

# Bay of Plenty Transport Futures Study

Bay of Plenty Regional Land Transport Strategy Supporting Paper No.06

Prepared for the Bay of Plenty Regional Council  
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## Glossary and abbreviations

Active transport mode	All forms of transportation not relying on motorised vehicles (including walking, cycling, wheeled pedestrianism, skateboarding, push scooter etc.)
Car-passenger	Person who travels in a private vehicle, along with the driver
Demand-side measures	Investments and policies that encourage people to manage their individual travel demands in an efficient way
Driver	Person who drives a private vehicle (either car or truck) with or without passengers
Household	An individual or collection of people who usually reside together in a particular dwelling
Sustainable transport	Transport modes that have a lowered average impact on the environment, includes active transport modes and public transport

BOP	Bay of Plenty
CAU	Census Area Unit
GPS	Government Policy Statement (on Land Transport Funding)
HCV	Heavy commercial vehicles
ICT	Information and communications technologies
JTW	Journey to work
LTCCP	Long-term Council Community Plan
MSAF	Mode share adjustment factors
NHTS	National Household Travel Survey
NLTP	National Land Transport Programme
NZTA	New Zealand Transport Agency
RLTP	Regional Land Transport Programme
RLTS	Regional Land Transport Strategy
SOV	Single occupancy vehicle

In addition, a number of acronyms have been used throughout the report referring to the various strategic options discussed in this paper. For full definitions, see Section 5.1.



# Executive summary

## Objectives of this study

The Bay of Plenty Regional Council has commissioned McCormick Rankin Cagney (MRC) to investigate the future performance of the region's land transport system in response to a range of non-transport factors and transport interventions. This study aims to identify a range of alternative futures and scenarios that may eventuate over the next 30 years and make recommendations on the strategic options that should be considered as part of the RLTS review process.

This study assesses the performance of the transport system across the entire region, without attempting to analyse the contribution of individual projects. Instead, it focuses on understanding the broader impacts and trends expected to influence transport priorities and policies over the next thirty years. Notwithstanding the strategic focus of the study, we have in some places disaggregated results at the sub-regional level.

## Modelling household travel demands

We developed and applied a strategic transport model for the Bay of Plenty region. Mode choice regression models based on a variety of demographic, socio-economic, and transport trends were able to explain a reasonable amount of the variation in journey to work (JTW) mode share observed around the region in the 2006 census.

Without intervention (in a "do minimum" option), we forecast that current trends would see considerable growth in the numbers of driver JTW trips in the Bay of Plenty region, that no amount of investment in road infrastructure could accommodate. Hence, there is an ongoing need for investment in the regional transport system, especially those infrastructure and services that are able to accommodate growth in a way that is both cost-effective and sustainable.

Analysis of broader household travel trends suggest that average per capita travel demand (both in the number of trips taken and total kilometres travelled) are reducing over time, not only in the Bay of Plenty but also across New Zealand, Australia, and the U.S. A range of factors are likely to be contributing to the decline in per capita travel demand, namely an ageing population, improvements in information and communications technology, and high and volatile fuel costs.

When compared to total per capita travel demand, journey to work mode shares (sourced from the census) tend to underestimate the numbers of trips taken by alternative modes, especially car-passengers but also walking/cycling and public transport. Before and after analysis of walking/cycling numbers on Matapihi Bridge and Cameron Road suggests that investment in walking/cycling has caused considerable growth in the uptake of these transport modes.

In the "business as usual" option, driver travel demand continues to increase, albeit at a much slower rate than in the "do minimum." Driver JTW mode share reduces in percentage terms (from 76% to 72%) although the total number of vehicles trips continues to grow.

Analysis suggests that current transport trends cannot be sustained and that there is a demonstrable need for continued investment in the regional transport system; put simply the "do minimum" is not an option. Further analysis suggests that even a "business as usual" option would be likely to result in high levels of vehicle use, especially in urban areas at peak times. As a result, there is a need for a shift in transport priorities if the future objectives of the region are to be met.

## Testing alternative transport futures

We tested the cumulative effects of changes in fuel prices, parking costs economic growth, and vehicle ownership. Results suggested that all of these factors have a major influence on future travel demands. Perhaps more importantly, these alternatives are correlated; low fuel prices, high economic growth, and higher vehicle ownership are likely to occur in tandem, and the impacts on travel demand are amplified as a result.

To investigate the cumulative effects of these factors, we developed “high” and “low” vehicle travel demand scenarios. Analysis of these scenarios highlighted the following key messages:

- **Volatility is the norm rather than the exception** – most of the alternative futures considered in this chapter are likely to be correlated, at least in terms of their effects on “car-based” travel demands. This means that if one occurs then the others are also more likely to eventuate, which in turn means that travel demand exhibits considerable volatility, at least on an annual basis.
- **Continued importance of the road network** – Car-based transport modes are likely to remain as the dominant transport mode in the Bay of Plenty region for the foreseeable future. Even in the low vehicle demand scenario, car-based transport modes (driver and car-passenger) made up approximately 74% of trips and 85% of kilometres travelled.
- **Non-car modes increase market share** – Notwithstanding the continued importance of the road network, non-car transport modes (namely public transport and walking/cycling) gain market share. This gain mainly impacts on travel demands at the margins, in terms of the overall growth in car-based transport modes.

The region should contribute to transport projects that support efficient freight movements for the following reasons:

- Freight movements are of high relatively high economic value. Improving the efficiency with which freight can move to and through the region is likely to generate economic benefits both locally and in adjacent regions, such as the Waikato and Auckland;
- Freight movements generate negative externalities, such as emissions to air, water, and soil, which have a range of economic, social, and environmental costs. The existence of these externalities (and the costs that they impose) creates a prima facie case for Government policies that support the efficient levels of freight movements; and
- Opportunities exist to improve connections between road, rail, and shipping networks, which in turn may reduce road freight volumes on key routes, such as routes to the Port of Tauranga. Moreover, the Port of Tauranga’s location means that shifting road freight to rail and/or coastal shipping may also help alleviate congestion.

Data suggests that growth in road freight slowed from 2001-09. Rail movements have recently returned to pre-recession levels, led primarily by strengthened dairy and forestry exports. KiwiRail’s Annual Report confirms that an export lead recovery began with a 14% lift in volumes (on the year before) during the second half of 2010, and road and rail volumes are expected to grow at 1-2% per annum in the coming years.

However, major developments in rail governance, in combination with economic trends, look likely to shake up rail freight movements. The recently released “KiwiRail Turnaround Plan” suggests KiwiRail will increasingly position itself to serve key markets where it holds a competitive advantage (particularly the bulk movement of dairy and forestry products), in order to earn more competitive rates of return (KiwiRail, 2010). The plan notes that minor

routes, such as the Gisborne to Napier line, may be closed or at least de-prioritised, so as to free up resources for key routes, such as those in the Bay of Plenty.

In terms of the Bay of Plenty, the implications of the KiwiRail Turnaround Plan seem relatively clear - freight volumes on the rail network are expected to increase. While this will undoubtedly bring benefits by removing trucks from the roads, it may also create new safety and environmental issues that need to be managed. Moreover, there are still large parts of the region that do not have access to the rail network. In some locations where rail provides a competitive alternative to road for part of the journey, there may be increased demand for freight-hubs that allow goods to be moved off trucks and onto the rail network.

We have evaluated a number of strategic transport options and assessed their performance against national, regional, and sub-regional objectives using a multi-criteria framework. Based on this assessment, we identified “mixed option 2” (MO2) as the preferred option. MO2 combined demand-side measures, such as parking reforms and support for ICT, with increased investment for sustainable transport modes and freight management measures.

To support the recommended strategic transport option, we made the following recommendations:

- Demand-side measures:
  - *Parking reforms* – remove minimum parking requirements and implement performance-based parking policies that rely on prices to manage demand; and
  - *Support of information and communications technologies* – facilitate increased uptake of telework, home delivery services, and car-share; and
  - *Time-of-use pricing* – initiate a high-level discussion on the merits of time-of-use pricing (premised on assumptions of mode and fiscal neutrality).
- Sustainable transport improvements:
  - Public transport – downtown terminals, integrated ticketing, bus priority measures, new interchanges, and park and ride; and
  - Walking / cycling – delivery of strategic urban cycle networks in Tauranga (40 km) and Rotorua (30 km), supported by localised improvements.
- Freight management: Establishment of a contestable regional fund to support freight initiatives that deliver external benefits to the region
- Road network: Remains the backbone of the regional transport system even if the growth in demand is increasingly accommodated in other ways. Investment should focus on improvements to:
  - Connectivity – improvements that increase the resilience of the wider road network. Improves community resilience to natural disasters, such as flooding, tsunamis, or earthquakes.
  - Quality – increased road maintenance, especially surface treatments that improve vehicle fuel efficiency and reduce wear and tear on tyres (thereby improving air and noise pollution).
  - Safety – heightened focus on road safety for all road users.

We note that the preferred option allows for much greater investment in walking and cycling, which will in turn allow for the development of a strategic cycle network in both Tauranga and Rotorua, and to a lesser extent Whakatane. The figures below illustrate the scale of networks that could be developed in Tauranga and Rotorua within 5-10 years, based on the quantum of funding that is available.



Figure 1 Existing (red) and potential new (green) strategic cycling corridors in Tauranga

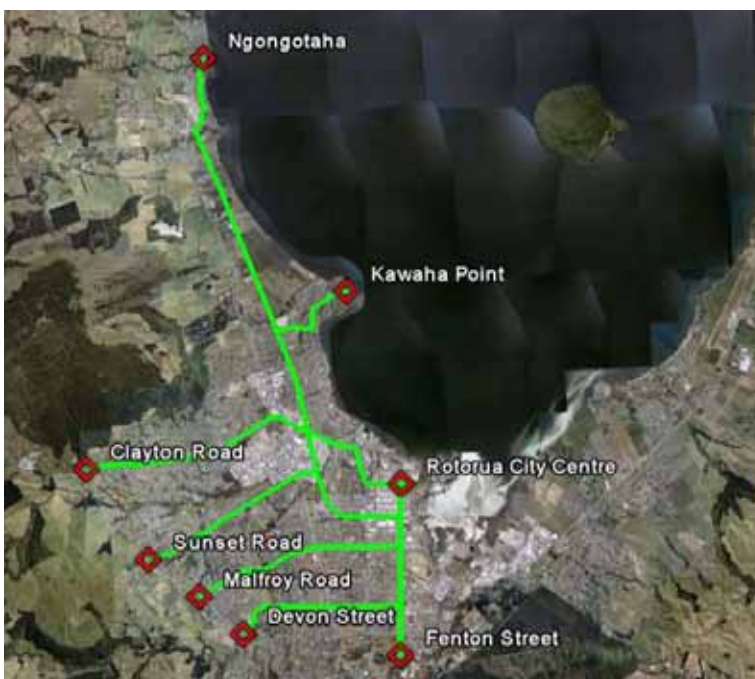


Figure 2 Potential new strategic cycling corridors in Rotorua

Finally, we considered the implications of the recommended strategic transport option at the local level. Predicted growth in vehicle trips for local transport models in Tauranga, Rotorua, and Whakatane were compared to forecasts generated by our model, under a range of different scenarios. Results suggest that the recommended strategic transport option may be expected to reduce peak hour traffic volumes (compared to the transport models) by approximately 5-20%. Much larger reductions in peak hour vehicle trips would be possible in the event that parking reforms were more widely applied or time-of-use pricing was implemented.

Ultimately, we consider that the preferred strategic option and associated recommendations signals a notable and necessary change in direction for the region, while balancing the respective strengths of different transport modes and providing for a reasonable level of continuity.





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# Part 1: Background to this study

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The Bay of Plenty Regional Council has commissioned McCormick Rankin Cagney (MRC) to investigate the future performance of the region's land transport system in response to a range of non-transport factors and transport interventions. The outputs of this study are intended to inform the development of strategic options for the next Regional Land Transport Strategy (RLTS). This study aims to:

- Identify a range of alternative futures and scenarios that may eventuate over the next 30 years; and
- Make recommendations on strategic options to be considered as part of the RLTS review process.

This study assesses the performance of the transport system across the entire region, without attempting to analyse the contribution of individual projects. Instead, it focuses on understanding the broader impacts and trends expected to influence transport priorities and policies over the next thirty years. Notwithstanding the strategic focus of the study, we have in some places interpreted results at the sub-regional level. The following sections introduce the structure of the report and summarise the planning and policy framework within which it sits.

## 1.1 Structure of this report

This report is structured as follows:

- Chapter Part 2: Outlines the modelling framework developed to inform the findings of this study. The purpose of this chapter is two-fold: First, it summarises the model on which some of the study's key conclusions and recommendations are drawn and, second, the model is applied to help highlight some of the transport challenges that the Bay of Plenty may encounter in the future, especially if current trends continue unabated.
- Chapter Part 3: Investigates how travel demands may respond to changes in fuel prices, parking costs, economic growth, and vehicle ownership. The purpose of this chapter is to shed light on potential factors that may influence travel demands in the region, as well as their potential cumulative effects.
- Chapter Part 1: Delves into freight travel demands in more detail. Freight travel demands require special attention for several reasons. First, freight movements are typically of high value. Second, freight demands tend to be highly diverse and suited to one particular mode. Third, freight typically generates large negative externalities.
- Chapter Part 1: Introduces several strategic transport options and evaluates their performance against national, regional, and sub-regional objectives. The preferred strategic option is developed in some detail and its impacts on travel demands are investigated (albeit still in a macro sense) at the local level.
- Chapter Part 1: Summarises the findings and recommendations of this study.

## 1.2 **Planning and Policy Framework**

The planning and policy framework for this study is formed by a number of national, regional, sub-regional, and local strategic documents. These documents are summarised in the table below and reviewed in detail in Appendix A.

Table 1 Summary of planning and policy framework that informs this study

Document	Purpose and links to other documents	Impacts on the provision of transport	Impacts on the funding of transport
Ministry of Transport Statement of Intent (SOI)	<p>Outlines how ministry will support Government strategic direction by improving the performance of the transport system and extracting more value from investment.</p> <p>Provides input into GPS</p>	Focus on network management to improve efficiency and safety. Consider impacts of volatile fluctuations in economic growth and fuel prices.	Helps to determine investment prioritisations and funding through determining returns on investment expected of major projects. Projects should contribute to economic productivity.
Transport Monitoring Indicator Framework (TMIF)	<p>Outlines a set of high-level indicators to provide monitoring of outcomes.</p> <p>Supports SOI and GPS</p>	Economic indicators evaluate the contribution of transport system to supporting economic productivity.	Determination of economic contribution guides the funding priorities set out in the GPS.
Government Policy Statement on transport (GPS)	<p>Describes funding priorities for six years and expected expenditure by mode.</p> <p>Supports specific policies, such as integrated transport and land use development.</p> <p>Determines NLTP and Guides RLTS and RLTP</p>	<p>Focuses on lowering the cost of transportation; network security; increasing market accessibility; road safety; increasing travel choices.</p> <p>Increased focus on state highway construction and reduced funding for active modes and PT in GPS2.</p>	Funding priority is for investment that supports national economic growth and productivity.
National Land Transport Programme – Bay of Plenty (NLTP)	<p>Prioritises the transport activities and packages for funding at a national level. Aligns Government goals with regional aspirations.</p> <p>Determined by GPS</p> <p>Input provided from RLTS</p>	Unique regional features (such as high exports/ imports, relatively low PT usage, aging population) impact on the focus of required transport infrastructure.	<p>Funding for road projects comparatively easier.</p> <p>Applications for funding to support PT, active modes, travel planning must demonstrate alignment with Government's strategic priorities.</p>
Bay of Plenty Regional Land Transport Strategy (RLTS)	<p>States the regional objectives and outlines transport projects.</p> <p>Guides RLTP and NZTA input into council community plans</p>	<p>Focus on transport networks that are safe, responsive, accessible and supportive of economic development.</p> <p>Identified managing traffic demand as highest priority.</p>	The projects and initiatives outlined must contribute to achieving an integrated, safe and responsive regional land transport system.
Bay of Plenty Regional Land Transport Programme 09/10-11/12 (RLTP)	<p>Prioritises activities where funding will be sought in the next three years.</p> <p>Provides input into NLTP. Receives input from RLTS, local council plans, NZTA.</p>	<p>Focus on congestion, PT mode share, safety, route security and accessibility</p> <p>Optimising the transport network seen as priority to improve travel times</p>	Funding needs to prioritise strategic infrastructure investments to ensure that transport systems support continued integrated growth in the region.





## Part 2: Modelling household travel demands

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This chapter outlines the framework for modelling household travel demands that was developed to inform the findings of this study. The purpose of this chapter is two-fold, first, it summarises the model on which some of the study's key conclusions and recommendations are drawn and, second, the chapter applies the model to help highlight some of the transport challenges that the Bay of Plenty may encounter in the future, if current trends continue unabated.

This chapter is structured as follows: 1

- Section 2.1 develops mode choice models for the Bay of Plenty region based on journey to work data from 2006 census.
- Section 2.2 introduces broader travel demand indicators, such as trips taken and kilometres travelled. We present travel demand forecasts for the region in both per capita and aggregate terms and use these to generate “do minimum” mode share forecasts for the region.
- Section 2.3 outlines how journey to work travel demands may be linked to broader indicators of household travel. The effects of transport investment on demand for public transport, walking, and cycling are discussed and incorporated into the model and a “business as usual” option is investigated.
- Section 2.4 discusses the key technical issues and underlying assumptions involved in the development of the travel demand forecasting model. Opportunities for further research are also identified and discussed.
- Section 0 summarises the key findings of the chapter.

From the outset, it is worth emphasising that there is no single metric to describe household travel demands. Instead, the following sections use three key indicators, namely: journey to work mode share, trips taken, and kilometres travelled.

The usefulness of each indicator is highly context dependent.<sup>2</sup> Journey to work mode share, for example, is a key determinant of road network congestion and is thus relevant to discussions of the capacity of the transport system. On the other hand, the number of kilometres travelled is an indicator of overall use of the network, which in turn impacts on maintenance costs.

Finally, we note that this chapter discusses the development of a modelling framework and is unavoidably technical in nature. We have, where possible, attempted to explain technical terms, often by way of footnotes. Readers interested in more technical material, especially on input data, are referred to the appendices located at the end of this report.

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<sup>1</sup> The concept of travel demands, however, is not as straight-forward as it first appears; complications exist that demand precise language. Most importantly, there is no single all encompassing “indicator” of travel demands. Instead the most appropriate unit of measurements depends on the context of the discussion. For example, household travel can be measured in terms of trips taken or kilometres travelled – both are, in the right context, informative measures. Similarly, commercial travel could also be measured in terms of volume of freight moved, such as tonne-kilometres travelled (TKT).

<sup>2</sup> For example, the number of trips taken is relevant when considering the contribution of various transport modes to people's accessibility. In contrast, the number of kilometres travelled is relevant when considering total loads placed on the network. The distinction between these two indicators should hopefully become clear in the following sections.

## 2.1 Modelling Mode choices in the Bay of Plenty

Mode share is an aggregate measure that describes the travel choices made by a population given the options that are available to them. Underlying these decisions are the unique circumstances in which individuals find themselves on a day-to-day basis. These circumstances relate to the specific preferences and circumstances of the individual concerned (e.g. household composition), but also include a wide range of external factors, such as community design (e.g. residential density).

To understand people's mode choices we therefore need to understand the environment in which those choices are made. Underpinning this approach is an assumption that while not all individual travel decisions appear especially rational, they are – in most cases – relatively predictable responses to the everyday situations that people face.<sup>3</sup> We should also at this stage note that many of these factors may not be easily influenced or altered, either by the individuals concerned or the Government (e.g. established land-use patterns).

To gain a better understanding of the factors that influence people's mode choices in the Bay of Plenty region, we developed "mode choice regression models" to analyse journey to work (JTW) data from the 2006 census. These models attempted to predict the percentage of people in each area unit who chose to travel to work by one of the following transport modes:<sup>4</sup>

- Walking and cycling
- Work at home<sup>5</sup>
- Car-passenger
- Public transport

Mode choice regression models provide insight into the simultaneous effects of countervailing changes in multiple variables. For example, we can estimate the combined impacts of changes in demographics (such as age and ethnicity), socio-economic factors (income and household size), and transport variables (vehicle ownership and distance to work). This ability to "trade-off" the size and direction of countervailing effects is very useful, for example, when evaluating the impact of decisions on transport choices (e.g. what level of Government investment in walking/cycling is necessary to offset the effects of increasing vehicle ownership?)

Appendix B provides a technical review of the literature on mode choice regression modelling.

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<sup>3</sup> In the following sections we make use of household data (from the 2006 census) because it often captures broader characteristics that influence the travel decisions people make, such as the need to drop and/or collect school children on the way to work.

<sup>4</sup> We do not estimate mode share for "driver" directly because shares for the four "alternative" transport choices allow us to derive driver mode share as the residual, i.e. driver is the mode share that is left over once the other travel choices have been accounted for. Later sections of this report will present a mode choice regression model that was developed for the "driver" choice.

<sup>5</sup> We consider work at home as a viable "transport choice" even though it is associated with a decision not to travel and does not directly affect travel demands. In many ways, the choice to work from home can be considered as "negative travel" in that it allows the affected person access to paid employment beyond their home, without the need to travel.

## 2.1.1 Results of the Mode Choice Models

Key results of the mode choice regression models are summarised in the following table; further details are available in Appendix C. This table includes a measure of the explanatory power of the regression model (in terms of R-squared) and the positive and negative relationships affecting each mode choice.

The table does not present information on the relative strength of the statistical evidence supporting these relationships (although in almost all cases we found strong statistical evidence for the relationships), nor does it describe the magnitude of the relationship. More information on both the strength and magnitude of the relationship is provided in Appendix C.

*Table 2 Results of the Mode Choice Regression Models*

Mode choice	R-squared <sup>6</sup>	Relationships	
		Positive	Negative
Walking / cycling	82%	Percentage of male residents; % households without a vehicle; % trips to central area unit; and Employment Density.	Average household size; % European residents; Average household vehicle ownership; Length state highway per resident; and Average journey to work distance.
Work at home	81%	Percentage of white collar workers; % Residents employed full time; % Residents employed part-time; % households with internet access; % ratio of jobs to residents; and residential dispersion.	Percentage of households with one vehicle; % households with two vehicles; % trips to central area unit; Mesh block weighted residential density; and Median household income.
Car-passenger	76%	Median age; median household income; % residents who smoke regularly; % Maori & pacific island residents; Average people per household; and Mesh block weighted residential density.	Percentage of white collar workers and average vehicle ownership.
Public transport	45%	Percentage of smokers; bus service kilometres <sup>7</sup> ; and % of trips to central area.	Median age

The table above illustrates that the models have reasonably high explanatory power for most modes. The notable exception is the public transport mode choice regression model, which explains only 45% of the variation in the underlying mode share. This result, while undesirable, is not entirely unexpected due to the limited scope of current public transport operations in the Bay of Plenty, which limits the sample size and in some cases introduces rounding errors.

<sup>6</sup> The explanatory power of the model is measured in percentage terms, which describes the proportion of the variation in the actual data that is explained by the model. Generally the higher the R-squared value is, the better the model is (all other factors being equal). We note, however, that even in a model with relatively low explanatory power, such as the public transport model, individual variables in the model may still be highly statistical significant. For further discussion on these and other technical issues please refer to Appendix C.

<sup>7</sup> Note that a non-linear relationship was detected for this variable. The relationship suggested that increasing bus service kilometers has a positive but reducing impact on public transport mode share. This finding suggests that bus service kilometers matter up to a point, after which other factors become more dominant drivers of mode share.

One feature of these models (which is more useful at the sub-regional and local level) is that they help to identify how area units are “performing” relative to their peers (i.e. those areas support higher uptake of public transport than would otherwise be expected given demographic, land use, and transport characteristics). Such information may be useful when benchmarking public transport performance around the region, which can in turn support more informed transport investment decisions.

For example, the figure below illustrates the differences between walking/cycling mode share predicted by the model and the actual mode share in central Whakatane. These differences can essentially be thought of as walking/cycling “premiums”; where positive values indicate areas that support unusually high levels of walking/cycling. The figure below suggests that all four area units (coloured orange) in central Whakatane have walking/cycling premiums that are 2.1-5.0% higher than the regional average, even when controlling for other relationships. Appendix C presents and discusses some reasons as to why this may be the case.

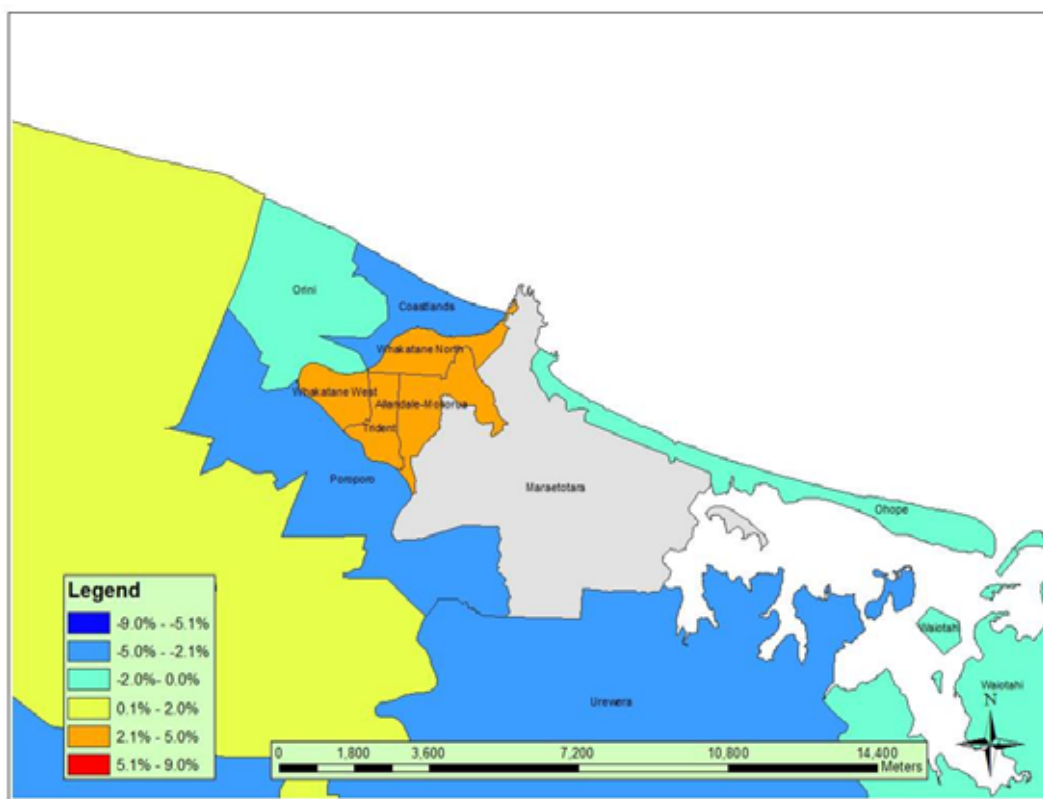


Figure 3 Walking and cycling “premiums” in Whakatane 2006<sup>8</sup>

Having developed some useful models to estimate mode share for JTW trips for walking/cycling, work at home, car-passenger, and public transport the next question we must answer is: How do we now use these models to estimating driver mode share?

<sup>8</sup> The grey shading for Maraetotara indicates that the number of people walking/cycling to work in this area unit were too few to be included in the model.

Understanding the answer to this question is easier if we consider the following equation, which states that the sum of all mode shares (M) must equal 100%:

$$M_{\text{Walking/Cycling}} + M_{\text{Work at home}} + M_{\text{Car-passenger}} + M_{\text{Public transport}} + M_{\text{Driver}} = 100\%$$

Hence, having estimated mode shares for walking/cycling, work at home, car-passenger, and public transport, we can then derive an estimate of driver mode share by a simple process of back-calculation. That is, if we subtract the sum of the mode share estimates for these four alternative modes from 100%, we are left with an estimate of the driver mode share for that area unit.<sup>9</sup>

We used this process to “derive” estimates of driver mode share, as illustrated below in comparison to the actual mode share for each area unit. The relatively high R-squared of 72% provides some confidence that we can not only derive reasonable direct estimates of mode share for the four alternative modes, but also derive indirect estimates of the driver mode share.<sup>10</sup>

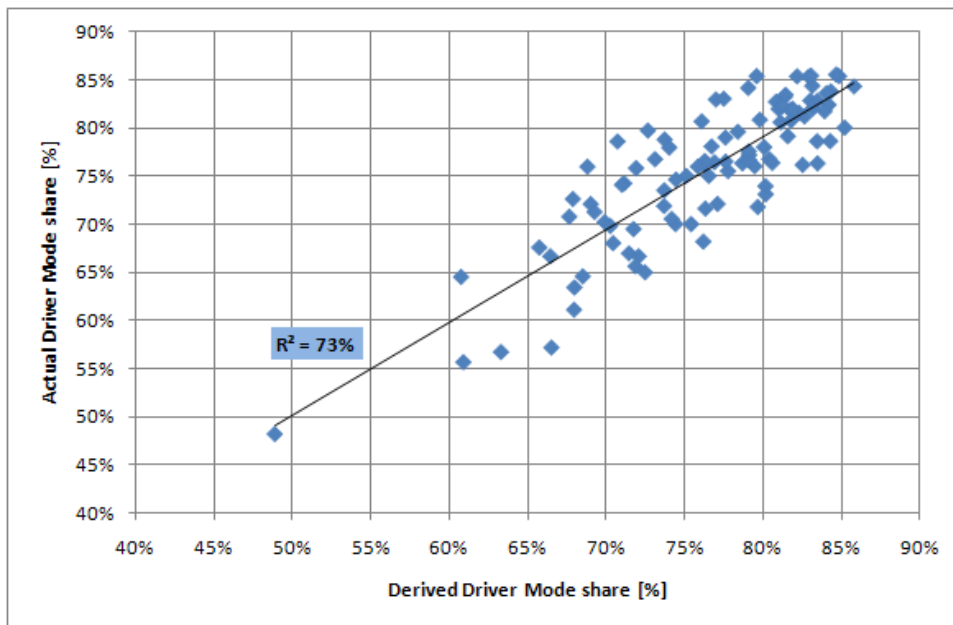


Figure 4 Derived estimates versus actual driver mode share for area units in the Bay of Plenty region 2006

Having developed models of current mode choices, the next section will consider how we can apply these models to forecast future journey to work mode shares for the Bay of Plenty region.

<sup>9</sup> When we say “back-calculate” we mean that we can use the mode choice regression models to estimate mode share for alternative modes. If we then subtract the total “non-car” mode share from 100 %, then whatever is left over is our estimate of driver mode share. Note that this result is by no means guaranteed, because our mode choice models are effectively independent of each other. Further research could consider techniques for “linking” the models (i.e. constraining them) such that they provided more accurate estimates of driver mode share.

<sup>10</sup> The scatter plot also shows how the errors in the model are relatively randomly distributed around the trend line shown in black. Thus there is no evidence to suggest that the regressions suffer from omitted variable bias, which in turn means that we can have more confidence in forecasts made using these models.

## 2.1.2 Forecasting journey to work mode share

The regression models discussed in the previous section identified relationships between peoples' mode choices and demographic, socio-economic, and transport variables, such as vehicle ownership. Predicting trends in JTW mode share thus requires that we first develop forecasts for these variables.

The figure below illustrates the process used to forecast changes in vehicle ownership, which was identified as a relevant explanatory factor for several of the mode choice models. First, we considered the rate of change in the proportion of households owning 0, 1, 2, or 3+ vehicles from 2001 to 2006, as illustrated in Figure 5. In this case, the slope of the regression line describes the average percentage change in the proportion of households that had access to the specified number of vehicles. For example, the points represented by blue diamonds are the proportion of households that have access to zero vehicles in the 2001 and 2006 censuses. In this case, the slope of the regression line is 0.80, which suggests that, on average, the proportion of households with access to zero vehicles in 2006 was approximately 80% of that observed in the 2001 census. This means that the proportion of households with access to zero vehicles declined, on average, by 20% from 2001 to 2006. More generally, we can see that the proportion of households with access to zero or one vehicle declined from 2001 to 2006, whereas the proportion with access to two or three plus vehicles increased.

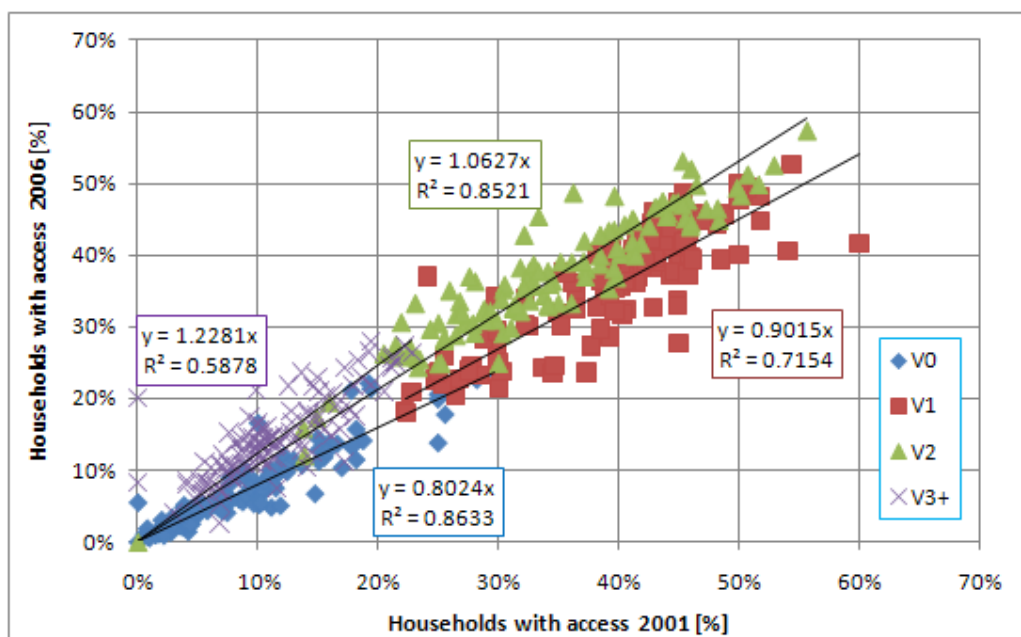


Figure 5 Observed change in numbers of vehicle owned per household from 2001-06

We used the slope of these regression lines to forecast the change in the proportion of households with access to different numbers of vehicles, which in turn defined average vehicle ownership, as illustrated below.

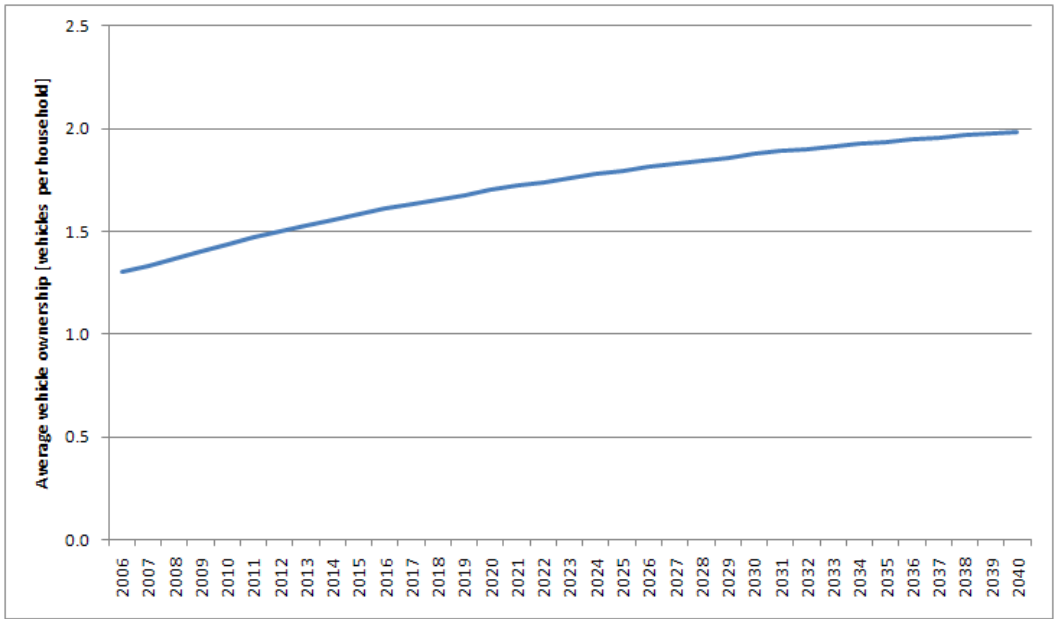


Figure 6 Forecast average vehicle ownership per household 2006-2040<sup>11</sup>

Figure shows vehicle ownership continuing to increase, although at a reducing rate. Based on this analysis we expect that a plateau of approximately 2.0 vehicles per household will have been reached by 2040. Methods used to forecast other variables are outlined in detail in Appendix D.

Having developed forecasts for the input variables, we can now generate mode share forecasts for the Bay of Plenty region. Figure 8 below shows the forecast mode share for public transport car-passenger, walking/cycling, and work at home from 2006-2040, assuming no investment in walking/cycling and public transport. Thus, the mode share forecasts effectively represent a “do minimum” option and are what we would expect to observe if no additional investment was made in alternative modes, beyond the funds already committed in 2009-12. This means that (beyond 2012) no bus services are provided, hence public transport mode share drops to zero after this point. And also no additional investment (public or private) is made in infrastructure to support work at home and/or walking/cycling.

<sup>11</sup> While the timelines for this study run from 2010 to 2040, we have indexed the following forecasts to 2006 to coincide with the starting point of our mode choice regression models. This also allows us to observe how mode share may have changed over the last four years.



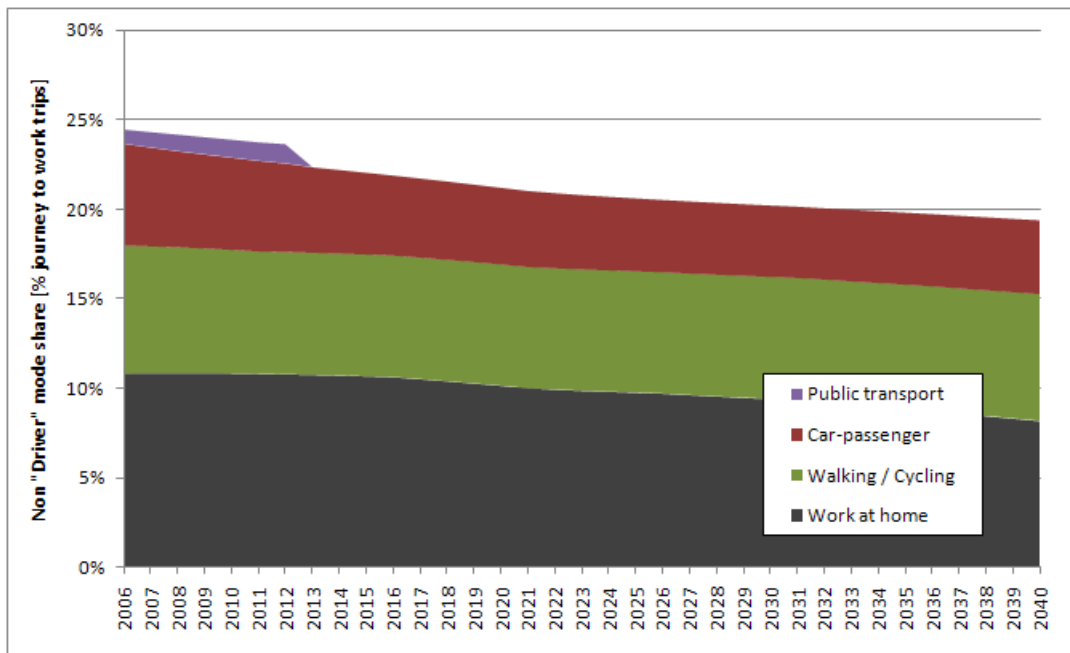


Figure 7 Regional journey to work mode share in the “do minimum” option 2006-40

The figure shows mode share decreasing from approximately 24% to 19% by 2040. By extension, the driver mode share increases from 75% to 79% by 2040. Combining this trend with continued growth in the regional population (assumptions for which are described in the following section) would contribute to a 75% increase in the numbers of JTW vehicle trips by 2040. This rate of growth equates to approximately 1.7% per annum, although the rate of growth would be higher in urban areas, such as Tauranga, which experiences both higher growth and is disproportionately affected by the loss of public transport services.<sup>12</sup>

It is essential to recognise that the mode share forecasts presented above do not, as yet, incorporate changes in supply side variables, which are instead considered in more detail in later sections, and as such should not be seen as a likely outcome. Nonetheless, the development of a “do minimum” scenario serves two useful purposes: first, it clearly highlights the (net) effects of underlying trends on regional travel demands and, second, it shows that the “do minimum” option would result in even higher levels of driver mode share than is currently observed in the Bay of Plenty region (which is already relatively high by national standards).

Trying to meet the levels of growth in vehicle trips observed in the “do minimum” option through continued expansion of road infrastructure is likely to prove to be prohibitively expensive. For example, California only managed to increase road network capacity (measured in lane miles) by 0.3% per annum in the 40 years since they began what is probably the world’s largest investment in urban motorways (Sorenson, 2009). We suggest that no amount of road investment can keep pace with growth in driver journey to work trips of 1.7% per year over a 40 year period.<sup>13</sup>

This rate of growth will inevitably lead to congested road corridors, highlighting the issues associated with the “do minimum” scenario and motivated the case for on-going investment in the Bay of Plenty’s transport network. A number of alternative

<sup>12</sup> We note that journey to work represents only a proportion of total peak hour vehicle trips. In Tauranga, for example, journey to work accounts for about 25% of all trips.

<sup>13</sup> California is now developing a voter approved high speed rail system.

strategic transport investment options are presented and discussed in later sections. First, however, we need to develop tools that enable us to model not just journey to work travel, but all the types of travel that people need to make.

### 2.1.3 Intra and inter regional journey to work movements

Previous sections have considered JTW travel in an aggregate sense. This section now focuses on the degree to which JTW travel demands are split between intra and inter regional movements. The level of inter-regional, or external, commuting helps us understand the degree to which communities in the Bay of Plenty region are “internalised”, i.e. the proportion of the workforce that travels to work in the local area. Put simply, internalisation describes the degree to which employment needs are able to be met within the same area.

All other factors being equal (such as workforce specialisation) then high levels of internalisation are a positive indicator, because it means that residents are able to meet their employment needs without travelling long distances. This is not to say it is undesirable for Bay of Plenty residents to make trips to other areas, because this travel may facilitate the transfer of specialised skills that are not available within the destination region.

However, it is more likely that residents who work outside the region do so primarily because insufficient employment is available locally. Similarly, an inward flow of commuters to the region increases the size of the labour pool, but raises questions around why the region is unable to attract these workers to live in the local area.

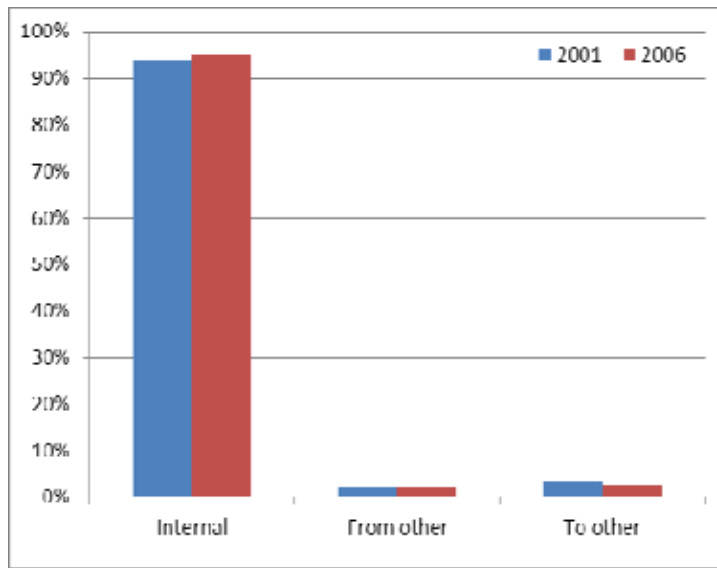
Inter-regional journey to work trips are collected as part of the national census data. We commissioned Statistics New Zealand to compile data on the destinations of JTW data between the Bay of Plenty region and other parts of New Zealand.<sup>14</sup> Based on this data we were able to identify three broad categories of inter and intra-regional travel:

- Internal – these are journey to work trips made within the region, which have informed much of the modelling undertaken in previous sections;
- To other – these are trips that originate in the Bay of Plenty but have destinations in other parts of New Zealand
- From other – these are trips that originate in other parts of New Zealand but have destinations within the Bay of Plenty.
- Trends in journey to work trips between the Bay of Plenty and other regions are illustrated in the figure below. A closer look at Figure 8 reveals that from 2001 to 2006 there was:
  - A marginal increase in the proportion of “internal” trips, up from 94.1% in 2001 to 94.9% in 2006, which suggests that the region is over time meeting a growing proportion of its residents’ employment needs;
  - An increase in the proportion of “from other” trips, up from 2.3% of the total in 2001 to 2.5% in 2006, which suggests that the region is attracting more labour from surrounding regions; and

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<sup>14</sup> Some caution is needed when interpreting this data because the Statistics New Zealand geo-coding process picks up only a sample of total journey to work trips. As such results are typically presented in percentage terms, rather than absolute numbers. Where absolute numbers are discussed they should be interpreted as only a sample of total census responses.

- A reduction in the proportion of “to other” trips, down from 3.6% in 2001 to 2.6% in 2006, which suggests that fewer residents are travelling to work in other regions.



*Figure 8 Trends in intra and inter regional journey to work flows in the Bay of Plenty, 2001-2006*

These shifts are all positive, at least insofar as the economic performance of the Bay of Plenty region is concerned. The major change is therefore a higher proportion of employment within the region on a percentage basis, with fewer people commuting to destinations outside of the region for work purposes, and a higher percentage of people commuting into the region. We note that the Bay of Plenty is still a marginal net “exporter” of labour. That is, more Bay of Plenty residents travelled to other regions for work than those who travelled into the Bay of Plenty. Although in 2006, this gap appears to have almost closed, with around 2,700 BOP residents leaving the region for work, compared with 2,600 commuting inwards.

We can break the trip data illustrated above down further by origins and destinations, which can in turn help highlight trends in internal and external JTW trips. The table below breaks down commuting patterns from the 2001 and 2006 census in terms of their origins and destinations, which are defined by trips from/to territorial authorities in the region, trips from/to undefined locations, and trips from/to other regions in New Zealand. It also shows the relative growth in travel demands for each origin-destination pair, which helps illustrate where travel patterns are growing more rapidly.

Table 3 Breakdown of the origins and destinations of community patterns in the Bay of Plenty region 2001-06<sup>15</sup>

2001 Census JTW Data		Traveling to							Total from
		Western BOP	Tauranga	Rotorua	Whakatane	Kawerau	Opotiki	Rest of NZ	
Traveling from	Western BOP	9,585	3,927	210	75	27		864	14,688
	Tauranga	1,788	29,733	210	81	54		1,038	32,904
	Rotorua	69	126	22,515	99	123		897	23,829
	Whakatane	54	69	162	9,309	1,113	99	273	11,079
	Kawerau			27	261	1,482		39	1,809
	Opotiki				141		2,217	78	2,436
	Rest of NZ	351	651	783	165	33	51	n/a	2,034
Total to		11,847	34,506	23,907	10,131	2,832	2,367	3,189	88,779
2006 Census JTW Data		Traveling to							Total from
		Western BOP	Tauranga	Rotorua	Whakatane	Kawerau	Opotiki	Rest of NZ	
Traveling from	Western BOP	10,551	5,286	234	129	30		459	16,689
	Tauranga	2,091	37,554	348	219	60		1,122	41,394
	Rotorua	105	267	24,543	150	198		720	25,983
	Whakatane	69	123	243	10,005	1,176	168	309	12,093
	Kawerau	21	24	57	360	1,473		57	1,992
	Opotiki				195	24	2,343	66	2,628
	Rest of NZ	447	864	891	213	87	75	n/a	2,577
Total to		13,284	44,118	26,316	11,271	3,048	2,586	2,733	103,356
Proportional changes in JTW trips recorded		Traveling to							Total from
		Western BOP	Tauranga	Rotorua	Whakatane	Kawerau	Opotiki	Rest of NZ	
Traveling from	Western BOP	10%	35%	11%	72%	11%		-47%	14%
	Tauranga	17%	26%	66%	170%	11%		8%	26%
	Rotorua	52%	112%	9%	52%	61%		-20%	9%
	Whakatane	28%	78%	50%	7%	6%	70%	13%	9%
	Kawerau			111%	38%	-1%		46%	10%
	Opotiki				38%		6%	-15%	8%
	Rest of NZ	27%	33%	14%	29%	164%	47%	n/a	27%
Total to		12%	28%	10%	11%	8%	9%	-14%	16%

The table above highlights how unevenly the changes in JTW patterns have been throughout the region. It is interesting to note that external trips from other parts of NZ (i.e. those trips from the rest of New Zealand into the Bay of Plenty) grew 27% from 2001 to 2006, which is larger than the increases from any other area in the BOP. Conversely, the travel from the BOP to other areas outside of the region was the other decrease seen for the areas examined.

<sup>15</sup> It is important to note that these numbers represent the percentage of JTW trips that were successfully geo-coded (i.e. located) by Statistics NZ. As such, they may not represent the total number of journey to work trips to/from destinations in the Bay of Plenty. Where the number of trips was less than 20, these have been excluded for confidentiality reasons.

To simplify these results, for each territorial authority in the region we calculated the trips that occurred internally, the proportion of trips from originated other parts of the region, and the proportion of trips that originated from other parts of New Zealand. The results of this analysis are illustrated below, for 2006.

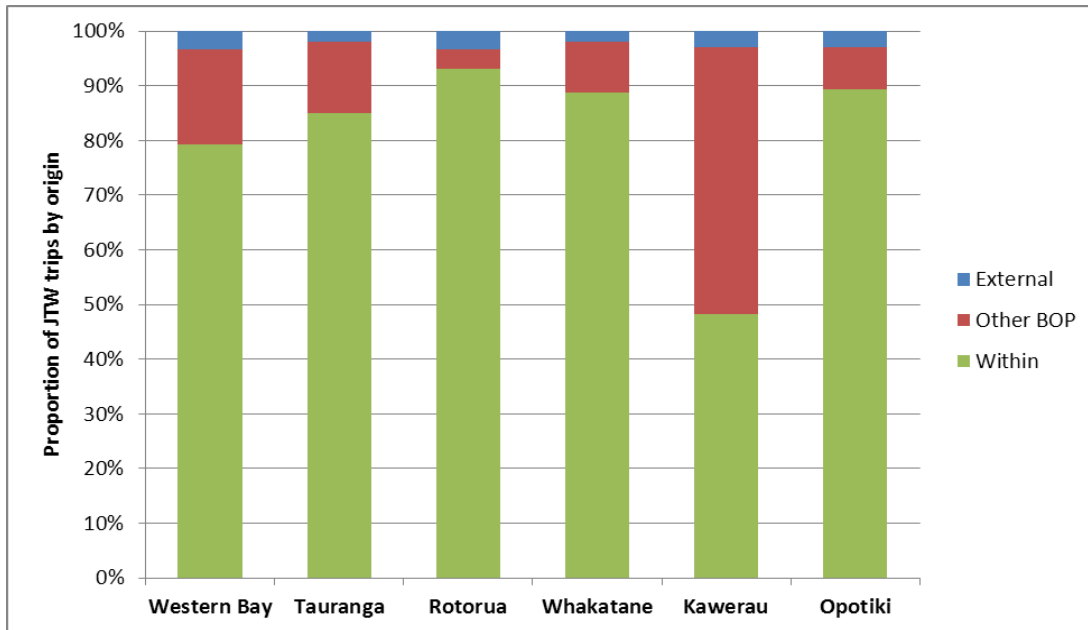


Figure 9 Breakdown in the origins of JTW trips for local authorities in the Bay of Plenty, 2006

This shows how the proportion of external JTW trips is relatively constant across the local authorities. The main outlier is Kawerau, which sources less than 50% of its workforce from the local area, compared with all of the other centres in the region, who source around 80-90% of their employment needs internally.

## 2.2 Wider trends in household travel demands

Until now we have focussed almost exclusively on travel demands in terms of journey to work mode share or, to a lesser extent, numbers of vehicle trips. As previously mentioned, “travel demands” can and should be measured using different indicators. For example, “travel” may be measured in terms of trips taken or alternatively (and no less valid) in terms of kilometres travelled. Similarly, travel demands may be measured in absolute terms (i.e. total trips taken or kilometres travelled) or relative proportions (i.e. as a percentage of total trips). Travel demands can also be measured for individuals (i.e. per capita) or for the whole population.

In this section we move beyond measures of journey to work travel and instead consider wider trends in household travel demands. For example, even in a situation where driver mode share declines in percentage terms, the number could increase in absolute terms because the per capita decline is more than offset by an increasing regional population. The following sections will discuss wider trends in household travel demands, consider some explanatory factors, and finally forecast how household travel demands may change in the future.

### 2.2.1 Introducing Broader Travel Demand Indicators

The Ministry of Transport's *National Household Travel Survey* (NHTS) provides consistent and comprehensive data on household travel for a relatively large sample of households selected from around the country.<sup>16</sup> The two figures illustrate travel trends (trips and kilometres travelled) from 2005-07 for drivers, car passengers, public transport, and pedestrians in the Bay of Plenty.<sup>17</sup> Results are presented below in per capita terms, which allows for simple comparisons across time. This shows how total kilometres travelled per capita reduced from 11,965 km to 11,644 km from 2005 to 2007.<sup>18</sup>

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<sup>16</sup> While the NHTS is a national survey, results are broken out for the Bay of Plenty region, which has a reasonable sample size of 947, 1049, and 1306 in 2005, 2006, and 2007 respectively.

<sup>17</sup> The results of the NHTS are reported annually but describe data collected over four year periods (2003-07, 2004-08, 2005-09). We have taken the mid-point of each period to enable us to present annual figures. However, the use of these four year bands may mean that the NHTS is relatively slow to respond to changes in on-the-ground trends. This is because the use of a four year rolling average may introduce a lag, or smoothing of survey results, such that the reported travel trends do not represent what is happening now, but more what happened over the last four years.

<sup>18</sup> Differences in the methodology and sample size associated with older NHTS surveys mean that their results are not comparable to the three most recent surveys.

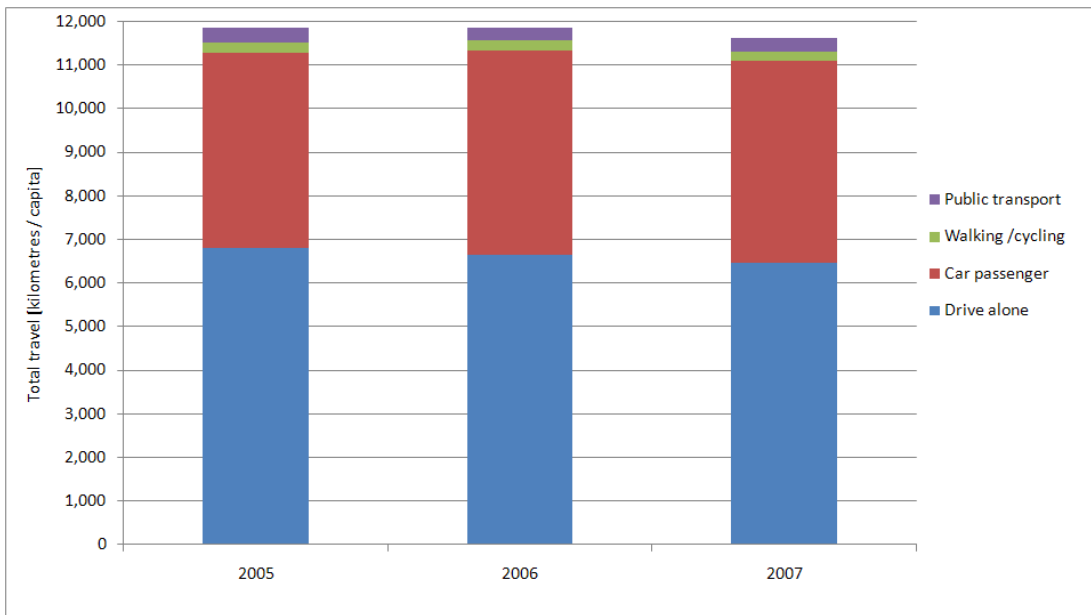


Figure 10 Annual kilometres travelled per capita in the Bay of Plenty region (2005-07)

Note that because kilometres travelled measures distance, it understates the relative contribution of walking/cycling. While walking/cycling accounted for less than 2% of the total kilometres travelled, it made-up approximately 13% of the total number of trips taken. In many respects the percentage of trips taken by each mode (Figure 11) is a more representative indicator.

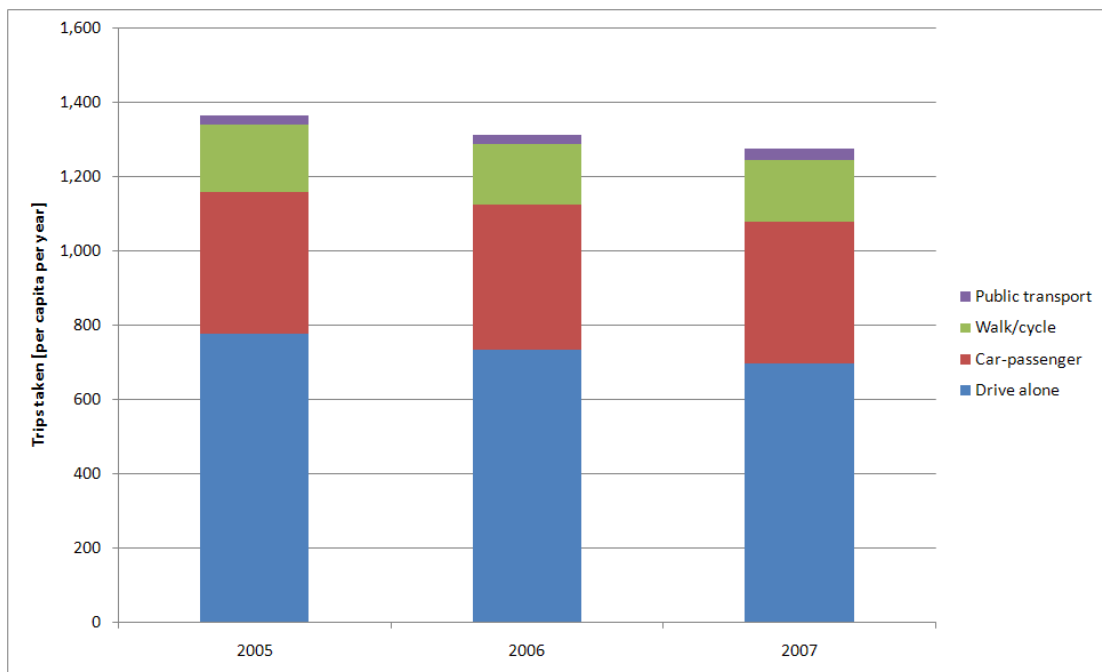


Figure 11 Annual trips taken per capita in the Bay of Plenty region (2005-07)

## 2.2.2 Interpreting travel demands trends

The two figures illustrated on the previous page are not only useful for illustrating the differences between kilometres travelled and trips taken; they also illustrate some general trends that are important to modelling future travel demands.

That is, from 2005-07 we observe a sustained downwards shift in the average number of annual trips taken per capita, from 1,366 in 2005 to 1,275 in 2007 – which represents a 6.7% decline in just two years. Similar, although somewhat slower, trends are observed for average number of kilometres travelled per capita per year, which declined 2.7% in the same period.

So why are per capita travel demands declining in the Bay of Plenty? We postulate that downwards trend in per capita travel demands reflect the combined effects of:<sup>19</sup>

- An ageing population;
- Increased use of information and communications technologies (ICT); and
- Impacts of higher fuel prices on demand for vehicle travel (driver and passengers).

Although other, as yet unobserved, factors are also possible. The next important question to consider is: do we expect the downward trend to continue in the future? Evidence suggests that all three of these factors will continue to affect travel demands over the next 30 years.

In December 2009, for example, Amazon reported that they had, for the first time, sold more electronic books than paper books through their website (Amazon, 2009). The recent release of the iPad and other “Smart Phones” is likely to accelerate the trend towards remote access and electronic delivery for a wide range of media. These developments will naturally impact on the number of trips people make to visit media retailers, such as book stores. In this way, developments in ICT are enabling people to substitute for physical travel without compromising their access to goods and services (if anything ICT improves consumers’ access to information).

Current and future developments in ICT will be discussed in more detail in subsequent sections, but for now it suffices to say that they are expected to have increasingly significant effects on travel behaviour. While electronic transactions do not replace physical trips on a one to one level, research by Corpuz & Peachman (2003) suggests that approximately 15% of ICT transactions (such as online banking, internet shopping, or electronic media purchase) offset a physical trip. Categories of travel most likely to be affected include: educational trips, personal business, and work related travel.

Nor do we expect the effects of an ageing population to dissipate during the timelines of this study. Barring a substantial change in immigration and/or fertility rates, an ageing population is a demographic certainty. Fuel prices are considered in more detail in a subsequent section, although most research suggests that a combination of production constraints, resource availability, and unilateral supply arrangements (that reduce the liquidity of global oil markets) are likely to keep prices at sustained high levels. The current downward trend in per capita travel demands, as observed in the NHTS, is thus expected to be sustained.

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<sup>19</sup> Further research could delve into the NHTS data and attempt to net out the relative effect of various factors on per capita travel demands. Alternatively, it may be worth supplementing the current NHTS with additional survey questions that may shed light on how people are adjusting their travel patterns in response to these factors.



This raises one final important question: How do the downward trends in per capita travel demand observed in the Bay of Plenty compare to trends in other jurisdictions? All Australian capital cities (including Darwin and Hobart – both of which are of a competitive size to Tauranga) observed downward trends in per capita vehicle travel from 2004 onwards (BITRE, 2009). Similarly, in the United States per capita VMT reached a peak around 2005 and has since declined rapidly to levels not seen since 1998 (Puentes & Tomer, 2008). More details on these comparative trends in travel demands are contained in Appendix E.

For these reasons, we suggest that trends towards declining per capita travel demands are consistent with qualitative explanations. Moreover, there is a reasonable body of quantitative evidence from comparative jurisdictions (such as the rest of New Zealand, as well as Australian capital cities and the majority of states in the US) to suggest that the trend towards declining per capita travel demands in the Bay of Plenty is not an isolated event.

### 2.2.3 Forecasts for total household travel demands

The next important question to answer is how might we extend current trends in household travel demands into the future?<sup>20</sup> As we have only one regional data point over three years, it is not possible to undertake more sophisticated modelling, such as that undertaken for journey to work mode share. Instead, given the lack of available data a simple extrapolation (i.e. extension) of current trends is likely to yield the best results. We considered the following three extrapolation methods:

- Persistence – this method simply uses the last known value (2007) for all future values;
- Modified linear – this method continues the linear trend observed from 2005-2007 for the next ten years (until 2017), after which persistence forecasting is applied; and
- Logarithmic – this method uses the logarithmic trend line through all points and uses this to forecast for the entire timelines of this study and illustrates the forecasts that are generated by each of these three methods (dashed lines) in relation to the actual data (solid grey line). Based on the current evidence we suggest that the logarithmic trend is the most appropriate mechanism for forecasting future trips taken per capita.

The logarithmic method is preferred because it gives some weight to current trends towards declining per capita travel demands, although this weight reduces for longer forecasts. The persistence forecast is not preferred because it is not representative of general trends towards declining per capita travel demands.

On the other hand, we consider that the large reductions in per capita travel demands associated with the modified linear trend line cannot be justified on only three years of data.

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<sup>20</sup> We note that this extrapolation is only based on three data points, which in turn suggests that the predictions are only likely to hold in the near future. It is important they are updated as more results from the NHTS become available.

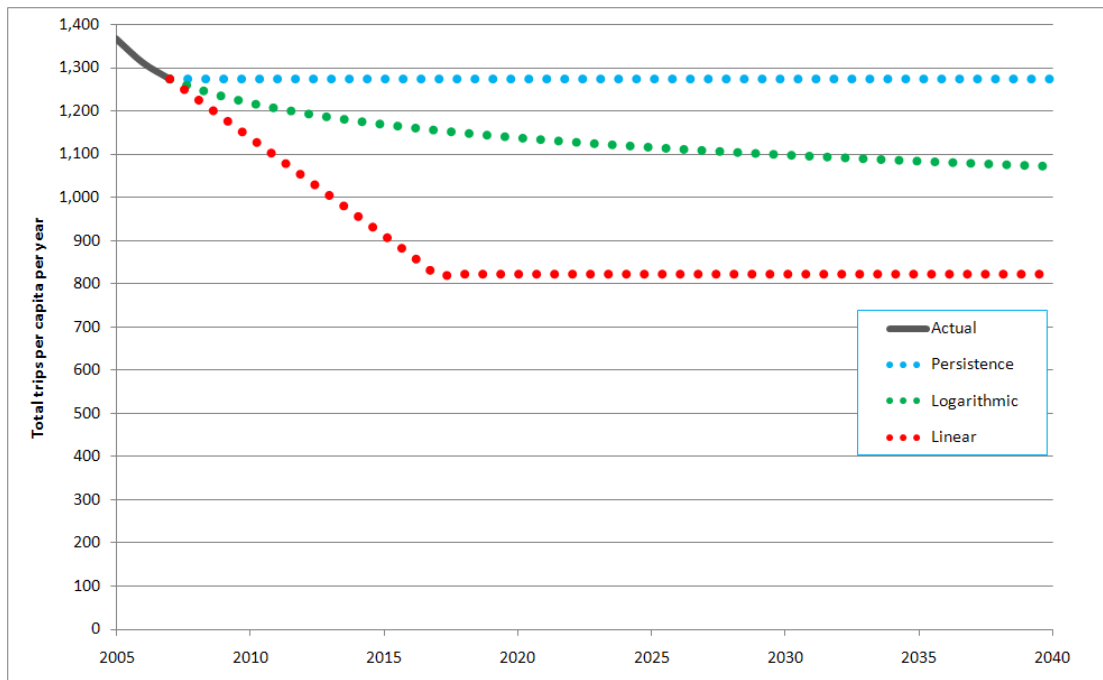


Figure 12 Forecast annual trips taken per capita 2005-2040

The same methods were used to extrapolate trends in annual kilometres travelled per capita, as illustrated below. Similar reasoning suggests that the logarithmic trend is the most appropriate method for forecasting future values for the kilometres travelled per capita.

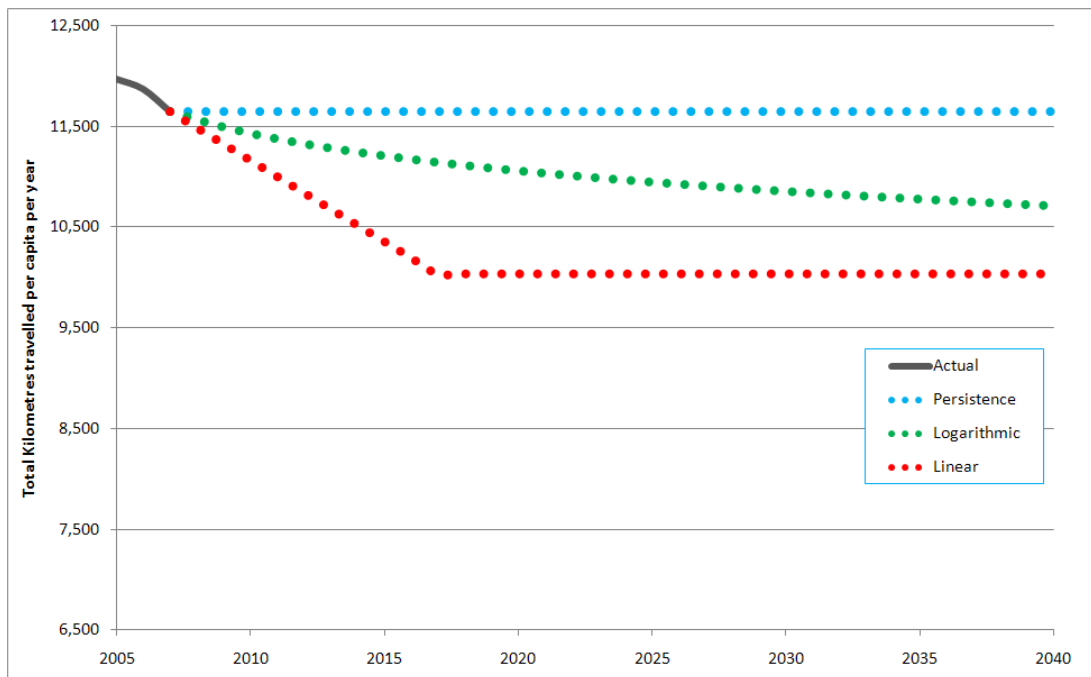


Figure 13 Forecast annual kilometres travelled per capita 2005-2040

Based on this analysis of trends in household travel demands, we expect annual trips taken per capita to decline by 16%, while annual kilometres travelled declines approximately 8% to reach 10,700 km per capita per year in 2040. Implicitly, this would suggest that on balance the factors affecting travel demands (such as ageing population, ICT, and fuel prices) are applying more downward pressure on short trips. Hence even though annual kilometres travelled per capita is expected to decline steadily, the average trip length is expected to grow.<sup>21</sup>

Because these travel demand forecasts are in per capita terms, aggregating them to the regional level first requires estimates of the regional population to 2040. Regional population estimates from 2006-40 were developed from the following sources:

- SmartGrowth land use assumptions for Tauranga City and western Bay of Plenty Councils; and
- Statistics NZ sub-national population projections for all other local authorities.

In order to limit the scope of the study and to ensure consistency with the regional and sub-regional planning and policy framework, alternative population scenarios were not considered.

Based on these population assumptions, the regional population is expected to increase over 40% within the timelines considered in this study, from approximately 260,000 in 2006 to 370,000 in 2040. For each year, we can multiply per capita travel demand forecasts (for both trips taken and kilometres travelled) by the regional population to generate travel demand estimates for the entire region. The

<sup>21</sup> Because these results are based on only three years of continuous NHTS data, caution should be exercised when extrapolating so far into the future. In many respects this is partially mitigated by the use of logarithmic trends, where the rate of change reduces as you go further into the future. It is nonetheless important that these forecast trends in travel demands are updated as soon as new NHTS data becomes available.

figure below illustrates the indexed growth in population and travel demands, where numbers have been base-lined to 2006 levels.

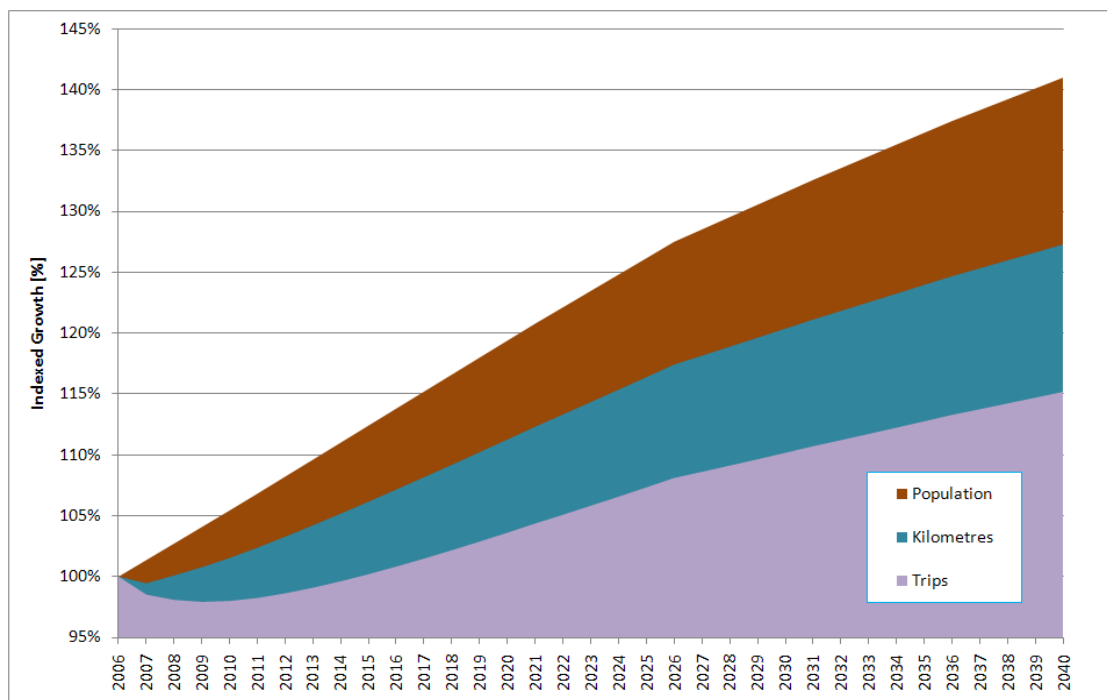


Figure 14 Indexed growth in regional population and travel demands 2006-2040

In spite of declining per capita travel, this figure demonstrates that significant population growth is expected to drive considerable increases in travel demands in the Bay of Plenty region. However, the rate of growth in travel demands is expected to be considerably lower than population growth, especially in terms of the number of trips taken.

## 2.3 The Travel Demand Forecasting Model

Having developed estimates of total regional travel demands (in terms of both kilometres travelled and trips taken) we will now consider how to link overall travel demands (as presented in Section 2.2) to the journey-to-work mode share forecasts (developed in Section 2.1).

There are two main reasons why we need to make this link. First, while the NHTS data provides a useful indication of total travel trends, it is nonetheless limited in terms of its sample size. These mean that it is not possible to analyse trends in travel demands at the sub-regional level. In contrast, the census provides a comprehensive survey of travel patterns for different areas.

Second, the census data also provides the opportunity to link travel choices to a comprehensive and consistent set of demographic and socio-economic characteristics. Indeed, it is the consistent and comprehensive nature of the census that allows us to investigate variations in travel demands at the area unit level.

The aim of this section is to combine the two data sources to both exploit their respective strengths and mitigate their respective weaknesses. In the process, we develop the final elements of the travel demand forecasting model that is used in later sections of this report to investigate effects and evaluate options.

The following sub-sections are structured as follows:

- First we present mode share adjustment factors that simply allow us to map journey to work mode shares onto overall travel demands;
- Second we consider how investment in public transport and walking/cycling might affect uptake of those modes and by extension how uptake of one mode might affect uptake of another mode (so called “diversion” factors); and
- Finally, we draw together all of these results to generate travel demands forecasts for the “business as usual” scenario, which assumes that current levels of expenditure on public transport and walking/cycling persist for the entire timeline of this study.

### 2.3.1 Estimating mode share adjustment factors

The simplest way to link census and NHTS mode shares is to apply “mode share adjustment factors” (MSAF) that allow us to map from one measure to the other.

Before doing so, however, it is necessary to adjust the original census mode shares so as to net out the proportion of people who chose to work at home, an option that is not recorded in the NHTS. The original and adjusted census mode shares are summarised in the following table, along the NHTS mode shares (for both trips taken and kilometres travelled).

Reading across the “Driver” row indicates how the significance of single occupant vehicles (SOV) is overestimated by the census (84.7%) in comparison to the NHTS (56.0%). In contrast, the census journey to work mode share underestimates the significance of travel by car-passenger, walking/cycling, and public transport. Finally, the MSAF column simply divides the (adjusted) census mode shares by the relevant NHTS column (for either trips or KMs).

*Table 4 Journey-to-work mode shares with and without “work at home” trips*

Mode	Census		NHTS		MSAF	
	Original	Adj. <sup>22</sup>	Trips	KMs	Trips	KMs
Driver	75.6%	84.7%	56.0%	56.2%	0.660	0.664
Car-passenger	5.7%	6.4%	29.7%	39.7%	4.674	6.246
Walk/cycle	7.2%	8.0%	12.5%	1.6%	1.555	0.200
Public transport	0.8%	0.9%	1.9%	2.5%	2.121	2.843
<b>Total</b>	<b>89.2%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>100.0%</b>	<b>N/A</b>	

The final result (MSAF column) shows that the census mode shares under-estimate the number of trips by car-passenger, walking/cycling, and public transport. The census under-estimates the number of kilometres travelled by car-passenger and public transport to an even greater degree, whereas the number of kilometres travelled by walking/cycling is considerably lower than predicted by their census mode share.

The MSAF factors are also illustrated in the figure below. This also shows the relative “multiplier” required to go from journey to work mode share to total travel,

<sup>22</sup> We first adjust the journey to work mode shares by netting out the work at home mode share, which is not recorded in the NHTS.

where the latter may be measured in either trips or kilometres. As mentioned earlier, the most notable difference between these metrics occurs for walk/cycle mode share – which represents a relatively large proportion of total trips even though it has only a small share of total kilometres travelled.

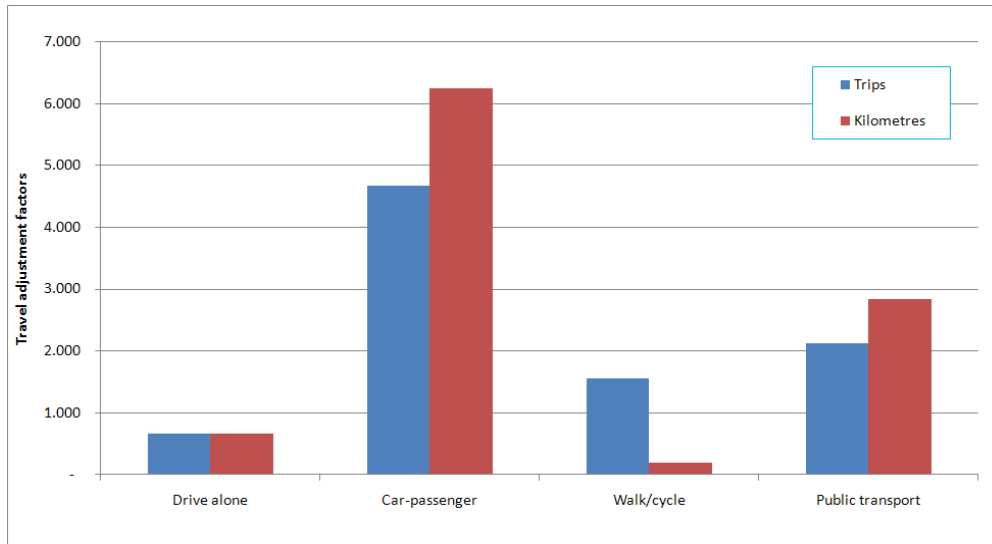


Figure 15 Travel adjustment factors for the Bay of Plenty (2006)

This analysis highlights how journey-to-work mode share (as collected in the census) overstates the driver mode share while tending to underestimate the importance of other modes, especially car-passengers and public transport. The MSAF are applied in an intuitive way – journey to work mode share is simply multiplied by the MSAF to determine the total share of kilometres and/or trips. Using the MSAF to transform mode shares between the census and NHTS is premised on the assumption that the relationship between census mode share and NHTS mode shares remains constant over time, which is indeed likely at least in the short term. Further research should seek to investigate the degree to which this assumption holds over longer time periods.

### 2.3.2 Modelling the impacts of transport system investment

The “do minimum” option modelled towards the end of Section 2.1 assumed the Bay of Plenty region made no investment in public transport or walking/cycling. The “do minimum” option was shown to result in unacceptably high growth in driver journey to work trips and a case was made for continued investment, of some form or another, in the regional transport system.

Subsequent discussions highlighted that even with investment in additional road capacity, the rate and quantum of growth in driver journey to work trips is expected to cause increased congestion and delays. This means that most of the realistic strategic transport options available to the Bay of Plenty will need to provide for some investment in alternative transport modes. The following sub-sections consider how to model the effects on travel demands of investment in alternative transport modes, namely public transport and walking/cycling.

Before we do, it is worth mentioning the concept of “diversion rates,” which describes the previous mode of those users that are encouraged, through investment, to switch to a new mode. Obviously it would be unrealistic to assume that all new bus users, for example, were previously driving to work alone. Instead,

new public transport users are likely to be attracted from all the other modes. In our model, we have assumed that people that decide to switch mode do so in equal proportions; that is, we have assumed the same diversion rates apply to all modes. Further research is required to validate this assumption.

## **Public transport**

The mode choice regression models developed in Section 2.1 identified a statistically significant positive relationship between bus service levels (measures in terms of annual bus-service kilometres per area unit) and public transport journey to work mode share. While positive, the relationship was non-linear, in that the effects of higher bus service tended to reduce as overall bus service levels increased. That is that while downtown Tauranga enjoyed five times more service than the average area unit (because it sits at the convergence of many routes), it did not support mode shares that were five times higher than average.<sup>23</sup>

Public transport investment levels were translated into bus service kilometres for each area unit, which was then incorporated directly into the mode choice regression model. We assumed a constant cost of \$2.15 per bus service kilometre. Thus, public transport investment was converted into a measure of the total bus service that could be delivered, which was in turn allocated to area units based on the proportion of service they currently received.

Bay of Plenty Regional Council staff suggested that at some point beyond 2019, public transport service was likely to be extended to additional area units in Tauranga, Rotorua, and Whakatane. Our model assumes that from 2019 these areas units receive service on the same pro-rata basis as the other area units. This simply means that after 2019 public transport services were extended to a number of area units close to the three urban centres, thereby expanding the scope of the population that could access public transport.

## **Walking and cycling**

The impacts of walking and cycling investment on travel demands were more difficult to model because, unlike public transport, it was not possible to derive a direct, area-based indicator of the “supply” of walking and cycling infrastructure. Without such an indicator, the infrastructure supply could not be included in the regression models; requiring a separate modelling process.

The development of this process was complicated by a lack of data on the historical impacts of investment in walking and cycling. Nonetheless, before and after pedestrian and cycling count data was available for two projects in Tauranga City, which allowed us to derive estimates of the impacts of walking and cycling investments on travel demands. Walking and cycling count data was gathered for Cameron Road and Matapihi Bridge, as summarised in the following table.

Using this data we estimated the increase in walking and cycling associated with increased investment according to the following process:<sup>24</sup>

- Time-series data on walking and cycling numbers on Cameron Road and Matapihi Bridge were used to determine the impact of investment on uptake;

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<sup>23</sup> Mathematically inclined readers may be interested to know that public transport mode share was best explained by taking the square root of bus service kilometers.

<sup>24</sup> “Before and after” data refers to the fact that data was available both prior to and after a new project was delivered.

- Construction cost data was used to determine how much expenditure was required per new kilometre travelled by walking and cycling; and
- The data on uptake and costs were combined to generate estimates of how much additional travel by walking and cycling could be generated by investment.

*Table 5 Before and after pedestrian and cyclist numbers in Tauranga city (2006-09)*

<b>Mode</b>	<b>Location</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>Annual growth</b>
Cyclists	Cameron Road	158	165	172	209	10%
	Matapihi Bridge	245	255	265	275	4%
Pedestrians	Cameron Road	115	127	224	321	41%
	Matapihi Bridge	35	37	49	60	20%

We assumed that 50% of the growth was associated with the investment in infrastructure, whereas the remaining 50% is attributable to other factors, most notably fuel prices and also trips being diverted off other parallel routes, such as Fraser Street.

### 2.3.3 Pulling it together – Base Travel demand forecasts

Previous sections have developed mode choice regression models and considered how to link these models to total travel demands. We have also discussed how Government investment in public transport and walking/cycling might affect future travel demands. These results can together generate overall travel demand forecasts by mode for the region. The following figure and table summarises a “business as usual” option, where funding allocations are assumed to be identical to those outlined in the NLTP-BOP (funding is discussed in more detail in subsequent sections).



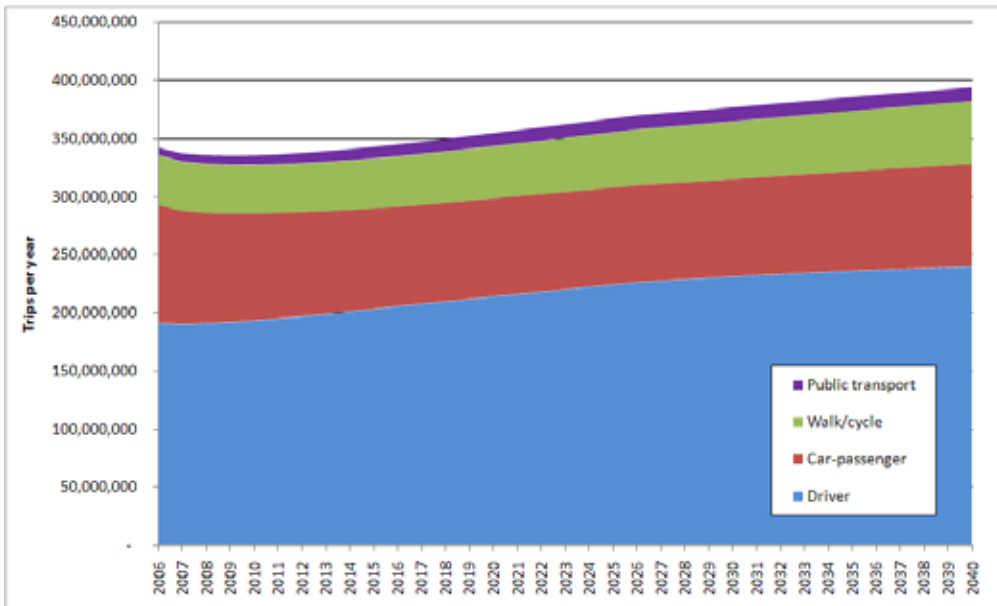


Figure 16 “Business as usual” travel demand forecasts 2006-2040 [trips/year]

Our model predicts total trips increasing from just less than 350 m per year in 2006 to almost 400 m per year in 2040 – an increase of approximately 15%. Even though trips by walking/cycling and public transport increase in relative terms, they are starting from a small base and as such do not make a major dent in the growth of vehicle trips.

By 2040, “car based” trips (which combines trips made either as the driver or as a passenger) still account for approximately 83% of trips in 2040, down only slightly from the 86% observed in 2006. While walking/cycling and public transport increase their share of total travel demands the increase is insufficient to offset the relatively large decrease in car-passenger share, which drops from 30% to 22% of trips from 2006-2040. As a result, overall driver mode share increases. These numbers are broken out in more detail in the following table.

Table 6 Base regional travel demand forecasts 2006-2040 [trips/year]

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	240	56.0%	60.9%	1778	2482	57.4%	63.0%
Car-passenger	102	88	29.7%	22.4%	1174	1143	37.9%	29.0%
Walk/cycle	43	54	12.5%	13.7%	56	130	1.8%	3.3%
Public transport	6	12	1.9%	3.0%	89	186	2.9%	4.7%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

The figure below illustrates changes in regional journey to work mode share for non-driver modes under the “business as usual” option. This result is markedly different from that associated with the “do minimum” option (illustrated in Figure ), which had non-driver mode share declining from 25% to 21% by 2040.

By 2040 the “business as usual” scenario sees non-driver mode share increasing to 28%, with driver mode share reducing from 75% to 72% respectively. When considered in terms of annual growth, the “business as usual” option would result in growth in “driver” journey to work trips of approximately 0.6% per annum from 2006-40 (compared to 1.7% in the “do minimum” option). Even 0.6% annual growth in driver journey to work trips is, over 30-40 years, likely to place considerable demand on the capacity of the regional transport system.

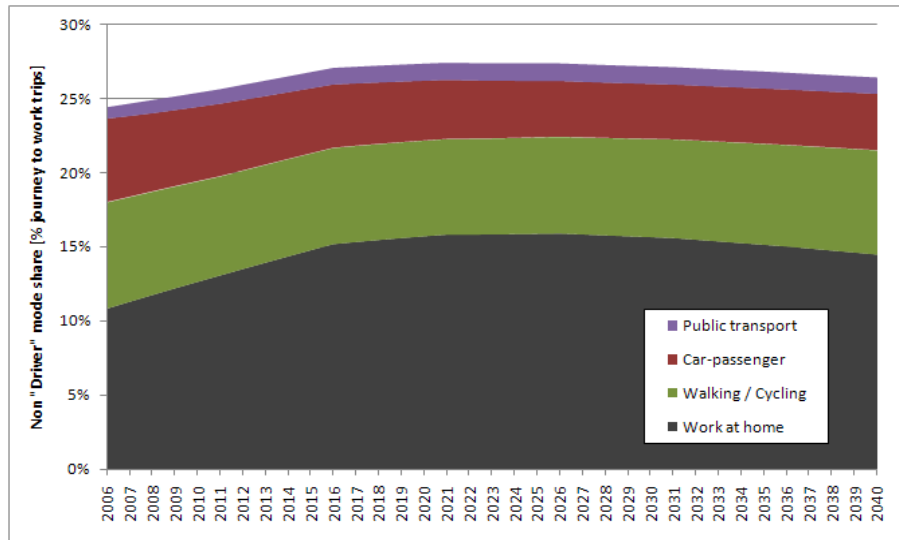


Figure 17 Regional non-driver journey to work mode share in the “business as usual” option

## 2.4 Issues and assumptions

Previous sections described the development of a framework for determining how changes in transport choices may flow through to impact on the demands placed on the regional transport system. In doing so, it was necessary to make a number of key assumptions, which in turn will influence the accuracy of the results. This section will summarise and discuss the assumptions that underpin the modelling framework. This is expected to help:

- Shed light on some of the inner workings of the model so that people can understand it’s relative strengths and weaknesses; and
- Identify when the model should be reviewed and updated as more information comes to light, i.e. new NHTS and census data is available every one and five years respectively.

The following table sets out some of the key assumptions made in the previous sections and discusses their implications for the accuracy of the modelling results.

Table 7 Summary of key technical issues and underlying assumptions

<b>Technical issues</b>	1 Causation and correlation:	The regression models developed in this chapter identify the size, direction, and strength of relationships between a number of variables and mode share. The implications of these relationships depend, however, on the nature of the variable, which tend to fit into one of two broad categories, namely: causal and proxies. First, causal variables model direct effects on mode share, such as effects of vehicle ownership on walking/cycling mode share, and are the most reliable. Second, proxy variables capture indirect effects on mode share, such as the effects of ethnicity on the propensity to car-pool. Proxy variables help us to model effects that are in themselves difficult to measure, but may be reasonably approximated by another variable. We suggest that variables such as ethnicity and smoking rates are acting as proxies for other effects, such as community connections, which are relevant to mode share but difficult to measure. The effects of proxy variables on mode share were considered only in those situations where we had quantitative reasons to support their inclusion.
	2 Omitted variable bias:	There is the risk that unexplained variation in the model (i.e. the residual variation in the mode share data that was not explained by the models) includes omitted variables. This is an important issue when making forecasts, because the omitted variable may also change over time and skew actual mode share away from what was forecast. For example, if people's choice to walk/cycle is linked to cultural perceptions of personal safety (which we are not modelling), and these perceptions change over time (say, for example, crime rates decline) then our mode share forecasts will underestimate future walking/cycling mode share. More advanced spatial and temporal techniques may help to detect and correct for omitted variables. Our preliminary inspection of the residuals identified little obvious spatial autocorrelation in the model errors, with walking/cycling in Whakatane being the notable exception. Further studies could investigate whether Whakatane's higher than expected rates of walking/cycling reflect the presence of omitted variables and, if so, the risk that these variables will change over time. Further research could consider matters for which Census/HHTS data is not easily available, such as the relationship between demand and aspects of transport supply, such as road congestion levels, availability of safe cycling networks.
	3 Simultaneous causality:	We identified a couple of "supply-side variables" such as internet access and bus-service kilometres. These variables are likely to be related in both

		directions, i.e. internet access not only influences people's decision to work at home, but also people's desire to work at home influences their decision to get internet. This means that we cannot be sure whether we are measuring the effect of internet on mode share or vice versa. Further research could investigate issues with endogeneity by considering panel data (which uses time-series data) to identify more precise causal relationships between variables that are likely to suffer from simultaneous causality.
	4 Sample size:	The models explain cross-section variation in mode share between 111 Census Area Units in the Bay of Plenty based on results from the 2006 census. This sample excludes area units with populations of less than 100 people or where there were no responses for a mode, most notably public transport. Issues with sample size are likely to partly explain why the public transport regression model suffered from a relatively low R-squared (45%) when compared to the other modes. This in turn means that forecasts for public transport are likely to be less precise than for other modes. Further research should consider potential improvements to the model, or whether alternative modelling techniques could yield better results.
	5 Temporal stability:	The modelling results are based on data from the 2006 census and the 2003-2009 NHTS. This means that our results are somewhat anchored to the options and preferences that people had at that particular point in time. Should these options and preferences change over time, then the results are not stable, and the accuracy of the forecasts will decline over time as people's options and preferences diverge from what was assumed in this study. Further research could seek to confirm the temporal stability of these results by using panel data sourced from the 2001 and 1996 census. Similar issues with temporal stability apply to our forecasts for key variables that act as inputs into the mode share forecasting model.
<b>Underlying Assumptions</b>	6 Population and employment growth	We assumed that growth in the regional population occurred in line with SmartGrowth and Statistics NZ (M-M-M) sub-national population forecasts. The regional population forecast is combined with changes in part and full time employment rates to determine future numbers of journey to work trips in the region. Regional trends in full and part time employment rates were assumed to continue in line with trends from 2001-06. This assumes that current levels of unemployment will (barring further major economic shocks) decline steadily over time. Similarly, the region population forecast is combined with changes in per capita travel demands (both in terms of trips taken and kilometres travelled) to determine overall travel demands.

	7 Trend towards reduced per capita travel demands	Three years of regional HTS illustrates marked downward trends in per capita travel demand both in terms of the kilometres travelled and the numbers of trips taken (we note that the latter has reduced more rapidly than the former). We have explained this trend by reference to the effects of an ageing population, increased use of information and communications technology as a substitute for physical travel, and high and volatile fuel prices. We have assumed that these trends are continued into the future, such that the total quantum of per capita travel declines over the course of this study. We have used a logarithmic trend to extrapolate from current levels.
	8 Link between journey to work and overall travel	We used the NHTS to establish mode share adjustment factors that allowed us to factor journey to work mode shares (as defined in the census) into shares of overall travel (as collected in the NHTS). We have assumed that these ratios (which vary between modes) are constant over time. Further research is required to confirm, or otherwise, the validity of this assumption.
	9 Constant diversion rates between modes	We have assumed that travel demands that are induced to switch modes do so in proportions equal to the number of available modes. For example, if public transport patronage was to increase by +9 trips, then this would be drawn equally from walking/cycling (-3); public transport (-3); and driver (-3).
	10 Impacts of transport system investment	We have assumed the effects of investment in walking and cycling and public transport can be robustly modelled at an aggregate level. In the case of public transport, we found that the effect of increased bus service levels declines as overall service levels increase (which is consistent with declining marginal returns). In the case of walking and cycling, we have assumed that new investment catalyses linear growth over a ten year period, after which gains remain constant. We have also implicitly assumed that transport investment does not affect land use patterns. While this assumption is reasonable in the short term, in the long run it misses the potential for transport policies and investment priorities to “induce” different development patterns, which in turn will affect peoples’ travel choices. For example, increased uptake of walking, cycling, and public transport is in turn likely to contribute to higher density land use patterns which in turn result in more demand for walking and cycling.

## 2.5 Summary of findings

This chapter has discussed the development and application of a strategic transport model for the Bay of Plenty region. The key findings of this chapter may be summarised as follows:

- Mode choice regression models based on a variety of demographic, socio-economic, and transport trends were able to explain a reasonable amount of the variation in journey to work mode share observed around the region in the 2006 census.
- In a “do minimum” option, we forecast that current trends would see considerable growth in the numbers of driver journey to work trips in the Bay of Plenty region. No amount of investment in road infrastructure could accommodate this growth.
- There is an on-going need for investment in the regional transport system, especially those infrastructure and services that are able to accommodate growth in a way that is both cost-effective and sustainable.
- Analysis of broader household travel trends suggest that average per capita travel demands (both in terms of number of trips taken and total kilometres travelled) are reducing over time, not only in the Bay of Plenty but also across New Zealand, Australia, and the US.
- A range of factors are likely to be contributing to the decline in per capita travel demands, most importantly an ageing population, continuing advances in information and communications technology, and increasingly high and volatile fuel costs.
- When compared to total per capita travel demands, journey to work mode shares (as sourced from the census) tend to underestimate the trips taken by alternative modes, especially car-passengers but also walking/cycling and public transport.
- Before and after analysis of walking/cycling numbers on Matapihi Bridge and Cameron Road suggests that investment in walking/cycling is likely to have caused considerable growth in the uptake of these transport modes.
- In a “business as usual” option, driver travel demands travel continues to increase, albeit at a much slower rate than in the “do minimum.” Driver journey work mode share reduces in percentage terms (from 76% to 72%) although the total number of vehicles trips continues to grow.

This chapter has highlighted some high-level issues that may emerge over the next 30 years, in the event that current transport trends are allowed to continue. Continued population growth and persistently high-levels of vehicle use have created a demonstrable need for continued investment in the regional transport system; the “do minimum” is not an option.

Further analysis suggests that even a “business as usual” option would result in levels of vehicle use that would present significant challenges, especially in urban areas at peak times. As a result, it may be necessary for transport priorities to shift over time; current priorities may not meet the future needs of the region.

Later sections will introduce and evaluate a number of strategic transport options. Before doing so, however, we should first investigate the degree to which the “business as usual” outcomes (described in this section) are sensitive to a range of external factors that currently lie outside the model but may be relevant in the future.<sup>25</sup> This is the topic of the following chapter.

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<sup>25</sup> When we say “external”, we mean those factors that exist outside of the model previously described, rather than external to the region.

## Part 3: Testing alternative transport futures

Having established how base travel demands respond to some key demographic, land use, and transport variables, our focus now shifts to understanding the impacts of alternative transport futures. Four alternative futures were tested; their key parameters and assumptions are summarised in the following table.

*Table 8 Summary of alternative transport futures*

<b>Alternative Future</b>	<b>Description</b>
Fuel costs	<p>In this scenario we assumed that real fuel prices increase from current levels to reach \$2.61 in 2040. We assumed:</p> <ul style="list-style-type: none"> <li>• Vehicles kilometres travelled were affected by short and long run demand elasticity of -0.12 and -0.24 respectively; and</li> <li>• Vehicle trips were affected by short and long run demand elasticity of -0.10 and -0.20 respectively.</li> </ul> <p>The short run elastic response was realised in the first year, with the residual long run impacts applied over the next four years.</p>
Parking costs	<p>Assumed that parking reforms in Tauranga, Rotorua, and Whakatane Central resulted in the average price of parking increasing to \$8, \$6, and \$4 per day by 2040 respectively. The elasticity of demand for vehicle trips and kilometres was assumed to be -0.19 and -0.29 with respect to parking costs in the short and long run respectively.</p>
Economic growth	<p>Considered the impacts of changes in economic growth on travel demands. Economic growth affects travel demands in two ways: first, it affects the quantum of travel that occurs and, second, it affects the income which people have at their disposal, which in turn affects the mode choices they make.</p>
Vehicle ownership	<p>In this scenario we considered how changes in vehicle ownership rates might affect travel demands, especially mode choices.</p>

The travel demand forecasting model (described in more detail in Appendix D) was used to assess these alternative futures. This forecasting model was used to test how travel demands may change in the Bay of Plenty over the next 30 years for a “business as usual” option.

Before continuing, we need to more clearly define the travel demand indicators that will be used when discussing the relative effects of these various alternative futures. Whereas the previous chapter focussed on mode shares and per capita travel demands, we are now more interested in the absolute travel demands that are placed on the regional transport system.

To describe these effects we will present the absolute and relative change in travel demands for each mode. We will break this change down further to assess the degree to which various travel modes contribute to the growth in travel demands from 2006-40. The growth in demands represents the extra trips and/or kilometres that are loaded onto the regional transport network by 2040. The need to accommodate growth is an important driver of transport investment, which will be discussed in more detail in subsequent sections.



### 3.1 Fuel costs

A high fuel cost future was modelled by assuming:

- Real fuel prices increase from the current price of \$1.77 to reach \$2.61 per litre by 2040 (equates to an average increase of 1.36% per year (Donovan and Genter 2008))
- The following elasticities of demand with respect to changes in fuel price:
  - Vehicle kilometres travelled (VKT) of -0.12 in the first year and -0.24 over five years (Kennedy and Wallis 2007); and
  - Vehicle trips of -0.10 in the first year and -0.20 over five years. The higher elasticity for VKT reflects that longer trips are more sensitive to fuel prices.
    - ♦ *The cumulative reduction in vehicle trips was reallocated to the other transport modes on a pro rata basis, i.e. the reduction in vehicle mode share was split across the non-driver transport modes based on their mode share relative to each other.*
    - ♦ *The shift in travel demands to car-passenger increases by 50%, because higher fuel prices will increase the costs of all vehicle travel – even where multiple passengers are carried.*
    - ♦ *Thus car-passenger mode share increases relative to driver mode share, although the increase is smaller than that observed for walking/cycling and public transport.*
    - ♦ *The impacts of high fuel prices on mode share are summarised below.*

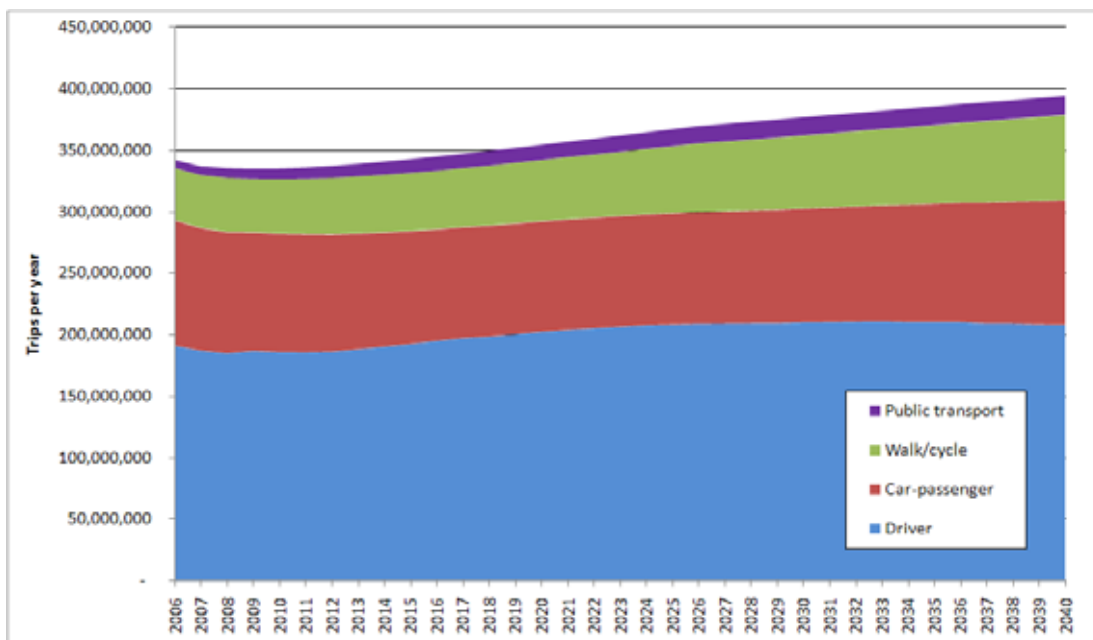


Figure 18 The impacts of high fuel prices on regional travel demands (2006-40)

High fuel costs cause considerable growth in the number of trips by public transport and walking/cycling, especially from 2020 onwards when fuel prices start to rise more rapidly. Growth in driver trips is naturally more subdued. The impact on overall regional travel demands is also summarised in the table below. Trip mode

shares for walking/cycling and public transport increase substantially, whereas car-passenger mode share reduces by about 4% (in contrast to the base scenario where it decreased by over 7%).

Table 9 The impacts of high fuel prices on regional travel demands (2006-40)

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	208	56.0%	52.9%	1778	2094	57.4%	53.1%
Car-passenger	102	101	29.7%	25.7%	1174	1393	37.9%	35.3%
Walk/cycle	43	70	12.5%	17.7%	56	187	1.8%	4.7%
Public transport	6	15	1.9%	3.8%	89	267	2.9%	6.8%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

The figure below breaks down the contribution of various modes to the growth in travel demands that is observed by 2040.

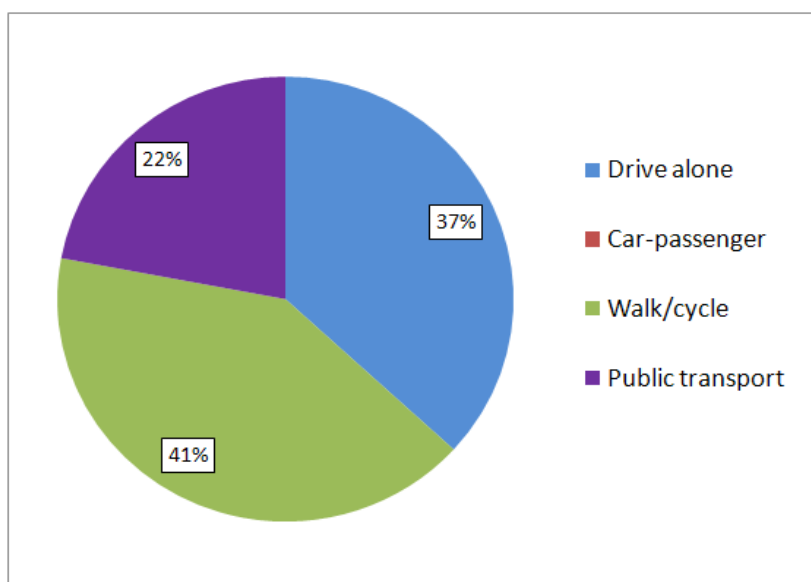


Figure 19 Fuel Costs - Breakdown in travel demand growth by mode 2006-40

The figure above shows that in a high fuel price scenario walking/cycling contributes the most to meeting growth in regional travel demands (as measured in terms of trips taken). Driver and public transport also make an important contribution to the region's growing travel demands.

### 3.2 Parking costs

The impacts of parking reforms were modelled by assuming:

- Average parking prices in central Tauranga, Rotorua, and Whakatane increase 200% in real terms from their current levels by 2040;

- Elasticity of demand for vehicle kilometres and vehicle trips of -0.19 and -0.29 in the short (first year) and long run (within five years) respectively (Litman (2007));
- Only trips to central city areas were affected, with suppressed vehicle trips diverted to alternative modes on a pro-rata basis.

The impact of parking costs on mode share are summarised in the figure below. This suggests that in a future characterised by high parking costs, the driver mode share may be expected to reduce by approximately 5% compared to the base scenario. The impact on overall travel regional travel demands is illustrated below.

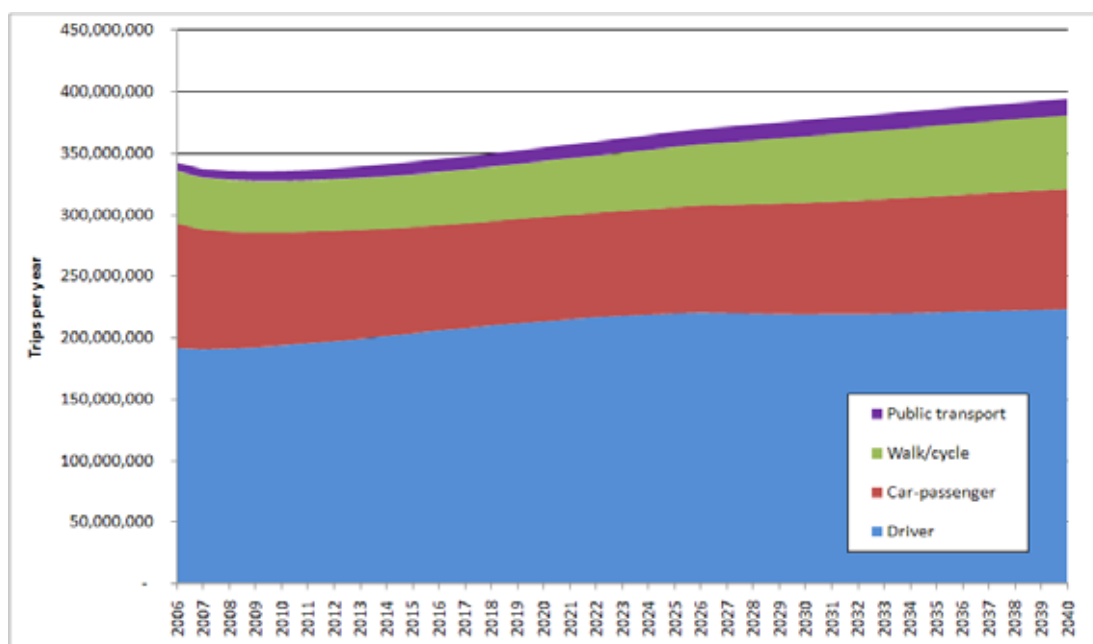


Figure 20 Impact of higher parking costs on regional trips (2006-40)

As with high fuel costs, the effects of parking costs do not kick in until around 2020 onwards, after which time the total number of driver trips remains broadly the same. Meanwhile, the number of trips by car-passengers also remains broadly the same over the entire time-horizon, whereas walking/cycling and public transport trips increase noticeably. The impacts of parking reforms on travel demands are summarised in the following table.

This illustrates how parking costs tend to have a smaller impact on overall travel patterns than fuel costs, because they only affect trips to central city areas. Notwithstanding their limited geographical coverage, the effects are significant: Driver mode share increases only marginally above 2006 levels, whereas it previously grew by approximately 2%.<sup>26</sup> The contribution of the various transport

<sup>26</sup> We note that we have only attempted to model “first order” responses to higher parking costs. That is, they consider the impacts of higher parking costs only on vehicle trips to central Tauranga, Rotorua, and Whakatane. The model does not consider second order effects, which occur over a longer time period. For example, higher parking costs in central city areas is likely to deter vehicle ownership in those areas, which in turn will impact on travel choices. Similarly, the model does not consider the potential for parking prices to “free up” additional space for development. More compact land use patterns facilitated by parking reforms may in fact be their most important long term impact. Not considering these second order effects is likely to underestimate the long term impacts of parking reforms on driver mode share.

modes to growth in travel demands is illustrated below for the “business as usual” scenario in comparison to a situation of higher parking costs.

Table 10 Impact of high parking costs on regional travel demands (2006-40)

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	223	56.0%	56.6%	1778	2307	57.4%	58.6%
Car-passenger	102	98	29.7%	24.9%	1174	1280	37.9%	32.5%
Walk/cycle	43	60	12.5%	15.2%	56	146	1.8%	3.7%
Public transport	6	13	1.9%	3.3%	89	208	2.9%	5.3%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

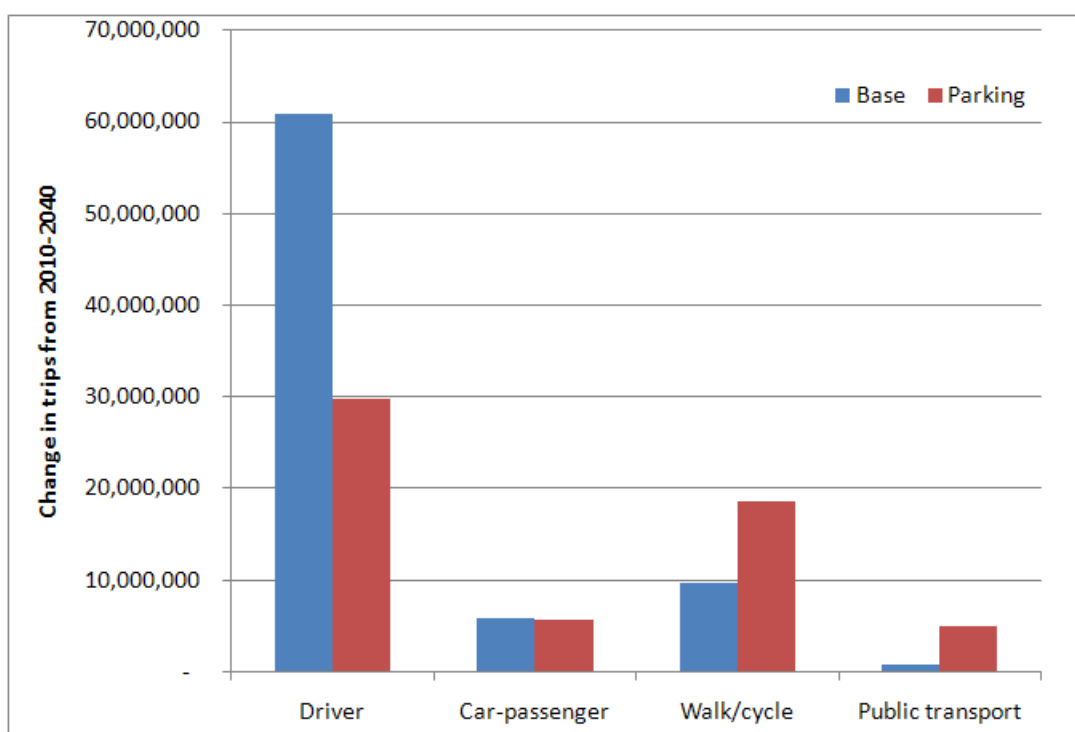


Figure 21 Parking prices - breakdown in travel demand growth by mode 2006-40 compared to business as usual scenario

Note also that the relative contributions of public transport and walking/cycling are more evenly balanced than in the fuel price analysis, because public transport service is disproportionately focussed on the same central the city areas most affected by higher parking prices.

### 3.3 Economic growth

Economic growth affects travel demands in two key ways:

- *Quantum effect* - economic conditions affect the total quantum of travel that occurs. Some types of travel (especially commercial vehicle travel) are closely linked to economic activity. Thus when the economy expands we can expect per capita travel to increase, and vice versa. We modelled the quantum effect by assuming a per capita elasticity of demand for total travel of +0.30 with respect to economic activity, as measured by GDP (Donovan and Genter 2008).<sup>27</sup>
- *Income effect* - economic growth ultimately flows through into higher incomes, which in turn affects the mode choices people make. We developed a separate regression model for the “drive-alone” mode choice, which included variables for income as well as other transport modes and had an overall R-squared of 99.5%.<sup>28</sup> We could thus test the effects of increasing income growth rates on driver mode share.

Unlike the alternative futures tested in previous sections (specifically fuel and parking) there are both high and low risks to economic growth. While there is a low chance of fuel prices and parking costs dropping below current levels, the future risks to economic growth are less clear – i.e. they lie on both the upside and the downside. For this reason, we have modelled the effects of economic growth rates  $\pm 12.5\%$  compared to long run trends.

The high economic growth scenario is illustrated in the following figure, which shows both the quantum and income effects. This now shows approximately 415 m trips per year, which is 5% more than previously forecast under “business as usual” assumptions. The higher economic growth tends to have a larger impact on the number of trips by drivers and car-passengers; walking/cycling and public transport trips remain largely unaffected.

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<sup>27</sup> NB: Results for the base model implicitly assume that regional economic growth does not vary from the rate observed from 2001-2006.

<sup>28</sup> Coefficients for the other JTW choices were close to one – which suggests that a 1% increase in mode share for that mode would cause a 1% reduction in driver mode share, as would be expected.

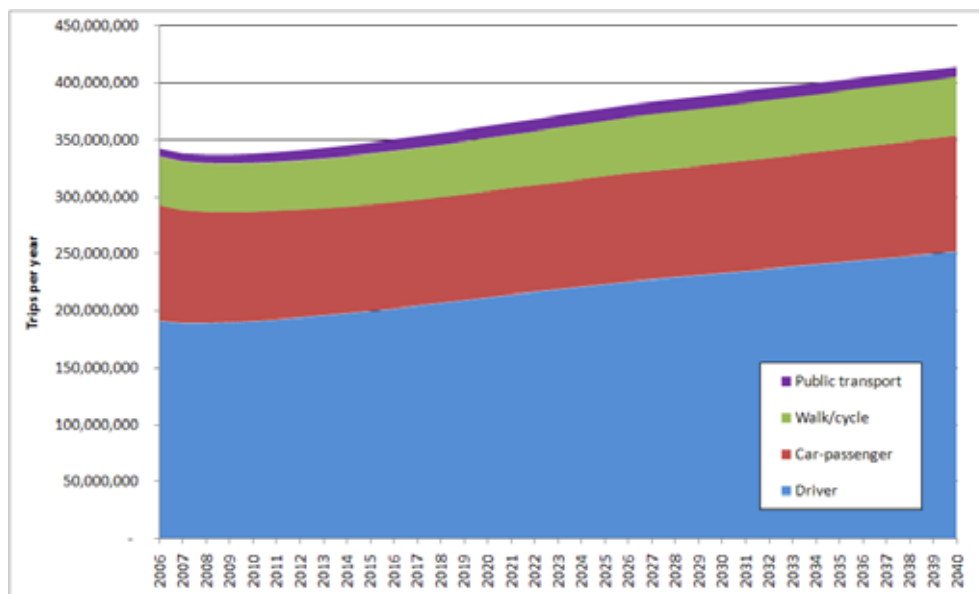


Figure 22 Impact of high economic growth on regional trips (2006-40)

The change in trips and kilometres for each mode is summarised in the following table for the high economic growth scenario.

Table 11 Impact of high economic growth on regional travel demands (2006-40)

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	252	56.0%	60.8%	1778	2549	57.4%	62.0%
Car-passenger	102	102	29.7%	24.6%	1174	1317	37.9%	32.1%
Walk/cycle	43	52	12.5%	12.5%	56	92	1.8%	2.2%
Public transport	6	9	1.9%	2.1%	89	150	2.9%	3.6%
<b>Total</b>	<b>342</b>	<b>415</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>4109</b>	<b>100%</b>	<b>100%</b>

To put these changes in context, a 0.25% increase in the rate of economic growth (i.e. a shift from average to high growth) would have the following effects on the transport system:

- The total amount of travel that takes place would increase by 5%; and
- Travel by car-based modes growing by 9% and non-car modes falling by 11%;
- The effects of economic growth on travel demands in a high and low economic growth scenario are summarised in the table below.

Table 12 *Relative change in travel demands for “car” and “non-car” modes in high and low economic growth scenarios*

Type of travel	Economic Growth Scenario	
	Low	High
Car	-9%	8%
Non-car	13%	-7%

This suggests that the effects of economic growth are asymmetric. Most interesting is the relatively good performance of the non-car transport modes in the low economic growth scenario, which suggests that they will have higher returns in times of sustained low economic growth. This is favourably unsynchronised with “car” based modes, which tend to do better at times of high economic growth, possibly in reflection of increased amounts of recreational travel.

### 3.4 Vehicle ownership

We tested the impacts of high and low vehicle ownership on future travel demands for both a high and low scenario, by changing the growth parameters such that average vehicle ownership rates change by about 10% from that assumed in the “business as usual” scenario. Our analysis suggests that if vehicle ownership increased 10% more than forecast then car-based travel demands would increase by 2% and vice versa.

Public transport mode share was relatively insensitive to changes in car ownership, whereas walking/cycling was much more sensitive. We suggest this reflects the relatively large effects associated with households gaining access to at least one vehicle. Most of these households are likely to be in rural areas; access to a vehicle does not change their use of public transport because it is basically non-existent.

### 3.5 Summary of findings

Previous sections have considered the individual impacts of changes in fuel prices, parking costs economic growth, and vehicle ownership. However it is somewhat more likely that several of these “futures” are experienced simultaneously, i.e. they are positively correlated. For example, high fuel prices are also likely to be associated with low economic growth and low vehicle ownership. On the other hand, low fuel prices are likely to be associated with high economic growth and high vehicle ownership rates.

To test the cumulative effects of these factors the following two travel demand scenarios, were considered: A “high car demand” scenario that combined high fuel prices, high parking costs, low economic growth, and low vehicle ownership, and vice versa for the “low car demand” scenario. The range of travel demands (in terms of car-based trips) for these two scenarios is illustrated in the following figure in comparison to the base assumptions. This illustrates how the two alternative scenarios combine to have a considerable impact on the overall number of trips taken by car-based transport modes.

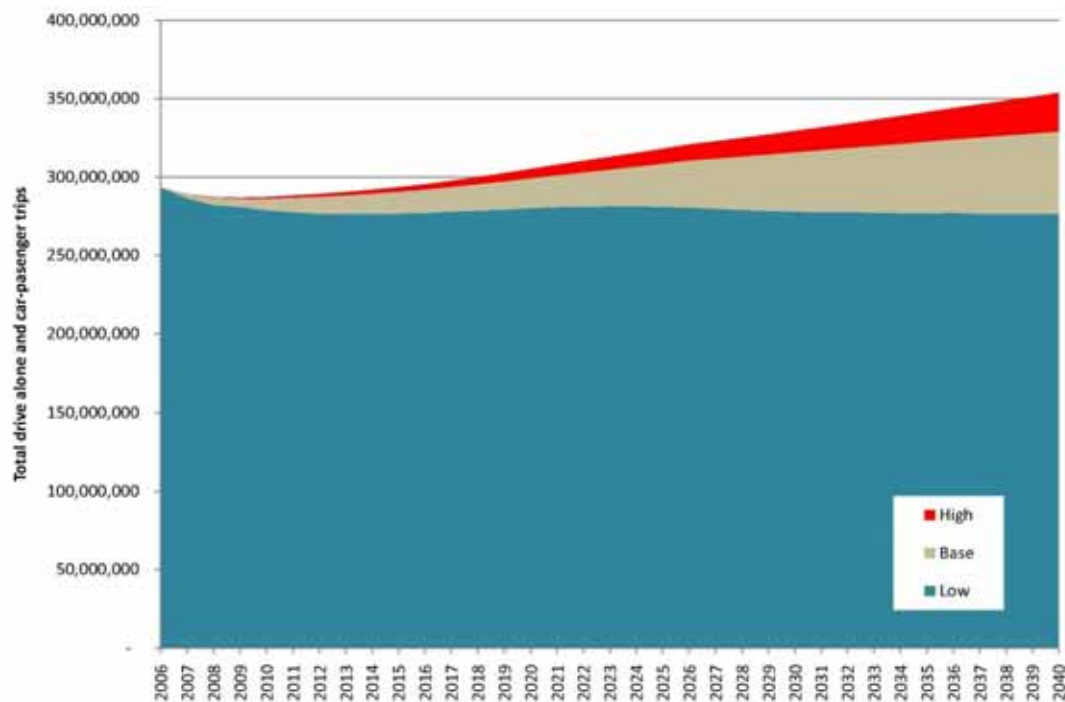


Figure 23 Cumulative impacts of alternative future scenarios on total driver and car-passenger trips (2006-40)

The effects of these scenarios are asymmetric: there is greater scope for car-based travel demands to be less than normal, which reflects the additional impacts of high fuel prices and parking costs in this scenario. Notwithstanding these cumulative impacts, we note the continued importance of road-based transport modes; even in the low demand scenario for road-based transport modes still accounted for 74% of all trips taken and 85% of all kilometres travelled in 2040. This highlights the continued importance of the regional road network, even in a future that is considerably different from what we know today.

On a related note, the key difference between the two scenarios lies in how they manage growth at the margin. The existing road-based travel demands remained largely unaffected throughout the various scenarios tested. In contrast, the different scenarios tended to affect how the growth in demand was accommodated between the various transport modes. Fuel prices had a considerable impact on regional travel demands because they affect the cost of all car-based travel within the region. Parking costs, in contrast, affected only trips to central areas.<sup>29</sup>

The graph below show the travel demands for non-car modes under the same three scenarios. There are a number of key features of this graph:

- Total trips by “non-car” modes increase in all three scenarios. The rate of growth varies from 0.64% to 2.1% per annum in the low and high scenarios respectively.
- Even in the low scenario, the rate of growth in “non-car” modes exceeds the highest growth observed in the high scenario for “car-based” modes (0.64% versus 0.55%); and

<sup>29</sup> Naturally, if the scope of parking reforms was extended beyond these areas then the effect of parking costs on travel demands would also increase.



- The low scenario results in only slightly less demands than in the base scenario, whereas the high scenario sees considerably more (100% higher than 2006 levels).

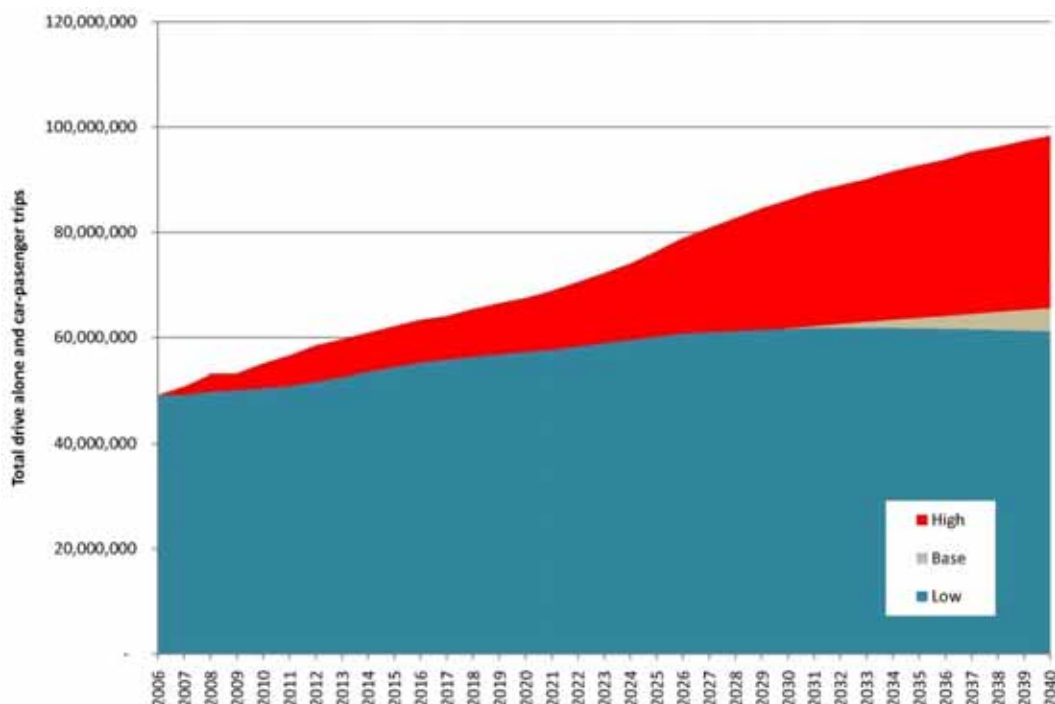


Figure 24 Cumulative impacts of alternative future scenarios on total public transport and walking/cycling trips (2006-40)

Our analysis of alternative transport futures has highlighted the following key messages:

- Volatility is the norm rather than the exception – most of the alternative futures considered in this chapter are likely to be correlated, at least in terms of their effects on “car-based” travel demands. This means that if one occurs then the others are also more likely to eventuate, which in turn means that travel demands exhibit considerable volatility, at least on an annual basis.
- **Continued importance of the road network** – Car-based transport modes are likely to remain as the dominant transport mode in the Bay of Plenty region for the foreseeable future. Even in the low scenario, car-based transport modes were used for approximately 74% of all trips and 85% of all kilometres travelled.
- **Non-car modes increase market share** – Even in a low demand scenario, non-car transport modes (namely public transport and walking/cycling) gain market share. Their effects are mainly felt at the margins, in terms of how much they impact on overall growth in car-based transport modes.

These key messages should be kept in mind when considering the relative strengths and weaknesses the various strategic transport options that are discussed in Chapter Part 1. The next chapter, however, will consider trends in freight travel demands in more detail.

## Part 4: Trends in freight travel demands

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Previous chapters have focussed on household travel demands, which tend to be dominated by the movement of people. In contrast, this chapter will now delve into more detail on general trends in freight travel demands across the region.

We note that while the NHTS considers all household travel, including that undertaken by commercial vehicle drivers, only a small proportion of total household travel is associated with freight movements, such that trends in the latter are subsumed by movements in personal travel demands. And, quite understandably, personal and freight travel demands are influenced quite differently by quite different factors (Donovan & J. Genter, 2008).

Freight travel demands also demand special attention for several reasons. First, freight movements are typically undertaken for commercial reasons and as a result tend to be relatively high value. Second, freight demands tend to be highly diverse and typically suited to one particular mode, whether road, rail, shipping, or air, such that mode shift is more difficult. Third, road freight (especially heavy vehicles) typically generates a host of negative externalities (noise, air pollution, and casualties) that have adverse impacts on surrounding communities.

This final reason provides the prima facie case for Government efforts to shape freight demands in such a way that they contribute to an efficient level of socio-economic welfare. Because these negative externalities are not priced, it is likely that overall freight volumes are higher than they would be in an “optimal” setting, where all costs were internalised to users.

The following sections of this chapter are structured as follows:

- Section 4.1 analyses trends in heavy vehicle volumes on the state highway network;
- Section 4.2 analyses recent trends in freight volumes on the rail network;
- Section 4.3 considers regional freight demands more broadly and presents information on forecast freight demands to 2040 by mode;
- Section 4.4 Estimates the potential impacts of freight management interventions on the demand for freight in the Bay of Plenty; and
- Section 4.5 summarises key trends in freight travel demands identified in this chapter.

To finish, this section presents a base freight scenario in terms of total tonne kilometres travelled by mode. Further research is required to break these demands down into more specific numbers for freight movements by day and route.

### 4.1 Trends in heavy vehicle volumes

The figure below shows numbers of heavy commercial vehicles (HCV) recorded on state highways in the Bay of Plenty region.

Some important observations can be drawn from this figure, including:

- HCV volumes are relatively volatile, with all routes experiencing a decline in volumes in at least one year and increases of up to 50% from one year to the next;

- Overall HCV volumes have increased, particularly in the period from 2001 to 2003. However the overall increase was in some locations marginal; State Highway 3, for example, recorded only a 5% increase in volumes from 2001-2009; and
- Since 2003 overall HCV volumes have been relatively stagnant; this may reflect slower economic growth and higher fuel prices.

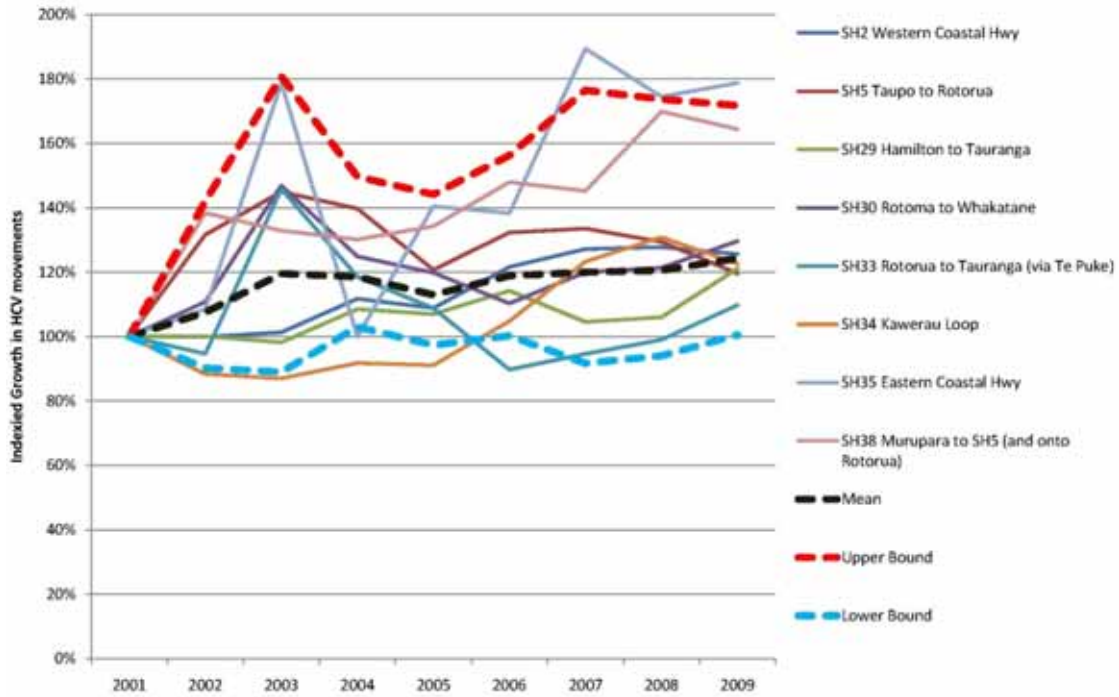


Figure 25 Heavy vehicle counts on the state highway network in the Bay of Plenty (2001-2009) Sourced from: NZTA, State Highway Traffic Volumes

Trend analysis (logarithmic and linear) of this data suggests annual average growth rates in the order of 1.1%-2.3% per annum would be appropriate, although the rate of growth varies considerably depending on location.<sup>30</sup> In this case a logarithmic model provides a considerably better fit with the underlying data (R-squared of 81% versus 67%). This is consistent with increasing economies of scale, as would be expected in a small but rapidly growing region such as the Bay of Plenty.<sup>31</sup>

## 4.2 Trends in rail freight volumes

KiwiRail supplied data on rail freight volumes for lines in the Bay of Plenty in the last two financial years. The freight data is broken down into *General Freight* and *Bulk Freight* categories and includes movements in and out of the Bay of Plenty region.

Within the bulk freight “Forestry” is the largest category within bulk freight, making up about 77% of the total net-tonne kilometres travelled (NTK).<sup>32</sup> General freight consists of import/export commodities. Changes between 2009 and 2010 are summarized in the table below. This shows the number of train movements approximately 8% higher than in 2009, while net tonne kilometres remains approximately equal. The number of TEU is up 4% on 2009.

Table 26 Summary of rail freight movements in the Bay of Plenty region (financial years 2009-10)

Train Grouping	Number of trains			Net tonne kilometres [m NTK]			Containerised twenty foot equivalent		
	2009	2010	Δ	2009	2010	Δ	2009	2010	Δ
<b>General</b>	4,626	5,009	8%	397 m	391 m	-2%	221,935	232,208	+5%
<b>Bulk</b>	7,114	7,706	8%	424 m	433 m	+2%	45,597	46,618	+2%
<b>Grand Total</b>	<b>11,740</b>	<b>12,715</b>	<b>8%</b>	<b>822 m</b>	<b>824 m</b>	<b>+0%</b>	<b>267,532</b>	<b>278,826</b>	<b>4%</b>

The 2010 monthly train volumes are presented in the graph below. This exhibits a general uniformity in train movements across the year, although there is some evidence of elevated rail volumes being carried during March, April, May, and June. Whether this is seasonal, or reflects a more sustained increase in activity on the rail network remains to be seen.

<sup>30</sup> Logarithmic models increase at a reducing rate, whereas linear models grow at a constant rate.

<sup>31</sup> We note that many “low-level” traffic studies and assessments make use of linear, rather than logarithmic growth trends. There is growing evidence to suggest that such trends over-estimate the growth in traffic, particularly for HCVs, because they tend to under-estimate the efficiencies that will be exploited by people and businesses as the overall “travel” market grows in size; so-called economies of scale.

<sup>32</sup> Net-tonne kilometers travelled indicates how much freight was carried over what distance. NTK is a useful measure of freight movements than just “trips taken” or “kilometers travelled” because the latter provide no information on the volume of freight that was carried.

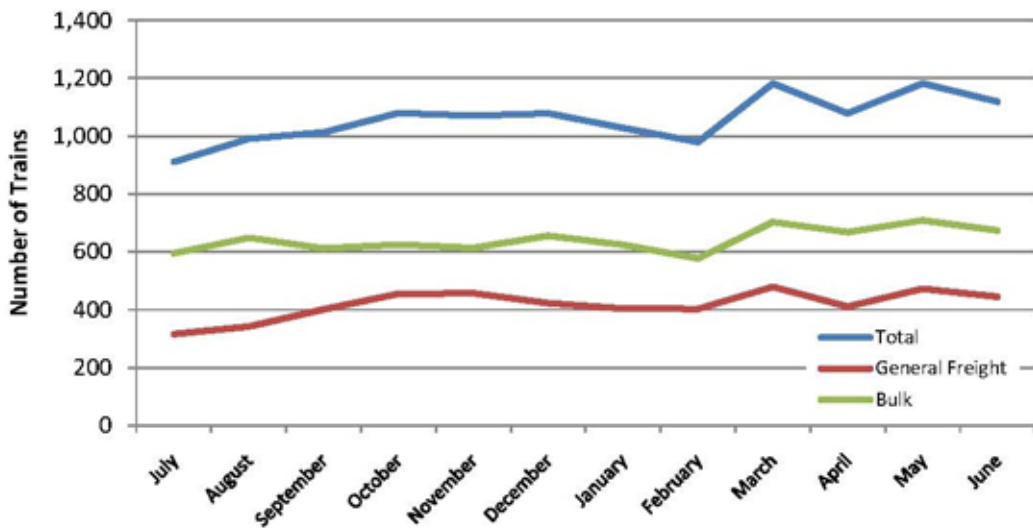


Figure 6 Monthly rail movements (2010)

KiwiRail's Annual Report confirms that an export lead recovery began with a 14% lift in volumes (on the year before) during the second half of 2010, lead primarily by movements in dairy and forestry products. Looking forward, major developments in rail governance, in combination with economic trends, look likely to shake up trends in rail movements. The recently released "KiwiRail Turnaround Plan" suggests KiwiRail will need to increasingly position itself in the key markets where it holds a competitive advantage, specifically the bulk movement of dairy and forestry products, such that it can start to earn more competitive rates of return. The Turnaround Plan may be summarised as follows: "The plan aims to increase rail traffic volumes and revenue, increase productivity, modernise assets and separate out the commercial elements of the business from the non-commercial." The implications for the national network are summarised in the figure below, which shows all rail lines in the Bay of Plenty as "key routes."

## Implementing the plan

There will be five major areas of investment and work to protect and grow our revenue, and create a sustainable rail system for New Zealand:

1. **Step change in the Auckland-Christchurch route**
  - Reduce transit time and improve reliability along the route - easing curves, removing speed restrictions, greater renewals investment in bridges and sleepers and passing loops
  - Improve exit and entry from Auckland and Wellington - improvements at terminals and on mainlines to reduce transit times and conflicts with commuter services
  - Increase ferry capacity for rail freight - extend length of Aratere and make Kaitaki rail-capable
2. **Other key routes**
  - Improve reliability and capacity with increased renewals investment in replacement of sleepers, strengthening of bridges, refurbishment of track formation
3. **Enabling investment**
  - Improved IT systems and processes, equipment and facilities at terminals
  - New locomotives, wagons
  - Improved track infrastructure
4. **The minor lines**
  - Review business on North Auckland, Stratford-Okahukura, Napier-Gisborne and North Wairarapa lines
  - Consultation with communities, customers and staff
  - Close or mothball by 2012 if anchor customers do not emerge
5. **Auckland and Wellington metro services**
  - Clarify and assign accountability for costs associated with operating metro networks



Figure 27 Implications of the “KiwiRail Turnaround Plan” for New Zealand’s Rail Network (Sourced from KiwiRail, 2010)

The plan notes that minor routes (illustrated in blue) may be closed or mothballed, so as to free up resources for the key routes (illustrated in yellow). The implication is that investment in the rail network will be increasingly focussed on certain parts of the network, where volumes may be expected to increase. In turn, maintenance and capacity issues on these lines will need to be addressed. These developments have been given additional impetus by the Government agreeing to spend \$500 m on new locomotives, which may be expected to improve travel times and cut operating costs, as well as unusually favourable weather conditions resulting in record milk production across the country.

In terms of the Bay of Plenty, the implications of the KiwiRail Turnaround Plan are clear: freight volumes on the rail network can be expected to increase. While this will undoubtedly bring benefits by removing trucks from the roads, it may also create new safety and environmental issues that need to be managed. Moreover, there are still large parts of the region that do not have access to the rail network. In some locations where rail provides a cost competitive alternative to road, the aforementioned rail improvements may be expected to increase demand for freight-hubs that allow freight to be moved off trucks and onto the rail network. The following section looks more generally at the future freight task in the Bay of Plenty region.

### 4.3 Regional freight demands analysis

The Bay of Plenty Regional Freight Study (2010) develops a picture of regional freight movements, both now and in the future. It specifically considered:

*“...the main modes of freight movements within the region and on the corridors connecting it to the rest of New Zealand particularly to the other regions in the Upper North Island and provides an analysis of both the 2006-07 position and the anticipated future position. Much of the analysis is based on the National Freight Demands Study (NFDS) which sets out the position for 2006-07. While there have been a number of changes since the date of this report a number of which are identified in this report, the comprehensive 2006-07 position identified in the NFDS has been taken to be broadly representative of the current position.”*

The study builds on and extends analysis undertaken as part of the National Freight Demand Study (NFDS).

In terms of headline numbers, the study notes the relatively high volumes of freight movements in the region, with per capita tonnes of freight running at 2.5 times the national average. Approximately 55% of freight movements occur internal to the region (mainly between Murupara/Kawerau and the Port of Tauranga), whereas 35% is associated with movements between the Bay of Plenty and other Upper North Island regions. The remaining 10% is associated with flows to other regions. Freight movements in the Bay of Plenty are dominated by movements of bulk commodities, such as logs, timber, aggregates, and dairy products, which together represent almost three quarters of freight demands. The split in freight movements in the Bay of Plenty strongly favours exports, which highlights the wider national economic importance of the Port of Tauranga.

In terms of mode share, road based freight transport caters for approximately 83% of volumes, while rail accounts for 15%, and coastal shipping the remainder. Rail and coastal shipping are particularly competitive for freight movements between the Bay of Plenty and Upper North Island regions, where road mode share declines to 67%, with rail and coastal shipping mode share increasing to 29% and 4% respectively. The higher rail mode share for movements to other regions in the Upper North Island reflects the existence of relatively direct rail and shipping routes (such as is provided by the Kaimai tunnel) as well as coal movements from the Bay of Plenty to the Huntly Power Station. Rail also competes relatively well for some internal freight demands, specifically logs travelling between Murupara/Kawerau and the Port of Tauranga.

Looking forward to 2040, the growth in regional freight movements is expected to be dominated by increasing demand for internal travel. Overall mode shares are expected to remain broadly the same as in 2006-07, with the cessation of coal freight movements impacting on rail's overall mode share. The study notes that:

*On the basis of these individual forecasts and assumptions, the Study predicted a total growth in the freight task of about 75 per cent nationally over the period, equivalent to average annual increases of about 2.25 per cent over the period. However, these forecasts did not take into account the effects of the recent economic downturn which has resulted in a hiatus in economic growth and in the volumes of freight transported, particularly as reflected in the movement of goods by road and through the port of Tauranga.*

A number of important “business as usual” assumptions are made in formulating the freight demand forecasts:

- Distribution patterns remain broadly the same;
- Shipping patterns remain broadly the same; and
- The effects of the economic downturn are not considered.

The 2.25% annual average growth is broadly similar to the linear annual growth rate for heavy vehicle movements on the state highway network from 2001-09 that was calculated in the previous section. This analysis also observed that a logarithmic growth model appears to be more appropriate, which in turn resulted in a much lower annual growth rate of 1.1%.

We expect that growth in future freight demands would struggle to exceed growth rates observed in the period 2001-09, when both the regional population and economy expanded rapidly. For these reasons, we consider that the demands presented in the *Bay of Plenty Regional Freight Study* provide a reasonable indication of future freight demands in the region, even if it is likely to be on the high side in the short term.

#### 4.4 **Strategic effects of freight improvements**

Forecasting future freight trends is complicated by the following factors:

- The competitive nature of freight movements means that the wider logistic networks must evolve rapidly over time in response to technological developments, such as large ships and heavy vehicles;
- Freight volumes tend to be volatile; this reflects their sensitivity to prevailing economic conditions. They are also extremely lumpy and closely associated with particular industries and/or activities, such as horticulture; and
- Economies of scale and New Zealand’s small market are driving consolidation around a couple of major international ports, which are in turn served by a number of smaller domestic ports. This dynamic is expected to unfold over the next few years.

With these developments in mind, we move cautiously towards modelling the impact of freight management measures on freight mode share in the Bay of Plenty. We start with a qualitative description of some specific developments that may impact on freight volumes in the Bay of Plenty region, as summarised below:



<b>Development</b>	<b>Associated infrastructure</b>	<b>Implications for freight movements</b>
Port of Tauranga expands facilities to handle larger (7,000 TEU+) ships	Expansion in port infrastructure at Sulphur Point (containerised) in particular	Places additional stress on supply chain capacity. Rail and inland ports may play a larger role
Capacity increases on ECMT line, and Murupara / Kawerau rail improvements	KiwiRail has indicated the potential for this line to accommodate expanded facilities and passing loops	Increased uptake of rail for regional movements of logs and other commodities from central regions
Opotiki Harbour Development and Freight Hub	Aquaculture industry may support new port facilities at Opotiki along with freight (road/ship) interchange	Increased use of shipping to transport logs and building materials (e.g. aggregates)

There is little in the way of background information on these potential developments, which in turn means that our assessment of their impacts on regional freight patterns must proceed in a cautious and general way.

To model their impacts on freight demands, we have made the following assumptions:

- The Port of Tauranga and ECMT and Murupara / Kawerau rail improvements are implemented by 2015 (mode shift to rail), whereas the Opotiki Harbour Development is up and running by 2020 (mode shift to coastal shipping); and
- Each development catalyses a “mode shift” of 25% in their respective markets. Total market size was determined by considering the total volume of internal freight movements that could potentially be served by each development.

Based on these assumptions, rail and coastal shipping increase their overall market share from 16% to 23% in 2040. These impacts are illustrated in the table below and figure on the following page. This shows how the majority of the impacts are felt in 2015 when the Port of Tauranga and rail improvements come on-stream. The bulk of the mode shift is picked up by rail, with only small gains for coastal shipping, which reflects the relatively small size of freight demands in Opotiki. These calculations are summarised in the following table.

Table 13 Impact of freight measures on regional freight demands 2006-40 (tonnes)

Year	Total Freight Market (MT)			Base Non-road market (MT)			Mode shift to non-road modes (MT)			
	Port of Tauranga	'ECMT / Murupara / Kawerau Rail Improvements	Opotiki Harbour Development and Freight Hub	Port of Tauranga	'ECMT / Murupara / Kawerau Rail Improvements	Opotiki Harbour Development and Freight Hub	Port of Tauranga	'ECMT / Murupara / Kawerau Rail Improvements	Opotiki Harbour Development and Freight Hub	Total freight mode shift (MT)
2006	10.50	17.40	1.59	5.25	1.30	0.159	0.00	0.00	0.00	0.00
2007	11.13	17.67	1.62	5.56	1.33	0.162	0.00	0.00	0.00	0.00
2008	11.75	18.34	1.66	5.88	1.37	0.166	0.00	0.00	0.00	0.00
2009	12.38	18.80	1.69	6.45	1.40	0.169	0.00	0.00	0.00	0.00
2010	13.00	19.27	1.72	6.29	1.44	0.172	0.00	0.00	0.00	0.00
2011	13.32	19.74	1.76	6.39	1.47	0.176	0.00	0.00	0.00	0.00
2012	13.63	20.21	1.79	6.49	1.51	0.179	0.00	0.00	0.00	0.00
2013	13.95	20.68	1.83	6.56	1.54	0.183	0.00	0.00	0.00	0.00
2014	14.26	21.14	1.86	6.81	1.58	0.186	0.00	0.00	0.00	0.00
2015	14.58	21.61	1.89	6.94	1.61	0.189	0.00	0.00	0.00	0.00
2016	14.89	22.08	1.93	7.07	1.65	0.193	0.01	0.00	0.00	0.01
2017	15.21	22.55	1.96	7.22	1.68	0.196	0.01	0.00	0.00	0.01
2018	15.53	23.02	1.99	7.39	1.72	0.199	0.02	0.00	0.00	0.02
2019	15.84	23.48	2.03	7.53	1.75	0.203	0.03	0.01	0.00	0.04
2020	16.16	23.95	2.06	7.68	1.79	0.206	0.05	0.01	0.00	0.06
2021	16.47	24.42	2.09	7.83	1.82	0.209	0.08	0.02	0.00	0.10
2022	16.79	24.89	2.13	7.98	1.86	0.213	0.13	0.03	0.00	0.17
2023	17.10	25.36	2.16	8.13	1.89	0.216	0.21	0.05	0.01	0.26
2024	17.42	25.82	2.19	8.28	1.93	0.219	0.33	0.08	0.01	0.41
2025	17.74	26.29	2.23	8.43	1.96	0.223	0.49	0.11	0.01	0.61
2026	18.05	26.76	2.26	8.58	2.00	0.226	0.70	0.16	0.02	0.88
2027	18.37	27.23	2.30	8.73	2.03	0.230	0.96	0.22	0.03	1.21
2028	18.68	27.70	2.33	8.88	2.07	0.233	1.24	0.29	0.03	1.56
2029	19.00	28.16	2.36	9.03	2.10	0.236	1.52	0.35	0.04	1.91
2030	19.31	28.63	2.40	9.18	2.14	0.240	1.76	0.41	0.05	2.22
2031	19.63	29.10	2.43	9.33	2.17	0.243	1.97	0.46	0.05	2.48
2032	19.80	29.36	2.45	9.41	2.19	0.245	2.11	0.49	0.05	2.66
2033	19.97	29.61	2.47	9.49	2.21	0.247	2.22	0.52	0.06	2.79
2034	20.15	29.87	2.49	9.58	2.23	0.249	2.29	0.53	0.06	2.89
2035	20.32	30.12	2.51	9.66	2.25	0.251	2.35	0.55	0.06	2.96
2036	20.49	30.38	2.52	9.74	2.27	0.252	2.39	0.56	0.06	3.01
2037	20.66	30.63	2.54	9.82	2.29	0.254	2.43	0.57	0.06	3.06
2038	20.84	30.89	2.56	9.90	2.31	0.256	2.46	0.57	0.06	3.10
2039	21.01	31.14	2.58	9.99	2.33	0.258	2.49	0.58	0.06	3.13
2040	21.18	31.40	2.60	10.07	2.35	0.260	2.52	0.59	0.07	3.17

While the improvements have a significant impact on the relative freight volumes carried by rail, they have only marginal impacts on total freight volumes carried by road – equivalent to approximately five years of background growth in freight demands. The adjusted freight and base road volumes are illustrated in the following figure.

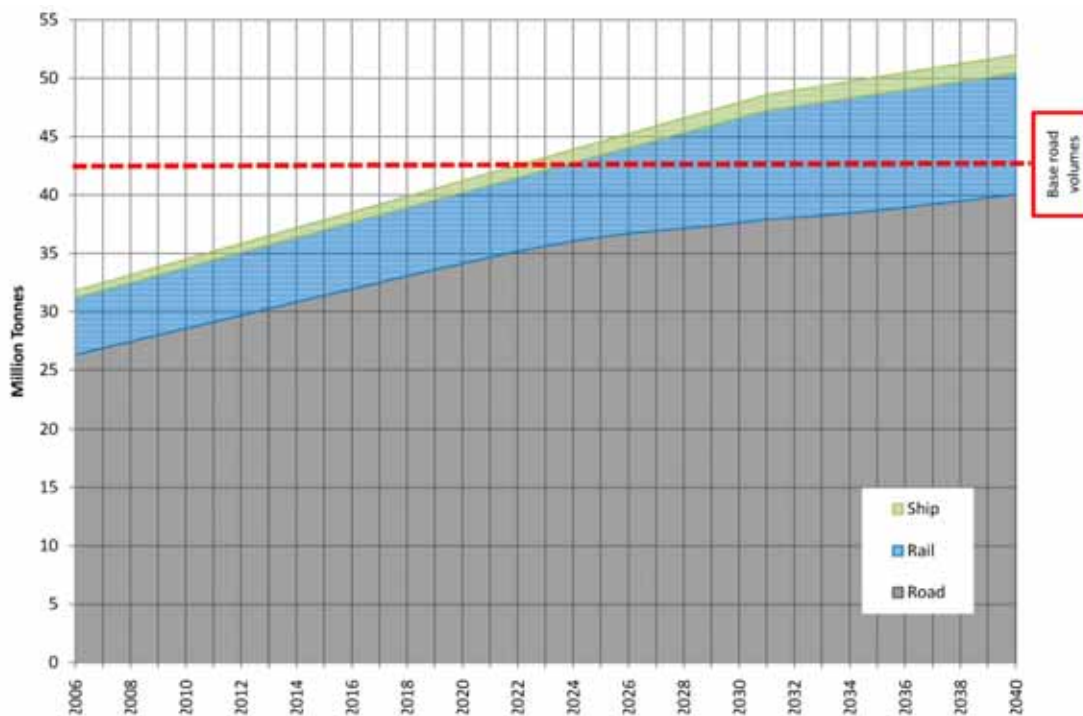


Figure 18 Regional freight demands following freight measures (2006-40)

More detailed studies should be undertaken to investigate the potential shift in freight volumes associated with each of these freight improvements.

## 4.5 Summary of findings

The rationale for increased regional investment in freight management measures, especially shifting freight from road to rail and coastal shipping, is relatively straightforward: first, freight movements are of relatively high economic value. Improving the efficiency with which freight can move through the region is likely to deliver economic benefits not only to the region but also adjacent region. Second, these movements often generate negative externalities, such as emissions to air, water, and soil, which have a range of economic, social, and environmental costs. The existence of these externalities and the costs they generate signals a need for Government involvement to ensure the safe and efficient movement of freight.

Data suggests that growth in road freight slowed from 2001-09. Rail movements have recently bounced back to pre-recession levels on the back of dairy and forestry exports. Looking forward, road and rail volumes are expected to grow at 1-2% per annum, although there is the potential for faster growth in rail freight on some key lines. Several opportunities exist to improve the connections between road, rail, and shipping networks were noted. While uncertainty surrounds the viability of these initiatives, it is reasonable to suggest that these initiatives have the potential to reduce road freight volumes into the Port of Tauranga. The Port of Tauranga's central city location means that shifting road freight to rail and/or coastal shipping may also help alleviate congestion, thereby generating additional external benefits to the region.

## Part 5: Evaluating strategic transport options

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This chapter introduces several strategic transport options (some of which have been discussed in previous sections) and evaluates their performance against national, regional, and sub-regional objectives. The preferred strategic option is developed in some detail and its impacts on travel demands are investigated (albeit still in a macro sense) at the local level.

The following chapter is structured as follows:

- Section 5.1 introduces the strategic transport options that were developed and evaluated during the course of this study;
- Section 5.2 identifies a preferred strategic option using a multi-criteria framework based on national, regional, and sub-regional transport objectives;
- Section 5.3 develops and refines the preferred strategic option in light of evidence presented in previous chapters, as well as our professional experience; and
- Section 5.4. investigates how the preferred strategic option may impact on travel demands at the local level, in comparison to local transport models; and
- Section 5.5 summarises the chapter.

The key output of this chapter is a recommended strategic transport option that we suggest is taken forward and further developed to inform the review of the RLTS.

### 5.1 Introducing the strategic options

The following future strategic options were developed in consultation with Bay of Plenty Regional Council staff and key stakeholders:

- **Do minimum (DM)** – The DM option makes no investment in walking, cycling, and public transport beyond 2012. This essentially means that future mode share and travel demands are influenced solely by the background trends identified in Section Part 2.
- **Business as usual (BAU)** – The BAU option assumes that current investment priorities (as per the current NLTP and GPS) and policy setting priorities continue until 2040. After 2012/13, funding for all modes is inflated in line with regional population growth, which means the relative proportions between modes is constant over time.
- **Regional priorities (RP)** – The RP option assumes that current RLTP funding levels applied in the period 2013-16, after which funding is inflated in line with regional population growth. The RP option provides for greater investment in walking/cycling and public transport than the BAU option.
- **Demand-side management (DSM)** – The DSM option combines BAU finding with two travel demand management measures. First, parking reforms are applied in downtown Tauranga, Rotorua, and Whakatane. Second, the region facilitates and enables the implementation of ICT initiatives that reduce the need to travel.

- **Sustainable transport improvements (STI)** – The STI option considers the effects of much higher levels of investment in walking/cycling and public transport (which is expanded to areas around the three larger urban centres) in the period 2013-16, after which funding grows in line with population growth.
- **Mixed option 1 (MO1)** – The MO1 option combines the DSM and STI options, which are, in many respects, complementary. The DSM option, for example, would generate some additional demand for public transport, walking and cycling, which would in turn improve the effectiveness of the investment associated with the STI option.
- **Freight management (FM)** – The FM option evaluates the benefits of an annual regional investment of \$5 m in the strategic freight network where it can leverage off the competitive advantages of rail and shipping, thereby driving cost-efficient mode shift.
- **Mixed option 2 (MO2)** – The MO2 option combines the DSM, STI, and FM options. This option essentially seeks to combine the complementary nature of the individual options. The additional investment in freight is funded from a reduction in funds allocated to roads.

The table below summarises the funding parameters for each option. Note that the funding timelines are from 2013-16, after which all options assume that funding increases in line with regional population growth. This assumption is used because it maintains the relative funding proportions between options and modes and as such only serves to reinforce the impacts from 2013-16. Total funding envelopes are discussed in more detail in subsequent sections.

*Table 14 Summary of funding parameters for each strategic transport option 2013-16*

Strategic option	Average funding 2013-16			
	Roads	PT	Walk/cycle	Freight
1 Do minimum	\$140,261,400	\$0	\$0	\$0
2 Business as usual	\$140,261,400	\$8,089,625	\$1,806,351	\$0
3 Regional priorities	\$198,353,673	\$17,528,914	\$5,275,812	\$0
4 Demand-side management	\$140,261,400	\$8,089,625	\$1,806,351	\$0
5 Sustainable transport	\$116,856,743	\$24,268,876	\$9,031,757	\$0
6 Mixed option 1	\$116,856,743	\$24,268,876	\$9,031,757	\$0
7 Freight management	\$135,261,400	\$8,089,625	\$1,806,351	\$5,000,000
8 Mixed option 2	\$111,856,743	\$24,268,876	\$9,031,757	\$5,000,000

The funding associated with each option is considered in more detail in Appendix F. We emphasise that the funding levels outlined in the table above are primarily intended to set a general direction and are likely to change as the RLTS continues to develop and more detailed studies are undertaken. Subsequent sections consider the types of projects and policies that should be implemented to support the recommended option. Even so, this discussion steers away from specific recommendations on individual projects and instead sketches out the types and scale of investment activities that might be undertaken with these funding levels. For these reasons, the funding allocation associated with the recommended option should be seen as the starting point for further, more refined discussions, rather than the final word.

We also note that while the level of funding allocated to roads is not used directly within the model, they are included here to demonstrate what would be leftover once expenditure on public transport and walking/cycling was taken out. In this way, the funds listed in the roads column for each option provides a useful benchmark for comparing the degree to which each option deviates from the BAU option. For example, the RP option allows for approximately 50% more expenditure on roads, 100% more on public transport, and 300% more on walking/cycling than the BAU scenario. Similarly, the STI option provides for 25% less funds for roads, but 300% more funds for public transport, and 500% more funds for walking/cycling. Finally, we see that the effect of the freight management measures is to reduce roads funding by approximately 4%. However, even in the MO2 option approximately 75% of available funds are still allocated to investment in the road network.

An example of a funding profile figure is illustrated below for the FM option.

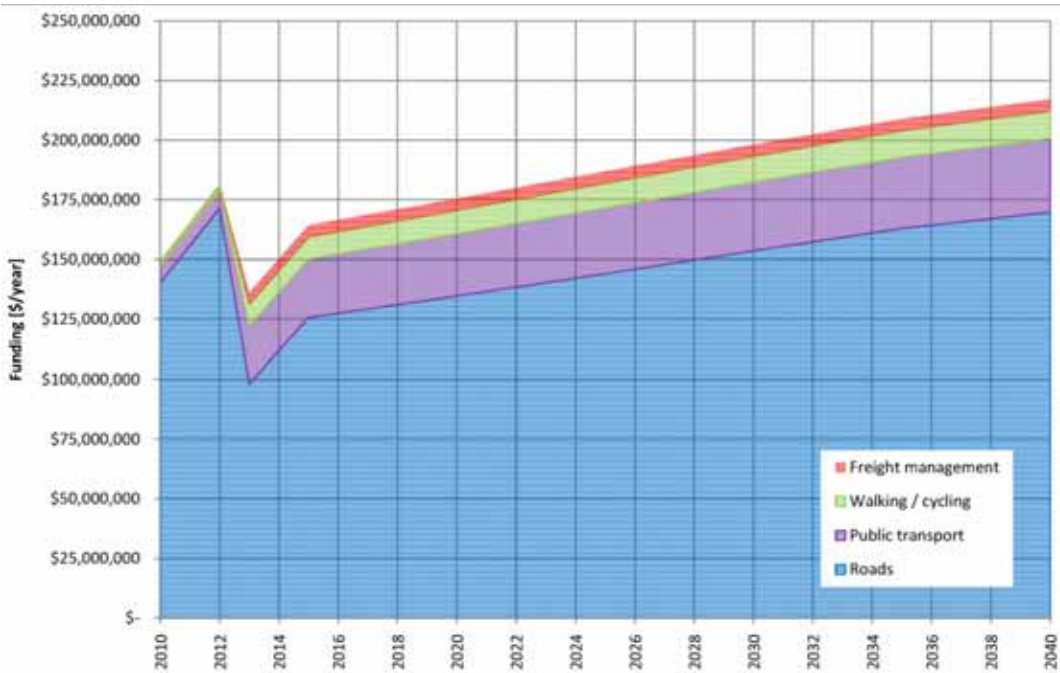


Figure 29 Funding profile for "freight management" option<sup>33</sup>

Finally, we note that the DM option was discussed previously in Section 2.1. Here, we found that the DM option resulted in continued growth in "Driver" mode share, which would in turn (when combined with regional population growth) place extremely high demands on the regional road network. It was further suggested that the additional investment in road capacity required to sustain current levels of service on the regional road network would be prohibitively expensive. This outcome is important insofar as it motivates the need for on-going investment in regional transport networks and moving the analysis beyond the DM option. For this reason, subsequent sections do not assess the performance of the DM option.

## 5.2 Evaluating the strategic transport options

The following sub-sections outline the assessment and evaluation framework that was used to identify a recommended strategic transport option.

### 5.2.1 Assessment framework

An assessment framework was developed for evaluating the strategic options. This framework was based on the background scoping paper developed for the regional council, which used a range of legislative and strategic documents to identify some key sub-regional, regional, and national priorities (Environment Bay of Plenty, 2010).

Key elements of the framework include:

- Primary objectives** – these have been derived from the documents that govern the development of the RLTS, such as the GPS, New Zealand Transport Strategy, as well as relevant sub-regional strategies. Primary objectives tend to reflect wider community values rather than specific outcomes. For this reason, while primary objectives are useful for outlining a

<sup>33</sup> The peak in funding in 2010-2012 reflects the temporary impacts of the Tauranga Eastern Link



vision for the transport system, they are often relatively complex and ill-suited towards options based performance measurement.

- **Key components** – these operate at a level below the primary objectives. Key components attempt to capture key areas through which progress towards the primary objectives may be evaluated. Key components are linked more strongly to outcomes.
- **Performance indicators** – These are used to measure progress towards key components. Such indicators rarely provide a complete measure of performance, although carefully selected indicators are useful proxies.

The primary objectives, key components and performance indicators considered in our assessment framework are outlined in the table below.

Table 15 Framework for evaluating the strategic transport options

Primary Objectives and Weighting		Key Components	Performance Indicators
<b>Economic Development</b>	50%	Cost-effectiveness	Marginal cost per new trip [\$ invested / new trip less additional user charges]
		Resilience	Value of fuel cost savings in high fuel price scenario 2010-40 [\$]
		Congestion	"Driver" journey to work mode share in 2040
<b>Environmental Sustainability</b>	20%	Global warming	Greenhouse gas emissions [value of tonnes CO2 saved by 2040, assuming \$20/tonne]
		Water Pollution	Demand for impermeable surface (car, passenger, public transport, HCV)
<b>Access and mobility</b>	15%	Access to alternative modes	Non-driver mode share in 2040 [% all trips]
		Multi-modal integration	Number of additional multi-modal freight hubs by 2040
			Additional bus interchanges (includes bus stations and P&R)
Average trip length	Walking/cycling and work at home mode share in 2040 [% journey to work trips]		
<b>Safety</b>	10%	Accidents	Estimated fatalities avoided from 2010-2040 [based on VKT reductions]
			Estimated casualties averted from 2010-2040 [based on VKT reductions]
<b>Health</b>	5%	Physical activity	Walking/cycling and public transport mode share [% trips in 2040]
		Air and noise pollution	% freight moved by road

Weights for each primary objective were developed in consultation with regional staff and stakeholders: Economic development - 50%; Sustainability – 20%; Access and mobility – 15%; Safety – 10%; and Public Health – 5%. These weights were considered appropriate given the current local, regional, and national planning and



policy framework (which was summarised in Section 1.2 and discussed in detail in Appendix A).

The following table below summarises the performance of each option (columns) in terms of the identified performance indicators (rows). Note that these results are not yet weighted.

*Table 16 Scoring the strategic transport options*

Primary Objectives and Weighting	Performance Indicators	Performance						
		2. BAU	3. RP	4. DSM	5. STI	6. MO1	7. FM	8. MO2
<i>Economic Development</i>	Marginal cost per new trip [\$ invested / new trip less additional user charges]	\$ 0.51	\$ 0.75	\$ 0.47	\$ 0.51	\$ 0.48	\$ 0.51	\$ 0.48
	Value of fuel cost savings in high fuel price scenario 2010-40 [\$ /capita]	\$ -	\$ -13	\$1,241	\$ -37	\$1,198	\$ 157	\$1,355
	"Driver" journey to work mode share in 2040	73.6%	72.9%	66.3%	72.3%	65.1%	73.6%	65.1%
<i>Environmental Sustainability</i>	Greenhouse gas emissions [per capita \$ value of tonnes CO2 saved by 2040, assuming \$20/tonne]	-	\$ -	\$ 2	\$ -	\$ 2	\$ 19	\$ 20
	Demand for impermeable surface [% reduction in kilometres travelled by road based modes compared to BAU]	0.0%	0.7%	1.0%	1.2%	2.4%	0.6%	3.0%
<i>Access and mobility</i>	Non-driver mode share in 2040 [% all trips]	39%	40%	43%	40%	45%	39%	45%
	Number of additional multi-modal freight hubs by 2040	0	0	0	0	0	1	1
	Additional bus interchanges (includes bus stations and P&R)	2	3	2	4	4	2	4
	Walking/cycling and work at home mode share in 2040 [% journey to work trips]	21.5%	22.3%	28.4%	23.1%	30.0%	21.5%	30.0%
<i>Safety</i>	Estimated fatalities avoided from 2010-2040 [based on VKT reductions]	0	2	20	4	24	4	28
	Estimated casualties averted from 2010-2040 [based on VKT reductions]	0	71	609	116	720	57	776
<i>Health</i>	Walking/cycling and public transport mode share [% trips in 2040]	13%	17%	18%	19%	21%	13%	21%
	% freight moved by road	83%	83%	83%	83%	83%	77%	77%

The relationships, assumptions, calculations, and sources involved in the derivation of these values are discussed in more detail in Appendix G.

Having scored the strategic options, we then proceeded to rank them as follows:

- For each key component, the strategic transport options were ranked in comparison to each other. For example, the best performing option was scored a "1" while the worst performing option was scored a "7" (equal rank awarded where scores are tied);
- Then for each primary objective, the average rank was calculated as the simple average of the ranks for the key components. For example, if an option received scores of "1" and "5" for the key components associated with a particular objective, then the average rank would be "3" (i.e. the average of 1 and 5); and finally

- Average ranks for each primary objective were then weighted (as per weights mentioned previously) to generate an overall rank for each strategic option.

The results of the ranking process are illustrated below. This shows that “mixed option 2” consistently out-performed the other strategic transport options for all of the primary objectives. “Mixed option 1” also performed well.

Table 17 Ranking the strategic transport options

Primary Objectives and Weighting		Key Components	Ranked						
			2. BAU	3. RP	4. DSM	5. STI	6. MO1	7. FM	8. MO2
<b>Economic Development</b>	50%	Cost-effectiveness	4	7	1	4	2	4	2
		Resilience	5	6	2	7	3	4	1
		Congestion	6	5	3	4	1	6	1
	<b>Average rank</b>		<b>5.0</b>	<b>6.0</b>	<b>2.0</b>	<b>5.0</b>	<b>2.0</b>	<b>4.7</b>	<b>1.3</b>
<b>Environmental Sustainability</b>	20%	Global warming	5	5	3	5	3	2	1
		Water Pollution	7	6	3	4	2	5	1
	<b>Average rank</b>		<b>6.0</b>	<b>5.5</b>	<b>3.0</b>	<b>4.5</b>	<b>2.5</b>	<b>3.5</b>	<b>1.0</b>
<b>Access and mobility</b>	15%	Access to alternative modes	6	4	3	4	1	6	1
		Multi-modal integration	3	3	3	3	3	1	1
			5	4	5	1	1	5	1
	<b>Average rank</b>		<b>5.0</b>	<b>4.0</b>	<b>3.5</b>	<b>3.0</b>	<b>1.5</b>	<b>4.5</b>	<b>1.0</b>
<b>Safety</b>	10%	Accidents	7	6	3	4	2	4	1
			7	5	3	4	2	6	1
	<b>Average rank</b>		<b>7.0</b>	<b>5.5</b>	<b>3.0</b>	<b>4.0</b>	<b>2.0</b>	<b>5.0</b>	<b>1.0</b>
<b>Health</b>	5%	Physical activity	6	5	4	3	1	6	1
		Air and noise pollution	3	3	3	3	3	1	1
	<b>Average rank</b>		<b>4.5</b>	<b>4.0</b>	<b>3.5</b>	<b>3.0</b>	<b>2.0</b>	<b>3.5</b>	<b>1.0</b>
<b>Weighted score</b>			<b>5.4</b>	<b>5.5</b>	<b>2.6</b>	<b>4.4</b>	<b>2.0</b>	<b>4.4</b>	<b>1.2</b>
<b>Overall rank</b>			<b>6</b>	<b>7</b>	<b>3</b>	<b>5</b>	<b>2</b>	<b>4</b>	<b>1</b>

Based on this prioritisation framework, we have identified “mixed option 2” (MO2) as the preferred strategic transport option, which combined the “demand-side management”, “sustainable transport improvements,” and “freight management options.”

We note that even large changes in the assumptions that underpin this evaluation framework, such as weighting assigned to the primary objectives, did not affect the preferred options. Further discussion on the range of sensitivity tests used to confirm these results are discussed in Appendix G.

The relative performance of the various strategic transport options is discussed in more detail in the following sub-section.

### 5.2.2 The preferred option

The previous section applied an evaluation framework that identified MO2 as the preferred strategic transport option. Table 16 and Table 17 show that MO2 performed consistently well against the primary objectives and key components that were considered in this assessment.

We now attempt to tease out some of the key reasons for the relative success of this option. First, we note that MO2 is essentially a composite of the following three unique strategic transport options:

- *Demand-side management (DSM)* – The DSM option combines BAU funding with two travel demand management measures. First, parking reforms are applied in downtown Tauranga, Rotorua, and Whakatane. Second, the region facilitates and enables the implementation of ICT initiatives that reduce the need to travel.
- *Sustainable transport improvements (STI)* – The STI option considers the effects of much higher levels of investment in walking/cycling and public transport by expanding to areas around the three larger urban centres in the period 2013-16. After which funding grows in line with population growth.
- *Freight management (FM)* – The FM option evaluates the benefits of an annual regional investment of \$5 m in the strategic freight network where it can leverage off the competitive advantages of rail and shipping, thereby driving cost-efficient mode shift.

If we now focus on the individual performance of these options, the evidence behind the high ranking of MO2 becomes clearer. Table 17 shows that out of the five non-mixed options (i.e. not considering MO1 or MO2) then DSM, FM, and STI were ranked 3, 4, and 5 respectively. The remaining two individual options (“business as usual” and “regional priorities”) were ranked last and second to last respectively. Hence, when we consider what was included in the MO2 option (and to a lesser extent MO1) then the reasons for its success become clear.

In a qualitative transport sense, MO2 provides a compelling blend of initiatives that supports economic, social, and environmental objectives. First, in terms of economic development, MO2 supports cost efficient travel demand management initiatives; innovative and relatively low-cost information and communications technology; and targeted investment in new services and capacity when and where justified by demand. Second, the components of MO2 support multi-modal access and mobility, integrated transport solutions, improved road safety, increased physical activity, and reduced air and noise pollution. Finally, in environmental

terms MO2 is expected to contribute to less growth in greenhouse gas emissions and improved water quality.

Ultimately, the effectiveness of this option reflects the combination of “push” and “pull” measures. Most research suggests that “push” factors, such as parking reforms and road pricing, are able to deliver more significant benefits than investment in transport infrastructure and services alone (see for example Eliasson (2007), Hugosson and Sjöberg (2006), and Litman (2006)). The value of combining “push” and “pull” factors comes through in our evaluation. The options that focussed on walking/cycling and public transport (namely “regional priorities” and “sustainable transport improvements”) did not perform particularly well, even in areas such as environmental sustainability, where only marginal improvements in greenhouse gas emissions were realised.

In contrast, “mixed option 2” complements increased investment in walking, cycling and public transport, with demand-side management measures, such as parking reforms and support for ICT. Demand-side management measures operate at both ends of the transport spectrum: They dissuade low-value trips (i.e. those that are put off by parking charges) while enabling high-value trips (i.e. professional services to avoid the need to travel altogether).

Finally, the inclusion of freight management within MO2 makes a considerable contribution to the overall performance of this option. The FM option actually ranks higher than the standalone STI option. Investment in more efficient freight management, by any mode, is likely to generate downstream economic benefits for the region if not the wider Upper North Island region, while also helping to reduce the negative environmental effects of freight movements.

### 5.2.3 What about the other options?

Some further comments are warranted on the ranking of the other transport options.

The low ranking for the “business as usual” (BAU) option is not a criticism of the NLTP per se, but more an observation that the proportions of current funding are unlikely to support broader regional transport objectives if they persist for the long term.

It is important to recognise that NZTA funding is constrained not only by the activity classes in the GPS, but also by the transport aspirations and projects proposed by other regions in the country. In this context, increased funding for projects in the Bay of Plenty will come at the expense of projects somewhere else in the country, which may or not be desirable from a national perspective. New Zealand Transport Agency, for example, has identified two communities (New Plymouth and Hastings) to target walking and cycling investment, because these towns are considered to provide greater opportunities for improvement. Transport funding in the Bay of Plenty region therefore does not occur in an isolated bubble and needs to consider wider implications.

Notwithstanding national funding constraints, this assessment clearly indicates that BAU transport investment and policies are unlikely to deliver on the region’s broader objectives. Nor, for that matter, would the investment priorities identified in the previous RLTP, which were implemented as the “regional priorities” (RP) option. Again, this should not be interpreted as a criticism of the RLTP or the projects it contains; the RLTP is, after all, only a three year programme so that evaluating its performance over thirty years is in some respects extending its implications beyond the purpose for which it was developed. For example, the RLTP could not consider the effects of measures such as parking reforms and ICT, which tend to lie on the

fringe of what are normally considered “standard” transport interventions. Indeed, most of the success of MO2 can be attributed to these “non-standard” factors. The assessment of the RP option is also instructive because it highlights the relative advantages of complementing increased investment in walking, cycling, and public transport with demand-side management measures.

### 5.3 **Elaborating on the recommended strategic option**

Section 5.2 identified MO2 as the preferred strategic transport option. In comparison to the BAU option, MO2 places an emphasis on the following three distinct areas:

- Demand-side management – improved parking policies and support for the uptake of information and communications technology;
- Sustainable transport improvements – increased investment in higher quality walking/cycling facilities and more frequent and expansive public transport services; and
- Freight management – support for multi-modal freight facilities that improve the connectivity and reliability of road, rail, and port facilities.

In this section we elaborate on some of the finer details of the recommended strategic option; in doing so, we draw not only on the results of the evaluation presented in Table 16 and Table 17, but also some key quantitative and qualitative findings from previous sections, evidence from external sources, and our professional experience. Ultimately, this section fills out the “bones” of the recommended strategic option based on available evidence, which in turn forms the basis for concrete recommendations. First we consider the three distinct aspects of MO2, namely: demand-side measures, sustainable transport improvements, and freight management. To finish, we highlight the continued importance of the regional road network.

#### 5.3.1 **Demand-side measures**

Demand-side measures describe investments and policies (collectively referred to as “transport interventions”) that encourage people to manage their travel demands in an efficient way. Such measures are distinct from measures that attempt to increase the supply of infrastructure or services. While a detailed review of demand-side measures lies outside the scope of this study, this section does elaborate on some key demand-side measures that could be implemented in the Bay of Plenty region in the near future, namely parking reforms and support for information and communications technology.<sup>34</sup> In the longer term, the region may also want to consider implementing a time-of-use charging policy for road and public transport users.

##### **Parking reforms**

Previous sections noted the considerable effect of parking reforms on travel demands. Based on the available research and our professional experience we suggest that current parking policies are the single most important transport and

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<sup>34</sup> We note that the recommended strategic transport option provides no specific funding for demand-side measures. The simple reason for this is that demand-side measures are essentially expected to be financially neutral over the long term, with revenues from parking and other services being used to offset the costs of other initiatives.

land use issue facing New Zealand's cities and towns (Donovan, 2009; J. A. Genter, Schmitt, & Donovan, 2008; Litman, 2006; 2009; Marsden, 2006; Shoup, 1999; 2005). Some of the issues associated with current parking policies include:

- *Economic development* – parking takes up valuable floor space and increases compliance costs (Donovan & J. Genter, 2008)
- *Land-use density* – providing parking with individual sites fragments the urban form and lowers the density of urban activities (Donovan, Petch, J. Genter, & Mumby, 2009)
- *Travel and lifestyle patterns* – an abundance of low-cost parking has stimulated excessive demand for vehicle based travel and lifestyle patterns (Shoup, 2005)
- *Urban liveability* – excessive vehicle use reduces the liveability of higher density urban areas, especially the town centres (Seibert, 2008)

Thus while minimum parking requirements ensure that enough parking is available, they do so in a way that generates unacceptably high economic, social, and environmental costs. Indeed, many of New Zealand's town centres are increasingly dominated by land reserved for parking. In the most extreme cases, the physical footprint of the transport infrastructure (parking and roads) is the single largest land use. Similar patterns are evident in the Bay of Plenty; the aerial below illustrates the amount of land used for parking in Rotorua town centre.



Figure 30 Land used for parking (red) – Rotorua

Instead of persisting with current practices, we recommend the new RLTS provide explicit support for the following parking reforms:

- *Minimum parking requirements* – These requirements sit in the district plan and seek to control the amount of parking that is supplied with new developments. Over the last 25 years a swathe of research has demonstrated the negative consequences of minimum parking requirements (Shoup, 1999; 2005). We suggest Tauranga, Rotorua, and Whakatane should simply remove minimum parking requirements and allow normal market forces to determine an appropriate parking supply; and
- *Performance-based parking policies* – Removing minimum parking requirements is necessary but not sufficient for achieving an efficient level of parking. Parking reforms should also look to implement a suite of performance-based parking policies that collectively ensure the right amount of parking is available in the right place, and at the right price. The most important practice is to price parking at the point where available car-parks are well-used but not over-saturated (Litman, 2006).

Together, the removal of minimum parking requirements and the implementation of performance-based parking policies will allow normal market processes to manage the provision of parking. Parking will be provided when and where it represents the best use of available resources, namely land. In the centre of town centres, where land is relatively valuable, it is likely that land currently used for parking will be redeveloped and used for other uses. As the supply of parking is concentrated on those sites where it represents the highest and best use of the land (most often these will be on the periphery of the town centre), we can expect parking prices will gradually rise over time. In turn, these prices will encourage people to manage their demand for parking in more efficient ways. Some people will undoubtedly switch modes and instead travel as car-passengers, public transport, and walking/cycling. Eventually prices will increase to the point where additional parking is made available.

Finally, while we have suggested that parking reforms are initially rolled out in the central areas of Tauranga, Rotorua, and Whakatane, they should eventually be expanded to other areas. We also suggest that addressing parking policies needs to ultimately extend beyond the RLTS and also be included in the Regional Policy Statement (RPS). Such a move is necessary to ensure the benefits of parking reforms are quickly and consistently realised around the region. Articulating the strategic benefits of parking reforms in the RPS will ensure that local Councils are obliged to move somewhat in concert.

### **Information and communications technology**

Section 2.2 discussed emerging trends in information and communications technology and considered their potential effects on future household travel demands. The upshot of this discussion was that developments in ICT are bringing about rapid changes in the way that people access work, goods and services. Many everyday items can now be purchased online and delivered either to your computer (in the form of media) or alternatively straight to your door, thereby avoiding the need to travel altogether.

While support for ICT is a key plank in our recommended option, it is important to define the scope of this support. National support is provided for teleworking through the Employment Relations (Flexible Working Arrangements) Amendment Act (2007). After six months of employment, employees can request flexible working



arrangements including teleworking and enabling work trips to be redistributed from the peak hours.

Furthermore, it is suggested that the regional council, via an updated Travel Demand Management Strategy, identify where economies of scale and/or attitudes are undermining the contribution of ICT to regional transport objectives. The intersection of attitudes and communications infrastructure leads to successful e-travel initiatives, as illustrated diagrammatically below. Regional support for ICT is about “growing” the size of the area. Tele-commuting, as mentioned previously, is the most obvious example of where attitudinal issues are restricting the uptake of ICT. Tele-commuting describes the use of communications technology, most notably the internet, to work from a remote location, thereby avoiding the need to travel at least some of the time. Tele-commuting is often suggested as an appropriate solution for occupations where employees have relatively flexible work schedules, such as professional services, which can complete work-related tasks remotely, such as checking email. Note that telecommuting does not necessarily involve working remotely for sustained periods of time. Indeed, tele-commuting also describes situations where people work remotely for a few days per week, or even a few hours in the morning. Tele-commuting thus helps to both *suppress* and *shape* travel demands in an efficient way. The limited uptake of tele-commuting partially reflects managerial reluctance to allow employees the opportunity to work remotely.

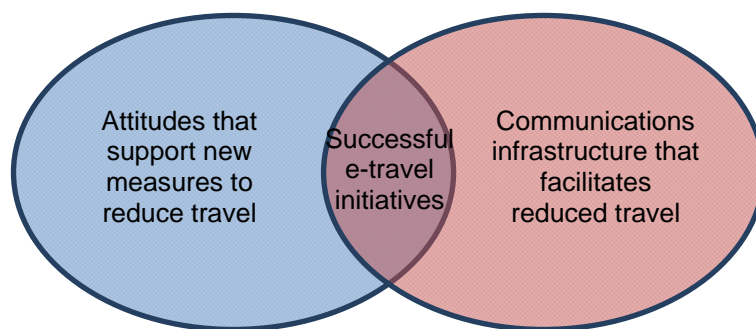


Figure 1 Required components for successful e-travel initiatives



There are a number of ICT initiatives that could be implemented. Some recommended e-travel initiatives for the Bay of Plenty region. These initiatives capitalise on improvements in ICT by providing attitudinal and financial support and are summarised in the table below:

*Table 18 Recommended ICT initiatives in the Bay of Plenty*

<b>Initiative</b>	<b>Attitudinal support</b>	<b>Infrastructure support</b>
Tele-work	Promotion and marketing of tele-work initiatives, possibly in collaboration with service providers, such as CITRIX and GoogleApps.	Financial support provided to companies that enables them to accelerate implementation of ICT where telework opportunities exist.
Home delivery	Work with groups of retailers that could benefit from coordinating home-delivery services as an alternative to subsidised parking.	Remove minimum parking requirements and establish parking brokerage services that help business access surplus parking.
Car-share	Collaborate with CityHop to promote the benefits of car-share in central Tauranga, Rotorua, and Whakatane and identify “anchor” clients.	Coordinate with local authorities to provide discounted off-street parking for car-share vehicles during the initial set-up phase.

We suggest that these three initiatives have the potential to deliver considerable benefits to the local and regional community in a cost-effective manner. Once the success, or otherwise, of these initiatives has been established there is potential for the region to also support the following ICT developments:

- Delivery of real-time information on public transport, taxis, and even car-pooling by way of a Bay of Plenty regional “Transport Application” for Smart Phones; and
- Trials of wireless internet access to public transport users at terminals/bus stops and on services, increasing the utility of public transport for commuting and business travel.

Again, the focus is on how the region can use ICT to provide consumers with accurate and timely information that allow them to make the choices that best suit their circumstances. Wireless internet access also improves the attractiveness of public transport services to high-value customers without requiring major investment in infrastructure or services.

It is suggested that these ICT related opportunities be assessed for local and regional implementation via the development of the updated TDM Strategy.

### **Time-of-use pricing**

Time-of-use pricing charges people based the time of the day that they travel, rather than just the distance. The concept of time-of-use pricing was initially proposed by (Nobel Prize winning) economist William Vickrey, who wrote (Vickrey, 1963):

*[[I]n no other major area are pricing practices so irrational, so out of date, and so conducive to waste as in urban transportation. Two aspects are*

*particularly deficient: the absence of adequate peak-off differentials and the gross under-pricing of some modes relative to others. In nearly all other operations characterized by peak load problems, at least some attempt is made to differentiate between the rates charged for peak and for off-peak service.*

Vickrey went on to estimate that rail and car users in New York should pay four and ten and times more to travel at peak times, based on the costs they impose on the transport system.

Time-of-use pricing makes it relatively more expensive to travel in peak periods, when the costs placed on the transport system are higher. For example, when someone drives during peak traffic, not only do they incur road maintenance costs, but they also increase the capacity of the road system (number of lanes and intersections etc.), capacity which is otherwise surplus to requirements at all other times.

The concept of time-of-use road pricing was discussed in the *National Infrastructure Plan* as an “Issue of primary importance,” which noted (National Infrastructure Unit, 2010):

*While there are immediate opportunities to improve key corridors in the roading network to provide better service levels at current and future traffic volumes, in the longer term building our way out of road congestion is unlikely to be an affordable or efficient strategy. As with any type of infrastructure investment, evidence of a capacity constraint does not automatically imply that more capacity should be built. With road transport, once a certain reasonable level of capacity is provided, the problems of limited land supply and environmental constraints point to the need for smarter solutions.*

Experience with time-of-use road pricing in Stockholm (population 1 m) suggests that it effectively reduces peak hour traffic volumes by 20-25% and eliminated traffic queues. One particularly attractive feature of the Stockholm system is that road users are charged a variable rate depending on the time of the day that they drive. The maximum charge of \$4 NZD applies only from 7:30 am to 8:30 am in the morning and 4:00 pm to 5:30 pm in the afternoon. Outside of these times the time-of-use charge reduces in approximately \$0.50 NZD increments, thereby encouraging peak spreading to occur. No time-of-use charge applies before 6:30 am in the morning, after 6:30 pm at night, or on weekends and public holidays. Analysis suggests the Stockholm scheme has effectively eliminated traffic congestion and has generated considerable economic benefits (see for example Eliasson (2007) and Hugosson & Sjöberg (2006)). The time-of-use road pricing technology used in Stockholm is illustrated in the figure below.



Figure 31 Time-of-use road pricing technology in Stockholm

The concept of time-of-use pricing is not mode specific and applies just as equally to public transport. Indeed, the costs of running public transport services in peak hours is often much higher than the background level of demand, mainly because it is the peak that defines the size of the depots and the number of buses that are required. For these reasons people who use buses in peak periods should also pay more than in the off-peak.

Objections to time-of-use pricing usually focus on issues of equity. We note, however, that vehicle ownership and use tends to be related to income. Evidence also suggests that low-income groups, such as students, beneficiaries, and retired people, are less likely to travel at peak times and, even when they do, are less likely to travel by car. Hence, we would expect time-of-use pricing to be, on average, a progressive form of user charges (Donovan, 2010).

We recommend that the Bay of Plenty region initiate high-level strategic discussions on the merits of implementing time-of-use pricing. In our opinion, both Tauranga and Rotorua have an urban form that is relatively well-suited to time-of-use pricing. Both cities have relatively constrained geographies that concentrate traffic and exacerbate bottlenecks, such as the Tauranga Harbour Bridge. On the other hand, this also reduces the number of access points that need to be monitored. The discussion could consider some or all of the following issues:

- Possible configurations of time of use pricing, such as those presented in the *Auckland Regional Road Pricing Evaluation Strategy* (MOT, 2006);
- The benefits of implementing time-of-use pricing to both the road and public transport systems;
- Special effort should be made to demonstrate the cost savings that accrue from deferring the need for major new road projects;
- The incremental costs associated with implementing time-of-use pricing, assuming that back-office costs are to some degree managed at the national level;
- Opportunities to trial time-of-use road pricing using existing toll roads, such as Route K and the soon to be constructed Tauranga Eastern Arterial;
- Potential effects on key sectors, namely: freight movements, low-income groups, and downtown retailers; and
- Measures to mitigate negative effects, such as discounts for the mobility impaired and low-income groups and bulk discounts for commercial vehicles.

We strongly recommend that time-of-use pricing be framed in neutral terms with respect to:

- *Modes* - the principle of time-of-use pricing should be applied consistently to both road and public transport users;<sup>35</sup> and

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<sup>35</sup> Although of course noting that the peak/off-peak differential for road users is likely to be larger than for public transport, which is less constrained by capacity

- *Fiscal impacts* – the aim of time-of-use pricing is to charge users more fairly for the costs that they impose on the transport system, not to raise more revenue.

Previous time-of-use pricing studies in New Zealand (see for example MOT (2006)) have received overwhelmingly negative feedback from the general public. We believe that this negative reaction primarily reflects the fact that the proposals have not been framed in sufficiently neutral terms.

### 5.3.2 Sustainable transport improvements

The recommended option assumed that investment in public transport and walking/cycling proceeded at three and five times the levels assumed in the BAU option. The choice of these “multipliers” was to investigate the strategic value of greater investment in public transport and walking/cycling. Having now identified the recommended strategic option, it is worth re-examining these multipliers and discussing their implications for the delivery of what we shall loosely refer to as “sustainable transport improvements.” The following sub-sections discuss how these multipliers may translate to projects on the ground.

#### Public transport

The recommended strategic transport option assumed that over the next 30 years expenditure on public transport would increase to levels approximately three times higher than assumed in the BAU scenario. We also assume that increases in public transport funding flows through into more service-kilometres, which in turn attracts new users.

In reality, we would expect increased public transport funding to be applied to a much more diverse range of projects than just service improvements, some of which may well attract more people to public transport. Examples of such projects include:

- *Central public transport terminals* – both Tauranga and Rotorua have plans for new PT terminals in their central city areas;
- *Integrated public transport ticketing* – it will be possible for the Bay of Plenty to leverage off work being undertaken nationally and in Auckland;
- *Key projects* – opportunities include bus priority measures on key corridors, park and rides at Omokoroa and Papamoa, and a new interchange at Bayfair; and
- *General improvements* – possible areas for investment include ICT (real-time information), and additional bus stop infrastructure (access and facilities).

We expect that these types of projects will soak up some of the additional funding associated with the recommended strategic option; hence the relative increase in service will be less than the three times multiplier assumed in the model. Nonetheless, we do expect that public transport services will be expanded to new areas in Tauranga, Rotorua, and Whakatane, as well as being intensified on existing routes in the three larger urban centres.<sup>36</sup>

On a more general level, public transport competes most effectively with private vehicles for medium distance, radial trips in urban areas (e.g. into central areas

<sup>36</sup> While Whakatane is considerably smaller than either of the other two urban centres, it has an urban form which is particularly well-suited to public transport (Coastlands being the notable exception, where the street network prohibits the efficient operation of public transport services).

affected by congestion and possibly priced parking). The use of public transport for journey to work travel in the 2001 and 2006 census are illustrated in the figure below. This graph (which is extracted directly from the *Public Transport Stocktake*) illustrates how considerable growth in public transport patronage occurred across many area units between 2001 and 2006, although most notably in Greerton and Ngongotaha north in Tauranga and Rotorua respectively. In Rotorua, the Ngongotaha north area unit superseded Western Heights as the largest origin of JTW trips. In Tauranga, Greerton now sits on par with Tauranga south as the largest origin of passenger transport JTW trips in the city.

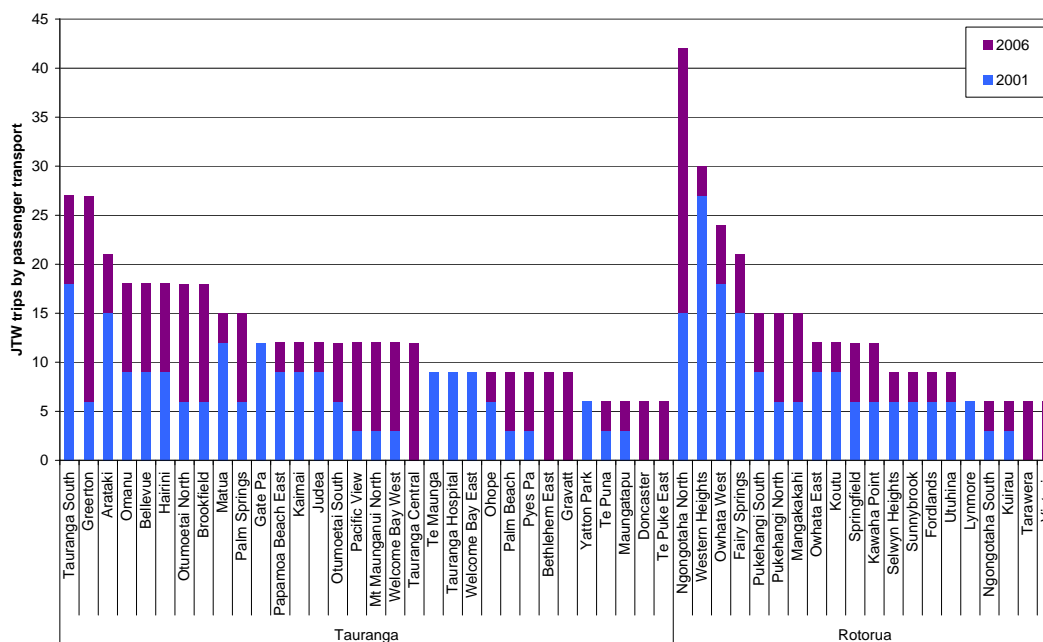


Figure 32 Change in census JTW trips in Tauranga and Rotorua by area unit from 2001-06 (Source: Statistics New Zealand)

Results suggest that the increase in patronage from 2001 to 2006 was concentrated in relatively few area units. When we analyse the cumulative share of these area units, we find that they make up an increasing proportion of JTW trips undertaken by public transport. The area units illustrated above increased their share of total JTW trips by passenger transport from 79% to 86% from 2001 to 2006. When considered in marginal terms (i.e. the change from 2001 to 2006), the Bay of Plenty region had an additional 321 JTW trips undertaken by passenger transport in the 2006 census as compared to the 2001 census. Of this increase, the Tauranga and Rotorua area units illustrated above contributed 318 trips, or approximately 99%.

This suggests passenger transport is becoming increasingly relevant in the areas where it does well, and less relevant in the areas where it performs poorly. And as high-quality public transport services become more focussed on particular areas, we also anticipate that people who are predisposed to using public transport will increasingly “self-select,” i.e. choose to locate where public transport is available.

### Walking/cycling

Walking and cycling investment is assumed to increase to five times the funding allowed for in the BAU option. This equates to approximately \$9 m per year from 2012/13 to 2015/16. After this point funding is assumed to increase in line with population growth.

We note that walking/cycling improvements on Cameron Road and Matapihi Bridge cost \$2.78 m and for a total length of approximately 14.5 km. This equates to a unit cost per “improved” kilometre of approximately \$150,000. If we conservatively assume \$300,000 per km (including investigation and design costs), then \$9 m per year will allow the completion of approximately 30 km of walking/cycling improvements per year.<sup>37</sup> This level of walking/cycling investment is considerably more than what has been available in the past and, as such, we suggest that a “blue skies” approach to possible new walking/cycling projects is warranted. A more aspirational approach for cycling could focus on development of a strategic regional cycling network that provides high-quality grade-separated corridors onto which more local walking/cycling improvements can connect.

Our preliminary investigations suggest that large areas of Tauranga are well-suited to investment in cycling, especially Papamoa and Mount Maunganui, possibly with a major cycling hub centred on Bayfair to allow for easy connections to public transport services. Omokoroa is more challenging, although it may be possible to develop a cycleway adjacent to the existing rail line. The trip from Omokoroa to the City Centre is approximately 17 km, which would take approximately 45-60 minutes for the average cyclist. The figure below illustrates potential (green) and existing (red) cycling corridors in Tauranga, where the total length of new routes is approximately 40 km.



*Figure 33 Existing (red) and potential new (green) strategic cycling corridors in Tauranga*

Rotorua is also particularly well-suited for investment in walking and cycling, by virtue of its demographic profile, socio-economic characteristics, topography, and urban form. In Rotorua we note an opportunity of using an existing (largely unused) rail corridor running north from the city centre towards Ngongotaha. Potential new strategic cycling routes are illustrated below in green, which comes to total length of approximately 30 km.

<sup>37</sup> We note that new structures, such as bridges could be considerably more expensive and hence reduce the length of improvements that can be funded.



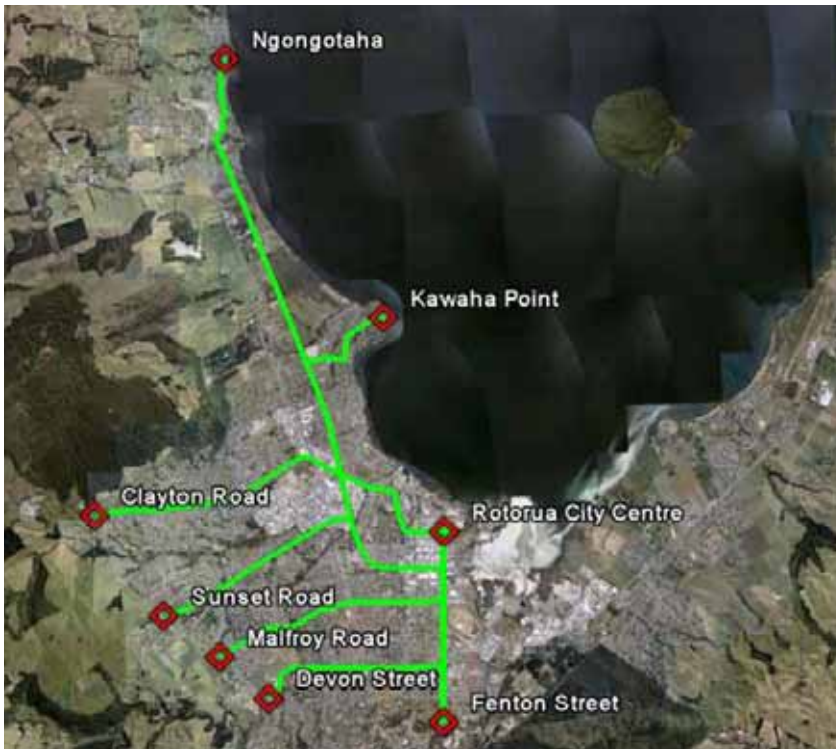


Figure 34 Potential new strategic cycling corridors in Rotorua

This figure clearly demonstrates the advantages of Rotorua's compact urban form and connected street network, which provides opportunities for a much denser cycling network than can be delivered in Tauranga.

While these routes are indicative only and more detailed work is required to identify exact alignments, the 70 km of cycle-ways sketched out in the previous figures are useful for identifying the scale of investment that could easily be achieved in approximately 10-30 years given the level of funding for walking/cycling associated with the recommended option.

We emphasise that the quality of the cycling infrastructure delivered with this funding would be noticeably higher than the Bay of Plenty's existing cycle ways and incorporate some of the following features:

- Minimum width of 1.5 m per cycle lane, or 3 m in total;
- High-quality surface with low rolling friction (e.g. concrete);
- Lighting and other amenities, such as seats and water fountains.

Moreover, there are a number of potential cycling routes that have obvious potential as recreational routes, in addition to meeting more standard travel demands. In these places it may be desirable to develop the route to a higher standard, with a particular focus on iconic structures such as bridges, which provide a focal point to the route. New Plymouth, for example, recently extended their coastal walking/cycleway. Part of this project involved fundraising for the Te Rewa Rewa Bridge, which is illustrated below. This bridge not only frames Mt Taranaki, but it also acknowledges sites of cultural interest (burial grounds) in the surrounding area. Both of these features of the bridge have contributed to the pulling power of the route.



*Figure 35 Integration of high-quality architectural elements into cycleway design – Te Rewa Rewa Bridge, New Plymouth*

Once the essential strategic cycling corridors have been constructed, the focus should shift towards improving local access to these routes by way of feeder facilities. While feeders have considerably lower standards traditionally (i.e. they will mostly run on-road) than that of off-road facilities, it is expected that future feeder facilities be of an adequate standard to ensure safety and amenity to ensure mode shift.

Some examples of high-quality on and off road facilities from Brisbane are illustrated in the following figures. The most important feature of the on-road facilities is the way the cycle routes have been incorporated within the intersections, where they are momentarily taken off-road and mix with pedestrians. We emphasise that because most people will access the strategic corridors via a feeder route, the legibility of the latter is essential – they must be well sign-posted and take a direct and safe path. The contrast between the strategic cycle routes, which are separated from vehicle traffic, and feeder routes is illustrated below. These images show high-quality cycle infrastructure from New Plymouth and Brisbane. The emphasis in the left hand image is on providing an extremely high-quality path dedicated to cyclists, whereas the right hand image is more focussed on how to safely integrate cyclists with general vehicle traffic and also pedestrians. Both types of infrastructure are needed if cycling is to become a viable option for short to medium length journeys in Tauranga and Rotorua.





*Figure 36 Highlighting the distinction between strategic corridors and feeder routes – cycle infrastructure from New Plymouth and Brisbane*

Walking improvements will be more dispersed across the region. We suggest that strategic pedestrian improvements are undertaken to support key activity centres, such as town centres, and also seek to complement investment in public transport. This could begin by identifying the busiest bus stops and prioritising pedestrian upgrades in these areas.

Finally, we recommend that a proportion of the increased walking/cycling funding is targeted to improving monitoring and reporting of walking and cycling numbers across the Bay of Plenty. Such information will greatly improve the quality of decision-making that can be made with respect to potential walking/cycling investments in the region.

### 5.3.3 Freight management

The recommended strategic option provides \$5 m per annum for freight management. The intention of this funding is to identify opportunities for targeted investment to improve the efficiency of freight movements throughout the Bay of Plenty region. Some potential projects were previously discussed in Section 4.4, such as improvements to the East Coast Main Trunk Line, capacity upgrades at the Port of Tauranga, and harbour developments at Opotiki.

We note that a major proportion of the costs of these improvements will be borne by external actors, either by the private sector, such as the Port of Tauranga, or by other Government agencies, such as KiwiRail. Regional involvement is intended to supplement funding from external sources to ensure that infrastructure improvements make an optimal contribution.

The deployment of freight management funds could proceed according to the following stages:

- Build relationships with external parties – such as KiwiRail, Port of Tauranga, freight suppliers/users, and parties involved with Opotiki Harbour development;
- Request freight funding applications – request that external parties submit freight funding applications that demonstrate the external benefits to the wider region associated with their proposed project; and
- Allocate available funds – available funding could then be allocated to a variety of freight management projects depending on the funding requirements and benefits associated with each project.

We note that the potential scope of projects considered should be wider than just transport investment, but also consider measures that improve the efficiency of freight movements.

“FreightHub,” for example, is a private sector initiative that aims to increase the utilisation of trucks on the road by connecting truck drivers with customers by way of GPS and internet. The FreightHub website and customers in the Bay of Plenty region are illustrated below.

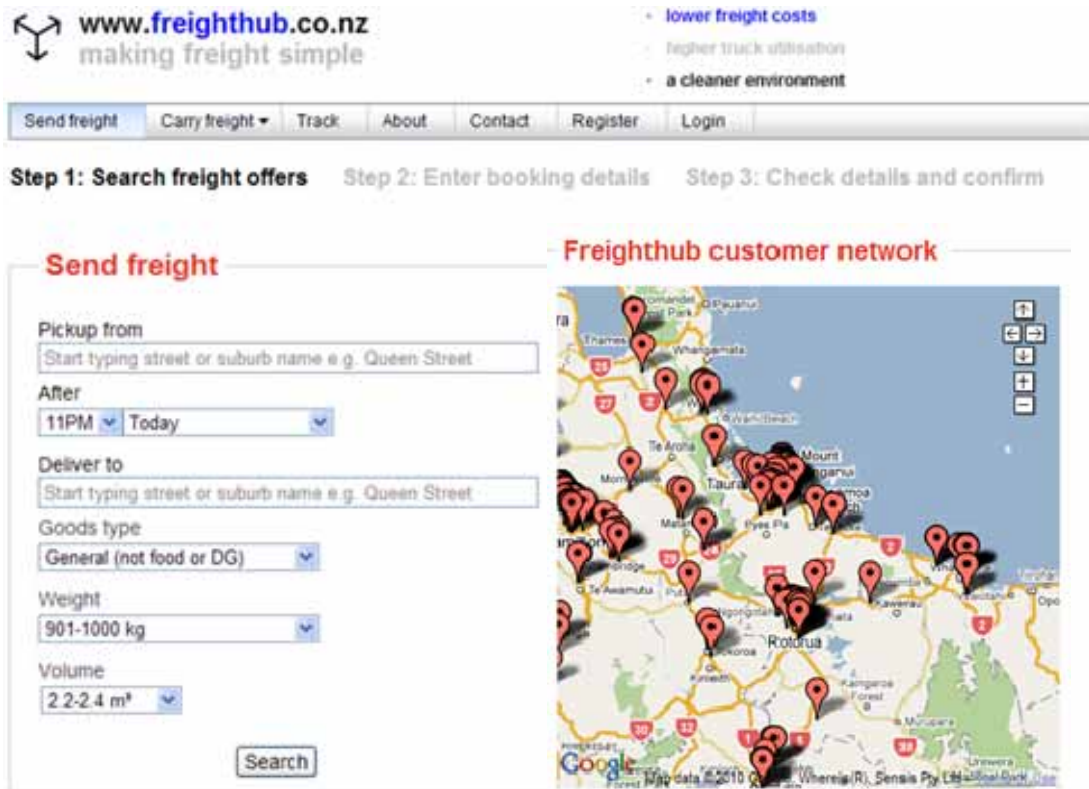


Figure 37 FreightHub website and customers in the Bay of Plenty

The concept is simple: Many trucks are driving around at least partially empty, especially on their return journey. Increasing the utilisation of these commercial vehicles could therefore benefit the drivers (through increased revenue) and the customers (through lower freight costs), as well as ultimately generating external benefits. On a simple level FreightHub is helping to “make markets” by improving the connections between consumers and suppliers. There may, however, be scope for regional support in promoting the development and/or promotion of these types of initiatives.

To put the scale of freight management improvements in context, it is worth considering a proposal from Ontrack to the Joint Officials Group (JOG) for rail improvements to the ECMT in the Waikato and Bay of Plenty regions. The proposal consisted of a series of improvements, as summarised in the following table. It is important to note that these improvements would effectively double the capacity of the rail line from two to four trains per hour, which (assuming full-trains) is the equivalent of approximately 120 truck movements. We note that cost-effective upgrades to the rail network do exist, especially where they can be completed without the need for land purchase and/or new structures. When placed in this context, the \$5 m annual investment in freight management measures appears

sufficient to make a considerable contribution to more efficient freight movements in the Bay of Plenty region.

<u>Project</u>	<u>Estimate (\$M)</u>
Reinstate Eureka Crossing Loop	\$1.90
New Crossing Loop at Tamihana	\$1.80
Lengthen Ruakura Crossing Loop	\$0.55
Lengthen Motumaoho Crossing Loop	\$0.60
Upgrade to Half Arm Barriers – SH 26 (Piako Road), Motumaoho	\$0.25
Upgrade to Half Arm Barriers – Waverley Road Eureka	\$0.25
Removal of permanent speed restrictions	\$1.05
Improve axle weights on Cambridge Branch Line	\$0.55

*Figure 2 Costs of rail improvements – examples from the Waikato region*

In the initial stages we would expect that the majority of funding would be used for investigation purposes and to accelerate the delivery of safety improvements (for example upgrades of rail level crossings).

### 5.3.4 The continued importance of the road network

Notwithstanding the increased emphasis on demand-side measures and sustainable transport modes, the road network will continue to be the backbone of the regional transport system. Even in the recommended strategic option, approximately 79% of all trips and 90% of all kilometres travelled will still be undertaken as either drivers or car-passengers by 2040, whereas trucks will still cater for approximately 70% of all freight demands.

In light of the continued importance of the road network, the recommended strategic option allocates the bulk of available funding to the on-going maintenance, management, and – in some places – development of the regional road network. However, a key shift needs to occur in the way that regional investment in the road network is focused. We suggest that the bulk of these funds should be used to improve:

- Connectivity – describes transport links between two locations;
- Quality – defined by investments in road alignments, surface treatments, and network management measures; and
- Safety – defined by the degree to which the road network is provided safely for all types of transport modes.

New capacity upgrades should be reconsidered in light of the demand-side measures and sustainable transport improvements discussed in previous sections. Capacity expansions should be avoided in those areas where demand-side measures (such as parking reforms) can be brought online relatively quickly, such as in downtown Tauranga, Rotorua, and Whakatane. Further undermining the case for capacity upgrades is the possible future roll-out of time-of-use pricing. We acknowledge that the implementation of time-of-use pricing is dependent on national and regional acceptance. However, it would be remiss to not accept the chance that some form of time-of-use pricing is implemented within the next 10-20 years, i.e.

within the lifetime of most capital intensive transport projects. Time-of-use pricing will almost undoubtedly take a large chunk out of peak hour traffic volumes and thereby undermine the benefits associated with major capacity expansions.

We suggest road improvements in the Bay of Plenty focus on:

- *Connectivity* – we note that connectivity improvements are particularly beneficial in situations where they improve the resilience of the wider road network. Several communities in the Bay of Plenty, such as Whakatane, are dependent on relatively sparse road networks, which in some cases are also vulnerable to natural disasters, such as flooding, tsunamis, or earthquakes.
- *Quality* – an increased focus on road maintenance, especially surface treatments, can provide benefits to a wide range of users. Road surface improvements contribute to overall vehicle fuel efficiency, which is especially important to heavy vehicles and cyclists. Smoother surfaces could in turn help improve the region’s ability to withstand sustained high fuel prices, while also reducing wear and tear on tyres, reducing their contribution to air and noise pollution.
- *Safety* – Recent trends show gradual ongoing improvements in regional road safety performance measures. An increased focus on road safety is beneficial to all transport users and also aligns well with the objectives of the GPS.

Instead, the recommended option acknowledges that achieving regional transport objectives requires shifting growth in travel demands towards a range of transport options, while improving the quality of the strategic regional road network. This means that while the road network is still overwhelmingly important, the role of accommodating growth in travel demands will increasingly shift to alternative modes, such as walking/cycling and public transport – for which the marginal costs of accommodating new users are relatively low.

## 5.4 Analysing sub-regional impacts

This section seeks to apply the modelling processes developed in the previous section to local transport models. Applying the results of our modelling to local transport models is necessary so as to close the loop between our aggregate regional analysis and the more targeted network models used to assess the performance of specific elements of the regional transport network.

The following sub-sections outline how we have used our forecasting models (and recommended strategic option) to generate high and low travel demand scenarios. The use of these scenarios effectively creates a “demand envelope” that can be compared to the travel demands in the local transport models.

The scenarios could also be used for “sensitivity testing” as follows:

- *High scenario* – performance in this scenario should define the level to which transport interventions are future-proofed. Where work is planned in areas where the road needs to operate at high levels of service at all times (i.e., even in the high scenario) then additional efforts should be made to future-proof.
- *Base scenario* – performance in this scenario should define the interventions that make-up a local transport strategy as well as the funding requirements that will be set out in LTCCPs and associated annual plans.

- *Low scenario* – performance in this scenario should be used to highlight where transport improvements could be delayed or deferred as a result of the recommended transport option. The low travel demand scenario in some respects helps shed light on where capital intensive capacity improvements may potentially be avoided, or at least scrutinised in more detail.

The individual elements of the three scenarios are summarised in the table below.

*Table 19 Summary of travel demand scenarios applied to local transport models*

Travel demand scenario	Scenario elements			
	Strategic option	Economy	Parking costs	Fuel prices
High	Business as usual	High	Low	Low
Medium	Mixed-option 2	Trend	High	Low
Low	Mixed-option 2	Low	High	High

The following section introduces the general modelling process before individual scenarios are presented based on the Tauranga, Rotorua, and Whakatane transport models.

#### 5.4.1 The general modelling process

The main steps in the process for applying the results of our modelling to local transport models are summarised below:

- **Translate travel demand forecasts to local area** – we used our travel demand forecasting model to estimate journey to work mode share, which were then base-lined to mode shares reported in the 2006 census. Mode share forecasts were then combined with employment trends and population growth to generate future journey to work numbers for each local area.
- **Baseline forecasts to initial modelling year** – the forecast trips for each local authority were indexed to the initial modelling year. This essentially created multipliers that could then be used to factor up or down the total number of light vehicle trips in each model. The freight demand scenarios developed in previous sections were also used to develop factors for heavy vehicle trips.

The following sections were used in the process to develop high, medium, and low travel demand forecast for Tauranga, Whakatane, and Rotorua. We then compare these to the travel demands used in local transport models. In all cases the results suggest that the local transport models forecast more trips than what we would expect based on the results of our model.

We suggest that the differences in the forecast rate of growth relates to the types of assumptions that underlie standard transport models. For example, many models assume that transport costs will remain the same for the next 30 years. This is incorrect. Even ignoring changes in fuel prices, parking reforms are on their own likely to have a large impact on the relative costs of travelling by car. Similarly, traditional transport models tend to underestimate the dynamic nature of trip generation rates. For example, trip generation rates for banks have reduced dramatically in the past decade, as an increasing number of customers make use of online services for every-day banking needs. Similar trends are likely to emerge for

other retail activities, such as supermarkets, which can potentially support much higher rates of online access. For these reasons, it is not surprising that the base travel demand scenario in these transport models are relatively “high” in relation to the “envelope” formed by our high and low scenarios. The simple fact is that most of the uncertainties associated with traffic forecasts are on the downside, not the upside, as the results of the following sections seem to suggest.<sup>38</sup>

#### 5.4.2 Tauranga transport model

The *Tauranga Transport Model* (TTM) covers Tauranga and the western Bay of Plenty district. We analysed AM peak travel demands from 2011-31, during which time the number of trips is forecast to grow by approximately 50%.<sup>39</sup> The impacts of the high and low scenario are illustrated in the figure below in relation to the “Base” demands.

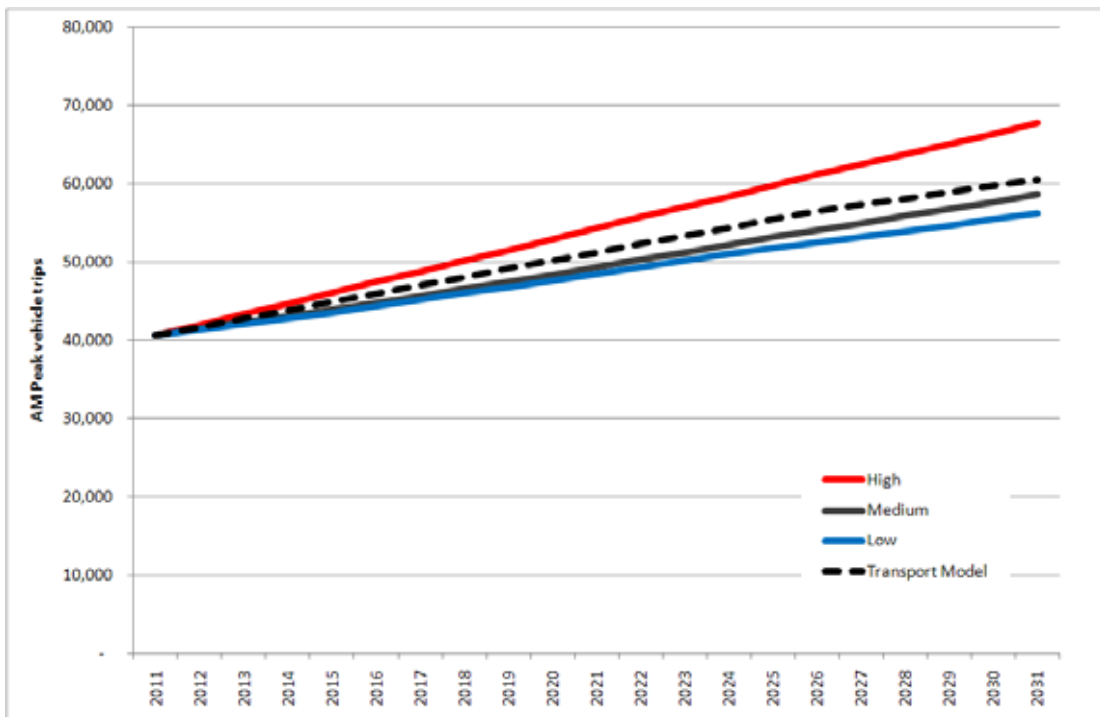


Figure 39` Forecast AM peak hour vehicle trips in Tauranga 2011-31

This shows that the travel demand forecasts in the TTM is slightly higher (3%) compared to our “Medium” scenario, which seems reasonable given the assumptions that underlie each of these forecasts. The forecasts are particularly well aligned in the period from 2011 to 2021, after which they diverge.

<sup>38</sup> This is not to suggest that the transport models are in any way “wrong” or “incorrect” – but that the assumptions that they are based on will, in our professional opinion, lead to relatively high estimates of travel demands. Moreover, in some situations, especially future planning and funding exercises, it may indeed be prudent to work with conservative estimates of future travel demands.

<sup>39</sup> We note that this level of growth is unusually high given that the population of Tauranga city is expected to grow by only 44% and also age considerably in the same period.

### 5.4.3 Application to the Rotorua transport model

Results for the *Rotorua Transport Model* (RTM) are illustrated below. The figure above suggests that the number of trips in our “Medium” scenario is similar to the numbers used in the RTM, at least until 2016. Over time the numbers increasingly diverge and by 2040 has widened to approximately 16%. In terms of general trends, the two models are well-aligned and the difference in vehicle numbers is reasonable given the assumptions for our “Medium” scenario. Growth in the “Medium” and “Low” scenarios levels off considerably after 2013, which indicates the effects of the recommended strategic transport option.

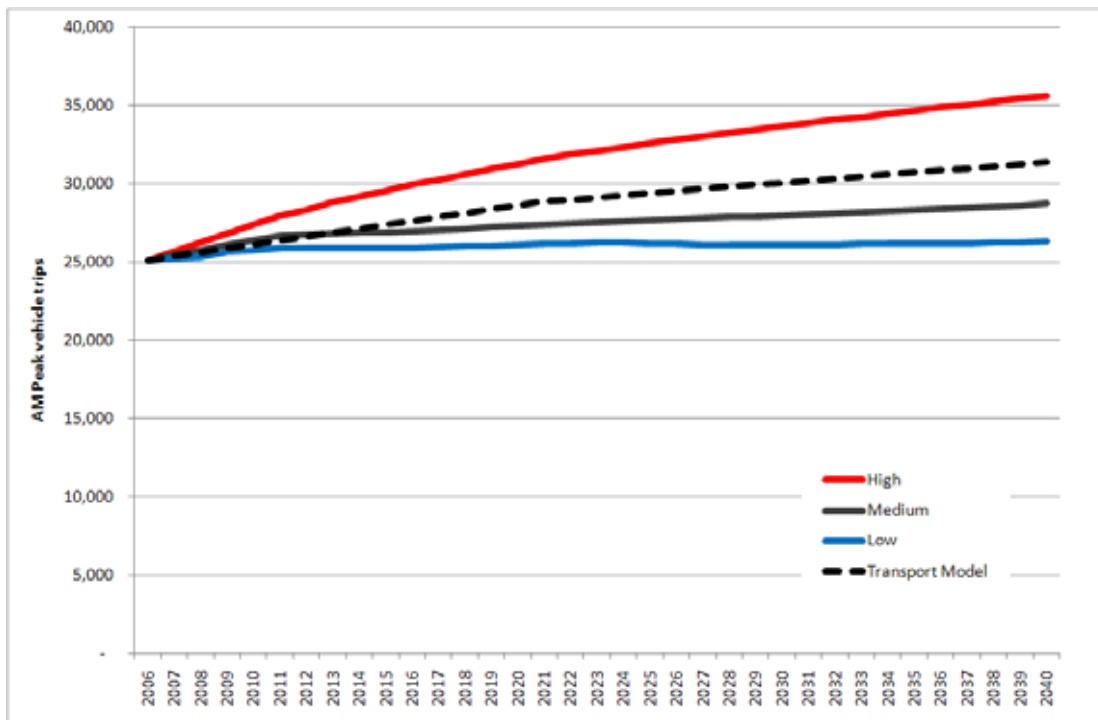


Figure 40 Forecast AM peak hour vehicle trips in Rotorua 2006-40

### 5.4.4 Application to Whakatane transport model

Results for the *Whakatane Transport Model* (WTM) are illustrated below. This shows a relatively large difference between the traffic volumes forecast based on our model and the WTM. There are, however, some important caveats that need to be placed on these results.

First, Whakatane's population characteristics are rather distinct from the other two main centres. It is home to a relatively young population which has relatively low rates of vehicle ownership, when compared to the rest of the region. Second, Whakatane's location means that it could well benefit from the rapid growth in Tauranga and the additional access facilitated by the Tauranga Eastern link, both of which could encourage a shift in population to the east. Whereas we have used Statistics NZ medium population forecasts, there may be a case to suggest that these are conservative given the step-change in accessibility associated with the TEL.

The balance of “risks” suggest that the difference between our scenarios and those modelled in the transport model may not be as great as it first appears; further investigation and modelling is certainly warranted. In general, both the WTM and our scenarios exhibit the same underlying trends, despite being characterised by



rather different growth rates. The large divergence in forecast traffic demands may suggest that a cautious approach to new capital investment is warranted, unless it is justified on grounds other than traffic growth. Instead, less capital intensive demand-side management measures, such as parking reforms, may well reduce the need for major capacity upgrades for some time to come.

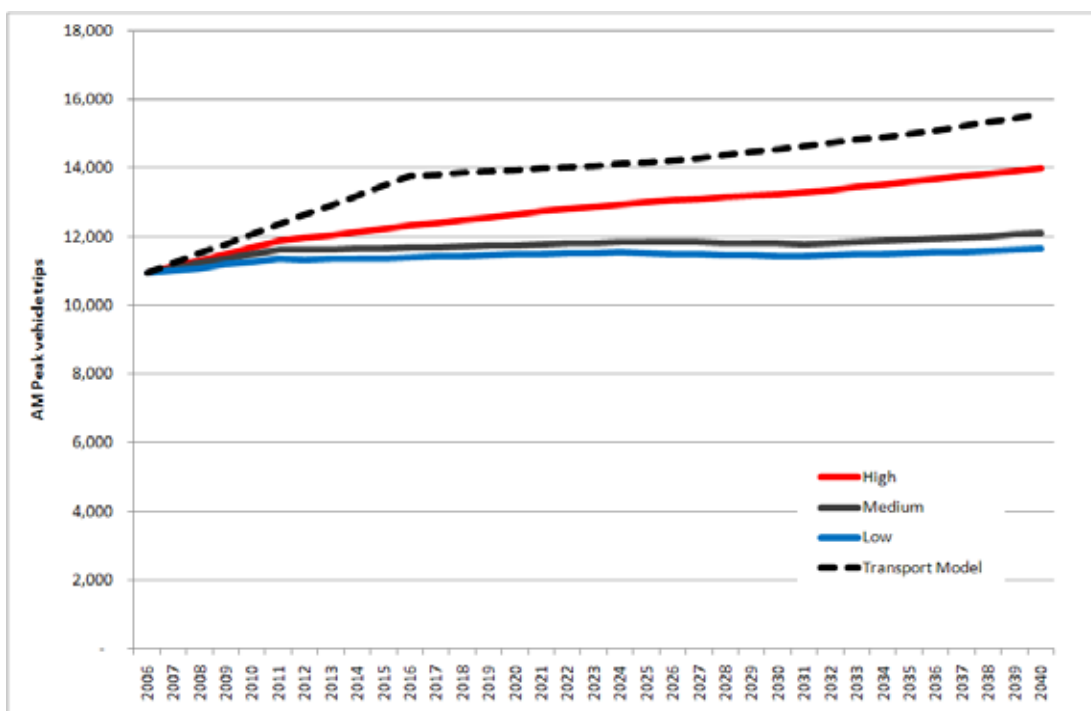


Figure 41 Forecast AM peak hour vehicle trips in Whakatane 2006-40

## 5.5 Summary of findings

This chapter introduced a number of strategic transport options and evaluated their performance against national, regional, and sub-regional objectives. Based on this evaluation we have identified “mixed option 2” (MO2) as the preferred option. MO2 combined demand-side measures, such as parking reforms and support for ICT, with increased investment for sustainable transport modes and freight management measures. The option consistently scored higher than the other options that were considered.

Having identified the preferred strategic option, we then discussed the finer details of how this option might influence the development of the regional transport system. Some of the key recommendations that emerged from this discussion include:

- Demand-side measures:
  - *Parking reforms* – remove minimum parking requirements and implement performance-based parking policies that rely on prices to manage demand; and
  - *Information and communications technologies* – facilitate increased uptake of telework, home delivery services, and car-share; and
  - *Time-of-use pricing* – initiate a high-level discussion on the merits of time-of-use pricing (premised on assumptions of mode and fiscal neutrality).



- Sustainable transport improvements:
  - *Public transport – downtown terminals, integrated ticketing, bus priority measures, new interchanges, and park and ride; and*
  - *Walking / cycling – delivery of strategic urban cycle networks in Tauranga (40 km – shown below) and Rotorua (30 km), supported by localised improvements.*



- Freight management: Establishment of a contestable regional fund to support freight initiatives that deliver external benefits to the region
- Road network: Remains the backbone of the regional transport system even if the growth in demands is increasingly accommodated in other ways. Investment should focus on improvements to:
  - *Connectivity – improvements that increase the resilience of the wider road network. Improves community resilience to natural disasters, such as flooding, tsunamis, or earthquakes.*
  - *Quality – increased road maintenance, especially surface treatments that improve vehicle fuel efficiency and reduce tyre wear (improving air and noise pollution).*
  - *Safety – heightened focus on road safety for all road users.*

Finally, we considered the implications of the recommended strategic transport option at the local level. Predicted growth in vehicle trips for local transport models in Tauranga, Rotorua, and Whakatane were compared to forecasts generated by our model, under a range of different scenarios. Results suggest that the recommended strategic transport option may be expected to reduce peak hour traffic volumes (compared to the transport models) by approximately 5-20%. Much larger reductions in peak our vehicle trips would be possible in the event that parking reforms were more widely applied or time-of-use pricing was implemented.

The key output of this chapter is a recommended strategic transport option that we suggest is taken forward and further developed to inform the review of the RLTS. In our opinion, the recommended option signals a change in direction, while providing for a continuity and balancing the respective strengths of different transport modes.

## Part 6: Summary and recommendations

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### **Modelling household travel demands**

We developed and applied a strategic transport model for the Bay of Plenty region. Mode choice regression models based on a variety of demographic, socio-economic, and transport trends were able to explain a reasonable amount of the variation in journey to work mode share observed around the region in the 2006 census.

In a “do minimum” option, we forecast that current trends would see considerable growth in the numbers of driver journey to work trips in the Bay of Plenty region. No amount of investment in road infrastructure could accommodate this growth. Hence, there is an on-going need for investment in the regional transport system, especially those infrastructure and services that are able to accommodate growth in a way that is both cost-effective and sustainable.

Analysis of broader household travel trends suggest that average per capita travel demand (measured in either trips taken or kilometres travelled) are reducing over time, not only in the Bay of Plenty but also across New Zealand, Australia, and the US. A range of factors are likely to be contributing to the decline in per capita travel demands, namely an ageing population, on-going developments in information and communications technology, and high and volatile fuel costs.

When compared to total per capita travel demand, journey to work mode shares (sourced from 2006 Census data) tend to underestimate the numbers of trips taken by alternative modes, especially car-passengers but also walking/cycling and public transport. Before and after analysis of walking/cycling numbers on Matapihi Bridge and Cameron Road suggests that investment in walking/cycling has caused considerable growth in the uptake of these transport modes.

In a “business as usual” option, driver travel demand continues to increase, albeit at a much slower rate than in the “do minimum.” Driver journey to work mode share reduces in percentage terms (from 76% to 72%) although the total number of vehicles trips continues to grow.

The analysis suggests that current transport trends are not sustainable. There is a demonstrable need for continued investment in the regional transport system; the “do minimum” scenario is not an option. Further analysis suggests that even a “business as usual” option would be likely to result in unacceptably high levels of vehicle use, especially in urban areas at peak times. As a result, there is a need for a shift in transport priorities if future objectives of the region are to be met.

### **Testing alternative transport futures**

We tested the cumulative effects of changes in fuel prices, parking costs, economic growth, and vehicle ownership. Results suggest that these factors have a major influence on future travel demands. Perhaps more importantly, the effects of these variables are correlated; low fuel prices, high economic growth, and higher vehicle ownership are likely to occur in tandem, and vice versa.

To investigate the cumulative effects of these factors, we developed “high” and “low” vehicle travel demand scenarios. The range of travel demand (in terms of car-based trips) for these two scenarios is illustrated in the following figure in comparison to the base assumptions. This illustrates how the two scenarios combine to have a considerable impact on the overall number of trips taken by car-based transport modes, when compared to the base.

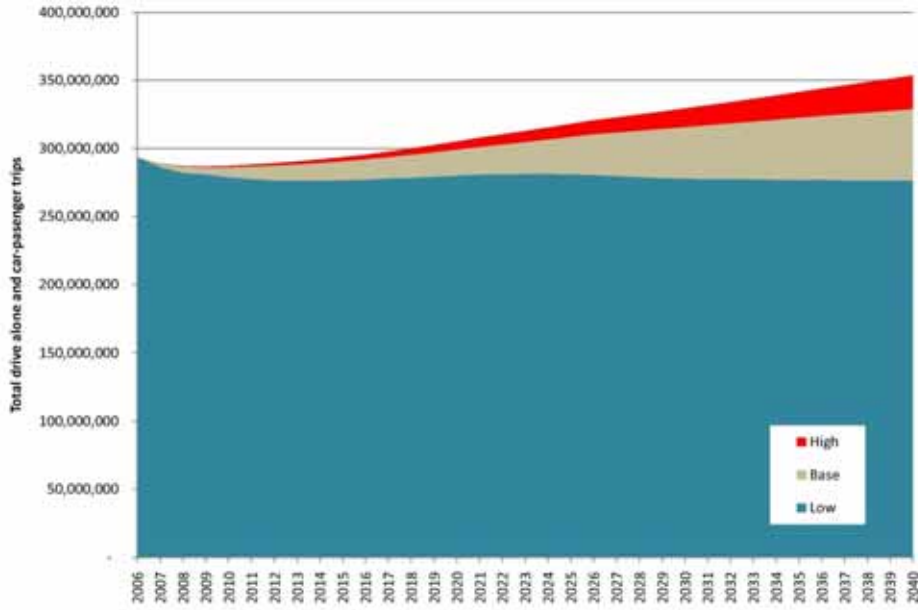


Figure 42 Cumulative impacts of alternative future scenarios on total driver and car-passenger trips (2006-40)

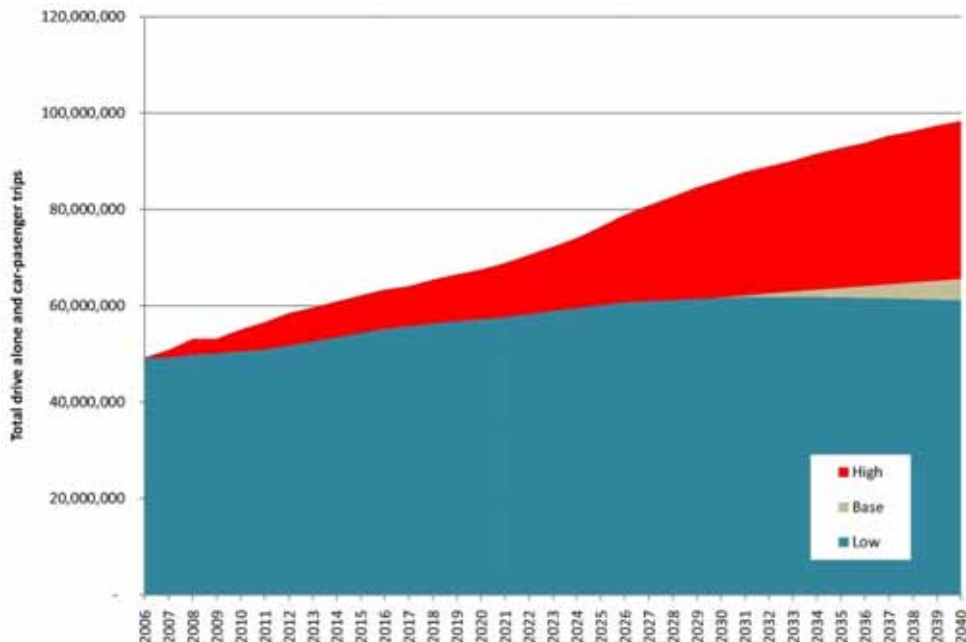


Figure 43 Cumulative impacts of alternative future scenarios on total public transport and walking/cycling trips (2006-40)

Our analysis of alternative transport futures has highlighted the following key messages:

- **Volatility is the norm rather than the exception** – most of the alternative futures are likely to be correlated, at least in terms of their effects on “car-based” travel demand. This means that if one variation occurs then the others are also more likely to eventuate, which in turn means that travel demands exhibit predictable yet considerable volatility, at least on an annual basis.
- **Continued importance of the road network** – Car-based transport modes are likely to remain as the dominant transport mode in the Bay of Plenty region for the foreseeable future. Even in the low scenario, car-based transport modes were used for approximately 74% of all trips and 85% of all kilometres travelled.
- **Non-car modes increase market share** – Even in a low demand scenario, non-car transport modes (namely public transport and walking/cycling) gain market share. Their effects are mainly felt at the margins, in terms of how much they impact overall growth in car-based transport modes.

Trends in freight travel demands are summarised in the following section.

We suggest that there is a strong rationale for the region to contribute to the efficient movement of freight. These reasons include:

- Freight movements are of relatively high economic value. Improving the efficiency with which freight can move through the region is likely to deliver economic benefits not only to the region but also adjacent regions, such as the Waikato and Auckland;
- Freight movements generate negative externalities, such as emissions to air, water, and soil, which have a range of economic, social, and environmental costs. The existence of these externalities (and the costs that they impose) creates a prima facie case for Government policies that support the efficient levels of freight movements; and
- Improved road freight efficiency would reduce congestion for all road users. Several opportunities exist to improve the connections between road, rail, and shipping networks. While uncertainty surrounds the viability of these initiatives, they have the potential to reduce road freight volumes into the Port of Tauranga. Moreover, the Port of Tauranga’s location means that shifting road freight to rail and/or coastal shipping will also help alleviate congestion.

Data suggests that growth in road freight slowed from 2001-09. Rail movements have recently returned to pre-recession levels on the back of dairy and forestry exports. Looking forward, road and rail volumes are expected to grow at 1-2% per annum, although there is the potential for faster growth in rail freight on some key lines.

KiwiRail’s Annual Report confirms that an export lead recovery began with a 14% lift in volumes (on the year before) during the second half of 2010, lead primarily by movements in dairy and forestry products. Looking forward, major developments in rail governance, in combination with economic trends, look likely to shake up trends in rail movements. The recently released “KiwiRail Turnaround Plan” suggests KiwiRail will increasingly position itself in the key markets where it holds a competitive advantage, particularly the bulk movement of dairy and forestry products, and therefore earn more competitive rates of return.

In terms of the Bay of Plenty, the implications of the KiwiRail Turnaround Plan are clear: Freight volume on the rail network is expected to increase. While this will undoubtedly bring benefits by removing trucks from the roads, it may also create new safety and environmental issues that need to be managed. Moreover, there are still large parts of the region that do not have access to the rail network. In some locations where rail is a competitive alternative to road, the aforementioned rail improvements may be expected to increase demand for freight-hubs that allow freight to be moved off trucks and onto the rail network.

## Implementing the plan

There will be five major areas of investment and work to protect and grow our revenue, and create a sustainable rail system for New Zealand:

1. **Step change in the Auckland-Christchurch route**
  - Reduce transit time and improve reliability along the route - easing curves, removing speed restrictions, greater renewals investment in bridges and sleepers and passing loops
  - Improve exit and entry from Auckland and Wellington - improvements at terminals and on mainlines to reduce transit times and conflicts with commuter services
  - Increase ferry capacity for rail freight - extend length of Aratere and make Kaitaki rail-capable
2. **Other key routes**
  - Improve reliability and capacity with increased renewals investment in replacement of sleepers, strengthening of bridges, refurbishment of track formation
3. **Enabling investment**
  - Improved IT systems and processes, equipment and facilities at terminals
  - New locomotives, wagons
  - Improved track infrastructure
4. **The minor lines**
  - Review business on North Auckland, Stratford-Okahukura, Napier-Gisborne and North Wairarapa lines
  - Consultation with communities, customers and staff
  - Close or mothball by 2012 if anchor customers do not emerge
5. **Auckland and Wellington metro services**
  - Clarify and assign accountability for costs associated with operating metro networks



Figure 44 Implications of the “KiwiRail Turnaround Plan” for New Zealand’s Rail Network (Sourced from KiwiRail, 2010)

The plan notes that minor routes (illustrated in blue) may be closed or mothballed, so as to free up resources for the key routes (illustrated in yellow). The implication is that investment in the rail network will be increasingly focussed on certain parts of the network, where volumes may be expected to increase. In turn, maintenance and capacity issues on these lines will need to be addressed. These developments have been given additional impetus by the Government agreeing to spend \$500 m on new locomotives, which are expected to improve travel times and cut operating costs.

## Evaluating Strategic Transport Options

We evaluated a number of strategic transport options and their performance against national, regional, and sub-regional objectives. Based on this evaluation we identified “mixed option 2” (MO2) as the preferred option. MO2 combined demand-side measures, such as parking reforms and support for ICT, with increased investment for sustainable transport modes and freight management measures. The option consistently scored higher than the other options that were considered.

To support the recommended strategic transport option, we made the following recommendations:

- Demand-side measures:
  - *Parking reforms* – remove minimum parking requirements and implement performance-based parking policies that rely on prices to manage demand; and
  - *Information and communications technologies* – facilitate increased uptake of telework, home delivery services, and car-share; and
  - *Time-of-use pricing* – initiate a high-level discussion on the merits of time-of-use pricing (premised on assumptions of mode and fiscal neutrality).
- Sustainable transport improvements:
  - *Public transport* – *downtown terminals, integrated ticketing, bus priority measures, new interchanges, and park and ride; and*
  - *Walking / cycling* – *delivery of strategic urban cycle networks in Tauranga (40 km) and Rotorua (30 km), supported by localised improvements.*
- Freight management: Establishment of a contestable regional fund to support freight initiatives that deliver external benefits to the region
- Road network: Remains the backbone of the regional transport system even if the growth in demands is increasingly accommodated in other ways. Investment should focus on improvements to:
  - *Connectivity* – *improvements that increase the resilience of the wider road network. Improves community resilience to natural disasters, such as flooding, tsunamis, or earthquakes.*
  - *Quality* – *increased road maintenance, especially surface treatments that improve vehicle fuel efficiency and reduce tyre wear (improving air and noise pollution).*
  - *Safety* – *heightened focus on road safety for all road users.*

Finally, we considered the implications of the recommended strategic transport option at the local level. Predicted growth in vehicle trips for local transport models in Tauranga, Rotorua, and Whakatane were compared to forecasts generated by our model, under a range of different scenarios. Results suggest that the recommended strategic transport option may be expected to reduce peak hour traffic volumes (compared to the transport models) by approximately 5-20%. Much larger reductions in peak hour vehicle trips would be possible in the event that parking reforms are more widely applied or time-of-use pricing is implemented.

The key output of this study is a recommended strategic transport option that we suggest is taken forward and further developed to inform the review of the RLTS. The need for and benefits of parking reforms is self-evident; the RLTS and RPS are suitable tools to achieve positive outcomes in this area.

Included in the recommended option is the development of high-quality strategic cycling networks in both Tauranga and Rotorua, so as to reduce short to medium length vehicle trips. It may be possible for these networks to leverage additional tourism and economic development benefits.

Ultimately, we consider that the preferred strategic option and associated recommendations signal a notable change in direction, balance the respective strengths of different transport modes, and provide for a reasonable level of continuity.

## Part 7: Appendices

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## Appendix A – Planning and Policy Framework

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This section reviews strategic documents that have a bearing on the provision and funding of transport at the central, regional, and local Government levels.

### Central Government Policy

The strategic direction provided by central Government reflects several factors including: (1) uncertainties created by volatile fluctuations in economic growth and fuel prices; (2) the establishment of a new agency to oversee transport planning and funding; and (3) changes in central Government priorities for transport investment that focus more specifically, at least in the short term, on economic growth and productivity.

The following sections discuss the strategic direction of central Government in relation to the following documents: the Ministry of Transport Statement of Intent (MOT 2009), the Transport Monitoring Indicator Framework (MOT 2009), and the Government Policy Statement on Land Transport Funding (GPS1 and 2) (New Zealand Government 2009).

### Ministry of Transport Statement of Intent and Transport Monitoring Framework

The Ministry of Transport Statement of Intent 2009-2012 discusses the strategic direction for the Ministry over the next three years (MOT 2009) in the following context:

- **Operating Environment:** The slowing global economy and higher fuel prices have impacted on economic activity, household income, and travel demands, with consequent impacts for revenue raised from fuel excise duties and road user charges.
- **Strategic Direction:** Realising the Government's goal to grow the economy while also reducing greenhouse gas emissions. Meeting environmental responsibilities while supporting economic development requires more productive use of resources.

The Ministry of Transport (MOT) aims to support the Government's strategic direction by improving the performance of the transport system and extracting more value from Government investment in transport infrastructure. The MOT intends to manage the road and rail networks so as to "move people and freight more efficiently, safely, and effectively." Essentially identical aspirations apply to the delivery of public transport services.

The MOT's progress towards achieving the outcomes discussed in the Statement of Intent is to be gauged using the Transport Monitoring Indicator Framework (TMIF). The TMIF outlines a large set of high-level indicators that provide both quantitative and qualitative information on aspects of transport, including the economy, safety, environment, health and access and mobility. Collectively, these indicators are intended to monitor the performance of the entire transport system, albeit at an aggregate and incomplete level. Economic indicators, such as national and household expenditure on transport infrastructure and services, will be used to evaluate the contribution of the transport system to supporting economic productivity.

The links between the statement of intent and performance (as monitored by the TMIF) and central Government funding priorities (as articulated in the Government Policy Statement on Transport) is discussed in the next section.

### Government Policy Statement on transport

The Government Policy Statement on Transport (GPS) outlines the "Government's desired outcomes and funding priorities for the use of the National Land Transport Fund to support activities in the land transport sector. The GPS covers impacts the Government wishes to

generate from its investment in land transport: how it will achieve these impacts through directing funding at certain activity classes, how much funding will be provided, and how this funding will be raised (New Zealand Government 2009).”

The relationship between central, regional, and local Government transport planning documents is illustrated in the diagram below, which has been extracted from the GPS. This shows how regional land transport programmes and strategies must be consistent with and guided by the objectives of the GPS. The first GPS (GPS1) developed under the previous Government was amended by the new Government (GPS2).

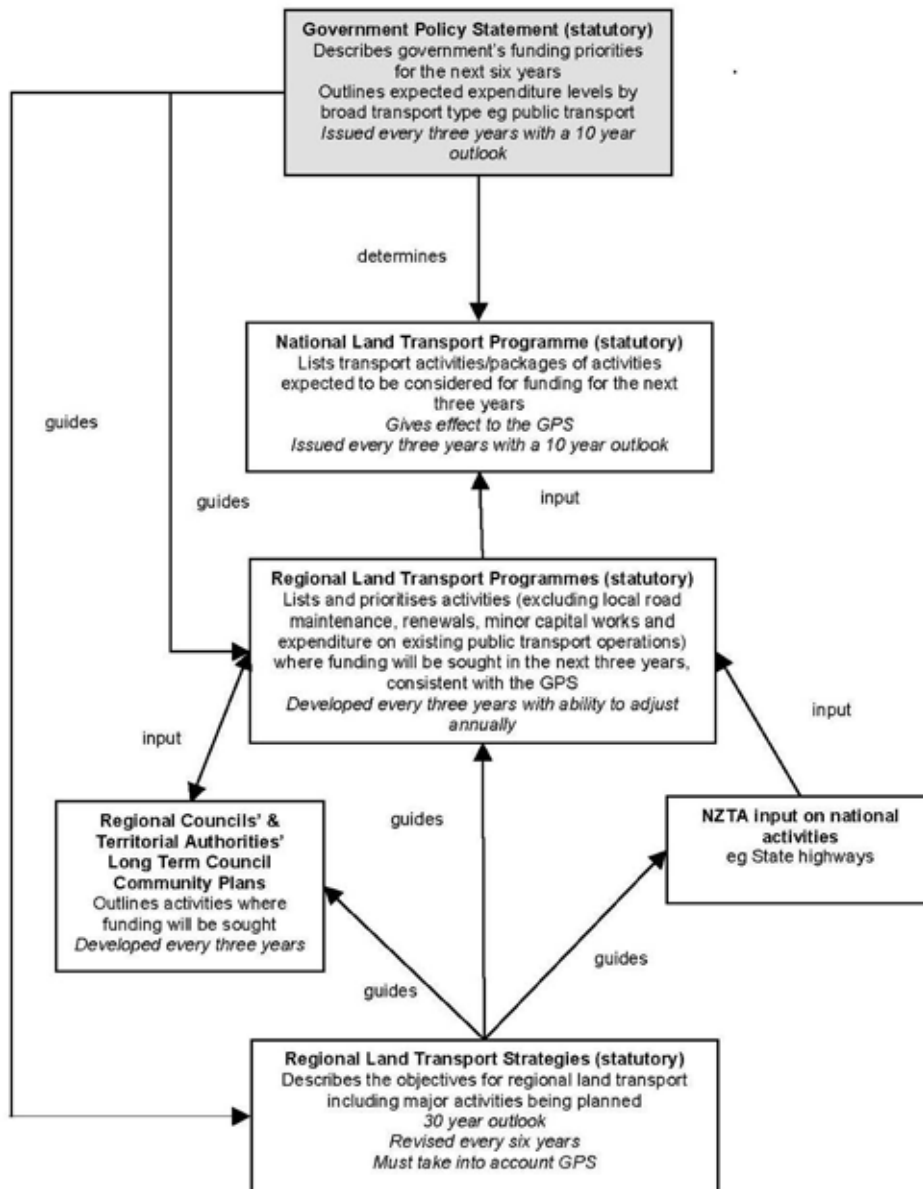


Figure 45 Relationship of the GPS to other central and regional planning documents

GPS2 states that the “priority is for land transport investment to support national economic growth and productivity” by directing “investment into high quality infrastructure projects and transport services that encourage the efficient movement of freight and people.” GPS2 notes the importance of enhancing efficiency and lowering the cost of transportation; increasing accessibility to markets and employment; ensuring a secure and resilient transport network; and improving road safety. Transport choices for those with limited access to a car, reductions in adverse environmental effects, and contributions to positive health outcomes are also identified as important outcomes associated with transport investment.

GPS2 identifies “integrated planning” as a specific funding policy, which aims to “ensure that decisions made in relation to land use, transport and urban design collectively contribute to the efficient use of public funds and achieve the Government’s objectives for transport and New Zealand ... transport strategies and packages of activities should be developed alongside ... land use strategies and implementation plans.”

GPS2 goes on to say that “the Government is particularly concerned to see that better integration of land use, transport planning and urban design activity contribute to national economic growth and productivity.” Integrated planning provides opportunities for “better integration within and between transport modes.”

### National Land Transport Programme – Bay of Plenty

The National Land Transport Programme – Bay of Plenty (NLTP-BOP) reflects NZTA’s dovetailing of the Government’s priorities for the transport sector with regional aspirations, as articulated in the Bay of Plenty Regional Land Transport Programme (RLTP). The table below is extracted from the NLTP-BOP and summarises some key statistics for the Bay of Plenty (BOP) region.

*Table 20 Comparison of key transport statistics in the Bay of Plenty region*

	Bay of Plenty region	New Zealand	Region as % of NZ
Population	368,200	4,268,500	9
Land area (km <sup>2</sup> )	12,400	275,400	5
Imports (gross tonne) <sup>1,2</sup>	13.4 million	79.2 million	17
Exports (gross tonne) <sup>1,2</sup>	12.2 million	73.4 million	17
Gross domestic product (GDP) (\$)	6500 million	155,400 million	4
Passenger transport – bus – boardings	1,534,700	92,777,200	2
Passenger transport – rail – boardings	-	18,346,600	-
Passenger transport – ferry – boardings	22,500	4,695,000	0
Vehicle kilometres travelled	2700 million	40,200 million	7
Fatalities	36	391	9
Serious injuries	169	2232	8
Local roads – urban all (km)	1101	17,298	6
Local roads – urban sealed (km)	1098	16,956	6
Local roads – rural all (km)	2731	65,601	4
Local roads – rural sealed (km)	1884	33,698	6
State highways – all (km)	747	10,906	7
State highways – sealed (km)	747	10,850	7
State highways – motorway (km)	-	172	-

It is interesting to note that the BOP region accounts for:

- A disproportionately high level of imports and exports per capita – reflecting the presence of the Port of Tauranga and major primary industries;
- Relatively few public transport boardings – reflecting the low-density, small scale urban areas, and largely dispersed rural populations; and
- Fewer vehicle kilometres travelled per capita – reflecting the generally older population and some areas of socio-economic deprivation.

The development of the NLTP-BOP was complicated by the transition from GPS1 to GPS2, which sought to place an increased focus on state highway construction and reduced funding for walking, cycling, and passenger transport. This change in focus is reflected in the funding splits for the NLTP-BOP as illustrated below.

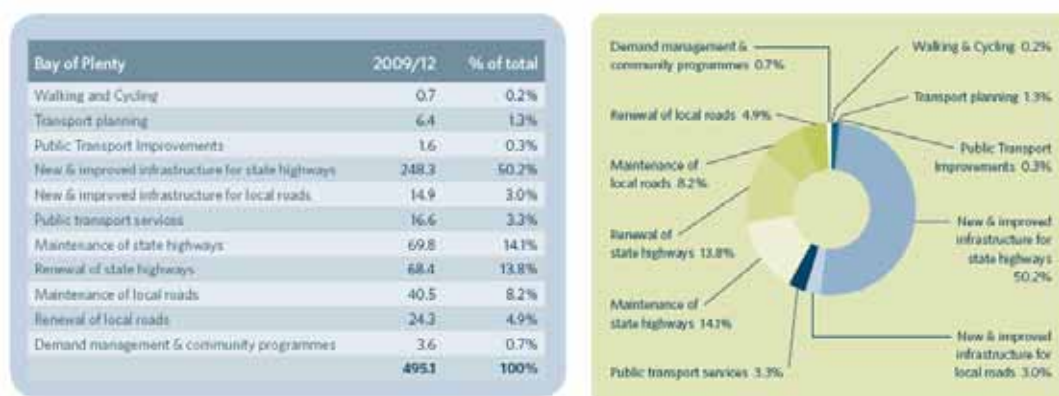


Figure 46 NLTP-BOP funding allocation by activity class 2009-12

The NLTP-BOP emphasises that applications for funding to support public transport, walking, cycling, and travel planning activities must demonstrate their alignment with the Government’s strategic priorities. The NLTP-BOP also signals some projects for these modes including the establishment of downtown bus stations in Tauranga and Rotorua, the Ngongotaha off-road cycleway, and a new pedestrian link at Poike Road in Welcome Bay.

### Regional Policy

The following sections review regional documents (both statutory and non-statutory) that relate to the delivery of transport infrastructure and services in the Bay of Plenty.

### Bay of Plenty Regional Land Transport Strategy

The Regional Land Transport Strategy (RLTS) must contribute to “achieving an integrated, safe, responsive and sustainable regional land transport system.”

The RLTS (2007) identified managing traffic demand (with some modifications in each of the sub-regions) as the preferred option to guide the strategic direction of the land transport system into the future. The RLTS identifies a suite of strategic outcomes associated with this direction, namely:

- *Integration:* Land use and transportation planning are closely linked; The land transport system provides opportunities and integrated linkages for all major modes; Demand management is considered in planning, design and transport investment decisions;

Existing and future transport corridors are defined and protected; and integrated transport packages for funding are developed;

- Safety and personal security: continual improvement of the safety and personal security performance of all modes will result in a land transport system that is safe to use; safety and personal security is improved through engineering, enforcement and education; the community is encouraged to play a greater role in transport safety; a safety culture is established throughout organisations involved in land transport.
- Responsiveness: transport planning processes are effective, engage those affected by transport decisions, and recognise diverse (including both urban and rural) needs within the region; public participation in land transport management is encouraged; the transport implications of growth are anticipated, recognised and sustainably managed; a sustainable funding strategy is developed to meet the region's transportation needs which concentrates on a number of different funding tools; Strategic alignment between the RLTS and both regional and local Long Term Council Community Plans is achieved.
- Sustainability: the development and operation of the land transport system recognises the value of the environment and avoids, remedies and mitigates its adverse effects; real efforts are made to manage travel and transport demand, optimise existing networks and improve alternative modes; people are made aware of the transport options available and the consequences of using each mode; and the land transport system is consistent with live, work and play principles.
- Economic development: the land transport system supports the continued growth and economic development of the region, and provides for the efficient, affordable movement of people and goods; Inter and intra-regional links are encouraged in order to improve access and connect settlements; and the life of all transport projects is extended through demand management initiatives.
- Energy efficiency: Development and operation of the land transport system recognises and provides for opportunities to improve energy efficiency and fuel efficiency and make more use of modes that use renewable resources; Innovative and alternative methods are used to promote a shift to more energy efficient modes; The region participates in the development of national energy efficiency policies and these policies are actively implemented within the region;
- Access and mobility: the people in the region, including the transport disadvantaged, enjoy ready access to health, education, employment and leisure activities; access is improved by providing linkages within and between settlements; and route security is well managed, particularly in vulnerable areas.
- Public Health: the land transport system provides opportunities for modes that contribute to improved public health and seeks to reduce the negative health effects of transport-related emissions; land use patterns and urban design promote safety and public health; and health facilities are accessible for all communities.

The journey to work (JTW) mode share targets for walking, cycling and public transport in the RLTS (2007) are summarised in Table 21 below. Figure 47 illustrates estimated progress towards the mode share targets for public transport. We have derived this by linking patronage data to census mode share. This suggests that actual mode share (dashed lined) increased steadily from 2001, although remained consistently below the RLTS targets (solid line). From 2006 onwards, however, the rate of increase in public transport mode share has

accelerated, which is likely to reflect the combined impacts of higher fuel prices and improved services. While it seems unlikely that the RLTS mode share targets for 2011 will be achieved, the 2021 targets are possible. Assessment of progress towards walking and cycling mode share targets was not possible due to a lack of comprehensive data sets.

Table 21 RLTS mode share targets 2001-2021

Town	Year	PT	Cycling	Walking	Total
Rotorua	2001	0.9%	3.5%	5.7%	10.1%
	2011	5.0%	4.0%	6.2%	15.2%
	2021	6.0%	5.5%	6.5%	18.0%
Tauranga	2001	0.5%	3.3%	4.6%	8.4%
	2011	5.5%	4.0%	5.0%	14.5%
	2021	10.5%	5.0%	5.5%	21.0%

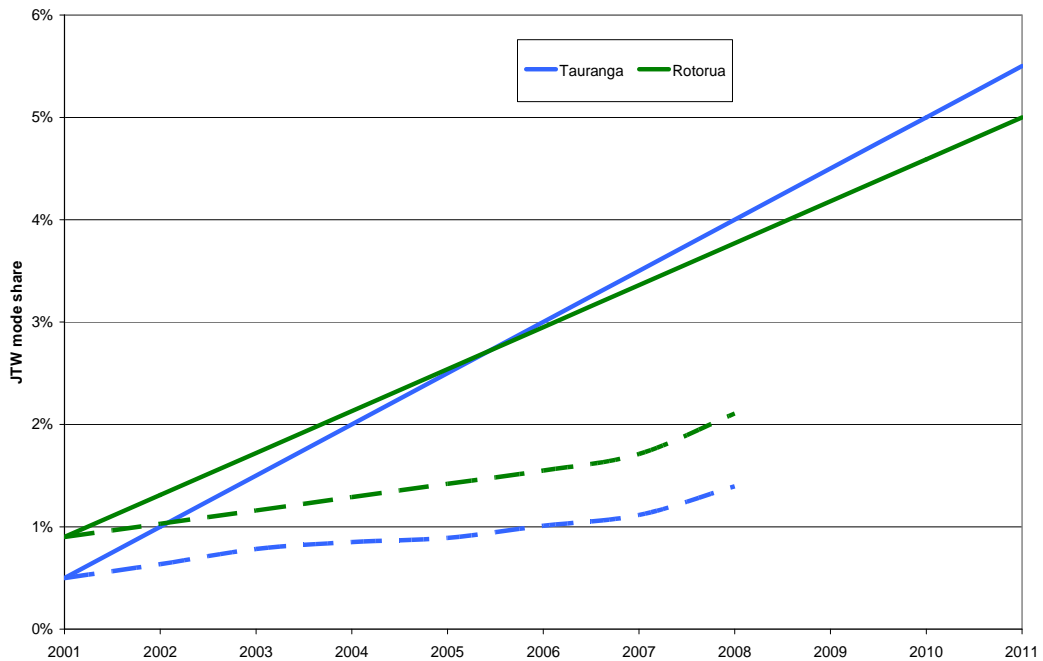


Figure 47 Estimated progress towards RLTS public transport mode share targets

## Bay of Plenty Regional Land Transport Programme 2009/10-2011/12

The Regional Land Transport Programme (RLTP) describes the strategic context affecting land transport investment in the region. This includes economic development, strategic infrastructure corridors accessing the Port of Tauranga, integrated growth management, development corridors, and strategic transport packages.

The transport issues and priorities discussed in the RLTP have been summarised and linked in the matrix below. The links identify where a particular priority is likely to contribute to resolving a particular issue. “Plus” and “minus” signs indicate where the identified priorities positively or negatively contribute to individual issues.

Improving travel-times on key routes, for example, is likely to contribute to managing traffic growth and congestion and improve access for rural areas, but simultaneously undermine public transport, walking, and cycling in urban areas.

Table 22 Matrix of Issues and Priorities identified in the RLTP

Priorities and Issues Matrix	1. Traffic growth and congestion	2. The incidence and severity of road crashes	3. Low public transport, walking and cycling mode share in urban areas	4. Route security	5. The effects of heavy vehicle traffic on the region's communities	6. A lack of access and mobility options for rural areas
1 Improve travel times and reliability on key routes to support economic development	++	-	-			+
2 Reduce casualties on the region's road network		++		+	+	
3. Optimise use of existing network by improving provision for public transport, walking, and cycling	+		++			+
4 Improve route security throughout the region				++		
5 Reduce the social and environmental effects of heavy vehicles					++	

The RLTP then goes on to identify a range of projects the region is seeking funding for over the next ten years. These projects were identified according to NZTA activity classes. In comparison to the RLTP, the NLTP-BOP reduced funding for public transport, walking and cycling, and local roads, and allocated a higher proportion of funding for new state highways.

## Appendix B – Mode Choices: A literature review

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### Introduction to mode choice regression modelling

Regression modelling is a process that investigates relationships between a dependent variables, or variables, and independent variables. The focus of the modelling is to determine the (causal) relationship between variables, and understand how the value of the dependent variables may change when one or more of the independent variables is changed.

More specifically, mode share regression modelling uses statistical models to understand the way that travel choices may be affected by a number of variables, including demographic (e.g. household size), transport (e.g. vehicle ownership) and land-use (e.g. employment density) factors. Data for such models is generally drawn from census data, land use and traffic databases and topographic maps (Federal Highway Administration, 1999).

Mode share regression models look at how each of these independent variables may relate to various mode shares for different travel options (e.g. walking and cycling, public transport). It is important to note the distinction between correlation and causation here. The regression function derived from these investigations will not conclusively determine the factors which will lead to increased mode share. Rather, it will identify those factors that are associated with higher mode shares, with the inferences of the findings needing further (economic) interpretation for implementation.

### Types of regression modelling

Within mode choice regressions, there are two main approaches:

- Aggregate behaviour studies; and
- Disaggregate modelling.

Both of these approaches can be used to investigate the impact of various factors on mode share, and each has its own advantages and the choice often depends on the available data and the purpose of the study. Oum (1989) considers these two approaches may in fact be complementary for most studies.

**Aggregate behaviour studies:** This method looks at the characteristics of a population group as a whole and how various factors may impact on the mode share experienced. With sufficient knowledge of various influencing factors, and the mode choice data, models can be made to compare various population areas (generally census area blocks) and determine which factors are associated with higher shares of various modes. Aggregate modelling is often the most applicable approach when dealing with investigating the total share of various modes in population areas (Oum, 1989).

**Disaggregate modelling:** This approach looks to “predict an individual’s behaviour and then aggregate individual decisions across a population to obtain overall travel characteristics.” It involves building a bottom-up understanding of mode share across a population base by determining which of the individual characteristics prevalent through the population have the largest impact on mode choice. The need for an extensive database for disaggregated modelling is noted as a common limitation for use of this type of approach by (Winston 1983, cited in Oum (1989)). Indeed, Bonnel (2003) notes that despite “considerable development in the last twenty years” that disaggregate modelling remains a less preferred method in mode share regression studies.



## Use of modelling approaches in determining population mode shares

Aggregate modelling is useful in that once the relationships between various factors and mode share levels has been determined across a large enough sample of areas, this can be used to infer expected mode share outcomes in other areas (Federal Highway Administration, 1999). This may help to identify areas that are either under-performing or over-performing on mode share relative to local factors. This data can then be used to further examine areas with high mode choice to investigate what may be causing these in order to replicate this success. Indeed, Oum (1989) notes that disaggregate modelling may be used once this type of analysis has been undertaken to further investigate individual characteristics impacting on mode share. The data can also be used in funding determinations, to target areas that may not be achieving the mode share targets that could be expected. Disaggregate models can also infer mode choice outcomes across populations by aggregating the individual outcomes for each person in the area, but this process often widens the confidence interval associated with each factor (Oum, 1989). For this reason, when looking to determine the impact of various factors on mode share values, aggregate modelling is more often used (Bonnell, 2003).

## Use of modelling to determine impact of individual policies

The main value of disaggregate modelling provides is its ability to determine and identify the impact of influencing factor at an individual level. This will ensure that any individual impacts are not lost in the aggregate process. A combination of some factors may be important at an individual level but that may be lost at an aggregate level. For example, individuals with close proximity to a bus stop and low car ownership may have a significantly higher PT usage level than the general population, but at an aggregate level, the weighting of these factors may lose their impact as they are averaged out across the population. The Federal Highway Administration (1999) in the United States notes this disadvantage of aggregate modelling in masking significant population variances. This may mean the outcomes of any modelling may lose complexity at the individual level for what measures could increase mode share levels. In attempting to analyse the impact of policy changes at an individual level, disaggregate modelling will offer a significantly more robust regression function.

## Common pitfalls and lessons learnt in regression modelling

The literature is generally in strong agreement about the important lessons in mode share regression modelling, and the methods which improve the value of the findings of any analysis undertaken.

**Size of zones:** Bonnell (2003) work contains a useful discussion on the size of zones that should be used in aggregate modelling. The zones should be as small as possible so as not to lose the accuracy of data that comes with larger data sets. However, they must also ensure that the areas analysed contain a sufficient number of data points to obtain a meaningful split of market mode share.

**Correct factors:** It is important that the right independent factors are analysed in the regression modelling. Given the nature of aggregate modelling, this is most often reliant on high-level data that is not as reliable on individual factors such as travel attitudes. Therefore, for disaggregate modelling, where possible, a range of individual factors should be investigated to determine which are most likely to be relevant to mode share. Ashley and Bannister's (1989) study (cited in Federal Highway Administration (1999)) of cycling mode share in UK cites the importance of selecting the correct variables, stating that the lack of attitudinal factors limits the value of their analysis to developing appropriate policy measures.

**Combination of regression modelling with GIS data:** The use of only statistical data can also hide a number of relevant spatial factors that may impact on mode share that are not as easily quantified. Hence, a number of authors have sought to combine GIS mapping techniques with traditional regression modelling to improve outputs. Sanni and Abrantes

(2010) discuss the failure of conventional transport modelling tools in relation to forecasting pedestrian trips, and use GIS to address this failure. Using census walking data from Leeds in the UK, in conjunction with detailed spatial characteristics of surrounding zones, they worked to improve the modal split estimates from traditional modelling. Their inclusion of GIS visualisation aided in the detection of correlations that may have gone unnoticed through purely statistical methods of regression.

### **Important lessons and applicability to Transport Futures study**

For the purposes of the Transport Futures study, aggregate modelling has been identified as the most appropriate modelling approach. This is due in most part to the purpose of the study in identifying the impact that independent factors may have on mode share, and how these factors influence different areas across the Bay of Plenty. The availability of census data at an aggregate level also supports this. Recognising the lessons from the international literature, the following observations on the regression modelling undertaken should be noted:

- *Zone sizing:* Data availability at a census area is not only the most convenient for, but supports the observations of Bonnel regarding appropriate size to ensure accurate data and a sufficiently high number of trips.
- *Selection of independent factors:* The reliance on census statistics represents a limitation of the modelling, but also an opportunity to use the outputs of this study to identify areas of sufficiently higher or lower levels of mode share. Investigating further factors such as attitudes and spatial characteristics in these areas via a disaggregated modelling approach will add further value to the modelling approach taken in this study.

## Appendix C – Details on the regression models

### Summarising the input data

The table below presents descriptive statistics; mean (average), maximum, and minimum values of each variable measured for each of the 111 Bay of Plenty Census Area Units (AUs).

Table 23 Descriptive statistics (sourced from 2006 census data for the Bay of Plenty)

NZ POPULATION CENSUS, 2006					
DESCRIPTIVE STATISTICS FOR 111 BAY OF PLENTY AREA UNITS					
TYPE	DESCRIPTION	NAME	MEAN	MAXIMUM	MINIMUM
AREA UNIT CHARACTERISTICS	AU POPULATION	POPN	2313	6921	267
	AU NUMBER OF HOUSEHOLDS	HH	852	2394	81
	AU AVERAGE HOUSEHOLD SIZE	HHSIZE	2.82	4.11	2.01
JOURNEY TO WORK MODE CHOICE	PROPORTION WORK AT HOME	WORKHOMER	0.114	0.358	0.025
	PROP'N CYCLE OR RIDE	ACTIVER	0.073	0.295	0.000
	PROP'N DRIVE	DRIVER	0.744	0.855	0.452
	PROP'N CAR PASSENGERS	POOLR	0.062	0.203	0.021
	PROP'N TAKE PUBLIC TRANSIT	PTR	0.010	0.038	0.002
HOUSEHOLD VEHICLE OWNERSHIP	PROP'N DON'T OWN VEHICLE	VDR	0.052	0.189	0.002
	PROP'N OWN ONE VEHICLE	V1R	0.303	0.477	0.136
	PROP'N OWN TWO VEHICLES	V2R	0.407	0.611	0.170
	PROP'N OWN THREE OR MORE VEHICLES	V3R	0.192	0.340	0.058
HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS	PROP'N EMPLOYED FULL-TIME	EFTR	0.452	0.609	0.291
	PROP'N EMPLOYED PART-TIME	EPTR	0.142	0.188	0.087
	PROP'N WHITE COLLAR WORKER	WHITECOLLAR	0.329	0.543	0.131
	PROP'N MAORI & PACIFIC ISLAND	MPIR	0.371	0.989	0.042
	AVERAGE AGE	AVAGE	36.6	54.0	24.0
	PROP'N HOUSEHOLDS WITHOUT CHILDREN	NOKIDSR	0.396	0.657	0.143
	PROP'N MALES IN HOUSEHOLD	MALER	0.490	0.550	0.439
	MEDIAN HOUSEHOLD INCOME	INCOME	50060.4	76700.0	24300.0
	PROP'N REGULAR SMOKERS	SMOKE	0.236	0.505	0.084
PROP'N H' HOLDS WITH INTERNET ACCESS	INTERNET	0.514	0.791	0.167	
LAND-USE CHARACTERISTICS	MESHBLOCK RESIDENTIAL DENSITY	RESDEN2	1450.1	3280.5	0.4
	EMPLOYMENT DENSITY	EMPDEN	296.6	5240.6	0.1
	RATIO JOBS/RESIDENTS	JOBSRATIO	0.413	6.263	0.034
	RESIDENTIAL CENTRALITY	RESCEN	47.016	128.426	32.136
	ANNUAL URBAN BUS KM	URBANBUSKM	20823	238580	0
	ANNUAL RURAL BUS KM	REGBUSKM	669	13532	0
	LENGTH OF STATE HIGHWAY PER CAPITA	HWAYperCapita	4.8	166.9	0.0

This table reveals that on average just over one half (0.514) of households had internet access. This is based on the implicit assumption that if the household has access, so do (all) the residents in the household. The Census also asks about the number of vehicles owned by the household, but does not ask who in the household owns them. So we see that in about 5% of households (0.052) there are no vehicles, whereas in 19% there are three or more. The latter case would include, for example, a multi-person household with most of the adult residents owning their own car or a family farm with multiple registered vehicles.

### Interpreting the regression models

In interpreting regression models, it is important to note that these are linear models and this has two implications. First, scale (units of measurement) matter. If a variable measured as a proportion is re-scaled to be a percentage (i.e., multiplied by 100), then its coefficient will come out exactly 100 times smaller, to give the same predicted effect of any actual change.

This means that variables measured in units such as dollars – here including median household income, which averages about \$50,000, will tend to have much smaller coefficients than variables measured as proportions, which by construction all lie between zero and one. The second point to note is that as a linear regression, the coefficients of the model should ideally only be relied on for predictive purposes within the range of data over which the model estimates.

When interpreting the results of the regression models we note that the initial point of interest is the statistical ‘significance’ of the individual variables. This is represented by the ‘p-value’, which is an estimate of the likelihood that there is actually no systematic relationship between the two variables (the explanatory and the dependent variables). A p-value of less than 0.01 indicates the coefficient is highly significant, in the sense that the estimated probability of it not being so is less than 1%. In the tables this level of significance is marked with three stars (\*\*\*) ; significance between 1 and 5% gets two stars, and significance between 5-10% receives a single star. No stars means not significant, although these variables still add to the overall explanatory power of the model. This is usually measured by R-squared and has therefore been retained. However, we note that interpretation of these variables is less reliable.

The coefficient of the variable, in contrast, indicates how much of an impact a change in that variable has on the mode share being observed (again noting that units of measurement are important such that large variables may appear to have smaller coefficients (in absolute terms). The estimated ‘coefficients’ are the model’s prediction of the effect of one particular explanatory variable. In the table below, for example, a 10% increase in the proportion of male residents would have a  $10\% \times 0.6045 = 6.045\%$  change increase in walking/cycling mode share, holding all the other variables constant.

## Results of the regression models

### Walking and cycling

We report first on variations across the 111 AUs in the proportion of journeys to work effected on Census day by walking or by cycling found in the regression model. The walking and cycling mode choice regression model identifies nine variables, which explain approximately 80% of the variation in observed walking and cycling mode share across the Bay of Plenty area units.

*Table 24 Results for walking and cycling regression model*

Category	Area Unit Variables	Coefficient	p-value	
Demographic	Prop'n male residents	0.6045	0.0001	***
	Average household size	-0.0376	0.0008	***
	Prop'n European residents	-0.0877	0.0099	***
Transport	Average household vehicle ownership	-0.0591	0.0096	***
	Prop'n households without a vehicle	0.3114	0.0158	**
	Length (km) state highway per resident	-0.0007	0.0000	***
	Prop'n trips to central area unit	0.0381	0.0820	*
Land use	Average journey to work distance	-0.0011	0.1864	
	Employment Density	3.11e-5	<0.0000	***

These results suggest that walking and cycling is positively related to the proportion of male residents, proportion of households without access to a vehicle, proportion of trips to a central area unit (i.e. Tauranga, Rotorua, and Whakatane central), and employment density. On the other hand, walking and cycling is negatively related to average household size (i.e. larger households walk and cycle less), proportion of European residents, household vehicle ownership, length of state highways per resident, and average journey to work distance.

## Work at home

The work at home mode choice regression model identified eleven variables that together explained approximately 81% of the variation in observed work at home mode share. Most of these variables were statistically significant (p-values of 0.1 or less) as illustrated below.

Table 25 Results for work at home mode choice regression model

Category	Area Unit Variables	Coefficient	p-value	
Demographic	Prop'n White collar workers	0.657	<0.000	***
	Prop'n Residents employed full time	0.634	0.011	**
	Prop'n Residents employed part-time	0.164	0.042	**
Transport	Prop'n households with one vehicle	-0.383	0.000	***
	Prop'n households with two vehicles	-0.432	0.000	***
	Prop'n households with internet access	0.145911	0.054	*
	Prop'n trips to central area unit	-0.214563	<0.000	***
Land use	Mesh block weighted residential density	-1.506e-05	0.017	**
	Ratio of jobs to residents	0.019	0.000	***
	Residential dispersion	4.404e-04	0.106	
	Median household income	-3.765e-06	0.000	***

Results indicate that work at home mode share is positively related to the proportion of white-collar workers, the proportion of people employed (either full or part time), internet access, the ratio of jobs to residents, and residential dispersion (which measures an area's proximity relative to the regional population). The positive relationship with internet access is interesting because it demonstrates how changes in the "supply" of communications infrastructure may in turn affect future mode choices.<sup>40</sup>

Results also suggest that work at home mode share is negatively related to increases in vehicle ownership, trips to central urban areas, residential density, and household income. The relationship with vehicle ownership suggests that the decision to work from home is to some degree related to limited access to private vehicles. Similarly, the percentage of trips to central areas suggests that the more specialised employment opportunities available in higher density employment centres tends to pull people away from working at home.

We suggest that most of the remaining 19% of the variation reflects geographical differences in the feasibility of working at home across the Bay of Plenty. This might reflect factors such as the viability of particular industries that are most suited to work at home. It might also reflect variation in the quality of internet access, for example the distinction between dial-up and broadband internet. Further research is required to confirm whether the quality of internet access plays a role in defining whether people work at home.

## Car-passengers

The car-passengers mode choice (i.e. people getting a lift to work with a vehicle driver) regression model identified ten variables, which together explained approximately 76% of the

<sup>40</sup> Although a word of caution is warranted due to the endogenous nature of this variable. We are modeling decision to work at home as a function of internet access, when the reverse is also likely to be true. That is, people's decision to subscribe to the internet is likely to be influenced by their decision to work at home. For this reason when forecasting future mode share we cannot assume that the decision to work at home is independent of internet access. This effect is discussed in more detail in subsequent sections.

variation in observed car-passengers mode share. Coefficient for these variables and their statistical significance are summarised in the table below.

*Table 26 Results for car-passenger regression model*

Category	Area Unit Variables	Coefficient	p-value	
Demographic	Prop'n White collar workers	-0.0949	0.002	***
	Median age	0.001	0.001	***
	Median household income	8.31E-07	0.003	***
	Prop'n residents who smoke regularly	0.133	0.025	**
	Prop'n Maori and pacific island residents	0.053	0.001	***
	Average people per household	0.017	0.022	***
Transport	Average vehicle ownership	-0.032	0.001	***
Land use	Mesh block weighted residential density	7.37E-06	0.007	***

Most of the remaining 24% of the variation is likely to reflect geographical differences in the viability of choosing to travel as car-passengers across the Bay of Plenty. This may reflect variation in diversity of employment opportunities, where certain industries, such as kiwifruit picking, may be more suited to car-passengers. It might also reflect the relative stability of an area, where lower residential turnover (i.e. changes in the residents) is observed then people may be more likely to establish strong community connections that in turn increase their ability to be car-passengers.

## Public transport

The public transport mode choice regression model identified four variables, which together explained approximately 45% of the variation in observed public transport mode share.

*Table 27 Results for public transport mode choice regression model*

Category	Variable	Coefficient	p-value	
Demographic	Median age	-0.0002	0.208	
	Prop'n of smokers	0.0352	0.005	***
Transport	Bus service kilometres	2.4e-05	0.000	***
Land use	Prop'n of trips to central area	0.0091	0.104	

The relatively low explanatory power (low R-squared) of the public transport regression model is undesirable but not unsurprising given the relatively small numbers of people travelling by public transport in the Bay of Plenty. This is likely to reflect relatively low and uneven access to attractive public transport, which is in turn related to a combination of factors. We note that even when considered at the area unit level (which is relatively large), the number of responses is often sufficiently low to fall within Statistics New Zealand's confidentiality "rounding" rules, which are designed to protect the confidentiality of responses.<sup>41</sup> Hence, this regression model was developed using only about 82 of the 111 area units that were used in the other models. It is important to emphasise that even those multi-modal transport models with robust data sources have difficulty predicting numbers of public transport trips, even in base years.

The unexplained variation in the model may reflect geographical differences in the origin and destinations of journey to work trips across the region, which are not picked up by our models. For example, public transport services accessing the Tauranga CBD from the south-west will also serve employment destinations along Cameron Road. Despite the low

<sup>41</sup> Work is ongoing to model public transport patronage in other parts of New Zealand where the numbers of public transport trips are sufficiently large to get around these issues.

R-squared, the variables included in the model have expected outcomes; older people are less likely to use public transport. On the other hand, areas that support higher proportion of trips to central areas and other employment centres and corridors have higher public transport mode share. While results suggest that smokers are more likely to use public transport this is unlikely to be a causal effect and is thus not implemented in the model even if it helps sharpen estimates for other variables, which have causal explanations.

The model performed better in those parts of Tauranga, Rotorua and Whakatane where overall levels of public transport patronage were higher. This suggests mode choice regression models for public transport are likely to become more accurate as overall uptake of public transport grows in the future. Further research could also seek to expand the analysis to other area units in New Zealand, where public transport systems are more established, such as parts of Auckland, Wellington, and Christchurch.

### **Understanding the errors in the regression models**

Some degree of unexplained variation is inevitable in most models. Residuals represent the unexplained portion of the variations in actual mode share. Mapping the residuals helps us understand where the models are performing accurately, and where they are not. By mapping the residuals unexplained variations are easily and transparently revealed.

Where spatial patterns are observed in the residuals then they can indicate the presence of local factors that may be affecting journey to work mode share, but which have been omitted from our regression models. Where variables are omitted, then the importance of this omission depends on whether the relationship between the omitted factor and the dependent variable (mode share) is subject to change in the future.

Our analysis of the residuals in the regression models highlighted no obvious spatial patterns (technically referred to as spatial auto-correlation), aside from the higher than expected values for walking/cycling in central Whakatane (discussed previously in Section 2.1). This suggests there are some factors (omitted from our model) that contribute to higher than expected walking/cycling in central Whakatane.

## Appendix D – Details on the forecasting model

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### Summarising the forecasting model

The travel demand model utilised for this report forecasts future input variables (e.g. demographics), which are then used to determine the expected changes in JTW mode share [% trips]. These mode shares are subsequently converted into an overall mode share [% kilometres], and multiplied by our forecast annual total travel demands [km per capita per year] to generate an estimate of the travel undertaken by a particular mode in a particular year [km travelled per capita per year]. This can then be multiplied by the total population of the Bay of Plenty region to generate estimates of aggregate travel demands. The forecasting model can thus be used to generate estimates of future travel demands by mode in response to changes in demographic, transport, and land use related factors for the entire region.

This appendix describes how the mode choice regression models developed in the report are integrated with total travel demands, as measured by both the number of trips and total kilometres travelled. It first analyses the trends in total travel demand using information from the Ministry of Transport's *Household Travel Survey (NHTS)*. Our analysis finds that travel demands have, in per capita trends, declined steadily over the past three years. Second, we extrapolate these trends forward to generate forecasts of future travel demands (per capita), which may be multiplied by the forecast regional population to provide an estimate of total regional travel demands. Thirdly, we develop mode share adjustment factors that link census journey-to-work mode share (which we can model using our mode choice regression models) to the total travel mode shares provided by the NHTS. Fourthly, we forecast the key variables identified in the mode choice regression models, which are expected to impact on future travel patterns. Finally, we pull all this information together within a modelling framework from which we can generate "base" travel demand estimates for the Bay of Plenty region. The impacts of transport investment priorities on travel demands are also discussed.

### Forecasting key variables

The following sub-sections outline the methods used to develop forecasts of the key variables identified by the regression models as being related to mode share in the Bay of Plenty region

In general, these methods extrapolate forward based on historical trends identified from a combination of data from the census and Statistics NZ. In some places, however, we have used our professional judgment to moderate underlying trends where we consider they are unlikely to be representative of trends.

Forecasts have, where possible, attempted to capture underlying trends in the simplest possible way. Simplicity is both an advantage and a disadvantage – it allows for easy interpretation, but is unlikely to capture long run trends. Once further data becomes available, particularly from the 2011 census, then the forecasts should be assessed and, where necessary, updated.

### Average household size

Regression models suggested that average household size was negatively related to walking/cycling mode share and positively related to car-passenger mode share. We developed a simple (autoregressive) model of average household size for each area unit in the Bay of Plenty region. This model considered average household size in 2006 (for each area unit) as a function of average household size in 2001, as illustrated below.



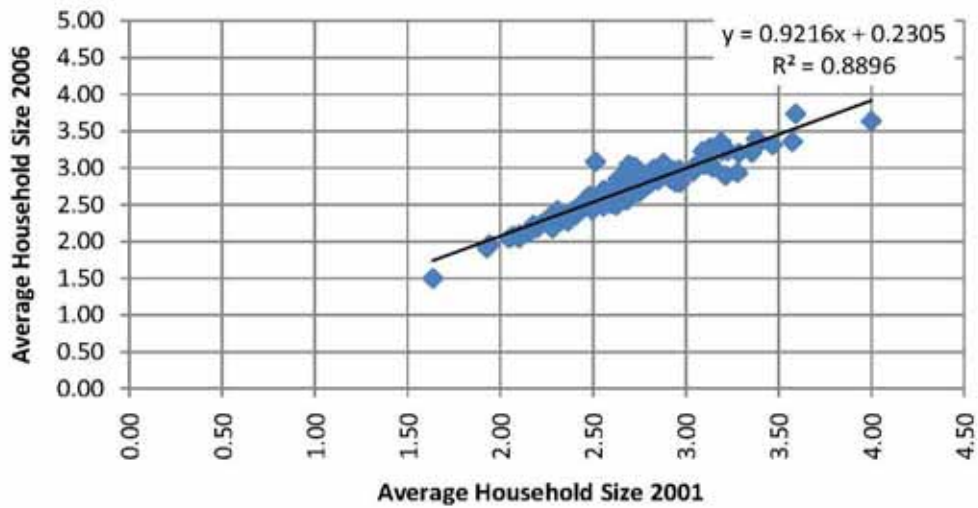


Figure 48 Average household size for area units in the Bay of Plenty 2001-06

The linear trend in this scatter plot is also shown, where the coefficient of the line (0.9216) is particularly important as it represents the average rate of change in average household size across the region between the 2001 and 2006 censuses. The coefficient is less than one because average household size has been declining over time (the intercept +0.2305 is not materially important). While the model is relatively simple it has a high r-squared of 89%, which suggests that it captures most of the variation in the underlying data. Using this relationship, we could then forecast changes in average household size for each area unit in the Bay of Plenty. The figure below illustrates the regional average household size.

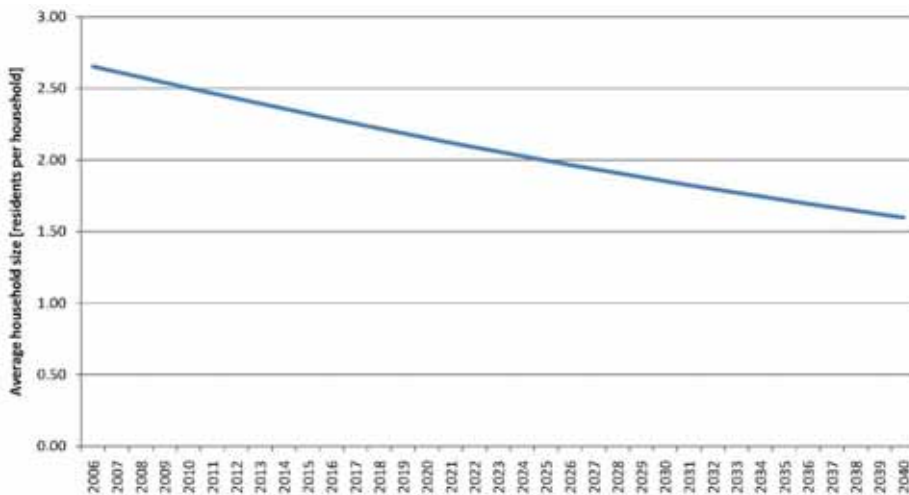


Figure 49: Forecast average household size in the Bay of Plenty 2006-40

## Median age

Regression models indicated that median age was positively related to car-passenger mode share and negatively related to public transport mode share. We derived forecasts of median age by indexing the regional age in 2006 to Statistics NZ national age forecasts to 2040. This relationship is illustrated in the figure below.

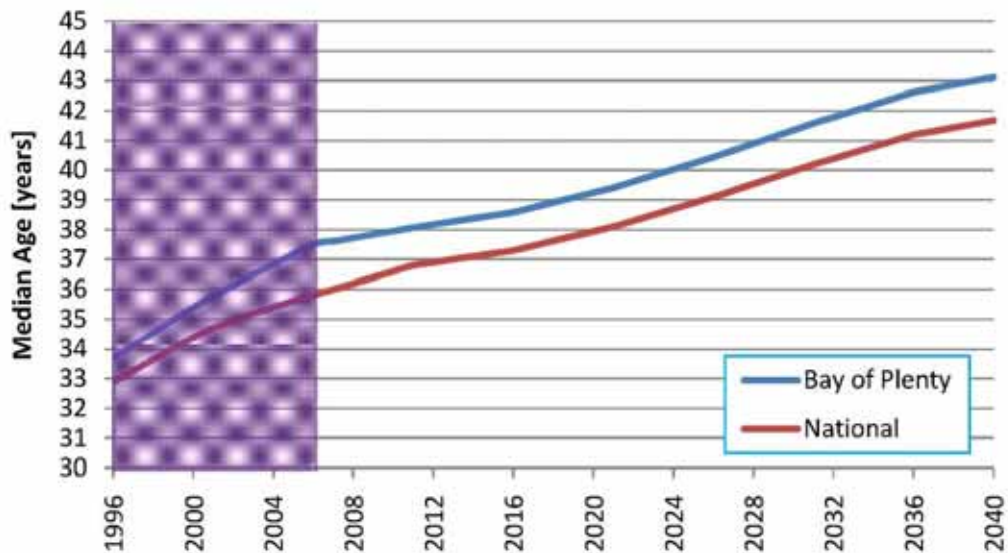


Figure 50 Forecasted median age for Bay of Plenty and nationally 1996-2040

### Median household income

Regression models suggested that median household income was positively related to car-passenger mode share and negatively related to work at home mode share. We modelled income growth by assuming 1.5% annual growth from 2006-2011; 1.0% annual growth from 2011-21; and 0.5% annual growth from 2021-2040. The effect of these growth rates on the regional median household income is illustrated in the figure below.

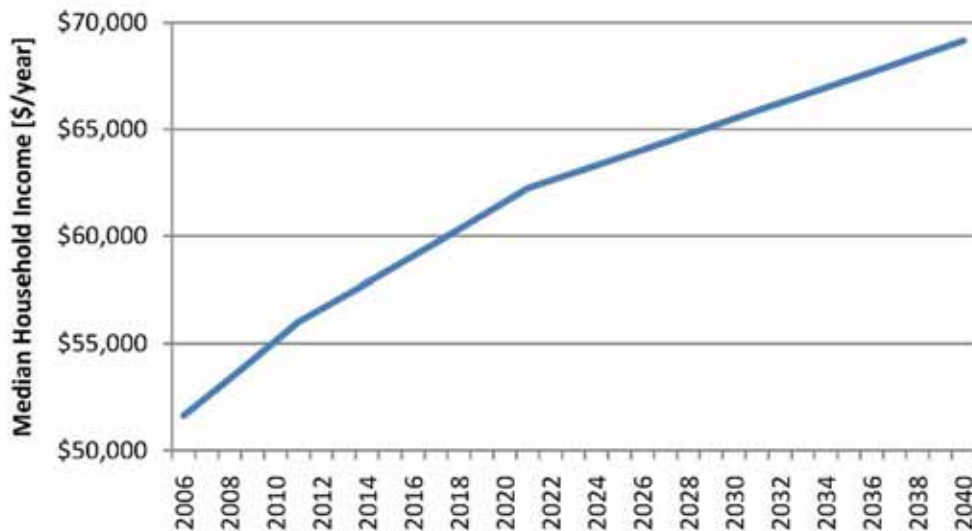


Figure 51 Forecast median household income in the Bay of Plenty region 2006-40

### Proportion of European and Maori residents

Regression models suggested that walking/cycling mode share was negatively related to the proportion of European residents, whereas car-passenger mode share was positively related to the proportion of Maori and Pacific Island residents. Both these variables are likely to be acting as proxies for cultural factors that in turn influence travel choices.

There is scant information available on New Zealand's forecast ethnic make-up; indeed immigration flows and birth rates are highly volatile. For this reason, we developed a simple (autoregressive) model, which ethnic proportions in 2006 as functions of the ethnic proportions in 2001. The results of these models are illustrated in the following figures.

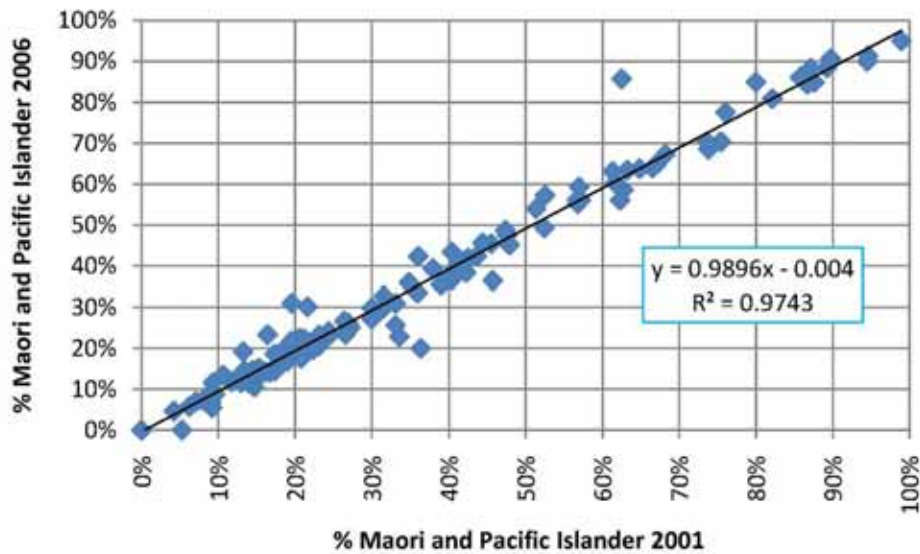


Figure 52 Proportion Maori and Pacific Island residents in the Bay of Plenty 2001-06

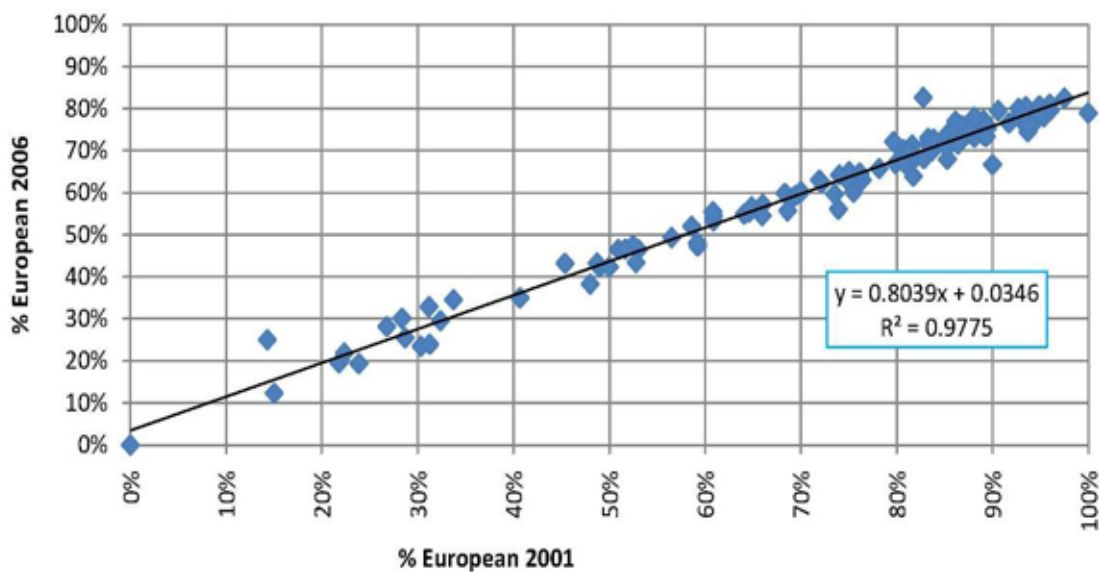


Figure 53: Proportion European residents in the Bay of Plenty 2001-06

Both models have high r-squared values in excess of 97% and both have slope coefficients of less than one – which reflects a declining percentage of Maori and European residents over time. We note that the percentage of European residents dropped dramatically from 2001-06, with regional average declining from 78% to 67%. It is unrealistic to expect this rate of decline to continue in the future so we adjusted the rate downwards over time. We then used these trends to forecast future ethnic proportions for individual area units, which can then be aggregated to the regional level, as illustrated below.

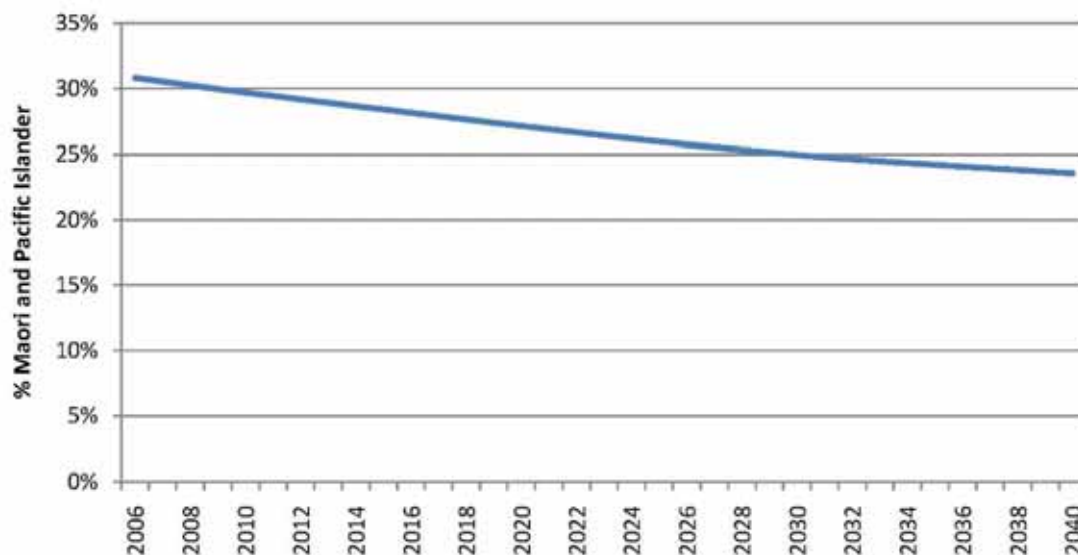


Figure 54 Proportion Maori and Pacific Island residents in the Bay of Plenty 2006-40

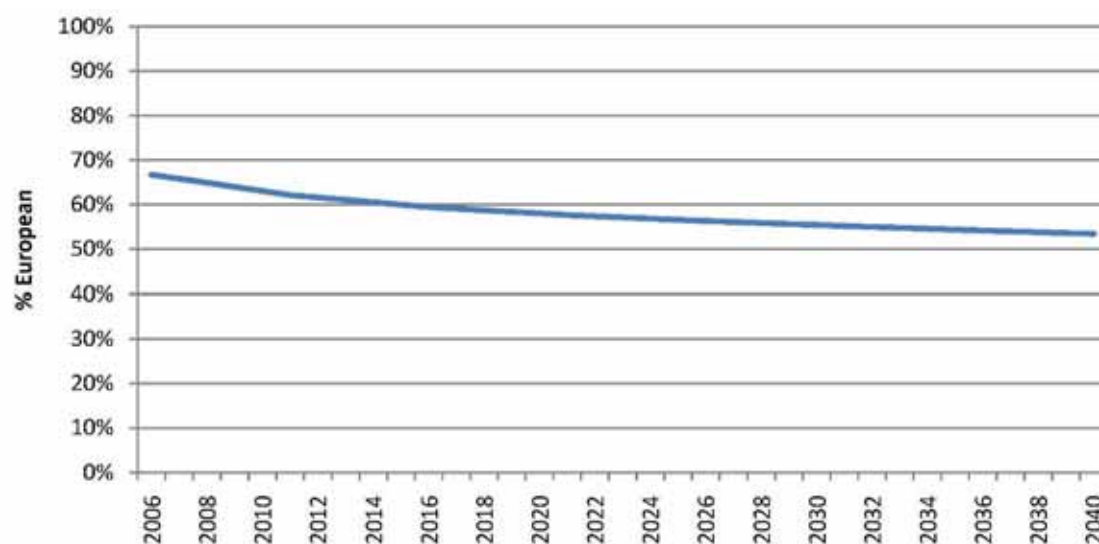


Figure 55 Proportion European residents in the Bay of Plenty 2006-40

### Households with no children

The regression model for car-passenger identified a negative relationship with the proportion of households with no children. This suggests that households with children are more likely to travel as car-passengers, which is likely to reflect households with children that are in part-time employment.

Little data exists on expected trends in the percentage of households without children, particularly at the regional level. For this reason we again used an autoregressive model to analyse changes from 2001-06, as illustrated below.

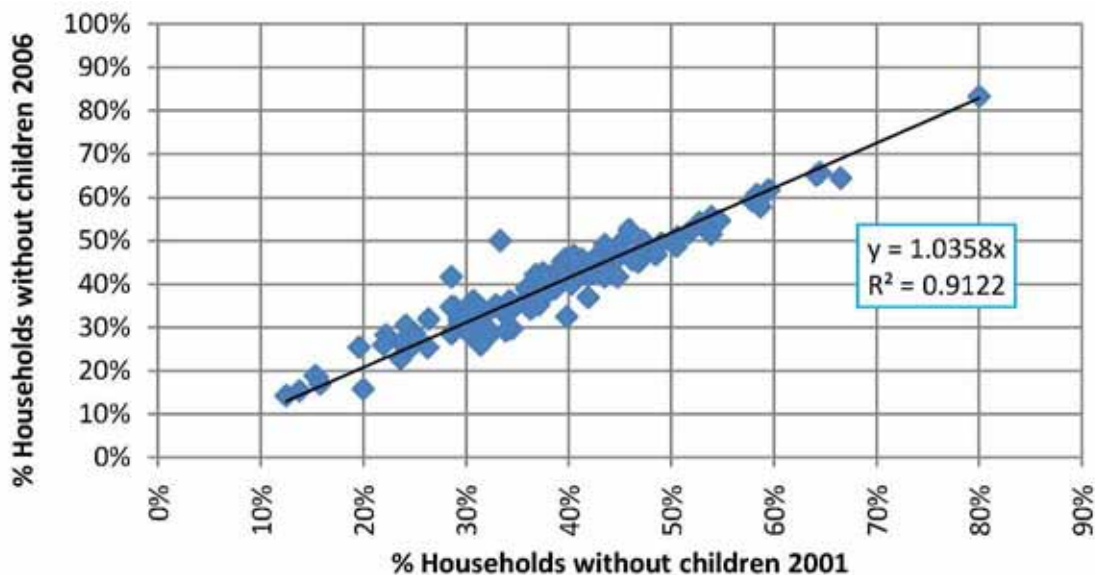


Figure 56 Proportion of households without children 2001-06

This model has an r-squared of 91% and a coefficient that is larger than one – which indicates that the proportion of households without children is increasing over time, as would be expected. Using this coefficient, we forecasted the proportions of households without children for individual area units in the Bay of Plenty, as illustrated below.

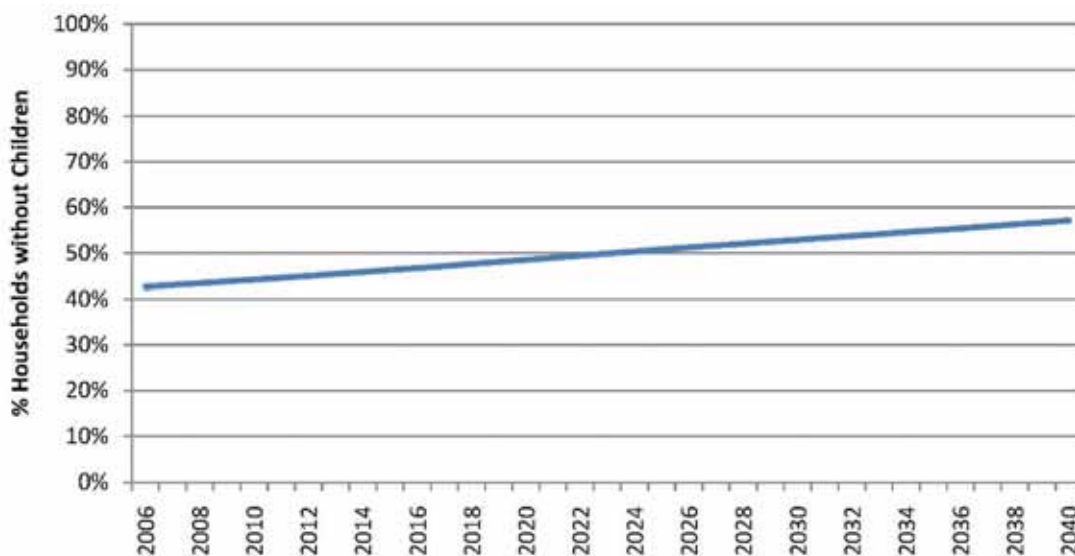


Figure 57 Forecast proportion of households without children in the Bay of Plenty 2006-40

### Male residents

The proportion of male residents was estimated using an autoregressive function with one time lag, similar to the models discussed in previous sections. This used a linear regression to model the proportion of male residents in 2006 using values from 2001, as illustrated below. The model had an r-squared of 77% and a slope coefficient of 0.9951, which confirms that the proportion of male residents in the Bay of Plenty is declining slowly over time.

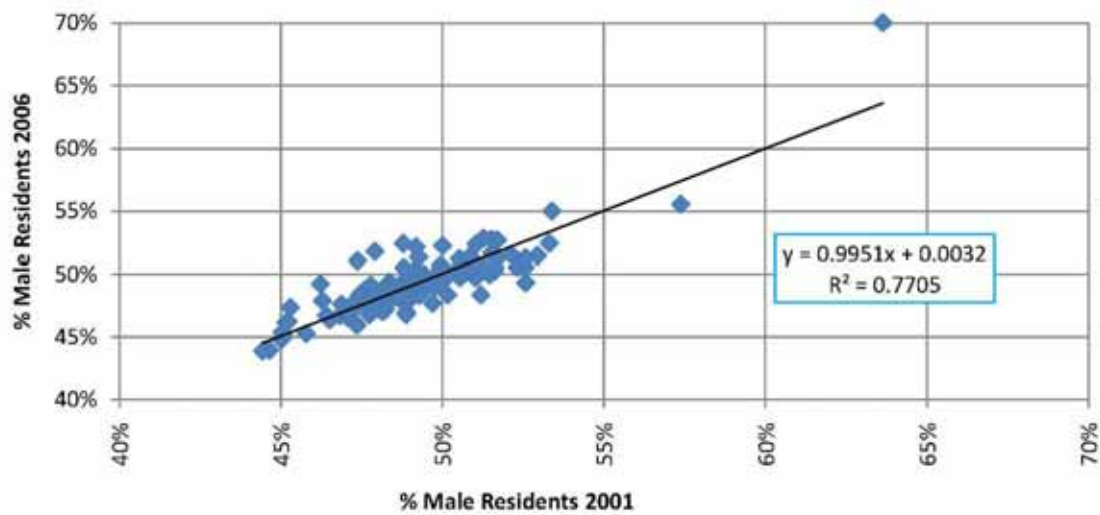


Figure 58 Change in proportion of male residents in Bay of Plenty area units 2001-06

Using the rate of change derived from this model, we could then forecast how the proportion of male residents might change in the future, as illustrated below.

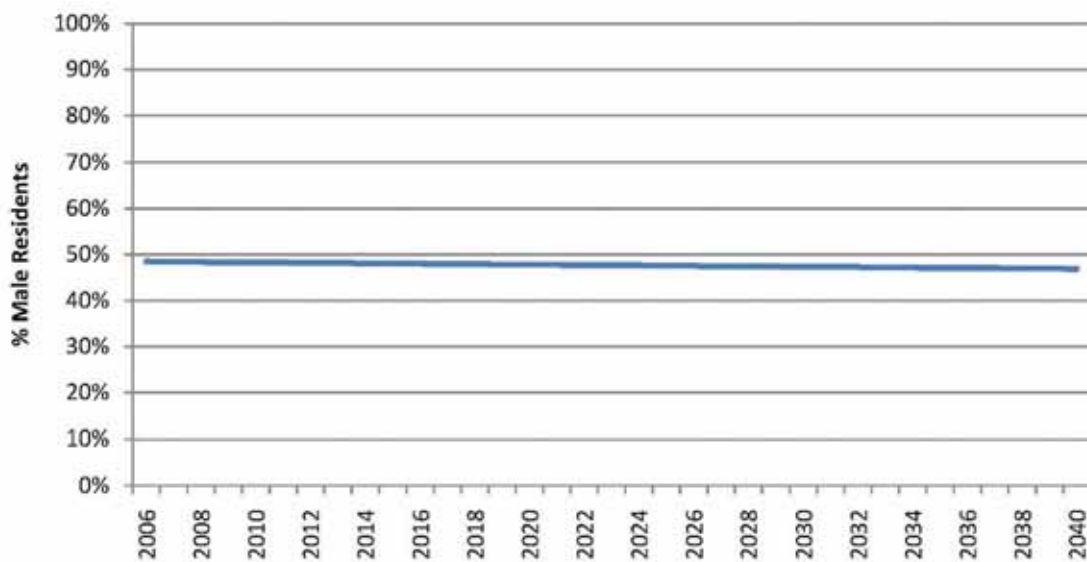


Figure 59 Forecast proportion of male residents in the Bay of Plenty 2006-40

## Smoking

Regression models suggested that the proportion of smokers was positively related to car-passenger and public transport mode shares. We analysed trends in smoking from the 1996 and 2006 census (data was not collected in the 2001 census), as illustrated below. We applied an autoregressive model to forecast 2006 values as a function of 1996 values. This model has an r-squared of 79% and a slope coefficient of 0.8844, as illustrated below. This suggests the proportion of Bay of Plenty residents who smoke reduced significantly from 1996 to 2001.



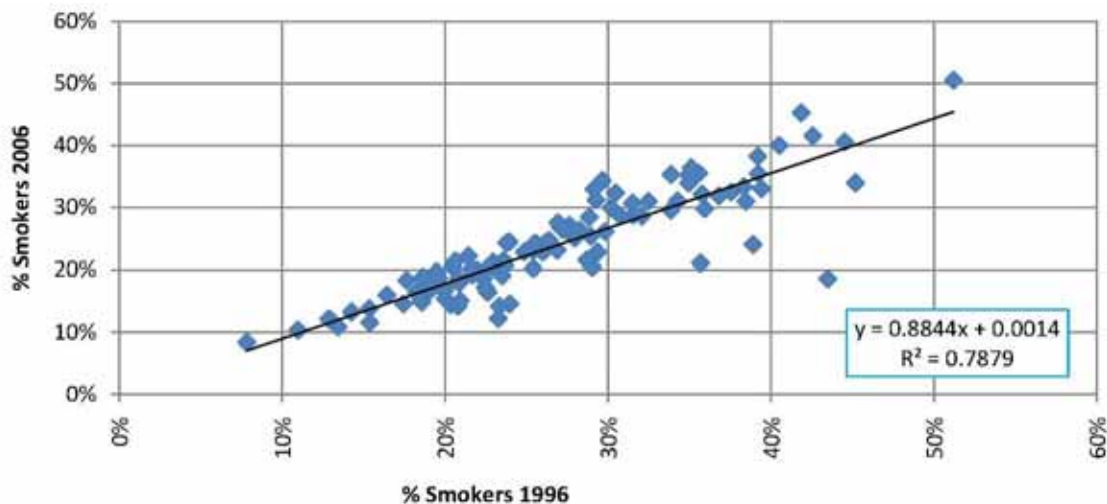


Figure 60 Change in proportion of residents who smoke in Bay of Plenty area units 1996-2006

Using this slope coefficient, we then forecasted the proportion of Bay of Plenty residents who smoke from 2006-2040, as illustrated below.

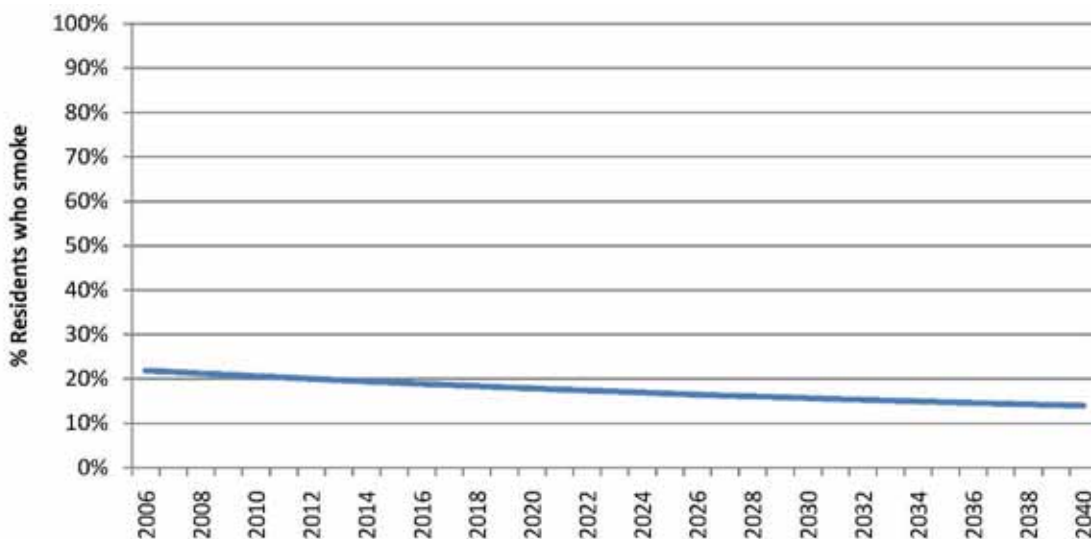


Figure 61 Forecast proportion of smokers in the Bay of Plenty 2006-40

### Full and part time employment rates

Regression models suggested that the full and part time employment rates were positively related to work at home mode share. That is, area units that supported high rates of employment enjoyed higher work at home mode share. The reasons for this relationship are not immediately clear, although we suggest that it reflects the tendency for new employees (at the margin) to be attracted into the workforce by jobs that allow them to retain some degree of personal autonomy. Working from home may therefore be an attractive way to increase workforce participation amongst people whom, for whatever reason, find it difficult to travel to a place of work. Changes in full and part time employment from 2001-2006 are illustrated below.

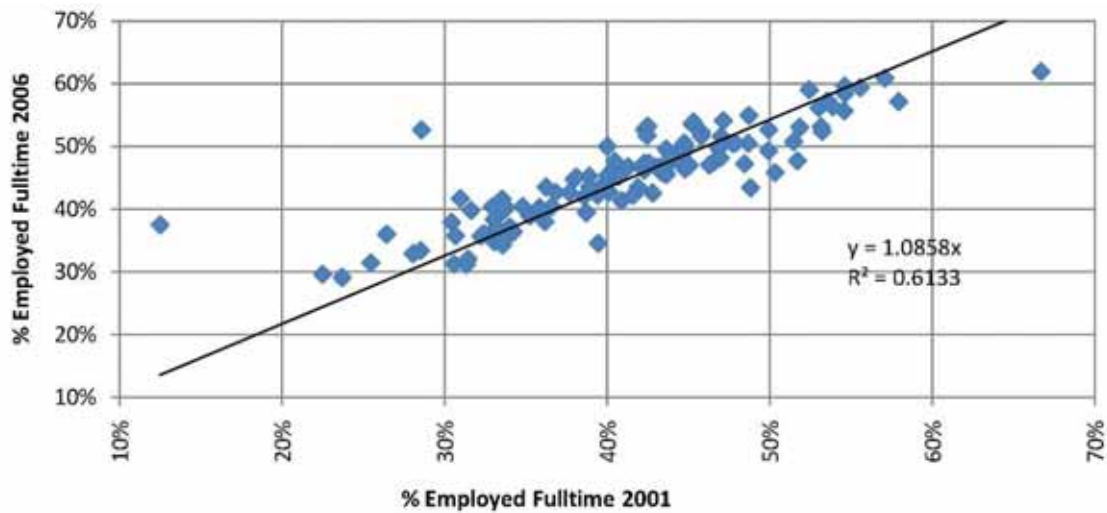


Figure 62 Change in full time employment in Bay of Plenty area units 2001-06

This shows that area units in the Bay of Plenty experienced, on average, an 8.58% increase in full time employment rates from 2001-06. Changes in part time employment rates at the area unit level were considerably more volatile and obscured general trends. For this reason we analysed trends in part time employment at the regional level, as illustrated below.

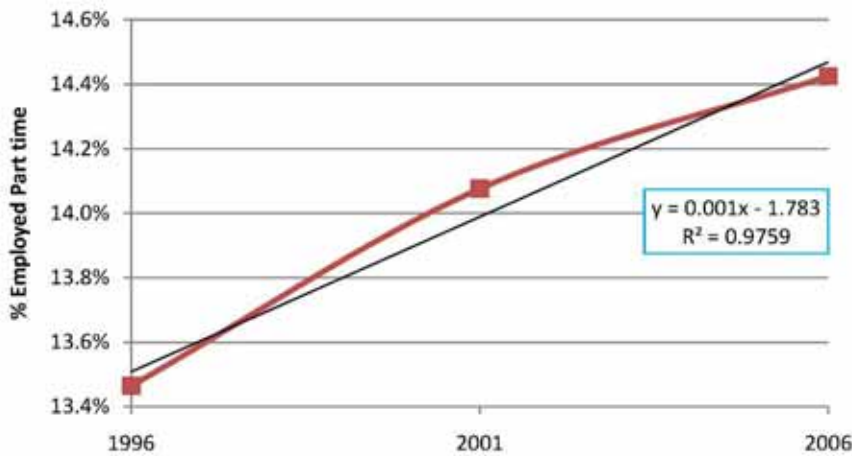


Figure 63 Change in part time employment in Bay of Plenty region 1996-2006

This shows the regional rate of part time employment increasing by approximately 2% over 10 years, or 0.2% per year, from 1996-2006. In comparison to full time employment rates, part time rates experienced much more gradual rates of growth in this period, which is likely to reflect people moving from part to full time employment, possibly in response to economic conditions.

We note that the period from 2001-06 was characterised by unusually high rates of growth in full time employment. These growth rates are unlikely to be sustained because of unfavourable economic conditions and population ageing, both of which will drag down the growth in full time employment rates.



In contrast, an ageing population may be expected to sustain higher rates of part time employment, as people move from full to part time positions as a precursor to retirement. For this reason we have elected to progressively factor down the growth in full time employment rates, but retain growth in part time employment. Our forecast full and part time employment rates, as determined by these assumptions, are illustrated below.

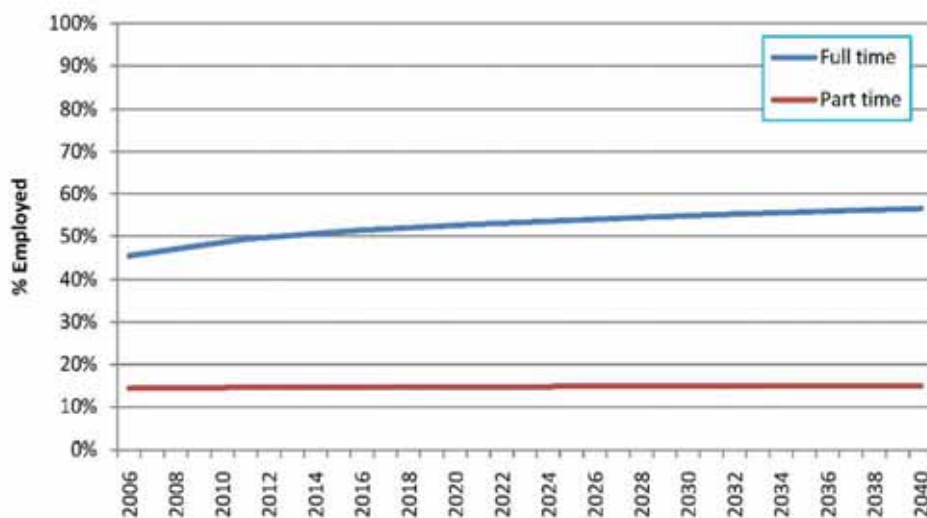


Figure 64 Forecast employment rates in Bay of Plenty 2006-40

### White collar workers

Regression models indicated that the proportion of white collar workers was positively related to work at home mode share and negatively related to car-passenger mode share. We defined white collar workers as people recorded in the census as being employed as either “Legislators, administrators, and managers” or “professionals.”

Trends at the area unit level exhibited a high degree of volatility, so we instead analysed trends at the regional level. The proportion of white collar workers in the Bay of Plenty region increased from 23.6% to 26.6% from 2001 to 2006, or approximately 0.599% per year.

Using this growth rate we forecast the proportion of white collar workers increases from 27% to 33% of the regional workforce by 2040.

### Internet access

Regression models indicated that household internet access was positively related to work at home mode share. Quite intuitively, this suggests that improvements in the availability of internet communications may be expected to increase work at home mode share.<sup>42</sup>

We modelled growth in household internet access by considering trends between the 2001 and 2006 census, as illustrated below. Trend analysis indicated that internet access for area units in the Bay of Plenty increased, on average, approximately 28% in this period.

<sup>42</sup> The census does not collect information on the quality of the internet connection, which means that we cannot draw any conclusions on how changes in the speed of internet access may impact on people’s willingness to work at home. This reduces our ability to forecast how the Government’s planned investment in high speed internet infrastructure may impact on future travel patterns.

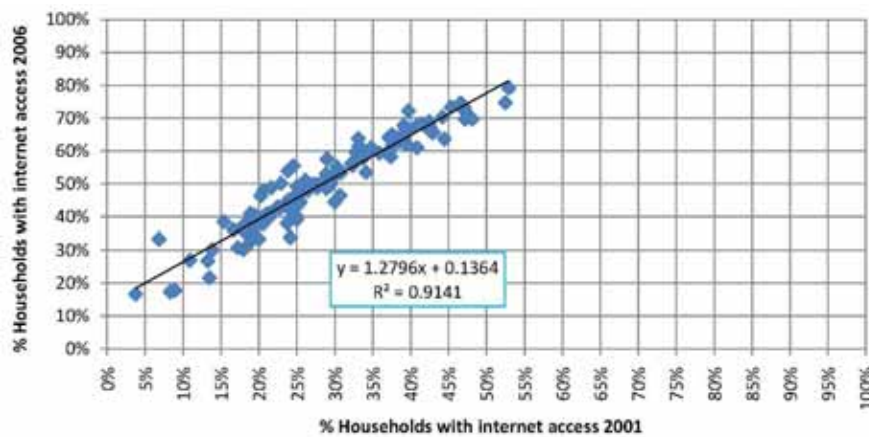


Figure 65 Change in household internet access in Bay of Plenty area units 2001-06

We have assumed that this high rate of growth continues in the future, as illustrated below. This shows internet access increasingly rapidly until around 2016 after which the rate of growth starts to level off as “market saturation” is in many places reached. We suggest that further research should seek to complement this analysis of “internet access” with information on the forecast change in the quality (i.e. speed) of internet access in the Bay of Plenty, and how this impacts on people’s ability to work from home.

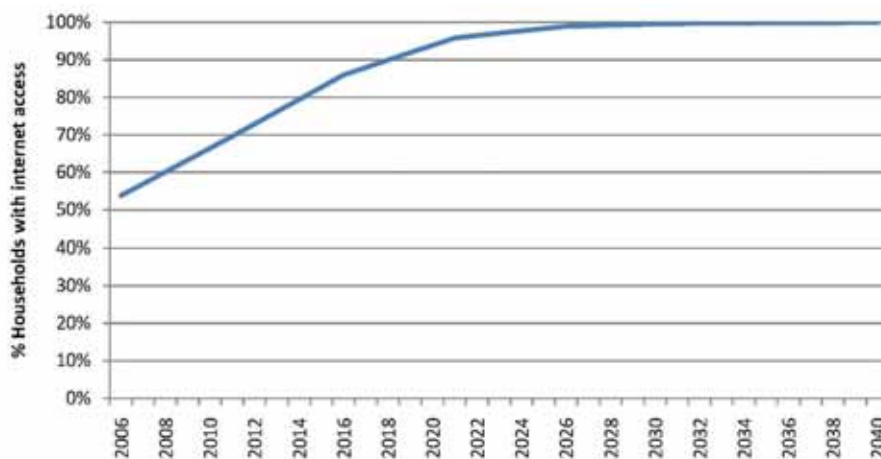


Figure 66 Forecast household internet access in the Bay of Plenty region 2006-40

### Trips to central areas

Regression modelling suggested that the proportion of trips to central areas (i.e. central Tauranga, Rotorua, and Whakatane) was positively related to walking/cycling and public transport mode shares and negatively related to work at home mode share.

The positive relationship with walking, cycling, and public transport may reflect a number of factors affecting travel choices to these areas, for example parking costs and congestion. The negative relationship with work at home may suggest that proximity to central areas may act as a disincentive to working from home, possibly because of the wider variety of higher paying, specialised employment opportunities that exist in central city areas.

We analysed trends in trips to central area units but identified no clear trend. Area unit data was sufficiently noisy so as to suggest that any changes were within the margin of error associated with the underlying data. For this reason, we have assumed no net change in the

percentage of trips to central areas during the duration of this study. Further research could seek to refine this analysis by considering how projected land use patterns may affect trips to central areas.

### Average journey to work distance

Regression analysis indicated that walking/cycling mode share is negatively related to average journey to work distance, as would be expected. Average journey to work distances have increased over time, despite the trend towards reduced kilometres travelled per capita overall, as illustrated below.

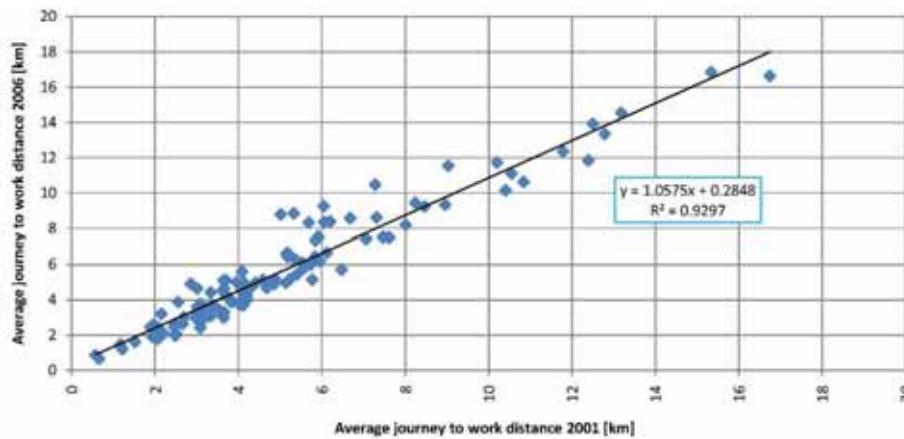


Figure 67 Change in average journey to work distance in Bay of Plenty area units 2001-06

This suggests average JTWD increased 5.75% from 2001-2006. We applied this linear growth rate to forecast average journey to work distances, as illustrated below.

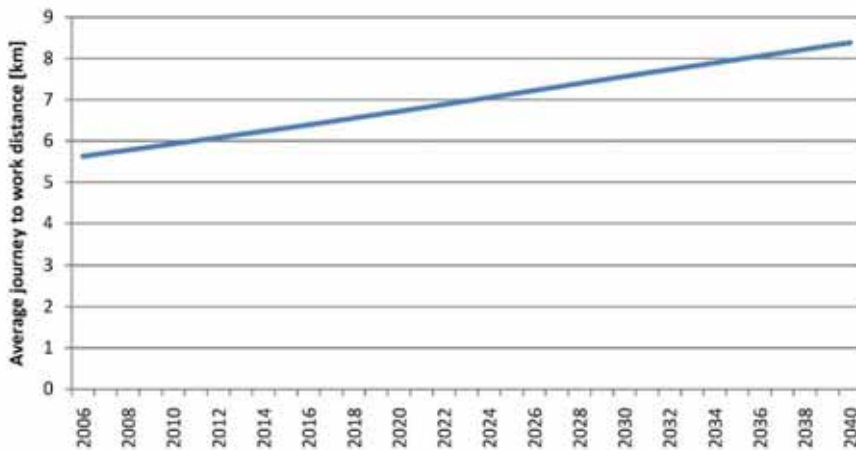


Figure 68 Forecast household internet access in the Bay of Plenty region 2006-40

### Residential and employment densities and ratios

Regression modelling suggested that walking and cycling mode share was positively related to employment densities. In contrast, residential density was negatively related to work at home and positively related to car-passenger mode share. We sourced population and employment forecasts from local authorities and used these to forecast how densities were expected to change.

It is important to distinguish between “average” and “mesh block weighted” density. The former is calculated by simply dividing the total number of residents or employees by the area of the CAU. Average densities tend to smooth out the density and misrepresent density in larger area units, where pockets of density may be surrounded by natural and/or rural areas.

In contrast, the mesh block weighted density calculates average densities at the mesh block level, which are then aggregated for each CAU by weighting them with the percentage of the population that is located in each mesh block. This approach attempts to provide a more reasonable measure of the effective density of the area unit.

The distinction between these density measures is highlighted below, for a hypothetical CAU consisting of two mesh blocks. The average density is simply the total population divided by the total area. In contrast, the weighted density calculates the density for each mesh block and then weights them by the proportion of the total population that live in the mesh block.

MB1 Area = 1 Pop = 500	MB2 Area = 10 Pop = 5	$\text{Average density} = (500+5)/(1+10) = 505/11 = 46$ $\text{Weighted density} = (500/505)*(500/1) + (5/505)*(5/10) = 495$
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We started with weighted densities for each area unit and adjusted these in response to forecast population figures over time, as illustrated below (NB: We have aggregated area unit densities to the regional level by weighting them in relation to the proportion of the population that live in each area unit).

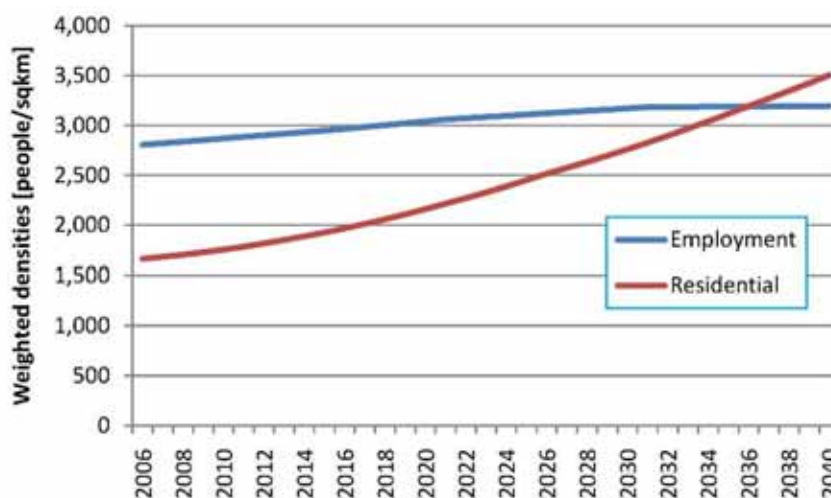


Figure 69 Forecast (weighted) residential and employment densities in the Bay of Plenty region 2006-40

This shows that the weighted employment and residential densities increase steadily during the duration of this study. The increase in residential densities is particularly notable and reflects the combined effects of more intensive land use patterns and the smaller household sizes that will result from an increasingly aged population characterised by lower birth rates. The important point to note is that while the rate of population growth may decline, the change in population density may accelerate.

Regression modelling also identified a positive relationship between the ratio of jobs/residents and work at home. Forecast values for this variable were derived from the employment and residential projections for each area unit.

## Residential dispersion

Regression modelling indicated that work at home mode share was positively linked to residential dispersion. This variable measures the degree to which a particular area unit is located with respect to the remainder of the regional population. It is calculated for every area unit (denoted by *i*) by multiplying the number of residents in other area units (denoted by *j*) by the distance from area unit *i* to area unit *j*. Changes in residential dispersion from 2001-06 for area units in the Bay of Plenty are illustrated below.

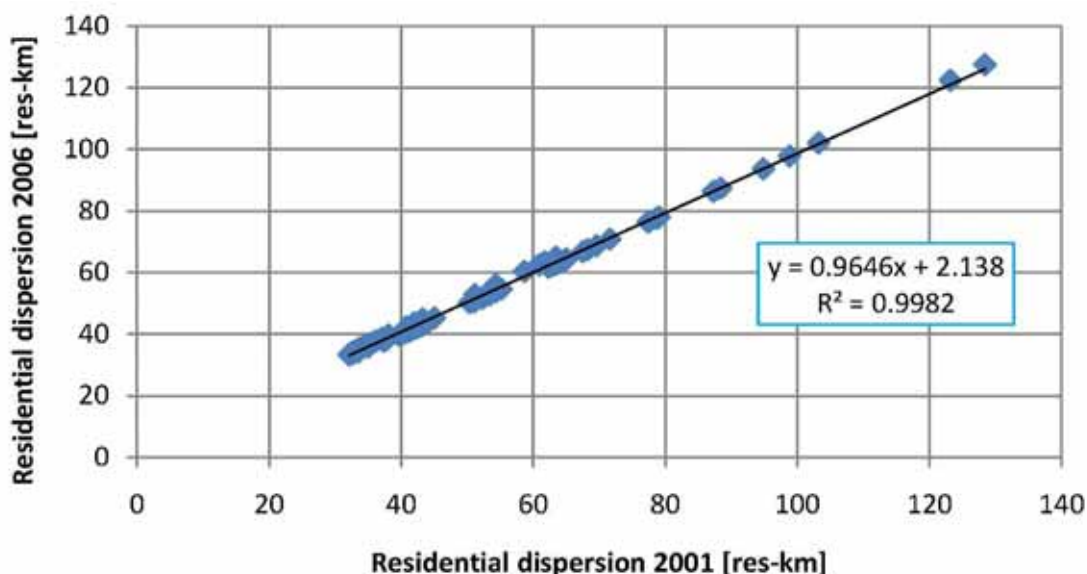


Figure 70 Change in residential dispersion for area units in the Bay of Plenty region 2001-06

The figure above (and associated trend line) illustrates how, on average, residential dispersion reduced by 3.54% (i.e.  $100 - 96.46\%$ ) in the period from 2001-2006. This confirms that the growth in the regional population occurred in area units that were located relatively close to existing population centres, namely Tauranga and Rotorua. The extremely high R-squared (almost 100%) suggests that this trend was relatively uniform across the region.

It is interesting to consider this conjunction with the trend towards longer journey to work trips. Taken together, these results suggest that people may be travelling further to work (which is consistent with greater workforce specialisation) as well as choosing to live more “centrally.” The choice to live more centrally is likely to reduce the distance travelled for other trips – such as social and retail purposes.

The population projections discussed previously were used to forecast residential dispersion, as illustrated below. This suggests that the average distance between residents will decline by approximately 20% from 2006-2040.

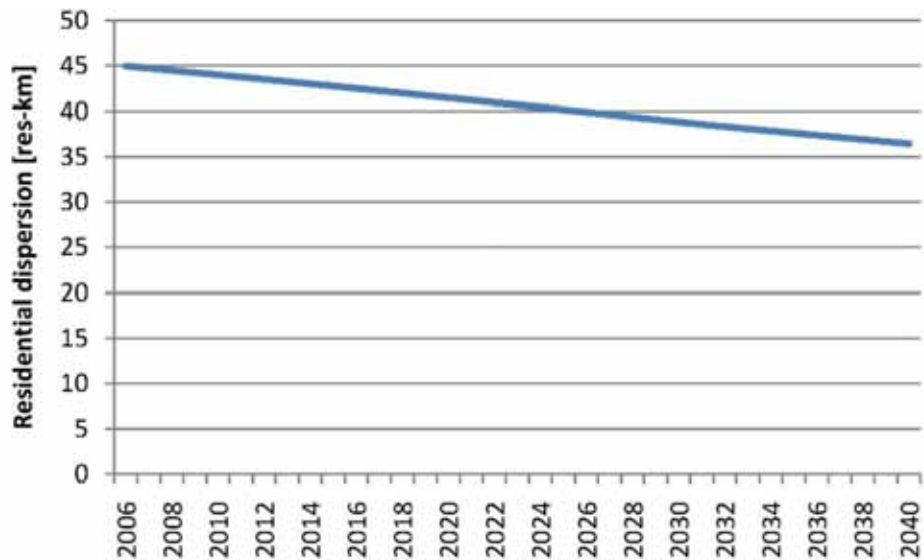


Figure 71 Forecast residential dispersion in the Bay of Plenty region 2006-40

### Vehicle ownership

Regression models indicated that vehicle ownership rates were related to all modes aside from public transport. We modelled vehicle ownership by considering the changes in households with access to 0, 1, 2, or 3+ vehicles from 2001-06, as illustrated below.

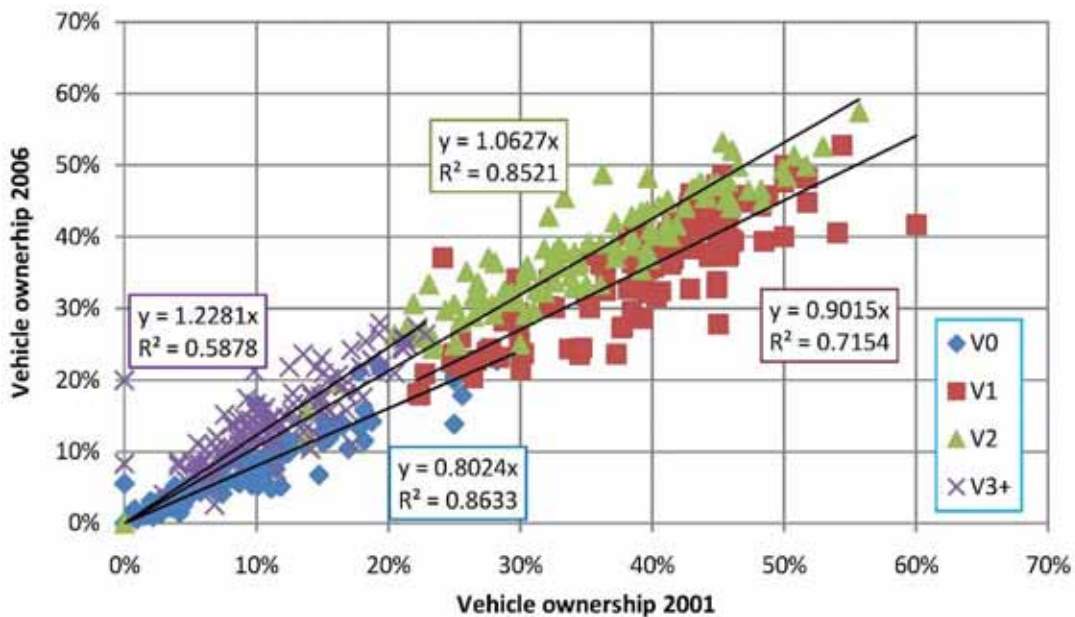


Figure 72 Vehicle ownership for area units in the Bay of Plenty region 2001-06

The proportion of V0 and V1 households (i.e. households with access to zero or one vehicles) is reducing, hence coefficients for their trend lines are less than one. This is in contrast to the proportion of V2 and V3 households, which are both increasing over time.

Forecast trends in vehicle ownership were developed by applying these growth rates to individual area units. The V3 proportion was not modelled directly, but “backed out” as the proportion left over once the V0, V1, and V2 proportions had been estimated. Forecast changes in vehicle ownership rates in the Bay of Plenty are illustrated below.



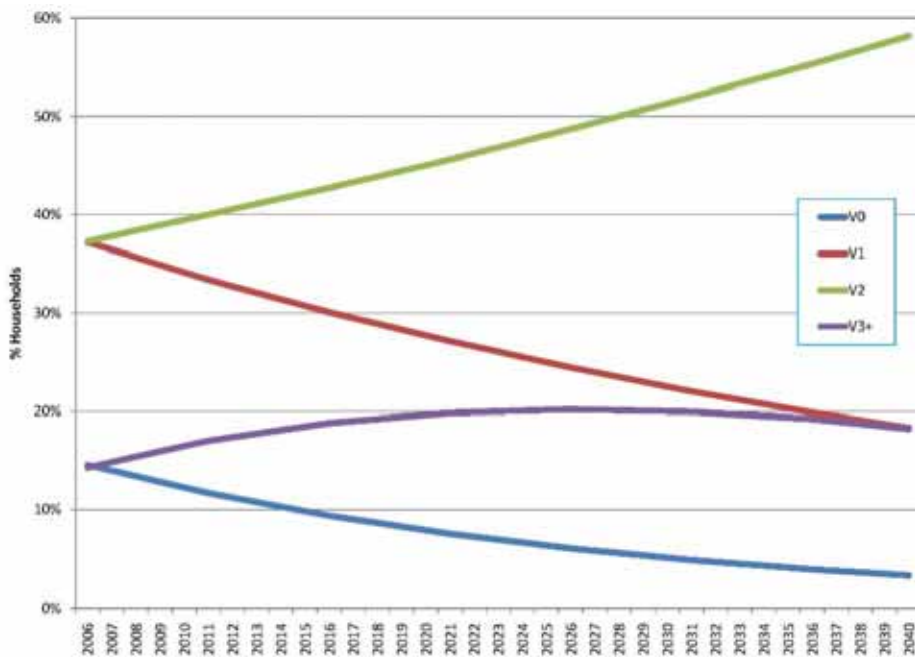


Figure 73 Forecast vehicle ownership rates in the Bay of Plenty region 2006-40

We forecast declining proportion of households with access to zero (blue) and one (red) vehicles, while increasing numbers of households will have access to two (green) or three plus (purple) vehicles. The impact of these changes on average vehicle ownership is illustrated below.

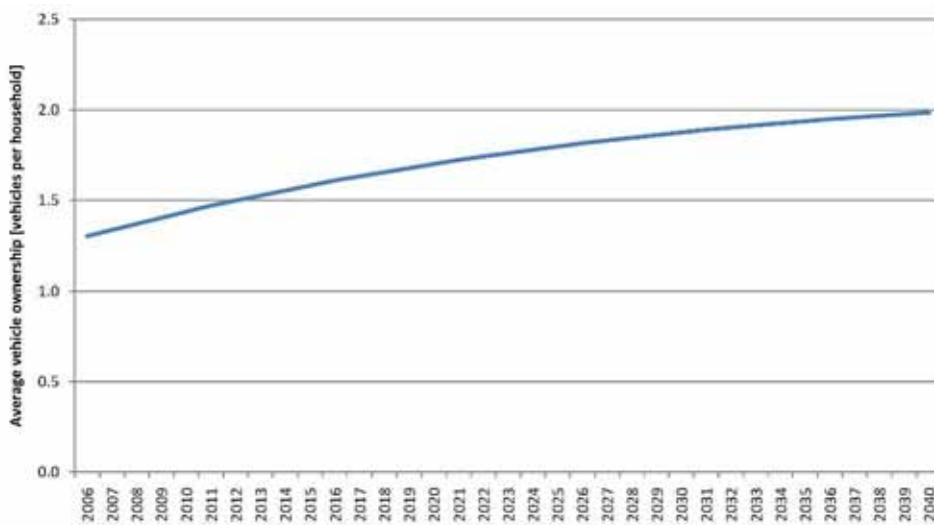


Figure 74 Forecast average vehicle ownership in the Bay of Plenty 2006-40

## Appendix E – Comparative Travel Demand Trends

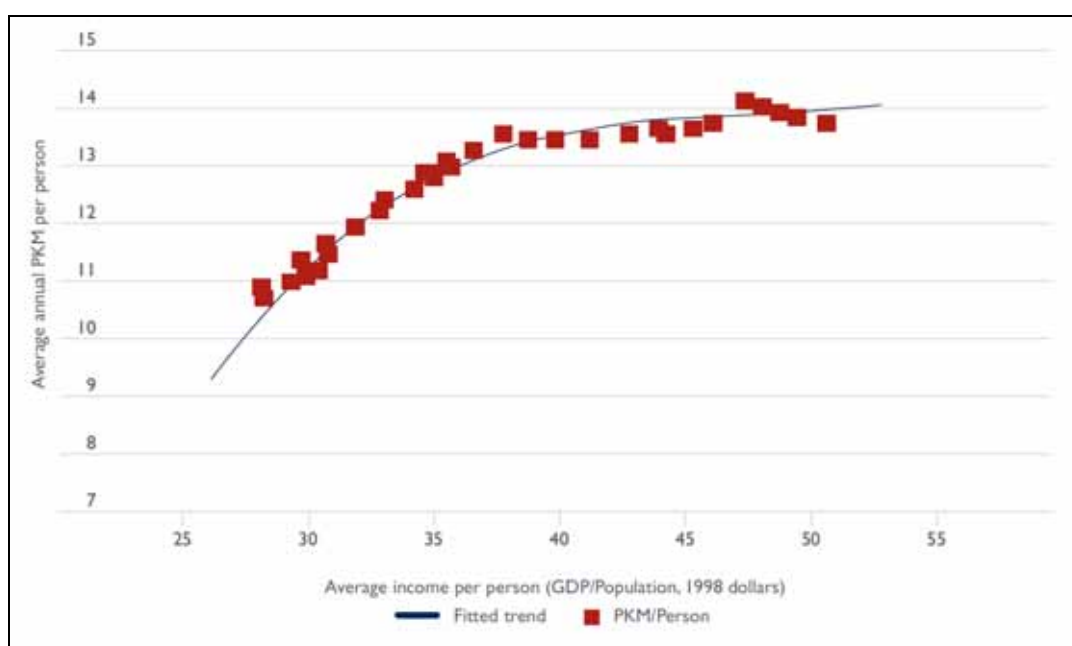
### Australia

In an inspection of the level of motorised travel in the eight Australian state capitals, the Department of Infrastructure, Regional Development and Local Government (2009) examine trends across the major forms of motorised travel. Private road vehicles dominate travel patterns, comprising 90% of total travel, which has increased almost tenfold since World War II.

The study aims to identify the components of this growth identifying the following as the two key drivers:

- Population growth (and by relation, employment growth)
- Per capita income

The study also notes that the effects of increasing income on the level of travel may be more historical, noting that saturation may have occurred in recent years. This is illustrated in Figure 2.



*Figure 2 Average travel versus incomes in Australian cities, 1977-2008. Source: Department of Infrastructure, Transport, Regional Development and Local Government (2009)*

As a result, the report suggests that any further increases in per capita income are unlikely to drive higher levels of travelled kilometres, and that this should grow more in line with population growth in the foreseeable future. However, total passenger travel in the last decade has not grown at the rate of population growth, which is likely explained by behavioural shifts supported by changes in land use and urban form, which may facilitate a reduced need for travel. In particular, the study identifies changes in relative prices (especially of petrol) and economic circumstances that drive these re-evaluations of travel patterns. It is likely that the mode share equilibrium will face further changes in future years as these underlying conditions continue to change.

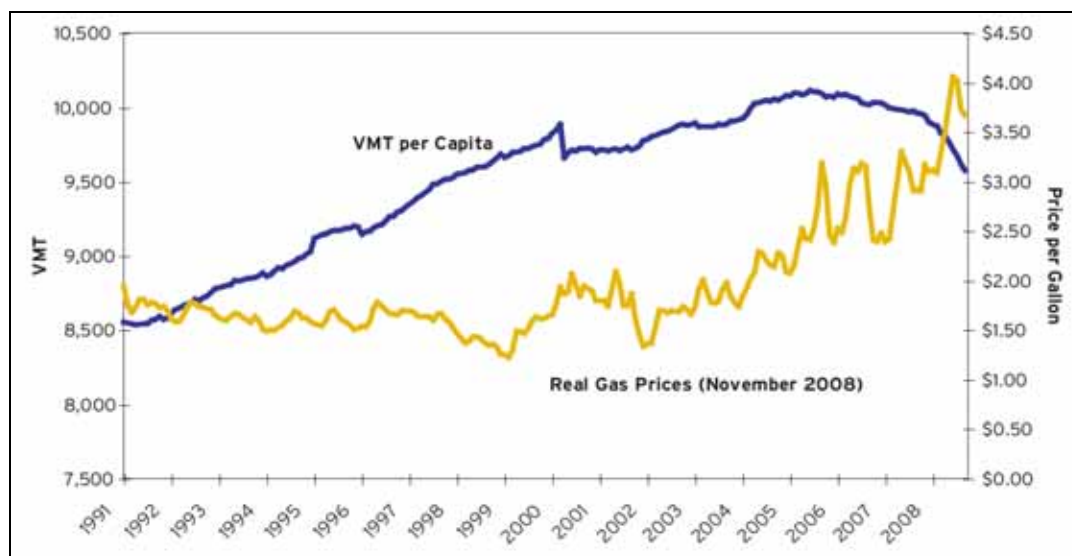


The report goes on to examine travel by urban public transport, which represents a higher share for commuter trips across all of the cities examined. It notes that the growth in PT from 2003 to 2008, at 18% was significantly higher than the growth in private motor vehicle travel (1%), although this is prefaced by the fact that PT has a smaller base to grow from. There are large differences seen here between cities in PT shares that represent further reaching PT networks, increased residential density and concentrated employment (particularly in CBDs) near transport nodes. This supports further investment in PT supply to capture potential latent demand that may exist in cities.

## USA

Peuntes and Tomer (2008) present a comprehensive study of vehicle miles travelled (VMT), both at a total and a per capita level across the major cities of the USA. This metric looks at travel on major arterial routes, rather than total vehicle travel, so does not cover any changes that may be occurring on local roads. Like New Zealand and Australia, private vehicles dominate total vehicle travel at a national level.

The authors note that the last decade has provided the first major shifts in VMT trends, following decades of steady growth since World War II. Transit levels are at their highest levels since the 1950s, and since 2000, VMT per capita has begun to level out before starting to fall consistently from a peak in 2005. This can be explained partially by the start of a series of oil shocks, which were seen from early 2006 onwards, continuing through to 2008. Per capita VMT travel and oil prices are illustrated in Figure 3.



*Figure 3 US vehicle miles travelled per capita, annualised and real gasoline pump prices, January 1991-September 2008. Source: Puentes and Tomer (2008)*

While total travel is still increasing as a result of population growth, these per capita drops represent the largest annualised falls seen in the USA since World War II. Not only is this a national average, but also per capita VMT has fallen in 48 of the 50 states since the end of 2006, showing that the trend is fairly consistent across the country.

However, there remain areas, which have shown higher falls in VMT, and also lower total levels of travel, such as states in the Northeast, the North-West Pacific and in the western mountain states. New York has the lowest per capita VMT in the country, followed by Chicago and Portland where the greatest driving per person occurs in Southern metropolitan areas. Peuntes and Tomer (2008) identify a number of factors that are likely to cause this

differential in travel patterns across the country. They have identified three factors that tend to correlate with lower levels of VMT per capita:

- Efficient and reliable transit systems
- High levels of active modes (walking and cycling) and infrastructure to support these choices
- Dense development patterns that both reduce the need for travel, and reduce the driving lengths of trips, particularly along main, arterial roads

From here, Peuntes and Tomer (2008) consider the impacts of falling VMT per capita and the impact of resulting transport investment. They believe that should per capita VMT follow forecasts and continue to fall, it is likely that the country will result in inefficiently assigned roadway capacity, as investment does not change to reflect the falling levels of total vehicle travel. Instead, the authors believe that future transport investment needs to be more aligned with land use and urban design, which will directly affect the transportation decisions of residents. Dense land-use developed alongside efficient and effective transit systems are likely to represent the best opportunity to reduce dependency on the automobile.

## Appendix F – Details on the strategic options

### Option 1 – Do minimum

The “do minimum” option assumes no investment in public transport, walking/cycling, and information and communications technology. We assume that all funds are investment in the road network, which will be subject to much higher travel demands.

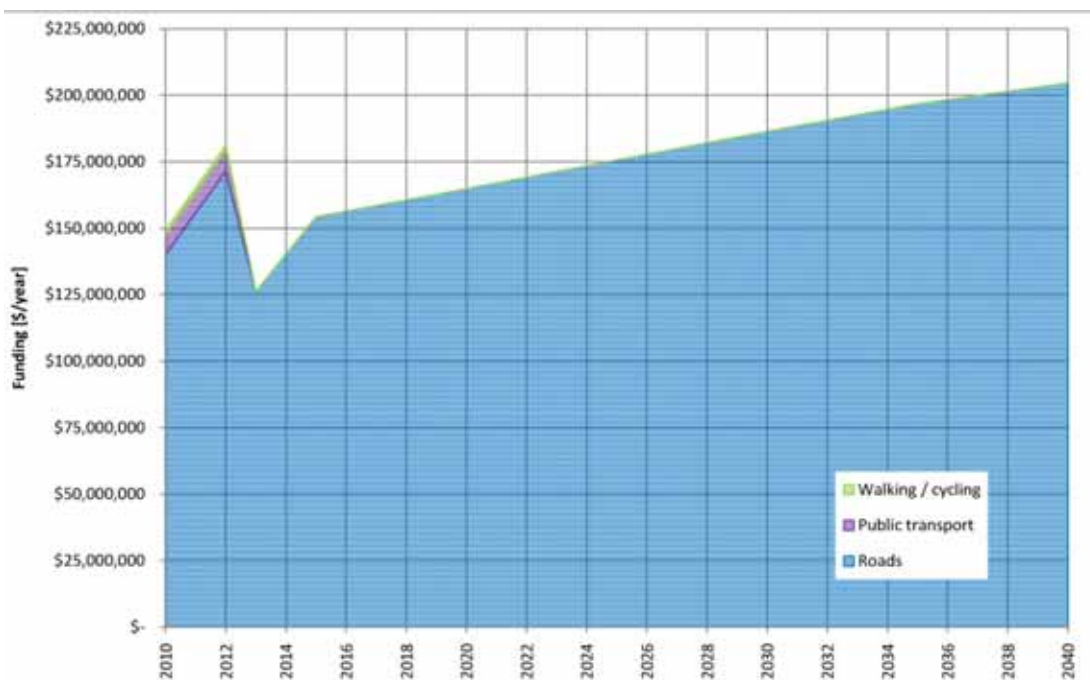


Figure 75 Funding levels in the “do minimum” strategic option (2006-40)

The resulting travel demands are thus defined by the underlying demographic, socio-economic, land use, and transport trends, rather than Government policies and/or priorities, as summarised in the table below.

Table 28 Travel demands in “do minimum” option

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	251	56%	64%	1778	2630	57%	67%
Car-passenger	102	91	30%	23%	1174	1165	38%	30%
Walk/cycle	43	52	13%	13%	56	146	1.8%	3.7%
Public transport	6	0	2%	0%	89	0	2.9%	0.0%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

This table shows how in the “do minimum” strategic option the “driver” mode share of trips taken and kilometres travelled increases by 8% and 10% respectively.

## Option 2 – Business as usual

“Business as usual” assumes that NLTP funding priorities persist for the foreseeable future, after which is increased in line with population growth, as illustrated below. The peak in funding in the 2010-2012 NLTP reflects the temporary impacts of the Tauranga Eastern Link.



Figure 76 Funding levels in the “Business as Usual” transport option

The effects on mode share are summarised in the following table.

Table 29 Travel demands in “Business as Usual” option

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	240	56%	61%	1778	2483	57%	63%
Car-passenger	102	89	30%	22%	1174	1144	38%	29%
Walk/cycle	43	54	13%	14%	56	130	1.8%	3.3%
Public transport	6	12	2%	3%	89	183	2.9%	4.7%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

In the “Business as Usual” option mode share for walking/cycling and public transport both increase by 1-2%. Outweighing these changes, however, is the considerable decline in car-passenger mode share, which results in a 5-6% increase in driver mode share by 2040. Approximately three-quarters of the increase in travel demands is accommodated through new driver trips, with the balance evenly split between walking/cycling and public transport.

Driver journey to work mode share reduces by about 2%, but this is outweighed by the considerable increase in population growth. Total driver journey to work trips grow by approximately 1.5% per year, or 65% in absolute terms.

### Option 3 – Regional priorities

The “regional priorities” option sees funding for each mode ramp up to levels identified in the previous RLTP, which allowed for considerably higher funding for all modes.

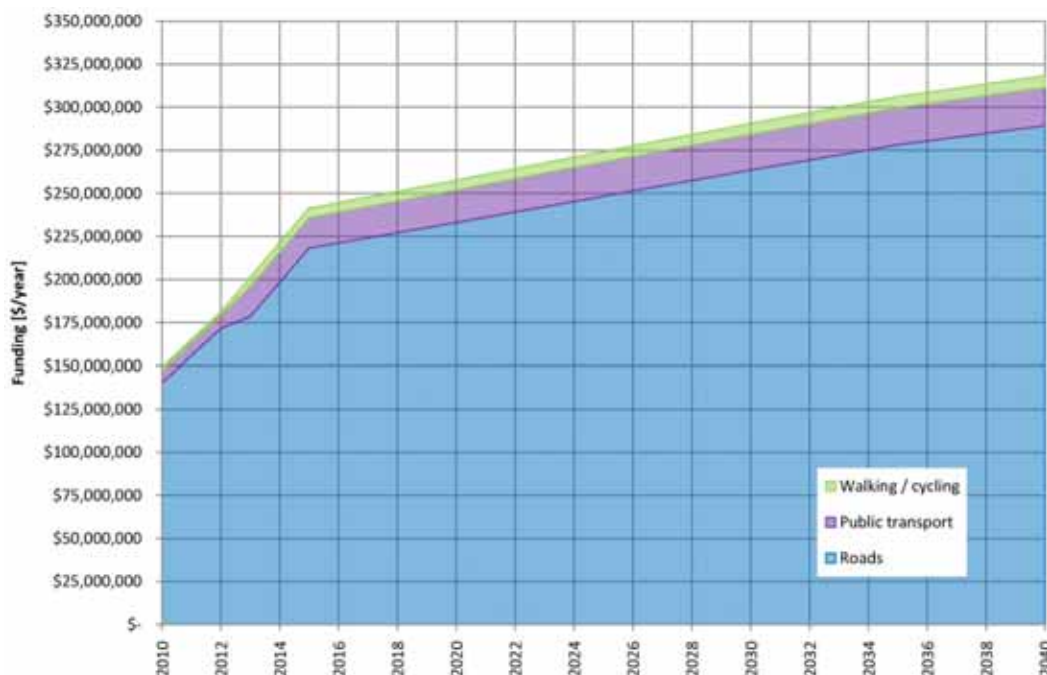


Figure 77 “Regional priorities” funding profile 2010-2040

The effects of the “regional priorities” on mode share are summarised in the table below.

Table 30 Travel demands in “regional priorities” option

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	237	56%	60%	1778	2469	57%	63%
Car-passenger	102	86	30%	22%	1174	1130	38%	29%
Walk/cycle	43	60	13%	15%	56	129	1.8%	3.3%
Public transport	6	12	2%	3%	89	212	2.9%	5.4%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

The table shows how the “regional priorities option catalyses additional mode shift away from driver towards walk/cycle. Nonetheless, approximately 70% of the growth in trips is accommodated by drivers, which sees their mode share of all trips taken and kilometres travelled increase to 60% and 63% respectively.

In terms of journey to work trips, driver mode share increases by approximately 1% by 2040, while the total number of journey to work vehicle trips increases by about 1.44% per annum.

## Option 4 – Demand-side management

The “Demand-side management” option assumes an identical funding profile to the “business as usual” option discussed in a previous section. However, this option includes:

- Parking reforms – as implemented in Section 3.2, which involves comprehensive parking reforms in central parts of Tauranga, Rotorua, and Whakatane; and
- Travel demand management – we have doubled the effect of ICT (as measured by internet access) on work at home mode share.

The effect of these policies on mode share is summarised in the following table. Interestingly, the “demand-side management” achieves better mode share outcomes to the “regional priorities” option, although with considerably less investment.

Table 31 Travel demands in the “demand-side management” option

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	223	56%	57%	1778	2307	57%	59%
Car-passenger	102	98	30%	25%	1174	1280	38%	32%
Walk/cycle	43	60	13%	15%	56	146	1.8%	3.7%
Public transport	6	13	2%	3%	89	208	2.9%	5.3%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

The “non-driver” mode share illustrated below for the “demand-side management” option in comparison to the “business as usual” and “regional priorities” options.

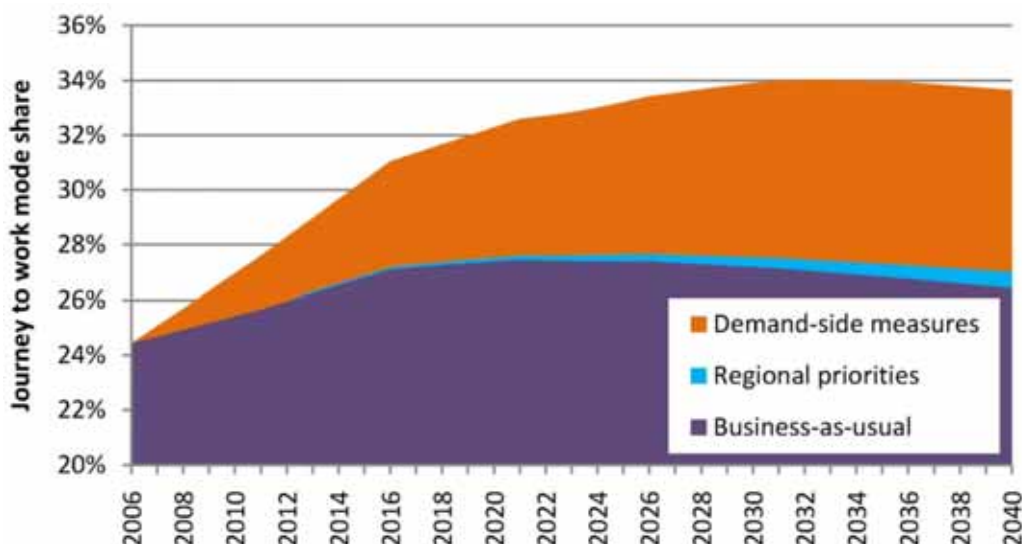


Figure 78 Non-driver journey to work mode share - “demand-side management” and “business as usual” options

The “demand-side management” option obviously has a considerable effect on journey to work mode share in comparison to the other two options, mainly because it encourages more people choose to work at home.

## Option 5 – Sustainable transport improvements

The “sustainable transport improvements” option considers substantial on-going investments in public transport and walking/cycling as an alternative to road investment. The funding profile associated with this option is illustrated below.



Figure 79 “Sustainable transport improvements” funding profile 2010-2040

The impacts of the “sustainable transport improvements” option is summarised in the table below.

Table 32 Travel demands in the “sustainable transport improvements” option

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	235	56%	60%	1778	2461	57%	62%
Car-passenger	102	83	30%	21%	1174	1122	38%	28%
Walk/cycle	43	66	13%	17%	56	134	1.8%	3.4%
Public transport	6	10	2%	3%	89	225	2.9%	5.7%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

The table shows that the investment in walking, cycling, and public transport flows through into considerably higher demands for these modes. However this demand shift is insufficiently large to counter the reduction in car-passenger mode share, which is a similar finding to the “business as usual” and “regional priorities” options. As a result, driver mode share continues to increase. This means that driver mode share will continue to increase despite the increased funding for alternative modes. Alternative modes therefore have only limited potential to reduce driver mode share.



## Option 6 – Mixed Option 1

“Mixed option 1” combines the “Demand management” and “sustainable transport improvements” options. This essentially seeks to test the combined influence of parking reforms, higher quality ICT, and improvements to public transport, walking, and cycling. The funding profile associated with this option is the same as the “sustainable transport improvements” option illustrated in Figure . The impacts of “mixed option 1” on mode share are illustrated in the table below.

Table 33 Travel demands in “mixed option 1”

Mode	Trips taken				Kilometres travelled			
	Million/year		Share [%]		Million/year		Share [%]	
	2006	2040	2006	2040	2006	2040	2006	2040
Driver	192	218	56.0%	55.4%	1778	2288	57.4%	58.0%
Car-passenger	102	92	29.7%	23.3%	1174	1253	37.9%	31.8%
Walk/cycle	43	73	12.5%	18.5%	56	149	1.8%	3.8%
Public transport	6	11	1.9%	2.9%	89	251	2.9%	6.4%
<b>Total</b>	<b>342</b>	<b>394</b>	<b>100%</b>	<b>100%</b>	<b>3096</b>	<b>3941</b>	<b>100%</b>	<b>100%</b>

This table illustrates that in “mixed option 1” the mode share for “Driver” actually declines (in terms of total trips taken) by 2040. Trips by walking, cycling and public transport increase by approximately 50%, with even greater gains in terms of kilometres travelled. Journey to work mode share exhibits even more dramatic changes, as illustrated in the figure below.

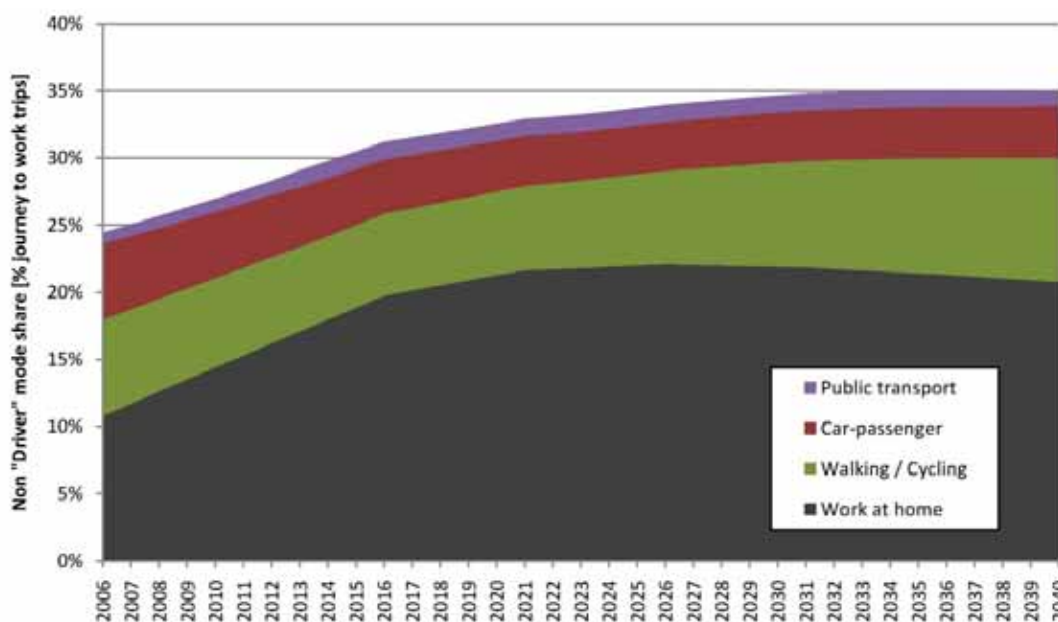


Figure 80 Non-driver journey to work mode share - “mixed option 1” and “business as usual” options

This illustrates “non-Driver” mode share growing to 35% by 2040, which is catalysed by higher uptake of work at home, walking/cycling, and public transport. In this option the growth in the total number of journey to work trips by car drops from 1.5% (“business as usual”) to 1.1%.



## Option 7 – Freight management

The freight management option involves the “do minimum” option, with an additional \$5 m per annum invested in the following freight improvements.

*Table 34 Intermodal freight improvements in the “freight management” option*

<b>Development</b>	<b>Associated infrastructure</b>	<b>Implications for freight movements</b>
Port of Tauranga expands facilities to handle larger (7,000 TEU+) ships	Expansion in port infrastructure at Sulphur Point (containerised) in particular.	Places additional stress on supply chain capacity. Rail and inland ports may play a larger role.
Capacity increases on ECMT line, and Murupara / Kawerau rail improvements	KiwiRail has indicated the potential for this line to accommodate expanded facilities and passing loops.	Increased uptake of rail for regional movements of logs and other commodities from central regions.
Opotiki Harbour Development and Freight Hub	Aquaculture industry may support new port facilities at Opotiki along with freight (road/ship) interchange.	Increased use of shipping to transport logs and building materials (e.g. aggregates).

These improvements facilitate a 25% mode shift away from road travel in the markets in which rail is competitive, such as dairy and forestry. The effect on mode split is illustrated below. Although this shift appears small in terms of tonnes-kilometres travelled, because each train carries considerably more TKT, it may enable a much larger reduction in HCV trips.

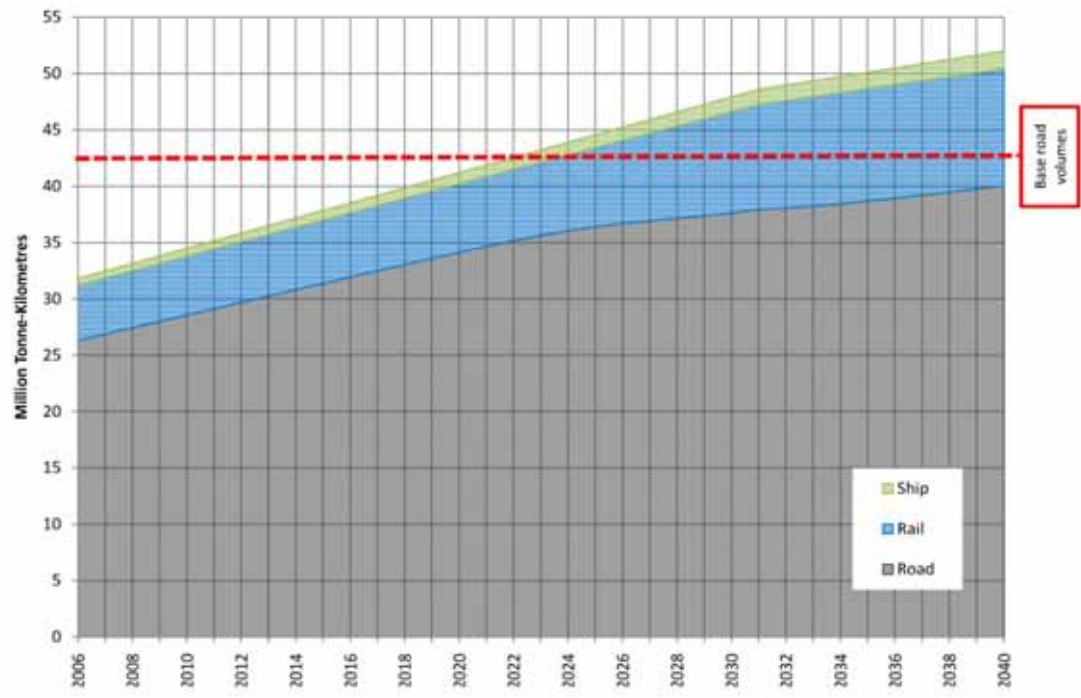


Figure 81 Estimated mode shift in the “freight management” option

**Option 8 – Mixed Option 2**

“Mixed option 2” combines the “mixed option 1” and “freight management” options. This in turn means that the travel demands (for both household and freight movements) are identical to these options (see Table 33, Figure 81 and Figure 82 respectively). The funding profile associated with “mixed option 2” is the same as “mixed option 1” (and for that matter the “sustainable transport improvements” option) except that an additional \$5 m was shifted from the road category and into the freight management category, as illustrated below.

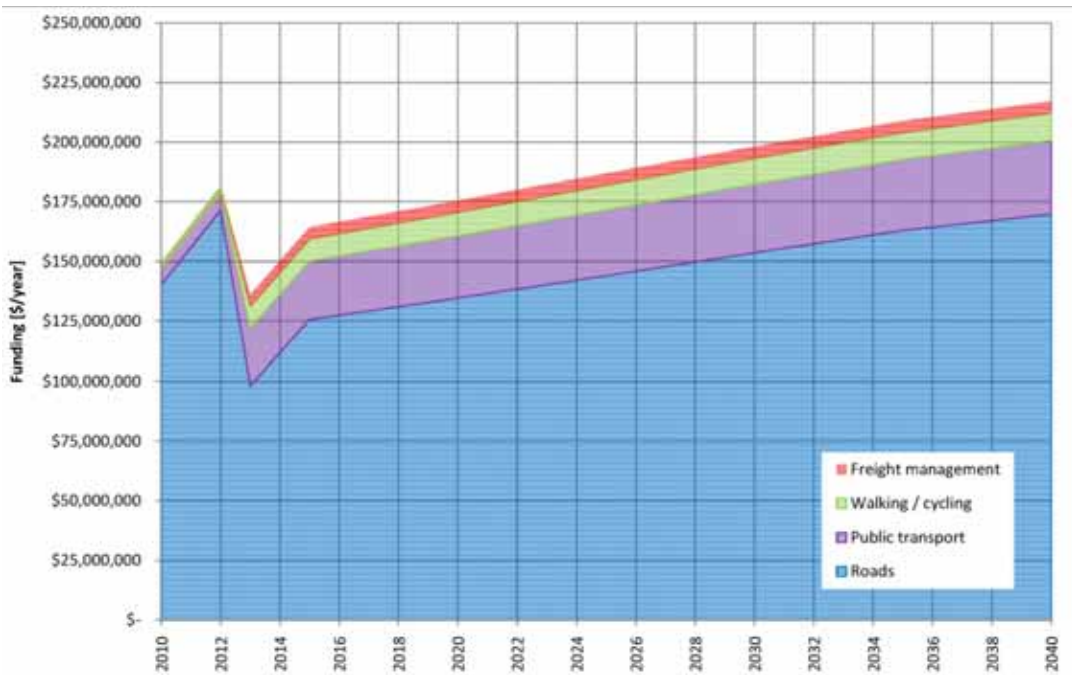


Figure 82 “Mixed option 1” funding profile 2010-2040

The annual average growth in funding in comparison to growth in travel demands is summarised in the following table. Note that we have combined the “Driver” and “Car-passenger” modes to provide a more reasonable indication of the value of “Road” expenditure.

Table 35 Comparing the growth in funding to growth in travel demands by mode

Expenditure category	Annual average growth		
	Trips	kms	Funding
Road	0.27%	0.60%	0.64%
Walking/cycling	1.90%	2.50%	6.80%
Public transport	1.15%	2.68%	5.00%

This analysis shows how even in this option, growth in road funding occurs in excess of the increase in travel demands. While funding for walking/cycling and public transport grows faster, these modes are starting from a relatively low base. Indeed, even in this scenario, by 2040 expenditure on these modes is only a small fraction of total expenditure.

## Appendix G – Methodology for option assessment

This appendix discusses the methodology underlying the evaluation of strategic transport outlines discussed in Section Part 1: .

### Economic development

#### Cost-effectiveness

This was evaluated by calculating the average cost of each additional trip accommodated on the transport system. Average annual transport costs for all modes are summarised below.

Strategic option	Average annual transport funding 2013-2040				
	Roads	PT	Walk / cycle	Freight	Total costs
1 DM	\$177,160,129	\$0	\$0	\$0	\$177,160,129
2 BAU	\$177,160,129	\$9,238,358	\$2,062,855	\$0	\$188,461,342
3 RP	\$250,534,803	\$20,018,034	\$6,024,981	\$0	\$276,577,818
4 DSM	\$177,160,129	\$9,238,358	\$2,062,855	\$0	\$188,461,342
5 STI	\$150,431,993	\$27,715,075	\$10,314,274	\$0	\$188,461,342
6 MO1	\$150,431,993	\$27,715,075	\$10,314,274	\$0	\$188,461,342
7 FM	\$172,160,129	\$9,238,358	\$2,062,855	\$5,000,000	\$188,461,342
8 MO2	\$145,431,993	\$27,715,075	\$10,314,274	\$5,000,000	\$188,461,342

The demand-side management measures (especially parking reforms) associated with strategic options 4, 6, and 8 will, however, generate additional revenue. We assumed an additional \$15 m per year was generated in the DSM option and an additional \$12 m per year was generated in the MO1 and MO2 options. The higher revenue generated by the DSM option reflects the fact that in this scenario no additional investment in public transport services occurred (above and beyond the investment associated with the BAU). In contrast, both the MO1 and MO2 option provide additional investment in walking/cycling and public transport, which in turn is likely to reduce the demand for car-parking and hence reduce the revenue associated with parking reforms. The following table summarises average annual costs, revenues, and expenditure as well as the average number of trips undertaken for each mode.

Strategic Option	Annual average				
	Costs	Revenues	Expenditure	Trips	\$/trip
1 DM	\$177,160,129	\$-	\$177,160,129	368,550,111	\$ 0.48
2 BAU	\$188,461,342	\$-	\$188,461,342		\$0.51
3 RP	\$276,577,818	\$-	\$276,577,818		\$0.75
4 DSM	\$188,461,342	\$15,000,000	\$173,461,342		\$0.47
5 STI	\$188,461,342	\$-	\$188,461,342		\$0.51
6 MO1	\$188,461,342	\$12,000,000	\$176,461,342		\$0.48
7 FM	\$188,461,342	\$-	\$188,461,342		\$0.51
8 MO2	\$188,461,342	\$12,000,000	\$176,461,342		\$0.48

Based on these figures, we could estimate the annual average cost per trip for each option, which in turn is used as an indicator of cost-effectiveness.

## Resilience

The resilience of the strategic transport options was calculated by estimating total expenditures on oil-based fuels in a situation of sustained high fuel prices. Fuel consumption for the various transport modes, which were derived from a number of sources, namely:

- Car-drivers consume 8 l/100 km (MED, 2006)
- Car-passengers consume 0.8 l/100 km (i.e. 10% of a car-driver) (Kenworthy, 2003)
- Walking/cycling consume zero oil-based fuels
- Public transport (buses) consumes 15 l/100 km (BTS, 2010)

It is important to note that car-passengers and walking/cycling are relatively energy efficient transport modes – even in comparison to public transport. As such, diverting people to public transport who were previously travelling either by walking/cycling or as car-passengers is unlikely to yield major improvements in fuel efficiency, as we shall see.

Fuel consumption rates for rail, coastal shipping, and rail in terms of million net-tonne kilometres (MTKM) travelled as follows (MOT, 2006b):

- Coastal shipping - 1,483 l per MTKM
- Rail – 2,433 l per MTKM
- Road – 2,848 l per MTKM

This suggests that coastal shipping and rail are approximately 100% and 25% more fuel efficient than road transport respectively (per MTKM).

Travel demand forecasts (in terms of either kilometres or MTKM travelled) were then used to calculate the fuel consumed in each year in a high fuel price scenario (see section 3.1 for further details). The cost of fuel consumed per year was then calculated by multiplying the volume of fuel consumed by the price in each year, as summarised in the table below.

Strategic option	Total value 2013-2040	Difference from BAU	Per capita cost (saving)
2. BAU	\$16,853,342,385	\$ -	\$-
3. RP	\$16,856,809,792	\$3,467,407	\$13
4. DSM	\$16,520,875,753	\$-332,466,632	(\$-1,241)
5. STI	\$16,863,150,402	\$9,808,017	\$37
6. MO1	\$16,532,366,443	\$-320,975,941	(\$-1,198)
7. FM	\$16,811,181,247	\$-42,161,138	\$-157
8. MO2	\$16,490,205,306	\$-363,137,079	(\$-1,355)

It is interesting that the RP and STI generate more greenhouse gas emissions than the BAU option. This suggests that running more public transport services will not only attract drivers, but also people previously travelling on foot, by cycle, or as car-passengers, all of which are transport modes that are relatively fuel efficient. Based on this analysis, we suggest that it is not possible to improve regional fuel efficiency simply through increased public transport services, unless this increase is also accompanied by demand-side management measures, such as parking reforms and/or road pricing.

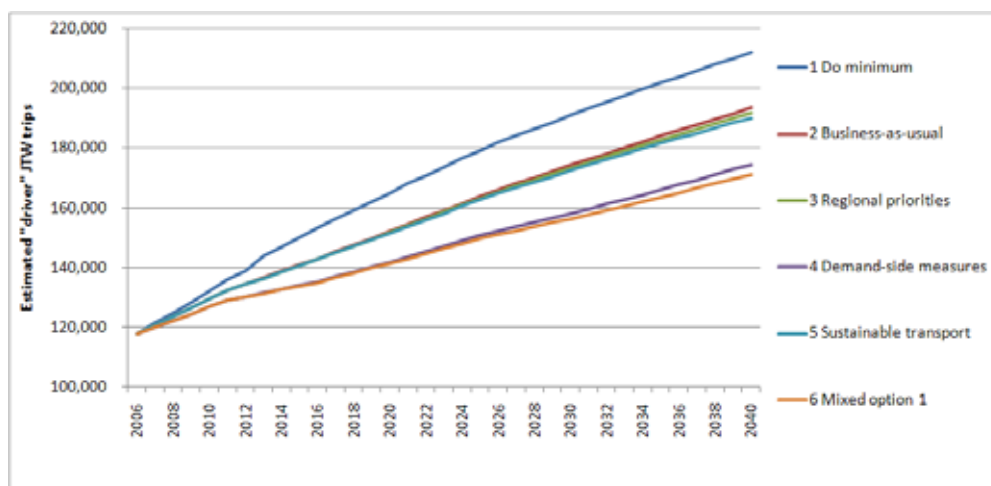
## Congestion

Drive alone mode share was used as a proxy for congestion. Using driver trips as a proxy for congestion is not ideal because JTW generated trips at off-peak times do not generate congestion) and congestion may also be influenced by road capacity expansions.

Nonetheless, we suggest driver JTW trips are a reasonable proxy for congestion because:

- In the absence of measures that encourage significant peak spreading (such as time-of-use pricing) the number of new JTW trips generated at peak times is likely to be strongly correlated with the total number of JTW trips that occur;
- In all options available funding is unable to expand road capacity in line with projected growth in vehicle trips. Thus the degree to which congestion worsens is primarily determined by the growth in peak hour vehicle trips, rather than capacity expansions.

Thus the level of congestion is likely to be primarily determined by the generation of new JTW trips, rather than increases in road network capacity. New “driver” JTW trips are illustrated in the figure below for strategic options 1-6 (NB: insofar as JTW trips are concerned strategic options 7 and 8 are identical to options 1 and 6 respectively).



This shows that in the “do minimum” JTW trips increase to 210,000 by 2040, whereas options 2, 3, and 5 result in only 190,000 trips. Options 4 and 6 are even more effective – with around 170,000 JTW trips. Annual average growth in “driver” JTW trips is presented in the table below.

Strategic option	Annual growth in driver JTW trips
1 Do minimum	1.59%
2 Business-as-usual	1.35%
3 Regional priorities	1.32%
4 Demand-side measures	1.07%
5 Sustainable transport	1.29%
6 Mixed option 1	1.01%

Thus growth in driver JTW trips exceeds 1% per year in all options considered. The MO2 option, however, reduces the annual growth by approximately 25% compared to the BAU.

## Environmental sustainability

### Global warming

Greenhouse gas emissions were estimated based on the number of kilometres travelled by each mode in each option. The light vehicle analysis was based on the fuel consumption discussed in the “Resilience” section, but modified to give CO<sub>2</sub> emissions as follows:

- Drivers generate 170 gms of CO<sub>2</sub> for every kilometre travelled (gmCO<sub>2</sub>/km) (MED, 2007);
- Car-passengers generate 17 gmCO<sub>2</sub>/km (Donovan & J. Genter, 2008)
- Public transport generates 90 gmCO<sub>2</sub>/passenger.km (DEFRA, 2007)

For freight, the following CO<sub>2</sub> generation rates were used:

- Road freight generates 92 gmCO<sub>2</sub> per tonne kilometre travelled (gmCO<sub>2</sub>/TKM);
- Rail freight generates 22.8 gmCO<sub>2</sub>/TKM; and
- Coastal shipping generates 13.9 gmCO<sub>2</sub>/TKM.

These rates were multiplied by the forecast kilometres travelled for each mode to estimate the total greenhouse gas generated for each option. Results did not vary that much between options 2-6, with the greatest difference associated with the change in freight demands associated with options 7 and 8.

### Water pollution

Water pollution is difficult to estimate on a strategic level, because it is related to not only the provision and use of transport infrastructure, but also the environment in which it sits and the degree to which its design mitigates effects on water quality.

Due to these complications, we elected to use the demand for impermeable surface as a proxy for the relative impacts of each strategic transport options on water pollution, where demand was defined by the vehicle kilometres travelled by road based transport modes.

It is worth noting that because regional travel demands increase in all options being considered, none of them represent an improvement on the status quo. Some do, however, offer an improvement in comparison to the BAU option, which is a more appropriate benchmark.

The relative demand for impermeable surface, as defined by kilometres travelled by road based transport modes, is summarised in the following table.

Strategic option	Relative demand (based on km travelled by road based modes)
2. BAU	-
3. RP	-0.75%
4. DSM	-1.04%
5. STI	-1.24%
6. MO1	-2.38%
7. FM	-0.61%
8. MO2	-2.99%

This highlights how the demand for impermeable surfaces in 2040 for the strategic transport options varies from 0.75%-2.99% less than the demand in the BAU scenario.

## Access and mobility

### Access to alternative modes

Total non-car mode share across the region was used as a proxy for access to alternative modes. Results for this indicator were extracted directly from the travel demand forecasting model and are reported in Table 16.

### Multi-modal integration

The number of additional freight-hubs and bus interchanges (including Park & Rides) associated with each option was used as a proxy for the multi-modal integration. The interchanges associated with each option are discussed in the following table.

Strategic option	Freight hubs		Public transport interchanges	
	#	Notes	#	Notes
2. BAU	0	No change in the number of freight hubs from the business-as-usual strategic transport option.	2	Assumes new downtown terminal constructed in Tauranga and Rotorua
3. RP	0		3	One additional interchange provided at either Bayfair, Omokoroa (plus P&R), or Papamoa (plus P&R)
4. DSM	0		2	Same as 2. BAU
5. STI	0		4	Two additional interchanges provided at either Bayfair, Omokoroa (plus P&R), or Papamoa (plus P&R)
6. MO1	0		4	Same as 5. STI.
7. FM	1	Assumes that at least one additional freight hub (e.g. inland port) is developed in response to regional support.	2	Same as 2. BAU
8. MO2	1		4	Same as 5. STI.

### Average journey length

Reductions in average journey length are, all other factors being equal, a positive outcome, because it reduces the need for travel and contributes to internal cost savings for consumers, as well as external benefits for society.

We suggest that walking/cycling and work at home mode share is an effective proxy for average journey length because walking/cycling trips are typically very short (i.e. less than 5 km), while work at home trips (by definition) require zero distance to be travelled.

The effect of the strategic transport options on the combined walking/cycling mode share was extracted directly from the travel demand forecasting model and reported in Table 16.



## Safety

Road casualties were modelled by comparing historical trends in accident rates and vehicle kilometres travelled (VKT) data for the Bay of Plenty region. Accident rates were estimated for changes in light and heavy vehicle travel that best matched the underlying data, as summarised in the table below.

	HCV	LCV
Fatality / VKT	1.54667E-08	1.02E-08
Injury / VKT	2.15733E-07	3.1E-07

This suggests that per kilometre, HCV travel causes approximately one-third more fatalities and one-third less injuries than LCV travel. Using these ratios, we then estimated the change in fatalities and injuries for each of the strategic transport options, as summarised below.

		2. BAU	3. RP	4. DSM	5. STI	6. MO1	7. FM	8. MO2
LCV	VKT [m]	60,786	60,556	58,824	60,413	58,465	60,786	58,465
	Fatality	617	615	597	613	593	617	593
	Injury	18,851	18,779	18,242	18,735	18,131	18,851	18,131
HCV	VKT	8,415	8,415	8,415	8,415	8,415	8,153	8,153
	Fatality	130	130	130	130	130	126	126
	Injury	1,815	1,815	1,815	1,815	1,815	1,759	1,759
Total	Fatality	747	745	727	743	724	743	720
	Injury	20,666	20,595	20,058	20,551	19,947	20,610	19,890
Base	Fatality		2	20	4	24	4	28
	Injury	-	71	609	116	720	57	776

Note that the fatality and injury “savings” presented here are an accumulated benefit over the lifetime of the 30-year horizon of the RLTS. Even so, the results suggest that MO2 is able to avert one fatality and 25 injuries per year by 2040.

## Health

### Physical activity

The effects of travel choices on physical are difficult to estimate on an individual level, because people who choose to walk to work may in turn reduce the activity elsewhere. On average, however, results suggest that people who walk/cycle or use public transport have higher average physical activity levels than people who drive (J. Genter, Donovan, & Badland, 2008). For this reason we used the combined walking/cycling and public transport mode share as a proxy for physical activity.

### Air and noise pollution

The percentage of freight moved by road was considered as a reasonable proxy for air and noise pollution. The road freight mode shares for the BAU and FM options were estimated previously in section 4.4 and are reported directly in Table 16.

## Appendix H – Testing the sensitivity of the evaluation

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The peer review of this study noted that the framework used to evaluate the strategic transport options was possibly subject to bias in the following ways:

- Duplication of indicators (such as drive alone mode share) between multiple objectives;
- Weighting of objectives may affect the preferred strategic option;
- Variation in the number of indicators assigned to components;
- Use of a ranking and averaging system may exaggerate differences between options.

The following sections investigate these potential sources of bias and test the sensitivity of the evaluation results to changes in the key assumptions. In all cases, the changes were not found to affect the result of the evaluation process in any meaningful way. Hence, we conclude (based on the material presented in the following section) that the process by which the recommended strategic transport option was identified is robust.

### Duplication of indicators

We investigated the potential for partially duplicated indicators and identified the following candidates:

- The use of “driver” journey to work mode share as an indicator of congestion, while “non-driver” mode share is used as an indicator of access to alternative modes; and
- The use of VKT reductions (in light and heavy vehicle travel) to forecast effects on number of fatalities and injuries.

Before investigating the effects of this duplication in detail, it is worth observing that these indicators are only partly duplicated as neither sets of indicators identified as being at risk of duplication uses exactly the same metric. Even the use of VKT reductions to forecast changes in fatalities and injuries is not exactly equivalent, because the effects of light and heavy VKT on the numbers of fatalities is different from its effect on the number of casualties. This point will become clearer in the following analysis.

Table 17 (Section 5.2.1) illustrates the ranks awarded to each option for every key component, based on their respective performance indicators. If we plot the scores for each set of duplicated indicators we can determine the strength of the duplication.

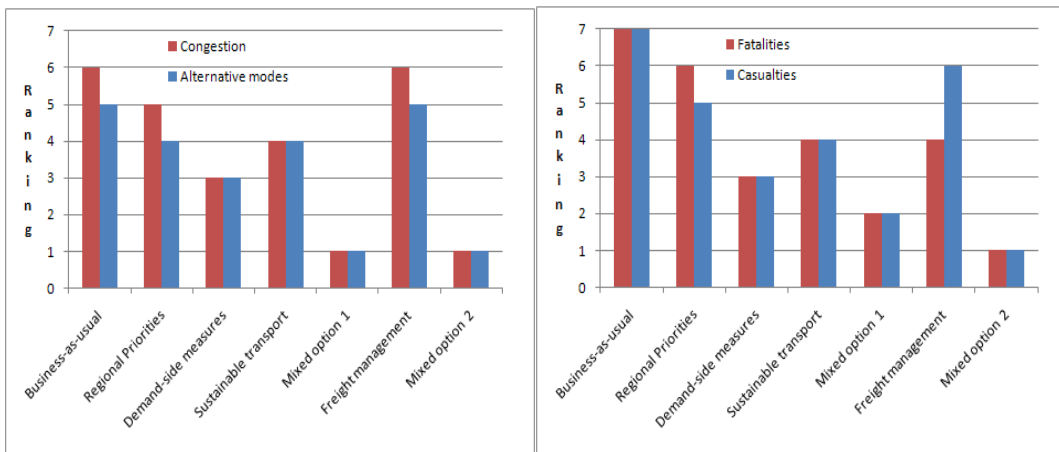


Figure 83 Scores for “Congestion” versus “Access to Alternative Modes” and “Fatalities” versus “Casualties”

In both cases the correspondence between the indicators is relatively high. To test the effects of this bias on the results, we eliminated the scores for one indicator from each set and recalculated the overall rankings. These are illustrated in the table below.

Table 36 Scores and rankings with and without partially duplicated indicators

Metric	Duplication	BAU	RP	DSM	STI	MO1	FM	MO2
Weighted score	With	5.54	5.55	2.70	4.40	2.03	4.35	1.17
	Without	5.29	5.75	2.45	4.65	2.28	4.11	1.25
Overall rank	With	6	7	3	5	2	4	1
	Without	6	7	3	5	2	4	1

Thus, the effects of partial duplication of indicators on the overall weighted score are minimal and had no impact on the overall ranking of the potential strategic transport options. Thus while duplication of indicators may in theory introduce bias, in practice it has no material effect because of the large number of other indicators included in the evaluation.

### Weighting of objectives

The weighting for each primary objective was determined in consultation with regional council staff and stakeholders. They felt that a high emphasis on economic development was justified, given the direction from central Government. We also tested the effects of a neutral weighting, whose impacts are illustrated in the table below.

Table 37 Scores and rankings for different weightings

Metric	Weighting	BAU	RP	DSM	STI	MO1	FM	MO2
Weighted score	Original	5.5	5.6	2.7	4.4	2.0	4.3	1.2
	Neutral	6.2	6.2	3.2	4.9	2.3	4.9	1.3
Overall rank	Original	6	7	3	5	2	4	1
	Neutral	7	6	3	4	2	5	1

In this case the top three ranked options are unchanged, although the STI and FM options swap to be ranked fourth and fifth respectively, which would be expected given that the reduced emphasis on economic performance would benefit STI because of its relatively high levels of expenditure. Similarly, the BAU and RP options swap rankings. In general, the overall effect from applying a neutral ranking is relatively small.

### One component multiple indicators

Multiple indicators were used for several key components so as to better capture how the different options might contribute to the primary objectives. For example, the scores for “multi-modal integration” and “accidents” both used two performance indicators.

The effects of this duplication on the weighted score and ranking of each option is summarised in the table below. This tested the effects of removing one of the multiple indicators from each component. As the results in the table show, this change had similar effects as the last sensitivity test, but in either case no material change is recorded for the preferred option.

*Table 38 Scores and rankings for rationalised number of indicators*

Metric	Indicators	BAU	RP	DSM	STI	MO1	FM	MO2
Weighted score	Original	5.5	5.6	2.7	4.4	2.0	4.3	1.2
	Rationalised	5.6	5.6	2.7	4.4	2.0	4.6	1.2
Overall rank	Original	6	7	3	5	2	4	1
	Rationalised	7	6	3	4	2	5	1

### Effects of ranking and averaging

This sensitivity test considered an alternative method of identifying the preferred strategic transport option. Instead of ranking the objectives, we calculated the percentage deviation from the worst performing option for each performance indicator. The average deviation for each key component was then multiplied by the weighting for each primary objective. The option with the largest (weighted) deviation is the one that is deemed to have “outperformed” the others. The effect of using this “performance” deviation scoring method is summarised in the table below.

*Table 39 Scores and rankings for “performance” deviation method*

Metric	Indicators	BAU	RP	DSM	STI	MO1	FM	MO2
Weighted score	Original	5.5	5.6	2.7	4.4	2	4.3	1.2
	Deviation	39.1%	39.1%	76.6%	47.3%	84.5%	54.2%	99.6%
Overall rank	Original	6	7	3	5	2	4	1
	Deviation	6	6	3	5	2	4	1

This shows how the only change is for the RP option, which shifts from 7<sup>th</sup> to 6<sup>th</sup> using this method so that we are now effectively indifferent between the RO and BAU options. MO2 retains its first rank, as does all the other options. There is also a relatively large gap (in percentage terms) between all the options aside from the BAU and RP options. This suggests that the ranking approach, while relatively crude, is able to provide a reasonable indication of overall performance when applied over a relatively large number of performance indicators.



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