NorthWellington public transport STUDY

Scenarios Technical Appendicies

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North Wellington Public Transport Study

NORTH WELLINGTON PUBLIC TRANSPORT STUDY SCENARIOS TECHNICAL APPENDICES

- Issue 1
- 6 June 2006

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Scenarios Technical Appendices

The Scenarios Report presents credible future public transport scenarios for the northern suburbs as part of the North Wellington Public Transport Study This document provides detailed information used in developing those scenarios.

Information on the Study is available at www.gw.govt.nz

Appendix C Enhanced Rail

C.1 Enhanced Rail Scenario

The current Johnsonville railway line service is a well established public transport service serving Johnsonville, Raroa Khandallah Ngaio and Crofton Downs for nearly seventy years. The essence of the enhanced rail scenario is:

- Replace the current English Electric Multiple Units (EEMUs) with their modern equivalent Electric Multiple Units (EMUs)
- Undertake station upgrades and other infrastructure improvements

Overall, this scenario proposes retaining the current rail service with some timetabling and service quality improvements.

C.2 New EMU Units

New EMUs could be purchased to replace the existing EEMUs on the Johnsonville railway line. These new units would have the following characteristics:

- Comparable carrying capacity to the existing EEMUs (or slightly more)
- Much improved passenger comfort and public attractiveness
- Improved operational characteristics (acceleration / deceleration etc.)
- Allow reduced operational costs (if implemented with integrated ticketing)
- Lower maintenance and operating costs than the existing units (in the order of 10%)

In October 2005, GRWC commissioned consultants to develop a procurement strategy for the purchase of new EMUs for use on the Wellington Network. The consultants are currently developing the specification for the new units. It is expected that the kinematic gauge would be similar to that of the existing Ganz Mavag (GM) units so that they can operate on the majority of the Network without the need for infrastructure modifications.

For the purposes of this study, we have assumed that any new units operated on the Johnsonville railway line would be the same as those being proposed for the rest of the network. This would provide standardisation of rolling stock on the Network. The new units would have a kinematic gauge which is larger than the existing EEMUs and would not be able to operate on the Johnsonville railway line without infrastructure modifications such as tunnel lowering and platform lengthening and raising. Because the units would have a similar kinematic gauge to the GM units, it has been assumed that the modifications required would be consistent with those which have been identified as required to allow the GM units to operate.

The operational performance of new units would be significantly better than the GM units and Greater Wellington procurement staff have been assured by manufacturers that new units would be able to operate efficiently on the Johnsonville railway line. The rolling stock consultants are to specify the new units to operate at the gradients etc. found on the Johnsonville railway line.

- Typical modern EMU

C.3 Refurbishment of the Existing English Electric Units

One option considered is to refurbish the existing EEMUs so that they could continue to operate on the line in the future. An advantage of refurbishing the EEMUs would be that they would be able to continue operating on the Johnsonville railway line without the need for extensive infrastructure modifications such as tunnel lowering and platform amendments.

As noted previously, the refurbishment work currently being undertaken would only extend the lives of the units for three to five years. A much more extensive refurbishment programme would be required to extend the lives of the units for some 10 years.

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In order for the EEMUs to provide an acceptable level of service in the future, it is considered that the following refurbishment and improvement works would be required as a minimum:

- Full body and structural refurbishment including excision of all areas of corrosion
- Full repainting
- Full mechanical overhaul
- Full electrical overhaul
- Complete replacement of vehicle interior. This would include complete redesign of the interior, with replacement of the seating, lighting windows, luggage racks etc.
- Total redesign of the drivers cab interior
- Fitment of air-conditioning
- Replacement of bogies (to improve ride quality or if significant bogie cracking problems are identified)
- Driver operated doors

It should be noted that even with a major refurbishment, there is little scope to improve the crashworthiness of the cars which fall well below modern standards. It is anticipated that station refurbishments would be undertaken as envisaged in the Rail Business Case (RBC).

The rolling stock refurbishment works would extend the life of the units for approximately 10 years. At that time, the condition and viability of retaining the units would need to be considered again. It is likely that due to their age and poor crashworthiness, the units would no longer be suitable for operation on the network and would need to be retired.

The RBC considered the possibility of refurbishing the EEMUs but rejected it on the basis that cost of the refurbishment of the units would approach the cost of purchasing new units.

C.4 Refurbishment of Ganz-Mavag Units for use on the Johnsonville railway line

The RBC envisaged that once new rolling stock had been purchased for operation on the busier, longer distance routes on the Network, the existing Ganz-Mavag (GM) Hungarian units would become available for refurbishment and transfer onto the Johnsonville railway line.

The GM units have a longer length and larger kinematic gauge than the EEMUs and to operate them on the Johnsonville railway line would require significant infrastructure works. These are likely to include:

- Tunnel floor lowering
- Horizontal track realignment

- Reduction of cant
- Introduction of slabtrack (or similar) to improve track fixity
- Bridge lowering adjacent to tunnels
- Extension of the Wadestown passing loop
- Some signal relocation
- Platform lengthening, raising and realignment
- Re-registration and regrading of the overhead catenary system
- Relocation of station platforms to reduce curvature and stepping distance

It has also been identified that the GM units have a lower power-weight ratio than the EEMUs. The GM units already suffer wheel slip during acceleration and slide during breaking on less demanding parts of the network (the effect of this is increased and unnecessary rail head wear). They would therefore struggle to maintain the uphill timetable in good adhesion conditions, and may not even be able to operate in poor adhesion (i.e. wet weather) conditions. There would be associated traction motor damage due to over speed operation and downhill there would be increased and unpredictable stopping distances.

A report is being produced by Toll and ONTRACK to address these issues and is due in 2006. Preliminary indications were that it would be unlikely that power-weight ratio improvements to address these problems would be economical, however latest reports indicate that the GM units may be able to operate with minor improvements and testing of the units is being undertaken at present to confirm their acceptability.

For the purposes of the public consultation it has been assumed that the use of the GM units would be viable and their performance and operation on the Johnsonville railway line would be similar to new EMU units.

C.5 New Metro or Light Rail Units

The purchase of new Metro (Underground) or light rail units which are small enough to operate on the Johnsonville railway line without infrastructure improvements has been considered. However, these smaller units would not provide significant operational or passenger benefits over new or refurbished EMUs, as without infrastructure improvements, LRVs or Metro units could only operate a similar timetable to EMUs.

There are safety issues with crashworthiness of these types of units when run on the same lines as heavy freight (i.e. Wellington yards).

The use of non-standard units on a small section of the Network would also be problematic for operational reasons. The units would not provide a strategic fit with the rest of the Network as they could not be used on other parts of the Network. This would result in disproportionate costs associated with operating and maintaining a small number of non-standard units.

Metro units would have lower passenger carrying capacity than EMUs, requiring more units or more frequent services. Again, given that the cost of a new Metro unit is in the order of $2 - $3m, a large proportion of the cost of infrastructure improvements required to allow new EMU units to operate on the line would be off-set by the smaller number of units required.

Advice from manufacturers is that a bespoke rolling stock build for Metro units coupled with the anticipated small order could in fact incur a premium of up to 50%.

For the above reasons, the purchase of new light rail or Metro units just for use on the existing tracks between Johnsonville and Wellington Station has not be considered further as part of this study. LRVs are considered further as part of a Light Rail scenario providing a seamless service through the CBD.

C.6 Timetable Improvements

Improvements to the existing rail timetable have been considered to provide additional capacity in the future and a more regular, reliable service. The RAMESES train performance modelling system (Railway And Motive Power Engineering Simulation And Evaluation System) was used to model the operation of rail units on the Johnsonville railway line. The documented characteristics of the EEMUs and modern EMUs were input into the simulator to obtain the necessary projections for the journey run times and the schedules were modelled assuming a 20 second dwell time at all stations.[1]

C.6.1 Without Infrastructure Improvements

The current timetable indicates a journey time of 21 minute between Wellington and Johnsonville for the EEMUs. Modelling using the documented characteristics of EEMUs suggests that actual journey times with a 20 second dwell time for all stations are on average 23 - 24 minutes with layover time used to make up the timetable.

The possibility of improving the frequency and capacity of the rail services on the line by introducing a new train in the 13 minute – 13 minute – 26 minute frequency to give a sustained 13 minute frequency has been investigated. The analysis indicates that with some minor adjustment to the timing of services, this could be achieved.

[1] This dwell time is less than existing. It is considered that with improved operational procedures, 20 second is appropriate.

Modelling of the modern EMUs reflected an improved performance for the journey between Wellington to Johnsonville of approximately 46 seconds over the EEMUs. The efficiency of the modern units could not be fully capitalised due to the constraints of speed restrictions on sections of track and tunnels throughout the line, and bottlenecks for crossing requirements between Wadestown and Wellington, and between Johnsonville and Khandallah.

The modelling undertaken indicates that using the existing track layout and station configuration, frequencies greater than 13 minute for the EEMUs or modern EMUs could only be achieved by imaginative rescheduling practices such as express or skip stops between selected sections or stations.

The introduction of an emergency only loop at Simla Crescent would need to be considered to provide further flexibility and reliability.

C.6.2 With Infrastructure Improvements

Improvements to the timetable through installation of new passing loops and station rationalisation and relocation were investigated.

As noted above, modelling of the train operations indicates that there is a bottleneck caused by the single track section between the Wadestown passing loop and Wellington Station. Trains must wait at the Wadestown loop for trains going in the opposite direction to make the approximately 5 minute journey from Wellington Station to Wadestown. An approximately 200m long passing loop is required in the Wellington Yards immediately north of where the Johnsonville railway line deviates from the Up Main Line to enable trains to cross.

The modelling undertaken also indicates there is a bottleneck caused by the single track section between the passing loop at Khandallah Station and Johnsonville. Trains must wait at the Khandallah loop for trains going in the opposite direction to make the journey from Johnsonville Station to Khandallah. A passing loop is required between Johnsonville and Khandallah to allow the trains to cross in the vicinity of Raroa Station. There is not sufficient room to maintain both a passing loop and station at Raroa, therefore one scenario is to remove the station and replace it with a passing loop. An alternative scenario is to relocate the station and passing loop to the vacant land north of the Fraser Avenue crossing. If a new station was constructed in this location it would provide potential for constructing additional park ‘n’ ride and offer links to the Melvina Major Retirement Village, Broadmeadows and surrounding schools.

A conflict between northbound and southbound trains also exists at Box Hill Station. Again there is insufficient room to maintain both a station and a passing loop. Box Hill Station is located on a section of the line with very close station spacing. If the station was removed, there would be little impact on catchment area for the line. The spacing between the remaining Simla Crescent and

Khandallah Stations would be in the order of 950m which is an appropriate spacing for stations on a suburban railway line. Rail surveys undertaken in 2002 indicate that the station is not heavily utilised with just 89 passengers boarding[2] at the station (both directions) over the entire day. Therefore, it is considered that removal of the station would not have a large impact on patronage. The level of public opposition to the removal of an existing station would need to be considered in some detail.

It can be concluded that with the addition of passing loops at the Wellington Yards, Box Hill and Fraser Avenue, 6 x four car trains could sustain a ten minute service frequency between Wellington and Johnsonville using either the EEMUs or modern EMUs. Frequencies greater than this would require twin tracking of substantial lengths of the line.

C.7 Suburban Rail Extension

Extension of the Johnsonville railway line into the CBD is one scenario for providing a seamless service through the CBD. A suburban rail extension would require its own right-of-way as it is not suited to on-street running because of safety issues, its scale and requirements for gradient and curve radii etc. It would therefore require a segregated running area (either horizontally or vertically).

Overhead running is unlikely to be acceptable through central Wellington because of visual intrusion and its environmental effects. It has therefore not been considered further.

An underground rail link between the existing Wellington Railway Station and the southern CBD has been considered since the 1950s, however, due to the large costs associated with tunnelling through the CDB, extension further south than this has not been taken any further. The report *Wellington Underground Rail, Railway Station to Taranaki Street, Opus, 2005,* considered the scenario of providing a twin track underground rail link from Wellington Station to the Taranaki Street / Courtenay Place intersection to cater for all suburban railway lines coming into Wellington Station.

The proposed alignment would follow Waterloo and Customhouse Quays to the first station at Post Office Square. The line would then continue south following Jervois Quay and Taranaki Street to the second station under the intersection of Taranaki Street and Courtenay Place. The proposed alignment is shown in Figure 1. It was proposed that the stations would be 100m island platform configurations. It should be noted that this would more than likely limit the usage to 4 car operations or require only some doors to open for access.

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[2] From Rail Survey March 2002

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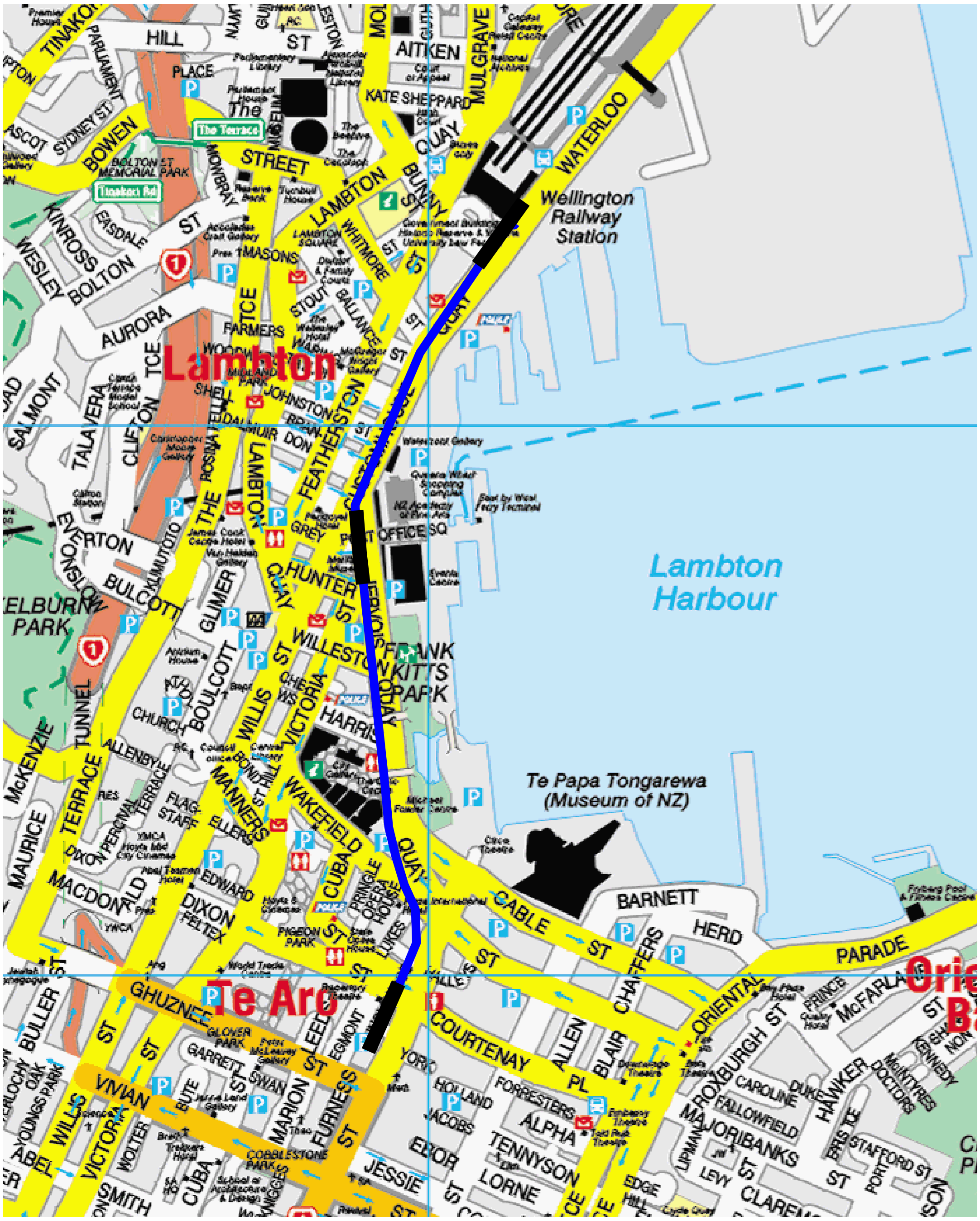
- **Figure 1: Wellington Underground Rail Alignment**



The proposed construction method for both the tunnels and stations is cut-and-cover. However, much of the alignment is in reclaimed land which provides significant engineering challenges.

The capacity of a twin track suburban rail underground link between Wellington Railway Station and Courtenay Place similar to that proposed in the Opus report has been considered. In modelling undertaken by Greater Wellington for the Ngauranga to Airport Study, it was previously assumed that 100% of services into Wellington could use the section of track. Given a train turnaround (layover) at the Courtenay Place of say 3-5 minute, it is considered that the maximum service frequency which could optimistically be expected to operate efficiently over this section of line is in the order of 5 minutes.

The current Wellington Station approach consists of 3 approach roads and it is anticipated that significant remodelling of the approach would be required, including the provision of a dedicated exit road for trains exiting the tunnel to eliminate train path conflicts. This could be tested through train path modelling of the Wellington Station throat area.

There are currently 42 services which arrive at Wellington Station during the peak two hours resulting in an average frequency of say 3 minute. If it was optimistically assumed that all servicing, cleaning etc would continue to take place at Wellington Station, it is likely that only say 30% of the trains entering Wellington could be extended to Courtenay Place.

The investigations into this scenario to date indicate this scenario would cost in the order of $300m (excluding operational costs and other improvements that would be required in any case). Given the level of funding available, this scenario is highly unlikely to be affordable. Even if only a proportion of the cost of the rail extension (based on patronage) was assumed to be borne by the northern suburbs, it would still be unaffordable.

The Ngauranga to Airport Strategic Study which is currently under way will investigate the potential for rail extension into the CBD on a region wide basis. If rail extension was found to have merit, then the potential for the Johnsonville railway line would need to be reconsidered.

C.8 Park 'n' Ride & Cycle 'n' Ride

Park 'n' Ride facilities that service the Johnsonville railway line are provided by Greater Wellington at the locations indicated in Table 1 and are usually heavily utilised during the day.

- **Table 1: Park 'n' Ride Facilities**

Station Name	No. of Spaces
Crofton Downs	44
Ngaio	50
Simla Crescent	6
Khandallah	7
Raroa	8
Johnsonville:	

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Station Name	No. of Spaces
- Station	49
- Moorefield Road	36
Total	**200**

As can be seen from the number of parks provided at each of the locations, formal park 'n' ride facilities only cater for a small percentage of train patronage on the Johnsonville railway line. This does not include informal parking on surrounding streets. Site visits have indicated that unrestricted parking is heavily utilised, particularly around Khandallah, Simla Crescent and Awarua Street stations.

Park ‘n’ ride and cycle ‘n’ ride facilities provide an opportunity to increase the catchment area of rail services (and potentially bus services) in the northern suburbs. Proposals exist for construction of some 500 park ‘n’ ride car parks at Johnsonville as part of the redeveloped Johnsonville town centre. Areas have also been identified for provision of further parks at Raroa / Fraser Avenue (15 parks) and Simla Crescent (15 parks). Cycle parking could be provided as part of station upgrades at all stations.

Sensitivity testing of the scenarios would be undertaken to understand the impact of provision of park ‘n’ ride facilities. Cycle parking would be assumed to be included in any station refurbishments.

Appendix D Bus with Walking and Cycling

D.1 Bus Overview

The existing Johnsonville railway line caters for a walking catchment including Crofton Downs, Ngaio, Khandallah, Raroa and Johnsonville Central. This is supplemented by passengers who utilise the park 'n' ride facilities provided. The majority of other public transport users including those in the remaining Study area catchments already utilise buses, in particular, Newlands, Paparangi, Grenada Village and Churton Park are very dependent on this mode of transport.

The essence of the *Bus with Walking and Cycling Scenario* is:

- Replace the existing train services with new buses between Johnsonville and the CBD
- Add to the current bus priority measures to assist buses to provide a reliable timetable
- Undertake upgrades of bus stops and other infrastructure improvements
- As the service expands, continue to introduce modern low floor buses

One of the major benefits claimed for buses as against rail based modes is that they are extremely flexible in terms of route and capacity. Buses are not constrained by a fixed network and can easily be extended to cater for additional demand without the need for costly infrastructure improvements and can be rerouted to cover additional catchment areas. Buses can be used to provide a seamless service (without interchange) from the northern suburbs through the CBD.

Buses will continue to play a major public transport role with all scenarios. Bus public transport usage is likely to grow as, unlike the rail corridor, the populations of both Newlands/Grenada and Churton Park are planned to grow significantly in the near future. Therefore, a suite of bus improvements is costed into all scenarios.

D.2 Bus Priority Measures

There are a large number of ways to improve conditions for buses to reduce journey times, improve journey time reliability and to provide an attractive transport alternative. These are generally referred to as bus priority measures because they often give buses priority over general traffic, however the appropriateness of different measures are highly dependent on local conditions and need to be considered carefully to achieve the desired outcomes.

Bus lanes are the most recognisable form of bus priority. Bus lanes are dedicated carriageway lanes that are created adjacent to existing traffic lanes or replace existing traffic lanes. They provide a dedicated right of way for buses so that they are not subject to general traffic conditions and have an uninterrupted priority over certain lengths, allowing buses to pass queued traffic. Bus lanes can operate permanently (all times of the day) or can operate in peak directions at peak times and be available for parking, loading or general traffic usage at other times of the day. Bus lanes generally run parallel with general traffic lanes and are constructed for the purpose, or replace existing general traffic lanes.

When bus lanes are completely separate from the road network they are referred to as busways and act in a similar way to railway lines, providing a fixed dedicated route for public transport. Busways can have stops at bus "stations" to pick up patrons or be used as expressways allowing buses which have already pick up patrons on local roads to travel at higher speeds, providing reduced journey times.

High Occupancy Vehicle (HOV) lanes are lanes that can only be used by vehicles with a minimum number of people in them and HOT lanes are a variation on this, where use of the lane by low occupancy vehicles is tolled. These types of measures can also provide improved operating speeds and journey time reliability for buses which operate in them.

Priority can be provided at intersections in a number of ways, the most drastic of which is grade separation, where buses go over or under intersections and are not effected by other vehicles at all. Other forms include queue jumping by installing a bus lane up to the intersection and providing an "early start" for buses at the beginning of a phase. Here, bus signals are used to allow buses to accelerate away at the beginning of a signal phase before general traffic is permitted to start. Signal pre-emption can be provided through the use of actuated detection, where a bus is detected approaching an intersection (through inductance loops or transponders) and the signal phase which includes the bus movement is called early or extended until the bus has passed. Intelligent transport systems can be used to optimise traffic signals in favour of buses and to regulate bus services depending on conditions at different times of the day.

Reducing the dwell times of buses when they stop to pick up passengers is another form of bus priority or service improvements. The time spent slowing down, stopping, ticketing and re-entering the traffic stream can make up a significant proportion of bus travel times and can greatly affect the reliability of travel times. Reduced dwell times can be provided by reducing time spent boarding passengers and ticketing though smartcard type or off bus ticketing systems. These types of systems remove the need for passengers to interact with the driver by purchasing a ticket and mean that passengers can enter the bus through any door. This can significantly reduce the amount of time the bus is actually stopped and enforcement can take place via roving inspectors.

Reduced dwell times can also be provided at bus stops at the expense of general traffic. Boarder bus stops can be provided where buses stop in the traffic stream to load and unload passengers, holding up a lane of traffic. This reduces the time taken to leave and rejoin the traffic stream. Passenger information systems can also be used to track buses and keep passengers informed of when the next bus is expected at the stop.

Reducing the number of bus stops a bus has to service is also an accepted method of reducing travel times and improving service reliability. In some situations, it in not necessary for every bus to stop at every stop. Certain services could only stop at specific stops, express services could operate and the number of stops and stop spacing can be rationalised so that buses do not queue waiting to use the same stop.

Bus Rapid Transit (BRT) is a common term used to describe a package of bus priority measures undertaken along specific routes to deliver vastly improved services. BRT aims to provide all the benefits of a rail based rapid transit mode while including the flexibility of bus services. It includes a comprehensive investment in the types of measures above with highly accessible interchange stations, service improvements, changes to route structures and clear passenger information and marketing similar to underground or light rail operations.

Buses operating in the northern suburbs have a limited number of bus priority measures provided at present. These include:

- Bus lane on Kaiwharawhara Road at the bottom of the Ngaio Gorge, allowing southbound buses to bypass queues from the Hutt Road intersection during the morning peak
- Central bus lane on Hutt Road on the approach to the Lambton Bus Interchange
- Bus lanes through the CBD bus route
- Traffic signal priority at the Dixon Street / Cuba Mall intersection

Based on a preliminary assessment and a review of previous reports, it is considered that the following measures are typical of the types of priority measures that may be required for the northern suburbs in the future to cater for additional numbers of buses. The measures are indicative in terms of their disruption and costs. This is a strategic study and has not attempted to undertake a rigorous investigation into the feasibility of bus priority measures, which are outside the scope. A detailed review of the options for providing bus priority and their wider impacts would need to be undertaken before plans for a substantial increase in bus numbers were progressed further.

D.2.1 CBD Bus Route

At present there are delays to buses using the existing CBD route due to the volume of buses using the route and conflict with general traffic. Given predicted continued traffic growth and the need for more buses to cater for increased bus patronage in the region this situation is only likely to worsen, resulting in longer travel times for buses and reduced journey time reliability. Because of the volume of buses using the route, we consider that bus priority measures would be required to maintain the existing level of service if significantly increased numbers of bus services are scheduled to use the route. These could include:

- Rationalisation of stops, to reduce the number of stops required through the city.
- Improved ticketing systems reducing the need for driver interaction and providing reduced boarding times
- Retiming of traffic signals and provision of actuated signal pre-emption at all signals on the CBD bus route. This would result in a loss of capacity for general traffic at each intersection.
- Rearrangement of parking and loading to provide dedicated bus lanes for the whole length of Lambton Quay
- Banning all right turn movements at the Lambton Quay / Bowen Street intersection
- Banning general traffic through Manners Street West to form a transit mall for buses
- Reallocation of parking and loading on Courtenay Place and narrowing of lanes to provide dedicated bus lanes
- Signalisation of the pedestrian crossings on Courtenay Place
- Provision of additional bus lay-over areas along the central median of Cambridge / Kent Terrace.

Other more drastic measures that may be required to provide capacity and reduced travel times include:

- Rerouting southbound buses (but not trolleybuses) via Featherston Street, Grey Street, Customhouse Quay to Willis Street
- Banning all right turn movements on Lambton Quay between Bowen Street and Willis Street by filling in the openings in the median. The perpendicular roads between Lambton Quay and Featherston Street would form one-way loops for access. Removal of traffic signals where appropriate to reduce the number of possible delays for buses.
- Banning general traffic (but not service vehicles) northbound on Lambton Quay to provide a dedicated bus lane

The Ngauranga to Airport Strategic Study, which is been undertaken in parallel with this study, will consider these issues in further detail.

D.2.2 Hutt Road

Delays are currently experienced by buses on Hutt Road, between the Lambton Interchange and where they access SH1 at the bottom of the Ngauranga Gorge. Again, given predicted traffic growth this situation is only likely to worsen on the future resulting in longer travel times for buses and reduced journey time reliability. The Greater Wellington report *CBD Corridor Review, Traffic Management Estimates, Report 2, Additional CBD and Fringe Bus Lanes, MWH, 2005* investigated installation of peak direction bus lanes on Hutt Road over this length. It has been assumed that lanes similar to those proposed could be installed as required, however these are likely to have an impact on general traffic conditions. Again, it is likely that the Ngauranga to Airport Study which is currently underway would consider these issues in more detail.

Delays are also experienced by buses at the Ngaio Gorge (Kaiwharawhara Road) and Onslow Road intersections with Hutt Road. It has been assumed that some form of traffic signal pre-emption and priority could be provided for buses at the Kaiwharawhara Road intersection as required, dependent upon the bus option. This could involve reconstruction of the existing traffic island and removal of parking to extend the Kaiwharawhara Road bus lane through to the Hutt Road intersection.

D.2.3 Johnsonville Hub

Johnsonville Town Centre (JTC) is a key component of the Council's two key urban form strategies – the Urban Development Strategy (UDS) and the Northern Growth Management Framework (NGMF). These strategies recognise that JTC is the largest and most significant town centre in Wellington outside of the CBD. The importance of the centre would grow with the implementation of the NGMF and subsequent population expansion in the north. JTC is also identified by the UDS as a town centre for intensification as part of the 'growth spine' concept.

Integral to any successful growth and development in JTC is the provision of high quality public transport. As part of implementing this strategic vision in JTC, the Council would consider how JTC can be promoted as a public transport hub. This would take into account location, amenity, connectivity and supporting facilities.

Improvements to the public transport facilities in Johnsonville town centre are planned under all the scenarios identified. The exact nature of the improvements will depend on the preferred scenario and the strategic vision for Johnsonville town centre, which is currently under development. Such considerations are outside the scope of this study.

It is assumed that as part of the ongoing planning, significant bus priority measures could be provided. These may include signal pre-emption at the Broderick Road / Johnsonville and Broderick Road / Moorefield Road intersections and include widening of the Broderick Road / Moorefield Road intersection on a structure above the railway line to provide a dedicated bus lane on the approach. Again, these measures are expected to have attendant impacts on general traffic conditions.

D.2.4 Ngauranga Gorge

Many of the buses which service the northern part of the Study area utilise the Ngauranga Gorge and become caught in congestion there. This is one of the major constrictions on the Wellington road network and travel times and trip time reliability for buses using the Gorge is only predicted to get worse in the future. The average length of a trip from Newlands onramp to the Aotea off-ramp

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via the SH1 Ngauranga Gorge in the two hour AM peak is anticipated to increase by some 20% between 2001 and 2016[3].

Ideally it would be desirable to provide additional bus priority measures through the Ngauranga Gorge. Due to topographical and capacity constraints, it is unlikely that these could be provided economically. Some work has been undertake by the Region looking at the possibility of replacing some of the general traffic lanes with HOV lanes if the demand for this link could be reduced by the construction of the Petone – Grenada Link road. However this is not part of the agreed base case for this study and, it is likely that the Ngauranga to Airport Study which is currently underway will consider these issues in more detail.

D.3 Bus Vehicles

Modern buses are clean, comfortable and efficient and can provide an attractive public transport service. The buses currently used in Wellington are 10m to 12.6m rigid diesel buses or electric trolleybuses, however trolleybuses do not currently operate in the northern suburbs. New buses which are purchased for use in the Wellington network are all low floor accessible to provide an accessible service for the disabled and it has been assumed that new buses purchased to operate the on street scenario would be new modern low floor buses with similar capacities to the existing.

The 10m rigid buses currently used have a seating capacity of 39 with an approximate standing capacity of 23 to give a total capacity of 69 people per fully laden bus, while the 12.6 m rigid buses have a seated capacity of 51 and standing capacity of approximately 23 to give a total capacity of 74 per fully laden bus.

Articulated buses which have greater seating capacity than traditional rigid buses provide an opportunity to increase bus capacities. There are a number of vehicle variations available internationally and articulation allows the larger capacity vehicles to have similar swept paths to traditional buses. 18m articulated buses which currently operate in Auckland have a seating capacity of 70 and approximately 55 standing to give a total capacity of 125 per fully laden bus. The standing capacity of the buses is generally constrained by the allowable axle loadings on New Zealand roads.

Bus service planning rarely uses fully laden loads for calculating frequency requirements. Instead a planning capacity of approximately 80% of total is often used, to ensure that sufficient capacity is provided even when buses are delayed, or when passenger arrivals at bus stops are not evenly distributed

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[3] WTSM model base forecasts

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- **Table 2: Vehicle capacities**

Vehicle	Approximate Seating	Approximate Total Capacity	Approximate Planning Capacity
10m single deck bus	39	62	50
12.6m single deck bus	51	74	55
18m single deck articulated bus	70	125	100

Investigations have not been undertaken to confirm that articulated buses can operate on proposed routes in detail. There are also some issues with operating articulated buses on the steep and winding topography of the northern suburbs. An earlier attempt to run an articulated bus through Khandallah was not successful due to geometric constraints. It has been assumed that articulated vehicles would not be used on general routes as part of the bus on-street scenario.

There may be potential to use alternatives to diesel buses such as Hybrid Diesel-Electric and Hydrogen Fuel Cell buses in the future, however is unlikely to be a determining factor in a strategic study of this nature. Trolleybuses require their entire route to be provided with overhead wires which are costly to install, intrusive and limit the flexibility of bus services to reroute on a permanent or temporary basis. Dual mode vehicles operate internationally which can operate on electricity or diesel, however there is a large cost premium for such units. For these reasons, trolleybuses and diesel alternatives will not be considered further as part of this study. Should a bus based strategy become a preferred scenario, the possibility of utilising trolleybuses or other diesel alternatives could be considered in more detail.

- **Typical 10m rigid bus**

One of the major issues with operating buses on-street is that in general they must share the road space with other vehicles and are subject to the same delays. Buses are therefore also susceptible to incidents on the road network. For example if there are delays to traffic due to an accident, buses are caught in the same disruption and do not provide an alternative travel option to avoid the problem in the same way that modes with dedicated right of ways do.

D.3.1 Facilities

In order to provide an attractive service, a high level of facilities such as bus shelters and real time passenger information would need to be provided. Waiting passengers should be kept informed at all times on any delays or problems that may have occurred and this is likely to require Passenger Information Systems (PIS) (automated updating timetable equipment at each of the stops). An allowance for new stops, shelters and PIS has been made for the rail replacement services in this scenario.

D.4 Possible Base Improvements to the Existing Bus Services

To cater for future patronage growth and increase Public Transport uptake, a series of improvements to the existing bus services will be required. The Stage 1 Consultation also highlighted a number of improvements that the pubic would like to see for the existing bus services.

Bus services in the northern suburbs are continually undergoing improvement and refinement as Greater Wellington and bus operators endeavour to meet the changing route and capacity requirements of the area to improve services for the public. Large scale improvements to the bus services in the area are therefore not readily identifiable.

This is a strategic study and has not attempted to undertake a rigorous investigation into development of new bus routes and timetables, as the level of detail required to provide this is outside the scope of this study. Instead, a typical future bus operating plan with indicative service frequencies has been developed which is representative of the general improvements to bus services which are likely to be progressed in the future.

The general improvements to bus services identified here are assumed for all scenarios except the busway. The busway option involves a comprehensive redesign of bus operations which are detailed under that option below. It should be noted that these improvements are possible improvements only, have yet to be considered fully and will be subject to a service and economic review by the Regional Council.

A review of the consultation feedback and the existing bus services was undertaken in conjunction with Greater Wellington Passenger Transport staff to identify what reasonable bus improvements could be provided in the future. The following improvements have been identified. It is assumed that these changes would be phased in with some taking place in the near future and others possibly over the next 10 years as required by demand and economic viability.

D.4.1 Route 43, 44, 45, 46, 50 and 53 Changes

The following changes could take place:

- New Route B – Broadmeadows via Homebush Road and Khandallah, terminating in Johnsonville. The new route would follow the existing 46 route via Onslow Road, Homebush Road, Cashmere Avenue and Khandallah Station to Broadmeadows. From here the route would utilise the yet-to-be-constructed John Sims Drive extension, then McLintock Street and its proposed extension to the top of Cortina Avenue, then via one of two possible routes to a terminus at Johnsonville. This route would also replace the existing Route 53 service for Johnsonville West and North
- "Broadmeadows Route" frequency of 10 minutes in the peak of the peak, 30 minutes interpeak and 30 minutes offpeak
- New Route K – Khandallah via the Ngaio Gorge. This new "Khandallah Route" would replace the Ngaio Gorge section of the existing Route 43 and 44 loop and follow the Ngaio

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Gorge and Cockayne Road, terminating at Khandallah. This route would continue beyond Courtenay Place via Wellington Hospital to a southern or eastern suburbs destination (curently Strathmore).

- "Khandallah Route" frequency of 5 minutes in the peak of the peak, 30 minutes interpeak and 30 minutes and offpeak.
- Route 45 continuing on its current route during peak times via the Ngaio Gorge and terminating in Khandallah
- Route 45 frequency of 20 minutes in peak only

These changes would address the following issues highlighted in the Stage 1 Consultation:

- Issues with legibility and operation of the existing 43 and 44 loop route and understanding of the way it operates
- More frequent services for Khandallah during the peak
- Desire for more frequent bus services for Khandallah in the interpeak and offpeak (in the desired direction of travel)
- Off-peak service for Broadmeadows
- Desire for an offpeak and weekend service for Johnsonville West

The Johnsonville Line corridor provides offpeak services within the same catchment as the Route 45. Therefore, it is considered that offpeak Route 45 services are unlikely to be efficient as an alternative is already provided. Note that in the bus on-street option below the Route 45 is included in the new Z route and therefore an offpeak service would be provided.

More frequent bus services to Ngaio during the peak are considered unlikely to be efficient, however additional buses during the heaviest demand could be considered over time.

The earliest service from Khandallah arrives in the CBD at 6:49am and a night bus (after midnight on Friday and Saturday nights) operates to Khandallah. Earlier or later services could be considered at a later time as required.

Co-ordination of bus and train timetables for Khandallah so that they leave at different times during the peak (so that if passengers misses one mode they can catch the other) is an operational issue and can be considered during timetable reviews.

D.4.2 Route 54 and 59 Changes

The following changes could take place:

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- New Route 54 which removes the section of the existing Route 54 loop that uses Middleton Road.
- The section between Basset Road and Halswater Drive would operate two-way.
- Middleton Road catchment catered for by the increased frequency on Route 59 with possible off-peak transfer from Route 59 to Route 54 at Johnsonville
- A reduced loop operating around Burbank Crescent or Lakewood Avenue, then Amesbury Drive, Erlestoke Crescent, Waverton Terrace, which could be extended as required to service new subdivisions.
- Route 54 frequency of 4 minutes in the peak of the peak, 30 minutes interpeak and offpeak.
- Route 59 frequency of 10 minutes in the peak of the peak, 30 minutes interpeak and offpeak.
- An approximately 4 minute combined frequency for Johnsonville during the peak of the peak depending on the scheduling of the two routes to best meet demand.

This would address the following issues highlighted in the Stage 1 Consultation:

- Rerouting to remove the long circular route and service new areas in Churton Park and Glenside
- Desire for more frequent buses (also required to cater for new subdivisions proposed)

The desire for additional express services which do not stop at Johnsonville is essentially an operational issue which can be considered at a later time. The additional frequency provided on the Route 54 should also provide additional capacity to reduce crowding on services to Johnsonville from the CBD.

D.4.3 Route 55, 56 and 57 Changes

The routes in this area have recently been amended, the most recent changes coming into effect on 30 January 2006. There have been “teething problems” with bedding down the changes, however most of these have now been addressed. It is considered that the current route structure is going to continue to form the basis for routes in this area in the future. The possible creation of a new link road between Woodridge and Grenada Village would provide an opportunity to link the routes in some way. Generally, changes to the Route 55, 56 and 57 services are likely to include frequency improvements to cater for the continued development of the area:

- Route 55 frequency of 10 minutes in the peak of the peak, 30 minutes interpeak and 30 minutes and offpeak.
- Route 56 frequency of 10 minutes in the peak of the peak, 30 minutes interpeak and 30 minutes and offpeak.
- Route 57 frequency of 15 minutes in the peak of the peak.

- An approximately 3-4 minutes frequency for Newlands Road during the peak of the peak

These changes and the recent amendments would address the following issues highlighted in the Stage 1 Consultation:

- Desire for more frequent bus services from Newlands, Grenada, Paparangi, and Woodridge

Changes to offpeak "connection" services can be considered as an operational issue.

D.4.4 Lower Hutt Connection

There have been some requests for connections between the northern suburbs and Lower Hutt. Currently, passengers can either change between bus companies on Hutt Road or travel into the city and travel back out to Lower Hutt via bus or trains. Extending existing Hutt bus services to service the northern suburbs has been considered, however provides difficulties due to the long distance and unpredictable journey times which would have a flow-on impact on journey time reliability for Hutt services. The demand would need to be reviewed over time, however at present, a service would be expensive and disruptive and has not been considered further.

D.5 Bus on street with Walking and Cycling Scenario

This scenario involves replacing the existing English Electric Multiple Units (EEMUs) which run on the Johnsonville railway line with buses which would run on-street. This would result in the existing rail alignment becoming available for use as a walking and cycling track. This would safeguard the transport corridor.

D.5.1 Proposed Rail Replacement Routes

Replacement of the rail services with on-road bus-based operation has been considered. This would require the establishment of three new bus routes to service the area. At this stage, these routes are proposed in addition to the existing bus routes, which could continue current operations. However, this scenario would provide an opportunity to undertake a full review of existing services in light of the rail-replacement routes. The exception is the existing Route 45 which would be incorporated into one of the rail replacement routes, providing an offpeak service for the area served by the 45 at present.

The current routes operating from Churton Park, Grenada and Newlands would continue to operate along the Ngauranga Gorge motorway from Johnsonville as this provides the shortest route (time and distance) for these areas.

The three routes have been designated indicative letters X, Y and Z to distinguish them from the existing routes.

While the routes are only outlined to Lambton Interchange, there is the opportunity to extend some, or all, the services through the CBD and beyond. A high degree of bus priority would be required at key points of the routes to provide sufficiently attractive travel times and reliable operation. A broad description of the routes is provided below.

D.5.2 Route X; Johnsonville – Crofton Downs – Wellington (Light Blue)

This route would provide access to all existing station catchments along the Johnsonville railway line. It would also provide an increased frequency of service to the Wadestown area.

The route proposed from Johnsonville to Wellington would be:

Johnsonville Rd, [R] Fraser Ave, [L] Burma Rd, [L] Station Rd, [R] Cashmere Ave, [R] Agra Cr, [R] Nicholson Rd, [L] Cockayne Rd, [R] Khandallah Rd / Ottawa Rd / Waikowhai St / Churchill Dr, [L] Blackridge Rd, [L] Wadestown Rd, [L] Lennel Rd / Grosvenor Tce, [R] Grant Rd, [L] Park St / Murphy St to Lambton Interchange.

The reverse of this route would be followed towards Johnsonville.

It would provide services to each of the existing stations which would cater for the Ngaio and Crofton Downs areas and for intermediate trips within the area.

D.5.3 Route Y; Johnsonville – Ngaio – Kaiwharawhara Rd – Wellington (Orange)

This route would provide services to most of the stations however, it would operate along the western side of the existing corridor between Johnsonville and Simla Crescent to provide access to the residents on that side of the corridor. There is also the possibility for limited services to operate on the western side of the corridor between Simla Crescent and Awarua St.

The route proposed from Johnsonville to Wellington would be:

Moorfield Rd / Burma Rd / Box Hill, [R]Clark St, [L]Simla Cr, [R] Khandallah Rd / Ottawa St, [L] Crofton Rd, [R]Kenya St, [L] Ngaio Gorge Rd / Kaiwharawhara Rd, [R] Hutt Rd / Thorndon Quay / Lambton Interchange.

The reverse of this route would be followed towards Johnsonville.

D.5.4 Route Z; Johnsonville – Khandallah – Cashmere – Wellington (Pink)

This route would serve the northern end of the corridor and travel via the quickest route to Wellington. It would join with the Route 45 from its current termination point at Khandallah to provide a peak and non-peak service for this catchment.

The route proposed from Johnsonville to Wellington would be:

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Johnsonville Rd, [R] Fraser Ave, [L] Burma Rd, [L] Station Rd, [R] before following the existing Route 45 route.

The reverse of this route would be followed towards Johnsonville. These routes would also be utilised for counter-peak services under the *Busway Scenario*.

D.5.5 Frequency & Capacity

The frequency of service on each of the three routes is proposed to be approximately 10 minutes during the peak hour and 15 minutes for the rest of the peak period and approximately 15 minutes out of peak. This provides a peak hour frequency of 3-5 minutes on those sections where routes overlap.

From the planning capacities of 55 passengers for a rigid bus and 100 passengers for an articulated bus, this provides a passenger capacity for the corridor of 990 passengers per peak hour using 12.6m rigid buses and 1,200 passengers per hour using 18m articulated buses. These corridor capacities could be further increased with a higher service frequency, if required, to meet demand.

Stops and shelters would need to be upgraded along the replacement route, particularly near the existing train stations.

Travel times will be longer on-street than the existing train journeys. This is because of the extra distance, stops and the fact that the buses now have to compete with traffic congestion. It is assumed that bus priority measures would be provided at the Ngaio Gorge (Kaiwharawhara Road) intersection with Hutt Road and that bus lanes could be provided along the section of Hutt Road / Thorndon Quay between Kaiwharawhara Road and Lambton Interchange. If this is possible, journey times would be in the order of 25 minutes or more compared with the existing train journey time of 21 minutes.

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Appendix E Busway Scenario

While a simple description of a busway is a system that enables buses to travel on their own lanes, it is likely to be much more than this. A busway would be a form of Bus Rapid Transit (BRT) for Wellington. The essence of a Busway Scenario is:

- It is a bus based urban transport system that can operate at average speeds of 25 to 30km/hr for shared street running and typically up to 100km/hr when operating in a dedicated corridor. (Operational speeds for a busway in the Johnsonville rail corridor are likely to be much lower than this)
- It is flexible and can travel around sharp curves, on steep gradients and along streets, run in its own reserve.
- Bus services can also travel on streets (picking up and dropping off commuters) but still avoiding congestion by travelling on the dedicated busway.
- Headways are as low as 1 minute
- Able to use standard buses, articulated buses and even modern, high capacity vehicles similar to light rail vehicles. All will incorporate 'low floor technology' which provides safe access for the mobility impaired.
- While current buses are powered by standard diesel engines, increasingly more environmentally sustainable power systems are being used including hybrid/diesel/electric, CNG.
- Some BRT systems also support a barrierless fare system.

E.1 Dedicated Busway

In a similar way to a railway line, a busway provides a dedicated right of way and means that buses will not be caught in general traffic congestion and can travel the length of a busway unimpeded. This would result in a more reliable journey times for most public transport users compared to other scenarios. Busways are commonly seen as a suitable mode of transport for carrying passengers on medium to low density corridors because of their ability to provide a rail like priority but maintain the flexibility of buses to extend routes or cover additional catchment areas. As part of a comprehensive package of bus priority measures, a busway could form the backbone of a Bus Rapid Transit corridor catering for the majority of northern suburbs public transport services and providing a comfortable high quality service for the area.

Buses are also not constrained by a fixed network in the way that trains are and therefore the busway would provide a more flexible system for extending routes at either end of the busway in the future.

E.2 Bus Rapid Transit

Bus rapid transit is described in the introduction to *TRCP Report 90 Bus Rapid Transit, Volume 1, Case Studies in Bus Rapid Transit* as "a flexible, rubber-tired rapid-transit mode that combines stations, vehicles, services, running ways, and Intelligent Transportation System (ITS) elements into an integrated system with a strong positive identity that evokes a unique image. BRT applications are designed to be appropriate to the market they serve and their physical surroundings, and they can be incrementally implemented in a variety of environments. In brief, BRT is an integrated system of facilities, services, and amenities that collectively improves the speed, reliability, and identity of bus transit."

Essentially BRT is bringing together a package of measures to make bus transport more efficient and attractive to the travelling public. It attempts to provide a bus service with all the benefits of a rail based mass transit system while retaining the flexibility of buses.

There are seven main strands of BRT measures:

- *Runningways* – this includes provision of segregated identifiable running areas through bus lanes, HOV lanes and busways to enable travel at higher average speeds with improved reliability.
- *Station*s – interchange with other transport modes, designed to reduce dwell times. Can range from enhanced shelters to large interchanges.
- *Vehicles* – comfortable, modern, reliable, efficient rubber tired vehicles. designed to provide easy fast boarding times even for the disables. Often use environmentally friendly clean fuels
- *Services* – frequent enough that no schedule is required, integrated with other public transport.
- *Route Structure* – logical routes. Simple, easy to read colour coded maps. Direct - no transfer routes to multiple destinations.
- *Fare Collection* – Reduced boarding time through the use of smart card, simple off vehicle payment, multiple door boarding etc.
- *Intelligent Transport Systems* – Use of technology to provide, passenger information operational safety, convenience speed and reliability

These measures can be selected as appropriate to the situation to provide an enhanced bus service.

E.3 Replacing Suburban Rail with Busway

This scenario involves replacing the existing English Electric Units (EEMUs) which run on the Johnsonville railway line with buses which would use the existing rail right of way modified to cater for buses.

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E.3.1 Why is a guided busway required?

Guided busways are installed because this allows them to operate safely at higher speeds with reduced width requirements and to provide a high quality of ride. This would also enable buses to negotiate tight tunnels as found on the Johnsonville rail corridor.

There are seven tunnels over the length of the corridor. For buses to use the existing rail right of way, they would need to pass through the existing tunnels. Using indicative tunnel profiles, the approximate dimensions of various vehicle types were superimposed on the tunnel profiles. The profiles were assessed on the basis that the finished road level would be the same as the top of rail point provided in the profiles. In practice, the floors may be able to be lowered with removal of ballast and construction of a pavement which would increase the clearances.

In general all the bus profiles tested were able to fit through the tunnels, however clearances are small. In some cases the higher GLT vehicles would foul the tunnel ceilings. Centre and end throw of the vehicles was also considered as this could also result in fouling of the tunnel walls. This preliminary review indicates that it should be possible to operate buses through the tunnels. Because of the small clearances, buses would however require guidance through the tunnels to ensure they did not foul the tunnel walls. Before progressing further with a bus scenario utilising the existing tunnels, a thorough review would be required to ensure buses could operate without fouling the tunnels.

The topography the existing rail right of way runs through is very steep and makes construction of a busway difficult. The section between Wellington Station and Crofton Downs which runs through the Ngauranga Gorge is particularly steep. Because of the narrow platform provided in the rail corridor which runs adjacent to steep drop-offs, large sections of the busway would need to be constructed as guided busway to ensure safe operation.

As noted below, an O-Bahn type guided busway has been chosen for this evaluation as it is the most suitable of the technologies currently available and has been proven in commercial applications.

E.3.2 Guided Light Transit

Guided Light Transit (GLT) refers to several systems currently under development. The oldest and most widely used form involves guidance via raised kerbs that connect with guide wheels attached to the steering of a modified bus. Although widely used in the UK, the most famous version is the "Adelaide O-Bahn" in South Australia. This has been in operation for over twenty years.

A variety of other technologies are used for guidance of the vehicles, including rail, magnetic and optical guidance.

These technologies are in the early stages of development and the majority of the systems detailed below are currently only in use in test track environments. However, the Bombardier TVR system is in operation in Caen and Nancy, and the Irisbus CIVIS / CHRISTALIS, in operation in Rouen, Lyon and Bologna.

- **Table 3: GLT models and manufacturers**

Model	Manufacturer	Notes / Details
TVR	Bombardier	Both systems in operation (Caen and Nancy) use electric vehicles. Central single rail guidance device. In commercial operation
CIVIS / Christalis	Irisbus / IVECO	Hybrid vehicles available: Euro 3 engines power an electric generator. Rigid 12m. Articulated 18.8m. Double articulated 24m. Guided by optical self steering system. Limited to 30kph when under guidance. In commercial operation
Translohr	Lohr Industries	Currently only electric vehicles are planned bus diesel power should be possible. Central single rail guidance device – not compatible with TVR
Phileas	Fokker	Gas powered hybrid vehicles available. 18m articulated. 24 metre double articulated. Guided by magnetic beacon system known as 'Frog'. Under development
f-t-r	Wright Group	18.8m articulated. Diesel. Cost A$500,000 per vehicle, but no guidance system built-in. Could be suitable for O-Bahn style conversion. Planned into operation early 2006
STREAM	Ansaldo Breda	Electric. Uses a magnetic pick-up to collect power, from a flexible conductor in a 300mm x 600mmm trench.
AEG	Cegelec	Diesel Uses buried cables that guide the bus by induction.

Sources: Smiler S New Era Hi Tech Buses 2005; www.trolleybus.co.uk 2005

Various GLT infrastructure costs have been sourced. A variety of different technologies exist, as shown in Table 4 and costs vary substantially for each technology. However, these figures are not directly comparable with each other or the cost of providing a guided busway in Wellington, and should not be considered as representative. The figures below indicate the large variability in costs associated with Guided Light Transit infrastructure.

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- **Table 4: GLT infrastructure costs**

System	Cost per km for two-way 'track' (2005 prices)	Source
GLT	$6.5million	Brand C and J Preston *Which Technology for Urban Public Transport? A Review of System Performance*, Costs and Impacts 2003. Does not state which system
CIVIS (Rouen)	$5.83mliion	*Rouen, France Brief: Tear Optically Guided Bus* 2001
Busway	$11million	Brand C and J Preston *Which Technology for Urban Public Transport? A Review of System Performance*, Costs and Impacts 2003. Nottingham Express Transit *Public Transport Mode Choice – The Scenarios for Nottingham* 2001
Conventional Guided Bus	$7.8 – $12.3million	Commission for Integrated Transport, *Affordable Mass Transit Guidance* 2005
O-Bahn	$16.1million (actual costs; not directly comparable to the northern suburbs) $ 5.6 million (based on figures assumed in Paper for converting a Railway line	Bray D. *The Performance of the Adelaide O-Bahn* 2000 Transit Cooperative Research Program *Case Studies in Bus Rapid Transit* 2003

The US Based Transit Cooperative Research Program undertook a paper *'Case Studies in Bus Rapid Transit'* in 2003 that compares the cost per kilometre for a 16 international high quality bus systems. Topography and level of segregation varies for each system but the key stats are:

- Mean cost per kilometre: $10.6m
- Minimum cost per kilometre: $1.3m (Leeds, UK)
- Maximum cost per kilometre: $28.5m (Cleveland, US)

Various GLT vehicle costs have been sourced. Again use of different technologies has an effect on price. See Table 5.

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- **Table 5: GLT vehicle costs**

Vehicle	Cost per vehicle (2005 prices)	Source
GLT	$3.0m	Brand C and J Preston Which Technology for Urban Public Transport? A Review of System Performance, Costs and Impacts 2003. Does not state which system
CIVIS	$1.8m	Transport and Land Use Coalition Revolutionizing Bay Area Transit 2002 Rouen France Tear Optically Guided Bus 2001
f-t-r	$0.6m a	Smiler S New Era Hi Tech Buses 2005
Standard guided bus / O-Bahn	$0.28m $0.37m	Nottingham Express Transit Public Transport Mode Choice – The Scenarios for Nottingham 2001 Bray D. The Performance of the Adelaide O-Bahn 2000
Conversion of standard bus to guided bus / O-Bahn	$0.01m	Nottingham Express Transit Public Transport Mode Choice – The Scenarios for Nottingham 2001

Notes: a) Does not include guidance system

E.3.3 O-Bahn

The O-Bahn is the most internationally recognisable application of a guided busway. The original guided O-Bahn was developed by Daimler-Benz and Ed Zublin AG in Germany in the early 1980s. The system's most high profile and largest application is in Adelaide, where a 12 kilometre guided busway was constructed to the city's northeast, as a spine for transport services to this area of the city.

The premise of the system is as follows. Standard buses are fitted with small guide wheels on either side of the vehicle. These wheels are then piloted by guide-rails fitted to either side of the busway, and the vehicle is guided and steered along the course of the route. Vehicles can join or leave the guide-way at pre-defined points along the system, allowing more flexible operations.

O-Bahn "tracks" provide concrete running strips for the bus wheels, with a kerb either side of the "track" approximately 180mm high. The tracks and kerbs are generally constructed in concrete. The track can be constructed on the surface or as an elevated roadway (similar to Adelaide).

The Adelaide O-Bahn cost A$104million (in 1988) for the 11.9 kilometres of guided busway. The average cost per kilometre was therefore A$8.7million at time of construction. In 2005 prices, this is equivalent to NZ$191 million or NZ$16 million per kilometre ([4, 5]). It should be noted that this

[4] Bray D. *The Performance of the Adelaide O-Bahn* 2000

[5] Transit Cooperative Research Program *Case Studies in Bus Rapid Transit* 2003

cost included for the busway being constructed on a raised structure and two way etc. and this cost is higher than what could be expected in the Johnsonville railway line corridor.

Subsequent to the construction of the Adelaide O-Bahn, the South Australian Government estimated the cost of converting a dual track railway line into a dual lane guided busway at an average cost per kilometre of A$4.1million. In 2005 prices, this is equivalent to NZ$5.6 million per kilometre ([6], [7]). It should be noted that this cost assumes good soil conditions and the train track was broad gauge. The figure included allowances for design, supervision, and physical contingencies but excluded the cost of depots, rolling stock, site preparation (e.g., earthworks, service relocation and fencing), and stops and stations.

In 1993, Travers Morgan NZ Limited produced a Report [8] describing options for Public Transport in the Johnsonville Wellington CBD Corridor. The report estimated the cost of a guided busway at $ 14.8 million (1993 $) between Johnsonville and the Station. This equates to a present day (2005 $) cost of $21 million.

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[6] Bray D. *The Performance of the Adelaide O-Bahn* 2000

[7] Transit Cooperative Research Program *Case Studies in Bus Rapid Transit* 2003

[8] Travers Morgan NZ Ltd. Study of Public Transport Options Johnsonville Wellington CBD Corridor, 1993

Example of the Adelaide O-Bahn

E.3.4 Busway vehicle capacities

Buses and GLT vehicles are typically of similar width of approximately 2.5metres. Therefore, the driver of capacity is typically vehicle length (though the exact level of seating and total capacity varies from model to model) and there is no real difference between buses and GLT vehicles of the same length. GLT vehicles typically come in length of 18 or 24 metres, whereas standard bus lengths tend to be 10-15 metres (rigid) or 18 metres (articulated). Table 6 sets out typical capacities of each type of vehicle.

Bus service planning rarely uses fully laden loads for calculating frequency requirements. Instead a planning capacity of approximately 80% of total is often used, to ensure that sufficient capacity is provided even when buses are delayed, or when passenger arrivals at bus stops are not evenly distributed.

Table 6: Vehicle capacities

Vehicle	Approximate Seating	Approximate Total Capacity	Approximate Planning Capacity
10m single deck bus	39	62	50
12.6m single deck bus	51	74	55
12m rigid GLT (Christalis)	40	70	55

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18m single deck articulated bus	70	125	100
18m articulated GLT	70	125	100
24m double-articulated GLT	90	190	150

E.3.5 Mode vs. capacity

There are a lot of contradictory comments on the suitable range of various modes – largely influenced by the particular mode-bias of the author. However, Brand and Preston appear to take a holistic view and present maximum hourly capacity for various modes. See Table 7.

- **Table 7: Typical system capacity by mode ('000 passengers per hour per direction)**

Metro	Suburban Rail	Busways [1]	Light Rail	GLT [2]	Bus Lanes	Guided Bus [3]
10 – 40	1 – 32	4.5 – 25	1 – 21	4.5 – 10	4.5 – 7.5	4.5 - 7.5

Source: Brand C and J Preston Which Technology for Urban Public Transport? A Review of System Performance, Costs and Impacts 2003.

Notes: 1. Dedicated bus only corridor without guidance system. 2. GLT system with large vehicles. 3. Guided bus system with standard vehicle size.

E.3.6 Assumed Technology for the Northern Suburbs

This is a strategic study and has not attempted to undertake a rigorous investigation into the feasibility of a guided busway system, which is outside the scope of this study. Instead, a literature review and previous reports have been used to develop a representative *Busway Scenario* for evaluation against other mode choices. As many of the guided busway technologies are in their infancy, and have not been proven commercially to date, the technology assumed for evaluation of a *Busway Scenario* will be O-Bahn, similar to that installed in Adelaide.

It is considered that an O-Bahn system would be the most appropriate guidance system for a busway conversion of the corridor. It would allow existing bus stock to be modified to use the busway and the vehicles could use the existing network without major disruption or the need to install overhead wiring. GLT vehicles tend to be complete guidance / bus packages and are therefore less flexible and would require construction of infrastructure along any length on which they were to operate. A more detailed review of the feasibility of a busway and the preferred technology would be required before progressing further with a busway option. Specific issues have however been identified where appropriate.

New low floor accessible buses would operate a rail replacement service on the busway providing an attractive, comfortable service. Articulated buses would provide greater capacity for the system and would be able to negotiate the curves and grades of the existing rail corridor. This would need to be confirmed before progressing further with articulated vehicles, particularly in relation to the constraints on the CBD bus route. New buses can be supplied with guide wheels to enable O-Bahn operation. Existing buses can be retro-fitted with the guide wheels for continued operation or as back up vehicles to operate on the busway. All busway buses equipped in this way would be able to operate on the road system as well.

E.3.7 Proposed busway

It is envisaged that the proposed busway would start at Johnsonville in the north and would be accessed at the existing Johnsonville Rail Station. It would then continue south following the existing rail alignment with intermediate access points to Hutt Road, where buses would revert to on-street running. The busway would be one lane wide for most of its length because of the narrow corridor and tunnels. In addition, buses would be fitted with a guidance system to ensure safe operation.

Bus stations would be provided at or near to the existing rail station locations. These stations incorporate the following:

- Low floor accessibility for the disabled
- New shelters to protect passengers from the elements
- Ticketing machines
- Passenger information systems
- Cycle storage

At grade entry and exit points could be provided at Johnsonville, Khandallah, Simla Crescent and Ngaio. This would allow for different service scenarios in the future and also provide access for service vehicles.

At the moment, the Johnsonville railway line runs through the Wellington Station Yards and shares tracks with trains from the other railway lines in the Station throat before accessing the station. If buses were to do this, they could come in conflict with rail vehicles and there are large safety issues associated with this because of the need to control movements and the likely consequences of an accident involving a bus and a heavy rail unit. As noted in Appendix F, a similar issue with light rail would require the light rail units to have Automatic Train Protection (ATP) systems installed or be constructed to an appropriate level of crashworthiness. It is not practical to implement these sorts of arrangements with buses.

Therefore, at the Hutt Road Overbridge, buses using the busway would return to grade and access Hutt Road. To provide bus access at this location a new signalised intersection would need to be constructed. The buses would then feed into bus lanes on Hutt Road to continue the journey along

Thorndon Quay to the Lambton Interchange. The installation of bus lanes on Hutt Road would require the existing angle parking on Hutt Road to be removed and replaced with parallel parking. This will reduce the amount of parking available for businesses that operate in this location.

Another option to provide priority for buses over the length between Hutt Road Overbridge and Lambton Interchange would be to provide a dedicated separate right of way through or adjacent to the Wellington Yards so buses could not come in conflict with rail vehicles. This would require the use of land currently used for train storage and maintenance and the operation and layout of the Wellington Station Yards would need to be altered. ONTRACK have advised that they believe that operation of a busway through the rail yards is not feasible due to safety and operational constraints.

Rail replacement services would be extended from the Lambton Interchange through to Courtenay Place. This would place extra demands on the CBD bus route and the bus priority measures outlined in the bus on-street scenario (refer to D.2.1) would also be required through the CBD. It may be possible to mitigate against some of the capacity constraints in the CBD, if bus routes from areas south and east of the CBD were through routed to the northern suburbs, rather than having the routes terminate in the CBD at the Lambton Interchange. The longer routes may however have reduced trip reliability, because they would not have the same opportunity to make up time lost along their routes.

It is assumed that the following bus priority measures would be required for the *Busway Scenario*:

- CBD bus route improvements
- Hutt Road / Thorndon Quay bus lanes between the busway entrance and Lambton Interchange requiring reallocation of parking and removal of the existing angle parking, required for buses in the off-peak direction
- Construction of new interchange facilities at Johnsonville and implementation of bus priority measures at surrounding intersections

There would be some additional congestion for cars in locations where bus priority is provided.

E.3.8 Construction and Staging

It has been assumed that the construction of the busway would be consistent with the Adelaide O-Bahn. For the majority of the length at narrower locations and in the tunnel sections, a one-way 2.6 metre wide pavement would be provided with guidance kerbs of approximately 180 mm high.

At the existing station locations (except Awarua), bus pull-off areas would be provided where buses can pass one another. Because of the topography at Awarua Street station, there is not sufficient room to construct passing areas, therefore Awarua Street Station could be removed to improve the operational characteristics of the busway if required. Low floor bus platforms would also be provided at these locations. Other pull off areas could be provided where existing rail passing loops are located. It has been assumed that a number of additional passing areas will be provided for incident management.

The busway would be constructed on the subgrade exposed by removal of the existing railway line and the track ballast with some widening and preparation of the subgrade and a layer of subbase required. It has been assumed the ground conditions have sufficient bearing capacity to cater for this busway design, however detailed geotechnical investigations would be required to confirm such a design and identify if and where piles or retaining structures may be required.

The construction of the busway would require the removal of the rail infrastructure including tracks, overhead power lines, stanchions and platforms before the construction of the busway and ancillary features could be commenced. Clearance and construction could take 12 – 18 months because of the constrained nature of the site and would require implementation of a bus service operating on the existing road network while construction takes place. If bus priority measures from Ngaio Gorge into the CBD were implemented prior to the closure of the rail service, the level of service during construction of the busway would be equivalent to that for the bus on-street scenario. Construction could be staged with the section from Ngaio to the CBD constructed earlier and enter operation within one year, before the rest of the busway was completed.

On-street operation during construction would require the provision of buses to be available at the outset to maintain a reliable, attractive service during construction. Such operation could be considered for any scenario that involves a period where the rail services would not operate.

It should be noted that if an attractive on-road service was not provided during the construction period, it is likely that an initial loss of passenger transport patronage would occur. It may take a significant period of time to regain the same level of patronage even with a new busway, once patrons had opted out of passenger transport. Issues with regaining patronage following major disruption have been experienced by Tranz Metro following the track temperature problems in the past.

E.3.9 Peak Direction Only Operation

The simplest scenario for operating a busway in a confined corridor such as this, is to have it operate in the peak direction only. This would allow for small headways as buses would not be constrained by having to wait for buses travelling in the opposite direction.

This would mean that in the morning peak, buses would operate from Johnsonville to Wellington CBD while counterpeak buses would return to Johnsonville via on street running. At some stage (for example midday) the busway would switch direction and operate with buses running from Wellington CBD to Johnsonville on the busway with counterpeak services running back to the

CBD via the road network. Counterpeak buses that were not required to provide counterpeak capacity would not need to follow the same route and could return via the Ngauranga Gorge Motorway.

A major issue with operating a busway in the peak direction only is the legibility of the system and confusion about when the busway operates in each direction.

Buses running in the counterpeak direction (i.e. in the opposite direction to peak traffic) would run on the existing road network with stops as close as possible to those on the busway. This would result in some stops being used for only part of the day and may lead to some confusion for people not familiar with the system. Clear information and signage would be required to direct passenger to the correct stops. Passengers would be directed as follows:

- Crofton Downs passengers would be directed to stops on Churchill Drive
- Ngaio passengers would be directed to stops on Ottawa Street
- Awarua passengers would be directed to stops on Khandallah Road
- Simla Crescent passengers would be directed to stops on Khandallah Road
- Box Hill passengers would be directed to stops on Cockayne Road
- Khandallah passengers would be directed to stops on Station Road
- Raroa passengers would be directed to stops on Fraser Avenue

It has been highlighted that there are significant numbers of school students travelling in the counter peak direction to Onslow College using the train at the moment and alighting at Raroa Station. The proposed counter-peak bus routes provide for pickups in the residential areas and travel past Onslow College and on Burma Road, thus providing a direct service. It also provides the opportunity for the other routes to divert if necessary to access the school directly.

It is anticipated that for an initial provision of capacity for say 1000 peak hour rail replacement trips a peak direction frequency of 16-18 rigid buses or 9-11 articulated buses per hour would be required. These rail replacement services would stop at each bus station for passengers to board or alight. It is expected that the travel time from Johnsonville to the Lambton interchange for rail replacement services would be comparable to the existing train service (approximately21 minutes). It is expected that these services could commence in residential areas a short distance (say 1km away) from the Johnsonville town centre to pick up additional patronage in the local area before entering the busway.

Non articulated buses which service the existing bus catchments could feed into the busway. It is expected that full buses would operate as "express" services only stopping to set down until Thorndon Quay.

The likely travel time for express services would be 17 minutes. The ultimate minimum travel time along the busway would depend on the practical maximum speed buses can achieve. The practical maximum speed is constrained by the horizontal alignment of the route as well as speed restrictions travelling through the tunnels. We have assumed that buses will be able to travel through the tunnels at speeds similar to trains, namely 35km/h.

The travel time of 17 minutes assumes that buses are able to achive an average speed of 50km/h on the non-tunnel sections. The travel time would reduce to 15 minutes if average speed of 60km/h could be achieved on the non-tunnel sections. Similarly it may be able to achive some travel time reduction for the assumed 21 minute rail replacement services which would stop at all stops. During the analysis, sensitivity testing will be undertaken to determine the benefits that could be achieved by a travel time reduction of 2 minutes. Detailed investigation would need to be carried out to confirm the feasibility of reduced travel times.

The travel times for some of these express services via the busway (from Newlands Road and Johnsonville to the Lambton Interchange for example) would be longer than the current scheduled times (approximately 20 minutes vs 16 minutes). They would however be more reliable because buses would not be affected by general traffic conditions which are likely to worsen in the future.

The distance travelled on the busway is also longer and operators may choose to continue to operate these services via the Ngauranga Gorge motorway. This is an operational issue and construction of the busway would allow for both alternatives.

E.3.10 Bus Route Changes for busway operation

This is a strategic study and has not attempted to undertake a rigorous investigation into development of new bus routes and timetables as the level of detail required to provide this is outside the scope. Instead, a typical future bus operating plan with indicative service frequencies has been developed which is representative of the type of services that could be provided.

It is anticipated that express bus services from Newlands, Grenada Village and Paparangi would feed into the busway during peak periods at Johnsonville by crossing over the Newlands Overbridge, travelling north on the Motorway and exiting at Johnsonville. Churton Park and Glenside services would also access the busway at Johnsonville. Johnsonville West and Broadmeadows services could access the busway at Khandallah.

It is expected that the following changes to services could be made:

E.3.11 Route 54 and 59 Changes

Route and frequency changes for Route 54 and 59 services north of Johnsonville could take place as detailed in the Base Bus Improvements in Section D.4 above. However, at Johnsonville the buses could continue to the CBD via the busway instead of utilising the Ngauranga Gorge Motorway.

E.3.12 Route 55, 56 and 57 Changes

Route and frequency changes for Route 55, 56 and 57 services north of the Newlands onramp could take place as detailed in the base bus improvements in Section D.4 above and base services would continue to operate down the Ngauranga Gorge. However during peak times, express buses could cross the Newlands Overbridge and travel north to Johnsonville where they would continue to the CBD via the busway instead of utilising the Ngauranga Gorge Motorway.

Alternatively, operators may choose to continue to operate these services via the Ngauranga Gorge motorway. This is an operational issue and construction of the busway would allow for both alternatives.

E.3.13 Route 43, 44, 45, 46, 50 and 53 Changes

It is anticipated that bus services for Ngaio, Homebush and Khandallah would remain similar to the existing. Routes 43, 44 and 45 would continue to operate as at present with some frequency improvements. Route 46 would be replaced by a new “West Johnsonville Route” W which would service Johnsonville West and Broadmeadows before accessing the busway at Khandallah.

Alternatively, the new "Broadmeadows Route” B described in the base bus improvements serving Johnsonville West, Broadmeadows, Khandallah and Cashmere (Homebush and Onslow Roads) could operate on-street as could the new "Khandallah route K" replacing the Ngaio Gorge, Cockayne Road, Te Kainga, Khandallah Village section of routes 43 and 44. This would result in a longer journey times for Johnsonville West and Broadmeadows, however the additional catchment would mean that more frequent peak services and offpeak and weekend service improvements could be provided.

Counterpeak buses would run via the on street routes identified for the *Bus with Walking and Cycling Scenario*. A frequency of 2-4 buses per hour would be operated on each of the routes. An off-peak busway frequency of 6 buses per hour is considered appropriate, with operation switching from southbound to northbound in the middle of the day. Off-peak buses operating in the opposite direction to the busway would again follow the on road routes at 2-4 buses per hour on each route.

A major advantage of the busway is that buses would not be subject to general traffic conditions between Johnsonville and Hutt Road resulting in a more reliable journey time compared to the bus on-street scenario. Buses in the counterpeak direction, however, would need to run on the road network so services could still be disrupted at times.

An alternative busway approach is to have the rail replacement service operate on the parallel roads and have the busway operate solely as an expressway. There would only be bus stations at Johnsonville, Raroa, Ngaio and Crofton Downs. Rail replacement services would run on parallel roads not on the busway, but could feed into the busway when full. This alternative approach would mean:

- The same bus stops would be used all day and so reduce the confusion associated with peak direction operation of the busway.
- Travel times for Rail Replacement Services would be greater than the existing rail service but faster than *Bus with Walking and Cycling Scenario* (as they would use the busway into/out of Wellington). Buses would be more frequent than the rail options.

The express bus service travel times and total capacity of the busway could be improved because express buses would not have to slow at bus stations.

E.3.14 Peak Direction Operation System Capacity

One-way operation of the busway can provide higher peak-flow frequencies than two way operation in a one lane busway arrangement. This is due to the removal of timing interfaces between peak and counterpeak buses required for two-way operation. Frequency is therefore only constrained by minimum headways.

A review of best practice for operation of busways has been undertaken. Given the need to operate in tunnels and to ensure that sufficient separation is maintained between vehicles to allow drivers to stop safely, it is considered that a practical maximum frequency for buses operating in one direction on the Johnsonville railway line right of way is likely to be in the order of 1 minute. This implies a maximum peak flow frequency of 60 buses per hour could be accommodated on a one-way corridor if required to meet demand. This would require signalling to be installed along the busway to ensure that separation is maintained.

The optimal ultimate capacity of the busway, operating as an express service with limited stops, would exceed the likely demand on the busway. A 1 minute headway during the peak hour would result in a capacity of 6,000 passengers per hour for articulated buses (using a planning capacity of 100), or approximately 3,300 passengers per hour using non-articulated buses (planning capacity of 55).

Again, peak frequency would be extremely sensitive to boarding and alighting times. Existing systems which require driver interaction for payment would affect the ability to provide short headways. To enable short headways, measures such as automated, integrated ticketing and all door access may need to be implemented.

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E.3.15 Two Way Operation

Another scenario considered for the rail corridor is replacing the existing heavy railway line with a dedicated two-way busway between Johnsonville and Wellington.

The existing railway line was constructed through difficult terrain. The line is, in many places, perched on a shelf cut into steep slopes and 7 tunnels were required. To provide additional width over much of the route (in particular the steep Ngaio Gorge section), significant earthworks and large retaining structures (above and below) would be required. A two-way busway over the whole length was considered, however given the constrained nature of the rail right of way it is likely this would not prove cost effective. A completely two way busway has therefore not been considered further.

In this regard, the two way operation has been considered on the basis that the busway would operate as a single "lane" along a substantial portion of its length, with two way operation occurring in those sections where passing opportunities exist in the rail corridor.

It has been assumed that passing opportunities could be provided at the existing crossing loop locations at Wadestown, Ngaio and Khandallah. A preliminary onsite review of the existing rail right of way was undertaken to identify locations were it is likely to be economic to provide additional width to allow buses to pass each other without significant earthworks or the need for large retaining structures. Following this review, passing oportunities been assumed at the locations listed below:

- Johnsonville Station
- New passing area immediately north of Fraser Avenue
- Existing passing loop location at Khandallah Station
- New passing area at Simla Crescent Station
- Existing Passing loop at Ngaio Station
- New Passing area at Crofton Downs Station
- New Passing Loop immediately north of Tunnel 5
- Existing passing loop location at Wadestown

A detailed analysis was then undertaken to determine the most regular service that could be provided reliably utilising the passing opportunities identified. No other two-way passing points are essential to busway operation, but extras could be of use to cater for unreliable service operation or break-downs. With one-way operation passing areas would only need to be provided at existing stations.

E.3.16 Two Way Operation System Capacity

Modelling of the two way operation of the busway in the morning peak was carried out to determine the most feasible operation. The model considered the whole route implications of two way operation on the bus way. The model looked at the maximum frequency of peak direction buses that can be operated in the morning peak given:

- Operation of a minimum desirable 2 counterpeak buses with minimum delay awaiting peak direction buses to clear one-way sections in the peak hour;
- 2 minute minimum peak-direction headway; and
- All other assumptions discussed above.

Results of the modelling on the above parameters provided the following key observations:

- The maximum capacity that could be offered by busway operation, as detailed above, would be 14 peak-direction buses per hour;
- Peak direction headways are constrained by each of the one-way sections, with a resultant gap in peak service of twice duration required to pass the one-way sections. The implication of this is that departures cannot be timetabled to leave at even intervals;
- Timings of morning peak departures from Johnsonville, assuming the cycle starts on the hour are:

  00, 05, 09, 13, 18, 22, 26, 30, 35, 39, 43, 48, 52, 56
- Timings of morning peak arrivals at Johnsonville:

  17, 47
- Articulated buses would be required to provide a peak-direction of 1,400 spaces. The counterpeak capacity would be 200 spaces. Rigid buses would only just provide for the current peak direction demand.
- Modelling further scenarios has not been progressed at this stage as this scenario already has 'minimum' headway and 'minimum' counterpeak frequency, and peak-direction capacity is only exceeded by articulated vehicles. Essentially a two way busway would be extremely complicated to operate requiring buses to be exactly on time, not have the potential to provide additional capacity in the future or cater for any other non-rail replacement services.
- The following travel times have been assumed:

  Morning Peak flow journey time (JV – WE) would be ~–20- 21 minute; and

  Morning Counterpeak journey time (WE – JV) would be ~21 - 22 minute.

  Counterpeak journey time is marginally longer due to delays waiting for one-way sections of the busway to be free. Afternoon peak results can be assumed to be broadly similar, noting:

- Location of passing points may be such that frequencies are marginally different; and

- Afternoon peak hour capacity requirements are typically less that morning peak hour, as afternoon peak travel is typically more spread out over time; implying that morning peak frequency is the key service provision target.

Off-peak frequencies have not been investigated at this stage, but it is anticipated that a more evenly distributed northbound versus southbound service, with a frequency of approximately 6 buses per hour in each direction could be operated. This is operationally feasible, but likely to incur increased journey times for one or both directions of travel due to the more complex interface between the two directions on constrained one-way sections.

There is a large difference between peak and counterpeak direction frequencies operating on the busway. Therefore allowance would be needed for buses returning to the origin of the peak-direction operation. It has been assumed that these vehicles would return to their origin on-road, and would run "out of service", unless demand justified running a proportion in service.

Peak frequency would be extremely sensitive to boarding and alighting times. Existing systems which require driver interaction for payment would affect the ability to provide short headways. To enable short headways, measures such as automated, integrated ticketing and all door access may need to be implemented.

Because of the inflexibility, complication and capacity constraints of a two-way operation, it has not been considered further as a viable option.

E.3.17 Signalling Requirements

It is anticipated that the following signalling would be required for safe one way operation:

- Signals at all entry points to prevent access to the busway in the wrong direction;
- A moving block signal system to ensure that adequate separation is maintained between vehicles;
- Variable signage to indicate which direction is in operation; and
- Careful management system to prevent any wrong-direction use of the busway.

It is likely that as part of the signalling system, some form of physical barrier would need to be installed which could incorporate vehicle traps, barrier arms or rising bollards to ensure that general vehicles could not enter the busway.

E.3.18 Stops

Each stop should provide for two platforms, one in each direction. Space should be allowed for buses accessing the platforms to pull clear of the through lane. The platform would be constructed to provide a level access from the kerb to the bus entry and be provided with a shelter or overhead awning to provide weather protection.

The provision of real time passenger information displays at each station, linked to the GPS system and monitored by the central control room would provide improved information for waiting passengers. This is particularly helpful to improve passenger confidence in bus-based operation, especially should delays occur.

E.3.19 Depot

The location of a depot for vehicles servicing the busway would need to be established near one of the access points to the busway. The depot would need to be of sufficient size to park approximately 25-28 rigid (12.5 metres) or 15-18 articulated buses. It would need to have ready access to the road system to enable on-road travel from the depot to the start point of a service (Johnsonville, Wellington or other start points). This would remove the requirement for travel on the busway for out of service buses and reduce possible conflict with passenger services.

The depot would be provided with maintenance facilities, fuelling facilities, staff and administration facilities for approximately 40-50 staff. If necessary, the central control room for the busway system operation could also be provided on this site. Room for expansion of the facilities should also be allowed for to cater for any future growth.

E.3.20 Operation of Buses on the Johnsonville railway line Right of Way

There is some debate over whether the Johnsonville rail corridor could be used for non-rail purposes such as a Busway. ONTRACK have written to Greater Wellington advising that under the Rail Network Bill which is currently before Parliament, the closure of a railway line would require the consent of the Minister of Transport. It also notes that unless ownership was passed to another Crown agency, buy-back provisions for the original owners of the land may have to be considered.

Appendix F Light Rail

F.1 Light Rail Transit (LRT) Introduction

A scenario for extending the rail penetration further into the CBD and providing a seamless service (without interchange) between the northern suburbs through the CBD is the installation of a Light Rail Transit (LRT) system. Extension of the LRT south to the Airport and north into Churton Park is also a possibility and can be considered if light rail is a preferred scenario.

F.2 Light Rail Transit Overview

While a simple description of light rail is that of a modern urban tram system, it is however much more than this. The essence of light rail is:

- It is a rail based urban transport system that can operate at average speeds of 25 to 30km/hr for shared street running and typically up to 80km/hr when operating in a dedicated corridor (note that the operating speed of an LRT system in the Johnsonville Rail corridor is likely to be much lower than this)
- It is flexible and can travel around sharp curves, on steep gradients and along streets, run in its own reserve, run on elevated track, share track with heavy rail and metro systems and go underground
- Headways can be as low as one minute, although 4 to 6 minutes is more common whilst still maintaining the ‘moving platform’ philosophy
- It uses modern, high capacity vehicles which are lighter than Suburban rail passenger systems. These can be articulated and skirted for street running. Many Light Rail Vehicles (LRVs) incorporate ‘low floor technology’ which provides safe access for the mobility impaired.
- It uses clean 600/750V electric current with either an overhead current collection or a third electric rail. It can also run on dual current (750V/15000V) as in Karslruhe, Germany
- It is a simple system, usually with a barrierless fare system, simple stops and one-person driven vehicles

A typical light rail system in a city has a line passenger capacity in the range of 2,000 to 6,000 persons per hour. The operation can offer a fast, frequent and comfortable service to the passengers with service intervals of 5 minute or less at peak periods. This frequency, coupled with reliability gives confidence in the system. The modern LRT service can be well integrated with other transport services, with interchanges at various points and through ticketing.

Compared to heavy rail, light rail is flexible and adaptable. With the ability of the LRV to negotiate curves of 20m radius and relatively steep gradients, the track can be laid through most city streets, and the system can be installed in a city without major disruption of the urban landscape. To be effective LRVs do however need to be given a large degree of priority over cars and other passenger transport modes which may lead to disruption.

Stops are typically spaced much closer than heavy rail passenger services and can be between 300 to 800 meters apart in the city centre. Closer stops provide more access for pedestrians; but the negative aspect is to reduce journey speed and hence increase overall transit times.

Proponents of light rail claim the following key advantages in implementing a light rail system include:

- Increase in passenger transport patronage by providing an attractive alternative to the car and therefore reducing road congestion
- Provide a clean, sustainable transport system by reducing energy consumption and air pollution
- Influence land use patterns through densification around stations and transit orientated development (TOD)
- Reduce passenger transport operating costs. Cheaper to construct, maintain and operate compared to Heavy rail or Metro systems
- Positively influence inner-city environment through good urban design and redistribution of space in the streetscape.

There is a large amount of debate as to whether the benefits claimed can be achieved with installation of a LRT system. It is clear that installation of an LRT system would need to take place as part of a package of other measures to be effective in obtaining these benefits.

There are a lot of contradictory comments on the suitable patronage range appropriate for various modes – largely influenced by the particular mode-bias of the author. However, Brand and Preston appear to take a holistic view and present maximum hourly capacity for various modes. See Table 8.

- **Table 8 Maximum capacity by mode (passengers per hour per direction)**

Metro	Suburban Rail	Busways	Light Rail	GLT	Bus Lanes	Guided Bus
40,000	32,000	25,000	21,000	9,600	7,500	7,500

Source: Brand C and J Preston Which Technology for Urban Public Transport? A Review of System Performance, Costs and Impacts 2003.

Evidence from Carmen Hass Klau, an eminent German academic, in her book "*Bus or Light Rail—Making the Right Choices*" and Barry Broe, Transport for London Director of Group Transport Planning and Policy in his presentation "*Why Light Rail offers value for Money in London*" at the

Waterfront Conference on light rail on 15 June 2004, suggests that tram systems are the most economical long term transport solution for routes carrying in excess of approximately 3,000 passengers per hour.

The House of Commons Transport Select Committee Inquiry into the future of light rail and modern trams in Britain 2005 states that the equivalent threshold is in fact 2,500 passengers per hour.

According to the Rail Transit Capacity report of the Transit Cooperative Research Program, the busiest light rail system in the US is Boston's Green Line and it only serves 10,000 peak hour passengers while the third busiest light rail trunk line in the country only carries 4,100 peak hour passengers.

The appropriate level of patronage required for successful implementation of an LRT system is not clear cut and would be largely dependent on the specific characteristics of the location in question.

F.3 Light Rail Vehicles (LRVs)

Modern LRVs are typically 2.4 to 2.6m wide, 20 to 40m long and can carry between 150 to 270 passengers at a time with a maximum speed between 70 to 80km/hr. LRVs are air-conditioned, often have full or part low floor technology systems and can operate bidirectionally.

The LRV is the public face of the entire LRT system. Thus it is important that vehicles are well designed and an adornment to the city. The use of low floor, air conditioned vehicles, combined with wide and frequently spaced doors, make the LRT service user friendly to all, young and old persons, those with baggage and persons with mobility impairment of one form or another. The LRV is comfortable and quiet, with a smooth ride afforded by use of good suspension and resilient wheels. To pass around sharp curves the LRV is articulated with tapered ends. Skirting which fits around the underfloor of the LRV ensures that it is pedestrian friendly for travel through city streets.

The use of electric traction provides for smooth and rapid acceleration of the LRV. It is also environmentally friendly with emissions far less than the number of cars required to carry equivalent numbers. The electric motors are compact and powerful, using the latest energy efficient advances in microprocessor and semi conductor control.

There are safety issues with crashworthiness of these types of units when run on the same tracks as heavy rail vehicles (i.e. in the Wellington Yards). Some manufacturers claim that their vehicles have the appropriate crashworthiness to operate on the same lines as heavy rail as in Karlsruhe Germany. Another possibility would be the installation of a train protection system such as ATP (Automatic Train Protection), which would provide an additional level of safety. In order for

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optimum effectiveness, the system would have to be introduced on the entire Greater Wellington Suburban System, with train borne equipment being installed to all existing passenger rolling stock and freight locomotives. It is considered that the introduction of such a system would not be financially viable unless being introduced network wide.

- **Typical LRV**

The use of non-standard units on a small section of the Network would also be problematic for operational reasons. The units would not provide a strategic fit with the rest of the Network as they could not be used on other parts of the Network. This would result in disproportionate costs associated with operating and maintaining a small number of non-standard units.

F.4 Light Rail Infrastructure

Tracks can be constructed in a number of different ways. When running in a dedicated corridor, traditional ballasted track can be used. When sharing roadspace with other vehicles, the tracks need to be embedded and paved or alternatively grassed. Service relocation is required to ensure that there is minimum disruption of the track in the future.

Stops are typically simple. Attractive design is necessary to ensure low visual intrusion and to ensure compatibility with street furniture and the architectural context of existing buildings and the streetscape. As required, there is also weather protection for patrons of the service waiting at stops. A low floor LRV provides a platform that is a little higher than footpath height on a street. Thus stops are unobtrusive features in the street.

Vehicle separation of LRVs running on street can be effected by simple line of sight and also by signalling systems where necessary, since the driver of each LRV is totally in control of the vehicle and is in constant radio communications with the central depot/control centre. Use of an automated vehicle monitoring system allows regulation of LRVs to a desired service schedule and pattern of service.

Electric substations are located at intervals along the LRT route to feed power to the system. In environmentally sensitive areas these can be built underground. In general, substations can be built to 'blend in' with their surroundings in an unobtrusive way. Overhead wiring systems need no longer appear as a heavy massed jumble of 'celestial knitting'. Today, lighter less obtrusive overhead wiring is in use in the great majority of LRT systems.

F.5 Light Rail for Wellington

In some ways, the characteristics of the Johnsonville railway line are well suited to operation of a LRT system because:

- the steep grades and tight curvature is suited to the performance characteristics of LRVs
- station spacings are smaller than generally accepted as appropriate for Suburban rail
- the patronage on the line is lower than generally accepted as appropriate for Suburban rail

Scenarios for converting the Johnsonville railway line, and in fact the entire Wellington commuter rail system, to light rail have been considered for some time and a number of reports have been produced which address this issue. Following a review of these reports an indicative plan for LRT has been adopted for this study as detailed below. The *Light Rail Scenario*s are broadly based on the *Light Rail Transit Feasibility Study, Works Consultancy / MVA Consultancy, 1995* report, which is the most recent and most detailed report on light rail in Wellington.

The proposals for LRT in Wellington considered in this study broadly consist of the following:

- Purchasing LRVs to replace the existing EEMUs on the Johnsonville railway line
- Installation of additional passing loops an station rationalisation and relocation on the Johnsonville railway line section
- Construction of twin track line through the CBD terminating at Mercer Street or Courtenay Place

This is a strategic study and has not attempted to undertake a rigorous investigation into the feasibility of an LRT system, which is outside the scope. Instead, previous reports into light rail for Wellington have been used to develop representative scenarios for evaluation against other mode choices. A detailed review of the feasibility of light rail would be required before progressing further. Specific issues have however been identified where appropriate.

LRT has a number of benefits including being able to influence land use patterns through densification around stations and transit orientated development (TOD). This is however unlikely to be the case on the Johnsonville railway line due to nature of the communities it travels through. The exception is at Johnsonville where densification and TOD are likely to be viable if encouraged by planning policies.

F.5.1 Power Supply

In general, LRT systems operate on 750 volt overhead electrical power supply systems and this is considered a safe voltage for on-street operation. However, the Johnsonville railway line currently operates on a 1500Volts DC overhead electric power supply system. This issue would need to be considered in some detail. One scenario is to convert the whole Network to 750 volt however, this would be disruptive and expensive. Another scenario is to purchase 750/1500 dual voltage LRVs as are in operation overseas.

F.5.2 Overhead Wire Conflicts

LRVs are powered via a single overhead wire with the return through the rail. Trolleybuses on the other hand operate on a two wire system. The two systems can not be allowed to contact and would need to be isolated from one another.

As trolleybuses currently operate along the same route as the proposed LRT, the overhead wires would be in conflict. Solutions to this problem have been developed overseas but the issue would need to be considered in detail before implementation.

F.5.3 Light Rail Vehicles & Platform Heights

As noted in the LRT overview above, LRVs are usually low floor vehicles which provide easy access for the less able and allow stop platforms of approx. 300mm high which are unobtrusive, and easy to fit into the desired streetscape. The normal maximum operating speed assumed for low floor LRVs is generally considered to be 80km/hr, however some new units have claimed operating speeds in the order of 100km/hr.

The vehicles considered in this study may also need to be able to operate on the rest of the Wellington Network, so that conversion of the whole Network to light rail could be facilitated in the future (in line with the proposals detailed in the Works / MVA report). To be able to maintain the existing timetables and capacity on the wider Network, LRVs would need to be able to operate at maximum speeds of 100km/hr. The platforms on the majority of the Network have platform heights of approx 680mm which would also need to be lowered if low floor vehicles were used. Therefore, the use of high floor LRVs was considered appropriate for Wellington in the Works/MVA report.

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The LRVs assumed as part of this study are the same as those assumed in the Works / MVA report. Figure 5.1 contained in Appendix F-A, sourced from the Works / MVA report, shows the typical LRV dimensions envisaged in that report. The use of new low floor LRV's with claimed operating speeds of 100km/hr is also possible and would need to be considered in more detail before progressing further with a LRT option. Basic parameters for the vehicles are set out in Table 9:

- **Table 9: Basic LRV Parameters**

Track gauge	1067mm
Power supply	Dual voltage 750/1500v
Max operating speed	100km/h
minimum curve radius	25m
Overall vehicle length	28m
Width	2.65
Height (excluding pantograph)	3.65
Floor Height	900mm
Seating capacity	170
Standing capacity	120*
Total Capacity	290

* Assuming NZR standard of 1.9 standees / m^2

F.5.4 Stops

It has been assumed that each stop would be required to cater for two LRV units coupled together. This requires a straight platform length of 60m to ensure there is only a small gap between the platform and the doors.

As noted above, high floor LRVs have been assumed and the stop platforms must cater for them. In order to provide a level of accessibility for the disabled and mobility impaired, the Works / MVA report assumed stop platforms similar to those adopted for the Manchester LRT. The same stop construction has been assumed for this study and includes:

- local raising of platforms to 900mm near the doors
- 1:20 sloping ramps
- paved platform
- shelter
- lighting
- railings
- integrated electronic ticketing machines

Island stops which have a single platform for both northbound and southbound LRVs are assumed to be a minimum of 3m wide. Kerbside platforms which only cater for one direction as assumed to me a minimum of 2m wide. Modifications to the central median and footpaths would be required to accommodate platforms, resulting in reduced footpath widths. Figures 5.2 and 3.1 included at the end of this appendicies, sourced from the Works / MVA report, shows the typical construction of platforms envisaged in that report.

There may be accessibility and urban design issues with the type platform stops described above and assumed in the Works / MVA report to allow for LRV option on the whole Wellington network in the future. Alternatively, low floor LRVs could be used, low floor platforms provided in the CBD and platforms on the Johnsonville railway line amended. The costs for either option is likely to be broadly similar and is not likely to be a significant determining factor in a strategic study of this nature. The issue would need to be considered in detail at the next stage of investigation if light rail was found to be a preferred scenario.

F.5.5 Signalling

It has been assumed that the existing signalling would be adequate for the operation of the LRVs on the existing section of track between Johnsonville and Wellington Station. On the sections south from Wellington Station, it is assumed that the units would operate on line-of-sight and also be controlled by signals included in the traffic signals. The LRV drivers would also be in contact with each other and a control station via radio telephone.

F.5.6 Depot

A new depot would be required to allow for servicing, cleaning etc. of the LRVs and also to provide office and amenity facilities for staff. It is assumed that an area can be put aside in the existing Wellington Rail Yards.

F.5.7 Construction

It has been assumed that significant service relocation would be required prior to installation of the track. The track is assumed to be installed on a concrete base with tracks flush with the paved surface. Where dedicated road space is provided it is assumed that the tracks and paving are slightly raised to deter use by other vehicles.

There would be a large amount of disruption caused by construction of a LRT system in the CBD. This would impact both general traffic and public transport for significant periods of time and affect services from around the region, not just from the northern suburbs. Construction could take a number of years from service relocation to completion. It should be noted that if an attractive public transport service was not provided during the construction period, it is likely that an initial large loss of passenger transport patronage would occur. It may take a significant period of time to

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regain the same level of patronage even with a new LRT, once patrons had opted out of passenger transport.

F.5.8 Light rail alignment

The alignment below is indicative only and based on previous reports. A detailed feasibility study would be required before proceeding further with this scenario. The alignment has only been considered in a very preliminary way to enable rough order costs to be developed.

It is assumed that the width required for the LRV corridors on road would be 3.5m on straight sections and determined by vehicle swept paths on curves. This would allow the area to be shared with non-rail vehicles if required and provide a safety gap between the vehicles and adjacent obstructions.

F.5.8.1 Johnsonville to Wellington Station

The section between Johnsonville and Wellington Station would use the existing track and station stops. Some station rationalisation and relocation is assumed for the improved timetable as detailed in section F.7.1.2.

F.5.8.2 Wellington Station to Mercer Street

The light rail line would extend from the existing Johnsonville railway line platforms on the western side of Wellington Railway Station, most likely requiring the removal of the adjacent utility building. The line would then cross Thorndon Quay at the Mulgrave Street intersection and extend through the Lambton Interchange, before follow the central median to Bowen Street and across into Lambton Quay. In Lambton Quay, the tracks would continue to follow the central median as far as Grey Street where they would switch to kerbside running before continuing to Hunter Street where the northbound and southbound tracks would diverge.

The southbound track would follow Hunter Street adjacent to the kerb, and make a 90 degree turn into Victoria Street. It would then follow the eastern kerbline past the Library to the intersection with Mercer Street.

The northbound track would continue on Lambton Quay to the intersection with Willis Street. This section would need to be shared with northbound general traffic and buses. Some kerb realignment of the intersection would be required to allow for the swept paths of the vehicles.

Between Lambton Quay and Mercer Street the line would follow the western kerbline of Willis Street and share the road space with general traffic and buses.

For scenarios which terminate at Mercer Street, the line would turn 90% into Mercer Street and rejoin as twin track and continue back to Wellington Station on the above alignment.

Stops

Stout Street: The first stop would be an island stop in the central median at Stout Street. The location would require some kerb realignment of the eastern kerbline. Pedestrian access to the platform would be provided by a new signalised crossing.

Cable Car: The stop would be an island stop in the central median adjacent to Panama Street. Some realignment of the median would be required to provide the appropriate straight platform length. Pedestrian access to the platform would be provided by a new signalised crossing.

Library Stop (southbound only): The stop would be a kerbside stop outside the Wellington Library with direct access from the footpath.

Willis Street (northbound only): This stop would be a kerbside stop adjacent to with direct access from the footpath.

F.5.8.3 Mercer Street to Courtenay Place

Southbound –Mercer Street to Manners Street East

From the Mercer Street / Victoria Street intersection, the southbound line would continue against the eastern kerbline on Victoria Street until Wakefield Street where it would turn into Wakefield Street and follow the kerbline until Cuba Street. The line would then turn into Cuba Street following the kerbline before rejoining the northbound track at Manners Street East.

Northbound - Mercer Street to Manners Street East

Between Mercer and Manners Street West the line would follow the western kerbline and share the road space with general traffic and buses. Along Manners Street West, the line would share the existing bus lane. The line would return to twin track at Manners Street East, and only the northbound line would run through the existing pedestrian only area in Manners Mall.

Manner Street East to Courtenay Place

Through Manners Street East, the lines would run adjacent to the kerblines and continue across Taranaki Street where both the northbound and southbound would start running adjacent to the central median. The alignment would continue against the median as far as Tory Street, where both tracks would shift to the southern side of the road and utilise the area which is currently used as a service road to provide a 2 platform 3 track terminus shared with buses.

Stops

Cuba Street (southbound only): This stop would be a kerbside stop with direct access from the footpath.

Manners Mall (northbound only): This stop would be provided in the pedestrian mall.

Taranaki Street Station: This stop would require two kerbside platforms with direct access from the footpath.

F.5.8.4 Potential Extension to the South

There is the potential to extend an LRT south from Courtenay Place to the Airport, however this is not being proposed as part of the options for the northern suburbs. From Courtenay Place the line could turn onto Cambridge / Kent Terrace and run along the central median as far as the Basin Reserve. The tracks could run with the traffic around the Basin Reserve and into Adelaide Road. Along Adelaide Road the line could then run along the widening strip provided on the eastern side of the road or share the existing bus lanes. The line could then follow Riddford Street to the Hospital at Newtown.

From the Hospital the line could continue as twin track along Riddford Street to Constable Street where it would turn and follow Constable and Crawford Streets to Kilbirnie Road in Kilbirnie. From Kilbirnie, the line would continue as single track and follow Rongaotai Road, Troy Street, Cobham Drive, Calabar Road and Stewart to the Wellington Airport terminal building.

If LRT was to become a preferred option, the extension of the LRT to the south could be considered in detail.

F.6 Impact on Traffic and Bus Services

LRT systems require a level of priority over other traffic to provide an efficient attractive and reliable service. In many cases, LRT systems have their own right of way and are given priority over other traffic at intersections. The CBD route is heavily congested at the moment and general traffic uses the route as well as trolley and conventional buses.

F.6.1 Traffic Impacts

To provide a regular reliable service, significant priority measures would need to be developed in for the LRVs which would use the CBD route. As noted above, this is a strategic study and has not attempted to undertake a rigorous investigation into the feasibility of light rail, which is outside the scope of this study. Based on a review of previous reports and preliminary assessments, it is considered that the following measures are typical of the types of priority measures that may be required, and are indicative in terms of their disruption and costs. A detailed review of the scenarios for providing priority and their impacts would need to be undertaken before a LRT system was progressed further:

- Retiming of traffic signals and provision of actuated signal pre-emption at all signals on the route. This would result in a loss of capacity for general traffic at each intersection.
- Light rail would be given a dedicated right-of-way adjacent to the central median in both directions on Lambton Quay between Bowen Street and Willis Street. General traffic and trolleybuses would share the remaining lanes on the western side.
- Banning all right turn movements on Lambton Quay between Bowen Street and Willis Street by filling in the gaps in the median. The perpendicular roads between Lambton Quay and Featherston Street would form one-way loops for access. Removal of traffic signals where appropriate and addition of signalised pedestrian crossing as Stout Street and Cable car stops.
- Banning all right turn movements at the Bowen Street / Lambton Quay intersection
- Narrowing of lanes and removal of parking on Victoria Street to provide a dedicated right-of-way.
- Banning general traffic through Manners Street West to form a transit mall for buses and LRVs
- Banning general traffic (but not service vehicles) through Cuba Street and Manners Street East to form a transit mall for buses and LRVs
- Reallocation of parking and loading on Courtenay Place to provide a dedicated Light rail right of way
- Reconstruction of the Courtenay Place / Kent / Cambridge Terrace intersection and removal of the service lane to allow for the construction of a terminus on the western side.

It is clear that changes required to provide priority for LRVs would cause significant disruption to traffic movements. The Ngauranga to Airport Study is currently being undertaken and may be able to address these issues in more detail. It should be recognised that moves to restrict movements or reallocate roadspace within the Wellington CBD have proved difficult in the past and resulted in strong opposition.

F.6.2 Bus Service Impacts

One of the significant assumptions made within the Works / MVA report was that bus services would continue to operate as at present when the LRT system is in place. The reason given for this assumption was that the catchment areas serviced by bus and LRT respectively would be different and through bus movements would need to continue to service the southeast. It was acknowledged that a small reduction of buses may be achievable on the Golden Mile, however this would be minor.

An alternative would be to truncate the bus routes and have people transfer to LRT at dedicated interchanges at either end of the route. To sever bus routes at either end of the CBD would remove the “seamless service” experienced by the majority of bus passengers at present. This would require them to change modes, which is one of the principle criticisms of the rail services at present.

At present there are delays to buses using the existing CBD route due to the volume of buses using the route and conflict with general traffic. To be able to provide LRT with a level of priority required to give benefits over the existing, a dedicated right-of-way is required where possible. The existing road reserve is not large enough to cater for LRT, bus lanes and general traffic requiring reallocation of roadspace, meaning that the existing bus lanes would need to be removed and used by general traffic. This would substantially increase delays to both buses and traffic.

Given the volume of buses using the route, we consider that some significant bus priority measures would be required to maintain the existing level of service with an LRT system operating. As noted above, this is a strategic study and has not attempted to undertake a rigorous investigation into the feasibility of road space reallocation and bus priority measures, which are outside the scope. Based on a preliminary assessment, it is considered that the following measures are typical of the types of priority measures that may be required, and are indicative in terms of their disruption and costs. A detailed review of the scenarios for providing bus priority and their wider impacts would need to be undertaken before a LRT system was progressed further:

- Rerouting southbound buses (but not trolleybuses) via Featherston Street, Grey Street, Customshouse Quay to Willis Street
- Banning general traffic (but not service vehicles) northbound on Lambton Quay to provide a dedicated bus lane
- Rationalisation of stops, with restricted services stopping at each stop / express services through the city.
- Providing off-vehicle ticketing machines to remove driver interface and allow all door loading.

F.7 Timetable

F.7.1 Timetable Johnsonville to Wellington Station

The timetable for LRT operation has been considered. The RAMESES train performance modelling system (Railway And Motive Power Engineering Simulation And Evaluation System) was used to model the operation of LRVs on the Johnsonville railway line. The documented characteristics of an LRV were input into the simulator to obtain the necessary projections for the journey run times and the schedules were modelled assuming a 20 second dwell time at all station stops.

F.7.1.1 Without Infrastructure Improvements

The possibility of replacing the existing EEMUs on the Johnsonville railway line section with LRVs and improving the frequency above the existing train timetable was considered. Introducing another vehicle in the existing 13 minute – 13 minute – 26 minute frequency to give a sustained 13 minute frequency was investigated. The analysis indicated that with some minor adjustment to the timing of services, this could be achieved without infrastructure improvements.

The modelling revealed that the overall journey time from Wellington to Johnsonville was improved by approximately two minutes and 36 seconds over the EEMUs and one minute and 48 seconds over the modern EMUs. The improved journey travel time of the LRVs could not be fully capitalised due to the constraints of speed restrictions for the sections of tracks and tunnels throughout the line and the bottlenecks for crossing requirements between Wellington and Wadestown, and between Khandallah and Johnsonville.

The modelling undertaken indicates that using the existing track layout and station configuration, frequencies greater than 13 minute for the LRVs could only be achieved by imaginative rescheduling practices such as express or skip stops between selected sections or stations.

F.7.1.2 With Infrastructure Improvements

Improvements over the existing rail timetable through installation of new passing loops and station rationalisation and relocation were investigated.

As noted above, modelling of the LRV operations indicates that there is a bottleneck caused by the single track section between the Wadestown passing loop and Wellington Station. LRVs must wait at the Wadestown loop for LRVs to make the journey from Wellington Station to Wadestown. An approximately 200m long passing loop is required in the Wellington Yards immediately north of where the Johnsonville railway line deviates from the Up Main Line to enable LRVs to cross.

The modelling undertaken also indicates there is a bottleneck caused by the single track section between the passing loop at Khandallah Station and Johnsonville. LRVs must wait at the Khandallah loop for LRVs to make the journey from Johnsonville Station to Khandallah. A passing loop is required between Johnsonville and Khandallah to allow the LRVs to cross in the vicinity of Raroa Station. There is not sufficient room to maintain both a passing loop and station stop at Raroa, therefore one scenario is to remove the station and replace it with a passing loop. An alternative scenario is to relocate the station and passing loop to the vacant land immediately north of Fraser Avenue.

A conflict between northbound and southbound LRVs also exists at Box Hill Station. Again there is insufficient room to maintain both a station stop and a passing loop. Box Hill Station is located on a section of the line with very close station spacing. If the station was removed, there would be little impact on catchment area for the line. The spacing between the remaining Simla Crescent and Khandallah Stations would be in the order of 950m which is substantial for a light rail line. Rail surveys undertaken in 2002 indicate that the station is not heavily utilised with just 89 passengers boarding[9] at the station (both directions) over the entire day. Therefore, it is considered that removal of the station would not have a large impact on patronage. The level of public opposition to the remove of an existing station would however need to be considered in some detail.

It can be concluded that with the addition of passing loops at the Wellington Yards, Box Hill and Fraser Avenue, LRVs operating as coupled pairs could sustain a ten minute service frequency between Wellington and Johnsonville. Frequencies greater than this would require twin tracking of substantial lengths of the line.

One of the major benefits of a LRT system is the regular, frequent services. As the costs associated with construction of an LRT system through the CBD are substantial compared with the cost of the infrastructure improvements required to allow a 10 minute frequency on the Johnsonville railway line section of the route, all scenarios considered further are assumed to include these improvements.

F.7.2 Timetable Wellington Station to Mercer Street

It should be noted that when considering the timetable for the LRT system it has been assumed that two platforms are available at Wellington Station.

For the 1.5km of the CBD route to a turnaround at Mercer Street, a light rail would be subject to local traffic conditions and travel at an average of 25 - 30kph stopping approximately every 500metres. The one way trip would take around 8 minute including a turnaround of three minute at Mercer and Wellington Station, giving an overall return trip duration Wellington Station – Mercer Street - Wellington Station of approximately 16 minute.

Because LRVs through the CBD section would be subject to traffic conditions, there would be a degree of variability in their journey times resulting in uncertainty as to the exact time they would arrive back at Wellington Station. The Johnsonville railway line section is sensitive to variation due to the need for trains to meet at the passing loops. Therefore, for the whole length from Johnsonville to Mercer Street to be converted to LRT and to account for the variation in arrival times at Wellington Station, it is estimated that one additional LRV would be required entering service at Wellington to maintain a 10 minute frequency within Wellington to Mercer Street and to Johnsonville.

If the Johnsonville railway line is converted to LRT on its own, a large number of patrons are likely to join the service in the CBD or at the Wellington Station. This would be compounded because

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[9] From Rail Survey March 2002

the interchange to LRT would be closer to the train platforms than the Lambton Bus interchange and is likely to prove the preferred scenario for train passengers to continue their journey through the CDB. There is a danger that the LRT may be heavily loaded and would leave passengers behind. It is assumed that four additional LRV services of 3 minute intervals would be required to bolster the services between Wellington Station and Mercer Street. If the whole Wellington Network was to be converted to LRT, services from other lines would provide this additional capacity through the CBD and additional services would not be required.

F.7.3 Timetable Wellington Station to Courtenay Place

Using the same assumptions as for the Mercer Street section, we can expect an overall return trip duration Wellington Station - Courtenay Place - Wellington Station of approximately 27 minute.

Again, it is estimated that one additional LRV would be required entering service at Wellington to maintain a 10 minute frequency within Wellington to Courtenay Place and to Johnsonville.

It is assumed that six additional LRV services of 3 minute intervals would be required to bolster the services between Wellington Station and Courtenay Place. If the whole Wellington Network was to be converted to LRT, services from other lines would provide this additional capacity through the CBD and additional services would not be required.

Appendix F – A: Light Rail Figures

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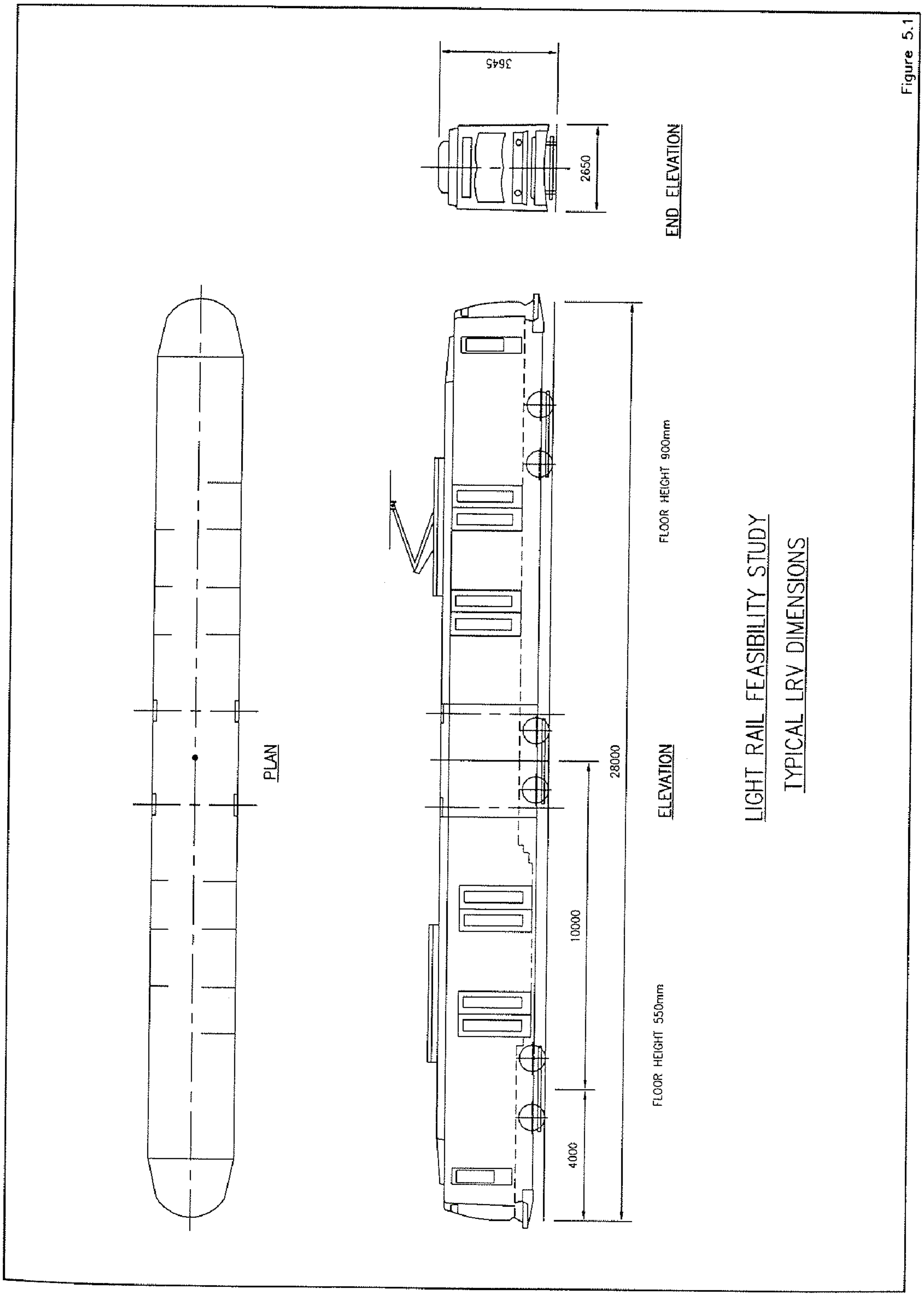
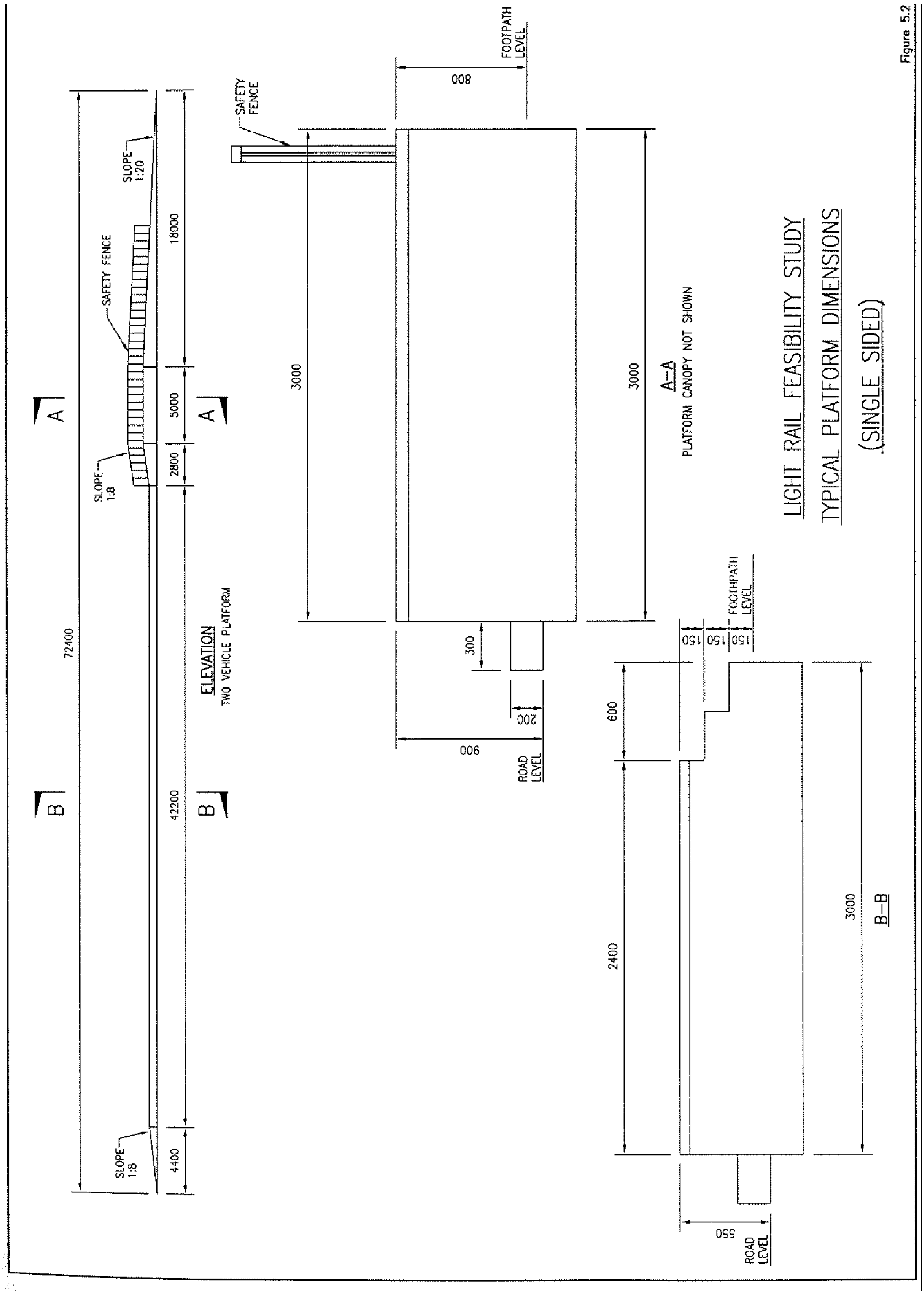


Figure 5.1
3645
2650
END ELEVATION
PLAN
FLOOR HEIGHT 900mm
28000
ELEVATION
10000
FLOOR HEIGHT 550mm
4000
LIGHT RAIL FEASIBILITY STUDY
TYPICAL LRV DIMENSIONS


LIGHT RAIL FEASIBILITY STUDY
TYPICAL PLATFORM DIMENSIONS
(SINGLE SIDED)
ELEVATION
TWO VEHICLE PLATFORM
A–A
PLATFORM CANOPY NOT SHOWN
B–B
SAFETY FENCE
SLOPE 1:20
SLOPE 1:8
FOOTPATH LEVEL
ROAD LEVEL
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2400
150
550
Figure 5.2

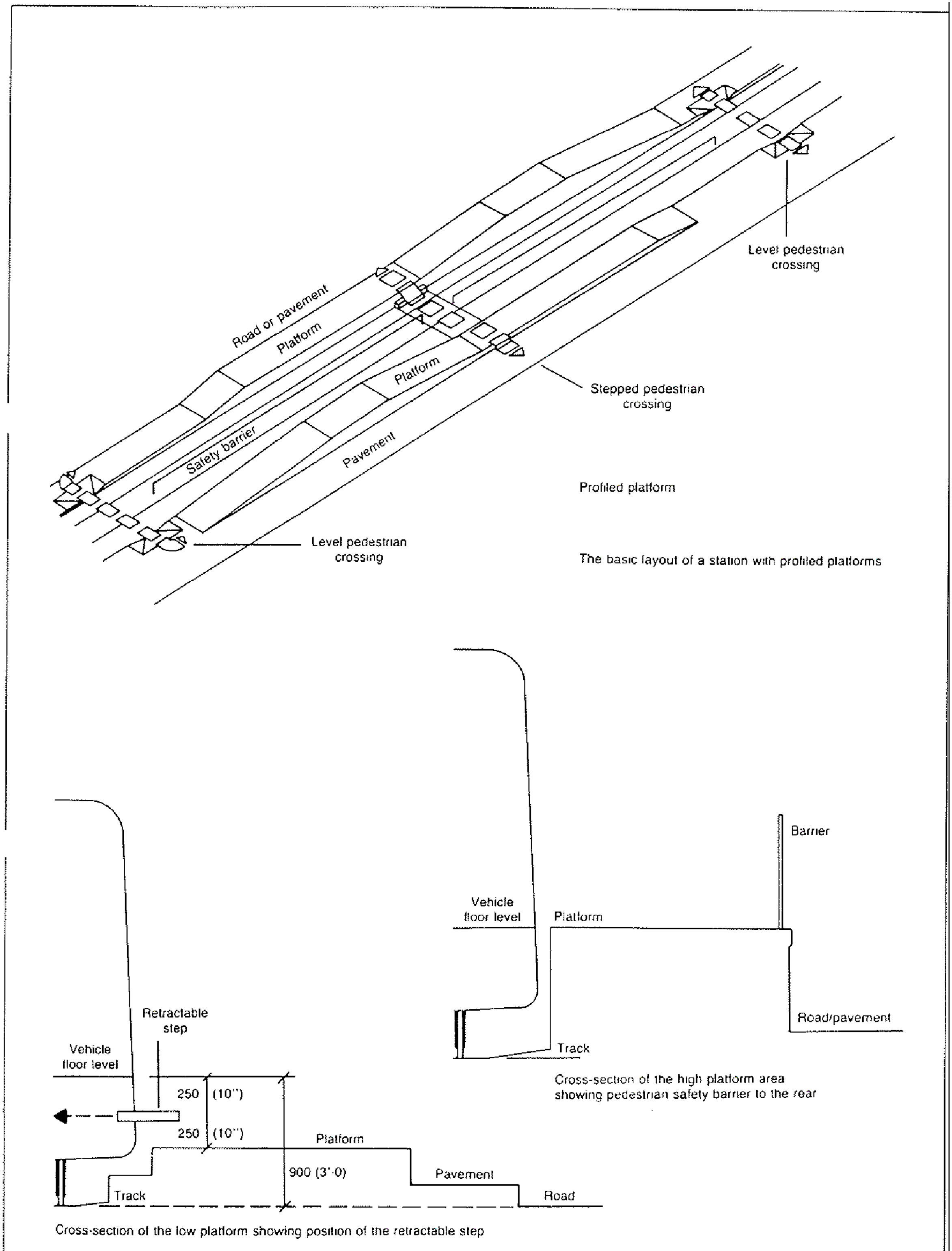
Road or pavement
Platform
Safety barrier
Platform
Pavement
Level pedestrian crossing
Stepped pedestrian crossing
Level pedestrian crossing
Profiled platform
The basic layout of a station with profiled platforms
Vehicle floor level
Platform
Barrier
Road/pavement
Track
Cross-section of the high platform area showing pedestrian safety barrier to the rear
Retractable step
Vehicle floor level
250 (10")
250 (10")
Platform
900 (3'-0)
Pavement
Road
Track
Cross-section of the low platform showing position of the retractable step

Figure 3.1

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