Wellington Road Pricing Study

STAGE 1 – INITIAL ROAD PRICING VIABILITY STUDY – FINAL REPORT

- V1
- July 2005

Wellington Road Pricing Study

STAGE 1 – INITIAL ROAD PRICING VIABILITY STUDY – FINAL REPORT

- V1
- July 2005

Sinclair Knight Merz
Level 12, Mayfair House
54 The Terrace
PO Box 10-283
Wellington New Zealand
Tel: +64 4 473 4265
Fax: +64 4 473 3369
Web: www.skmconsulting.com

Contents

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
1	29/7/05	AWB	DSM	29/7/05	Final

Distribution of copies

Revision	Copy no	Quantity	Issued to
1	1	3	GWRC – Tony Brennand

Printed:	5 August 2005
Last saved:	2 August 2005 10:40 AM
File name:	T:\MM\GWRP Study - Final Report V1 29-07-05.doc
Author:	Andrew Bell
Project manager:	Derek McCoy
Name of organisation:	Greater Wellington Regional Council
Name of project:	Wellington Road Pricing Study
Name of document:	Wellington Road Pricing Study
Document version:	1
Project number:	AN00680

Executive Summary

Background

The Regional Land Transport Strategy has for some years contained policies and strategies that refer to the need for road pricing at some stage in the future. It has however not been clear whether a road pricing scheme would have benefits for the Wellington regional transport network, nor has the form or timeframe for introducing such a system been identified. Therefore in October 2004, Greater Wellington Regional Council (GWRC) appointed Sinclair Knight Merz Ltd (SKM) to undertake the initial stages of the Wellington Road Pricing Study, to investigate the feasibility of road pricing in the greater Wellington region.

The objective of this initial stage of work was to determine whether any sort of road pricing scheme is viable in the greater Wellington region, rather than which concept would be most appropriate. This initial stage was also not intended to address the complex legal, technical and governance issues associated with the operation of a road pricing scheme. These issues will be dealt with in subsequent stages of the study.

Road Pricing Objectives and Performance Measures

A Technical Group controlling the study concluded that the key objective for road pricing should be to reduce congestion on the regional road network, and that road pricing options should be evaluated against the objectives of the Draft Regional Land Transport Strategy, which are as follows:

- assist economic and regional development;
- assist safety and personal security;
- improve access mobility and network reliability;
- protect and promote public health;
- ensure environmental sustainability; and
- consider economic efficiency and affordability.

Based on these objectives, specific performance measures were developed to enable different pricing options to be evaluated against the objectives and each other.

Development of Options

A review of congestion in the region was undertaken using the Wellington Transportation Strategic Model (WTSM) and the central Wellington SATURN Model. This indicated that the majority of the radial routes into central Wellington and much of the CBD itself are heavily congested at peak times and highlighted where pricing would be likely to be most effective.

A number of generic road pricing concepts targeted to reduce congestion, were considered. Screenline cordon charges were tested initially as they are the most practical option available with currently proven technology and provide a good indication of how a number of different pricing concepts would perform. Other options will be investigated fully in later phases of the study once it has been demonstrated that some form of road pricing is likely to be feasible.

A series of cordons were developed, starting around the Wellington CBD area and then extending northwards up the two corridors of State Highway 1 and 2 (referred to below as the "Y" options). It should be stressed that at this stage these cordons are only indicative and developed solely for the purposes of initial viability tests.

In the case of the Y screenlines, several tolling combinations are possible and peak period tolls at each of these cordons were proposed at levels based on initial marginal congestion cost tests. Tests were made of alternative strategies with different pricing emphases: the inner strategy in which prices were highest closer to the Wellington CBD, the outer in which pricing was highest on the more distant screenlines and a medium strategy involving a more balanced distribution of road user charges. From this work, six general options were developed for testing, with sub-options involving differing levels of charge:

- A tightly drawn Wellington CBD cordon (excluding the Inner City Bypass)
- Ngauranga screenline
- Y screenlines - inner emphasis
- Y screenlines - outer emphasis
- Y screenlines – medium emphasis
- Wellington CBD plus Y screenlines

Option Testing

Each pricing concept was tested, using the adapted WTSM model. Given that the prime objective was to reduce congestion (which occurs predominantly during peak periods) it was assumed that tolls would only be imposed in the periods between 7 to 9am and 4 to 6pm and in the peak travel direction (the exception to this is the Y – medium emphasis option which has an element of counter peak charging on SH2 near Petone). Also, no differentiation was made between different vehicle classes; commercial and private vehicles were assumed to pay the same toll. The testing results are summarised below:

CBD Cordon **-** The CBD cordon would be expensive to implement due to the large number of exit and entry points and overall, this option generated little congestion relief. There were travel time savings for traffic north of Ngauranga, but these were offset by increased delays on approaches to the CBD with volume to capacity ratios in the Terrace Tunnel increased from just over 1.0 to 1.23. This result reflected the cordon location, in that excluding SH1 caused traffic to divert from the Aotea Quay / Harbourside route. However, the initial conclusion was that a tightly drawn cordon around the CBD would be neither effective nor viable and so it was not evaluated further. A wider, re-designed CBD cordon option will need further investigation in the next stage of the study.

Ngauranga Screenline **-** This option would be simple to implement due to the single cordon. However, with higher charges, this option was generally inefficient and provided no further travel time or congestion benefits over the lower charge options. Sections of the network upstream and downstream of the charging points were extensively under utilised, with volume to capacity ratios reduced to less than 0.5. It was considered this would not be acceptable, nor would it be an efficient use of the existing road network resource.

Y – outer emphasis **-** The concept behind this option was to impose higher charges on longer distance trips in the peak, to reduce their impact on congestion. However, due to the relatively small number of vehicles travelling from outer parts of the region, the overall benefits were relatively small. In addition, the extra capacity created induced more traffic south of Porirua, thereby offsetting some of the benefits. Also with this option the capacity in the Kapiti - Mana area which has recently been created is under utilised, with volume to capacity ratios in the peak reduced to less than 0.8. The initial conclusions are therefore that higher tolls on the outer edge of the Y are inefficient and create disbenefits elsewhere on the network.

Y – inner emphasis **-** This concept differed from the outer Y tolling option, by imposing higher charges on trips closer to Wellington City. The tests indicated that there were fewer trips on the network and congestion was reduced more effectively that with the outer Y option. However, the impact on medium to longer distance trips was small.

Y – medium emphasis **-** This option imposed tolls at more regular intervals across the Y network, with modest tolls at several cordon points. The marginal congestion cost analysis undertaken also indicated that congestion levels experienced on SH2 in the counter-peak direction warranted investigation of counter-peak charges. Therefore, counter-peak charges were included on SH2. The maximum toll tested was for a trip from Upper Hutt into the Wellington CBD, at $5.20. This concept delivered the best overall benefits for the network, generally reducing congestion at each of the key bottlenecks, while retaining a high utilisation of the existing network capacity.

Key findings from the testing based on the most beneficial options tested were:

- Total person kilometres would be reduced by up to 2 to 3% in the AM peak.
- Passenger transport kilometres could increase by 9.3%
- Travel times to the CBD from the north could reduce by up to 40%
- Delays at key bottlenecks may be reduced by between 10-15% (dependent on the level of toll proposed)

To varying degrees, the options all contributed to the regional transport strategy objectives. However, following a preliminary review of the modelling results, a number of the options were obviously much less effective and could be discounted. These were removed from further consideration and the remaining options were as follows:

- Ngauranga Screenline ($2, $4) - NS
- Y- screenlines - inner emphasis - YI
- Y- screenlines - outer emphasis (low toll level) - YO
- Y- screenlines - medium emphasis - YM

These options were scored against the performance measures developed using an unweighted planning balance sheet approach and the results are set out in Table 1-1 below.

- **Table 1-1: Option Scores**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
ECONOMIC DEVELOPMENT & ACCESS AND MOBILITY	0	0	0	0+	√	0+	0+	0+	√
SAFETY & PERSONAL SECURITY	0	0	√√	√	√√	0	0	√	√√
PUBLIC HEALTH	0	√	√+	√	√+	0	0	√	√+
ENVIRONMENTAL SUSTAINABILITY	0	0+	√√	√	√√	0+	0+	√	√√
ECONOMIC EFFICIENCY & AFFORDABILITY	0	0	√√+	√+	√√+	0	0-	0+	√+

Technology and Rough Order Costs

The focus of the work to date was not about the administration or technology required to operate road pricing. Nevertheless, some consideration of technical and institutional issues had to be made to determine rough order estimates of capital and operating costs. The following assumptions were used:

- The technology would be similar to that proposed by the Transit New Zealand National Tolls Administration Project (NTAP)
- The system would be a stand alone system, owned and operated by a single operating entity
- Payment would be by electronic means only
- Enforcement would be carried out as part of the system operation.

The capital costs could range from $10m for the Ngauranga Screenline options through to $45m for the CBD + Y options. For these options, annual operating costs could range from $3m to 13m respectively.

A comparison of economic benefits and costs was undertaken for the various options tested to date. The range of scheme costs vary between $28-48 million. By comparison, benefits would range between $24-63 million. After deduction of user charges (revenues) all but 3 of the concepts deliver benefit to cost ratios in excess of 1. When revenues are included in the equation, the benefits can outweigh costs by a factor approaching 3.9.

Passenger Transport Constraints and Complementary Measures

It is noted above that the impact of road pricing might be to increase passenger transport by just over 9%. The Porirua to Wellington corridor would be most affected, however it is recognised that presently the rail network is constrained by several factors. Specific issues which need to be addressed are:

- The Wellington station approach
- Signalling requirements
- New rolling stock provision
- Track duplication in the Pukerua Bay area

However, the Regional Council already has plans to address these constraints. Demand on the rail network is also very "peaky", and therefore even modest travel time shifts would spread the impact on the peak of the peak. Therefore it is not unreasonable to assume that with modest changes to the passenger transport network these additional trips could be accommodated.

A review of bus constraints indicates that there are unlikely to be any fundamental constraints to increasing bus capacity to cater for additional demand resulting from the introduction of road pricing.

Regional Economic Issues

Work to date in this area has been limited. However, on a basis of the changes to transport patterns explored so far, it is likely that the direct regional economic effect of road pricing will be marginal.

As a proportion of the regional GDP, the maximum estimated toll revenue is less than 0.8% of regional GDP. Only around 5% of journeys to work could face the maximum toll in the most viable option (of $5.20) if all journeys to the CBD were by car. In practice only around a third of the journeys to the CBD are by car.

In terms of overall regional economic growth, while the impacts will be small, road pricing is likely to contribute positively, based on the estimated benefits from reduced congestion and improved travel times at the peak, identified in the transportation work to date. However, there could be differential impacts by location, although these are likely to be very small based on the marginal overall impact.

In addition, a number of characteristics of the regional economy offer scope to complement the peak period travel improvements in supporting further regional economic growth, such as:

- the relatively high self-containment of employment in the individual local authority areas,
- the relatively highly qualified regional workforce
- the strength of the Wellington regional economy in some of the faster growing industry sectors such as business and other services, transport and communications.

Acceptability

Experience throughout the world indicates that a key factor in the successful introduction of road pricing will be the level of public acceptability.

A review of available local and international literature was undertaken and has identified the following major factors that can affect the acceptability of road pricing measures:

- Alternatives to the car and their perceived effectiveness
- Use of the revenues generated
- Scale of the congestion problem
- Understanding the purpose of road pricing
- Considerations of equity and fairness of the pricing
- Form, technology, complexity and privacy
- Political leadership and public trust

These issues do not form part of the formal evaluation, but will need to be considered in detail before a road pricing scheme is implemented.

SKM

Conclusion and Recommendations

This initial work suggests that a road pricing scheme can be designed in Wellington Region which would be financially self-sustaining, provide surplus revenues for investing in improved transport infrastructure and services and which would bring significant peak decongestion benefits as well as environmental and safety improvements etc. There would be an overall contribution to the economic growth of the region and the differential impacts on separate areas within the region would be small. The impact on areas with higher levels of social deprivation would be very small. Charges would be modest, consistent with passenger transport fares, and would only affect a small proportion of road users.

It is therefore recommended that Wellington Road Pricing Study proceed to the next stage which should include detailed investigation of road pricing in the Wellington region and address the issues set out in the Terms of Reference for the full study. The next steps involve refining the concepts developed to date, and reviewing the social and environmental impacts of road pricing in more detail. A key aspect of the next stage of the study will be to identify the system administration and technological issues, including a robust risk assessment.

1. Introduction

1.1 Background

Since 1993, the Regional Land Transport Strategy has referred to the need for road pricing in the future. Introduction of the Land Transport Management Act (LTMA) in 2003 foresaw the introduction of new toll roads (but not charging for using existing roads). Nevertheless, interest in road pricing at a national level has continued, with the Ministry of Transport (MOT) conducting a road pricing study in Auckland.

It has not been clear whether such a scheme would have benefits for the regional transport network, nor has the form and timing of introducing such a system been identified. Therefore in 2004, Greater Wellington Regional Council (GWRC), in association with Transit New Zealand, Land Transport New Zealand (LTNZ) and the region's territorial authorities, developed terms of reference for a road pricing study to answer these questions. The study was also to examine what specific transport issues road pricing might address, the pricing level appropriate for Wellington and what the impacts would be.

In October 2004, GWRC appointed Sinclair Knight Merz to commence the Wellington Road Pricing Study and the interim stage of work - Stage 1, has now been completed.

1.2 Study Governance

This study was commissioned by GWRC, however a Technical Group, comprising officials from the Ministry of Transport, Transit New Zealand, the region's territorial authorities and GWRC, was convened to provide direction and context for the project. The Group was Chaired by Tony Brennand of GWRC and their role was to ensure that the study is based on sound processes and information.

Three Technical Group meetings were held on 6 December 2004, 4 April 2005 and 2 June 2005. At these meetings, study progress and interim findings were presented to the Technical Group and the scope and methodology of subsequent work was agreed with the consultant team.

1.3 Objectives

The overall objective of the Wellington Road Pricing Study is to identify whether a road pricing proposal can be found that best supports national and regional objectives for transport in the region. It is intended that such a proposal should meet regional needs in a manner that facilitates and supports social, business, recreational, environmental and other strategic goals (including current and future land use). The Technical Group concluded early in the study that a key focus for road pricing should be to reduce congestion on the regional road network.

The full terms of reference (TOR) for the Wellington Road Pricing Study are included in Appendix A. Following the development of the TOR, the Wellington Road Pricing Study was split into two stages:

Stage 1 – Initial Road Pricing Viability Study

Stage 2 – Road Pricing Strategy Study

In Stage 1 of this study, SKM was asked to investigate whether a pricing scheme could be found which would address congestion, would be economically and financially viable, and would contribute towards all the objectives of the Regional Land Transport Strategy. Consequently the objectives of Stage 1 of the Wellington Road Pricing Study have been to:

1) develop a set of road pricing performance measures so that the relative benefits of different options can be evaluated;
2) determine whether any form of road pricing is likely to be viable in the greater Wellington region; and
3) recommend viable generic road pricing options to be taken forward for testing in the next stage, where they can be developed further and assessed against agreed performance measures.

Stage 2 will develop the options further and address the issues associated with road pricing in more detail as set out in the TOR.

1.4 This Report

This report sets out the investigations and findings of Stage 1 of the Wellington Road Pricing Study. This stage has involved developing prototypes for road pricing and undertaking a coarse screening of options to identify those which are feasible and are most likely to address the key study objectives.

The report is structured as follows:

- Chapter 2 – Objectives and Performance measures
- Chapter 3 – Model Development and Testing Procedures
- Chapter 4 – Development of Options
- Chapter 5 – Preliminary Screening of Pricing Options
- Chapter 6 – Option Evaluation
- Chapter 7 – Technology & Rough Order Costs
- Chapter 8 – PT Constraints & Complementary Measures

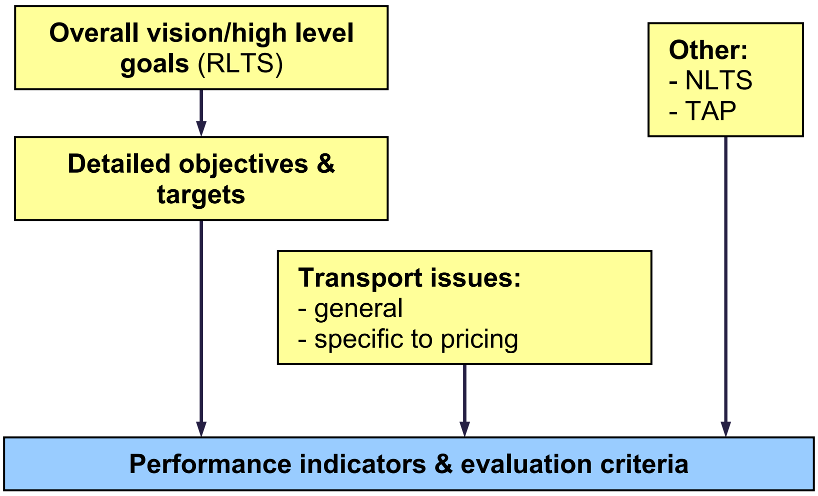
- Chapter 9 – Regional Economic Issues
- Chapter 10 – Public Acceptability
- Chapter 11 – Conclusions & Recommendations
- Appendices

2. Objectives & Performance Measures

2.1 Strategic Context

Major transport strategy components, such as road pricing, should be evaluated against the broader vision, objectives and goals of national and regional transport policy. Therefore a review of all relevant sources of transport policy was undertaken, from which a set of detailed transport objectives for the region was established. From these, performance indicators were designed which could be used to evaluate the road pricing strategies. Figure 2-1 below summarises this approach.

- **Figure 2-1: Development of Road Pricing Performance Indicators and Evaluation Criteria**



Relevant guidance from each of the key policy and strategy documents is described below.

2.2 National and Regional Objectives

2.2.1 New Zealand Transport Strategy

The New Zealand Transport Strategy (NZTS, Ministry of Transport, 2002) has five main goals:

1) Assisting economic development
2) Safety and personal security
3) Access and mobility
4) Protecting and promoting public health
5) Ensuring environmental sustainability

The following draws out the main themes under these headings:

- ***Assisting economic development:*** Social, economic and environmental costs and benefits, minimising transport growth and energy consumption, a focus on non car modes and other alternatives to roading, management of the existing transport system, transport meeting its total costs, congestion pricing and the distribution of surface transport costs.
- ***Safety and personal security:*** reduce car use, road safety education, engineering, enforcement and management systems, regulation, safety for the aged and children, personal security and public transport.
- ***Access and mobility:*** promote optimal use of different modes of transport through pricing and funding, improve access for including the disadvantaged, sharing road space with other modes via road space management, provide choice, improve public transport and pedestrian facilities.
- ***Protecting and promoting public health:*** promote walking and cycling, encourage reduced car use, reduce emissions, reduce run-off, noise and promote public transport use.
- ***Ensuring environmental sustainability:*** increase energy efficiency, enhance mobility by promoting alternatives to roads, reduce traffic growth, integration of transport modes, reduce the need for travel and develop more efficient urban forms.

Under initiatives to assist economic development, the NZTS states that work in progress includes a detailed investigation into the potential use of congestion pricing for roads in major urban areas. *'Congestion pricing may help reduce the impact congestion has on economic activity in areas such as Auckland, where congestion is estimated to cost around $1 billion per annum.'* (Ministry of Transport, 2002).

The Ministry of Transport is presently undertaking a study into road pricing in Auckland.

2.2.2 Greater Wellington Regional Council Objectives

In common with many other places, Wellington faces increasing demand for movement of people and goods, in a constrained infrastructure and funding environment. How this will be addressed is set out in the Regional Land Transport Strategy (RLTS), which is presently being revised. Current *draft* objectives for transport in Greater Wellington are that the RLTS should:

- assist economic and regional development;
- assist safety and personal security;
- improve access mobility and network reliability;
- protect and promote public health;
- ensure environmental sustainability; and
- consider economic efficiency and affordability.

A draft set of performance measures related to these objectives was developed by GWRC (GWRC, 2004), and is presented in Table 2-1 below.

- **Table 2-1: RLTS Draft Objectives and Performance Measures**

Objective and Definition	Performance Measures
Assist economic and regional development Aid the development of national and regional economic prosperity; and foster the housing, employment, education, health and recreation aspirations of the regional community.	Economic growth index Population distribution Employment distribution Transport system costs Freight movement by modes & costs
Assist safety and personal security Achieving a safer community through a land transport system that improves or achieves regional road casualty targets and contributes to a sense of individual and community security when using the transport system, particularly passenger transport, or when travelling as a pedestrian.	Deaths plus hospitalisations (from road traffic) Perception of personal security
Improve access, mobility and network reliability Transport should provide for the access and mobility needs of our regional community. Improving them is the primary purpose of a Regional Land Transport Strategy. Access and reliability are to enable social participation, inclusion and independence. Mobility is to ensure the availability of realistic transport choices for the individual or community, including affordability and equity of costs.	**Access & reliability** Congestion Indicator Travel time variance Network enhancement (road, rail) VKT/average trip length Severe network closures **Mobility** Vehicle ownership Public transport service extension Transport user cost Patronage/vehicle trips/active trips
Protect and promote public health Provide a transport system that allows for social participation and interaction, and healthy communities via reduced transport impact on natural resources, and increased uptake of active mode use for short trips.	Ambient pollutant levels Active mode trips
Ensure environmental sustainability Avoid, remedy or mitigate the negative impacts of transport on the environment, including encouragement of energy efficiency, reduced CO_2 emissions, and high quality new development and project design.	CO_2 emissions Fuel use Land use patterns
Consider economic efficiency and affordability Economic efficiency and funding availability for new transport packages.	**Affordability** Transport system cost New transport package cost/fund availability **Efficiency** BCR of new transport packages

2.2.3 Long-term Council Community Plan for Greater Wellington

Towards a Sustainable Region, GWRC's ten-year plan (GWRC, 2003), describes the desired outcomes for the region, including relevant targets for transport and energy by 2013:

- less than 45% of work trips into central Wellington made by private car (currently 45%)

- a 70% increase in walking and cycling for short trips (65% of all trips up to 1km and 48% of all trips up to 2km are walked or cycled)
- average travel times to key facilities do not increase
- no more than a 1% per annum worsening of congestion despite traffic growth
- no recorded instance when air pollution reaches the ‘alert’ level of the national ambient air quality guidelines due to traffic
- over the next ten years petrol and diesel used for transport purposes remain below 400 million litres per annum.

These targets provide an indication of GWRC’s strategic direction and it is intended that the strategies and policies contained within the RLTS support the achievement of these outcomes. Therefore, these targets also provide guidance on the targets and performance measures that road pricing options may be tested against.

2.3 Road Pricing Objectives

Internationally, road pricing is advocated as a means of addressing one or more of the following objectives:

- increasing the extent of costs recovered (particularly environmental and congestion costs);
- changing the pricing signals to road users, and hence influencing travel demand;
- providing additional funds for transport infrastructure investment (to supplement or replace existing funding sources).

The Technical Group considered that the primary objective of road pricing in Greater Wellington should be to manage demand, thus ensuring balanced use of infrastructure and reducing congestion at peak times. This would be achieved through the second objective above (changing pricing signals). The group also advised that the following should be considered in detail in Stage 2 of the study:

- demand management opportunities and measures
- revenue potential
- social distributive effects
- consistency with Wellington Regional Strategy land use policies
- privacy issues
- public acceptability
- technical feasibility/implementation issues (including establishment and operating/enforcement costs)

- administrative simplicity
- legislative implications
- options to mitigate adverse effects (e.g. additional public transport services, discounts/exemptions from potential charges)

2.4 Development of Performance Measures

It was agreed with the Technical Group that the evaluation of road pricing options should be undertaken using the draft RLTS objectives, which encompass the NZTS objectives.

A general approach to road pricing performance measures was detailed in the report "Wellington Road Pricing Study - Objectives and Performance Measures" (SKM, 2004). The report was based on the national, regional and local objectives as well as a set of performance measures developed for consideration in the Auckland Road Pricing Study terms of reference.

Subsequently, a set of performance measures were developed (Table 2-2), based on these general concepts. These measures were all extracted from the transport model and reviewed.

Table 2-2: Detailed Performance Measures Extracted from WTSM

Phase 1 Modelled Performance Measures
Assist economic and regional development & Improve access mobility and network reliability Mobility statistics: ▪ trips and trip kilometres by mode ▪ mode shares ▪ mode shares by origin/destination type (TLAs, CBDs) ▪ public transport service provision: bus and rail vehicle kms Journey Time: ▪ car: total regional travel time, distance and average speed ▪ public transport: total regional passenger travel time, distance and average speed ▪ commercial vehicles: total regional travel time, distance and average speed Generalised cost (GC, includes charges): ▪ car: total regional travel GC, distance and average GC ▪ public transport: total regional passenger GC, distance and average GC ▪ commercial vehicles: total regional GC, distance and average GC Charges: ▪ car: total charges, average charge/trip, average charge paid ▪ commercial vehicles: total charges, average charge/trip, average charge paid Accessibility distributions ▪ road: average inter/intra-sector road speeds and journey times; ▪ public transport: average inter/intra-sector journey times (generalised); ▪ distributions by zone & TLA of average speed changes, average tolls paid, average road, public transport and multi-modal GC/accessibility changes (inputs to economic development analyses); associate these with zonal socio-demographic characteristics[1] and CBDs (relates to equity issues);

[1] Probably would seek to develop a zonal socio-demographic classification, then the differential impacts by class over the region could be summarised.

▪ toll payments: distribution of trips by charge level, distribution of toll payments by location (zone & TLA); Capacities: ▪ road: vehicle kilometres below level-of-service D; distribution of vehicle kilometres by V/c ratio by time period ▪ rail: measures of overcrowding ▪ bus: assumes that bus services will be extended to eliminate overcrowding
Assist Safety and Personal Security Number of annual casualties using WTSM.
Ensure environmental sustainability Regional CO2 emissions Regional energy consumption
Protect and promote public health Regional emission estimates. Emission impacts at hotspots. Emission and noise impacts on people can be indicated by measuring traffic flow changes in high population density areas. Changes in active mode trips are not reliably forecast by the model and unlikely to be a differentiating factor for RUC strategies. So this will be done by judgment.
Consider economic efficiency and affordability A discounted 30 year financial and economic evaluation. Indicators are: ▪ Capital cost and annual costs ▪ Revenues by type ▪ Net financial cost to government[2] ▪ User benefits, segmented by mode ▪ Total benefits ▪ BCR
Other This mainly concerns public acceptability, which would be inferred from statistics above.

A representative subset of these performance measures (Table 2-3) was then used in the evaluation presented in this report, to provide an indication of the relative performance of the different options being tested. The measures were chosen to be representative, show the main impacts of road pricing and provide a reasonably comprehensive basis for assessing and comparing the impacts of the alternative strategies against the RLTS objectives. In Stage 2 of this study, these performance measures will be reviewed again and will incorporate additional measures from the above report.

[2] It seems likely that this should include some consideration of taxation effects (fuel etc)

Table 2-3: Indicative Performance Measures Used in the Evaluation

RLTS Objectives	Performance Measures	
Assist economic and regional development	The impact on travel	Person-kilometres of travel by private vehicle, passenger transport and heavy commercial vehicles
		Private vehicle and passenger transport trips
	Travel times and speeds	Vehicle travel times on routes
		Average private vehicle and passenger transport speeds
	Congestion	The level of congested vehicle-kilometres, where congested is defined as volume/capacity >0.8
		volume/capacity at identified bottlenecks
	User Charges	The average charge paid
		The distribution of charges
Assist safety and personal security	Annual injury crashes	Predicted network wide annual vehicle injury accident
Improve access mobility and network reliability	The impact on travel	Person-kilometres of travel by private vehicle, passenger transport and heavy commercial vehicles
		Private vehicle and passenger transport trips
	Travel times and speeds	Vehicle travel times on routes
		Average private vehicle and passenger transport speeds
	Congestion	The level of congested vehicle-kilometres, where congested is defined as volume/capacity >0.8
		Volume/capacity at identified bottlenecks
	User Charges	The average charge paid
		The distribution of charges
Protect and promote public health	Estimates of vehicle noise and emissions	Nitrous oxides (NOX), particulates, and volatile organic compounds (VOC) for the whole of the modelled area
		The sum of traffic volumes on approx. 100 selected links in residential areas as a measure of the impact of noise and emissions on people
	Increased active modes	Person-kilometres by walking and cycle
Ensure environmental sustainability	Greenhouse gas emissions and fossil fuel use	Carbon dioxide emissions
		Fuel use

SKM

Consider economic efficiency and affordability	Economic and Fiscal Measures	User Benefits / Scheme Costs Revenues / Scheme Costs

2.5 Rating the Measures

Purely as a means of summarising the overall outcomes and illustrating the main thrust of the impacts, we have applied a judgmental rating system (Table 2-4). The ratings should not be taken as a formal evaluation, not as representing the views of GWRC or other stakeholders.

- **Table 2-4: Rating System**

Rating	Meaning
XXX	Very poor
XX	Poor
X	Worse than average
0	Average
√	Better than average
√√	Good
√√√	Very good
+, -	These are used for marginal adjustments to the above ratings

SKM

3. Model Development and Testing Procedures

3.1 Model Development

The Wellington Transport Strategy Model (WTSM) was used to forecast the impacts of the road pricing strategies. The original version of the model had a base year of 2001, with associated planning data, networks and other model inputs along with a specification and model validation (which was formally documented) and a User Guide.

Since then a number of potential changes have been investigated and others implemented in the model by GWRC. Some of the changes have been incorporated into the model used for the Western Corridor Study. For the WRPS, these changes were reviewed (in the "Model Specification Report", SKM 2004) and the following were implemented by the Study team:

- small base year network corrections implemented by GWRC;
- incorporation of the latest GDP growth forecasts used by GWRC;
- the revised model iteration procedures.

In addition processes were developed for broadly optimising the charges in each pricing strategy (Section 3.3).

3.2 Forecasting Scenarios

The forecast years and future networks and other inputs were discussed and agreed with GWRC and the Technical Group prior to the forecasting:

- the forecast years are 2016 and 2026, with the analysis focused on 2016;
- land use inputs (population, employment, etc) are the same as currently used by GW;

GWRC network scenarios consist of a committed base plus improvements for Hutt Corridor, Western Corridor (old package) and the CBD (pragmatic view). The 2016 network specifically includes:

- Adelaide Rd Upgrade
- Dowse / SH2 Grade Separation
- Inner City Bypass
- MacKays Crossing 2 laning
- Kapiti Link Road Stages I&2
- Paekakariki Hill Rd improvements

- Roundabout Changes at Paremata and Plimmerton
- Paremata Bridge Duplication
- Pauatahunui Bridge Replacement
- Pukerua Bay to Mana 2 laning
- Mana Lights, Wellington CBD bus priorities, increases in bus and rail frequencies.

3.3 Charging Optimisation Process

Option tests were undertaken with the model, assuming specific charges were imposed at physical locations on the road network. The locations of the charging points were specified for all the options modelled as described in Section 4.5 and alternative pricing levels were also specified for the simpler single screenline/cordon options.

For the multi-screenline options, a series of tests were carried out using WTSM to determine an efficient or optimal balance of tolls between the screenlines. The process was designed to maximise the time savings benefits (ie congestion reduction) from an overall level of payment by road users (in effect, this minimises the charges paid by road users for a given outcome in terms of congestion reduction).

The modelling procedure was designed to reflect the following:

- road users who have a convenient alternative to their peak period road journey may be more likely to change their travel behaviour;
- road users whose route takes them through the most congested part of the network are likely to impose the highest congestion costs and changes in their travel behaviour are likely to bring the greatest congestion relief.

4. Development of Options

4.1 Introduction

An initial task was to develop preliminary road pricing options for evaluation that reflect the wide range of pricing options available. To ensure that appropriate options were developed to address congestion, the following steps were undertaken:

- Review of the scale of the congestion problem faced by the region at present, and forecasting of future congestion.
- A general review of road pricing concepts that may be suitable for the Wellington region.
- Initial option screening to identify those options which are most likely to be effective in addressing congestion in Wellington.
- Development of preliminary options for testing.
- Review of the road pricing technology options currently available, or likely to be developed in the near future.
- Development of rough order capital and operating costs for the preliminary options.
- Comparison of benefits with costs, and initial coarse screen evaluation.

4.2 Congestion Review

With road pricing being intended to reduce congestion in Wellington, a brief review of the distribution of peak period congestion currently and forecast in the future has been undertaken. WTSM and the central Wellington SATURN model were used for this purpose. Significant congestion also occurs on Saturdays (late morning to mid-afternoon); however this was not considered as part of this study.

4.2.1 Model Congestion Levels: 2003

The following figures are plots from the 2003 base year SATURN model and show the road network links that have a V/C ratio which exceeds 1.0, indicating those links over capacity.

Figure 4-1: V/C >1.00 for the 2003 Base Year AM Peak

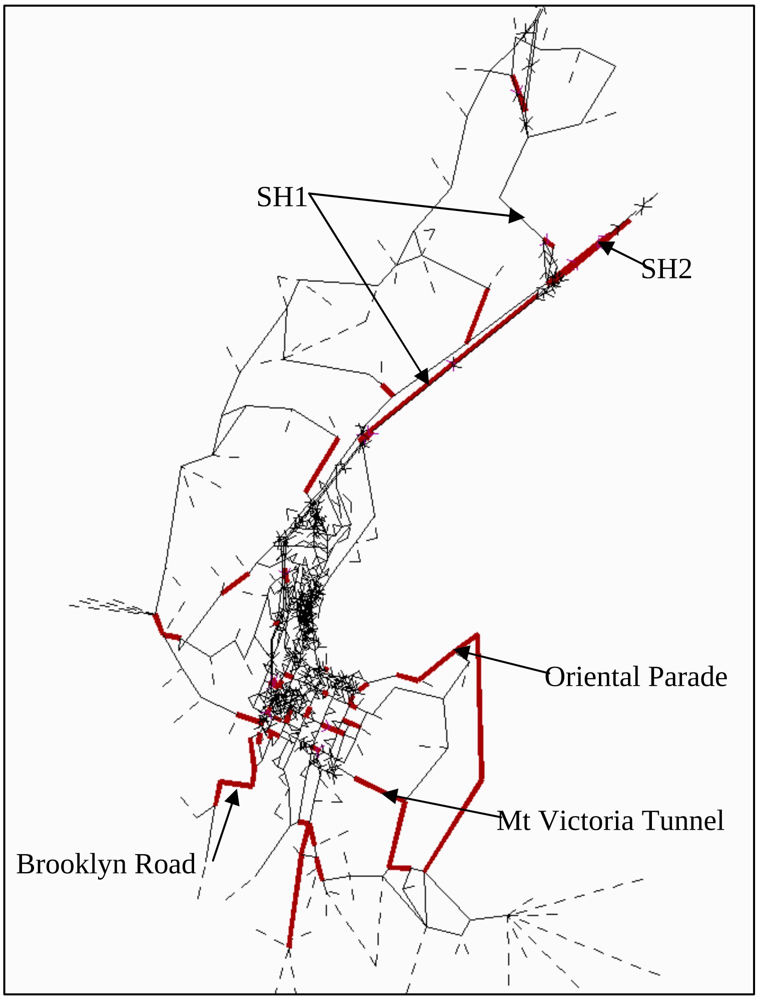


Figure 4-1 shows that the following links into central Wellington are over capacity.

From the north:

- Johnsonville Road
- SH2 north of Ngauranga
- SH1 north of Ngauranga and on the approach to the CBD
- Kawharawhara Road
- Grovesnor Road

From the south:

- Brooklyn Road
- Adelaide Road
- Riddiford Street
- Mt Victoria Tunnel
- Oriental Parade

This indicates that most routes into the city from the north and the southeast experience significant congestion. It should be noted that these plots only show the links which are over capacity, however the queuing effects resulting from this extend much further than indicated on the plots.

- **Figure 4-2: V/C > 1.00 for the 2003 Base Year AM Peak: CBD**

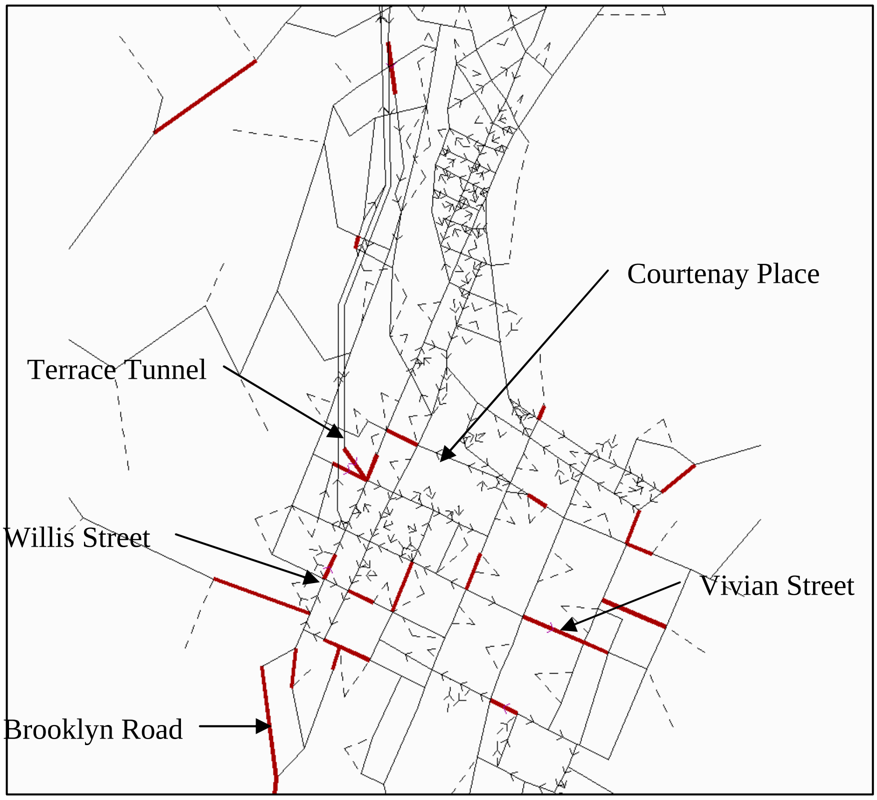


Figure 4-2 indicates that the bottlenecks in the CBD are limited to a relatively small number of links. These include:

- The Terrace Tunnel

- Ghuznee Street
- Willis Street
- Webb Street
- Aro Street
- Vivian Street
- Buckle Street
- Elizabeth Street
- Cable Street
- Courtenay Street / Dixon Street

It should be noted that enhancing the capacity at these bottlenecks will not necessarily reduce the level of congestion in the CBD, as it may simply transfer congestion downstream to the next intersection.

Table 4-1 below shows the Volume / Capacity (V/C) ratios at a number of selected bottlenecks taken from the 2016 WTSM model. This indicates these links are forecast to be over capacity in the future.

- **Table 4-1: V/C Ratios for Selected Bottlenecks**

Location	V/C Ratio
Mount Victoria Tunnel	1.08
Terrace Tunnel off-ramp	1.04
SH1 south of the Ngauranga Merge	1.01
SH1 north of the Ngauranga Merge	1.03
SH2 north of the Ngauranga Merge	1.04
SH2 Western Hutt Road (by Petone)	1.00
SH2 Western Hutt Road (north of Buchannans Rd)	1.04
SH1 north of Mana Bridge	1.03

4.2.2 Congestion Summary

Observations of the network indicate that congestion is predominantly limited to the weekday AM and PM peak times associated with commuter travel and Saturday in the late morning and early afternoon. Congestion also occurs at some locations outside the peaks including weekend (Friday evening/Sunday afternoon) bottlenecks at Mana as people leave and re-enter the city for the weekend.

The areas identified as particular congestion bottlenecks are predominantly on the main radial approaches to the city. The locations of the congestion are:

- along SH1 and SH2;
- on the approaches to the central city from the south and southeast;
- in the Wellington CBD.

4.3 Road Pricing Concepts

The study TOR envisaged seven generic concepts for road pricing that could be suitable for Wellington. These were as follows:

- Tolls for new roads and facilities (specific tolled roads and lanes)
- Strategic (arterial) Network Charges
- Full Network Charges i.e. charges based on time and distance travelled
- Cordon Charges i.e. charges for crossing a particular cordon
- Area Charges (e.g. London's congestion charge)
- Parking Charges
- Other mechanisms (for example increased regional fuel levies)

A brief description of the concepts is included below. Other than new toll roads, only parking charges are possible under present legislation in New Zealand. The Land Transport Management Act, 2003 (LTMA) requires the Regional Land Transport Strategy (RLTS) (currently under review) to include a travel demand management (TDM) strategy. Although the LTMA does not permit the introduction of road pricing for the purposes of TDM, the Government has signalled an interest in investigating road pricing in special cases.

Tolls for new roads and facilities (specific tolled roads and lanes)

Tolling for new facilities includes tolling of new strategic road links and also tolling for use of HOV lanes (HOT lanes). ALPURT B2 (the Auckland Northern Motorway Extension) will be the first toll road promoted under the LTMA.

Strategic (arterial) Network Charges

Strategic (arterial) network charging is effectively levying a charge for using a particular route or road. This type of route charging is most commonly applied for toll roads, bridges and tunnels, normally to fund private construction and maintenance. In the Wellington context, charges could be levied for use of the city's motorways and key arterial routes. This could be through route access charging or time and distance based charging.

Full Network Charges

Full network charging involves levying a charge for any use of the network. This can be based upon distance travelled or time spent travelling on roads within a defined roading network. A time based system is normally considered potentially dangerous as it would encourage speeding, but charges for any type of system can be varied by time of day. Many examples of distance based charging exist, most commonly on toll roads, although the recently introduced European Lorry Road User Charging systems include it. In the Wellington road pricing context, charges could be levied for use of the whole network with charges varying depending on location, the time of day or levels of congestion.

Area Charges

Area based charging involves levying a charge for the use of all public roads within a defined area or zone. The most well known example of this system is the London Congestion Charging system. In Wellington, charges could be levied for trips in and around the central CBD or sub-regional centres.

Cordon Charges

Cordon based charging involves levying a charge for crossing a defined cordon - normally around a defined area. Although the area defined may be the same as for an area based charging system, the charge only applies when the cordon is crossed, in one or both directions. Travel within the area enclosed by the cordon does not involve a charge. Multiple cordons can be included. The Ring Road systems in the Norwegian cities of Oslo, Trondheim and Bergen and Singapore’s Electronic Road Pricing scheme (CBD part), are examples of cordon based systems. In Wellington, charges could be levied for crossing single or multiple cordons on local and strategic roads extending concentrically from the central Wellington CBD or sub-regional centres.

Parking Charges

Parking levies or charges are defined as any charge for parking on public and/or private property within a defined area or areas, which would be in addition to any parking charges that may already be in place. In the Wellington road pricing context, additional parking charges could be levied in central Wellington or sub-regional centres.

4.4 Initial Option Screening

Preliminary marginal congestion cost testing strongly suggested that road user charging covering the Wellington city centre and the major motorway corridors would have the greatest benefits for the regional road network. Only cordon charges or full network charges could directly address this geographical spread. However, there is considerable debate about the timeframe for when technology would be available to implement full network charges (Section 7.2). Currently available technology either uses or emulates toll gates, which is an application of the cordon concept. The initial testing was therefore focused on options that can also emulate either area or to some degree strategic network charges. The next phase of the work will examine the impacts of other options, which we comment on briefly below.

Tolling for new facilities is likely to become more relevant in next stage of the study, when there is a need to examine complementary measures, including new infrastructure. At which point, the benefits of tolling the new infrastructure in terms of providing funding and locking in the benefits should be considered.

International evidence suggests that targeting tolling high quality strategic (arterial) road networks can potentially cause problems with diversion of trips to secondary roads. Therefore strategic network charging was not considered in this early stage. Nonetheless, in the next stage it may be appropriate to look at differential rates of tolling by road class, partially reflecting this concept.

Area charges of the type used in London have not been tested at this stage. However, the cordon around the Wellington CBD in this first stage of testing provides an indication of their potential.

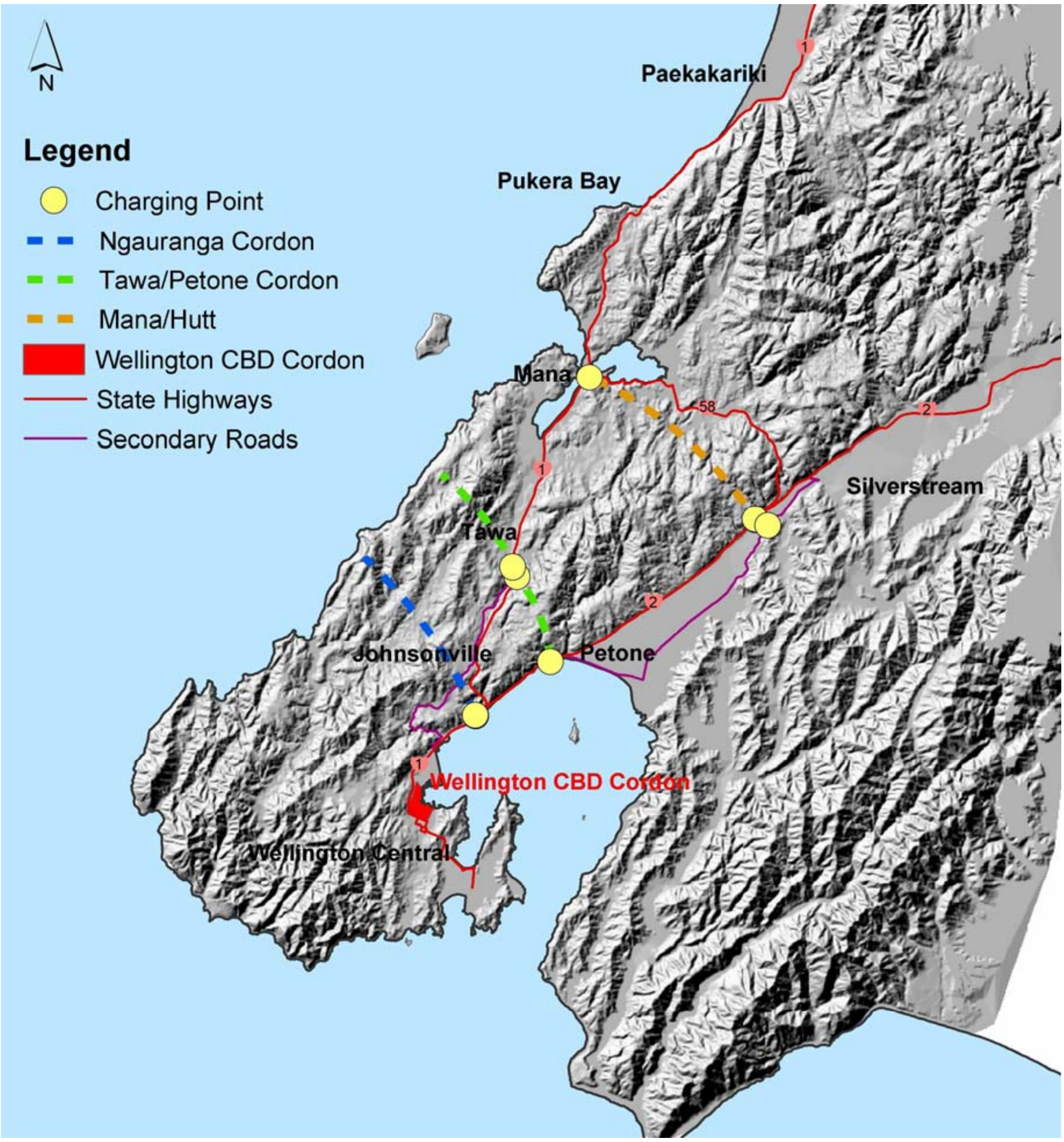
Finally, it is unclear whether parking charges could be easily implemented and we would not expect them to have the effectiveness of cordon charging in addressing peak congestion. They may be considered further in the second stage of this study.

4.5 Designing the Charging Cordon Options

Pricing options targeted to reduce congestion at the locations described in Section 4.2, have been developed. A series of screenlines acting as cordon boundaries have been prepared starting around the Wellington CBD area and then extending northwards up the two corridors of SH1 and SH2. Figure 4-3 below show the locations of the initial set of cordons and associated charging points in relation to the greater Wellington region, while Figure 4-5 to Figure 4-9 show the specific cordon charging locations in more detail.

SKM

▪ **Figure 4-3: Initial Cordon and Charging Point Locations.**



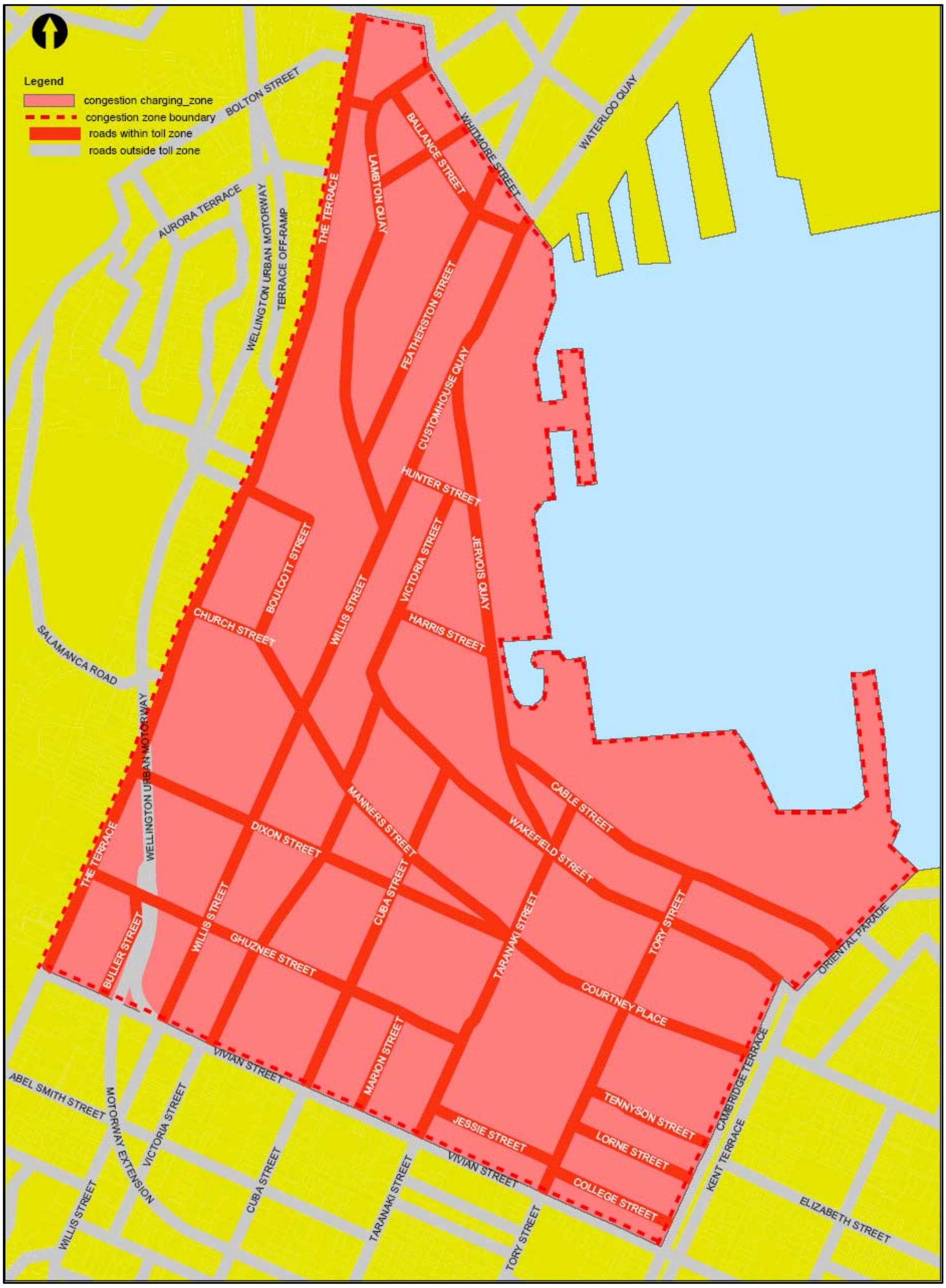
The charging points on the outer cordons have been located at congestion bottlenecks. The configuration was selected to ensure that the majority of inbound and outbound trips would be charged without the option of rerouting to avoid them.

4.5.1 CBD Cordon

The boundary of this tightly drawn cordon runs along Whitmore Street to the north, The Terrace to the west, Vivian Street to the south, Cambridge Terrace to the southeast and the cordon is closed by the waterfront. The charging points were chosen to capture any through movements, for example, along Jervois Quay and The Terrace.

The cordon does not however, encompass the Inner City Bypass, allowing trips that bypass the central city to avoid paying a charge. Charging points would be required on all roads that cross the cordon boundary, or they would need to be closed to ensure rat-running to avoid the charges would not occur. Figure 4-4 below shows the location of the CBD cordon in greater detail.

- **Figure 4-4: CBD Charging Point Location**

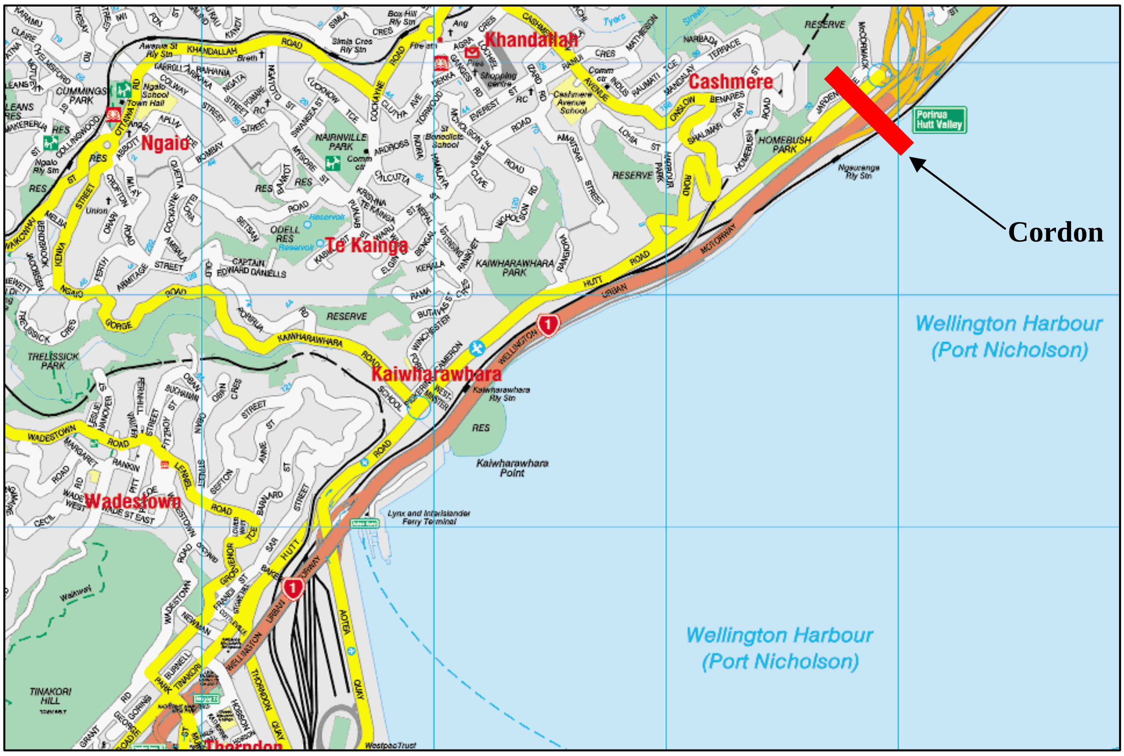


SINCLAIR KNIGHT MERZ

4.5.2 Ngauranga Cordon

The Ngauranga cordon is located immediately south of the of the SH1 / SH2 merge to capture trips into and out of the central Wellington area from the north of the region on the SH1 and SH2 Hutt Valley corridors. Charging points have been placed on SH1 and on the adjacent Hutt Road as indicated in Figure 4-5 below.

- **Figure 4-5: Ngauranga Cordon Charging Points**

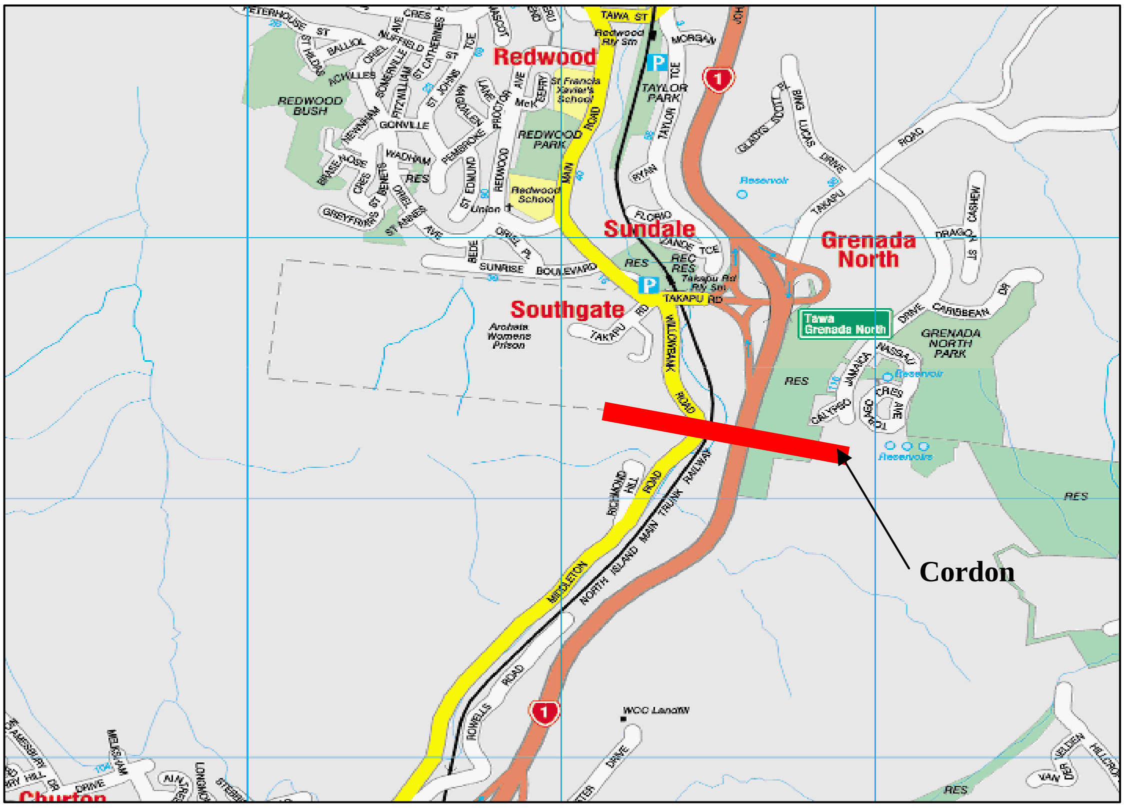


4.5.3 Tawa / Petone Cordon

The Tawa / Petone cordon is located to capture trips from the north of the region on the SH1 corridor and from the Hutt Valley on the SH2 corridor prior to merging at Ngauranga.

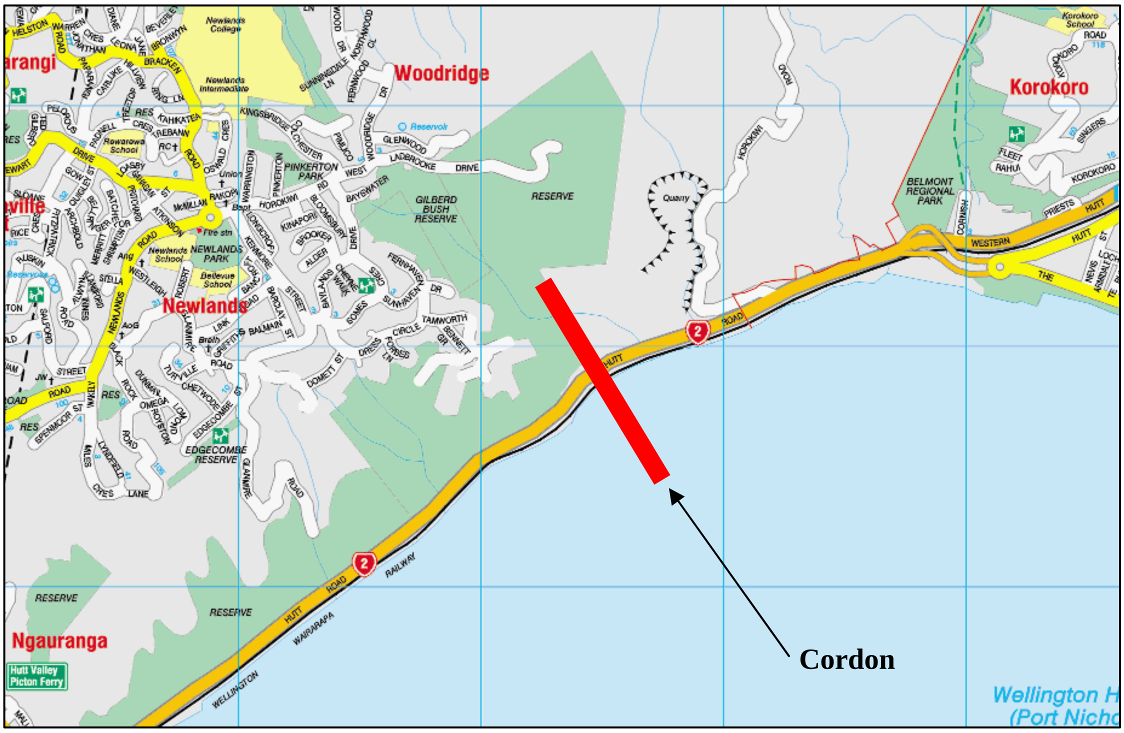
The charging points at the Tawa section of the cordon were placed on SH1, immediately south of the Tawa / North Grenada interchange and on Middleton Road (the local road which runs parallel to the motorway) as indicated in Figure 4-6.

- **Figure 4-6: Tawa Charging Point Locations**



The charging point at the Petone section of the cordon was placed on SH2, immediately south of the junction with The Esplanade which runs along the Petone foreshore, as indicated in Figure 4-7.

- **Figure 4-7: Petone Charging Point Location**

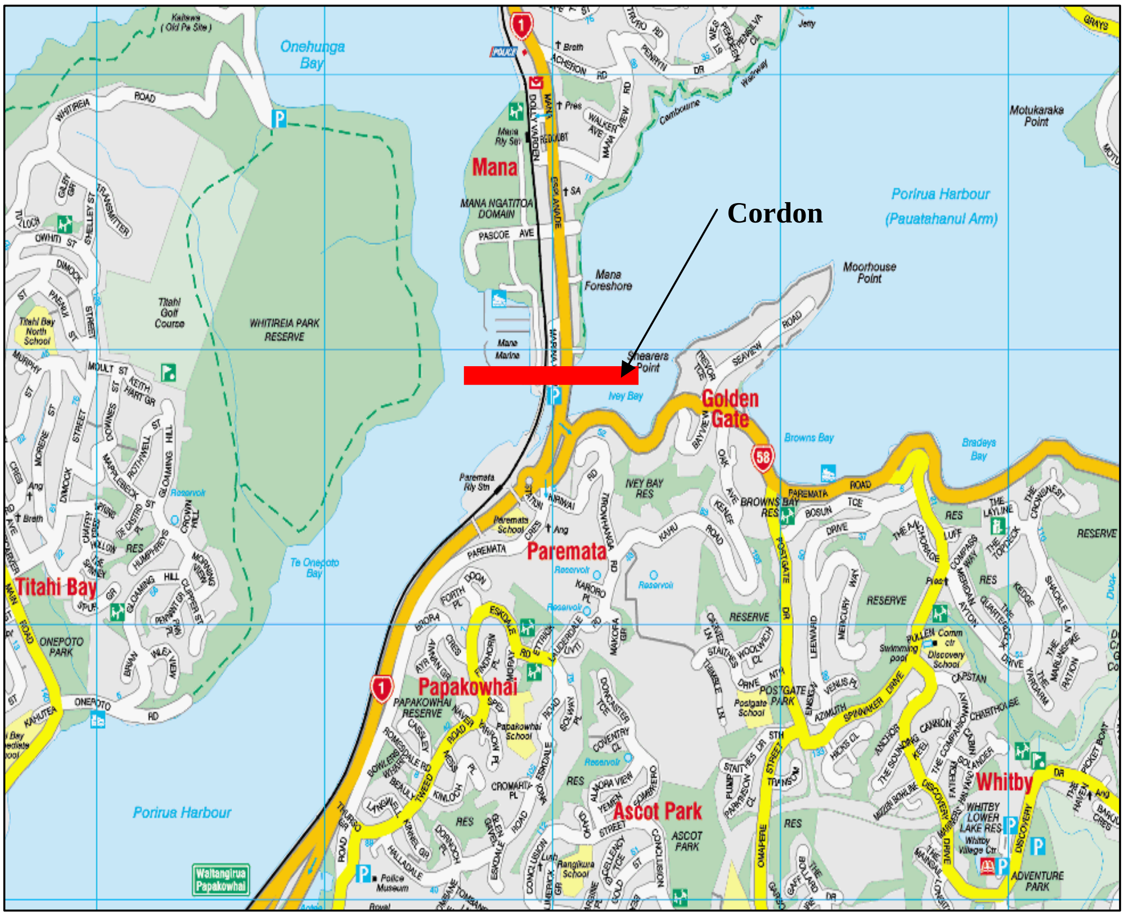


4.5.4 Mana / Hutt Cordon

The Mana / Hutt cordon is located to capture trips from the northernmost parts of the region on the SH1 corridor and north of the Hutt Valley on the SH2 corridor.

The charging point at the Mana section of the cordon was placed on the SH1 Mana Bridge, immediately north of the Paremata roundabout where SH1 joins with SH58 Paremata Road (Figure 4-8).

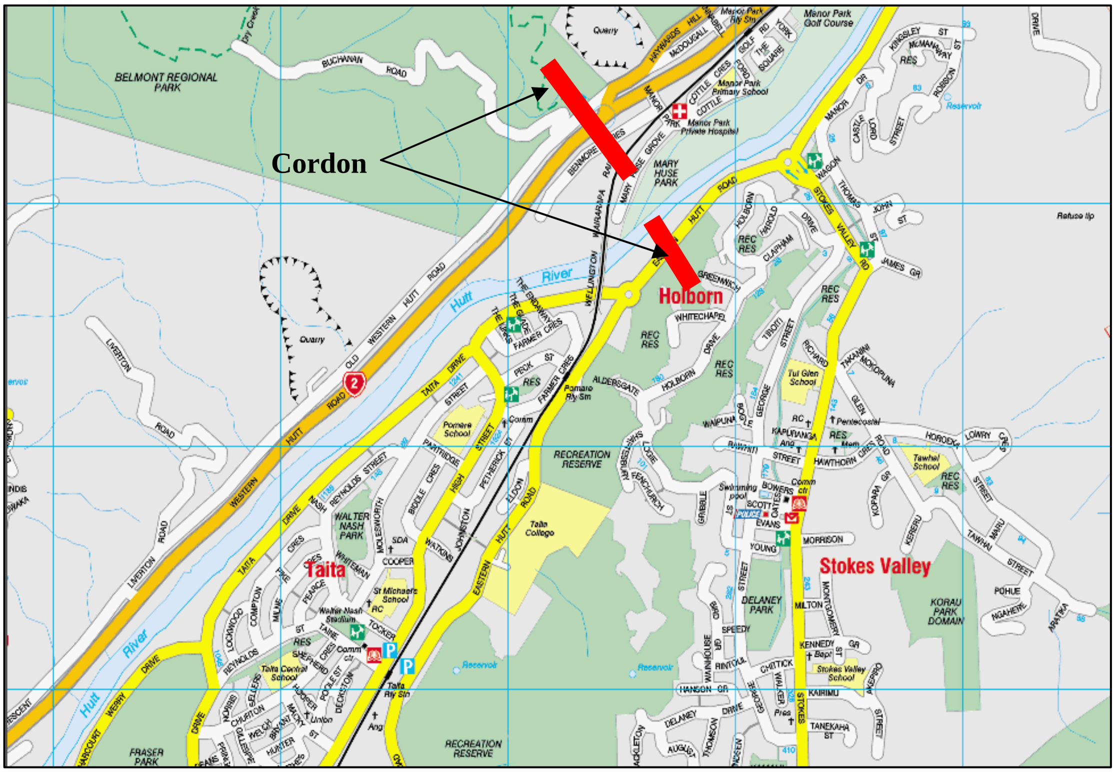
- **Figure 4-8: Mana Charging Point Location**



SKM

The charging points at the Hutt section of the cordon have been placed on SH2, immediately south of the junction with SH58 Haywards Hill and on Eastern Hutt Road (Figure 4-9).

- **Figure 4-9: Hutt Charging Point Location**



4.6 Pricing Options Tested

Using the cordon locations detailed above, four alternative cordon charging strategies were identified, each to be tested with varying levels of charge. These options are as follows:

- the Wellington CBD cordon
- the Ngauranga cordon
- the Y screenlines (combining the Ngauranga, Tawa/Petone and Mana/Hutt cordons)
- the Wellington CBD plus the Y screenlines

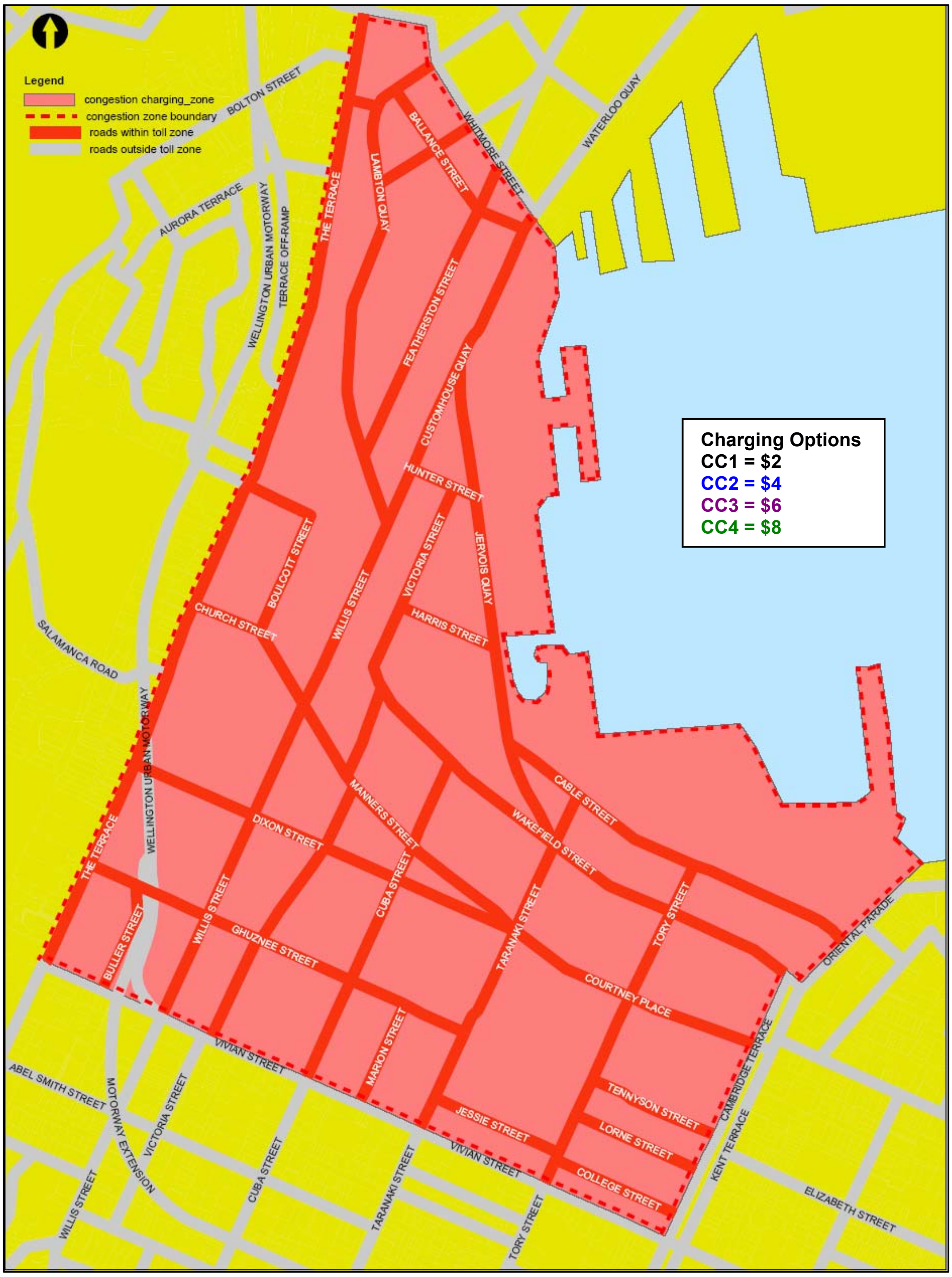
Given that the prime objective is to reduce congestion in peak periods, tolls are only imposed in the periods between 7 to 9am and 4 to 6pm. Clearly, with a system in place, alternative charging rates and times could be applied. However, as this study has not yet addressed issues of public acceptability in detail, these initial tests were limited to a minimal charge imposition with tolls broadly comparable with the equivalent public transport fares. This was seen to be a suitable benchmark to start from, in establishing whether a viable pricing system could be identified.

4.6.1 The Wellington CBD Charging Cordon

The Wellington CBD cordon intercepts all peak period traffic to/from the CBD. Four charging levels between $2 and $ 8 were tested (Figure 4-10), denoted CC1 to CC4. All vehicles crossing the cordon were assumed to pay the same charge regardless of location. Charges were made for trips that crossed the cordon in the peak direction i.e. inbound to the CBD in the AM peak and outbound from the CBD in the PM peak.

SKM

- **Figure 4-10: Wellington CBD Cordon Charging Options**

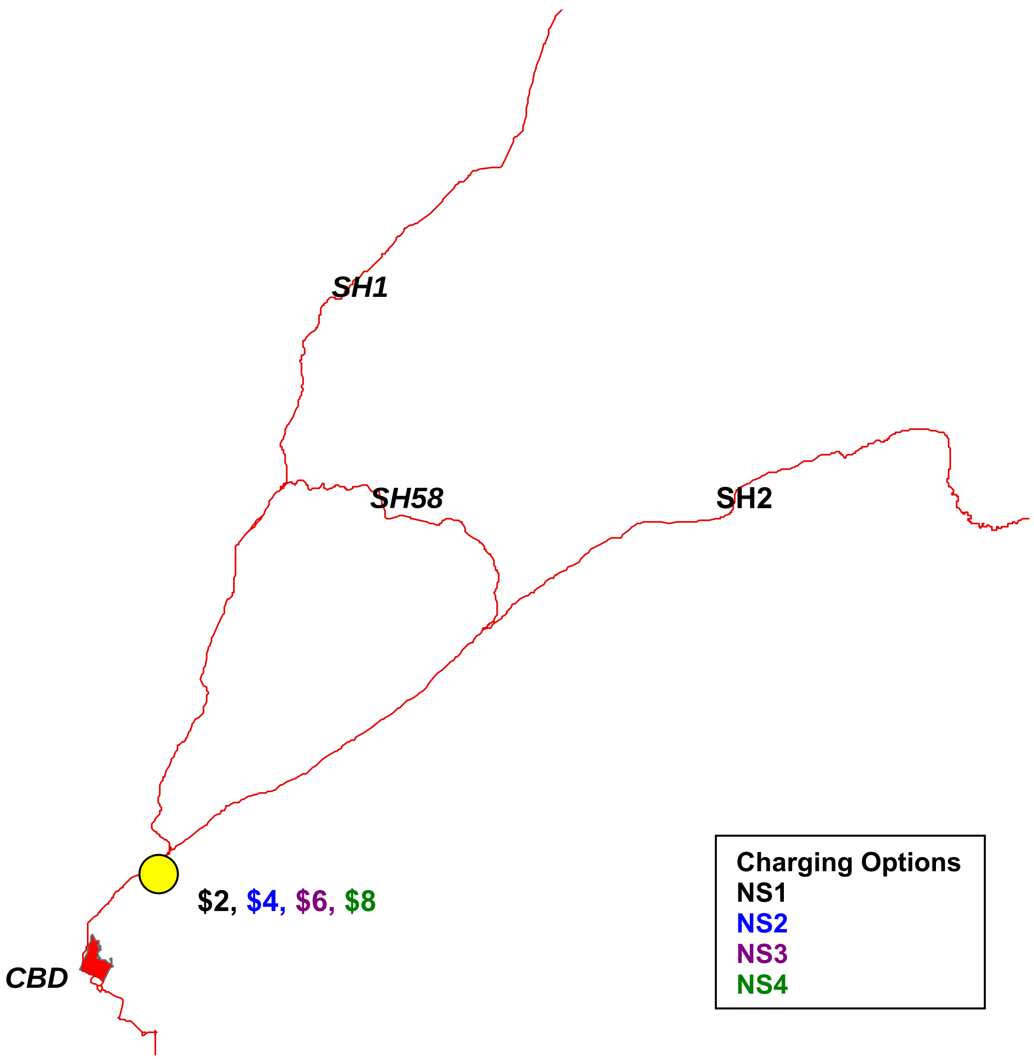


4.6.2 The Ngauranga Charging Cordon

Due to the topography of the region, the strategic routes into Wellington are very restricted. SH1 and SH2 join at the bottom of the Ngauranga Gorge and run along the coast into the central city. There are therefore a very limited number of charging points required for the Ngauranga Screenline (NS) option to be able to intercept the majority of trips from the north.

Four charging levels between $2 and $8 were tested (Figure 4-11). Charges were levied for trips that crossed the cordon in the peak direction i.e. inbound towards Wellington CBD in the AM peak and outbound away from the CBD in the PM peak.

- **Figure 4-11: Ngauranga Screenline Charging Options**



SKM

4.6.3 The Y Charging Screenlines

The “Y” options have been named as such because of the resemblance the strategic road network layout has to a Y. Using the charging optimisation methodology described in Section 3.3, 3 sets of charging strategies have been developed, termed ‘outer’, ‘inner’ and ‘medium’ emphasis.

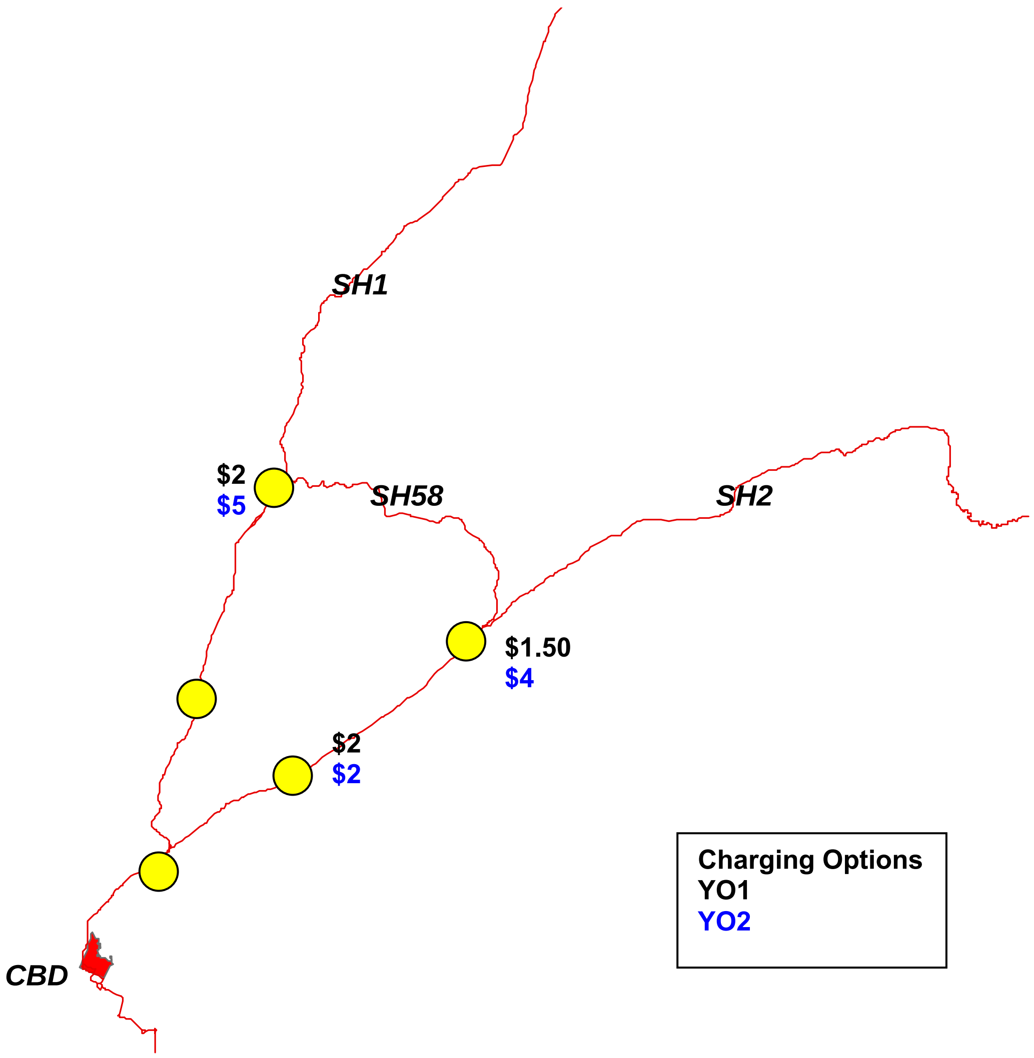
The ***Y screenlines (outer emphasis) option*** (YO) was designed to impose higher charges on longer distance trips in the peak, to reduce their impact on congestion. Therefore, charging was focussed on trips originating from the north of the region travelling to or from the central Wellington area.

Two levels of charges were tested (options YO1 and YO2) as shown in Figure 4-12, where the yellow dots represent the charging points and the amounts are linked to the notation for the options tested by colour.

The lowest charge tested was $1.50 for trips between Upper and Lower Hutt. The highest charge paid would be $6 for trips originating north of Lower Hutt and terminating in the central Wellington area. In that situation, $4 would be charged at the Hutt cordon and $2 would be charged at the Petone cordon. Trips coming from Tawa, Johnsonville etc. on the SH1 corridor and accessing SH1 below the Mana cordon would experience no charge. Trips originating closer to the CBD than the Petone cordon would also experience no charge.

Charges were only modelled for trips that crossed the cordons in the peak direction i.e. inbound towards Wellington CBD in the AM peak and outbound away from the CBD in the PM peak.

- **Figure 4-12: Y Screenline (outer emphasis) Charging Options**



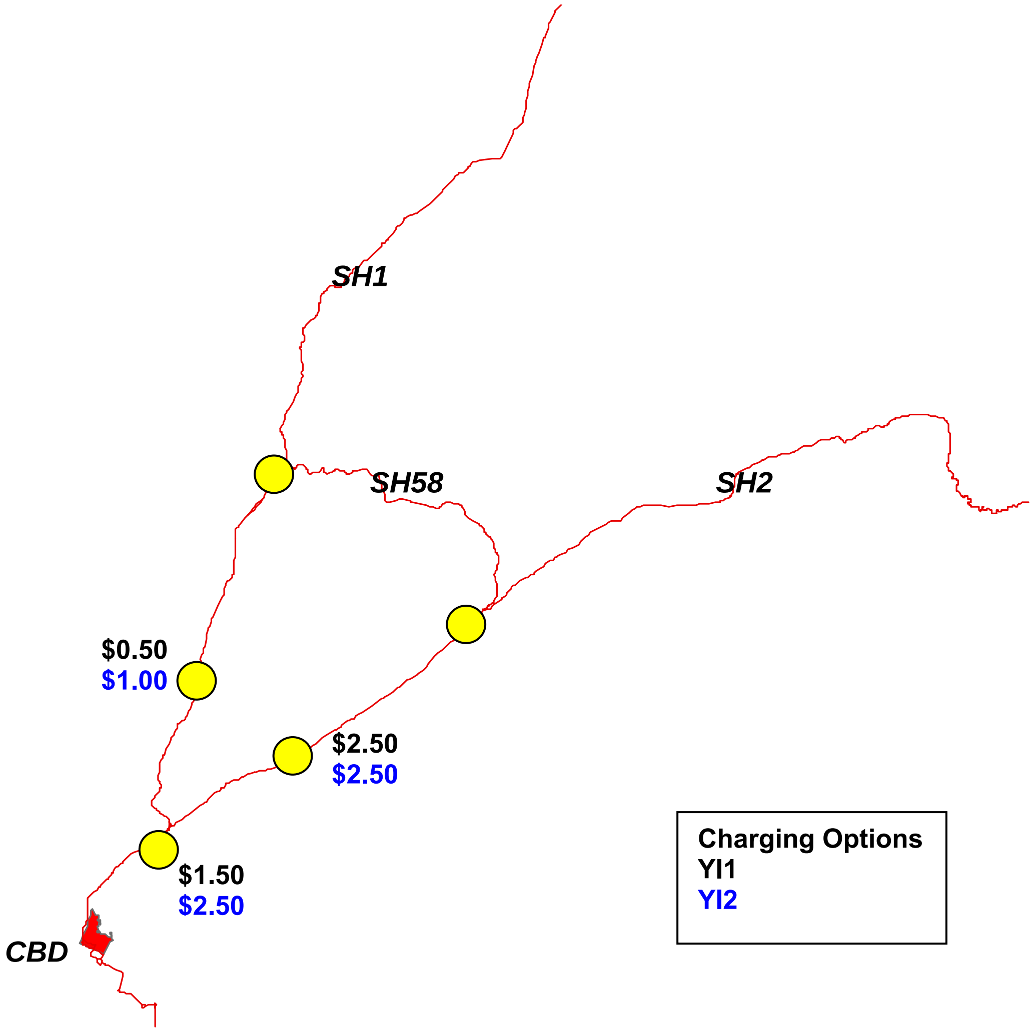
The ***Y screenlines (inner emphasis) option*** (YI) was designed to impose higher charges on trips closer to Wellington City to reduce their impact on congestion. Therefore, charges were only levied at the Ngauranga cordon and at the Tawa / Petone cordon.

The charges tested for options YI1 and YI2 are set out in Figure 4-13. The lowest charge tested was $0.50 for trips between the area north of Tawa and the Ngauranga merge. The highest charge paid would be $5 for trips originating north of Petone on the SH2 corridor and ending in the central Wellington area. In that situation, $2.50 would be charged at the Petone cordon and $2.50 would be charged at the Ngauranga cordon.

The charges are higher for trips from the Hutt Valley on the SH2 corridor than for trips from the north on the SH1 corridor, reflecting the results of the charging optimisation process.

Charges were for trips that crossed the cordons in the peak direction i.e. inbound towards Wellington CBD in the AM peak and outbound away from the CBD in the PM peak.

- **Figure 4-13: Y Screenline (inner emphasis) Charging Options**



The ***Y screenlines (medium emphasis) option*** (YM) was designed to impose charges more evenly across the Y network, with modest tolls at all cordons.

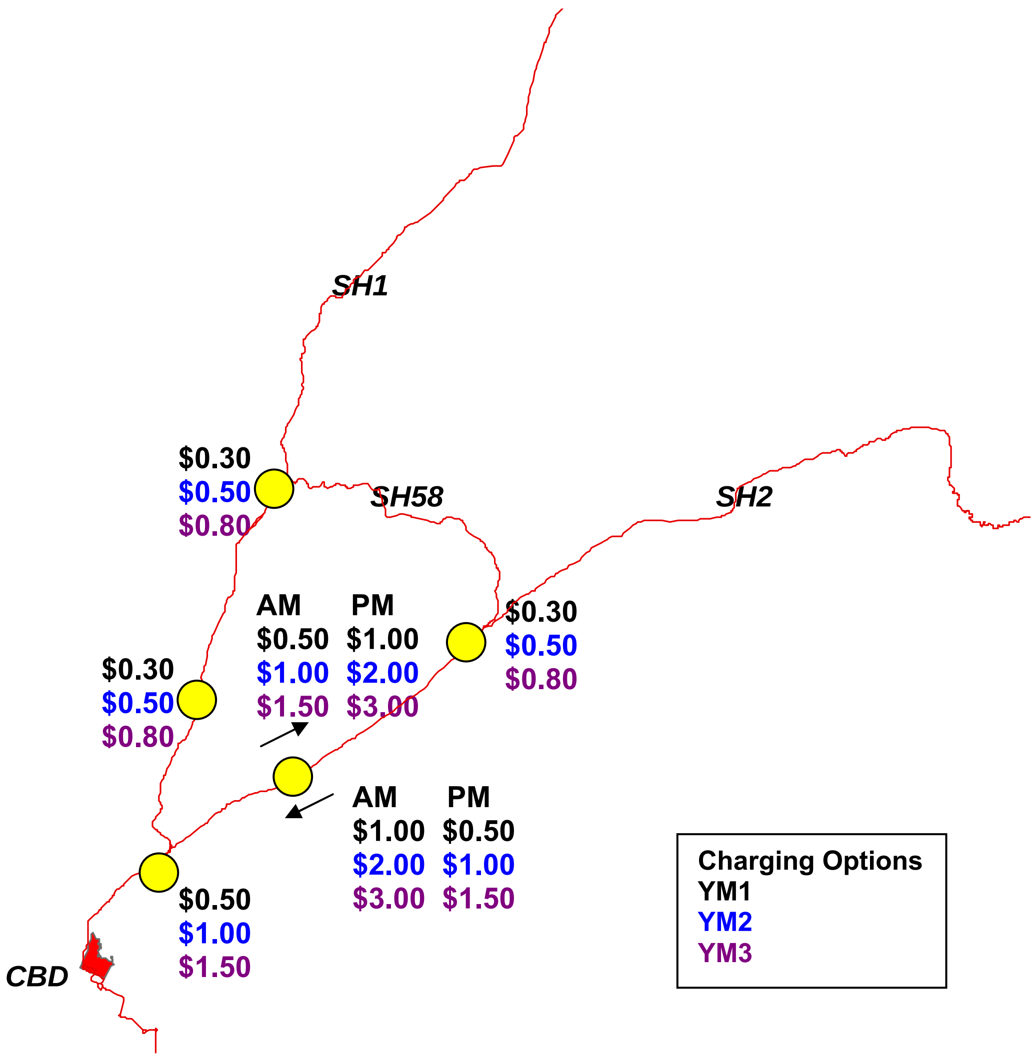
The charges tested for options YM1 – YM3 are set out in Figure 4-14 . The lowest charge tested was $0.30 for trips only crossing the Tawa, Hutt or Mana cordons. The highest charge paid would be $5.30 for trips originating north of Lower Hutt on the SH2 corridor and ending in the central Wellington area. In that situation, $0.80 would be charged at the Hutt cordon, $3.00 would be charged at the Petone cordon and $1.50 would be charged at the Ngauranga cordon.

It should be noted that while the larger number of charging points mean that the total number of trips that incur a charge is likely to be greater, the individual charges are lower than the other Y options, although charges continue to be relatively higher for trips from the Hutt Valley on the SH2 corridor than for trips from the north on the SH1 corridor.

Charges were generally made for trips that crossed the cordons in the peak direction i.e. inbound towards Wellington CBD in the AM peak and outbound away from the CBD in the PM peak. However, the charging optimisation process undertaken also indicated that congestion levels experienced on SH2 in the counter-peak direction warranted counter-peak charges at the Petone cordon. The directional charges are indicated by the arrows in Figure 4-14 below.

SKM

▪ **Figure 4-14: Y Screenline (medium emphasis) Charging Options**



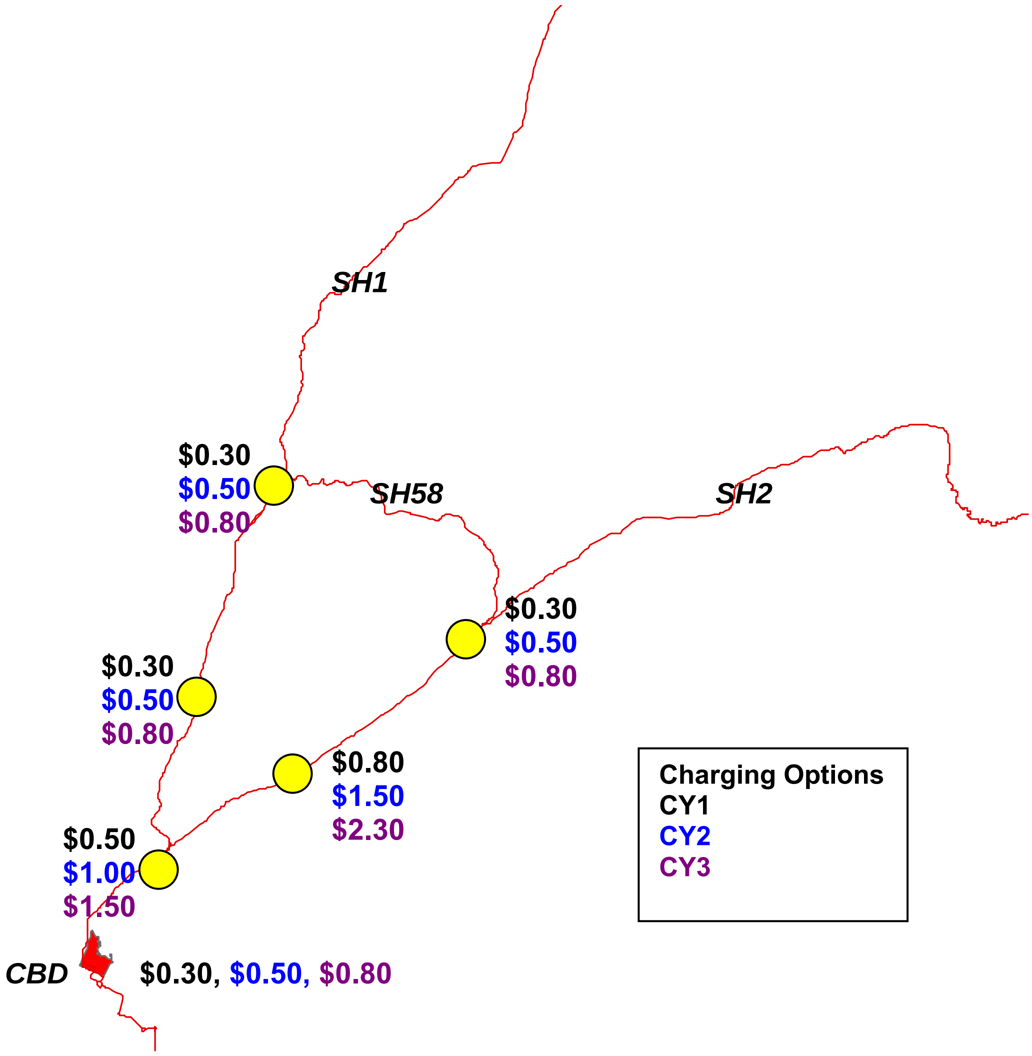
4.6.4 CBD + Y Screenline Charging

The Wellington CBD plus Y screenlines option (CY) was designed to impose charges similar to the Y medium emphasis option, but including also a cordon around the CBD.

The charges tested for options CY1 – CY3 are set out in Figure 4-15. The lowest charge tested was $0.30 for trips only crossing the CBD, Tawa, Hutt or Mana cordons. The highest charge paid would be $5.40 for trips originating north of Lower Hutt on the SH2 corridor and ending in the Wellington CBD. In that situation, $0.80 would be charged at the Hutt cordon, $2.50 would be charged at the Petone cordon, $1.50 would be charged at the Ngauranga cordon and $0.80 would be charged at the CBD cordon. Charges continue to be relatively higher for trips from the Hutt Valley on the SH2 corridor than for trips from the north on the SH1 corridor.

Charges were applied for trips that crossed the cordons in the peak direction i.e. inbound towards Wellington CBD in the AM peak and outbound away from the CBD in the PM peak.

■ **Figure 4-15: CBD + Y Screenlines Charging Options**



5. Preliminary Screening of Pricing Options

5.1 Introduction

After each of the options described in Section 4 were modelled, an assessment was made of each option with regard to the evaluation framework and performance measures described in Section 2. An initial screening indicated that some charging options were much less effective and could be discounted, as described below.

In addition, some analysis of the general forecast impacts of road pricing, not directly related to the formal evaluation, but useful in understanding the network response, was undertaken. This included reviewing changes in modal shares, private vehicle vkt and travel times, and changes in traffic flows on different parts of the network. An overview of the general road pricing forecasts for the different options is included in Appendix B.

5.2 CBD Cordon and CBD Cordon + Y Options

The user benefits of these options are generally negative with the time savings north of Ngauranga offset by increases in congestion on the approaches to Wellington CBD. For the $4 toll case the Ngauranga to CBD peak journey time increases over the do minimum by 65% and the time from the CBD to the airport by 20%. The volume-to-capacity ratio on the Terrace Tunnel off-ramp also increases from 1.04 to 1.23.

These options also have high capital and operating costs due to the large number of tolling points.

It was therefore concluded that a tightly drawn cordon around the CBD, in which through traffic diverted to the Terrace Tunnel, is neither effective nor viable, and that it should not be considered further. In the next stage, the merits of a more intuitively designed area cordon, which would not divert traffic onto already congested routes, may be explored.

5.3 Ngauranga Screenline Option (at high charging levels)

The higher toll levels ($6 and $8) for this option bring no additional benefits or time savings over the more acceptable lower tolls, primarily because the volume-to-capacity ratio at the Ngauranga bottleneck has been reduced to around 0.5, such that this part of the network is underutilised. Also, higher charges are less likely to be acceptable. Hence our detailed analysis was restricted to the lower toll levels ($2 and $4) for this option.

5.4 Outer Y Option

Similarly, the Outer Y option provides reasonable time savings at the lower toll level but only very small additional savings at the higher level, a consequence of increased congestion south of Porirua and in the Ngauranga Gorge, upstream of the Y (where the volume-to-capacity ratio is 1.08 with the high toll level, compared with 1.04 for the do minimum). For these reasons, the high toll level was not considered further.

6. Option Evaluation

6.1 Objective 1 & 3: Assisting Economic Development and Improving Access and Mobility

The objectives Assisting Economic Development and Improving Access and Mobility were considered together in the evaluation. The following measures were used in the evaluation, and are discussed in turn:

- The impacts on travel demand
- Travel times and speeds
- Congestion
- User charges
- Social impacts

6.1.1 The impact on travel

The impact on travel were measured in terms of:

- person-kilometres of travel by private vehicle, passenger transport and heavy commercial vehicle, and
- private vehicle and passenger transport trips in the AM peak.

Table 6-1 gives the person-kilometres of travel by private vehicle, passenger transport, and heavy commercial vehicle in each of the three modelled time periods and Figure 6-1 presents this for the AM peak period.

All options have a negative impact on travel, in that the sum of person-kilometres is less than in the no pricing case. Private vehicle person-kilometres have a maximum reduction of 5% in the AM peak for theYM3 option. The sum of all person-kilometres has a maximum reduction of 2% in the AM peak for the same option. These reductions will be the result of redistribution (shorter trips) and retiming (travelling outside the charged periods). There is no significant change in person-kilometres in the non-charged Interpeak period.

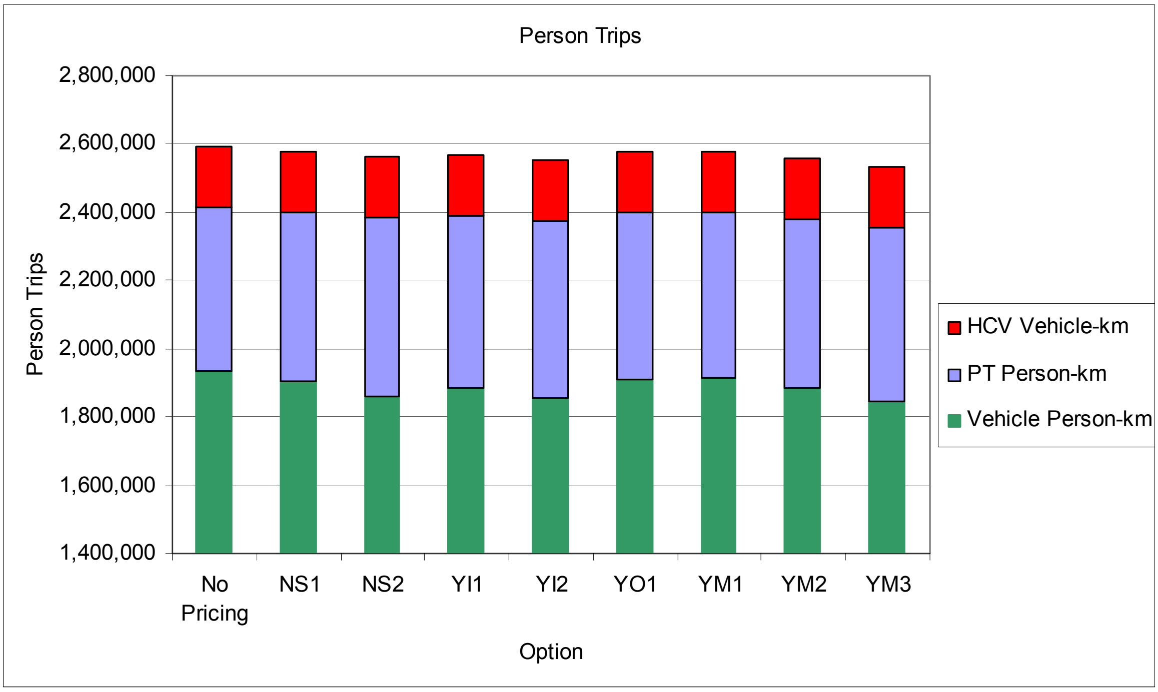
Change in HCV person-kilometres is due to changes in routes taken. The number of HCV trips and their distribution (i.e. the HCV trip matrix) remains the same.

The person-kilometres by passenger transport increases over the do minimum with all options in both the AM peak and the Interpeak, the greatest being with the Ngauranga Screenline at the higher ($4) level.

Table 6-1: Person-kilometres of Travel – Percentage Change

	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
AM								
Private vehicle	-1.6	-3.8	-2.6	-4.3	-1.5	-1.2	-2.6	-4.7
PT	4.0	5.2	-3.3	3.3	-5.2	-1.6	2.2	2.9
HCV	0.0	0.1	0.1	-0.1	0.3	-0.4	0.1	0.2
IP								
Private vehicle	-0.2	-0.5	-0.3	-0.6	-0.1	-0.1	-0.3	-0.7
PT	2.1	5.0	3.0	4.9	1.5	0.9	2.1	3.7
HCV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PM								
Private vehicle	-1.6	-3.6	-2.8	-4.3	-1.6	-1.2	-2.8	-4.6
HCV	0.0	0.0	0.2	0.1	0.4	0.0	0.1	0.3

Figure 6-1: Person-kilometres of Travel (AM peak)



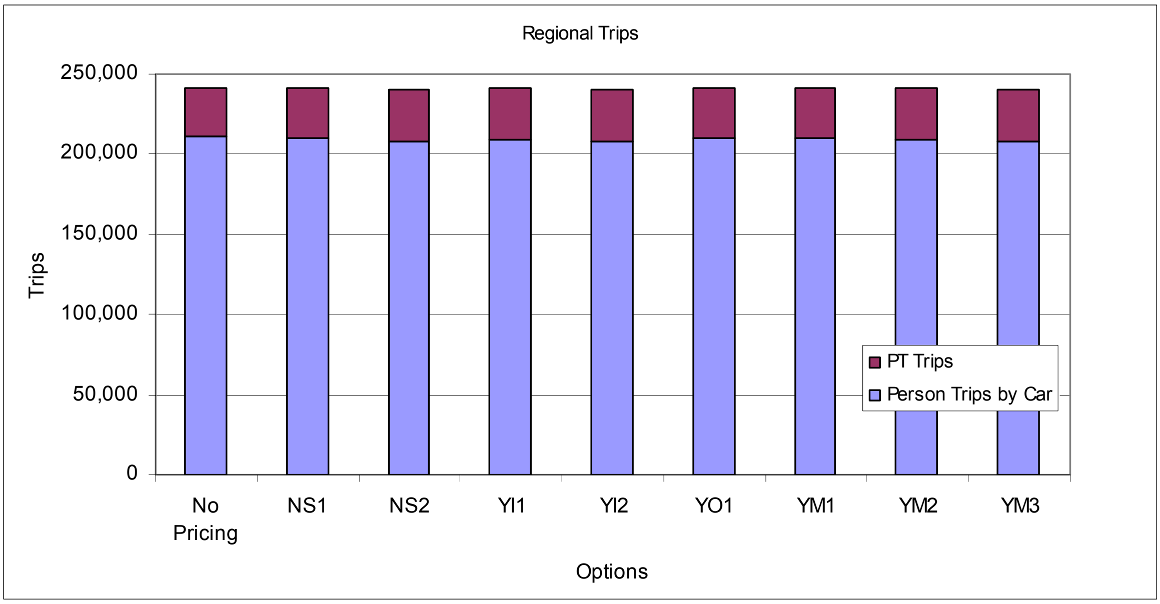
The second measure for the impact on travel is the number of persons travelling by private vehicle and passenger transport in the AM peak. Table 6-2 gives these data, which is also shown graphically in Figure 6-2.

All options have fewer total trips in the AM peak and therefore a negative impact on travel. The reductions are all within 1%; the largest occurs with the Medium Y option at the highest charging level, -0.6%.

- **Table 6-2: AM Peak Person Trips – Percentage Change**

	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Private vehicle	-0.6	-1.4	-0.9	-1.4	-0.5	-0.3	-0.7	-1.4
PT	3.0	6.7	3.9	6.2	1.7	1.2	2.7	4.6
Sum	-0.2	-0.4	-0.3	-0.4	-0.2	-0.1	-0.3	-0.6

- **Figure 6-2: AM Peak Person Trips**



This shows that while the impact on travel is negative, the scale of the reduction in person-kilometres and number of trips is minor and unlikely to significantly effect economic development, access and mobility. Table 6-3 gives the qualitative ratings for the impact of the pricing options on travel as measured by person-kilometres of travel and the number of person trips by vehicle and PT. Those higher toll strategies which reduce overall travel demand were marked down as reducing mobility and in turn potentially impacting adversely on economic development.

- **Table 6-3: Impact on Travel**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Impact on Travel	0	0	X	0	X	0	0	X	X

6.1.2 Travel times and speeds

Vehicle travel times and speeds were measured with:

- vehicle travel times on routes, and
- average private vehicle and passenger transport speeds

All options improve the travel times on some routes (Table 6-4 and Figure 6-3):

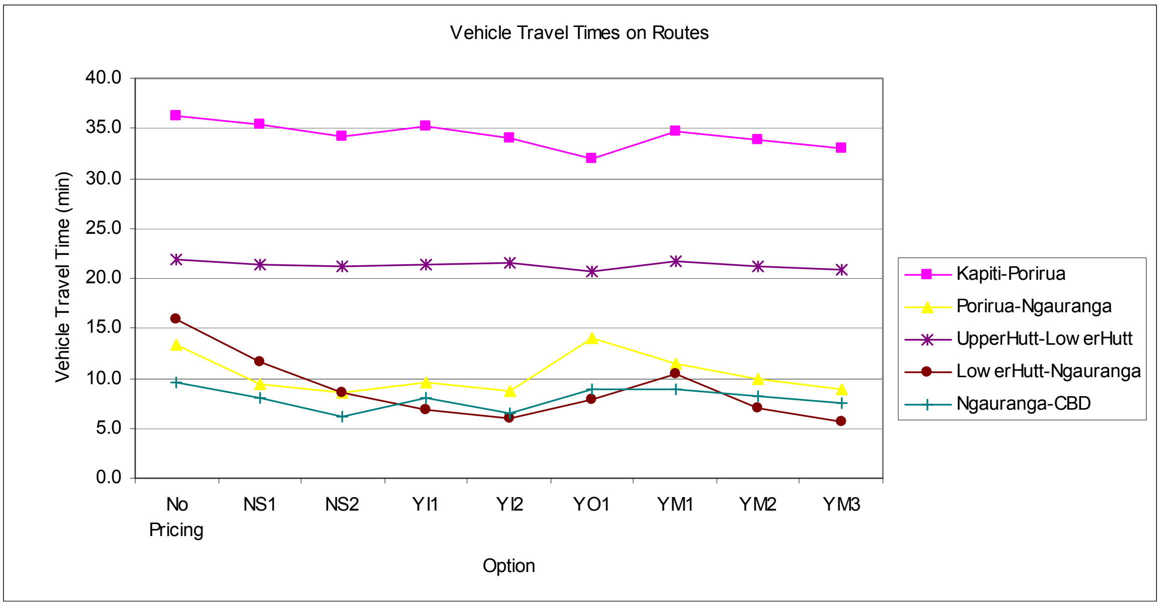
- all options, but the Outer Y, improve travel times from Porirua and Lower Hutt to the CBD between 20 and 40%;
- the Outer Y option only improves the times between Lower Hutt and Ngauranga and to a lesser extent Kapiti to Porirua;
- none of the options improve times significantly from Masterton to Upper Hutt to Lower Hutt;
- in the contra-peak direction and between the CBD and the airport there is little change.

- **Table 6-4: Vehicle Travel Times on Routes**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Kapiti-Porirua	36.2	35.4	34.2	35.2	34.0	31.9	34.7	33.8	32.9
Porirua-Ngauranga	13.3	9.4	8.6	9.6	8.7	14.0	11.5	9.9	8.9
Masterton-Upper Hutt	58.2	58.2	58.2	58.2	58.2	58.2	58.2	58.2	58.2
Upper Hutt-Lower Hutt	21.8	21.4	21.1	21.3	21.6	20.7	21.7	21.3	20.9
Lower Hutt-Ngauranga	15.8	11.5	8.5	6.9	6.1	7.9	10.5	7.0	5.7
Ngauranga-CBD	9.6	8.0	6.2	8.0	6.5	8.9	8.9	8.3	7.5
CBD-Airport	13.5	13.3	13.1	13.4	13.2	13.5	13.5	13.4	13.3
Porirua-Kapiti	31.5	31.4	31.4	31.4	31.4	31.1	31.4	31.4	31.3
Ngauranga-Porirua	8.4	8.4	8.4	8.3	8.3	8.3	8.4	8.3	8.3
Upper Hutt-Masterton	61.4	61.4	61.5	61.4	61.4	61.4	61.4	61.4	61.4
Lower Hutt-Upper Hutt	21.0	20.9	20.7	20.9	20.9	20.7	20.9	20.8	20.6
Ngauranga-Lower Hutt	7.3	7.6	7.2	6.0	5.5	6.9	6.5	5.6	5.1
CBD-Ngauranga	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Airport-CBD	17.5	17.6	17.5	17.5	17.3	17.3	17.2	17.3	17.2

SKM

■ **Figure 6-3: Vehicle Travel Times on Routes**



This indicates that road pricing in Wellington could significantly reduce travel times on some important routes. Table 6-5 gives the resulting scores for the measure, vehicle travel times on routes, in which those options which most improve travel times (and reduce congestion) were marked highest.

■ **Table 6-5: Vehicle Travel Times on Routes**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Veh Travel Times	0	√	√√	√√	√√√	√√	√	√√	√√√

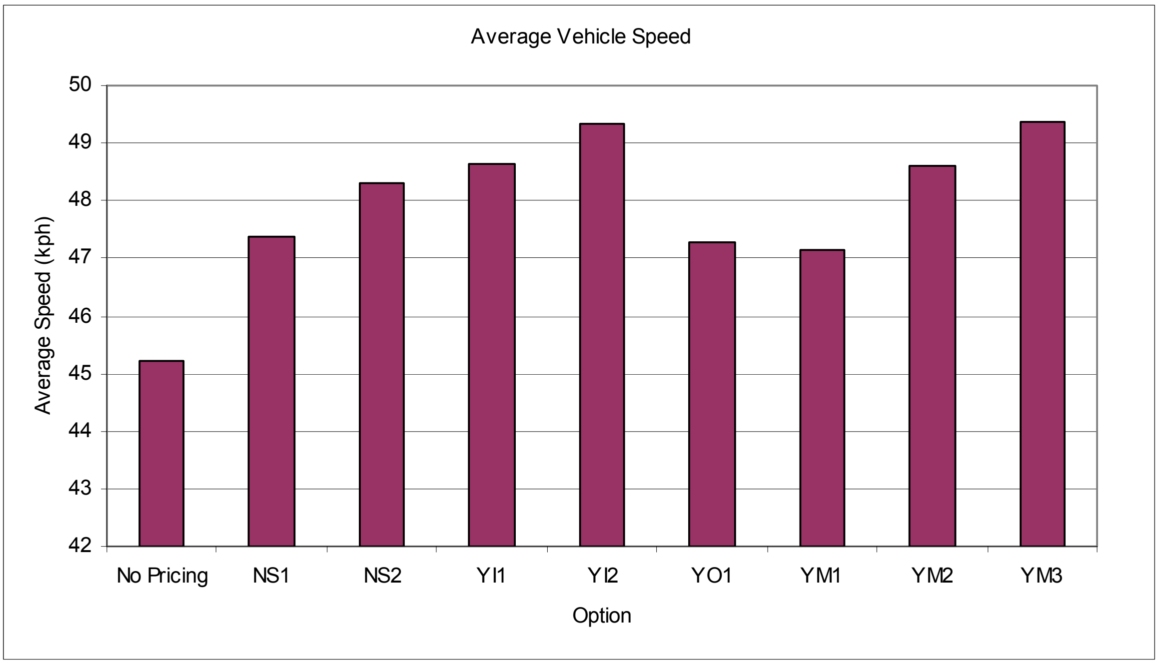
Average speeds by private vehicle (Table 6-6 and Figure 6-4) increase by 4-9% over the whole network; the greatest improvements being for the Inner and Medium Y options at the higher charging levels. The average PT speeds (which are weighted by the trips made by each mode) increase very slightly over the no pricing case, by 1-3%, due to improved bus speeds, whereas rail speeds remain constant.

■ **Table 6-6: Average Private Vehicle and PT Speeds**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Private Vehicle	45	47	48	49	49	47	47	49	49
PT	21	21	21	21	21	21	21	21	21

SKM

▪ **Figure 6-4: Average Private Vehicle Speeds**



This clearly shows that road pricing in Wellington could significantly increase average vehicle speeds. Table 6-7 gives the resulting scores for the measure, average private vehicle and PT speeds, in which those options which most improve average speeds were marked highest.

▪ **Table 6-7: Average Private Vehicle and PT Speeds**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Private Vehicle	0	√√	√√	√√√	√√√	√√	√√	√√√	√√√
PT	0	0	0	0	0	0	0	0	0
Resultant	0	√	√	√√	√√	√	√	√√	√√

6.1.3 Congestion

Congestion was measured using:

- the level of congested vehicle-kilometres, where congested is defined as volume/capacity >0.8, and
- volume/capacity at identified bottlenecks

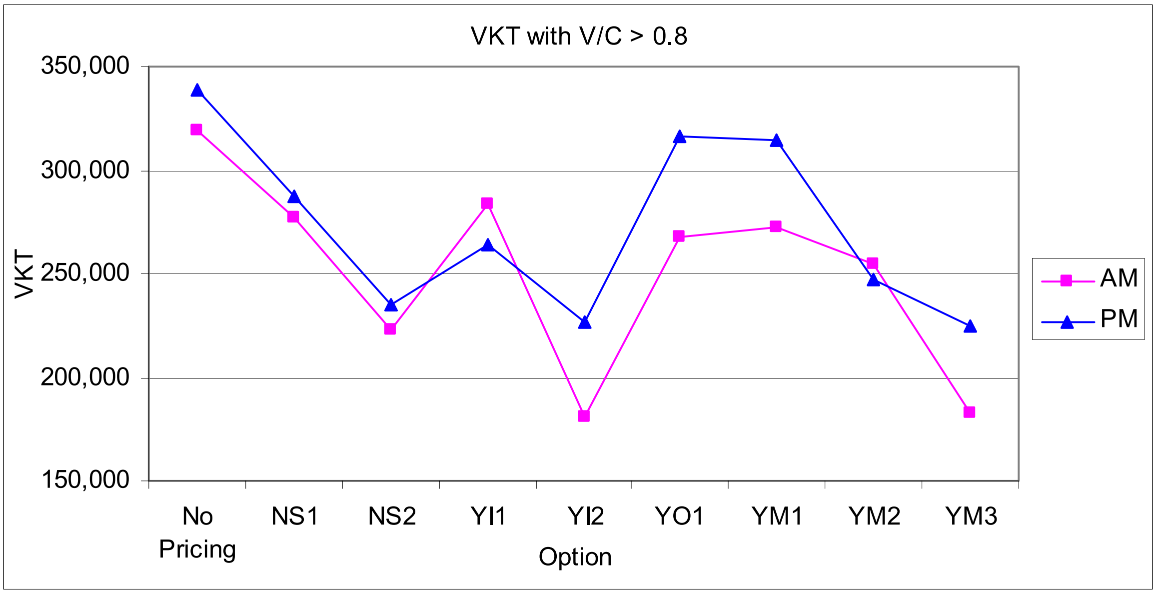
SKM

All options have a positive impact on the level of congestion by reducing the amount of congested VKT (Table 6-8 and Figure 6-5). This impact increases with the level of the charges. The Inner and Medium Y options at the high levels provide the greatest reductions in congested VKT.

- **Table 6-8: Congested VKT (000 km)**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
AM	319	277	223	283	181	267	273	255	182
IP	37	37	37	37	37	37	37	37	37
PM	338	288	235	264	227	317	314	247	225

- **Figure 6-5: Congested VKT**



This indicates that road pricing in Wellington could significantly reduce congestion on the road network. Table 6-9 gives the resulting scores for the measure, in which those options which most reduce congestion (congested VKT) were marked highest.

- **Table 6-9: Congested Vehicle-Kilometres**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Congested VKT	0	√	√√	√	√√√	√	√	√	√√√

Table 6-10 gives the volume to capacity ratio at selected existing congestion bottlenecks in the morning peak and highlights the number of bottlenecks where the V/C <1. The options generally improve the network performance at these bottlenecks, but this varies between the sites and the options as follows.

- None of the options tested improve the Mt Victoria Tunnel, which is not unexpected since no charges are applied east of the CBD. The Terrace Tunnel still has poor performance with all options.
- The higher charging level at the Ngauranga Screenline addresses congestion at this point, while the other options improve it only slightly.
- At SH1 upstream of Ngauranga all but the Outer Y and the low level Medium Y improve the congestion level. The higher level of the Ngauranga Screenline option reduces the ratio (and traffic levels) to an extent that it is tending towards inefficient use of the network.
- On SH2 upstream of Ngauranga only the Medium Y option at the higher charging levels and the Outer Y option alleviate congestion, and the latter reduces traffic to such an extent that it makes inefficient use of the network.
- On SH2 near Petone all the options reduce congestion, though the Inner Y option (both charging levels) and the Medium Y option (highest level) reduce traffic to an extent that the network is inefficiently used.
- On SH2 north of Buchanan the higher levels of the Inner and Medium Y options have some impact on congestion, whereas the other options and levels do not.
- On SH1 just north of the Mana Bridge the higher charging levels of the options reduce congestion as does the Outer Y option.

In summary, the Medium Y option at the highest charging level has the lowest average V/C ratio for the bottlenecks highlighted and also the greatest number of sites with V/C < 1 (7 of the 9 sites). The Inner Y option at the higher level performs the next best in this regard. The lower charging levels do not give much improvement over the no pricing case.

SKM

▪ **Table 6-10: Volume/Capacity at Bottlenecks**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Mt Victoria Tunnel	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Terrace Tunnel off-ramp	1.04	1.02	1.00	1.01	1.00	1.03	1.03	1.02	1.01
SH1 Ngauranga (dnstream of Y)	1.01	0.99	0.88	0.99	0.93	1.00	1.00	0.99	0.98
SH1 Ngauranga (upstream of Y)	1.04	0.95	0.81	0.96	0.88	1.05	1.01	0.97	0.93
SH2 (upstream of Y)	1.05	1.03	1.00	1.02	0.99	0.71	1.00	0.97	0.93
SH2 W Hutt Rd (by Petone)	1.00	0.97	0.92	0.83	0.80	0.90	0.96	0.87	0.75
SH2 W Hutt Rd (nth of Buchn)	1.06	1.05	1.04	1.01	0.98	1.02	1.04	1.01	0.97
SH1 (nth of Mana Br)	1.01	1.00	0.99	0.99	1.00	0.97	1.00	0.99	0.97
Average	1.04	1.01	0.97	0.99	0.96	0.97	1.02	0.99	0.95
No. <1	0	3	4	3	6	4	1	3	7

Table 6-11 gives the resulting scores for the measure. Those options which have the greatest number of bottlenecks with V/C < 1 were marked the highest.

▪ **Table 6-11: Volume/Capacity at Bottlenecks**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Average v/c at bottlenecks	0	0	√	0	√√	√	0	0	√√

6.1.4 User charges

User charges are presented in terms of:

- the average charge paid, and
- the distribution of charges

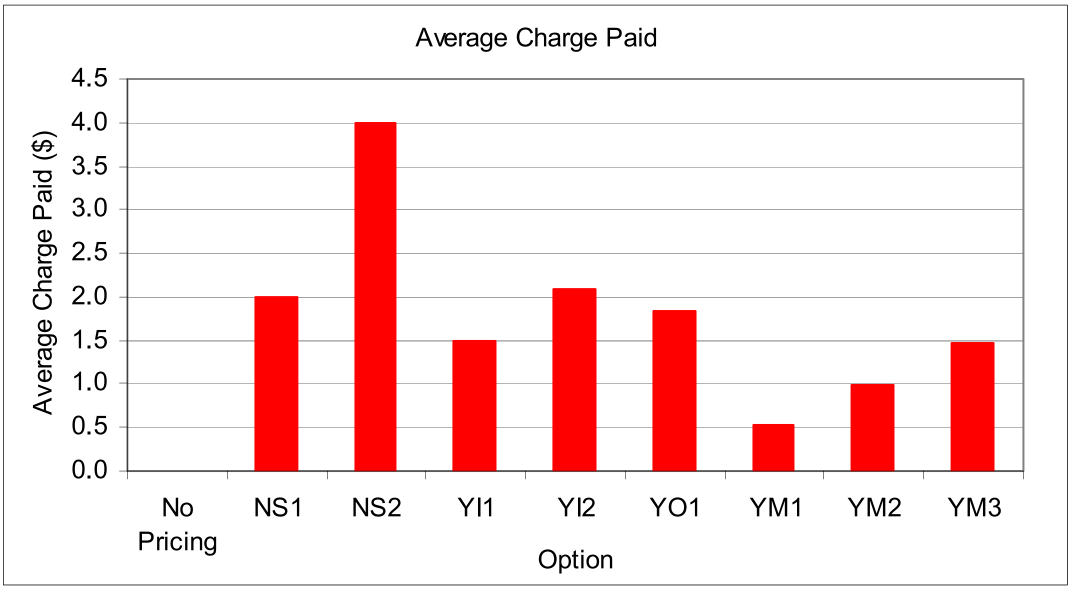
Table 6-12 and Figure 6-6 show the average charge paid of those trips that pay a toll in each of the options.

The $4 charging level for the Ngauranga Screenline option has the highest average, while for the Y options, the averages are lower, especially for the Medium Y option.

▪ **Table 6-12: Average Charge Paid (of those trips that pay a toll)**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Average Charge Paid ($)	0.0	2.0	4.0	1.5	2.1	1.8	0.5	1.0	1.5

- **Figure 6-6: Average Charge Paid**



This shows that a road pricing scheme in Wellington could be designed to have relatively low average toll charges. Table 6-13 gives the resulting scores for the measure, in which those options which have the highest user charges (average charge paid) are marked the lowest.

- **Table 6-13: Average Charge Paid**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Average Charge Paid	0	XX	XXX	XX	XX	XX	X	X	XX

Table 6-14 and Figure 6-7 show the distribution of charges paid, that is the percentage of all vehicle trips that pay different charge levels, including zero charge. Note that the vast majority of trips on the network to not incur any charge and that the vertical scale in Figure 6-7 does not begin at zero in order to show the differences between the options.

In the evaluation a wider distribution of charges and lower charges were considered better than a narrow one. The Ngauranga and Outer Y Options all (or practically all) trips paying charges pay the same amount so were evaluated lower than the other options.

- **Table 6-14: Distribution of Charges**

Charge	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
$0	100%	93%	94%	91%	92%	93%	84%	85%	86%
$1	0%	0%	0%	2%	1%	0%	12%	8%	4%

$2	0%	7%	0%	4%	0%	6%	4%	4%	7%
$3	0%	0%	0%	1%	2%	0%	0%	3%	1%
$4	0%	0%	6%	3%	2%	1%	0%	1%	0%
$5	0%	0%	0%	0%	3%	0%	0%	0%	3%

- **Figure 6-7: Distribution of Charges**

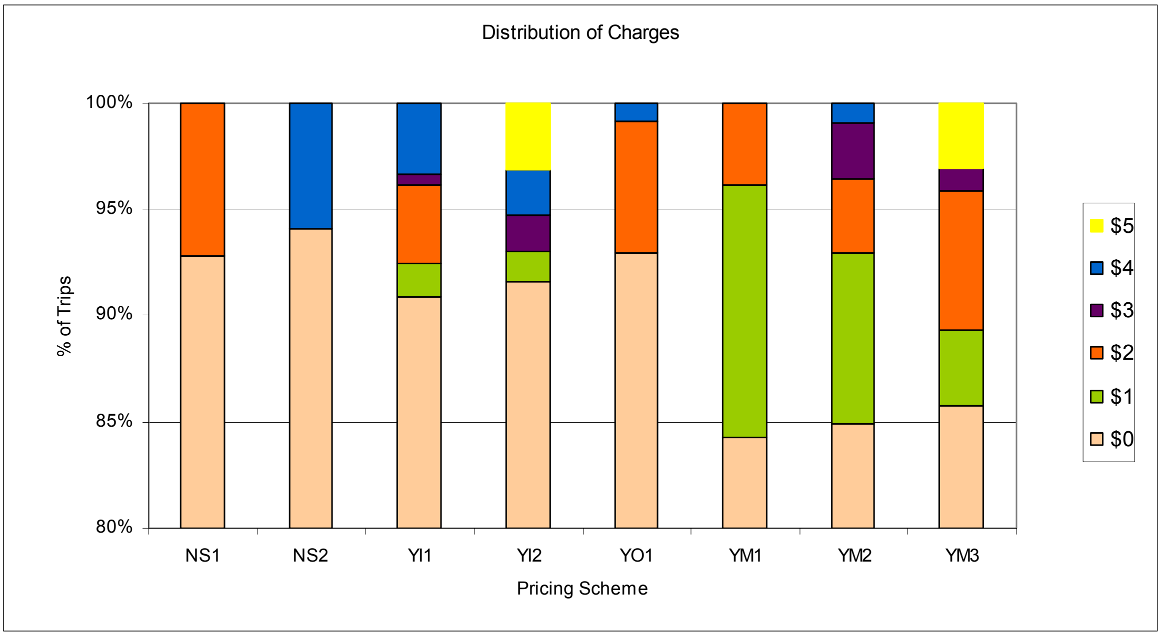


Table 6-15 gives the resulting scores for the measure.

- **Table 6-15: Distribution of Charges**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Distribution of Charges		X	XX	0	0	X	0	0	0

6.1.5 Social impacts

Social impacts were measured by way of:

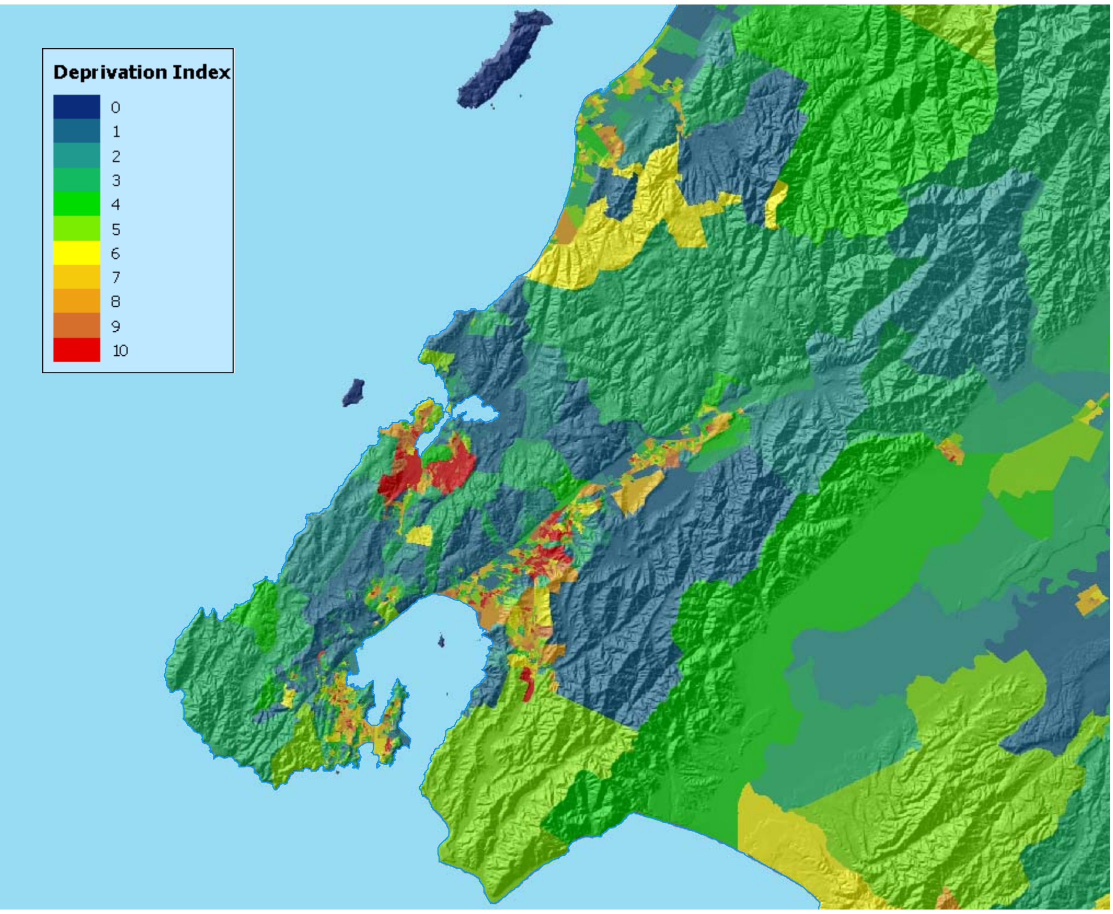
- Distribution of charges in relation to the deprivation index

The deprivation index prepared by Statistics New Zealand combines nine variables from the 2001 census which reflect 8 dimensions of deprivation. It provides a deprivation score for each meshblock in New Zealand. Meshblocks are geographical units defined by Statistics New Zealand containing a median of approximately 90 people in 2001. The index has a score which ranges from

1 to 10, where 1 represents areas with the least deprived scores and 10 the areas with the most deprived scores.

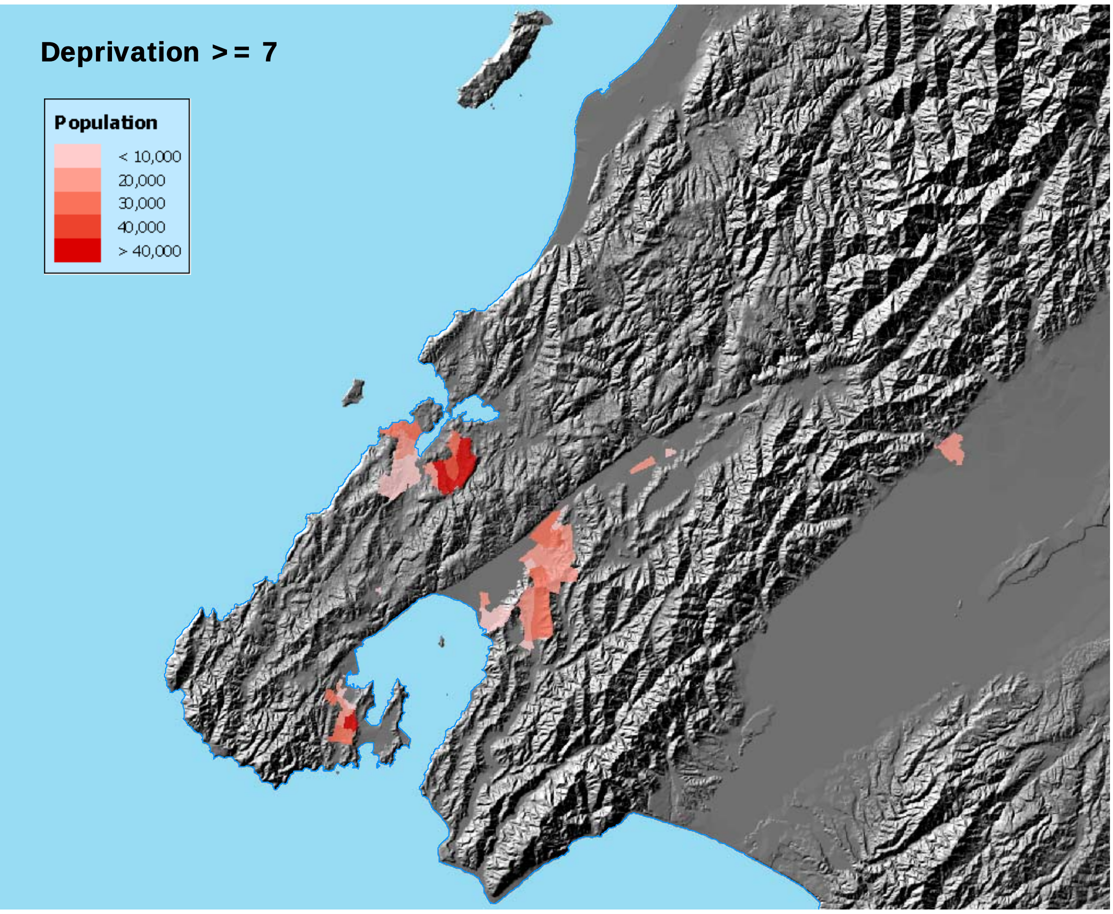
To enable direct correlation with the WTSM model outputs, the meshblock scores were combined, using a population weighted average approach, to give a score for each model zone. The deprivation index is represented in Figure 6-8 below.

- **Figure 6-8: Deprivation Index by WTSM model zone**



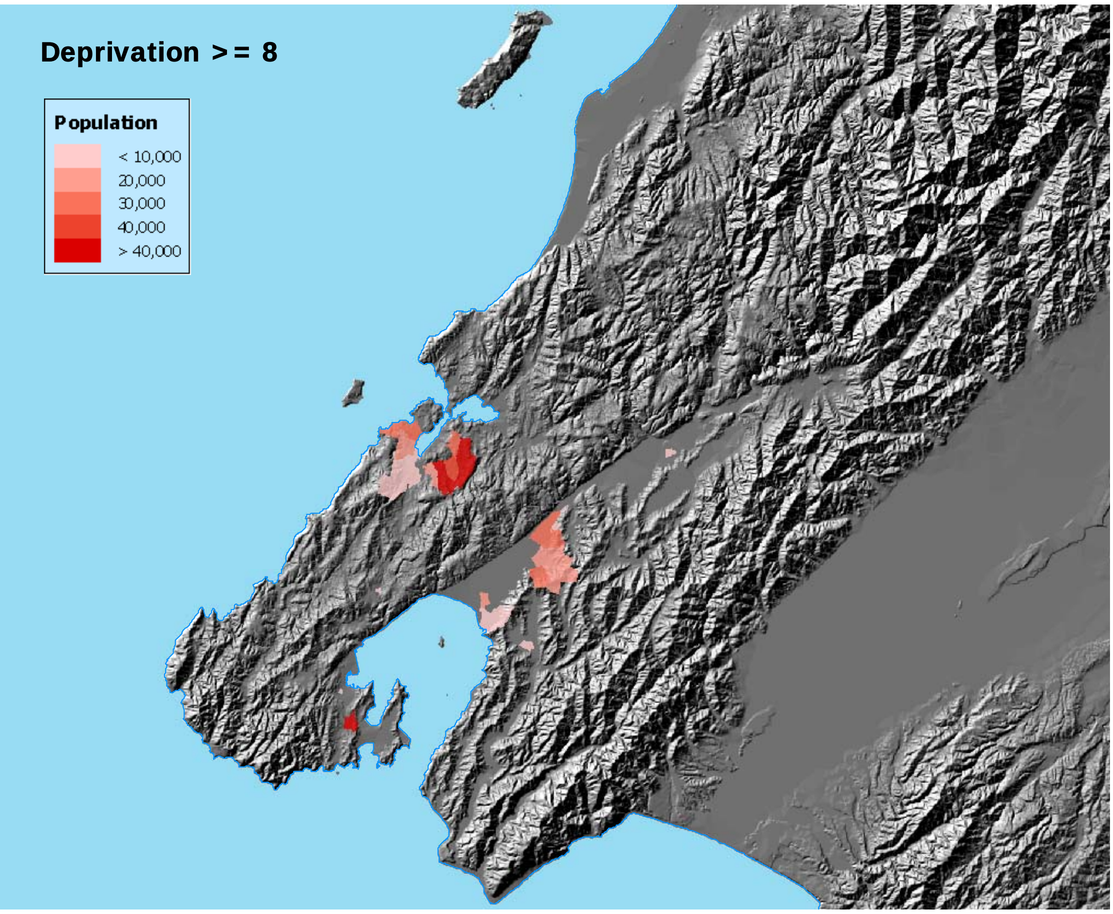
An exercise was then undertake to identify the locations where there were large population in areas with high deprivation scores. Figure 6-9 to Figure 6-11 show the relative populations for areas with deprivation scores greater than 7, greater than 8 and greater than 9 respectively.

Figure 6-9: Population with Deprivation Index Score Greater than 7

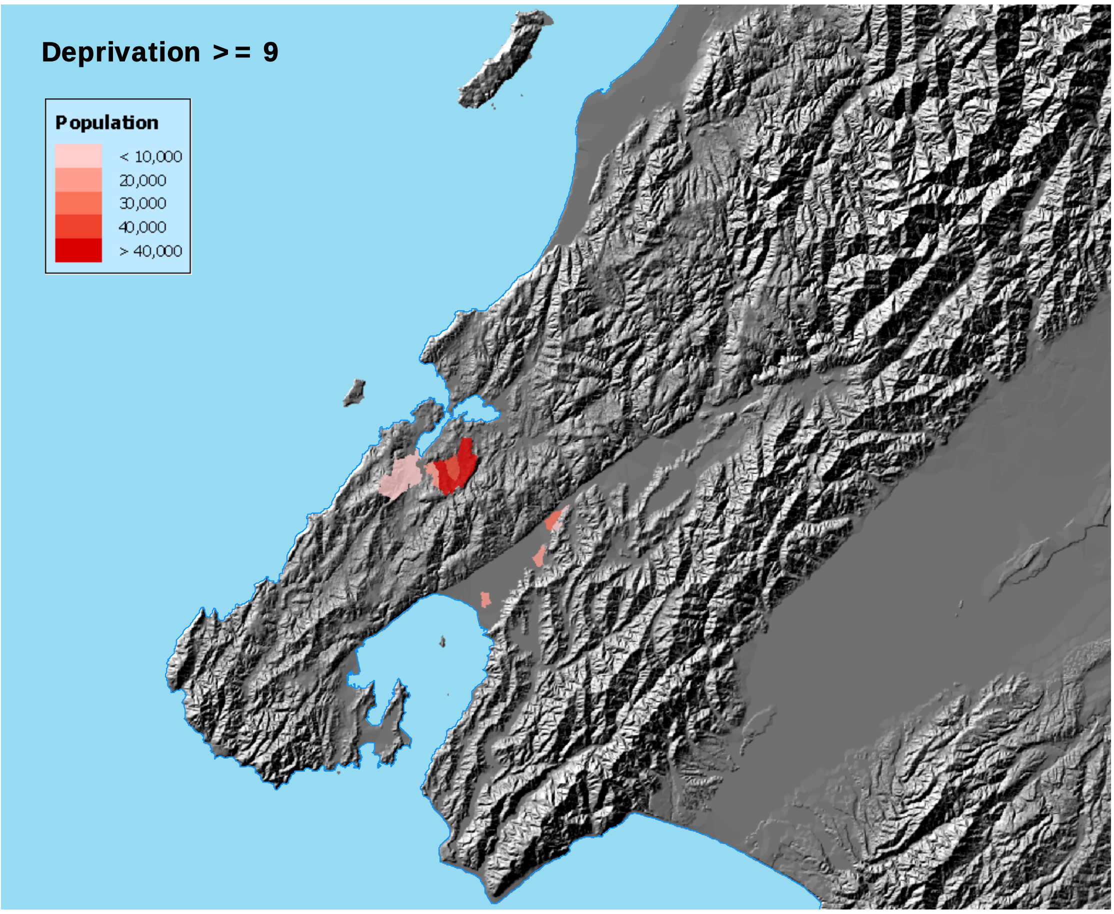


SKM

■ **Figure 6-10: Population with Deprivation Index Score Greater than 8**



- **Figure 6-11: Population with Deprivation Index Score Greater than 9**



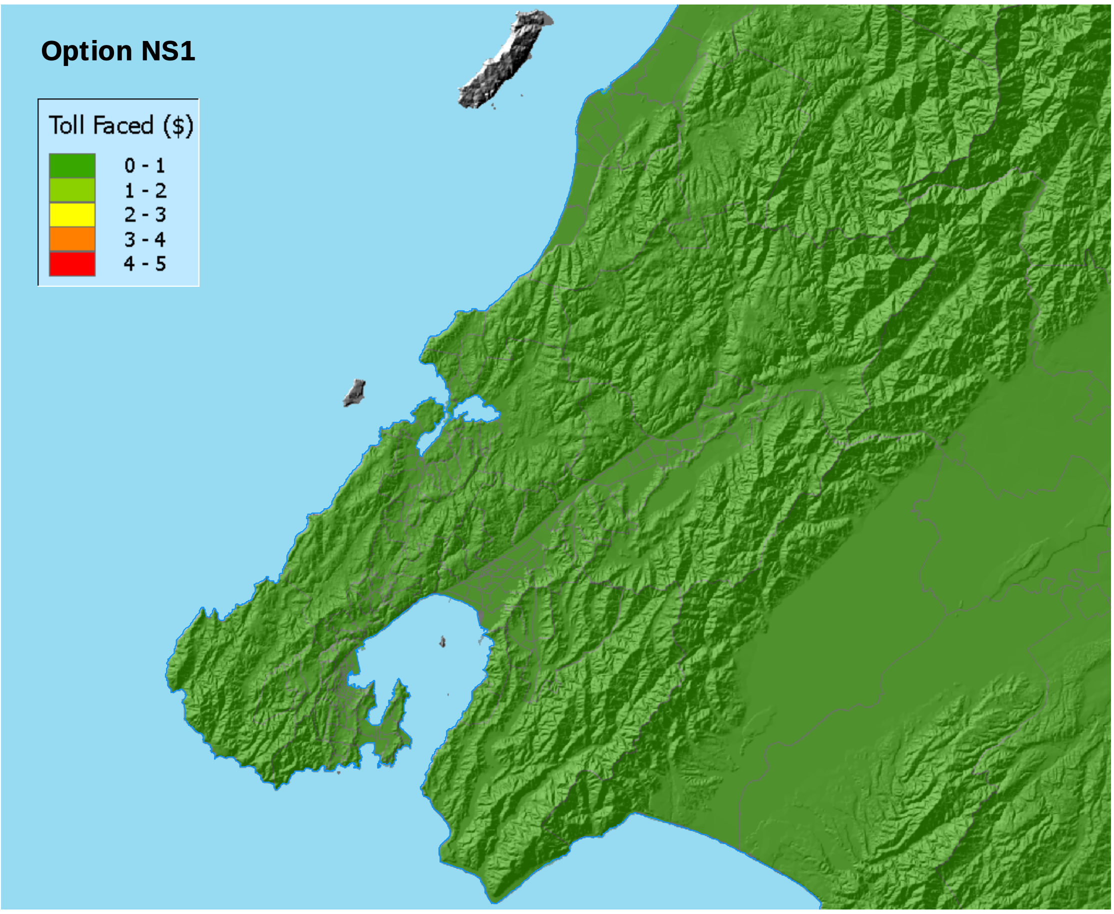
This analysis highlights the areas where additional charges could have a disproportionate impact on lower socioeconomic groups. The areas highlighted include parts of:

- Porirua
- Newtown / Kilbirnie
- Lower Hutt

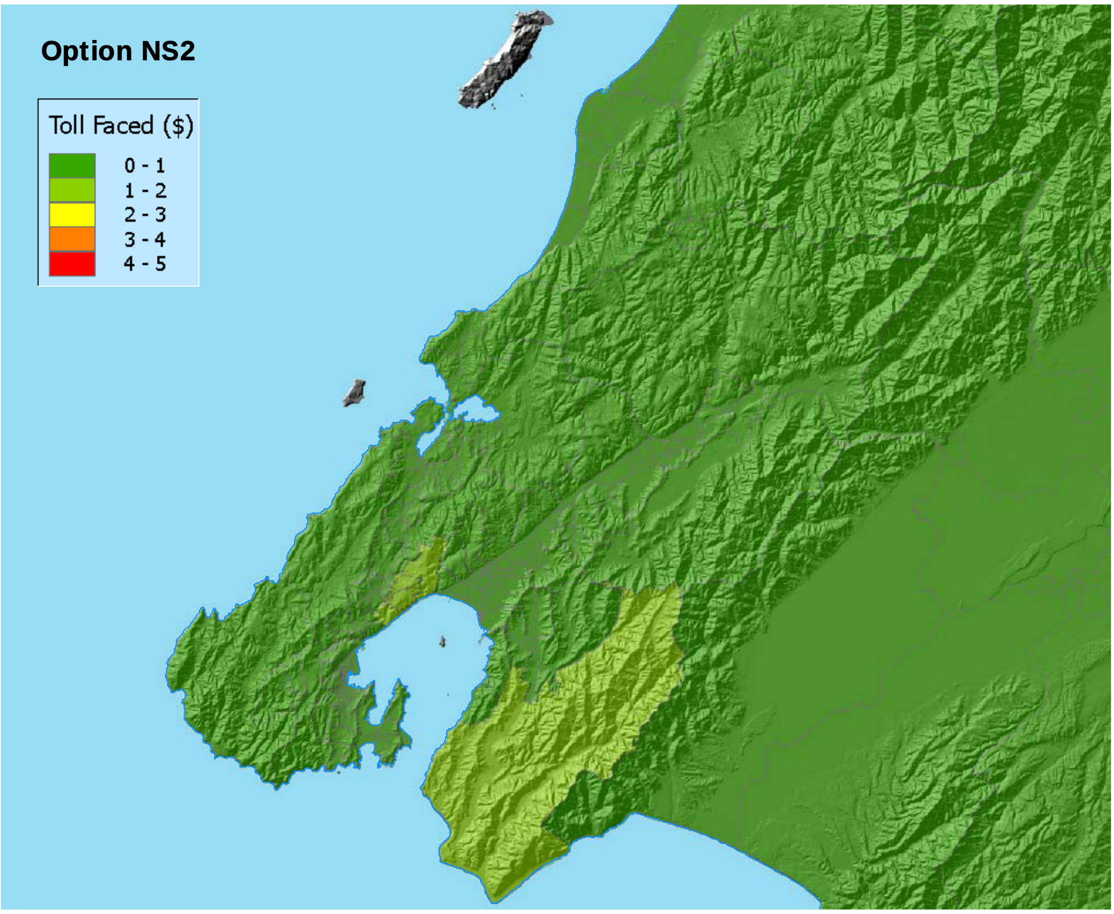
In this context, it is considered that high charge levels in these areas would have a detrimental social impact.

Figure 6-12 to Figure 6-19 show the average toll faced by model zone for each of the options tested. The average toll faced is the average toll which would be paid per trip originating in that zone if travel patterns and mode choice were to remain exactly the same before and after implementation of road pricing. It therefore represents the charge that would be felt before any response was made to the increased cost of travel.

- **Figure 6-12: Average Toll Faced NS1**

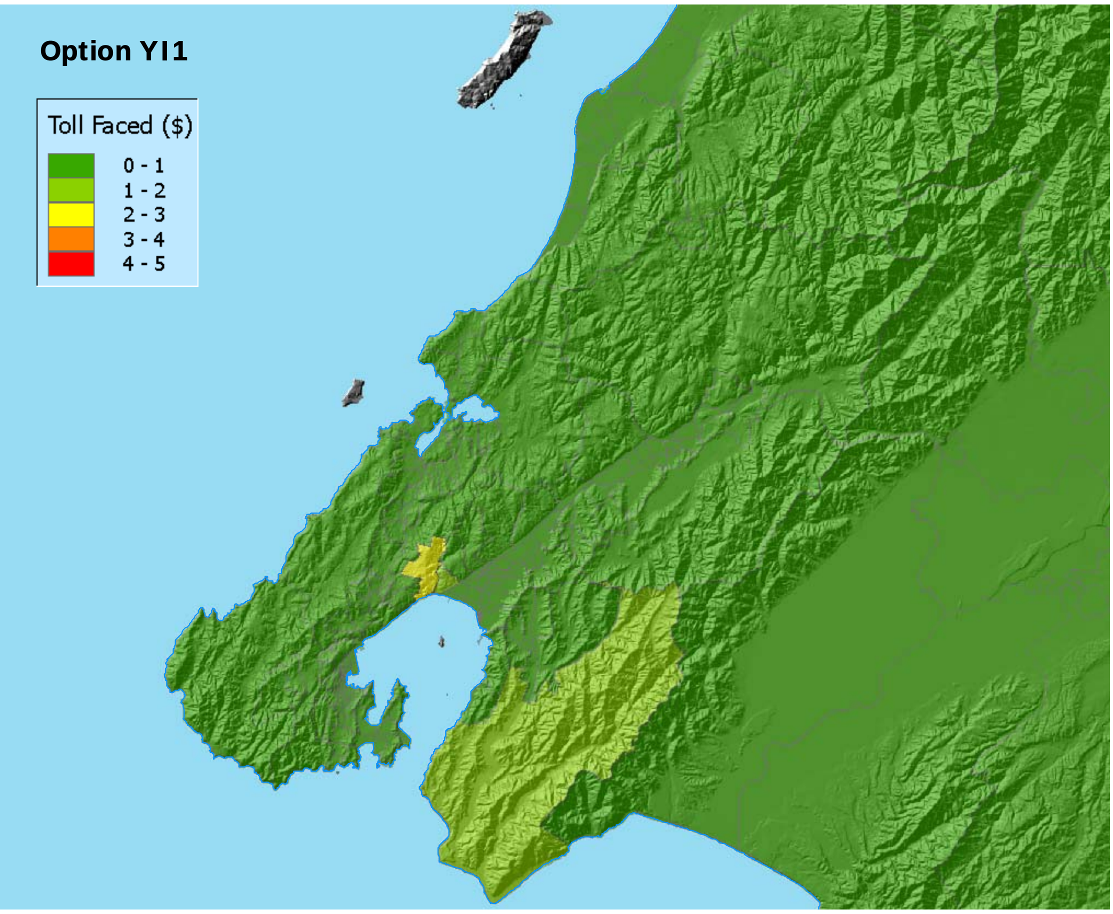


- **Figure 6-13: Average Toll Faced NS2**

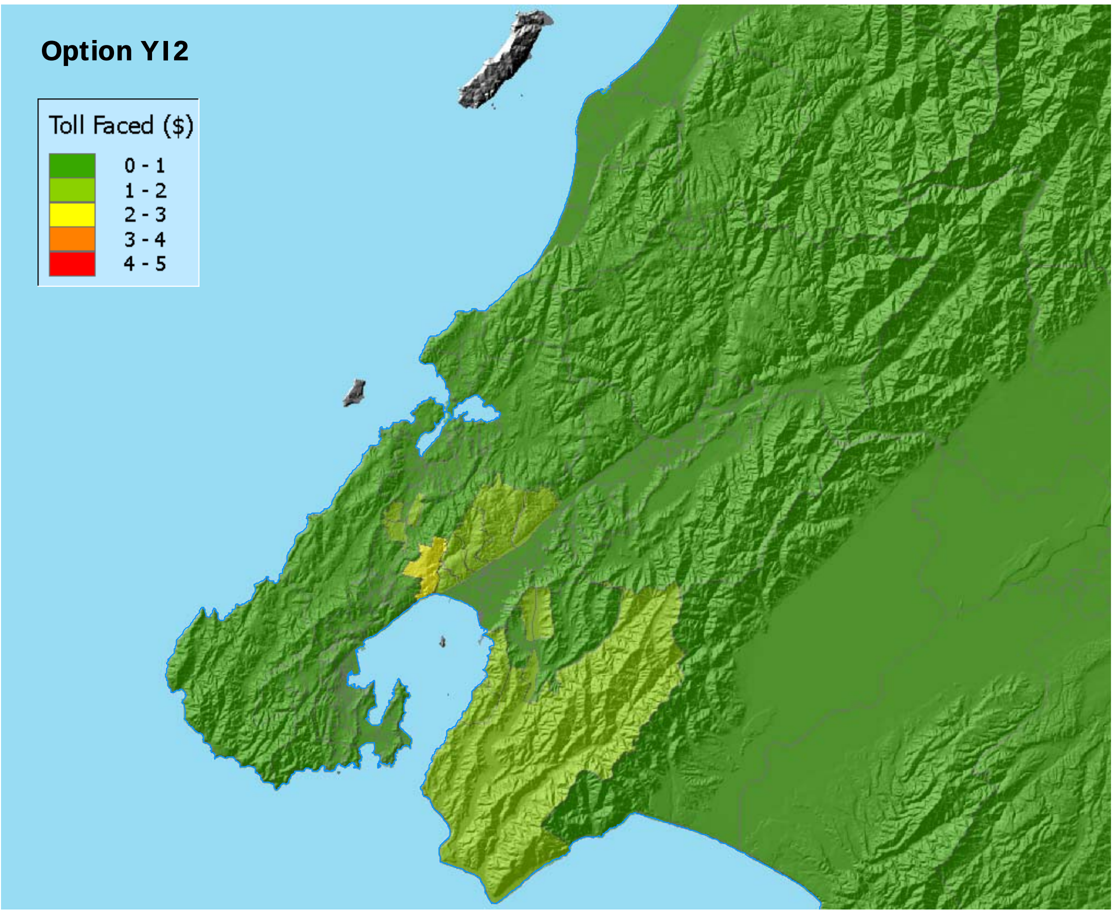


SKM

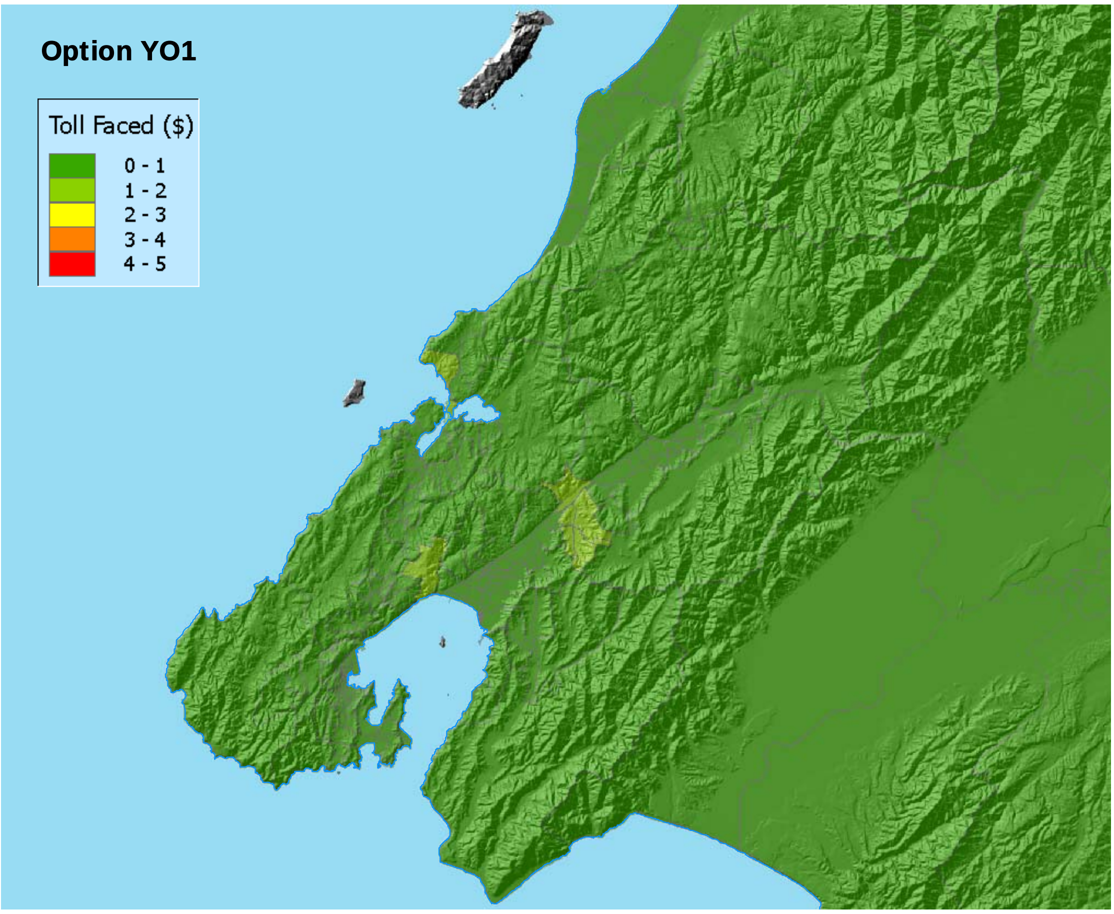
- **Figure 6-14: Average Toll Faced YI1**



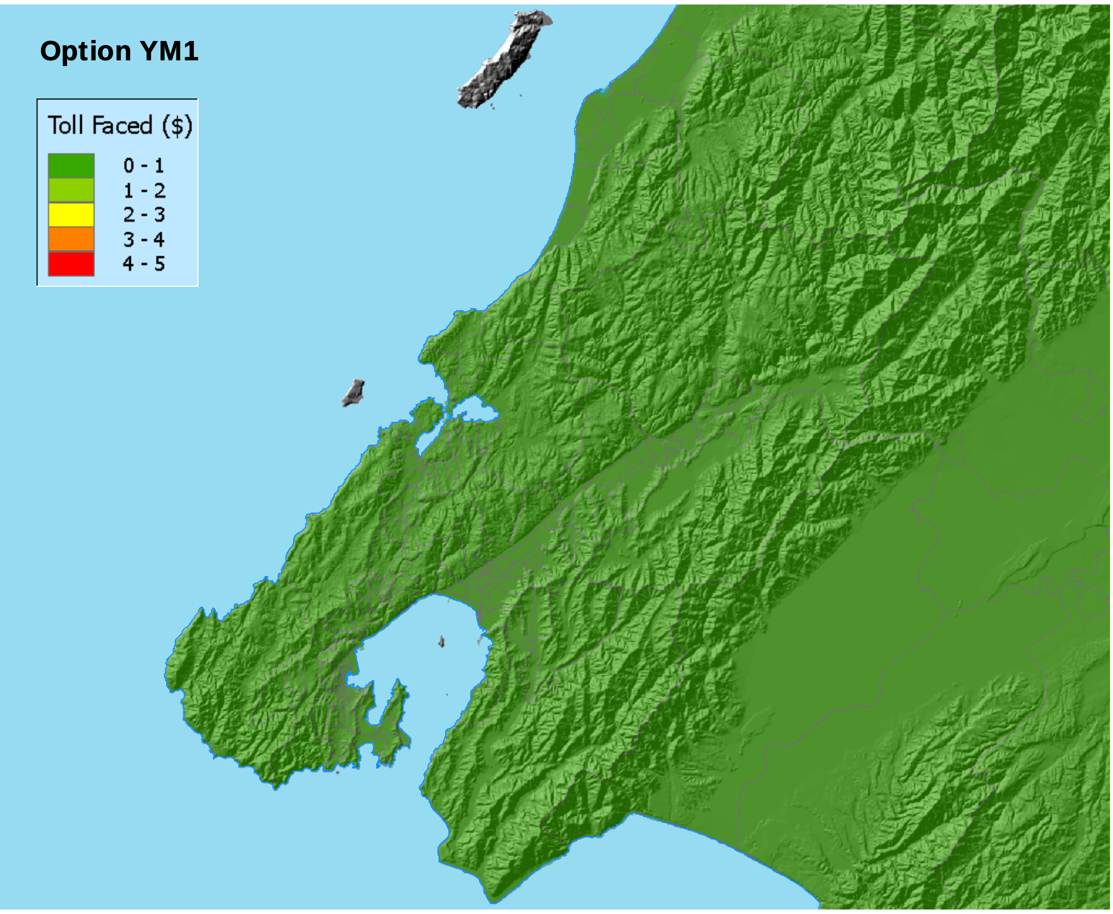
- **Figure 6-15: Average Toll Faced YI2**



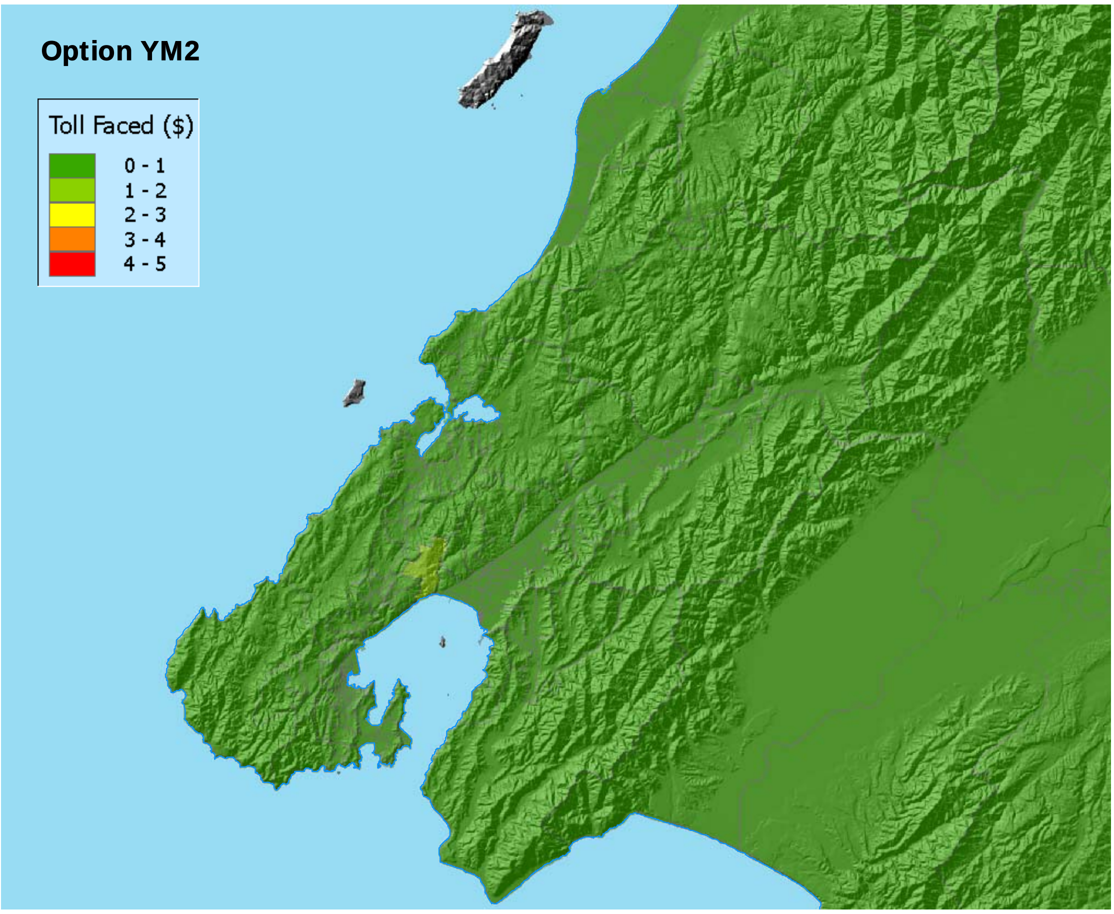
■ **Figure 6-16: Average Toll Faced YO1**



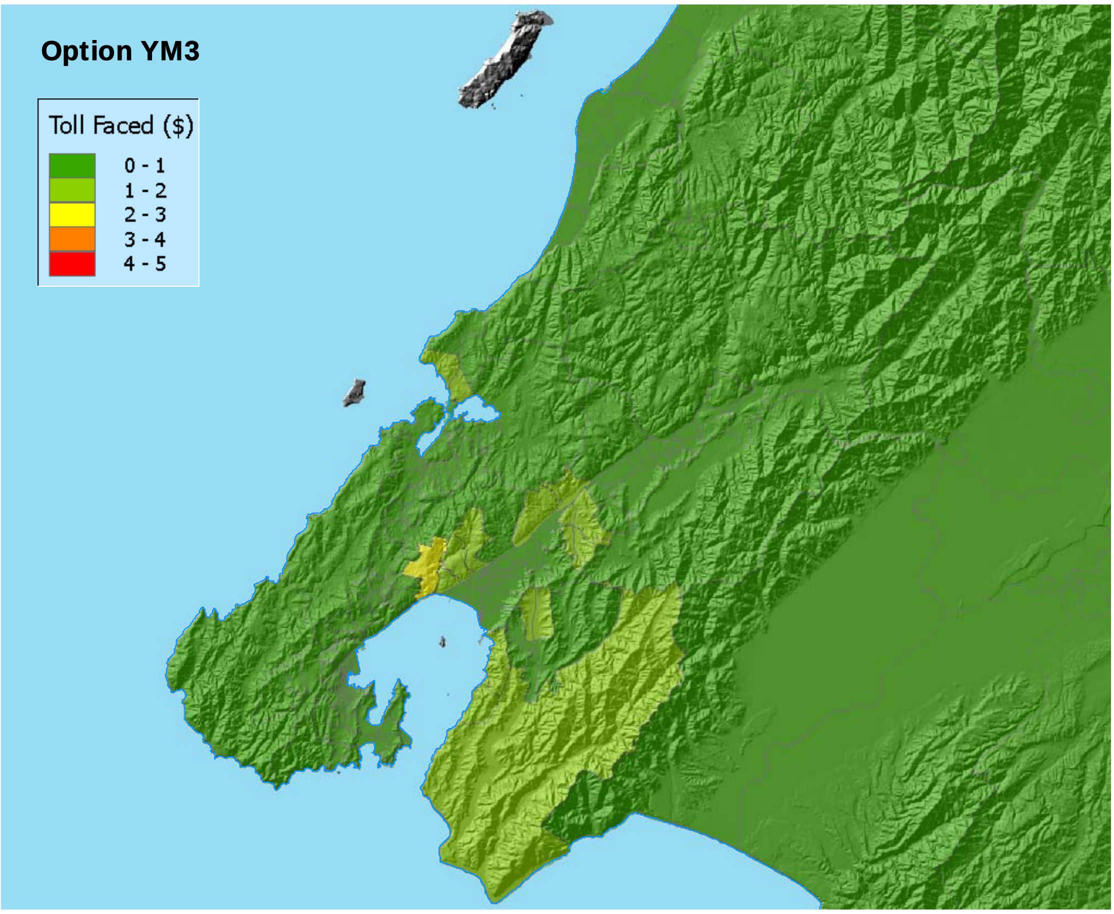
- **Figure 6-17: Average Toll Faced YM1**



- **Figure 6-18: Average Toll Faced YM2**



▪ **Figure 6-19: Average Toll Faced YM3**



It can be clearly seen that the charges are well spread over the areas and there is very little variation in the average charge paid by location. Particularly of note, is that there is no evidence of disproportionately heavy charges in the areas which have the highest deprivation index scores.

The relationship between deprivation score and the level of toll was not scored in a formal manner. Similarly, travel time impacts were plotted geographically, but not scored or presented here. No disproportionate effects were noted.

6.2 Objective 2: Assisting Safety and Personal Security

The objective Assisting Safety and Personal Security was measured in terms of estimated annual injury crashes. A simple crash rate model was used with different rates applied to the vehicle-kilometres of travel on motorways, urban arterials and rural arterials. This does not account for any changes in crash rates due to, safety improvements, changes in numbers of pedestrians or cyclists, or other external factors. It was therefore considered to represent a relative measure rather than an absolute one.

Table 6-16 gives the crash estimates for the no pricing case and the eight options, and Figure 6-20 shows the total crashes graphically (note vertical scale is between 800 and 1200 to show differences).

The data shows that all options reduce the estimated crashes to some extent, though this varies between them. The higher the charging level, the greater the reduction in crashes. At the lower charging levels the numbers of crashes for all options are similar to that for no pricing.

Table 6-16: Annual Injury Crashes – Percentage Change

	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Total	-1.6	-3.3	-2.2	-3.5	-1.3	-1.0	-2.2	-3.9
Urban arterials	-1.8	-3.3	-2.6	-3.8	-1.5	-1.0	-2.5	-4.3
Rural arterials	-1.0	-1.6	0.0	-0.3	-0.3	0.0	0.0	-0.3
Motorways	-1.8	-6.0	-4.2	-7.8	-1.8	-2.4	-4.8	-8.4

Figure 6-20: Annual Injury Crashes

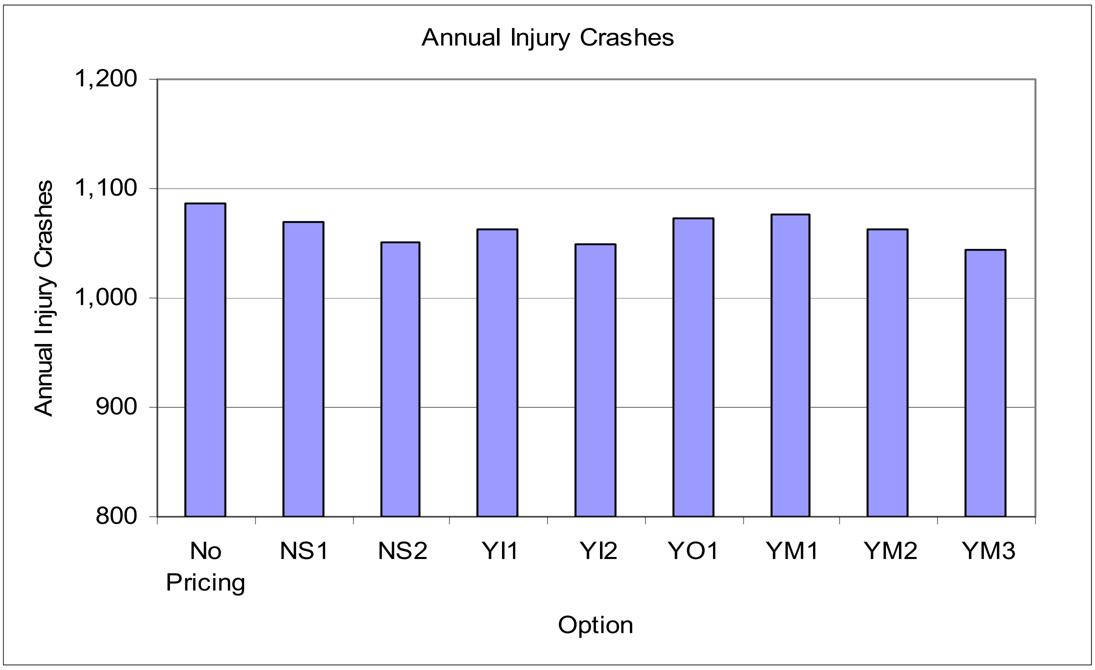


Table 6-17 gives the resulting scores for the measure annual injury crashes. Higher scores were given to those options which reduce the accidents the most.

- **Table 6-17: Annual Injury Crashes**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Annual Injury Crashes	0	0	√√	√	√√	0	0	√	√√

6.3 Objective 4: Protect and Promote Public Health

The objective of Protecting and Promoting Public Health was measured in two ways:

- Estimates of vehicle emissions: nitrous oxides (NOx), particulates, and volatile organic compounds (VOC) for the whole of the modelled area, and
- The sum of traffic volumes on about 100 selected links in residential areas as a measure of the impact of noise and emissions on people.

The vehicle emissions are estimated with the procedures used in the Western Corridor Study as provided by GWRC. Table 6-18 gives the estimate of the three emissions for each of the modelled time periods and Figure 6-21 shows those for the AM peak period.

All options reduce vehicle emissions to some extent at least and those with the higher charging levels have the greatest reductions. The Outer Y and Medium Y options with lower charging levels have similar emissions to the no pricing case.

Table 6-18: Vehicle Emissions – Percentage Change

	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
AM								
NOx	-0.6	-1.1	-0.7	-1.3	-0.2	-0.5	-0.8	-1.3
Part	-0.2	-0.5	-0.2	-0.5	0.2	-0.2	-0.2	-0.5
VOC	-2.9	-5.2	-3.9	-6.3	-2.1	-1.9	-4.2	-6.9
IP								
NOx	0.0	-0.1	-0.1	-0.1	0.0	0.0	-0.1	-0.1
Part	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

SKM

VOC	-0.1	-0.6	-0.2	-0.5	-0.1	-0.1	-0.1	-0.4
PM								
NOx	-0.7	-1.3	-1.0	-1.5	-0.5	-0.6	-1.2	-1.7
Part	-0.5	-0.7	-0.7	-1.0	-0.2	-0.5	-0.7	-1.2
VOC	-3.0	-5.1	-4.6	-6.8	-2.6	-2.8	-5.3	-7.7

- **Figure 6-21: Vehicle Emissions (AM Peak)**

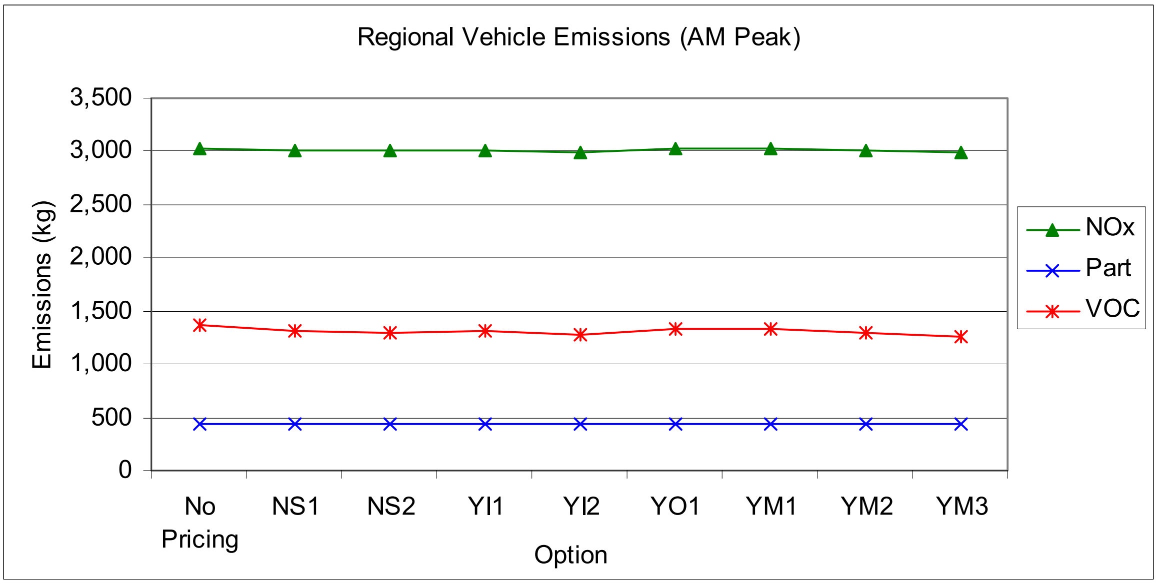


Table 6-19 gives the resulting scores for the indicator vehicle emissions. The lower the emissions, the higher the score.

- **Table 6-19: Vehicle Emissions**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Vehicle Emissions	0	√	√√	√	√√	0	0	√	√√

The second measure for this objective, the impact of noise and emissions on people as traffic flows on a selection of roads in residential areas, is given in Table 6-20 and then graphically in

Figure 6-22. Note that the vertical scale is between 40,000 and 100,000 in order to show the differences between the options.

All options show reductions in traffic flows and hence reduced noise and emissions impacts on people. These reductions will be slight in real terms, especially given the logarithmic variation in noise with distance. At the lower charging levels the Outer and Medium Y options are very similar to the no pricing case.

- **Table 6-20: Impact of Noise and Emissions on People**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Traffic volumes on selected links (000)	91	90	89	90	89	91	91	90	89

- **Figure 6-22: Impact of Noise and Emissions on People**

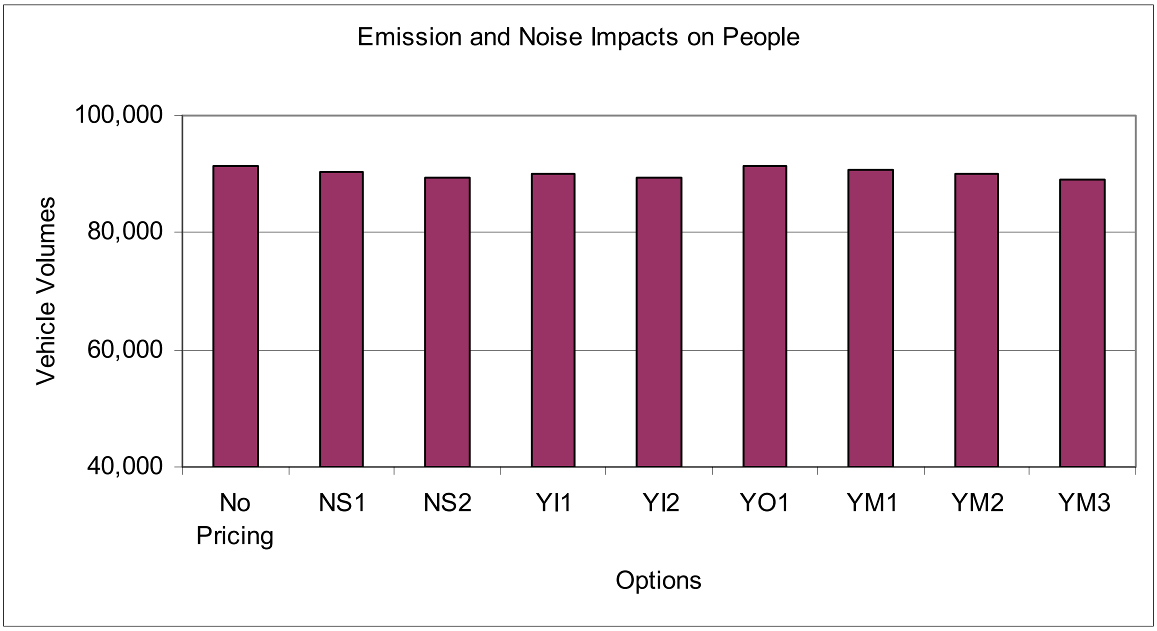


Table 6-21 gives the resulting scores for the measure related to the impact of noise and emissions on people.

- **Table 6-21: Impact of Noise and Emissions on People**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Emission and Noise Impacts	0	√	√	√	√	0	0	√	√

6.4 Objective 5: Ensure Environmental Sustainability

The objective Ensuring Environmental Sustainability was measured in terms of estimates of carbon dioxide emissions and fuel use. Given that the two are related only the CO2 emissions are presented here.

The estimates of annual CO_2 emissions are given in and shown graphically in Figure 6-23 (note that the vertical scale is between 2 and 3 million in order to show the differences between the options).

All options have reduced CO_2 emissions compared with the no pricing case, though the levels for the options with lower charges are similar.

- **Table 6-22: Annual Emissions of Carbon Dioxide – Percentage Change**

	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
CO2 emissions (000s)	-0.5	-1.2	-0.8	-1.4	-0.5	-0.4	-0.8	-1.6

- **Figure 6-23: Annual Emissions of Carbon Dioxide**

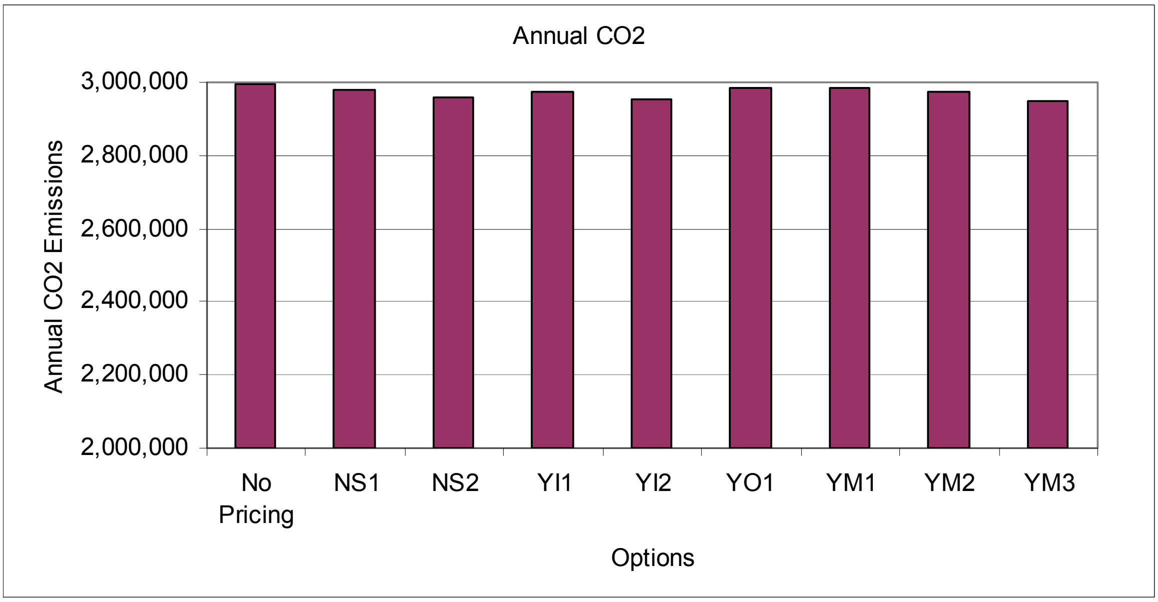


Table 6-23 gives the resulting scores for the indicator annual emissions of carbon dioxide. Those options which reduced CO_2 emissions the most were marked the highest.

- **Table 6-23: Annual Emissions of Carbon Dioxide**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
CO2 Emissions	0	0	√√	√	√√	0	0	√	√√

6.5 Objective 6: Consider Economic Efficiency and Affordability

The objective Economic Efficiency and Affordability was measured by way of a comparison of economic benefits and costs for the options.

Table 6-24 illustrates the range of benefits and scheme costs, which vary between $27-47 million. By comparison, benefits would range between $24-63 million. The figures presented are Net Present Values (NPV) discounted over a 25 year evaluation period. After deduction of user charges (revenues) all but 3 of the concepts deliver benefit to cost ratios in excess of 1. When revenues are included in the equation, the benefits can outweigh costs by a factor approaching 3.6.

User Benefits / Scheme Costs: is a measure of the economic performance of the options, that is the extent to which users benefits compare with the scheme costs (and ignoring the charges that they might pay).

Revenues / Scheme Costs: is a measure of the financial performance, that is its financial viability; how much it earn compared with how much it costs.

This demonstrates that a road pricing scheme in the Wellington region could be self financing and provide surplus revenues to invest in improved passenger transport. When the wider economic effects are considered, the impact of a well designed road pricing scheme would also be positive.

- **Table 6-24: Benefits and Costs**

	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
User Benefits	24	40	42	56	25	27	49	63
User Charges (revenues)	-61	-100	-93	-121	-61	-55	-100	-139
Scheme Costs	27	26	35	34	33	48	48	47
Rough Ratios								
User Benefits / Scheme Costs	0.9	1.6	1.2	1.6	0.8	0.6	1.0	1.3
Revenues / Scheme Costs	2.2	3.9	2.7	3.6	1.9	1.1	2.1	2.9

Table 6-25 gives the resulting scores for the benefits and costs based on the ratios of user benefits to scheme costs and revenues to scheme costs and then overall scores based on the unweighted average of the two.

- **Table 6-25: Benefits and Costs**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
User Benefits / Scheme Costs		X	√√	√	√√	X	X	0	√
Revenues / Scheme Costs		√	√√√	√√	√√√	√	0	√	√√
Overall	**0**	**0**	**√√+**	**√+**	**√√+**	**0**	**0-**	**0+**	**√+**

6.6 Summary of Evaluation Scores

The evaluation scores given in the preceding sections are summarised here for the purposes of understanding the overall performance of each option.

The results of the evaluation related to the objectives Assisting Economic Development and Improving Access and Mobility are presented in Table 6-26 and an overall assessment provided. This is based on the unweighted average of the scores for each measure and no attempt was made to determine or apply weightings.

- **Table 6-26: Overall Assessment for Economic Development and Accessibility**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
Impact on Travel	0	0	X	0	X	0	0	X	X
Travel Times on Routes	0	√	√√	√√	√√√	√√	√	√√	√√√
Average Speed	0	√	√	√√	√√	√	√	√√	√√
Average Charge Paid	0	XX	XXX	XX	XX	XX	X	X	XX
Congested VKT	0	√	√√	√	√√√	√	√	√	√√√
V/C at key bottlenecks	0	0	√	0	√√	√	0	0	√√
Distribution of Charges	0	X	XX	0	0	0	0	0	0
Overall assessment	**0**	**0**	**0**	**0+**	√	**0+**	**0+**	**0+**	√

Table 6-27 presents the scores for each of the objectives. An overall score was not determined as this would require consideration of the relative weight or importance given to each objective.

It should be noted that the modest impacts on safety and personal security, public health and environmental sustainability are in part due to schemes only impacting on a small number of people and that those who do pay charges are only paying modest charges. A scheme that impacted on more people and had higher charges may have bigger impacts in these areas.

The summary indicates that the Inner Y option at the higher pricing level, YI2, provides the best overall performance across all objectives but that there is little difference between this option and the Medium Y and Ngauranga Screenline options at the higher pricing levels.

The Medium Y option, YM2, has the same evaluation results as YI2, except for a slightly lower score for the Economic Efficiency and Affordability objective.

The Ngauranga Screenline option, NS2, also scores the same as Y12 apart from one result, in this case the Economic Development and Access and Mobility objectives.

- **Table 6-27: Summary of Evaluation**

	No Pricing	NS1	NS2	YI1	YI2	YO1	YM1	YM2	YM3
ECONOMIC DEVELOPMENT & ACCESS AND MOBILITY	**0**	**0**	**0**	**0+**	√	**0+**	**0+**	**0+**	√
SAFETY & PERSONAL SECURITY	**0**	**0**	√√	√	√√	**0**	**0**	√	√√
PUBLIC HEALTH	**0**	√	√**+**	√	√**+**	**0**	**0**	√	√**+**

SKM

ENVIRONMENTAL SUSTAINABILITY	**0**	**0+**	√√	√	√√	**0+**	**0+**	√	√√
ECONOMIC EFFICIENCY & AFFORDABILITY	**0**	**0**	√√**+**	√**+**	√√**+**	**0**	**0-**	**0+**	√**+**

7. Technology & Rough Order Costs

7.1 Introduction

The focus of this stage of the Wellington Road Pricing Study was not about how road pricing would be administered or delivered. Nevertheless, some consideration of technical and institutional issues is required to determine the feasibility and rough order cost estimates for any road pricing scheme. A preliminary review of the road pricing technology options currently available (or likely to be developed in the near future), was therefore undertaken. This review is detailed in the Wellington Road Pricing Study Technology Options Paper included as Appendix C. This section provides a summary of the findings of the initial review.

When considering issues related to road pricing technology for the Wellington region, we have considered the following functional charging regimes as they relate to the seven generic pricing options detailed in Section 4.3 above:

- *Distance and Time Based Charging* i.e. for application of Strategic (arterial) Network of Full Network Charges
- *Route Based Charging* i.e. for application of Strategic (arterial) Network Charges
- *Area Based Charging* i.e. for application of Area Charges
- *Cordon Charging* i.e. for application of Cordon Charges and Strategic (arterial) Network Charges

The technology required for each of these charging options consists of two main functional components:

1) payment whereby drivers pay for road usage; and
2) enforcement whereby the payment is checked in relation to travel.

7.2 Payment Options

The payment options available partly depend upon the charging option being considered. The main ones are:

- Offline Payment
- Toll Booths
- In Vehicle 'tag'
- GPS Based

7.2.1 Offline Payment

- Offline payment (as used in the London Congestion Charging Scheme) is where the payment is separated from the charged event.

- Payment can be made in a number of different ways including by phone, SMS, retail outlet, internet and on-street payment machine.
- Payment must be linked to an easily identifiable aspect of the vehicle that can be used in the enforcement process. Most commonly, this is the Vehicle Registration Mark (number plate)
- Important that offline payment uses a very simple charging basis. A fixed charge is ideal, and offline payment is very suitable for a simple area based charge or a cordon crossing charge.
- Could be used for a simple route based charge - providing the route was clearly defined
- Not really suitable for a distance based charge as there is no ready means of measuring the distance - either for the driver when making payment, or for an enforcement system when checking whether the payment was correct.

7.2.2 Toll Booths

- Payment at a 'toll booth' is used for toll roads and as part of the Oslo Toll Ring for example.
- Normally provide a variety of means of making payment including by cash, bank card or automatically using an electronic device.
- Require a large area for a toll plaza
- Unlikely to be a practical solution in most congestion charging situations.

7.2.3 In Vehicle 'tag'

- Payment based upon a device fixed within and associated with a particular vehicle that transacts with a payment site on the road.
- DSRC, Direct Short Range Communication most commonly used to communicated between tag and beacon, however IR is also used
- Technology most suited to a point payment and hence is very suitable for cordon based charging. For route based charging, its suitability depends upon route length and definition.
- Can be used for distance based tolling, but cost of this becomes prohibitive if there are a large number of entry and exit points - such as in an urban area.
- Area based charging, requires a large number of beacons to ensure that the majority of potential journeys, including ones wholly within the charging area, to be covered adding significantly to the cost.

7.2.4 GPS Based

- Payment based upon a GPS based module fitted in the vehicle that can be used to detect a passage across a zone boundary, for example, or for measuring distance along a road.

- For enforcement and checking there would normally be a communications method provided between the GPS unit and the outside world, often by cellular or DSRC.
- Very flexible and can be used to charge for any charging option with equal efficiency.
- There is currently debate as to whether the accuracy of current GPS units is sufficient for urban road pricing schemes.
- GPS units normally require specialist fitting into the vehicle, need some means of communication with the charging system i.e. cellular radio or DSRC to communicate directly with an enforcement site, and are therefore costly.

Table 7-1 below shows the potential use of the payment options outlined above related to the charging regimes listed in the above.

- **Table 7-1: Scoring for Payment Technologies in relation to Charging Options**

Payment Options	Distance Based	Route Based	Area Based	Cordon Based
Offline Payment	5	3	1	1
Toll Booths	5	3	3	1
In vehicle 'tag'	3	3	3	1
GPS based	1	1	1	1

Key - Scoring 1 is most suitable, 5 is least suitable

The scoring shown in Table 7-1 above is based primarily upon technical suitability, not cost effectiveness. A practical charging system may utilise a number of payment methods and should be designed so that it can be extended and new technology be introduced as it matures.

7.3 Enforcement Options

By far the simplest and most reliable enforcement option is a barrier based system. It links payment directly with enforcement and the barrier prevents passage until the payment is made, therefore no follow up action is required. The major disadvantages of barriers are that they require considerable space and introduce capacity restrictions. A barrier based enforcement system is highly unlikely to be usable in a practical urban road pricing system.

Reading of a paper pass or ticket (which indicates payment like a 'pay and display' parking ticket) in free-flow conditions is not possible with currently available technology.

In practice, the only method that has been found to be practical involves the use of the Vehicle Registration Mark or VRM. This is unique to a vehicle, is normally linked to the vehicle keeper via the central Vehicle Licence Database. VRMs are used extensively for enforcement of motoring offences and hence their use for this process is well understood.

Enforcement using VRMs is most commonly undertaken using Automatic Number Plate Readers (ANPR) and 2 cameras are normally required. The first is an infra red (IR) camera which focuses on capturing the number plate image. The output from the camera is fed into an ANPR computer system that records the VRM with an expected read accuracy of at least 80%. The second camera commonly used as part of the enforcement system is a colour context camera that takes a colour context overview image of the vehicles as they pass. The overview image, together with the number plate image, ANPR output, time stamps and location data form an evidential record for issue of a Penalty Charge Notice (PCN).

Table 7-2 below identifies potential enforcement strategies for the most appropriate payment options identified in Table 7-1 above.

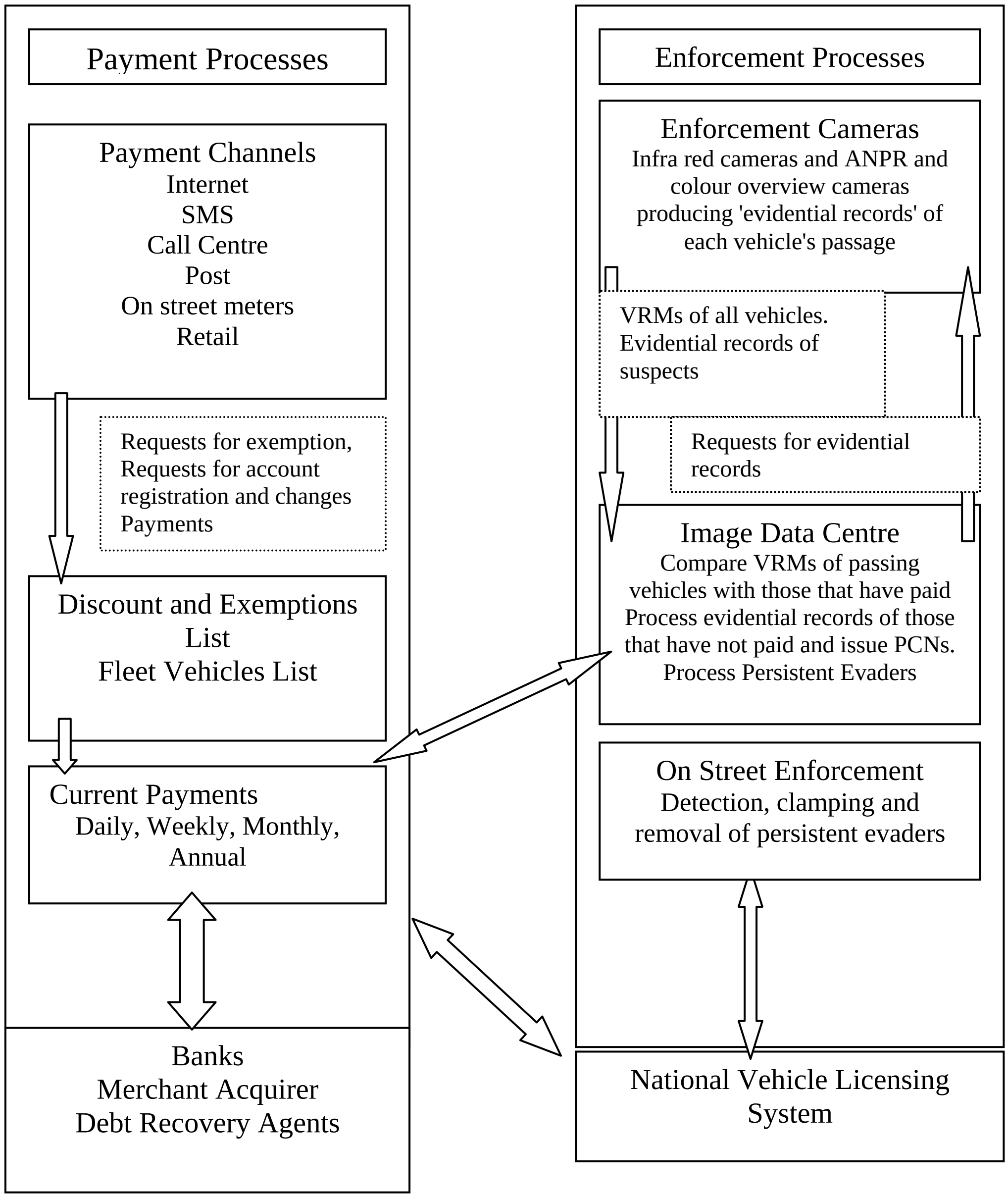
- **Table 7-2: Potential Enforcement Options for Different Charging Regimes**

Payment Means	Distance	Route	Area	Cordon
Offline	XXX	XXX	Entry and Exit, with screenlines for internal trips	At cordon crossing points
Toll Booths	XXX	XXX	XXX	At toll booths (at cordons)
Tag Based	XXX	XXX	XXX	At cordon crossing points
GPS	Screenlines in charged area	Screenlines along route	Screenlines within area	At cordon crossing points

7.4 Back Office Functions

There are two main functional elements to a congestion charging system. They are payment processes and enforcement processes. Figure 7-1 below shows a functional architecture.

▪ **Figure 7-1: Functional Architecture for a Road Pricing System**



7.4.1 Payment Processes

Payment channels could be provided for via the Internet, SMS, retail outlets, post, on-street payment machines or a call centre. Payment processes should be designed to allow 'bulk purchase' of charges through weekly, monthly, or annual tickets and be automated as far as possible and to minimise human intervention which is essential to reduce costs. Generally speaking, the use of SMS and Internet are the cheapest options, while a call centre and retail outlets are the most expensive and it is desirable that charges are set to encourage the use of cheaper options so that operating costs are reduced.

Frequent users should be encouraged to set up an account. The account would be linked to the vehicle's VRM and could be topped up using any of the above methods and direct debited from a bank account. Many tag based automatic toll collection systems require a pre-paid account to be set up with the authority and this is kept topped up by debiting the user's bank account.

Whichever payment method is used, it is important that some form of receipt is provided to act as evidence in case a PCN is mistakenly issued.

7.4.2 Enforcement Processes

The enforcement process starts with the capture of an 'evidential record' at the enforcement site. This record would be checked against the 'Currents Payments Database'. Where payment has not been recorded, the evidential record will be transmitted for processing of a PCN. This will require access to the Vehicle Licensing Database to obtain keeper details of vehicles where an offence is suspected. Because the enforcement system will have inaccuracies, it is important that a manual check be made of the evidential records before a PCN is issued. When these checks have been completed and an address for the registered keeper has been obtained, a Penalty Charge Notice can be issued.

The process should probably be similar to that used for parking penalties and an appeals process will be necessary to cater for those that believe that the PCN has been issued in error. Parking and road pricing PCN processing could be combined to reduce costs and maximise efficiency.

7.5 System Architecture

7.5.1 Potential National System

If amalgamation with a national system was to be pursued, the architecture is likely to be 'imposed' by the designers of the national system. For such a system to be practical, it is necessary that many of the functions and interfaces between the building blocks are standardised. For a tag based or GPS based system the air interfaces between tag and roadside infrastructure must be standardised. This activity is not trivial and, although some aspects are being subject to international standardisation, there are still many standards that must be developed locally.

The LTMA 2003 provided a legislative framework for the implementation of tolling schemes for new roading infrastructure. Transit New Zealand has a number of schemes that it intends to operate as toll roads in the near future. The first is ALPURT B2, which is currently under construction, followed by the new Tauranga Harbour Bridge. Transit NZ is therefore developing a National Toll Collection Strategy (NTCS) and has established the National Toll Administration Project (NTAP) to develop a national approach to the administration of New Zealand toll roads. One of the requirements for the development of the system is that it is flexible enough to also cater for urban road pricing schemes. The advantage of a national system is that it would allow a user to have one (or more) account and to use it nationally.

The preliminary work undertaken by Transit indicates that the use of e-tags with DSRC communication to roadside beacons is preferred. Enforcement would be through ANPR cameras. Each scheme would essentially be a separate client to the national system and provide all the roadside equipment. The national system would then be responsible for communication of the information collected, handling payment processes, interface with the vehicle registration database, and undertaking the enforcement (including issuing PCNs and following up through the courts).

There is some concern whether a national tolling system would adequately cater for the needs of an urban road pricing scheme and a substantial amount of work would need to be done to liaise with the developers to ensure compatibility. There will clearly however be many similarities between the needs of the systems, and the national toll system will hopefully address many of the technical, legal and governance issues likely to be faced by a Wellington scheme.

7.5.2 Local System

For a local system, the functions should be divided on the basis of potentially available existing technology and systems that might be adapted for road pricing. This will ensure that there is minimum risk associated with procurement and that costs are minimised.

It is assumed that the total system is divided into a Payment and Accounting System - dealing with cash handling and accounting, and an enforcement Image Management System, dealing with image capture and enforcement issues. The overall architecture is shown in Figure 7-2 below.

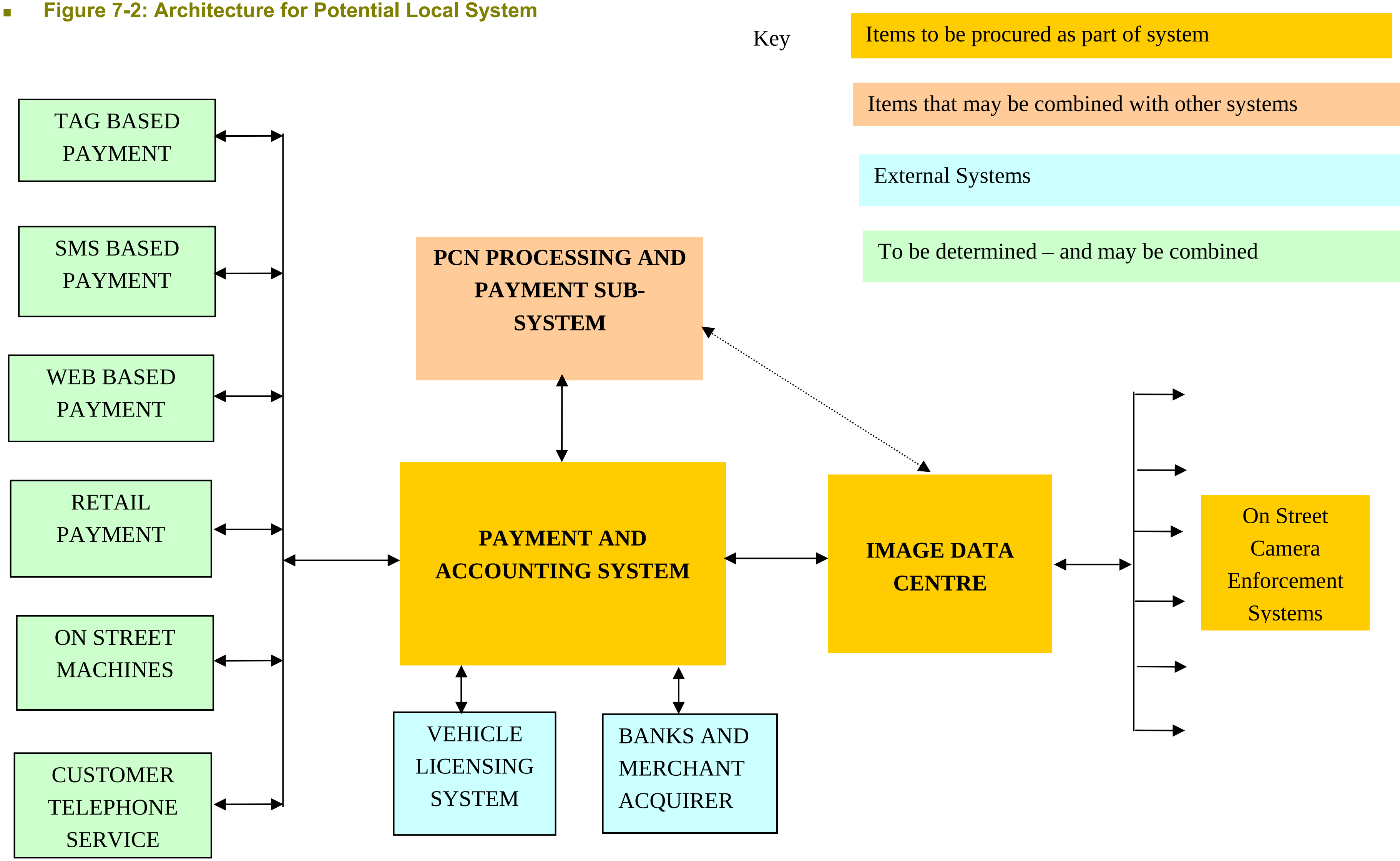
The Image Management Centre is linked with the On Street Enforcement Cameras and deals with the capture, validation and storage of enforcement images.

The Payment and Accounting System are linked with a number of payment channels that may be specifically provided or shared with other uses.

The PCN Processing and Payment Sub-system may be separate or combined with parking PCNs (assuming similar legislation and operation).

SKM

- **Figure 7-2: Architecture for Potential Local System**



7.6 Initial Testing Technology Conclusions

In considering the appropriate technology on which to base initial testing of road pricing technology the following conclusions were reached:

- In the short to medium term, GPS based technology is unlikely to have the accuracy required for an urban road pricing scheme and the technology will require costly fitting and additional communication equipment.
- Given the need for large amounts of space and adverse effect on traffic flows, toll booths are unlikely to be a feasible or desirable payment option for an urban road pricing scheme.
- Some form of off-line payment will be require for infrequent users of any scheme and a variety of payment options should be provided, including via phone, SMS, retail outlet, internet and on-street payment machine.
- In vehicle tags are appropriate for cordon based charging. This is in line with the aspirations for a national toll system and therefore it is appropriate that this technology be included in initial testing and costing.
- IR cameras, ANPR readers and colour context cameras are likely to be the most appropriate tool for enforcement.
- Given the small scale of a Wellington scheme, uncertainty over the applicability of national tolling systems, and to ensure a robust analysis, the system assumed in this interim stage of work should be stand-alone, utilising readily available technology and existing systems.

7.7 Rough Order Costs

One important factor in assessing the viability of road pricing in the Wellington region will be the cost of the system, initially to implement - ***capital costs***, and subsequently to run - ***operational costs.*** The costs of providing and running a road pricing system are significant, and need to be covered by the revenues if the scheme is to be financially viable.

This stage of project was focused on determining if any sort of road pricing scheme was feasible in the greater Wellington region and is not intended to address the complex legal, technical and governance issues associated with the operation of a road pricing scheme. Therefore, the costing exercise undertaken for this stage was targeted to determine the rough order costs for use in preliminary scheme evaluation, not to provide detailed costings.

Tolling and congestion pricing is also a new sector of the transport market for New Zealand and technological developments in these sectors are advancing at a considerable pace. It is likely that there will be significant variation in the costs of systems from elsewhere, given the relatively limited application of at least some forms of road pricing. Therefore, contingencies of approximately +/- 30% have been assumed in determining the rough order costs.

There are several different forms and models for road pricing utilising different technologies with highly varying costs. To enable realistic rough order costings to be produced, the following high level assumptions were made:

- It was assumed that the roadside technology would be similar to that proposed by NTAP, which is essentially in vehicle transponders (e-tags) with roadside beacons to detect passage across a particular screenline.
- Payment would be available by electronic means only. This would be via e-tag (DSRC communication) or prepay via phone, Internet, SMS, payment machines etc. No form of manual payment at the site of charging would be provided.
- Operating costs would be based on maintenance costs and costs for processing payment. These costs would vary depending on the method of payment chosen and vehicles which crossed cordons more than once a day would only interact with the payment processing facility once, paying for multiple crossings at the same time.
- Enforcement would be decriminalised and carried out by the operating entity as part of the system operation. Enforcement would be undertaken electronically through the use of infra red (IR) cameras and Automatic Number Plate Readers (ANPR). Colour context cameras would be used to take enforcement images.
- The system would be a stand-alone, owned and operated by a single operating entity. All front office and back office functions would be undertaken in house. This approach is conservative as integration with a national system, for example the Transit system, could provide savings.

Table 7-3 below shows the rough order costs estimates developed for the options under evaluation.

- **Table 7-3: Rough Order Capital and Operating Costs**

	Capital Costs	Operating Costs
Wellington CBD	$43 million	$8.5-10million
Ngauranga Screenline	$10 million	$3-4 million
Y Screenline	$10-12 million	$4-8 million
CBD plus Y Screenlines	$45 million	$10-13 million

8. PT Constraints and Complementary Measures

One of the impacts of road pricing is likely to be a modal shift away from use of the private motor vehicle and towards the use of public transport. Modelling using WTSM indicates that there could be a maximum total increase in PT-kilometres of 9.3% as a result of road pricing. The greatest individual corridor increase (+9% - 14% at the higher toll levels) would be felt along the Porirua corridor. As small shift from train usage to bus usage was also identified in the Hutt corridor. This change may result from the congestion improvements delivered by road pricing making bus travel more attractive.

A preliminary review of the existing public transport services that operate in the greater Wellington region was undertaken to assess the impact of these changes, and highlight potential constants to providing additional capacity.

There are no train services south of Wellington Station, therefore commuter bus services serve the central, southern and south-eastern suburbs. The bus services to the north and northwest of the Wellington CBD, serving areas like Porirua, Kapiti Coast and the Hutt Valley, mainly act as feeder services to support the rail network which provides services into the central city.

8.1 Rail Network Constraints and Complementary Measures

The major commuter rail lines servicing the Wellington Region are the:

- Wairarapa Line - Wellington to Masterton (via Petone, Taita and Upper Hutt)
- Melling Branch - Wellington to Melling (via the Wairarapa Line)
- Paraparaumu Line - Wellington to Paraparaumu (via Plimmerton and Porirua)
- Johnsonville Line - Wellington to Johnsonville

Figure 8-1 below shows the location of the lines and the areas that they serve.

SKM

■ **Figure 8-1: Wellington Rail Lines**

8.1.1 Rail Demand

Demand volumes for the Wellington rail network are not readily available for the individual rail corridors. The Wellington Commuter Rail Network Business Case was produced for GWRC by Warwick Walbran Consulting Ltd in 2004, and sets out the future business case for the development of the rail network in the Wellington region. It states that the current AM passenger delivery to Wellington Station is in the order of 12,500 over the two-hour peak. It is not understood how this demand is split by line and exact time of travel. Experience would suggest that patronage is focused around specific routes and that the peak volumes are not constant between 7:00am to 9:00am, but have a pronounced shorter peak.

Modelling of road pricing options indicates that an additional maximum demand of 400 trips in the AM peak in 2016 would result from implementing road pricing.

8.1.2 Rail Capacity

A preliminary review of each of the lines was undertaken to identify any major constraints to increasing capacity to cater for road pricing. This review details the lines rolling stock, operation, capacity constraints and possible capacity improvements which may be required, and is included in Appendix D. The current delivery capacity is summarised in Table 8-1 below. These capacities have been based on the number of carriages and lines available, with a moderate crush factor.

SKM

Table 8-1: Current Delivery Capacity (Peak Period)

Corridor Descriptor		Peak period CBD Passenger Delivery Capacity	=	Corridors CBD Rail Access Corridors	x	Corridor Trackage Tracks / Corridors	x	Track Capacity Trains per Peak / Tracks	x	Train Consist Cars / Train	x	Train Capacity Seats / Car	x	Average Crush Factor Seated + Standing / Seats	x	Seat Turnover Factor Time Seats Occupied per trip	x
Melling	1	1269		1		1		5		2.67		72		1.10		1.00	
Johnsonville	2	2365		1		1		7		4		64		1.10		1.00	
Hutt Valley (Upper Hutt)	3	3279		1		1		6		6		72		1.10		1.00	
Hutt Valley (Taita)	4	3136		1		1		6		6		72		1.10		1.00	
Wairarapa	5	1267		1		1		3		6		64		1.10		1.00	
NIMT (Parapaumu)	6	2732		1		1		5		6		72		1.10		1.00	
NIMT (Plimmerton)	7	2281		1		1		4		6		72		1.10		1.00	
NIMT (Porirua)	8	2851		1		1		5		6		72		1.10		1.00	
NIMT (Capital Connection)	9	512		1		1		1		8		64		1.00		1.00	
		19693															

This indicates a total capacity of the network inbound to the CBD is in the order of approximately 19,500 people, over a peak period.

Following the review described above, a summary of the rail capacity constraints was developed. This is set out below.

8.1.3 Rail Constraints

1) The Wellington Station Approach / Throat is the main constraint. Currently the throat capacity is between 18 and 20 trains each way per hour (TEWPH). The Johnsonville line can be considered as separate. A terminal station with 9 platforms can easily accommodate 50 Train arrivals and departures (with a typical 10 minute turn-around). Therefore, any improvements to the throat need to facilitate 25 TEWPH. Preliminary analysis has taken this as a base when calculating service and timetable enhancements.

   If this is not done then there is no real value in spending several hundred million on new rolling stock (with the exception of Melling and Johnsonville Lines where passenger capacity constraints are clearly down to availability of rolling stock) it would be more prudent to refurbish the coach interiors to reflect an MRT where the design is based on a 80/20 split (80% train capacity is standing and 20% is seated). This approach would possibly reduce the overall appeal of rail transportation but could be countered with lower fares.
2) Signalling improvements would be required to accommodate shorter headways.
3) Provision and refurbishment of additional rolling stock would be required.
4) Other infrastructure enhancements such as track duplication in the Pukerua Bay area will remove any unnecessary operational issues and will improve service delivery and punctuality.
5) The provision of new stations and extended electrification will increase demand (not capacity).

8.1.4 Rail Constraint Conclusion

The improvements set out above are currently substantially planned for in the GWRC Rail Business Case. It is therefore unlikely that the additional demand of 400 trips, predicted as a result of introducing road pricing, would trigger the need for significant further investment in the rail network.

8.2 Bus Network Constraints and Complementary Measures

Discussions took place with GWRC staff aimed at establishing current demand/bus patronage levels and possible future constraint issues. The following information should be regarded as indicative at this stage only.

8.2.1 Bus Demand

The following table summarises monthly patronage figures during the AM Peak Period.

- **Table 8-2: AM Peak Period Patronage 2004**

Suburb	Monthly AM Peak Period Patronage	Approximate Daily AM Peak Period Patronage
Wellington (excl J'Ville and Newlands)	250,000	12,500
Hutt Valley	106,667	5,333
J'Ville and Newlands	58,333	2,917
Porirua	36,667	1,833
Kapiti	11,667	583
Wairarapa	2,500	125
TOTAL	465,834	23,292

The data indicates that with 250,000 AM peak passengers, Wellington (excluding Johnsonville and Newlands) accounts for over half of all peak bus patronage generated in the region. Following behind Wellington is the Hutt Valley (106,667), Newlands and Johnsonville (58,333), Porirua (36,667), Kapiti (11,667) and the Wairarapa (2,500) together, totalling approximately 465,834 AM peak trips per month.

8.2.2 Bus Capacity

Analysis of GWRC bus timetables allows an approximate analysis of the region's bus capacity as shown in Table 8-3 below.

- **Table 8-3: Summary of Theoretical Bus Capacity into Wellington CBD**

Sectors	Wellington CBD bound AM peak services[3]				Total AM peak buses	Theoretical AM Peak Capacity[4] (services to Wgtn CBD)
	0700-0729	0730-0759	0800-0829	0830-0859		
Wellington (excluding J'Ville and Newlands)	38	59	56	39	192	12480
Newlands and J'Ville	14	10	8	3	35	2275
Kapiti	0	0	0	0	3[5]	195

[3] As determined by Regional bus timetables.

[4] Determined by assuming an average of 65 persons per bus. For example a Mercedes 0.305 bus carries 46 passengers seated and 26 standing.

Hutt Valley	8	4	3	3	18	1170
Wairarapa	0	0	0	0	0	0
Porirua	0	0	0	0	0	0
TOTAL	***60***	***73***	***67***	***45***	***248***	***16120***

The table shows that 78% of all bus services entering the Wellington CBD during the AM peak come from Wellington suburbs. Further, Porirua and the Wairarapa have no bus services that provide a direct service into the Wellington CBD in the AM peak (0700-0900), while Kapiti has three services that leave before 06:30. These areas do have other bus services, however they are primarily designed to provide feeder services for the region's train network as described above.

8.2.3 Bus Constraints

GWRC do not have any specific information on future bus constraint issues. As such, the following issues are those recalled by GWRC staff through conversation. The three main future constraint issues are as follows:

- **Bus Driver Shortage:** With low unemployment rates, NZ is experiencing a shortage of bus drivers, thereby constraining the ability to deliver more services. It is assumed that this situation could be addressed over time. .

- **The Golden Mile:** The stretch of Wellington CBD streets that runs along Lambton Quay and Willis Street is known as the Golden Mile. This route has designated bus lanes and the intention is to extend the lanes to the end of Courtenay Place in the future.

  However, even with an extension to Courtenay Place, it is anticipated that in the near future, the bus lanes will reach capacity, and no more services could feasibly be added to this stretch of network.

- **Regional Topography:** As the region's main infrastructure is limited by topography, so too are the main bus service routes. Buses currently move along the same network as other vehicles, finding problems at the same "choke" points. Therefore, if congestion worsens in the future, buses will be adversely affected too (unless HOV lanes, etc are introduced on some routes such as Petone – Wellington on SH2).

---

[5] All three "Kapiti Commuter" bus services depart from the Kapiti Coast before 0630.

8.2.4 Bus Constraint Conclusion

Because the majority of bus services use the existing roading infrastructure, the provision of additional capacity would have to be catered for through the procurement of additional or larger capacity buses. As road pricing is intended to reduce congestion, buses would experience reduced travel times after implementation, improving service performance. It is assumed that as part of a package of complementary measures associated with road pricing, bus priority improvements such as bus lanes and signal pre-emption would also be provided to improve services.

GWRC has indicated that central Wellington bus lanes (particularly the "golden mile") are already nearing capacity. Adding additional services that would utilise this section of the network may lead to capacity constraints. Consideration would need to be given to routing choices.

It is considered that current difficulties recruiting bus drivers can be resolved, however there may be financial implications associated with this.

This review indicates that there are unlikely to be any fundamental constraints to increasing bus capacity to cater for additional demand resulting from the introduction of road pricing.

9. Regional Economic Issues

This section reviews the potential effects on the regional economy of imposing the range of road pricing measures proposed in this report. This section indicates the relevant features of the current regional economy and discusses the implications of road pricing and reduced congestion. At this stage the information is based on limited research and the findings should be taken as preliminary in nature,

9.1 Greater Wellington Regional Profile

The Wellington economy provided some 12.8% of the national economic activity of New Zealand in the year to March 2004. This compares with some 11.3% of the total population. The regional GDP in the same year was $17.5 billion with a per capita nominal GDP of some $36,700 (year to March 2003). Wellington's per capita GDP is the highest of the twelve regions covered by the NZIER's regional economic data sets.

Wellington's economic growth between March 2000 and March 2004 averaged 3.9% per annum compared with growth in the national economy of 3.5%. However, Wellington's real per capita growth averaged 1.6% between 1998 and 2001 below the national per capita growth rate of 2.3%[6].

The NZIER report also indicates the structure of the regional economy. The industries that account for a higher proportion of the regional economy than they do of the national economy include transport and communications, business services, other services and government. These tend to be sectors that:

- Could benefit from a less congested road network
- Do not necessarily need a fixed work location including opportunities to work from home
- Either do, or could, operate with more flexible working hours, or
- With the exception of some areas of government tend to be located at the various regional centres and potentially closer to the employees' homes.

The two service sectors and the transport and communication sector are fast-growing sectors at the national and regional level. However, as these are sectors that are, or could be, relatively flexible in terms of service location and/or business hours they are unlikely to be impacted significantly by the proposed congestion pricing model. Government employees with working locations inside the cordons, but who live outside could face some additional travel costs if they are required to travel in the peak.

---

[6] New Zealand's regional economic performance NZIER Report to MED September 2004

The tourism and trade sector is also a significant and growing part of the regional economy although marginally less significant than the sector's national significance. However, tourists are less likely to need to travel at peak times and many are more likely to be staying in the Wellington City area so that a peak pricing system for roads should have limited, if any effects.

The region also has a relatively high proportion of residents with formal qualifications and a low unemployment rate.

The region has a number of regional centres including the Kapiti Coast on the west coast north east of the Wellington CBD, Porirua City accessed by the main western link of the 'Y' State Highway network broadly north of the CBD and en route to the Kapiti Coast, and Lower Hutt in the Hutt Valley on the eastern branch of the 'Y' State Highway network. These centres have significant retail, commercial and community hubs and some industrial operations particularly in Lower Hutt.

Kapiti Coast[7]

The Kapiti Coast had a total population of 42,447 at the 2,001 census, a rise of some 1.93% per annum over the 1996 census. This compares with some 0.47% for the Wellington Region as a whole and some 0.65% per annum nationally.

Kapiti has approximately double the proportion of its population over 65 (22.3%) compared with New Zealand as a whole (12.1%), with similar proportions of people under 15 (21% in Kapiti and 22.7% nationally) and 56.7% in the 15 to 64 years age bracket compared with 65.2% nationally.

A slightly higher proportion of Kapiti residents have post school qualifications (33.6% compared with 32.2% nationally) with a significantly higher proportion belonging to the European ethnic group (91.9% compared with 80.1% nationally). The median income level per person, at some $17,900 in 2001, was a little lower than the national median of $18,500 broadly reflecting the higher proportion of older retirees in the population.

The most popular occupational group in the Kapiti Coast was Service and Sales Workers (17.2% in Kapiti compared with 14.8% nationally), this was followed by Professionals (15.8%) and Legislators, Administrators and Managers (15.4%).

Slightly more households in the Kapiti Coast had access to:

- The telephone (97.8%) than nationally (96.3%)
- The Internet (38.9%) than nationally (37.4%)

---

[7] Information taken from 2001 Census of Population and Dwellings, 2001 Household Expenditure Survey and the New Zealand Business Demographics Statistics

- A motor car (90.3%) than nationally (89.9%).

Internet access is likely to have increased significantly since 2001 providing opportunities to mitigate any additional travel costs by such aspects as working wholly or partly from home.

Average household expenditure per Household on transport was $7,310 which was some 17.8% of total household expenditure. This compared with $7,358 and 16.8% nationally.

There were 3,192 business locations in the Kapiti Coast District compared with 309,749 for New Zealand as a whole in 2002. On this basis the number of business locations is a little under represented in Kapiti compared with population (1.03% of the national business units compared with 1.14% of the national population). This again may reflect the higher number of older residents and the lower household income and expenditure.

Porirua City

Porirua had a total population of 47,387 at the 2,001 census a rise of some 0.32% per annum over the 1996 census. This compares with some 0.47% for the Wellington Region as a whole and some 0.65% per annum nationally.

Porirua has approximately half the proportion of its population over 65 (6.8%) compared with New Zealand as a whole (12.1%), with a higher proportions of people under 15 (28.1% in Porirua and 22.7% nationally) and almost identical proportion of its population 65.1% in the 15 to 64 years age bracket compared with 65.2% nationally.

A slightly lower proportion of Porirua residents have post school qualifications (30.8% compared with 32.2% nationally) with a significantly lower proportion belonging to the European ethnic group (63.9% compared with 80.1% nationally) and significantly higher Maori and particularly Pacific Peoples proportion. The median income level per person, at $20,500 in 2001, was higher than the national median of $18,500 partly reflecting the higher proportion of working age and lower number of retirees in the population.

The Porirua district has some significant areas of disadvantage as measured by the New Zealand Deprivation index particularly communities to the north east of the City Centre.

The most popular occupational group in the Porirua was Clerks (17.2% in Porirua compared with Sales Workers at 14.8% nationally), this was followed in Porirua by Professionals (16.2%) and Service and Sales Workers (15.2).

In Porirua City there is a:

- Slightly lower proportion of the population had access to the telephone (94.8%) than nationally (96.3%)

- Slightly higher proportion of the population had access to the Internet (40.7%) than nationally (37.4%)
- Slightly lower proportion of the population had access to a motor car (85.6%) than nationally (89.9%).

Internet access may reflect the relatively high proportion of professionals in the City. As access is likely to have increased significantly since 2001 there may be opportunities to mitigate any additional travel costs by such aspects as working wholly or partly from home.

Average household expenditure per Household on transport was $8,573 which was some 17.8% of total household expenditure. This compared with $7,358 and 16.8% nationally.

There were 2,614 business locations in the Porirua City compared with 309,749 for New Zealand as a whole in 2002. On this basis, the number of business locations is considerably under represented in Porirua compared with population (0.84% of the national business units compared with 1.27% of the national population).

Lower Hutt

Lower Hutt had a total population of 95,478 at the 2,001 census a fall of some 0.08% per annum in the period from 1996 to 2001. This compares with some 0.47% growth for the Wellington Region as a whole and some 0.65% per annum nationally.

Lower Hutt has a slightly lower proportion of its population over 65 (10.5%) compared with New Zealand as a whole (12.1%), with a higher proportions of people under 15 (24% in Lower Hutt and 22.7% nationally) and almost identical proportion of its population 65.5% in the 15 to 64 years age bracket compared with 65.2% nationally.

A slightly higher proportion of Lower Hutt residents have post school qualifications (33.6% compared with 32.2% nationally) with a slightly lower proportion belonging to the European ethnic group (76.7% compared with 80.1% nationally) and slightly higher Maori and Pacific Peoples proportions. The median income level per person, at $22,000 in 2001, was higher than the national median of $18,500 partly reflecting the higher proportion of working age and lower number of retirees in the population.

The most popular occupational group in the Lower Hutt was Clerks (18.3% in Lower Hutt compared with Sales Workers at 14.8% nationally), this was followed in Lower Hutt by Professionals (16.3%) and Service and Sales Workers (14%).

In Lower Hutt there is a:

- Slightly higher proportion of the population had access to the telephone (96.8%) than nationally (96.3%)
- Slightly higher proportion of the population had access to the Internet (40.0%) than nationally (37.4%)
- Slightly lower proportion of the population had access to a motor car (86.8%) than nationally (89.9%).

Internet access may again reflect the relatively high proportion of professionals in the City. As access is likely to have increased significantly since 2001 there may be opportunities to mitigate any additional travel costs by such aspects as working wholly or partly from home.

Average household expenditure per Household on transport was $8,341 which was some 18.1% of total household expenditure. This compared with $7,358 and 16.8% nationally.

There were 7369 business locations in the Lower Hutt compared with 309,749 for New Zealand as a whole in 2002. On this basis, the number of business locations is slightly under represented in Lower Hutt compared with population (2.38% of the national business units compared with 2.55% of the national population).

9.2 Potential regional economic impact

The overall potential economic impact on the region will depend on the level of the total tolls charged and the use made of the revenues. If a system involved substantial export of funds from the region, the impact would be compounded by a negative multiplier effect.

Alternatively, if tolls are largely spent within the region directly on operating costs and where the surplus is allocated to regional activities, the impact would be small and potentially insignificant. The total impact would depend on the change in use of the toll net income and any difference in the multiplier effect.

The pricing options described in previous sections of this report effectively meet the latter scenario. The preferred three non CBD options are estimated to cost some $10 to 12 million to install and some $8 to 10 million to maintain and operate (O&M) per year. The capital cost equates to around 0.11% and the O&M cost around 0.06 % of the regional GDP.

The highest total toll income under the three-cordon scheme is estimated at just under $140 million or some 0.79% of regional GDP. In addition to the toll providing a marginal amount in terms of the total regional GDP even this amount will be partially offset by the estimated user benefit. The net cost to individuals will vary but on average the net cost to users would nearly halve ensuring a minimal net regional impact.

If the net toll income after O&M costs, is allocated to transport projects or other uses within the region, the net impact on the region could be negligible. In this case any impact would only relate to any outflow of funds from the region for such aspects as debt servicing, taxes, imported spare parts and/or specialist technical services.

In theory, if the surplus toll funds are spent on projects that generate higher than average multipliers the project could generate a positive regional economic impact. Based on the above and on the changes to transport patterns explored so far, it is likely that the direct economic impact on the region as a whole of road pricing will be at worst marginal.

While the overall impact is likely to be marginal, consideration needs to be given to whether there could be differential impacts across the region, with more significant adverse impacts at a local level. Based on the level of work to date it is only possible to give an indicative view on this at this stage.

Payment of the maximum toll proposed every working day would add significantly to the annual expenditure on travel. On the average expenditure it could add some 10-15% of the average transport expenditure. In mitigation of this, less than 4% of travellers would pay the maximum toll and those paying this level would tend to be the commuters from furthest away who would have higher than average transport costs at present and who could gain higher travel time benefits. In most cases there would be a public transport alternative and potentially options to avoid the peak period by varying working patterns.

In most districts outside Wellington City there is already a reasonably high level of employment self containment. That is, a relatively high proportion of people work in the same area as they live and relatively few who travel into the centre of Wellington as shown by the following data taken from journey to work data as part of the Census:

- Current level of self containment reasonably high (2001) eg in:
  - Kapiti 43% of workers and 38% who travel to work by car, live and work in the District
  - Porirua the figures are 32% and 31% respectively
  - Lower Hutt 32% and 31% respectively.
- Low proportion of journey to work travel to Wellington including:
  - Kapiti 17% of workers and 15% who travel to work by car
  - Porirua 28% and 23% respectively
  - Lower Hutt 27% and 18% respectively.

Based on the 2001 journey to work data only 5% of work trips would have been affected by all 3 cordons. Given that not all this travel would have been at peak times or by car this number supports the traffic modelling findings that less than 4% would be affected by the maximum toll.

Clearly there will be people paying more for their peak hour travel. However, few will pay the maximum charge and in all cases there will be direct time-savings due to reduced congestion to offset the cost. In addition, depending on the use of the surplus toll funds, there may be additional travel benefits for these individuals.

9.3 Regional economic opportunities and issues

The full impact of road pricing at a regional level needs further investigation. In addition to the benefits of improved peak travel times which offers scope to improve productivity for freight transport and other workplaces and increase leisure time for individuals, there is scope for other potential regional economic benefits based on:

- Opportunities for higher value land uses at specific locations
- Encouragement for increased regional self containment of employment and economic activity including:
  - More home based employment
  - Increased establishment of regional enterprises
  - More intensive use of the regional activity centres (eg: Lower Hutt, Porirua, Kapiti)
- Increasing optimisation of the provision of road infrastructure reducing transport input costs
- Encouragement for the use of public transport options
- Encouragement for more flexible working arrangements.

In addition there are a number of issues that could be addressed including:

- The scope to change the CBD retail offering and ancillary services to address any potential reduction in commuter generated CBD activity and to cater for increases in tourism and other destination markets
- Issues generated by people encouraged to live further out created by improved travel times. For example this could lead to:
  - Increased congestion at peak times including Friday evening and over the weekend
  - Increasing property prices
  - Reduced urban consolidation
  - Changes in the location of economic activity
- Ways to encourage more use of public transport
- Consideration of complementary measures to reinforce the net benefits of road pricing.

9.4 Regional Economics Summary

As noted, work to date in this area has been limited. However, on a basis of the changes to transport patterns explored so far, it is likely that the direct regional economic effect of road pricing will be marginal at worst. As a proportion of the regional GDP, the maximum estimated toll revenue is less than 0.8% of regional GDP. If the surplus revenue from the tolls is spent in the region the net impact on the region as a whole could be insignificant.

From journey to work data only around 5% of journeys to work could face the maximum toll if all journeys to the CBD were by car. In practice only around a third of the journeys to the CBD are by car. The transport modelling suggests that less than 4% of travellers would pay the highest toll.

In terms of overall regional economic growth, while the impacts will be small, road pricing is likely to contribute positively, based on the estimated benefits from reduced congestion and improved travel times at the peak, identified in the transportation work to date. However, there could be differential impacts by location, although these are likely to be small based on the marginal overall impact.

If road pricing generates a positive benefit and any resulting positive revenue is wholly expended in the region, and on projects with a net positive benefit, the regional net benefit would increase. However, given the initial net benefit is likely to be marginal, the likely extended benefit will also be small. Whether this leads to a net positive or negative benefit over the pre-tolling position would depend on the use the original holders of the revenue made of the money they have now paid in tolls. If the money transferred to tolls was originally invested in opportunities with regional returns significantly in excess of the return on tolling (and from projects funded from toll revenue) the regional benefit could fall.

In either case, the actual return will depend on the extent of leakage from the region. If a scheme involved substantial export of funds from the region through such aspects as offshore contractors, debt servicing, taxes, imported spare parts and/or specialist technical services, it could result in a positive impact becoming negative. On this basis, further work is needed to be confident about the likely net benefit, although on balance the benefit is likely to be positive, small and potentially increased by good investment decisions related to investing the toll revenue surplus.

In addition, a number of characteristics of the regional economy offer scope to complement the peak period travel improvements in supporting further regional economic growth, such as:

- the relatively high self-containment of employment in the individual local authority areas
- the relatively highly qualified regional workforce
- The strength of the Wellington regional economy in some of the faster growing industry sectors such as business and other services and transport and communications.

10. Public Acceptability

A key factor in the successful introduction of road pricing within the greater Wellington region will be the level of public acceptability for the general principle of road pricing.

The principle of public sector tolling to fund new infrastructure is well understood with experience of tolling schemes such as the Lyttelton Tunnel, the Auckland Harbour Bridge and the Tauranga Harbour Bridge. The options being investigated in this study however, involve tolling existing roads for the purposes of reducing congestion, not tolling as a funding mechanism for new infrastructure. The public is likely to have substantially different opinions on this form of road user charging. It is therefore critical that the response to road pricing be investigated and evaluated.

There are significant social, political and economic barriers to the introduction of almost any road pricing scheme and a knowledge gap surrounding acceptability, education and marketing has resulted in otherwise well justified road pricing schemes failing to be implemented elsewhere. This was the case with the Edinburgh Congestion charge, which was defeated by adverse public opinion. Experience in a number of countries has indicated that these obstacles can be overcome through development of schemes that address public concerns and maximise acceptability.

Given that any road pricing scheme is unlikely to enjoy majority acceptability initially , and that schemes can be designed to promote acceptability, it is appropriate that we look at the factors that influence accessibility.

A review of available local and international literature was undertaken and has identified the following major factors that can effect the acceptability of road pricing measures:

- Alternatives to the car and their perceived effectiveness
- Use of the revenues generated
- Scale of the congestion problem
- Understanding the purpose of road pricing
- Considerations of equity and fairness of the pricing
- Form, technology, complexity and privacy
- Political leadership and public trust

Discussion of these factors is set out below.

10.1 Alternatives to the car and their perceived effectiveness

Road pricing is likely to be more acceptable in situations where people can choose to pay for reduced journey times, but alternatives such as public transport exist. Measures become less acceptable if there is no choice but to continue to use the charged roads, or not make the journey at all. People see this as restricting their freedom of movement and commonly, the lack of a perceived viable alternative to the car is cited as a major reason why road pricing as not acceptable to the public.

While Wellington has a relatively good public transport system, there is likely to be significant concern about it's ability to provide an alternative to the car. This would be particularly true if public transport was expected to carry increased volumes as a result of road pricing. The 2004 Greater Wellington regional Council Transport Perceptions Surveys found that only 62% of respondents felt trains were reliable and only 61% of respondents felt buses were reliable.

The acceptability of road pricing in Wellington could be improved by implementing road pricing as part of a package of measures which included improvements to public transport.

10.2 Use of the revenues generated

The acceptability of road pricing in Wellington could be improved by hypothecating revenues to transport improvements such as traffic restraint measures and infrastructure and service provision. A review of a large number of international surveys was undertaken for the UK DfT and "reveals quite clearly that once investment to improve public transport is offered in return for charging the motorist, acceptance of charging increases. This shift is substantial in all these cases and in some instances marks a swing from net opposition to net support" (UWE, 2004).

This was also highlighted in interviews undertaken for Greater Wellington Regional Council, which indicated that when Wellingtonians "consider road pricing a little further it tends to become more acceptable if the revenue is spent on improving/developing public transport or expanding the road network" (Forcyte 2001).

Hypothecating of revenues would include allocating specific budgets from the revenues generated to bus, rail, road safety and road network improvements. Where possible, allocation should be specific to particular projects and will involve marketing road pricing as part of a package of measures not as a stand alone solution.

An alternative is to hypothecate revenues to maintenance and operation of the road network, allowing other road user charges such as fuel taxes and registration or access charges to be reduced, such that there is no net increase in overall charges, but a more efficient allocation.

10.3 Scale of the congestion problem

If the roads in a region are extremely heavily congested, resulting in extensive environmental and economic hardship, the likelihood that road pricing will receive public acceptance is much greater than it would be for a region where there is minimal congestion. Put simply, the greater the recognition that there is a congestion problem, the more likely it is that road pricing will be acceptable to the public.

While congestion is a recognised by the community as being of concern, Wellington is not faced with the scale of congestion problems such as those found in Auckland, let alone those found in major cities like London and New York. This raises the question of whether the public will accept a measure as radical as road pricing.

Section 4.2 above, clearly indicates that there is a significant level of congestion in Wellington at peak times. In the GWRC Transport Perception Survey undertaken in 2004, 62% of respondents considered that congestion has worsened over the past two years. A Transit NZ survey conducted in 2003 also found that 70% of respondents believed congestion in Wellington needed either some or a lot of improvement. This result is an increase of 12% over 2003.

Surveys undertaken for Greater Wellington regional Council showed that the "greatest share of respondents agree that central Wellington currently has a significant congestion problem (63%) and therefore are likely to be open to suggestions for solutions" (Gravitas 2003). However, interviews also undertaken for GWRC earlier indicate that "the urgency of addressing congestion with action now is not there so much regionally. However, Wellingtonians are looking for planning and future action in specific areas – the motorways in and out of Wellington"

While there is not yet convincing evidence that the congestion problem is significant enough at present to make road pricing acceptable, there does seem to be consensus that the problem of congestion is going to get worse and that measures needs to be put in place to plan for it. "Eighty-three percent of respondents agree that traffic congestion will become a serious problem for Wellington over the next few years. Therefore, while not all Wellington motorists feel the region has a congestion problem currently, they support the proactive investigation of possible initiatives, including road pricing, to mitigate the impact of congestion in the near future." (Gravitas 2003)

10.4 Understanding the purpose of road pricing

For road pricing to be acceptable, it must be seen as providing an effective means of reducing congestion or generating revenues to fund new infrastructure. If road pricing is proposed as a way to reduce congestion, there can be a lack of faith in its effectiveness. If people believe that the measures will not be successful in reducing congestion and have a significant effect on travel times, they will be opposed to road pricing. There is a need to clearly show that the scheme has been designed as to address the concerns that led to road pricing being considered.

Consideration needs to be given as to the way that road pricing is marketed to the public. Although there may be some skepticism that road pricing will be effective in reducing congestion, forecast congestion benefits will still be an important tool in developing acceptance. A marketing campaign to educate people about the purpose of road pricing, the role that individuals play in producing congestion and the proposed use of revenues will be key to ensuring acceptability of road pricing in Wellington.

Convincing people of the effectiveness of road pricing will be a considerable task, as in a recent surveys “74% of respondents said that, in the last six months, costs had had no bearing on their usage of a private vehicle (81% in 2003)” (National Research Bureau, 2004), and that “Almost half of all respondents (44%) state that immediately upon the introduction of road pricing, they wouldn’t or couldn’t change their travel patterns. Similarly, in the medium term, almost half of all motorists (43%) will not make any attempt to change their travel patterns or use alternative forms of transport” (Gravitas 2003).

10.5 Considerations of equity and fairness of the pricing

It is considered that a major factor influencing the acceptability of road pricing is the effect on lower socio-economic groups, ethnic groups and the less able. The DfT’s evidence-base review concludes “considerations of equity are major determinants of attitudes to road pricing” and that a “widespread perception that a road pricing scheme is operating on an equitable basis is likely to be a major determinant of its public acceptance” (UWE, 2004).

By introducing a system where mobility is linked to the ability to pay a charge, the impact will be greater on those with lower incomes. Road pricing is regressive in that it requires everyone to pay the same amount for access, irrespective of their level of income. A charge is unlikely to restrict the mobility of those who have higher incomes but will affect those on lower incomes. This can lead to social exclusion.

As car use is seen as ‘necessary’ in New Zealand, charges would need to be significant to change driver behaviours. There is generally a key trade-off in pricing schemes between effectiveness and acceptability. An acceptable road pricing scheme would need to minimise divisiveness in terms of the effects on different sorts of people in different locations and provide improved mobility and accessibility; in this respect, the economic efficiency of high charges and wide variations by location and time of day may have to be balanced against the acceptability benefits of systems having smaller fixed charges.

A general perception that the charge is fair is an important factor in determining acceptability. People may feel that they already pay for the roading assets that they use through road and fuel taxes. In New Zealand only a proportion of the road and fuel taxes are actually used for transport improvements. The acceptability of road pricing schemes can be adversely effected if people believe that road pricing is unfair as they are already paying too much to the government who is profiteering and road pricing is only going to make this worse.

Experience shows that variable pricing in the transport sector has "been defeated by adverse public opinion. The public objection was, in each case based on the supposed unfairness of the new pricing regime and it's failure to have the desired effect" (University of Leeds 2004).

10.6 Form, technology, complexity and privacy

There seems to be a clear preference for simple schemes and the form and complexity of the charging structures will be a factor in determining acceptability. The simpler the scheme, the more likely it will be acceptable. This is noted by the DfT's evidence-base review which concludes that any "proposed road pricing scheme needs to be one which can be amenable to public understanding" and that "its complicated character may itself be a barrier to public acceptance" (UWE, 2004).

There is likely to be adverse public opinion to the use of complicated or new technology. There appears to be a general distrust of technology that is new or unproven and this was highlighted by adverse response to the previous National government's ERP proposals. In the UK, surveys for the DfT also indicated that "Overall, people had fairly negative views on satellite based charging, with 68% expressing such opinions." (DfT 2005). The DfT also noted that "there is a clear connection between the efficiency of the technology and the likely acceptability of the scheme. Put basically, if the technology does not work, or is not easily understood by the public, then its credibility is fatally undermined." (UWE, 2004). Developing public faith in the technology will be important and could be facilitated by using proven technology in the first instance, and running the system prior to opening without charges to prove reliability.

Acceptability will also be influenced by the degree to which a scheme appears to be fair in terms of the balance of costs and benefits. The development of a large, expensive system that is perceived to require a large bureaucracy to run, but delivers little in the way of revenues, is unlikely to be acceptable.

The literature generally acknowledges that perceptions of the effect on personal privacy can effect acceptability. This is linked to concerns over "big brother" type government and it is considered that schemes which collect personal information are less acceptable that those where use is anonymous. Measures to address these concerns can be seen in the stringent conditions imposed in relation to the collection of personal information for proposed toll schemes under the LTMA 2003.

10.7 Political leadership and public trust

As appreciation that there is a large funding gap between what the region can afford and public expectations grows, the political acceptability of road pricing is likely to increase. This can be seen in moves by the MOT, GWRC and Local Authorities to investigate TDM measures including road pricing. The organisations involved will need get high level buy-in from politicians at an early stage to promote acceptability. Political leadership is likely to be the most significant factor in road pricing acceptability. In the case of London's successful congestion charging scheme, the "Mayor included proposals for a scheme to reduce congestion in his election manifesto and won the election. Londoners voted for him knowing that he would probably implement congestion charging" (Rye et al 2003). Other schemes where political leadership has been less evident have been unsuccessful, for example Edinburgh.

There seems to be very real skepticism about the purpose of road pricing and people feel that it is just another "stealth tax" put forward by politicians. This was confirmed in interviews undertaken in Wellington where it was found that "both the general public and the business community are very skeptical about the money actually being spent in this way. They fear the revenue will disappear into "government coffers", not be used in the region it was collected and/or used for politicians' "perks"" (Forcyte 2001).

Developing public trust will be an important task and would be facilitated by making clear assertions on where revenues will go and commencing projects funded by the revenues prior to commissioning of the system. A measure to be considered is the formation of a new body to administer road pricing.

SKM

11. Conclusions and Recommendations

This initial work described in this report suggests that a road pricing scheme can be implemented in greater Wellington region, which would be financially self-sustaining, provide surplus revenues to invest in improved passenger transport , which would bring large peak decongestion benefits with environmental and safety improvements. There would be a small, but positive contribution to the economic growth of the region and impacts on different parts of the region would be small. The impact on areas with high levels of social deprivation would be very small. Charges would be modest, consistent with passenger transport fares, and would only affect a small proportion of road users. There would be improvements to safety and personal security, including network security

Key conclusions based on the most beneficial options tested were:

- Person kilometres could be reduced by 2 to 3%
- Passenger transport kilometres could increase by 9.3%
- Travel times to the CBD from the north could reduce by up to 30%
- Delays at key bottlenecks may be reduced by between 10-15% (dependent on the level of toll proposed)
- 80% of peak period trips would not incur any toll
- Of those that pay a toll, only 4% would pay $5

All the pricing concepts delivered small but tangible benefits in terms of vehicle emissions and the number of crashes, thereby contributing to an improvement in public health. CO2 emissions would also be reduced, which supports the environmental sustainability objective in the RLTS. Social equity issues were also investigated, by examining the deprivation index published by Statistics New Zealand and comparing the highest level of deprivation with where the maximum tolls would be imposed. This work suggests that very modest levels of additional costs would be imposed on average, and those areas which would incur the highest average costs would not be those with the higher socially deprived populations.

An important aspect of the concepts tested was that typically no more than 15% of vehicle trips on the network would pay a toll. The maximum toll would be of the order of $5.00, roughly equivalent to the passenger transport fare for an equivalent journey. It should also be noted (depending on the concept adopted) that only a small proportion of all travellers (less than 4%) would pay the highest toll of $5.00. From overseas experience, it is clear that community acceptance of road pricing is in part determined by the maximum toll levels, and the proportion of trips that would pay the maximum charge.

It can be concluded from the work completed to date that road pricing could reduce network congestion and be economically and fiscally viable while at the same time having marginal social and economic effects. Moreover reduced congestion in the Wellington Region would improve accessibility and may well improve the regional economy by allowing greater mobility for higher value traffic including commercial traffic.

It is therefore recommended that Wellington Road Pricing Study proceed to the next stage which should include detailed investigation of road pricing in the Wellington region and address the issues set out in the Terms of Reference for the full study. The next steps involve refining the concepts developed to date and reviewing the social and environmental impacts of road pricing in more detail. A key aspect of the next stage of the study will be to identify the system administration and technological issues, including a robust risk assessment.

Road pricing will also involve a number of complimentary measures, which may include road and rail infrastructure, bus service improvements, travel demand management, etc. Ultimately, a detailed traffic impact assessment would be needed to examine localised effects; for example the need for measures to ensure that traffic will not divert onto in-appropriate routes. However, this may take place in subsequent study phases. In any case, many of these projects are already contemplated by Councils in the region; it will be important to see road pricing as one component of the overall regional transport strategy, rather than a stand-alone initiative.

Appendix A Wellington Road Pricing Study - Terms of Reference

Introduction

Greater Wellington Regional Council in association with Transit, Transfund and the region's territorial authorities wish to develop a road pricing strategy for the region's strategic road network that best meets national and regional objectives for transport. Key questions that this study must answer include:

A1. What issues can road pricing address?

A2. What is the impact of road pricing on regional land use patterns?

A3. Can strategies be developed to acceptably manage the regional and local economic and social impacts of road pricing?

A4. How can the revenues earned by road pricing be best deployed recognising equity issues?

A5. Does Wellington's unique network structure require a model for road pricing that would be different from other urban areas?

B1. What level of road pricing is appropriate for Wellington?

B2. What form of road pricing (cordon tolls, route specific tolls, HOT lanes, distance by time charges etc) best achieves our transport objectives?

B3. What time periods (peak, interpeak, outside peak, weekend) are appropriate for road pricing and at what levels?

B4. When should road pricing be introduced into the Wellington region?

C1. What is the impact of road pricing on infrastructure investment and when is it optimal to invest?

C2. How can road pricing be used to sustain the benefits of infrastructure investment?

This study is concerned with the strategic issues associated with road pricing. It is not concerned with the detailed technological questions of implementing road pricing. For the purposes of this study it is assumed that suitable technology will be available when required.

Purpose

The purpose of this study is to identify whether a road pricing proposal can be found that best supports national and regional objectives for transport in the region. Proposals should best meet regional needs in a manner that facilitates and supports, social, business, recreational, environmental and other strategic goals (including current and future land use).

The proposed solutions should reasonably:

- Assist economic development
- Assist safety and personal security, including network security
- Improve access and mobility
- Protect and promote public health
- Ensure environmental sustainability

These are national objectives but in the Wellington region there will be particular emphasis in each of the above objectives which best meets the Wellington region's needs. This emphasis is outlined in the discussion of objectives that provides the platform for the development of the new RLTS.

Road pricing should not be seen as an isolated transport measure but part of an integrated package of infrastructure and service enhancements; complemented by other TDM measures and land use policies designed to achieve strategic transport and other objectives for the region.

Background

The Land Transport Management Act (LTMA) requires the consideration of TDM as part of a package of measures designed to achieve national and regional objectives for transport. Such an initiative is currently being developed for the Wellington Region. Although the Land Transport Management Act does not permit the introduction of road pricing for the purposes of TDM the Government has signaled an interest in investigating road pricing in special cases. It is envisaged that if a good case can be demonstrated then this may lead legislative changes to permit road pricing on existing roads. This will require a clear determination of whether the pricing is designed for revenue gathering, efficiency or both.

The RLTS 1999-2004 is underpinned by extensive analysis of measures that contribute to achieving regional objectives. The RLTS 1999-2004 gives clear direction as to the need to consider road pricing.

In addition, this study will need to take into account the following:

- New Zealand Transport Strategy (NZTS), LTMA and National Energy Efficiency and Conservation Strategy (NEECS)
- The RLTS
- Regional Transport Baseline Report
- Wellington Regional Strategy (WRS)

It is relevant to note that parallel initiatives are also taking place such as the Auckland Road Pricing Study, the development of ERUC for heavy vehicles, the development of tolling for new roads consistent with the LTMA, the Government agencies investigation and other MoT policy work. This Wellington project will complement these investigations.

Scope

This study will consider the whole of the region's strategic transport network as identified in the RLTS 1999-2004. All modes of travel will be included such as private car, bus, passenger rail, walking, cycling, road freight and rail freight.

A variety of road pricing mechanisms will be considered but they must be considered as part of an integrated package of transport initiatives. Examples of road pricing initiatives include:

- Tolls for new roads and facilities (specific tolled roads and lanes)
- Specific network charges (SH1 and SH2 access charge, time and distance based charges)
- Cordon tolls (single/multiple CBD toll rings, CBD toll ring and sub-regional CBD toll rungs)
- Area charges (area wide charge around CBD)
- Parking charges
- Combinations of the above

Technical group

A technical group made up of officers from GWRC, Ministry of Transport, Transit New Zealand, Transfund New Zealand, LTSA and the region's Territorial Local Authorities, is responsible for overseeing the technical work of the study. When Transfund and LTSA amalgamate they will have a single representative. Their role is to ensure that the study is based on sound processes and information. The technical group is chaired by Tony Brennand of GWRC

Programme

This study is programmed to commence in August 2004 and will be completed by December 2005. The indicative timelines are provided in the table below:

Date	Phase
31 August 2004	Project commencement
August – September 2004	Confirm issues
September – October 2004	Develop performance measures for objectives
November 2004 – March 2005	Evaluation of options against scenarios
July – September 2005	Documentation and report writing

Resources

Although there is a budget available for this study it is envisaged that much of the study will be conducted in house by GWRC staff with specialist support provided by external consultants.

Issues and needs

- The population of the region is forecast to grow around 0.9% per year with modest growth in future years.
- The region's cars are forecasted to increase in number by about 1% per annum.
- Trip numbers are expected to grow at a rate of 3.5% per annum
- Sixty percent of the region's employment is in Wellington City which has only 38% of the region's population
- The Wellington City CBD will continue to be the dominant employment centre

- The region's economy is expected to have lower output and employment growth than the New Zealand average
- The region is experiencing tourism growth
- Freight movements are increasing significantly across the region
- Recreation and shopping journeys are increasing particularly in weekends
- School travel continues to grow
- Peak time and weekend congestion continues to grow
- Buses and goods traffic gets caught in congestion
- Convenient pedestrian connections to the major central areas and key public transport modes may produce significant benefits but providing direct and safe routes may be difficult
- There is limited carparking available in Wellington CBD which constrains the viability of a car based community
- There is a growing awareness about the environmental impact of the transport system
- Peak time rail services are inadequate as an attractive alternative to car travel
- Some community groups have strong objections against further road improvements in their area
- The introduction of road pricing will generate social and economic impacts which will need to be considered and addressed
- The linear nature of the region's transport network means changes in the distribution of land use could have significant impacts on the demand for travel and choice of mode
- This road pricing study will need to interface with a variety of parallel studies which include the WRS, Western Corridor Study and the CDB Corridor Study

Analysis

The performance of road pricing options will be analysed using the regional transport strategy model (WTSM) together with other tools and approaches. There may be a need to determine local elasticities using stated preference methods.

A series of agreed performance indicators will be used to assess alternative road pricing scenarios. There will be two design years used for the analysis. These will be 2016 and 2026.

The alternative road pricing scenarios will be evaluated using a planning balance sheet approach. The planning balance sheet uses a performance matrix where each row of the matrix gives a ranking against objectives.

Outputs

A detailed technical report that:

- summarises the performance indicators that describe each objective
- summarises the performance of each road pricing proposal against transport and wider objectives
- describes the impact of each road pricing proposal on the identified needs and issues
- provides a response to the questions raised in the introduction of this terms of reference
- provides recommendations on the feasibility and desirability, the most desirable form, level and timing of introduction of road pricing for the Wellington region.

Evaluation Framework

1. Social, economic and environment impact assessment (including equity and efficiency dimensions)

2. Evaluate against NZTS objectives:
    - Assisting economic development
    - Assisting safety and personal security
    - Improving access and mobility
    - Protecting and promoting public health
    - Ensuring environmental sustainability

3. Identify and assess:
    - Demand management
    - Revenue potential
    - Social distributive effects
    - Consistency with Auckland Regional Policy Statement land use policies
    - Privacy issues

SKM

Appendix B Overview of the Road Pricing Option Forecasts

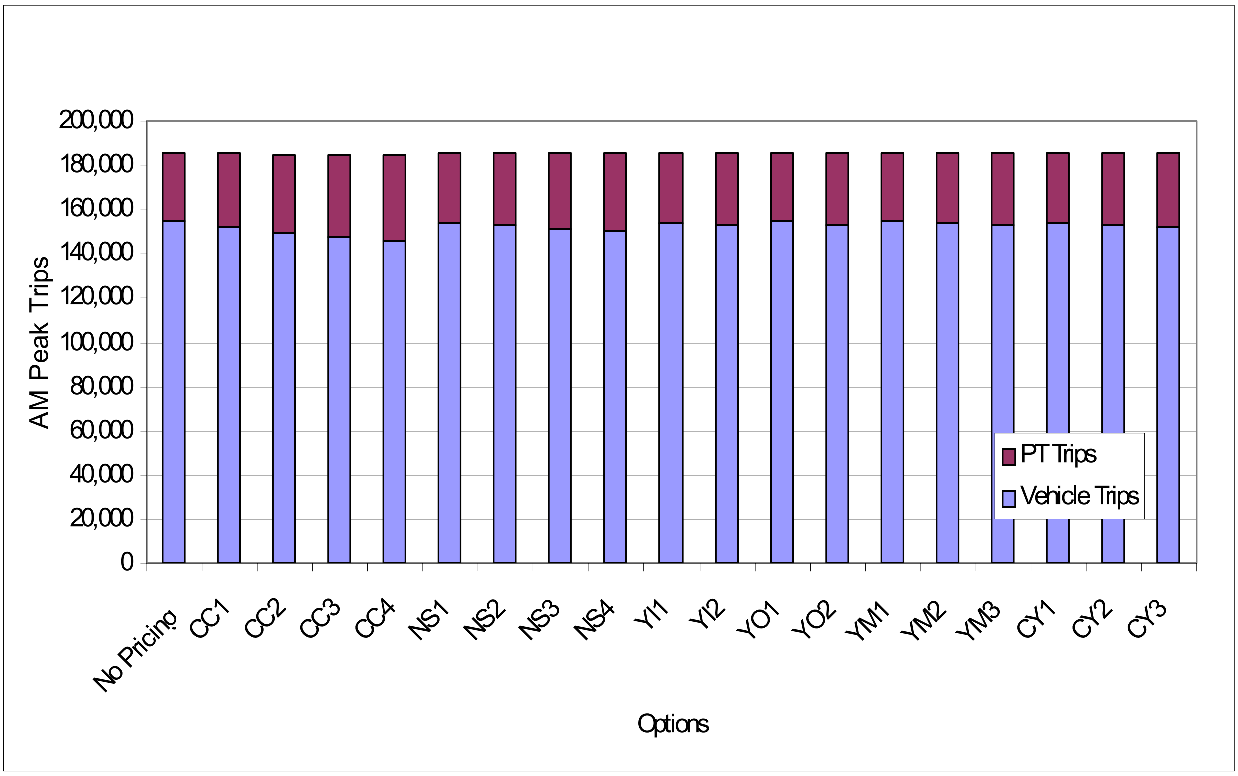
Introduction

This section presents a summary of initial results from the modelling of the different pricing options and highlights some of the general impacts, not specifically related to the evaluation criteria. For all figures, the notation used for each option is that set out in Section 4.

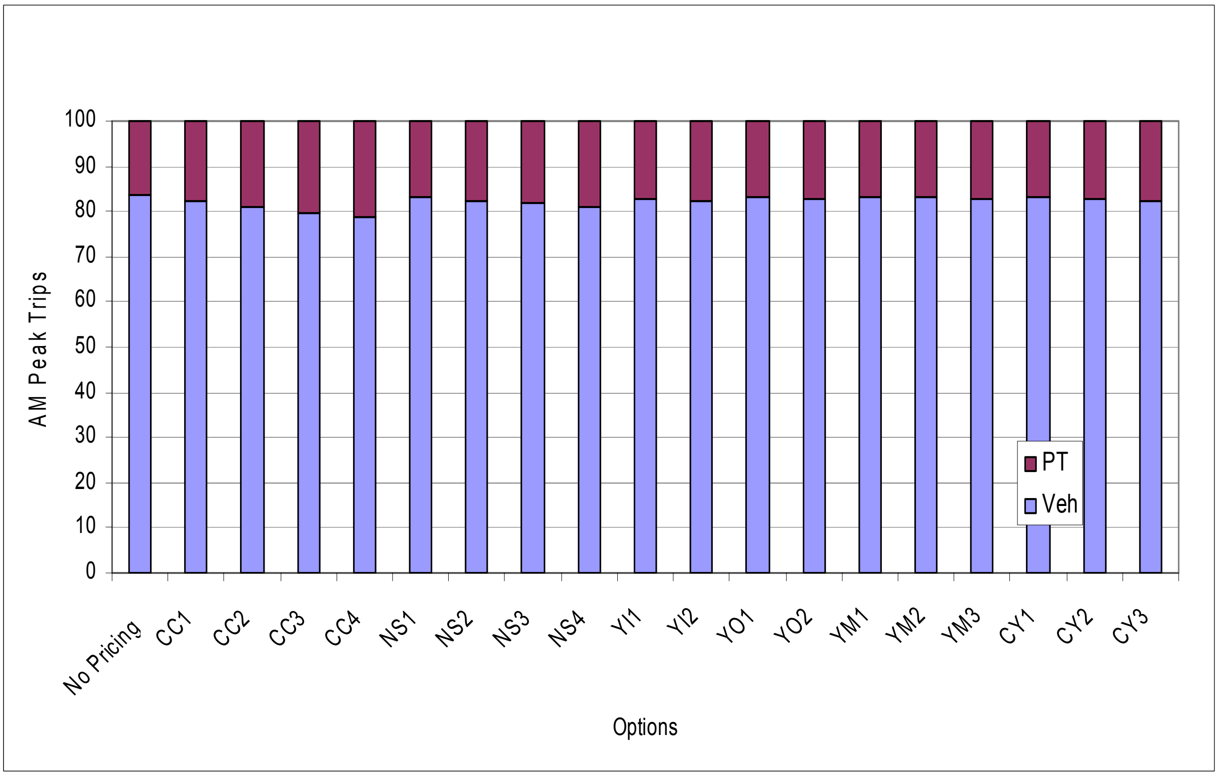
Travel Demands

Figure 11-1 presents the AM peak trips by private vehicle and PT for each of the options. While all options increase the number of PT trips and reduce private vehicle trips, these changes are small for all but the CBD Cordon. This is confirmed by the mode share analysis summarised in Figure 11-2.

- **Figure 11-1: AM Peak Private Vehicle and PT Trips**



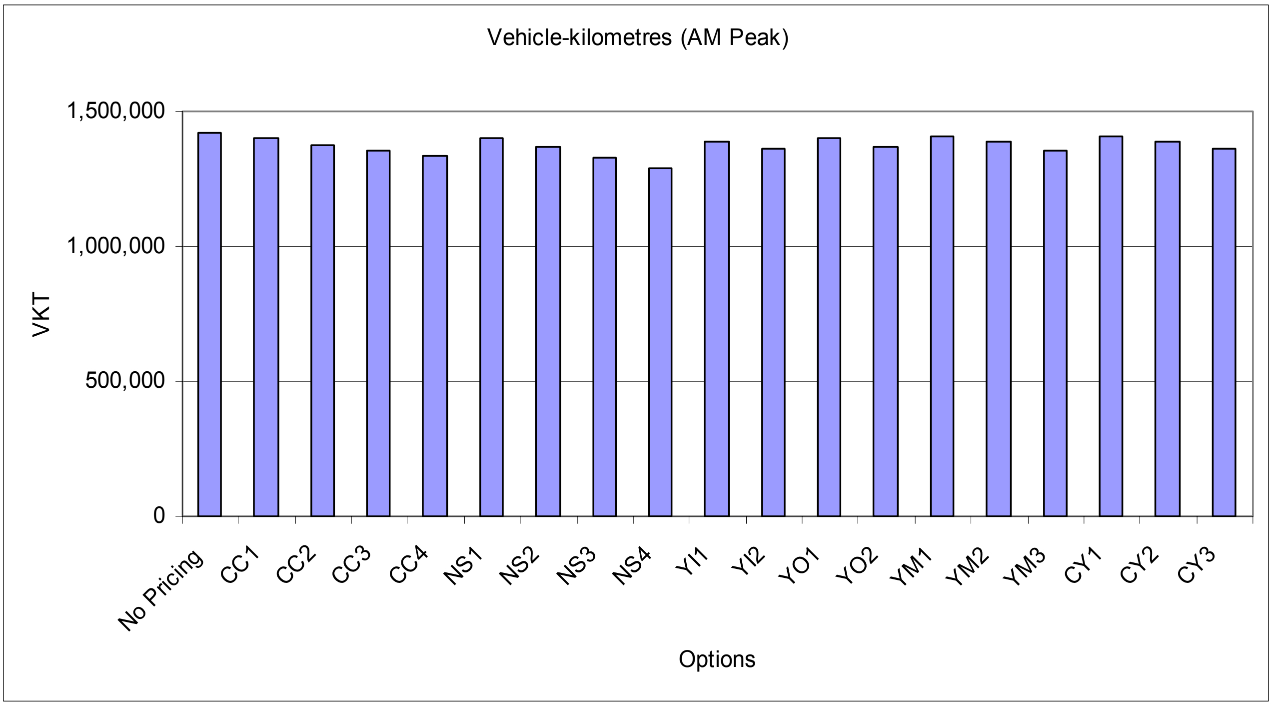
■ **Figure 11-2: AM Peak Private Vehicle and PT Mode Shares**



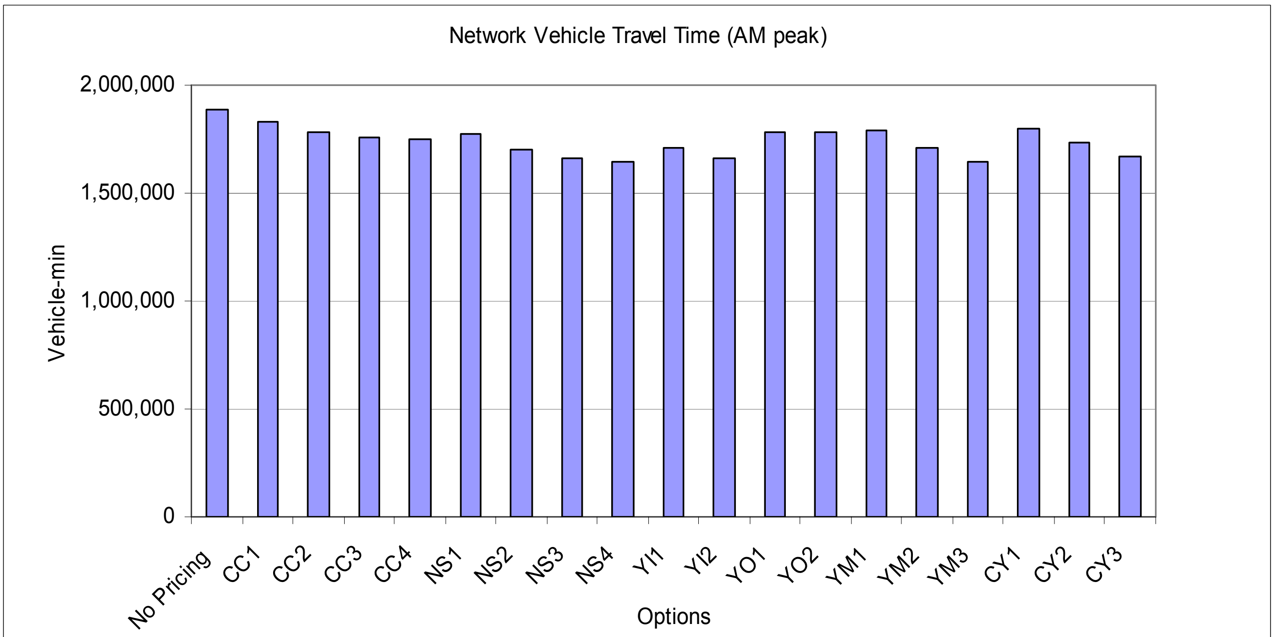
Road Vehicle Kilometrage and Travel Time

Figure 11-3 and Figure 11-4 show the private vehicle-kilometres of travel and network travel time in the AM peak period. All options have less private vehicle-kilometres of travel and network travel time than the no pricing case. The reductions in VKT range from 1% to 9%, the latter being for the highest pricing level for the Ngauranga Screenline option, NS4. This option also gives the greatest reduction in network travel time along with the highest pricing levels of the Inner Y, Medium Y and CBD Cordon +Y options. Given the small effect on total number of vehicle trips, it is clear that road pricing has had a proportionally larger impact on longer trips, reducing average car trip lengths in the peak periods.

■ **Figure 11-3: AM Peak Private Vehicle-Kilometres**



■ **Figure 11-4: AM Peak Private Vehicle Network Travel Time**

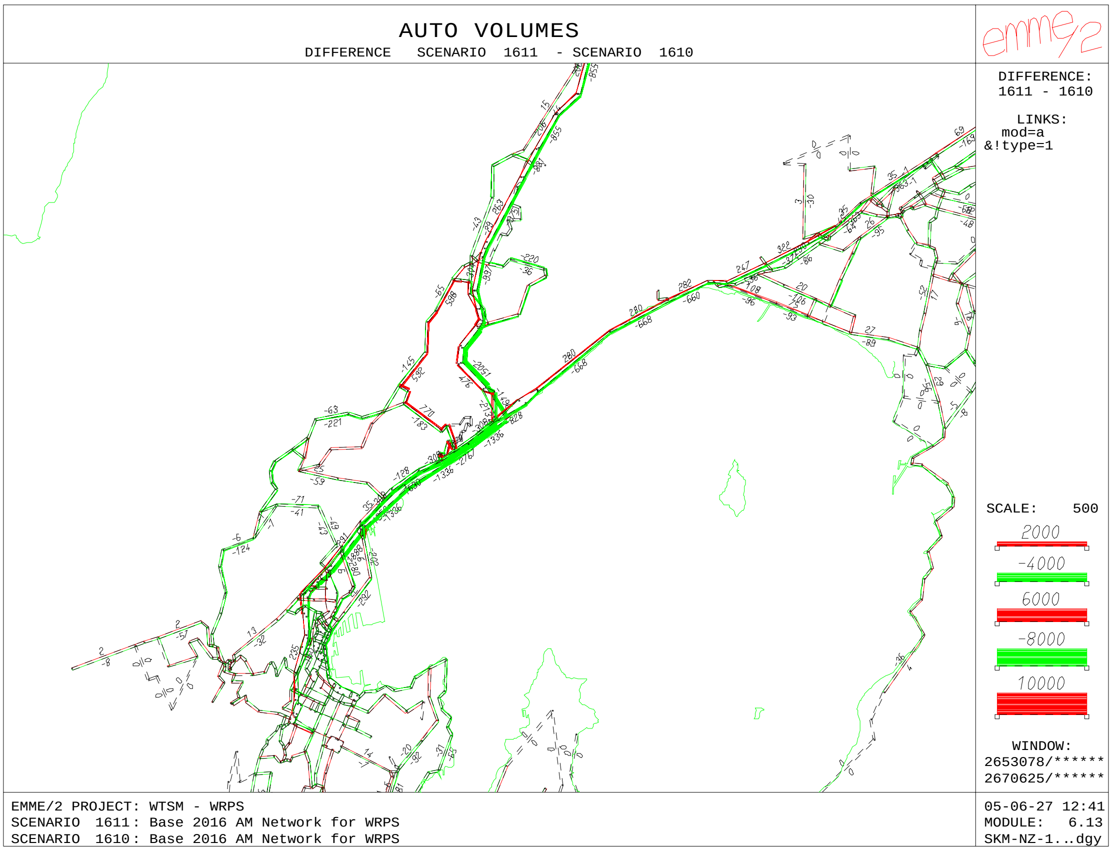


Changes in Traffic Flows

Plots showing the changes in AM peak period traffic flows on the regional motorway network between the options and the no pricing case are presented for a selection of the options.

For the $4 Ngauranga Screenline option (NS2, Figure 11-5), there are decreases in flows on SH1 and SH2 and the Hutt Road upstream and downstream of the Y; a total of some 4,000 vehicles in 2 hours at the point of the tolls just south of the Y. Traffic increases on SH1 and SH2 in the contra-peak direction as well as on Burma and Cashmere Roads in the peak direction (up to 770 vehicles/2-hours). The latter avoids payment of the toll and indicates where trips reroute to avoid paying the charges.

- **Figure 11-5: Change in AM peak Traffic Flows, Ngauranga Screenline Option, $4, (NS2)**



For the Inner Y option (YI2, Figure 11-6), as for the Ngauranga Screenline, flows decrease on SH1 and SH2 and the Hutt Road upstream and downstream of the Y and there is increased traffic on Burma and Cashmere Roads in the peak direction. In this option, traffic reductions are greater in the SH2 Hutt valley corridor, reflecting the higher charges.

- **Figure 11-6: Change in AM peak Traffic Flows, Inner Y Screenline Option (YI2)**

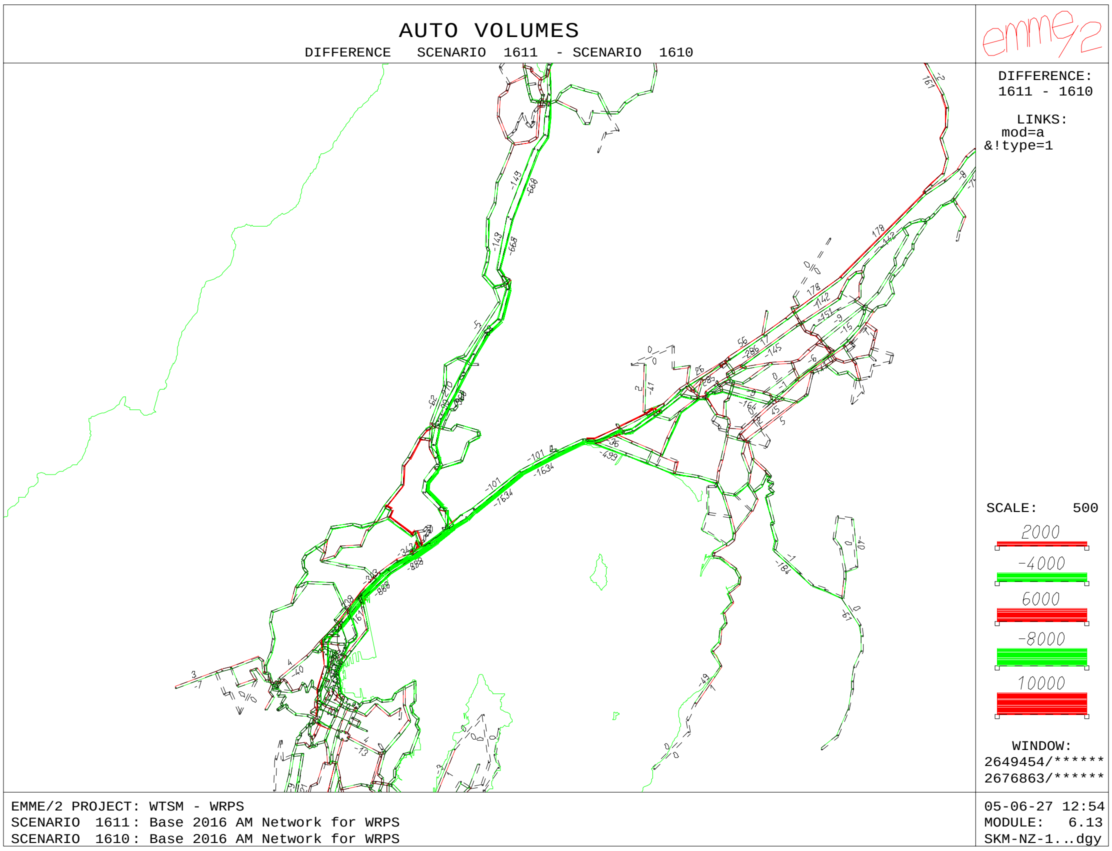
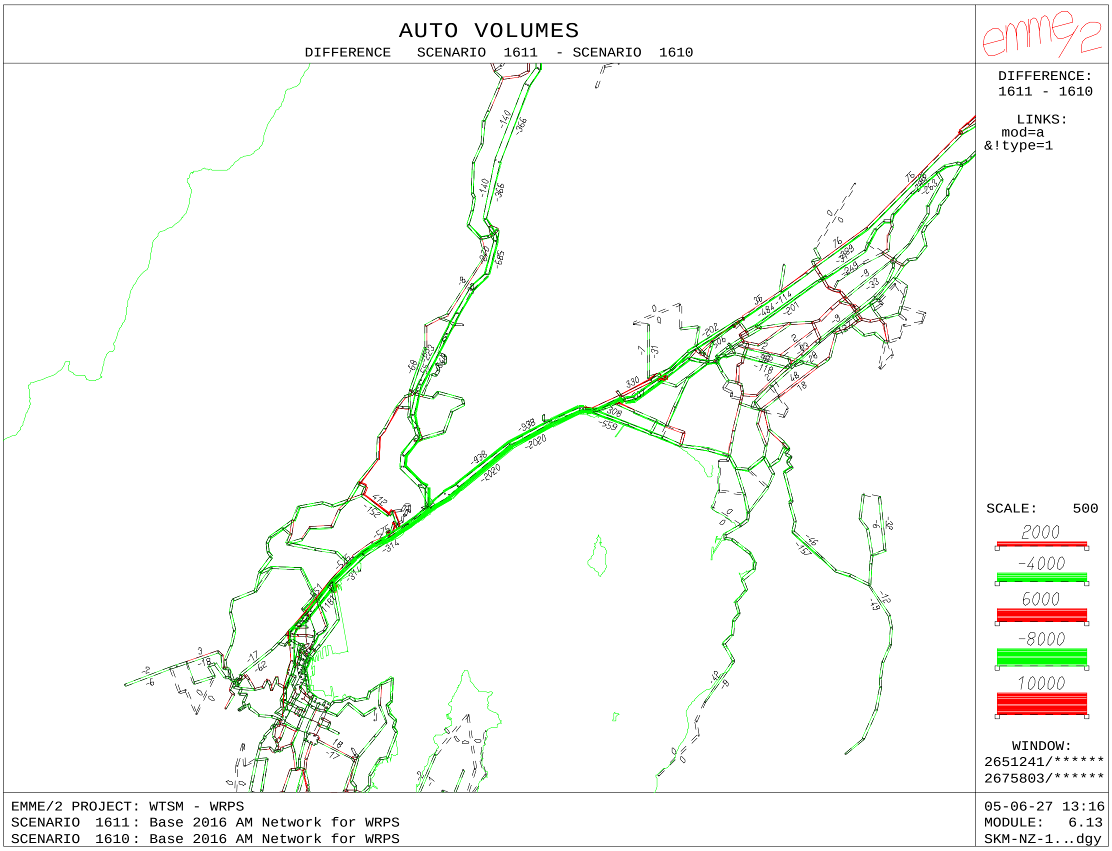


Figure 11-7 shows the change in flows for the Medium Y option (YM3). Again, there are traffic reductions on SH1 and SH2 and the Hutt Road upstream and downstream of the Y, and some increase on Burma and Cashmere Roads in the peak direction. The larger traffic reduction in the SH2 Hutt Valley corridor is also apparent. With this option there is also an increase on SH58 westbound of some 400 vehicles per 2 hours.

▪ **Figure 11-7: Change in AM peak Traffic Flows, Medium Y Option (YM3)**



Appendix C Wellington Road Pricing Study Technology Options Paper

Wellington Road Pricing Study
Technology Options

1 Introduction

The charging options being considered in the study include the following:

- Distance and Time Based Charging;
- Route based charging;
- Area based charging;
- Cordon based charging.

Distance and Time Based Charging involve levying a charge based upon distance travelled or time spent travelling on a road or in an area subject to a charge. A time based system is normally considered potentially dangerous as it would encourage speeding, but charges for any type of system can be changed by time of day. Many examples of distance based charging exist, most commonly on toll roads although the recently introduced European Lorry Road User Charging systems include it.

Route based charging is effectively levying a charge for using a particular route or road. It is most commonly applied for toll roads and bridges and tunnels, normally to fund private construction and maintenance. The author is not aware of any examples that are used for demand management.

Area based charging involves levying a charge for the use of public roads within a defined area or zone. The most well known example of this system is the London Congestion Charging system.

Cordon Based charging involves levying a charge for crossing a defined cordon - normally around a defined area. Although the area defined may be the same as for an area based charging system, the charge only applies when the cordon is crossed, in one or both directions and travel within the area enclosed by the cordon does not involve a charge. Multiple cordons can be included if required. The Ring Road systems in Norway are examples of a cordon based system.

The technology required for each of these charging options consists of two main functional components. The first of these is the charging component whereby drivers pay for road usage, based upon the charging option selected. The second is the enforcement component whereby the payment is checked in relation to travel.

This paper reviews the technical aspects of both payment and enforcement. It also considers central office functions and links to external facilities.

2 Payment Options

The payment options available partly depend upon the charging option being considered. The main ones are:

a) Offline payment (as used in London Congestion Charging) whereby the payment is separated from the charged event. A payment can be made in a number of different ways including by phone, SMS, retail outlet, internet and on-street payment machine. It must be linked to an easily identifiable aspect of the vehicle that can be used in the enforcement process. In London this is the Vehicle Registration Mark (number plate) or it could be a paper receipt for display in the vehicle - as used in the original Singapore Area Licensing System. As discussed below, the Vehicle Registration Mark is preferable as it eases the enforcement process.

b) Payment at a 'toll booth' as used for toll roads and as part of the Oslo Toll Ring for example. Payment can be in cash, by using a card or automatically using an electronic device - as described below.

c) Payment based upon a device fixed within and associated with a particular vehicle that transacts with a payment site on the road. In the first trial of such technology in Hong Kong in the early 1980s an 'electronic number plate' was welded to the underside of the vehicle. The modern Singapore System used a 'microwave tag' fitted in the vehicle windscreen which communicates with a gantry mounted beacon. There are now international standards covering some aspects of this communication - DSRC, Direct Short Range Communication and a trial of interoperability between different suppliers is being conducted in Leeds in England, the DIRECTS trial. There is also a system used at some toll collection sites that uses Infra Red communication rather than microwave, but this has fewer supporters.

d) Payment based upon a GPS based module fitted in the vehicle that can be used to detect a passage across a zone boundary, for example, or for measuring distance along a road. For enforcement and checking there would normally be a communications method provided between the GPS unit and the outside world. This can be using cellular radio (again being trialled as part of the DIRECTS project) or by DSRC to a roadside or gantry mounted beacon - as being used by the German Lorry Road User Charging System and in Austria.

Whatever method payment is used, it is necessary to have a back office system that takes data from the payment channels and provides the central accounting system and communicates with the enforcement system. That element of the back office dealing with this function can be called the 'Payment and Accounting System'.

A significant issue related to payment that has a major impact upon enforcement is whether it is intended to charge different classes of vehicles a different charge. From a payment point of view this should be relatively straightforward but, as discussed below, it brings in major issues related to enforcement.

Table 1 below shows the potential use of the payment options outlined above related to the charging regimes listed in the Introduction. Note that no mention is made of time based charging, i.e. charging based upon time on the charged road network. This is because it is normally considered unsafe to charge by time as it will encourage speeding. If it is of particular interest in Wellington, or a particular aspect is being considered, it can be added to the technical consideration. Any system can, of course, be operated within certain defined time periods.

Table 1 Scoring for Payment Technologies in relation to Charging Options

Payment Options	Distance Based	Route Based	Area Based	Cordon Based
Offline Payment	5	3	1	1
Toll Booths	5	3	3	1
In vehicle 'tag'	3	3	3	1
GPS based	1	1	1	1

Key - Scoring 1 is most suitable, 5 is least suitable

The scoring shown in Table 1 above is based mainly upon technical suitability and not cost effectiveness. The comments below explain the scoring used.

Offline Payment is a relatively easy method to set up but does need to have payment terminals in locations where payment is collected linked back to a central computer so that payment can be registered soon after it is made. The arrangement made depends upon the charging and enforcement regime. For the London system, payment can be made before or on the day of travel. This means that enforcement must take place after the day of travel - in London, the next day. Depending upon the enforcement regime, this means that evidence of travel must be held for a day until payment can be confirmed. It is very important for ease of understanding by the public and enforcement that offline payment uses a very simple charging basis. A fixed charge is ideal, as used in London. This implies that a charge is not based upon quantity and uses one payment for any number of cordon crossings or similar. The payment method is very suitable for a simple area based charge or a cordon crossing charge. It could be used for a simple route based charge - providing the route was clearly defined - when it would become effectively an area based charge - the area defined as the route. It is not really suitable for a distance based charge as there is no ready means of measuring the distance - either for the driver when making payment, or for an enforcement system when checking whether the payment was correct.

Toll Booths are a well known means of collecting charges for toll roads, bridges and tunnels. They normally provide a variety of means of making payment including by cash, bank card and using a DSRC tag. Their main disadvantage for a congestion charging system is the space required for provision on an existing highway network. Throughput, particularly for manual payment is around 400 vehicles per hour, depending upon the toll, and hence for a busy highway a significant number are required, necessitating a large area for a toll plaza. The 'toll rings' in Norway use toll booths at some locations, but they are unlikely to be a practical solution in most congestion charging situations.

In Vehicle Tag This technology is most suited to a point payment and hence is very suitable for cordon based charging. For route based charging, its suitability depends upon route length and definition. It is used extensively for toll collection on highways and bridges, but is best suited for a toll that is fixed for use of a road. It can be used for distance based tolling, whereby details of entry point are stored on the tag on entry and on exit, this is read and the charge is calculated. The cost of this becomes prohibitive if there are a large number of entry and exit points - such as in an urban area. For area based charging, it would be necessary to ensure that sufficient beacons were erected to ensure that the majority of potential journeys, including ones wholly within the charging area, were covered. Depending upon normal journey patterns, this may be practical but where there are a lot of journeys starting and finishing within the charged area (for example if it included substantial residential areas), this may be a problem and add significantly to the cost.

GPS Based A GPS based system is very flexible and can be used to charge for any charging option with equal efficiency. There are issues in relation to possible loss of signal from the GPS satellites in built up areas where high buildings may prevent line of sight signal pick up. This may restrict the accuracy, but various techniques are available (which may add to the cost) to improve accuracy. Another advantage of this technology is that no roadside infrastructure is required for payment, although it may be for enforcement. A GPS unit normally requires specialist fitting into the vehicle, which will add to the cost. Apart from the GPS element, it needs some means of communication with the charging system and this would normally be via cellular radio, although it could be used in conjunction with DSRC (see below) to communicate directly with an enforcement site.

The correct operation of this system also relies upon the accuracy of the GPS satellite signals. As these satellites are primarily for use of the US military, the accuracy and availability may be changed in the future. This may pose a risk to using this system. When the European Gallileo system becomes operational this risk will be reduced as it will be a commercial system.

A practical charging system may utilise a number of payment methods and should be designed so that it can be extended and new technology be introduced as it matures. For example, a cordon or area based system could be set up based upon a tag payment system. It is highly unlikely that all vehicles could be assumed to be equipped as infrequent users have to be catered for. Although they could be equipped with tags, it is likely to be more flexible to allow an offline payment option. Also, as more vehicles become equipped with satellite navigation systems, payment options using that technology may also be appropriate as much of the cost would already be covered by the satellite navigation in-vehicle equipment.

It has been suggested that payment might be levied based upon data captured by the enforcement system. This is possible, but as discussed below, because the enforcement system is not 100% reliable, it would be necessary to accept that some of the potential revenue would be lost. If sufficient enforcement cameras were installed such that in a typical journey a vehicle passed several, this would increase the chance of image capture and hence payment. This would not be suitable for a cordon crossing system where effectively there is only one chance of image capture, at the cordon. If this charging approach was used, it would be necessary to have vehicles pre-register, as with a tag based system as it would not be practical or cost effective to pursue a vehicle keeper for a relatively modest road pricing charge. In the London system, fleet operators can pre-register their vehicles with the operating authority and are charged based upon data obtained from the enforcement system. The charge payable is increased by 10% to account for the potential inaccuracies of the enforcement system.

3 Enforcement Options

By far the simplest and most reliable enforcement option is a barrier based system used in many toll plazas. This is linked directly with payment and the barrier prevents passage until the payment is made. This has the major advantage of dealing with enforcement at the same time as payment and hence no follow up action is required. The major disadvantages of barriers are that they require considerable space and introduce capacity restrictions when associated with electronic payment using Tags. The capacity of a free flow lane tag based payment lane might be reduced from 1,600 vph or more to 900 vph when a barrier is introduced. With a manual or card based payment at a toll booth, there is no impact upon capacity with a well designed system as the need to stop and make a payment reduces the throughput rather than the barrier.

A barrier based enforcement system is highly unlikely to be usable in a practical urban road pricing system and reliance must be placed on methods that do not interfere with traffic flow and do not require a significant amount of space for installation. In practice, the only method that has been found to be practical involves the use of the Vehicle Registration Mark or VRM. This is unique to a vehicle, is normally linked to the vehicle keeper via a central Vehicle Licence Database and is relatively easy to read automatically, particularly if, as in New Zealand, retro reflective number plates are used. VRMs are used extensively for enforcement of motoring offences and hence their use for this process is well understood.

The use of a paper pass or ticket to indicate payment (as with a 'pay and display' parking ticket) is very difficult to check automatically and hence is not suitable for a congestion charging system. In contrast to parking payment, the ticket must be checked while the vehicle is moving in free flow traffic which is not possible with currently available technology.

A key issue with using the VRM is the accuracy of the central vehicle licence database and the ease to which access can be obtained. In England, varying claims are made about accuracy (including prompt updating when vehicles change hands or owners move). In practice, it seems that it is about 80% accurate, and it is accepted that some vehicle keepers never correctly register their vehicle. Although systems will normally be in place to allow police access, it is likely that road pricing will not involve the police and hence secure on-line access must be made available to the operating or enforcing authority. For the London system, the Driver and Vehicle Licensing Authority developed a separate 'shadow' read only database that is automatically updated from the main database. Access is provided at two levels - firstly when an account is being set up, access is provided so that details of vehicle and keeper can be checked. Secondly, access is provided automatically, normally at night when queries arising because of suspected non payment are dealt with and responses are provided in time for the start of the following working day.

In order to introduce an enforcement system, it is necessary to provide cameras at suitable locations on the road that are able to read number plates. Depending upon the road width (number of lanes) it would normally be possible to mount cameras on poles at the roadside. A normal system would require two types of camera (but this depends upon local legislation). The first camera would be the one that focuses on number plate reading. This would normally operate in the infra red band and would have an associated infra red illuminator. It would be facing towards the direction of traffic flow to read the front number plate (less likely to be dirty or obscured). Infra red is used as it is invisible to the eye and hence does not cause any safety problems. With retro reflective plates, the level or IR illumination required is low and hence it is well within safe limits. A standard (non digital) camera would be able to view a width of road of approximately 2.5 to 3 m. This provides the resolution required for good performance of number plate reading technology. The width of the road would determine the number of cameras required. Modern digital cameras have significantly higher resolution and one camera should be able to adequately cover two full lanes.

The output from the IR camera is fed into an Automatic Number Plate Reading (ANPR) computer system, normally at the roadside. This reads the number plate in real time and stores the information. It also sends details of the number plate back to the central system. A normal system would include software that continually scans the images looking for number plates. This means that no external detection system is required to trigger image capture. The read accuracy depends upon a number of factors but would normally be at least 80%.

The overall aims of the enforcement system are to read the number plates of passing vehicles and to collect sufficient data that can be used to form an evidential record for issue of a Penalty Charge Notice and, if necessary further prosecution. In UK, an evidential record requires further evidence of the presence of the vehicle at the site and the second camera used as part of the enforcement system is a colour context camera that takes a colour context overview image of the vehicles that pass. Normally one camera can cover two lanes. The camera sensitivity and street lighting must be sufficient that images can be captured in night time conditions - assuming that charging may be operational during the hours of darkness. The overview image together with the number plate image, ANPR output, time stamps and location data forms an evidential record that is sufficient to prove that the vehicle was present. This is the requirement in UK and it is necessary to check - probably by reference to police speed cameras, what is required to form an evidential record in New Zealand, particularly in relation to digital evidential records rather than those based upon film.

The method of payment adopted and the charging strategy both influence the detailed design and location of the enforcement systems. As mentioned above, it is likely that a practical system must include offline payment for infrequent users. For these, the evidential record must be stored until payment (or non payment) is confirmed.

For a tag based system, payment can be confirmed at the time that an evidential record is obtained and hence it can be discarded. It should be noted that in a multi lane free flow situation, accurately relating a tag based payment with an enforcement image is not simple. It is likely to require a gantry mounted system and problems of matching payment tag location with image can still be found. These problems can be significantly reduced if the vehicle VRN is stored on the tag as it can be directly compared with that read by ANPR, but this reduces flexibility of tag issue as they need to be individually programmed for the vehicle.

The locations for installation of enforcement depend upon charging regime and payment method. For a distance based charge, it depends upon the precise system and method of payment adopted, but Table 2 below identifies potential enforcement strategies for the most appropriate payment options identified in Table 1.

Table 2 Potential Enforcement Options for Different Charging Regimes

Payment Means	Distance	Route	Area	Cordon
Offline	XXX	XXX	Entry and Exit, with screenlines for internal trips	At cordon crossing points
Toll Booths	XXX	XXX	XXX	At toll booths (at cordons)
Tag Based	XXX	XXX	XXX	At cordon crossing points
GPS	Screenlines in charged area	Screenlines along route	Screenlines within area	At cordon crossing points

It should be noted that cordon crossing based systems can be difficult to enforce unless careful thought is given to the definition of the chargeable action of 'Cordon Crossing' that is being enforced. An enforceable cordon cannot be a 'line' but must be nominally 10m wide to allow an area for enforcement. In addition, consideration must be given to the definition of crossing as it is not practical to enforce the actual passage of the vehicle across the cordon as this would require two time related images, one one side and another the other. Similarly demonstrating movement would also require at least two images, which may be difficult to obtain clearly demonstrating movement in congested conditions.

One very important issue related to enforcement and charging is the question of charging at different rates for different vehicle classes. From an enforcement point of view, this requires the ability to accurately classify vehicles in a free flow traffic situation. Despite what manufacturers may claim, this is virtually impossible with current technology, although it is easier with some classification regimes than others. Unless a classification system is near perfect, it will raise continual 'classification mismatch' alarms that need to be checked manually, which can add substantially to operating costs. This does not mean that uniform charging for all vehicles is required and it is possible to have some variation, providing that it is not necessary to automatically enforce. It is necessary to ensure that any non-standard vehicles are registered before hand, probably with some checks with the vehicle licensing database. The question of classification then becomes not relevant. With a tag based system, it is necessary to ensure that tags are not misused and that a tag for an exempt or low charge vehicle is not used in a higher charge vehicle. This can be done by associating a tag with a particular vehicle and storing the VRM on the tag, which will increase administration as discussed above. It is also possible to securely fix a tag in the vehicle so that it cannot be moved, but again this reduces flexibility and increases costs.

Motorcycles cause particular problems mainly because the main number plates are normally on the rear. Also, because of the way that they weave between traffic they are difficult to detect and differentiate from other vehicles. Motorcycles are charged in Singapore and are equipped with tags but the charging and enforcement system requires a three gantry solution to enable correct operation.

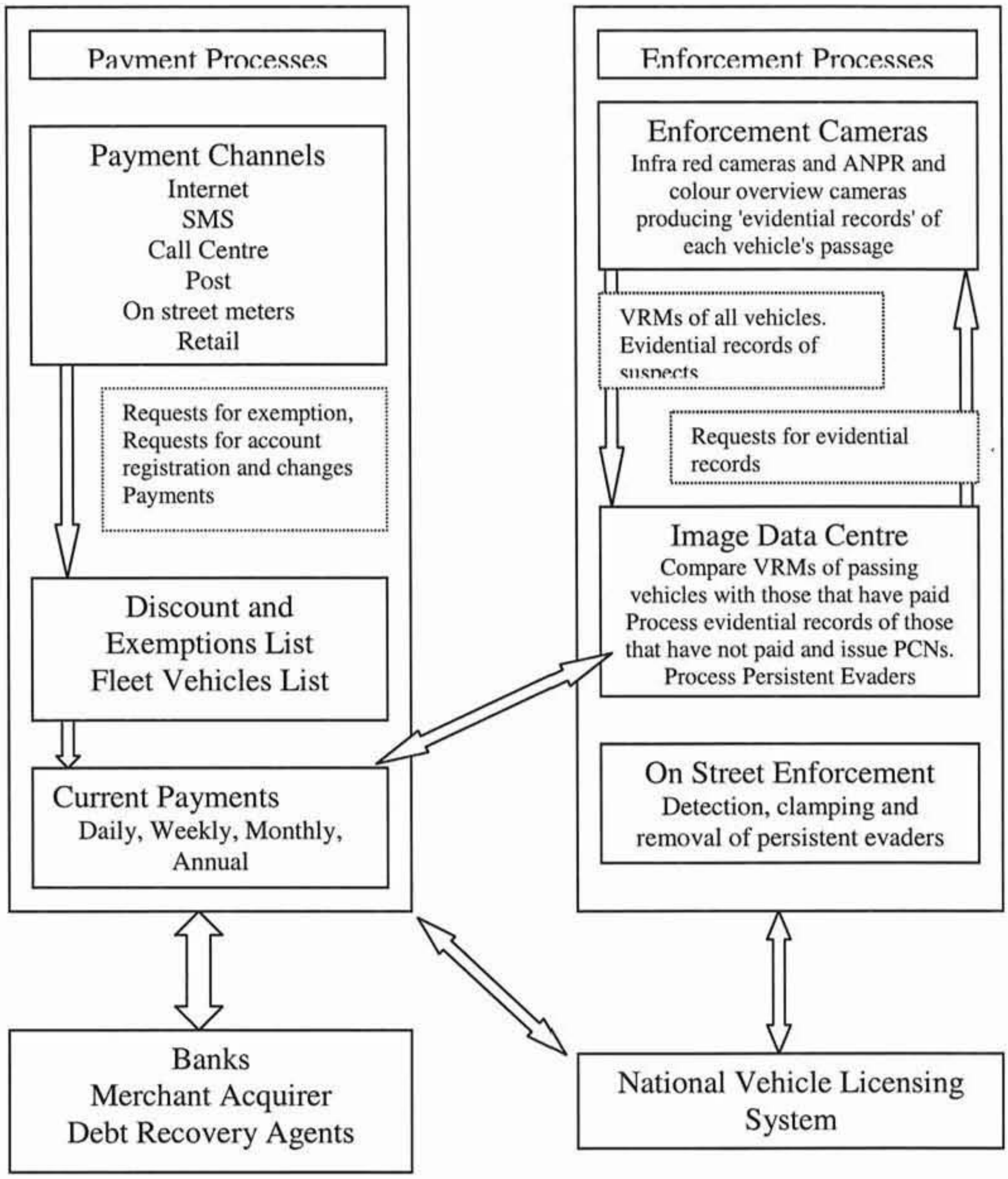
4 Back Office Functions

The detail of the back office functions depends upon the type of system that is introduced, in particular whether it uses off line payment only, payment based upon tags or similar or a combination of both. For the purposes of this discussion, it will be assumed to utilise off line payment methods only, and changes necessary if a tag based system is used will be highlighted.

The functional design also depends upon whether a system in Wellington is designed as a stand alone system or whether it is part of a national system including toll collection and potentially Lorry Road Used Charging. For the purposes of this description, it is assumed to be self contained.

There are two main functional elements to a congestion charging system. They are payment processes and enforcement processes. Figure 1 below shows a functional architecture.

Figure 1 - Functional Architecture for a Road Pricing System



Payment Processes

Whatever payment channels are provided, it is of vital importance to ensure that these are designed to allow 'bulk purchase' of charges through weekly, monthly, or annual tickets and be automated as far as possible and to minimise human intervention. This is essential to reduce costs which can be a relatively high proportion of the charge collected. For example, in London, the cost of charge collection by telephone to a human operator is close to £1 which is one fifth of the current charge (and would have been a half of the charge proposed for Edinburgh).

The payment processes involve a number of activities. The first of these is the payment channels. These can be provided in a number of ways and, as mentioned above, should be designed to minimise human intervention. It is expected that many of the users of a potential system in Wellington will be frequent users and these should be encouraged to set up an account with the charging authority. This can be related to the purchase of 'season tickets' but should also allow for ready making of individual charge payments. For example, a method in use in London involves sending an SMS from a pre-registered mobile phone on the day that a payment is required. This is related to the account and an automatic debit made from a bank account. Many tag based automatic toll collection systems require a pre-paid account to be set up with the authority and this is kept topped up by debiting the user's bank account. Which method is most appropriate depends upon the charging methodology and the amount of charge. For a toll collection system, the payment is normally required at the time - to avoid the need for any follow up action. For a road pricing system, this may not be the case and, as with London, payment may be accepted anytime on or before the day of travel.

Arrangements should be made for accounts to be set up using the internet, by post and through a call centre. The account will be linked to the vehicle's VRM and it would be desirable for a check to be made with the vehicle licensing records that the details provided match those registered.

It is likely that there will be some exemptions to the charge (buses, emergency services, disabled drivers) and some reduced charge vehicles (residents within the charged area). Wherever possible, these should be registered in advance to reduce the processing required and on registration, the details that warrant exemption or reduced charge should be checked.

Payment of a charge could be provided by SMS, internet, retail outlets, on-street payment machines (possibly converted Pay and Display parking payment machines) and using a call centre.

It is also desirable that the charges are set to encourage the use of the payment options that are cheaper to administer so that operating costs are reduced. Generally speaking the use of SMS and internet are the cheapest options while a call centre and retail outlets are the most expensive.

Whichever payment method is used, it is important that some form of receipt is provided to act as evidence in case a PCN is mistakenly issued. This might be an electronic payment confirmation with a payment reference number or a paper receipt from a payment machine or retail outlet. The details of the payment must also be registered in a central database, shown in the figure as 'Current Payments'. This will be used to check against details of vehicles captured by the Enforcement Process.

Enforcement Processes

The enforcement process starts with the capture of an 'evidential record' at the enforcement site. To reduce transmission costs, the records would probably be stored at site and details of the VRM only sent to the centre. These would be stored in a database and compared with the 'Current Payments' database in the payments system. Where a record of payment existed, the evidential record stored at site could be deleted. At the end of the allowed period for payment, the enforcement system would have a list of VRMs of vehicles that had been seen by the enforcement system, but where no payment had been registered.

Each enforcement site would be asked to transmit the evidential records of those vehicles with no payment record and these would be stored in an evidential record store. There will probably be procedures in place used by the Police governing the handling of digital evidential records and it would be desirable that these be followed as far as is possible.

In parallel with receipt of evidential records, access will be necessary to the Vehicle Licensing database to obtain keeper details of vehicles where an offence is suspected.

Because the enforcement system will have inaccuracies, it is important that a manual check be made of the evidential records before a Penalty Charge Notice is issued. This will involve checking the VRM as read automatically for correctness, checking the overview image to ensure that it is the vehicle as registered and checking the overview image to ensure that it provides the basis of a valid PCN.

When these checks have been completed and an address for the registered keeper has been obtained, a Penalty Charge Notice can be issued. For simplicity and to minimise confusion amongst drivers, the process should probably be similar to that used for parking penalties, assuming that that is reasonably well developed and works successfully. Depending upon who the operating authority is, the parking and road pricing PCN processing could be combined to reduce costs and maximise efficiency.

It is expected that an appeals process will be necessary to cater for those that believe that the PCN has been issued in error. Again, this may be combined with a parking appeals system.

As with any similar system, there will be a number of offenders that cannot be identified because the vehicle licence records are incorrect or who persistently refuse the pay the penalty charge. There will be systems in place for parking enforcement to deal with these offenders and powers should be provided to the road pricing enforcement authority to be able to clamp and/or tow away vehicles of persistent evaders. The enforcement system should also be designed to allow persistent offenders to be 'hot listed', so that an alarm is raised when one passes an enforcement point.

5 System Architecture

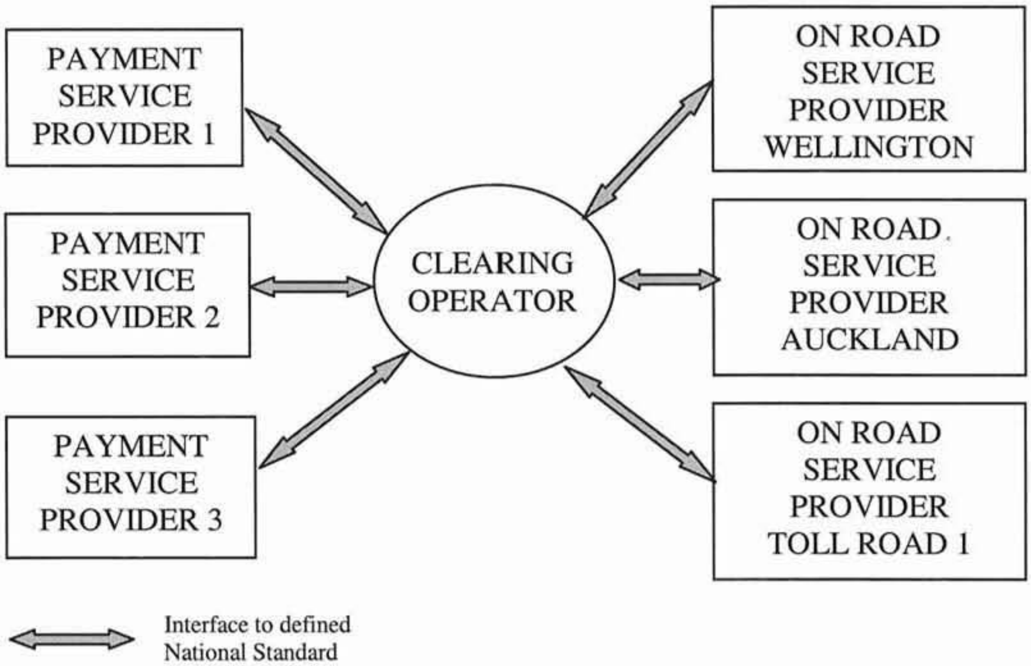
Potential National System

The system architecture required depends upon a number of factors, the most important of which is whether the system is self contained for Wellington only or whether it is part of a National system. In the latter case, the architecture is likely to be 'imposed' by the designers of the national system. For the purposed of this paper, the architecture for a possible national system is described, based upon the UK DIRECTS architecture, and a simpler local system is also illustrated.

The architecture for the DIRECTS project in UK assumes a national system with a number of charging authorities in different cities and on various tolled facilities. The architecture separates the on-road service provision (called an ORSP - On Road

Service Provider) from the payment function (called a PSP - Payment Service Provider). These functions are linked through a central Clearing Operator (CO). The architecture is shown in Figure 2 below. It assumes that charging is based upon automatic means utilising Tags or GPS based in vehicle units.

Figure 2 Architecture for National Charging System



The functions of the PSP are primarily:

To issue tags to drivers and set up accounts, both tag based and non tag based;
To transmit the account information to the CO;
To receive from CO information about payments made from accounts;
To receive from CO information about PCNs to be issued;
To deal with all communications with drivers, including payments and PCNs;
To hold account and payment data and remit appropriate funds to CO for transmission to ORSPs;
To take part in reconciliation of accounts with CO.

The functions of the ORSP are primarily:

To provide charging and enforcement equipment on street;
To set tariff tables and transmit to CO;
To transmit to CO all details of charges made by the system;
To review all enforcement images captured and transmit valid ones to CO;
To receive funds based upon transactions and PCNs from the CO;
To take part in reconciliation of accounts with CO.

The functions of the CO are primarily;

To receive details of all accounts set up from PSPs;
To receive details of all transactions and PCNs from ORSPs and transmit to appropriate PSP;
To reconcile all accounts between PSPs and ORSPs and transfer appropriate payments from PSPs to ORSPs
To act as arbiter between ORSPs and PSPs as necessary.

The advantages of such a system are that it allows a user to have one (or more) account and to use it nationally – and potentially internationally as required. This would be similar to the use of a Visa or Mastercard issued by one bank that can be used Nationally and Internationally.

For such a system to be practical, it is necessary that many of the functions and interfaces between the building blocks are standardised. This applies to the interfaces shown, but also for a tag based or GPS based system the air interfaces between tag and roadside infrastructure must be standardised. This activity is not trivial and, although some aspects are being subject to international standardisation, there are still many standards that must be developed locally.

The benefit of such a National system are very limited unless there are a large number of facilities that charge and these are reasonably closely spaced and with similar requirements so that there is a reasonable chance of significant volumes of vehicles using more that one facility.

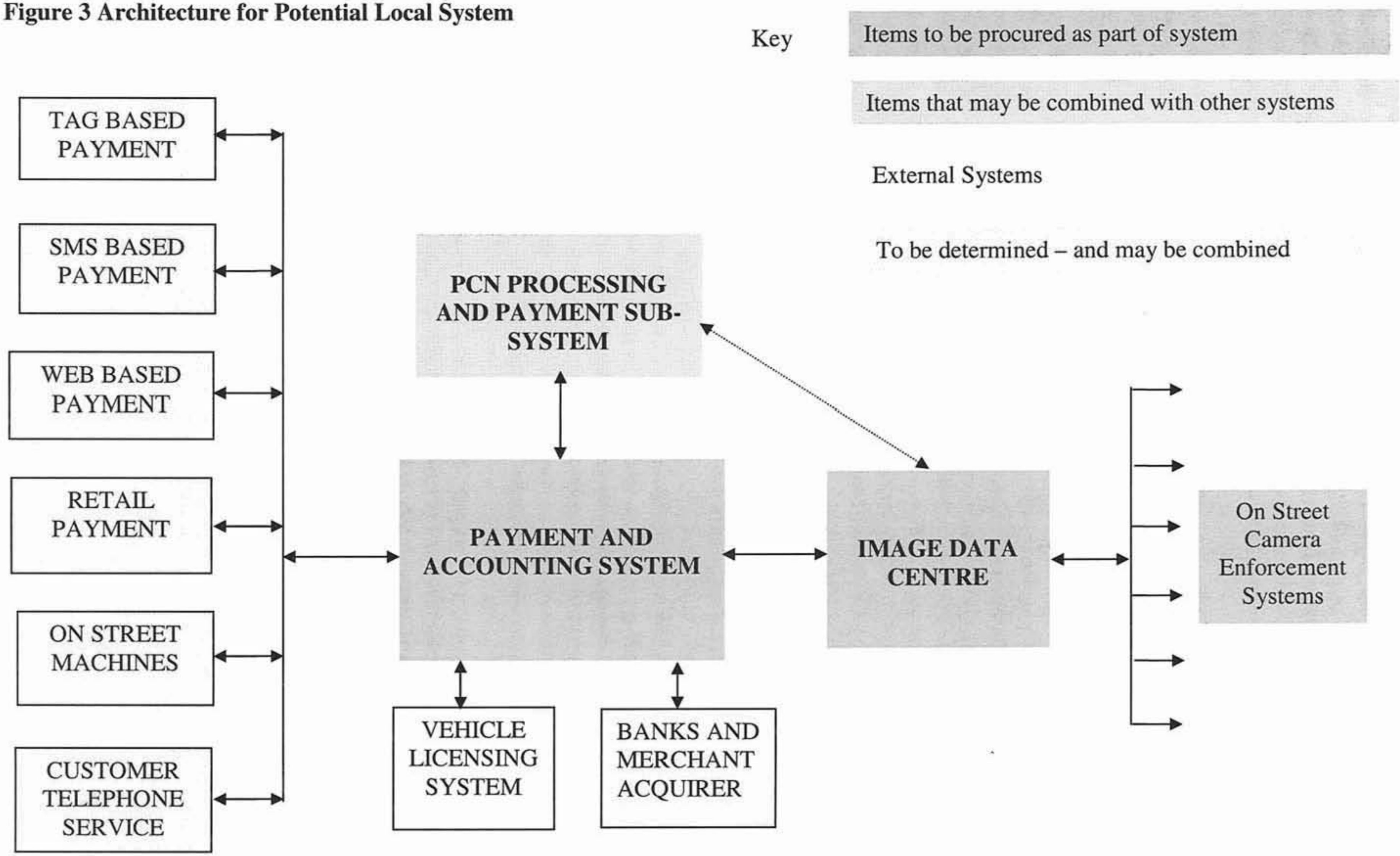
Local System

For a local system, the general functions to be performed are as previously described, but the complications of split of functions as might be appropriate for a national system are not required. It is more appropriate to assume that the functions are divided on the basis of potentially available existing technology and systems that might be adapted for road pricing. This will ensure that there is minimum risk associated with procurement and that costs are minimised.

It is assumed that the total system is divided into a Payment and Accounting System - dealing with cash handling and accounting, and an enforcement Image Management System, dealing with image capture and enforcement issues. The overall architecture is shown in Figure 3 below.

The Image Management Centre is linked with the On Street Enforcement Cameras and deals with the capture, validation and storage of enforcement images.
The Payment and Accounting System are linked with a number of payment channels that may be specifically provided or shared with other uses.
The PCN Processing and Payment Sub-system may be separate or combined with parking PCNs (assuming similar legislation and operation).

Figure 3 Architecture for Potential Local System



6 Additional Facilities

There are a number of facilities that can be combined with or added to a road pricing system to give added value, or reduce overall costs. A selection of those that may be most relevant are given below.

Off Street Car Park Payment and Access Control

If a DSRC tag based system is implemented, it is a simple matter to extend the use of the associated account to provide additional facilities. Combination with a toll road payment system has already been mentioned, but in addition, the system could be used to provide payment at car parks and to provide access control to secure premises, both residential and commercial.

Some types of tags operate with a smart card that is slotted into the card. Although this type of tag is more expensive, the inclusion of a smart card provides the ability to include a number of other transport related functions using the same smart card. In Malaysia, for example, the card can be used to pay for some public transport modes as well as for toll collection.

Satellite Navigation

Satellite navigation systems are becoming more and more popular. Some of these are self contained with navigational data stored on a CD or equivalent. These do not provide any communication facilities and hence ar unsuitable for payment as there is no means of signifying that payment has been made. More sophisticated systems are being introduced that include a GSM communication link so that routing information provided can take into account the current and predicted level of traffic congestion. This type of system should become more popular in the future as the availability of real time traffic information grows. It is ideal for adding a facility to pay a road pricing charge as the GPS system will know when a charge is incurred and can initiate payment over the GSM link.

Because of the increasing requirement to include 'hands free' kits in vehicles, it should be quite possible to design a GPS based satellite navigation system with a link to a drivers mobile phone so that the payment of a charge could be initiated.

Traffic Journey Time and Congestion Data Collection

The enforcement system used with a road pricing system relies upon the ability to read number plates of passing vehicles. Where two enforcement points exist on the same route, the journey time between the two enforcement points can be measured and gives a direct measurement of speed and, by comparison with historical data, congestion.

The London Congestion Charging System includes cameras around the zone boundary and screen line cameras inside the zone. In addition, further cameras with similar functionality (but not used for enforcement) were included on approach radials and around the boundary ring road. The output form the additional cameras are combined with the data from the enforcement cameras to obtain a comprehensive measure of traffic speed and congestion in the centre of London. As London uses the SCOOT traffic control system that provides a measure of traffic data on all traffic signal approach links, this data is combined with data from the camera system in a Real Time Traffic Management database that provides comprehensive traffic data to the London Traffic Control Centre.

7 Implementation Steps and Timescale for a Proposed System

It is assumed that the outcome of this study recommends that a Road Pricing system is an appropriate demand management solution for Wellington and fits well with current and proposed transport policy. It is assumed that the Study recommends two or three preferred charging strategies for more detailed study.

The steps necessary from this stage to operation of a system are shown in Figure 4 below. These assume that any necessary 'political' and legislative processes can be accommodated within the timescale and do not take into account any need for public consultation and the like. The steps and timescales are very subject to local requirements and the eventual scope of the scheme. The overall timescale is considered realistic.

Figure 4 Steps to Implementation and Operation of a Road Pricing System

Step	Description of Activities	Timescale
1	**Selection of Preferred Option** Detailed design studies for short listed options. Preparation of Detailed Cost and Revenue models for short listed options. Detailed investigation of technology and system options. Investigation of local traffic impacts and schematic designs of boundary/charging points. Investigation of legal issues and requirements for enabling legislation Investigation of signing issues Preparation of detailed procurement plan, including proposed split of contracts.	8 months
2	**Detailed design and preparation of Procurement Documents** Detailed design of charging/enforcement points, including signing. Prepare Tender specifications and Contract Documents Prepare Tender Drawings Prepare documents for short listing	12 months
3	**Short Listing of Bidders** Short list suitably pre-qualified bidders for each anticipated contract.	4 months
4	**Tendering and Contract Award** Tender and award contracts for appropriate contracts.	6 months
5	**Contract** Detailed design by contractors, any on street trials specified and interface testing. Development of software, implementation of systems, implementation of on street equipment, interfacing to vehicle	36 months

	licensing system; set up and testing of complete system. Initial publicity for system and set up of user accounts. Dry running of system and operator training.	
6	Operation	

8 Conclusions

For a relatively small system, with a modest charge as proposed for Wellington, it would be desirable to provide a system that minimised cost, both capital and operation. A separate paper will examine costs of different charging options, but the following initial conclusions can be drawn:

a) A central system will have a relatively fixed cost, almost regardless of the extent of the system in terms of number of charging points (obviously within limits);

b) The prime variable aspect of capital cost (and operating cost in terms of maintenance and telecommunication costs) is the number of charging/enforcement points installed;

c) The simplest charging system to implement (and hence potentially the least expensive) is a zone based system, followed by a cordon based system. Distance based charging is the most complex. A route based system may be straightforward, depending upon how the route is defined.

d) Charging systems that involve classification (different charges for different vehicle classes) are significantly more complex in terms of roadside equipment and are likely to require greater manual input as current technology does not provide completely reliable classification systems and hence some manual checking will be required;

d) Variations in charges for different vehicles can be provided through a pre-registration system where particular vehicles are pre-registered as having a different charge. This will not require a classification system;

e) Payment options that minimise the amount of manual input will probably be the cheapest to operate. A charge structure that encouraged the use of pre-registration and electronic payment would probably reduce operating costs;

f) The use of a DSRC (tag) based payment system would be more expensive to install initially as it would require more on-street equipment. Once a tag was installed in a vehicle and an account was set up, payment would be automatic and hence would minimise costs. If such a system was installed on adjacent toll roads it may be sensible to install for road pricing but in isolation, its viability would depend upon the percentage of total transactions that used it;

g) The manual processes of the enforcement system should be similar to enforcement of on-street parking and a combined system may be beneficial;

h) The enforcement authority should have powers to wheel clamp and/or tow away vehicles whose drivers/keepers are persistent offenders.

Appendix D Wellington Rail Operation and Capacity Constraints

Wairarapa Line

Route

Wellington to Masterton (via Petone, Taita and Upper Hutt)

Rolling Stock

Ganz Mavag (72 seats / car) + Loco Hauled Coaches (64 seats / car - Masterton)

Operation

- Wairarapa / Masterton - 3 Inbound Trains in the AM peak, running as 6 car consist with a peak period CBD passenger delivery capacity of 1267.
- Upper Hutt - 6 Inbound Trains in the AM peak, running as 6 car consist with a peak period CBD passenger delivery capacity of 2851.
- Taita - 6 Inbound Trains in the AM peak, running as 6 car consist with a peak period CBD passenger delivery capacity of 2851.

Constraints

- Limited number of Ganz Mavag units available for use.
- The route beyond Trentham is single line.
- Available train paths as the route gets closer to Wellington, namely Taita and Petone.
- Wellington Approach (Track Layout / Signalling).

Capacity Enhancements required to increase Passenger Capacity

1) Remodelling of Wellington Station throat and Marshalling Yard. Minimum work would be needed to increase capacity from the assumed 18 / 20 Trains Each Way Per Hour (TEWPH) to +25 TEWPH. This would be achievable with one extra approach track.
2) Signalling upgrades from NIMT / Wairarapa Line Junction to Wellington to accommodate remodelled track layout / rationalisation.
3) With enhancement works 1) and 2) complete then the Wairarapa Line could be resignalled as follows:-
    - Petone to NIMT Jcn – 3 to 5 Minute Headway
    - Taita to Petone – 5 Minute Headway
    - Upper Hutt to Petone – 10 Minute Headway

If Items 1 to 3 above were undertaken then the net increase in inbound train paths would be 4 trains / 2 hour AM peak (2 trains from Upper Hutt and 2 Trains from Taita). Fleet scenario would be 8 x 6 car consists operating from Upper Hutt; 8 x 6 car consists operating from Taita with trains from Masterton remaining as per existing. This would increase peak period CBD passenger delivery capacity to 3802 (33.3% increase) for Upper Hutt and 3802 (33.3% increase) for Taita.

4) In addition to the infrastructure up grades, additional rolling stock would need to be purchased.

5) GWRC reports also discuss the duplication of the track from Trentham to Upper Hutt. However, preliminary train path analysis shows that the only potential conflict that would cause delay is if the 5:50am service from Masterton and the 6:12am service from Wellington were simultaneously running with delay as they approached the Upper Hutt to Trentham section. Therefore, it is considered that track duplication in this area would not have a significant impact in capacity.

Melling Branch

Route

Wellington to Melling (via the Wairarapa Line)

Rolling Stock

Ganz Mavag

Operation

5 Inbound Trains in the AM peak, running as 4 x 2 car consist and 1 x 4 car consist with a peak period CBD passenger delivery capacity of 1057.

Constraints

- Limited number of Ganz Mavag units available for use.
- Route is single line branch connected to the main Wairarapa Line.
- Available train paths south of Petone.
- Wellington Approach (Track Layout / Signalling).

Capacity Enhancements required to increase Passenger Capacity

1) Increase number of and replace / refurbish all rolling stock. Fleet scenario would be as a minimum 5 x 6 car consists operating as per existing timetable with 1 x 4 car consist operating as a spare. This would increase peak period CBD passenger delivery capacity to 2376 (124.8% increase).
2) Alternatively timetable and operating adjustments may allow extra train paths to be realised. For example the AM peak could operate inbound only at a more frequent departure say 12 to 15 minute frequency. If this were adopted then 8 x 2 car consists (cars modified to accommodate greater crush loading (factor 1.5) then corridor capacity would be 1728 (increase of 63.5%), with limited rolling stock investment. This would require detailed modelling to ascertain if it was actually possible.
3) Remodelling of Wellington Station throat and Marshalling Yard.
4) Signalling upgrades from NIMT / Wairarapa Line Junction to Wellington to accommodate remodelled track layout / rationalisation.

Paraparaumu Line

Route

Wellington to Paraparaumu (via Plimmerton and Porirua)

Rolling Stock

Ganz Mavag (72 seats / car) + Loco Hauled Coaches (64 seats / car – Capital Connection)

Operation

- Paraparaumu - 5 Inbound Trains in the AM peak, running as 6 car consist with a peak period CBD passenger delivery capacity of 2376.
- Plimmerton - 4 Inbound Trains in the AM peak, running as 6 car consist with a peak period CBD passenger delivery capacity of 1901.
- Porirua - 5 Inbound Trains in the AM peak, running as 6 car consist with a peak period CBD passenger delivery capacity of 2376.
- Capital Connection – 1 Inbound Train in the AM peak, running as 8 car consist with a peak period CBD passenger delivery capacity of 512.

Constraints

- Limited number of Ganz Mavag units available for use.

- The route in the area of Pukerua Bay has sections of single line.
- Conflicting Freight Train movements.
- Available train paths as the route gets closer to Wellington, namely Plimmerton and Porirua.
- Wellington Approach (Track Layout / Signalling).

Capacity Enhancements required to increase Passenger Capacity

1) Remodelling of Wellington Station throat and Marshalling Yard (minimum work would need to increase capacity from the assumed 18 / 20 TEWPH to +25 TEWPH. This would be achievable with one extra approach track
2) Signalling upgrades from NIMT / Wairarapa Line Junction to Wellington to accommodate remodelled track layout / rationalisation.
3) Track duplication in the Pukerua Bay area (between the South and North Junctions) and from Mackays Jcn to Paraparaumu area.
4) With enhancement work 1), 2) and 3) complete then the Paraparaumu Line could be resignalled as follows
   - Porirua to NIMT Jcn – 3 to 5 Minute Headway
   - Plimmerton to Porirua – 5 Minute Headway
   - Plimmerton to Paraparaumu – 10 Minute Headway

If Items 1) to 4) above were undertaken then the net increase of inbound train paths could be 11 trains / 2 hour AM peak (3 trains from Paraparaumu, 4 Trains from Plimmerton and 4 Trains from Porirua). Fleet scenario would typically be 8 x 6 car consists operating from Paraparaumu; 8 x 6 car consists operating from Plimmerton; 9 x 6 car consists operating from Porirua with Capital Connection remaining as per existing. This would increase peak period CBD passenger delivery capacity to 3802 (60% increase) for Paraparaumu; 3802 (100% increase) for Plimmerton; and 4277 (80% increase) for Porirua.

5) In addition to the infrastructure up grades, additional rolling stock would need to be purchased.
6) GWRC reports also discuss the electrification of the NIMT from Paraparaumu to Waikanae. This would lengthen the electrified network and provide additional passenger access (outside of the service currently provided by the capital connection). Whilst this work would improve the operational limits of the Wellington Urban Network it would not provide capacity improvement but would increase demand.
7) GWRC reports also discuss the construction of two new stations (Raumati and Lindale). This would provide additional passenger access to the network. Whilst this work would improve the

operational limits of the Wellington Urban Network it would not provide capacity improvement but would increase demand.

8) The operation of freight paths during the AM peak would require resolution. Even with reduced headways the passage of freight trains would reduce the available train paths in the areas where the headways are 3 to 5 minutes. A simple solution would be to restrict the freight paths during the peaks and provide an increased number of available train paths for freight usage during the inter-peak. Alternatively strategic freight passing loops or a dedicated additional freight loop line would need to be provided.

Johnsonville Line

Route

Wellington to Johnsonville

Rolling Stock

English Electric Units (64 seats / car)

Operation

7 Inbound Trains in the AM peak, running as 4 car consist with a peak period CBD passenger delivery capacity of 1971.

Constraints

- Gauge clearance issues in tunnels.
- Restricted use of current Wellington 'Metro' fleet (route is cleared for English Electric Units only due to 1 above).
- Limited number of English Electric Units and consequently can only run 3 trains (4 car consists).
- Route is single line with passing provision at Hutt Road Junction, Ngaio Station and Khandallah Station.
- Available train paths for current operation.
- Wellington Approach (Track Layout / Signalling).

Capacity Enhancements required to increase Passenger Capacity

1) Increase number of and replace all rolling stock to replicate current rail vehicle kinematic gauge. Fleet scenario would be as a minimum 3 x 6 car consists operating as per existing

timetable with 1 x 4 car consist operating as a spare. This would increase peak period CBD passenger delivery capacity to 2957 (50% increase).

2) Undertake tunnel modifications that would allow the utilisation of common Wellington rolling stock. For this to be worthwhile train operation would have to reflect 1 above.

3) Timetable adjustments may allow 1 extra train path to be realised (to fill the 26-minute gap). A limited stop service departing from Johnsonville 7:33am as a 4 car consist maybe able to make the loops at Khandallah, Ngaio and Hutt Road Jcn thus not affecting the existing timetable, if this were possible then a further capacity increase of approximately 281 passengers could be achieved. This would require detailed modelling to ascertain if it was actually possible. Previous studies have identified the possible additions of passing loops at Raroa and Stadium (Wellington Yard), the actual reason for these is not documented but it is anticipated that they would provide additional operational flexibility at times of perturbation, rather than any increase in capacity.

References

BMRB Social Research 2004, *Public Attitudes to Road Pricing in the UK: a qualitative study - Report*, produced for UK Department of Transport

Department for Transport, 2005, *Attitudes to Road Pricing*, http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/page/dft-transstats_029807.hcsp

Forcyte Research, 2001, *Public Attitudes to Road Pricing in Auckland & Wellington*

Gravitas Research and Strategy Limited, 2003, *Community Attitudes to Road Pricing in the Wellington Region*, prepared for the Greater Wellington Regional Council

Greater Wellington Regional Council, 2003. *Towards a Sustainable Region: Adopted Ten-Year Plan 2003-2013.* (http://www.gw.govt.nz/aw/tenyearplan)

Greater Wellington Regional Council, 2004a. *Annual Report 2004: Progress towards a sustainable region.*

Greater Wellington Regional Council, 2004b. *Report 04.466: Regional Land Transport Strategy Review: Defining the RLTS Objectives* (unpublished, June 2004).

Mathews R., Davidson C., Weaver S. and Williamson J. 2000, 'Public Attitudes to road pricing and funding and the provision of transport services in Auckland, New Zealand', *Transport Roundtable Conference 2000*

McDermott Miller Limited, 1999, *Transmission Gully Community Survey – Report on Household Survey of Regional Residents*, produced for the Greater Wellington Regional Council & Transit NZ

McDermott Miller Limited, 1999, *Transmission Gully Community Survey – Stage II: Face-to-Face and Household Willingness –to-Pay Surveys*, Produced for Greater Wellington regional Council & Transit NZ

Ministry of Transport, 2002. *New Zealand Transport Strategy.*

Ministry of Social Development, 2003, *Literature Review, International best practice to mitigate social impact of specific transport demand management measures*

National Research Bureau, 2004, *Market Research Report - Greater Wellington Regional Council – Transport Perception Survey (May / June 2004)*

Rye T., Ison S. & Santos G., 2003, ‘Implementing road pricing perfectly: will London confirm the theory?’ *AET Conference Paper*.

Sinclair Knight Merz, 2004, *Wellington Road Pricing Study* - *Objectives and Performance Measures*”

T&E, Swedish National Road Administration, 2002*, Road pricing in urban areas*

University of Leeds, 2004, *Road User Charging – Pricing Structures*, produced for the Department for Transport

UWE Bristol Faculty of the Built Environment, 2004, *Evidence-Base Review – Attitudes to Road Pricing*, produced for UK Department of Transport

Wellington Regional Council, 1999. *The Wellington Regional Land Transport Strategy 1999-2004: Realistic transport choice.*