Bus Priority; Wellington CBD

Review Report

prepared by **Tim Kelly Transportation Planning Limited**

for **Wellington Regional Council**

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1 Purpose and Content of Report

1.1 Purpose

The objectives of this study are to:

- highlight the issues relating to the movement of buses in the central Wellington area
- review recent studies with respect to bus priority initiatives
- report the findings of consultations with bus operators, WCC and WRC
- review the potential for any localised bus priority measures in the Wellington CBD area
- evaluate the traffic and economic benefits associated with any such measures
- make recommendations for actions that will work towards a significant enhancement of bus operating conditions.

It is not the intent of this study to repeat any of the substantial volume of work which has already been undertaken or is currently in progress in relation to the assessment of conditions for buses through the Wellington central area.

1.2 Content of Report

Section 2 describes the issues identified through a consultative process

Section 3 describes recent and current initiatives for bus priority measures

Section 4 describes the identification and evaluation of a specific bus priority measures within the CBD area

Section 5 provides a commentary on the criteria for the establishment of traffic signal timings

Section 6 gives conclusions and recommendations for actions to achieve an enhancement of bus services in the Wellington CBD area.

2 Identification of Issues

2.1 Overview

Buses on routes through the Wellington central business district share road space with general traffic for most of their journeys. Background growth in traffic is giving rise to increasing levels of delay for bus services; this is compounded in some areas by an increase in the number of bus vehicles.

Particularly in the weekday morning and evening peak periods, bus operators are finding it increasingly difficult to keep to published timetables. At some locations downstream from areas of regular congestion, bus arrival times are subject to a high degree of variance.

These conditions reduce the attractiveness of bus services relative to the use of the private car, contrary to the declared transportation policies of both the city and the region.

Wellington City Council (WCC) has a responsibility to maintain and improve the city street network and provide the infrastructure for bus services. Wellington Regional Council (WRC) has a responsibility to provide public transportation services and implement its policies as embodied in the Regional Land Transport Strategy. A 'Quality Partnership Agreement' is in place between WRC, WCC and Stagecoach; this results in regular meetings and an exchange of information.

Recent years have seen a number of studies but little significant action with respect to the improvement of conditions for bus services. This report describes the current status of proposed bus improvement measures and makes recommendations for action.

2.2 Consultations

Wellington Regional Council

- WRC responsibility is for the provision of public transportation services in the Wellington region
- the promotion of bus services in the Wellington city area is reliant upon the co-operation of WCC to provide the necessary infrastructure
- WCC have a statutory obligation under Section 42H(7) of the Transit NZ Act to implement the Regional Land Transport Strategy, which clearly identified the need to progress bus priority measures in the CBD area
- WRC are frustrated that despite years of rhetoric and the commissioning of studies, WCC have not yet introduced any bus priority measures which have had a significant effect upon bus operating conditions in the CBD area
- WRC have invited tenders for a real time bus information system

Wellington City Council

- of the four bus priority measures recommended in the Booz Allen and Hamilton report, three are being progressed, and in addition a proposal is being considered for Chaytor Street, Karori
- consider that the scope for significant improvements in bus travel times in the central area is limited, partly due to a likely outcry against any potential measures which would restrict private car use
- WCC have commissioned consultants Montgomery Watson to review conditions in the Dixon St / Victoria St / Manners St area; an initial scoping report was published in January 2001

- do not consider that the introduction of 3 lanes on Hunter Street between the Featherston Street and Customhouse Quay intersections would be feasible
- many buses through CBD area appear to have low patronage figures
- suggest that efforts should be spent on the provision of real time bus information systems for passengers
- are concerned that WRC are straying into areas of traffic management, the traditional responsibility of WCC.

Stagecoach

- frustrated at the lack of action, especially for some very minor improvements
- some journeys between Courtenay Place and the Railway Station, a timetabled journey of 10 – 15 minutes, are taking around 28 minutes in the peak hours
- passenger surveys have identified the most important issues as service reliability, frequency and journey time; in this order
- passengers complain more about the late arrival of a bus than the late running of a bus when they are already on it; intolerance to waiting delays is greater than that for transit delays
- consider that there is a reluctance in Wellington to seriously tackle the traffic management issues for fear of a backlash from the users of private motor vehicles, but this needs to be done in order to improve conditions for bus services
- traffic management which has taken place in Wellington appears to be in the form of piecemeal localised improvements with no overall guiding objectives
- the running of Newlands buses to/from Courtenay Place (which previously terminated at Brandon Street) has increased the total number of buses between this area and the Golden Mile and aggravated the congestion problems
- would like to see the introduction of signal pre-emption in the CBD area for all bus movements.

Newlands/Mana Bus Company

- very concerned at delays experienced by bus services, especially in PM peak period
- through running to/from Courtenay Place has been very successful, together with other initiatives this has raised patronage by 20%
- some inconvenience to boarders at Brandon Street has been experienced as a result of delays and seats already being full on buses coming from Courtenay Place
- would not agree with any measures to restrict bus numbers through the central area
- see services expanding in the future with residential growth at Churton Park, Woodridge and elsewhere
- the provision of a bus lane along Thorndon Quay from the Capital Gateway centre into the bus terminus would be beneficial in the AM peak period
- provision of 3 lanes in Hunter Street seen as a good idea, but turn from Hunter Street into Customhouse Quay is tight and would need to check that there is sufficient room to manoeuvre
- would like to see the provision of more spaces at bus stops in the central areas – existing stops at Farmers and Cable Car Lane on Lambton Quay are a 'disaster'

- would like to see a more systematic enforcement of parking restrictions to prevent blockage of bus lanes and stops; currently a short period of enforcement follows each meeting with WCC when the issue is raised
- the lack of continuity of staff at WCC is a cause for concern, whilst have a good working relationship with Anthony Cross at WRC.

3 Current Initiatives

3.1 Booz Allen & Hamilton Study[1]

Consultants Booz Allen & Hamilton (BAH) were appointed by WCC in 1999 to undertake a feasibility study of bus priority and high occupancy vehicle lanes in Wellington City. The main focus of the project was to provide a 'strategic overview' of opportunities for traffic management measures in Wellington City which would assist bus services and high occupancy vehicles.

Site visits and workshop sessions were used to identify a 'long list' of eleven locations where suitable priority measures were possible and were likely to be effective. Indicative assessments of probable benefits and costs associated with these were estimated and used to eliminate seven of the locations. As a result, four schemes were taken forward to a more detailed level of assessment.

The following bus lane schemes were recommended to be given a high priority for implementation, on the basis of low capital outlay relative to benefits;

1) Kaiwharawhara Road : a kerbside bus lane plus right hand turn from inside lane for buses only
2) Hutt Road: a kerbside bus lane up to the Kaiwharawhara Road traffic signals in the southbound direction
3) Hutt Road : a kerbside bus lane to the Tinakori Road intersection, in the southbound direction
4) Adelaide Road : a bus/HOV lane leading up to the Basin Reserve intersection, in the northbound direction.

Of these, WCC are progressing all except (3) and in addition progress is being made on a bus lane proposal for Chaytor Street in Karori. All are expected to take place in the 2000/2001 financial year; WCC then propose to monitor their success before deciding whether to proceed further.

[1] Feasibility Study: Investigation of Bus Priority and High Occupancy Vehicle Lanes in Wellington City. *Booz Allen & Hamilton (in associated with Kingston Morrison), October 1999.*

Comment

The measures recommended by the BAH study all involve the provision of bus lanes on the periphery of the Wellington central area. This is unsurprising; in these areas there is more physical space available to introduce such measures without significant capital works and hence costs. Benefits are high to buses without significant dis-benefits to other road users and therefore calculated benefit cost ratios (BCRs) are high.

In contrast, the study showed that measures in the CBD perform poorly. Whilst benefits to bus movements may be significant, costs of implementation can be high and there may also be a high level of dis-benefit to other traffic.

For example, the study considered the problems experienced by buses in the Dixon Street / Victoria Street / Manners Street area. A proposal to restrict Victoria Street to northbound bus movements only with the closure of Manners Street to non-bus traffic was evaluated, together with an advanced bus phase at the Dixon Street / Cuba Street pedestrian traffic signals. This generated benefits to bus users of a level similar to the recommended measures (1) – (3) above. However, significantly higher costs of construction together with substantial dis-benefits to other traffic resulted in a negative BCR for the project. It would have been useful for the benefits of the advanced bus phase at the Dixon Street / Cuba Street pedestrian traffic signals to have evaluated separately to determine if this was warranted as a more localised improvement.

Project 4 in the BAH report, a southbound bus lane on Thorndon Quay to Mulgrave Street was not taken forward because of uncertainties regarding the routing of Newlands/Mana bus services, despite having a BCR of 10.8. The consultation with Newlands/Mana bus company (see ***Section 2.2*** above) raised this as an important issue. Now that these uncertainties have been removed, this project should be subject to a detailed investigation.

Project 5, the introduction of bus pre-emption at all traffic signals on the Golden Mile, was not taken forward on the basis of the high costs involved, despite having a BCR of 4.7. The high costs arise largely from the need to fit all buses with electronic transponders to ensure detection by traffic signals. A shorter term and cheaper improvement would be to simply install inductive loop detectors at those locations which are bus-only, for example from Lambton Quay into Hunter Street and from Willis Street into Mercer Street. If combined with the prohibition of other vehicles in some areas, the number of locations where this could be applied could be increased.

Project 8, bus detection at Hunter Street, was not taken forward because WCC was understood to be evaluating a bus detection system in this area. However, this does not appear to have happened.

Projects such as these are evaluated as roading projects (rather than 'Alternatives to Roading') using the guidelines set down in the Transfund *Project Evaluation Manual*

(PEM)[2]. This takes into account time savings to bus passengers and changes in travel time and vehicle operating costs for other road users.

Many bus priority improvements are promoted on the basis of less tangible benefits which nonetheless may be quite significant in terms of the benefits to the city as a whole. For example, the removal of general traffic from retail and commercial areas would bring environmental benefits as well as additional travel times for the dislocated traffic. Whilst the PEM procedures do allow for the inclusion of such 'intangible benefits', in practice the extensive surveys required to establish what may be quite subjective valuations tends to result in their exclusion and hence an understatement of the 'true' benefits arising from such proposals.

The following specific recommendations are made in relation to the BAH study;

- project 4, the southbound median bus lane on Thorndon Quay should now be investigated further in the light of more certainty with regard to the bus terminus layout and the movement of the Newlands/Mana buses

- the benefits of providing a separate bus phase at the Cuba Street pedestrian crossing on Dixon Street should be broken out from the general appraisal of the Manners / Victoria / Dixon Street area improvements in order to establish whether this more localised improvement is worthwhile

- the use of localised bus pre-emption on the Golden Mile using inductive loops should be investigated as a short-term measure

- the introduction of full bus pre-emption on the Golden Mile using transponders fitted to buses should be taken forward to a detailed evaluation.

3.2 Montgomery Watson Study[3]

In a study commissioned by WCC, Montgomery Watson has reviewed the operation of the public transport services within the Dixon Street / Victoria Street / Manners Street area of the Wellington CBD. This study is part of a package of work being undertaken to address traffic management issues arising from the introduction of the Wellington Inner City Bypass (WICB) project.

Stage 1 of the study, which has only been reported in draft form, has reviewed the changes in traffic demands on the central area network arising from the introduction of the WICB and associated measures such as two way traffic flow on Ghuznee Street. From this, the performance of key intersections in the network has been assessed to identify those areas where problems of congestion will occur. This information, together with patterns of

[2] Project Evaluation Manual. *Transfund New Zealand, 1997 (and subsequently updated).*

[3] Optimisation of Public Transport Operations within the Dixon/Victoria/Manners Street Area. Stage 1 : Network Evaluation (Draft). *Montgomery Watson, January 2001.*

demand for bus movements and pedestrian flows has been used to formulate and assess potential improvement options.

An initial seven options were reduced to four for detailed evaluation; the criteria used to select these is not described. These four options are;

Option	Public Transport Feature	Other Network Changes
1	Northbound buses to use Dixon St, with right turn into Willis St	Victoria St (Manners – Dixon) one way southbound. Manners St to become a pedestrian mall.
2	As (1)	As (1) but Manners St one-way eastbound. Traffic from Boulcott St permitted to proceed straight ahead into Manners St
3	All traffic except buses prohibited from turning right from Dixon St into Victoria St northbound.	As (2) for Manners St. Manners St between Victoria St and Willis St, and Victoria St (Dixon St – Manners St) effectively used for bus contra flow operation.
4	Buses only within Manners St (westbound)	Victoria St (Manners St – Dixon St) one-way southbound for all traffic with northbound contra-flow bus lane.

Table 1 : Options Short-Listed in Montgomery Watson Study

These options were evaluated using a traffic model for both the one way and existing operation of Willis Street between Ghuznee Street and Boulcott Street. Evaluations were also undertaken for the existing network and the network with the WICB in place. The traffic model was used to generate performance indicators relating to the network covering broadly the Te Aro area.

Results show that the lowest overall travel costs (for all vehicles) occur with the WICB in place; the introduction of any of the four bus priority measures leads to a small increase in these costs. Of the four measures tested, Option 1 generated the lowest overall bus vehicle hours in the network and Option 3 the lowest bus vehicle distances travelled. In terms of total passenger time and distance, Option 4 performed best.

The study therefore recommended that;

- Options 3 and 4 be retained and taken forward for detailed analysis
- Option 1 be taken forward *if* feedback from the general public and business operators suggests a preference for this option.

Stage 2 of the study is expected to develop the recommended options in more detail with engineering investigations, economic assessments and micro-simulation modelling. Montgomery Watson is currently awaiting feedback on the draft Stage 1 report from WCC and hence the programme for Stage 2 is unclear.

Specific measures to afford priority to public transport vehicles through intersections or along road sections are the subject of an additional study to be reported later; the programme is unknown.

Comment

The Montgomery Watson report makes reference to a study undertaken by Opus International Consultants in 1997 which considered the reopening of Manners Mall to buses in the northbound direction. This correctly states that the generally adverse reaction of the business community resulted in the project being dropped, even though substantial reductions in bus running times and hence passenger journey times were expected.

It is not known whether this is one of the three projects which were considered by Montgomery Watson and dropped in discussion with WCC. However, it is considered that this project offers sufficient merit to warrant a detailed investigation so that the benefits can be properly considered alongside any concerns raised by the local business community.

The following recommendations are made (at the request of WCC) regarding the way forward for this study;

- clarify the three options which were considered but rejected, and the reasoning for their elimination
- if it has not already been done, evaluate an option (5?) which takes the northbound bus route through Manners Mall and off Dixon / Victoria Street, and compare results with those options already evaluated
- Option (2) does not appear to perform well under any of the criteria used; this should be dropped from further analysis
- Options (1), (3) and (4) should all be taken forward to more detailed investigation, together with option (5) above if this appears to be worthwhile
- detailed investigations should consider costs, benefits, operational issues, commercial and social impacts in each area
- assessments should be integrated with those currently being undertaken by the WRC for the CBD Corridor Study and should be reported in the Quality Partnership meetings between WRC, WCC and the bus companies.

3.3 CBD Corridor Study

This is one of a number of 'corridor studies', co-ordinated by WRC, which review the transportation requirements of specific areas in detail, and which ultimately provide proposals to be incorporated within the Regional Land Transport Strategy document.

The CBD Corridor Study, which was initiated in September 2000, involves the development of wide ranging transportation proposals by a technical group with representation from WRC, WCC, Transit NZ, and Transfund NZ. These proposals are then evaluated using transportation models and scored against agreed performance indicators.

To date, the Technical Group has agreed on the Terms of Reference for the study. A number of outline scenarios have been assessed using the modelling tools; these are currently being evaluated by each of the stakeholders in the process.

Initial scenarios include road based and public transportation (PT) based solutions. The specific PT scenarios include;

- PT01 ('incremental PT'); future year roading network plus additional bus priority schemes, traffic signal pre-emption and an anti-clockwise City Circular route

- PT02 ('aggressive PT'); as PT01 but also with increased frequency on selected CBD routes, SuperBus services, bus only access and outer CBD circular route.

Results from these assessments will become available over the next few months. These will give a good indication of the benefits to be obtained from the promotion of PT in the Wellington central area and the degree to which dis-benefits would be incurred by those road-users who continue to use private vehicles.

3.4 Lambton Quay Bus Priority

WRC and WCC have recently worked together to improve bus-rail interchange facilities adjacent to Wellington Railway Station. Part of these proposals include the re-routing of northbound buses from Stout Street to Lambton Quay.

As part of a wider objective to improve the attractiveness of public transportation in this area it has been proposed that bus access to the new interchange should be assisted by the provision of a scheme giving northbound buses priority along the northern section of Lambton Quay, between the Ballance Street and Bunny Street intersections.

The scheme provides a bus only lane between Ballance Street and Whitmore Street, which is extended to provide direct access to the new interchange. This will allow buses to avoid the congestion in this area, particularly in the PM peak period.

An economic analysis indicates that the project is worthwhile and is eligible for funding. A funding application is currently with Transfund NZ and construction is anticipated in late 2001 with opening in early 2002.

3.5 Real-Time Bus Information Systems

Real time bus information systems provide passengers at bus stops with up to date information regarding the status of their bus and the expected time to arrival using

hardware fitted to buses and a central tracking computer. Potential exists to link the system to the internet, allowing passengers to check the status of their bus from their PC.

The Stagecoach survey (described in ***Section 2.2***) found that passengers are less tolerant of delays to buses whilst waiting compared to delays whilst in the bus; much of this is due to a lack of information about how long the bus will be or even if it is running at all.

Whilst such systems do not provide any improvement in bus transit times, they remove one of the deterrents to bus travel and hence improve the relative performance of this mode compared to the private car.

In April 2001, WRC invited tenders for the establishment of such a system in the Wellington urban area. Tenders have been received and a contractor is expected to be appointed shortly.

4 Identification of Specific Improvement Measures

4.1 General Review

The preceding sections of this report have identified that;

- Under current evaluation criteria, bus priority projects in the central area are likely to involve significant dis-benefits to other road users and hence are unable to generate a sufficient benefit-cost ratio to warrant funding

- The critical Dixon St/Victoria St/Manners St area is in the process of being investigated by consultants Montgomery Watson on behalf of WCC (and this report has made recommendations for action in this respect)

- There is limited scope for bus improvement measures in the Wellington CBD area without a fundamental review of traffic management and the removal of extraneous traffic; the evaluation of more 'radical' proposals will form part of the Wellington CBD Corridor Study. The introduction of such measures would require wide ranging support from the public, politicians and the retail sector.

However, critical observations of the operation of bus services through the central area have been made and two localised measures have been identified which are considered worthy of further investigation;

- The provision of an additional traffic lane on Hunter Street between the Featherston Street / Lambton Quay and Customhouse Quay intersections

- Changes to signal phasing at the Willis / Mercer Street intersection and the provision of a third traffic lane in Mercer Street.

4.2 Hunter Street

Problem Identification

Southbound buses through the CBD area currently experience significant delays at the intersection of Lambton Quay and Hunter Street / Featherston Street.

This arises because the current signal installation, using three phases, shares the available time between the competing demands of general traffic (from Featherston Street to Hunter Street), buses (from Lambton Quay to Hunter Street) and pedestrians. These signals are, however, linked to those at the Hunter Street / Customhouse Quay and Customhouse Quay / Willis Street / Willeston Street intersections with the objective of providing a 'green wave' for buses once they have been released from the Lambton Quay intersection. This appears to work well in interpeak periods but in peak periods the benefits are sometimes lost due to bus movements being impeded by congested traffic on Hunter Street.

Only four buses can clear the intersection on each green phase for the approach from Lambton Quay; this can be reduced if other traffic on Hunter Street impedes the movement of buses. In the peak hours, some buses are therefore required to wait for a second signal cycle. Observations showed that buses at this location routinely jump the red signal phase.

Potential Solution

The proposal is for the provision of an additional traffic lane in Hunter Street between the Featherston Street / Lambton Quay and Customhouse Quay intersections. Adjustments to the phasing and timing of the traffic signals at the Featherston Street / Lambton Quay intersection is also proposed.

This would permit buses to run concurrently with general traffic from Featherston Street using a simpler two phase signal arrangement. This would allow buses to run for a greater proportion of the available signal cycle time and hence reduce the delays experienced by them. Some delay reductions could also be experienced by general traffic.

WCC have considered this proposal in the past and have rejected it on the basis of an insufficient available carriageway width on Hunter Street.

Assessment – Engineering Feasibility

An engineering feasibility assessment was undertaken by Opus International Consultants.

Three options were investigated for the provision of a third lane in the existing two lane section of Hunter Street;

- Option 1 - Utilise the existing carriageway
- Option 2 - Widening on the south side

- Option 3 - Widening on the north side.

These options are shown by diagrams at ***Appendix A***.

The existing width of Hunter Street, between Featherston Street and Willis Street is a minimum of 9.63m between kerbs. At the loading bay/motorbike stand the width between kerbs is 12.52m, with 3.05m marked for the loading bay. The footpath on this side is 2.90m wide and 2.65m closer to Willis Street adjacent to the old bank building. On the northern side of Hunter Street the footpath width ranges from 2.95m to 3.25m.

All options include proposed kerb extensions at the intersection of Featherston Street/Hunter Street and Customhouse Quay/Hunter Street on the northern side, to provide more waiting room and better viewing for pedestrians while providing better guidance for drivers. An adjustment to the stop line in Customhouse Quay is also required so that right turning buses from the modified lane are not impeded turning towards Willis Street. All options include a small modification to the pedestrian crossing marking at the Featherston/Hunter Street intersection. Vehicles accessing the loading zone/motor bike stand will need to cross the bus lane in all options.

Option 1 involves the remarking of the existing two lanes in Hunter Street, east to Customhouse Quay, as three lanes. The lane configuration proposed is 3.20m on the northern kerb side, 3.00m in the centre lane and 3.43m for the bus lane.

The use of a solid line and raised pavement markers is recommended to delineate the bus and general traffic lanes. Consideration should be given to using a coloured surface for the bus lane.

Option 2 widens Hunter Street on the northern side by about 0.5m, which reduces the footpath width to 2.75m. The encroachment into the existing footpath can only take place to the east side of the existing veranda. The lane widths proposed are 3.40m, 3.20m and 3.53m for the bus lane. Some minor adjustment of the kerb within the loading zone is proposed.

Option 3 widens Hunter Street on the southern side by 0.5m, reducing the footpath width to 2.15m. The lane widths proposed are 3.40m, 3.20m and 3.53m for the bus lane. The loading zone would be widened by a similar amount which would reduce the adjacent footpath width to 2.4m.

All options narrow the existing lanes, with the minimum lane proposed at 3.00m. Some slight changes can be made to the lane configurations shown for the various options. The lane width for the left turn from Featherston to Hunter Street is reasonably tight for all options. When trucks or larger vehicles are making this turn it is expected that drivers may need to adjust their position in the lane so the vehicles are not adjacent to each other when making this turn.

Footpath widths reduce to a minimum of 2.65m for option 1 and 3 and 2.15m for Option 2, unless additional width was achieved by reducing the lane widths from that shown. This minimum footpath width should be acceptable in this vicinity because of the low volume of pedestrian traffic. However some handrail/barrier or bollards may be desirable on the edge of the footpath adjacent to the bus lane for Option 3.

All options require vehicles to angle across the Hunter Street/Customhouse Quay intersection to line up with the existing two lanes east of Customhouse Quay. This angling takes place at present but the proposed options exacerbate this situation. Option 3 is best in this respect; Option 2 is the worst.

Overall, option 3 is recommended as the best solution from an operational perspective. Preliminary investigations indicate that no major relocation of service infrastructure would be required, although this would be subject to confirmation by the relevant service authorities at the design stage. There are known to be underground service cables in the vicinity although these are expected to be lower than the new kerb and channel and may also be clear of the proposed 0.5m widening.

Assessment – Economic Feasibility

A detailed economic feasibility assessment is shown at ***Appendix A***. The project has been assessed as a roading project using the framework established by the Transfund NZ *Project Evaluation Manual* (PEM). Where assumptions have been necessary due to a lack of reliable information, these have been the subject of sensitivity testing.

Time Zero for the analysis has been assumed to be 1st July 2001.

Project construction costs have been estimated to be $37,908. A breakdown of the rough order cost estimate is shown at ***Appendix A***. It has been assumed that additional maintenance costs would be 3% of the construction costs, though in practice any additional maintenance liability would be negligible.

The calculation of each of the five sources of benefits associated with the project are discussed in turn below. These relate to savings in travel time and costs of vehicle operation; it has been assumed that there would be no change in accident costs.

User Benefits

These are time savings to bus passengers who currently travel through this intersection.

Unit values of time per passenger / hour have been established by reference to values in the PEM.

The number of buses in each time period has been derived from the count data supplied by WCC; this is considered more reliable than the manual count undertaken at the time of the delay surveys.

The average occupancy in each period has been assumed, but is based upon observations made during delay surveys.

The number of time periods / year are standard values recommended by the PEM.

The unit time saving has been determined by reference to the results of delay surveys. Existing delays to buses at the Lambton Quay / Hunter Street intersection were recorded by survey for typical weekday AM peak, Inter-Peak and PM peak conditions in May 2001.

Table 2 below summarises the results of these surveys.

	Time Period		
	AM peak	**Inter peak**	**PM peak**
Average Delay (secs)	45	23	72
Range of Delay (secs)	0 - 124	0 - 69	0 - 120
Buses/Hour – observed	90	54	100
Buses/Hour – WCC *	101	67	108

Table 2 : Recorded Bus Delays at Lambton Quay / Hunter Street intersection.
(counts supplied from SCATS system by WCC)*

It has been assumed that the reduction of the signals to a simple two phase arrangement in which the only red period to buses was during the pedestrian crossing phase would reduce delays to around an average 10 seconds / bus.

The achievement of these delay reductions is dependent upon the continued ability to link the Lambton Quay / Featherston Street signals with downstream signal installations for southbound bus movements. Discussions with WCC have ascertained that this should be feasible to ensure that buses released earlier from the Lambton Quay intersection did not simply wait for longer instead at one of the downstream signals and hence negate the delay benefits.

Undiscounted user benefits summate to $147,333 in the first year of operation.

Decongestion Benefits

One of the principal objectives of such bus priority measures is to prompt some transfer of private car users to bus travel by changing the relative 'cost' of travel by these modes. The reduction in private car use then leads to some reduction in overall traffic levels and hence decongestion benefits.

An assessment procedure for such benefits has been developed by Booz Allen & Hamilton and is reported in the report which details the economic evaluation of the Lambton Quay

Bus Priority Scheme.[4] This adopts an elasticity approach which assumes that for every 1% fall in the generalised cost of bus travel, demand will increase by 1%.

For Wellington, a typical journey involving bus travel has been taken to comprise a 5 minute walk to the bus, a 5 minute wait, a 15 minute transit time, a fare of $1.20 and a 5 minute walk from the bus to the ultimate destination. The application of unit values from the PEM gives a total generalised cost for the journey of $5.02.

The forecast reduction in generalised cost arising from the delay reduction at the traffic signals can then be expressed as a percentage of the total generalised cost and from this, the expected percentage change in patronage can be estimated.

A study undertaken by Booz Allen & Hamilton for Transfund in 2000 indicated that for each vehicle-km of bus travel, there are benefits to other road users of $1.251 in travel time savings and $0.112 for environmental and safety improvements.

Results are then factored to take into account an average trip length of 5kms, an induced trip factor of 0.5 (the 'rule of a half' which accounts for some new users who will offset the decongestion) and an additional 5% for vehicle operating costs.

Using this approach, total undiscounted decongestion benefits in the first year of operation have been estimated to be $106,433.

Impacts on Other Road Users

In most cases, bus priority measures have a detrimental impact upon travel times for other traffic and this needs to be considered in the overall evaluation. However in this case, the introduction of a two phase signal arrangement will also benefit traffic on Featherston Street by the provision of more signal green time in each time period.

Traffic counts on Featherston Street have been supplied by WCC.

A unit time saving per vehicle of 5 seconds per vehicle has been assumed.

Unit values of time have been taken from the PEM.

Total impacts on other road users is calculated to be an undiscounted benefit of $16,515 in the first year of operation.

New Bus Users

As discussed above, the project can be expected to result in some new bus users, each of whom will benefit from the reduction in delays at the intersection. Because new users

[4] Lambton Quay Bus Priority Scheme : Economic Evaluation. *Booz Allen & Hamilton, March 2001.*

receive a range of benefits between zero to the full amount, the 'rule of a half' has been applied by taking an average value.

The total undiscounted benefit is calculated to be $1,420 in the first year of operation.

Costs of Bus Operation

Although there may be some savings in the costs of bus operation, these have been assumed to have been assessed within the overall values of time. For this reason, separate calculations have not been undertaken.

Results

Total undiscounted benefits in the first year of operation are $271,700. These occur for each year of the 25 year assessment period and have been discounted using the 10% discount rate specified in the PEM.

Over the assessment period, total discounted benefits are $2.624m. When compared with total costs of $0.047m, the project is estimated to return a benefit to cost ratio of **55**.

Sensitivity Testing

The analysis has been subject to a number of sensitivity tests on key assumptions and variables to ensure that the reported BCR is robust. The results of these tests are summarised in ***Table 3*** below.

Test	BCR Result
Base Case	**55**
Increase construction costs by 100%	28
Assume bus delay savings reduced by 50%	29
Assume growth in benefits 0%	47
Assume bus occupancy reduced by 20%	45
Assume no decongestion benefits	34
Assume no impacts on other road users	52

Table 3 : Results of Sensitivity Tests

These results show that, even under the most pessimistic assumptions, the project is eligible for funding.

Recommendation

This project is clearly fundable and should proceed to detailed design.

4.3 Mercer Street

Problem Identification

Traffic signals at the Willis St/Mercer St intersection divide priority between the southbound bus movement from Willis St into Mercer St, the northbound flow of general traffic and pedestrians.

These signals operate under a three stage arrangement. Stage 1 allow southbound buses from Willis Street to Mercer Street to run concurrently with northbound general traffic on Willis Street. Stage 2 releases the stream of general traffic from Willis Street into Mercer Street; this stage intentionally follows the bus stage in order to allow buses to be first in the queue at the Mercer Street stop line with Victoria Street. Finally, the third stage is an 'all red' period allowing all pedestrian movements to take place.

There is no detection of either buses or general traffic on the lanes turning into Mercer Street. As a result, buses may be delayed whilst the general traffic stage is running. Conversely, general traffic is frequently delayed for the bus stage, when no buses are in the area.

Most of the traffic on Mercer Street crosses Victoria Street into Wakefield Street. This traffic occupies the nearside lane on Mercer Street; the lower flow to Victoria Street (south) occupies the offside lane.

Virtually all of the buses from Willis Street (north) continue across Victoria Street to Wakefield Street; however a small number each hour turn right from Mercer Street into Victoria Street.

Potential Solution

The proposal (shown at ***Appendix B***) is for the provision of an additional traffic lane in Mercer Street and a change of the Willis Street / Mercer Street traffic signals to two stage operation in which the flows into Mercer Street from the north (buses) and south (general traffic) run concurrently.

The nearside lane on Mercer Street would be designated as 'bus-only'; other traffic from Mercer Street to Wakefield Street would be required to occupy the middle lane and then merge with bus movements.

Assessment – Engineering Feasibility

An engineering feasibility assessment was undertaken by Opus International Consultants.

The existing width of Mercer Street varies. It is a minimum of 7m between kerbs near the Mercer Street/Victoria Street intersection and up to 13m between kerbs in the central section of Mercer Street, although this includes a 6.5m wide loading zone and motorcycle

parking area. The lane widths are a nominal 3.2m to 3.4m wide. On the inside of the left turn from Willis Street, the kerb has been extended by approximately 1.4m. On the right hand side turning from Mercer Street to Victoria Street there is a large kerb extension up to 13.5m from the old kerb. This area contains footpaths and significant planting. At the Mercer Street/Wakefield Street/Victoria Street intersection the two lanes from Mercer Street split into one lane into Wakefield Street and two lanes in Victoria Street

There are major pedestrian flows at the Willis Street/Mercer Street intersection, which is aided by a central physical island. The pedestrian flows at the Mercer Street/Wakefield Street/Victoria Street intersection are significant, especially as this is the main city access to the City Square. The existing footpaths adjacent to the buildings are 4.5m on the northern side and 3.5m on the southern side.

There is basically only one layout that is feasible, although the layout needs to include some adjustments to the signal phasing to ensure the lane layout operates successfully; this layout is shown at ***Appendix B***. The typical cross-section for the option allows for 3 lanes plus a reduced loading zone width. The bus lane width has been assumed as 3.5m wide with the other two lanes at 3.25m wide. The loading zone/motorcycle parking area is reduced to 3m. No encroachment into the footpaths adjacent to the building line is proposed. The layout requires modifications to the kerbs, footpaths and the planted area, extending the pavement carriageway width, modifying paint markings, erecting additional signage and making adjustments to the location of signals and signal timing.

At the Mercer Street/Wakefield Street/Victoria Street intersection approach the 3 lanes in Mercer Street divide so that the left hand bus lane connects to Wakefield Street, the centre lane links with either Wakefield Street or Victoria Street and the right hand lane joins Victoria Street. With two adjacent lanes of traffic turning into the one lane of Wakefield Street has the potential to cause operational problems. However it is anticipated that this can be overcome by a mixture of adjustment to signals to give an early green phase for the bus lane only at these signals, a cut back of the kerbed island downstream from these signals and appropriate paint marking. This layout can be reinforced by suitable signage.

Assessment – Economic Feasibility

A detailed economic feasibility assessment is shown at ***Appendix B***. The project has been assessed as a roading project using the framework established by the Transfund NZ *Project Evaluation Manual* (PEM). Where assumptions have been necessary due to a lack of reliable information, these have been the subject of sensitivity testing.

Time Zero for the analysis has been assumed to be 1st July 2001.

Project construction costs have been estimated to be $155,000. A breakdown of the rough order cost estimate is shown at ***Appendix B***. It has been assumed that additional maintenance costs would be 3% of the construction costs, though in practice any additional maintenance liability would be negligible.

The calculation of each of the five sources of benefits associated with the project are discussed in turn below. These relate to savings in travel time and costs of vehicle operation; it has been assumed that there would be no change in accident costs.

User Benefits

These are time savings to bus passengers who currently travel through this intersection.

Unit values of time per passenger / hour have been established by reference to values in the PEM.

The number of buses in each time period has been derived from the count data supplied by WCC; this is considered more reliable than the manual count undertaken at the time of the delay surveys.

The average occupancy in each period has been assumed, but is based upon observations made during delay surveys.

The number of time periods / year are standard values recommended by the PEM.

The unit time saving has been determined by reference to the results of delay surveys. Existing delays to buses at the Willis Street / Mercer Street and Mercer Street / Victoria Street intersections were recorded by survey for typical weekday AM peak, Inter-Peak and PM peak conditions in June 2001.

Table 4 & 5 below summarise the results of these surveys.

	Time Period		
	AM peak	**Inter peak**	**PM peak**
Average Delay (secs)	14	17	14
Range of Delay (secs)	0 - 58	0 - 44	0 - 46
Buses/Hour – observed	105	47	100
Buses/Hour – WCC *	101	67	108

Table 4 : Recorded Southbound Bus Delays at Willis Street / Mercer Street intersection.

(counts supplied from SCATS system by WCC at Hunter St/Lambton Quay)*

It has been assumed that the reduction of the Willis Street / Mercer Street signals to a simple two phase arrangement in which the only red period to buses was during the pedestrian crossing phase would reduce delays by around an average 5 seconds / bus.

	Time Period		
	AM peak	**Inter peak**	**PM peak**
Average Delay (secs)	25	24	26
Range of Delay (secs)	0 - 45	0 - 90	0 - 81
Buses/Hour – observed	105	47	100
Buses/Hour – WCC *	101	67	108

Table 5 : Recorded Southbound Bus Delays at Mercer Street / Victoria Street intersection.

(counts supplied from SCATS system by WCC at Hunter St/Lambton Quay)*

The achievement of these delay reductions is dependent upon the continued ability to link the Willis Street / Mercer Street signals with those at Mercer Street / Victoria Street to ensure that earlier release at one location did not simply result in longer delays at another. Discussions with WCC have ascertained that this should be feasible.

It has also been assumed that the provision of a third lane at the Mercer Street stop line would allow a higher saturation flow and hence some reduction in average delays to both buses and other vehicles on this approach. A reduction of bus delay by 5 seconds/bus has been assumed.

Undiscounted user benefits summate to $40,884 in the first year of operation.

Decongestion Benefits

Using the approach and assumptions described in ***Section 4.2***, total undiscounted decongestion benefits in the first year of operation have been estimated to be $29,535.

Impacts on Other Road Users

In most cases, bus priority measures have a detrimental impact upon travel times for other traffic and this needs to be considered in the overall evaluation. However in this case, the introduction of a two phase signal arrangement will also benefit traffic from Willis Street into Mercer Street.

Counts of traffic turning from Willis Street into Mercer Street have been supplied by WCC.

A unit time saving per vehicle of 10 seconds per vehicle has been assumed.

Unit values of time have been taken from the PEM.

Total impacts on other road users is calculated to be an undiscounted benefit of $14,519 in the first year of operation.

New Bus Users

As discussed above, the project can be expected to result in some new bus users, each of whom will benefit from the reduction in delays at the intersection. Because new users receive a range of benefits between zero to the full amount, the 'rule of a half' has been applied by taking an average value.

The total undiscounted benefit is calculated to be a negligible $85 in the first year of operation.

Costs of Bus Operation

Although there may be some savings in the costs of bus operation, these have been assumed to have been assessed within the overall values of time. For this reason, separate calculations have not been undertaken.

Results

Total undiscounted benefits in the first year of operation are $85,023 These occur for each year of the 25 year assessment period and have been discounted using the 10% discount rate specified in the PEM.

Over the assessment period, total discounted benefits are $0.821m. When compared with total costs of $0.193m, the project is estimated to return a benefit to cost ratio of 4.2.

Sensitivity Testing

The analysis has been subject to a number of sensitivity tests on key assumptions and variables to ensure that the reported BCR is robust. The results of these tests are summarised in ***Table 6*** below.

Test	BCR Result
Base Case	**4.2**
Increase/decrease construction costs by 20%	3.5 – 5.3
Assume bus delay savings reduced/increased by 50%	2.5 – 6.0
Assume growth in benefits 0%, 4%	3.6 – 4.9
Assume bus occupancy reduced / increased by 20%	3.5 – 5.0
Assume decongestion benefits reduced / increased by 50%	3.5 – 5.0
Assume impacts on other road users reduced / increased by 50%	3.9 – 4.6

Table 6 : Results of Sensitivity Tests

These results show that the economic performance of the project is sensitive to the size of the delay savings which are assumed. As indicated, these are considered to be conservative and hence the project is likely to meet current funding criteria.

Recommendation

This project is likely to be fundable and should be taken forward to detailed design. Particular attention should be given to ensuring the safe merge of vehicles between the Mercer Street stopline and Wakefield Street.

Consideration should be given to the use of localised bus pre-emption detection using an inductive loop at the Willis Street (north) approach to call the bus phase. Linkage of this detector with the Mercer Street / Victoria Street traffic signals could potentially allow buses free movement from Willis Street through to Wakefield / Victoria Street. This could also reduce delays to vehicles turning from Willis Street (south) into Mercer Street when no buses are present on the Willis Street (north) approach. Such a localised pre-emption system would not require transponder units in buses and hence costs would be low.

5 Bus Priority at Traffic Signals

The high number of traffic signals in the central Wellington area creates an opportunity for traffic management through an adjustment of priorities between general traffic and public transport vehicles.

Traffic signals in the Wellington CBD area are controlled using software known as SCATS (Sydney Co-Ordinated Adaptive Traffic System). Information concerning traffic flow, including the requirements of pedestrians, is relayed from the intersection controller via a telephone line to a central computer. The computer continuously responds to the conditions at each site by adjusting the green times allocated to each phase and by changing cycle times. The computer also collects traffic data from each section of a linked route to determine the best linking strategy for current traffic volumes.

Systems such as this are aiming to achieve the smooth flow of platoons of traffic through the network, though the degree to which this can be achieved in practice depends upon the patterns of traffic demand and the configuration of the roading network itself.

The system is aiming to equalise the degree of saturation on each intersection approach with the implicit objective of minimising the delay per vehicle in the road network. As a result, the highest traffic demands receive the largest proportion of the available signal green time at each set of traffic signals.

However, where there are large numbers of public transport vehicles in the network, the allocation of traffic signal green times will not properly reflect the flow of *people* as opposed to the flow of *vehicles*. An alternative approach, to minimise delays per person, could be seen as an over-riding objective.

The current signal settings at the Lambton Quay / Featherston Street / Hunter Street intersection illustrate this point. ***Figure 1*** shows the numbers of bus vehicles and other

vehicles competing for signal green time at the intersection. This clearly shows the predominance of general traffic vehicles relative to the number of buses in all time periods.

Figure 2 presents the same information, but in terms of the number of vehicle occupants by each mode of transport. This shows the predominance of bus occupants to those in private vehicles in all time periods.

A theoretical approach would therefore be to set traffic signal timings in order to minimise delay to vehicle occupants, rather than vehicles. An appropriate adjustment would be required to reflect the saturation flow of vehicle occupants across the intersection stop lines.

Whilst some increase in delays would be experienced by general traffic, intersection delays experienced by buses and other high occupancy vehicles would be substantially reduced. The net effect would be a more equitable distribution of intersection delay which more properly reflects the efficiency with which each mode of transport is able to move people through the central area.

The consideration of such issues is not new, as evidenced by a considerable body of literature on the subject of public transport priority at traffic signals. However, such a change would be controversial and hence should be assessed in the first instance using a transportation model to determine the possible wider impacts.

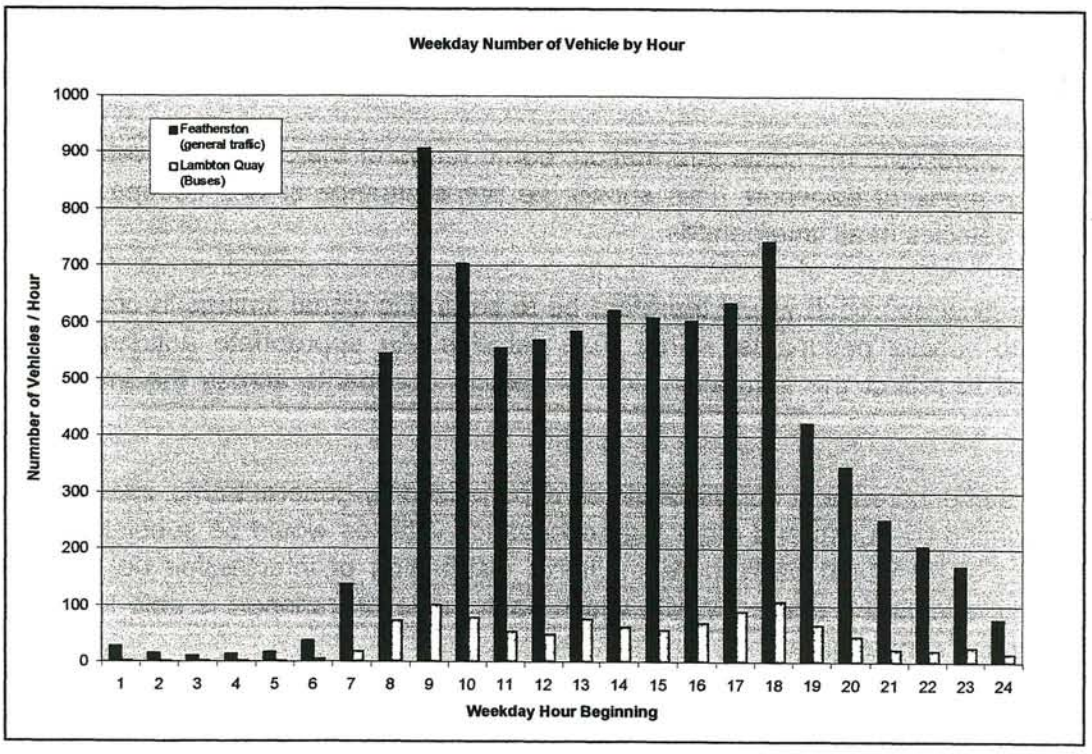


Figure 1 : Distribution of Intersection Demands, by Vehicle Type

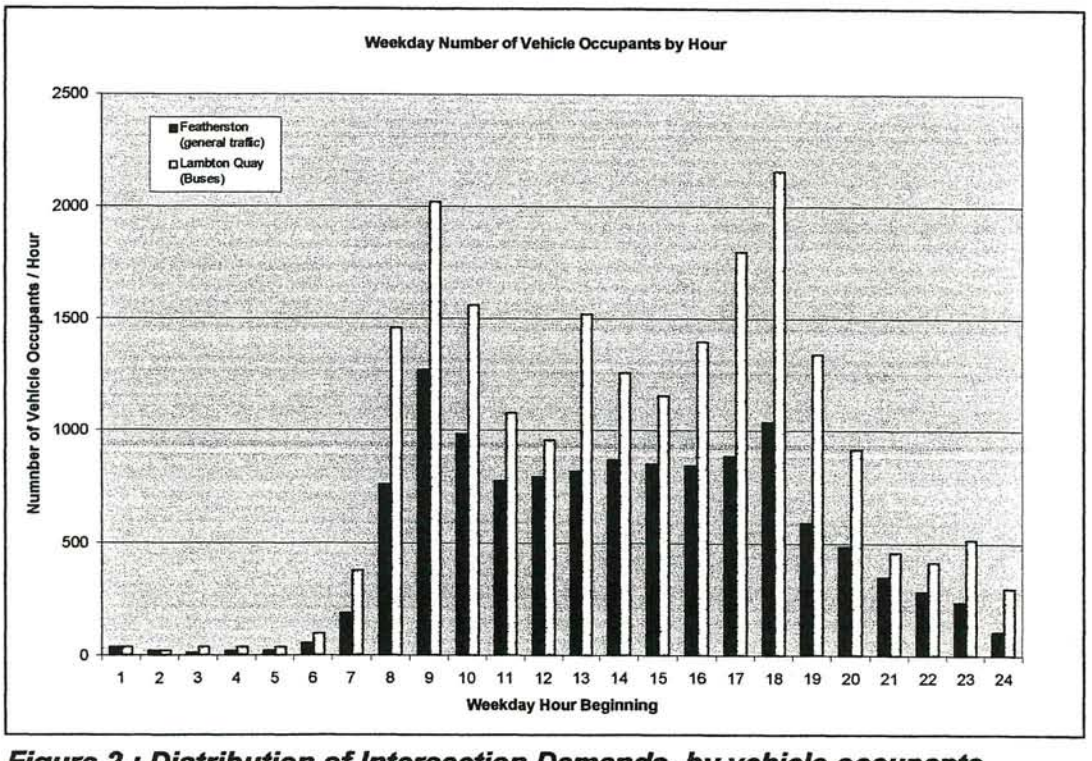


Figure 2 : Distribution of Intersection Demands, by vehicle occupants

6 Conclusions and Recommendations

6.1 Conclusions

Buses in central Wellington are being subject to increasingly levels of delay and travel time variability due to rising volumes of general traffic and the number of bus vehicles operating through the area. Bus travel between Courtenay Place and the Railway Station, a journey timetabled as 10 – 15 minutes, may take up to 28 minutes in the evening peak period.

Uncertainty with respect to the arrival time of a bus service is cited by bus passengers as an important issue, and one which acts against the general objective of both city and regional councils to increase the patronage of public transport services.

Current initiatives to improve the reliability of bus service times are concentrated in areas on the edge of the central area, for example the Hutt Road and Chaytor Street, where there is little inconvenience to other road users and costs are low due to the availability of space. In contrast, bus priority measures in the critical central areas have generally not met funding requirements due to low or negative net benefits (when additional congestion to other road users is evaluated) and the lack of space for the provision of separate running lanes for buses.

A critical review of the operation of bus network in the central area has identified two isolated improvements, in the Hunter and Mercer Street areas, which would lead to some reductions in delays experienced by buses. Analysis has shown that these are feasible from both engineering and economic perspectives.

In the central area there is little scope for further measures which would have any significant impact on the movement of buses. More radical proposals to free the CBD area of extraneous traffic have not been advanced because of a fear of an adverse reaction from the public and the retail sector. It is now appropriate to determine the importance the community places upon accessibility for the private car to the central area, public transport services, pedestrian accessibility and levels of environmental amenity in order to give a mandate for change.

6.2 Recommendations

It is recommended that;

- the Lambton Quay / Featherston Street / Hunter Street improvement which has been evaluated should proceed to detailed design and implementation
- the Willis Street / Mercer Street improvement which has been evaluated should proceed to detailed design, subject to an assessment of the potential benefits arising from the application of localised bus pre-emption in this area

- the proposal for a southbound median bus lane on Thorndon Quay, identified in the BAH report, should now be investigated further in the light of more certainty with respect to the bus terminus layout and the movement of the Newlands/Mana buses

- the separate benefits associated with the provision of a separate bus phase at the Cuba Street pedestrian crossing on Dixon Street should be identified to determine if this project is worthwhile on its own

- the use of localised bus pre-emption on the Golden Mile using inductive loops should be investigated as a short term measure

- the introduction of full bus pre-emption on the Golden Mile using transponders fitted to buses should be taken forward to more detailed evaluation

- the available traffic modelling tools should be used to assess opportunities for the removal of extraneous traffic from the central area between Courtenay Place and Lambton Quay (co-ordinate with the 'aggressive' public transport scenarios to be evaluated as part of the current Wellington CBD Corridor Study)

- the criteria which are implicitly used to set traffic signal timings and which hence determine relative priorities within the CBD area should be reviewed and alternatives evaluated

- the costs and benefits associated with northbound bus running from the Courtenay Place / Taranaki Street intersection through Manners Mall should be assessed

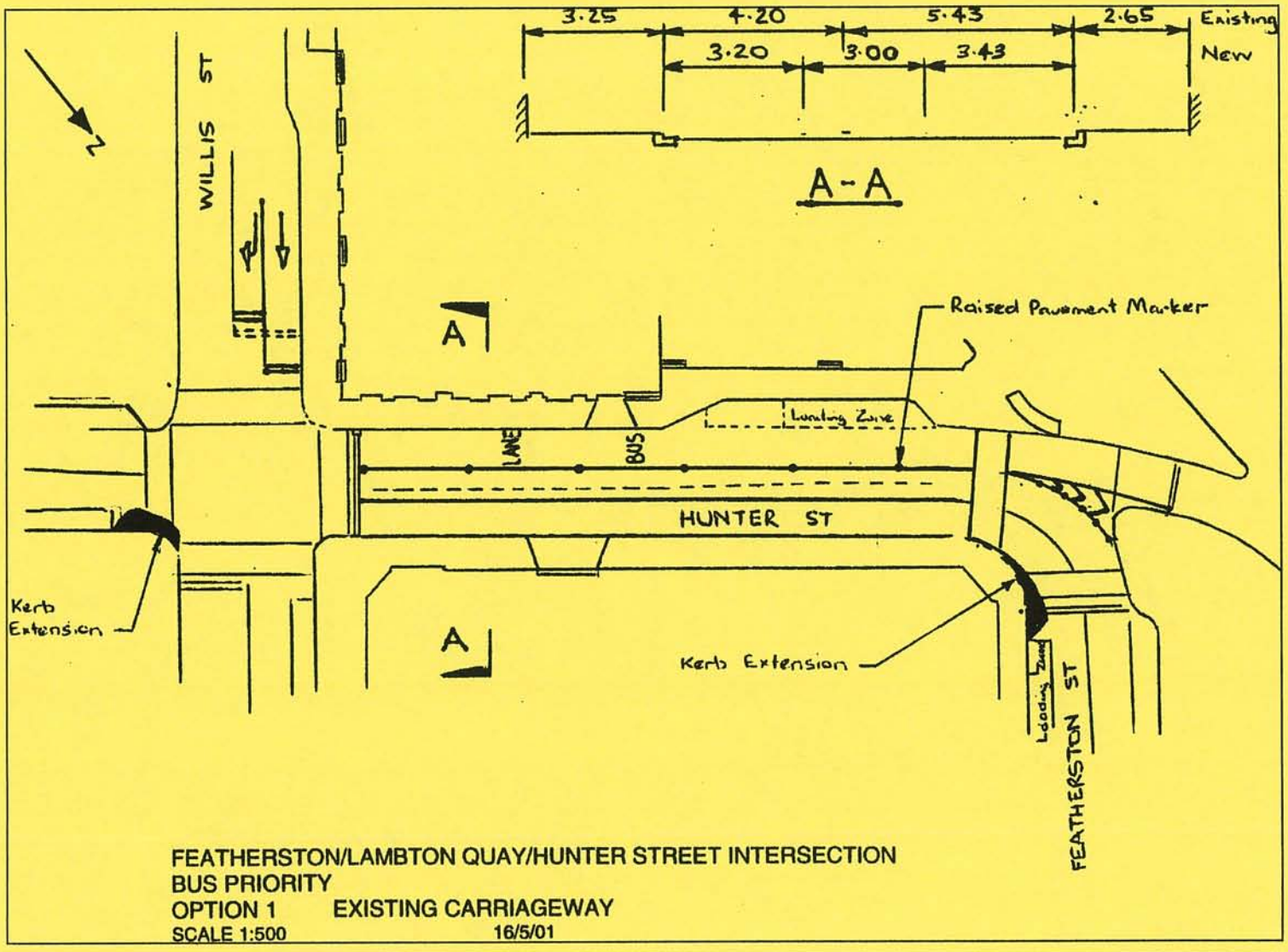
- opportunities for a reduction in the number of bus vehicles running through the central area (whilst maintaining capacity) should be reviewed with bus operators

- a greater emphasis should be placed upon the 'intangible' benefits of bus priority projects; this will require work to identify and evaluate such benefits

- WCC and WRC should work more closely together to ensure the achievement of improved operating conditions for public transport; this may require a review of the current 'Quality Partnership Agreement' arrangement.

Appendix A

Hunter Street / Featherston Street Proposal;
Engineering & Economic Assessments


3.25
4.20
5.43
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Existing
New
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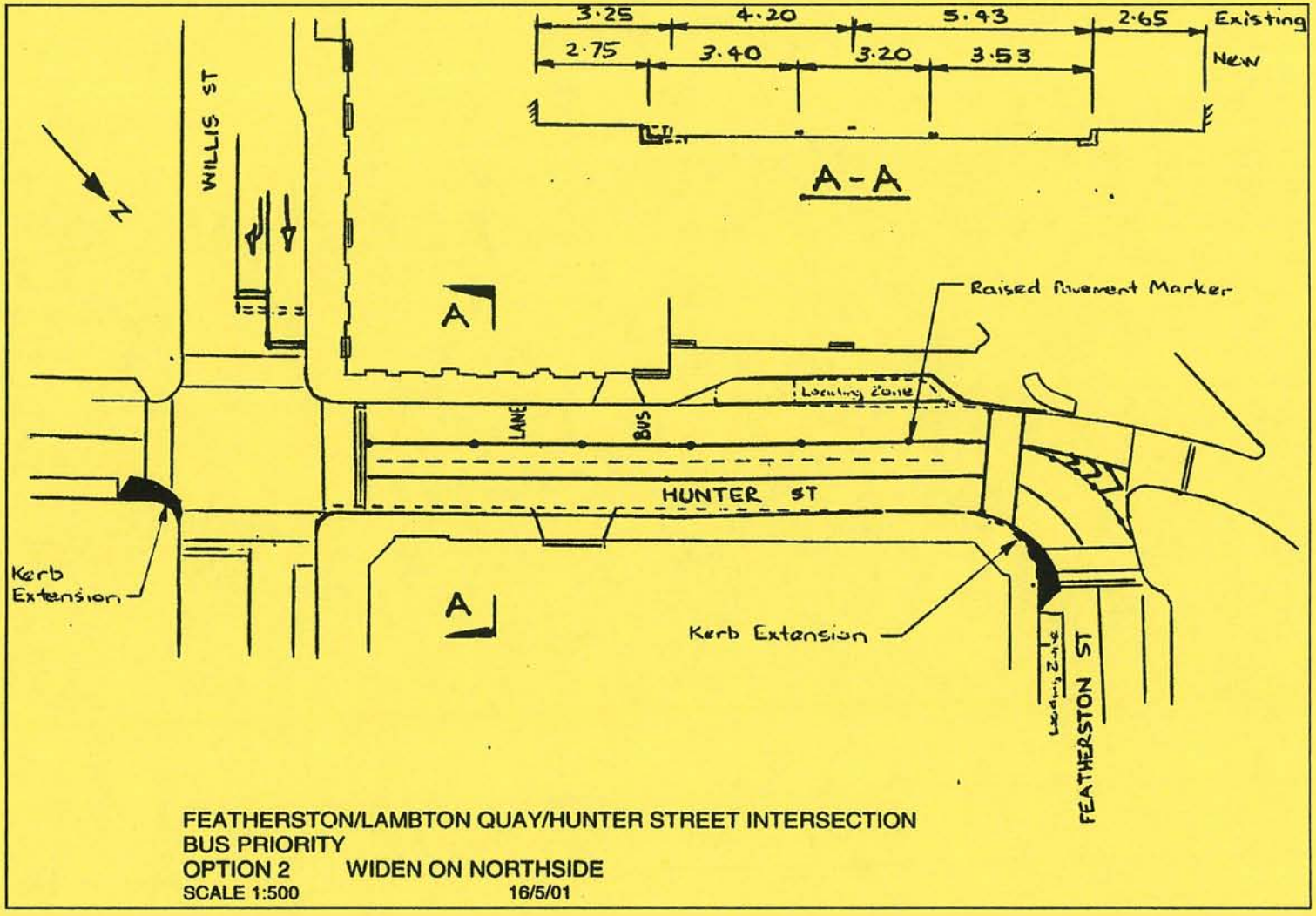
A-A
WILLIS ST
A
Raised Pavement Marker
Loading Zone
LANE
BUS
HUNTER ST
Kerb Extension
A
Kerb Extension
Loading Zone
FEATHERSTON ST
FEATHERSTON/LAMBTON QUAY/HUNTER STREET INTERSECTION
BUS PRIORITY
OPTION 1 EXISTING CARRIAGEWAY
SCALE 1:500
16/5/01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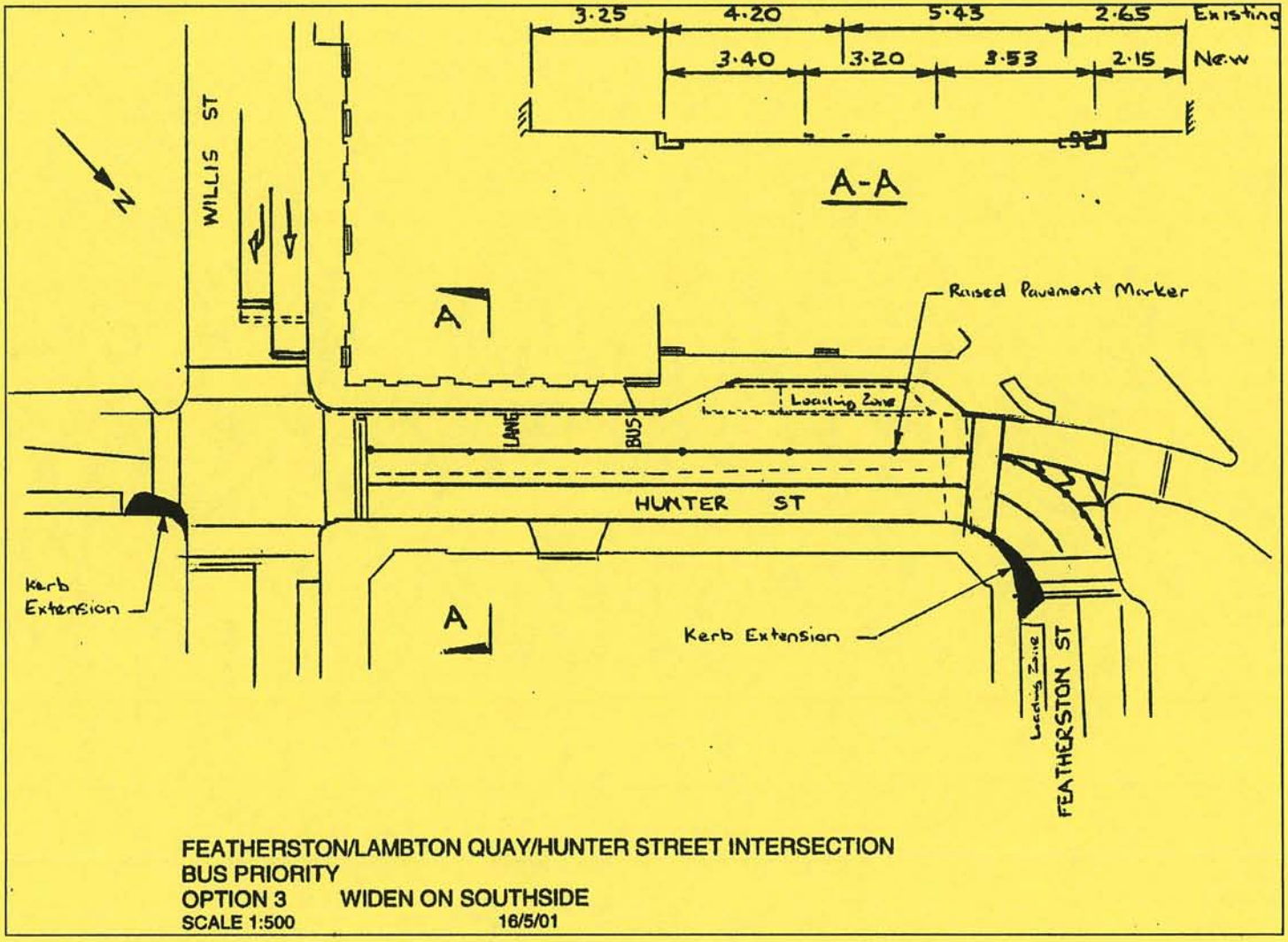
Raised Pavement Marker
Loading Zone
LANE
BUS
HUNTER ST
Kerb Extension
A
Kerb Extension
Loading Zone
FEATHERSTON ST
FEATHERSTON/LAMBTON QUAY/HUNTER STREET INTERSECTION
BUS PRIORITY
OPTION 2 WIDEN ON NORTHSIDE
SCALE 1:500 16/5/01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WILLIS ST
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Raised Pavement Marker
Loading Zone
LANE
BUS
HUNTER ST
Kerb Extension
A
Kerb Extension
Loading Zone
FEATHERSTON ST
FEATHERSTON/LAMBTON QUAY/HUNTER STREET INTERSECTION
BUS PRIORITY
OPTION 3 WIDEN ON SOUTHSIDE
SCALE 1:500 16/5/01

SetUp Parameters			
	Growth in Benefits	2%	% pa
	Maintenance Costs	3%	% of capital costs
	UnDisc Capital Cost	37,908	$, undiscounted

Bus Vehicle Trips

	VoT					CRV	$/pass-hr	Buses/Hour	Hours/Day	Buses/Day	Days/Yr	Occupancy	Expected	Vehicle Time
	Work	Non-Work		%work	%standing			number	number	number			TimeSaving	
	All	Seated	Standing										secs	$/hr
Weekday AM Peak	21.30	5.25	10.55	0%	5%	2.60	8.12	101	1	101	245	20	35	0.00
Weekday PM Peak	21.30	5.25	10.55	0%	5%	2.60	8.12	108	1	108	245	20	62	0.00
Weekday InterPeak	21.30	5.25	10.55	10%	0%	0.00	6.86	67	8	536	245	10	13	0.00
Weekends	21.30	5.25	10.55	0%	0%	0.00	5.25	20	8	160	60	10	13	0.00

Private Vehicle Trips from Featherston -> Hunter Street

	Base	VoT CRV	Total	Volume vehs/hr	VoC Adjust	Time Saving (secs)
Weekday AM Peak	15.30	4.55	19.85	907	1.05	5
Weekday PM Peak	15.30	4.55	19.85	744	1.05	5
Weekday InterPeak	15.30	4.55	19.85	611	1.05	5
Weekends	12.60	5.40	18.00	300	1.05	5

Decongestion Parameters		
Base Rate	1.251	$/pass-km
VoC Factor	1.07	
Accident & Environment	0.112	
Average Trip Length	5.0	kms
Induced Trip Factor	0.5	
Benefit/Trip	3.63	$
Generalised Cost of Typical Bus Trip		
Total Generalised Cost	5.02	$

COST ESTIMATE

Project: FEATHERSTON/LAMBTON QUAY/HUNTER STREET INTERSECTION		Type:	[redacted]	PAC -25%/+25%	FEC -5%/+10%
Contract No.:	Office:		Name	Signature	Date
Bus Priority		Prepared:	B Craig		17-05-01
Option 3 - Widen on Southside		Verified:			
Cost Index: Opus	Index Value: December 2000 : 4420				

Item	Description			Unit	Quantity	Rate	Amount $
1.0	GENERAL						
1.1	Establishment			LS	1	500	500
1.2	Traffic Control			LS	1	3000	3000
2.0	EARTHWORKS						
2.1	Cut to Waste and Dispose off Site	(Solid Volume)		m3	30	15	450
2.2	Supply, Place and Compact Fill	(Solid Volume)		m3	20	25	500
2.3	Additional Undercut (Provisional)	(Solid Volume)	(PS)	m3	10	50	500
3.0	DRAINAGE						
3.1	Kerb and Channel			m	65	35	2275
3.2	Supply and Install Single Sump			ea	2	1400	2800
4.0	ROADING						
4.1	Saw Cutting Seal			m	100	1	100
4.2	Supply and Construct AP65 Subbase	(Solid Volume)		m3	15	35	525
4.3	Supply and Construct M/4 Basecourse	(Solid Volume)		m3	10	56	560
4.4	Asphaltic Concrete			t	5	250	1250
4.5	Pavement Marking			LS	1	650	650
4.6	Raised Pavement Markers			ea	12	30	360
4.7	Sand Blasting (Provisional)			m	70	5	350
4.8	Kerb Extension			ea	2	1200	2400
5.0	PAVING						
5.1	Remove Existing Pavers			m2	80	30	2400
5.2	Relay Existing Pavers			m2	50	60	3000
6.0	MISCELLANEOUS						
6.1	Relocate Traffic Signals			ea	2	3000	6000
6.2	Relocate Signs			ea	2	200	400
	Sub Total						27620
	Contingencies (Earthworks)			%	1450	25	363
	Contingencies (Other)			%	26170	15	3926
	Non Contract Costs						
	Design and Supervision Fees			LS	1	5000	5000
	Testing			LS	1	1000	1000
	TOTAL (Excluding GST)						**$ 37,908**

User Benefits					
		AM Peak	InterPeak	PM Peak	Weekend
Unit Value of Time	$/hour	8.12	6.86	8.12	5.25
Buses / Day	number	101	536	108	160
Avg Occupancy	no./ bus	20	10	20	10
Passengers/Day	number	2020	5360	2160	1600
Days/Year	number	245	245	245	60
Unit Time Saving	seconds	35	13	62	13
Benefit	$/pa	39,046	32,507	73,960	1,820
Total Benefit	$/pa	147,333			

Decongestion Benefits					
		AM Peak	InterPeak	PM Peak	Weekend
Benefit/trip	$	3.63	3.63	3.63	3.63
Users/day	number	2020	5360	2160	1600
Unit Time Saving	hours	0.01	0.00	0.02	0.00
Unit Value of Time	$/hour	8.12	6.86	8.12	5.25
Value of Time Saving	$/hour	0.08	0.02	0.14	0.02
Bus Generalised Cost	$	5.02	5.02	5.02	5.02
As % of Gen. Cost	%	1.6%	0.5%	2.8%	0.4%
New Users/Day	number	31.7	26.4	60.1	6.0
Days/Year	number	245	245	245	60
Annual Benefit	$	28,206	23,483	53,428	1,315
Total Benefit	$/pa	106,433			

Impact on Other Road Users					
		AM Peak	InterPeak	PM Peak	Weekend
Vehicles/Period	veh/hr	907	611	744	300
Time saving/vehicle	secs	5	5	5	5
VoT/veh	$/hour	19.85	19.85	19.85	18.00
Days/Year	number	245	245	245	60
Adjust for VoC	factor	1.05	1.05	1.05	1.05
Annual Benefit	$	6,433	4,333	5,277	473
Total Benefit	$/pa	16,515			

New Peak Bus Users					
		AM Peak	InterPeak	PM Peak	Weekend
Unit VoT	$/hour	8.12	6.86	8.12	5.25
New Users/Day	number	31.7	26.4	60.1	6.0
Days/Year	number	245	245	245	60
Time Savings	hours	0.01	0.00	0.02	0.00
Rule of a half	factor	0.5	0.5	0.5	0.5
Annual Benefit	$	307	80	1,030	3
Total Benefit	$/pa	1,420			

Savings in Bus Costs					
		AM Peak	InterPeak	PM Peak	Weekend
Buses/period	number	101	67	108	20
Periods/Year	number	245	245	245	60
Time Savings	hours	0.01	0.00	0.02	0.00
Value/Hour	$/hour	0.00	0.00	0.00	0.00
Annual Benefit	$	0	0	0	0
Total Benefit	$/pa	0			

Summary of Benefits					
	AM Peak	InterPeak	PM Peak	Weekend	**TOTAL**
User	39,046	32,507	73,960	1,820	**147,333**
Decongestion	28,206	23,483	53,428	1,315	**106,433**
Other Road Users	6,433	4,333	5,277	473	**16,515**
New Peak Bus Users	307	80	1,030	3	**1,420**
Bus Costs	0	0	0	0	**0**
Total	**73,991**	**60,404**	**133,695**	**3,611**	**271,700**

Undiscounted Capital Cost =	37908	$, undiscounted
Point in Time at Which Costs Incurred =	Q4, 2001	
Discount Factor	1.000	
Discounted Costs	37908	$, discounted
Benefits in 1st Year =	271,700	$, undiscounted

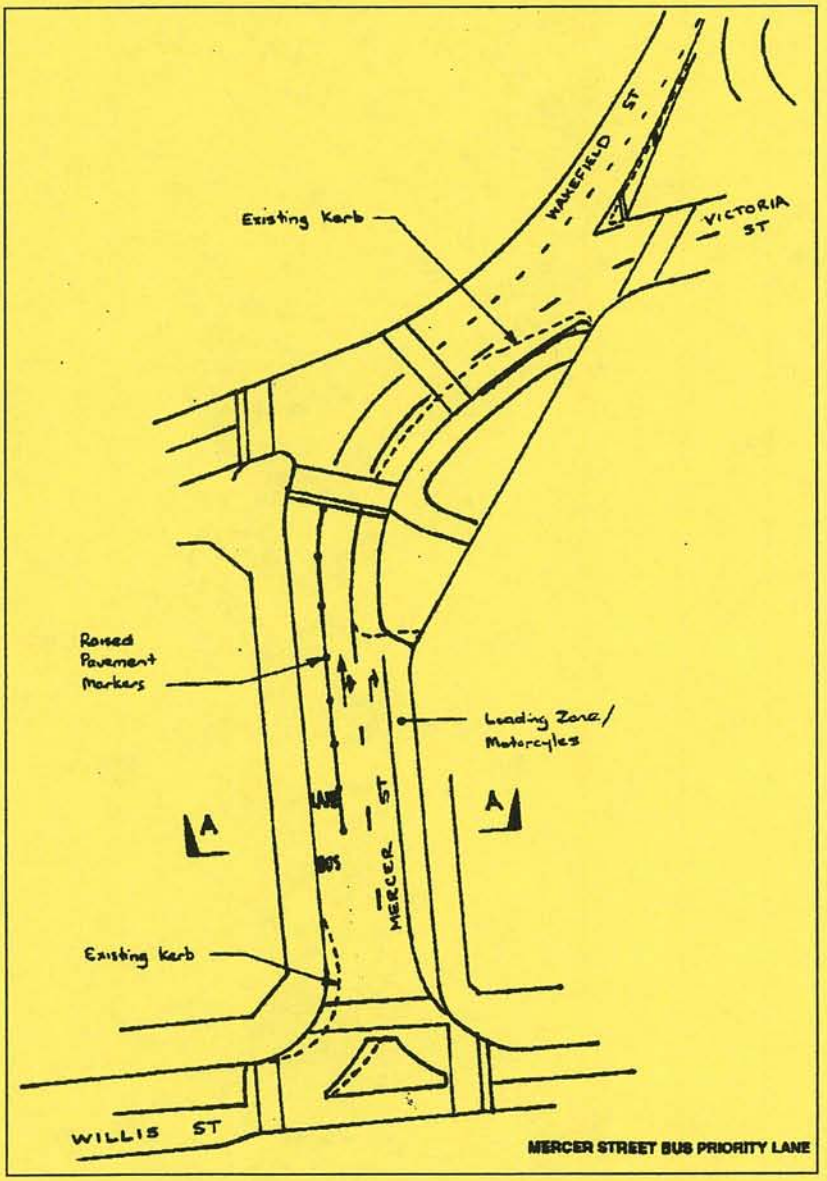
Maintenance

Year Commencing 1st July	Discount Factor	Annual Cost	PV (Costs)	Benefits	PV(Bens)
2000	1.0000				
2001	0.9091				
2002	0.8264	$1,137	$940	$277,134	$229,037
2003	0.7513	$1,137	$854	$282,569	$212,298
2004	0.6830	$1,137	$777	$288,003	$196,710
2005	0.6209	$1,137	$706	$293,437	$182,201
2006	0.5645	$1,137	$642	$298,871	$168,705
2007	0.5132	$1,137	$584	$304,305	$156,156
2008	0.4665	$1,137	$531	$309,739	$144,495
2009	0.4241	$1,137	$482	$315,173	$133,664
2010	0.3855	$1,137	$438	$320,607	$123,608
2011	0.3505	$1,137	$399	$326,041	$114,275
2012	0.3186	$1,137	$362	$331,475	$105,618
2013	0.2897	$1,137	$329	$336,909	$97,590
2014	0.2633	$1,137	$299	$342,343	$90,150
2015	0.2394	$1,137	$272	$347,777	$83,255
2016	0.2176	$1,137	$247	$353,211	$76,869
2017	0.1978	$1,137	$225	$358,645	$70,956
2018	0.1799	$1,137	$205	$364,079	$65,483
2019	0.1635	$1,137	$186	$369,513	$60,418
2020	0.1486	$1,137	$169	$374,947	$55,733
2021	0.1351	$1,137	$154	$380,381	$51,401
2022	0.1228	$1,137	$140	$385,815	$47,396
2023	0.1117	$1,137	$127	$391,249	$43,694
2024	0.1015	$1,137	$115	$396,683	$40,273
2025	0.0923	$1,137	$105	$402,117	$37,115
2025	0.0923	$1,137	$105	$402,117	$37,115
		NPV(C)=	$9,394	NPV(B)=	$2,624,216

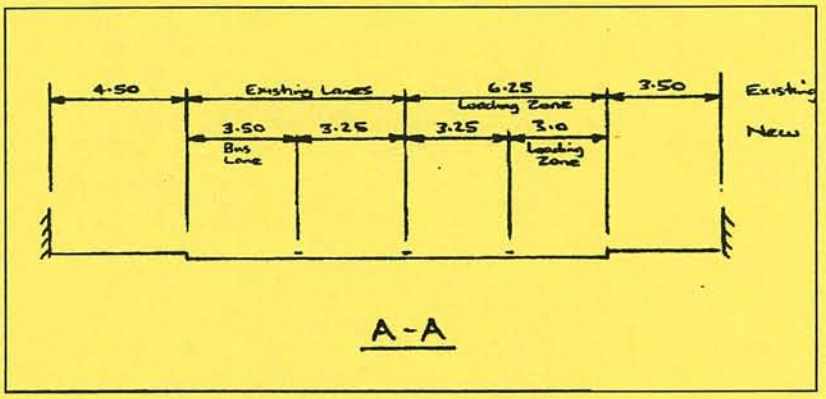
Summary	
Discounted Costs =	$47,302
Discounted Benefits =	$2,624,216
Benefit / Cost Ratio =	**55**

Appendix B

Willis Street / Mercer Street Proposal; Engineering & Economic Assessments



MERCER STREET BUS PRIORITY LANE



A-A

SetUp Parameters			
	Growth in Benefits	2%	% pa
	Maintenance Costs	3%	% of capital costs
	UnDisc Capital Cost	154,963	$, undiscounted

Bus Vehicle Trips

	VoT Work All	VoT Non-Work Seated	VoT Non-Work Standing	%work	%standing	CRV	$/pass-hr	Buses/Hour number	Hours/Day number	Buses/Day number	Days/Yr	Occupancy	Expected TimeSaving secs	Vehicle Time $/hr
Weekday AM Peak	21.30	5.25	10.55	0%	5%	2.60	8.12	105	1	105	245	20	10	0.00
Weekday PM Peak	21.30	5.25	10.55	0%	5%	2.60	8.12	100	1	100	245	20	10	0.00
Weekday InterPeak	21.30	5.25	10.55	10%	0%	0.00	6.86	47	8	376	245	10	10	0.00
Weekends	21.30	5.25	10.55	0%	0%	0.00	5.25	20	8	160	60	10	5	0.00

Private Vehicle Trips from Willis St (S) -> Mercer St

	Base	VoT CRV	Total	Volume vehs/hr	VoC Adjust	Time Saving (secs)
Weekday AM Peak	15.30	4.55	19.85	180	1.05	15
Weekday PM Peak	15.30	4.55	19.85	246	1.05	15
Weekday InterPeak	15.30	4.55	19.85	249	1.05	15
Weekends	12.60	5.40	18.00	100	1.05	5

Decongestion Parameters		
Base Rate	1.251	$/pass-km
VoC Factor	1.07	
Accident & Environment	0.112	
Average Trip Length	5.0	kms
Induced Trip Factor	0.5	
Benefit/Trip	3.63	$
Generalised Cost of Typical Bus Trip		
Total Generalised Cost	5.02	$

User Benefits					
		AM Peak	InterPeak	PM Peak	Weekend
Unit Value of Time	$/hour	8.12	6.86	8.12	5.25
Buses / Day	number	105	376	100	160
Avg Occupancy	no./ bus	20	10	20	10
Passengers/Day	number	2100	3760	2000	1600
Days/Year	number	245	245	245	60
Unit Time Saving	seconds	10	10	10	5
Benefit	$/pa	11,598	17,541	11,045	700
Total Benefit	$/pa	40,884			

Decongestion Benefits					
		AM Peak	InterPeak	PM Peak	Weekend
Benefit/trip	$	3.63	3.63	3.63	3.63
Users/day	number	2100	3760	2000	1600
Unit Time Saving	hours	0.00	0.00	0.00	0.00
Unit Value of Time	$/hour	8.12	6.86	8.12	5.25
Value of Time Saving	$/hour	0.02	0.02	0.02	0.01
Bus Generalised Cost	$	5.02	5.02	5.02	5.02
As % of Gen. Cost	%	0.4%	0.4%	0.4%	0.1%
New Users/Day	number	9.4	14.3	9.0	2.3
Days/Year	number	245	245	245	60
Annual Benefit	$	8,378	12,672	7,979	506
Total Benefit	$/pa	29,535			

Impact on Other Road Users					
		AM Peak	InterPeak	PM Peak	Weekend
Vehicles/Period	veh/hr	180	249	246	100
Time saving/vehicle	secs	15	15	15	5
VoT/veh	$/hour	19.85	19.85	19.85	18.00
Days/Year	number	245	245	245	60
Adjust for VoC	factor	1.05	1.05	1.05	1.05
Annual Benefit	$	3,830	5,298	5,234	158
Total Benefit	$/pa	14,519			

New Peak Bus Users					
		AM Peak	InterPeak	PM Peak	Weekend
Unit VoT	$/hour	8.12	6.86	8.12	5.25
New Users/Day	number	9.4	14.3	9.0	2.3
Days/Year	number	245	245	245	60
Time Savings	hours	0.00	0.00	0.00	0.00
Rule of a half	factor	0.5	0.5	0.5	0.5
Annual Benefit	$	26	33	25	1
Total Benefit	$/pa	85			

Savings in Bus Costs					
		AM Peak	InterPeak	PM Peak	Weekend
Buses/period	number	105	47	100	20
Periods/Year	number	245	245	245	60
Time Savings	hours	0.00	0.00	0.00	0.00
Value/Hour	$/hour	0.00	0.00	0.00	0.00
Annual Benefit	$	0	0	0	0
Total Benefit	$/pa	0			

Summary of Benefits					
	AM Peak	InterPeak	PM Peak	Weekend	TOTAL
User	11,598	17,541	11,045	700	**40,884**
Decongestion	8,378	12,672	7,979	506	**29,535**
Other Road Users	3,830	5,298	5,234	158	**14,519**
New Peak Bus Users	26	33	25	1	**85**
Bus Costs	0	0	0	0	**0**
Total	**23,832**	**35,544**	**24,283**	**1,364**	**85,023**

COST ESTIMATE

Project: Mercer Street Bus Priority Measu	Type:	[redacted]	PAC -25%+25%	FEC -5%+10%
Contract No.: Office: Wellington				
Option 1 - Three lane Mercer Street		Name	Signature	Date
	Prepared:	B Craig		08-06-01
Cost Index: Opus Index Value: March	Verified:	M Carpenter		

Item	Description	Unit	Quantity	Rate	Amount $
1	**ESTABLISHMENT**	LS	1	3000	3000
2	**TRAFFIC CONTROL**	LS	1	5000	5000
3	**EARTHWORKS**				
3.1	Site clear a) General	LS	1	1000	1000
	b) Remove existing trees	ea	7	2000	14000
3.2	Cut to Was (Solid Volume)	m3	50	15	750
3.3	Undercut t (Solid Volume) (PS)	m3	5	30	150
3.4	Cut to Fill (Solid Volume)	m3	10	12	120
3.5	Subgrade Preparation	m2	150	2.3	345
4	**PAVEMENT**				
4.1	Sawcutting	m	120	5	600
4.2	Subbase (150mm)	m3	25	30	750
4.3	Basecours (150mm)	m3	25	40	1000
4.4	First Coat Seal	m2	140	4	560
4.5	Asphaltic Concrete	t	10	270	2700
4.6	Bus Lane F (coloured surface)	m2	250	10	2500
4.6	Pavement (remove old , install new)	LS	1	2000	2000
4.7	Kerb and Channel				
	a) Kerb and Channel	m	85	40	3400
	b) Mountable kerb blocks	m	35	30	1050
5	**DRAINAGE**				
5.1	Sump a) Single Sump	ea	2	1000	2000
5.2	Subsoil Drain	m	25	8	200
5.3	225mm dia pipe	m	6	120	720
5.4	Manholes covers - lower and fit gattic covers	ea	2	1500	3000
6	**SERVICES**				
6.1	Relocate underground services	PS	1	10000	10000
7	**MISCELLANEOUS**				
7.1	Traffic Sig a) Relocate Signs	ea	3	100	300
	b) New Signs and supports	ea	2	3000	6000
7.2	Traffic Sig a) Relocate Signals	ea	3	10000	30000
	b) Signal modifications/phasing	LS	1	5000	5000
7.3	Landscapir a) paving	LS	1	1000	1000
	b) planting	LS	1	6000	6000
7.4	Timber Barrier	m	20	80	1600
7.5	Asphatic concrete footpath	m2	90	20	1800
7.6	Miscellaneous street furniture	LS	1	5000	5000
	Sub Total				108545
8	**CONTIN** item 3	%	16365	25	4091
	other items	%	92180	15	13827
	Sub Total				**129463**
9	**FEES**				
9.1	Survey , Design & Supervision	LS	1	15000	15000
9.2	Contingency for item 11.1	%		10	1500
9.3	Consent Fees	LS	1	4000	4000
9.4	Safety Auc - Stage 3	LS	1	5000	5000
	TOTAL (Excluding GST)				**$ 154,963**

Undiscounted Capital Cost =	154963	$, undiscounted
Point in Time at Which Costs Incurred =	Q4, 2001	
Discount Factor	1.000	
Discounted Costs	154963	$, discounted
Benefits in 1st Year =	85,023	$, undiscounted

Maintenance

Year Commencing 1st July	Discount Factor	Annual Cost	PV (Costs)	Benefits	PV(Bens)
2000	1.0000				
2001	0.9091				
2002	0.8264	$4,649	$3,842	$86,723	$71,672
2003	0.7513	$4,649	$3,493	$88,424	$66,434
2004	0.6830	$4,649	$3,175	$90,124	$61,556
2005	0.6209	$4,649	$2,887	$91,825	$57,016
2006	0.5645	$4,649	$2,624	$93,525	$52,792
2007	0.5132	$4,649	$2,386	$95,226	$48,866
2008	0.4665	$4,649	$2,169	$96,926	$45,217
2009	0.4241	$4,649	$1,972	$98,626	$41,827
2010	0.3855	$4,649	$1,792	$100,327	$38,680
2011	0.3505	$4,649	$1,629	$102,027	$35,760
2012	0.3186	$4,649	$1,481	$103,728	$33,051
2013	0.2897	$4,649	$1,347	$105,428	$30,539
2014	0.2633	$4,649	$1,224	$107,129	$28,210
2015	0.2394	$4,649	$1,113	$108,829	$26,053
2016	0.2176	$4,649	$1,012	$110,530	$24,054
2017	0.1978	$4,649	$920	$112,230	$22,204
2018	0.1799	$4,649	$836	$113,931	$20,491
2019	0.1635	$4,649	$760	$115,631	$18,907
2020	0.1486	$4,649	$691	$117,331	$17,441
2021	0.1351	$4,649	$628	$119,032	$16,085
2022	0.1228	$4,649	$571	$120,732	$14,831
2023	0.1117	$4,649	$519	$122,433	$13,673
2024	0.1015	$4,649	$472	$124,133	$12,603
2025	0.0923	$4,649	$429	$125,834	$11,614
2025	0.0923	$4,649	$429	$125,834	$11,614
		NPV(C)=	$38,401	NPV(B)=	$821,192

Summary

Discounted Costs =	$193,364
Discounted Benefits =	$821,192
Benefit / Cost Ratio =	**4.2**