

Is Road Pricing Viable in a Small Urban Area? A Wellington case Study

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Disclaimer : The views expressed in this paper are not necessarily the views of the study client – The Wellington Regional Council. The views expressed in this paper are those of its authors.

1 Introduction

The management of urban congestion by road pricing is controversial. The examples of genuine pricing regimes to manage congestion are few. The urban areas where road pricing is being considered are usually typified by being large, densely populated and the reality of congestion is a daily spectre that impacts severely on the quality of life of its inhabitants and imposes severe costs on the functioning of economic activities within its boundaries.

Wellington is a small urban area. Its urban population is only 420,000 people (about 450,000 total including the Wairarapa rural hinterland which is expected to be excluded from any road pricing proposals) and regional GDP is in the order of NZ\$13.5 billion. Yet for some years, through its Regional Land Transport Strategy, it has been signalling the need to investigate road pricing as a tool to manage congestion. Certainly, Wellington does not immediately present itself as an obvious candidate for an urban area that might embrace road pricing.

This paper examines the reasons why Wellington is considering road pricing as a tool to manage congestion. It explores its unique geographical and topographic structure that constrains its strategic transportation network. The paper considers the economic and legislative contexts that contribute to a unique environment where road pricing may be a real option.

The paper then considers the viability of road pricing in the context of Wellington. It investigates whether road pricing options exist where the revenue streams are sufficient to be financially self sufficient. The economic efficiency of road pricing is examined in terms of transport benefits generated, such as travel time savings, to ensure that road pricing is economically viable. This paper considers the contribution of road pricing to broader objectives such as environmental sustainability and other objectives mandated by New Zealand legislation.

2 Background

The Wellington region is small by international standards. The urban population was estimated at 420,000 and the regional GDP is in the order of \$13.5 billion in 2005. The Wellington region is situated at the southern part of the North Island. The Wellington region has a land area of 813,005 hectares and a coastline of 497 kilometres.

New Zealand has a two tier local government structure. The Wellington region is a single regional local government unit. Within the region there are eight constituent city or district councils (refer Figure 1) including Wellington City, the nation's capital. Of the eight local councils, there are three district councils that form the rural hinterland, namely South

Wairarapa, Carterton and Masterton District Councils whose combined population is about 40,000 people.

The Wellington CBD contains nearly 83,000 full time equivalent jobs which is about 40% of total regional employment. The regional economy is dominated by the service sector which accounts for 80% of output. The main industries being transport and communications, business services, other services and government. These sectors are fast growing at the regional level.

Two primary transport corridors provide access to Wellington City, its central business district, regional airport and port. Both the northern and northeastern corridor provide highway and rail access. The difficult topography of the region creates barriers that constrain the locations and capacities of major transport corridors and limits its ability to expand highway capacity. At peak times, there are numerous bottlenecks in each corridor.

At peak times almost 30% of commuters use public transport to access employment in the CBD, whereas for commuting to the central areas of outlying suburbs the public transport share was less than 10%. Demand for rail trips to the CBD is acutely peaked. At the top of the peak commuter services are frequently crowded, but at interpeak times many rail units are under deployed.

3 Why Road Pricing?

The need for the Wellington region to investigate road pricing had been signalled for some time, and, in particular, in Wellington Regional Council's (1999) Regional Land Transport Strategy. A number of studies that underpinned the Regional Land Transport Strategy and ones that followed (refer Brennand (2002) and Brennand, Taylor and Knowles (2005)) have provided significant realisations.

3.1 The Cost of Roads

A primary realisation is that providing road capacity in Wellington is a very expensive exercise. There are several reasons for road capacity being very expensive. Firstly, Wellington is typified by difficult topography. Corridors are highly constrained by water and very steep hills. The terrain is frequently difficult requiring major roads to have steep gradients. New Zealand's young soils, Wellington's seismically active environment and many water courses create high construction costs. Highway construction costs frequently are in the order of \$40 million per lane kilometre.

Wellington's strategic highways run immediately adjacent to its rail commuter corridors. At peak times there exists a delicate balance between rail ridership and car use in the two northern corridors. The provision of additional road capacity disturbs that balance and induces more road use, which consumes the additional road capacity. Further, the provision of road capacity induces a threat to the operation of a viable passenger rail service which would lock in car dependency where the road network is highly constrained.

Wellington's strategic road network is very linear. This is a consequence of the very difficult topography which constrains transport corridors. This enables only one route into Wellington on each of its northern corridors and limited ability to connect these corridors. This means that any additional road capacity in one part of the corridor, combined with additional traffic that the increased capacity induces from the passenger rail services increases the demands on the corridor downstream. Thus, additional road capacity can lead to a futile task of "shifting bottlenecks." The true cost of relieving congestion in one part of the corridor quickly escalates when induced traffic and downstream impacts are

considered. The extraordinary cost of strategic road improvements in the context of a small urban population and economy raises real questions about the reasonableness of these road improvements.

3.2 The Efficiency of Roads

Another question that becomes apparent is the efficiency of these strategic road improvements if they were to be contemplated. This has several dimensions which will be separately discussed.

In economic terms the high costs and modest demands means that in simple benefit-cost terms it is hard to get a compelling benefit-cost ratio even allowing for the vagaries of Land Transport New Zealand's Project Evaluation Manual. Any benefit-cost ratio is further compromised when we examine the economic efficiency in a multi-modal sense in the corridor because of the interrelationship between road and rail at peak times and the problems caused by downstream impacts. Consequently it is not unusual to find the benefit-cost ratio for major strategic roads to be as low as 0.3 such as the controversial proposal to build an inland motorway between Wellington and Kaipiti known as Transmission Gully.

The demand on the strategic road network is peaked. This leads to bottlenecks at peak times during the week and in the middle of the day at the weekend. However, outside the peak times the road network runs freely. The demand on the strategic road network in a typical interpeak hour can be as little as 75% of that at peak times. This leaves useful levels of spare capacity on the current network at interpeak times. In this respect, the current use of the road network is not efficient and the provision of expensive additional road capacity to address peak demands will not encourage its efficient use.

This same issue is true of the region's public transport system, both rail and bus. This means that if road pricing is adopted, then care will be required to ensure that people are not priced off the road on to an already crowded public transport system at peak times. This may require a clever approach to the pricing of public transport to ensure the efficient utilisation of that system.

Demographic trends may raise questions over the efficiency of providing additional strategic road capacity. Wellington, like many urban areas throughout the world, is seeing its population age over time. Depending on whether future work practices retain older people in the workforce, this trend may lead to a de-emphasising of the peak period commute.

Another important demographic is the fall in the birth rate. Wellington has had modest population growth in recent years which has largely been due to a low and falling birth rate and low population migration into the region. Figure 2 shows the forecast of total regional population.

The current population is in the order of 450,000. The projections of medium population growth indicate a peak population of about 470,000 in 2026. The current high projection indicates a peak population of 530,000 in 2041. Low and high growth projections show that the likely bounds of growth for the Region is in the order of 5-20% over the next 20 to 40 years and then decline from that point forward. This is the consequence of low migration rates and a birth rate that continues to fall.

The limited amount of growth reduces the effects that land use strategies might have on future travel demand. More importantly, the forecast peak in population raises the possibility that the provision of expensive additional strategic road capacity now may be found to be surplus to requirement some time in the future. Might it be better to manage

the demand on the strategic road network in anticipation of possible reducing demands in the future?

This may appear as a gamble and clearly future population forecasts will need to be reviewed. However, based on current information, investment in expensive strategic road infrastructure is also a risk. It may be that if a road cannot be justified now, it may never be justified.

3.3 Socio-economic factors

Wellington has the highest per capita GDP of New Zealand's twelve regions. Wellington has a low unemployment rate compared nationally and its mean income per capita is the highest in the country. Census 2001 data showed that Wellington's mean per capita income was 20.6% higher than the national average. The region has a high proportion of residents with formal qualifications.

The above factors contribute to a comparatively high willingness to pay for transport improvements, particularly public transport, as borne out surveys conducted on behalf of the Regional Council (refer Gravitas (2003) and McDermott Miller Limited (1997)). These surveys indicated that significant proportions of the population were make contributions through additional fuel or land taxes to advance transport investment. The level of support from the population varied with the size of the fuel or land tax.

Although willingness to pay for infrastructure and services is different from willingness to pay to purchase a time savings or reliable travel time, it is believed that this socio-economic context does make Wellington relatively more likely to accept road pricing than other regions. Hypothecation of road pricing revenues to support public transport is likely to add to road pricing's acceptability.

Wellington's regional economic structure has a strong emphasis on the service sector including transport and communications, business services, other services and government. It is thought these sectors would benefit from a less congested road network and have greater flexibility in terms of working hours and business location so could be less affected by a peak period pricing system.

3.4 Legislation

Well before Government passed the Land Transport Management Act, the Wellington Regional Council had been using the principles of integrated multi-modal land use-transport planning (Ashley, Brennan and Houghton, 1999) including travel demand management. This work along with the realisations discussed above had shown that the Wellington Region could no longer depend on a "predict and provide" mentality if it were to develop a transportation system that met the community needs and had acceptable impacts.

Travel demand management has to be part of the package to ensure a balance between road use, public transport, walking and cycling. Travel demand management is needed if the system is to be affordable, efficient and have acceptable community and environmental impacts.

The passing of the Land Transport Management Act 2003 enshrined in legislation what the Wellington Regional Council had been doing for sometime. It required that transport strategies contributed to the objectives of :

- Assists economic development; and
- Assists safety and personal security; and
- Improves access and mobility; and

- Protects and promotes public health; and
- Ensures environmental sustainability.

The Land Transport Management Act requires transportation strategies and proposals to take account of the National Energy Efficiency and Conservation Strategy and to develop a travel demand management strategy. At the regional level the Wellington Regional Council added to the five Land Transport Management Act objectives by amending the third objective to include “reliability” and added a sixth objective which was to :

- Consider economic efficiency and affordability.

Consequently, the Wellington region has been investigating a range of travel demand management measures for some years and has been careful to determine what impacts they might have on the balance of private vehicle versus alternative mode use, what impact it might have on the need for strategic road infrastructure and the wider impacts it might have on the community and the environment.

These investigations showed that whilst soft travel demand management measures do have useful and worthwhile contributions to make, it appears that these contributions are likely to be modest in the overall scheme of things. This would suggest that soft measures should be part of the package, but if significant outcomes are to be achieved in terms of the balance between private vehicle and alternative mode use, or contributions to broader environmental or community outcomes, then road pricing needs to be considered.

Road pricing raises the possibility of the deferral or even avoidance of major road infrastructure provision. At the very least, the case for major road construction should be carefully considered if it is contemplated and it is almost certain that pricing will be required to manage the balance between private road use and public transport, and the consequential impacts on the downstream network should major road pricing take place.

4 The Attributes Of Road Pricing In Wellington

The above discussion enables a number of attributes for a successful road pricing scheme in Wellington to be identified. These include :

- Financially viable - generated revenues need to exceed system costs;
- Economically viable – net present value of user benefits exceed net present value of system costs;
- Avoids or defers the need additional strategic road capacity;
- Does not unduly exacerbate demand on peak passenger transport services;
- Contributes to reducing road congestion, improving travel time reliability and the more efficient use of road infrastructure;
- Contributes to desired community and environmental outcomes required by legislation;
- The social impacts are acceptable and the road pricing scheme is perceived as equitable.

It is clear that a low cost scheme, both in terms of capital and operational costs will make a useful contribution to the first two attributes listed above. Examination of Wellington’s strategic road network shows that it has a simple linear structure. As such, it appears to have potential for a simple pricing scheme to be implemented whose overall costs are not high.

5 Road Pricing Options For Wellington

Sinclair Knight Merz Ltd has been engaged by the Wellington Regional Council to develop road pricing options for the Wellington urban area. As such the rural hinterland, made up of the three Wairarapa District Councils has been excluded from this study.

5.1 Proposed Options

The development of the specific options has emerged through a process of refinement in the road pricing study. Details of this study are to be found in the reports Sinclair Knight Merz Ltd (2005) and Sinclair Knight Merz Ltd (2006). The key options are illustrated in Figures 3 to 7 and include :

- CBD cordon (CC)
- Ngauranga Screenline (NS)
- Y Screenlines – Inner Emphasis
- Y Screenlines – Medium Emphasis
- Y + South of CBD Screenline (YMS)
- CBD + Y Screenlines (CY).

The two northern strategic roads merge at a place known as Ngauranga, then continue as a single highway to and through the Central Business District. In this respect, the highway system forms a “Y” shape as shown in Figure 3. One of the arms of the “Y” provides a highway (State Highway1) that links Wellington to Kapiti. The other arm (State Highway 2) links Ngauranga to Hutt and Upper Hutt.

The CBD cordon is a ring around the CBD where a charge is paid to cross any point on that ring. A screenline is a single point on the “Y” where a charge is paid to cross that point.

The pricing options make use of key features of the Wellington strategic road network, namely the CBD; Ngauranga where the two arms of the “Y” merge; and the “Y” structure of the strategic road network, itself (refer Figures 3 to 7). The “Inner Emphasis” on the “Y” means higher charges near the bottom of the “Y” whereas the “Medium Emphasis” means more uniform charges throughout.

These options make use of the inherent simplicity and linearity of the Wellington strategic road network. The lack of alternative routes enables well chosen tolling points to intercept the major traffic flows with little opportunity of avoidance. This sets Wellington aside from other conurbations which are characterised by the myriad of alternative routes that traffic can use. In this respect, the unique structure of Wellington and its strategic road network enables effective pricing options to be contemplated which maintain inherent simplicity. The other feature of Wellington is that major public transport corridors are closely juxtaposed to the strategic road network.

The level of pricing for each option has been the subject of an iterative approach. In essence the prices chosen for each option have been set at a level that broadly achieves the outcomes sought in Section 4 above. The pricing levels depend on the particular pricing option but have been found to be broadly similar to a parallel public transport fare. These are shown in Figures 3 to 7. A single point charge at the Ngauranga screenline was found to be \$4 at peak times. Where charges are made on multiple screenlines on the “Y” then these charges varied between \$0.50 and \$2.50 at each screenline depending on the option and the location.

5.2 Costs of Options

Rough order costs have been developed. These include capital and operational costs that are predicated on assumptions about technology and legislation should road pricing be introduced. Scheme set up costs may be less than assumed if other road pricing or toll road schemes were introduced in New Zealand. It is understood that technology costs are reducing in real terms over time. For the purposes of this study a back office operation has been assumed to cost in the order of \$30 million. This is the operation where all the transactions of the pricing option are processed. Estimated capital and operational costs for the key options in a Wellington context and are shown in table 1.

Table 1 Order of Capital and Operational Costs for each Option

Option	CC	NS	YI	YM	YMS	CY
Capital Costs (\$million)	40	37	38	39	40	42
Operational Costs (\$million pa)	7	4	5	5	5	6

5.3 Option Performance

The performance of each option has been considered against the requirements of the Land Transport Management Act and its refinements made at the regional level discussed in Section 3.4 above. It will be noted that many of the attributes desired in Section 4 can be mapped into the objectives in Section 3.4. The exceptions being the potential impact on the passenger transport system, and issues of equity and social impact. Taking into account the National Energy Efficiency and Conservation Strategy has been subsumed into the environment sustainability objective.

In order to assess the performance of an option against the objectives, each objective is assigned one or more performance indicators that relate to the objective. A conventional four stage strategic model is used to calculate these indicators in the design year of 2016. These indicators are then brought together and compared with the other pricing options and the option of no pricing. These results are tabulated in tables 2 to 5.

5.3.1 Economic Development

Two performance indicators are used. These are average generalised cost of travel per kilometre by mode and the average charge paid by those paying a charge.

Where the option performs poorly a “X” is scored. Neutral performance is a “0” score and a good performance is scored a “√”. Multiple use of these symbols indicates increasing levels of poor or good performance.

Table 2 Evaluation of Options against Economic Development

Economic Development	No Pricing	CC	NS	YI	YM	YMS	CY
Generalise cost/km	0	XX	0	0	0	X	X
Charges paid	0	XX	X	0	0	X	X

The charges paid will impact on regional economic activity if they are additional to current taxes. The modest level of these charges suggests that the real impact of these charges will be small. As discussed above, the structure of the Wellington economy is dominated by the service sector. In particular, transport and communications, business services, other services and government. In these

sectors there could be real gains in economic activity due to their value of time being high as a result of congestion relief.

Further, the analysis and its qualification above, are about a case where charges are paid and then lost to the regional economy. If, however, surplus revenues are reinvested back into the economy by way of additional transportation infrastructure and services, this may deliver positive impacts on the economy.

5.3.2 Environmental Sustainability and Public Health Impact

The performance indicators used included traffic volumes in sensitive stormwater receiving catchments, vehicle emissions as a measure of local air quality, carbon dioxide emissions as a measure of Greenhouse gas emissions, fuel consumption as a measure of energy use, and traffic volumes in residential areas as a measure of noise, severance and general amenity. Local air quality is also a factor in public health and so this measure relates to the public health objective as well.

It was found that all pricing options produced improved environmental outcomes against each of these measures when compared with the no pricing option. However, at the level of charging proposed which was commensurate with adjacent public transport fares, the scale of the improvement was minor.

5.3.3 Access, Mobility, Reliability and Safety

The performance indicators used here are the impact on the volume of travel, the travel time on selected routes, average road network speed, the vehicle kilometres travelled where the volume to capacity ratio exceeds 0.8, the average volume to capacity ratio at key bottlenecks, the average charge paid and the distribution of these charges. A number of these performance indicators against pricing options are shown in Figures 8 to 10. Broadly crash rates are related to travel volume that reduce when road pricing is applied. This leads to an increase in safety.

Travel time reliability is disturbed by unforeseen incidents and congestion. Pricing regimes are not able to address unforeseen incidents. The standard deviation of travel time starts to increase when congestion levels on links and bottlenecks exceed 0.8.

Table 3 Evaluation of Options against Access, Mobility and Reliability

Access, Mobility and Reliability	No Pricing	CC	NS	YI	YM	YMS	CY
Travel Volume	0	XX	X	X	X	XX	X
Travel Times on Routes	0	√√√	√√	√√	√√	√√√	√√√
Average Speed	0	√√√	√√	√√	√√	√√√	√√√
VKT with V/C > 0.8	0	√√√	√√√	√√√	√√√	√√√	√√√
V/C at Bottlenecks	0	√√	√√	√√	√√	√√√	√√
Charge Paid	0	XX	XX	X	X	X	X
Distribution of Charges	0	XX	X	X	X	X	X

In the cases of options CC, YMS and CY average speeds on the strategic road network improved by almost 5 kilometres per hour over the no pricing base. This is particularly significant as it is a network wide average.

5.3.4 Economic Efficiency and Affordability

The model has been used to calculate user benefits and revenue. These can be compared with scheme costs. This has been done over 25 years and expressed as a net present value using a 10% discount rate as required by the Land Transport New Zealand Project Evaluation Manual. In New Zealand the public sector discount rate is fixed by Treasury at 10%. The annual revenue surplus, which is the annual revenue less the operating cost, has been calculated for the design year of 2016. These are presented in table 4.

Table 4 Economic Efficiency and Affordability Performance of Options

\$ millions	No pricing	CC	NS	YI	YM	YMS	CY
NPV User Benefits	0	101	52	72	81	120	97
NPV User Charges	0	245	110	133	147	221	214
NPV Option Costs	0	62	49	50	53	57	59
NPV User Benefits/NPV Option Costs	-	1.6	1.1	1.4	1.5	2.1	1.6
NPV Revenues/NPV Option Costs	-	4.0	2.3	2.6	2.8	3.9	3.6
2016 Annual Revenue Surplus	0	40	18	19	17	28	23

The user benefits are the usual travel economic benefits such as travel time, vehicle operating cost and accident savings. These do not include any user charge component.

Despite the coarse analysis, all of the options are economically and financially viable from the road pricing agency's perspective, even with a crippling discount rate of 10%. The net present value of user benefits exceed the net present value of scheme costs, the net present value of revenue exceeds net present value of scheme costs, and there are positive annual revenue surpluses. The car drivers pay the charge in order to "purchase" the travel benefits and the road pricing agency collects the revenues.

It should be noted, as discussed above, hypothecation of the revenue surplus would generate even higher user benefits, particularly if the surplus revenues are deployed on economically efficient proposals. The annual surplus revenues are such that when compared to the scheme costs, if the surplus revenues were deployed on schemes that gave quite modest returns, the overall pricing-investment package would give high economic user benefits compared to scheme costs. As discussed in Section 5.3.1 there is potential for these hypothecated revenues to deliver strong benefits to the regional economy. An indication of this can be arrived at by applying even modest benefit cost ratios to the surplus revenues, which represents the further user benefits accrued by reinvesting the surplus revenues in transport infrastructure and services, evaluated over 25 years and comparing it to the net present value of the scheme costs.

A strategy of hypothecation of surplus revenues would need to be carefully considered. It could be used to contribute to the funding of expensive strategic roads. However, as discussed in Section 3 above this may not be prudent. Another option is to invest in passenger transport to increase its capacity, efficiency and effectiveness. Again, this runs the risk of providing expensive peak public transport capacity which remains under utilised in those periods outside the peak. Another approach is to utilise some of the surplus revenues to provide pricing and service level incentives, outside the currently sharp peak of public transport use, to encourage more efficient public transport use.

5.3.5 Overall Evaluation of Options

The evaluations summarised in the previous sections are brought together as in table 5. In each case the sub-attributes for each objective have been given equal weighting in the evaluation of the objective.

Table 5 Overall Evaluation against Option

Option	No Pricing	CC	NS	YI	YM	YMS	CY
Economic Development	0	XX	X	0	0	X	X
Safety and Personal Security	0	√√	√	√	√	√√	√√
Access, Mobility and Reliability	0	0	0	√	√	√	√
Public Health	0	0	0	0	0	√	0
Environmental Sustainability	0	0	0	0	0	0	0
Efficiency and Affordability	0	√√	√	√	√	√√	√

It should be noted in table 5 that the scores of “0” in Access, mobility and reliability, and in Public health, and environmental sustainability represent small minor improvements.

Examination of the modelling outputs showed that the increase on rail patronage was small. This was partly due to the modest levels of the applied charges. The retiming of road trips was a significant response.

At this stage the social impact analysis is not well advanced. Preliminary results suggest that there is no obvious disadvantaging of any particular socio-economic groups. The relatively modest levels of the charges and the availability of a public transport alternative give further comfort regarding this issue.

6 Conclusions

Road pricing is normally considered to be a measure employed by large urban areas that are densely populated to manage congestion. However, it is apparent that small urban areas such as Wellington might want to consider road pricing.

The construction of major strategic roads in Wellington is problematic. Generally, such roads are very expensive and difficult to build. Wellington’s unique structure and the layout of its transport network militate against major road construction as being a successful strategy. Current road use and demographic trends give reason to suspect that strategic road construction may not be an efficient use of resources and may be a threat to passenger transport use.

Wellington’s unique structure, the simplicity and linearity of its strategic road network contribute to road pricing scheme being relatively easy to implement and not a particularly expensive option. This enables simple road pricing schemes to be contemplated that are efficient, effective and relatively inexpensive. A numbers of options for road pricing in the Wellington that uses these unique structural features have been identified.

The road pricing options have been evaluated against a broad range of objectives. The economic and financial evaluations are very promising. Hypothecation of the surplus revenues by reinvestment into the strategic transport network is likely to contribute

positively to the overall economic performance and assist the regional economy. Road pricing contributes positively to transport efficiency.

The modest levels of proposed pricing lead to a small improvement in environmental and public health performance. However, at modest levels of charging, social and equity issues are expected to remain small.

7 References

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Figure 1 The Wellington Region



Figure 2 Population Forecasts for the Wellington Region

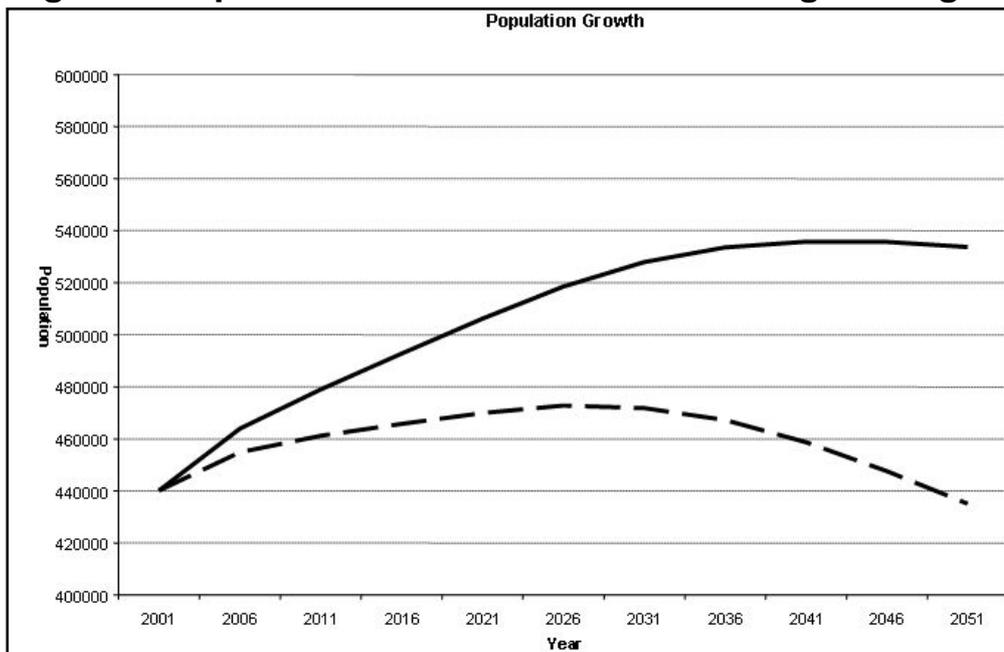


Figure 3 Ngauranga Screenline (NS)

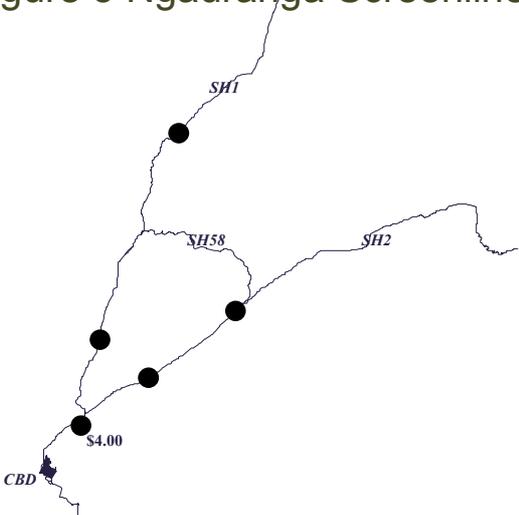


Figure 4 Y Screenline Inner Emphasis (YI)

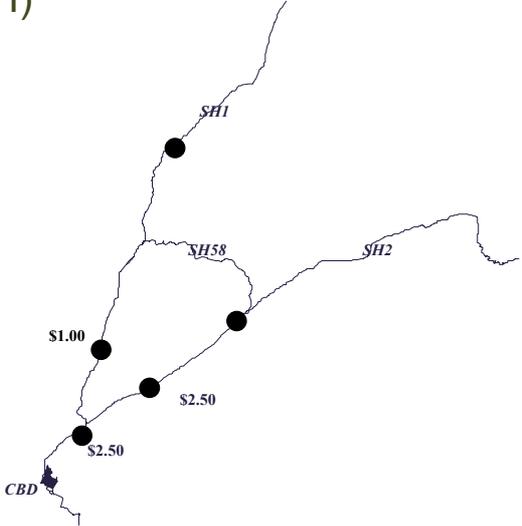


Figure 5 Y Screenlines Medium Emphasis (YM)

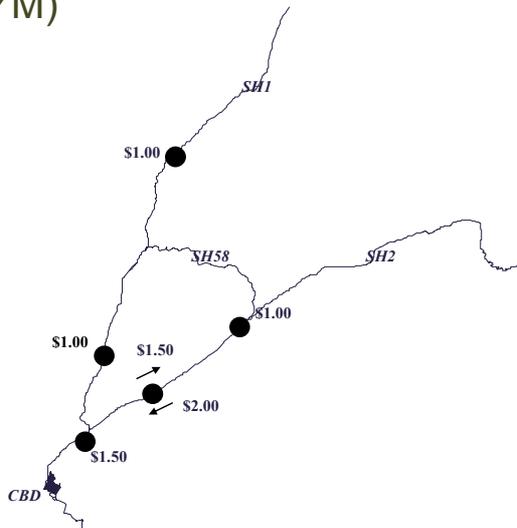


Figure 6 CBD + Y Screenlines (CY)

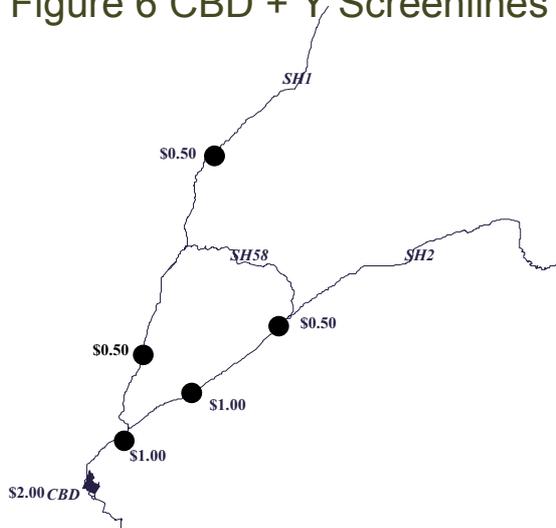


Figure 7 Y + South of CDB Screenline (YMS)

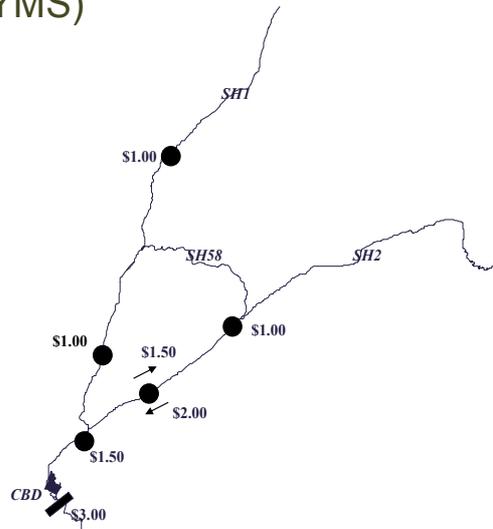


Figure 8 Access and Mobility - vehicle travel times on routes

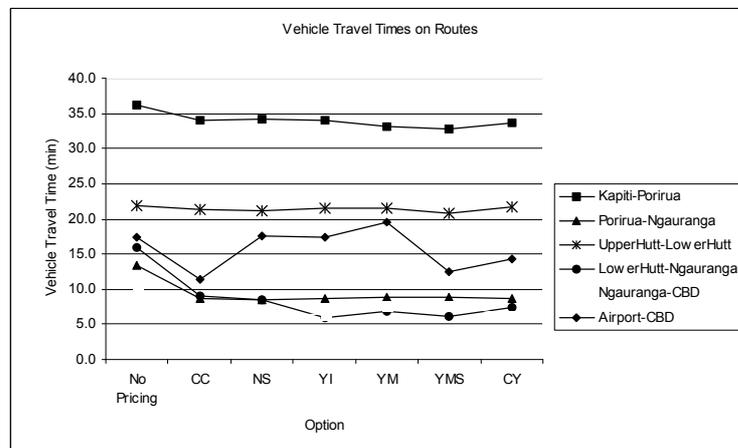


Figure 9 Access and Mobility
- average vehicle speed

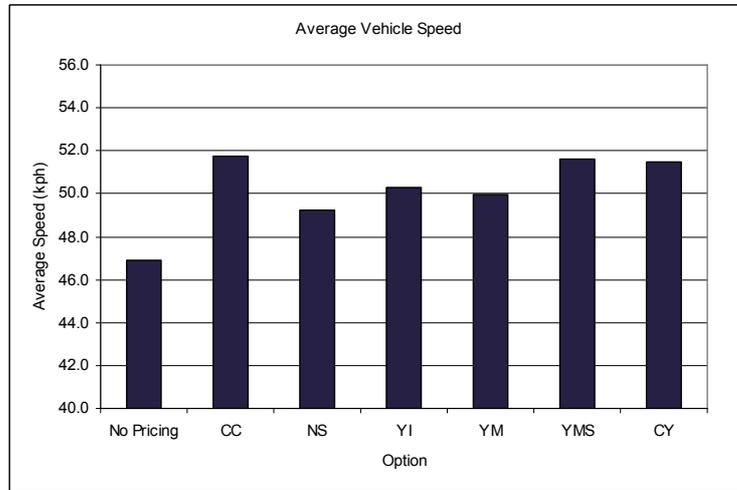


Figure 10 Access and Mobility
- V/C at key bottlenecks

