Appendix D

Economic Evaluation Methodology

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2.0 Introduction

2.1 Background

The Wellington Public Transport Spine Study (PTSS) is a study commissioned by Greater Wellington Regional Council (GWRC), Wellington City Council (WCC) and the New Zealand Transport Agency (NZTA) about determining what a future public transport solution for Wellington might be.

The three options that are considered as part of the final short list evaluation are:

- Bus Priority (BP)
- Bus Rapid Transit (BRT)
- Light Rail Transit (LRT)

This technical note describes the methodology and assumptions used to develop benefit cost ratios (BCRs).

2.2 Development of Methodology

The methodology used for the economic evaluation was developed and agreed with the independent peer reviewer (Ian Wallis) as the study progressed. This included agreement over:

- The reference case assumptions
- The models to be used to assess the highway and public transport benefits
- The nature of the evaluation
- The values of time used
- Details relating to PT travel time components and perception factors

This note details the agreed outcomes from the review process and the assumptions and values that have been applied.

3.0 Base Assumptions

3.1 Reference Case

The Reference Case provides a representation of the future level of service should the present assumptions regarding improvements to the PT and vehicle network be realised. Reference case assumptions were agreed amongst stakeholders and have been documented elsewhere in report. It also provides a base line against which the options can be assessed. Benefits over and above the Reference Case reveal how potential options may provide a superior level of service compared to the minimum levels provided. The Reference Case includes future capital projects which are already committed, or are predicted to be needed to maintain a minimum level of service over the evaluation period of 30 years. This includes all relevant projects in the Regional Land Transport Programme, including the Roads of National Significance (RoNS), integrated ticketing for public transport and the recommendations of the Wellington Bus Review.

3.2 Evaluation Assumptions

The economic evaluation assessed the viability of the options against a Reference Case scenario. The evaluation was underpinned by a number of basic assumptions that were consistent regardless of the option or the method of calculating benefits.

- Evaluation period – 30 years assumed from the first year when major expenditure occurs (see Table 1 below)

- Real prices expressed at a constant price for all costs and benefits, discounted to the base date of 1 July 2012. In the EEM the base date is set at the 1 July of the financial year in which the evaluation is undertaken.
- Real discount rate – 8% as per current New Zealand Treasury and NZTA guidance.
- Year Zero – 2012/13. Year zero is the year to which all of the costs and benefits have been discounted to.
- The rule of a half has been applied to the benefits to new users The rule of half assumes that a new user who was just discouraged from using a service before the service change (or implementation of a new service) will receive the full benefit of the service change or introduction and a user who is just marginal after the service change will receive nearly zero benefits. Hence, on average, new users receive half the unit benefits
- Model year outputs from 2021, 2031 and 2041 with interpolation between model years and extrapolation before and after.

The main inputs to the assessments of benefits for the economic evaluation were derived from the Wellington Transport Strategy Model (WTSM) for highway time savings benefits and Wellington Passenger Transport Model (WPTM) for public transport time savings benefits.

3.3 Timing of Construction

Table 1 displays the assumed construction timeline for theoptions. These timeframes provide the base from which the 30 year evaluation is calculated. Costs have been split evenly between years and benefits accrue from the end of the construction phase.

Option	First year of construction / Start of evaluation period	Construction period (years)	First Year of benefits
Bus Priority	2014/15	2	2016/17
Bus Rapid Transit	2014/15	3	2017/18
Light Rail Transit	2015/16	4	2019/20

Table 1 Construction period for options

4.0 Approach to Evaluation

4.1 Approach to Calculating of User Benefits

Three potential options for calculating user benefits were considered and debated

- **EEM Simplified Procedures**

  The EEM simplified procedure SP10 (Existing Passenger Transport Services) provides a generic approach to calculate benefits when no appropriate assessment tools exist. In this instance bespoke transport models exist which are designed to provide the outputs to assess options in more detail than outlined in SP10. Furthermore, the options affect both public transport and road traffic differently meaning there is a need to assess the impact of each option on both modes separately but consistently.

  The EEM simplified procedures were also not considered appropriate due to the high value and significance of the possible options and the availability of appropriate models.

- **EEM Procedures**

  To derive the value of benefits for each of the options the principals described in the NZ Transport Agency Economic Evaluation Manual, Volume 1 Appendix 4, are applied using the standard unit values defined there. The standard unit values are applied to unweighted model outputs to provide an estimated user cost for each option in constant price terms (excluding inflation).

  This evaluation methodology provides full consistency with the EEM and hence with other economic evaluations elsewhere in New Zealand. The EEM is the main approach adopted in the PTSS economic evaluation.

- **Alternative Approach.**

  This approach uses the same general procedures as in the EEM assessment but applies the perceived weightings used in the model to represent user costs and multiplies this by values of time which are inflation adjusted. The advantage of this approach is that benefits are calculated on the basis of how users perceive the value of time (all relative to in-vehicle time) and is in line with how decisions on trip making are made within the model.

  e.g people perceive waiting for a bus to be more onerous than travelling on a bus. Therefore 10 minutes of waiting time is actually perceived as be greater than 10 minutes, whereas 10 minutes of IVT is perceived as usual.

To provide consistency with the EEM and in recognising the shortcomings of the simplified procedures it was decided that the EEM methodology would be used to provide the main economic assessment. However, evaluating the BCR using a number of different methods is useful in understanding the risks and opportunities of the project. In particular, the EEM may not provide the most appropriate assumptions for assessing high quality services which involve transfer such as Bus Rapid Transit and Light Rail Transit. (See Section 4.3)

Both the EEM and the Alternative approach have been used to provide a range of potential evaluation outcomes rather than a single number.

4.2 Source of Benefits

The benefits were derived from from the following sources

- Public transport users, both new and existing were extracted from WPTM (weighted and unweighted) to produce an EEM and alternative approach set of benefits.
- Highway benefits due to the combined effects of reductions in capacity and mode shift away from car. These were extracted from WTSM directly to produce an EEM set of benefits.
- Wider economic benefits were assumed to be 25% of conventional benefits. This is at the higher end of the range from similar schemes elsewhere, reflecting the fact that the scheme gets more people into the CBD and wider economic benefits are generally associated with promoting growth in employment and business, most of which takes place in Wellington CBD.

4.3 Source of Costs

The costs were derived from the following sources

- Capital costs – high level estimates of construction costs based on option concepts.
- Operating costs for public transport – high level annual operating costs based upon service level information extracted from theWellington Transport Models..
- Savings in the cost of providing car parking due to fewer cars entering CBD.

4.4 Sensitivity Analysis

It is important to gain an understanding of the relative sensitivity of each option to changes in the calculation of costs, benefits, base assumptions and the process that is used to calculate the BCR. The following sensitivity tests were considered:

- Sensitivity testing of the assumptions which have been used in the calculation of benefits and costs and the changes to the BCR. The tests included are:
  - 20% lower construction costs (an increase was not considered as the costs are considered conservative)
  - 6% discount rate and 40 year evaluation period, recognising the long term strategic nature of the options. This takes account of the NZTA policy changes to the EEM approved on July 29 2013.
- Sensitivity testing of scenario input assumptions and the way in which they affect the uptake of public transport and the resulting BCR. The tests included, both of which were implemented through the relevant models, are:

- Cap the demand for total parking in the CBD to recognise that parking provision will not continue without limits. This is implemented based upon the adjustment of parking costs.
- Deferment of RoNS projects - Petone to Grenada, Transmission Gully and Mount Victoria Tunnel Duplication

5.0 Calculation of Benefits

5.1 Modelling Approach

Highway Benefits

The Wellington Transport Strategy Model (WTSM) is a strategic transport model of the Wellington Region which takes future development forecasts and provides information on the pattern of trips, the number of trips choosing public transport and the implications of vehicle travel on the road network. Future year models for 2021, 2031 and 2041 morning and interpeak periods were used.

Whilst WTSM is a relatively coarse model, the PTSS is predominantly a PT scheme where highway benefits are most likely to be small and secondary to PT benefits. Therefore it was decided that WTSM was the most appropriate tool for assessing highway benefits.

Outputs from the WTSM used in the evaluation are the total vehicle-hours for the region, which show the impact of the change in mode share and reduction in road capacity for cars incurred by the PTSS schemes. The vehicle-hour outputs were monetised using a suitable value which included the base value of time (VoT), congested VoT and vehicle operating costs, all taken from EEM.

Due to the relatively high mode share for cars in Wellington, small variations in travel time for car users can potentially result in large benefits or disbenefits totals when aggregated over the whole regional demand. However, it was estimated that small travel time changes of less than 1 minute would be within daily variations for a trip and would be imperceptible for users, compared with the potential savings of up to 10 minutes for PT users. For this reason, benefits (positive or negative) below 1 minute were excluded from the highway benefit totals (for further information see the GWRC Modelling Report, Chapter 10, Section 10.7).

Public Transport Benefits

The Wellington Public Transport Model (WPTM) is a transport model developed specifically to understand the operation of public transport futures and the costs associated for passengers travelling by public transport. Future year models were developed for 2021, 2031 and 2041 morning and interpeak periods.

The Wellington Public Transport Model (WPTM) is used to obtain PT time benefits that are then used for the calculation of monetised benefits. Procedures were developed to provide both actual and perceived (i.e unweighted and weighted) time components for PT journeys between all origin-destination pairs, respectively for the EEM and behavioural evaluations.

5.2 Values of Time Used in Evaluation

In order to convert travel times into monetised dollar values and, ultimately, estimate the level of benefits for each option, appropriate values of time need to be applied to PT and highway travel times.

WPTM and WTSM use specific values of time to calculate the generalised costs of a journey. These costs are used in the mode split module in WTSM (to allocate trips to either car or PT) and are then used in the respective highway (WTSM) and PT (WPTM) assignment modules to distribute trips across attractive routes.

Public Transport Values of Time

The values of time in WTSM are derived from the EEM, factored based on household travel surveys information to give different value for different user class (adult, child), trip purpose (work, education, employers business, other) and car availability. The values of time in WPTM are based on the WTSM values, but an uplift of 1.6 was applied to the WTSM values when converting to WPTM to replicate observed behaviour.

Table 2 displays the values of time for 2011 used for PT benefit evaluation for both the EEM and Alternative approaches. These values are the appraisal values and differ slightly from the behavioural values used in the

model. They are consistent with values used in other studies around New Zealand, so that projects can be easily compared against each other.

Value of Time	Work		Education		Other		Children
	CA	NCA	CA	NCA	CA	NCA	
Behavioural VoT ($/hr)	12.29	9.17	8.85	5.83	10.75	7.56	6.73
EEM VoT ($/hr)	11.90	11.90	8.78	8.78	8.78	8.78	8.78

Where CA: Car available
NCA: no car available

Table 2 Values of time used in evaluation

In the EEM approach, values of time are kept constant in all future years, whereas the behavioural values include inflation. This was calculated using the increase in GDP / working age population, with an elasticity of 1 for work purpose and 0.8 for non-work purpose. Table 3 below shows the resulting value of time increase for future year.

Purpose	2021	2031	2041
Work Purpose	1.18	1.37	1.59
Non-work Purpose	1.14	1.30	1.47

Table 3 Increases in value of time

5.3 Public Transport Behavioural Weighting Factors

The generalised cost of travel for a typical PT journey is comprised of a number of time based components:

- Walk access time to PT stop
- Wait time
- Boarding time
- In-vehicle time
- Walk egress time to final destination

If the trip includes a transfer to another service, another wait time, boarding time and in-vehicle time are added for the second service (plus walk if they don't use the same stop). In this case, the generalised costs may also include a transfer penalty to represent the inconvenience of having to interchange.

These generalised costs are converted into monetised costs using the values of time detailed in the previous section, and finally the total fare paid for the trip is added to get the total cost. Integrated ticketing has been included for all scenarios at the main interchanges so transferring between services does not incur an additional boarding fee.

The WPTM itself uses perceived times, which include various perception factors for different modes, and these were used directly for the alternative "behavioural" approach. For the main EEM approach, actual unweighted time components were extracted from the model, and the weighting factors recommended by the EEM guidelines were applied. Table 4 displays weighting or perception factors used for both approaches.

Journey Component	EEM Approach Factors	Alternative Approach Factors
Walk Access	2	1.8
Boarding Penalty	N/A	
Bus		4.5 to 5.5
BRT		3
LRT		3
Wait Time	0.368	
Bus	2	2
BRT	2	1.6
LRT	2	1.6

Journey Component	EEM Approach Factors	Alternative Approach Factors
In Vehicle Time		
Bus	1	1
BRT	1	0.88 (AM)
LRT	1	0.88 (AM)
Transfer Penalty	5min per transfer	N/A
Fare	Actual Fare	Actual Fare

Table 4 EEM and Alternative approach weightings

Walk time, wait time and in-vehicle time are very similar for both approaches, the only difference relating to the perception factors. The main difference between the two approaches relates to the representation of the penalties incurred by boarding vehicles, and transfer between services:

- in the EEM, there is no penalty for boarding a vehicle, but a standard 5 minutes penalty is applied for any transfer between services.
- In the WPTM and alternative approach on the other hand, there is no transfer penalty as such but a boarding penalty is applied for any boarding of vehicle, which varies by mode and quality of stop (i.e. regular bus stop, high quality stop, rail station, etc). In effect, transferring between services does result in an additional boarding penalty and waiting time, which mirrors the transfer penalty in EEM but allow for its mitigation to represent high-quality interchange with dedicated transfer, coordinated services etc.

5.4 Annualisation Factors

Benefits were calculated for the morning peak period and the interpeak period, and were then factored up to represent a whole year. Table 5 displays the annualisation factors used in the evaluation. The factors for public transport were derived from bus Electronic Ticket Machine (ETM) data and analysis of Kiwirail guard counts (by GWRC). The factors for highway benefits represent the time over which the options would affect road traffic (Business hours 7AM-7PM) during the working week. This equates to, two times the morning peak (to represent morning and evening) and three and a half times the interpeak period (to expand two hours to seven hours).

Demand Segment	Period	Hours covered by model	Factor
Highway	AM Peak	7 AM -9 AM	490
	Inter-peak	Average 2 hours between 9 AM and 4 PM	857.5
PT Adult	AM Peak	7 AM -9 AM	583
	Inter-peak	Average 2 hours between 9 AM and 3 PM	1745
PT Child	AM Peak	7 AM -9 AM	647
	Inter-peak	Average 2 hours between 9 AM and 3 PM	2114

Table 5 Annualisation Factors

The PTSS options have been modelled in WTSM and WPTM for 2021, 2031 and 2041 modelled years. Benefits are calculated for each modelled year and are then estimated for years in-between by simple interpolation. Any benefits before or beyond the modelled years are estimated through extrapolation.

5.4.1 Wider Economic Benefits

Wider economic benefits (WEB's) describe the productivity advantages that arise from the close spatial concentration of economic activity. There is a strong link between transport provision and the benefits that arise from the spatial concentration of economic activity. The contribution of the Bus Priority, Bus Rapid Transit and Light Rail Transit options to the upgrading of the Wellington public transport system qualifies for the wider economic benefits to be taken into consideration.

For the purpose of this economic evaluation the WEB's were assumed at 25% of all other benefits. Such a figure is consistent with the amount of WEB's of similar projects.

6.0 Calculation of Costs

6.1 Capital Costs

The capital cost for construction of each option was based on construction rates derived from similar projects, and recent unit rates for major infrastructure such as tunnelling. Table 6 displays the estimated costs of each of the projects .

Option	Estimated cost
Bus Priority	$ 58.6
Bus Rapid Transit	$ 207.1
Light Rail Transit 2 Tunnel Option	$ 938.0

Table 6 Capital costs

6.2 Operational Costs of Options

The operational costs of the options were developed based upon in service hourly and kilometre costs for bus and light rail across the whole Wellington region. Rail operating costs are exclude as they are the same for each option. The in service time and distance totals for the Reference Case and option were extracted from the WPTM by mode. Table 7 displays the resulting annual operating costs.

Option	$ / annum	Difference from Reference Case
Reference Case	$ 88.3	-
Bus Priority	$ 88.0	-$ 0.3
Bus Rapid Transit	$ 82.6	-$ 5.7
Light Rail Transit	$ 89.1	$ 0.8

Table 7 Operating costs (millions)

6.3 Cost savings associated with reduced car park provision

Cost savings associated with the reduced demand for parking in the CBD has been captured as an annual saving. The cost saving of not providing additional car parks was calculated based on a cost of $ 5,000 per annum per car park space and car occupancy of 1.2.

7.0 Results

7.1 Benefits

Table 8 displays the public transport and highway benefits extracted from the transport models and discounted over the period 2014/15-2044/45 to obtain the Net Present Value(NPV) of benefits.The NPV of the benefits is the difference between the option present value of the discounted benefit stream and the reference case present value of the benefit stream. Highway benefits are negative for all options. This is due to the small delays created by reductions in road capacity impacting on many vehicles.

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
Public Transport User Benefits	$ 34.7	$ 95.5	$ 56.0
Highway Benefits	-$ 18.2	-$ 23.6	-$ 31.6
Discounted Benefits ($ million)	$ 16.5	$ 71.9	$ 24.4
Wider Economic Benefits (25%)	$ 4.1	$ 18.0	$ 6.1

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
Total NPV Benefits	$ 20.6	$ 89.9	$ 30.5

Table 8 Net Present Value of Benefits

7.2 Costs

Table 9 presents the discounted net present value of costs based on construction of the options and the operational cost of the public transport services. The savings in cost from not providing car parks is shown as a negative cost.

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
Option Costs ($ million)	$ 46.4	$ 126.6	$ 679.6
Car Parking ($ million)	-$ 10.2	-$ 22.7	-$ 8.4
Total NPV Costs	$ 36.2	$ 103.9	$ 671.2

Table 9 Net Present Value of Costs

7.3 Benefit Cost Analysis

7.3.1 EEM BCR

The BCR's for each option based on discounted benefits and costs are shown in Table 10.

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
NPV Costs ($ million)	$ 36.2	$ 103.9	$ 671.2
NPV Benefits ($ million)	$20.6	$ 89.9	$ 30.5
EEM BCR	0.57	0.87	0.05

Table 10 Benefit Cost Ratio calculation

7.3.2 Sensitivity Tests – Calculation of the BCR

Table 11 displays the results of the sensitivity tests. Overall the sensitivity tests reveal that the BCR for each test increases but the relativity between options remains the same.

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
EEM BCR	0.57	0.87	0.05
Decreased costs (-20%)	0.78	1.27	0.06
Discount rate and evaluation period	0.81	1.49	0.05
Alternative Approach	0.67	1.55	0.10

Table 11 BCR sensitivity analysis

7.3.3 Sensitivity Tests – Changes in Scenario Inputs

Table 8 displays the results of the sensitivity tests.

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
Base Assessments			
EEM BCR	0.57	0.87	0.05

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
Base Assessments			
Deferred RONS	0.32	0.70	0.02
Parking Cap	1.42	1.29	0.12

Table 12 BCR summary