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LIGHT RAIL TRANSIT FEASIBILITY STUDY

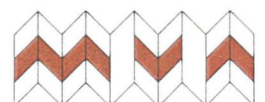
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Works Consultancy Services Ltd



in association with

MVA Consultancy



WELLINGTON CITY COUNCIL
and
WELLINGTON REGIONAL COUNCIL

**LIGHT RAIL TRANSIT
FEASIBILITY STUDY**

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1.1 General

In March 1995 the Wellington City Council, together with the Wellington Regional Council, engaged Works Consultancy Services in association with MVA Consultancy of the United Kingdom to undertake an initial feasibility study into providing a light rail transit system (LRT) on Wellington suburban rail lines and through the Wellington City Central Business District (CBD) as far as Courtenay Place.

The investigation was to build on the results of previous studies on the subject as well as overseas experience. The broad approach taken has been to concentrate on areas which appear to have been least covered in the previous studies. These are assessing the patronage levels and the overall wider economic benefits, and the practicalities of providing LRT in the streets and converting to LRT existing commuter rail services into Wellington from Johnsonville, Hutt Valley and the Kapiti Coast.

The Terms of Reference also called for a preliminary investigation into taking a light rail service from Courtenay Place through to Wellington Airport.

The work has been undertaken with significant inputs from the Wellington City and Regional Councils, including providing relevant information and assisting in determining the effects on traffic of the LRT system. MVA Consultancy has provided the study inputs relating to the choice of rolling stock, route choice and form, demand forecasting, revenue and financial assessment and economic evaluation. Works Consultancy Services has undertaken the work relating to defining the track routes (leading to the choice of a specific option), providing the scope of the construction involved (with costs), assessing traffic and environmental impacts, and addressing the question of possible ownership and funding options.

This report documents the investigation undertaken and the conclusions which may be drawn from the study.

1.2 Background

In common with many other urban areas around the world, there is an appreciation in Wellington that improved public transportation will play a key role in ensuring the future prosperity of the City.

Forecasts indicate that on present trends, the number of car trips will increase by over 50 per cent by Year 2011, resulting from increased population, car ownership levels and leisure time. The accommodation of these demands would require a substantial investment in highway infrastructure.



Recent policy statements by both Wellington Regional Council (WRC) and Wellington City Council (WCC) have recognised the need for a balanced approach to the provision of transport in the city where private car deterrents in the central area are combined with public transportation improvements.

WCC recognises that if pressures for the movement of people and goods are not to become detrimental to the working of the city, then it is crucial to identify now the most appropriate transport strategy for the medium to long term period.

The establishment of a set of measures which retain some accessibility by car whilst offering sufficient incentives to encourage car occupants to transfer to public transport is often problematic. To be successful, public transport therefore not only needs to represent good value for money, but must also be perceived as a realistic and convenient alternative to the private car.

In comparison with many major cities, the central Wellington area is unusual in that the main railway station is located outside the central business district. This results in a high passenger transfer to buses or other modes and an inclination towards the use of cars in lieu of public transport. A study in 1993 examined Light Rail Transit (LRT) as one option for the replacement of the existing rail service from Johnsonville, with continuation of the service into the central CBD area. This concluded that, although the LRT option offered the greatest benefits, these were out-weighed by the significantly higher costs associated with the system. This conclusion is consistent with overseas experience where the relatively small number of schemes which have gone to construction has shown that, for many areas, the high capital costs associated with LRT are not always met by the benefits it can offer, and as a consequence, other public transportation measures have been implemented.

Proponents of LRT recognise however, that it provides a modern mode of transport with high accessibility and levels of service. A successful system would see a reduction in the level of traffic within the CBD and on the feeder corridors, and through a combination of old imaging and new technology has the ability to add vitality to the City.

1.3 Extent of the Study

The general extent of the study has been as follows:

- (a) determination of the most appropriate route for a light rail line through the city, with consideration of a minimum of three potential routes;
 - the Waterfront (utilising Jervois Quay)
 - the Golden Mile (Lambton Quay, Willis Street, Manners Street, Courtenay Place)
 - Featherston Street, Hunter Street, Victoria Street, etc.



- (b) a brief examination of the practicality of connection between a city LRT and existing rail lines at the station
- (c) identification of potential obstacles and constraints to the construction of an LRT system in the city area
- (d) identification of the location and extent of disruption to traffic movements in the city arising from LRT, and suggestion for possible mitigation measures where applicable
- (e) assessment of the legal issues regarding operation of LRT in conjunction with existing bus services
- (f) highlighting items which need to be addressed in order to satisfy the requirements of the Resource Management Act
- (g) assessment of the viability of LRT services from the Kapiti Coast and the Hutt Valley (or some portion of these routes)
- (h) discussion of the options for a staged installation of a light rail service
- (i) preliminary assessment to determine the likely viability of connecting a LRT system through to the airport
- (j) examination of potential funding options and mechanisms, and ownership issues
- (k) consultation with interested organisations for input to the study



Section 2

THE EXISTING SYSTEM

2.1 Historical Background

The Johnsonville, Hutt Valley and Kapiti Coast rail lines are shown in diagrammatic form in Figure 2.1. The Johnsonville line was electrified in 1939 and English Electric (EE) electrical multiple units (EMUs) were purchased to operate the line.

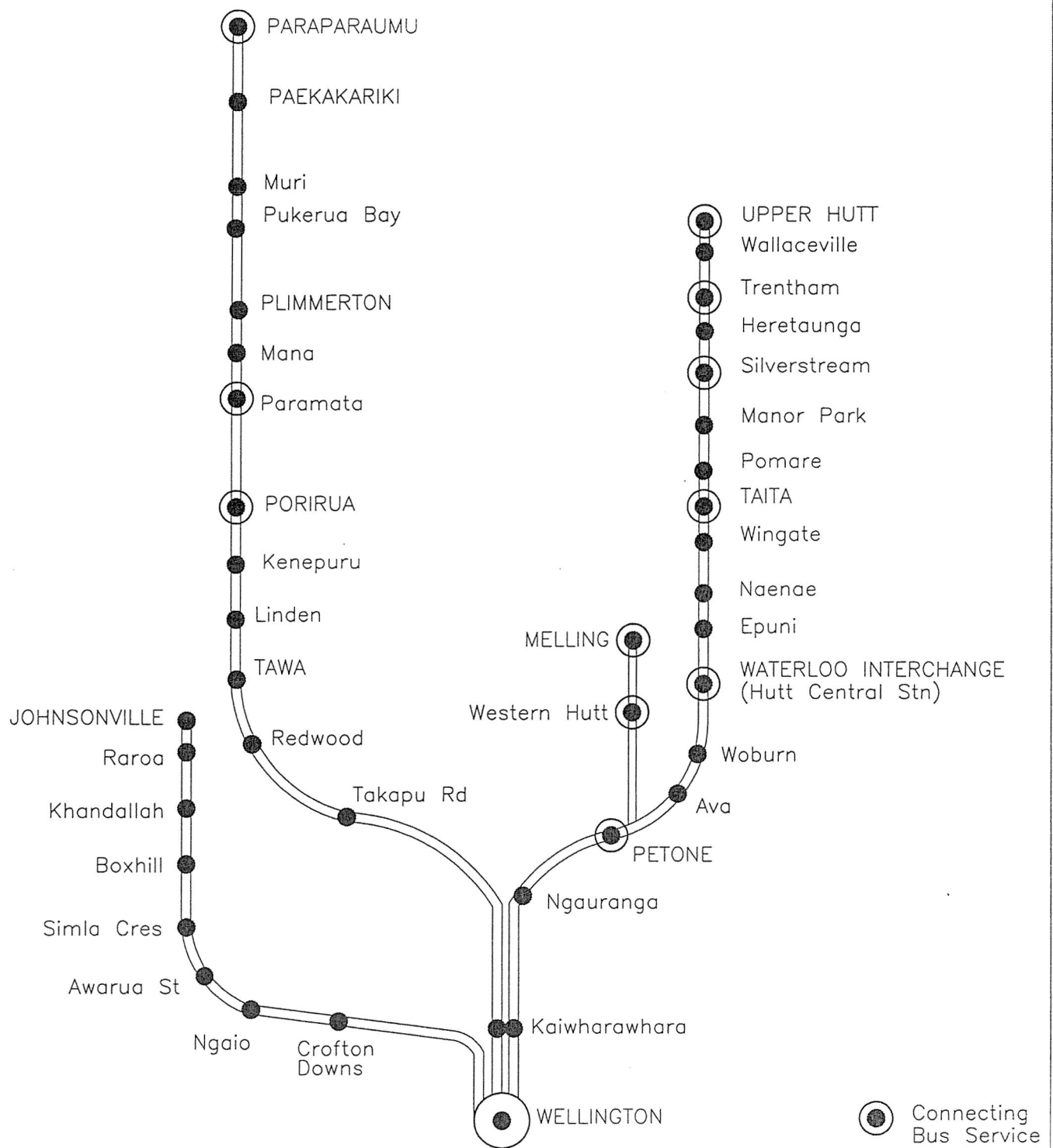
The Hutt Valley line was electrified in 1946. By 1953 local electric trains were introduced as far as Taita and then to Melling and Upper Hutt in 1954 and 1955 respectively. The Kapiti Coast line was electrified to Paekakariki in 1940 and to Paraparaumu in 1983. EE EMUs were initially used for all of the lines but in 1981-82 the units were all over 30 years old and Ganz Mavag (GM) EMUs were purchased as replacements, to enter service on the Kapiti Coast and Hutt Valley lines. EE EMUs were refurbished to continue to be employed on the Johnsonville line and some unrefurbished units remain in operation at peak periods on the other two routes. The GM units are now approaching the halfway point in their technical life and will soon be due for heavy overhauls and refurbishment. There is an agreement between New Zealand Rail (NZR) and WRC that provides for one third of the units to be refurbished between 1995 and 1998.

The rolling stock now in use on the three lines is shown in Table 2.1 and some principal characteristics of the EMUs are given in Table 2.2.

Table 2.1 Rolling Stock Currently in Use on the Three Lines

Type	Built	Peak Requirement		Fleet Owned (including spares)		Used on
Eng. Electric Refurbished two-car sets	1948-50 (Refurb 1984-87)	3 x four- car trains	12 cars	7 x two-car sets	14 cars	Johnsonville
Eng Electric Unrefurbished three-car sets	1948-50	2 x six-car trains	12 cars	6 x three- car sets	18 cars	Hutt Kapiti
Ganz Mavag two-car sets	1981-82	39 x two- car trains	78 cars	44 x two- car	88 cars	Hutt Kapiti





SUBURBAN TRAIN SERVICES TO – JOHNSONVILLE
PARAPARAUMU, MELLING AND UPPER HUTT

Table 2.2 Some Principal Characteristics of EMUs in Wellington Area

Class Manufacturer	DM English Electric	EM Ganz Mavag
Overall length	19.30 m	21.53m
Maximum width	2.65m	2.70m
Unladen weight - power car - trailer car	42460 kg 27200 kg	37500 kg 34500 kg
Maximum speed	100 km/h	100 km/h
Seating Capacity - 2 car set - 3 car set	128 (Johnsonville line) 200 (Hutt/Kapiti lines)	148 Not applicable

2.2 The Rail Lines

2.2.1 Johnsonville Line

The Johnsonville line is single track throughout with three passing loops and rises over 6.5km at a maximum gradient of 1 in 40. Speeds do not exceed 50km/h and the journey time between Wellington and Johnsonville stations is 21 minutes. During peak periods headways are run with a repeating pattern of 13, 13, and 26 minutes. An earlier attempt to run at an even 13 minute headway resulted in a more unreliable service. The basic off-peak and evening service is half hourly. A 60 minute service is provided on Saturdays and no service is run on Sundays.

2.2.2 Hutt Valley Line

The Hutt Valley main line is basically double track to Trentham Station and single track beyond this to Upper Hutt. The Waterloo Interchange at Hutt Central provides connection to bus services serving most of Lower Hutt. As the line is relatively flat and straight, speeds of up to 100km/h are attained with restrictions at curves and other locations.

During peak periods an express service runs approximately every 20 minutes and calls at Hutt Central, Taita and all stations to Upper Hutt. The journey time from Wellington to Upper Hutt is around 40 minutes. Also at this time an approximately 20 minute service stops at all stations between Wellington and Taita (except Ngauranga), taking around 30 minutes. During weekday off peak periods a half hourly service is provided to stop at all stations between Wellington and Upper Hutt, with a journey time of 50 minutes.



On Sundays and after 2100 hrs on weekdays the all stations service to Upper Hutt is hourly.

The line is also used by freight trains and by four diesel locomotive hauled long distance passenger trains (the Wairarapa Connection)

There is, in addition, a single track branch line to Melling, which diverges from the main line east of Petone Station and is served only by peak period services with headways of 30 minutes in the morning and 20 minutes in the evening.

2.2.3 Kapiti Coast Line

The Kapiti Coast line diverges from the Hutt Valley line north of Kaiwharawhara. The line is double track as far as Pukerua Bay and beyond that has long single track sections. Speeds of up to 100km/h are achieved on some sections. In peak periods there are three broad service patterns. A 20 minute service calls at all stations between Wellington and Porirua, taking 23 minutes. A 20 minute Plimmerton express calls at Porirua and all stations to the north, taking 27 minutes. Finally, a 30 minute Paraparaumu express calls at Porirua, Plimmerton and all stations to the north taking 50 minutes.

The basic daytime, evening and Saturday service is half hourly calling at all stations to Plimmerton, with alternate trains running to Paraparaumu. On Sundays an hourly service is operated, stopping at all stations.

As the Kapiti Coast line forms part of the North Island Main Trunk it is heavily used by freight trains and also by some long distance passenger trains.

2.2.4 Previous Studies

Previous studies of light rail in Wellington have concentrated on the conversion of the Johnsonville line. However the Kapiti Coast and Hutt Valley lines differ from Johnsonville in a large number of respects which will make their conversion much less straightforward. The most important difference is that, unlike the Johnsonville line which is almost free standing and only carries local passenger traffic, the other two lines carry long distance passenger and freight trains. Extensive sharing of tracks between light and heavy rail vehicles would be necessary, raising issues of compatibility and safety and probably requiring specialised signalling systems. These issues are discussed in more detail in the following section.

2.3 Rail Fares

Adult single fares increase by sections or stages along the rail lines and are shown in Table 2.3 for trips out of Wellington Station.



Table 2.3 Adult Single Fares Between Wellington and Other Stations

Adult single fare from Wellington	to (on Johnsonville line):	to (on Hutt Valley line):	to (on Kapiti Coast line):
\$ 1.50		Ngauranga	Kaiwharawhara
\$ 2.90	all stations	Waterloo and Melling	Linden
\$ 3.50		Taita	Porirua
\$ 4.20		Manor Park	Plimmerton
\$ 4.80		Trentham	
\$ 5.40		Upper Hutt	Muri
\$ 6.00			Paekakariki
\$ 7.20			Paraparaumu

Various fare reductions are offered and these include those for 10 trip tickets, monthly passes, child (50% reduction) and off-peak (approximately a 25% reduction) fares. The precise mix of fares was not known for any particular origin-destination pair. To calculate fares fixed revenues per trip or revenues per trip kilometre were developed (see Table 2.4). These revenue levels were factored to control the total revenue to that reported in confidence to us by New Zealand Rail.

Fares between stations which do not include Wellington station are lower than those shown in Table 2.4.



Table 2.4 Revenue Rates used to Convert Trips to Total Revenue

	Line	
	Johnsonville	Upper Hutt and Kapiti Coast
Trips from Wellington station		
Fixed revenue per trip	\$1.39 peak \$1.23 off-peak	
Revenue per trip km		\$0.109 per km peak \$0.096 per km off-peak
Trips not including Wellington station		
Fixed revenue per trip	\$0.87 peak \$0.77 off-peak	\$1.69 peak \$1.57 off-peak

2.4 Existing Rail Patronage

To assess existing rail patronage, counts of passengers at Wellington Station were carried out during 27 April 1995 (a week day). This information was compared with counts for previous years. The 1995 count information is reported in Table 2.5.

In addition to the passengers reported in Table 2.5, there were two trains from Masterton and one train from Palmerston North which brought the total passengers arriving over two hours to 8041. This compares with the GATS 1988 two hour matrix total of 10697, a two and a half hour count by NZR in 1993/94 of 9945 and a WCC strategy document one hour total of 4930. Taking all of this information into consideration it appears that there has been a substantial reduction in rail patronage over the last seven years, perhaps by as much as 4% per year.



Table 2.5 Results of Passenger Counts Alighting from Morning Peak Period Trains at Wellington Station (local trains only)

	Johnsonville line	Upper Hutt line	Kapiti Coast line	All lines
Peak one hour (0733-0832)				
Passengers	736	2079	2238	5053
Trains	4	8	8	20
Pass/train	184	260	280	253
Peak two hours (0701-0900)				
Passengers	966	3265	3057	7288
Trains	7	17	14	38
Pass/train	138	192	218	192
Maximum load in single train	246	368	444	444

2.5 Existing Bus and Car Use and Mode Choice

Table 2.6 shows the relative use of rail, bus and car for journeys into the central area for the morning two hour peak period (0700 to 0900 hours) and the seven hour off peak period (0900 to 1600 hours). The data was put together by using matrix information from GATS and controlling the totals to rail counts (as noted above), car screenline counts carried out as part of other monitoring studies and information from bus companies concerning the average loads on buses during the peak and off peak periods.

The table shows that during the peak period, rail provides an important mode of transport for the Hutt Valley and Kapiti Coast corridors, carrying 30% of journeys into Wellington. Bus only carries 2% to 5% of this traffic (with the majority of the Hutt corridor bus trips coming from Petone and Eastbourne. For the Johnsonville corridor, bus is the most important public transport mode with 14% of the journeys to Wellington; rail only carries 10%.



During the peak period car is by far the dominant mode for trips within the corridors (carrying nearly 90% of the trips).

In the off peak, car trips per hour to Wellington drop to around 30% of their peak levels but rail trips fall to 7% of their peak flows. This massive drop in use of rail means that investment in costly infrastructure and rolling stock to carry passengers must be justified mainly on the basis of the peak period services.

Table 2.6 Summary of Trips on the Three Rail Corridors

Trips in Period ¹	Rail Trips	Bus Trips	Car Trips	Total Trips	Rail %	Bus %	Car %	Total %
AM Peak trips between Wellington (central area) and corridors								
Johnsonville	967	1326	7366	9659	10	14	76	100
Hutt Valley	3831	648	7758	12237	31	5	64	100
Kapiti Coast	3234	179	6794	10207	32	2	66	100
All	8032	2153	21918	32103	25	7	68	100
Trips Within the Corridor								
Johnsonville	581	129	5664	6374	9	2	89	100
Hutt Valley	1777	4074	45499	51350	3	8	89	100
Kapiti Coast	819	2031	21572	24422	3	8	89	100
Off Peak trips between Wellington (central area) and corridors								
Johnsonville	363	112	6469	6944	5	2	93	100
Hutt Valley	925	278	11453	12656	7	2	91	100
Kapiti Coast	803	182	5015	6000	13	3	84	100
All	2091	572	22937	25600	8	2	90	100
Trips Within the Corridor								
Johnsonville	591	206	15686	16483	4	1	95	100
Hutt Valley	1395	6120	109738	117253	1	5	94	100
Kapiti Coast	960	3149	59505	63614	2	5	93	100

¹ AM Peak 0700 to 0900 Off Peak 0900 to 1600



Section 3

DESIGN CONSIDERATIONS FOR LIGHT RAIL SYSTEMS

3.1 On-street Operation

The most fundamental reason for considering the conversion of all or part of the Wellington local rail network to LRT is to improve its penetration of the Central Business District (CBD). The location of the Railway Station on the northern edge of the CBD is a major deterrent to rail use in comparison with the use of a car, particularly for shorter distance travellers.

Light rail vehicles (LRVs) are designed to be "highway compatible". They can run in the street, and can cross roads, normally under the control of traffic signals. In recent years both Manchester (UK) and Karlsruhe (Germany) have extended rail lines into city centres by converting from heavy rail to light rail.

In this section some of the important characteristics of light rail vehicles are considered and compared where necessary with heavy rail. The design criteria which are believed to be suitable for Wellington are provided.

3.2 Minimum Radii and Maximum Gradients

Most light rail vehicles (LRVs) are designed to negotiate curves down to a 25m radius. Although smaller radii are possible 25m is considered suitable for Wellington. An appropriate vehicle would have a length of around 26m to 30m.

The vehicles will need to negotiate the gradients on the Johnsonville line. This should prove possible with a typical LRV which has the capability to climb 5% gradients.

3.3 Vehicle Width, Length, Frequency

Conversion of the rail lines in Wellington to LRT will require vehicles with a high passenger carrying capacity, leading to the need to maximise floor area inside the vehicles. As LRVs are guided, they are typically able to be slightly wider than buses. A width of 2.65 metres is common and should be used for Wellington unless more detailed engineering design studies, of possible routes, highlight the need for narrower vehicles. This width is similar to the current heavy rail rolling stock and should allow the use of existing platforms on the three rail lines. Although most 2.65 wide vehicles are made for standard (1435mm) gauge tracks some systems do run such units on narrower gauges such as the 1067mm gauge found in New Zealand.

The number of light rail trips per hour which can pass along a street will be restricted by the need to stop at dedicated "platforms" (to ensure safe and



convenient access for passengers, especially those who are mobility disabled), and the cycle time of traffic signals which must be crossed. A train will leave a stop and pass across a signalised street junction. The following train will need to stop at the vacated "platform", load and unload passengers and then proceed across the junction. At heavily used stops and with signal cycle times of around 90 seconds in the city centre, it is quite possible that the following vehicle will also be stopped at the signals. Allowing for this and also for sufficient time between vehicles to ensure reliability of service, it is considered that a maximum number of light rail trains should not, ideally, exceed 30 per hour through the central area.

3.4 Passenger Capacity

Investigations show that capacity considerations will be a key issue for a possible LRT system in Wellington. Existing peak period trains are carrying up to 450 passengers per train with an average of around 270 passengers per train on the Hutt and Kapiti Coast lines. Also, during the peak hour nearly 20 suburban trains terminate at Wellington station. Very few of the passengers have to stand and the seating capacity of the current trains is between 56 to 78 per 20m car compared with that in a typical LRV, which may have a around 85 seats in a 30m vehicle. To avoid making too many passengers stand, and with a limitation on maximum frequency, it will therefore be necessary to use as long a light rail "train" as possible.

However, physical constraints imposed by the street network limit the maximum train length that can be accommodated. In particular a train stopped at a junction or a stop must not be so long as to block important intersections. It may also be difficult to find space for long stops for such vehicles. For Wellington, investigations have shown that the maximum light rail train length which can be accommodated will be around 60m. This could be supplied by coupling two 30m articulated LRVs. Such lengths are used in some other cities.

Typical specifications for LRVs are given in Table 3.1 for the vehicles which currently operate in Manchester (UK), Cologne and Karlsruhe (Germany) and Portland (USA). The LRV that has been suggested for Auckland is also shown.

New Zealand Rail have a criteria that no more than 1.9 passengers per square metre should stand within a suburban train. As very few passengers currently stand it is considered prudent to assume that the NZR criteria should not be exceeded in the most heavily loaded LRVs of a new service. The design capacity for a 60m unit (two coupled vehicles) would therefore be around 170 seated passengers and 120 standing, a total of 290 passengers. Given the current loads per train on the rail system, it is evident that a higher frequency of service will be required than is currently run if these services are converted to LRT.



Table 3.1 Characteristics of Light Rail Vehicles

Vehicle Description:	Stadtbahnwagen B-100 (Cologne)	Manchester LRV	Karlsruhe GT8-100#	Portland LRV	Auckland (proposed LRV)
Manufacturer:	Duewag	Firema	Duewag	BN/Bombardier	-
Type:	six-axle artic	six-axle artic	eight-axle artic#	six-axle artic	six-axle artic
Length over body panels (m)	26.850	29.000	36.570#	26.510	28.000
Length over couplers (m)	28.000	29.840	37.610	27.710	approx 29.000
Floor height (mm)	1000	940	1000	984	950
Width over body panels (m)	2.650	2.650	2.650	2.650	2.650
Distance between bogie centres (m)	10.000	10.700	10.100/9.770	9.040	10.000
Distance from bogie centre to end panel (m)	3.425	3.800	3.300	4.210	4.000
Bogie wheelbase (m)	2.100	2.065	2.100	?	?
Maximum speed (km/h)	100	80	100	88	80
Minimum curve radius (m)	25	25	23	25	25
Unladen weight (kg)	38,300	48,000	58,000	41,800	-
Traction motor rating	2 x 235kW = 470kW	4 x 105kW = 420kW	2 x 280kW = 560kW	2 x 195kW = 390kW	(All axles powered)
Seating capacity	70	84*	100	76	80
Standing capacity (at 4/m ²)	86	122	120	90	110
Total capacity	156	206	220	166	190
Boarding arrangements (platform height)	High/med/low	High/med	Low	Low	Medium

Notes: * Plus space for two wheelchairs. Without this provision, seating capacity would be approximately 90.

This is the eight-axle double-articulated dual voltage (750V/15 kV) version of the Karlsruhe vehicle. The six-axle single-articulated version (GT6) is 26.8m long over body panels.

3.5 Wheels, Tracks and Electrification Systems

In the street, LRVs normally run on grooved track. However, there can be difficulties in achieving a wheel profile which is suitable for both ground tracks and normal train tracks. Solutions to the problems have been found in other cities but expert advice should be sought if this scheme is to be taken further.

Safety in the street requires that LRVs collect current from an overhead line which in most countries carries a voltage of no greater than 750 Volts. The Wellington suburban lines are electrified at 1500 Volts DC and it is understood that the sub-stations and electrical distribution system have been modernised in recent years.

If the Johnsonville line only were to be converted to LRT, there could be a case for converting the line to 750V DC and using single voltage LRVs. However if the Hutt Valley and/or the Kapiti Coast were to be operated by LRVs, it is likely to be more economical to use 750/1500V dual voltage LRVs (unless the safety authorities would authorise the use of 1500V in street). The additional cost for dual voltage is likely to be relatively small, and such systems do operate elsewhere in the world.

3.6 Platform Heights and Floor Heights in LRVs

The existing rail system boards passengers from raised platforms but steps must be climbed inside the entrance to the trains. There is now great pressure to make new public transport systems fully accessible to disabled persons. Section 12, Consultation, includes the comments from those representing disabled groups, pointing out the advantages of total accessibility. For high floor LRT systems, solutions adopted elsewhere have included the use of wheelchair lifts (on the platform or on the vehicle), or a short section of high level platform. The solution arrived at in Manchester, when converting an existing rail line to light rail with on street operation, was to construct a profiled platform with a high section on street as shown in Figure 3.1. The solution has been successful and represents a cost efficient method of meeting the needs of mobility impaired people. However, this issue needs to be considered further if the scheme is taken forward.

A different solution would be to use one of the new low floor trams which are currently being produced. Such vehicles are boarded from platforms only around 300mm high and level with the floor of the tram. However, there are several disadvantages in the Wellington situation. These include:

- higher cost of low floor vehicles;



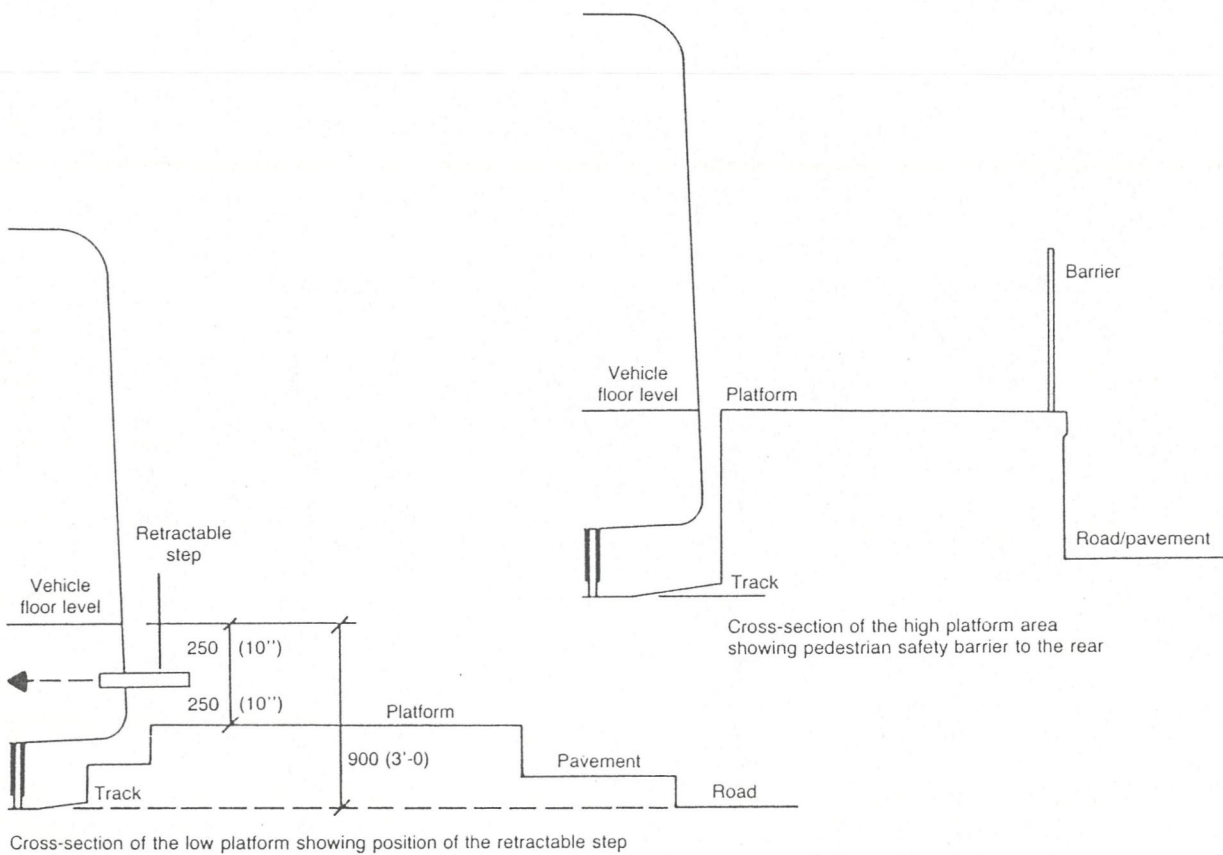
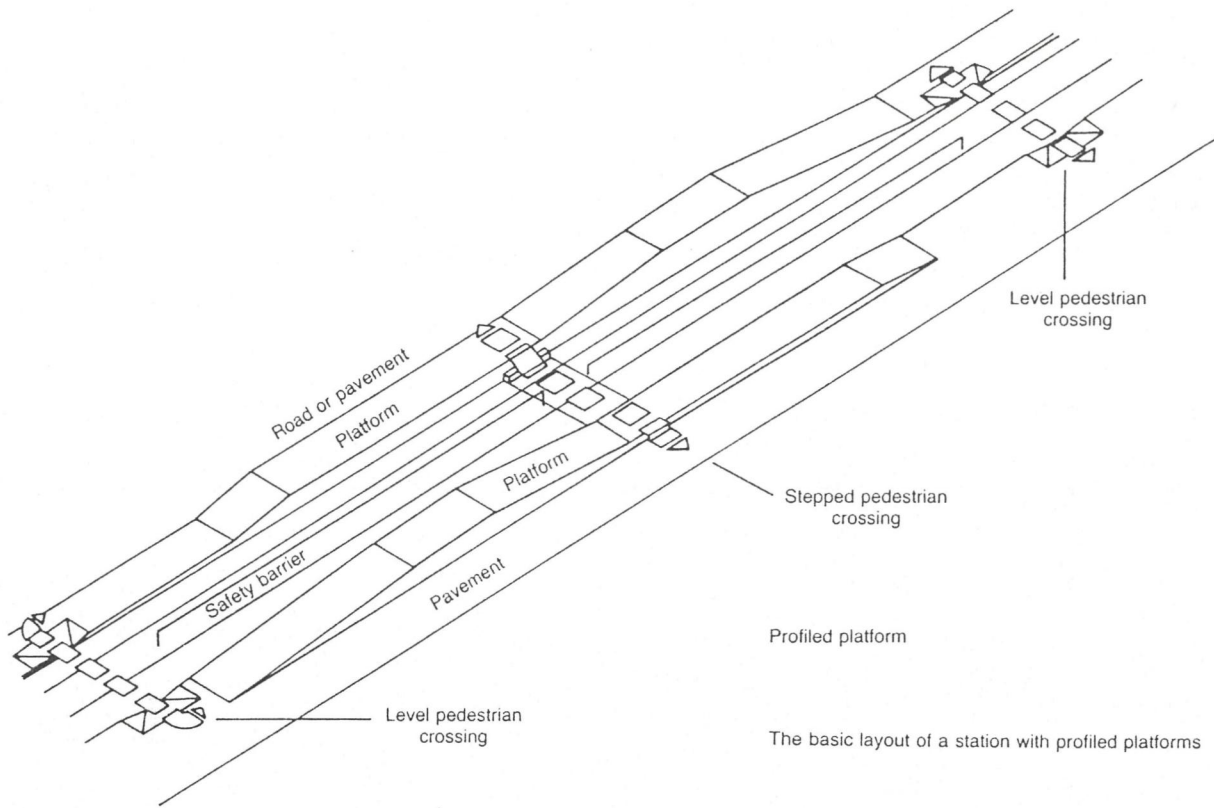


Figure 3.1 Typical Platform

- maximum speeds are, currently, below the 100km/h required for the Kapiti and Hutt lines;
- existing rail platforms are 680mm high and would need to be lowered (or the tracks raised) for a length of at least 60m;
- the Hutt and Kapiti lines (and some platforms) must be shared with other trains, with possible problems of allocating space on shared platforms and of speed differences if the LRVs travelled more slowly than the other rail vehicles;
- passengers could feel insecure if standing on a low platform while a large, fast long distance train went past.

3.7 LRT/NZR Compatibility Issues

LRVs are of lighter construction than conventional trains. Safety considerations mean that when the two types of vehicle are operating on the same line the LRV needs to be designed to withstand collision with heavier trains or a signalling system such as Automatic Train Protection (ATP) needs to be employed. ATP systems continuously monitor train speeds and braking rates and, if necessary, will automatically stop the vehicle to ensure compliance with signals. Some systems in Germany and Switzerland are equipped with ATP. The recent Auckland study into light rail concluded that a form of automatic system would be required for an LRT system to share tracks with heavy rail in that city.

A meeting was held with the Land Transport Safety Authority (LTSA) to discuss the need for ATP in New Zealand. LTSA specify that each operator must produce a safety case and that this must be approved by an independent approved auditor. They were not able to advise whether ATP would be a requirement for track-sharing in Wellington.

3.8 Compatibility of LRVs and Trolley Buses

An LRT scheme extension into the centre of Wellington would almost certainly interact with the trolley bus system, especially if the LRT route was along the Golden Mile. Issues of compatibility would therefore have to be resolved. Both trams and trolley buses collect current from overhead wires, with trams requiring one wire and the trolley buses two. In Wellington the trolley bus power supply is at 550V DC compared with the 750V DC likely to be adopted for an in-street LRT scheme.

Compatibility problems between such systems have been resolved in many cities around the world, for example in Zurich and Berne in Switzerland, Ghent in Belgium and Sofia in Bulgaria. Where LRVs and trolley buses share the same street the trolley bus wires are typically located on the kerbside of



the LRT wire. Where LRT and trolley bus wires cross, special fittings are used which prevent the LRV pantograph coming into contact with the trolley bus wire.

Although technically feasible there would be many issues, such as those of finding supports for two sets of wires and ownership and maintenance, which would have to be resolved.

3.9 LRT and the Waterfront Tramway

In order to link new developments on the Waterfront with the remainder of the CBD a "Waterfront Tramway" has been proposed. It is understood that the latest proposal would start at Grey Street next to Lambton Quay and proceed to the Courtenay Place area via Queens Wharf and the new National Museum. An alternative scheme being considered is for a "Parry People Mover" (also rail based), to be installed.

If the system shared or crossed LRV tracks, several issues would need to be resolved, including those of different track gauges, design and voltage of power supplies, platform height and location and operating speeds. The simplest procedure would be to ensure that the two systems did not cross or otherwise physically interact. The Grey Street to Queens Wharf route for the Heritage tramway would provide a separate system if the LRT system was routed along the Golden Mile.

It is worth noting that the LRT and Waterfront Tramway schemes would principally serve two different markets. The LRT scheme would act as means of bringing long distance travellers directly into the heart of the city and also as a high frequency carrier of trips along the spine of the central area. The Waterfront Tramway could provide a lower frequency/capacity link between several important sites within the central area. It could act as a tourist attraction similar to that in Christchurch.



Section 4

ROUTE SELECTION

4.1 Description of Locality

The investigation into suitable routes has principally been confined to the central business area of the city as earlier appraisals of the likely economic viability of extensions to serve areas outside this zone have indicated that they would be difficult to justify. However, in accordance with the Terms of Reference for the study, a preliminary assessment of the viability of extending the route to Wellington Airport has been undertaken.

The topography of the Central Business area is generally a flat plane, bounded by the harbour, The Terrace escarpment and the gently rising area of Te Aro. Some relatively small changes in level across the plane occur but these are not sufficient to be a restraint on the choice of route.

Street widths in many instances are not generous, and vary not only between streets but in some instances along a street. For example, the kerb to kerb distance for Lambton Quay varies from 6 m to 20 m (excluding median).

Some of the streets, notably Lambton Quay, Willis St, Victoria St, and Manners St have been upgraded over recent years to improve the environment, particularly for pedestrians.

The condition of the street surfacing appears to be generally good. There are relatively few locations where the pavement camber at the kerb line is significant and unfavourable to the LRT track in that position.

The distribution of underground services varies widely but generally the routes of highest "services density" coincide with those which are most suitable for LRT operation.

The majority of the area is generally built over with the exception of parts of the waterfront and Courtenay Place. Some sites are occupied by relatively low intensity development which could change as replacement of old buildings takes place in the future. An objective of the route evaluation has been to avoid taking property or altering buildings to accommodate the light rail. However, if the light rail proposal proceeds there may be refinements and improvements possible to the route which involve either small scale property purchase or integration with redevelopment opportunities.

The area is partly reclaimed land and partly original alluviums and colluviums which have been reworked to varying degrees. No specific geotechnical investigation has been undertaken for this study but it is expected that foundation strengths will be adequate for light rail vehicle loads, and



settlement will not be a significant determinant in evaluating the viability of a particular route. Seismic effects have not been considered except that the waterfront route could be more susceptible to the results of soil liquefaction.

4.2 General Objectives

The general initial objectives in determining the feasibility of alternative routes have been:

- to position the route to serve the largest patronage catchment
- to keep within the existing kerb lines as far as possible
- to adopt twin tracks and central running where possible.

The features of central running are:

- parking and goods servicing zones can be retained (or provided).
- the underground and overhead services are least affected, in particular local connections.
- a single platform can serve both north and southbound directions.
- passengers have to access the platform across traffic lanes. This could be integrated with pedestrian crossings to give a greater feeling of security, and traffic signal phases to reduce delays to traffic.

The features of kerbside running are -

- motor vehicles can pass a stationary LRV on the right hand side
- direct access is possible for pedestrians to the LRV from the footpath.
- it is more likely to affect a larger number of services.

4.3 Route Options

4.3.1 Investigation Process

A "long list" of routes considered in a preliminary analysis is given in Appendix A, Table A1. A number of these routes have been reported on by others in previous studies of light rail schemes within the CBD. The routes have been grouped into three general categories and one selected from each category for further analysis. The selection was based primarily on the physical constraints and traffic implications. A brief description of the selected



routes is given below and the routes are shown in Figures 4.1 (a)-(c).

4.3.2 Route Descriptions

- **Golden Mile Route**

The Golden Mile Route follows Lambton Quay, Willis Street and Manners Street/Mall through to Courtenay Place. Where two tracks cannot be accommodated such as at "Stewart Dawson's" corner, the southbound LRVs can be routed via Hunter St, Victoria St and Cuba Street, and the north bound by Manners Mall, Manners St and Willis St.

Stout Street provides an alternative link to Lambton Quay from the Railway Station. Refer to Figure 4.1(a). The general locations of the station/stops are also shown on the figure.

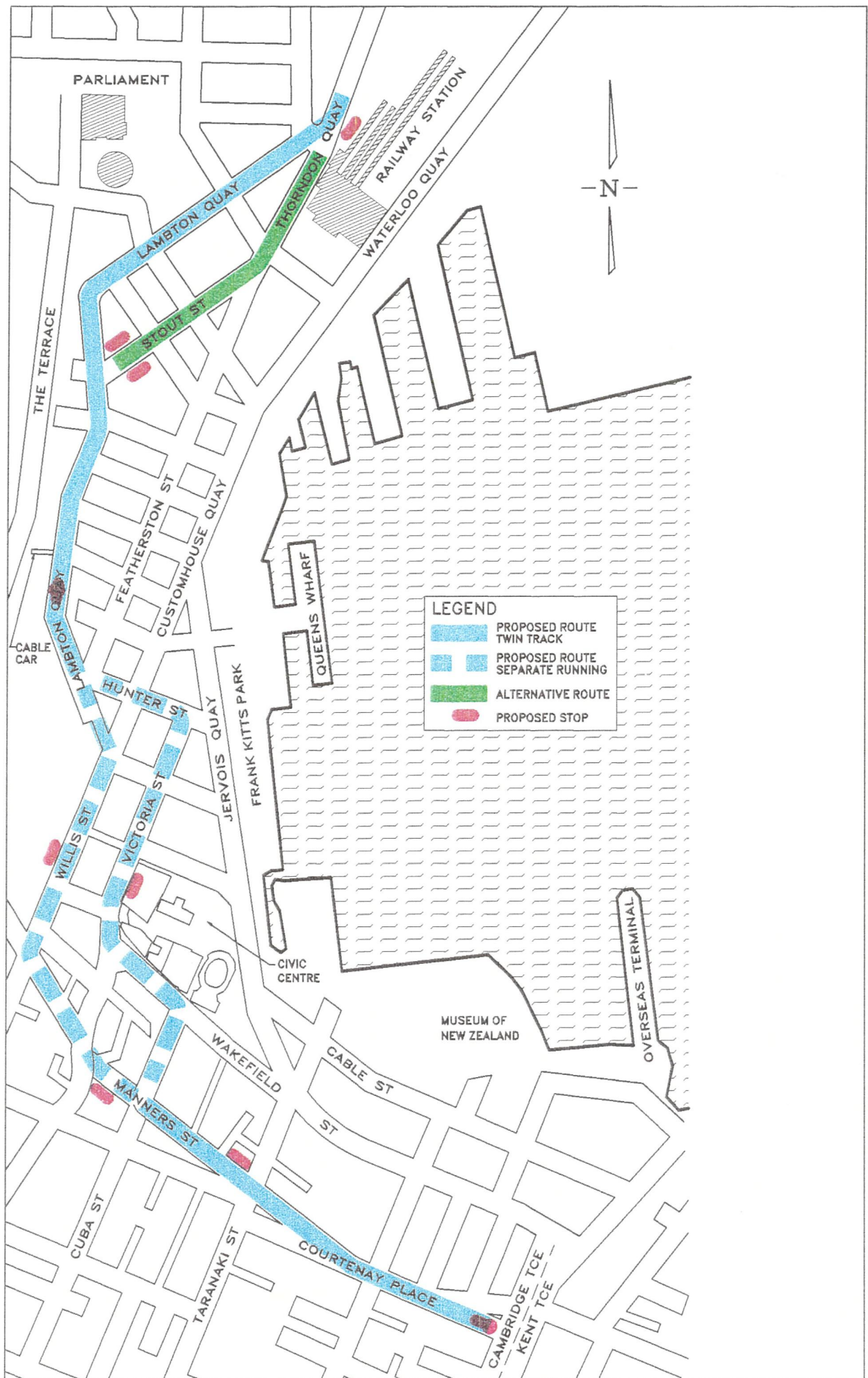
- **Central Routes**

This route utilises Featherston Street from the Railway Station through to Hunter St. From there on it is identical to the Golden Mile Route through to Courtenay Place.

- **Waterfront Route**

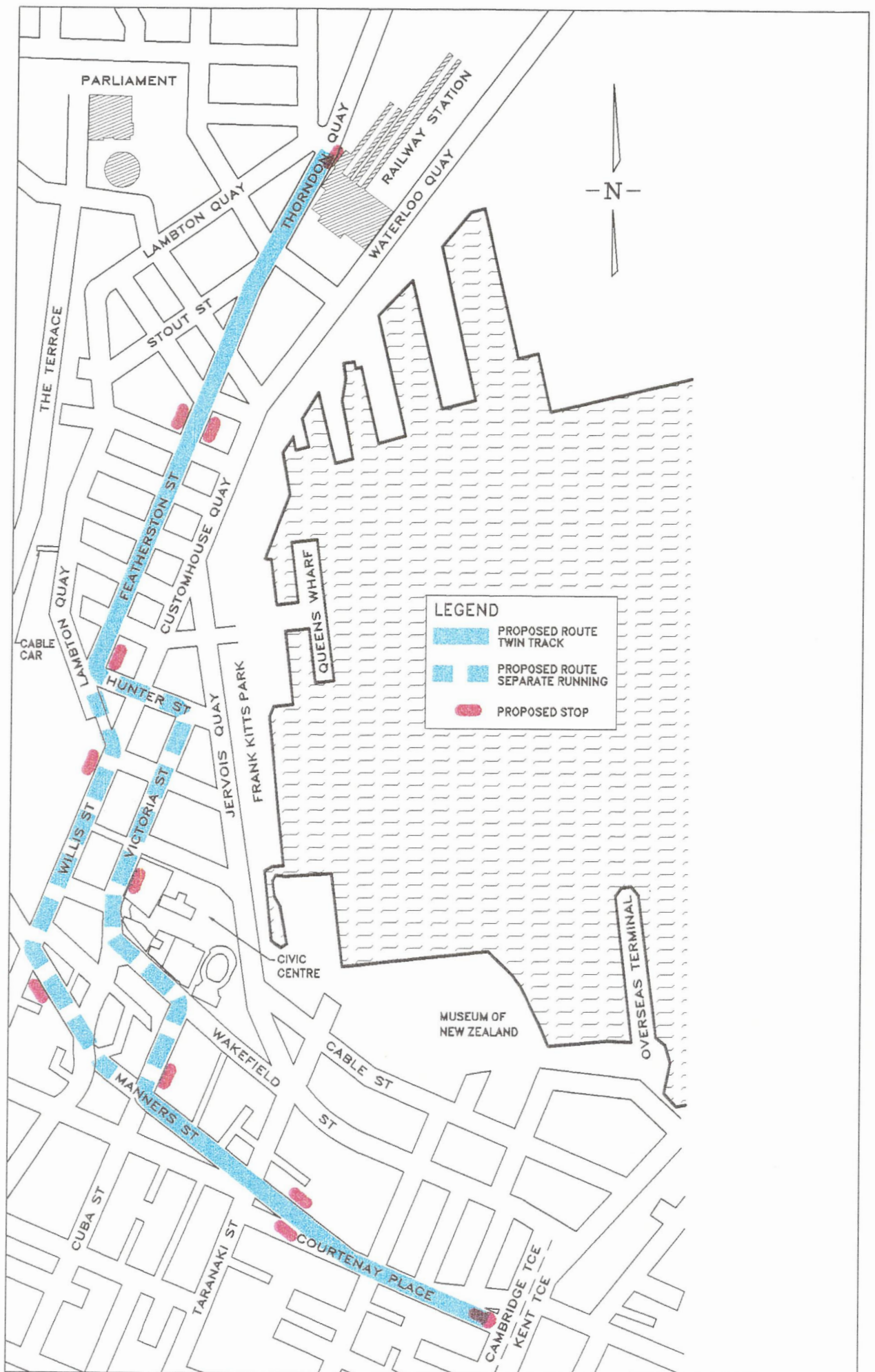
The route follows Featherston St as far as Whitmore St, then Whitmore into Custom House and Jervois Quays. At the City Sea Bridge the choice is to continue on via either Cable St or Wakefield St. The Cable St route ends up in Courtenay Place via Oriental Parade and Kent/Cambridge Terrace. The terminus could however, be located at the end of Cable St. The route via Wakefield Street also follows Kent/Cambridge Tce to Courtenay Place.





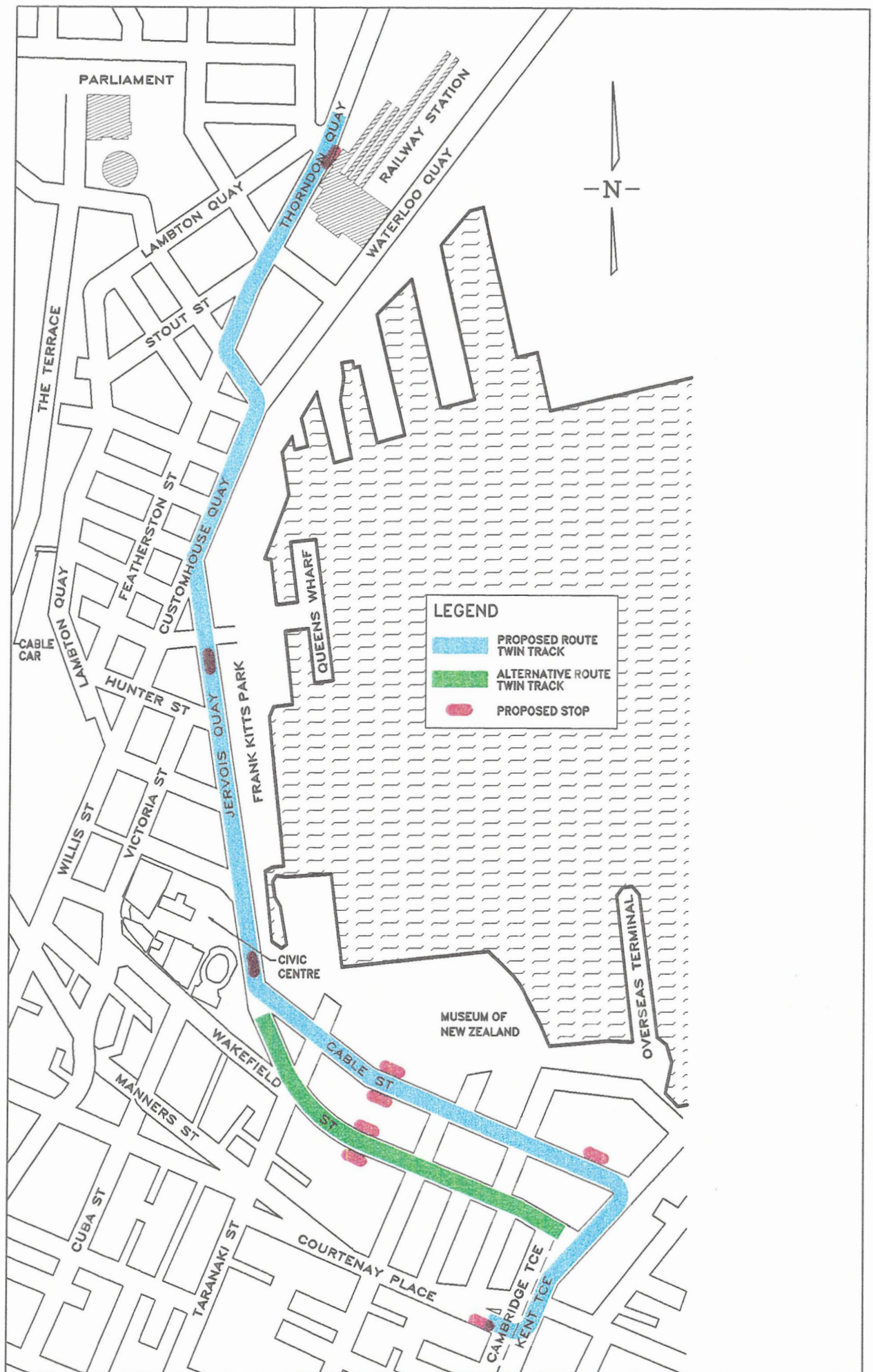
LIGHT RAIL TRANSIT FEASIBILITY STUDY
- "GOLDEN MILE" ROUTES -

Fig 4.1(a)



LIGHT RAIL TRANSIT FEASIBILITY STUDY
- CENTRAL ROUTES -

Fig 4.1(b)



**LIGHT RAIL TRANSIT FEASIBILITY STUDY
- WATERFRONT ROUTES -**

Fig 4.1(c)

4.4 Selection of Preferred Route

4.4.1 Catchment/Cost Analysis

The models developed for demand analysis and economic and financial predictions associated with the study utilise data collected at a regional level, principally from the Wellington Regional Council GATS model. These models while robust, are insensitive to small changes in route location.

In order to refine the route choice, a coarse analysis of the potential demand and costs of construction was undertaken. Demand was based on "catchment" maximisation derived from census mesh block data applied to:

- *total employment*, representing the demand for commuter trips
- *sales and service employment*, representing the relative demand for retail and tourist trips

The catchment of each route was initially derived on the basis of employment within a particular walk distance. The resulting plots for total employment are shown in Figures 4.2 and 4.3. It can be seen that the Featherston St-Willis St and Lambton Quay-Willis St routes provide the most attractive catchments and all proposed routes provide greater "penetration" than the current railway station.

It should be noted that the data available was collected as part of the 1991 Census and does not include developments under construction such as the Museum of New Zealand and Lambton Harbour Development. Although each is a major development, their significance in terms of the total available catchment is small. Furthermore, while LRT has been identified as a catalyst for development, a deficit of approximately 17,500 jobs within 100 m of the route exists between the more central alignments and the Waterfront route. It is therefore unlikely that the Waterfront route catchment will surpass the central alignments.

In order to provide an overall measure, a Public Transport Index (PT Index) was developed from existing mode split data. The index has been used to assess the potential for "transfer" to public transport. It is useful to consider the potential increase in catchment of each route option as compared with the existing Railway Station catchment. As indicated in Figure 4.3 and Table 4.1 the Lambton Quay-Willis St route provides the greatest potential for LRT.

The "catchment" increase (as a percent of current) for each route option has then been divided by the corresponding construction cost to determine a ranking. Relative costs (rather than absolute) have been used for this purpose based on route length. The resulting analysis (refer Table 4.1) indicates that little difference exists between the Golden Mile and Central routes from a



catchment/cost perspective.

Also from Table 4.1 it can be seen that the bulk of the catchment increase (41% of the possible 75%) may be obtained from a route terminating in the vicinity of the Willis Street/Lambton Quay intersection (BNZ site), possibly as part of a staged development. However, the catchment/cost ratio for a BNZ stage is lowered by the relatively high cost of constructing a terminus in that vicinity.

Although loops such as Lambton Quay/Hunter/Victoria/Willeston Streets and Victoria/Cuba/Manners Mall/Wills Streets can be formed, adequate space needs to be available for laying over vehicles for return running. To achieve this, the track would need to be extended to a location having sufficient area for that purpose which could impact further on the traffic flows and/or parking.

Given that the difference between the two central routes is small, attention was given to the potential catchment based around service and sales employment. This employment may be related to retail and tourist activity. This catchment analysis produced similar results to that for total employment. However, the important issue for trips associated with sales and service employment is proximity to the LRT route. Table 4.2 identifies the number of persons employed in sales and service within 100 m of the LRT routes. Although the catchment of sales and service employees is smaller than that for total employment, each sales and services employee represents more potential trips.



Figure 4.2
CBD Employment Catchment Analysis

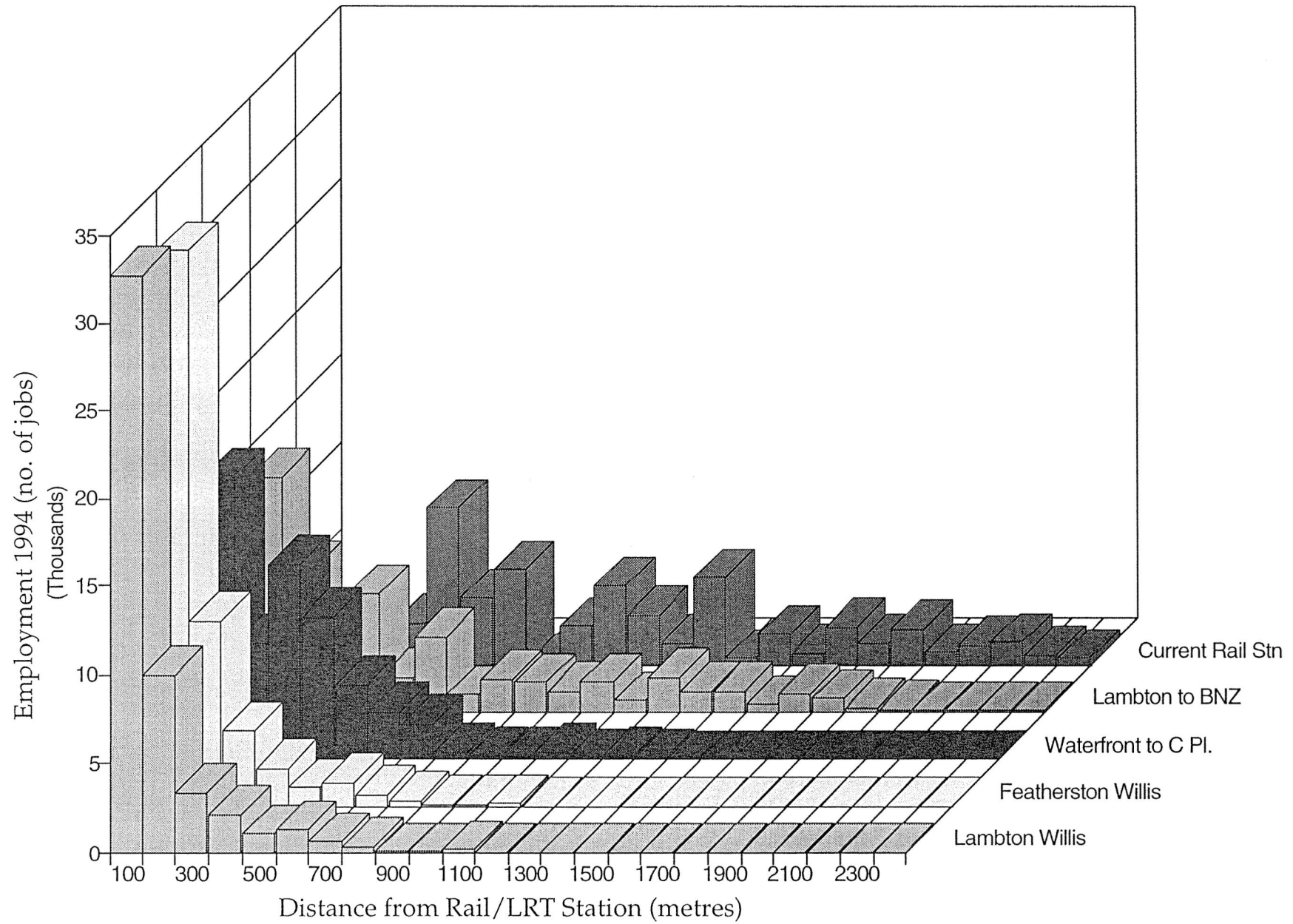


Figure 4.3
CBD Employment Catchment Analysis

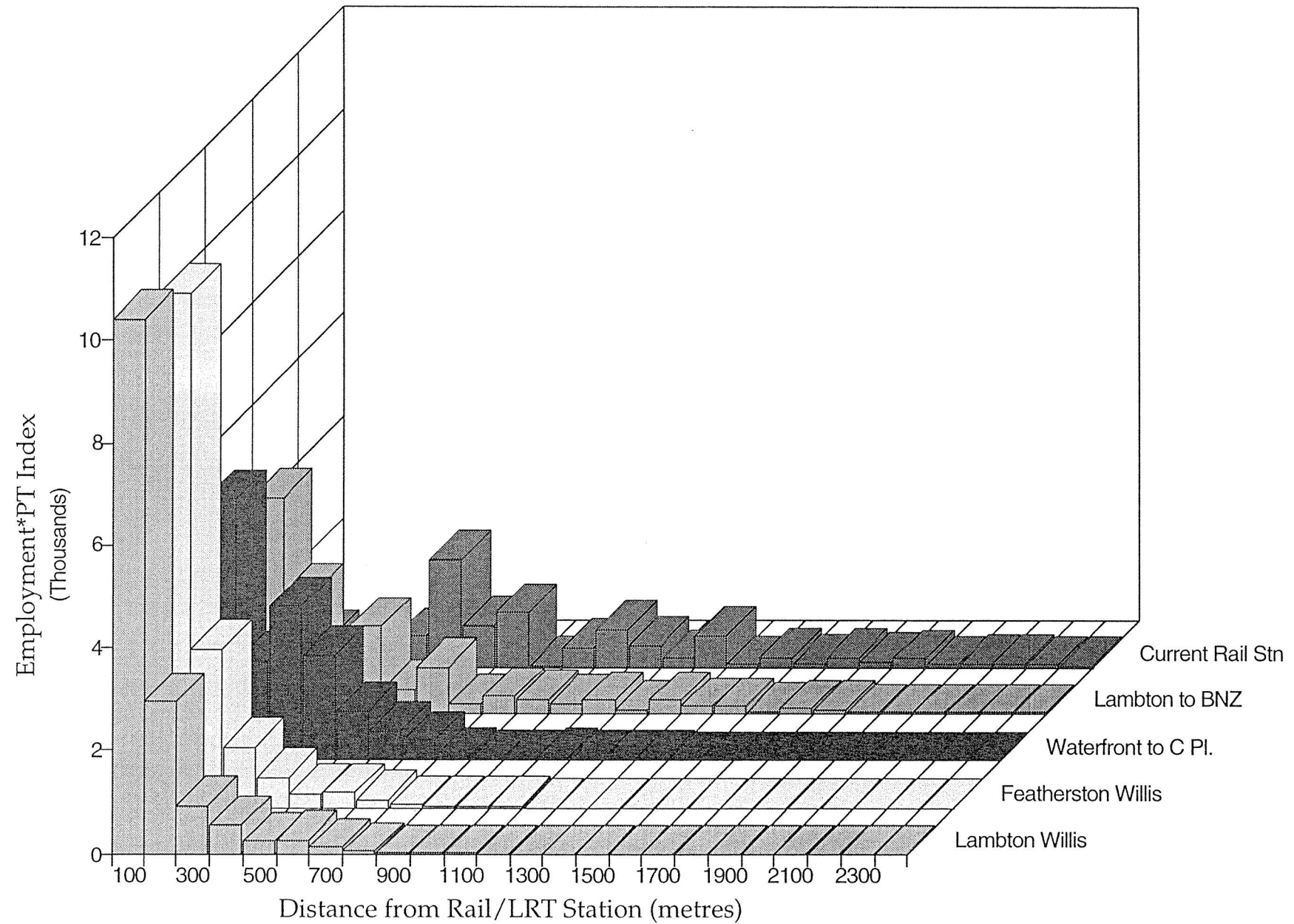


Table 4.1 Catchment/Cost Analysis

Route	To Courtenay Place			To BNZ	Existing Railway Station
	Golden Mile	Central	Waterfront	Golden Mile	
Employment x PT Index	15507	15458	14126	12485	8828
Potential Increase (% of Present Rail)	75.7%	75.1%	60.0%	41.4%	
Length of Route (km)	2.4	2.3	2.2	0.9	
Construction Cost \$M (ROC)	40.1	37.9	36.4	26.5*	
Percentage Catchment increase/Route length	31.5	32.6	27.3	46.0	
Percentage Catchment increase / Construction Cost \$M	1.89	1.98	1.65	1.56	

* Cost includes terminus in the vicinity of Lambton Q/Willis St Intersection.

Table 4.2 Employment in Sales and Service Within 100m of LRT Track

Route	To Courtenay Place			To BNZ	Existing Railway Station
	Lambton Quay Willis St	Featherston Willis St	Waterfront	Lambton Quay	
Employment (SS) within 100m	2817	2607	1053	1242	60

In summary, the additional length of track required for a Lambton Quay alignment rather than a Featherston Street alignment provides the latter with a better catchment increase to cost ratio. This is offset, however, by the greater potential of the Lambton Quay route to attract short duration "retail" trips.

From the point of view of demand, a route through to Courtenay Place utilising Lambton Quay is favoured, with staged construction to the vicinity of the BNZ, at the foot of Willis Street, as a possible initial option.



4.4.2 Traffic Impact

An important consideration in the assessment of any LRT proposal is the degree of disruption to existing traffic movements likely to be caused by the presence of the system.

It is clear that some of the initial LRT route options will have a significantly greater impact upon traffic flows in the city centre than others. Using information from the WCC TRIPS traffic model, a quantitative approach was developed to assess the impact on traffic of each route option. For each link in the modelled area, an index value was calculated by taking into account the traffic flow, length of section and capacity loss arising from the presence of the LRT. An overall index value for each route option was then established by summation of the individual link values.

The most heavily trafficked routes in the Wellington city business centre area are Customhouse Quay/Jervois Quay and Featherston St/Hunter St/Victoria St. The LRT route options which disrupt the flow of these movements will therefore have the greatest impact overall.

The Waterfront Routes, by following the Customhouse Quay and Jervois Quay route would have the most disruptive effect. Similarly, high traffic flows on Featherston Street result in high index values for that route.

The route via Stout Street to Lambton Quay avoids Featherston Street and as a result, the overall impact upon traffic is significantly lower than the Featherston Street options.

Utilising the relatively lightly trafficked Lambton Quay corridor and the separation of the LRT from the heavy traffic streams is estimated to have the least disruptive effect on traffic movements. Sub-options encroaching upon the Featherston St/Hunter St/Victoria St traffic flow, result in marginally higher index values. The sub-option involving twin LRT tracks along Victoria Street has a significantly greater impact.

4.5 Preferred Option

The three main route options were assessed as to their relationship to the passenger catchment, impacts on other road users and cost as described in the preceding sections.

It was concluded that the Golden Mile route was the most attractive alternative and should form the basis of the remainder of the study. A detailed description of the Golden Mile Route is given in Appendix A.



Section 5

INFRASTRUCTURE

5.1 Design and Construction Issues

5.1.1 LRV Dimensions

The dimensions adopted for the "design" light rail vehicles are given in Table 5.1. and illustrated in Figure 5.1. These are based on the recommendations made in Section 3.

Table 5.1 Car Dimensions

Distance between bogie centres	10 m
Front overhang	4.0 m
"Back" overhang	zero
Axle centres on each bogie	1.8 m
Overall car length	14.0 m
Width	2.65 m
Cut back at front corner	0.5 m
Kinetic width	2.9 m
Height (excluding pantograph)	3.65 m
Floor height**	900 mm
Track gauge	1067mm
Overall vehicle length	28.0 m

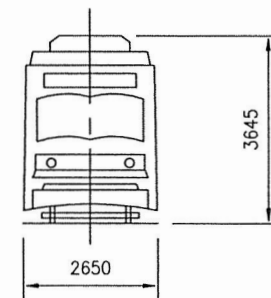
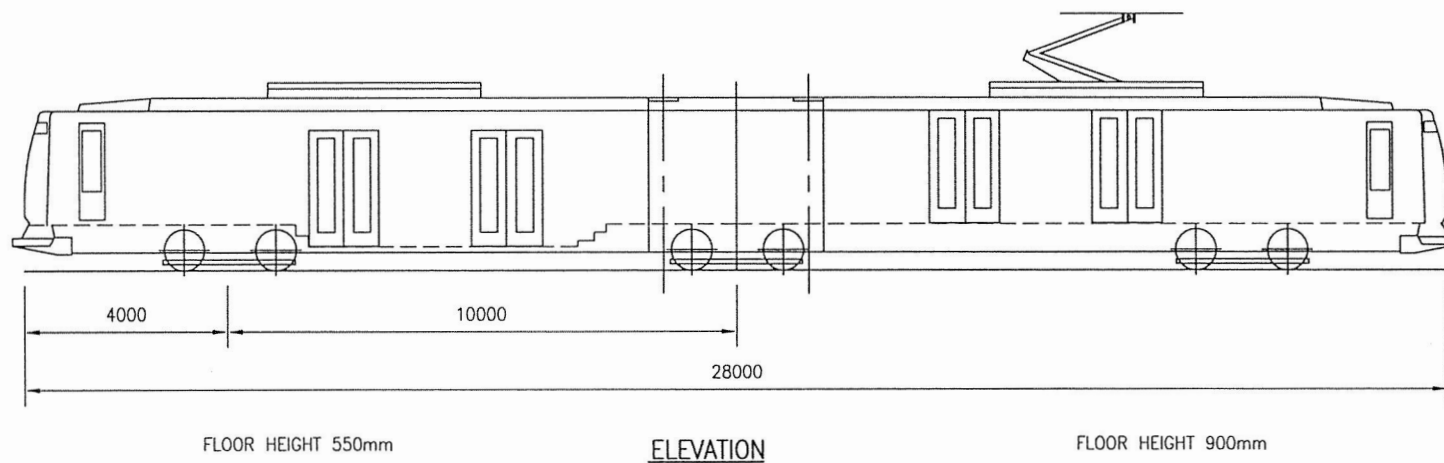
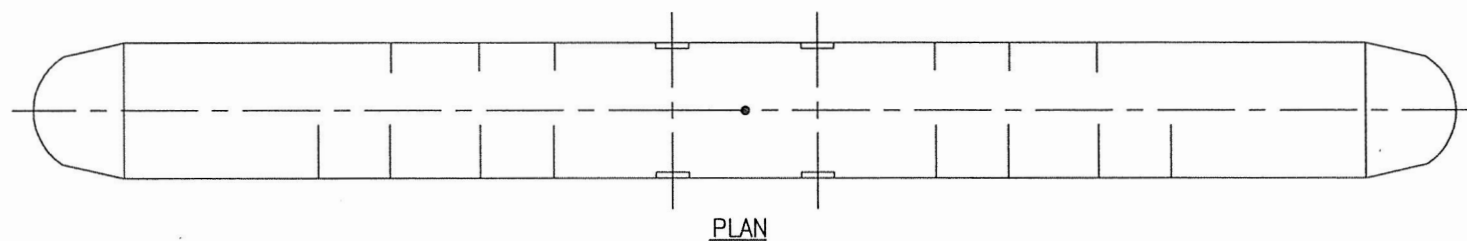
** The NZR GM carriages have a floor height of 1100 mm above top of rail

The number of vehicles, and hence the cost of the rolling stock, is dependent upon the operating scenario ultimately selected. This is discussed Sections 7 and 8.

5.1.2 Track Geometry

On straight lengths of track the operational width of the LRV lane has been taken as 3.5m. This allows for shared use of the lane by LRV and motor vehicles, and an emergency safety gap of 1.2m for pedestrians caught between passing LRVs. For segregated LRV operation the width allows for either kerbs/barriers or the like to be installed between opposing traffic flows. These items should be designed so as to not hinder emergency access to buildings alongside the route.





LIGHT RAIL FEASIBILITY STUDY
TYPICAL LRV DIMENSIONS

Figure 5.1

At nearly all changes in direction along the route it has been necessary to adopt the recommended minimum 25m radius for curves to minimise the impact on other road user operations and to keep within the road reserve boundaries. With no cant (superelevation) applied the operational speed for these curves is about 15 km/h.

The general features of central and footpath edge running of LRVs have been described in Section 4.2. It appears that the ideal practical arrangement is to have either central running with a 2 to 3 m wide median traffic turning lane (also suitable for siting a platform), or footpath edge running with the track located sufficiently out from the kerb so that stations/stops and parking/good servicing can be provided.

5.1.3 Station/Stops

A design spacing for the stops of approximately 500 m has been adopted as one which provides a good standard of service, taking into account the need to keep time delays to a minimum and the patronage catchment areas. The exact location is also related to adequate street space and key destinations. It is desirable that all stations/stops be on straight sections of track. However this is difficult to achieve in all cases and a compromise may be necessary at the detailed design stage between location, space available and the train length which can be accommodated. Thus changes to the locations given in Appendix Table A2 may result.

The platform level is related to the floor level of the LRV. The advantages and disadvantages of high floor versus low floor are described in Section 3. A high floor LRV has been recommended for this study. The general platform layout is based on a similar one adopted for the Manchester LRT, but with some modifications. It provides a 1 in 20 graded ramp up to the level access section of the platform for wheeled passengers. It is assumed that the LRV will be equipped with a retractable step so that the remainder of the platform can be constructed to a lower level. The suggested basic station platform layout dimensions to suit are given in Figure 5.2. The length of the platform to serve a two train LRV is 60m, though a lesser length of 50m which provides level access between the first and last doors on the LRVs is acceptable where the desirable criteria cannot be met.

A typical station platform construction consisting of concrete side walls, infill and paved top surface has been costed, plus an allowance for a shelter, lighting, railings, drainage, and automatic ticket vending machines.

The minimum platform widths adopted are 3.0m for an island type serving both directions and 2.0m for a platform adjacent to a footpath edge. The desirable widths are 1.0m greater for both.



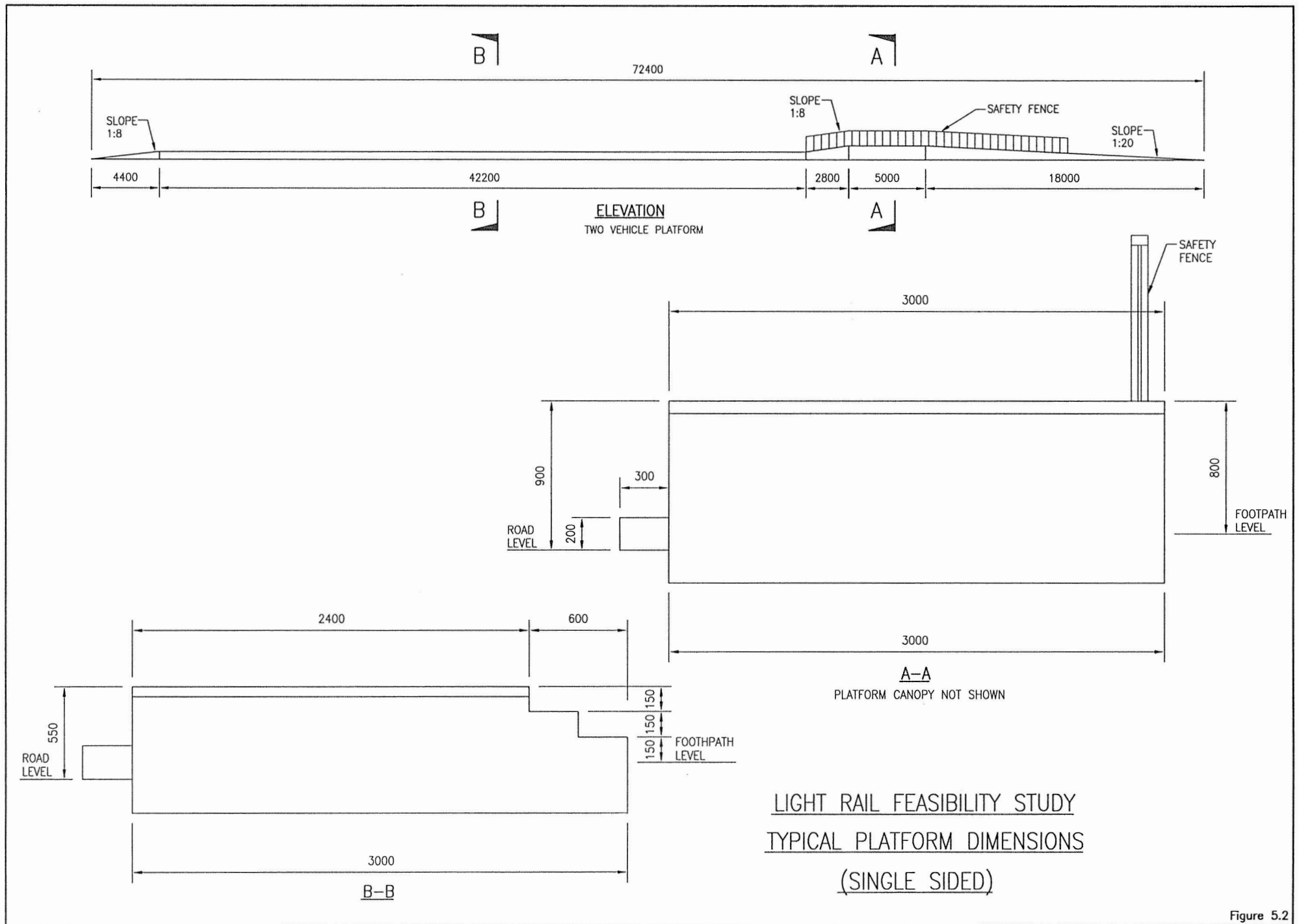


Figure 5.2

5.1.4 Existing Railway Station

For this study it has been assumed that all of the routes will depart from the western side of the existing railway station by extension of the Johnsonville line. This appears to fit in best with the operation of the NZR railway yard tracks and the preferred Golden Mile route. The western side is also the most logical for both direct and indirect connection between the light and heavy rail systems.

For commuter rail services from Kapiti and the Hutt Valley, it is desirable to have the connection between the EMUs and LRTs at the railway station as close as possible, and at the same level to encourage patronage of the LRV system. A layout which provides this has been investigated but requires taking the track through the existing single/two storey annexes to the NZR station building.

If the Porirua and/or Hutt Valley lines are connected into the LRT system the trains which carry on into the CBD would use the same platform. The track connections/cross overs will need to be sited at a suitable location within the present yards to the north. This, however, has not been investigated in detail.

5.1.5 Depot

A depot sited in the area adjacent to the existing Johnsonville platform at the central Railway Station, and used at present for the storage of EMUs, appears to suit the LRV requirements. If full services are to be located there a substantial area will be required and the EMUs will need to be parked elsewhere. If the servicing of LRVs can be undertaken at the present EMU workshop then the area required could be reduced to providing adequate track length for storage capacity, and staff/operational facilities only.

Depot facilities including storage tracks, staff and office accommodation, and cleaning and servicing bays, have been allowed for in the cost estimates. The cost of land has not been included.

(It is noted that some of the land considered for the depot is now a building site).

5.1.6 Services

All of the LRT routes affect services generally to a similar degree. Policies regarding the technical requirements for service relocation have not been established but there are a number of issues such as safety, accessibility and interference between service and LRT which are recognised and need to be addressed. It is considered that the cost of service relocation is likely to be



significant in absolute terms, but it is assumed for this study that the differential between routes is not great.

In the economic analysis any betterment through replacing services which are in poor condition and would be due for replacement, and upgrading to improve the capacity, has not been included.

5.1.7 Track Construction

Although there are no indications that the subsoil conditions are inadequate, a reinforced concrete base has been adopted throughout. Despite being more expensive than a ballasted track it has the advantage of providing a more rigid fixing for the track, resulting in a better ride, less loading on underground services and better paving finish with less maintenance. However it does have the disadvantage of requiring to be set up very accurately during construction, is less able to be corrected during the life of the system, and is more noisy than ballasted track.

An earthing mat within the slab to minimise the stray current leakage paths will be necessary.

It has been assumed that the rail used for the track will be the special grooved type Ri 60 (50 kg/m).

The work involves excavation, construction of the track bed including subsoil drainage, laying the track and cross overs, and reinstatement of the paving.

It is understood that much of the original tram track was laid on concrete and the bases may still exist in some areas.

The construction method, choice of track and base details, the attachment of the rail to the base, and the pavement surfacing can only be determined by detailed investigation which is outside the scope of this study.

Associated with track construction is the repositioning of kerbs, street drainage alterations, correction of pavement levels, relocating traffic signal poles and detectors, street lighting, lane marking and sign changes.

5.1.8 Overhead Electric Line Equipment

To construct a system which provides a continuous supply of power and is both simple and aesthetic, and caters for the trolley buses is likely to be complex. This aspect of the LRT system has not been investigated in any detail and the estimated cost for the installation of the overhead electrical equipment is based on previous costings, overseas examples and that of local equivalent examples.



A substation to supply 750 volt DC has been allowed for but not specifically located.

5.1.9 Signalling and Communications

It has been assumed that line of sight operation will be possible within the CBD. However signals will be necessary on the Johnsonville line, at the Railway Station and possibly the Courtenay Place terminus.

To operate LRVs on the existing rail system an automatic train protection system (ATP) may be required. The cost of an ATP system depends on the type and complexity of the system to be installed, the level of risk which is deemed acceptable, the equipment used within the trains and on the track by the current signalling system and the number of vehicles and signals to be fitted with the system.

It is understood that a form of ATP already exists at certain signal locations and that NZR are concerned that full implementation of ATP could reduce the capacity of the lines. Specification and provision of ATP will require specialised engineering and design before an acceptable system and firm costs can be established.

Due to the uncertainty of whether such a system would be required, the cost of ATP has not been included in either the capital cost estimate or the economic and financial analyses. However a magnitude of cost has been noted below each relevant table.

5.1.10 Traffic Signals

The majority of the traffic signal controlled intersections which the LRT will pass through will need to be modified, either to include an additional phase or change the cycle times so that the LRV is given adequate time to clear the intersection or priority. Some additional traffic signals will be necessary where the LRV route crosses a major distributor road, eg Stout St/Whitmore St intersection, which is not signalised at present .

5.1.11 Railway Yards

To avoid delays to services entering the railway station, increasing the number of tracks through the present two-track "bottleneck" would be desirable. However, this has not been investigated and no item has been included in the estimate for the cost of the work involved.



The siting of the proposed stadium in the railway yards is recognised, but the benefits of being able to service it by rail have not been included as it's use is likely to be intermittent. It is assumed that the cost of providing a rail halt will be included in the cost of that complex.

There could be operational advantages if the train services from Johnsonville are diverted onto Thorndon Quay near the Davis Street footbridge, and then proceed on the street to the Railway Station. The additional cost to the schemes of this alternative is of the order of \$4 million.

5.2 Stage Construction

The options for stage constructing the total length from the Central Railway Station through to Courtenay Place are:

- (a) Single track all of the length with strategically placed passing loops. This scheme is likely to have operational problems and a severely restricted capacity.
- (b) Double track as far as the Lambton Quay - Willis St intersection. As the double track splits into two single tracks in the area it is possible to form a loop via Hunter St and Willeston St. However layby sidings need to be provided for operational purposes. A possible site is Willeston St between Victoria Street and Jervois Quay but it's suitability is dependent on the number of LRVs in service.
- (c) A cross-over system located in Lambton Quay near the proposed Cable Car station which permits the LRVs to switch tracks and hence direction. This is a low capacity solution only.
- (d) A loop at the Cuba St - Manners St/Mall intersection. The required change in direction is greater than 90° which can be accommodated. However, the vehicle swept path clearance to buildings is low and will create a potentially dangerous situation for pedestrians. A limited number of layby sidings could be accommodated in Cuba St but traffic flows in the street would be severely disrupted.

Of the above staged construction options, Option (b) was examined in the catchment/cost analysis and carried forward to the economic analysis in Sections 7 and 8.

5.3 Costs

Table 5.2 gives a breakdown of the estimated construction costs for the Golden Mile route (Railway Station to Courtenay Place via Lambton Quay) and the possible intermediate stage terminating in the vicinity of the BNZ. The cost of



providing an additional passing loop and platform capacity on the Johnsonville line is included in both.

Within the level of investigation undertaken for this study and the reliability of the data used, these estimates are to rough order accuracy only.

The quantities used in deriving the estimates have generally been those suitable for parameter costing. For items such as track and overhead electrification the lengths have been measured as centreline distances from the 1/2 tone aerial photographs. For the stations and track bed, the parameter cost has been based on a preliminary assessment of dimensions, with unit rates applied to the quantities derived from local consolidated figures.

Table 5.2 Summary of Infrastructure Costs for Recommended Schemes

\$1995 Millions		
Item	Johnsonville to Courtenay Place via Stout Street	Johnsonville to Bank of New Zealand via Stout Street
Track	\$4.9	\$2.8
Street modifications	\$0.4	\$0.5
Services	\$14.9	\$8.7
Electrification	\$2.4	\$2.0
Signals/Communications	\$1.2	\$1.2
Stations	\$2.6	\$2.1
Depot	\$1.5	\$1.5
Contingencies	\$6.3	\$4.3
Professional Services/Administration	\$5.8	\$3.9
Total	\$40.0	\$27.0

5.4 Extension from Courtenay Place to Wellington Airport

A preliminary investigation into extending a light rail service through to the Airport was carried out. This mainly involved reviewing previous studies and costing figures.



Two principal routes exist -

- 1 via Newtown (Adelaide Rd/Constable St)
 Kilbirnie (Crawford Rd/Rongotai Rd)
 Rongotai (Cobham Dr/Calabar Rd)
- 2 via Mt Victoria (Pirie St/Bus Tunnel)
 Hataitai (Moxham Ave)
 Kilbirnie (Kilbirnie Cres/Rongotai Rd)
 Rongotai (Cobham Dr/Calabar Rd).

It has been assumed that twin tracks will be required as far as Kilbirnie, and a single track will be adequate between Kilbirnie and the Airport. In estimating the cost of extending the line from Courtenay Place through to the Airport it has been assumed that over the suburban section less onerous track standards will suffice and a ballasted base will be adequate.

For this study specific station/stops have not been identified but generalised costs based on work done for the CBD section have been included in the estimates.

For alternative 1, the route length is approximately 7.2 km, and the cost of the track and associated facilities (excluding vehicles) is of the order of \$44 million. This cost is additional to that given for the Railway Station to Courtenay Place scheme.



Section 6

METHODOLOGY FOR ASSESSING DEMAND, REVENUE AND TRANSPORT BENEFITS

6.1 Study Requirements

A study methodology was developed that allowed the following to be established for each of a number of implementation options for light rail:

- annual patronage and revenue;
- ridership levels on the light rail scheme for peak and off-peak periods;
- specific impacts on traffic movements within the city centre;
- annual benefits to users of the scheme;
- annual benefits to car users, remaining on the road network, due to congestion relief as trips switch from use of car to use of LRT;
- annual disbenefits to car users caused by the addition of light rail vehicles on-street;
- impact on existing public transport in the city.

6.2 Sources of Data and Available Models

Data was obtained to assess the implications of each implementation option for two time periods:

- Morning Peak weekday, 0700 to 0900.
- Off Peak weekday, 0900 to 1600.

Two analysis years, a base year of 1995 and a future year of 2011, were considered.

The following data and existing computer models were made available:

- GATS transportation model information supplied by WRC. The model provided data on trips by highway and public transport at a strategic zone level throughout the region, and also modelled journey time and journey distances;
- TRIPS highway model of the city of Wellington. Data from this model was supplied by WCC, and consisted of highway trip matrices for base



(1995) and future (2011) years, together with journey travel time and distance information;

- rail timetables, fare tables (from WRC), and information on train workings and formations (from NZR);
- information on central area parking supply and costs, from WCC and private operators;
- highway screenline flows, from WRC;
- bus counts, from Stagecoach, in confidence;
- accident statistics, from LTSA;
- pedestrian and cycle flows, from WCC;
- bus travel times and counts from Golden Mile Bus Survey, from WCC.

6.3 Overall Procedure

Forecasts of patronage, revenue, and user and non-user benefits were produced for two years, a base year of 1995 and a future year of 2011. Forecasts for intervening years were obtained by interpolation and for later years by extrapolation.

An initial analysis (Section 4) identified that, the greater the distance between Wellington station and the final city centre destination, the lower the share of trips made by rail. However modal share is also dependent on train frequencies and the journey times of all modes. A mode choice model was therefore developed to take into account all of the above factors. A public transport model based on the PT-TRIPS computer software provides time and cost information for each tested option and can assess route choice and multi-routing within the central area.

LRT patronage can be expected to come from six main sources:

- extension of rail trips
- diversion from previous bus trips
- diversion from previous highway trips
- "new", generated or re-distributed trips
- park and ride



- diversion from "slow mode" (walk and cycle) within the central area.

Different approaches were used to assess each of the six elements. However, the main approach was to obtain demand data from the GATS model and to construct mode choice and assignment models which were sensitive to changes in journey time, frequency and mode of travel.

6.4 The Structure of the Modelling Process

The structure of the modelling process which was developed for this study is shown diagrammatically in Figure 6.1

6.5 Screenline Counts and Update of GATS Matrices

Screenline counts were carried out for the existing rail services by counting passengers alighting and boarding trains at Wellington Station. A summary of the results of these counts is given in Table 2.5. For highway trips, existing screenline counts were obtained from a database supplied by WCC.

For bus movements, the number of services and average bus occupancy levels, (supplied in confidence by operators), provided screenline flows.

The GATS "observed" matrices for peak and off-peak time periods for car and public transport trips in 1988 were updated using the screenline data.

The GATS model trip estimates of movements for peak and off-peak periods for years 1988 and 2011 were used to factor the 1995 car matrices to 2011. For public transport trips GATS predicted a significant reduction by 2011. Given the recent reductions in public transport ridership and following discussions with WCC and WRC the 2011 public transport matrix was kept equal to the 1995 matrix.

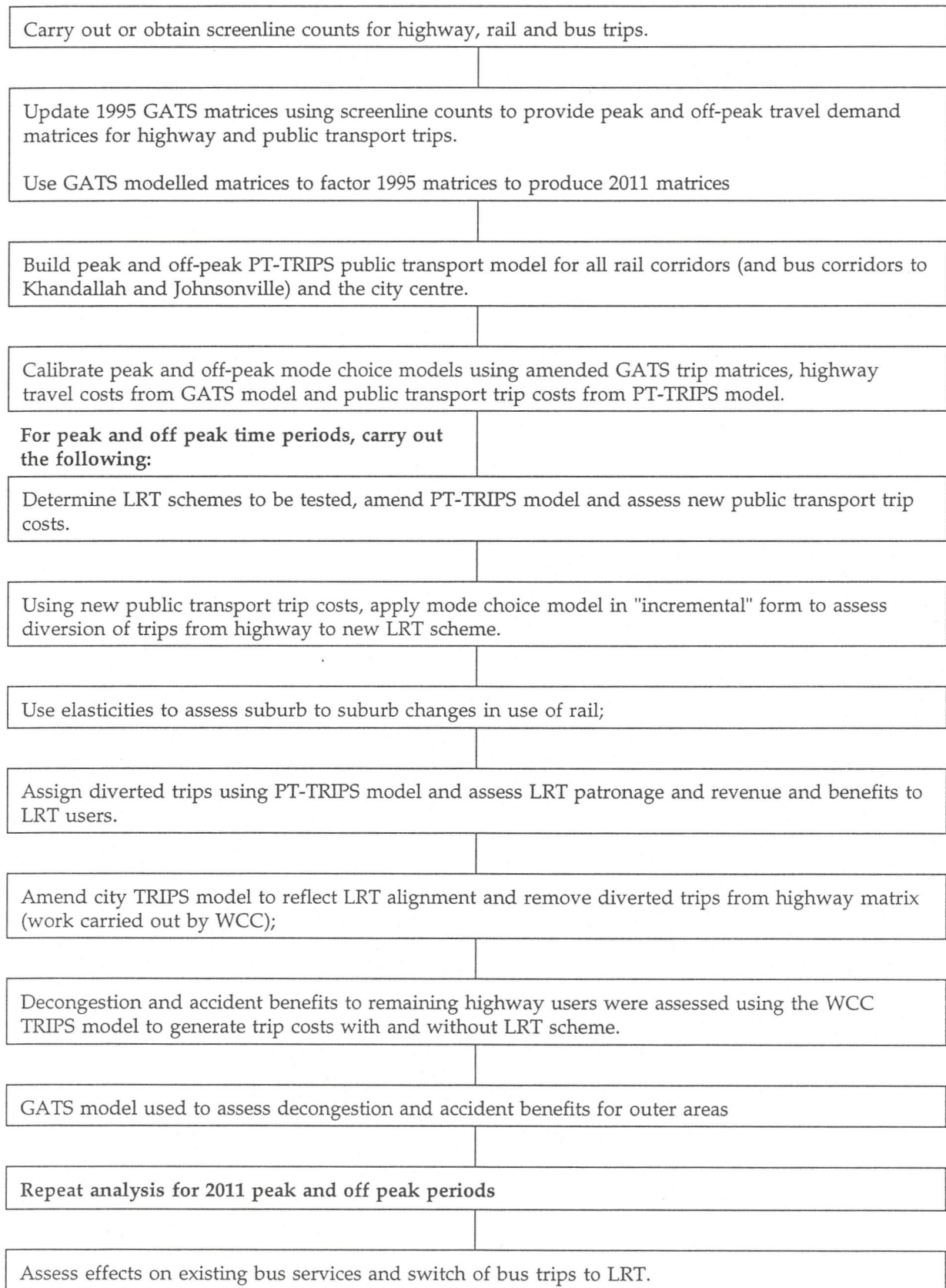
6.6 The PT-TRIPS and Mode Choice Models

A PT-TRIPS assignment model for the area surrounding the rail corridors and the city centre was developed with rail, bus and walk links being included. Central area bus routes were included in the model to enable trips to be split between bus, walk and LRT.

Peak and off-peak trip data and travel costs were used to calibrate mode choice models for the corridor trips. The weightings applied to the costs having been established from local research, experience from other similar studies, and inspection of results.



Figure 6.1 Structure of Modelling Process to Calculate LRT Revenue, Passenger Benefits and Effects on Highway Users



The purpose of the mode choice model was to establish how many more people would use public transport if the "costs" of public transport travel (ie travel time or fare) were reduced or the "costs" of travel by car were increased. The calibration values indicated that travellers are more sensitive to changes in generalised cost in the peak period than in the off-peak period.

Bus speeds were decreased by around 17% to take account of the effects of increased traffic congestion in the year 2011.

6.7 Assessing Diversion of Trips from Car to LRT

Diversion of car trips to LRT will occur where LRT offers a better level of service than current rail operations. It will therefore occur mainly within the rail corridors. New routes and timetables were input to the PT-TRIPS model producing revised generalised costs for travel by public transport. The mode choice model was applied in an "incremental" manner to identify how many car trips would divert to public transport. This reduction in car trips is used to establish the reduction in congestion (decongestion) and the associated benefits.

Outside the city centre, within the rail corridors themselves, percentage changes in journey times were calculated.

6.8 Assessing Patronage, Revenue and User Benefits

The PT-TRIPS assignment model was used to establish the final mode used within the central area (ie. whether walk, bus, or LRT).

The trips diverted from car were similarly assigned to establish their use of the public transport system. Diversion of bus trips currently made wholly within the central area was calculated based on the proportion of future LRV and bus kilometres within this area.

Existing walk trips made between origins and destinations wholly within the central area were assessed not to divert to a new mode since the frequency and level of service provided by buses in this area is already very high, and these trips have already chosen to walk.

Revenue attributable to car diversion was assessed by multiplying new trips and trip kilometres by fares.

Where journey time savings would occur for existing public transport passengers, they were multiplied by a value of time (\$5.50 per hour) to establish "user benefits". Trips diverting from car were similarly assessed, using changes in public transport time, but benefits were halved (a normal practice in economic assessment).



User benefits for additional trips wholly within the suburbs were assessed similarly, with an assumption that around half would have diverted from previous use of car.

Users diverting from car would save an average operating costs of \$0.30 per km, based on the Transit New Zealand Project Evaluation Manual 1994 (PEM).

6.9 Assessing Decongestion Benefits, Accident Savings and Traffic Effects of On-Street LRT

Decongestion benefits due to diversion of car trips, and the congestion effects of an on-street LRT system, were calculated using the WCC TRIPS model, the work being carried out by WCC.

For three levels of diversion from car in each of two time periods and two modelled years the WCC TRIPS model was used to predict the reduction, over the Do Nothing, in journey times and vehicle kilometres. From the results factors were derived that relate the benefits, and disbenefits, in terms of travel time and vehicle kilometres travelled for each trip diverted from car.

Time and distance savings were valued at \$15.83 per vehicle hour and \$0.30 per vehicle km, both values being derived from the PEM. Using information from the PEM and an LTSA survey, accident savings were valued as \$0.27 per vehicle kilometre removed.

6.10 Effects on Existing Bus Services

Buses from the Johnsonville area serve a catchment area which somewhat overlaps with the Johnsonville rail service. After assessing current journey times by rail and bus and walking distances to buses and rail stations, it was concluded that the conversion of this line to LRT could have little effect on the bus services. In addition, it is unlikely that a feeder bus service to Johnsonville rail station would prove attractive enough, as the direct bus journey time to most city centre destinations would remain less than that by bus plus rail.

Buses from the south and south-west of the city centre would compete with an LRT scheme to Courtenay Place only in areas west and north of that location. It would be expected that most of the patronage for these bus services would arise south and east of Courtenay Place, and therefore, these bus services will not be affected by the LRT in any significant way.



Buses through the city centre will have some of their internal city centre traffic taken by the LRT scheme. This may result in some reductions in frequency or decisions by the bus companies to turn some lightly loaded services short of the edge of the CBD. However, a major deterioration in levels of bus service is not expected.

6.11 Decongestion Benefits in the Suburban Areas

For decongestion outside the TRIPS network the GATS model has been used. However due to some concern over the large size of benefits predicted for 2011, 1995 values were used for both years. These benefits are given in Table 6.1.

Table 6.1 Decongestion Benefits in Suburban Areas Per Vehicle Removed

	Time (hr)	Distance (km)
AM peak	0.43	0.28
Interpeak	0.10	0

6.12 Annualisation Factors

Scheme revenue, highway decongestion benefits and user benefits were annualized on the basis of data provided by NZR, WCC and on GATS survey data.

The resulting expression was:

$$\text{Annualisation} = 455 \text{ AM Peak}(2 \text{ hrs}) + 453 \text{ Inter Peak}(7 \text{ hrs})$$



Section 7

SELECTION OF OPTIONS TO TEST

7.1 General

The principal objective of the Study is to establish whether an LRT scheme serving the Hutt Valley, the Kapiti Coast and Johnsonville (or some part of these routes) is a viable proposition. The purpose of conversion to LRT would be to make the extension of a light rail system into the central area of Wellington an attractive proposition. The Study has therefore considered the implementation options for such a scheme.

The Brief stipulated that a Do Minimum option would be the conversion of the Johnsonville rail line to LRT with it terminating at Wellington Railway Station. However, discussions with the WCC and WRC revealed that a key question that must be answered in the short term is whether, when the time comes to replace the English Electric EMUs on the Johnsonville line (and those in service on the other lines), they should be replaced with LRVs or EMUs.

To answer this question it was necessary to establish a series of tests to determine what scheme for LRT would give the greatest benefits and to compare this with an option of replacing the old EMUs with new, similar stock.

This section details a number of important considerations and outlines the options that were tested following discussions with WCC and WRC.

7.2 The Schedule for Replacement

It is understood that the EE EMUs should be replaced at the earliest opportunity. This would be around 1999. However, construction of an LRT line through the city centre is unlikely to be achievable until 2001. To simplify the analysis, 2001 has been taken as the earliest year when replacement of the EE EMUs and (if warranted) an LRT extension would be implemented.

The GM EMUs will also require refurbishment, and eventually replacement. However, it is unlikely that this will be necessary to consider until around 2011 which coincides with the year for which future planning information is available. This has been taken as the second opportunity for implementing major changes to the system.

In determining the options it has been noted that, if all of the EE EMUs were replaced then although the GM units would be required in the peak period, all off-peak services could be run using the new replacement rolling stock.



7.3 Frequency of Service and Central Area Fare

In Section 3, a practical maximum for light rail frequency on street of 30 per hour was established. Initial tests based on all lines being converted to LRT and running these into the city centre showed that the lower capacity of an LRV and the additional, generated patronage would result in far more than 30 LRVs per hour being required. It therefore appeared desirable to not take all trains through to Courtenay Place. An approximate relationship between frequency and patronage was established to determine suitable frequencies for any line, or part of a line which would be converted to LRT operation. It was decided that the best lines to terminate at Wellington station were the longer distance express services for which it may be more appropriate to retain EMU operation because of their greater seating capacity.

For the Johnsonville line a regular peak headway of 13 minutes was specified, with possible improvements to a 10 minute headway. Such headways would only be maintainable if an extra passing loop was installed and probably a second track at the Johnsonville terminus. It was also assumed that new rolling stock, whether LRVs or EMUs would allow journey times to be decreased by 5%.

Selected results from the initial tests are displayed in Figures 7.1 and 7.2. These figures show the effect of running all lines into the city centre, both with and without an additional central area fare. Figure 7.1 shows that (with a central adult fare of \$1.00) significant additional ridership could be gained in the peak and off peak periods, especially in future years. However, most of the benefit can be achieved by improving the rolling stock running into Wellington station.

Figure 7.2 illustrates how, with a no additional central area fare, significant additional ridership would arise from an extension to the BNZ. In this case there would be little to be gained from extending the line further, from BNZ to Courtenay Place.

The two figures demonstrate how important the level of a central area fare is likely to be. Further assessment of this issue should be undertaken if it is decided to pursue LRT in the CBD. For the purposes of this study a central area additional adult fare of \$1.00 has been adopted. This is compatible with the current fare scheme used on buses.

7.4 Selection of Options to Test

Options selected for testing were agreed with WCC and WRC and are described in Table 7.1. They were designed to provide information regarding:

- the viability of extending an LRT line beyond Wellington Railway Station;



Table 7.1 Description of Tested Options

Option	Rail Corridor	Year 2001	Year 2011
A (Do minimum)	Johnsonville	LRT to Wellington Station	
	Hutt Valley & Kapiti Coast	New EMUs to replace old EE EMU units	New EMUs to Wellington Station
D	Johnsonville	LRT to Wellington station	LRT to Courtenay Place
	Hutt Valley & Kapiti Coast	New EMUs to replace old EE EMU units	LRT to Courtenay Place except Expresses and Melling (new EMUs)
E	Johnsonville	LRT to Courtenay Place	
	Hutt Valley & Kapiti Coast	LRT to Courtenay Place except Expresses and Melling	
F	Johnsonville	LRT to Wellington station	LRT to BNZ area
	Hutt Valley & Kapiti Coast	New EMUs to replace old EE EMU units	LRT to BNZ area except Expresses and Melling (new EMUs)
G	Johnsonville	LRT to BNZ area	
	Hutt Valley & Kapiti Coast	LRT to BNZ area except Expresses and Melling (new EMUs)	
H	Johnsonville	LRT to Wellington Station	LRT to Courtenay Place
	Hutt Valley & Kapiti Coast	LRVs to replace old EE EMU units. Off peak LRT to Wellington Station	LRT to Courtenay Place except Expresses and Melling (new EMUs)
J	Johnsonville	LRT to Wellington Station	
	Hutt Valley & Kapiti Coast	New EMUs to Wellington Station	



Figure 7.1 Improvements to Ridership
New rolling stock, extra \$1 CBD Fare

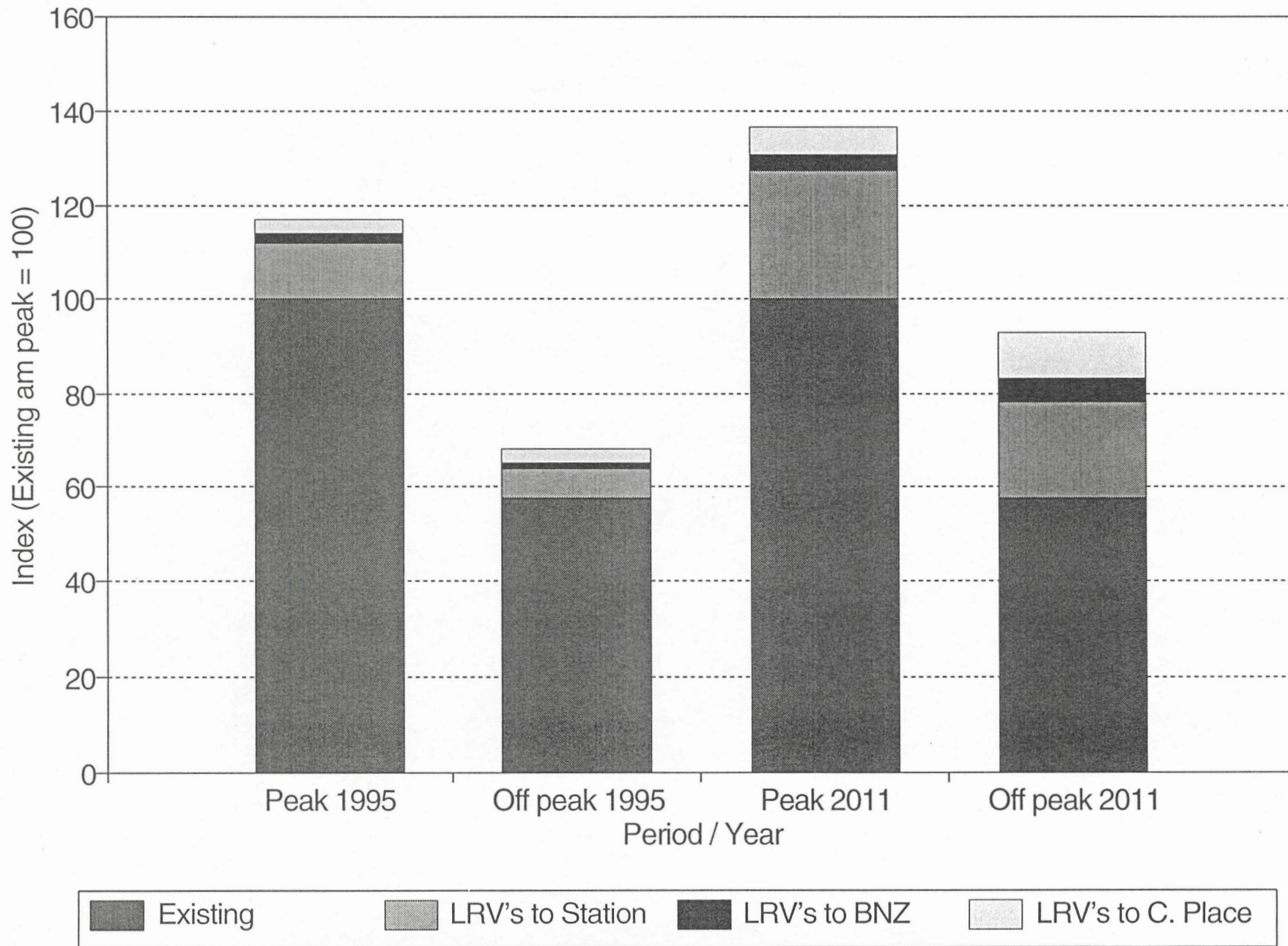
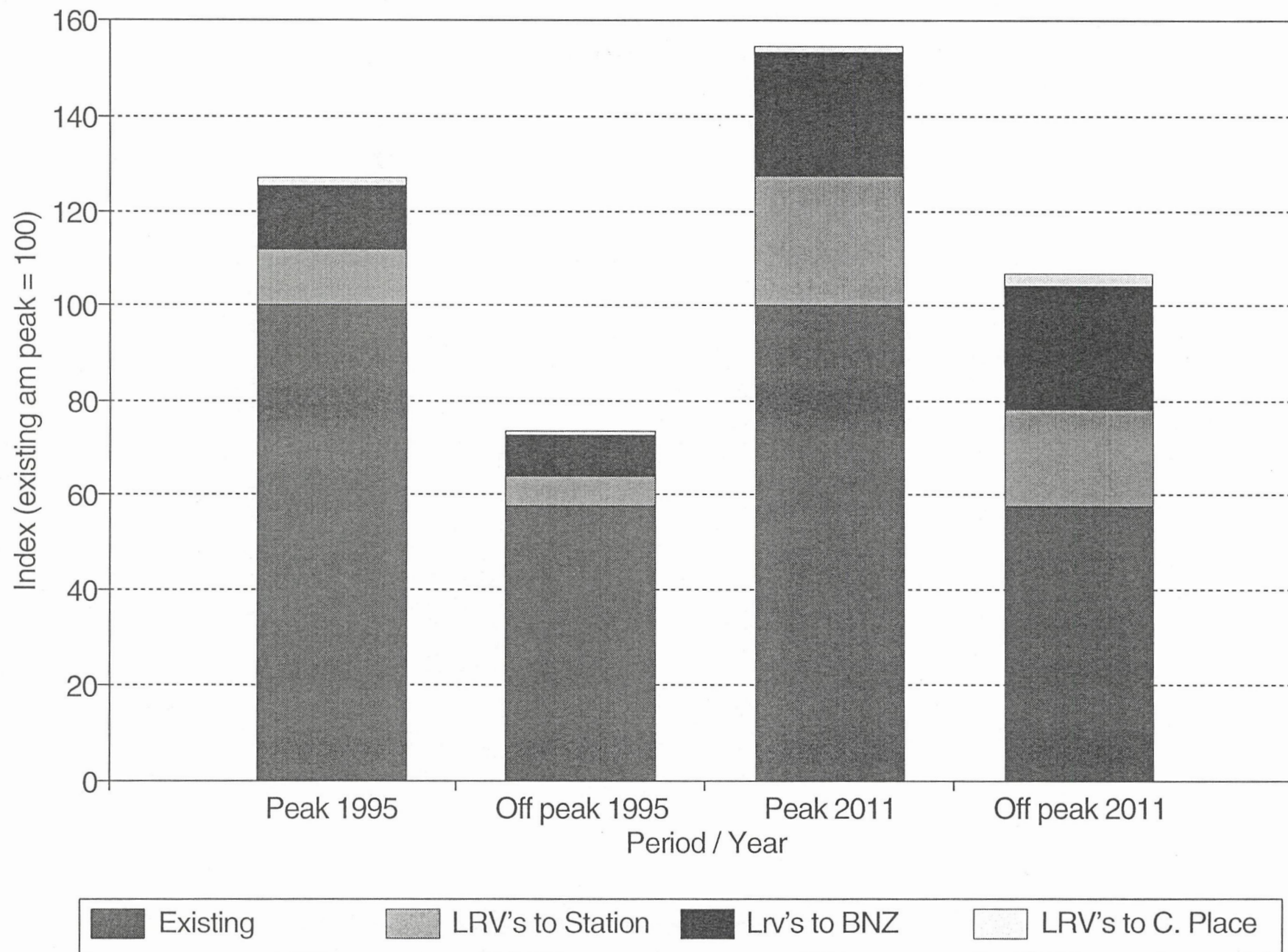


Figure 7.2 Improvements to Ridership
New rolling stock, no extra CBD fare



- selection of a terminal in the BNZ or Courtenay Place area;
- comparison of benefits of conversion to LRT (with an extension into the city centre) or of replacement of EMUs;
- the most appropriate timing for replacement of existing rolling stock.

The option of extending only the Johnsonville line into the central area was not listed, as it was determined by earlier work, reported to WRC, to be an uneconomic proposition.

Option A is the Do Minimum option. In 2001, LRT operation is implemented on the Johnsonville line and the old English Electric EMUs on the Kapiti and Hutt lines are replaced with new EMUs. In 2011, the GM EMUs on the Kapiti and Hutt lines are replaced.

In all of the other options, the old EE EMUs on the Kapiti and Hutt lines are replaced.

For Option D, in year 2011 the LRT to Johnsonville is joined by LRT on the Kapiti and Hutt lines, with an on-street extension to Courtenay Place. The EE units on the Hutt and Kapiti lines are replaced with new EMUs in 2001.

In Option E the implications of early conversion of all lines to LRT with an extension to Courtenay Place is examined. This option would incur the highest costs at an early stage.

Option F is as Option D, except the extension is only taken to the BNZ area.

Option G is as Option E, except the extension is only taken to the BNZ area.

Option H is a slight variation on Option D. In year 2001 all of the off-peak services (to Wellington Railway Station) are provided by the fleet of new LRVs.

Finally, Option J examines the early replacement conversion (in year 2001) of the GM EMUs on the Kapiti and Hutt lines. This test is designed to establish whether there are likely to be economic or financial advantages in simply providing modern, faster rolling stock on all lines. Options E and G, which contain early replacement of all rolling stock with LRVs, can be compared with the results of Option J.

Table 7.2 gives the approximate headways which were used for the various tests.



Table 7.2 Approximate Headways Used in the Option Tests

Headways (minutes)	Period	Branch	LRV/ EMU	Existing	Do Minimum	2001 Options	2011 Options
Johnsonville	peak		LRV	120	10	12	10
	off-peak		LRV	30	30	30	30
Hutt valley	peak	Melling	EMU	30	30	30	30
		Taita	LRV	20	20	6.5	5
		Upper Hutt	EMU	20	20	20	20
	off-peak	Melling		/	/	/	/
		Taita		/	/	/	/
		Upper Hutt	LRV	30	30	30	30
Kapiti Coast	peak	Porirua	LRV	24	24	10	10
		Plimmerton	LRV	30	30	12	10
		Paraparaumu	EMU	30	30	30	30
	off-peak	Porirua		/	/	/	/
		Plimmerton	LRV	60	60	60	60
		Paraparaumu	LRV	60	60	60	60

Note: 1 The 20 minute headway on the Johnsonville line is made up from headways of 13, 13 and 26 minutes.



Section 8

TEST RESULTS AND ECONOMIC EVALUATION

8.1 General

For each option, the rolling stock and infrastructure costs, operating costs, revenue and transport benefits are presented together with the financial and economic evaluation. Comparisons are made for each against the Do Minimum (Option A) being replacement of English Electric EMUs in 2001 with LRVs on the Johnsonville line and with new EMUs on the Hutt/Kapiti lines.

8.2 Rolling Stock

The rolling stock requirements under each option are given in Table 8.1. Option A (Do Minimum) is shown for comparison. Regardless of option, there is a requirement to replace all EE units by the year 2001; with LRVs for options E, G and H; or with new EMUs for Options D, F, J and A.

Table 8.1 Rolling Stock Acquisition Required for Options

Number of LRVs or EMUs	LRV		EMU	
	2001	2011	2001	2011
Option				
A (Do-Min)	9	0	7	40
D	9	92	7	19
E	101	0	26	0
F	9	87	7	19
G	96	0	26	0
H	20	81	0	26
J	9	0	47	0

Note: 1. In the above table, one LRV is one 30m articulated unit and one EMU is a two car unit.
2. Rolling Stock includes provision for spare vehicles



8.3 Capital Costs

Table 8.2 shows the funding requirements for rolling stock and infrastructure for each Option in \$1995.

Table 8.2 Infrastructure and Rolling Stock Costs

	\$ 1995 Millions					
	2001			2011		
Option	Infra-structure	Rolling Stock	Total	Infra-structure	Rolling Stock	Total
A (Do-Min)	0.5	61.1	61.6	0.0	182.0	182.0
D	0.5	61.1	61.6	39.5	385.5	425.0
E	40.0	446.6	486.6	0.0	0.0	0.0
F	0.5	61.1	61.6	25.5	369.2	394.7
G	26.0	430.3	456.3	0.0	0.0	0.0
H	0.5	65.0	65.5	39.5	381.6	421.1
J	0.5	243.1	243.6	0.0	0.0	0.0

- Notes
- Rolling stock costs are based on costs of
 - \$3.25m for a single articulated LRV unit
 - \$4.55m for a coupled, two-car, EMU.
 - Infrastructure costs could be higher if private sector finance is sought and private sector wished to upgrade existing rail facilities to avoid future risk.
 - The costs of Automatic Train Protection are not included.



8.4 Operating Costs and Revenue

Operating costs were determined by applying unit costs to the estimates of the peak rolling stock requirements (with and without spares), annual vehicle kilometres, annual vehicle-tonne kilometres, annual train hours, total on-street (single) track kilometres, total on-street route kilometres and the number of stops.

A vehicle was defined as a single articulated LRV or two coupled cars for an EMU. A train was defined as the complete LRV or EMU operating under the control of one driver.

It is assumed that control room and supervisory duties would not be significantly affected by any increase in the operations. This presupposes that the enhanced rail/LRV network would be integrated into the existing rail operations.

Overall, the unit operating marginal cost was calculated to be approximately \$2.10 per LRV km. EMU marginal operating costs were calculated to be approximately \$2.50 per (2-car) EMU km.

The values given in Table 8.3 include allowances for traction energy, wages, maintenance and an allowance for spare units.

There is a negative marginal operating cost for option J in 2001 because the peak EMU requirement is lower in Option J (new, faster EMUs) than in the Do-Minimum option (with existing EMUs).



Table 8.3 Annual Operating Costs and Revenue
(in addition to the costs and revenue for the Do Minimum option)

	\$ 1995 Million					
	2001			2011		
Option	Operating Cost	Revenue	Cost - Revenue	Operating Cost	Revenue	Cost - Revenue
A (Do-Min)	0.0	0.0	0.0	0.0	0.0	0.0
D	0.0	0.0	0.0	8.1	8.8	0.7
E	7.9	8.7	0.8	8.1	8.8	0.7
F	0.0	0.0	0.0	6.9	7.6	0.7
G	6.6	7.8	1.2	6.9	7.6	0.7
H	0.2	0.8	0.6	8.1	8.8	0.7
J	-0.2	2.2	2.4	0.0	0.0	0.0



8.5 Benefits

Table 8.4 shows the user benefits (time savings for travellers) and non-user benefits (accident reduction and time and vehicle operating cost savings for remaining road users) for each option.

Table 8.4 User and Non-User Benefits
(in addition to any user and non-user benefits arising from Option A - the Do Minimum option)

	\$ 1995 Million					
	2001			2011		
Option	User Benefits	Non- user Benefits	Total Benefits	User Benefits	Non- user Benefits	Total benefits
A (do-min)	0.0	0.0	0.0	0.0	0.0	0.0
D	0.0	0.0	0.0	15.5	33.7	49.1
E	20.3	43.0	63.3	15.5	33.7	49.1
F	0.0	0.0	0.0	13.6	27.9	41.5
G	19.2	40.1	59.3	13.6	27.9	41.5
H	3.4	3.8	7.2	15.5	33.7	49.1
J	8.7	21.6	30.3	0.0	0.0	0.0



8.6 Financial and Economic Analyses

Table 8.5 presents the results of the financial and economic analysis compared with the Do Minimum (Option A). The assessment has been undertaken based upon a discount rate of 10% and a project life of 30 years. The latter has been chosen as it represents the theoretical economic life of the rolling stock and ties in conveniently with the planning period data. The Benefit Cost comparison is shown graphically in Figure 8.1.

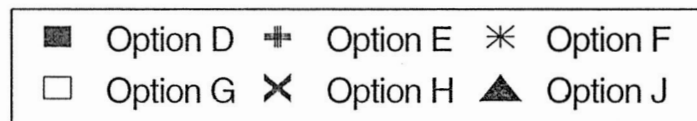
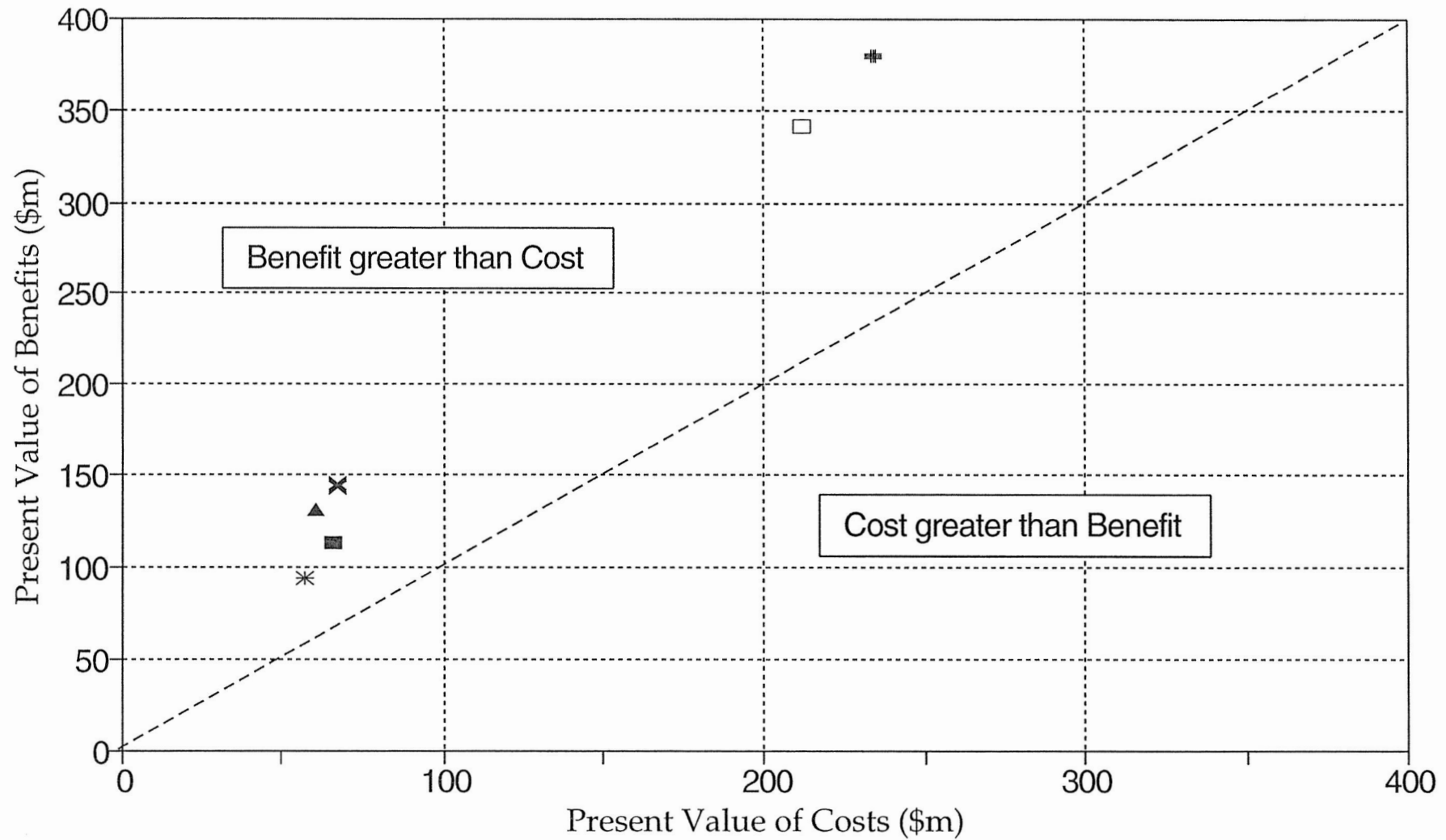
**Table 8.5 Financial and Economic Analyses of Options
(compared with Do-Minimum - Option A)**

Present Value \$m 1995	Options					
Costs and Benefits	D	E	F	G	H	J
Infrastructure Cost	7.81	20.27	5.05	13.09	7.81	0.00
Rolling Stock Cost	42.67	171.47	39.25	162.63	43.97	60.82
Total Capital Cost	50.48	191.74	44.30	175.72	51.78	60.82
Operating Costs	15.30	42.60	12.99	36.02	15.91	-0.61
Total Costs	65.78	234.35	57.29	211.74	67.68	60.21
Revenue	19.46	54.28	16.73	48.17	23.02	9.48
Operating Surplus (Revenue less Operating Costs)	4.16	11.68	3.74	12.15	7.12	10.09
Total Cash Flow (Revenue less Costs)	-46.32	-180.07	-40.56	-163.57	-44.66	-50.73
User Benefits	34.02	113.61	29.37	104.07	47.84	34.37
Decongestion & Accident Benefits	78.89	265.59	64.47	237.53	95.99	96.69
Total Benefits	112.92	379.20	93.84	341.60	143.82	131.06
Benefits less Costs	47.14	144.85	36.55	129.86	76.14	70.85
Benefit/Cost Ratio	1.7	1.6	1.6	1.6	2.1	2.2

- Notes
1. Some additions in the above table may appear inaccurate due to rounding.
 2. Automatic Train Protection (ATP) costs have not been included. In present value terms, ATP could add up to \$8.5m to Options E and G, \$3.3m to Options D and F, and \$5.1m to Option H.
 3. Operating costs include a sum for half-life refurbishment



Figure 8.1 Benefit Cost Analysis
(Comparison with Option A)



In summary the following comments are made:

- The financial analysis is presented in terms of the operating surplus (revenue less operating cost) and total cash flow (revenue less total costs).
- The economic analysis is presented in terms of benefits less costs, and the benefit/cost ratio (B/C).
- Compared with Option A, all options generate additional revenues which exceed additional operating costs. This implies that if the capital costs can be funded, the revenue subsidy may be reduced.
- The largest revenue surpluses are generated by Options E, G and J, all of which have early replacement of existing EMUs.
- The financial cash flows are, as expected, all negative and are an indication of the level of public funding which would be required to implement any of the schemes.
- User and non-user (decongestion and accident) benefits are large positive values for all schemes. With the exception of Option D, higher levels of benefit are generated by higher (total) cost schemes.
- Benefit cost ratios show that four Options (D, E, F and G) generate similar ratios of between 1.6 and 1.7. From experience of other public transport schemes all schemes are worthwhile projects.
- Options H and J generate even higher benefit cost ratios (over 2.1). This occurs with Option J because there is a large net benefit predicted from the use of new EMUs at an early date. However, this benefit is heavily dependent on people's perceptions of improved comfort and reduced journey times. Market research surveys would more accurately identify passengers' reactions where it is proposed to improve service quality.
- An incremental cost benefit analysis indicated the best option at different levels of cut-off benefit to cost ratio. For a B/C cut-off of 1.4 or above, Option J performs best; for a cut-off below 1.4, Option E performs best.
- The additional cost of ATP will affect the economic performance of all the schemes, except Option J. However, all schemes should retain positive benefit cost ratios.



8.7 Extension to Wellington International Airport

The economics of an extension of the base scheme from the proposed CBD terminus in Courtenay Place to the Airport via Kent and Cambridge Terraces, Adelaide Road to Wellington Hospital and over Constable Street to Kilbirnie and on to Wellington International Airport has been assessed at a very preliminary level.

From the sketch analysis based upon a 10 min frequency and a 15 minute one way journey time the extension would generate a small operating surplus of approximately \$1 million (NPV) and a benefit cost ratio of 0.28.

The total cash flow (revenue - costs) of -\$31 million, may be roughly translated into the order of subsidy required to operate the route. On this basis such an extension is not considered viable.



Section 9

ENVIRONMENTAL IMPACTS

9.1 General

There are a number of significant environmental and road user impacts that will result from LRT, both positive and adverse. Due to the preliminary nature of the study, the impacts have mainly been evaluated in a qualitative rather than quantitative form.

Impacts occur both during construction and operation of the LRT. This section examines both types of impact. However, road user impacts have been considered in greater detail in relation to operation of LRT.

9.2 Construction Environmental Impacts

During the construction phase the centre of Wellington will experience a number of impacts that are likely to be considered intrusive due to the nature and phasing of the construction work. However, in many cases these are comparatively short term. These effects are likely to include the following:

- exacerbation of peak time traffic congestion due to re-routing, road narrowing and constriction, temporary loss of bus and trolley bus lanes, and changes to on-street car parking;
- potential increase in vehicle emissions due to effects of congestion (because of construction) leading to a localised, temporary increase in the CO₂ contribution to national greenhouse gas emissions;
- disruption of existing underground services and potential realignment of services due to excavation work associated with new track laying within the town centre;
- dust and particulates associated with construction work;
- noise and vibration associated with construction work;
- pedestrian inconvenience due to footpath restriction and construction work;
- temporary construction employment opportunities;
- potential loss of retail trade from those businesses adjacent to construction work.



- possible modifications to Wellington Railway Station, which is listed as a heritage building in the Proposed Wellington City District Plan, in order to accommodate the LRT platforms.

The range and impacts of construction activities are summarised in Table 10.1, along with proposed mitigating measures.

Table 9.1 Potential Environmental Effects of Construction Activities

Construction Activities	Description	Potential Environmental Effects	Mitigating Measures
Utility Diversions	Existing building services and utilities may have to be diverted and/or protected. Services that may be affected include power, gas, telecommunications, water and sewerage. Track systems may have to be designed to accommodate underground service access.	Potential for disruption of utility services to users for limited time. Generation of noise, dust and particulates that may affect pedestrians. Vibration due to construction activities including piling. Potential traffic flow congestion, disruption and diversion. Loss of on street car parking. Potential retail sales impacts due to inconvenience to potential customers along route and reduced pedestrian movements	Consultation with, and explanation to all affected parties to minimise anticipation of utilities disruption. Potential for realignment of utilities to permit subsequent access. Construction site management measures include noise barriers and dust suppression techniques, whose use should ensure that there is no perceptible decline in air quality. Sensitive phasing of works should ensure traffic effects are minimised
On street track laying	This will require the excavation of existing roadways, the siting of foundations and track laying. The track will lie flush to the relaid road surface.	Potential disruption due to construction noise, dust and vibration. Excavation and movement of aggregates may also cause a degree of traffic disruption. Potential traffic congestion. Potential retail sales impacts.	Construction site management measures include dust suppression techniques, whose use should ensure that there is no perceptible decline in air quality. Sensitive phasing of works should ensure traffic effects are minimised.
Off street track laying	Additional track laying may be appropriate on part of the line between Johnsonville and Wellington.	Potential for limited disruption of existing rail services.	Track laying and associated works phased to avoid majority of rail movements.
Construction of Platforms	Some work may be needed to modify existing platforms to accommodate the new vehicles. There will also be a need to establish additional platforms along the new city route. These could comprise of approximately 60 metre long low level structures with ramp access for individuals with impaired mobility.	Pedestrian and retail disruption due to construction noise, dust and vibration. Potential restriction of pedestrian walkways. Potential traffic flow congestion, disruption and diversion.	Phasing and construction of platforms undertaken to minimise and ensure sympathy with surroundings. Platform design includes access for mobility impaired and could 'channel' pedestrian road crossings at specific points.
Mechanical and Electrical Works	Installation of poles, cables and overhead power supply equipment, secured as necessary to adjacent buildings.	Potential construction disruption includes noise and vibration due to piling for poles. Potential alteration to listed heritage buildings in the Proposed Wellington District Plan, where overhead cabling would be attached to buildings.	Impact upon identified heritage buildings minimised through sensitive design and connections only when, and if, necessary.



Construction Activities	Description	Potential Environmental Effects	Mitigating Measures
Servicing Depot	The depot could be located adjacent to the existing Johnsonville platform; however, existing EMU workshops could also provide servicing facilities	Potentially could require substantial area, dependent upon the track requirements.	Construction work phased to minimise disruption to existing rail services.
Transfer Facilities	Involves taking the track through the existing single/two story annexes to the NZR Station building	These would require modifications to part of Wellington Railway Station, a listed heritage building in the Proposed Wellington District Plan.	Sensitive design to retain historic character.

9.3 Operational Impacts

9.3.1 Environmental

The implementation and operation of the LRT could have the following environmental effects:

- provide a contribution towards the city transport sector reducing or stabilising its greenhouse gas emissions;
- result in the reduction of vehicle emissions and contribute towards an improved local air quality through alleviating congestion;
- improve transport network performance and enhance transport network capacity through reducing existing congestion and promoting greater energy and environmental efficiency in passenger movement - more people moving faster occupying less road space;
- provide a public and visible demonstration of progress towards an integrated transport solution for Wellington;
- reduce noise and vibration effects when compared with existing public transport provision;
- provide greater accessibility to, and mobility within the town centre, enhancing the city's retail and tourism opportunities;
- increase the number of passenger movements without additional adverse environmental impact;
- provide potential reductions in the number of road accidents through reduced congestion and improved traffic management.



Table 9.2 provides a more detailed summary of the significant operational environmental impacts resulting from the LRT. Where adverse effects are identified, mitigating measures are proposed.

Table 9.2 Potentially Significant Environmental Effects of LRT Operation

Environmental Effects	Potential Environmental Impacts (positive and negative)	Scale (Global, Regional, Local)	Mitigation Measures
Carbon dioxide (CO₂) emissions are one product of hydrocarbon combustion, and the global increases in CO ₂ levels are accepted as a prime contributor towards global climatic change. In particular, in developed countries, road transport (both diesel and petrol engined vehicles) are responsible for the emission of a substantial and increasing quantity of carbon dioxide.	The introduction of LRT into Wellington is anticipated to improve existing road traffic flows, which could reduce fuel consumption per passenger movement. By reducing fuel demand and consumption it is anticipated that CO ₂ emissions could be reduced by 165,000 tonnes during a 25 year period ending 2023.	Global	
Local road traffic atmospheric pollutants include primary pollutants such as hydrocarbons, particulates and oxides of nitrogen (NO _x). In addition there are the secondary pollutants such as low level ozone (O ₃). The effect of exposure to these pollutants, has been linked to a number of adverse health effects including the exacerbation of existing respiratory problems such as asthma and bronchitis. Oxides of nitrogen are acidic pollutants and can cause building material damage.	The introduction of LRT into Wellington will improve existing traffic flows through LRT passenger capture from other transport modes. Increasing transport efficiency will reduce the quantity of pollutant emitted per passenger and should lead to a comparative improvement in local air quality.	Regional and Local	



Environmental Effects	Potential Environmental Impacts (positive and negative)	Scale (Global, Regional, Local)	Mitigation Measures
Noise is likely to emanate from the vehicle itself and the interface between wheel and rail however, operational noise is difficult to ascertain against background of existing road traffic noise. Vibration from LRT operation include; wheels, interactions between wheel and track joints, and road surface irregularities.	It is anticipated that existing noise levels are unlikely to be substantially altered by the introduction of the LRT into Wellington because the change in road flows will be insufficient to produce a noticeable change in noise levels. The conclusion of other LRT studies (Sheffield, Nottingham and Croydon) has been that for city centres, the additional LRT noise is unlikely to be perceived as a nuisance once in operation. UK studies (Nottingham and Croydon) have concluded that there is no additional, unwanted vibration following the introduction of LRT.	Local	Good design of the LRT vehicles should reduce any vibration emanating from the vehicles themselves, whilst well laid continuous track and carefully laid road surfaces should minimise any vibration associated with the interaction between the wheels and other surfaces.
Transport: the LRT is anticipated to have an overall beneficial effect upon traffic movements within the Wellington city area.	The LRT should contribute towards reducing time spent travelling to city or through destinations and reduce the total distance travelled. It is anticipated that by 2011, the LRT will have reduced the average time spent in the road network by 13.5% compared with a 'do-nothing' scenario.	Local	
	Other road users apart from road vehicles may be affected. Pedestrians may be affected by the changes to existing walkways whilst cyclists may be affected or intimidated by the presence of rails in the road and the physical presence of the LRT vehicle.		The introduction and routing of cycle lanes may reduce the adverse impacts upon cyclists whilst the use of pavement textures and markings could provide clarity to all road users of the 'sweep' of the LRT.

Environmental Effects	Potential Environmental Impacts (positive and negative)	Scale (Global, Regional, Local)	Mitigation Measures
Visual Effects are likely to occur due to the introduction of the LRT, cabling and new structures such as platforms.	The degree of intrusion remains subjective. The impacts include substantial changes to the existing street scene and the potential temporary blocking of light by passing vehicles. Overhead cabling and supports may also cause a degree of visual intrusion.	Local	Sympathetic use of colours and design could enhance existing streetscape
Access and Mobility	Through ticketing should ensure improved accessibility to, and within Wellington city centre for both employment and tourism. The route and platforms provide the opportunity to make clear crossing points and to channel pedestrians to these points.	Local	Design consideration could include provision for persons with impaired mobility through the use of ramps and vehicle access points.
Economic factors	Improved accessibility to the city centre could ensure increased patronage of city retail centre, and that Wellington maintains its attraction as a employment centre. The LRT could ensure the city improves its attraction for tourists, especially if linked with the heritage tram proposals. The presence of the LRT could enhance the prestige of the city. The LRT could provide a combination of temporary short and long term employment opportunities through construction and operational work.	Regional and Local	

9.3.2 Impacts on Other Road Users

(a) *Traffic*

The presence of the LRT will have two principal impacts upon traffic flows. Firstly, the provision of a new transport mode will encourage some people to switch from using their cars to using the LRT, resulting in fewer vehicle trips on the network as a whole. Secondly, as a street running system, the LRT will also lead to the loss of some road capacity, and this is expected to increase travel times for those vehicles which remain on the network.

These two effects to some extent counter-balance each other. The WCC's TRIPS traffic model was used to identify the net or combined impact of these two effects which appears to be beneficial upon traffic conditions in the Wellington City area. Overall, travel times and distances are reduced, and in general, a marginal improvement in vehicle speeds is forecast. This benefit has been accounted for in the economic appraisal of schemes (Sections 7 & 8).

At any individual intersection level within the CBD, the maximum degree of saturation and queue length has been examined for each turning movement, to determine the change in conditions attributable to the presence of the LRT. The intersections and turning movements most affected in 2011 are shown by Table 9.3. In the AM Peak period, all intersections where a significant deterioration is forecast are already over-saturated without the LRT and hence the additional effect of the LRT is to disproportionately increase queues and hence delays at these locations. Improvements to the intersection control and refinement of the LRT proposals may generate some additional capacity at these locations to off-set that taken by the LRT.

Table 9.3 also shows the intersections where a significant improvement in conditions is forecast, due to general reductions in traffic levels and reassignment to alternative routes.

(b) *Trolley Buses*

The recommended CBD route coincides with a trolley bus route throughout the total length. This produces the need to have a second and independent overhead power supply system. Separation of the two sets of wires will be necessary and systems have been developed elsewhere. If the project proceeds, very careful consideration will be necessary to achieve the correct technical result and an acceptable aesthetic appearance. Some rearrangement of stops will be necessary including possibly changing the LRT stops described elsewhere.



Table 9.3: Intersection Performance, With and Without LRT

Intersection	Movement	Maximum Degree of Saturation (%)	
		No LRT	With LRT
<u>2011 AM Peak (Deterioration)</u>			
Mulgrave St/Thorndon Quay Lambton Quay/Hunter St Wakefield St/Cuba St	from Mulgrave St	109	115
	from Thorndon Quay	121	135
	Featherston St - Hunter St	102	135
	Wakefield (N) - Cuba	108	125
<u>2011 AM Peak (Improvement)</u>			
Hunter St/Customhouse Quay Stout St/Featherston St/Bunny St Mercer St/Victoria St Willis St/Manners St Taranaki St/Courtenay Pl	from Featherston St	84	74
	from Featherston St	145	110
	from Mercer St	107	90
	Boulcott - Willis (N)	114	100
	from Taranaki (S)	128	95
	from Manners St	143	103
	Taranaki (N) - Taranaki(N)/CP	144	77
	from CP - Taranaki (S)	141	9
	from CP - Dixon St	141	125
	from CP - Taranaki (N)	220	126
<u>2011 Inter-Peak (Deterioration)</u>			
Taranaki St/Courtenay Pl	from Taranaki (S) - Dixon St	96	113
	from Taranaki(S) - Taranaki (N)	96	113
	from CP - Dixon St	87	117

(c) *Pedestrians*

From the pedestrian point of view, the LRT runs through three types of environment, which are kerbside running, central running and through pedestrian only areas (ie Manners Mall).

Three areas of pedestrian impact have been identified:

- (i) access and egress from platforms
- (ii) impact of kerbside platforms on footpath flows
- (iii) running LRV vehicles in pedestrian malls

With the adoption of the sub option using Stout Street the length of "central" running is reduced. Only one median platform is proposed, on Lambton Quay near Panama Street.

Where kerbside running occurs the platforms are located in the parking lane. The height (generally 550mm) and length (60m) will form a barrier to persons crossing at random, even though steps are provided over part. However, stations are generally located close to intersections and the impact on free random crossings by pedestrians is considered to be minimal. Some studies indicate that random street crossings near but not on the crossing facilities provided, are associated with heightened accident risk. The "barrier" of the platform may, as a consequence, be beneficial in that it will channel road crossings by pedestrians towards the designated crossing points.

The location of the raised platforms against the kerbside reduces the "effective" width of the footpath. A level of service assessment indicates that in some areas a reduction in the effective width of the footpath will introduce localised pedestrian congestion.

In design it will be necessary to ensure that poles, canopy supports and the like are not located adjacent to the footpath. Covered platforms are recommended to ensure that people waiting for a LRV in inclement weather will not congest the footpath further by seeking shelter under shop verandas. Shop signs will also require control. Platforms sited in areas of wider footpaths such as the entrance to arcades should be favoured.

The running of LRVs in pedestrian-only areas is a common practice overseas. Even though the space available in Manners Mall is limited, it should not pose a major problem, particularly as there will only be a single track, and LR vehicles will pass through from only one direction. In areas shared by pedestrians and LRVs it is important to ensure that the most vulnerable users of the area, (ie pedestrians), exercise care and attention. Both pavement texture changes and markings should be employed to indicate the "swept" area of the LRV.



There are however some parts of the route where the swept path of turning vehicles results in minimal clearance to dedicated pedestrian areas such as footpaths. In these cases some form of "barrier", desirably flexible such as "bollard and chain" rather than a "solid" type, should be provided to delineate the areas.

(d) *Cyclists*

The principal impact upon cyclists results from crossing the tracks. While a well constructed track should not result in significant height differences between the pavement surface and the track the commonly experienced problems are loss of side friction when cornering and "tracking" .

Loss of side friction is most likely to occur at intersections where cornering cyclists cross the track. This is also a problem for motor cyclists. No data on rates and exposure has been located.

"Tracking" problems arise where cycle tyres are caught within the track. This occurs when the cycle paths and LRT track cross at an acute angle. The exposure is greatest with kerbside running but a particular problem results with the transition from central to kerbside running.

At the intersection of Lambton Quay and Willis Street and at Manners Willis Street the LRV swept paths are such that cyclists may be "squeezed" on the kerb side. LRV driver and cyclist education, together with pavement markings that indicate cyclists should allow the LRV to pass on the left, may be required.

No data on accident rates and exposure to the above problems has been located. However given that the majority of cyclists within the CBD are regular users this will assist to minimise the impact.

(e) *Accidents and Driver Behaviour*

In assessing the possible benefits from LRT account has been taken of the reduction in vehicle kilometres travelled. For a given accident rate (accidents per 100 million vehicle kilometres), which is assumed to not change, the accident reduction is calculated on a city wide basis.

The possibility of accidents involving the LRT vehicles themselves have not been included since specific data has been located. However public transport has a significantly lower accident rate per person kilometre travelled than private transport.



Section 10

RESOURCE MANAGEMENT ACT

10.1 General

Light rail comprises a number of activities which will require authorisation under the Resource Management Act 1991.

The land use activities associated with construction and operation include:

- erection and placement of structures - shelters, platforms, overhead wires, electrical supply, poles for overhead wires, LRT track in street, stations, depots, transfer facilities, signals and signs, and traffic and pedestrian management works
- attachment of overhead wires to buildings
- alteration of structures -

There is likely to be alterations required to existing structures, such as to accommodate transfer from heavy to light rail.

- removal and demolition of structures -

This is particularly likely around the Wellington Railway Station to accommodate transfer to light rail, and Courtenay Place areas. Some bus stops will need to be moved. Existing street furniture and traffic and pedestrian management works will require removal or demolition.

- excavation and other disturbance of the land - for moving services and adding the structures.
- street improvements - such as paving, lighting, bollards, warning signs to accommodate the light rail system and enhance the streetscape.
- removal or trimming of trees -

Some trees will have to be removed along the existing median strip along the Golden Mile.

- operation of the light rail system.

Under the Resource Management Act any land use activity can occur provided that it does not contravene a rule in a transitional district plan or a proposed district plan unless it has a resource consent or is an existing use.



The discussion of the Resource Management Act implications assumes that the construction and operation of a light rail system is not likely to occur within the next three years. This means that the new district plans in these areas are likely to be operative and will contain the rules which govern the construction and operation of a light rail system. If the new plans are not operative (or the relevant provisions effectively operative because there have been no appeals to the Planning Tribunal), then the transitional district plans will also have to authorise the activities involved.

There could also be a need for consents from the regional council for activities involving land disturbance, the taking, damming, or diversion of water, or discharges to air, land, or water, or work in stream and river beds and in the coastal marine area. The need for consents will depend on the provisions of regional coastal plan and other regional plans.

10.2 Light Rail System from Wellington Railway Station into the Central Business District

As proposed, the light rail system will run on existing roads from Wellington Railway Station and through the Central Business District. There could be a need for track and other works and the operation of the light rail system outside existing roads, such as around the Railway Station.

The Proposed Wellington City District Plan does not explicitly provide for the construction and operation of a light rail system in the central city. Neither does it explicitly provide for activities associated with roads either by listing them as an activity, or by designating them, in the central city. Instead the central city area provisions contain performance standards. If any activity not otherwise regulated can meet the performance standards, it can go ahead as of right. It is unlikely that the light rail system could meet all of these standards, either during the construction or operation phase.

The Proposed Wellington City District Plan would allow some, but not all, of the activities associated with a light rail system as of right. There are no restrictions on removing and trimming the trees affected. The proposed plan also provides for some traffic management activities as permitted activities.

The Proposed Wellington City District Plan has specific provisions related to heritage buildings which a light rail system would have to comply with unless the work proceeded under a designation. Resource consents would be required for attaching overhead wires to heritage buildings listed in the Proposed Wellington City District Plan.

There could be a need to alter or demolish part of the Wellington Railway Station, which is a listed building in the Proposed Wellington City District Plan. The Wellington Railway Station is designated in the Proposed



Wellington City District Plan for "railway purposes", with New Zealand Rail Limited as the designating authority. The designation would allow New Zealand Rail Limited to undertake works consistent with it.

It is noted that the Christchurch Heritage Tram proceeded on the basis that the Council could construct and operate a light rail system on public road designated as road in the Christchurch City Transitional District Plan. However, this authorization was only to the extent that the heritage tram creates no undue interference with traffic or public nuisance. It did not extend to works on privately owned land which were the subject of resource consents. As explained above, the roads involved in the light rail proposal are not designated as road in the Proposed Wellington City District Plan, and therefore the position is different.

There could be an argument that a light rail system is a form of transportation which would not prevent the common law right to pass and repass on a public road and therefore could occur on the existing public road as an existing use. However, the effects of a light rail system are likely to be different in character, intensity, and scale and therefore the use not qualify as an existing use.

It is advisable that the Wellington City Council provide appropriately for the activities associated with light rail in its district plan. This would put the status of the project beyond any doubt. It would also provide for public consideration of the proposed system, and allow mitigation measures to deal with any adverse effects on the environment.

10.3 Light Rail on Existing Railway Lines

The position with the running of light rail units on existing railway lines is different from laying new tracks and running light rail units.

The operation of light rail units on the railway line does not change the nature of the land use and therefore could be considered an existing use. However, the different units and an increase in the number of units using the line may change the character, intensity, and scale of the environmental effects.

New structures and works, such as the doubling of track, in the rail corridor are likely to require authorization through the proposed plan either through permitted activity status or designation, or by way of a resource consent. Any activities outside the existing rail corridor will also require such authorization.

It is noted that New Zealand Rail Limited is a requiring authority "for the operation, maintenance, and improvement of the existing railway system on land belonging to the Crown, or the New Zealand Railways Corporation, which is leased to New Zealand Rail Limited or in respect of which New



Zealand Rail Limited has a licence to occupy". This means that New Zealand Rail Limited can designate the land involved for railway purposes. New Zealand Rail Limited could also apply for requiring authority status for a project or work to construct or operate a railway line. This would then allow New Zealand Rail Limited to designate the land concerned.

10.4 Conversion of Johnsonville Line to Light Rail

The Wellington City Proposed District Plan designates the Johnsonville Railway Line as a "railway corridor", with New Zealand Rail Limited as the requiring authority. This would allow the necessary works within the designated corridor. Any areas outside the designated corridor would require separate authorization, which could be through an alteration to the designation to take in adjoining areas.

10.5 Use of Hutt Lines for Light Rail

The district plans of Hutt City and Upper Hutt City will soon be released. It would be advisable for these plans to clearly provide for activities associated with the dual use of the Hutt lines for light and other forms of rail.

10.6 Use of Kapiti Line for Light Rail

The Proposed Porirua City District Plan designates the route of the existing railway line for "Railway Purposes" with New Zealand Rail Limited as the requiring authority. The designation will allow a light rail use of the existing railway lines by New Zealand Rail Limited.

10.7 Summary

If the Council intends to undertake a light rail system, it is advisable that the council's district plan clearly and appropriately provide for the construction and operation of a light rail system. This will avoid any doubt about the position under the Resource Management Act. It will also allow public input into mitigation measures to deal with any adverse environmental effects.

It is also desirable that the district plans of Porirua City and Kapiti District (for the Kapiti line) and Hutt City and Upper Hutt City (for the Hutt line) provide for the activities associated with light rail.

Relevant regional plans and the regional coastal plan of the Wellington Regional Council could also provide appropriately for any activities required for the construction and operation of the light rail system.



Section 11

OWNERSHIP AND FUNDING

11.1 Framework

Before considering the ownership and funding options it is necessary to consider the opportunities arising from, and constraints imposed by, existing legislative, administrative, ownership, and contractual arrangements.

11.1.1 Ownership

- The Wellington streets for the extension of the light rail system are vested in the Wellington City Council and New Zealand Rail Limited owns the railway lines, so the two are critical parties to be involved in the design and planning process.
- The WCC could construct the light rail system and own the infrastructure. It could not operate the light rail system (including owning the rolling stock) unless it set up a Local Authority Trading Enterprise (LATE) for this purpose. However, it could contract out the operation of the LRT.
- The WCC can use roads for the construction and operation of a light rail system. There is a question as to whether private operators have the same powers available to them.
- The Wellington Regional Council cannot construct, own or have an interest in, or operate a light rail system unless an exception is made under the Local Government Act.
- New Zealand Rail Limited could run LRVs on its existing railway lines in terms of its lease of the land from the Crown. New Zealand Rail could also alter and extend its activities on its leased land, such as by doubling track, to meet the operational needs of a LRT.
- New Zealand Rail would have to agree to any other party using its existing railway lines, stations and other infrastructure, and leased land (unless penalty clause in effect).
- On Wellington streets the WCC could make appropriate arrangements with a private operator to construct and operate an LRT.



11.1.2 Funding

At present there is really no capital funding available from central government for a new public transport system such as light rail. However, the position is about to change. The Land Transport Law Reform Bill reported back to the House will completely change the funding arrangements for transport, including roading.

As the reform is still in its early stages, it is not possible to be certain about the way in which it will work. However, the Ministry of Transport, the body responsible for the legislation, advises:

- There will be a set amount of money available for transport over a long period of time (not year to year as it is at the moment).
- Transfund will decide how to allocate this money to all forms of transport, public and private.

The Land Transport Law Reform Bill gives Transfund the power to "fund outputs that consider or develop efficient alternatives to the provision or maintenance of roading" (clause 3CA(a)). These outputs can relate to passenger services and rail transport.

- The regional council will continue to be responsible for allocating subsidies to public transport operators. These subsidies will cover operating costs and not capital works. It is accepted that public transport operators will indirectly use operating subsidies to fund capital works, including upgrading buses and rolling stock.

The Regional Council may be able to negotiate longer term operating subsidies than it does at present which will provide greater certainty of a revenue stream for passenger transport operators and allow for their further investment.

- The future of the regional fuel tax is uncertain but appears limited.
- The Road Pricing Study is yet to be completed. Its implications have not been considered and Government policy developed in the current transport law reform.



11.1.3 Is the position likely to change?

It appears unlikely that central government will review its policy and the legislation which puts it into effect in the foreseeable future, particularly in view of the recent Land Transport Law Reform legislation. However, it may consider special legislation to provide powers to private operators to undertake light rail, if this is necessary.

11.2 Ownership Options

11.2.1 Important Ownership Factors

There are a large number of ownership options available for a light rail system. These options must recognise the:

- use of public roads vested in Wellington City Council for the LRT and LRVs.
- powers available to Wellington City Council in respect of the use and management of the roads, including the relocation of services
- ownership of the existing railway infrastructure by New Zealand Rail
- lease of railway land from the Crown by New Zealand Rail
- constraints on the Wellington City Council's involvement in constructing and operating an LRT.
- constraints on the Wellington Regional Council operating, or having an interest in, a passenger transport undertaking or operation
- arrangements with New Zealand Rail Limited and bus operators and their needs, and the requirement on Wellington City Council to not advantage or disadvantage any passenger transport operation unless acting in accordance with "accepted principles of town planning and sound traffic management". This would include considering the needs of Stagecoach for their use of trolley wires and related infrastructure down the Golden Mile.

The most suitable ownership option is likely to reflect the funding needs for the system.



11.2.2 General Funding Sources

Central Government has already rejected a continuation, increase, and/or extension to other fuels of the current regional petrol tax, with its decision to only support a continuation of the tax for the 1995/1996 financial year.

Central Government has also consistently opposed introducing other forms of taxes dedicated for public transport purposes. Examples of such taxes overseas are a pay-roll tax payable by all employees, a sales tax payable on all goods purchased or sold, and a poll tax payable by all persons on the electoral roll, within a given area.

It is possible that the Road Transport Pricing Study may recommend policy and legislation changes which open up other funding sources, such as introducing electronic road-use pricing and allocation of the revenues for transport purposes. It may recommend mechanisms for increasing parking charges, such as by giving councils the power to tax the supply of commuter car parks. While such mechanisms are likely to improve its economic viability, the private sector is likely to consider there is an associated risk because these policies can always be changed.

Increasing fares so that public transport users fund a greater proportion of the costs is likely to put the economics of the project at risk. It is also unlikely to achieve the council's objective of attracting more people onto public transport.

The likelihood of the Wellington City Council successfully borrowing funds from the commercial sector and servicing this debt from existing and/or new revenue sources is not known.

The Johnsonville-Wellington Corridor Report by Traverse Morgan (1993) suggested new territorial local authority funding for public passenger transport services, either as a contribution through the regional council or directly to providers of passenger transport works or services. The Government's new policy will go some way towards this, with a guaranteed amount over a long period available for regional councils to distribute as operational subsidies.

11.2.3 Specific Project Funding Sources

It is difficult to see that increasing the rates payable on land located close to stations which are most likely to benefit from the project will raise the necessary funding. Also it would only deal with those stations in Wellington City, unless the other councils agreed to participate and provide the additional rate take to fund the project which is unlikely.



Selling debentures in the project to ratepayers, with ownership of debentures qualifying the ratepayer for some form of rate relief has been suggested. However, this would need to be looked at carefully to check whether it was legally possible, or required a change to the legislation.

Selling development rights, particularly at or near stations, does not appear to be a feasible option at this stage of Wellington's development. New Zealand Rail Limited does not stand to gain from any development rights around Wellington Railway Station because the land is in Crown ownership and New Zealand Rail Limited only leases it for specific purposes. Some of the land around Wellington Station is subject to existing claims to the Waitangi Tribunal, and there are likely to be other claims. The Wellington Regional Council owns the Waterloo Interchange and is having difficulty divesting itself of it.

The Council would also need to gain the community's support to creating such development rights through its district plan. There could be difficulties in justifying development rights and financial contributions for the specific purpose of funding light rail under the Resource Management Act.

The Chamber of Commerce consultation suggested investigation of a system proposed for an LRT for Sydney could be worthwhile. This involves a proportion of the increased value of real estate along the route going to the developer of the light rail system. Such a system would require a change to the present legislation, or could be achieved by special legislation for Wellington.

11.2.4 Private Sector Funding

"Pure" private sector funding seems very unlikely to make anything more than a small contribution to the initial capital required. It is also noted that such private sector funding is likely to rely on a guaranteed revenue stream from an operational subsidy, as appears to be the case with the private consortium's proposals for light rail in Auckland.

11.2.5 The More Promising Options

Nearly all overseas light rail projects have a major injection of central government money to fund the capital works. Without this, any light rail project is very unlikely to proceed.

The new capital fund available for passenger transport appears to be the most promising source of funds for the capital works. There could be some potential to fund part of the capital works out of the operating revenue (including a guaranteed level of subsidy).



New Zealand Rail could be a potential private sector source of funding for capital works to extend the rail line through to Courtenay Place and for rolling stock. Its interest in this is likely to depend not only on the commercial viability of the project, but also the operating subsidy available. The company is also in a strong negotiating position because its agreement is a prerequisite to another operator using its railway lines.



Section 12

CONSULTATION

12.1 General

There was consultation with the following groups towards the end of the study, on the basis that this was a preliminary feasibility study. All groups indicated that they wished to be consulted on any further work into the feasibility of a light rail system for Wellington.

The main points to come out of the consultation are as follows:

12.2 Historic Places Trust

- Light rail can be compatible with the heritage buildings and the heritage areas in Wellington, if well designed.
- A concern that the light rail system does not affect the character of heritage buildings listed in the Wellington City Proposed and Transitional District Plans.
- In some situations it may be preferable for heritage buildings to act as supports for overhead wires, as is already the case with trolley wires, than for there to be special poles.
- The Trust wishes to be kept advised of and have the opportunity to be involved in further work on a light rail system if it proceeds beyond the pre-feasibility stage.

12.3 Chamber of Commerce

- A light rail system could bring people into Wellington to shop, thereby helping reverse the decline in Wellington's share of the regional retailing market.
- A concern that a light rail system could be another project which requires a high level of Council and therefore ratepayer funding. The Council is already considering how to fund the proposed Stadium. The Wellington City rates are already high nationally.
- An interest in the economic forecasts on which the assessment of the viability of a light rail system is based. The decline in the current economic environment of Wellington City, with industries moving out and the likelihood that office employment will not grow.



- An interest in the demand for a light rail system reflected in the assumptions made in the modelling work, including fares. A concern that European experience may not relate to the different situation in New Zealand, with factors such as driving for choice of school and a desire to reach home before dark.
- A light rail system, if economic, could increase bus patronage by taking the short distance passengers off the buses thereby speeding up the buses.
- There should be coordination of fares and ticketing for heavy and light rail and buses.
- Support for light rail if central government funding is involved and does not result in a reduced standard of other forms of public transport in Wellington.
- Could be potential to increase attractiveness of locations outside Wellington, such as the Kapiti Coast, for people to live because of more convenient journey to work.
- Suggested looking at the potential of a property value increase tax to go to a developer of a light rail system, as is being considered for Sydney.

12.4 Tangata Whenua

The Wellington Tenth Trust is the tangata whenua for the central city area. The central city area is where there would be extensions required to the existing rail network and a new interchange.

The Trust has two important interests in respect of a light rail system for Wellington. One interest is in connection with existing and any possible new land claims to the Waitangi Tribunal. The other is as the tangata whenua in terms of the Resource Management Act.

The Trust asked that the Wellington City Council consult with it over any further work on a light rail system for Wellington.

12.5 Disabled

There was consultation with the Disabled Persons Assembly (NZ) Inc and Accessible Buses Campaign. Both groups had similar points to make.

- The light rail system should be designed to be fully accessible. Retrofitting costs are high, as is being found overseas.



- There are major advantages for not only the disabled, but also the elderly, those with young children, young children, and other public transport users in having a fully accessible light rail service.
- A fully accessible light rail vehicle can load and unload people more quickly and reduce standing time at stops and delays for cars and public transport backed up behind the unit.

Reducing standing time at stops makes the service more attractive because people perceive that the service is faster. It also enables improved frequency.

- There are a large number of sources of demand for accessible transport.

There will be greater numbers of old and very old people with increasing likelihood of mobility impairment in the region demanding accessible public transport.

There are also greater numbers surviving from serious accident and illness, and greater participation in education, work, and recreation demanding appropriate transport.

Individuals with physical disabilities, intellectual disabilities, and multiple disabilities have greater independence and accessible transport requirements.

- If light rail units are not fully accessible, there will be a demand for disabled taxis (with wheel chair hoists) and parking in central city areas.
- The demand for disabled vehicle access and parking could mean exceptions need to be made in areas where cars are otherwise banned. This could reduce the amenity values of these areas.

Also the public reaction to perceived favoured treatment for a particular group could make it difficult for the Council to enforce the ban. This unfairly results in negative publicity for the disabled.

- Accessibility should include signage and other design features, including easy interchange between the various lines and the light rail service through the city.
- The design should involve market research into signage visibility, calling of stops, hand rails, and other features of light rail.



- There is a large amount of overseas experience and expertise in this area which should be drawn on.
- The Human Rights Act 1993 is an important piece of legislation which could require light rail units to be fully accessible.
- There is work underway by a range of Government agencies including the Ministry of Transport and the Land Transport Safety Authority into mechanisms which can ensure that public transport is totally accessible.

The Disabled Persons Assembly (NZ) Inc and its Wellington Branch, and Accessible Buses Campaign, would like to be consulted if the City Council undertakes further work into a light rail system for Wellington.

12.6 Stagecoach

- Stagecoach would want to continue running buses up the Golden Mile, as this route is very important to them. The linear nature of the route means that bus frequency is high and people are more likely to use buses.
- Stagecoach opposed the suggestion put up earlier by Transport 2000 that all public transport users in the city centre transfer to the light rail system. Note that this report does not propose this.
- A concern that light rail could result in there being less funding available for other forms of public transport, particularly buses.
- A possible interest in operating a light rail system, depending on the likely returns and operating subsidy.
- Stagecoach had indicated to the City Council that it would not be prepared to reroute buses, including trolley buses, down Featherston Street because of the loss of revenue until there was further development between the Waterfront and the Golden Mile. The WCC Urban Design Strategy (1994) proposed the change in route.

12.7 New Zealand Rail Limited

- New Zealand Rail could be interested in undertaking the capital works for and/or operating a light rail system depending on the likely funding, returns and operating subsidy.
- Light rail would be a more attractive commercial proposition if road users had to pay the real costs of their travel.



- New Zealand Rail had looked at allowing other operators to use their railway lines, but had concluded that there were operational and commercial reasons why this should not occur.

12.8 Newlands Coach Services

- LRT will enhance present competition.
- A concern with the economics of LRT which involves a big investment with doubtful returns.
- There is a funding shortfall in public transport, particularly for buses. It is better to put funding into enhancing the present system. There are several problems to be addressed, such as old bus stock, improving shelters, better transfer facilities.
- Relies on rail for the success of bus operation because of feeder services. Also relies on rail to reduce congestion on roads thereby speeding up buses.
- Loss of regional petrol tax has serious implications.
- Passengers have a resistance to transferring from one form of public transport to another. Passenger growth has occurred with the past two years, with nil fare increases.



Section 13

CONCLUSIONS

13.1 Route and Station/Stop Selection

- Three principal LRT corridors through the CBD have been investigated and approximately 15 options identified for preliminary analysis.
- Technically feasible routes are available in each principal corridor.
- A "Golden Mile" route following Featherston St, Stout St, Lambton Quay through to Courtenay Place will have the greatest potential to attract patronage and the least relative impact upon traffic. It offers the best penetration of existing and overall future land uses and does not separate the LRT system from the rest of the public transport system.

From the end of Lambton Quay to Manners St (East) the northbound and southbound tracks are divided because of the physical restriction at "Stewart Dawson's" corner; southbound via Hunter St, Victoria St and Cuba St; northbound by Manners Mall, Manners Street (West) and Willis St.

- Terminals must have space to allow LRVs to layover to ensure that proper schedules can be maintained. Courtenay Place is suitable though the area required for tracks and platform would impact severely on the proposed redevelopment.
- A stage development to the Bank of New Zealand at the corner of Lambton Quay and Willis St is feasible but could have some operational limitations.
- Station/stop locations are restricted to those which can accept 60m train lengths. Given the relatively short blocks in Wellington this has restricted the number of suitable sites.
- At the railway station a LRT station/stop on the station building side of Featherston St has been chosen to enable close, level access between the existing and proposed platforms to be provided.



13.2 Operational Features

- LRVs hold fewer seated passengers than EMUs. To maximise the use of LRVs it will be necessary for the most heavily loaded vehicles to carry up to 58 standing passengers. (This is much less than typical urban design standards of 122 standing passengers per LRV adopted elsewhere).
- The street/traffic signal environment will limit the frequency of light rail trains to 30 per hour. To carry the maximum number of passengers two complete LRVs are required which results in 60m long "trains". This is the maximum length that can be accommodated.
- Even with 60m trains, not all existing rail passengers can be carried. As a result it has been chosen to leave long distance passengers from Upper Hutt and Paraparaumu on express EMUs terminating at the Railway Station. To reduce total LRVs movements, the EMU service from Melling is also retained.
- There could be a track capacity problem at the entrance to the Wellington station. Improvements will be necessary to reduce train delays if it is decided to proceed with the project.
- In assessing future LRV frequencies passenger diversions from cars due to the improved quality, shorter door to door journey time and higher service frequency have been taken into account.
- When operating on the existing heavy rail track system LRVs must be capable of 100 km/hr to match existing train speeds. Currently, only high floor LRVs are capable of such speeds.
- A practical, low cost solution for improving accessibility to high floor LRVs in the central area is to use profiled platforms (as for Manchester (UK)). This decision could be reviewed if the project proceeds further.
- A dual voltage system is proposed (1500 V on rail lines, 750 V in central area).
- For safety reasons an Automatic Train Protection (signalling/control) system may be required on the rail lines as light rail vehicles will be mixed with heavy rail traffic. This could cost up to \$15m. The specific requirements will require further investigation.
- Compatibility with trolley buses can be achieved. Other cities do this.



13.3 Economic and Financial

- The financial and economic analyses used Nett Present Values based upon 10% discount value over 30 years. The Do Minimum (Option A) considers the conversion of the Johnsonville Rail Line to LRT in the year 2001 with replacement of the English Electric (EE) Electric Multiple Units (EMUs) in 2001 and replacement of the Ganz Magav (GM) EMUs in 2011.
- Compared with the Do Minimum, all options generate additional revenues which exceed additional operating costs. This implies that if the capital costs can be funded, the revenue subsidy may be reduced.
- The largest revenue surpluses are generated by options which have early replacement of existing EMUs.
- The financial cash flows are negative for all options and are an indication of the level of public funding which would be required to implement any of the schemes.
- User and non-user (decongestion and accident) benefits are large positive values for all schemes. The highest benefits, \$379.2M, are generated by the conversion of all lines to LRT and the extension of the LRT lines to Courtenay Place (Option E).
- The introduction of LRT on the Johnsonville Line together with early replacement of EMUs on the other lines (Option J) provides the highest Benefit Cost Ratio (B/C) of approximately 2.2.
- The use of LRVs on the Johnsonville Line and replacement of off-peak EE EMUs on the Hutt and Kapiti Lines with LRT to Wellington Railway Station in the year 2001 and the subsequent extension of the LRT line as far as Courtenay Place in 2011, (Option H) provides a B/C of 2.1. Note express and Melling services would run EMUs to Wellington Railway Station.
- Benefit cost ratios for the other four options tested (Options D, E, F and G) are between 1.6 and 1.7. From experience of other public transport schemes all schemes are worthwhile projects.
- An incremental cost benefit analysis indicated the best option at different levels of cut-off benefit to cost ratio.
 - For an incremental B/C cut-off of 1.4 or above, Option J (conversion of the present Johnsonville Line to LRT, and the early replacement of the EMUs on the other lines) performs best;



- For a cut-off below 1.4, Option E (conversion of all services except Express and Melling services to LRT, and the extension of the LRT line to Courtenay Place).
- The additional cost of ATP will affect the economic performance of all the schemes, except Option J. However, all schemes should retain benefit-cost ratios greater than one.
- In summary, the economic analysis clearly shows that an LRT scheme which extends rail services into the centre of Wellington is worthwhile.
- Unquantifiable benefits not taken into account include:
 - reduction in traffic noise and pollution;
 - less need for new, intrusive roads and car parks;
 - much better transport for disabled and mobility impaired persons;
 - assistance in enabling strong central areas for business, shopping and leisure activities.
- In economic terms, the best LRT terminal site is shown to be at Courtenay Place. However a lower cost scheme could be implemented, terminating in the vicinity of the Bank of New Zealand Willis St. In practical terms it could be worthwhile having two terminals to improve flexibility, increase space (and time) to layover vehicles and to assist in recovering when schedules are significantly disrupted.

13.4 Impacts

- There will be short-term adverse environmental effects associated with construction of a light rail system, but these will be outweighed by the long term environmental benefits that will result.
- There are mitigation measures which can deal with the adverse environmental effects resulting from the construction, and operation, of a light rail system.
- The presence of the LRT will have two principal impacts upon traffic flows. Firstly, the provision of a new transport mode will encourage some people to switch from using their cars to using the LRT, resulting in fewer vehicle trips on the network as a whole. Secondly, as a street



running system, the LRT would lead to the loss of some road capacity, and this is expected to increase travel times for those vehicles which remain on the network. Overall, travel times and distances are reduced, and in general, a marginal improvement in vehicle speeds is forecast.

13.5 Resource Management Act 1991

- If the council intends to undertake a light rail system, the council's district plan and the other relevant district plans and regional plans should appropriately provide for the construction and operation of a light rail system.
- Appropriate provisions in district and regional plans will make the status of the light rail system under the Resource Management Act clear. It will allow public input into mitigation measures to deal with any adverse environmental effects.

13.6 Funding and Ownership

- The WCC owns the streets and New Zealand Rail Limited owns the railway lines, so the two are critical parties to be involved in the design and planning process.
- The WCC could construct the light rail system and own the infrastructure. It could not operate the light rail system (including owning the rolling stock) unless it set up a LATE for this purpose. However, it could contract out the operation of the light rail system.
- The WCC can use roads for the construction and operation of a light rail system. There is a question as to whether private operators have the same powers available to them.
- The Wellington Regional Council cannot construct, own or have an interest in, or operate a light rail system unless an exception is made under the Local Government Act.
- New Zealand Rail could run light rail units on its existing railway lines in terms of its lease of the land from the Crown. New Zealand Rail could also alter and extend its activities on its leased land, such as by doubling track, to meet the operational needs of a light rail system.
- New Zealand Rail would have to agree to any other party using its existing railway lines, stations and other infrastructure, and leased land (unless penalty clause in effect).



- On Wellington streets the WCC could make appropriate arrangements with a private operator to construct and operate an LRT.
- The Land Transport Reform Bill, when enacted, will bring in a new funding framework for public transport.
- The most likely source of funding for the capital works appears to be a contribution from the proposed new transport fund for the capital costs of establishing the LRT, including purchasing the rolling stock.
- The most likely funding prospects for the operating costs of the LRT is the revenue stream from the operation of the light rail system and an operating subsidy.

13.7 Consultation

Key points from those groups and organisations consulted were:

- the need to ensure design of LRT in Wellington City considers heritage buildings and character areas (Historic Places Trust);
- the need for LRT to be fully accessible, and advantages of this (Disabled Persons Assembly (NZ) Inc and Accessible Buses Campaign);
- concern by existing bus operators that LRT could divert funding in an already underfunded area away from buses (Stagecoach and Newlands Coach Services);
- Stagecoach wants to continue running buses on the Golden Mile;
- New Zealand Rail Limited could be interested in undertaking the capital works for and/or operating an LRT depending on the likely funding, returns, and operating subsidy;
- Bus operators could be interested in operating an LRT.

The Wellington Tenth Trust, the tangata whenua for the central city area, has two important interests. One is in connection with existing and any possible new land claims to the Waitangi Tribunal. The other is as the tangata whenua in terms of the Resource Management Act. The Trust asked that the Wellington City Council consult with it over an LRT for Wellington.

If the Council intends to advance the light rail work further, the Council continue to consult with interested groups (including the Wellington Tenth Trust, the Historic Places Trust, the Disabled Persons Assembly (NZ) Inc and its Wellington Branch, the Accessible Buses Campaign, the bus operators, and New Zealand Rail Limited) and also consult more widely.





13/12/2014
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APPENDIX



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- 2 Table A1 - Long List of Routes Considered in Preliminary Analysis
- 3 Table A2 - Details of Proposed Station/Stop Locations



DETAILED DESCRIPTION OF GOLDEN MILE ROUTE

1 Main route

Northbound and southbound tracks following the same route.

1.1 Railway Station to Lambton Quay

The route passes through the centre of the Mulgrave St/Thorndon Quay/ Featherston St intersection and brought to the centre of Lambton Quay. The alignment through the bus terminal would need to be set to minimise the effect on the bus operations and parking. An additional phase will be required in the traffic signals at the intersection.

1.2 Lambton Quay

Bus Terminal to Hunter St. The route follows the existing median and the tracks are located adjacent to the kerbs.

The width of the median is adequate for an island platform at both the Stout St (Public Trust) and Cable Car stations. Access to the platform will depend on the floor height of the vehicles. For the high floor vehicle access will be via ramps at the end which connect to existing pedestrian crossings (at one or both ends).

The platforms will require some existing trees to be removed or trimmed.

To accommodate a stop at the Public Trust Building it is proposed that the eastern kerbs of both the outside and median edge of the road be modified to form a straight section suitable for a 60 m long platform. Access to the platform would be via the pedestrian crossing at the Stout St crossing and an additional one provided close to the De Bretts Tavern.

Some similar but less extensive modifications will be necessary to the median between Panama and Brandon Streets to form a 50 m long straight platform. Access to the stop will be via the existing pedestrian crossing at Brandon St and a new one formed across Lambton Quay opposite the south side of Panama St.

1.3 Hunter St to Willis St

Between Brandon and Hunter St, Lambton Quay reduces in width, and between Hunter St and Willis Street. The kerb to kerb distance is 6.0 m



For two tracks to be fitted in between the existing kerbs at the minimum point the standard distance between LRVs, and between LRVs and kerb would be 100 mm and 50 mm respectively on the straight, without taking into account the swept paths. The width of the footpath on the old BNZ side is already narrow and reducing the width further to obtain greater clearances is undesirable.

On the eastern side of the street the escalators which provide access to the BNZ underground shopping complex restrict any modifications to the kerb location.

It is understood that the future development of the old BNZ building includes removal of the up escalator which would permit the swept paths to be accommodated but not the minimum width on the straight. It is also noted that it is proposed to reduce the lane width to 4.5 m between kerbs. Thus Alternative 2 of the two given below is the favoured option at present.

Trimming of the existing trees will be necessary over the whole length.

The number of marked traffic lanes varies over the length of Lambton Quay. As a consequence, the impact on traffic changes between locations. A shared LRV/vehicle lane will be necessary.

The alternatives to this route over this section are given in Section 2.

1.4 Willis St

Willis Street is at present two-way with a minimum kerb to kerb to width of 8 m. The southbound direction is bus only. The road width should be adequate for two LRT tracks, and the present goods loading bays on the western side can be maintained though the width of the bay would be about 2.3 m which is minimal and not entirely suitable for large trucks. However this could be increased by reducing the separation gap between the opposing LRV tracks.

At both the Lambton Quay and Manners St end of Willis Street the location of the tracks within the street is influenced by the LR vehicle tracking curves at those points.

The change in direction turning from Willis St into Manners St is approximately 60°. A twin track turn can be achieved but requires adjustment to the kerb lines on both the inside and outside of the curve which also affects some service covers. The northern shift is of the order of 3 m at about the centre of the curve which pulls the kerb back to where it was originally once before the street upgrading works. A reduced width between the track, or overlapping, could be adopted at these corners but is not desirable because of the



delays it will introduce at peak times on the LRT.

Between Mercer St and Manners St, Willis St is one way for vehicles. With a contra-flow LRV direction, one lane will be lost to traffic and the existing Goods Loading Zone may have to be relocated to the opposite side of the street (with loss of trees) or abandoned.

The traffic island at the Mercer St intersection will have to be modified to accommodate the "Southbound" track and the right turn from Willis St into Mercer will have to be combined with the through lanes unless the street is widened. If the kerb is set back to the original location (ie before the street improvements) there would be room for 2 traffic lanes but at the expense of the pavement used by patrons of the local restaurants.

1.5 Manners St (West)

Manners St is generally 7 m between kerbs though this reduces at the Victoria St Extension end to 6 m. The street operates as one lane (one way). The width overall is sufficient for two LRV tracks. However, to provide a platform requires taking over some footpath space which is undesirable.

1.6 Manners Mall

The distance between verandas varies along its length but is generally 9.5 m. This is adequate for 2 tracks. The existing streetscape, in particular the trees, will be substantially effected. If only one track is taken through the Mall then it would have least impact on the existing trees and street furniture if it is located generally on the northern side of the centre-line.

1.7 Manners St (East)

As this street is one way (one lane marked) the northbound track will occupy a dedicated lane and be located close to the southern kerb line. Kerbside running, ie track centreline located 1.5 m out from south side kerb, will fit in with having a station platform occupying the loading zone. The southbound track and vehicles will share the same space while parking/goods loading can be retained adjacent to the northern kerb.

1.8 Courtenay Place

It is proposed that the tracks be centrally placed although kerb side running over part could be necessary

To accommodate the anticipated peak number of LRV arrivals, passenger volumes, turn around times, delays and possible breakdowns, four tracks, each 60 m long, are needed at the Courtenay Place terminus. A suitable layout can



be achieved within the available space, but would occupy all of the southern side of the present roadway area and remove all of the planned streetscape development. The proposed roading layout could be largely retained although some modifications would probably be necessary.

2 Alternative Routes

2.1 Southbound Direction (Lambton Quay/Hunter St to Manners St East/Cuba St)

Alternative 1. Southbound track via Hunter and Custom House Quay/Willis Street. Northbound track via the Old BNZ/Stewart Dawson's "throat".

The two turns at Lambton Quay/Hunter St and Hunter/Custom House Quay (90°) can be negotiated by a single LRV using 25 m radius curves. However for both central and kerb side running the track path interferes with other vehicles and pedestrians severely. Refer Figure A2.

Alternative 2. Southbound track via Hunter/Victoria/Wakefield/Cuba Streets.

For the turn from Hunter St into Victoria St, the comments made above apply except that Hunter Street, between Custom House Quay and Victoria Street, is wider and the problems of swept paths is eased but not entirely mitigated. The inside lane will have to be for cars only as the tracking of larger vehicles including buses overlaps with the LRV.

The street geometry, traffic direction and the station/stop location favours footpath kerb side running over this length.

- Victoria St

The street is 12.5 m wide, one way, and with parking on both sides except for a section by the Bank of New Zealand.

The track location is influenced by the geometry of the turn into the street from Hunter St and will be best located immediately outside the present parking along the eastern side of the street.

A station/stop outside the Central Library is proposed. The existing local parking would be lost, but the footpath space will be only marginally reduced.

- Wakefield Street

This street is two-way with parking on both sides. A track location as for Victoria St retains the existing parking. The LRV and "southbound" traffic would share the same lane including the turn into Cuba St.



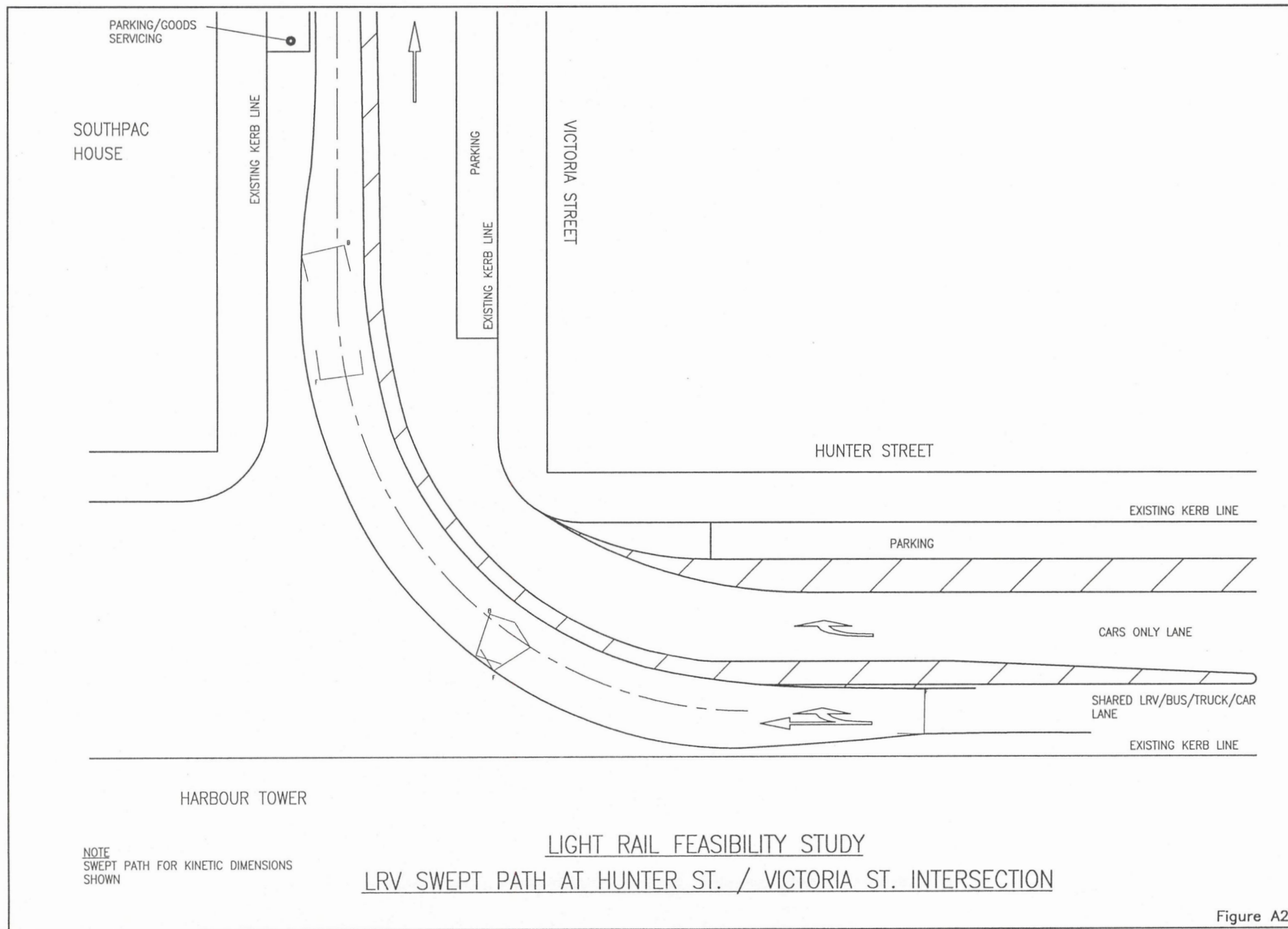


Figure A2

- Cuba St

Cuba St is at present one-way with one marked traffic lane. Parking and goods servicing occur on both sides. With the track located at 4.75 m from the kerb the existing goods servicing/bus stop can be retained. However this will be severely affected by the platform if a LRV stop is located here.

2.2 Northern End

A sub option is for the route from the railway station to be via Featherston and Stout Streets into Lambton Quay. This has the advantage of shortening the route length, fits the disposition of passenger catchment and proposed station locations well, and suits the preferred railway station connection better than the Lambton Quay option.

Either central or kerbside running is possible but with a slight preference being given to a footpath side location of the track to suit the platform locations.

Two station/stops would be provided at the Lambton Quay end of Stout St.

3 Station/Stops

The recommended location of the station/stops including details such as platform length, distance from the Railway station for the favoured option are given in Table A2.



Table A1: Light Rail Feasibility Study - Routes Considered in Preliminary Analysis

Vtroute

Golden Mile"	1	Twin track all the way		Lambton Q	Willis	Manners W	Manners M	Manners E	Courtenay				Length	Comments
													2.42	
	1a	Split track part way	South bound	Lambton Q	Hunter	Willis	Manners W	Manners M	Manners E	Courtenay			2.46	South bound
			North bound	Lambton Q	Willis	Manners W	Manners M	Manners E	Courtenay				2.42	North bound
	1b	Split track part way	South bound	Lambton Q	Hunter	Victoria	Wakefield	Cuba	Manners E	Courtenay			2.49	South bound
			North bound	Lambton Q	Willis	Manners W	Manners M	Manners E	Courtenay				2.42	North bound
	1c	Twin track all the way		Lambton Q	Hunter	Victoria	Wakefield	Cuba	Manners E	Courtenay			2.49	
	1d	Twin track all the way		Featherston	Stout	Lambton Q	Willis	Manners W	Manners M	Manners E	Courtenay		2.37	
	1e	Split track part way	South bound	Featherston	Stout	Lambton Q	Hunter	Willis	Manners W	Manners	Manners E	Courtenay	2.42	South bound
			North bound	Featherston	Stout	Lambton Q	Willis	Manners W	Manners M	Manners E	Courtenay		2.37	North bound
	1f	Split track part way	South bound	Featherston	Stout	Lambton Q	Hunter	Victoria	Wakefield	Cuba	Manners E	Courtenay	2.45	South bound
			North bound	Featherston	Stout	Lambton Q	Willis	Manners W	Manners M	Manners E	Courtenay		2.37	North bound
Central"	2	Twin track all the way		Featherston	Lambton Q	Willis	Manners W	Manners M	Manners E	Courtenay			2.29	
	2a	Twin track all the way		Featherston	Hunter	Willis	Manners W	Manners M	Manners E	Courtenay			2.33	
	2b	Twin track all the way		Featherston	Hunter	Victoria	Wakefield	Cuba	Manners E	Courtenay			2.33	
	2c	Twin track all the way		Featherston	Hunter	Victoria	Wakefield	Taranaki	Courtenay			2.36		
Waterfront"	3	Twin track all the way		Featherston	Whitmore	Custom Hse	Jervois Q	Cable	Kent	Oriental	Courtenay		2.37	
	3a	Twin track all the way		Featherston	Whitmore	Custom Hse	Jervois Q	Wakefield	Oriental	Kent	Courtenay		2.26	
	3b	Twin track all the way		Featherston	Whitmore	Custom Hse	Jervois Q	Cable	Taranaki	Courtenay		2.2		

Table A2 Details of Proposed Station/Stop Locations

	Location	Distance from Railway Station	Platform Length	Impact/Effect	Comment
1. Railway Station	Featherston St SB NB, Option 1 NB, Option 2		65 m 60 m + ramps 60 m + ramps	SB lanes reduced from 3 to 2, SB lanes in Featherston St affected as for Option 1 Bus lane outside Rutherford House reduced in width	Possible connection to existing pedestrian subway sited in bus park
2. Stout St	Lambton Quay, kerbside	400 m	50 m + ramps 55 + ramps	NB - occupies existing bus stop/parking SB - occupies existing angle parking	
3. Lambton Quay	Harbour City Centre/ Cable Car, Median	750 m	55 m + ramps	Platform in median. Track occupies traffic lane	NB traffic lane reduced in width to provide adequate length of straight for platform. Bus stop and goods loading zone retained.
4. Willis St (NB)	Airways House/Capital Carpark, Kerbside	1250 m	55 m + ramps	Platform occupies 2 loading zones and pedestrianised area	Platform edge forward of existing kerb (of pedestrianisation)
5. Victoria St	Central Library	1350 m	50 m + ramps	Occupies short term parking zone and metered parks	
6. Manners St (East)	The Oaks (NB) Taranaki St (SB) Option 1 Option 2	1750 m 1750 m 1750 m	60 m + ramps 60 m + 4 m ramps 50 m + 4 m ramps	Service/loading zone Bus stop/Taxi Stand/traffic lane at intersection	Service Access to the Oaks will have to be resited approx 10 m towards Taranaki St Lukes Lane - exit/entrance to Manners St closed Lukes Lane remains open



	Location	Distance from Railway Station	Platform Length	Impact/Effect	Comment
7. Courtenay Place	Cambridge Tce	NB 2350 m SB 2450 m	2 @ 60 m + ramps	ex Bus Stop, proposed parking and street improvements	A third 50 m length could be provided.

NB = Northbound direction
SB = Southbound direction



