FOUR CITIES & A REGION:
INTEGRATED TRANSPORT - LAND USE PLANNING AS A SUSTAINABLE TRANSPORT SOLUTION FOR THE WELLINGTON REGION

by

Susan Chapman

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ABSTRACT

Greater Wellington Regional Council is responsible for the Regional Land Transport Strategy (RLTS) for the Wellington region, comprising of four cities, numerous towns and governed by eight disparate territorial authorities. The strong central core of Wellington City and the geographically enforced 'Y' formation of the transport corridor have traditionally dominated the region's urban development. To date, transport and land use planning in the region have been undertaken independently, when research demonstrates that a combination of land use, transport, financial and regulatory planning mechanisms are required to establish a successful sustainable transport solution. This research examines six different policy intervention scenarios, and identifies the optimal transport - land use intervention (for growth projections to 2026) as the densification of development around key public transport nodes. This policy intervention meets the RLTS vision of providing a balanced and sustainable transport system through the increased adoption of active modes across all trip types of short duration, an increase in public transport use for longer distance trips and an overall decrease in daily trips by car.

Key words: integrated planning; sustainable transport; land use; Wellington

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LIST OF ABBREVIATIONS

active modes	incorporates non-motorised modes of transport, principally walking and cycling
am peak	weekday morning peak period from 07:00 to 09:00
ave	average
CBD	Central Business District of Wellington City as defined in Appendix 10
CO	Carbon monoxide
CO^2	Carbon dioxide
FTE	full-time equivalent. The measure used by Statistics New Zealand to record job numbers whereby two part-time jobs are counted as one full-time job
GW(RC)	Greater Wellington (Regional Council)
ha	hectares
HCC	Hutt City Council
HOT lane	High occupancy vehicle toll lane, for vehicles conveying two or more people. Single occupancy vehicles must pay a toll to travel in the lane
HOV lane	High occupancy vehicle lane for vehicles conveying two or more people
hrs	hours
JTW	journey to work
KCDC	Kapiti Coast District Council
km	kilometres
NZD	New Zealand dollars
pax	passenger(s)
PCC	Porirua City Council
PKT	passenger kilometres travelled
PT	public transport. Includes buses, mini buses, suburban rail, commuter ferries

SH1	State Highway 1
SH2	State Highway 2
SOV	single occupancy vehicle
TA(s)	territorial authority(ies)
UHCC	Upper Hutt City Council
VCR	vehicle / cost ratio.
VKT	vehicle kilometres travelled
WCC	Wellington City Council
WTSM	Wellington Transport Strategy Model

GLOSSARY OF TERMS

Affordable Housing: Based on the ratio of housing costs to household income, housing is "affordable" if the people living there pay no more than 30% of their income towards the rent or mortgage. Affordable housing projects are typically aimed at low and moderate-income households.

Brownfield Development: Redevelopment of disused industrial sites now within an urban area. For example, factories and quarries.

Decoupling: The aiding of sustainable development through slowing or reversing the growth in environmentally damaging activities in relation to economic expansion.

Gentrification: Changes in a neighbourhood or city that reflect the inflow of money and affluence from the outside. Often this inflow of money and resultant capital investment coincides with an increase in the amount of professional and managerial jobs within an area. This then leads to an increase in the numbers of "gentry" living in the neighbourhood or city. The effect of this inflow of affluence is a rise in rental and property values that often quickly exceeds the ability of long-term residents to afford.

Greenfield Development: Development on previously undeveloped 'green fields'.

Greyfield Development: Redevelopment on disused or under-utilised low-density commercial and institutional sites, often in suburban areas, such as shopping malls, airports, military bases and hospitals. Named after the large tracts of asphalt on these sites.

Location Efficiency: The ability to minimize automobile dependency (and more generally the need to travel long distances by any mode) by maximizing the potential synergies between different land uses and development and transit. Location efficiency can be quantified through measures such as parking demand, automobile ownership, mode split (the percentage of people using a given mode of transportation) and vehicle kilometres travelled.

Location Efficient Mortgage (LEM): LEM is a mortgage instrument by which a lender takes into account the reduced per household transportation costs that exist in TOD or TOD-like developments (i.e. areas located near high-quality transit). This proximity thereby increases the purchasing power of a homebuyer.

Mixed Use: Multiple uses of a particular piece of land. For example: Arterial streets lined with 2-3 story buildings, with retail space on the ground floor and housing or office space on the upper floors. The streets behind the arterial can contain a mix of housing types that are clustered near key features of the community (e.g. parks, community centres, schools etc.). Consequently, community members only have to walk a short distance in order to meet many of their daily transportation needs.

Park-and-Ride Lot: A parking area besides a transit stop. Transit riders who leave their personally operated vehicle behind as they board either a bus or a train use park-and-ride lots.

Settlement Systems: Settlements are the result of decisions made by governments, organisations, households, and individuals regarding the environment, transport, land use, financial, property, commercial, health, utilities, education, and safety. Thus settlements comprise multiple interacting systems.

Spatial Mismatch: A situation that has arisen as more new jobs are created in ever distant locations which are inaccessible to a high percentage of lower-skilled, lower-income workers who live in more central areas.

Sub-centres: Self-contained ‘urban villages’ built around transit nodes &/or positioned along transport corridors. These centres create a back flow in transit trips as residents of the core city travel out to sub-centres for work and recreation.

The New Urbanism: Established in the 1980s by a group of United States architects, the new urbanism (also known as neo-traditional planning) promotes the creation and restoration of diverse, walkable, compact, mixed-use, complete communities, as well as the increased use of trains and light rail rather than building more roads. It is based on the “traditional” cities and towns built around the world prior to World War II. The new urbanism focuses on improving the quality of life through place making, with the establishment of a discernible centre and quality public spaces.

Transit: Transit is used in this report interchangeably with the terms ‘mass transportation’, ‘public transit’ and ‘public transport’. Specifically, it refers to any means of publicly available travel by which a significant number of persons are transported at a single time. This includes, but is not limited to; bus (including Bus Rapid Transit), ferry, light rail, shuttles, commuter and inter-regional trains.

Transit-oriented Development (TOD): Transit-oriented development is moderate to higher density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment and shopping opportunities designed for pedestrians without excluding vehicles. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use. TOD is built both to support rail transit and to leverage the development opportunities a transit station may provide.

Value Capture: Term developed in the 1970's by the California state government to describe TOD-like development around transit stations. The theory was that proper development patterns around a transit station would increase ridership at that station along with generating additional tax dollars. Therefore these monies could then be used to eventually 'pay' for the capital costs of building the station.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

Unlike many European cities, which have had high urban densities for centuries, many cities of North America and Australasia have evolved into large areas of low-density suburban sprawl serviced, primarily, by extensive road networks. The Wellington region (Figure 4.1) is one such example, with a population of around 445,000 (Greater Wellington Regional Council, 2003) spread over four cities, numerous towns, and a large rural area. The 'Y' formation of the transport corridor, containing both rail and road links into Wellington City, is the dominant attribute in the region's urban development (Victoria University of Wellington, 1967). Over the years suburbanisation has seen housing sprawl up hills and around harbours as land close to the motorways and rail lines was developed. However, the region's transport infrastructure has not expanded at the same rate as the suburbs it's there to support.

Automobile dependence, sprawl, and the resulting traffic congestion have spawned a number of sustainable transport and settlement movements, all of which are founded on the integration of transport and land use planning. Objectives of such planning vary dependent upon a project's desired outcome, but generally include reducing vehicle ownership, pollution and energy use, while increasing liveability through safer, visually appealing pedestrian-friendly design (Center for Transit-Oriented Development, 2003).

1.2 RESEARCH AIM

This research investigates integrated transport - land use planning systems as a way of achieving the vision of the *Wellington Regional Land Transport Strategy* (RLTS) 'to deliver a balanced and sustainable land transport system that meets the needs of the regional community' (Wellington Regional Council, 1999, 33), and the aim of the *New Zealand Transport Strategy* to make more efficient use of existing resources (Ministry of Transport, 2002).

The aim of this research is to identify the optimal integrated transport - land use planning system for the Wellington region to provide a sustainable transport solution, focusing on passenger transport. To achieve this aim, the research is divided into two sections. Section One documents background investigations on integrated transport - land use planning systems. Section Two addresses a research question on integrated planning in the Wellington region by drawing on these investigations and undertaking an analysis of scenarios modelled by Greater Wellington Regional Council (GWRC).

1.3 SECTION ONE: EXISTING INTEGRATED PLANNING SYSTEMS

Chapter Two investigates the interrelationship between transport and land use, and defines integrated transport - land use planning via literature review. The different regulatory and physical planning mechanisms that can comprise integrated planning systems in developed countries with predominantly European-based cultures are canvassed and documented using examples from cities in Europe, North America and New Zealand.

Integrated planning systems in Stockholm, Sweden; Freiburg, Germany; Portland and Santa Clara County, USA; and Waitakere, Auckland are investigated to identify the range and combination of transport - land use mechanisms successfully implemented internationally to provide sustainable transport systems. This is done through a literature review, while discussions with managers at Waitakere City Council (Appendices 1, 2, 3) and site visits to higher density housing projects in Waitakere are drawn on to provide a primary research component to the background investigations. The combination of land use, transport and financial mechanisms adopted in these cities are summarised, and the similarities and differences in the approach taken by each city is discussed.

The success of integrated planning systems in providing a sustainable transport solution is investigated. Individual reviews of Freiburg, Stockholm and San Francisco Bay Area are undertaken due to the lack of consistent and comparable figures for the five cities studied. The influence of Freiburg's integrated planning system on commuter travel behaviour is tested through the identification of changes in commuter numbers using private and public transport. The influence of sub-centring on transit is examined through a review of commuting patterns in Stockholm's master-planned urban villages. Publicly available data on population and employment growth is summarised to demonstrate the impact of San Francisco's Bay Area Rapid Transit system on sub-centring over a twenty-year period. Commuter data are selected over total trip data, as the former is more readily available for the cities selected.

1.4 SECTION TWO: INTEGRATED PLANNING IN THE WELLINGTON REGION

1.4.1 Research Question

What is the optimal integrated transport - land use planning system required to provide a sustainable transport solution in the Wellington region?

The methodology adopted to answer this research question is contained in Chapter Three, while the research question is addressed in Chapter Four through:

- the comparative analysis of results of six transport and land use policy intervention scenarios, incorporating projected population and employment growth in the Wellington region to 2026
- the ranking of the six scenarios based on their ability to deliver five attributes (affordability, accessibility, mobility, economic and network efficiency and environmental sustainability) defined as desirable outcomes of the *Regional Land Transport Strategy*
- the combining of the comparative analysis and scenario ranking results to select the scenario best meeting the RLTS vision

The conclusion of this research is in Chapter Five, along with recommendations for further research associated with this report.

SECTION ONE: EXISTING INTEGRATED PLANNING SYSTEMS

CHAPTER TWO: LITERATURE REVIEW

2.1 BACKGROUND

Historically, government agencies treated transport and land use planning independently, when in fact these two factors of human development are co-dependent. Over the last 40 years many researchers (see, for example Bachels, 1999, Barnett, 1995, Beimborn, 2002, Boarnet and Crane, 2001, Bourne, 1975, Calthorpe and Fulton, 2001, Cervero, 1998, Dittmar, 1995, Hall and Pfeiffer, 2000, Haughton and Hunter, 1994, Hibbs, 2003, Kunstler, 1996, Mees, 2000, Newman and Kenworthy, 1989, Simpson, 1988) have studied the relationship between transport and land use, particularly as their combined effect on dependent variables like congestion, pollution, and energy use amplifies.

Escaping the urban problems associated with high-density city living, settlers in ‘New Urban Frontier’ cities in Australasia and North America built detached family homes on cheap land bordering these 19th century cities. Mass transport enabled breadwinners to commute to work in the city each day (Barnett, 1995, Kunstler, 1996, Westerman, 1998). The reliable public transport systems in turn supported further suburban expansion.

The increasing availability of motor vehicles in the 20th century shifted governments’ focus on infrastructure away from mass transit to roading for the masses. Town planners meet land use demands by opening up new areas for development on the suburban fringe, and transport planners apply the ‘predict and provide’ model to ‘predict traffic increases and provide new roads to accommodate the predicted increase’ (Mees, 2000, 52). The resulting automobile dependence reinforces this cyclical pattern by supporting further low-density, single-use developments that are equally dependent on roads (Beimborn, 2002, Gillham, 2002, Mees, 2000, Sierra Club, 2003). The end result is often maligned weak-centred cities with sprawling low-density development, motorways and neglected public transport systems throughout North America, Europe and Australasia (Barnett, 1995, Congress for the New Urbanism, 1996, Gillham, 2002, Gow, 2000, Simpson, 1988).

Since the 1960s there has been growing discontent amongst residents and government officials that suburban sprawl is not the utopia it was thought to be (Chen, 2000, Kunstler, 1996), with general agreement that it degrades the environment, economy and quality of life (Gillham, 2002, Kunz, 2001). Urban renewal and intensification are promoted as solutions to increased sprawl and its negative effect on travel, energy use and environmental and human health (Belzer and Autler, 2002).

2.2 INTEGRATED PLANNING

In *Sustainability and Cities. Overcoming Automobile Dependence*, Newman and Kenworthy conclude that ‘the patterns of transportation infrastructure and land use in cities around the world reveal automobile dependence to be a combination of high car use, high provision for automobiles and scattered low-density land use’ (1999, 124), and such patterns are not sustainable based on economic and environmental indicators. The United Nations Environment Programme’s (UNEP) *Agenda 21* recommends ‘the integration of land use and transportation planning to encourage development patterns that reduce transport demand’ (1992, 10).

Integration implies a concern with the whole, agreement on common outcomes, and a commitment to actions and targets to achieve these outcomes (Westerman, 1998, 3). The New Zealand Parliamentary Commissioner for the Environment sees integrated urban management as 'the process of taking a more holistic and strategic approach to managing the interrelated aspects of the urban environment' (1998, 32). The New Zealand Department of Prime Minister and Cabinet (2003) considers the development of mechanisms to ensure integration across government agencies as a key action in achieving urban sustainability. Any government body truly hoping to control sprawl must combine regional (land use) planning and transportation planning into a single activity (Duany *et al.*, 2000). Integrated transport - land use planning can ensure full stakeholder participation, private / public partnerships, cross-agency planning, multi agency / institution initiatives, and decision-making based on social, environmental and economic factors (Westerman, 1998).

Integrated planning addresses issues beyond the mere function of a city and its systems, as it recognises that cities are more than collections of houses linked by traffic routes, or functional systems whose linkages need to be optimised (Hall and Pfeiffer, 2000, 331). Kunstler (1996) and Hines (in Garreau, 1991) suggest zoning disintegrates human settlement through its rigorous segregation of activities and reliance on the motor vehicle and roads as the only acceptable connecting mechanism between these activities. Planning solutions integrating land uses and transport systems recognise the pluralistic nature of cities, and promote a move away from functionalist town planning characterised by zoning for single use (Culot, 1997, Haughton and Hunter, 1994).

Many local, regional, state and national governments around the world are trying to reduce the negative effects of low-density sprawl and automobile dependence through the employment of smart growth and sustainable transport solutions like transit-oriented development (TOD) and the new urbanism. An aim of these integrated planning systems is to get people out of cars and on to their feet, bicycles, &/or public transport through a combination of more intensive development, improved transit systems and better utilisation of existing resources. The following planning solutions are founded on integration to create desirable, affordable, functioning settlement systems that address sprawl and its externalities.

2.2.1 Sustainable Transport

Sustainable transport is concerned with transport - land use interrelationships, because transportation systems shape land markets and development opportunities, and land use patterns are a key factor in determining what kinds of transportation choices people can and will make (Deakin, 1998, Newman and Kenworthy, 1999). The OECD's Working Group on Transport (2000, 15-16) considers policy guidelines for a sustainable transport strategy should address growth through better demand-side management policies, see a shift towards more environmentally sound and energy efficient transport and communication modes, and enhance access to other people, goods and services while reducing the need for physical movements. Brindle (1998) suggests sustainable transport is not a series of problems to be fixed; rather it should be viewed as part of a desired future vision requiring a combination of integrated policy actions including:

- **technological**, such as direction to industry to produce more fuel-efficient vehicles and develop alternative fuels
- **pricing**, including congestion and parking charges, emissions fees and removal of all subsidies to cars

- **urban systems** incorporating stronger regional and city planning systems encouraging growth management programmes, higher density, compact, mixed-use, accessible cities, infill development, transit-oriented development, traffic calming and road space allocation to walking, cycling and public transport
- **demand management** to influence the pattern of demand for transportation through encouraging voluntary changes in activities and lifestyles, rather than adding to the transport network to accommodate demand (Auckland Regional Council, 2003, Brindle, 1998, Deakin, 1998, Hall and Pfeiffer, 2000)

Sustainable transportation focuses on environmental, social and economic issues while ensuring mobility and accessibility for all people. The Environmental Sustainable Transport (EST) guidelines adopted, in 2001, by the OECD's environment ministers aims to ensure a high level of mobility with a minimal environmental impact. The primary goal of the EST is the reduction of emissions, noise, pollution, ozone depletion and car ownership while increasing mobility by over 20 percent on 1990 levels, through a combination of technological improvements and travel demand management (Herala, 2003, Wiederkehr and Caid, 2002).

Household composition, times of travel, land use configurations and trip patterns are now extremely diverse (Boulter, 2003). Thus, people travel to participate in spatially disjointed activities, and therefore require a variety of transport solutions to meet their diverse needs (Bertolini and le Clercq, 2003). Put simply; most people want to avoid travelling in order to spend more time at their destinations, and therefore transport should be a servant, not our master (Dittmar, 1995, Cervero, 1998).

In meeting all these requirements, sustainable transport can be defined as:

> *Sustainability promoted in a way that meets the mobility needs of society while taking into account the economic viability, the social balance and the environmental soundness. (COM, 2000)*

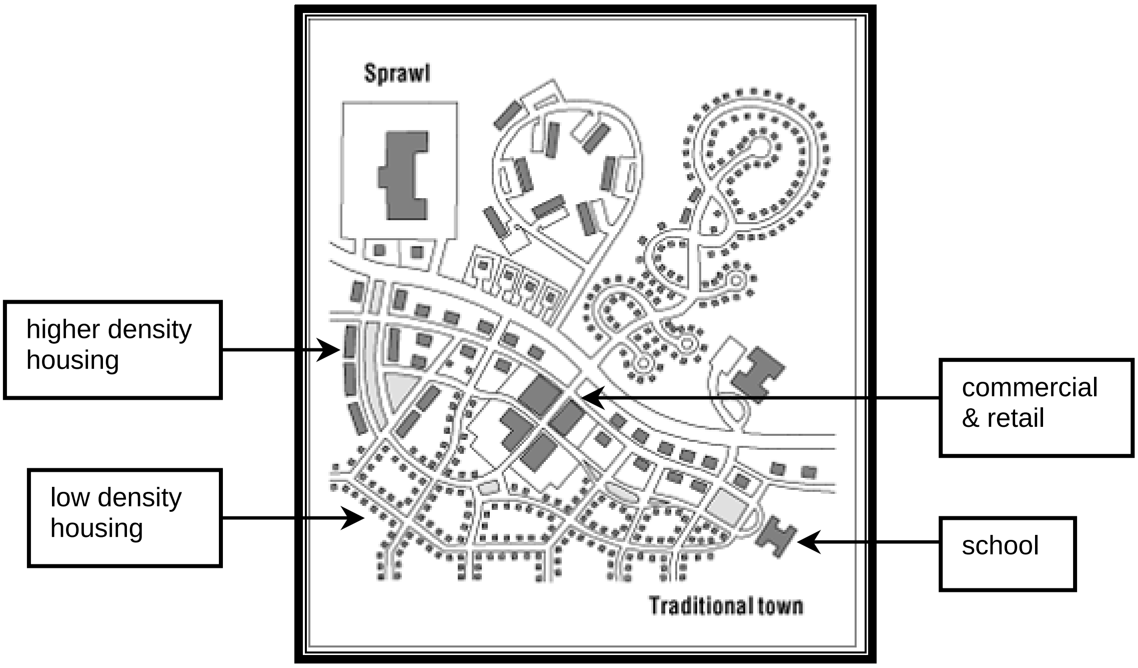
2.2.2 Smart Growth

The United States federal Environmental Protection Agency (EPA) coined the term ‘smart growth’ to encompass a number of programmes, including the new urbanism and transit-oriented development, implemented across the United States (US) to counter the effects of sprawl and automobile dependence. Objectives focus on the long-term economic, environmental and social health of existing communities by:

- focusing new housing and commercial development within already developed areas, and preserving historic and cultural landmarks
- providing greater accessibility and mobility choices
- stabilising and improving the long-term financial performance for commercial developments and home owners
- maximising the return from public investments in existing and new infrastructure
- sharing the benefits of growth through allowing all residents to participate in their regional economy
- protecting natural habitat and watersheds
- creating safe, livable, walkable neighbourhoods that foster a greater sense of connection, responsibility and continuity (Fleissig *et al.*, 2002, Smart Growth America)

Benefits espoused by advocates of smart growth include reduced crime due to more ‘chaotic’ activity patterns in vibrant central cities and small towns. While mixed land use with compact building design mean the coordination of job and housing growth can reverse the trend toward longer commutes, as people live within easy walking distance of shops, offices, schools, parks and public transit (Association of Bay Area Governments, 2001). This in turn reduces congestion, pollution and the negative health effects of a sedentary lifestyle (Chen, 2000). Figure 2.1 illustrates the difference between single-use zoned, automobile-dependent sprawl and traditional town planning now practiced in smart growth programmes like the new urbanism.

Figure 2.1: Sprawl versus Traditional Town Planning
source: (Duany et al. in Steuteville, 2000)



There is no single definition of smart growth: The common thread among different perspectives is development that revitalises central cities and older suburbs, supports and enhances public transit and preserves open spaces and agricultural lands. Smart growth is not no growth; rather it creates communities that are more livable by developing efficiently within the already built environment (Association of Bay Area Governments, 2001).

Both planning solutions have their own, particular, primary focus: Smart Growth is concerned with using what we have in a better way in order to improve the natural and built environments for all. Sustainable transport is focused on improving mobility and accessibility with minimal environmental, economic and social impacts. However, the underlying theme of these, and any other urban sustainability solution, is the integration of land use and transport planning.

2.3 MECHANISMS COMPRISING INTEGRATED PLANNING SYSTEMS

2.3.1 A Regional Approach

Haughton and Hunter (1994) suggest that cities with dominant centres can create a reliance on mass flows of people, energy, materials, and information, causing a build up of complex infrastructures that become unable to cope with the pressure exerted on them. This pressure can be alleviated through the adoption of regional planning incorporating:

- mixed-use **centres** at a neighbourhood, village, town and urban scale
- **districts** of special-use areas not appropriate for a mixed-use environment
- **preserves** of open space
- **corridors** to connect the region’s centres and districts (Calthorpe and Fulton, 2001)

Calthorpe and Fulton (2001) are of the view a regional approach is successful when the range of policies embodied in it operate on a metropolitan and region -wide scale. Projects integrating transit and land use goals may contain conflicts owing to a mismatch in the distribution of the costs and benefits between local and regional project stakeholders. For example, empirical studies to date provide insufficient evidence that transit-oriented development on a regional scale, even when supported by large transit investments, is likely to produce significant regional benefits. The region often pays for the expensive transit system, gaining increased ridership, reduced congestion and air pollution. However, private developers incur and recover the costs of commercial and retail developments, with the advantages accruing disproportionately to the local governments containing the developments (Boarnet and Crane, 1997, Niles and Nelson, 1999).

Integrated planning systems require the participation of many parties including transit agencies, local and regional government, developers, lenders and the community, none of who is solely responsible for a project and its outcomes. Stakeholders often operate at cross-purposes to one another as they focus on a project at either a regional or local level and from their own particular perspective. With many stakeholders involved there is often no, one, leader for a project, resulting in a lack of vision and leadership (Belzer and Autler, 2002, Center for Transit-Oriented Development, 2003). This suggests that regional and local bodies need to work together in order to exploit and share the full benefits of a regional transit system, and local bodies need to integrate their planning rather than fight each other with fiscal zoning (Langdon, 1994).

The San Francisco Bay area, incorporating nine counties, provides an example of the difficulties involved in establishing a comprehensive approach to integrated planning. The

Bay Area has had various forms of regional planning since the 1950s led by sub-regional governments and active citizens groups. Successful initiatives include large open space systems, the Bay Area Rapid Transit (BART) rail system, and rezoning of industrial areas to free up land for housing. However, planning efforts have been somewhat decentralised and incremental, largely due to disagreements on what form a regional government should take and because the state government has failed to provide a strong growth management framework (Calthorpe and Fulton, 2001).

New Zealand isn't divided into states; however its government structure encompassing national, regional and local government agencies and legislation led the Auckland region to adopt a regional strategy to deal with projected growth and associated externalities to 2050. The *Auckland Regional Growth Strategy: 2050* (ARGS) states transport and land use goals for the seven territorial authorities and one regional authority comprising the region; each of whom have a representative on the Regional Growth Forum responsible for managing the ARGS. The growth strategy incorporates compact, mixed use development around town centres and transport routes, identification of specific areas for future greenfield urban areas, protection of highly valued and sensitive natural areas and catchments and transport systems that will service and facilitate growth patterns (Auckland Regional Council, 1999). The territorial authorities annual and long term plans, and the *Regional Land Transport Strategy* are aligned with the ARGS (Auckland Regional Council, 2003) to ensure consistency in transport - land use planning throughout the region.

2.3.2 Growth Management Strategies

Between 1950 and 1990 the population in all urban areas in the United States of America grew by 92.3 percent, while land area usage increased by 245.2 percent (Kahn, 2000). A number of cities have introduced urban growth boundaries (UGB) or green belts to contain urban growth, and protect natural habitats and water catchments. For example; since the 1970s the Portland region has implemented a number of regional initiatives, including an urban growth boundary to protect agricultural land from development (Calthorpe and Fulton, 2001).

To be successful, a growth management framework should be defined and administered at a regional level to ensure cooperation between local authorities, thereby preventing local growth management initiatives from diverting impacts to neighbouring areas (Gillham, 2002, Newman and Kenworthy, 1999). These initiatives should be planned as long-term or permanent designations, with green belts being valued for their intrinsic nature as well as their planning role (Newman and Kenworthy, 1999).

An UGB or green belt won't, by itself, contain a city's growth, or guarantee quality growth or a better transport system, it must be complemented by other integrated planning policies (Calthorpe and Fulton, 2001, Newman and Kenworthy, 1999), such as the concentrating of urban expansion into growth corridors and sub-centres to realise infrastructure efficiencies and opportunities for reduced travel (Westerman, 1998). In addition to it's tight UGB, Portland's *Region 2040 Growth Management Strategy* focuses growth in transit centres and corridors, and requires local governments' zoning and comprehensive plan changes to be consistent with the strategy (Business Transportation and Housing Agency and California Department of Transportation, 2002b, 34).

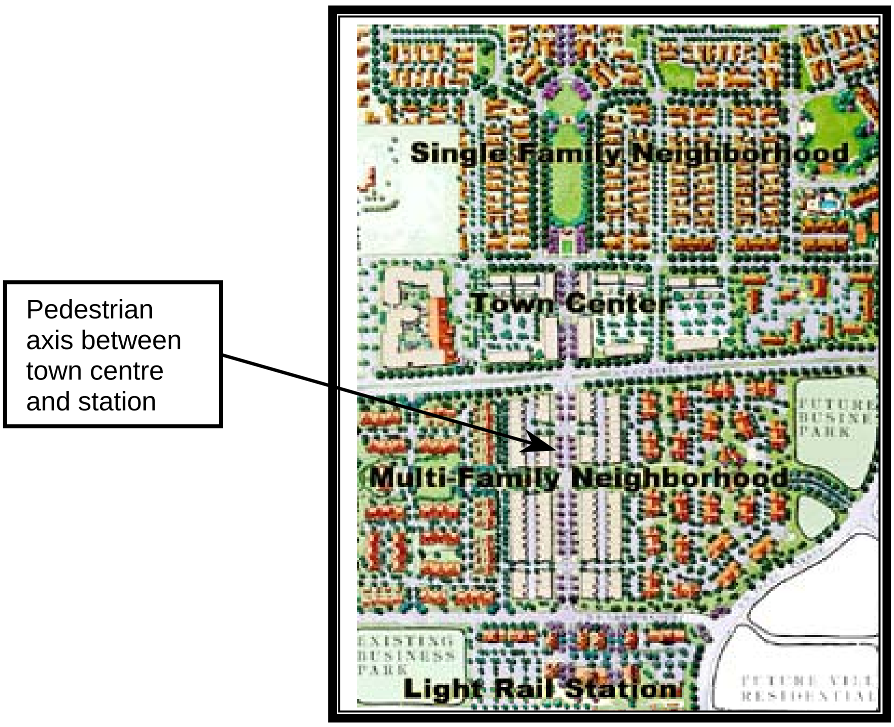
2.3.3 Zoning

The term zoning usually invokes a negative reaction as it is commonly linked to single-use developments that separate out housing areas from work and retail zones, thereby increasing reliance on private transport. While zoning was originally conceived to separate unpleasant land uses from residential areas (Santa Clara Valley Transportation Authority Congestion Management Program, 2003), as a requirement set down by government planning agencies single-use zoning is costly and time-consuming to contest, making it the path of least resistance for developers (Chen, 2000).

Zoning in this traditional sense, sometimes referred to as 'exclusionary zoning' (Calthorpe and Fulton, 2001), is now being replaced by zoning to meet a precise planning goal. However, once established, zoning is not easily changed, especially if the intent is to increase density, convert commercial strips to more compact nodes and create a greater mix of uses (Niles and Nelson, 1999). Westerman (1998) suggests that zoning should not just be based on land use, but also on the desired type of accessibility for the development / area, i.e.; people generating activities like office blocks and residences, and vehicle-oriented activities like warehouses and factories. Authorities can use incentives and disincentives to meet the accessibility zone criteria, for example provision of high quality public transport and parking policies to discourage car use.

The City of San Jose, California introduced a Transit Corridor Residential land use zone to encourage high density residences within 2,000 feet of rail stations (Santa Clara Valley Transportation Authority, 2001). The purpose of such zones is to support the light rail system through allowing higher densities, mixed-uses, and the creation of a safe pedestrian environment (Santa Clara Valley Transportation Authority Congestion Management Program, 2003). A key strategy of the Portland, Oregon regional approach is the rezoning of land adjacent to light rail stations to create new mixed-use, transit-oriented development. Such zoning permits developments incorporating housing, office and retail in a variety of building combinations (Calthorpe and Fulton, 2001). One example is Orenco Station (Figure 2.2), a 190-acre TOD with 1834 homes, where the station areas are designated as mixed-use town centres (Business Transportation and Housing Agency and California Department of Transportation, 2002b, Mehaffy, 2003).

Figure 2.2: Layout of Orenco Station, Portland
source: (Mehaffy, 2003)



Residential redevelopments in urban areas can result in gentrification and a concentrating of poverty. The state of New Jersey enforces 'inclusionary' zoning policies, specifying that affordable housing goals must be set and met within each housing development project. A state agency approves local plans and oversees implementation of these policies (Calthorpe and Fulton, 2001).

2.3.4 Increased Density

Urban consolidation, or increasing population densities, is promoted as a way of saving on physical and social infrastructure costs, reducing demand for land on the city fringe, travel distances and energy use, and increasing the use of public transport. Policies include brownfield and greyfield infill, mixed-use zoning, subdivision of existing residential plots, reducing minimum residential plot sizes and rezoning to permit medium density housing in low density areas (Haughton and Hunter, 1994). A number of studies draw a correlation between urban density and sustainable transportation (Bachels, 1999, Brindle, 1994, Cervero, 1998, Kahn, 2000, Newman and Kenworthy, 1989, 1999), citing a required urban density of 30 people per hectare to make public transport sustainable (Bernick and Cervero, 1997, Duany *et al.*, 2000).

There is little disagreement that higher densities near major public transport routes create greater choice in transport mode than lower densities remote from major transit routes (Westerman, 1998, 46). However, Brindle (1996) argues that density isn't a mandatory prerequisite for an increase in transit use, rather proximity to public transport nodes has a greater impact. He suggests this can be achieved through manipulating urban structure to change travel patterns, for example reducing the spacing between transit stops within low density suburbs designed to traditional town planning principles.

Irrespective of the urban structure argument; density increases are best achieved when focused in mixed-use nodes or sub-centres along public transport corridors that link these nodes to the rest of the city (Newman and Kenworthy, 1999, Santa Clara Valley Transportation Authority Congestion Management Program, 2003). The Santa Clara VTA (2003) warns that while increased density is sensible wherever transit investments are made, an appropriate density level for a large city will not be suitable in an urban village. To this end it has developed density guidelines to assist local jurisdictions in their development initiatives. The Congress for the New Urbanism (1996) suggests that when appropriate building densities and land uses are within walking distance of transit stops, public transit becomes a viable alternative to the automobile. Furthermore, the centring of higher density, mixed-use development around transit nodes can foster a rich mixture of activities, like in a traditional city centre (Haughton and Hunter, 1994).

Residents of neighbourhoods where transit-oriented development has been proposed tend to resist increased density and its impacts, whether real or perceived, especially if they believe there will be impacts such as increased vehicle traffic (Niles and Nelson, 1999). A recent state-wide study on TOD in California noted the higher densities associated with TOD can result in additional traffic on neighbouring streets in spite of a higher rate (compared to non-TODs) of transit use by residents and employees of these developments (Business Transportation and Housing Agency and California Department of Transportation, 2002a, Taylor, 2004).

2.3.5 Financial Mechanisms

Subsidies can be used to encourage more desirable forms of growth, rather than undertaking complex and lengthy district or regional plan changes to overcome zoning and planning requirements. Private development can be induced through density bonuses, tax abatement, tax increment financing and direct grants (Niles and Nelson, 1999). The city of San Diego provides density bonuses for developments that include child-care facilities near transit stations (Bernick and Cervero, 1997) thereby reducing the complexity and number of trips made each day by working parents.

Austin, Texas operates a *Smart Growth Criteria Matrix*, awarding points to developments meeting criteria including proximity to transit, pedestrian-friendly design, redevelopment of abandoned buildings and improvements in depressed and older neighbourhoods. Projects accruing enough points receive benefits like fast-tracking of permits, waiving of development fees and council purchase of green space within the developments (Chen, 2000).

The San Francisco Bay Area Metropolitan Transportation Commission administers the Transportation for Liveable Communities programme. Established in the mid 1990s to encourage community-based land use and transportation decisions, this programme awards grants for planning and capital projects including those that improve connections to regional transportation, for technical assistance from selected planning firms, and according to a project's quality and inclusiveness of public involvement, overall impact, connection of transportation to land use and promotion of internal community mobility (Association of Bay Area Governments, 2001).

In the Minnesota-St Paul region in the United States, seven counties and around 190 municipalities redistribute 40 percent of the growth in commercial and industrial property tax base amongst each other every year. This revenue sharing increases the likelihood that development will occur where it will most benefit all people in the region, guarantees a degree of fairness for the poorer communities, and counters economic competition and politics between local governments within a region (Langdon, 1994).

The Location-Efficient Mortgage (LEM) is a tool used to counter the gentrification occurring as poor urban residents are pushed out by higher income earners returning to live in the city. Banks offer the LEM to homebuyers who choose to live in compact neighbourhoods close to public transport. Because these households can do without a second car they are able to apply the annual savings associated with car ownership to finance mortgages larger than they would ordinarily qualify for (Chen, 2000).

2.3.6 Public / Private Partnerships

Local governments can use the provision of public amenities like parks and recreation facilities and government services to leverage denser and more diverse development. Initiating joint development schemes stimulates developer interest, however, such actions are subject to the financial limitations of local government budgets; having to compete with other demands on the public purse (Niles and Nelson, 1999).

To increase transit use, generate revenue, and enhance station environments, the Santa Clara Valley Transportation Authority (VTA) runs joint development projects including locating a childcare centre, village housing and a mixed-use project on council land, allowing easy access to transit for residents and employees (Santa Clara Valley Transportation Authority, 2001).

Walnut Creek, San Francisco, provides comprehensive support of the downtown area and adjacent Bay Area Rapid Transit (BART) station area that results in economic vitality and generates successful developments: A free city-funded shuttle bus transports people in and around the downtown area and BART station, which are zoned high density mixed-use to promote the use of BART. Incentives encourage development of affordable housing. A public / private taskforce prepares specific plans for the downtown area (including an environmental review), so that when a developer proposes a project consistent with it, only the design review remains, greatly streamlining the development review process (Association of Bay Area Governments, 2001).

Waitakere City Council's property development company works with private developers to create more sustainable urban environments on council-owned land (Waitakere City Council Manager, 2003). Ambrico Place (Figures 2.3 & 2.4) in the urban village of New Lynn is one such example where a number of small property developers built a medium density town house complex on the (council-owned) site of an old brick works (Figure 2.5) in a mixed use zone (Kenkel, 2003).

Figures 2.3 & 2.4: Ambrico Place, New Lynn *source: (Chapman, 2003)*

Figure 2.5: Ambrico Place Kiln *source: (Chapman, 2003)*

2.3.7 Transport Mechanisms

The provision of accessible, reliable and fast public transport systems, and allocation of space to non-motorised forms of transport, has already been recognised as integral to any successful integrated planning initiative. In addition, there are a number of travel demand management (TDM) techniques that can be incorporated to ensure an initiative's success. Table 2.1 classifies various TDM techniques within the strategies of improved asset utilisation, physical restraint, and pricing and urban and social changes.

Luk *et al*., (1998) observe that it's advisable to implement TDM techniques in a package with other transport - land use mechanisms such as public transport improvements. This is shown in many cities: The VTA in Santa Clara, California issues an ECO Pass entitling residents in transit-oriented developments to commute free on VTA services (Santa Clara Valley Transportation Authority Congestion Management Agency, 2003). When congestion pricing was introduced in central London in 2002 so too were several hundred additional buses and a 33 percent reduction in the price of bus travel across the entire city (Transport for London, 2003). Singapore has combined compact, mixed urban form and high capacity transit services with vehicle quotas and electronic road pricing in congested zones (Cervero, 1998).

Table 2.1: TDM Measures *source: (AUSTROADS, 1991 in Luk et al., 1998, 72)*

Strategy	Method	Technique
Improved asset utilisation	Peak spreading	Staggered hours Flexible hours Working week changes Fare or toll differentials Parking cost differentials Parking availability differentials
	Vehicle occupancy	Ride-sharing Van pools Transit lanes Parking priority Park and ride schemes
Physical restraint	Area limitation	Traffic cells Traffic mazes Area licences / permits Cordon collars
	Link limitations	Access metering Signal timing Reduced capacity Public transport priority
	Parking limitations	Parking space limits Parking access controls
Pricing	Road pricing	Tolls Area entry fees / licenses Congestion pricing / electronic road pricing
	Parking prices	Short term priority policies Higher entry costs
	Taxes	Higher fuel taxes Parking taxes Higher ownership taxes
Urban and social changes	Urban form	More compact cities Efficient urban development
	Social attitude	Community information and awareness Community education
	Technical change	Communication substitutions Transport development

2.4 ESTABLISHED INTEGRATED PLANNING SYSTEMS

Integrated planning systems established in the cities of Stockholm, Sweden; Freiburg, Germany; Portland, Oregon; Waitakere, Auckland; and Santa Clara County, California (also known as Silicon Valley) are selected to identify the similarities and differences in integrated planning approaches used across a range of developed countries and population sizes.

Stockholm started on a comprehensive planning campaign after World War II that channelled growth into master-planned rail-served suburbs surrounded by green spaces. The resulting settlement system is a polycentric metropolis of semi self-contained towns surrounding a strong central core city (Cervero, 1998). Like Stockholm, Freiburg's current settlement system has evolved since World War II; however this is due to the city being raised during the war. The rebuilding process is based on a traditional city model with higher density, pedestrian-friendly streets supported by public transport. Further development around Freiburg continues to use this model (Newman and Kenworthy, 1999).

In contrast, Portland, Santa Clara county and Waitakere City's settlement systems favour the automobile over alternate transport forms. Each city is in varying stages of changing to a more traditional and sustainable settlement structure: Portland started in the 1970's, while Santa Clara and Waitakere adopted sustainable development approaches in the last decade (Calthorpe and Fulton, 2001, Waitakere City Council, 2003).

Sustainable development is the common vision for all these 'cities', with a desire to reduce the human impact on the environment and improve personal amenity through increased mobility and accessibility. All but Santa Clara openly display a strong affinity with and valuing of their natural landscapes, and recognise the importance of protecting areas of significance (Cervero, 1998, Kenkel, 2003, Ryan and Throgmorton, 2003).

The common tool for implementation is a regional approach incorporating varying degrees of government intervention. The two US cities reviewed use government intervention in land use planning to create a production-driven change: Development subsidies, project grants or public/private partnerships encourage developers to produce high density and mixed-use developments in the hope people will buy into them (physically and psychologically). While transit is actively promoted, no financial mechanisms are employed as disincentives to private vehicle use, perhaps because the dominance of the car is accepted in America; even in Portland where light rail was built instead of the Mt Hood expressway (Calthorpe and Fulton, 2001, Cervero, 1998).

The European cities, perhaps because of their age and existing ethos of compact mixed-use development, actively discourage car use especially in the Central Business Districts. These cities use government intervention in transport planning to create market-driven change in land use and transportation, in that residents and businesses actively seek alternatives to low density sprawl and automobile dependence as they're too expensive and inconvenient. The high vehicle ownership taxes and fuel taxes in the European Union (Ryan and Throgmorton, 2003, Newman and Kenworthy, 1999) aid Stockholm and Freiburg in their sustainability goals.

Waitakere city is in the early stages of integrated planning: While it has had an Eco City philosophy since 1993 and has progressed a number of measures locally, the *Auckland Regional Growth Strategy,* released in 1999, sets out a number of transport and land use goals which are inter-city and rely on inter-agency commitment, and these have modified or slowed progress on some of Waitakere's original objectives (Waitakere City Council Manager, 2003). While Waitakere City Council supports financial mechanisms such as congestion pricing to discourage car use, it is unable to introduce such tools as they are legislated at a national level. Furthermore, Auckland region's public transport system is in a state of crisis, so the adoption of any mechanisms to encourage mode shift from private vehicle to public transport would exacerbate the problem and irritate the public (Waitakere City Council Manager, 2003).

Belzer and Autler (2002, 53) suggest that 'as a model of development in which efficient land use and transportation work together, transit-oriented development can help lay the groundwork for larger regional efforts'. All the cities reviewed have established mixed-use, higher density infill and greenfield developments along transport corridors, particularly around transit nodes, i.e. transit-oriented development. All but Waitakere (because of the region's public transport crisis) operate comprehensive transit networks consisting of key transport corridors with feeder transit services radiating out from transit nodes, providing the public with road, rail and safe non-motorised transport choices (Auckland Regional Council, 1999, Cervero, 1998, Newman and Kenworthy, 1999, Ryan and Throgmorton, 2003, Santa Clara Valley Transportation Authority Congestion Management Program, 2003, Waitakere City Council, 2003).

The integrated planning mechanisms utilised by Stockholm, Freiburg, Santa Clara County, Portland and Waitakere are summarised in Table 2.2. Personal communications with managers at Waitakere City Council enabled the identification of mechanisms proposed for implementation. This was not possible for the other cities tabled as the data sources were published works.

Table 2.2: Cities with Integrated Planning Systems *source: (Cervero, 1998, Newman and Kenworthy, 1999, Ryan and Throgmorton, 2003, Santa Clara Valley Transportation Authority Congestion Management Program, 2003, Waitakere City Council Manager, 2003)*

City & Population / Mechanism	Stockholm 720,000	Freiburg 200,000	Santa Clara county 1,700,000	Portland 1,000,000	Waitakere 169,000
Regional Planning	✓	✓	✓	✓	✓
Land Use					
mixed use zoning	✓	✓	✓	✓	P
higher density	✓	✓	✓	✓	✓
TOD	✓	✓	✓	✓	✓
urban villages	✓	✓	✓		✓
corridor development	✓	✓	✓	✓	✓
sub-centring	✓		✓	✓	regional
infill development	✓	✓	✓	✓	✓
greenfield development	✓	✓	✓	✓	P
urban growth boundary	✓	✓		✓	✓
green belt	✓	✓		✓	P
affordable housing	✓	✓	✓		
public/private partnerships	✓	?	✓	✓	✓
Transport					
transit network *	✓	✓	✓	✓	P
transit priority	✓	✓	✓	✓	P
high occupancy vehicle lanes			✓		P
ride-sharing			✓		
cycle lanes	✓	✓	✓		P
pedestrian zones	✓	✓	✓	✓	P
reduced roading	✓	✓		✓	
reduced parking	✓	✓	✓	✓	
traffic calming	✓	✓	✓	✓	✓
vehicle slow zones	✓	✓	✓	✓	✓
Financial					
higher vehicle ownership tax	✓	✓			
higher parking fees	✓	✓			✓
higher fuel taxes	✓	✓			
congestion pricing					
toll roads	✓				
transit pass discount	✓	✓	✓	✓	
sales tax			✓		
density bonuses					
development subsidies				✓	
tax abatement/incentives	✓			✓	
project grants			✓		

* Transit network may be rail, light rail, bus, or combinations of all. P = proposed.

2.5 MEASURING THE SUCCESS OF INTEGRATED PLANNING SYSTEMS

The influence of integrated planning in the cities previously examined is determined by analysing changes in the transportation and land use patterns within them. Comprehensive, individual, studies on Freiburg, Stockholm and San Francisco are summarised, as a comparison of trends in travel and land use changes is not possible due to a lack of consistent and comparable figures for the five cities. This is due to differences in spatial reference of the data (metropolitan, inner city, outer city), temporal reference (work days, all days) and functional reference (work trips, all trips) (Bratzel, 1999).

2.5.1 Integrated Planning's Influence on Mode Share

The success of the multi-faceted approach to reducing car use in Freiburg, Germany is seen in changes in mode share over a 20-year period (refer Table 2.3). The limiting of motorways into urban areas and restriction of vehicle use in central areas, combined with increased vehicle operating costs and provision of inexpensive, convenient alternatives (Ryan and Throgmorton, 2003) resulted in the decline of the share of total trips by car from 60 percent in 1976 to 43 percent in 1996. Total bicycle trips absorbed the majority of this decline; growing by 11 percent, while public transport's share of total trips rose from 22 percent to 28 percent over the same period.

These changes in mode share are most interesting when viewed along side the change in the total daily trips made: Between 1976 and 1991 there was an increase of 30.4 percent across all modes, with the total daily car trips only increasing by 1.3 percent. Transit use increased by 48.2 percent, while the total daily trips made by bicycle grew from 69,300 in 1976 to 135,540 in 1991 – a 95.6 percent increase. Along with the transport mechanisms previously mentioned, the council's provision of a cheap transport pass, prioritised cycleways and the rebuilding of Freiburg in a compact form with mixed use zones resulted in the growth in transit use and cycling and the decline in mode share of the car (Bratzel, 1999, Newman and Kenworthy, 1999).

Table 2.3: Modal Shares in Freiburg *source: (Bratzel, 1999, Newman and Kenworthy, 1999, Ryan and Throgmorton, 2003)*

Year	Car			Transit			Bicycle			All Modes	
	total daily trips	% increase	% of total trips	total daily trips	% increase	% of total trips	total daily trips	% increase	% of total trips	total daily trips	% increase
1976	231,000		60%	84,700		22%	69,300		18%	385,000	
1991	234,000	1.3%	47%	125,500	48.2%	25%	135,540	95.6%	27%	502,000	30.4%
1996			43%			28%			29%		

All % figures and total daily trips for car & all modes sourced, all other figures calculated from these.

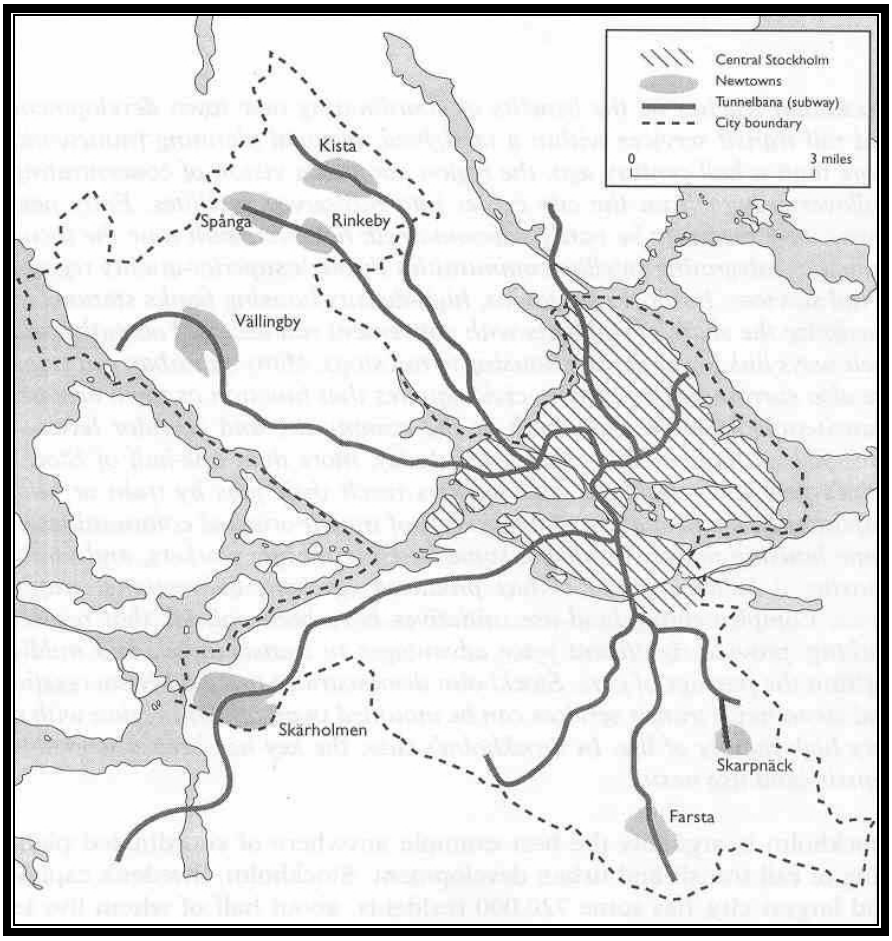
2.5.2 Sub-centring's Influence on Mode Share

Sub-centres are self-contained urban villages built around transit nodes &/or positioned along transport corridors. These centres generate a back flow in transit trips as residents of the core city travel out to sub-centres for work and recreation, thereby increasing the return on the transit investment. Cervero (1998) suggests that sub-centres are an essential base on which to mount and sustain integrated regional transit networks. Stockholm (Figure 2.6), with its master-planned urban environment and public rail transport, is a suitable model on which to determine if development in sub-centres along transit corridors results in a sustainable transport solution.

Designed as satellite communities surrounding central Stockholm, the first generation 'new towns' of Vällingby, Farsta and Skärholmen were to be 'half-contained' with half the working inhabitants commuting out, and half the workforce commuting in to each of these towns from elsewhere, thereby achieving a job-housing balance. Stockholm's later new towns of Spånga, Kista and Skarpnäck were not designed to be half-contained individual communities; rather a balance across all communities interconnected by efficient rail services was sought. This was due to a switch in focus by Stockholm's planners from the intra-community travel associated with the jobs-housing balance in the original new towns to balanced inter-community transit flows (Cervero, 1998).

Figure 2.6: Stockholm's Major New Towns & Transit System

source: (Cervero, 1998)

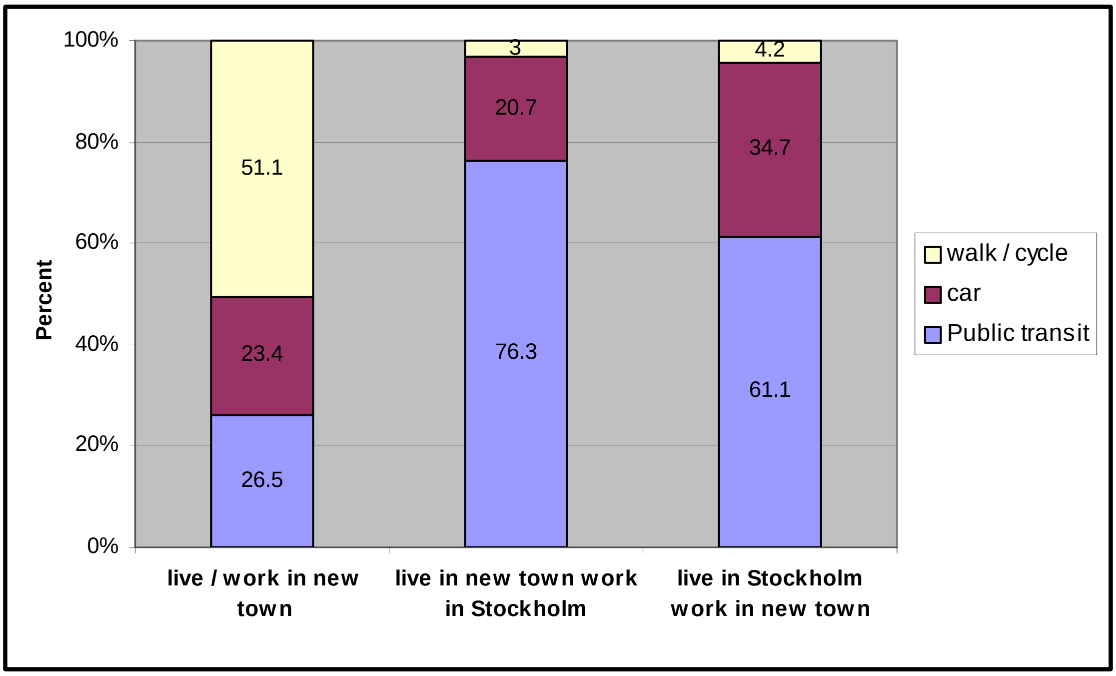


All new towns comprise a hierarchy of centres, with the commercial and civic buildings near the rail station, and residential areas surrounding them. A range of housing options in tapering density, from high-rise apartments closest to the rail stations through to single-family dwellings further away from the centre, ensures most residents are able to walk to the station and undertake household chores enroute (Cervero, 1998).

While a level of self-containment was sought within and between the new towns, the reality is they rely heavily on the rest of the region for labour and employment. An overall land-use pattern within the region of balanced flows of travel (on transit systems) among the sub-centres and the central core resulted in considerable inter-town commuting, with peak-time directional splits on some rail lines reaching 45.55 percent (Cervero, 1998). Figure 2.7 illustrates the mode split for workers undertaking this cross-regional travel. The multi-directional flow of commuters on public transport is seen in the 76.3 percent of 'new town' residents commuting into Stockholm CBD and the 61.1 percent of Stockholm residents commuting out to new towns. The success of mixed-use planning in new towns is confirmed by the 51.1 percent of residents who walk or cycle to work.

Figure 2.7: Modal Splits for Different Spatial Patterns of Commuting

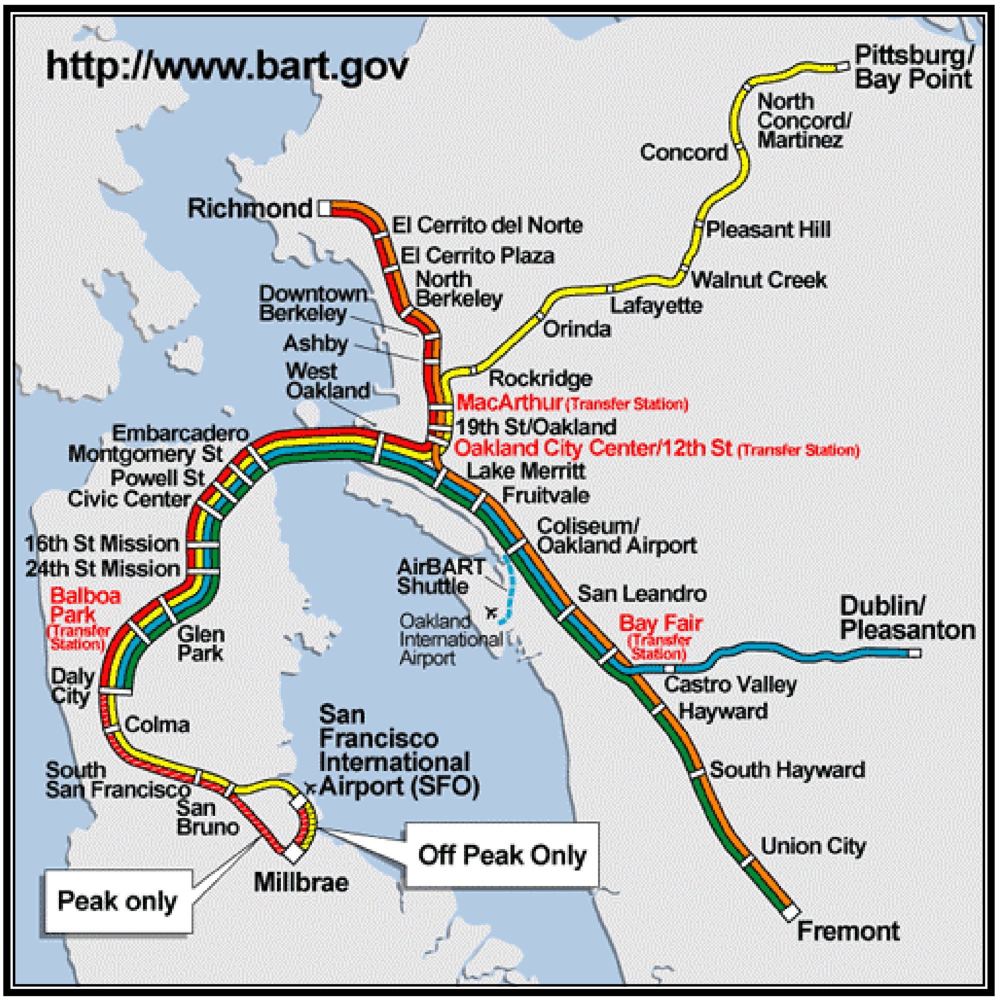
source: (Cervero, 1998)



2.5.3 Transit's Influence on Sub-centring

The Bay Area Rapid Transit (BART) rail system (Figure 2.8) in San Francisco provides a contrasting study on the relationship between sub-centring and transit use. While a regional authority master-planned Stockholm's transport and land use development, in the San Francisco Bay Area (the Bay Area) development has, by and large, occurred in an unrelated manner. There are now over 30 public transport agencies providing bus, ferry, shuttle, light and heavy rail services to over 100 local authorities within the San Francisco region.

Figure 2.8: San Francisco Bay Area Rapid Transit System
source: (San Francisco Bay Area Rapid Transit District, 2004)



Since 1980 employment decentralisation in the Bay Area occurred via natural evolution whereby firms located where workers reside (co-location hypothesis) (Cervero and Wu, 1998). During this time land use development was controlled by local government agencies that have determined, autonomously, if and how they will encourage development around BART. BART (Figure 2.9) was constructed between 1963 and 1974 with an expectation that it would guide suburban growth, in sub-centres, along the rail corridor whilst preserving the central business core of San Francisco (Cervero and Landis, 1997): Thus, San Francisco adopted a free-market approach to integrated regional planning.

Figure 2.9: San Francisco Bay Area Rapid Transit Service

source: (Loader, 2003)

The *BART @ 20* study undertaken by Cervero and Landis (1997) assesses the impact of BART on land use and urban form in its first 20 years of operation. Table 2.4 summarises findings for population and employment growth across 25 'superdistricts', including the nine served by BART, within the three counties of San Francisco, Alameda and Contra Costa. Superdistricts are census tracts that have been aggregated, by the Metropolitan Transport

Commission, to examine travel patterns at a sub regional level (Purvis, 1994 in Cervero and Landis, 1997).

Table 2.4: 1970-1990 Population & Employment Growth in BART-served & Non-BART Superdistricts, by County *source: (Cervero and Landis, 1997)*

County	Population				Employment			
	1970	1990	Total Change	% Change	1970	1990	Total Change	% Change
San Francisco								
BART served district	387,180	402,538	15,358	4.0%	357,761	442,370	84,609	23.6%
Non BART served	325,729	321,421	-4,308	-1.3%	94,436	113,037	18,601	19.7%
Alameda								
BART served district	990,497	1,143,347	152,850	15.4%	393,755	532,872	139,117	35.3%
Non BART served	77,637	135,835	58,198	75.0%	19,908	71,817	51,909	260.7%
Contra Costa								
BART served district	410,288	547,470	137,182	33.4%	120,406	236,174	115,768	96.1%
Non BART served	146,301	256,259	109,958	75.2%	27,817	77,390	49,573	178.2%
Total								
BART served district	1,787,965	2,093,355	305,390	17.1%	871,922	1,211,416	339,494	38.9%
Non BART served	549,667	713,515	163,848	29.8%	142,161	262,244	120,083	84.5%

San Francisco was the only county to experience higher population and employment growth in BART-served superdistricts than in those without BART services. In this respect BART met its creators' expectation that it would enable San Francisco to maintain its primacy as an employment centre (Cervero and Landis, 1997). Population growth in freeway-served (i.e.; non-BART) superdistricts in Alameda and Contra Costa counties increased 75 percent, but while this outstripped (percentage change) growth in BART-served superdistricts the latter experienced a greater total population increase of over 140,000 across all three counties. The non-BART superdistricts in Alameda and Contra Costa experienced massive relative employment growth over the 20 years studied as businesses decentralised, seeking out greenfield sites near freeway interchanges (Cervero and Landis, 1997).

Overall, BART's influence on land use development was minor in the free market environment existing between 1970 and 1990: BART's presence in San Francisco county may have helped slow employment decentralisation, while employment and population growth around BART stations in Alameda and Contra Costa was mainly due to aggressive development strategies adopted by local government agencies and private developers seeking to leverage benefits from the rail system (Cervero and Landis, 1997). In this respect BART has had some influence in the development of sub-centres; however it is questionable as to whether such land use development would have occurred without the policies encouraging it. Cervero and Landis (1997) conclude that in the absence of any regional forum to manage and guide growth, BART's influence on localised developments was predictable.

2.5.4 Integrated Planning: Stockholm versus San Francisco

Stockholm's co-development of the rail-served new towns with their job-housing balance, and the fully integrated transit system results in public transport's dominant share of commuter trips, and a considerably lower total annual passenger-kilometres per capita figure than San Francisco. The growth in suburban and employment centres near freeway interchanges, and the limited development of sub-centres around BART stations is reflected in the 80 percent of work trips, and high total annual passenger-kilometres per capita, undertaken by private car in the San Francisco Bay Area (Table 2.5).

Table 2.5: Annual Travel Patterns, 1990 *source: (Newman and Kenworthy, 1999)*

City	Annual Travel (km per passenger)			% of total passenger km on Public Transport	Work Trips (% of total)			Journey to Work	
	Private Car	Public Transport	Total		Private Car	Public Transport	Non-motorised modes	Average Distance (km)	Average Time (mins)
Stockholm	6,261	2,351	8,612	27.3%	31%	55%	14%	8.6	32.2
San Francisco	16,229	899	17,128	5.3%	80%	14.5%	5.5%	15.4	26.6

Cervero and Wu (1998) suggest that workers in jobs in the CBD and urban job centres average relatively long (temporal) commutes but do so using higher-occupancy modes of transport (e.g. public transport), resulting in relatively low levels of VKT per employee. This might explain the difference in mode, spatial and temporal journey to work figures for Stockholm and San Francisco, as the former city has a far greater number of work trips on public transport to employment located in the central city and sub-centres positioned along the rail line. When viewing Stockholm‘s average work trip time of 32.2 minutes, allowance must be made for the 14 percent of commuters using non-motorised transport (walking, cycling, etc), especially when comparing to the same figures for San Francisco. In fact, the average speeds by car and train in both Stockholm and San Francisco are just over 43km/h (Newman and Kenworthy, 1999), confirming the influence of non-motorised modes on the average commuting time listed for Stockholm.

The primary difference in the approaches undertaken in Stockholm and San Francisco is the former’s region-wide master planning, compared with the Bay Area’s free market approach to land use planning. The studies on Stockholm and San Francisco Bay Area demonstrate the co-dependent relationship between transport and land use: The positioning of residential, commercial and retail development can have a strong influence on mode split and therefore the sustainability of transport systems within a region.

2.6 SUMMARY

Researchers and government agencies across the world recognise the need for an integrated approach to successfully address the relationship between transport and land use planning. Many cities have implemented integrated planning solutions to reduce sprawl, transport demand and associated externalities. The key to a successful integrated planning system is an agreed policy vision incorporating desired functional attributes that residents, businesses and government agencies all support, along with the establishment of a comprehensive mix of land use, transport, financial and regulatory planning mechanisms to drive development to meet the vision.

Despite their differences, the cities studied in section 2.5 have all adopted a similar approach in establishing their integrated planning systems. They recognise that a traditional settlement structure is more environmentally, economically and socially sustainable than the post-World War II car-oriented sprawl that has evolved in North America, United Kingdom and Australasia. To counter sprawl and reduce automobile dependence growth management strategies including green belts to protect the natural environment, higher density and infill developments to reduce land take and zoning to meet precise planning goals were introduced at a regional level. Extensive public transport networks, provision for non-motorised modes and the restraint of private vehicles are combined to provide accessible, reliable, affordable transport systems. In all these cities government agencies form partnerships with developers, and most employ a mix of financial mechanisms like development subsidies, tax incentives and road and parking pricing strategies to encourage the desired land use and transport results.

This research has established that many cities with successful integrated planning systems have large populations and big budgets, or are small-scale developments within a highly populated region, meaning the economies of scale for transport infrastructure already exist. However, as demonstrated in Freiburg, integrated planning systems can be successfully established in small cities too. These findings provide a sound base from which to address this thesis's research question as it seeks to establish the transport and land use interventions that will best contribute to a sustainable transport solution for the Wellington region.

SECTION TWO: INTEGRATED PLANNING IN THE WELLINGTON REGION

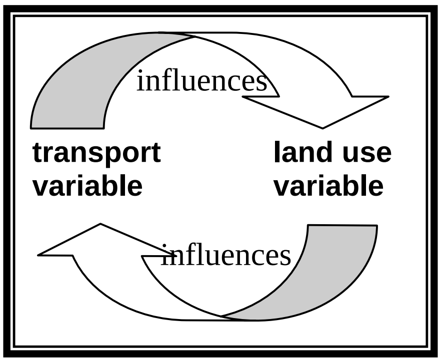
CHAPTER THREE: METHODOLOGY

3.1 THEORETICAL FRAMEWORK

3.1.1 A Systems Approach

As demonstrated in Chapter Two; past research suggests that a combination of land use and transport planning mechanisms are needed in order to establish a successful sustainable transport solution. The result of integration of land use and transport mechanisms can be described as a complex system, as each mechanism (or variable) comprising the system has a causal relationship with the others. Senge (1990) suggests that 'systems thinking' is an appropriate conceptual framework to help understand such complex systems and the interrelationships within them. Systems Thinking recognises that nothing is ever influenced in just one direction, meaning a cause and effect relationship is actually circular (Senge, 1990). Therefore, the causal relationship between transport and land use identified in Chapter Two can be depicted in a (simplified) feedback loop where any change to one variable influences the other (Figure 3.1).

Figure 3.1: Example of a System Diagram



A systems model approach is utilised by Bachels (1999) in his PhD thesis to undertake an extensive and highly relevant study of the interaction of transport and land use factors affecting urban transport energy use. He concludes, 'well meaning independent and uncoordinated planning processes may be producing synergistic and unintended system outcomes' including increasing urban area, car use, environmental externalities, decreasing population density and use of alternate transport modes. Bachels' observations and the integrated planning systems implemented in the cities studied in Chapter Two both demonstrate the need to take a holistic view of transport and land use planning interactions in order to effect positive changes within a system. Such a holistic view is encompassed in Systems Thinking, and it is within this framework that data will be analysed to answer the thesis research question.

3.1.2 Research Question

What is the optimal integrated transport - land use planning system required to provide a sustainable transport solution in the Wellington region?

3.1.3 Hypothesis

Chapter Two identified a range of planning mechanisms that are often included in integrated planning systems, and demonstrated the uptake of these mechanisms through case studying a number of cities (Table 2.2). These mechanisms are variables in the systems they are part of as individually they are in a causal relationship with one another. The extent of these relationships can be determined by manipulating certain variables. Greater Wellington Regional Council (GWRC) hypothesises that:

> *Due to the failure of New Zealand's current planning framework to adequately address transport - land use interrelations land use is developing in a way that results in unnecessary travel, and (sic) transport developments enable and encourage a more dispersed land use pattern (which then costs more to serve with transport).* (Brennand, 2003)

It is testing these relationships by modelling six scenarios (Appendix 4) to determine the response of the current transport network to different transport and land use policy directions within the Wellington metropolitan area (Appendix 5) in 2026. Greater Wellington selected 2026 as a reference point to identify the significance of integrated policies over a design period for the *Regional Land Transport Strategy* (RLTS) and longer. Three scenarios incorporate variations on the transport projects listed in the RLTS (Appendix 6) to test the impact of changes to the transport network. Scenarios 4 to 6 reassign the metropolitan population in different ways to test the impact of land use policies on the transport network.

This research analyses GWRC's modelling results, combining them with the findings of Chapter Two to identify the intervention that best contributes to a sustainable transport solution for the Wellington region.

3.2 ANALYSIS PROCESS

Using base data from 2001, population and employment growth projections for 2026 are applied to each of the six policy intervention scenarios. The 2001 base data are sourced from Statistics New Zealand 2001 Census, the Household Travel Survey undertaken by the National Research Bureau for GWRC, Greater Wellington's Transport Strategy Model

(WTSM; Appendix 7) and the Graphical Information System complied by Land Information New Zealand and the Department of Scientific and Industrial Research.

3.2.1 Characteristics of the Performance Indicators

Twenty-three performance indicators (Appendix 8) are selected by GWRC to assist in understanding the impacts of the various scenarios (Brennand, 2003) on household distribution and private travel. The indicators correspond to those in the 1998-9 Scenario Modelling Reports undertaken for the RLTS Review (Wellington Regional Council Transport Policy Department, 1998, 1999a, 1999b, 1999c). A number of the indicators are expanded to provide mode split and journey to work data, as results are reported in this manner in a number of international studies (see, for example Cervero, 1998, Newman and Kenworthy, 1999, Ryan and Throgmorton, 2003). Performance indicators relating to network and public security and safety are not collected, despite the RLTS containing a strong focus on them. This deliberate omission is due to the limited scope of this research paper and the inability of the WTSM to forecast traffic accidents. It is recognised that this WTSM limitation may in turn restrict its applicability in the formation of policy.

Previous scenario modelling by GWRC and the functionality of the WTSM and GIS have set the following parameters in the performance indicators:

- The **total metropolitan area** covers 164,180 hectares (Appendix 5) and remains unchanged in all scenarios. It is the metropolitan area used since 1996 to provide data to an international study on Sustainable Cities and Car Dependence undertaken by M Bachels, G Kenworthy and P Newman.

- The growth of each Territorial Authority's (TA) **urbanised area** is constrained, for all scenarios, within the WTSM Transport Activity Zones where development existed in 2001. This is due to the inability of the WTSM to predict how urbanised areas will spread, accounting for variables like the impending Regional Strategy, topography, household composition and population. **Urban density** is calculated based on this.
- **Population** is defined, and growth allocated, within each TA's urbanised area rather than across its entire land area. This is because the territorial authorities all support containment and increased density in their District Plans. It is also due to the way the urbanised area is defined above. Population projections are from Statistics New Zealand and are applied to a 2001 base population. They allow for fertility, mortality and net migration rates based on historical trends.
- As each job regardless of hours worked generates a trip, **employment** is defined as the number of full-time and part-time jobs. Employment is allocated within each TA's urbanised area, as opposed to across its entire land area, because of the way the urbanised area is defined in the WTSM.

  Employment by TA remains unchanged for all scenarios. However, for Scenarios 4 to 6 the WTSM redistributes trips by origin-destination based on the proportion of trip type by location for the population and employment in that location.
- The **central business district** (CBD) covers 218 hectares (Appendix 10) and remains unchanged in all scenarios. It is the CBD area used in the WTSM by Greater Wellington, and since 1996 to provide data to an international study on Sustainable Cities and Car Dependence undertaken by M Bachels, G Kenworthy and P Newman.
- All **trip** data (indicators 7 to 16a) exclude heavy commercial vehicles as this research focuses on private transportation and travel.
- **Trip** data are compiled in two time periods:

- Daily (i.e. 24 hours) for the total number of trips.
- The weekday morning peak period from 07:00 to 09:00 for vehicle kilometres travelled (VKT), passenger kilometres travelled (PKT), travel time and averages associated with these. The morning peak is selected as it includes the greatest variety of trips; work, education and general purpose. Furthermore, as WTSM doesn't calculate results for the off-peak period (18:01 to 06:59) these would have to be manually estimated from interpeak data then aggregated with peak and interpeak results to obtain daily totals, resulting in a moderate level of data inaccuracy.

♦ **Trip** data are split by car, public transport and active modes. Car trips incorporate both driver and passenger numbers, as people rather than vehicles are the focus of this analysis. PKT in cars has an occupancy rate of 1.3 factored into the WTSM.

♦ **Travel time** data for active modes are based on a speed of 5 kph travelled on the road network, i.e. shortcuts between buildings or on walkways are not accounted for.

♦ **Fuel consumption** for 2001 are sourced from the Ministry of Transport *Vehicle Fleet Efficiency Model* (Ministry of Transport, 1998).

♦ **Transport emissions** data for 2001 are based on the Ministry of Transport *Vehicle Fleet Efficiency Model* and calculated using the WTSM trip data outputs.

♦ **Congested motor vehicle hours** are the total hours travelled by cars in the am peak in heavily congested traffic conditions. This is based on a volume / capacity ratio (VCR) of greater than or equal to 0.8, where at 1.0 the road is at full capacity.

♦ **System economic cost** is the total annual cost to move everyone travelling by the modes chosen. It is calculated based on the Transfund *Project Evaluation Manual* (PEM) guidelines and values (Transfund New Zealand, 1997). Travel time, the frustration component of congested travel time and operating costs are included.

Accident costs, time associated with active trips and public transport waiting times are excluded. Heavy commercial vehicles are included in the PEM, and therefore the figures provided in this analysis.

- The **cost of congestion** is calculated on the additional travel time due to congestion, plus the extra frustration time when VCR is greater than or equal to 0.7 for each extra hour of travel over the free-flow speed, plus additional vehicle operating costs due to congestion. Costs of trip reliability are excluded. Heavy commercial vehicles are included in the PEM, and therefore the figures provided in this analysis.

Each scenario is run in Greater Wellington's Transport Strategy Model, and results for the performance indicators are reported in a table (Appendix 9) from which the following quantitative and qualitative analysis are undertaken.

3.2.2 Comparative Analysis of the Performance Indicators for Each Scenario

- The results of Scenario 1: Status Quo are compared with the base data. Changes in population and employment numbers by TA, mode split, average trip time and distance, road network speed and journey to work data are tabled and examined. Conclusions are drawn on the relationship between the land use and transport changes and the projected land use and transport trends across the region to 2026 are summarised.

- A comparative analysis between the Status Quo and Scenario 2 to Scenario 6 determines how each of these scenarios differs from the Status Quo, and the impact of each scenario on the transport network. Data tabulated and discussed include total trips, average trip time and length, network speeds, passenger kilometres travelled, trips into and within the CBD, journey to work trips and economic and environmental costs.

- Due to the inconclusiveness of parts of the above analysis origin-destination data, by mode, by TA are modelled and analysed for the Status Quo and Scenario 6. Scenario 6 is selected as it incorporates the RLTS projects, and of the three land use interventions it redistributes the population in the most realistic manner given the growth trends prevalent in 2004. This is undertaken to gain a greater insight into the impact of a land use intervention on mode split and trip patterns.

3.2.3 Testing the Scenarios' Ability to Meet RLTS Vision & Attributes

GWRC includes the attributes of affordability, accessibility, mobility, economic and network efficiency and environmental sustainability as desirable outcomes of the *Regional Land Transport Strategy* (McConnell and McDavitt, 2004, Wellington Regional Council, 1999). The findings in Chapter Two also identify them as necessary attributes of a successful integrated transport - land use system. The definition of each attribute is currently being revisited as part of the process of updating the RLTS. The definitions below incorporate these revisions and also take into consideration the current RLTS vision and attributes.

- **Access and mobility**: Transport should provide for the access and mobility needs of our regional community. Improving them is the primary purpose of a RLTS. Access is to enable social participation, inclusion and independence. Mobility is to ensure the availability of realistic transport choices for the individual or community, including affordability and equity of costs.

- **Efficiency** and **affordability**: Economic efficiency and funding availability of new transport packages, network efficiency and individual transport affordability.
- **Environmental sustainability**: Avoid, remedy or mitigate the negative impacts of transport on the environment, including encouragement of energy efficiency, reduced CO_2 emissions, and high quality new development and project design (McConnell and McDavitt, 2004, Wellington Regional Council, 1999).

The ability of each scenario to meet these RLTS attributes is tested through the following process:

- The performance indicators are assigned to the RLTS attributes based on the above attribute definitions, their allocation to attributes within the existing RLTS and discussions with Greater Wellington Transport Division staff. Simultaneously the aim of each performance indicator's result is determined based on:
    - the indicator's ability to positively impact on the vision of the RLTS
    - the attribute the indicator is associated with
    - in some cases, the indicator's relationship with other indicators. For this reason performance indicators are listed separately by mode. For example, the performance indicator 'total daily trips' is a measure of (the RLTS attribute of) mobility, but based on the definition of this attribute, the aim of this indicator is different for each mode: To reduce the car share of mode split, and to increase the public transport and active modes share of mode split.

- A 6-point ordinal scale (1 = best performer, 6 = worst performer) is used to rank each of the six scenarios, by performance indicator, against each other. Using the results of the comparative analysis they are ranked according to their ability to meet the aim of each performance indicator, and therefore the associated RLTS attributes. An ordinal scale is being used to establish an indication of the ability of each scenario to meet the RLTS attributes. For this reason the magnitude of difference between each ranking, and the weighting of each attribute are not being accounted for in this analysis.

Data relating to indicators one to six are derived from GIS rather than the Wellington Transport Strategy Model, and as indicators of demographic change rather than of a scenario's performance they are not ranked. The performance indicators, their aims, the associated RLTS attributes and the ranking of scenarios are combined in Table 4.16.

- ♦ The rankings for each scenario are totalled and the scenario with the lowest score is identified. Its ability to deliver the RLTS attributes is discussed, including any shortfalls it may have in providing a sustainable transport solution for the Wellington region.

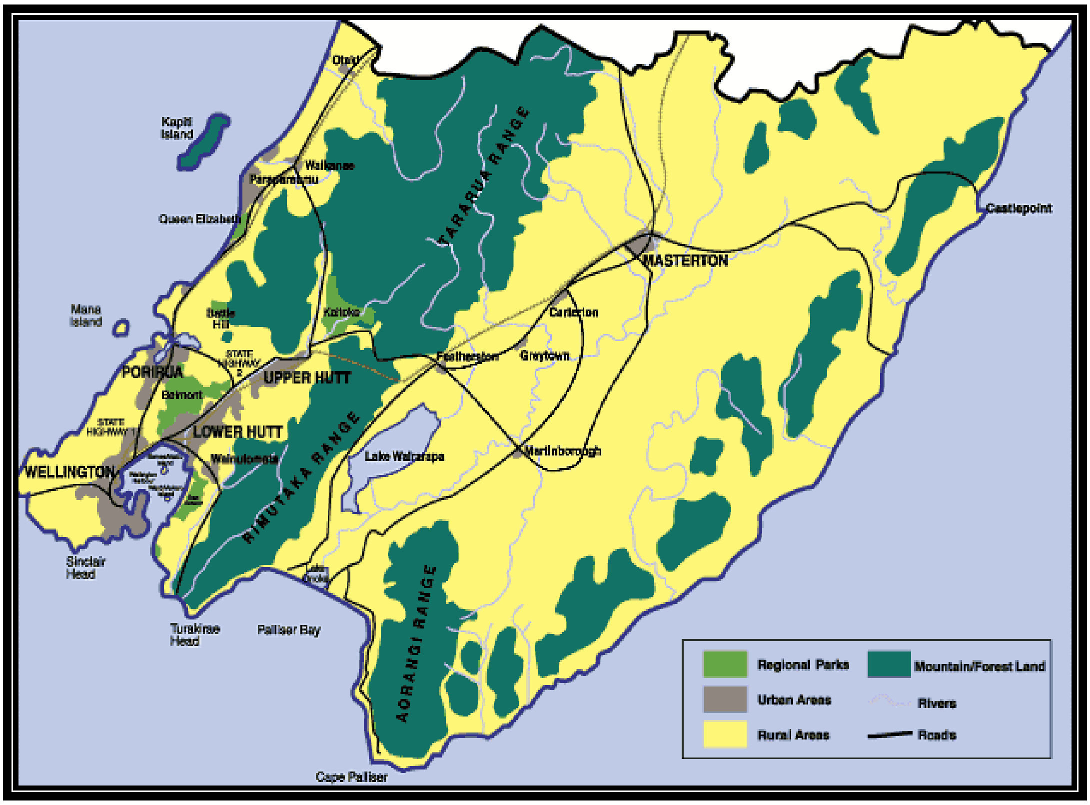
The results of the comparative analysis and scenario ranking table are discussed, and the scenario that best meets the RLTS vision is selected based on the results from both sections of analysis.

CHAPTER FOUR: WELLINGTON CASE STUDY

4.1 BACKGROUND

The Wellington region (Figure 4.1) comprises a regional council, four city councils and four district councils spread over 813,005 hectares (Greater Wellington Regional Council, 2003). As a capital city, Wellington is small with a population of 179,156, being 40 percent of the region's total population of 451,700. The populations within the other local authorities range from a combined 39,272 in the four district councils covering the dispersed, predominantly rural, Wairarapa to 99,931 in Lower Hutt (Statistics New Zealand, 2001).

Figure 4.1: Map of the Wellington Region
source: (Wellington Regional Council, 2002)



The region's settlement systems are shaped by its topography (Figure 4.2), with two corridors of development running from Wellington City through the Hutt Valley and Wairarapa (Figure 4.3), and through Porirua to the Kapiti Coast (Figure 4.4). A well-established, but run down, rail network serves the Wellington region with feeder bus services to outer-lying suburbs. Wellington's hilly and earthquake-prone terrain makes the transport system vulnerable to natural disasters, and limits improvement options both physically and financially. Over the years, suburbanisation has seen housing sprawl up hills and around harbours as land close to the motorways and rail lines were developed. Given Wellington region's small population and its limited predicted annual growth rate of 0.5 percent over the next 50 years (Statistics New Zealand, 2003), available expenditure for greenfield sustainable transport and settlement solutions is unlikely to be large.

Figure 4.2: Wellington CBD & Port *source: (Chapman, 2004a)*

Figure 4.3: State Highway 2 & Rail Track on Earthquake Fault
source: (Chapman, 2004a)

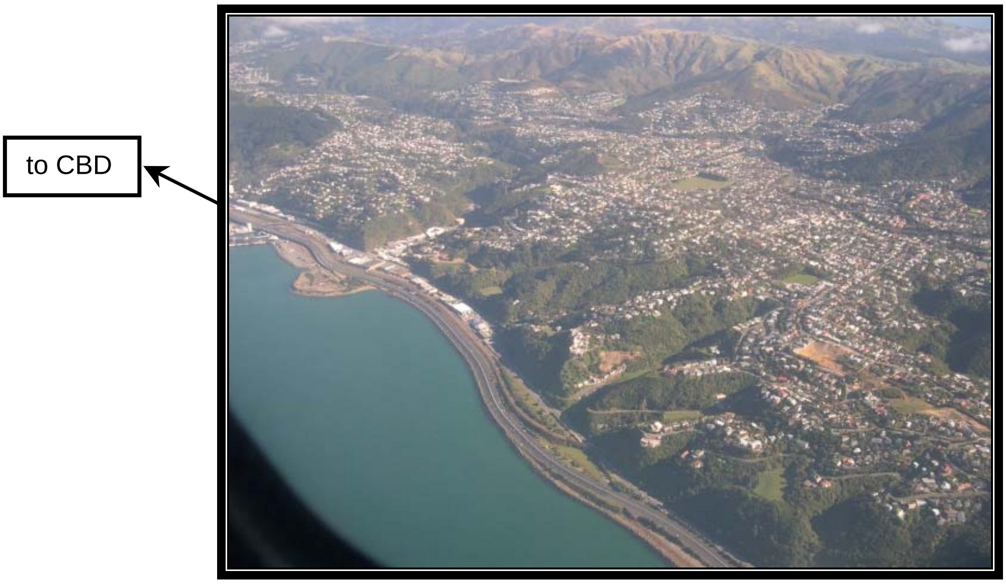
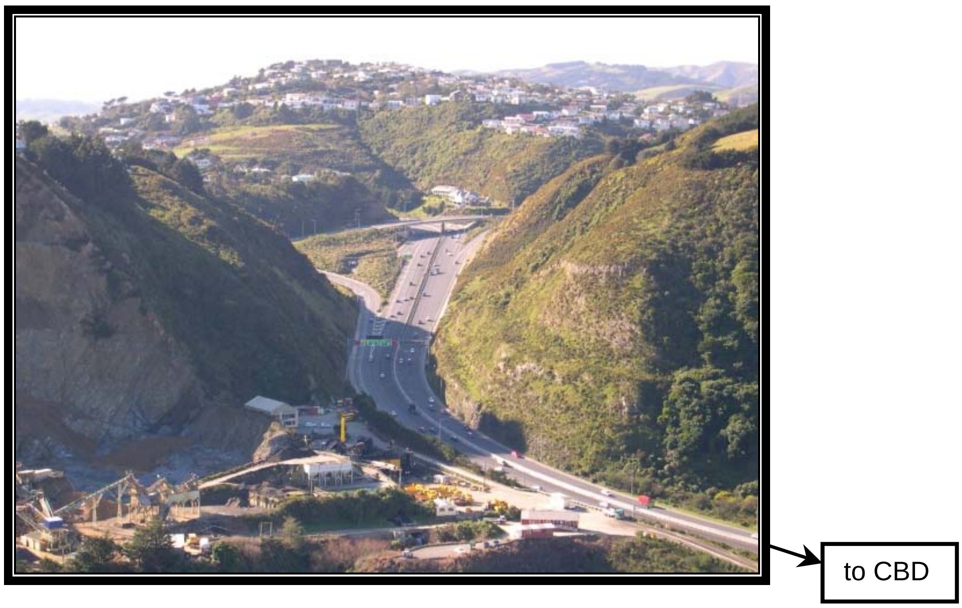


Figure 4.4: State Highway 1 North up Ngauranga Gorge
source: (Chapman, 2004b)



Traditionally, legislation resulted in segmented development in that each local authority developed its own Annual and District Plans to attract and provide for businesses and residents, in so doing competing with neighbouring councils. Unlike its counterparts in

Auckland and Christchurch, the Wellington region does not have a regional growth strategy. The Terms of Reference are complete for a regional strategy due for implementation in 2006; however establishing the detail on how the policy direction is accomplished is still to be undertaken.

4.2 CASE STUDY FOCUS

The findings of the review of integrated transport – land use planning undertaken in Chapter Two can be categorised in two areas:

- The high-level 'What', or strategic vision, encompasses what is to be done and is defined in policy direction and legislation
- The low-level How, being how the policy direction is implemented, incorporates specific policy interventions comprising individual planning mechanisms that together form an integrated planning system

The vision of the *Wellington Regional Land Transport Strategy* is to 'deliver a balanced and sustainable land transport system that meets the needs of the regional community' (Wellington Regional Council, 1999, 33). The following research addresses the 'How' as it analyses six specific policy intervention scenarios (set in 2026) and determines which of them best meets the RLTS vision. Appendix 9 is the source for all data in the following tables and text.

4.3 COMPARISON OF BASE CASE & STATUS QUO RESULTS

In comparing the 2026 Status Quo with the 2001 Base Case data (Appendix 9) the resulting population and employment trends do not vary over the 25 years, as the former is modelled with growth allocated according to the prevalent underlying trends in the region. It is the impact of the size and location of the growth on the transport network that is of interest. This comparative analysis sets the scene as the Status Quo illustrates where the region will be in 2026 if the traditional pattern of land use and transport policy interventions and a segmented approach to planning continue.

4.3.1 Urban Changes

Table 4.1: Metropolitan Population & Employment by Territorial Authority

TA	Population of Urbanised Area				Employment in Urbanised Area			
	2001	2026	total change	% change	2001	2026	total change	% change
KCDC	40,412	59,714	19,302	48%	12,662	17,666	5,004	40%
PCC	46,635	53,093	6,458	14%	12,831	14,281	1,450	11%
WCC *	162,915	202,407	39,492	24%	117,910	136,930	19,020	16%
HCC	95,289	102,025	6,736	7%	40,735	43,806	3,071	8%
UHCC	34,451	33,931	-520	-2%	11,245	11,040	-205	-2%
Total	**379,702**	**451,170**	**71,468**	**19%**	**195,383**	**223,723**	**28,340**	**15%**
*Wgtn CBD					68,470	80,886	12,416	18%

Table 4.1 shows the metropolitan population is projected to increase by 19 percent; 71,500 people in the 25 years to 2026, with the largest proportional population increase of 48 percent on the Kapiti Coast. The change in population in Upper Hutt and Lower Hutt are proportionally the smallest in the region at -2 percent and seven percent respectively. Wellington City's population is projected to grow by 39,500, being 24 percent of the metropolitan total, however it maintains its position as the primary employment centre with 19,000 additional jobs – two thirds of which are in the CBD. Metropolitan employment is projected to increase by 28,300 jobs with the largest increase of 40 percent on the Kapiti

Coast, while a slight drop in total employment in Upper Hutt is possibly due to the relocation of industrial plants to other regions and offshore.

The WTSM does not allocate population growth to any new zones in the metropolitan area, thereby resulting in an increased density in each sub-centre. Due to this system limitation it is of no value to compare the number of households per hectare in 2026 with that of 2001, however a link between density, mode split and number of trips is explored in the comparative analysis of the six 2026 scenarios.

4.3.2 Transport Changes

The number of daily trips across all modes is projected to increase by 20 percent from 1.8 million to almost 2.2 million in 2026. Of this just under 260,000 are into and 190,000 within the CBD (Appendix 10); increases of 20 and 29 percent respectively, with insignificant change in mode split (Table 4.2). Mode split across all daily trips remains largely unchanged at 71 percent by car, five percent by public transport and 24 percent by active modes (mostly walking, with a small portion cycling): There is an insignificant movement of one percent from public transport to cars. Mode split for trips within the CBD paints a different picture with 47 percent by car, only one percent by public transport, but 52 percent by active modes.

Table 4.2: Total Daily Trips within the CBD

YEAR	Car			Public Transport			Active Modes			All Modes	
	total daily trips	% increase	% of total trips	total daily trips	% increase	% of total trips	total daily trips	% increase	% of total trips	total daily trips	% increase
2001	68,604		47%	1,751		1%	76,501		52%	146,856	
2026	89,204	30%	47%	2,315	32%	1%	98,518	29%	52%	190,037	29%

Table 4.3: Average Travel Time & Distance

YEAR	Car in am peak						Public Transport in am peak					
	ave trip length (km)	km change	ave trip time (mins)	mins change	ave road netwrk spd (kph)	kph change	ave trip length (km)	km change	ave trip time (mins)	mins change	ave PT spd (kph)	kph change
2001	8.9		11.1		49.2		15.4		20.0		40.0	
2026	8.9	0.0	14.6	3.5	36.5	-12.7	16.9	1.5	22.5	2.5	38.7	-1.3

The total distance travelled (PKT) by car occupants during the morning peak is projected to increase 30 percent (up 539,300 kilometres), while total travel time increases 72 percent. The average length of a car trip remains unchanged at 8.9 km but it will take over three minutes longer to travel (Table 4.3) – a 32 percent increase in travel time. This disproportionate increase in time to distance is typical as the number of vehicles heads towards a critical congestion level on the road network, and is borne out by the 12.7 km per hour (kph) drop in average road network speed to 36.5 kph and the 206 percent increase in congested motor vehicle hours during the morning peak: At 22,300 hours, the amount of time spent by car occupants travelling in heavily congested conditions in the morning peak is over a third of the total travel time for this period.

The difference in mode split between total daily trips and trips within the CBD provides an indication as to why the average car trip length is so, unusually, low by world standards and unchanged in 25 years: The resident population in the CBD grew 250 percent in the 10 years to 2001 (Wellington Civic Trust, 2002). This is much faster than the low density growth occurring in the sub-centres. These population growth rates combined with the slow economic growth (meaning there have been few new commercial or industrial developments throughout the region) result in an unchanging trip pattern and the static average trip length.

The distance travelled and travel time using public transport in the morning peak increase 21 and 17 percent respectively. The small increases in the average public transport trip distance and time are proportional at 10 and 12 percent respectively. This is probably due to the high number of trips by bus in the CBD being offset by a smaller number of longer distance train trips, and the minimal increase (10 percent) in total trips of 2,800 having only a marginal effect on travel time. These factors are confirmed by the drop in average public transport speed of only 1.3 kph: The drop in speed is also because buses share the congested road network, rather than slower train speeds or the influence of additional passenger loadings on the rail network.

Table 4.4: Daily Journey to Work Trips

YEAR	Car JTW						Public Transport JTW				Active Modes JTW			
	total daily trips	% of total trips	ave trip length (km)	km change	ave trip time (mins)	mins change	total daily trips	% of total trips	ave trip length (km)	km change	total daily trips	% of total trips	ave trip length (km)	km change
2001	195,787	73%	11.0		14.0		45,443	17%	17.3		25,549	10%	2.6	
2026	227,146	75%	10.9	-0.1	19.2	5.2	49,898	17%	19.0	1.7	24,721	8%	2.8	0.2

The number of journey to work (JTW) trips, by all modes, is projected to increase by almost 35,000 to 301,800 each day. Of this 75 percent are by car, 17 percent by public transport (Figure 4.5), and eight percent by active modes (Table 4.4): A three percent drop in total JTW trips by active modes is absorbed by car; equating to a two percent change in overall mode split. The impact of the additional 31,400 JTW trips on the road network is seen in the extra five minutes it takes to travel the same distance for the average car trip. This reinforces the trends established in Table 4.3; which is to be expected given journey to work is a subset of total trips.

Figure 4.5: Morning Commuters at Wellington Station
source: (Chapman, 2004b)

4.3.3 Environmental and Economic Costs

While there is a small increase in petrol consumption (10 percent), diesel consumption is projected to increase 127 percent to 322 million litres per annum. Carbon monoxide emissions are expected to fall to half the 2001 figure of 27,300 tonnes as expected vehicle efficiency increases. Annual carbon dioxide emissions increase 51 percent to 1.6 million tonnes, which isn't surprising given the 24 percent increase in VKT in the morning peak period (an annualised figure is not available), and the direct relationship between these indicators.

The annual cost of congestion rises 67 percent to $1 billion, while the cost during the morning peak increases 95 percent to $701,300. The annual system economic cost (the cost to move all travellers by the modes chosen) is projected to increase $1 billion to over $2.8 billion. This equates to a system economic cost per person kilometre in the morning peak of 0.57 cents – up 37 percent from 2001. It is likely that these huge increases in transport system costs negatively impact on the Wellington region's modest economic growth, as they make the cost of doing business more expensive.

4.3.4 Conclusion

Adopting a business as usual approach to population and employment growth over the next 20 years has a negative effect on the transport network, even accounting for the implementation of RLTS road and public transport projects included in the Status Quo scenario.

The ongoing dominance of the motor vehicle as the preferred mode choice can be attributed to four key factors:

- population increases in the sub-centres, particularly on the Kapiti Coast
- the ongoing dominance of Wellington CBD as the region's employment centre
- minimal improvements to the public transport network
- the continued supply of (and demand for) stand alone housing in low density suburban developments

Together, these factors contribute to increases in total trips and travel time by car and a small movement in mode split from active modes and public transport to car, resulting in a high level of road network congestion in the morning peak. The lack of change in the average trip length by car, when considered alongside the factors above, suggests that the increase in daily trips is proportionally spread over each trip purpose (i.e.; school, retail, work, other).

The population growth on the Kapiti Coast may explain the (small) increase in the average distance of a JTW trip by public transport, while the small shift in mode split from active modes to car may also be the result of more people having to travel further to work.

The 29 percent increase in daily trips within the CBD compared with the 20 percent increase in trips into the CBD may be attributed to the assumption that a portion of the 39,500 extra people living in Wellington City in 2026 will reside and most likely work, recreate and shop in the CBD, and some of these will have moved to the CBD from other sub-centres. The 52 percent of all daily trips within the CBD undertaken by active modes supports this assumption.

The difference between average trip length by public transport and car, combined with the dominance of cars in mode choice for all trip purposes (except those within the CBD) demonstrates that public transport is primarily used to travel greater distances than cars, and cars are used for the majority of trips, which also happen to be of short duration (under 10 kilometres).

Increases in environmental and economic costs are to be expected, however the comparison of Status Quo data with 2001 results is not as useful as comparing it with the other five 2026 scenarios to determine which future scenario will be the most environmentally and economically sustainable.

In summary; the disproportionate increase in population to jobs in Kapiti, Porirua and Lower Hutt, slight decline in population and employment in Upper Hutt, continued growth of Wellington City as the metropolitan area’s primary employment centre and the lack of substantial improvements to the public transport network result in the ongoing dominance of the motor car and lack of change in mode split for all trip types. The following analysis of all six 2026 scenarios seeks a more sustainable transport solution for the Wellington region.

4.4 COMPARISON OF SCENARIOS 2 TO 6 WITH STATUS QUO

This section reviews the results of Scenario 2 to Scenario 6 against those of Scenario 1, the Status Quo. The discussion that follows this section, whilst involving a comparative analysis of these scenarios with the Status Quo, also assesses the Status Quo scenario in its own right. Refer to Appendix 4 for descriptions of the six policy intervention scenarios.

4.4.1 Urban Changes

As explained in the Methodology, total jobs by territorial authority (TA) remain unchanged for all six scenarios.

Table 4.5: Metropolitan Population & Employment, 2026

TA	Scenario 1, 2, 3	Scenario 4	% change	Scenario 5	% change	Scenario 6	% change	Jobs
KCDC	59,714	40,354	-32%	40,354	-32%	66,663	12%	17,666
PCC	53,093	41,284	-22%	97,662	84%	52,863	-0.4%	14,281
WCC	202,407	258,873	28%	191,541	-5%	175,886	-13%	136,930
HCC	102,025	88,836	-13%	99,789	-2%	122,498	20%	43,806
UHCC	33,931	29,589	-13%	29,589	-13%	41,026	21%	11,040
Wgtn CBD								80,886

Table 4.6: Average Urban Density, 2026

TA	Households per hectare			
	Sc 1, 2, 3	**Sc 4**	**Sc 5**	**Sc 6**
KCDC	11	7	7	12
PCC	8	6	17	8
WCC	13	17	12	11
HCC	8	7	8	10
UHCC	6	5	5	7

Scenarios 1 to 3: Transport Interventions

The population by TA (Table 4.5) is the same for Scenarios 1, 2 and 3, as the WTSM does not redistribute population due to changes to the transport system. Accordingly, average urban density by TA remains unchanged (Table 4.6). Wellington City has the highest density with 13 households per hectare (ha), caused by the hilly terrain restricting where the 202,000 residents live. Upper Hutt, with its slow growth and small population spread over a large river valley, has a low six households per ha.

Scenario 4: Wellington CBD

The allocation of population growth in and around Wellington central city results in 56 percent of the metropolitan area's residents residing in Wellington City (Figure 4.6) – a 28 percent increase on the Status Quo (Table 4.5). The likelihood of this happening is questionable given the associated decreases in all other TAs reduces their populations to below the 2001 level. Kapiti's 19,000 drop in population is unlikely as it reverses the growth trends of the last few years and predicted trends that are modelled in the Status Quo. However, this scenario will still demonstrate the impact of such a policy direction on the transport system.

Figure 4.6: Wellington City & Harbour from Brooklyn Hill
source: (Chapman, 2004b)

In all but two cases in Scenarios 4 to 6 the percentage change in density (Table 4.6) exceeds the population percentage change. This can be attributed to the proportion of single-person households relocating in each scenario. For example, Upper and Lower Hutt both have a 13 percent drop in population and 15 percent drop in households per ha in Scenario 4 suggesting a higher number of single-person households are leaving these cities than multiple-person households.

<u>Scenario 5: Big Three</u>

Allocating regional growth around Wellington, Lower Hutt (Figure 4.7) and Poriua (Figure 4.8) central areas results in an 84 percent increase in Porirua's population, and a five and two percent drop in Wellington and Lower Hutt's populations respectively (Table 4.5). Kapiti and Upper Hutt are again hit hard with their populations returning to pre-2001 levels, at 40,300 and 29,600. Urban density (Table 4.6) responds in a proportional manner except in Porirua, where density increases 107 percent to 17 households per ha, most likely as a result of the constraint on development of the Porirua harbour and Pauatahanui Inlet.

Figure 4.7: Lower Hutt Valley from Petone

source: (Chapman, 2004b)

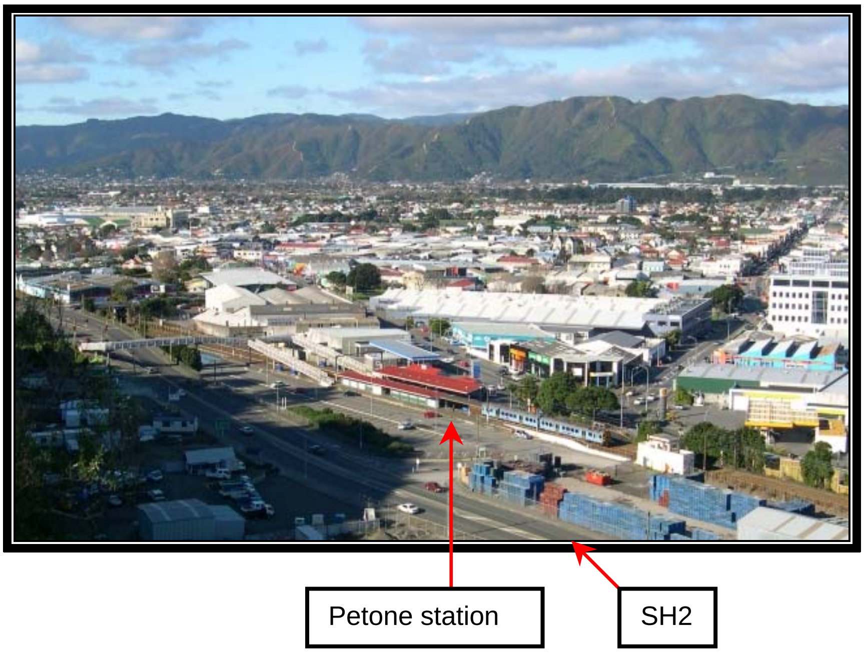


Figure 4.8: Porirua City *source: (Chapman, 2004b)*

Scenario 6: Densification Around Public Transport Nodes

Densification around key railway stations moves the metropolitan population from Wellington City to Upper Hutt (Figure 4.9) and Lower Hutt with growth of 21 and 20 percent respectively (Table 4.5). Kapiti's population increases 12 percent to 66,700 while Porirua remains static.

Figure 4.9: Upper Hutt City *source: (Chapman, 2004b)*

4.4.2 Transport Changes

Table 4.7: Total Daily Trips, 2026

SCEN-ARIO	Car			Public Transport			Active Modes			All Modes	
	total daily trips	% of total trips	% change	total daily trips	% of total trips	% change	total daily trips	% of total trips	% change	total daily trips	% change
1	1,555,930	71%		109,219	5%		532,260	24%		2,197,409	
2	1,550,811	71%	-0.3%	111,227	5%	2%	534,831	24%	0.5%	2,196,869	0.0%
3	1,555,930	71%	0%	109,219	5%	0%	532,260	24%	0%	2,197,409	0%
4	1,543,939	70%	-0.8%	103,356	5%	-5%	555,597	25%	4%	2,202,892	0.2%
5	1,539,598	70%	-1%	111,149	5%	2%	541,316	25%	2%	2,192,063	-0.2%
6	1,544,315	70%	-0.7%	113,135	5%	4%	535,863	24%	0.7%	2,193,313	-0.2%

Table 4.8: Total Daily Trips into the CBD, 2026

SCEN-ARIO	Car			Public Transport			Active Modes			All Modes	
	total daily trips	% of total trips	% change	total daily trips	% of total trips	% change	total daily trips	% of total trips	% change	total daily trips	% change
1	174,031	67%		49,667	19%		36,043	14%		259,741	
2	171,022	66%	-2%	51,354	20%	3%	35,703	14%	-1%	258,079	-1%
3	174,031	67%	0%	49,667	19%	0%	36,043	14%	0%	259,741	0%
4	162,810	67%	-6%	36,237	15%	-27%	43,617	18%	21%	242,664	-7%
5	167,159	66%	-4%	48,057	19%	-3%	36,372	14%	1%	251,588	-3%
6	170,276	66%	-2%	54,954	21%	11%	33,268	13%	-8%	258,498	0%

Table 4.9: Total Daily Trips within the CBD, 2026

SCEN-ARIO	Car			Public Transport			Active Modes			All Modes	
	total daily trips	% of total trips	% change	total daily trips	% of total trips	% change	total daily trips	% of total trips	% change	total daily trips	% change
1	89,204	47%		2,315	1%		98,518	52%		190,037	
2	89,817	47%	1%	2,401	1%	4%	99,308	52%	1%	191,526	1%
3	89,204	47%	0%	2,315	1%	0%	98,518	52%	0%	190,037	0%
4	133,581	50%	50%	5,992	2%	159%	129,485	48%	31%	269,058	42%
5	103,869	48%	16%	3,351	2%	45%	107,537	50%	9%	214,757	13%
6	87,241	47%	-2%	2,025	1%	-13%	97,270	52%	-1%	186,536	-2%

Table 4.10: Journey to Work Trips, 2026

SCEN-ARIO	Car						Public Transport				Active Modes			
	Daily trips		JTW in am peak				Daily trips		JTW in am peak		Daily trips		JTW in am peak	
	total daily trips	% of total trips	ave trip length (km)	km change	ave trip time (mins)	mins change	total daily trips	% of total trips	ave trip length (km)	km change	total daily trips	% of total trips	ave trip length (km)	km change
1	227,146	75%	10.9		19.2		49,898	17%	19.0		24,721	8%	2.8	
2	225,369	75%	10.6	-0.3	17.6	-1.6	51,302	17%	19.0	-0.0	25,072	8%	2.7	-0.0
3	227,146	75%	10.9	0	21.7	2.5	49,898	17%	19.0	0	24,721	8%	2.8	0
4	230,119	76%	9.8	-1.1	16.7	-2.5	41,363	14%	14.9	-4.1	31,091	10%	2.4	-0.4
5	227,655	75%	11.0	0.0	26.9	7.7	50,196	17%	17.9	-1.1	25,007	8%	2.6	-0.2
6	223,829	74%	11.1	0.2	20.8	1.6	54,606	18%	20.8	1.8	23,263	8%	2.7	-0.1

Table 4.11a: Average Car Travel Time & Distance, 2026

SCEN-ARIO	Car in am peak							
	ave trip length (km)	km change	ave trip time (mins)	mins change	ave road ntwrk spd (kph)	kph change	congested motor vehicle hours	% change
1	8.9		14.6		36.5		22,350	
2	8.7	-0.2	13.3	-1.3	38.5	2.0	18,732	-16%
3	8.9	0.0	16.2	1.6	32.3	-4.2	28,615	28%
4	8.5	-0.4	13.6	-1.0	37.0	0.5	19,696	-12%
5	9.0	0.1	19.3	4.7	27.5	-9.0	37,868	69%
6	8.9	0.0	15.3	0.7	35.0	-1.5	23,790	6%

Table 4.11b: Average Public Transport & Active Modes Travel Time & Distance, 2026

SCEN-ARIO	Public Transport in am peak						Active Modes in am peak	
	ave trip length (km)	km change	ave trip time (mins)	mins change	ave PT ntwrk spd (kph)	kph change	ave trip length (km)	km change
1	16.9		22.5		38.7		4.4	
2	16.9	0.0	23.1	0.5	37.5	-1.2	4.3	-0.1
3	16.9	0.0	22.5	0.0	37.5	-1.2	4.4	0.0
4	14.6	-2.3	21.1	-1.4	36.8	-1.9	4.0	-0.4
5	16.9	-0.0	22.0	-0.5	40.1	1.4	4.2	-0.2
6	18.5	1.6	23.2	0.6	42.5	3.8	4.3	-0.0

Table 4.12: Annual Environmental Costs, 2026

SCEN-ARIO	Annual Fuel Consumption						Annual Emissions					
	petrol M litres	M litres change	% change	diesel M litres	M litres change	% change	CO tonnes	tonnes change	% change	CO2 tonnes	tonnes change	% change
1	329			322			13,669			1,607,000		
2	325	-4	-1%	322	0	0%	13,640	-29	-0.2%	1,597,000	-10,000	-1%
3	337	8	2%	324	2	1%	14,156	487	4%	1,632,000	25,000	2%
4	338	9	3%	314	-8	-2%	13,820	151	1%	1,606,000	-1,000	-0.1%
5	354	25	8%	318	-4	-1%	14,548	879	6%	1,654,000	47,000	3%
6	332	3	1%	316	-6	-2%	13,699	30	0.2%	1,597,000	-10,000	-1%

Table 4.13: Economic Costs, 2026

SCEN-ARIO	Congestion						System Economic Cost					
	annual cost $M	$M change	% change	cost in am peak $	$ change	% change	annual cost $M	$M change	% change	$ per PKT in am peak	$ change	% change
1	1,032			701,344			2,867			0.57		
2	1,035	2.7	0%	650,714	-50,630	-7%	2,859	-7.8	0%	0.55	-0.02	-3%
3	1,131	100	10%	815,796	114,452	16%	3,047	180	6%	0.64	0.07	12%
4	1,117	85	8%	666,812	-34,532	-5%	3,016	148	5%	0.58	0.01	2%
5	1,222	190	18%	933,304	231,960	33%	3,230	363	13%	0.70	0.13	23%
6	1,029	-2.9	0%	716,173	14,829	2%	2,858	-8.9	0%	0.57	-0.00	0%

Scenario 1: Status Quo

The Status Quo is a policy intervention in its own right, and so its performance is compared with the other five scenarios.

If total daily trips (Table 4.7) are an indication of mobility then this scenario provides a high level. However, it has the highest number of car trips at 1.56 million per day, lowest number of trips by active modes, and the second lowest amount of public transport trips of all the scenarios. Given the Status Quo has a transport network designed specifically to meet the needs of the region's current growth and travel patterns, it's not surprising that it has the highest number of daily trips by car into the CBD (Table 4.8) and the third lowest figure for congested motor vehicle hours, at 35 percent of total hours travelled in the morning peak (Table 4.11a). The average road network speed of 36.5 kph in the morning peak compares favourably with the other scenarios, but the Wellington region doesn't look so good when compared with Stockholm's and San Francisco's average road speeds of 43kph (Newman and Kenworthy, 1999).

Economically, the Status Quo performs moderately well (but then the designers of the RLTS projects would expect this); sitting in the middle of the six scenarios with an annual congestion cost of $1.03 billion and a system economic cost per PKT of 57 cents (Table 4.13). It is also an environmentally 'unremarkable' option compared with the other scenarios; its fuel consumption and emission levels are the third lowest (Table 4.12). What lets this scenario down in the environmental stakes is its poor uptake of public transport and active modes when compared with the other five scenarios.

<u>Scenario 2: Status Quo but 2004 Transport Network</u>

Differences in daily trip data are relatively insignificant between Scenario 2 and the Status Quo. Public transport and active modes both increase by over 2,000 trips at the expense of car trips (Table 4.7), however this is not sufficient to alter mode split. The number of trips within the CBD (Table 4.9) increase one percent, with the majority in public transport trips. A three percent increase in public transport use offsets a two percent drop in car and a one percent decrease in active modes for trips into the CBD (Table 4.8). Mode split for daily journey to work (JTW) trips (Table 4.10) doesn't alter, however a drop of 1,800 car trips is absorbed by public transport (1,400) and active modes (350).

Along with a drop in total trips, total person kilometres travelled (PKT) by car in the morning peak decreases, resulting in the average trip length falling by just under a third of a kilometre (Table 4.11a). Whilst the decrease in total trips is small, it is enough to increase the average road network speed by 2 kph on the Status Quo speed of 36.5 kph. Congested motor vehicle hours in the morning peak remains at almost a third of the total travel time, despite a drop of 16 percent, as total hours travelled have also fallen. The average public transport trip length doesn't change (Table 4.11b), however it is taking almost a minute longer to complete in the morning peak. This is due to the high proportion of trips on buses in the CBD (Figure 4.10), where the number of car trips has increased thereby slowing down the average public transport network speed by 1.2 kph.

Figure 4.10: Courtenay Place Bus Interchange
source: (Greater Wellington Regional Council Transport Division, 2004)

Not surprisingly, the decrease in total daily trips by car converts into a small (one percent) annual drop in petrol consumption of 4 million litres with corresponding 0.2 and one percent decreases in carbon monoxide (CO) and carbon dioxide (CO_2) emissions respectively (Table 4.12). The annual cost of congestion rises $2.7 million, while the annual system economic cost falls slightly ($7.8 million) to $2.8 billion – equating to a drop of two cents per PKT in the morning peak (Table 4.13).

This scenario is based on a business as usual situation in that the transport network is as it was in 2004 and population growth follows the prevalent trends at that time too. The overall increase in public transport patronage and decrease in car use, particularly for trips of longer duration (into the CBD and JTW), is due to the WTSM rematching trip origins and destinations to reduce travel time and distance.

In reality the reduction in congested motor vehicle hours and associated costs would probably represent a change in short-term equilibrium and would be unlikely to continue as, given people's propensity for car use, there would be a move away from public transport and active modes until congestion returns it equilibrium level. That said, on the face of these results, Scenario 2 does appear to be the most appealing if seeking an economically and environmentally efficient policy direction.

Scenario 3: RLTS Trip Distribution & Mode Choice on 2004 Transport Network

Scenario 3 uses trip distribution and mode choice results from the Status Quo, and therefore has the same daily trip results as seen in Tables 4.7 to 4.10. However, because these results are modelled on the 2004 transport network the WTSM reassigns trips to longer routes to avoid congestion on the shorter / usual routes (assignment of vehicles to routes is based on a time / distance relationship where one can offset the other to create a nil net effect). This results in different travel time and distance for the same number of trips as the Status Quo, and is seen in the additional 9,300 PKT and 6,500 hours travelled by car in the morning peak (Appendix 9).

As a result of this trip redistribution the marginal increase in average trip length (up 0.4 km on the Status Quo) takes almost two minutes longer to travel (Table 4.11a), and the average road network speed falls over four kph to 32.3kph. Congested motor vehicle hours are up 28 percent, and comprise 41 percent of total travel time by car in the morning peak. Active mode trips are also redistributed in this scenario, resulting in an increase in the total distance travelled and trip time (Appendix 9).

A large proportion of public transport trips are by bus, and as bus routes don't change to avoid congested conditions the drop in road network speed also affects them: Although the average public transport trip length and time remain unchanged, the network speed falls 1.2 kph (Table 4.11b). This is faster that the road network speed due to the inclusion of the unaffected rail speeds in the calculation.

The increase in kilometres travelled and congested motor vehicle hours result in an additional $100 million in annual congestion costs and $180 million in system economic costs (Table 4.13). The system economic cost per person kilometre travelled in the morning peak rises 12 percent to 64 cents.

Scenario 3 illustrates the impact of 2026 trip data on the transport network if it remains as it is in 2004. While assuming that people don't change their modes of transport, this scenario demonstrates the increased frustration of motorists as they travel alternate routes to avoid congestion on the main roads in the network.

Scenario 4: Wellington CBD

The densification of population in Wellington CBD results in decreases in daily trips of 12,000 by car and 5,900 by public transport and an increase of over 23,000 trips by active modes, equating to a one percent mode shift from car to active modes (Table 4.7). Not surprisingly the number of daily trips into the CBD (Table 4.8) falls (six percent) as people now live closer to work and the amenities they use, however, a drop of 11,000 car trips isn't enough to alter its mode share of 67 percent. A 13,400 decrease in public transport trips into the CBD and a 7,600 increase in active modes results in a four percent mode shift from the former to active modes when compared with the Status Quo, and again reflects the proximity of residences to amenities (Figure 4.11).

Figure 4.11: Cuba Mall Residential over Retail

source: (Chapman, 2004b)

The number of trips within the CBD (Table 4.9) rise 42 percent to 269,000, with a 159 percent increase in public transport patronage. This increase is spread across all modes and, interestingly, results in a mode shift of three percent from active modes to car and one percent to public transport. Active modes comprise 48 percent of all trips within the CBD, with car trips at 50 percent and public transport two percent. The impact of the increase of 79,000 trips each day within the CBD is seen in an overall increase of 5,500 daily trips over the Status Quo.

The locating of the population closer to CBD employment results in a 26 percent increase in JTW trips (Table 4.10) by active modes, one percent increase in car and 17 percent decrease in public transport daily JTW trips. Car remains the dominant mode for these trips at 76 percent, but active modes rise to 10 percent at the expense of public transport. The average JTW trip length by car falls one kilometre to 9.8 km, and is 2.5 minutes faster. Average JTW trips by public transport and active modes fall four and 0.4 km respectively.

As people are located closer to amenities in Scenario 4 the total travel time and distance are both around seven percent lower than the Status Quo (Appendix 9). The time spent travelling in congested conditions (Table 4.11a) drops by 12 percent but remains one third of the total hours spent travelling in the morning peak. The fall in the number of trips and distance travelled results in a slight increase in the average road network speed to 37 kph. The small drop in average trip length and the one minute decrease in average travel time can be attributed to the redistribution of 44,400 trips to within the CDB – thereby improving the travel time for longer distance trips, and consequently the average road network speed. However, the average public transport speed (Table 4.11b) falls by almost two kph, most likely due to the large rise in patronage (probably on buses within the CBD) combined with the more congested traffic conditions within the CBD due to the large increase in daily trips there.

Annual fuel consumption and the resulting transport emissions increase one percent (Table 4.12), while the annual congestion cost increases $85 million and system economic cost increases $148 million – the latter equating to only one cent more per PKT in the morning peak (Table 4.13).

Overall, this scenario provides the greatest improvement in regional mobility and accessibility as it has the largest increase in total daily trips along with the biggest decreases in time and distance travelled for all modes when compared with the other five scenarios. However, the 42 percent increase in trips within the CBD, specifically the 50 percent increase in car trips, and eight percent rise in annual congestion costs confirm the findings of other researchers that urban densification can increase congestion in spite of higher uptake of public transport and active modes (Business Transportation and Housing Agency and California Department of Transportation, 2002a, Taylor, 2004).

Scenario 5: Big Three

Like Scenario 4, this scenario has a one percent mode shift from car to active modes, however the total number of daily trips (Table 4.7) is the lowest of all scenarios at 5,300 below the Status Quo. The concentration of regional population growth around the Lower Hutt, Porirua and Wellington central areas has a similar, but less marked, impact on trips into and within the CBD (Tables 4.8 and 4.9) as Scenario 4, with a three percent drop and 13 percent increase in these trips respectively. Car trips into the CBD fall 6,900 and public transport trips drop 1,600 while active modes increase by 300. Daily trips within the CBD see a one percent increase in the mode share of both car and public transport at the expense of active modes.

The increase in the number of daily trips by active modes and public transport and the fall in car trips suggest that people are seeking employment and undertaking activities in the sub-centres they now reside in, and that active modes and public transport have become more convenient transport options in this scenario than in the Status Quo situation.

A marginal increase in total PKT (Appendix 9) offsets the small drop in daily car trips and results in the average trip length (Table 4.11a) increasing from 8.9 to 9.0 kilometres: When combined with the 29 percent rise in total travel time the average car trip takes almost five minutes longer to complete. This reduces the average road network speed by 9 kph to 27.5 kph, and increases the hours spent in congested conditions to almost half the total travel time in the morning peak. The most likely explanation for this is a combination of the 16 percent and 45 percent increases in car and public transport trips within the CBD (Figure 4.12), combined with the need for Porirua residents to travel out of their city to work and to undertake other activities: The almost doubling of Porirua's population at the expense of all other sub-centres probably causes an increase in intra-regional travel, but origin-destination data are needed to confirm this assumption.

Environmentally (Table 4.12), this scenario is the worst performer with annual fuel consumption up 21 million litres, and annual CO and CO2 emissions rising 879 and 47,000 tonnes respectively. Not surprisingly the economic costs (Table 4.13) associated with Scenario 5 rise considerably: Congestion costs are up 18 percent to $1.2 billion, and rise 33 percent in the morning peak. The system economic cost in the morning peak is the highest of all scenarios at 70 cents per PKT – making it the least affordable for operators and travellers.

Figure 4.12: Wellington Bus Interchange
source: (Chapman, 2004b)

Scenario 5 performs very poorly compared with the Status Quo, and appears to be the worst option of all six scenarios. Fewer daily trips point to reduced mobility, whilst the low average road network speed and high proportion of travel time in congested conditions confirm that redistributing population without consideration of the location of employment and amenities creates an unsustainable transport situation. On the positive side, the increase in shorter public transport and active mode trips demonstrates that people change their travel behaviour if other mode choices become more convenient than their current mode of transport.

<u>Scenario 6: Densification Around Public Transport Nodes</u>

This land use intervention, not surprisingly, results in the greatest increase in public transport trips with 3,900 more than the Status Quo each day (Table 4.7). As with the other two land use interventions, the number of daily car trips falls and active mode trips increase, with the total number of daily trips across all modes 4,100 lower than the Status Quo.

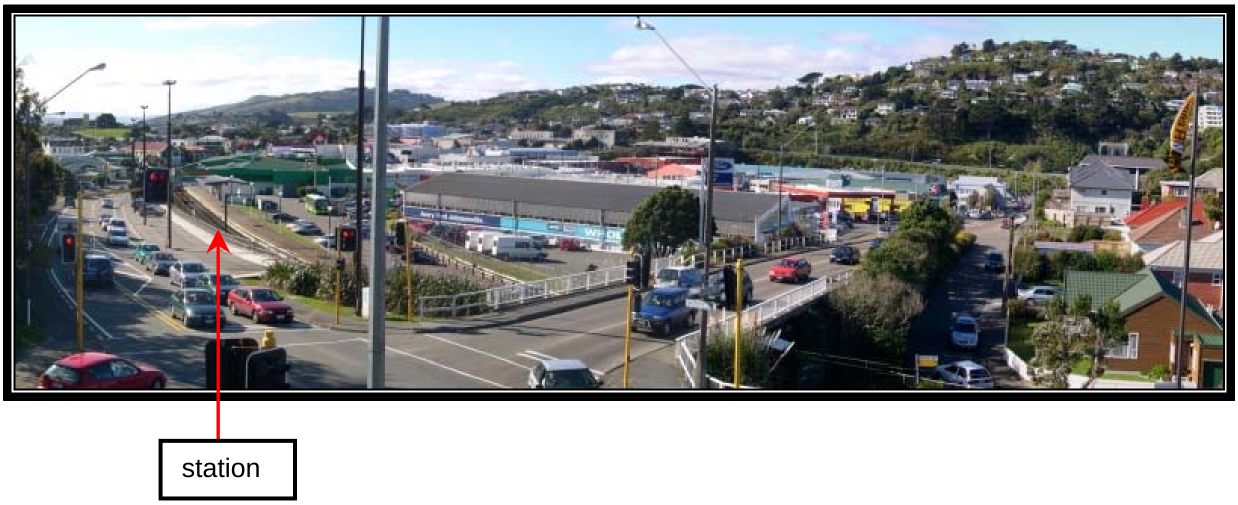
The densification of population around public transport nodes (Figures 4.7, 4.8, 4.9, 4.13, 4.14, 4.15, 4.16, 4.17, 4.18) results in public transport dominating mode split for trips into the CBD (Table 4.8) at 21 percent – an 11 percent increase. This is at the expense of trips by active modes, which fall eight percent making Scenario 6 the poorest performer for this mode. Journey to work trips (Table 4.10) follow the pattern seen in trips into the CBD: Public transport use increases nine percent to take a one percent movement in mode split from car trips. Active modes, while dropping six percent, don't lose any of their eight percent share of JTW trips. The average JTW trip length for both car and public transport increase, which isn't surprising given the high proportion of regional jobs in the CBD, and the increase in population in the sub-centres at the expense of Wellington City's population.

Figure 4.13: Waterloo Station & Park 'n' Ride
source: (Chapman, 2004b)

The number of daily trips within the CBD (Table 4.9) is the lowest of all the scenarios at 186,500, with public transport trips falling 13 percent and car and active mode trips down two and one percent respectively. The decrease in trips within the CBD may be offset by a comparable increase in trips within the sub-centres where the population has relocated, but origin-destination data are required to confirm this. There is no change in the mode split for trips within the CBD.

Figure 4.14: Taita Village Shops & Station *source: (Chapman, 2004b)*

Figure 4.15: Johnsonville Station & Urban Village *source: (Chapman, 2004b)*



An increase in total public transport distance travelled and travel time in the morning peak (Appendix 9) of 17 percent and 11 percent respectively equates to a 1.6 km increase in the average trip length to 18.5 km, taking an extra half a minute to complete (Table 4.11b). When considered with the increase in total daily trips it appears that more people are using public transport to travel longer distances – most likely by train given the average public transport network speed rises 3.8 kph to 42.5 kph while the average road network speed falls 1.5 kph on the Status Quo (Table 4.11a & Figure 4.16).

Figure 4.16: Paremata Station Park 'n' Ride, & SH1 Bottleneck
source: (Chapman, 2004b)

The redistribution of population out of Wellington City to key public transport nodes in the region's sub-centres has a negative effect on car travel time: While the number of car trips decreases across all trip types and the total PKT also falls marginally against the Status Quo, total travel time in the morning peak rises three percent resulting in a 40 seconds increase in average trip time (Table 4.11a), a 1.5 kph drop in the average road network speed and a six percent increase in congested motor vehicle hours. As is the case in Scenario 4, these findings support the view that densification is not necessarily linked with decreased congestion, however, origin-destination trip data would provide a more robust base on which to make such an assumption.

Annual fuel consumption (Table 4.12) falls 3 million litres as a result of the drop in total car trips. CO emissions increase marginally while CO2 emissions fall 10,000 tonnes. The annual cost of congestion falls only $2.9 million, while the cost of congestion during the morning peak rises two percent to $716,000. System economic cost in the morning peak is 57 cents – the same as in the Status Quo (Table 4.13).

Figure 4.17: Linden Station
source: (Chapman, 2004b)

Scenario 6 compares favourably with the Status Quo: By redistributing the population around existing public transport nodes this scenario has increased peoples' accessibility between the sub-centres. It has better environmental sustainability and economic efficiency (on an annual basis) and less people are using their cars in favour of public transport, particularly for longer trips and trips at peak times. However, those remaining in motor vehicles experience a higher level of congestion. This scenario also results in fewer trips by active modes, despite people residing near public transport nodes that all have other facilities within walking distance.

4.5 COMPARISON OF SCENARIOS 1 & 6 TRIPS BY ORIGIN – DESTINATION

The data reviewed in the preceding comparative analysis provides a useful indication of the likely impact of various transport and land use interventions on travel patterns. However, it doesn't provide any insight into the number of trips and the mode chosen for trips between and within sub-centres. Such information is particularly important when assessing the potential effect of land use policy interventions, as it can highlight new areas of congestion and requirements for changes in transport infrastructure. The following comparison of Status Quo and Scenario 6 origin-destination data for daily trips between the five territorial authorities is undertaken in order to gain a better understanding of the relationship between a land use intervention and the transport system. Scenario 6 is selected as it incorporates the RLTS projects, and of the three land use interventions it redistributes the population in the most realistic manner given the growth trends prevalent in 2004. This analysis excludes trips between each TA and Wairarapa and other regions as these areas are not directly affected by any of the interventions in this research.

Tables 4.14a and 4.14b break down total daily trips for both scenarios, showing the number of trips between and within each TA by mode. Total trips by all modes within Wellington City fall eight percent, but this is expected given the WCC population in Scenario 6 is 13 percent lower than in the Status Quo. Comparing Scenario 6 with the Status Quo confirms the earlier supposition that the redistribution of population from Wellington City to the sub-centres results in an increase in the number of trips by active modes within each sub-centre (in this case 17 percent) that more than offsets the fall in active mode trips in the CBD (refer Table 4.9). So while the earlier analysis shows Scenario 6 to be a poor performer with regard to the uptake of active modes, these results establish otherwise.

The view that densification can lead to increased congestion is also confirmed; the number of daily car trips within each sub-centre increases, in spite of the overall decrease in daily car trips across the metropolitan area (Tables 4.7, 4.14a & b). This increase in car trips on

Table 4.14a: Total Daily Trips by Origin-Destination: Status Quo

Table 4.14b: Total Daily Trips by Origin-Destination: Scenario 6

Table 4.15: Total Daily Trips from TA into Wellington City

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smaller inner city and suburban roads with lower maximum speed limits than the motorway is the most likely cause of the 1.5kph drop in the average road network speed (Table 4.11a).

Public transport patronage within each TA is either static (in Lower Hutt and Upper Hutt) or decreasing (Porirua, Kapiti and Wellington), but rises considerably for trips into Wellington City (Figure 4.18). Table 4.15 verifies this with a 30 percent increase in such trips; accounting for the 3.8kph rise in average public transport network speed (Table 4.11b) – as the majority of these trips will be by train, and confirming earlier assumptions.

Figure 4.18: Wellington Railway Station
source: (Chapman, 2004b)

Obtaining detailed origin-destination data proves how misleading high-level analysis can be: Tables 4.8 & 4.9 both detail two percent drops in the number of daily car trips into and within the CBD, while Table 4.15 shows an 18 percent increase in trips into Wellington City from the sub-centres and an eight percent decrease in trips within Wellington City. Planning decisions relating to the transport network based on the initial analysis might discount the need for improvements to Wellington's urban motorway on the grounds of a decrease in car use, however the detailed origin-destination data in Table 4.15 contradicts this decision – even allowing for the difference in destinations – the CBD (Appendix 10) is only part of Wellington City – the point of this example is valid.

In summary, the more detailed comparative analysis of Scenario 6 with the Status Quo enabled by origin-destination data validates the assumptions made in the earlier analysis, and confirms conclusions such as public transport use rises for longer distance trips. Misleading data is clarified, for example the decrease in active mode trips is only in one city, without which accurate policy and planning decisions would not be possible.

4.6 TESTING THE SCENARIOS AGAINST THE RLTS

The data used to undertake the comparative analysis of the six scenarios is also of value in determining the ability of the scenarios to meet the vision of the *Regional Land Transport Strategy*. Table 4.16 details the RLTS attributes that apply to each performance indicator, and ranks the six scenarios against each other according to their ability to meet the RLTS attributes, and therefore its vision.

Scenario 2 appears to be the best performer with the lowest overall score of 73. It provides the greatest accessibility and network efficiency for car travel in that it reduces the average trip length, increases the road network speed, and decreases the time spent travelling in congested conditions. Because of this it is also the most environmentally sustainable option with regard to reducing transport emissions. Accessibility provided by, and the network efficiency of, public transport are also well met with increases in mode share and in the use of public transport for longer trips particularly into the CBD and journey to work trips. While it

Table 4.16: Allocation of Performance Indicators to RLTS Attributes & Ordinal Ranking of Scenarios by Performance Indicator

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ranks second for active modes, Scenario 2 really only provides improved accessibility for trips within the CBD and in its ability to increase the share of journey to work trips by active modes. This scenario meets the economic efficiency and personal affordability attributes with the lowest system economic cost per person kilometre travelled, but its ability to provide economic efficiency through reduced congestion costs is only moderate.

Scenario 6, densification around public transport nodes, is ranked second in overall ability to meet the RLTS attributes. Its increased use of public transport without a drop in the network speed results in the best accessibility and network efficiency rankings, except for trips within the CBD where it is the poorest performer. This scenario appears to rank the worst for active modes, although it provides a moderate level of personal affordability with a ranking of third for its ability to increase this mode's share of all daily trips. The origin-destination trip analysis for Scenario 6 is not included in Table 4.16, and therefore does not improve its active modes ranking against the other scenarios. Accessibility and network efficiency are well met through this scenario's reduction in car mode share, although its ability to decrease average trip length and congested motor vehicle hours is only moderate. Environmental sustainability, economic efficiency and personal affordability are all high.

The Status Quo ranks third in meeting the RLTS vision; however, it is only a moderate performer in all areas making it a safe bet to improve the transport network, but not to any exceptional level.

Scenario 3's improved accessibility and network efficiency for active modes, due to an increase in average trip length, is an anomaly: This scenario has such an increase because the WTSM redistributes trips to avoid congestion – congestion that is unlikely on footpaths and for cyclists given the number of trips is the same as the Status Quo. When compared with the Status Quo, Scenario 3's poor results confirms that the projects listed for completion in the RLTS (Appendix 6) will make a positive impact on the transport network, and therefore on regional mobility, accessibility and economic and environmental efficiency.

Scenarios 3, 4 and 5 all perform poorly in their overall ability to provide the RLTS Attributes. Congestion increases in all three; on the motorways and main routes in Scenario 3, and within built up areas in the latter two scenarios due to the redistribution of population around key sub-centres. This congestion reduces accessibility and environmental sustainability, working against the excellent mobility and environmental sustainability Scenario 4 provides through its increase in total daily trips and decrease in the distance people are travelling. All three scenarios also have poor economic efficiency, as this attribute is associated with high congestion.

4.7 SUMMARY

Scenario 1, the Status Quo encompasses a transport network specifically 'designed' for it, incorporating road and public transport projects translated from the RLTS objectives, themes and policies and derived from considerable technical analysis (Wellington Regional Council, 1999). These projects are designed to meet regional transport needs based on the anticipated population and employment growth and locations, and for this reason the Status Quo performs moderately well. However, as a policy intervention it is somewhat reactive as it follows the traditional 'predict and provide' transport planning model (Mees, 2000) by continuing to meet anticipated needs without introducing any method of breaking the automobile dependence cycle. Continuing with this policy direction will result in more of the same: Low-density development primarily supported by roads.

Scenario 2 is modelled to determine the impact of a ‘do nothing’ approach: The 2004 transport network is applied to growth patterns prevalent in that year. Although it appears to be the best performing scenario, this is due to the WTSM redistributing trips based on their cost. Therefore, based on the assumption people make rational long-term decisions on their residential, recreational, shopping and employment locations, the origin and destination of trips in Scenario 2 are matched to minimise distance travelled, travel time and cost. The success of this trip matching is evident in the high average road network speed, low PKT, emissions and economic costs. However, as people don’t always act rationally, and because Wellington’s regional growth is slow (but not static or declining), this scenario’s business as usual approach simply delays the inevitable environmental, economic and social costs demonstrated in Scenario 3. For this reason Scenario 2 is not considered the most suitable intervention to meet the RLTS vision.

Scenario 3 is a combination of the first two scenarios in that it incorporates the prevalent growth patterns, but applies the Status Quo trip patterns to the 2004 transport network – i.e. it doesn’t rematch the origin and destination of trips to avoid high travel costs, distances and time. Thus, it demonstrates what would happen on the transport network if the RLTS projects weren’t implemented but people still lived, worked, shopped and exercised as predicted in the Status Quo, and confirms that transport or land use changes are necessary to avoid the problems demonstrated in this scenario. For this reason it’s not surprising that Scenario 3 performs poorly for car and public transport modes, and has high environmental and economic costs. Scenario 3 is not a sustainable transport solution; it reinforces the benefits gained from the RLTS projects and confirms the Status Quo as the best transport policy intervention of the three modelled.

The results of Scenarios 4 to 6 also contain the RLTS projects, but these projects were not designed for the land use interventions they are applied to. These scenarios might perform better without the RLTS network being implemented, although given none of the projects are substantial changes this is unlikely. What is likely is that Scenarios 4 to 6 would better meet the RLTS attributes if transport network improvements specific to their land use interventions are implemented.

Scenarios 4 and 5 demonstrate that a planning solution can be unsustainable if all land use and transport factors aren't considered together: In these scenarios the population is redistributed to a very few locations, resulting in adverse effects on various parts of the transport network as large numbers of people travel further (Scenario 5), or share a confined road network (Scenario 4), to get to work and leisure activities. This increases congestion and decreases accessibility, network and economic efficiency, network and user affordability and environmental sustainability making both these scenarios unsustainable options.

Population distribution was the only land use mechanism to be altered in Scenario 6, but its redistribution to 10 key sub-centres along the region's two transport corridors minimises the negative effects on the transport network seen in Scenario 5. It also revitalises the cities of Upper and Lower Hutt: Trends established in section 4.3.1 reveal slow to declining population growth in these cities, which is turned around in Scenario 6.

Scenario 6 fulfils the aim of the *New Zealand Transport Strategy* by making more efficient use of existing resources (Ministry of Transport, 2002) with an overall increase in public transport patronage, a decrease in car use during the morning peak and an increase in active mode trips within all territorial authorities except Wellington City. The increase in total passenger kilometres travelled is all on public transport so isn't as environmentally unsustainable as it first appears. This scenario suffers from the same congestion problems experienced in the other two land use interventions: More people are travelling to activities within their residential environment resulting in shorter trips with slower travel times, mostly undertaken by car. However, the effect on economic and environmental sustainability is negligible.

All of the six scenarios would most likely benefit from the redistribution of employment and leisure activities to match the population projections, and origin-destination data for each would enable a greater level of analysis than undertaken in this research. However, based on the data analysed (and even ignoring the origin-destination analysis of Scenario 6 in section 4.5) Scenario 6 best meets the *Regional Land Transport Strategy* vision and attributes by providing the most sustainable and balanced transport solution of the scenarios as they are modelled.

Figure 4.19: Wellington City from the Northern Suburbs

source: (Chapman, 2004b)

CHAPTER FIVE: CONCLUSION & RECOMMENDATIONS

This research tests the relationship between transport and land use in the Wellington region in 2026 by analysing the impact of six transport and land use scenarios on the transport network. It identifies the land use policy intervention of densification around key public transport nodes (Scenario 6) as the optimal solution (of the scenarios tested) to provide a balanced and sustainable transport system for the Wellington region – thereby meeting the vision of the *Regional Land Transport Strategy*.

The analysis process undertaken in Chapter Four actually identified Scenario 2 as the best performing policy intervention. Its lower average trip length, higher average road network speed and lower person kilometres travelled, than those achieved by the other five scenarios, provide a high level of accessibility and network efficiency for car travel, and results in good environmental and economic sustainability.

Scenario 2 demonstrates that the Wellington region would most likely cope with its current land use and transport patterns, probably because of the slow predicted growth rate, but its 'do nothing' approach falls down in its lack of provision for social and environmental issues considered relevant to integrated planning systems and now included in the RLTS. For example, Upper Hutt's declining population and employment will result in increasing fixed infrastructure costs for those remaining, while the population boom on the Kapiti Coast will place further strain on an already critical water supply situation, and continue to choke the road network at existing bottlenecks. Scenario 2 is a reasonable transport intervention but it delays the inevitable environmental, economic and social costs demonstrated in Scenario 3 with its inability to provide the holistic approach necessary to classify it as a sustainable transport solution.

Scenario 6 is preferred over Scenario 2 as it incorporates a number of objectives of sustainable transport and Smart Growth (COM, 2000, Fleissig *et al.*, 2002, Smart Growth America):

- Enhanced accessibility and mobility are provided through the repositioning of Wellington's metropolitan population around key transport nodes within walking distance of local shops or shopping malls, thereby giving people a greater choice of transport modes
- Reduced car use and fewer greenfield developments improve environmental sustainability
- Social balance and participation are enhanced by focusing new housing within existing developments
- Economic efficiency is improved through increased patronage on existing public transport infrastructure

In meeting sustainable transport objectives this scenario confirms the co-dependence of transport and land use planning. However, by focusing only on land use changes, Scenario 6 also demonstrates the negative side of this relationship through its increased congestion in the newly densified areas. This reinforces that no one intervention is entirely successful, rather an integrated approach incorporating transport and land use planning mechanisms is required if a truly sustainable transport solution is sought; one that provides a foundation to which further planning mechanisms can be added without impacting negatively on parts or all of the system.

This is demonstrated in the cities studied in Sections 2.4 and 2.5, and Greater Wellington can draw on similarities it has with Stockholm and San Francisco when considering the mechanisms required to successfully implement Scenario 6: Both these cities have established rail systems feeding strong central cores that contain a high percentage of employment, and neither has tried to interfere with this. They have positioned residential, commercial, industrial and retail growth in mixed-use developments around key transport nodes to improve mode choice and split and enhance the sustainability of the transport system. Wellington could do this with any new growth rather than trying to reposition existing businesses, and following Stockholm's model and Smart Growth principles it can improve inter-community transport flows (Cervero, 1998, Fleissig *et al.*, 2002) by building on the existing strengths of each sub-centre.

Johnsonville, Lower Hutt and Petone already have comprehensive retail centres with supermarkets, boutique and chain clothing and homeware stores, restaurants and automobile outlets and service centres. As the closest sub-centres to the CBD, with excellent public transport services, there is strong potential to further develop the existing commercial centres too. A level of self-containment can be achieved in each of these sub-centres by positioning offices and / or apartments on top of the existing low-rise retail centres.

Paraparaumu, on the Kapiti Coast, and Porirua have 'big box' retail developments with car parks covering more land than the buildings they're supporting. Porirua has a tertiary education facility, aquatic centre, library and cultural centre positioned beside the retail development, and it is encouraging national retailers to establish distribution centres in the disused car assembly plant on the hill overlooking this area. Both these sub-centres are experiencing moderate levels of low-density residential growth at present with some new suburbs up to 10 kilometres away from their civic centres. To offset this 'sprawl' the retail rooftops could be developed, as recommended for Johnsonville, Lower Hutt and Petone, to bring the residents to the facilities and within walking distance of the public transport nodes.

Upper Hutt and Petone, on the same transport corridor, have long-standing industrial areas, with the latter's containing underutilised rail yards adjacent to an operational wharf. The ability to maximise the potential of these facilities exists, when Wellington City redevelops it port into a (London) Docklands-style area, through the establishment of an inland port in Upper Hutt's industrial area. As both Upper Hutt and Petone are on the same railway line the movement of goods from the inland port to Petone wharf could be via this transport mode.

Taita and Linden are residential suburbs (the former with a small light industrial area) positioned midway between Wellington and Upper Hutt / Paraparaumu on their respective transport corridors. They both have neighbourhood shops adjacent to railway stations. Tawa, one stop up from Linden, would be a better node to develop as it has a retail centre and other public amenities beside the railway station, giving it potential as an urban village. Taita would benefit from revitalisation through the introduction of mixed density housing including provision for improvements to the existing affordable housing stock. Paremata station services a large low-density residential area as a park / kiss 'n' ride node. As it is constrained by State Highway 1, hills and Porirua harbour it is best left as this type of transport node.

Wellington City is the Capital of Aotearoa / New Zealand and the business, civic and social core of the region. It is also the primary transport hub for the lower North Island: A small international airport is located in the southern suburbs, and the Port of Wellington, adjacent to the business district, handles export products, cruise ships and local and interisland ferry services. The CBD is a compact area currently experiencing enormous growth in high-density residential development. This could be slowed in favour of sub-centre development without a negative impact on the CBD – as demonstrated by Scenario 6.

Adopting this development approach, within a regional strategy, is prudent given the region's slow predicted economic growth rate when compared with the national figure, as it maintains the CBD but also revitalises older suburbs and creates safer, liveable communities with greater connections within and between the sub-centres. Furthermore, this approach will enhance rather than replace the existing transport network, which already supports the sub-centres as they currently function.

In order to increase density and land uses around key public transport nodes the Wellington region's territorial authorities should draw on the experiences of other cities, and consider which of the planning mechanisms identified in this research best suit it. Factors to account for include the current legislative and planning environment, desired economic development, predicted population and economic growth, the social and cultural needs of residents and the means of financing the desired integrated planning system. Such an exercise is a logical progression of this research and would provide the region's decision makers with a comprehensive mix of land use, transport, financial and regulatory planning mechanisms to drive development to meet the optimal sustainable transport solution.

As discovered by BART's planners, the building of a transport network doesn't necessarily result in increased patronage. A similar outcome is possible in the Wellington region if higher density housing in mixed-use sub-centres is adopted as proposed in Scenario 6. How and why people would change their housing and travel preferences is a prudent investigation to follow this research, and would help avoid costly mistakes in the implementation of Scenario 6.

The main limitation of this study, from a research and policy perspective, is the transport modelling system (WTSM) used by Greater Wellington: The research is dependent on the WTSM, and policy decisions may be made based on this research. However, the inability of the WTSM to forecast traffic accidents associated with each scenario results in a gap in information on which regional policy is developed around the critical RLTS objectives of network and safety and security. The determination of each scenario's impact on safety and security would be an important addition to this research, thereby providing a broader base on which policy may be developed.

Through the analysis of a variety of transport and land use interventions this research confirms other academics' findings that an integrated planning approach provides a more sustainable transport solution than interventions from only one policy discipline. The densification around public transport nodes demonstrates how a small city supporting a dispersed regional population can use an existing transport system as a skeleton on which to design a more sustainable region. In applying existing research to such a small city (by international standards) these findings add value to that research, and could be used to help create a framework for the analysis of similar small metropolitan areas grappling with transport sustainability.

APPENDIX 1

INTEGRATED TRANSPORT-LAND USE PLANNING BACKGROUND INVESTIGATION POINTS FOR DISCUSSION WITH WAITAKERE CITY COUNCIL STAFF

Planning Mechanisms

<u>Land Use</u>

- Zoning for -mixed use
-higher density
- Urban Growth Boundary
- Transit-oriented development
- Pedestrian-friendly design
- Greenfield developments
- Brownfield developments / infill
- Affordable housing projects
- Public / private partnerships
- Subsidies / incentives to encourage specific types of development
- Location efficient mortgage
- Council provision of infrastructure, e.g.; increased storm water capacity for high density in brownfields, child care facilities beside transport hubs

<u>Transport</u>

- Transit-oriented development
- Parking constraints -physical
-financial
- Congestion pricing
- Teleworking
- Public transport provision and type
- New roads
- Provision for non-motorised transport modes
- Traffic restraints -calming
-financial

<u>Queries relating to the above mechanisms</u>

- Have any of the above mechanisms been employed yet in Waitakere?
- Yes = which ones? No = why not?
- Are any of these mechanisms to be introduced in the future (to meet Waitakere's LTCCP &/or the ARGS)?
- Are there any other land use-transport planning mechanisms that have been (will be) introduced in Waitakere?
- Have you drawn on any overseas models, and why?

- In implementing these mechanisms, what is/was the overall goal being sought?
- What process did you use to determine which mechanisms would be the most effective?
- How have these mechanisms been introduced? i.e. what tools have been used? (charette, unilateral decision making)
- How have the various integrated planning initiatives been “sold” to the ratepayers?
- What is the level of uptake?
- How do you measure the success of the initiatives? e.g. mode shift, changes in VKT, population and employment growth within the new developments.
- Explain the level and type of integration between policy disciplines / council departments that has occurred / will occur.
- How have you influenced developers in the adoption of new mechanisms? e.g.; development subsidies, tax abatement.
- What sort of barriers, if any, existed between policy disciplines within WCC prior to establishing any integrated planning initiatives?
- How were they overcome?
- How do you plan to increase patronage on public transport?
- Have any financial mechanisms been introduced? If so, which ones and what for?
- What are the benefits and disadvantages of introducing integrated planning initiatives?
- What advice would you give other local and regional authorities looking to do the same?

Existing Legislation and Regulations

Discussions relating to the ARGS are to determine the effectiveness of a regional approach to integrated planning. It is recognised that the ARGS is in its infancy so measurement data may not be of use yet.

<u>Auckland Regional Growth Strategy: 2050</u>

- How will the Growth Concept be implemented given existing legislation?
- Will legislation have to change? How?
- The ARGS seems to be based on principles of “smart growth”: Were these principles familiar to / in use in Waitakere City Council (WCC) prior to the development of the ARGS?
- If not, how has the Growth Concept been “sold” to Councillors, staff, businesses and residents?
- How well has it been received?
- How did the ARGF determine where to place specific employment zones, infill, future residential etc?
- What sort of barriers existed to gaining consensus among the local authorities in order to establish the ARGS?
- How were these barriers overcome?
- What are the benefits and disadvantages of adopting a Regional approach to urban sustainability?

District Plan & Long Term Council Community Plan

- What is the “relationship” between the WCC District Plan (DP) and the Growth Concept, i.e. is the DP required to be “not inconsistent with” the latter?
- Has/will the DP had/have to be modified to meet the proposals in the Growth Concept?
- How / in what way?
- Are the ARGS, Local Government Act 2002 (LGA) and (RMA) DP aligned to enable WCC to meet its growth projections?
- Is the District Plan proposed or operative?

Susan Chapman
Master of Environmental Studies Student
Victoria University of Wellington

APPENDIX 2

NOTES FROM DISCUSSION WITH A GROUP MANAGER, WAITAKERE CITY COUNCIL

2 December 2003

Transport
Waitakere City Council (WCC) favours light rail (LRT) as a transport solution, however as Auckland City favours buses it wouldn't support LRT running into the centre of the CBD. This made LRT within Waitakere and from Waitakere to the CBD uneconomic, so it was given up in favour of improvements in the existing regional electric heavy rail (DMUs) system. The type of rail system – DMUs/EMUs or LRT, needs to be supported in the Auckland Regional Land Transport Strategy (RLTS) and the Auckland Regional Growth Strategy (ARGS) (existing RLTS supports light rail) as mechanisms set in the RLTS have to be consistent with the ARGS. A problem with heavy rail is it separates the community on either side of the rail corridor, and potentially makes it more difficult to provide for a cycle corridor running parallel to the track like LRT can.

Auckland's public transport system is in crisis at present. The DMUs are full during the morning and evening commutes, and there are no bus feeder services to the rail stations – there is no point creating this integration until the rail services are increased and reliability is improved. ARC hasn't yet had the resources to study how feeder services would operate.

The recent change in how and what Transfund funds, in line with the NZ Transport Strategy, has made it much easier for local authorities to obtain funding for public transport over roading projects. This fits very well with Waitakere's Eco City philosophy.

WCC's transport platform is consistent with the ARGS. It has a lobbying role to the ARC regarding regional transport solutions, but it is responsible for creating local transport solutions to support the regional strategy e.g. safe walkways to stations, and the education of end users to encourage them to adopt alternative forms of transport to the motor vehicle.

Future transport within Waitakere includes double track to Swanson (the 10 year plan) and buses to Kumeu and Helensville. High occupancy vehicle (HOV) lanes are to be introduced once the shoulder bus lanes on the highways are completed. WCC is behind the rest of the region, particularly NSCC, on bus lane creation, but has made a start. WCC receives a lot of suggestions for transport infrastructure improvements through consulting with stakeholders, and has a large network of community groups who it consults with.

School and tertiary students make up 40 percent of all public transport trips within the region, so these users are a priority for using alternatives to the car. WCC intends to work with schools (two pilot studies are currently underway), universities and businesses to change travel behaviour. It has been identifying the barriers to changing travel habits that the public encounter, for example businesses require funding to provide bike lockers and racks.

Approximately 80 percent of all public transport trips in Auckland region are by bus, 15 percent by rail, and five percent by ferry.

The council is investigating altering the parking requirements for new buildings currently specified in the District Plan. Currently all parking in Waitakere is free, but WCC is about to start a trial by charging for parking on two existing car parks on council-owned land. The local mall owner is not happy about this, but is likely to also start charging by introducing discounted parking for shoppers who provide a receipt for purchases from retailers within the mall.

Traffic calming has been introduced in town centres and within newer residential areas like Harbour View. Vehicle slow zones have been established around schools. Other TDM mechanisms like toll roads or congestion pricing (the council would support the latter) are regional or national decisions. WCC is working with the other authorities comprising Auckland region to lobby central government for financial assistance to ease the traffic problem: An announcement, most likely increasing the fuel tax, is expected on 12 December 2003.

Land Use

WCC is now encouraging development in the town centres along the rail corridor by attracting investment into the town centres. The District Plan has been altered to permit mixed use in town centres, and smaller lot sizes to encourage infill development. There is a greater demand for higher density residential; to a maximum of three stories, within town centres, but not above retail (this is taking off in Auckland City). WCC does not use financial incentives, but undertakes public/private partnerships to establish more sustainable developments on council owned land through its property development company. An improvement in the public transport system is needed to justify these development efforts around transport nodes. WCC has started collecting data on changes in housing and commercial development around transport nodes, but there is not yet enough data to provide a valid and useful trend analysis.

WCC has teamed up with UNITEC to share the costs of a new city library and large car park to be developed on council land in Henderson. The council is also making some land available to UNITEC so it can expand its campus. Another development will include a new civic centre, station complex, and rail over bridge to connect Henderson where the rail corridor currently divides it.

Integrated Planning

European cities traditionally had a central city core, which they now want to protect, whereas North American cities have developed in a more dispersed manner. Auckland is like the latter, so WCC studied and uses the Portland, Oregon model for integration between transport and land use: This is where the support for light rail came from.

A regional approach is a valuable mechanism for enabling integrated planning between the various local authorities.

The various policy groups within WCC work closely, with a lot of cross-council teams for various developments. This results in initiatives being challenged to consider different perspectives, and wider issues are incorporated, for example roading projects are no longer being assessed using only Transfund New Zealand's benefit-cost (BC) analysis.

WCC undertakes quadruple bottom-line reporting; social, economic, environmental and cultural. All councillors are mindful of this, and of the nine platforms incorporated in the LTCCP. The public is very aware of environmental issues and supportive of the Eco City approach.

50 percent of Waitakere's work force travels out of the city each day, while only 25 percent of workers in local businesses travel into Waitakere. The major component missing in the plans for Waitakere is economic development, although local employment will rise if the Hobsonville/Whenuapai industrial zone goes ahead. The more money spent developing the public transport system the more likely it is that workers will continue to commute out of Waitakere each day to work in other cities in the region. It is essential that local employment is encouraged and a passenger transport system planned to meet local travel as well as travel outside Waitakere City.

APPENDIX 3

NOTES FROM DISCUSSION WITH CATHY KENKEL. GROUP MANAGER: STRATEGIC PLANNING & POLICY, WAITAKERE CITY COUNCIL

2 December 2003

Legislation
Northern and Western Sector Agreements, established by Rodney District Council (RDC), Waitakere City Council (WCC) and North Shore City Council (NSCC), sit under the Auckland Regional Growth Strategy (ARGS). These sub-regional agreements detail the agreed plan and associated strategies for growth, transport, environment, open space areas, air quality etc for the next 20 years. The projected population growth in Waitakere over this period is 50,000 people.

The lack of a National Policy Statement for land use planning makes sustainable urban development difficult for councils, especially as the RMA is not really seen as a tool to manage such development. However, the Sustainable Development Programme for Action is very helpful. As the funding structure and delivery mechanisms of Transfund follow a free market model it is hard for local authorities to implement the transport strategies they want to, especially public transport. Even roading solutions can be difficult to establish, for example roundabouts are 50% funded but traffic lights have no Transfund funding. The former are not pedestrian friendly, while traffic lights are as they reduce the amount of road to be crossed.

The LGA 2002 sets up creative tension for councils between listening to the community and acting in a leadership role –refer to s3 (c) and (d). LTCCPs are about prioritising for connectivity.

WCC does not undertake reactive planning: It has a vision and goals and works from there on how to achieve them. Charettes are used for all major stakeholder consultations. They work well to bring all the different perspectives together at the same time. This avoids trade-offs and results in a win-win situation. The WCC District Plan was a “forerunner” to the ARGS for WCC, as the DP already included an urban growth boundary, TOD and transport nodes.

Mixed Use
Integrated planning is successful if all the pieces of the puzzle fit together. Mixed use is required to make public transport work (i.e.; to become “attractive”/convenient to the public), then political will is required to maintain these mechanisms, and decision-making in the design process to encourage a behaviour change in the public. Parts of the WCC District Plan don’t work well together to create or support mixed use; e.g. the car-parking requirement in the central city doesn’t match with resource requirements.

Developers in NZ tend to specialise in one area, for example commercial, industrial or residential, so getting them to understand and buy into the concept of mixed use is pretty difficult. Australian counterparts have said, based on their own experience, that mixed use is too difficult to implement so councils should look to have developments built for adaptability. This enables changes in use more readily after the building is completed.

The rules on body corporates in the Unit Titles Act is not conducive to good urban living in that the developer chooses the body corporate, and any rule change requires 100% agreement by all the owners. WCC raised this anomaly with Parliament who is now looking at making changes to the Act.

Existing Higher Density Developments
Ambrico Place, New Lynn was a brownfield site – a brick pit and kiln. The changes to New Lynn, including the Ambrico Pl development came about as a result of a charette in 1996. Refer to *The New New Lynn* booklet. Big development firms weren't interested in Ambrico Place; smaller developers took a punt on it. This was the council's first higher density development, so there are things that WCC would do differently in future

Land use and transport patterns in Te Atatu, Titirangi, New Lynn, Glen Eden and Swanson have all had intensive design exercises

WCC provide a development fee waiver for water recycling initiatives

Harbour View, while not being close to a public transport node, was successful in so far as it:

- ♦ convinced developers that the public wanted this type of development
- ♦ provides safer walking through traffic calming
- ♦ has a wetland with open access
- ♦ provides greenways
- ♦ has revitalised the local shops

Other
There aren't really any disadvantages to integrated planning. It is hard to undertake, as it requires a change in mindset by all stakeholders. There is a need to change cultural and emotional resilience at all levels.

Malmo, Sweden is an excellent example of a sustainable city. It has green buildings, greywater recycling, PV cells, and green roofs.

Place making can alter people's actions, as it makes an area nicer to walk in / through.

APPENDIX 4

GREATER WELLINGTON TRANSPORT - LAND USE POLICY INTERVENTION SCENARIOS

Base Data: 2001 data form the base on which the scenarios are modelled. Data are sourced from Statistics New Zealand 2001 Census, WTSM, and the Regional Travel Survey.

Scenario 1 – Status Quo: Growth in the region is allocated according to the prevalent underlying trends that exist in the region. The transport network incorporates projects listed in the RLTS as per Appendix 6. A full four-stage model run is completed.

Scenario 2 – Status Quo Excluding RLTS Projects:
Growth in the region is allocated according to the prevalent underlying trends that exist in the region. The transport network is as at 2004. A full four-stage model run is completed.

Scenario 3 – Trip Distribution & Mode Choice from RLTS, 2004 Transport Network:
Growth in the region is allocated according to the prevalent underlying trends that exist in the region. The transport network is as at 2004. Trip distribution and mode choice are as per the results of Scenario 1 - Status Quo.

Scenario 4 – Focus on Wellington CBD:
Regional growth is concentrated in and around the Wellington City central area. The transport network incorporates RLTS projects.

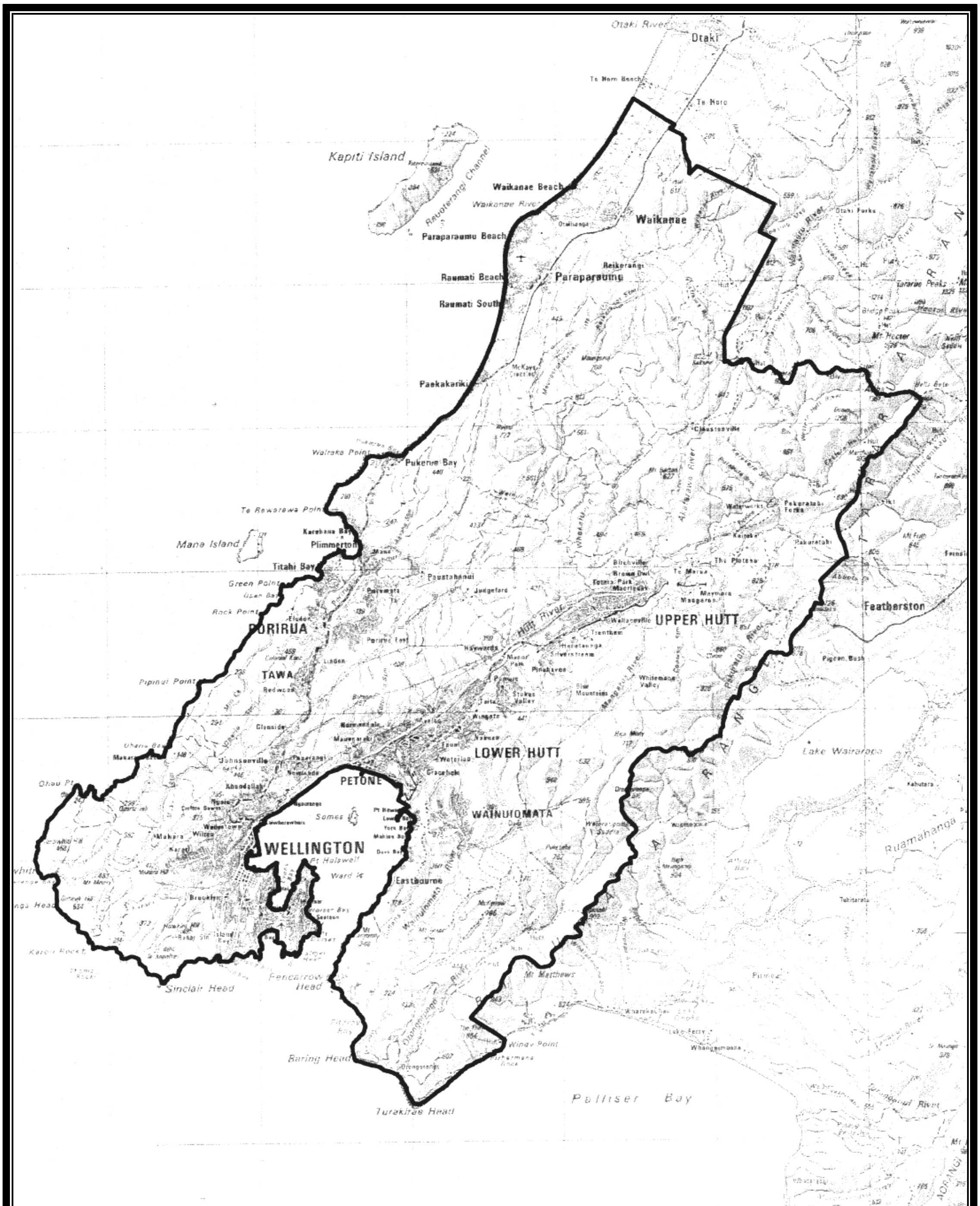
Scenario 5 – Big Three: Regional growth is distributed in and around the Wellington, Lower Hutt and Porirua central areas. The transport network incorporates RLTS projects.

Scenario 6 – Densification around PT Nodes:
Regional growth is distributed around the key public transport nodes of Wellington, Petone, Waterloo, Taita, Upper Hutt, Linden, Porirua, Paremata, Paraparaumu and Johnsonville railway stations. The transport network incorporates RLTS projects.

GWRC recognises these policy interventions are only indicative of policy directions in the real world.

APPENDIX 5

WELLINGTON METROPOLITAN AREA



APPENDIX 6

REGIONAL LAND TRANSPORT STRATEGY PROJECTS

Future Year Road Projects

Project	**2004**	**2026**
Paremata Bridge Duplication	Y	Y
Plimmerton to Mana Stage 2	Y	Y
Lindale Grade Separation	-	-
Kaitoke to Te Marua Realignment	-	Y
Inner City Bypass Stage 2	N	Y
Western Link Road – Stage 1	N	Y
Western Link Road – Stage 2	N	Y
Rimutaka Corner Easing (Muldoon’s)	N	-
Dowse to Petone	N	Y
MacKay’s Crossing Overbridge	N	Y
Melling Interchange	N	Y
SH2/58 Grade Separation	N	Y
Tawa Interchange	N	-
Basin Reserve Interchange	N	Y
ATMS Expansion	N	Y
Hayward’s – SH2 to Summit 4 laning	N	Y
Ngauranga – Aotea 8 laning/Tidal flow	N	Y
Wellington inner-city traffic management	N	-
Featherston – Masterton passing lanes	N	-
Upgrade Adelaide Rd (Basin – John St)	N	Y
Petone-Ngauranga (HOT lane)	N	Y
Rimutaka corner easing	N	-
Paekakariki Interchange	N	-
SH1 upgrade Waikanae - Paraparaumu	N	-
SH1 upgrade Otaki - Te Horo	N	-

Key: Y = part of, and has an effect on, the transport network
- = part of the transport network but has no effect on it (within the WTSM model)
N = not yet part of the transport network

Future Year Public Transport Projects

Project	**2004**	**2026**
Real time information for buses	N	-
Park and ride improvements	N	-
Integrated ticketing	N	-
Porirua Bus/Rail interchange	N	Y
Adelaide Rd Bus Lane	Y	Y
Kaiwharawhara Rd Bus Lane	Y	Y
Karori Rd Bus Lane	Y	Y
New station at Raumati	N	Y
Electrification to Waikanae (incl Lindale Station)	N	Y
Johnsonville line tunnel lowering	N	-
Johnsonville line – passing loop	N	-
Station upgrades (including new stations at Cruickshank and Timberlea)	N	Y
Rolling stock – English Electric refurbishment	N	-
Rolling stock – additional units	N	Y
Rolling stock – Wairarapa trains refurbishment	N	-
Rolling stock – Ganz Mavag refurbishment	N	-
Rolling stock – British Rail conversion	N	-

Key: Y = part of, and has an effect on, the transport network
- = part of the transport network but has no effect on it (within the WTSM model)
N = not yet part of the transport network

(Row, 2004b)

APPENDIX 7

WELLINGTON TRANSPORT STRATEGY MODEL

Greater Wellington Regional Council operates a multimodal transport model to evaluate integrated transport packages within the Wellington region. The Wellington Transport Strategy Model (WTSM) is based on Emme/2, a transportation-modelling package used by over 645 government and private organisations worldwide. WTSM is a four-stage model (trip generation, trip distribution, mode choice and assignment) so is well suited to evaluating roading and public transport options.

WTSM models three time periods on an average weekday, the AM (7-9am) and PM (4-6pm) peak periods, along with the inter-peak period (9am-4pm). The model splits the Wellington region into 225 internal and 3 external transport zones for the generation, distribution and assignment of trips (Figure 1). The modelled network includes all major roads in the region, with greater detail within regional CBDs, and all public transport (rail, bus, cable car and ferry) services (Figure 2)

The latest version of WTSM was developed jointly by Beca Carter Hollings & Ferner and SKM Australia between 2001 and 2003. This allowed the latest demographic information on the region from the 2001 Census to be used as a base, detailing population, household and employment distribution. Specific additional information for sub-model development and validation included:

- Household Travel Survey (2,500 households, 7,000 people, 36,000 trips)
- Other Surveys: Rail (5,100 people), School (3,900 students), External Screenline (7,200 people)
- Road screenline traffic counts
- Public Transport boarding and screenline counts
- Bus speed and car travel time surveys

The development process and finished version of WTSM has been peer reviewed by Arup Australia.

Evaluation of projects in future years uses demographic projections for 2016 and 2026 under Statistics NZ growth assumptions. (Row, 2004a).

Figure 1: WTSM Transport Zones and Major Roads

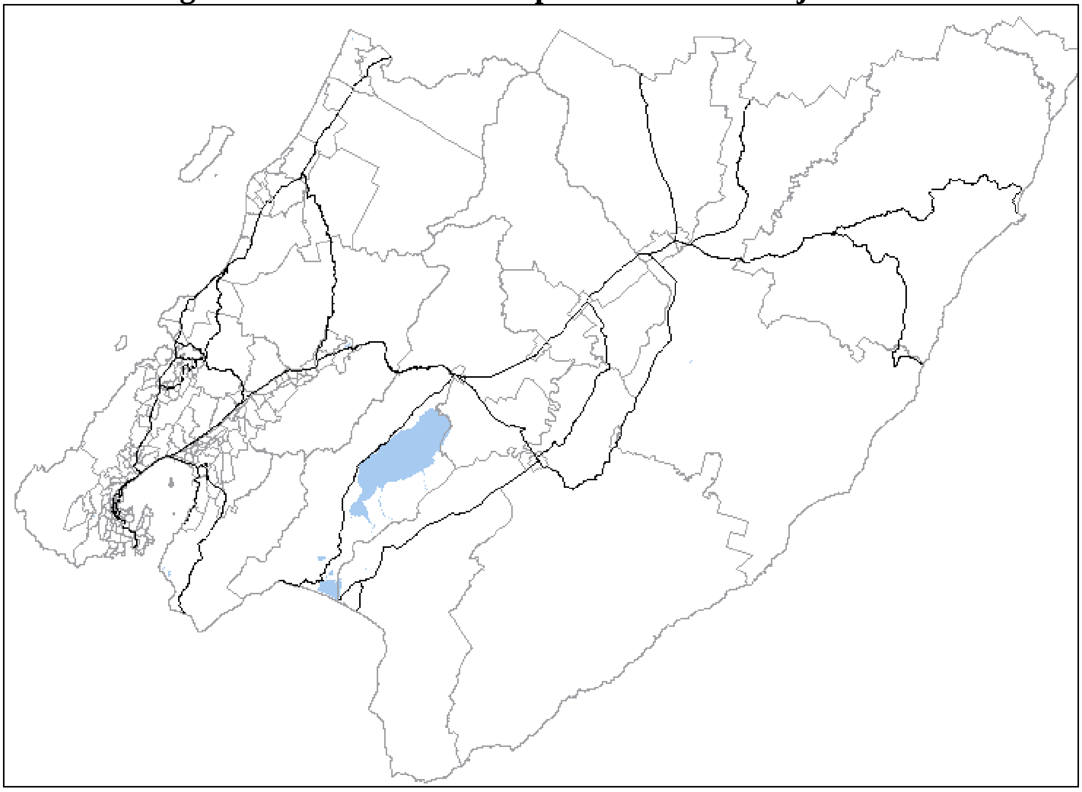
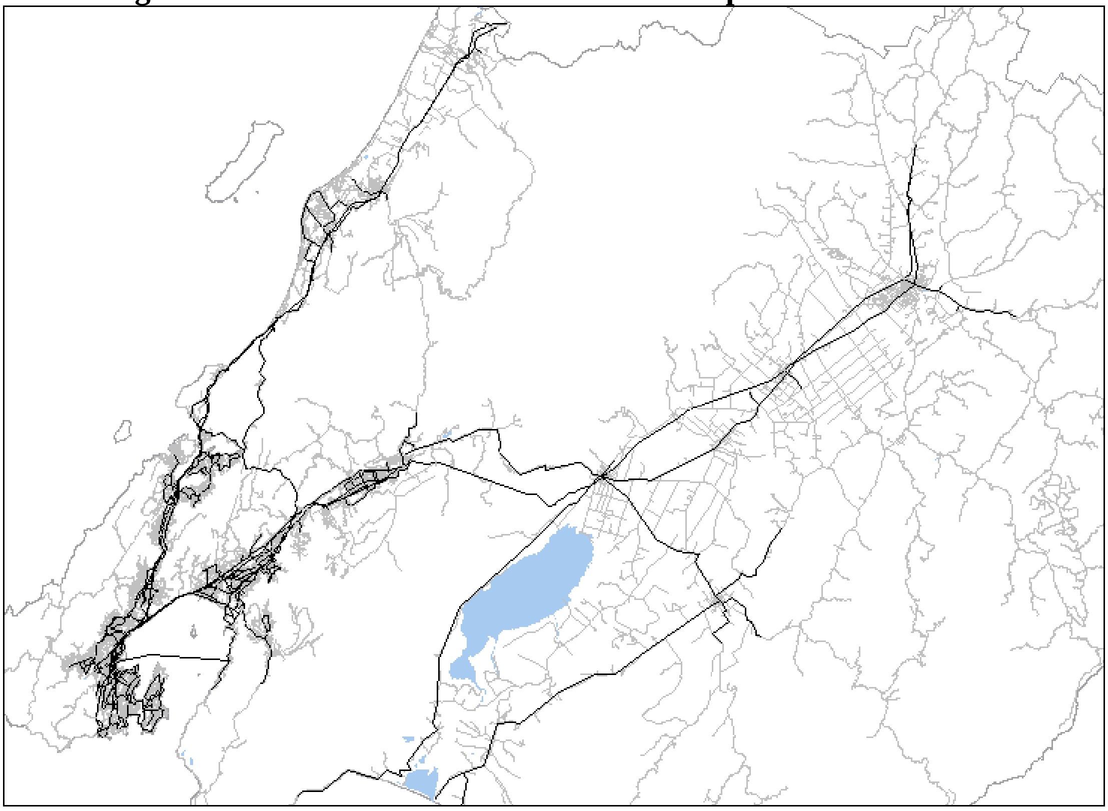


Figure 2: WTSM Road and Public Transport Network - 2001



APPENDIX 8

GREATER WELLINGTON SELECTED PERFORMANCE INDICATORS

INDI-CATOR No.	PERFORMANCE INDICATOR	UNIT OF MEASUREMENT
1	total metropolitan area	hectares
2	urbanised area by TA	hectares
3	average urban density by TA	households per ha
4	total population in urban area by TA	usually resident
5	total jobs in urban area by TA	number
6	total jobs in the CBD	number
7	total daily trips by mode	number
8	total daily JTW trips by mode	number
9	total daily trips into the CBD by mode	number
9a	total daily trips within the CBD by mode	number
10	total daily trips by mode in am peak	number
11	total VKT / PKT by mode in am peak	kilometres
11a	total JTW VKT / PKT by car in am peak	kilometres
12	total travel time by mode in am peak	hours
12a	total JTW travel time by car in am peak	hours
13	average trip length by mode in am peak	kilometres
14	average JTW trip length by mode in am peak	kilometres
15	average road network speed in am peak	km per hour
15	average PT speed in am peak	km per hour
16	average trip time by mode in am peak	minutes
16a	average JTW trip time by car in am peak	minutes
17	annual fuel consumption	million litres
18	annual transport CO emissions	tonnes
19	annual transport CO2 emissions	tonnes
20	congested motor vehicle hours (>/= VCR of 0.8)	hours
21	annual cost of congestion	Million NZD
21a	cost of congestion in am peak	NZD
22	annual system economic cost	Million NZD
22a	system economic cost in am peak	NZD
23	system economic cost per person km in am peak	NZD

APPENDIX 9

COMPARATIVE ANALYSIS OF GWRC SCENARIOS

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APPENDIX 10

WELLINGTON CENTRAL BUSINESS DISTRICT

218 hectares

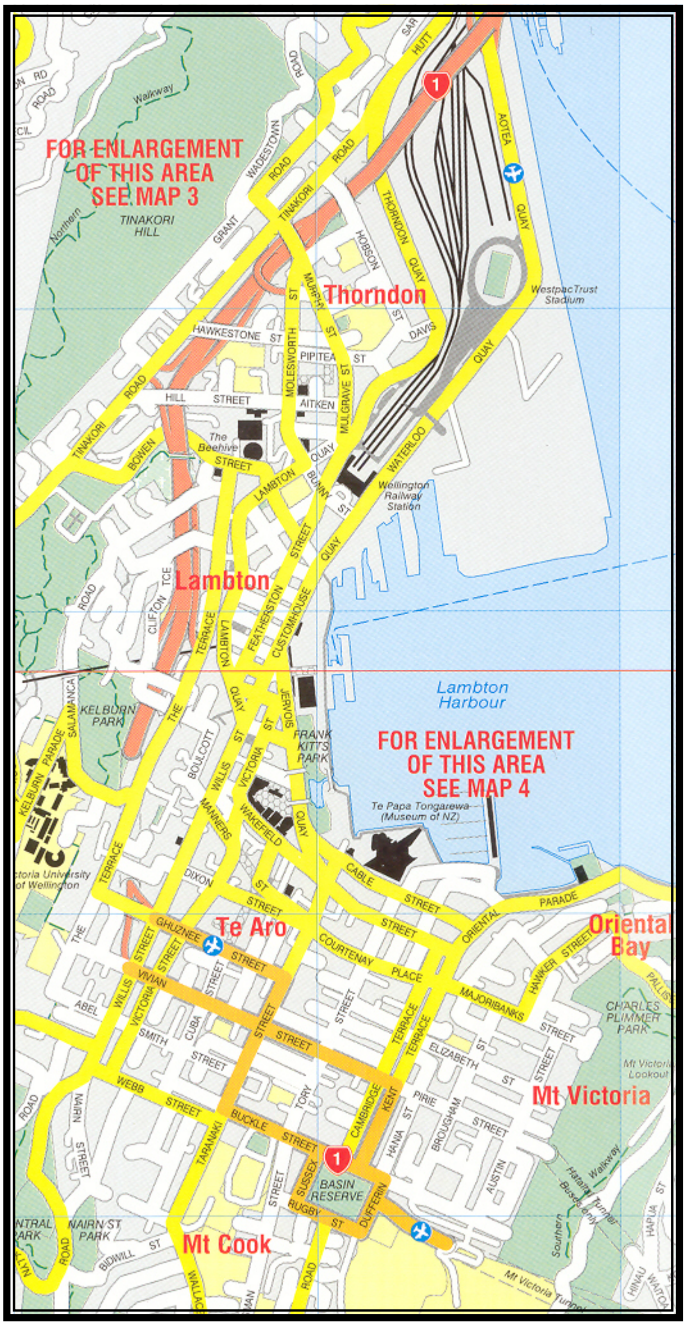

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Table 4.14a: Total Daily Trips by Origin-Destination
<u>Scenario 1: Status Quo</u>

destination:	KCDC				HCC				PCC				UHCC				WCC				TOTAL OUT OF TA			
origin	Car	PT	Active Modes	Total into KCDC	Car	PT	Active Modes	Total into HCC	Car	PT	Active Modes	Total into PCC	Car	PT	Active Modes	Total into UHCC	Car	PT	Active Modes	Total into WCC	Car	PT	Active Modes	ALL MODES
KCDC	157,594	4,832	46,924	209,350	1,832	202	0	2,034	2,493	267	1	2,761	1,082	42	0	1,124	6,367	4,539	0	10,906	169,369	9,881	46,924	**226,174**
PCC	9,430	1,023	1	10,454	8,521	339	0	8,860	97,040	3,200	22,560	122,800	4,572	70	0	4,642	28,196	7,660	86	35,942	147,759	12,293	22,647	**182,699**
WCC	5,488	675	0	6,163	30,948	2,336	64	33,348	15,500	974	207	16,681	6,204	419	0	6,623	621,525	51,680	171,340	844,545	679,665	56,085	171,611	**907,361**
HCC	3,665	239	0	3,904	238,250	8,512	48,941	295,703	5,716	145	0	5,861	13,078	732	62	13,872	49,546	11,518	49	61,113	310,254	21,145	49,052	**380,451**
UHCC	2,300	69	0	2,369	11,439	848	29	12,316	2,869	33	0	2,902	77,605	2,239	14,566	94,410	11,227	2,389	0	13,616	105,440	5,576	14,595	**125,611**
TOTAL	**178,479**	**6,837**	**46,925**	**232,241**	**290,990**	**12,237**	**49,034**	**352,261**	**123,619**	**4,618**	**22,767**	**151,004**	**102,540**	**3,502**	**14,628**	**120,670**	**716,860**	**77,786**	**171,475**	**966,121**	**1,412,487**	**104,980**	**304,829**	**1,822,296**

Table 4.14b: Total Daily Trips by Origin-Destination
<u>Scenario 6: Densify Around PT Nodes</u>

destination:	KCDC				HCC				PCC				UHCC				WCC				TOTAL OUT OF TA			
origin	Car	PT	Active Modes	Total into KCDC	Car	PT	Active Modes	Total into HCC	Car	PT	Active Modes	Total into PCC	Car	PT	Active Modes	Total into UHCC	Car	PT	Active Modes	Total into WCC	Car	PT	Active Modes	ALL MODES
KCDC	163,649	4,412	53,070	221,131	1,991	220	0	2,211	2,718	294	0	3,012	1,114	43	0	1,157	7,556	5,869	0	13,425	177,029	10,838	53,071	**240,938**
PCC	5,876	481	1	6,358	7,965	289	0	8,254	97,450	2,723	23,062	123,235	3,921	56	0	3,977	31,306	9,218	91	40,615	146,518	12,767	23,154	**182,439**
WCC	3,538	352	0	3,890	26,075	1,864	50	27,989	14,427	893	288	15,608	5,095	334	0	5,429	570,623	46,223	160,250	777,096	619,759	49,666	160,588	**830,013**
HCC	2,534	145	0	2,679	266,373	8,559	57,350	332,282	5,845	171	0	6,016	12,759	778	60	13,597	62,453	17,988	67	80,508	349,965	27,640	57,477	**435,082**
UHCC	1,653	47	0	1,700	12,426	911	33	13,370	3,110	45	0	3,155	84,648	2,303	17,008	103,959	14,408	4,223	0	18,631	116,244	7,528	17,041	**140,813**
TOTAL	**177,250**	**5,438**	**53,071**	**235,759**	**314,831**	**11,843**	**57,433**	**384,107**	**123,552**	**4,126**	**23,351**	**151,029**	**107,537**	**3,513**	**17,068**	**128,118**	**686,345**	**83,521**	**160,409**	**930,275**	**1,409,515**	**108,439**	**311,331**	**1,829,285**

Table 4.15: Total Daily Trips from TA into Wellington City

Mode by Scenario / origin	CAR INTO WCC						PUBLIC TRANSPORT INTO WCC						ACTIVE MODES INTO WCC						ALL MODES INTO WCC			
	Sc 1	% of total trips	Sc 6	% of total trips	total change	% change	Sc 1	% of total trips	Sc 6	% of total trips	total change	% change	Sc 1	% of total trips	Sc 6	% of total trips	total change	% change	Sc 1	Sc 6	total change	% change
KCDC	6,367	58%	7,556	56%	1,189	19%	4,539	42%	5,869	44%	1,330	29%	0	0.0%	0	0.0%	0	0%	10,906	13,425	2,519	23%
PCC	28,196	78%	31,306	77%	3,110	11%	7,660	21%	9,218	23%	1,558	20%	86	0.2%	91	0.2%	5	6%	35,942	40,615	4,673	13%
WCC	621,525	74%	570,623	73%	-50,902	-8%	51,680	6%	46,223	6%	-5,457	-11%	171,340	20%	160,250	21%	-11,090	-6%	844,545	777,096	-67,449	-8%
HCC	49,546	81%	62,453	78%	12,907	26%	11,518	19%	17,988	22%	6,470	56%	49	0.1%	67	0.1%	18	37%	61,113	80,508	19,395	32%
UHCC	11,227	82%	14,408	77%	3,181	28%	2,389	18%	4,223	23%	1,834	77%	0	0.0%	0	0.0%	0	0%	13,616	18,631	5,015	37%
TOTAL	**716,861**	**74%**	**686,346**	**74%**	**-30,515**	**-4%**	**77,786**	**8%**	**83,521**	**9%**	**5,735**	**7%**	**171,475**	**18%**	**160,408**	**17%**	**-11,067**	**-6%**	**966,122**	**930,275**	**-35,847**	**-4%**
Total ex WCC Trips	95,336	78%	115,723	76%	20,387	18%	26,106	21%	37,298	24%	11,192	30%	135	0.1%	158	0.1%	23	15%	121,577	153,179	31,602	26%

Table 4.16: Allocation of Performance Indicators to RLTS Attributes & Ordinal Ranking of Scenarios by Performance Indicator

PI no.	Performance Indicator	Aim of Indicator Result	RLTS Attribute	Ranking of Scenarios					
				1	2	3	4	5	6
	Car								
7	total daily trips	reduces car share of mode split	Accessibility	5=	4	5=	2	1	3
11	total PKT in am peak	reduces car share of PKT	Accessibility. Efficiency	3	2	4	6	5	1
20	congested motor vehicle hours	reduces time spent travelling in congested conditions	Accessibility. Environmental sustainability. Efficiency	3	1	5	2	6	4
13	average trip length	decreases, as homes should be closer to facilities	Accessibility. Efficiency	3=	2	5	1	6	3=
15	average road network speed	increases network speed	Accessibility. Efficiency	3	1	5	2	6	4
8	total trips JTW	increases mode shift from car to PT & AM	Accessibility	3=	2	3=	6	5	1
9	total trips into CBD	reduces car share of mode split	Accessibility. Efficiency	5=	3	5=	4	1	2
9a	total trips within CBD	reduces car share of mode split	Accessibility. Efficiency	2=	4	2=	6	5	1
17	annual fuel consumption	reduces fuel consumption	Environmental sustainability	3	1	5	4	6	2
18 & 19	annual transport emissions	reduces transport emissions	Environmental sustainability	3	1	5	4	6	2
			SUBTOTAL: CAR	**33**	**21**	**44**	**37**	**47**	**23**
	Public Transport (PT)								
7	total daily trips	increases PT share of mode split	Accessibility	4=	2	4=	6	3	1
11	total PKT in am peak	increases PT share of PKT	Accessibility. Efficiency	5	2	4	6	3	1
13	average trip length	increases as PT should be used for longer trips	Accessibility. Efficiency	3=	2	3=	6	5	1
15	average PT network speed	increases network speed	Accessibility. Efficiency	3	4=	4=	6	2	1
8	total trips JTW	increases mode shift from car to PT & AM	Accessibility	4=	2	4=	6	3	1
9	total trips into CBD	increases PT share of mode split	Accessibility. Efficiency	3=	2	3=	6	5	1
9a	total trips within CBD	increases PT share of mode split	Accessibility. Efficiency	4=	3	4=	1	2	6
			SUBTOTAL: PUBLIC TRANSPORT	**26**	**17**	**26**	**37**	**23**	**12**
	Active Modes (AM)								
7	total daily trips	increases AM share of mode split, ie AM used for more trips	Accessibility. Affordability	5=	4	5=	1	2	3
11	total PKT in am peak	increases AM share of mode split	Accessibility. Efficiency	2	4	1	6	5	3
13	average trip length	increases, as AM should be used for longer trips	Accessibility. Efficiency	5	2	1	4	3	6
8	total trips JTW	increases mode shift from car to PT & AM	Accessibility	4=	2	4=	1	3	6
9	total trips into CBD	increases AM share of mode split	Accessibility. Efficiency	3=	5	3=	1	2	6
9a	total trips within CBD	increases AM share of mode split	Accessibility. Efficiency	2=	1	2=	6	5	4
			SUBTOTAL: ACTIVE MODES	**21**	**18**	**16**	**19**	**20**	**28**
	All Modes								
7	total daily trips	increases trips	Mobility	2=	4	2=	1	6	5
11	total PKT in am peak	reduces total PKT by all modes in am peak	Environmental sustainability.	3	2	4	1	5	6
22	cost of congestion	reduces cost of congestion	Efficiency	2	3	5	4	6	1
22	system economic cost	reduces annual cost of running the transport system	Efficiency	3	2	5	4	6	1
23	system economic cost per PKT	reduces per person km cost of running trans system	Efficiency. Affordability	2=	1	5	4	6	2=
			SUBTOTAL: ALL MODES	**12**	**17**	**21**	**14**	**29**	**15**
			GRAND TOTAL: ALL MODES	**92**	**73**	**107**	**107**	**119**	**78**

RANKING SCALE: 1= best performer to 6= worst performer

RLTS ATTRIBUTES:

Accessibility
Mobility
Affordability (system & user)
Efficiency (economic & network)
Environmental sustainability

APPENDIX 9

COMPARATIVE ANALYSIS OF GWRC SCENARIOS

INDI-CATOR No.	PERFORMANCE INDICATOR	UNIT OF MEASURE-MENT	TRANSPORT INTERVENTIONS: BASE DATA 2001		1: STATUS QUO 2026		1: STATUS QUO Change on 2001		2: STATUS QUO but 2004 NETWORK 2026		2: Change on Status Quo		3: TRIP & MODE from RLTS BUT 2004 NETWORK 2026		3: Change on Status Quo	
			Result	% of Total	Result	% of Total	Total	% Change	Result	% of Total	Total	% Change	Result	% of Total	Total	% Change
1	total metropolitan area	hectares	164,180		164,180											
2	urbanised area by TA: KCDC	hectares	2,302	12%	2,302	12%	0	0%	no change				no change			
2	urbanised area by TA: PCC	hectares	2,394	13%	2,394	13%	0	0%	no change				no change			
2	urbanised area by TA: WCC	hectares	6,489	35%	6,489	35%	0	0%	no change				no change			
2	urbanised area by TA: HCC	hectares	5,007	27%	5,007	27%	0	0%	no change				no change			
2	urbanised area by TA: UHCC	hectares	2,302	12%	2,302	12%	0	0%	no change				no change			
2	**urbanised area: Region**	**hectares**	**18,494**		**18,494**		**0**	**0%**	**no change**				**no change**			
3	average urban density: KCDC	hshlds per ha	7.2		11.4		4.2	58%	no change				no change			
3	average urban density: PCC	hshlds per ha	6.1		8.0		1.9	31%	no change				no change			
3	average urban density: WCC	hshlds per ha	9.6		12.6		3.0	31%	no change				no change			
3	average urban density: HCC	hshlds per ha	6.9		8.1		1.2	17%	no change				no change			
3	average urban density: UHCC	hshlds per ha	5.5		6.1		0.6	11%	no change				no change			
3	**average urban density: Region**	**hshlds per ha**	**7.7**		**9.9**		**2**	**29%**	**no change**				**no change**			
4	total population in TA urban area: KCDC	usually resident	40,412	11%	59,714	13%	19,302	48%	no change				no change			
4	total population in TA urban area: PCC	usually resident	46,635	12%	53,093	12%	6,458	14%	no change				no change			
4	total population in TA urban area: WCC	usually resident	162,915	43%	202,407	45%	39,492	24%	no change				no change			
4	total population in TA urban area: HCC	usually resident	95,289	25%	102,025	23%	6,736	7%	no change				no change			
4	total population in TA urban area: UHCC	usually resident	34,451	9%	33,931	8%	-520	-2%	no change				no change			
4	**total population in urban area: Region**	**usually resident**	**379,702**		**451,170**		**71,468**	**19%**	**no change**				**no change**			
5	total jobs in TA urban area: KCDC	number	12,662	6%	17,666	8%	5,004	40%	no change				no change			
5	total jobs in TA urban area: PCC	number	12,831	7%	14,281	6%	1,450	11%	no change				no change			
5	total jobs in TA urban area: WCC	number	117,910	60%	136,930	61%	19,020	16%	no change				no change			
5	total jobs in TA urban area: HCC	number	40,735	21%	43,806	20%	3,071	8%	no change				no change			
5	total jobs in TA urban area: UHCC	number	11,245	6%	11,040	5%	-205	-2%	no change				no change			
5	**total jobs in urban area: Region**	**number**	**195,383**		**223,723**		**28,340**	**15%**	**no change**				**no change**			
6	total jobs in the CBD	number	68,470		80,886		12,416	18%	no change				no change			
7	total daily trips: car driver & pax	number	1,281,375	70%	1,555,930	71%	274,555	21%	1,550,811	71%	-5,119	-0.3%	1,555,930	71%	0.0	0.0%
7	total daily trips: PT	number	100,397	6%	109,219	5%	8,822	9%	111,227	5%	2,008	1.8%	109,219	5%	0.0	0.0%
7	total daily trips: active modes	number	442,355	24%	532,260	24%	89,905	20%	534,831	24%	2,571	0.5%	532,260	24%	0.0	0.0%
7	**total daily trips: all modes**	**number**	**1,824,127**		**2,197,409**		**373,282**	**20%**	**2,196,869**		**-540**	**0.0%**	**2,197,409**		**0.0**	**0.0%**
8	total daily JTW trips: car driver & pax	number	195,787	73%	227,146	75%	31,359	16%	225,369	75%	-1,777	-1%	227,146	75%	0.0	0.0%
8	total daily JTW trips: PT	number	45,443	17%	49,898	17%	4,455	10%	51,302	17%	1,404	3%	49,898	17%	0.0	0.0%
8	total daily JTW trips: active modes	number	25,549	10%	24,721	8%	-828	-3%	25,072	8%	351	1%	24,721	8%	0.0	0.0%
8	**total daily JTW trips: all modes**	**number**	**266,779**		**301,765**		**34,986**	**13%**	**301,743**		**-22**	**0%**	**301,765**		**0.0**	**0.0%**
9	total daily trips into CBD: car	number	142,038	66%	174,031	67%	31,993	23%	171,022	66%	-3,009	-2%	174,031	67%	0.0	0.0%
9	total daily trips into CBD: PT	number	43,852	20%	49,667	19%	5,815	13%	51,354	20%	1,687	3%	49,667	19%	0.0	0.0%
9	total daily trips into CBD: active modes	number	29,795	14%	36,043	14%	6,248	21%	35,703	14%	-340	-1%	36,043	14%	0.0	0.0%
9	**total daily trips into CBD: all modes**	**number**	**215,685**		**259,741**		**44,056**	**20%**	**258,079**		**-1,662**	**-1%**	**259,741**		**0.0**	**0.0%**
9a	total daily trips within CBD: car	number	68,604	46.7%	89,204	47%	20,600	30%	89,817	47%	613	0.7%	89,204	47%	0	0.0%
9a	total daily trips within CBD: PT	number	1,751	1.2%	2,315	1%	564	32%	2,401	1%	86	3.7%	2,315	1%	0	0.0%
9a	total daily trips within CBD: active modes	number	76,501	52.1%	98,518	52%	22,017	29%	99,308	52%	790	0.8%	98,518	52%	0	0.0%
9a	**total daily trips within CBD: all modes**	**number**	**146,856**		**190,037**		**43,181**	**29%**	**191,526**		**1,489**	**0.8%**	**190,037**		**0**	**0.0%**

APPENDIX 9

COMPARATIVE ANALYSIS OF GWRC SCENARIOS

INDI-CATOR No.	PERFORMANCE INDICATOR	UNIT OF MEASURE-MENT	TRANSPORT INTERVENTIONS													
			BASE DATA		1: STATUS QUO				2: STATUS QUO but 2004 NETWORK				3: TRIP & MODE from RLTS BUT 2004 NETWORK			
			2001		2026		Change on 2001		2026		Change on Status Quo		2026		Change on Status Quo	
			Result	% of Total	Result	% of Total	Total	% Change	Result	% of Total	Total	% Change	Result	% of Total	Total	% Change
10	total trips: car driver & pax in am peak	number	201,362	71.8%	261,644	75%	60,282	30%	259,811	74%	-1,833	-0.7%	261,644	75%	0.0	0.0%
10	total trips: PT in am peak	number	27,919	10.0%	30,713	9%	2,794	10%	31,346	9%	633	2.1%	30,713	9%	0.0	0.0%
10	total trips: active modes in am peak	number	51,219	18.3%	58,229	17%	7,010	14%	58,470	17%	241	0.4%	58,229	17%	0.0	0.0%
10	**total trips: all modes in am peak**	**number**	**280,500**		**350,586**		**70,086**	**25%**	**349,627**		**-959**	**-0.3%**	**350,586**		**0**	**0.0%**
11	total VKT by car in am peak	km	1,218,034		1,507,181		289,147	24%	1,452,256		-54,925	-4%	1,513,089		5,908	0.4%
11	total Person KT by car driver & pax in am peak	km	1,789,373	73%	2,328,709	75%	539,336	30%	2,258,156	74%	-70,553	-3%	2,338,002	75%	9,293	0.4%
11	total Person KT by PT pax in am peak	km	430,478	18%	519,314	17%	88,836	21%	530,684	17%	11,370	2%	519,458	17%	144	0.0%
11	total Person KT by active modes in am peak	km	229,134	9%	255,289	8%	26,155	11%	248,574	8%	-6,715	-3%	256,770	8%	1,481	0.6%
11	**total PKT in AM Peak**	**km**	**2,448,985**		**3,103,312**		**654,327**	**27%**	**3,037,414**		**-65,898**	**-2%**	**3,114,230**		10,918	0.4%
11a	total JTW VKT by car in am peak	km	615,338		731,738		116,400	19%	702,448		-29,290	-4%	733,928		2,190	0.3%
11a	total JTW Person KT by car in am peak	km	732,253		870,768		138,515	19%	835,913		-34,855	-4%	873,375		2,607	0.3%
12	total travel time by car in am peak	hours	25,447		41,910		16,463	65%	37,980		-3,931	-9%	46,532		4,622	11%
12	total travel time by car driver & pax in am peak	hours	36,923	37%	63,336	47%	26,413	72%	57,649	45%	-5,688	-9%	69,823	49%	6,486	10%
12	total travel time by PT pax in am peak	hours	17,835	18%	20,793	15%	2,958	17%	21,571	17%	778	4%	20,793	15%	0.0	0%
12	total travel time by active modes in am peak	hours	45,828	46%	51,060	38%	5,232	11%	49,716	39%	-1,344	-3%	51,354	36%	294.0	1%
12	**total travel time in am peak**	**hours**	**100,586**		**135,189**		**34,603**	**34%**	**128,935**		**-6,254**	**-5%**	**141,969**		**6,780**	**5%**
12a	total JTW travel time by car in am peak	hours	13,052		21,426		8,374	64%	19,410		-2,017	-9%	24,232		2,806	13%
12a	total JTW travel time by car pax in am peak	hours	15,532		25,497		9,965	64%	23,098		-2,400	-9%	28,837		3,339	13%
13	average trip length by car in am peak	km	8.89		8.90		0.01	0%	8.69		-0.2	-2%	8.94		0.0	0.4%
13	average trip length by PT in am peak	km	15.42		16.91		1.49	10%	16.93		0.0	0.1%	16.91		0.0	0.0%
13	average trip length by active modes in am peak	km	4.47		4.38		-0.09	-2%	4.25		-0.1	-3.0%	4.41		0.0	0.7%
14	average JTW trip length by car in am peak	km	11.00		10.91		-0.09	-1%	10.59		-0.3	-2.9%	10.94		0.0	0.3%
14	average JTW trip length by PT in am peak	km	17.30		19.04		1.74	10%	19.03		0.0	-0.1%	19.03		0.0	-0.1%
14	average JTW trip length by active modes in am peak	km	2.63		2.77		0.14	5%	2.73		0.0	-1.4%	2.76		0.0	-0.4%
15	average road network speed in am peak	km per hour	49.20		36.50		-12.70	-26%	38.50		2.0	5%	32.30		-4.2	-12%
15	average PT network speed in am peak	km per hour	40.00		38.70		-1.30	-3%	37.50		-1.2	-3%	37.50		-1.2	-3%
16	average time of a car trip in am peak	minutes	11.07		14.57		3.50	32%	13.32		-1.3	-9%	16.18		1.6	11%
16	average time of a PT trip in am peak inc walk etc	minutes	38.33		40.62		2.29	6%	41.29		0.7	2%	40.62		0.0	0%
16	average in-vehicle time of a PT trip in am peak	minutes	20.03		22.53		2.50	12%	23.05		0.5	2%	22.53		0.0	0%
16a	average time of a car JTW trip in am peak	minutes	13.99		19.16		5.17	37%	17.55		-1.6	-8%	21.67		2.5	13%
17	annual petrol consumption	million litres	300		329		29	10%	325		-4	-1%	337		8	2%
17	annual diesel consumption	million litres	142		322		180	127%	322		0	0%	324		2	1%
18	annual transport CO emissions	tonnes	27,315		13,669		-13,646	-50%	13,640		-29	0%	14,156		487	4%
19	annual transport CO2 emissions	tonnes	1,065,530		1,607,000		541,470	51%	1,597,000		-10,000	-1%	1,632,000		25,000	2%
20	congested motor vehicle hours (>/= VCR of 0.8)	hours	7,301.2		22,350.1		15,049	206%	18,731.9		-3,618	-16%	28,615.3		6,265	28%
21	annual cost of congestion	M NZD	617.06		1,031.85		414.8	67%	1,034.52		2.7	0%	1,131.48		99.6	10%
21a	cost of congestion in am peak	NZD	359,108		701,344		342,236	95%	650,714		-50,630	-7%	815,796		114,452	16%
22	annual system economic cost	M NZD	1,821.78		2,867.09		1,045.3	57%	2,859.27		-7.8	-0.3%	3,046.94		179.9	6%
22a	system economic cost in am peak	NZD	1,019,696		1,766,739		747,043	73%	1,671,794		-94,945	-5%	1,981,082		214,343	12%
23	system economic cost per person km in am peak	NZD	0.42		0.57		0.15	37%	0.55		-0.02	-3%	0.64		0.07	12%

APPENDIX 9

COMPARATIVE ANALYSIS OF GWRC SCENARIOS

INDI-CATOR No.	PERFORMANCE INDICATOR	UNIT OF MEASURE-MENT	LAND USE INTERVENTIONS											
			4: WGTN CBD				5: BIG THREE				6: DENSIFY AROUND PT			
			2026		Change on Status Quo		2026		Change on Status Quo		2026		Change on Status Quo	
			Result	% of Total	Total	% Change	Result	% of Total	Total	% Change	Result	% of Total	Total	% Change
1	total metropolitan area	hectares												
2	urbanised area by TA: KCDC	hectares	no change				no change				no change			
2	urbanised area by TA: PCC	hectares	no change				no change				no change			
2	urbanised area by TA: WCC	hectares	no change				no change				no change			
2	urbanised area by TA: HCC	hectares	no change				no change				no change			
2	urbanised area by TA: UHCC	hectares	no change				no change				no change			
2	**urbanised area: Region**	**hectares**	**no change**				**no change**				**no change**			
3	average urban density: KCDC	hshlds per ha	7.2		-4.2	-37%	7.2		-4.2	-37%	12.3		0.9	8%
3	average urban density: PCC	hshlds per ha	6.1		-1.9	-24%	16.5		8.5	107%	8.2		0.2	3%
3	average urban density: WCC	hshlds per ha	16.6		4.0	32%	12.0		-0.6	-5%	10.9		-1.7	-14%
3	average urban density: HCC	hshlds per ha	6.8		-1.3	-15%	7.8		-0.3	-3%	9.8		1.7	21%
3	average urban density: UHCC	hshlds per ha	5.2		-0.9	-15%	5.2		-0.9	-15%	7.4		1.3	21%
3	**average urban density: Region**	**hshlds per ha**	**10.1**		**0.2**	**2%**	**10.1**		**0.2**	**2%**	**10.1**		**0.2**	**2%**
4	total population in TA urban area: KCDC	usually resident	40,354	9%	-19,360	-32%	40,354	9%	-19,360	-32%	66,663	15%	6,949	12%
4	total population in TA urban area: PCC	usually resident	41,284	9%	-11,809	-22%	97,662	21%	44,569	84%	52,863	12%	-230	-0.4%
4	total population in TA urban area: WCC	usually resident	258,873	56%	56,466	28%	191,541	42%	-10,866	-5%	175,886	38%	-26,521	-13%
4	total population in TA urban area: HCC	usually resident	88,836	19%	-13,189	-13%	99,789	22%	-2,236	-2%	122,498	27%	20,473	20%
4	total population in TA urban area: UHCC	usually resident	29,589	6%	-4,342	-13%	29,589	6%	-4,342	-13%	41,026	9%	7,095	21%
4	**total population in urban area: Region**	**usually resident**	**458,936**		**7,766**	**2%**	**458,936**		**7,766**	**2%**	**458,936**		**7,766**	**2%**
5	total jobs in TA urban area: KCDC	number	no change				no change				no change			
5	total jobs in TA urban area: PCC	number	no change				no change				no change			
5	total jobs in TA urban area: WCC	number	no change				no change				no change			
5	total jobs in TA urban area: HCC	number	no change				no change				no change			
5	total jobs in TA urban area: UHCC	number	no change				no change				no change			
5	**total jobs in urban area: Region**	**number**	**no change**				**no change**				**no change**			
6	total jobs in the CBD	number	no change				no change				no change			
7	total daily trips: car driver & pax	number	1,543,939	70%	-11,991	-1%	1,539,598	70%	-16,332	-1%	1,544,315	70%	-11,615	-1%
7	total daily trips: PT	number	103,356	5%	-5,863	-5%	111,149	5%	1,930	2%	113,135	5%	3,916	4%
7	total daily trips: active modes	number	555,597	25%	23,337	4%	541,316	25%	9,056	2%	535,863	24%	3,603	1%
7	**total daily trips: all modes**	**number**	**2,202,892**		**5,483**	**0%**	**2,192,063**		**-5,346**	**0%**	**2,193,313**		**-4,096**	**-0.2%**
8	total daily JTW trips: car driver & pax	number	230,119	76%	2,973	1%	227,655	75%	509	0%	223,829	74%	-3,317	-1%
8	total daily JTW trips: PT	number	41,363	14%	-8,535	-17%	50,196	17%	298	1%	54,606	18%	4,708	9%
8	total daily JTW trips: active modes	number	31,091	10%	6,370	26%	25,007	8%	286	1%	23,263	8%	-1,458	-6%
8	**total daily JTW trips: all modes**	**number**	**302,573**		**808**	**0.3%**	**302,858**		**1,093**	**0%**	**301,698**		**-67**	**0.0%**
9	total daily trips into CBD: car	number	162,810	67%	-11,221	-6%	167,159	66%	-6,872	-4%	170,276	66%	-3,755	-2%
9	total daily trips into CBD: PT	number	36,237	15%	-13,430	-27%	48,057	19%	-1,610	-3%	54,954	21%	5,287	11%
9	total daily trips into CBD: active modes	number	43,617	18%	7,574	21%	36,372	14%	329	1%	33,268	13%	-2,775	-8%
9	**total daily trips into CBD: all modes**	**number**	**242,664**		**-17,077**	**-7%**	**251,588**		**-8,153**	**-3%**	**258,498**		**-1,243**	**-0.5%**
9a	total daily trips within CBD: car	number	133,581	50%	44,377	50%	103,869	48%	14,665	16%	87,241	47%	-1,963	-2%
9a	total daily trips within CBD: PT	number	5,992	2%	3,677	159%	3,351	2%	1,036	45%	2,025	1%	-290	-13%
9a	total daily trips within CBD: active modes	number	129,485	48%	30,967	31%	107,537	50%	9,019	9%	97,270	52%	-1,248	-1%
9a	**total daily trips within CBD: all modes**	**number**	**269,058**		**79,021**	**42%**	**214,757**		**24,720**	**13%**	**186,536**		**-3,501**	**-2%**

APPENDIX 9

COMPARATIVE ANALYSIS OF GWRC SCENARIOS

INDI-CATOR No.	PERFORMANCE INDICATOR	UNIT OF MEASURE-MENT	LAND USE INTERVENTIONS											
			4: WGTN CBD				5: BIG THREE				6: DENSIFY AROUND PT			
			2026		Change on Status Quo		2026		Change on Status Quo		2026		Change on Status Quo	
			Result	% of Total	Total	% Change	Result	% of Total	Total	% Change	Result	% of Total	Total	% Change
10	total trips: car driver & pax in am peak	number	261,710	75%	66	0.0%	261,760	74%	116	0%	259,398	74%	-2,246	-1%
10	total trips: PT in am peak	number	27,562	8%	-3,151	-10%	31,100	9%	387	1%	32,712	9%	1,999	7%
10	total trips: active modes in am peak	number	61,158	17%	2,929	5%	58,650	17%	421	1%	57,793	17%	-436	-1%
10	**total trips: all modes in am peak**	**number**	**350,430**		**-156**	**0.0%**	**351,510**		**924**	**0%**	**349,903**		**-683**	**-0.2%**
11	total VKT by car in am peak	km	1,439,915		-67,266	-4%	1,528,170		20,989	1%	1,496,226		-10,955	-1%
11	total Person KT by car driver & pax in am peak	km	2,225,514	78%	-103,195	-4%	2,348,495	75%	19,786	1%	2,308,276	73%	-20,433	-1%
11	total Person KT by PT pax in am peak	km	401,702	14%	-117,612	-23%	525,661	17%	6,347	1%	605,297	19%	85,983	17%
11	total Person KT by active modes in am peak	km	242,686	8%	-12,603	-5%	243,909	8%	-11,380	-4%	250,188	8%	-5,101	-2%
11	**total PKT in AM Peak**	**km**	**2,869,902**		**-233,410**	**-8%**	**3,118,065**		**14,753**	**0%**	**3,163,761**		**60,449**	**2%**
11a	total JTW VKT by car in am peak	km	671,027		-60,711	-8%	744,661		12,923	2%	732,733		995	0.1%
11a	total JTW Person KT by car in am peak	km	798,522		-72,246	-8%	886,147		15,379	2%	871,952		1,184	0.1%
12	total travel time by car in am peak	hours	39,280		-2,631	-6%	55,505		13,595	32%	43,465		1,554	4%
12	total travel time by car driver & pax in am peak	hours	59,767	48%	-3,570	-6%	81,901	54%	18,564	29%	65,385	47%	2,049	3%
12	total travel time by PT pax in am peak	hours	17,267	14%	-3,526	-17%	21,390	14%	597	3%	23,164	17%	2,371	11%
12	total travel time by active modes in am peak	hours	48,540	39%	-2,520	-5%	48,780	32%	-2,280	-4%	50,040	36%	-1,020	-2%
12	**total travel time in am peak**	**hours**	**125,573**		**-9,616**	**-7%**	**152,070**		**16,881**	**12%**	**138,589**		**3,400**	**3%**
12a	total JTW travel time by car in am peak	hours	19,007		-2,419	-11%	30,445		9,018	42%	22,737		1,311	6%
12a	total JTW travel time by car pax in am peak	hours	22,618		-2,879	-11%	36,229		10,732	42%	27,057		1,560	6%
13	average trip length by car in am peak	km	8.50		-0.4	-4%	8.97		0.1	1%	8.90		0.0	0%
13	average trip length by PT in am peak	km	14.57		-2.3	-14%	16.90		0.0	0%	18.50		1.6	9%
13	average trip length by active modes in am peak	km	3.97		-0.4	-9%	4.16		-0.2	-5%	4.33		0.0	-1%
14	average JTW trip length by car in am peak	km	9.83		-1.1	-10%	10.95		0.0	0%	11.14		0.2	2%
14	average JTW trip length by PT in am peak	km	14.91		-4.1	-22%	17.94		-1.1	-6%	20.76		1.7	9%
14	average JTW trip length by active modes in am peak	km	2.37		-0.4	-14%	2.55		-0.2	-8%	2.70		-0.1	-3%
15	average road network speed in am peak	km per hour	37.00		0.5	1%	27.50		-9.0	-25%	35.00		-1.5	-4%
15	average PT network speed in am peak	km per hour	36.80		-1.9	-5%	40.10		1.4	4%	42.50		3.8	10%
16	average time of a car trip in am peak	minutes	13.62		-1.0	-7%	19.29		4.7	32%	15.27		0.7	5%
16	average time of a PT trip in am peak inc walk etc	minutes	37.59		-3.0	-7%	41.27		0.7	2%	42.49		1.9	5%
16	average in-vehicle time of a PT trip in am peak	minutes	21.14		-1.4	-6%	22.01		-0.5	-2%	23.16		0.6	3%
16a	average time of a car JTW trip in am peak	minutes	16.71		-2.5	-13%	26.85		7.7	40%	20.75		1.6	8%
17	annual petrol consumption	million litres	338		9	3%	354		25.0	8%	332		3.0	1%
17	annual diesel consumption	million litres	314		-8	-2%	318		-4.0	-1%	316		-6.0	-2%
18	annual transport CO emissions	tonnes	13,820		151	1%	14,548		879	6%	13,699		30	0.2%
19	annual transport CO2 emissions	tonnes	1,606,000		-1,000	0%	1,654,000		47,000	3%	1,597,000		-10,000	-1%
20	congested motor vehicle hours (>/= VCR of 0.8)	hours	19,695.8		-2,654	-12%	37,867.8		15,518	69%	23,789.5		1,439	6%
21	annual cost of congestion	M NZD	1,117.11		85.3	8%	1,221.82		190.0	18%	1,028.97		-2.9	0%
21a	cost of congestion in am peak	NZD	666,812		-34,532	-5%	933,304		231,960	33%	716,173		14,829	2%
22	annual system economic cost	M NZD	3,015.51		148.4	5%	3,229.81		362.7	13%	2,858.20		-8.9	-0.3%
22a	system economic cost in am peak	NZD	1,674,493		-92,246	-5%	2,174,813		408,074	23%	1,798,347		31,608	2%
23	system economic cost per person km in am peak	NZD	0.58		0.01	2%	0.70		0.1	23%	0.57		0.0	0%