalty is reduced for origin–destination pairs which have a direct rail connection compared to origin–destination pairs that are only connected by the road network. This variable takes a value of zero if the origin–destination pair does not have a direct rail connection, and is set equal to the log of the straight line distance between the origin–destination pair if there is a direct rail connection.

There is a modest increase in explanatory power as a result of the inclusion of these two variables. The parameter estimates for the four retained variables undergo little change in response to the inclusion of additional variables in the regression model. The two additional variables are statistically significant in both the 2001 and 2006 regressions and signs are in accordance with expectations. However, the two additional variables make a relatively minor contribution to explaining commuter flows, compared to the core gravity model variables.

As expected, the existence of a direct rail connection between an origin–destination pair has the effect of reducing the distance penalty and boosting commuter flows. Consider an origin–destination pair located five kilometres apart which each have 20 000 employed residents and jobs and for which there is no skills mismatch. The 2006 model predicts that if they have no direct rail connection there will be a commuter flow of 1112 people, while the commuter flow will be somewhat higher (1327 persons) if this origin–destination pair are directly connected by the rail system. If instead the two SLAs are located 10 kilometres apart, the model predicts 682 commuters with a rail connection and 530 commuters without one.

T8.6 Estimation of extended gravity model of origin–destination commuter flows, Perth, 2001 and 2006

	2001	2006
Sample	1308	1359
Adjusted R-squared (per cent)	80.4	82.4
Parameter estimates		
Constant	–9.97	–11.17
Log of number of employed residents in origin SLA	0.92	1.02
Log of number of jobs in destination SLA	0.97	0.99
Log of distance between origin and destination SLA	–1.03	–1.07
Direct rail connection X Log of distance	0.08	0.11
Skills mismatch index for origin–destination pair	–1.91	–1.26
Robust t-value		
Constant	–29.48	–37.46
Log of number of employed residents in origin SLA	35.69	45.37
Log of number of jobs in destination SLA	46.17	49.55
Log of distance between origin and destination SLA	–31.48	–31.86
Direct rail connection X Log of distance	3.51	5.21
Skills mismatch index for origin–destination pair	–8.72	–6.82

Notes: The dependent variable is the log of the number of persons commuting from the origin SLA to the destination SLA in the given year. The skills mismatch index was calculated using slightly different categories for 2001 and 2006 so the parameter estimate is not directly comparable across the two models.

Sources: Estimated by BITRE using SAS OLS estimation and robust standard errors. Based on ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WA DPI, Transperth rail timetables, BITRE-derived estimates of distance between SLAs and BITRE-derived skill mismatch index.

When an origin–destination pair has a high degree of skill mismatch, commuter flows are predicted to be significantly lower than if the supply and demand for skills is well aligned between the two SLAs. If we take the origin–destination pair described above, the predicted 2006 commuter flow falls from 1112 persons with no skills mismatch (i.e. perfect alignment) to just 315 persons if there is complete mismatch between the skills available in the origin SLA and the jobs available in the destination SLA.

In summary, the regression results for the base and extended gravity models show that a very high proportion of spatial variation in Perth commuting flows can be explained by reference to just a few key factors, namely:

- the number of employed residents in the origin SLA
- the number of jobs in the destination SLA
- the distance between the two SLAs
- whether there is a direct rail connection between the SLAs
- the degree of alignment between the skills available in the origin SLA and the skills demanded in the destination SLA.

Explaining changes in origin–destination commuter flows

The main drivers of change in commuter flows can be explored by transforming the gravity model into log difference form:

$$[\ln C_{ij2006} - \ln C_{ij2001}] = \theta + \mu\,[\ln R_{i2006} - \ln R_{i2001}]$$

$$+\rho\,[\ln W_{j2006} - \ln W_{j2001}] - \varphi\,[\ln D_{ij2006} - \ln D_{ij2001}]$$

where $\theta, \mu, \rho, \varphi$ are the model parameters to be estimated.

As the distance between any origin–destination pair remains unchanged between 2001 and 2006, this equation can be further simplified to:

$$[\ln C_{ij2006} - \ln C_{ij2001}] = \theta + \mu\,[\ln R_{i2006} - \ln R_{i2001}]$$

$$+\rho\,[\ln W_{j2006} - \ln W_{j2001}]$$

The dependent variable in this specification closely approximates the percentage change in commuter flows from zone i to zone j between 2001 and 2006. Thus, the percentage change in commuter flows between zone i and j is expressed as a function of the percentage change in employed residents in zone i and the percentage change in jobs in zone j. This specification closely resembles that used by BITRE (2009d) to project growth in intercity passenger travel.

A practical issue with this specification is that the dependent variable tends to take very extreme values for origin–destination pairs which have zero or low commuter flows in one of the two periods. For example, one origin–destination pair increased from 3 to 21 persons over the period, representing 600 per cent growth. Such observations were highly influential in the regression analysis and detracted from its usefulness.

BITRE has dealt with this issue by focusing the analysis on those origin–destination pairs which had non-trivial commuter flows in both periods. Origin-destination pairs with less than 100 commuters in either period were excluded from the analysis.[38] This resulted in a sample of 621 observations.

Initial testing of the model identified some issues with heteroskedasticity and non-normality of errors. Following Chen et al (2003), robust standard errors were derived and the resulting robust t-values have been presented.

Table 8.7 summarises the regression results for the change in commuting flows between 2001 and 2006. Three different models have been estimated:

a. the baseline model which includes just the residential growth and jobs growth variables

b. adds in the skills mismatch variable

c. adds in an 'infrastructure investment' variable to capture any impact that major road and rail infrastructure investments have had on growth in commuter flows during the period—the variable is set equal to one for origin–destination pairs impacted by an expansion of the Perth railway or freeway system (see "Transport Infrastructure" discussion earlier in this chapter) and equals zero for all other origin–destination pairs.

38 The analysis was repeated using a cutoff of 50 commuters, which gave a sample of 809 observations. The explanatory power was lower than for the model with a cutoff of 100, but in qualitative terms the model results were otherwise very similar.

Table 8.7 reveals that the base model explains just over half of all variation in the dependent variable. This is much lower explanatory power than achieved by the snapshot models for 2001 and 2006, but change is traditionally much more difficult to predict. Growth in employed residents and jobs play a very important role in explaining changes in commuting flows within Perth. These two factors alone can explain about half of the variation in commuting growth rates for origin–destination pairs that have non-trivial commuter flows.

Both explanatory variables are statistically significant and positively signed. However, growth in jobs in the destination SLA is a rather more powerful influence on changes in commuting flows, than is growth in employed residents of the origin SLA. Consider an origin–destination pair where employed residents in the origin SLA grew by 20 per cent between 2001 and 2006, while jobs in the destination SLA remained stable. Commuter flows would be predicted to grow by 5 per cent for this origin–destination pair. This compares to a predicted growth rate of 15 per cent for an origin–destination pair in which employed residents were stable but jobs grew by 20 per cent.

T8.7 Estimation of extended gravity model of changes in origin–destination commuter flows, Perth, 2001 and 2006

	Base model a	Model b	Model c
Sample	621	621	621
Adjusted R-squared (per cent)	51.8	51.8	51.7
Parameter estimates			
Constant	–0.06	–0.05	–0.06
Growth rate of employed residents in origin SLA	0.55	0.54	0.55
Growth rate of jobs in destination SLA	1.04	1.04	1.05
Skills mismatch index for origin–destination pair 2001	na	–0.07	na
Transport infrastructure investment	na	na	–0.01
Robust t-value			
Constant	–4.81	–3.99	–6.32
Growth rate of employed residents in origin SLA	7.86	7.80	7.92
Growth rate of jobs in destination SLA	22.96	22.87	22.75
Skills mismatch index for origin–destination pair 2001	na	–1.14	na
Transport infrastructure investment	na	na	–0.35

na not applicable

Notes: The dependent variable is essentially the percentage change in the number of persons commuting from the origin SLA to the destination SLA between 2001 and 2006.

Sources: Estimated by BITRE using SAS OLS estimation and robust standard errors. Based on ABS Census of Population and Housing data, corrected 2001 commuting matrix provided by WA DPI, Transperth rail timetables, BITRE-derived estimates of distance between SLAs and BITRE-derived skill mismatch index.

These results suggest that the location of jobs growth in Perth is a very important driver of changes in commuter flows. Chapter Four identified Wanneroo North-East, Rockingham, Mandurah, Wanneroo North-West, Wanneroo South and Perth Inner as the SLAs experiencing the most rapid rate of jobs growth between 2001 and 2006. The model therefore predicts that commuter flows into these SLAs should be growing rapidly, with growth expected to be

particularly strong when the origin SLA is experiencing rapid residential growth (e.g. Wanneroo North-East, Perth Remainder). This is consistent with the fact that the origin–destination pair that experienced the most rapid commuting growth in the sample was Wanneroo North-East to Wanneroo North-West. The origin–destination pair that experienced the most rapid decline in commuting was Nedlands to Cottesloe, reflecting the limited residential growth in Nedlands and a loss of jobs in Cottesloe between 2001 and 2006.

Model (b) includes an additional variable, capturing the degree of alignment between the skills available in the origin SLA and the skills demanded in the destination SLA. Theoretically, one would expect growth in commuter flows to be greater for origin–destination pairs with little or no skills mismatch. While the sign is in accordance with expectations, the skills mismatch variable is not statistically significant.

Finally, model (c) includes an additional variable, reflecting major expansions of the road and rail network in Perth between 2001 and 2006. The specific expansions considered are the opening of the Thornlie spur line and the expansion of the northern rail line to Clarkson station, plus the extensions of the Roe, Tonkin and Kwinana Freeways. These have been captured using a simple dummy variable approach, where the dummy variable is set equal to one for origin–destination pairs assessed as being directly impacted by these expansions and to zero for all other origin–destination pairs.

While it might be expected that major infrastructure investments would have a positive impact on commuter flows, the variable was not statistically significant and the sign was in fact marginally negative. This may reflect the simplistic dummy variable approach used to capture infrastructure investment, the very limited set of transport projects considered or the use of origin–destination data on commuter flows (as opposed to detailed route data). Commuting effects may also have occurred outside the 2001 to 2006 period examined in this study. However, the result is also consistent with a scenario in which transport infrastructure expansions are largely reactive rather than proactive, in that they represent a response to anticipated or realised increases in demand (which are in turn driven by spatial patterns of residential and jobs growth), rather than an attempt to directly alter spatial commuting patterns.

The rationale for transport infrastructure investments in cities is typically focused on improving productivity and reducing costs (e.g. reduced congestion and travel time, reduced emissions). The effect of transport infrastructure on travel costs in Perth was illustrated in the snapshot regressions presented earlier, which showed that origin–destination pairs with a direct rail connection have greater commuter flows than those without such a connection (holding other factors constant).

The two transport-related results are not inherently contradictory. The significance of the direct rail connection variable in the snapshot regression analysis shows that the current rail system, built over many decades, plays an important role in shaping current commuting flows. The insignificance of the transport infrastructure investment variable in the change regression analysis suggests that the incremental infrastructure expansions that occurred between 2001 and 2006 did not significant alter the overall spatial pattern of commuting in Perth during the period. While the five selected major road and rail investments cost hundreds of millions of dollars in total, this represents a relatively minor proportion of Perth's existing stock of transport infrastructure, and so should not be expected to fundamentally alter the spatial patterns of commuting in Perth.

In models (b) and (c), the parameter estimates for the jobs growth and residential growth variables remained highly stable. While the change model has moderate explanatory power (R-squared = 52 per cent), the analysis has successfully identified two fundamental drivers of spatial change in commuting patterns in Perth. It has also singled out the location of jobs growth as the dominant driver of changes in commuting flows within Perth.

Perth is the first of the five major cities for which this gravity model regression analysis has been completed. The analysis shows how commuting behaviour in Perth has responded to spatial change in employment and population, but the full value of the analysis will not be evident until the analysis is replicated for the remaining cities and results are compared. Such comparisons should provide useful insight into the different ways in which residential growth, jobs growth, skills and transport infrastructure are shaping commuter flows across our major cities.

Scenario modelling

The purpose of the scenario modelling is to reveal the interplay between the spatial patterns of residential and jobs growth and the following longer-term outcomes:

- employment self-sufficiency
- the pattern of origin–destination commuter flows
- average commuting distance
- public transport usage.

The change models express the change in origin–destination commuter flows as a function of small area residential growth and jobs growth. Chapters Three and Four discussed the available small area projections of residential and jobs growth for Perth—these projections can be entered into the change model (i.e. the base model from Table 8.7) to provide some insights into the potential impacts of future residential and jobs growth on spatial commuting flows in Perth.

The scenarios

To explore this issue, we consider four different scenarios, each involving a different spatial allocation of population and/or jobs in 2031. The scenarios are described in Table 8.8. All four scenarios assume, consistent with the *Directions 2031* (WAPC 2009a) and WA *Tomorrow* (WAPC 2005b) projections, that the aggregate population of Perth, Murray and Mandurah will be 2.2 million in 2031, with 993 000 people employed. The scenarios explore the commuting impacts of different spatial allocations of population and jobs, but do not explore the impacts of different aggregate rates of growth.

The base scenario (scenario one) reflects the Local Government Area (LGA) projections of the working age population in WA Tomorrow (WAPC 2005b) and unpublished SLA projections of employment prepared by WA's DPI in 2006. The growth in employed residents between 2006 and 2031 is assumed to equal the growth rate of the working age population for the small area. Where an LGA contained more than one SLA (i.e. City of Perth, Fremantle, Stirling, Wanneroo and Joondalup), each of the contributing SLAs were assumed to have the same rate of growth

in the working age population. Thus, scenario one reflects the WA government's projections of growth that were in place between 2005 and June 2009.

T8.8 Description of scenarios and source data

Scenario	Source of residential growth projections to 2031	Source of employment growth projections to 2031	Key difference to base scenario
One	WA Tomorrow projections of working age population for LGAs (WAPC 2005b)	Unpublished WA DPI projections of employment for SLAs (prepared in 2006)	Base scenario
Two	*Directions 2031* population projections for subregions (WAPC 2009a), allocated to LGAs using WA Tomorrow projections of working age population	*Directions 2031* employment projections for subregions, allocated to SLAs using unpublished WA DPI employment projections (prepared in 2006)	Reflects additional urban consolidation of the residential population
Three	Australian Government DHA (2009) projections of working age population for SLAs, rescaled to match total Perth working age population from WAPC (2005b)	Unpublished WA DPI projections of employment for SLAs (prepared in 2006)	The population projections are based solely on demographic considerations, while the base scenario also reflects land availability and other local factors
Four	WA Tomorrow projections of working age population for LGAs (WAPC 2005b)	BITRE derived these projections using the unpublished WA DPI projections of employment for SLAs (prepared in 2006) to 2016, but with all areas assumed to grow at the Perth average rate from 2016 until 2031	The projected rate of jobs growth in the Outer subregions and Peel is more moderate

Source: BITRE

Scenario two reflects the more recent projections of population and jobs for subregions, as published in *Directions 2031* (WAPC 2009a). The jobs projections are qualitatively very similar to those in scenario one, with very rapid jobs growth projected in the Outer subregions. However, WAPC (2009a) projects substantially greater population growth in the Central subregion than does WAPC (2005b). Thus, scenario two differs from scenario one in that it reflects the urban consolidation objectives expressed in *Directions 2031*.

Scenario three differs from scenario one in that it reflects the Australian Government Department of Health and Ageing's (2009) allocation of the working age population across SLAs in 2027. The Department of Health and Ageing (DHA 2009) projects higher population growth for Perth than does the WA government, but BITRE has rescaled the projections to match the WAPC (2005b) total for Perth, Murray and Mandurah.[39] The DHA (2009) projections are based purely on demographic considerations, whereas the WAPC projections also reflect local intelligence and land supply constraints. DHA (2009) projects greater residential growth for the North-West and South-West subregions, and lower growth for Peel. The employment projections are identical under scenarios one and three.

Scenarios one to three all involve some urban consolidation, but not enough to stop the Central subregion's share of population being lower in 2031 than it is today. In 2006, the Central subregion accounted for 44 per cent of the population of Perth, Murray and Mandurah, but that is projected to decline under all four scenarios (Table 8.9).

39 Assessing the impacts of a higher rate of aggregate population growth would require consistent employment projections, which were not available. Instead the focus here is on assessing the impacts of different spatial allocations of population and jobs, taking the aggregate growth level as given.

While they vary with respect to population, scenarios one to three all involve extremely rapid jobs growth in the Outer subregions, with the Central subregion's share of jobs falling considerably. Scenario four was constructed to provide some insight into the impact of less rapid jobs growth in the Outer subregion.

T8.9 Population and job distribution under four scenarios

Scenario	Proportion of population in Central subregion (per cent)	Proportion of jobs in Central subregion (per cent)
2006	44	66
2031 projections		
Scenario One	36	57
Scenario Two	41	59
Scenario Three	38	57
Scenario Four	36	64

Note: The Central subregion refers to the combination of the Inner and Middle subregions.
Source: BITRE

Approach

The scenario modelling has been undertaken for exploratory purposes and is not intended to be predictive. The available projections of residential and jobs growth are inputted into BITRE's model of change in commuting flows to provide some indicative information about likely outcomes in terms of spatial commuter flows if the population and jobs growth projections are realised. This approach involves several assumptions:

- The change model for the 2001 to 2006 period (Table 8.7 model (a)) explains about half of the observed variation, implying that a range of other factors not captured in the model have an important influence on origin–destination commuter flows. All potential influences other than residential and jobs growth are assumed constant.
- The parameters in the change model are assumed to remain stable over time. The model was initially estimated for a short term time horizon (i.e. 2001 to 2006) but is being applied to a much longer time period (i.e. 2006 to 2031). Over such an extended period, fundamental changes in the nature of the relationship are likely.
- In calculating average commuting distance, the population and job weighted centroids of each SLA are assumed to remain unchanged.

The change model serves as a device for identifying the commuting implications of the available population and employment growth projections.

Results

Employment self-sufficiency

Directions 2031 contains targets for employment self-sufficiency which aim to achieve substantial increases in the self-sufficiency ratio in each of the Outer subregions (WAPC 2009a). The self-sufficiency ratio is simply the ratio of employed residents to jobs in a subregion, and currently ranges between 0.42 and 0.66 across the four Outer subregions.

Scenarios one to three all involve a very rapid rate of growth in outer suburban jobs and more modest growth in jobs for the Inner and Middle subregions. In the outer suburbs, the projected increase in jobs is greater than the projected increase in employed residents. Therefore, the population and jobs growth projections in these scenarios are entirely consistent with achievement of a substantial increase in the self-sufficiency ratio for each of the Outer subregions.

Commuter flows

To gain a broad understanding of the likely impacts on Perth commuter flows in 2031, commuter flows have been grouped into five categories:

- within the home SLA
- elsewhere in the home subregion [40]
- inward commutes to another subregion or the City of Perth
- outward commutes to another subregion
- from one outer subregion to another (i.e. cross-subregion).

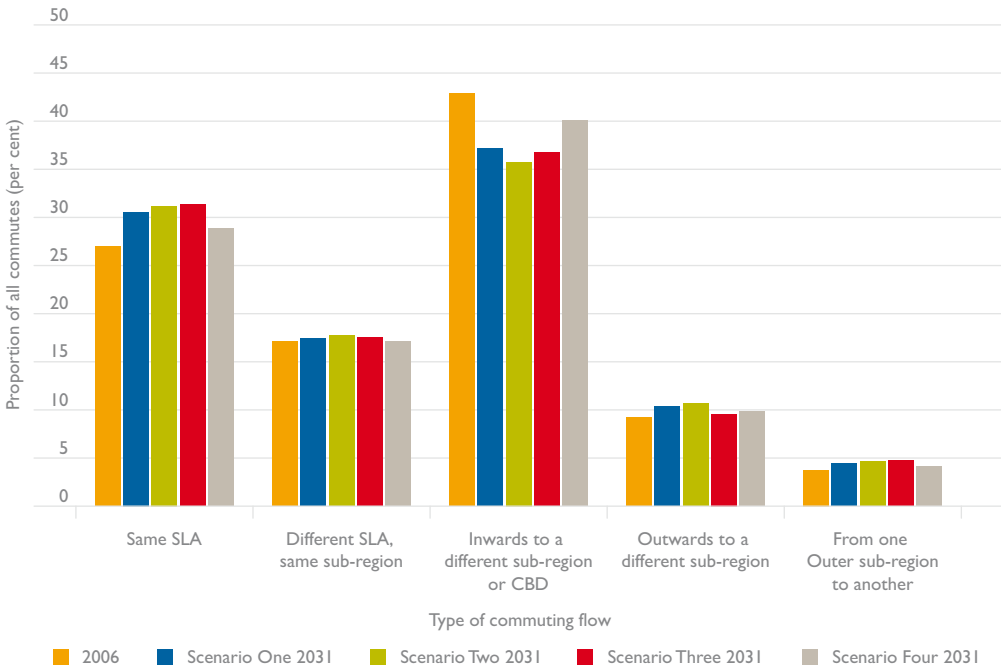
Figure 8.2 compares the results for each of the four scenarios and the actual pattern of commuter flows in 2006.

All four scenarios show the same overall pattern, namely a significant reduction in inwards commuting and substantial growth in commutes within the home SLA. This pattern is more subdued, but still evident, for scenario four. The key difference between scenario four and the other scenarios is the more moderate rate of outer suburban jobs growth. Thus, the projections of very rapid outer suburban jobs growth are an important contributor to the projected shift away from inwards commuting and towards intra-SLA commutes. Another relevant factor is the extent to which residential growth is accommodated within the Inner and Middle subregions. Scenario two, which involves the most urban consolidation, has the greatest projected drop in inwards commuting.

All four scenarios also display rapid growth in outwards commuting and cross-subregion commuting, but these two types of commuter flows are coming off a comparatively low 2006 base. The proportion of outwards commuting is projected to be greatest under scenario two—this reflects the combination of urban consolidation and rapid outer suburban jobs growth. Cross-subregion commuting is at its peak in scenario three, reflecting the combination of rapid population and jobs growth in the Outer subregions. Commutes to another SLA within the home subregion remain basically unchanged across all four scenarios.

40 Excludes commutes to the City of Perth LGA from a place of residence elsewhere in the Inner subregion.

F8.2 Comparison of results from four scenarios and 2006 outcomes by type of commuter flow



Source: BITRE analysis

The similarity of the results from all four scenarios, but particularly scenarios one to three, is striking. Thus, if we assume very rapid jobs growth in the Outer subregion, consistent with WAPC (2009a) and WAPC (2005b), and a total population of about 2.2 million for Perth in 2031, a range of different spatial allocations of that population all point to the same basic outcome:

- A reduction in inwards commuting from 43 per cent to roughly 35–38 per cent of commuter flows
- An increase in commutes within the home SLA from 27 per cent to roughly 30–32 per cent of commuter flows.

The results can also be considered at a more spatially disaggregated scale. The discussion here focuses on scenario two, which reflects the most up-to-date WA Government projections of population and jobs growth. The comments made about the scenario two results for subregions also apply to scenario one, but are not more generally applicable to scenarios three or four.

At the subregional scale, the greatest projected increases in the number of commuters occur for the within-subregion commutes, particularly commuting within the North-West and Middle subregions. The greatest projected increase for intersubregion commutes occurred for commutes from the Middle to the Inner subregion, although this reflects a relatively low rate of growth. The rate of increase is projected to be greatest for commutes involving a place of work in the North-West, South-West or Peel subregions, while the rate of increase is projected to

be at its lowest for commutes from the South-East and South-West subregions to the Inner and Middle subregions of Perth.

At the SLA scale, the greatest projected increases in the number of commuters occur for within-SLA commutes, most notably within the urban fringe SLAs of Wanneroo North-West, Mandurah, Swan and Rockingham.

The mix of origin–destination commuter flows that emerges from these four scenarios also has implications for commuting distances and transport mode. These implications are explored below.

Distance

Directions 2031 (WAPC 2009a) aims to reduce commuting distances and times in Perth. In 2006, BITRE estimates that the average commuting distance was 10.8 kilometres for Perth, Mandurah and Murray.

The set of origin–destination commuter flows that emerge from the four scenarios can each be used to generate a calculation of the average journey to work travel distance. The average commuting distance is projected to remain unchanged under scenario three (10.8km), decline marginally under scenarios one and four (10.7km) and decline a little more under scenario two (10.5km). However, it needs to be borne in mind that these calculations hold the centroids of each SLA fixed over time, when it would be reasonable to expect that the centroids of urban fringe SLAs would drift outwards over time, potentially offsetting the minor decline in average distance generated under these scenarios.

BITRE's measure of average travel distance appears to be very robust to a range of different spatial allocations of population and jobs within Perth. While the scenario two results suggest that pursuing urban consolidation goals is consistent with the objective of reducing travel distances, much greater urban consolidation may be required to significantly reduce travel distances.

Achievement of the planning goals of urban consolidation and outer suburban jobs growth will not automatically lead to a reduction in average commuting distances. Scenario three reflects both urban consolidation and outer suburban jobs growth, but average commuting distance remains unchanged.

While average travel distance remains relatively stable between 2006 and 2031 across all four scenarios, the results do point to a substantial increase in the proportion of short distance trips. In 2006, trips of less than five kilometres in length accounted for 33 per cent of all trips, but this is projected to increase under all four scenarios (to between 34 and 36 per cent of trips). However, very long trips of more than 20 kilometres are also projected to grow in importance, while trips of between 5 and 20 kilometres become less prevalent.

Transport mode

What are the implications of the scenario modelling results for commuter use of different transport modes in Perth? Firstly, the projected increase in the relative importance of within-SLA commutes, which tend to involve reasonably short distances, is likely to offer opportunities for increasing the proportion of residents who walk to work. More than two-thirds of all

commutes to work on foot in 2006 involved within-SLA trips. Secondly, any significant shift away from inward commutes is likely to be unfavourable to public transport use because inward commutes dominate public transport usage, accounting for over three-quarters of public transport use in 2006. Recent WA strategic plans have aimed to encourage a shift towards public transport usage and reduce car dependence.

Table 8.10 summarises the public transport mode share by the five broad categories of commuting. Inward commutes have by far the highest public transport mode share at 17 per cent. While the scenario modelling results suggest that within-SLA commutes and cross-subregion commutes will become much more important over time, these two types of commuter flow both currently have a very low public transport mode share.

T8.10 Public transport mode share by type of commuter flow, 2006

Type of commuter flow	Public transport mode share, 2006 (per cent)
Same SLA	2
Different SLA, same subregion	
(excludes trips to City of Perth, from elsewhere in the Inner subregion)	5
Inwards to a different subregion or City of Perth	17
Outwards to a different subregion	4
From one Outer subregion to another	1
All commuter trips	9

Source: BITRE analysis of ABS Census of Population and Housing data for 2006 using Tablebuilder software.

If the public transport mode shares for each of these trip types were to remain stable to 2031, the shift in commuting patterns under scenarios one, two and three would be associated with a reduction in the public transport mode share for Perth (by about 0.7 percentage points). Scenario four, with its more modest reduction in inward commuting, is associated with a relatively stable public transport mode share.

The changes in commuting patterns that flow from the available spatial projections of population and jobs growth to 2031 pose challenges for maintaining or increasing the public transport mode share. Specifically, it is the projections of rapid jobs growth in the outer suburbs that pose the main challenge, as the existing public transport system is not well suited to accessing outer suburban workplaces. A reorientation of the public transport system, to better service those making short-distance trips in the home SLA and those accessing outer suburban workplaces, may be needed to encourage a significant shift towards public transport.

Lessons from scenario modelling

The scenario modelling results highlight the interdependence of the various stated planning objectives (e.g. urban consolidation, outer suburban jobs growth, reduced commuting distances, growth in public transport usage) and the tensions between them.

The WA Government's current subregional projections of residential and jobs growth reflect their planning objectives regarding urban consolidation and outer suburban jobs growth. BITRE's scenario modelling results suggest that the location of a much greater proportion of Perth's jobs (and a somewhat greater proportion of the residential population) in the Outer subregion will involve:

- increased self-sufficiency in Perth's Outer subregion
- an increase in the relative importance of commutes within the home SLA
- a decline in the importance of inward commuting.

However, realisation of the urban consolidation and outer suburban jobs growth goals will not automatically generate shorter average commuting distances. The scenario modelling also highlights the potential tensions between the desire to increase public transport's mode share and the WA Government's plans for residential and jobs growth in Perth. The projected changes in commuting patterns are unfavourable to public transport. Nevertheless, the WA Government's projections could potentially be compatible with achievement of an increased public transport mode share if the existing transport system is reoriented to meet changing commuter demands.

CHAPTER 9
Reviewing the evidence

The aim of this paper has been to provide key stakeholders with an evidence base on the spatial nature of changes in population, jobs and commuting flows in Perth, with a focus on the 2001 to 2006 period.

This chapter presents an overview of the main findings of the analysis. It begins with a summary of trends in the spatial distribution of population and employment as well as a description of commuter usage of different transport modes in Perth. This is followed by a snapshot of commuting flows throughout the city and a discussion of how commuting behaviour has responded to the observed changes in employment and population. Finally, some comments are made about the extent to which progress has been made against key urban policy objectives that relate to shaping the spatial distribution of population, employment and commuting in Perth.

Residential and jobs growth

Historical overview of residential and jobs growth

The population of the Perth and Peel region grew from 175 000 in 1921 to 715 000 in 1971 (WAPC 2003b), and has more than doubled since then to reach 1.6 million in 2006 (ABS 2008a).[41] The average annual rate of population growth was 1.8 per cent between 1971 and 1981 and 2.7 per cent in the following decade, but has been lower than this in recent years, with growth averaging 1.7 per cent between 1991 and 2001 and 1.8 per cent between 2001 and 2006.

The Outer subregion (which is comprised of the North-East, North-West, South-West and South-East subregions) has grown rapidly since 1971, and accounts for 74 per cent of Perth and Peel's total population increase of 879 000 between 1971 and 2006. However, Peel has grown more rapidly than Outer Perth since 1981. The Inner subregion experienced population decline in the 1970s, but recorded historically strong growth between 2001 and 2006. Despite this growth, Perth remains a low density city, with 'spreading suburbs predicated on a cultural preference for owner-occupied detached houses on large lots and the use of private cars' (WAPC 2003b p.7). The Perth urban centre is less densely populated than Sydney, Melbourne or Adelaide, but of comparable density to Brisbane.

41 ABS ERP figures for 2006 are preliminary.

Historically, Perth's development pattern has been based on linear corridors stretching out from the city's core, with large non-urban wedges between each of these corridors (Hill 2005). The two coastal corridors (i.e. the North-West and South-West subregions) have consistently achieved higher rates of population growth than the two inland corridors (i.e. the North-East and South-East subregions). Growth has not occurred uniformly throughout these corridors, but has instead been concentrated on the urban fringe.

Since 1961 there has been considerable dispersal of employment away from the central business district and towards the middle and outer suburbs. In 1961, 72 per cent of jobs were located in the Inner subregion, but this fell to 38 per cent in 2006. The pace of change was particularly rapid in the 1960s and 1970s. While the employment share of the City of Perth LGA and the Inner subregion continues to decline, and the Outer subregion continues to increase in importance, the employment share of the Middle subregion peaked in 1991.

Employment in the Outer subregion has grown strongly over the last few decades, but the outer suburbs continue to account for a much greater proportion of population than employment. Outer suburban employment increased from 14 to 32 per cent of Metropolitan Perth's employment between 1971 and 2006, while outer suburban population increased from 23 to 53 per cent of Metropolitan Perth's population. A lack of jobs, relative to population, has been particularly evident in the South-East and North-West subregions.

Residential growth, 2001 to 2006

Perth's population increased by 139 200 persons from 2001 to 2006, reaching 1.61 million (ABS 2008a). Roughly half of the city's population lives in the Outer subregion, 29 per cent in the Middle subregion, 15 per cent in the Inner subregion and 5 per cent in Peel. Between 2001 and 2006, the annual rate of population growth was greatest for Peel (3.4 per cent) and the South-West (2.9 per cent), and lowest in the Middle subregion (0.9 per cent). This compares to 1.8 per cent average annual growth for Perth as a whole and 2.3 per cent for the Outer subregion as a whole.

The areas experiencing the most rapid rate of population growth were Wanneroo North-East and Wanneroo North-West (on the city's northern fringe) and Perth Inner and Perth Remainder (which together comprise the City of Perth). The Outer subregion statistical local areas (SLAs) of Rockingham, Wanneroo North-East, Wanneroo North-West, Gosnells and Swan were the major contributors to Perth's population growth, each adding between 12 000 and 14 000 residents between 2001 and 2006.

As a whole, the Outer subregion recorded strong population growth, but there were also some significant concentrations of population loss within Perth's outer suburbs, such as the suburbs of Safety Bay, Craigie and Girrawheen. Major focal points of population growth include the suburbs of Butler, Tapping and Carramar (on the city's northern fringe), Ellenbrook (in the Swan Valley), Success (in Cockburn), Port Kennedy and Secret Harbour (to the south of Rockingham town centre) and Canning Vale (largely in Gosnells).

The increased population was accommodated largely through expanded residential development on the urban fringe but also through redevelopment of some existing suburbs, particularly in the Inner subregion.

High population density areas are scarce within the Perth metropolitan area—those that do exist are concentrated in the inner and middle suburbs. The Vincent SLA is the most densely populated within Perth, but there are SLAs within Sydney, Melbourne and Brisbane which are two to three times as densely populated. Despite these generally low densities, two-thirds of Perth's suburbs raised their population density between 2001 and 2006, sometimes by a very substantial amount.

Employment participation surged across Perth between 2001 and 2006. The number of employed residents grew much more rapidly than the city's population, with an average annual growth rate of 2.8 per cent, compared to 1.8 per cent for population. The areas that experienced the largest population growth also typically recorded very substantial growth in employed residents.

Employment growth, 2001 to 2006

Jobs are widely distributed across the Perth working zone. However, as compared to population, jobs are more heavily clustered in particular parts of the city. The City of Perth alone accounts for 17 per cent of Perth's employment. Other important employment clusters include the industrial centres of Kewdale-Welshpool, Malaga, Osborne Park and Canning Vale. These and other industrial centres accounted for 17 per cent of Perth's employment in 2006.

Perth's employment is concentrated in the inner and middle suburbs, while population is concentrated in the outer suburbs. The Inner and Middle subregions together have 66 per cent of jobs, but just 44 per cent of employed residents. The Outer subregion has 50 per cent of employed residents, but only 30 per cent of jobs.

Dormitory suburbs, offering few job opportunities for local residents, are clustered to the north-west and south-east of the city. There is less than one job for every two employed residents of the North-West and South-East subregions.

Between 2001 and 2006, Outer subregion employment grew by 3.7 per cent per annum, much higher than the Perth-wide average of 2.3 per cent. Jobs growth was strongest in the South-West, North-West, North-East and Peel subregions, which all had a growth rate exceeding 3.5 per cent per annum. Jobs growth was lowest in the Inner and Middle subregions, but was still reasonably strong, at 1.8 and 1.4 per cent per annum, respectively. There was a decline in the number of Perth residents who worked from home from 2001 to 2006.

The City of Perth local government area (LGA) added 11 000 jobs between 2001 and 2006, but this represented a marginal decline in its share of employment. The Swan LGA added 6600 jobs and the Rockingham LGA added 5100 jobs. The rate of jobs growth was highest for the Wanneroo, Rockingham and Mandurah LGAs.

Industrial centres and specialised centres (such as airports, universities and hospitals) had very strong jobs growth between 2001 and 2006. Centres experiencing particularly rapid jobs growth include the Perth airport, Murdoch University and the Malaga industrial area. Areas experiencing job loss are scattered around the city, but occur more frequently in the Inner and Middle subregions, than in the Outer subregions.

In 2006, the major employing industries in Perth were retail trade (15.4 per cent of employment), *property and business services* (12.5 per cent), *health and community services* (11.5 per cent) and *manufacturing* (11.0 per cent). Jobs in *finance and insurance, government administration* and *property* and *business services* were all heavily concentrated in the Inner subregion. Perth's SLAs each had their own distinctive mix of industries. Some were specialised in *education* (e.g. Melville, Joondalup North), and others in transport (e.g. Belmont, Fremantle Remainder) or *manufacturing* (e.g. Kwinana).

The long-term trend towards increased service industry dominance of employment has halted, at least temporarily, for Perth. From 2001 to 2006, jobs growth was greatest for *construction* (which added 19 000 jobs), *health and community services* (14 900), *government administration and defence* (10 100) and *mining* (9 400).

The industry drivers of jobs growth vary across Perth—industries which have grown strongly in one place can be stagnant in another. For example, retail employment tended to decline in the Inner subregion but increased rapidly on the urban fringe. *Government administration and defence* was the largest contributor to jobs growth in Inner Perth, *manufacturing* was the largest contributor in the South-West and North-East subregions, retail in Peel and the North-West, and health and community services in the South-East and Middle subregions. *Mining* jobs growth was highly concentrated in the City of Perth, but most SLAs shared in the jobs growth of the *construction and health and community services* industries.

Recent changes in population and employment

The rate of population growth has ramped up for Perth since 2006. While Perth's estimated resident population grew at an average annual rate of 1.8 per cent between 2001 and 2006, it grew by 2.7 per cent for the year ended June 2007 and 2.9 per cent for the year ended June 2008 (ABS 2009b).[42] However, the population growth continues to be concentrated in essentially the same set of urban fringe locations, with Wanneroo, Rockingham, Swan, Cockburn and Mandurah recording the largest population increases. The City of Perth is continuing to experience very rapid population growth, growing by 21 per cent between June 2006 and June 2008, while the City of Wanneroo grew by 16 per cent (ibid). One notable change is the recent emergence of Serpentine-Jarrahdale as an area experiencing rapid residential growth.

The 2004 to 2008 period was one of extraordinarily rapid employment growth for the Perth metropolitan region, with a 135 700 person increase in employed residents, representing average annual growth of 4.4 per cent (ABS 2009c). The number of employed residents grew by 4.9 per cent in the year ended June 2007 and by 3.3 per cent for the year ended June 2008, but between October 2008 and June 2009 there has been a 3.7 per cent decline in employed residents (ibid). The main industry drivers of jobs growth in Perth seem to have remained reasonably consistent between the intercensus period and the post-2006 period. The key differences are the recent emergence of transport and warehousing as a driver of jobs growth and a loss of mining employment following the global financial crisis.

42 The 2008 ABS ERP figures remain preliminary.

Future growth projections

Official population projections (ABS 2008b) indicate that Perth will continue to be one of the fastest growing capitals alongside Brisbane, although growth is expected to moderate from the current, historically high, rates of growth. WAPC (2009a) notes that the Perth region will need to accommodate over half a million new residents by 2031, but claims there is sufficient available land to comfortably meet these growth demands.

Recent sets of projections vary considerably and highlight the uncertainty about the magnitude and location of the city's future growth. Reflecting the urban consolidation goals of recent strategic plans, the WA Government projects that the Central and North-West subregions will face the greatest increase in the size of their population through to 2031 (WAPC 2009a). However, Peel is projected to face the most rapid rate of population growth (ibid).

The WA Government projects 350 000 additional jobs for Perth and Peel by 2031, reflecting average annual growth of 1.9 per cent (WAPC 2009a). The strongest jobs growth is projected for the North-West and Peel subregions, and the employment share of the Outer subregions is expected to increase from 30 per cent in 2008 to 38 per cent in 2031 (ibid).

Transport usage

Perth is a car dependent city, with 70 per cent of employed residents travelling to work by private vehicle in 2006. Car dependence was very high for people living in the South-West subregion and for those working in the Middle, South-West and North-East subregions. It was lowest for those living or working in the Inner and Avon Arc subregions. People who work in Belmont, Canning, Kwinana, Cockburn, Stirling Central and Swan are amongst the most car dependent. These places contain large numbers of jobs, but many are located in industrial estates, which are not well served by public transport.

Levels of commuter use of public transport are highest for residents of Inner Perth and, more generally, for residents who live in the immediate vicinity of railway stations. The Inner subregion also had the highest proportion of employed residents travelling to work by bicycle or on foot. Public transport usage was least prevalent amongst employed residents of the outlying Peel and Avon Arc subregions.

While only 17 per cent of Perth's employment was located in the City of Perth, 67 per cent of commuter public transport usage involved travel to a workplace in the City of Perth and 81 per cent involved travel to a workplace in the Inner subregion. Less than 8 per cent of usage was to a workplace in an Outer subregion.

Over the last two decades, public transport use has risen in Perth, supported by expansion of existing infrastructure. Strong growth in rail usage occurred following the opening of the Joondalup line in 1992 and the Mandurah line in 2007. Between 2001 and 2006, the proportion of employed Perth residents using public transport to get to work rose from 7.5 to 8.4 per cent.

A lack of access to transport is a potential barrier to participation in the labour force. About 2 per cent of Perth households do not have access to either a private vehicle or a nearby frequent public transport service. Transport access difficulties appear to be greatest for residents of suburbs such as Victoria Park in the Inner subregion, Maylands and Dianella in the

Middle subregion and Gosnells, Midland, Forrestfield and Rockingham in the Outer subregion. However, transport access is generally quite good, with 87 per cent of employed residents of the Perth working zone and more than 99 per cent of employed residents of the Inner and Middle subregions living within one kilometre of a frequent public transport service.

Commuting flows

Overview of Perth commuting flows in 2006

Commuter flows in an outward direction from the Perth working zone are much greater than the inflows to Perth. Perth attracts relatively few commuters from surrounding regions, because of the small population of the surrounding areas. However, the rapid growth of WA's mining industry in recent years and a shift to fly in fly out operations, has resulted in significant commuter flows from Perth to remote mine sites.

Turning to commuting flows *within* the Perth working zone, we find that the proportion of employed residents who work in their home subregion (i.e. the self-containment rate) is highest for the Inner subregion (65 per cent) and very low for the South-East and North-West subregions (29 and 33 per cent, respectively). The Inner and Middle subregions draw more than half their workforce from beyond their boundaries, but only 20 per cent of Peel and North-West subregion workers are sourced from further afield.

Trips to work operating in an inward direction dominate those in an outward direction (43 and 9 per cent of Perth trips, respectively). A particularly common form of inward commuting is commuting to a workplace located in the central business district (CBD). The probability of commuting to the CBD is highest for residents of nearby areas (e.g. Vincent) and less than 5 per cent for many of the more distant SLAs (e.g. Rockingham, Kwinana, Armadale).

Nine of the ten most common commuter trips were trips within the home SLA (e.g. 14 194 Rockingham residents travelled to a workplace in Rockingham). The most common inter-SLA flows, with more than 5000 daily commuters each, were Gosnells to Canning, Joondalup South to Stirling Central, and Joondalup South to Perth Inner. Residents of Perth Remainder had a very high probability of commuting to a place of work in Perth Inner (25 per cent), while residents of the Murray SLA had a similarly high probability of commuting to neighbouring Mandurah (23 per cent).

Average commuting distances are relatively low for Inner and Middle subregion residents, higher for the Outer subregions and highest for Peel and the Avon Arc. There is less variation in average commuting distance by place of work. However, those with jobs in the North-West and South-East subregions do travel comparatively short distances to work, particularly compared to those who work in the Avon Arc.

Changes from 2001 to 2006

There has been no progress in improving the self-containment of Perth's Outer subregion between 2001 and 2006. In both years, 35 per cent of the employed residents of Perth's Outer subregions had a place of work within their home Outer subregion. However, Peel's

self-containment rate declined between 2001 and 2006, due to increased commuting from Peel to other parts of Perth.

The North-East subregion attracted a higher proportion of its workers from other subregions in 2006, than in 2001. An expanded employment base in Swan and Kalamunda, driven by the transport, manufacturing and construction industries, generated rapid growth in the number of people commuting into the North-East subregion from other parts of Perth. The largest increases occurred for residents of the Middle and North-West subregions. The South-East subregion also attracted a higher proportion of its workers from other subregions in 2006, than in 2001, with residents of the Middle subregion being the primary source of that growth. Another source of change was the rapid population growth in Wanneroo North-East and Rockingham, which generated increased commuter flows to nearby areas.

Inward commuting and commutes within the home SLA are the two most important forms of commuting in Perth, but both recorded a below-average rate of growth between 2001 and 2006. More complex forms of commuting, such as journeys between Outer subregions, grew most rapidly, but can be hard to service by public transport.

Commuting travel times and distances appear to have remained quite stable in Perth in recent years. Very short trips and very long trips have both risen in importance, with minimal net effect on the average distance travelled to work. Residents of the North-West subregion have a slightly lower average commuting distance in 2006 than in 2001. The average distance travelled to a workplace in the North-East or South-East subregions has risen, reflecting their increased drawing power as places of work.

Some drivers of commuting flows

In addition to describing spatial patterns and trends in commuting, this project set out to explore how commuting behaviour has responded to recent spatial changes in population and employment. Regression analysis was used to investigate this issue. A simple gravity model of commuter flows explained about 80 per cent of all variation in origin–destination flows within Perth. The fundamental drivers of commuter flows, identified through this gravity model, remained very stable for Perth between 2001 and 2006.

The number of people commuting between an origin–destination pair tends to increase with the number of employed residents of the origin SLA and the number of jobs in the destination SLA, but declines as the distance between the two SLAs widens. This distance penalty is lower when there is a direct rail connection between the origin–destination pair.

The spatial concentration of industries also has implications for commuting, particularly where workers have specialised skills that tie them closely to specific industries. The greater the alignment between the skills available in the origin SLA and the skills demanded in the destination SLA, the greater the predicted commuting flows between those two places.

Growth in employed residents and jobs both play an important role in explaining changes in commuting flows in Perth between 2001 and 2006. These two factors alone explain just over half of the variation in commuting growth rates for origin–destination pairs with non-trivial commuter flows. The rate of jobs growth in the destination SLA is the most powerful predictor of spatial change in commuter flows in Perth.

Due to this relationship, the WA Government's spatial projections of residential and jobs growth to 2031 have implications for future commuting patterns in Perth. Scenario modelling suggests that the current projections (which reflect urban consolidation and outer suburban jobs growth objectives) are likely to be associated with a shift away from inward commutes towards commutes within the home SLA. However, realisation of the urban consolidation and outer suburban jobs growth goals will not automatically generate shorter average commuting distances and poses challenges for increasing the public transport mode share.

Shaping the spatial distribution of population, employment and commuting in Perth

Commuting flows within Perth are clearly driven by the spatial distribution of the residential population and jobs throughout the city. The spatial distribution of population and jobs which we see today reflects the accumulated pattern of development over many decades, but continues to be shaped and influenced by demographic trends, cultural preferences, economic forces and government interventions.

There are a range of mechanisms through which governments attempt to directly influence the spatial allocation of population, jobs and commuting within our cities, including through the development of strategic metropolitan plans, provision of urban infrastructure, management of land release and zoning of land use. Many other social, economic and environmental policy domains also play an important role in shaping our cities, even where that is not the primary aim.

The primary focus of this study has been identifying spatial changes in population, employment and commuting, with a view to providing a solid evidence base about the reality of the trends that have been shaping Perth in recent years. A secondary focus has been to provide some contextual information about urban policy directions for Perth and to investigate the extent to which policymakers have been successful in their attempts to mould the city's spatial distribution of population, employment and commuting.

The most recent plans for Perth are Metroplan 1990, *Network City* 2004 and the 2009 draft strategic plan, *Directions 2031*. All three plans aim to improve urban containment and urban consolidation, encourage employment growth in centres and the outer suburbs, encourage use of public transport and reduce commuting times and distances. BITRE has analysed the extent to which progress has been achieved against these common goals between 2001 and 2006 and the remainder of this chapter summarises the results.

Limiting urban sprawl

Management of population growth and the city's outward expansion is central to Perth's strategic plans. *Network City* aimed to accommodate 60 per cent of required dwellings in existing urban areas and 40 per cent in new growth areas (WAPC 2004c), while the draft *Directions 2031* spatial framework is less ambitious, requiring only 47 per cent of new dwellings to be located within existing developed areas.

BITRE's analysis focused on population growth, rather than growth in dwellings. Between 2001 and 2006, 64 per cent of Perth's population growth occurred in the Outer subregion and a

further 8 per cent in Peel, although some of this growth occurred in established outer suburbs. Further analysis revealed that despite the longstanding urban containment goals, the majority of Perth's growth (61 per cent) occurred within new growth areas. Perth has had success with urban consolidation in some established suburbs, with East Perth, Perth city, Joondalup, Stirling and Subiaco all experiencing very strong population growth between 2001 and 2006.

Adams (2007) pointed to a significant gap between the WA Government's spatial plans and actual residential outcomes between 1971 and 2006, arguing the spatial plans have 'been relatively impotent in determining the location and timing of urban expansion patterns' (p.1). This disjuncture is reflected in survey research which finds that 65 per cent of Perth residents support ensuring 'growth is encouraged to be in existing areas of development, and undeveloped land remains that way', but only 23 per cent expect this to happen, the lowest expectation across all the surveyed trends (Colmar Brunton n.d.).

Raising population density

As a means of combating urban sprawl, high density developments are being encouraged in certain activity centres and transit-oriented developments (TODs), while increased population density on the urban fringe is also being targeted (WAPC 2009a).

Perth remains a low density city, but has had some success with raising population densities in recent years. Between 2001 and 2006, there were substantial increases in the population density of inner city suburbs such as East Perth, Northbridge and Subiaco due to large scale building of apartment-style accommodation. Numerous outer suburbs, such as Kinross, Atwell and Quinns Rocks, also increased their population density markedly. Relatively small lot sizes have become much more common for newly released land in Perth and Peel. There has not, however, been a shift towards higher density forms of housing. Instead, Perth continues to be dominated by detached dwellings—of the 54 000 additional dwellings added between 2001 and 2006, 85 per cent were separate houses.

Eighty-four per cent of Perth's population find the idea of living in a high population density area 'not at all attractive' or 'not very attractive' (Colmar Brunton n.d.). Thus, community opposition is likely to continue to pose a challenge to planners' attempts to raise densities in existing suburbs.

Employment in centres

Strategic plans for Perth have aimed to concentrate employment growth within nominated centres. Reviews have previously identified a lack of success in encouraging employment to concentrate in these centres (State Planning Commission 1987, Hill 2005). Key issues include the past focus on retail centres, which captures only a fraction of total employment, and inadequate implementation mechanisms (WAPC 2003d).

Reflecting these concerns, *Directions 2031* has defined activity centres much more broadly to encompass universities, hospitals, airports and industrial estates as well as shopping centres (WAPC 2009a). Under this new definition, about half of Perth's employment is located in activity centres, which provides considerable scope for activity centre policy to shape the spatial distribution of employment in Perth. Between 2001 and 2006, employment in these

activity centres grew at a slightly more rapid pace than non-centred employment, and this result was largely attributable to the strong jobs growth experienced by industrial centres and specialised centres. The traditional retail-focused activity centres generally recorded below-average jobs growth, but there were some exceptions such as Joondalup and Stirling/Innaloo.

Transit oriented development

TODs are an important element of the WA Government's *Network City* and *Directions 2031* urban plans as a means of providing compact mixed-use residential, employment and service centres linked to public transport. Perth has a relatively proactive approach to promoting TODs involving forward planning to identify TOD opportunities as well as planning of individual transit places (Renne 2008, PIA 2005). However, there has been limited achievement of land use change around rail stations in Perth to date (Curtis 2005, PIA 2005). Important exceptions include the TODs in the inner city suburbs of Subiaco and East Perth, which have high and growing density, following redevelopment.

As of 2006, none of the rail or major bus station precincts in Perth's Outer subregion met Newman and Kenworthy's (2006) minimum density threshold of 30 residents and jobs per hectare, required to create viable town centres with high levels of amenity and strong links to public transport. The Inner and Middle subregion stations that did meet this threshold mainly did so due to having higher contributions of employment density rather than residential density.

Outer suburban employment growth

Since *The Corridor Plan 1970*, authorities have aimed to improve self-containment of the corridors by creating large numbers of jobs in Perth's outer suburbs (Hill 2005). Most recently, *Directions 2031* aims to increase levels of employment self-sufficiency within Perth's subregions.

Employment growth in the Outer subregion considerably outpaced employment growth in the Inner and Middle subregions of Perth between 2001 and 2006, reflecting a trend towards greater decentralisation of employment. The Outer subregion contributed 47 per cent of Perth's job growth over the period, while Peel contributed a further 6 per cent. However, the average annual growth rate of employment in the Outer subregion (3.7 per cent) was very much in line with growth in employed residents (3.5 per cent), resulting in continued low rates of employment self-sufficiency. The main industry contributors to jobs growth in the Outer subregion were Manufacturing (which added 5181 jobs), Construction (5157), Retail trade (4127), Health and community services (3961) and Education (3448), while the main declining industry was Agriculture (which lost 817 jobs).

Estimates from the *Land Use and Employment Survey*, from 2002 to 2008, show an average annual rate of jobs growth for the Outer subregion at 7 per cent, with the Middle and Inner subregions at 3 and 2 per cent respectively. This strong growth for the Outer subregion suggests further expansion in employment since 2006.

Despite these recent improvements, many outer suburbs offer little in the way of job opportunities for local residents, especially in the North-West and South-East subregions. The Outer subregion accounted for just 30 per cent of Perth's employment in 2006, despite being home to 50 per cent of the city's population. The strong jobs growth in the Outer subregion

between 2001 and 2006 did not generally translate into improvements in self-sufficiency or self-containment in the subregions.

Encouraging public transport use

The *Network City* strategic plan aimed to 'encourage public transport over private transport' (WAPC 2006, p.2). Reflecting this goal, there were significant expansions of public transport services in Perth between 2001 and 2006, including the opening of the Thornlie spur line and the extension of the Joondalup line to Clarkson. Public transport patronage increased by 3.3 per cent per annum between 2001 and 2006, and the opening of the Mandurah line in December 2007 led to particularly strong growth in patronage in 2008 (BITRE 2009a). The proportion of employed Perth residents using public transport to get to work rose from 7.5 to 8.4 per cent and public transport's mode share increased significantly amongst residents of the Inner, Middle and North-West subregions. This was due to increased rail use in the North-West, increased bus use in the Inner subregion and growth in both modes in the Middle subregion. However, commuter use of public transport is dominated by those travelling to a workplace in the Inner subregion. Perth remains a very car dependent city, with 70 per cent of employed residents travelling to work by private vehicle in 2006. Car dependence is particularly high for those travelling to a workplace in the Middle or South-West subregions.

Reducing average commuting times and distances

Metropolitan plans for Perth have long aimed to achieve reductions in commuting times and distances. For example, *Metroplan* aimed to encourage jobs growth in the outer suburbs to 'allow people to work closer to their homes, reducing peak hour commuter travel' (Hill 2005 p134). Similarly, *Directions 2031* aims to promote 'higher levels of employment self-sufficiency in subregional areas, thereby reducing commuting distances and times' (WAPC 2009a).

The available evidence suggests that commuting travel times and distances have remained quite stable in Perth in recent years. Very short trips and very long trips have both risen in importance. While some parts of the city have experienced a reduction in average commuting distances for residents (e.g. the North-West subregion), residents of other places are travelling greater average distances than before.

Overall assessment

Good progress was achieved against some of these objectives between 2001 and 2006, such as encouraging public transport use and outer suburban employment. With some objectives—such as raising population densities and encouraging employment in activity centres—the pace of change has been slow, but the available evidence suggests things are heading in the desired direction. For other objectives, such as reducing commuting distances, there has been no real change over the 2001 to 2006 period.

The different objectives are also highly inter-related and progress against one objective may aid or hinder progress in other areas. For example, rapid outer suburban jobs growth is likely to have a negative effect on public transport's mode share (holding other factors constant).

Where progress has been made, it has been incremental in nature—longstanding consumer preferences and the accumulated effects of decades of residential and industry development do not reverse in a period as short as five years.

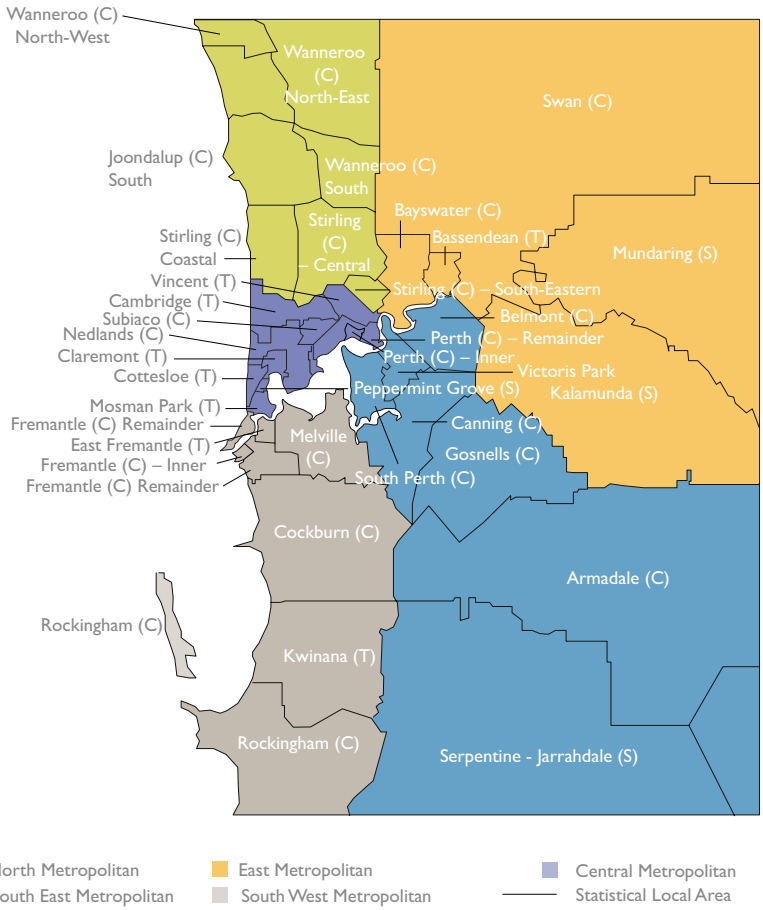
Future directions

This paper represents the first case study of a broader research project which aims to identify the spatial changes in major capital city employment and residential patterns and how commuting behaviour has responded to those changes. Reports are also being prepared for Sydney, Melbourne, Brisbane and Adelaide.

The full value of the Perth study will not be evident until the analysis is replicated for the remaining cities and results are compared. A comparative report will be produced, which provides an overview of relevant statistics for the five cities, pulls out some common themes and differences, and discusses the implications for urban development, infrastructure and local government policy.

APPENDIX A
Geographic boundaries

MA.1 Statistical Local Area boundaries for Perth statistical division, 2006

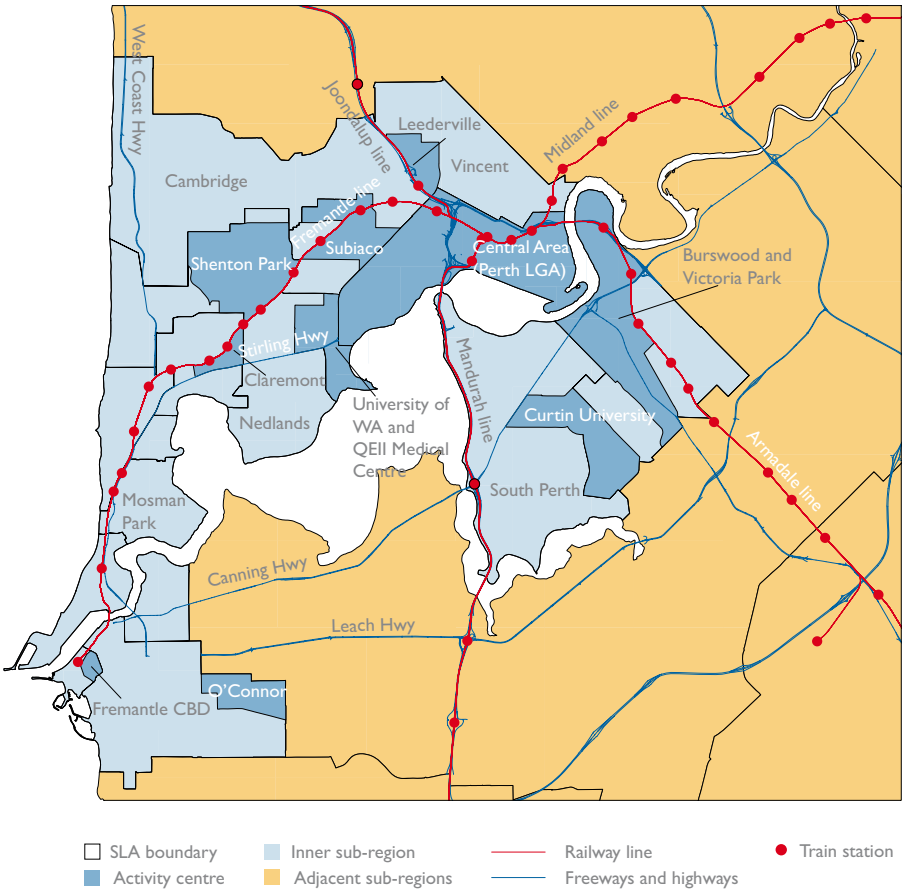


Note: Murray, Mandurah and Waroona are part of the Perth working zone but are not shown on this map: they are located to the south of Rockingham. Gingin, Toodyay and Chittering are also part of the Perth working zone, but are not shown on this map: they are located to the north of Wanneroo and Swan.

Source: ABS Cat. 1216.0, 2006 issue.

Maps A.2 to A.9 present Perth's planning subregions, highlighting the, activity centres, roads, public transport rail networks and geographical boundaries such as Statistical Local Areas.

MA.2 Inner planning subregion, activity centres and transport networks.

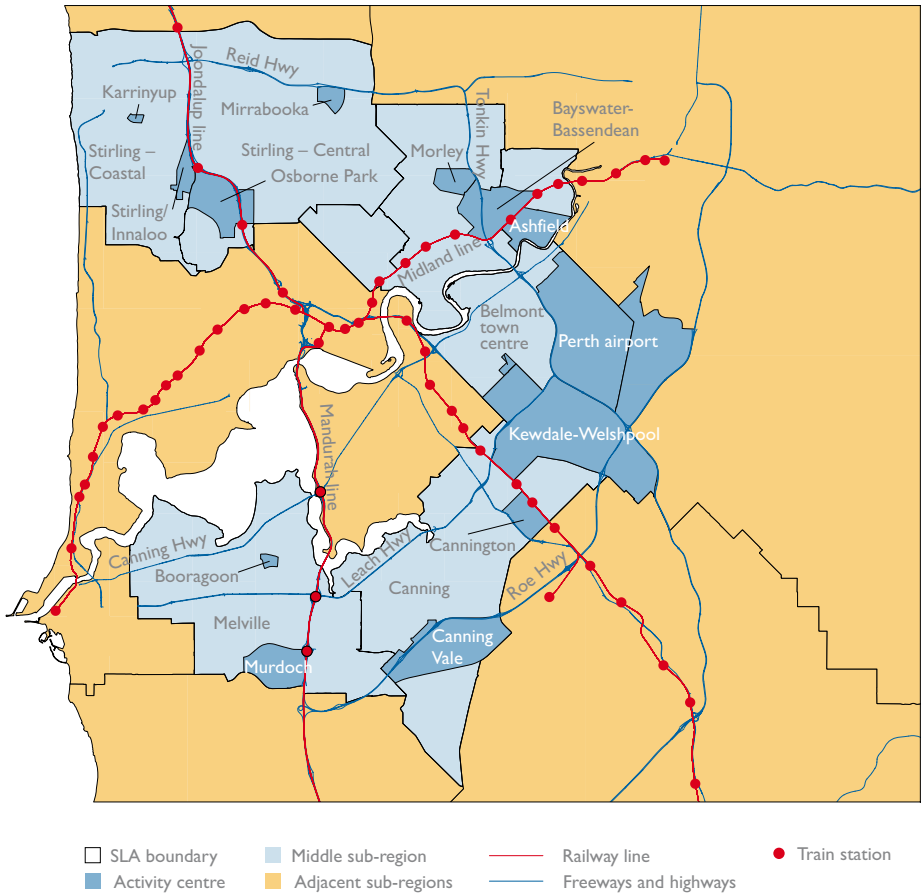


Note: Mandurah rail line was not operational until late 2007.

Activity centre boundaries were estimated by BITRE using information from WAPC (2009c), in conjunction with various street directories and constructed using 2006 destination zones. Individual destination zones may be larger than the area being used by the actual activity centre, thus the BITRE's activity centre boundaries may be larger than those used by the WAPC.

Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, ABS Cat. 1216.0, 2006 issue, and BITRE analysis of WAPC (2009c).

MA.3 Middle planning subregion, activity centres and transport networks.

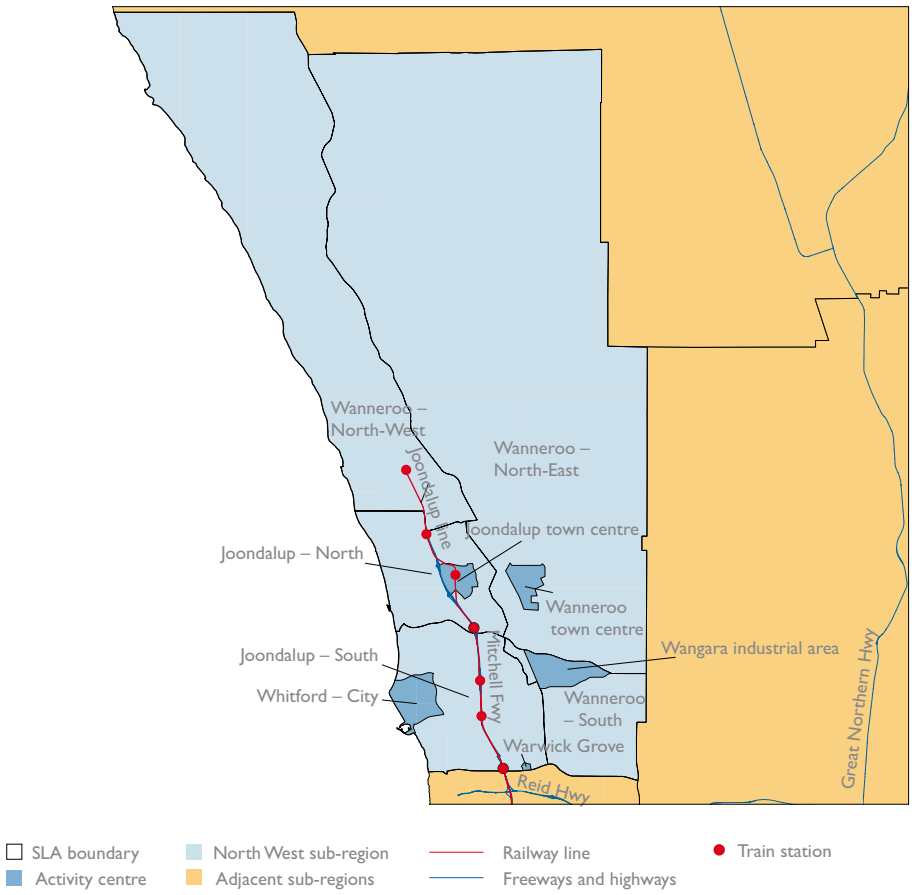


Note: Mandurah rail line was not operational until late 2007.

Activity centre boundaries were estimated by BITRE using information from WAPC (2009c), in conjunction with various street directories and constructed using 2006 destination zones. Individual destination zones may be larger than the area being used by the actual activity centre, thus the BITRE's activity centre boundaries may be larger than those used by the WAPC.

Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, ABS Cat. 1216.0, 2006 issue, and BITRE analysis of WAPC (2009c).

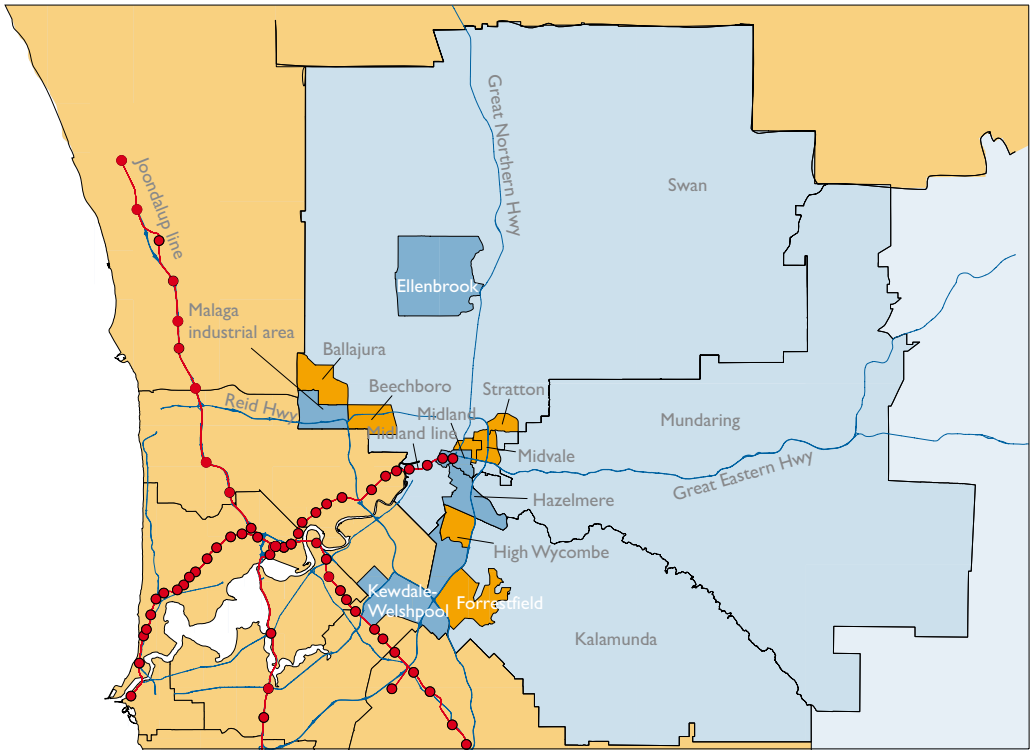
MA.4 North-West planning subregion, activity centres and transport networks.



Note: Activity centre boundaries were estimated by BITRE using information from WAPC (2009c), in conjunction with various street directories and constructed using 2006 destination zones. Individual destination zones may be larger than the area being used by the actual activity centre, thus the BITRE's activity centre boundaries may be larger than those used by the WAPC.

Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, ABS Cat. 1216.0, 2006 issue, and BITRE analysis of WAPC (2009c).

MA.5 North-East planning subregion, activity and population centres and transport networks.



Note: Mandurah rail line was not operational until late 2007.

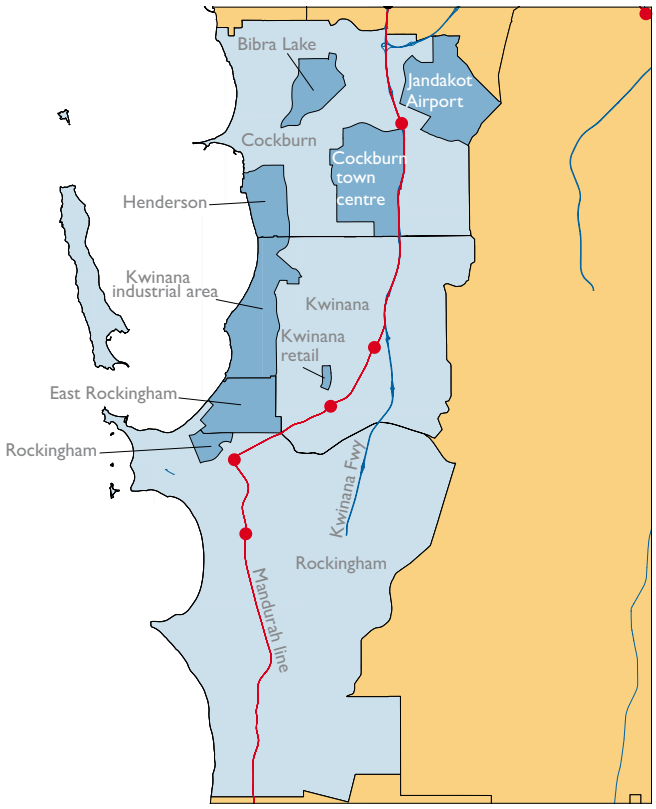
Activity centre boundaries were estimated by BITRE using information from WAPC (2009c), in conjunction with various street directories and constructed using 2006 destination zones. Individual destination zones may be larger than the area being used by the actual activity centre, thus the BITRE's activity centre boundaries may be larger than those used by the WAPC.

The selection of population centres in the map is based on the population clusters identified in Chapter 3.

Population centre boundaries were based on 2006 SSC boundaries as described in ABS (2007a).

Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, ABS Cat. 1216.0 2006 issue, ABS Cat. 2905.0 2007 issue, and BITRE analysis of WAPC (2009c).

MA.6 South-West planning subregion, activity centres and transport networks.

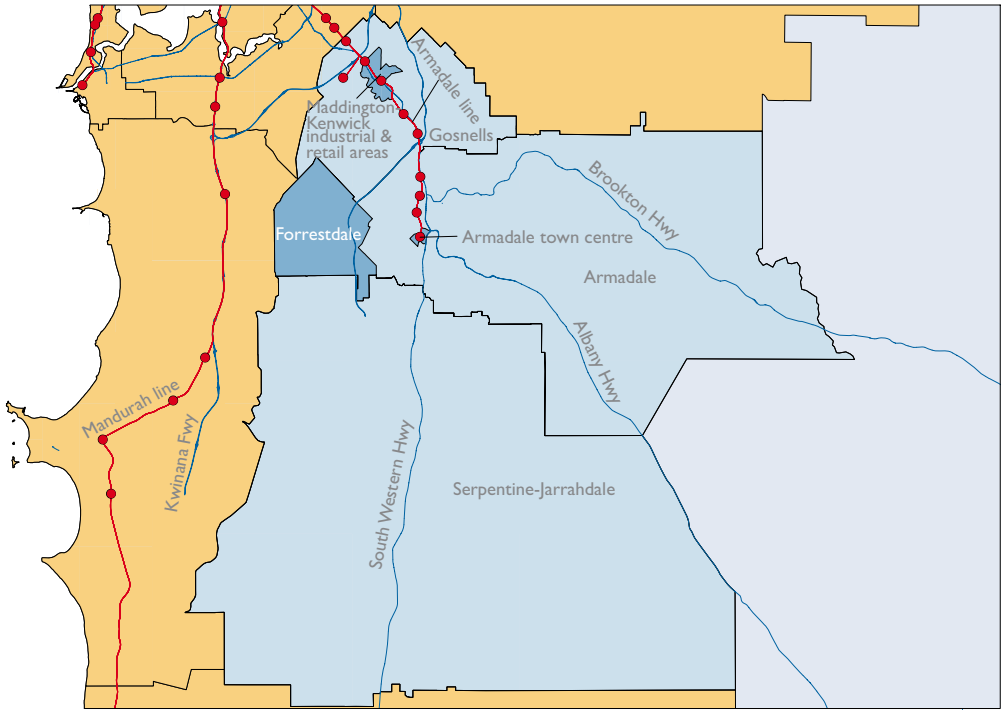


Note: Mandurah rail line was not operational until late 2007.

Activity centre boundaries were estimated by BITRE using information from WAPC (2009c), in conjunction with various street directories and constructed using 2006 destination zones. Individual destination zones may be larger than the area being used by the actual activity centre, thus the BITRE's activity centre boundaries may be larger than those used by the WAPC.

Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, ABS Cat. 1216.0, 2006 issue, and BITRE analysis of WAPC (2009c).

MA.7 South-East planning subregion, activity centres and transport networks.

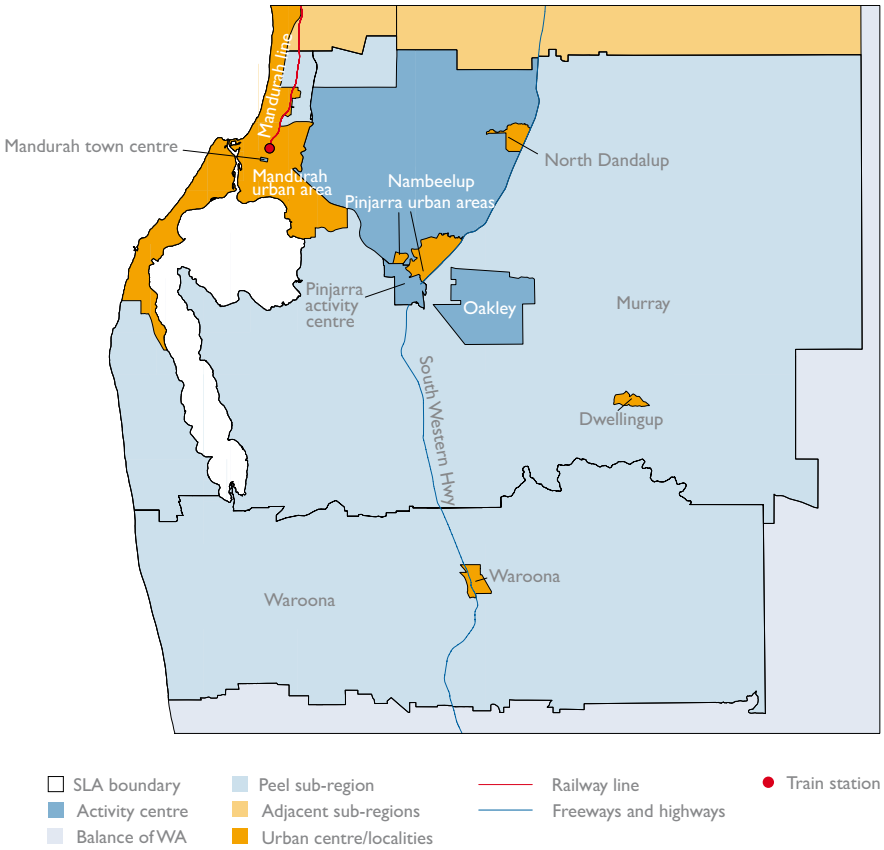


Note: Mandurah rail line was not operational until late 2007.

Activity centre boundaries were estimated by BITRE using information from WAPC (2009c), in conjunction with various street directories and constructed using 2006 destination zones. Individual destination zones may be larger than the area being used by the actual activity centre, thus the BITRE's activity centre boundaries may be larger than those used by the WAPC.

Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, ABS Cat. 1216.0, 2006 issue, and BITRE analysis of WAPC (2009c).

MA.8 Peel planning subregion, activity centres and transport networks.



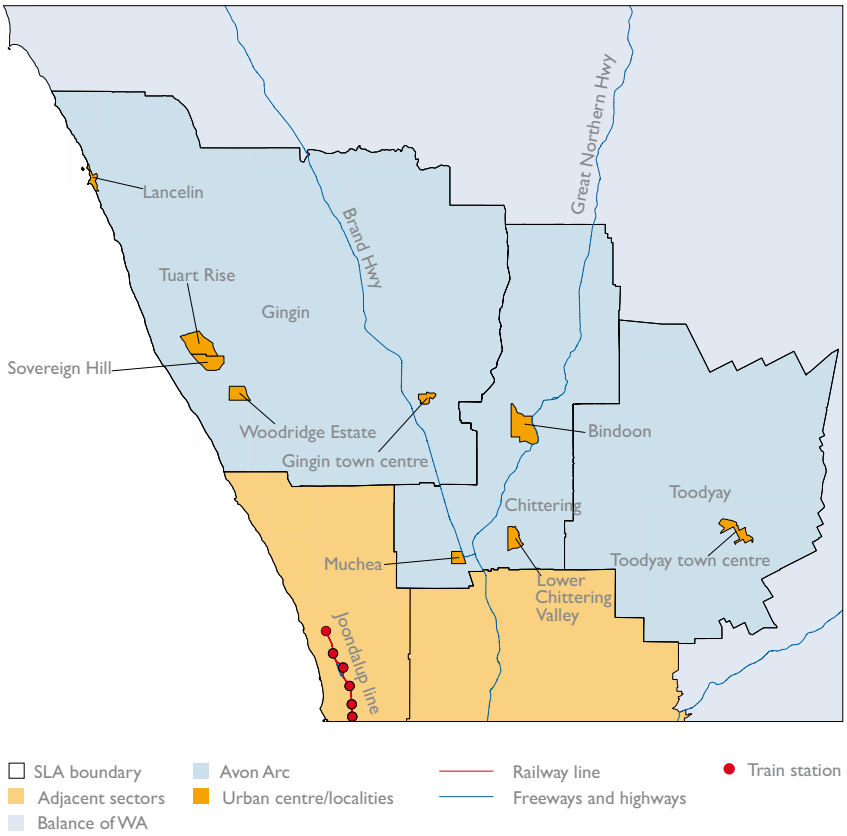
Note: Mandurah rail line was not operational until late 2007.

Activity centre boundaries were estimated by BITRE using information from WAPC (2009c), in conjunction with various street directories and constructed using 2006 destination zones. Individual destination zones may be larger than the area being used by the actual activity centre, thus the BITRE's activity centre boundaries may be larger than those used by the WAPC.

Pinjarra urban area includes the whole of Pinjarra activity centre.

Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, ABS Cat. 1216.0, 2006 issue and Cat. 2909.0, 2007 issue, and BITRE analysis of WAPC (2009c).

MA.9 Avon planning subregion and transport networks.



Source: WA Public Transport Authority stops and services data for 2008, PSMA 2009 roads data, and ABS Cat. 1216.0, 2006 issue and Cat. 2909.0 2007 issue.

TA.1 Classification of Local Government Areas to subregions, Perth working zone, 2006

Local Government Area	Planning subregion (detailed)	Planning subregion (summary)
Cambridge	Inner	Inner
Claremont	Inner	Inner
Cottesloe	Inner	Inner
East Fremantle	Inner	Inner
Fremantle	Inner	Inner
Mosman Park	Inner	Inner
Nedlands	Inner	Inner
Peppermint Grove	Inner	Inner
Perth	Inner	Inner
South Perth	Inner	Inner
Subiaco	Inner	Inner
Victoria Park	Inner	Inner
Vincent	Inner	Inner
Bayswater	Middle	Middle
Belmont	Middle	Middle
Canning	Middle	Middle
Melville	Middle	Middle
Stirling	Middle	Middle
Joondalup	North-West	Outer
Wanneroo	North-West	Outer
Kalamunda	North-East	Outer
Mundaring	North-East	Outer
Swan	North-East	Outer
Armadale	South-East	Outer
Gosnells	South-East	Outer
Serpentine-Jarrahdale	South-East	Outer
Cockburn	South-West	Outer
Kwinana	South-West	Outer
Rockingham	South-West	Outer
Mandurah	Peel	Other
Murray	Peel	Other
Waroona	Peel	Other
Chittering	Avon Arc	Other
Gingin	Avon Arc	Other
Toodyay	Avon Arc	Other

Source: WAPC (2005b).

Abbreviations and acronyms

ABS	Australian Bureau of Statistics
ANZSIC	Australian and New Zealand Standard Industrial Classification
ASGC	Australian Standard Geographical Classification
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BTRE	Bureau of Transport and Regional Economics
Cat.	Catalogue number
CBD	Central business district
CCD	Census collection district
DHA	Department of Health and Ageing
DPI	Department for Planning and Infrastructure
DZ	Destination zone
ERP	Estimated Resident Population
HILDA	Household, Income and Labour Dynamics in Australia
HURIWA	Housing and Urban Research Institute of Western Australia
IRSD	Index of Relative Socio-economic Disadvantage
km	Kilometre
LGA	Local Government Area
MDP	Metropolitan Development Program
MRIT	Metropolitan Region Improvement Tax
MRS	Metropolitan Region Scheme
na	not applicable
n.d.	not dated
No.	Number
OLS	Ordinary least squares
PIA	Planning Institute of Australia
PC	Productivity Commission
SEIFA	Socio-economic Indexes for Areas
SD	Statistical Division
SLA	Statistical Local Area
St	Street
Stn	Station
TAFE	Technical and Further Education
TOD	Transit oriented development
Vol.	Volume

WA	Western Australia
WAPC	Western Australian Planning Commission
WZ	Working zone

References

ABS 2009a, *Australian demographic statistics, December 2008*, Cat. 3101.0, ABS, Canberra

ABS 2009b, *Regional population growth, Australia, 2007–08*, Cat. 3218.0, ABS, Canberra

ABS 2009c, *Labour force, Australia, detailed: Electronic delivery,* Cat. 6291.0.55.001, ABS, Canberra

ABS 2009d, *Labour force, Australia, detailed: Quarterly, May 2009*, Cat. 6291.0.55.003, ABS, Canberra

ABS 2009e, *Consumer price index, Australia, Jun 2009*, Cat. 6401.0, ABS, Canberra

ABS 2008a, *Regional population growth, Australia 2006-07*, Cat. 3218.0, ABS, Canberra

ABS 2008b, *Population projections, 2006 to 2101*, Cat. 3222.0, ABS, Canberra

ABS 2008c, *Perth: a social atlas 2006*, Cat. 2030.5, ABS, Canberra

ABS 2008d, *An introduction to socio-economic indexes for areas (SEIFA) 2006*, Cat. 2039.0, ABS, Canberra

ABS 2007a, *Statistical geography: Volume 2-Census Geographic Areas*, Cat. 2905.0, ABS, Canberra

ABS 2007b, *Statistical geography: Volume 3-Australian standard geographical classification (ASGC) Urban centres/localities*, Cat. 2909.0, ABS, Canberra.

ABS 2006, *Statistical geography Volume 1-Australian standard geographical classification (ASGC) 2006*, Cat. 1216.0, ABS, Canberra

Adams T 2007, 'Taming an urban frontier? Urban expansion and metropolitan spatial plans in Perth, 1970–2005', *Paper presented to the 2007 State of Australian Cities Conference*, 28–30 November, Adelaide

Albrechts L 2006, 'Shifts in strategic spatial planning? Some evidence from Europe and Australia', *Environment and Planning* A, Vol. 38, pp. 1149–70

Bunker R 2009, *Paradigm lost or paradigm regained? – current Australian metropolitan strategies*, Paper presented to the State of Australian Cities conference, Perth, November 24–27

Bunker R and Searle G 2009, 'Theory and practice in metropolitan strategy: situating recent Australian planning', *Urban Policy and Research*, Vol. 27, No. 2, pp. 101–16

Bureau of Infrastructure, Transport and Regional Economics 2009a, *Information sheet 31, Urban passenger transport: how people move about in Australian cities*, Bureau of Infrastructure, Transport and Regional Economics, Canberra

Bureau of Infrastructure, Transport and Regional Economics 2009b, 'An economic outlook: the role of urban rail', *Paper presented to Australasian Railway Association Urban Rail Conference,* 18 March, Sydney

Bureau of Infrastructure, Transport and Regional Economics 2009c, *Changes in industry structure 2001 to 2006*, Information sheet No. 32, BITRE, Canberra

Bureau of Infrastructure, Transport and Regional Economics 2009d, *National road network intercity traffic projections to 2030*, Working paper No. 75, BITRE, Canberra

Bureau of Transport and Regional Economics 2003, *Focus on Regions No. 1: Industry structure,* Information paper No. 49, BTRE, Canberra

Chen X, Ender P, Mitchell M and Wells C 2003, *Regression with SAS*, from <www.ats.ucla.edu/stat/sas/webbooks/reg/default.htm>

City of Stirling 2008, *Osborne Park*, viewed 7 May 2009, <www.stirling.wa.gov.au/home/council/Suburbs/Osborne+Park.htm>

Colmar Brunton n.d., *Dialogue with the city: survey results*, viewed 13 May 2009, <www.dpi.wa.gov.au/mediafiles/dialogue_results.pdf>

Costa M 2009, 'Not so super markets', *The Australian*, July 3rd

Currie G 2009, 'Australian urban transport and social disadvantage', *The Australian Economic Review*, Vol. 42, No. 2, pp. 201–8

Curtis C 2006, '*Network city*: Retrofitting the Perth Metropolitan Region to facilitate sustainable travel', *Urban Policy and Research*, Vol. 24, No. 2, pp. 159–180

Curtis C 2005, 'The windscreen world of land use transport integration: experiences from Perth, WA, a dispersed city', *Town Planning Review*, Vol. 76, No. 4, pp. 423–453

Department of Health and Ageing 2009, *Statistical local area population projections, 2007* to 2027, revised, viewed June 24 2009, <www.health.gov.au/internet/main/publishing.nsf/Content/EE40D9F505C33B79CA2574C50080D735?OpenDocument&SUBMITCHECK=on&SUBMIT=View+documents>

Department of Planning 2009, *About the Department of Planning*, accessed 14 May 2010, <http://www.planning.wa.gov.au/The+planning+system/About+the+Department+of+Planning/default.aspx>

Department for Planning and Infrastructure (DPI) 2009 (forthcoming), *Land Use and Employment Survey*, DPI, State of Western Australia

Department for Planning and Infrastructure 2006, *Extended public bus service trial: Yarloop – Waroona – Pinjarra – Mandurah*, viewed 9 April 2009, <www.dpi.wa.gov.au/planning_regtrialbus-y-w-p-m2006.pdf>

Department for Planning and Infrastructure (DPI) 2002, Summary of the *Land Use and Employment Survey (1990, 1993, 1997 and 2002),* DPI, State of Western Australia

Environment Protection Authority 2007, *State of the Environment Report: Western Australia 2007,* website, Department of Environment and Conservation, Perth, Western Australia.

Frewer P 2001, 'The need for new directions in metropolitan strategic planning', *Urban Policy and Research*, Vol. 19, No. 1, pp. 93–100

Harsman B and Quigley J 1998, 'Education, job requirements and commuting: an analysis of network flows' in Beckman (ed), *Knowledge and networks in a dynamic economy*, pp. 261–72

Hill L 2005, 'Guiding Perth's growth: a regional perspective', *Berkeley Planning Journal*, Vol. 18, pp. 119–149

Holling C 2008 *The attraction and retention of small and medium enterprises in transit oriented development*, Housing and Urban Research Institute Western Australia, Perth

Holling C and Haslam McKenzie F 2009, *The attraction and retention of small and medium enterprises in transit oriented development in Perth*, Paper presented to the State of Australian Cities Conference, Perth, November 24–27

Housing and Urban Research Institute of Western Australia (HURIWA) 2007, *Housing in railway station precincts: some empirical evidence of consumer demand for transit oriented housing in Perth, Western Australia*, Research commissioned by Landcorp and the Department of Housing and Works

Hurni A 2006, *Transport and social disadvantage in Western Sydney*, Western Sydney Community Forum, Parramatta

Infrastructure Australia 2009, *National infrastructure priorities*, viewed 27 August 2009, www.infrastructureaustralia.gov.au/files/National_Infrastructure_Priorities.pdf

Lawrence P 2005, *Some empirical observations on travel behaviour from the Perth and Region Travel Survey*, Paper presented to the PATREC Research Forum, Curtin University, 3 October.

Maginn P 2007, 'Deliberative democracy or discursively biased? Perth's Dialogue with the City initiative', *Space and Polity*, Vol. 11, Issue 3, pp. 331–52

Mees P 2009, *How dense are we? Another look at urban density and transport patterns in Australia, Canada and the USA*, Paper presented to the State of Australian Cities Conference, Perth, November 24–27

Melbourne Institute 2009, 'Time spent travelling to and from work', in *Families, income and jobs, volume 4: A statistical report on Waves 1 to 6 of the HILDA survey*, Melbourne Institute, pp. 202–204

Newman P and Kenworthy J 1989, *Cities and automobile dependence: an international sourcebook*, Aldershot: Gower

Newman P and Kenworthy J 2006, 'Urban design touce automobile dependence', *Opolis*, Vol. 2, No. 1

New South Wales Ministry of Transport 2008, *TransFigures, December 2008*, New South Wales Ministry of Transport, Sydney

Planning Institute of Australia 2005, *Reconnecting Perth: The cross-portfolio transit-oriented development program*, July

Productivity Commission 1993, *Impediments to regional industry adjustment*, Report No. 35, PC, Canberra

Public Transport Authority 2008a, *Annual report 2007–2008*, viewed 5 March 2009, <www.pta.wa.gov.au/annualreports/2008/index.html>

Public Transport Authority 2008b, *1976 to 2000,* viewed 23 March 2009, <www.pta.wa.gov.au/scripts/viewarticle.asp?NID=1823>

Public Transport Authority 2008c, *2001 to present*, viewed 23 March 2009, <www.pta.wa.gov.au/scripts/viewarticle.asp?NID=1824>

Public Transport Authority 2007, *Major boost to northern suburbs park and ride*, viewed 14 April 2009, <www.pta.wa.gov.au/scripts/viewarticle.asp?NID=2299>

Renne, J 2008, 'Smart growth and transit-oriented development at the state level: Lessons from California, New Jersey and Western Australia', *Journal of Public Transportation*, Vol. 11, No. 3, pp. 77–108

Renne J, Chandra L, Tippett B and Kolapalli, S 2007, *Measuring the performance of transit-oriented developments in Western Australia*, Planning and Transport Research Centre, Bentley.

Socialdata Australia 2000, *Potential analysis "Perth"*, Socialdata Australia, Fremantle

State Planning Commission 1987, *Planning for the future of the Perth Metropolitan Region*, State Planning Commission, East Perth

Stokes R 2006, 'The WA model—what makes the WA planning system different', *Paper presented to the Housing Industry Association's National Planning Conference*, 31 August 2006, Sydney

Thomson JM 1977, *Great cities and their traffic*, Victor Gollancz, London

Transperth n.d, *Car parking at Transperth bus & train stations*, viewed 13 October 2009, <http://www.transperth.wa.gov.au/UsingTransperth/CarParking/tabid/119/Default.aspx>

Transperth 2009a, *Northern timetable 60*, viewed 13 October 2009, <http://www.transperth.wa.gov.au/timetablePDFs/Northern%2060%2020090628.pdf>

Transperth 2009b, *Northern timetable 61*, viewed 13 October 2009, <http://www.transperth.wa.gov.au/timetablePDFs/Northern%2061%2020090628.pdf>

Transperth 2009c, *Northern timetable 62*, viewed 13 October 2009, <http://www.transperth.wa.gov.au/timetablePDFs/Northern%2062%2020091018.pdf>

Trendle B and Siu J 2005, *Commuting patterns of Sunshine Coast residents and the impact of education*, Working Paper No. 37, Queensland Government Department of Employment and Training

WAPC 2009a, *Directions 2031: Draft spatial framework for Perth and Peel*, WAPC, June

WAPC 2009b, *Planning activity centres for communities and economic growth*, Discussion paper, WAPC, June

WAPC 2009c, *Planning makes it happen—a blueprint for planning reform*, WAPC, September.

WAPC 2009c, *Draft state planning policy: Activity centres for Perth and Peel*, WAPC, June

WAPC 2008, *Western Australian Planning Commission Annual Report 2007–08*, WAPC, Perth, September

WAPC 2007, *State lot activity, September quarter 2006*, WAPC, Perth

WAPC 2006, *Statement of planning policy: Network City*, WAPC, March

WAPC 2005a, *Network City—a milestone in metropolitan planning*, WAPC, November

WAPC 2005b, *Western Australia tomorrow: Population projections for planning regions 2004 to 2031 and local government areas 2004 to 2021*, Population Report No. 6, WAPC

WAPC 2004a, *Network City: community planning strategy for Perth and Peel*, WAPC, September

WAPC 2004b, *The evolving city: An atlas of change in the City of Perth 1990–2001*, July

WAPC 2004c, *Network City action plan*, WAPC, September

WAPC 2004d, *Metropolitan Development Program: Urban land release plan 2004–05 to 2008–09*, WAPC, Perth

WAPC 2003a, *Greater Perth planning context*, Discussion Paper No. 1, WAPC, August

WAPC 2003b, *Greater Perth population and housing*, Discussion Paper No. 2, WAPC, August

WAPC 2003c, *Greater Perth economy and employment*, Discussion Paper No. 3, WAPC, August

WAPC 2003d, *Greater Perth integrating land use and transport*, Discussion Paper No. 5, WAPC, August

WAPC 2003e, *Greater Perth residential land balance*, Discussion Paper No. 6, WAPC, August

WAPC 2000, *Metropolitan centres policy statement for the Perth metropolitan region*, Statement of Planning Policy No. 9, WAPC, Perth