NorthWellington
public transport
STUDY

Technical Evaluation Report

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North Wellington Public Transport Study

NORTH WELLINGTON PUBLIC TRANSPORT STUDY - TECHNICAL EVALUATION REPORT

- Issue 3
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1. Introduction

1.1 Background

Options for the future of public transport services in Wellington's northern suburbs have been debated since the early 1990s without a clear strategy being adopted for the future. As the existing rail units on the Johnsonville Line are nearing the end of their economic lives, a considerable investment is now required to replace the units and continue operation of the line.

In November 2004 Transfund NZ (the predecessor to Land Transport New Zealand) agreed to provide $276m of funding to the region over 10 years in response to the Rail Business Case developed by Greater Wellington Regional Council. One of the conditions of that decision was:

Confirmation by GWRC that a full review of the Business Case will be completed in 3 years, including a review of the passenger transport services to Johnsonville and Melling

Before proceeding with large scale investment, the Greater Wellington Regional Council (GWRC) Passenger Transport Committee considered it appropriate to review public transport services in the northern suburbs as a whole, and identify the most appropriate long term strategy for the future. Wellington City Council (WCC) supported this approach and the two Councils jointly developed a scope for the review.

In August 2005, Sinclair Knight Merz (SKM) with support from Boffa Miskell Limited (BML) was commissioned by Greater Wellington Regional Council and Wellington City Council (WCC) to undertake the North Wellington Public Transport study. The scope of the study was set out in the Request for Tender (RFT) dated July 2005 and focuses on developing "a plan to address the needs and issues associated with Wellington City's northern suburbs passenger transport services, including the Johnsonville Rail Corridor and bus services."

1.2 Study Objectives

The purpose of the North Wellington Public Transport Study is to develop a strategic framework for future investment in public transport. The study objectives are:

1) to identify the current and future passenger transport needs of the northern suburbs
2) to develop a passenger transport strategy to meet these needs
3) to develop a passenger transport strategy which supports and informs the strategic land use and transport planning objectives of the Regional Land Transport Strategy, and the Wellington City Council Transport Strategy and the Wellington City Council Urban Development Strategy incorporated into the Wellington City Long Term Council Community Plan (LTCCP).

In achieving these objectives, the study must consider investment efficiency and economic costs and benefits as well as environmental and urban planning matters.

1.3 Study Process

This study was undertaken in three broad stages which correspond with the stages of public consultation undertaken:

Stage 1: Issues and Needs – This stage involved investigating the issues associated with public transport and identifying the community's needs in respect to public transport.

Stage 2: Scenarios Development – Using the information gathered in Stage 1, four broad future public transport scenarios were developed for the northern suburbs. These were presented to the community and their feedback was received.

Stage 3: Scenario Evaluation – Based on the feedback from the Stage 2 consultation and through discussions with stakeholders, four final scenarios were developed. An evaluation framework and performance measures were developed and used to evaluate the scenarios in detail. This evaluation is the subject of this report.

1.4 Report Structure

Background information, details of the initial investigations and the scenarios developed are set out in the *North Wellington Public Transport Study Scenarios Report*, NWPTS Project Team, June 2006 and the *North Wellington Public Transport Study Scenarios Technical Appendices*, SKM, June 2006. The findings of the Stage 2 consultation process are detailed in the report *Stage 2 – Scenarios Summary of Submissions*, BML August 2006.

This report sets out the evaluation of the scenarios proposed in the Stage 2 Consultation. The detailed evaluations undertaken under each objective are included as appendices and are summarised in the main body of the report.

The report is structured as follows:

Chapter 1	**Introduction**
Chapter 2	**Scenario Development**
Chapter 3	**Development of Performance Measures and Evaluation Framework**
Chapter 4	**Scenarios Evaluation**
Chapter 5	**Conclusions and Recommendations**

2. Scenario Development

Submissions from the Stage 1 Issues and Needs consultation and a detailed review of the public transport issues and needs of the northern suburbs were used to identify four scenarios for further consideration and consultation:

a) *Scenario One – Enhanced Rail* – improvements to existing rail services

b) *Scenario Two – Bus with Walking and Cycling* – replacement of rail with buses running on-street (the existing railway line would be converted to a walking and cycling track)

c) *Scenario Three – Busway* – replacement of rail with buses on a guided busway

d) *Scenario Four – Light Rail* – replacement of rail with a light rail service along the existing railway line

2.1 Scenarios for Detailed Evaluation

These scenarios were set out in some detail in the Scenarios and Scenarios Technical Appendices documents produced for the Stage 2 Consultation. Refer to these documents for detailed descriptions of the scenarios. Some refinements to the scenarios were made as detailed investigations were completed, patronage forecasts undertaken and as a result of feedback from the community and stakeholders in the Stage 2 scenarios consultation. Where revisions were made, these are included below.

2.1.1 Base Case (BC)

The base case has not been included in previous study documentation but was developed in order to provide a benchmark to assess the performance of the different scenarios against. This base case is not a “do-nothing” scenario, because the existing rolling stock on the Johnsonville Line is nearing the end of its economic life and therefore would need to be replaced by something.

The base case assumes the replacement of the existing English Electric Units with 4-car refurbished Ganz Mavag units operating the same 13-minute, 13-minute, 26-minute timetable. We have assumed that the infrastructure improvements required are those anticipated by ONTRACK in their report *Clearance for a Ganz Mavag Profile on the Johnsonville Line*, April 2006. This report sets out the minimum works ONTRACK believe are required to enable the larger Ganz Mavag units to operate on the Johnsonville Line. There are some concerns about the viability of the improvements and costs stated, but this provides a base point for assessment of the other scenarios.

Bus services are assumed to remain the same as they are at present and the general bus improvements included in Section 2.1.2 are not included. Table 2-1 sets out the tasks included and indicative timeframes used in the evaluation.

- **Table 2-1: Tasks and timeframes for implementation of the Base Case**

Task	Timing
Infrastructure improvements for new units (tunnel lowering, platforms etc.)	07/08
Refurbished Ganz Mavag units (14 units)	08/09
New EMU units (14 units)	23/24

In this document, timeframes for implementation were assumed to be that any new services would be operating in time to replace the English Electric units at the end of their economic lives in 2008/09. This approach was adopted consistently to assess the economic performance of the scenarios against each other. Potential for these timeframes to be extended as a result of procurement, consenting and approvals is dealt with under relevant sections in the evaluation.

2.1.2 General Improvements to Bus Services

The scenarios mostly impact on the current rail corridor serving Johnsonville, Khandallah, Ngaio and Crofton Downs and not on other areas of the northern suburbs. Additional bus improvements are therefore proposed under all scenarios, except the base case or the Busway[1], to benefit Newlands (Route 56), Woodridge (Route 57), Grenada Village (Route 55), Churton Park (Route 54), Johnsonville West (Route 53), Broadmeadows (Route 46) and Khandallah East and Ngaio (Routes 43, 44 & 45).

These additional bus improvements will cater for new patronage. Before any improvements can be implemented Greater Wellington will need to carry out a full bus route service review to ensure that changes meet the needs of residents and are economically viable.

At this stage a service review has not been undertaken, so the following list of potential improvements are simply indicative of those that may take place under all scenarios (except the base case or the busway) subject to a full service review. The potential enhancements to bus services in the northern suburbs include:

- New Route B – Broadmeadows via Homebush Road and Khandallah and terminating in Johnsonville. This route replaces the Homebush Road section of the existing Route 43 and 44 loop, Route 46, Route 50 and the existing Route 53 service for Johnsonville West.
- New Route K – Khandallah via the Ngaio Gorge. This route replaces the Ngaio Gorge section of the existing Route 43 and 44 loop.

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[1] A full redesign of the operation of bus services in the northern suburbs is proposed as part of the busway scenario and is detailed under the description of that scenario. No general bus improvements are included in the base case.

- New Route 54 which removes the section of the existing Route 54 loop that uses Middleton Road. Capacity for this section of Middleton Road would be provided for by additional Route 59 services running to / from Courtenay Place and / or connecting with the Route 54 at Johnsonville.
- Peak frequencies of between 4 and 15 minutes and off-peak frequencies of no less than 30 minutes to all suburbs served by bus.

It was assumed that these improvements would take place incrementally over the next ten years as justified by patronage with all improvements proposed to be in place by 2016.

2.1.3 Scenario One – Enhanced Rail (ER)

The Enhanced Rail scenario would involve improving the existing rail services between Johnsonville and the Wellington railway station by replacing the existing trains, with new or refurbished units and improving the frequency of trains to either 10 or 13 minutes. Also included in this scenario is a comprehensive rebuilding and refurbishment of station facilities and improvements to interchange facilities. Bus services would be improved as detailed above.

In the Scenarios documents, we had envisaged that Crofton Downs Station platform would be relocated a short distance to reduce curvature and stepping distances to improve accessibility. We were advised that the design of the new or refurbished rail rolling stock would need to cater for similar situations in other locations, therefore platform relocation is no longer required to provide accessibility and is not allowed for.

The difference between the base case and the enhanced rail scenario is that the base case provides a less frequent train timetable (same as the existing), no improvement to bus services (the same as existing) and does not allow for any significant improvements to the stations.

Enhanced Rail 1 (ER1): New Units and 13-minute Timetable

This sub-scenario involves replacing the English Electric Units with refurbished Ganz Mavag Units (GMUs) and operating a 13-minute timetable between Johnsonville and Wellington station during peak periods. Table 2-2 sets out the tasks included and indicative timeframes used in the evaluation.

- **Table 2-2: Tasks and timeframes for implementation of ER1**

Task	Timing
Infrastructure improvements for new units (tunnel lowering, stations etc.)	07/08
Refurbished Ganz Mavag units (14 units)	08/09
General bus service improvements begin	08/09
New EMU units (4 units)	11/12
New EMU units (14 units)	23/24
Half life refurbishment of EMUs (4 units)	26/27

Enhanced Rail 2 (ER2): New Units and 10-minute Timetable

This sub-scenario involves replacing the English Electric Units with refurbished Ganz Mavag Units (GMUs) and operating a 10-minute timetable between Johnsonville and Wellington station during peak periods. To facilitate the 10-minute timetable Box Hill Station would need to be removed and Raroa Station moved to Fraser Avenue. Table 2-3 sets out the tasks included and indicative timeframes used in the evaluation.

- **Table 2-3: Tasks and timeframes for implementation of ER2**

Task	Timing
Infrastructure improvements for new units (tunnel lowering, stations etc.)	07/08
Refurbished Ganz Mavag units (18 units)	08/09
General bus service improvements begin	08/09
New EMU units (4 units)	11/12
New EMU units (18 units)	23/24
Half life refurbishment of EMUs (4 units)	26/27

GWRC is presently starting the process to purchase replacement rolling stock for the majority of the regional passenger train fleet. There is an option to use new Electric Multiple Units (EMUs) to operate either the 10 or 13-minute timetables but this has not been assumed in the evaluations undertaken. It is intended that refurbished units would be used on the line to enable the new units purchased to operate on the longer distance routes where they would have the greatest benefits. If it was determined that the GMUs could not operate on the Johnsonville Line because of gradient problems, new units would need to be used.

The refurbishment of the GMUs would be paid for by GWRC and operated and maintained by Trans Metro.

2.1.4 Scenario Two – Bus with Walking and Cycling (OS)

The Bus with Walking and Cycling Scenario would involve replacing the existing rail services with bus services and providing enhanced bus services for the rest of the northern suburbs. The railway line could be converted to a walking and cycling track or “greenway”, preserving the railway line as a transport corridor and helping to promote active modes of transport and additional recreational amenity.

The buses would operate on new Routes X, Y and Z between Johnsonville and Lambton interchange via Wadestown or the Ngaio Gorge on the routes identified in the Scenarios Report.

The frequency of new bus services would be 10 minutes during peak periods, combining in some locations to provide 3 to 5 minute frequencies.

Contracts would be tendered for the supply of bus services to replace the existing train services. Table 2-4 sets out the tasks included and indicative timeframes used in the evaluation.

- **Table 2-4: Tasks and timeframes for implementation of OS**

Task	Timing
CBD bus route improvements	07/08
Hutt Road bus priority measures	07/08
Johnsonville Hub improvements	07/08
New bus shelters on replacement bus routes	07/08
Remove rail infrastructure and replace with walking / cycling track	08/09
New bus services operating	08/09

2.1.5 Scenario Three – Busway (BW)

The Busway Scenario would involve converting the existing Johnsonville railway line to a guided busway. The busway would operate in a similar fashion to rail between Johnsonville town centre in the north and Hutt Road in the south. The busway would be a dedicated right-of-way with buses able to enter from and exit to the existing road network and travel the length of the busway with no delays from congestion.

The busway would be one-lane wide for most of its length because of the narrow corridor, steep drops and narrow tunnels. Buses would be fitted with a guidance system to ensure safe operation and provide an improved ride quality. One possible guidance system is the “O-Bahn” type system used in Adelaide which works by fitting small guide wheels on standard buses and installing raised curbs on the busway to guide the buses.

As the busway would only be one-lane wide it would operate in the peak direction only with return buses using the existing road network. The busway would operate with services running along the busway from Johnsonville to the CBD during the morning peak and then switching at some point during the day so that services travel back along the busway from the CBD to Johnsonville during the evening peak. Counterpeak bus services would run on routes X,Y and Z between Johnsonville and Lambton interchange via Wadestown or the Ngaio Gorge as proposed for the bus on-street scenario and as detailed in the Scenarios Report.

The frequency of stopping services on the busway would be 5-minutes during peak periods and 10-minutes during non-peak periods.

The busway would involve a comprehensive redesign of the way bus services operate in the northern suburbs. The following list of potential improvements is simply indicative of those that may take place under the busway subject to a full service review. The potential enhancements to bus services in the northern suburbs include:

- New route W – West Johnsonville via Broadmeadows and Khandallah where it would access the busway and continue through to the CBD. This route would replace route 53 and the top section of route 46.
- New routes 54 and 59 - Churton Park (54) and Glenside (59) would operate in line with the general improvements to bus services discussed in Section 2.1.2 except that peak express services could enter the busway at Johnsonville rather than use Ngauranga Gorge.
- Routes 55, 56, 57 – Paparangi (55), Newlands (56) and Grenada Village (57) would operate in line with the general improvements to bus services discussed in section 2.1.2 except that peak express services could cross the Newlands over-bridge and travel north on the motorway to enter the busway at Johnsonville rather than use Ngauranga Gorge.
- Routes 43, 44 and 45 – Ngaio, Homebush and Khandallah would remain similar to existing services but the frequency of these services would be improved.

Contracts would be tendered for the supply of bus services.

Busway 1 (BW1): All Routes Express

Under this sub-scenario, it is proposed that the busway would operate with a mixture of express and ‘rail replacement’ bus services to replace the existing trains during peak periods. Express services would operate from Churton Park, Grenada Village, Glenside, Paparangi and Newlands with services from the last four areas turning right at the Newlands Overbridge to travel north and enter the busway at Johnsonville. The busway would improve the journey time reliability for all these services, although travel time for services that currently use the Ngauranga Gorge would increase from 16 minutes to approximately 21 minutes.

Express services are expected to be full by the time they enter the busway and would run through to the CBD without stopping. Other services could also enter part way along the busway when full.

Rail replacement services would carry people who currently use the train, stopping at every stop on the busway. These services would not start in Johnsonville town centre but would start in nearby residential areas (for example, Johnsonville West) so as to provide additional coverage and to pick up passengers before entering the busway.

In addition to peak express services on the busway, normal non-express services would run throughout the day (including peak periods) on existing roads and would ensure a bus service to most bus stops at all times of the day. This should reduce any confusion arising from peak direction services operating only on the busway.

Busway 2 (BW2): Selected Routes Express

This sub-scenario is the same as BW1 except only rail replacement bus services and services from Churton Park and Tawa (which would operate as express services) would run on the busway. All other bus services would operate on-streets, including services from Grenada Village, Glenside, Paparangi and Newlands, which would continue to travel down the Ngauranga Gorge.

Table 2-5 sets out the tasks included for both busway scenarios and indicative timeframes used in the evaluation.

- **Table 2-5: Tasks and timeframes for implementation of BW1 and BW2**

Task	Timing
CBD bus route improvements	07/08
Johnsonville hub improvements	07/08
Hutt Road bus priority measures	07/08
Busway construction	08/09-09/10
Rail replacement service during construction	08/09-09/10
New busway services operating	11/12

The exact details of the way the busway could operate would need to be developed in future investigations. The busway could be operated in a number of ways and the sub-scenarios above are only indicative. An alternative would be to operate the busway for non-stopping express services from north of Johnsonville only, with services within the Johnsonville Line catchment operating on-street and feeding into the busway when full. It is expected that this mode of operation would perform in a similar way to the sub-scenarios set out above.

2.1.6 Scenario Four – Light Rail (LR)

The Light Rail Scenario would involve replacing the existing trains with new light rail vehicles running on an extended Johnsonville railway line through the CBD to Courtenay Place.

The general improvements to bus services discussed in section 2.1.2 would be implemented in addition to light rail improvements.

Light rail vehicles would operate on the existing railway line much as trains do at present but with some infrastructure improvements. The railway line between Johnsonville and the Wellington railway station would require similar infrastructure improvements as outlined for ER2, except that it was assumed that tunnel lowering would not be required. However, to extend services through to

Courtenay Place significant additional infrastructure would be required including construction of an ‘at-grade’ twin track line through the CBD and reconfiguration of existing CBD bus routes.

The frequency of services along the railway line during peak periods would be 10 minutes between Johnsonville and the Wellington railway station and approximately 3 minutes through the CBD. During off-peak periods the frequency of service would be between 15 and 30 minutes along the Johnsonville railway line and 6 minutes through the CBD.

It was assumed that low floor LRT units would be purchased to operate the service. This requires that station and platform upgrades be undertaken on the Johnsonville Line section prior to implementation. This also allows for a consistent comparison with the other scenarios which have improvements to stations / stops along the Johnsonville Line corridor.

In the *North Wellington Public Transport Study Scenarios Report*, NWPTS Project Team, June 2006, it was envisaged that the light rail would operate on its own right of way adjacent to the central median along Lambton Quay and that buses and general traffic would share the remaining road space. The evaluation was undertaken on the basis of light rail vehicles and buses and sharing the western side of Lambton Quay as a transit mall with general traffic using the eastern side of Lambton Quay for access. It should be noted that this would require the relocation of overhead wires for southbound trolley buses.

Table 2-6 sets out the tasks included for both busway scenarios and indicative timeframes used in the evaluation.

- **Table 2-6: Tasks and timeframes for implementation of LR**

Task	Timing
Infrastructure improvements to Johnsonville railway line for new units (platforms etc.) and to allow for 10 minute timetable	07/08
General bus services improvements	08/09
Light rail track construction to Courtenay Place	07/08-08/09
New Light rail vehicles (22 units)	08/09
Half life refurbishment of light rail vehicles (22 units)	23/24

2.2 Stage 2 Scenarios Consultation

Key stakeholders, including land transport providers, community groups, schools, affected residents and the general public, were invited to participate in the consultation process.

Notification of the consultation process was undertaken in June 2006 through public notices in local papers, displays at the central and northern suburbs’ libraries, poster displays on buses and trains, and letters to those who participated in the first consultation stage and wished to be further consulted on the study. An information/open evening at the Johnsonville Community Centre was held to answer questions from interested persons. In addition, a webpage was set up to increase awareness and provide an ongoing reference point for interested parties.

The findings of this stage of public consultation are detailed in the report *Stage 2 – Scenarios Summary of Submissions*, BML August 2006.

3. Development of Performance Measures and Evaluation Framework

The evaluation of scenarios has been undertaken with reference to the RLTS objectives and WCC Transport Strategy and Urban Development Strategy desired outcomes, which are derived from national transport policies.

Current *draft* objectives for transport in Greater Wellington are that the RLTS should:

1) **assist economic and regional development;**
2) **assist safety and personal security;**
3) **improve access mobility and network reliability;**
4) **protect and promote public health;**
5) **ensure environmental sustainability; and**
6) **consider economic efficiency and affordability.**

Wellington City Council's LTCCP long-term outcomes for transport and urban development are[2]:

- ***More liveable –***
  - Wellington will be easy to get around, pedestrian-friendly and offer quality transport choices.
  - Wellington will be a great place to be, offering a variety of places to live, work and play within a high quality public environment.
- ***More compact –***
  - Wellington will have a contained urban form, with intensification in appropriate areas and mixed land-use, structured around a vibrant central city, key suburban centres and major transport corridors.
- ***Better connected –***
  - Wellington will have a highly interconnected public transport, road and street system that supports its urban development and social strategies.
  - Wellington will be easy to get around, pedestrian-friendly and offer quality transport choices on a highly interconnected public transport and street system.
- ***More sustainable –***
  - Wellington will minimise the environmental effects of transport and support the environmental strategy.
  - Wellington's urban form will support an efficient and sustainable use of our rural and natural resources and promote prosperity and social well-being over the long term.

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[2] Contained in WCC's LTCCP

- ***Safer –***
  - Wellington will seek to improve the safety and security of its citizens as they move around the city and region.
  - Wellington will be a safe place to be, with well designed buildings, spaces and connections between them.
- ***Healthier –***
  - Wellington's transport system will contribute to healthy communities and social interaction.
- ***More prosperous –***
  - Wellington will have a coherent and efficient transport system that aids economic development.
  - Wellington's urban form, and flexible approach to land use planning in the central city, centres and industrial areas, will contribute to economic growth and prosperity.
- ***Stronger sense of place –***
  - Wellington will be a memorable, beautiful city, celebrating and building on its sense-of-place, capital city status, distinctive landform and landmarks, defining features, heritage and high quality buildings and spaces.

3.1 Issues and Needs

The Stage 1 consultation identified that a sufficiently frequent, reliable public transport system with convenient routes is the main overall issue that submitters reported. General issues and needs raised in the Stage 1 consultation included:

- frequency
- reliability
- proximity
- cost
- journey time
- capacity
- condition of vehicles
- condition of waiting areas
- accessibility for less able
- parking provision
- passenger transport integration (connectivity, integrated ticketing etc)

It should be noted the responses from the Stage 1 consultation were primarily received from current public transport users and were dominated by the access issues above such as the frequency and reliability of services. A large number of respondents also raised the issue of the condition of the existing rail vehicles.

3.2 Detailed Study Objectives

The objectives of the North Wellington Public Transport Study are to:

1) to identify the current and future passenger transport needs of the northern suburbs
2) to develop a passenger transport strategy to meet these needs
3) to develop a passenger transport strategy which supports and informs the strategic land use and transport planning objectives of the Regional Land Transport Strategy, and the Wellington City Council Transport Strategy and the Wellington City Council Urban Development Strategy incorporated into the Wellington City Long Term Council Community Plan (LTCCP).

In achieving these objectives, the study must consider investment efficiency and economic costs and benefits as well as environmental and urban planning matters.

3.3 Performance Measures and Evaluation Method

The measures used in the evaluation of scenarios in this study provide an indication of the relative performance of the different scenarios being tested. The measures were chosen to be representative, to show the main impacts of different scenarios and to provide a reasonable basis for assessing and comparing the alternative scenarios against; the RLTS objectives, the WCC LTCCP transport and urban development outcomes, and each other.

Table 3-1 sets out the Objectives / Outcomes, associated performance measures developed and describes the way the measures were assessed.

In a strategic study such as this, the absolute performance of a scenario may be difficult to define in detail, without extensive analysis and investigation. Instead, it is important to understand the approximate scale of the impacts and to ensure that differences that distinguish between the scenarios are identified to inform the decision process on which scenario should be adopted.

The Wellington Transport Strategy Model (WTSM) was the main analytical tool used to evaluate scenario performance,. The model is a relatively high-level strategic multi-modal model covering the whole of the region. It was developed to a base year of 2001 and has subsequently been used in the development of the RLTS and for corridor studies (eg Western Corridor). Details of the model development and testing procedures used for this study are included in Appendix J.

While the use of WTSM in a strategic study of a corridor of this scale is appropriate, it is important that the level of detail of the model in the context of this corridor is understood, as are any subsequent and underlying limitations. For example the zoning system in the corridor is quite coarse for detailed assessment of PT scenarios, and not all of the roading system is represented. These, and other aspects, mean that care is required as to the level of detail model outputs are reported, interpreted and then used in the evaluation. This is particularly the case in respect of absolute results.

As well as use of WTSM, some measures have been assessed by other means. In some cases a detailed quantitative evaluation cannot be undertaken. For these, qualitative professional assessments have been used to discuss the performance of the scenarios and provide an indication of how the scenarios perform against one another.

- **Table 3-1: Objectives and Performance Measures**

RLTS OBJECTIVE (WCC LTCCP Criteria)	Measure	Evaluation Method
ASSIST ECONOMIC AND REGIONAL DEVELOPMENT (More Prosperous)		
Average cost of travel per kilometre by mode	Average generalised cost per km by private vehicle, HCV, and PT for all trips originating and destinating in the northern suburbs	Extracted from WTSM model
Average cost of travel to key economic and employment destinations	Average generalised cost of travel per trip by private vehicle and PT from the northern suburbs to key destinations on the growth spine *(Key destinations: CBD North, CBD South, Newtown, Kilbirnie, Airport)*	Extracted from WTSM model
ASSIST SAFETY AND PERSONAL SECURITY (Safer)		
Travel safety	Average annual injury accidents by car, bus and rail	Extracted from WTSM model for private vehicle accidents based on existing GWRC procedures. Bus and rail accident forecasts based on accident rates for VKT.
Personal security on public transport	Assessment of the personal security impacts of different scenarios	Professional Assessment
IMPROVE ACCESS MOBILITY AND NETWORK RELIABILITY (Better Connected / More Liveable)		
Impact on travel	Person km of travel by private vehicle, HCV and PT from the northern suburbs	Extracted from WTSM model
Construction disruption	Assessment of construction disruption to PT patrons of different scenarios	Professional Assessment
Travel times (journey times)	Private vehicle and PT travel times from the northern suburbs to key destinations on the growth spine *(Key destinations: CBD North, CBD South, Newtown, Kilbirnie, Airport)*	Extracted from WTSM model
Vehicle speeds	Average private vehicle, and PT speeds in the northern suburbs and the CBD corridor	Extracted from WTSM model
Level of congestion and network reliability	Congested VKT (where congestion is defined as V/C > 0.8)	Extracted from WTSM model
	V/C ratios at identified key locations in corridor *(Key locations:*	Extracted from WTSM model

RLTS OBJECTIVE (WCC LTCCP Criteria)	Measure	Evaluation Method
	Ngauranga Gorge north of merge, Ngauranga Gorge south of merge, Hutt Road south of Kaiwharawhara Road, Kaiwharawhara Road, Onslow Road, Grant Road, Newlands Road, Ottawa Road, Johnsonville onramp, Moorefield Road)	
PT network reliability	Qualitative professional comparative assessment of operational reliability	Professional Assessment
	Person-km on dedicated right of way in the northern suburbs	Extracted from WTSM model
Access to PT (proximity)	% of northern suburbs population living within 400m of a PT stop	Calculated using GIS by drawing 400m walking catchments around PT stops and summing the populations in the meshblocks
PT integration (seamlessness of service)	The number of transfers required from the northern suburbs to key destinations on the growth spine. *(Key destinations: CBD North, CBD South, Newtown, Kilbirnie, Airport)*	Extracted from WTSM model
Vehicle Comfort and Condition	Qualitative professional comparative assessment of the relative ride quality, comfort and condition of the PT vehicles	Professional Assessment
PT Frequency	Average waiting time for trips to / from the northern suburbs	Extracted from WTSM model
PROTECT AND PROMOTE PUBLIC HEALTH (Healthier)		
Effects on local air quality	Volume of nitrous oxides (NOX), particulates (PM10), and volatile organic compounds (VOC) for general traffic in the northern suburbs and CBD corridor	Extracted from WTSM model for general traffic
	Assessment of relative local emissions from public transport	Professional Assessment.
Effects of noise	The sum of traffic volumes on approx. 20 selected links in residential areas (used as a measure of the impact of noise and emissions on people)	Extracted from WTSM model
	Assessment of relative noise emissions from public transport	Professional Assessment

RLTS OBJECTIVE (WCC LTCCP Criteria)	Measure	Evaluation Method
Amount of active travel (walking and cycling)	Walking and cycling and PT trips in the northern suburbs and CBD corridor	Extracted from WTSM model
ENSURE ENVIRONMENTAL SUSTAINABILITY (More Sustainable / More compact) (Stronger Sense of Place)		
Climate Change	General Traffic Greenhouse gas emissions - CO2 emissions	Extracted from WTSM model for private vehicle and HCV
	PT Greenhouse gas emissions - CO2 emissions	Sustainability Assessment
Energy use	General traffic fossil fuel use by type	Extracted from WTSM model
	PT energy use	Sustainability assessment
Ability to provide for residential intensification along transport routes including the CBD	Assessment of the ability to provide for residential intensification along transport routes including the CBD	Professional Assessment
Retention of cultural heritage	Assessment of ability to contribute towards retention of cultural heritage	Professional Assessment
Contribution to quality of urban space	Assessment of ability to contribute towards the quality of urban space	Professional Assessment
CONSIDER ECONOMIC EFFICIENCY AND AFFORDABILITY		
Consider economic efficiency	Benefit Cost Ratio	Economic analysis in line with with the LTNZ Economic Evaluation Manual, Volume 2
Consider affordability	Regional subsidy required compared to funding anticipated in GWRC LTCCP	Affordability analysis spreadsheet calculation
Least Risk		
Risks associated with implementation and operation	Risk Assessment scores	Professional Assessment
Procurement and Implementation Staging	Assessment of potential for staging of construction or procurement to defer investment	Professional Assessment.
Consentability	Professional assessment of the issues associated with obtain consents and approvals	Professional Assessment

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3.4 Rating the Measures

As a means of summarising the evaluation of performance measures and illustrating the main impacts, we have applied a qualitative rating system. These ratings are shown below in Table 3-2.

▪ **Table 3-2: Rating System**

Rating	Meaning
XXX	Significant negative impact
XX	Moderate negative impact
X	Minor negative impact
0	Similar to the base
√	Minor positive impact
√√	Moderate positive impact
√√√	Significant positive impact
+, -	These are used for marginal adjustments to the above ratings

4. Scenarios Evaluation

Summaries of the evaluations undertaken under each objective are set out below. The detailed assessments are included as appendices.

4.1 Objective 1: Assisting Economic Development (More Prosperous)

The following measures were used in the evaluation of the objective Assisting Economic Development:

- Average cost of travel per kilometre by mode
- Average cost of travel to key economic and employment destinations

Table 4-1 shows the overall score for the objective Assist Economic Development, where each of the measures was given equal weighting. A reduction in costs was considered to be a positive impact on economic development and all scenarios have a positive impact overall.

The average cost of travel per km does not reduce for vehicle trips under any of the scenarios. This was expected because of the marginal impact of any scenario on private vehicle trips. The average public transport (PT) cost per km reduces under all the scenarios compared to the base. The rail and bus on-street scenarios show minor positive impacts, while the busway and light rail scenarios show moderate positive impacts.

With all the scenarios, the average cost of travel by private vehicle to key destinations on the WCC "growth spine" is similar to the base. Average PT cost to key destinations reduces under all scenarios, with similar minor positive impacts, except for the light rail scenario, which has a moderate reduction.

The rail and the bus on-street scenarios perform similarly overall with minor positive impacts. The two busway scenarios perform slightly better than the rail or bus on-street scenarios due to greater reductions in the average cost of travel per km. The light rail scenario performs the best overall resulting in a moderate positive impact.

- **Table 4-1: Assist Economic Development Score**

1) ASSIST ECONOMIC AND REGIONAL DEVELOPMENT (More Prosperous)	Base	ER1	ER2	OS1	BW1	BW2	LR1
Average cost of travel per kilometre by mode	0	√	√	√	√√	√√	√√
Average cost of travel to key economic and employment destinations	0	√	√	√	√	√	√√
Average	**0**	√	√	√	√+	√+	√√

4.2 Objective 2: Assist Safety and Personal Security (Safer)

The objective Assisting Safety and Personal Security was measured in terms of:

- Travel Safety
- Personal security on public transport

Table 4-2 shows the overall score for the objective Assist Safety and Personal Security, where each of the measures was given equal weighting.

None of the scenarios have a significant impact on safety or personal security and were scored accordingly.

Table 4-2: Assist Safety and Personal Security Score

2) ASSIST SAFETY AND PERSONAL SECURITY (Safer)	Base	ER1	ER2	OS1	BW1	BW2	LR1
Travel safety	0	0	0	0	0	0	0
Personal Security on Public Transport	0	0	0	0	0	0	0
Average	**0**	**0**	**0**	**0**	**0**	**0**	**0**

4.3 Objective 3: Improve Access, Mobility & Network Reliability (Better Connected / More Liveable)

The following measures were used in the evaluation of the objective Improve Access, Mobility & Network Reliability:

- The impacts on travel
- Construction disruption
- Travel times (journey times)
- Vehicle speeds
- Level of congestion and network reliability
- PT network reliability
- Resilience of the PT network
- Access to PT (proximity)
- PT integration (seamlessness of service)
- Vehicle comfort and condition
- PT frequency

Table 4-3 shows the overall score for the objective Improve Access, Mobility & Network Reliability, where each of the measures was given equal weighting. All schemes show a marginal positive impact.

The measures *impact on travel*, *level of congestion and network reliability* and *access to PT (proximity)* do not change significantly between the scenarios or against the base. This is due to the marginal impact on vehicle trips and the fact that the majority of the northern suburbs catchment is already catered for by public transport. The scenarios all perform very similarly under the measure *vehicle speeds* and *travel times*, with all having a minor positive impact.

The two rail scenarios score very similarly, with the ER1 scenario performing slightly better than ER2 in respect of reduced construction disruption impacts.

The two busway scenarios perform very similarly. Despite the busway scenarios performing better than the rail scenarios under *frequency*, *PT Integration* and *PT network reliability*, this is offset by the larger construction disruption associated with the busway scenarios and poorer performance under *vehicle comfort and condition*. Hence they score similarly overall.

The bus on-street scenario performs slightly worse than the rail scenarios overall. Improvements in regard to frequency and seamlessness of the services are offset by reduced network reliability as a result of on-street running and consequential delays due to congestion, and poorer vehicle comfort and condition. The bus on-street performs slightly worse the busway scenarios overall, as the busway offers better performance under *network reliability* and *vehicle comfort and condition* due to the guideway, albeit offset by the large construction disruption which this scenario entails.

Light rail performs similarly to the heavy rail and busway scenarios overall. While light rail could offer improved network reliability and interpeak frequencies over the rail and improved vehicle comfort over the busway, these gains are offset by the significant disruption during construction.

- **Table 4-3: Improve Access, Mobility & Network Reliability Score**

3) IMPROVE ACCESS MOBILITY AND NETWORK RELIABILITY (Better Connected / More Liveable)	**Base**	**ER1**	**ER2**	**OS1**	**BW1**	**BW2**	**LR1**
Impact on Travel	0	0	0	0	0	0	0
Construction disruption	0	0	X	0	XX	XX	XXX
Travel times (journey times)	0	√	√	√	√	√	√
Vehicle speeds	0	√	√	√	√	√	√
Level of congestion and network reliability	0	0	0	0	0	0	0
PT network reliability	0	√	√	XX	√√	√√	√√
Access to PT (proximity)	0	0	0	0	0	0	0
PT integration (seamlessness of service)	0	0	0	√	√	√	√
Vehicle Comfort and Condition	0	0	0	XX	X	X	√
PT Frequency	0	√	√	√√	√√	√√	√√
Average	**0**	**0+**	**0+**	**0**	**0+**	**0+**	**0+**

4.4 Objective 4: Protect and Promote Public Health (Healthier)

The objective of Protect and Promote Public Health was measured in three ways:

- Effects on local air quality;
- Effects of noise on people; and
- Amount of active travel (walking and cycling)

Due to the marginal impact on vehicle trips, there is little impact on forecast emissions from private vehicles.

The difference between the scenarios in terms of emissions relates to whether diesel buses which have local emissions, or electric rolling stock, which have zero local emissions are used. While alternatives to diesel buses may be available economically in the future, the bus based scenarios were scored as having a minor negative impact overall.

The differences between the scenarios related to noise arise chiefly from increased frequencies. The busway scenarios were scored as having moderate negative impacts because they concentrate a large number of services into the Johnsonville corridor. The bus on-street and ER2 scenarios were scored as having minor negative impacts. The remaining scenarios were considered to have similar noise impacts to the base.

All scenarios show increases in PT usage that could have a minor positive impact on the amount of walking and cycling. Public transport usage is a useful measure of active travel because there is usually a walking component of the trip between the PT stop / station and the origin / destination. All scenarios were scored the same under this measure except for the bus on-street scenario which was scored higher because it provides better walking and cycling facilities by reusing the Johnsonville corridor as a walking and cycling track.

Table 4-4 shows the overall scores for the objective Protect and Promote Public Health, where each of the measures was given equal weighting. Overall, ER1 has a small positive impact and performs slightly better than ER2 because it has less noise impacts as a result of lower frequencies. Light rail performs similarly to ER1 overall. Despite having higher frequencies, the absolute noise emissions from each train are expected to be lower.

The bus on-street scenario has no net impact overall, as improvements due to the walking and cycling facilities provided are offset by increases in emissions and noise impacts. The busway scenarios have a small negative impact overall due to increased emissions and noise impacts.

- **Table 4-4: Protect and Promote Public Health Score**

4) PROTECT AND PROMOTE PUBLIC HEALTH (Healthier)	Base	ER1	ER2	OS1	BW1	BW2	LR1
Effects on local air quality	0	0	0	X	X	X	0
Effects of noise	0	0	X	X	XX	XX	0
Amount of active travel (walking and cycling)	0	√	√	√√	√	√	√
Average	**0**	**0+**	**0**	**0**	**0-**	**0-**	**0+**

4.5 Objective 5: Ensure Environmental Sustainability (More Sustainable / More Compact) (Sense of Place)

The objective Ensure Environmental Sustainability was measured in terms of:

- Climate change
- Energy use
- Ability to provide for residential intensification along transport routes including the CBD
- Retention of cultural heritage
- Contribution to quality urban space

There is little impact under *climate change* or *energy use* for any of the scenarios.

Rail or busway based scenarios encourage land use development because the fixed infrastructure provides a level of permanence that encourages adjacent investment. Light rail provides minor opportunities to increase intensification along the corridor because of amenity and image benefits while the bus on-street scenario reduces this potential because the fixed infrastructure along the corridor would be lost.

The rail based scenarios (ER1, ER2 and LR1) would retain the cultural heritage of the existing railway line.

All the scenarios have a positive impact in contributing to quality urban space except for the bus on-street scenario which removes the fixed infrastructure. Light rail has a moderate positive impact because it provides the opportunity to form an integral part of urban landscape through the development of transit malls in the CBD.

The two rail scenarios perform identically with a small positive impact overall. Compared to light rail, they perform worse because light rail has greater potential to provide for intensification and contribute towards quality urban space. The busway scenarios do not perform as well as the rail or light rail scenarios because they were not considered to contribute effectively to retention of cultural heritage. Bus on-street performs the worst of the scenarios because the lack of dedicated right of way is not conducive to intensification, does not retain the rail heritage and does not contribute to the quality of urban space.

Table 4-5 shows the overall score for the objective Ensure Environmental Sustainability, where each of the measures was given equal weighting.

- **Table 4-5: Ensure Environmental Sustainability Score**

5) ENSURE ENVIRONMENTAL SUSTAINABILITY (More Sustainable / More compact)	**Base**	**ER1**	**ER2**	**OS1**	**BW1**	**BW2**	**LR1**
Climate Change	0	0	0	0	0	0	0
Energy Use	0	0	0	0	0	0	0
Ability to provide for residential intensification along transport routes including the CBD	0	0	0	X	0	0	√
Retention of Cultural Heritage	0	√	√	0	0	0	√
Contribution to Quality Urban Space	0	√	√	0	√	√	√√
Average	**0**	**0+**	**0+**	**0**	**0**	**0**	√

4.6 Objective 6: Consider Economic Efficiency and Affordability

The objective Consider Economic Efficiency and Affordability was measured using the following criteria:

- Consider economic efficiency
- Consider affordability
- Procurement and implementation staging

Table 4-6 shows the overall score for the objective Economic Efficiency and Affordability.

The impacts on economic efficiency are negative for all scenarios compared to the base. None of the scenarios have NPV economic benefits which outweigh the additional NPV costs associated with providing the improvements using a 10% discount rate. The bus on-street is the most economically efficient scenario by a considerable margin with a Benefit Cost Ratio (BCR) of 0.56, however it is not economically viable with the NPV of costs outweighing the NPV of benefits. It was scored as having a minor negative impact. The benefits are in the same order as the busway and light rail scenarios, however the costs are significantly less. This scenario also performed best when an incremental BCR analysis was undertaken.

The BCR of the rail and busway scenarios are in the same order (between 0.1 and 0.23) and so have been scored as having moderately negative impacts. The light rail scenario performs poorly at around 0.08 and has been scored as having a moderately negative impact. Light rail has the highest benefits compared to the other scenarios, but also has very high costs.

When compared against the anticipated funding allowed for in the LTCCP over the next ten years, relative to the base all scenarios except the bus on-street scenario have negative impacts on affordability. The bus on-street scenario scored the same as the base. ER1 and the two busway scenarios have minor negative impacts on affordability while the ER2 scenario have moderate negative impacts. The capital costs associated with the light rail scenario are substantial and this scenario significantly exceeds the anticipated level of funding. It was therefore scored as having a significant negative impact on economic efficiency and affordability.

The ability to stage construction and defray financial costs was considered a financial and economic benefit. There is little opportunity to stage construction of the rail scenarios because new rolling stock and associated infrastructure improvements would be required before the operational life of the existing units is exhausted in the near future.

The on-street bus scenario could be staged with construction of the walking and cycling track taking place after abandonment of the rail line. It was therefore scored as having a minor positive impact.

The busway scenarios could require the new buses to operate on-street for a considerable period before the busway was completed. It is estimated that the busway would take between 18 and 24 months to complete. Construction of the busway could be staged with sections completed incrementally. The busway scenarios were therefore scored similarly to the bus on-street scenario as having a minor positive impact. Light rail provides the largest scope for staging construction by allowing the CBD section to be completed in the future, potentially as part of a wider light rail network.

Overall, the rail scenarios perform similarly, with the ER1 scenario performing slightly better overall due to performing better under the affordability criteria. The busway scenarios perform similarly to ER1 but have more potential for implementation staging. The bus on-street scenario performs the best overall due to the smallest negative economic impact and potential for staging. The light rail option performs poorly in terms of economic and affordability impacts.

- **Table 4-6: Consider Economic Efficiency and Affordability Score**

6) CONSIDER ECONOMIC EFFICIENCY AND AFFORDABILITY	Base	ER1	ER2	OS1	BW1	BW2	LR1
Consider Economic Efficiency	0	XX	XX	X	XX	XX	XX
Consider Affordability	0	X	XX	0	X	X	XXX
Procurement and Implementation Staging	0	0	0	√	√	√	√√
Average	**0**	**X**	**X-**	**0**	**0-**	**0-**	**X**

4.7 Risk

The risk criteria was measured using the following criteria with the objective of scoring those with least risk as being the most beneficial:

- Risk scores
- Consentability

Table 4-7 shows the overall score for the least risk criteria.

The two rail scenarios perform in a similar way to the base and each other, having the best overall score which is similar to the base case risks. Bus on-street performs the next best having a moderately negative impact. The major risks for the bus on-street scenario are associated with failure to meet community expectations, resulting under demand for the services, and difficulties interfacing with existing infrastructure through the CBD. Compared to light rail it performs better overall because of the risks associated with consenting and construction of the light rail line. Light rail and the busway perform similarly overall. However, both have substantial risks. The risks associated with the busway in terms of construction and implementation are less than the light rail due to light rails large construction requirements through the CBD. This difference is offset by the additional consenting issues associated with the busway scenario.

- **Table 4-7: Risk Score**

7) Risk	Base	ER1	ER2	OS1	BW1	BW2	LR1
Risks associated with implementation and operation	0	0	0	XX	XX	XX	XXX
Consentability	0	0	0	X	XXX	XXX	XX
Average	**0**	**0**	**0**	**X-**	**XX-**	**XX-**	**XX-**

Note that risk related to adverse public reaction to the chosen option has not been included in this assessment.

4.8 Planning Balance Sheet Scoring Summary

Table 4-8 summarises the unweighted scores under each of the six objectives. No attempt was made to determine or apply different weightings and an overall score has not been determined as this would require consideration of the relative weight or importance given to each objective.

- **Table 4-8: Planning Balance Sheet Scores (Equal Weights)**

Summary	Base	ER1	ER2	OS1	BW1	BW2	LR1
1) ASSIST ECONOMIC AND REGIONAL DEVELOPMENT (More Prosperous)	0	√	√	√	√+	√+	√√
2) ASSIST SAFETY AND PERSONAL SECURITY (Safer)	0	0	0	0	0	0	0
3) IMPROVE ACCESS MOBILITY AND NETWORK RELIABILITY (Better Connected / More Liveable)	0	0+	0+	0	0+	0+	0+
4) PROTECT AND PROMOTE PUBLIC HEALTH (Healthier)	0	0+	0	0	0-	0-	0+
5) ENSURE ENVIRONMENTAL SUSTAINABILITY (More Sustainable / More compact)	0	0+	0+	0	0	0	√
6) CONSIDER ECONOMIC EFFICIENCY AND AFFORDABILITY	0	X	X-	0	0-	0-	X
7) Risk	0	0	0	X-	XX-	XX-	XX-

The assist safety and personal security objective does not differentiate between the scenarios.

The two rail scenarios perform very similarly across all objectives with little to differentiate between them. The bus on-street scenario performs better than the rail scenarios under the economic efficiency and affordability criteria because it has a similar level of benefits but significantly reduced costs. This is offset by the poorer performance of the bus on-street scenario under the access and mobility, public health, environmental and risk objectives. A decision between rail and bus on-street would be made by comparing the improved economic performance of the bus on-street scenario with the larger risks associated with it. Bus on-street is the least preferred from a public consultation perspective and this would need to be considered in the decision making process.

The busway scenarios generally perform similarly to the rail scenarios. The busway scenarios perform slightly better under the economic development and economic efficiency and affordability objectives, and slightly worse under the public health and environmental sustainability objectives. There is significantly increased risk associated with the busway, related to obtaining consents, construction and operation and hence it scores poorly compared to rail. There would need to be a large reduction in risk before a busway could be considered preferred above rail. The bus on-street scenario performs similarly to the busway in most respects but has a lower risk level.

Light rail generally performs as well or better than the other scenarios across all objectives except economic efficiency and affordability and risk, where it performs relatively poorly. It has the highest benefits of all scenarios but also has very high costs. The funding contribution required from GWRC over the next10 years is significantly more than allowed for in the LTCCP. On this basis it would be difficult to choose light rail without a significant commitment of additional funds from another source (such as central government) and a reduction in the risks associated with the scenario. Without a commitment to extension of light rail to serve the wider region, deployment of light rail on this corridor alone would not seem sensible.

5. Conclusions and Recommendations

From the investigations and assessments undertaken, it is concluded that significant differences between the scenarios for the North Wellington Passenger Transport Study relate to costs, risks and public opinion. It would seem logical that the option which provided the best economic performance, with an acceptable level of risk should be the preferred scenario. Also, it would be important to consider if this outcome would be acceptable to at least a significant section of the community.

Of the scenarios considered, the bus on-street performed the best in terms of economic performance, over and above the base case which retains rail. However, none of the scenarios have a benefit cost ratio (BCR) greater than 1, meaning that none of the scenarios provide NPV benefits over the base which are greater than the additional NPV costs. The base case, which has the lowest cost over 25 years, and provides a minimum acceptable level of service, would be the preferred option from an economic perspective.

The base case has the lowest cost and is within the allowance in the LTCCP. The base case was developed for comparison of the proposed scenarios and did not include an allowance for risk. Using the assumptions outlined in this report, the cost for the bus on-street scenario is similar to the base. Changes at the margin to optimise a number of factors such as risk and to minimise expenditure could influence the relative economic performance of these two scenarios.

The risks associated with the bus on-street scenario such as difficulties interfacing with existing infrastructure through the CBD, are more significant than those for the base case. It may also fail to meet community expectations resulting in under use of the services. If a lower risk strategy is desired, the base case should be selected. The base case also retains rail services on the Johnsonville Line, which was seen to be desirable by a significant number of respondents to the community consultation.

The enhanced rail and busway scenarios provide additional benefits over the base, but do not perform as well in terms of risk and affordability.

Light rail is substantially outside the funding envelope set by the LTCCP and has poor economic performance combined with a high level of risk. It is not recommended as a preferred scenario based on the requirements of the northern suburbs alone. It is possible that if light rail were adopted as a solution for regional transport needs, then the economics of introducing this mode to the Johnsonville line might improve. However, this prospect is outside the scope of this study and has not been considered further.

Taking all the factors above into consideration, our conclusion from this evaluation is that the base case involving the minimum level of rail improvements should be taken forward. In addition the base case scenario has some measure of support judged on the basis of the consultation process. Incremental improvements to bus services and bus priority measures could be put in place to enhance passenger transport services for parts of the northern suburbs that are not directly served by rail.

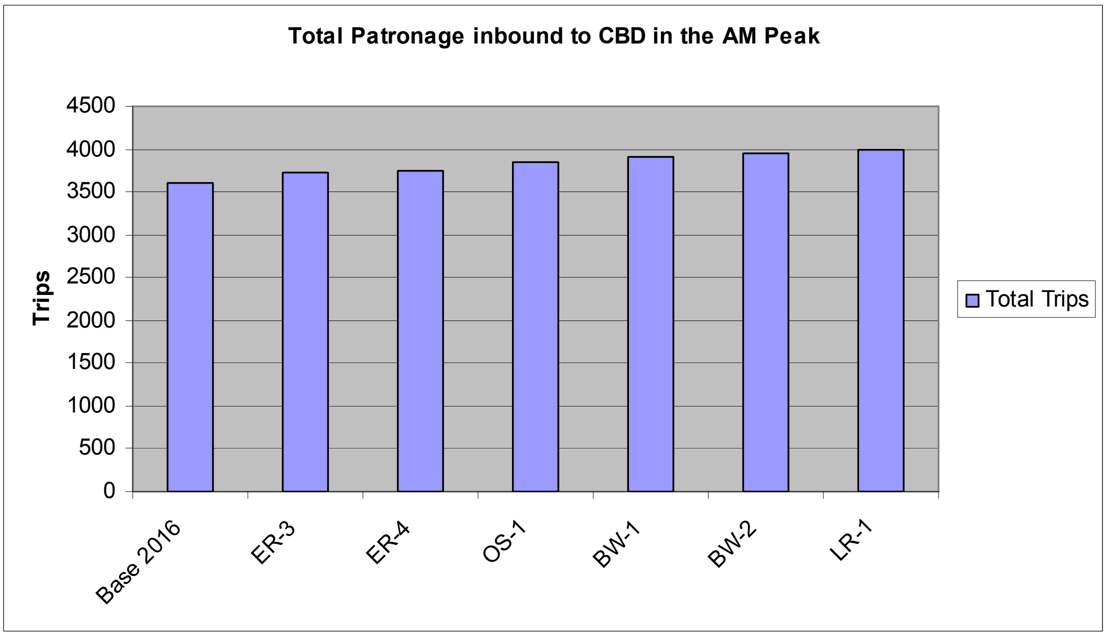
Appendix A Patronage

Public transport patronage figures for the AM peak, inbound to the CBD (Table 5-1 and Figure 5-1) were extracted from the model for the trips originating in the northern suburbs. These figures include trips wholly within the northern suburbs as defined in the RFT.

- **Table 5-1: Public Transport Patronage in the Northern Suburbs**

	2001	Base 2016	ER1	ER2	OS-1	BW-1	BW-2	LR-1
Bus	1,936	2,586	2,650	2,573	3,841	1,977	2,185	1,850
Bus %	65%	72%	71%	69%	100%	51%	55%	46%
Rail / Light Rail / Busway	1,043	1,024	1,085	1,173	-	1,929	1,764	2,137
Rail / Light Rail / Busway %	35%	28%	29%	31%	0%	49%	45%	54%
Total	**2,979**	**3,610**	**3,735**	**3,746**	**3,841**	**3,906**	**3,949**	**3,987**
Total %(compared to 2016 base)	**83%**	**100%**	**103%**	**104%**	**106%**	**108%**	**109%**	**110%**

- **Figure 5-1: Public Transport Patronage in the peak direction in the Northern Suburbs (AM peak)**



In general, the number of public transport trips as a proportion of all the trips from the northern suburbs remains relatively constant across all scenarios. The light rail scenario is the most effective in increasing public transport uptake in the study area however, the increase represents only 10% of total public transport patronage in the 2 hour AM peak. This equates to approximately 370 additional trips and highlights that all of the scenarios only have a marginal impact on the number of vehicle trips.

While patronage increases to some extent, the major changes between the scenarios occur where existing public transport users shift between modes. For example, when rail services are improved, patronage is attracted away from bus onto rail. Clearly, if a busway is installed, the existing rail users have to change to bus as rail would no be longer available.

Public transport mode share is shown in Table 5-2 for the AM peak inbound to the CBD. From this it can be seen that none of the options have a significant impact on public transport mode share.

- **Table 5-2: Public transport Mode Share AM Peak Inbound to CBD**

Trips from NS	2001	Base 2016	ER-3	ER-4	OS-1	BW-1	BW-2	LR-1
PT	2,979	3,610	3,735	3,746	3,841	3,906	3,949	3,987
Car (persons)	16,813	18,824	18,634	18,612	18,486	18,476	18,438	18,371
PT %	15%	16%	17%	17%	17%	17%	18%	18%
Car (persons) %	85%	84%	83%	83%	83%	83%	82%	82%

Appendix B Objective 1: Assisting Economic Development (More Prosperous)

The following measures were used in the evaluation of the objective Assisting Economic Development:

- Average cost of travel per kilometre by mode
- Average cost of travel to key economic and employment destinations

B.1 Average Cost of Travel per kilometre by Mode

Table 5-3 gives the average generalised cost of travel by private vehicle, heavy commercial vehicle (HCV) and public transport (PT) for trips with origins or destinations in the northern suburbs in each of the modelled time periods. Figure 5-2 presents this graphically.

The generalised cost of travel represents the cost to a traveller of making a particular trip by their chosen mode in terms of time. For trips made by private vehicles it consists of travel time, vehicle operating costs, parking charges and any toll payments required. For public transport trips the generalised cost comprises travel time, walk time, wait time, boarding penalty, transfer penalty and fare. Monetary based attributes are converted into time values before being added to the travel times. A dollar value can be developed for the generalised cost by multiplying the time unit by a value of time.

Both private car and HCV have similar costs to the base under all scenarios. This is because none of the scenarios significantly impact on private vehicle or HCV trips.

PT costs per km decline under the scenarios because of the improved services provided, with the rail and bus on-street scenarios showing a reduction in the order of 6 – 9%. The busway and light rail scenarios show a reduction in the order of 16%, and this reflects the fact that their services extend through the city for a longer distance without the need for transfers.

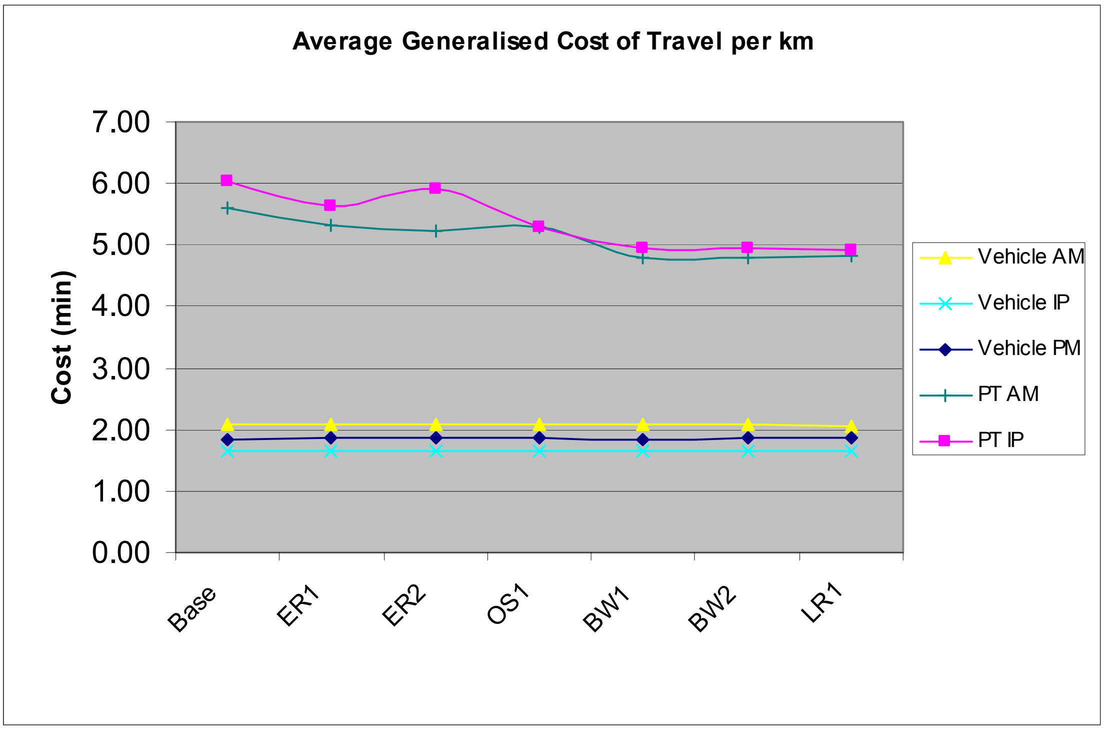
In scoring the scenarios (Table 5-3), the busway and light rail scenarios were judged to have a moderately positive impact while the rail and bus on-street scenarios were considered to have a minor positive impact.[3]

[3] No PM figures are shown for PT. This is because there is no PM PT model in the version of WTSM used. Outputs are annualised based on the AM and IP only.

- **Table 5-3: Average Generalised Cost of Travel per kilometre for Trips with Origins or Destinations in the Northern Suburbs (min/km)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Vehicle AM	2.07	2.07	2.07	2.08	2.07	2.07	2.06
Vehicle IP	1.65	1.65	1.65	1.65	1.65	1.65	1.65
Vehicle PM	1.85	1.85	1.85	1.86	1.85	1.86	1.86
PT AM	5.59	5.33	5.22	5.30	4.80	4.78	4.82
PT IP	6.03	5.62	5.91	5.30	4.93	4.94	4.92
PT%	**100%**	**94%**	**96%**	**91%**	**84%**	**84%**	**84%**
HCV AM	2.03	2.02	2.02	2.03	2.02	2.02	2.01
HCV IP	1.64	1.64	1.64	1.64	1.64	1.64	1.64
HCV PM	1.86	1.87	1.87	1.88	1.87	1.87	1.87
Score	**0**	√	√	√	√√	√√	√√

- **Figure 5-2: Average Generalised Cost of Travel per kilometre for Trips with origins or Destinations in the Northern Suburbs (min/km)**



The data shown in the figure above is depicted using a line chart where the results for each data series are shown linked between scenarios. This is not intended to suggest any linkage between the scenarios, but is to display a large amount of data on one chart as clearly as possible. This approach has been continued, where appropriate, throughout the evaluation described below.

B.2 Average Cost of Travel to Key Economic and Employment Destinations

Table 5-4 shows the average generalised cost of travel per trip by private vehicle and PT from the northern suburbs to key economic and employment destinations for each of the modelled periods. This is represented graphically in Figure 5-3 and Figure 5-4 for the AM peak period.

The key economic and employment destinations used for this and the other measures below are:

- CBD North (represents a comfortable walking distance from the Wellington Railway Station to Willis Street);
- CBD South (Willis Street – Basin Reserve);
- Newtown;
- Kilbirnie; and
- Airport

These destinations are consistent with the WCC urban development "growth spine" concept.

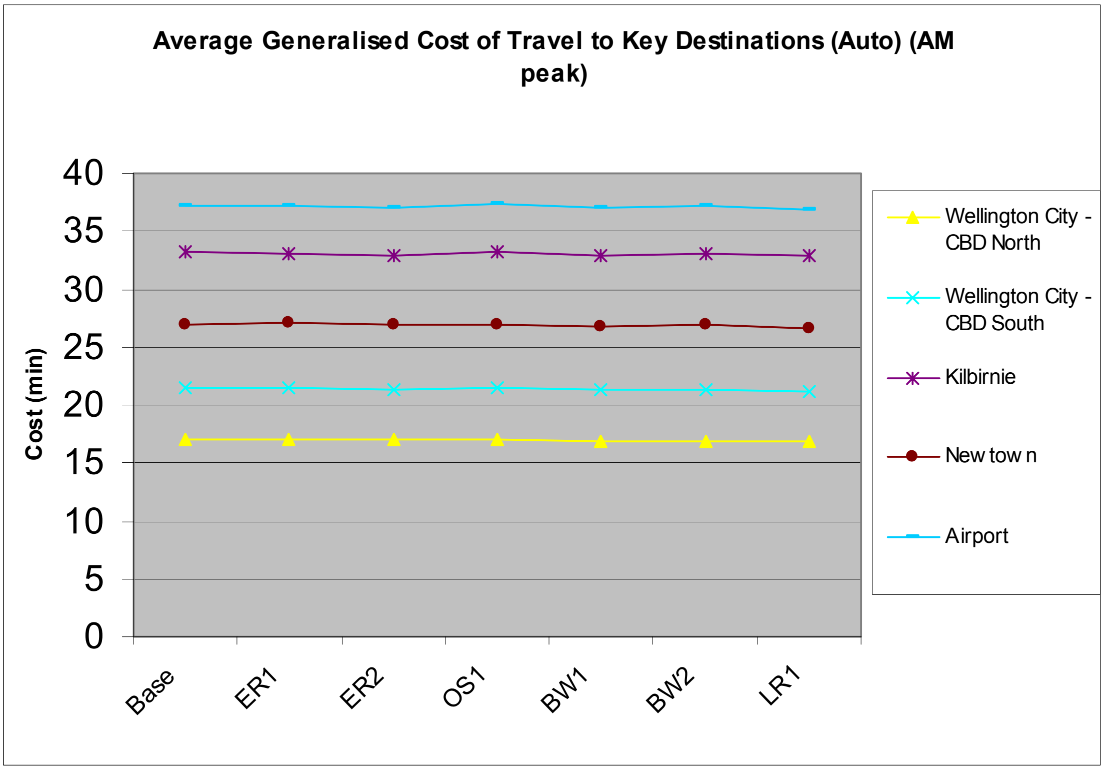
With all the scenarios, average private vehicle costs are similar to the base. This was expected because of the marginal impact on private vehicle trips.

Average PT costs decline under the scenarios, with similar minor reductions under all scenarios except light rail which has a moderate reduction (13%). Therefore in the scoring (Table 5-4), the light rail scenario was scored higher than the other scenarios.

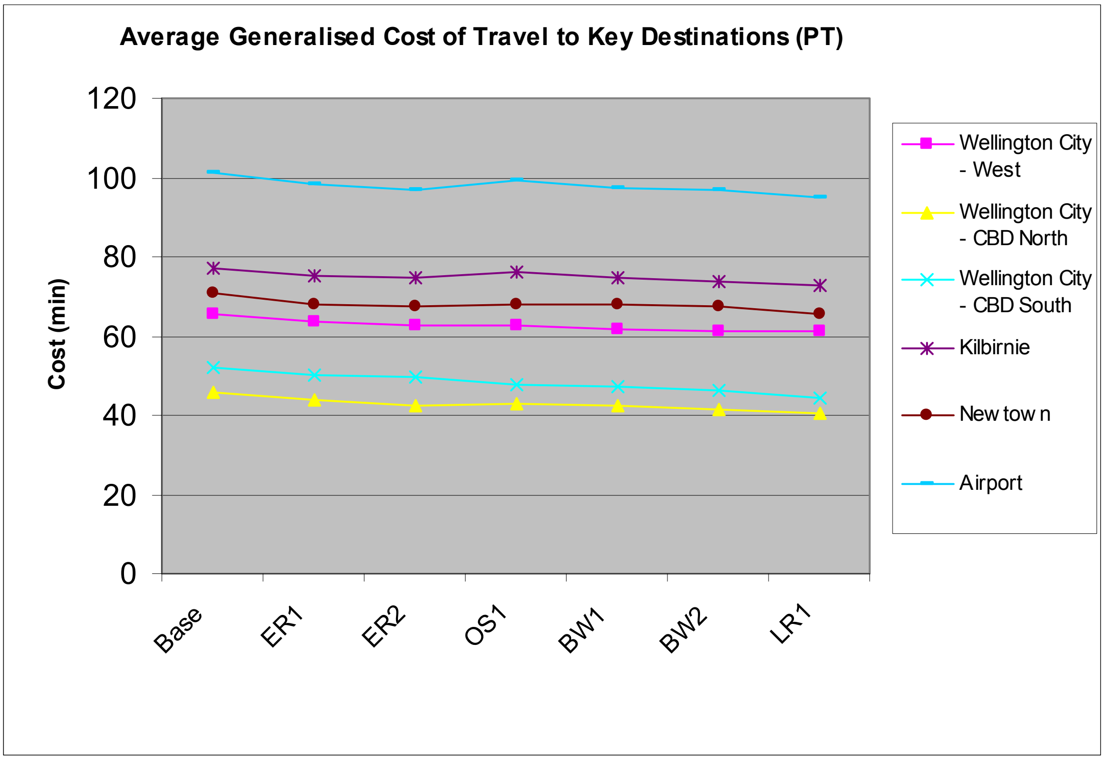
- **Table 5-4: Average Generalised Cost of Travel from the Northern Suburbs to Key Destinations (min)**

AM Auto							
Destination	**Base**	**ER1**	**ER2**	**OS1**	**BW1**	**BW2**	**LR1**
Wellington City - CBD North	17.0	17.0	17.0	17.1	16.9	16.9	16.8
Wellington City - CBD South	21.4	21.4	21.4	21.4	21.3	21.3	21.2
Kilbirnie	33.1	33.1	32.9	33.2	33.0	33.0	32.8
Newtown	27.0	27.1	27.0	27.0	26.9	26.9	26.7
Airport	37.2	37.2	37.1	37.3	37.1	37.2	36.9
AM PT							
Wellington City - West	65.6	63.8	62.8	62.7	61.6	61.0	61.3
Wellington City - CBD North	45.8	43.8	42.6	42.8	42.3	41.5	40.7
Wellington City - CBD South	52.2	50.3	49.7	47.6	47.1	46.4	44.1
Kilbirnie	77.3	75.0	74.6	76.0	74.5	73.8	72.8
Newtown	70.8	67.8	67.4	68.1	67.8	67.3	65.7
Airport	101.2	98.3	97.0	99.2	97.5	96.7	95.2
Average Auto	19.9	19.9	19.9	20.0	19.9	19.8	19.7
Average Auto %	100%	100%	100%	100%	100%	100%	99%
Average PT	49.78	47.73	46.82	46.19	45.62	44.91	43.46
Average PT %	100%	96%	94%	93%	92%	90%	87%
Score	**0**	√	√	√	√	√	√√

- **Figure 5-3: Average Auto Generalised Cost of Travel from the Northern Suburbs to Key Destinations (min) (AM peak)**



- **Figure 5-4: Average PT Generalised Cost of Travel from the Northern Suburbs to Key Destinations (min) (AM peak)**



B.3 Assist Economic Development Summary

Table 5-5 shows the overall score for the objective Assist Economic Development, where each of the measures was given equal weighting. A reduction in costs was considered to be a positive impact on economic development and all scenarios have a positive impact overall.

The average cost of travel per km does not reduce for vehicle trips under any of the scenarios. This was expected because of the marginal impact on private vehicle trips. The average public transport (PT) cost per km declines under all the scenarios compared to the base. The rail and bus on-street scenarios show a minor positive impact while the busway and light rail scenarios show a moderate positive impact.

With all the scenarios, the average cost of travel by private vehicle to key destinations on the WCC “growth spine” is similar to the base. Average PT cost to key destinations decline under all scenarios, with similar minor impacts except for the light rail scenario, which has a moderate reduction.

The rail and the bus on-street scenarios perform similarly overall with minor positive impacts. The two busway scenarios perform slightly better than the rail or bus on-street scenarios due to greater reductions in the average cost of travel per km. The light rail scenario performs the best overall resulting in a moderate positive impact.

- **Table 5-5: Assist Economic Development Score**

1) ASSIST ECONOMIC AND REGIONAL DEVELOPMENT (More Prosperous)	Base	ER1	ER2	OS1	BW1	BW2	LR1
Average cost of travel per kilometre by mode	0	√	√	√	√√	√√	√√
Average cost of travel to key economic and employment destinations	0	√	√	√	√	√	√√
Average	**0**	√	√	√	√**+**	√**+**	√√

Appendix C Objective 2: Assist Safety and Personal Security (Safer)

The objective Assisting Safety and Personal Security was measured in terms of:

- Travel Safety
- Personal security on public transport

C.1 Travel Safety

Travel safety was measured by:

- Road crashes
- Annual transport casualties

Road safety was measured in terms of estimated annual injury crashes. A simple crash rate model was used with different rates applied to the vehicle-kilometres of travel (from WTSM) on motorways, urban arterials and rural arterials within the northern suburbs and CBD corridor. This does not account for any changes in crash rates due to safety improvements, changes in numbers of pedestrians or cyclists, or other external factors. It is therefore considered to represent a relative measure rather than an absolute one.

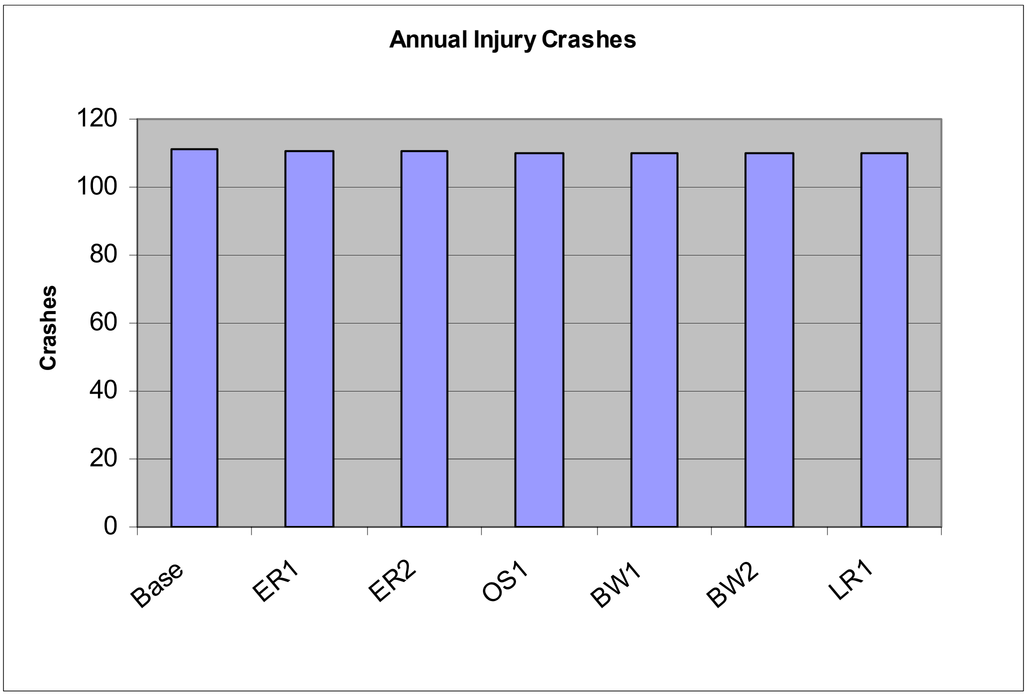
Table 5-6 gives the crash estimates for the base case and the six scenarios, along with the resulting scores, and Figure 5-5 shows the total crashes graphically.

The data show that none of the scenarios have an impact on the number of injury crashes. This is because of the marginal impact on private vehicle trips.

- **Table 5-6: Annual General Traffic Injury Crashes in the Northern Suburbs**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Total	111	111	111	110	110	110	110
%	100.0%	99.4%	99.4%	98.9%	98.9%	98.7%	98.8%
Score	0	0	0	0	0	0	0

- **Figure 5-5: Annual General Traffic Injury Crashes in the Northern Suburbs**



The UK Department for Transport (DfT) publishes passenger casualty rates by mode[4]. The casualty rates per billion passenger kilometres are shown in Table 5-7.

- **Table 5-7: Passenger Casualty Rates per Billion Passenger kilometres by Mode (Average for period 1994 – 2003)[4]**

Severity	Car	Rail	Bus or Coach	Two wheeled motor vehicle	Pedal cycle	Pedestrian
Killed	2.8	0.4	0.3	113	39	52
KSI[1]	34	2.0	13	1471	776	583
All[2]	327	74	194	5520	5276	2448

Notes:

1) Killed or seriously injured
2) Killed, seriously and slightly injured
3) Figures provided are for Financial years
4) Passenger casualties involved in train accidents and accidents occurring through movement of railway vehicles. Reporting regulations changed on 1 April 1996. Since then figures are only available for passenger fatalities and injuries. The reporting trigger for an injury is the passenger being taken to hospital directly from the scene.
5) Driver and passenger casualties

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[4] http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/page/dft_transstats_041409.xls#'1.7'!A1

Indicative numbers of casualties were estimated by applying casualty rates to passenger-km travelled in the northern suburbs. For bus, rail and car, the "All" figure in Table 5-7 was used. No information was provided for light rail, but international literature suggests that light rail performs somewhere between rail and on-street bus. The rate for the section between the Wellington Station and Courtenay Place would be somewhere between rail and bus, so an indicative rate of 134 was used. Light rail will act in a very similar way to rail on the dedicated Johnsonville line corridor and the casualty rates used for this section was the same as for rail.

Similarly, no rate was provided for a guided busway. Information on casualties on guided busway accidents is limited because of the limited number of applications. In Essen, the guided bus system has been operating successfully at speed for over 20 years and only one accident has occurred.[5] The O-bahn in Adelaide also has an excellent safety record, with no accidents in the last decade.[6]. These applications are for a busway with relatively low gradients, large radii horizontal curves and good sight distance. It could be expected that the accident rate for a guided busway on the constrained Johnsonville corridor alignment would be higher than for rail, therefore a rate similar to that for Light Rail operating on-street was applied.

Indicative annual casualties for the different scenarios are shown in Table 5-8 and Figure 5-6 and the difference between the scenarios is very slight. All scenarios were scored the same. The difference in the number of crashes forecast for general traffic and the casualty rates could be the result of multiple casualties within injury crashes.

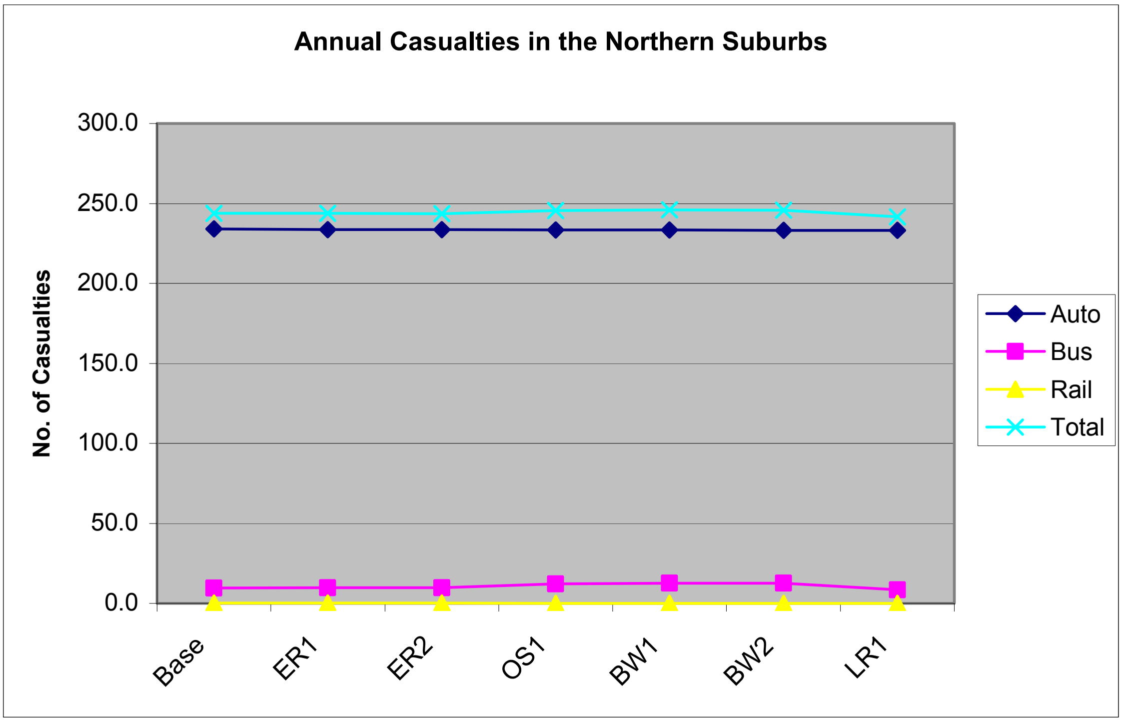
- **Table 5-8: Annual Casualties by Mode in the Northern Suburbs**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Auto	234.0	233.6	233.6	233.3	233.3	233.2	233.2
Bus	9.5	9.8	9.8	12.1	12.6	12.6	8.4
Rail	0.3	0.3	0.3	0.0	0.0	0.0	0.0
Total	243.8	243.8	243.6	245.5	246.0	245.8	241.6
Score	0	0	0	0	0	0	0

[5] Cambridgeshire Guided Busway Order Proof of Evidence of Dr Alan Brett: Transport and Business Case CCC/ACB/14, Sept 2004

[6] Cambridgeshire Guided Busway Order Proof of Evidence of Dr Alan Brett: Transport and Business Case CCC/ACB/14, Sept 2004

- **Figure 5-6: Annual Casualties by Mode in the Northern Suburbs**



The resulting overall score for the measure Travel Safety is shown in Table 5-9. There was little impact as a result of any of the scenarios and they have all been scored as 0.

- **Table 5-9: Travel Safety Score**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Annual General Traffic Injury Crashes	0	0	0	0	0	0	0
Annual Casualties Score	0	0	0	0	0	0	0
Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**

One issue which has not been addressed above is the impact of at grade crossings of the Johnsonville Corridor. Those scenarios which significantly increase the frequency of service in the corridor could have an impact on crashes at level crossings. Additionally, pedestrian crossings of the corridor are made at grade at present. Should service frequencies increase significantly, there could be a need to provide signalised or grade separated pedestrian facilities to ensure that a safety problem does not arise. This would need to be considered during detailed safety audits in the future.

C.2 Personal Security on Public Transport

The scale of crime and assaults on public transport in Wellington is currently minor. GWRC does not receive public transport crime statistics except figures on car break-ins at park 'n' ride sites. Recently there were limited issues with intimidation on longer distance train services during late evening services. Trans Metro addressed this issue by providing additional security staff. Feedback from GWRC passenger transport staff is that personal security is not considered a large issue in the region.

This was highlighted in the recent Public Transport Customer Satisfaction Monitor 2006 survey where the public's perception of personal security was investigated, and in general people indicated they felt safe using public transport. On a scale of 1 – 5 where 1 is poor and 5 is excellent the mean satisfaction scores were:

- Feeling safe at the bus stop 3.8
- Feeling Safe on the bus 4.1
- Feeling Safe on the train 3.0
- Safety of pedestrian access to stations e.g. Subways 3.4

Public transport users are vulnerable throughout their journey from their origin to a public transport stop / station, waiting at the stop / station, travelling on the mode and completing their journey from the stop / station to their destination.

One of the major factors influencing personal security is visibility. This relates to formal surveillance (CCTV cameras etc), informal surveillance (by staff, other users and passers-by), landscaping (making it difficult for people to hide or be obscured) and lighting. Clearly marked entrances and exits, easy escape routes and provision of emergency call facilities (telephones) are also factors influencing personal security. These issues would be addressed similarly for all scenarios during detailed design of the preferred scenario and are unlikely to be significant in decision making at this strategic level.

Perceived personal security is also related to exposure to a threat (time spent waiting at stops), and access to help from other people. Generally people feel safer while travelling on public transport than waiting for it or using associated parking facilities. Rail based services typically have a less frequent services than bus based services (to carry the same patronage), therefore passengers wait at stations / stops for longer durations. Conversely, there are generally more people waiting at individual rail based stations / stops than at bus stops so there would be more people around to intervene.

Unlike bus stops, rail based stations / stops are typically removed from passive surveillance from passing traffic, so can lead to a feeling of isolation. However, there are likely to be more formal surveillance from CCTV cameras etc. at stations.

In general, the more people that use a public transport mode, the more people who are on the vehicles, at stations / stops and surrounding areas, and can intervene to stop crime or call for help. An increase in the percentage of passenger transport usage could therefore be seen as a having a positive impact on personal security for those using public transport. Conversely, because people are generally safe using private vehicles it could be viewed that a move from private car to public transport could have an overall negative impact. All scenarios improve public transport patronage between 4 and 9% so are unlikely to have significant differences.

Some people claim to feel less safe in a bus that is not fixed to it's route compared to rail based modes and vulnerable to assault by drivers when they are alone in a bus. Conversely some people claim to feel safer because the driver is close by in a bus and could intervene during an assault.

The majority of the study area would be served by bus under any of the scenarios being considered and therefore would have similar personal security characteristics. The major difference between the scenarios would be in the Johnsonville Line corridor section of the route. Here under the rail, busway or light rail scenarios, the stop / station facilities provided would have similar personal security characteristics. Busway and light rail would have slightly increased frequencies over rail; however, this impact is unlikely to be substantial. Under the bus on-street scenario, personal security characteristics over this length would be similar to the remainder of the bus based network.

Personal security on public transport is generally considered good in the region as a whole and is not a major issue for passengers. Therefore, this measure was not given a high weighting. The personal security of passengers under the scenarios being considered is unlikely to change significantly between the scenarios, and all scenarios were scored the same (Table 5-10).

- **Table 5-10: Personal Security on Public Transport Assessment Scores**

Scenario	Score
Base	0
Scenario 1 – Enhanced Rail	0
Scenario 2 – Bus on-street with Walking and Cycling	0
Scenario 3 - Busway	0
Scenario 4 – Light Rail	0

C.3 Assist Safety and Personal Security Summary

Table 5-11 shows the overall score for the objective Assist Safety and Personal Security, where each of the measures was given equal weighting.

None of the scenarios have a significant impact on safety or personal security and were scored accordingly.

Table 5-11: Assist Safety and Personal Security Score

2) ASSIST SAFETY AND PERSONAL SECURITY (Safer)	Base	ER1	ER2	OS1	BW1	BW2	LR1
Travel safety	0	0	0	0	0	0	0
Personal Security on Public Transport	0	0	0	0	0	0	0
Average	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Appendix D Objective 3: Improve Access, Mobility & Network Reliability (Better Connected / More Liveable)

The following measures were used in the evaluation of the objective Improve Access, Mobility & Network Reliability, and are discussed in turn:

- The impacts on travel
- Construction disruption
- Travel times (journey times)
- Vehicle speeds
- Level of congestion and network reliability
- PT network reliability
- Resilience of the PT network
- Access to PT (proximity)
- PT integration (seamlessness of service)
- Vehicle comfort and condition
- PT frequency

Accessibility for the less able is an issue which has recently been considered by the Human Rights Commission. Following this review, it is envisaged that legislation will require all public transport services to be fully accessible in the future. This means that all scenarios would have to be designed to provide an accessible service - this could be through the provision of low floor vehicles or selected access points etc. In consultation with GWRC and WCC, it was agreed that accessibility would not be considered further. It was assumed that any form of public transport would have to provide for access by the less able and was therefore not a key issue in differentiating between scenarios.

D.1 The Impact on Travel

The impact on travel was measured in terms of person-kilometres of travel by private vehicle, public transport (PT) and heavy commercial vehicle (HCV) originating in the northern suburbs. Table 5-12 gives the person-kilometres of travel by private vehicle, public transport, and heavy commercial vehicle, and Figure 5-7 presents this for the AM peak period.

Where there was more person-km of travel made there was assumed to be a positive impact on mobility because people could travel where they want to travel. A reduction was therefore seen as a negative impact on travel.

In terms of total travel across all modes, there was a very minor impact for all scenarios and this overall effect was used in the scoring. The person-kilometres by public transport however increases over the base with all scenarios in both the AM peak and the interpeak. This increase in the PT person-km for the busway and light rail scenarios becomes quite large and is greater than the corresponding PT mode share increase (up to 16%). This would indicate that people are making longer trips on PT.

Any change in HCV person-kilometres is due to changes in routes taken as, in the model, the number of HCV trips and their distribution (i.e. the HCV trip matrix) remains the same.

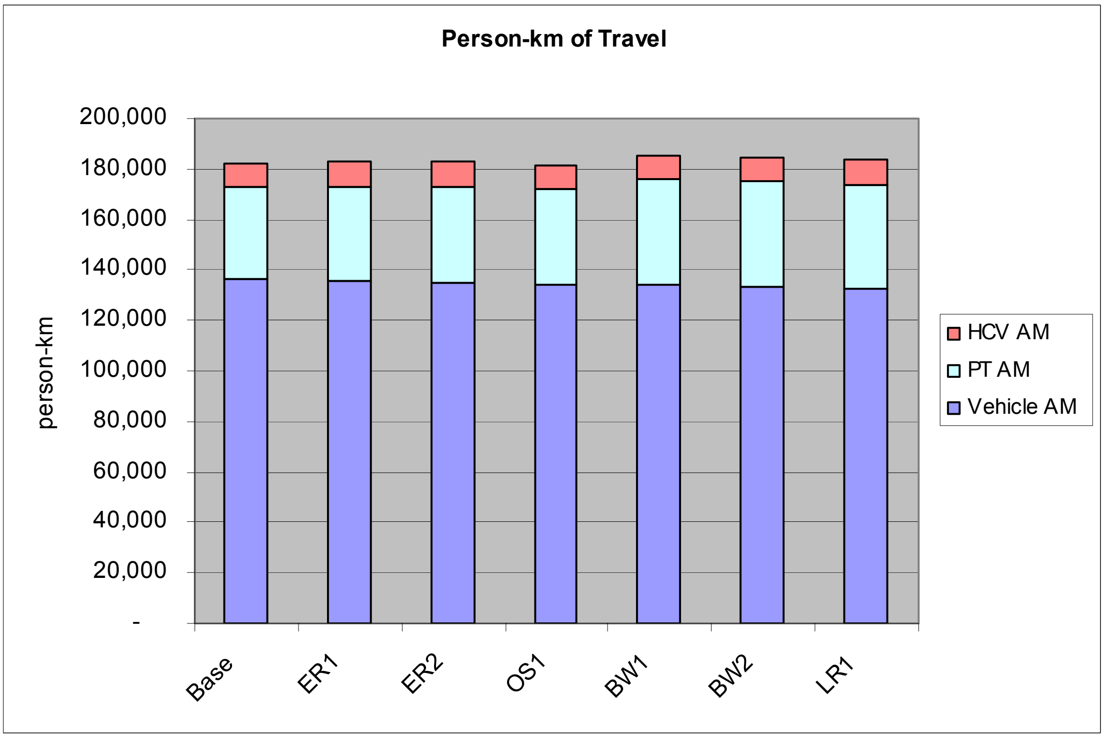
Table 5-12 includes the resulting scores for the measure impact on travel. All scenarios have a negligible impact on travel over all (all modes), and so were scored 0[7].

- **Table 5-12: Person-km of Travel from the Northern Suburbs**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Vehicle AM	136,806	135,282	135,137	134,210	134,059	133,649	132,933
Vehicle IP	73,386	73,194	73,185	73,071	73,124	73,048	72,866
Vehicle PM	108,203	108,338	108,300	108,560	108,187	108,131	108,340
PT AM	35,953	37,821	37,995	37,692	41,622	41,418	40,944
PT IP	7,423	7,756	7,496	7,914	8,755	8,665	8,500
HCV AM	9,523	9,522	9,521	9,521	9,521	9,522	9,521
HCV IP	9,982	9,985	9,986	9,985	9,988	9,986	9,984
HCV PM	8,956	8,982	8,976	9,017	8,957	8,945	8,977
Total AM person-km %	100.0%	100.2%	100.2%	99.5%	101.6%	101.3%	100.6%
Total PT person-km %	100.0%	105.1%	104.9%	105.1%	116.1%	115.5%	114.0%
Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**

[7] No PM figures are shown for PT. This is because there is no PM PT model in the version of WTSM used. Outputs are annualised based on the AM and IP only.

- **Figure 5-7: Person-km of Travel from the Northern Suburbs (AM peak)**



D.2 Construction Disruption

There would inevitably be short term disruption to public transport and general traffic services in the northern suburbs as a result of constructing or implementing any of the scenarios. The duration and scale of this disruption was considered for each scenario.

Because of the extended scale and duration of disruption under some scenarios, there may be a longer term impact on patronage. Once people have shifted back to the use of private vehicles, the public transport “habit” is broken and it can be difficult to attract them back out of their cars. If this were to happen it would take some time to rebuild patronage up to the levels forecast for the long term.

The impact that this type of extended disruption can have on public transport service patronage was highlighted by the sustained patronage loss experienced by Tranz Metro following track temperature problems in the past. Trans Metro have advised that once the problems were addressed it took a considerable time before patronage returned to the levels experienced before the problem. Equally, it could be argued that a new or improved service would attract patronage immediately as people would want to try the improved facilities and service.

Under all scenarios, it was assumed that the construction of interchange facilities at Johnsonville would take place as part of the Johnsonville Town Centre upgrade and may require waiting and stopping facilities to be relocated temporarily around the site and adjacent roads.

The implications and practicalities of obtaining funding and planning approvals are considered in Section H.2 and could be significant for scenarios which propose conversion of the Johnsonville rail corridor to alternative modes. For the purposes of this assessment, all scenarios were assumed to begin construction in the same year. No allowance was made for delays due to funding or planning approvals which could alter the possible start dates for construction.

D.2.1 Base Case Construction Disruption

The base case assumed for construction disruption was the construction programme proposed by ONTRACK in their report *Clearance for a Ganz Mavag Profile on the Johnsonville Line*, April 2006, which proposes two 1 week long full closures of sections of the line, 3 weeks of extended night closures and 2 weeks of passing loop closures. Platform alterations would take place sequentially while the line remained operating. When the line is unavailable, replacement bus services would operate. There are some concerns over the viability of this programme, however it was assumed as the base for construction disruption.

D.2.2 Scenario 1 – Rail Scenario Construction Disruption

ER1 – 13 minute timetable

The implementation of the 13 minute timetable scenarios require improvements to the infrastructure to cater for the new or refurbished rail units and extension of the Wadestown passing loop. The lowering of tunnels to fit the new larger rolling stock could be completed during weekend closures of the line and the tracks blocked and stabilised so that services could recommence operating with speed restrictions during the week. It was estimated that the lowering of tracks within tunnels could be completed with 3 - 4 months of weekend closures and two extended closures for approximately 1 week at a time. During the closures, a rail replacement bus service would be operated. It may be possible to stage the closures so that a train services could be operated to intermediate termination points with rail replacement bus services only operating over certain lengths as required.

Station and platform upgrades could be undertaken in stages, with stations closed consecutively and affected passengers shuttled to adjacent stations by minibus. Alternatively, platforms could be maintained as operational with restricted boarding / alighting areas.

The changes to enable the larger units to operate on the line would take place in 2007/08 to allow new or refurbished units to begin operation in 2008/09 when the first delivery of new units is expected and the operational life of the English Electric are programmed to end.

For this scenario, the disruption due to construction would be minor requiring weekend closures over 3 – 4 months and two extended closures for durations of 1 week. Rail replacement bus services could be operated over these times. Individual stations would be affected for short durations and may require passengers to be bussed to adjacent stations. It was not anticipated that this level of disruption would have a significant or long term impact on public transport patronage.

ER2 – 10 minute timetable

Using a similar methodology as for ER1 above, tunnel lowering and station and platform upgrades would take place in 2007/08 to allow new or refurbished units to begin operation in 2008/09 when the first deliver of new units is expected. This would allow a 13 minute timetable to operate and the level of disruption expected would be similar.

The construction of new passing loops to cater for the enhanced 10 minute timetable services would result in more disruption than the tunnel lowering and station upgrades. The works to facilitate the new timetable would likely take place in 2010/11 so that additional new units delivered in 2011/12 could begin operation. This would allow for additional capacity as patronage grows.

Weekend closures would be utilised to construct the passing loops adjacent to existing tracks and any retaining structures required. Offline works could be undertaken during normal operations with speed restrictions and defined / separated working areas. It was estimated that the entire programme of works could be implemented over a 12 month period, with the utilisation of a combination of weekend closures and a number of extended partial line closures for approximately 3 weeks at a time.

For this scenario, the disruption due to construction would be more significant that that required for the 13 minute timetable scenarios, but relatively minor in the longer term. The construction works would require weekend closures and a number of extended line closures when rail replacement bus services would be operated over a 12 month period. It was not anticipated that this level of disruption would have a significant or long term impact on public transport services.

D.2.3 Scenario 2 – Bus on-street Construction Disruption

Under this scenario, CBD bus route improvements would take place in 2007/08 so that buses could begin operating on-street in 2008/09 when the operational life of the English Electric Units are programmed to end.

Installation of bus lanes and other bus priority measures would generally involve limited disruption to general traffic for relatively short durations, requiring lane closures and for the most part could be completed in off-peak periods. Installation of bus priority signalling, new stops and ticketing machines could take place with off-peak lane and footpath closures. Alterations to Kaiwharawhara Road / Hutt Road intersection could take place with limited closures at off peak times. Changes in constrained parts of the CBD such as Willis / Mercer Street or Courtenay Place / Taranaki Street intersections have the potential to cause large short term disruption.

The Johnsonville Line would need to be closed between Raroa and Johnsonville Stations for up to 2 months when the Broderick Rd / Moorefield Road Intersection was widened out over the existing railway line, however the majority of the line could continue to operate as normal with shuttle services provided between Raroa Station and Johnsonville.

New bus stops would be constructed along the rail replacement routes utilising lane and footpath closures.

All works could be completed within 6 months, and it was anticipated that these works would be completed before the Johnsonville Line was closed. After the bus services were operating, the rail infrastructure could be taken up and the walking and cycling track constructed. It was anticipated that the construction disruption resulting from the Bus on-Street scenario would be minor for both general traffic and public transport services.

D.2.4 Scenario 3 – Busway Construction Disruption

The busway construction disruption is the least easy to estimate because of the large scale of the works required along the whole length of the corridor. Clearance and construction of the busway could take a minimum of 18 months but this timeframe would need to be confirmed through a more detailed analysis. Closing the rail line over this period of time would require implementation of a rail replacement bus services operating on the existing road network while construction takes place. It was assumed that construction would take place in 2007/08 and 2008/09. Construction could be staged with the section from Ngaio to the CBD constructed earlier and optimistically enter operation within 12 months (before the rest of the busway was completed).

The CBD bus priority works would be constructed in a similar way to that described for the Bus on-street scenario above, largely using lane and footpath closures at offpeak times. The bus priority works at Johnsonville would also be constructed in this manner. It was assumed that the bus priority works would be completed in 2007/08 prior to stopping operation of the Johnsonville Line so that where possible, priority would be provided for the replacement bus services during construction.

Construction of the busway would require the removal of the rail infrastructure including tracks, overhead power lines, stanchions and platforms before the busway track and ancillary features could be commenced. It would not seem sensible to attempt to continue operation of the Johnsonville Line services to intermediate termination points during construction. This is due to the power supply and signalling systems being removed and the lower section of the line needing to be constructed first if staged construction was to be possible. It was anticipated that all serviceable railway infrastructure would be recovered by ONTRACK, for use elsewhere on the National Rail System.

On-street operation during construction would require the new rail replacement buses to be purchased at the outset and operated on-street to maintain a reliable, attractive service during construction. The replacement buses would operate in a very similar way to the bus on-street scenario. If as assumed above, 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 similar to that expected for the bus on-street scenario.

A major information and promotional campaign would be required to inform people of the changes, educate them on the short term rail replacement bus services operating on-street, and the longer term operation of the busway.

Access to the corridor for site clearance and construction would be one of the largest issues with construction of the busway. The corridor is very narrow and would result in linear working arrangements. Access could only be provided from a limited number of access points limiting the number of workfaces. Trucks hauling spoil and materials would have to be well co-ordinated because they would not be unable to pass one another. It was assumed that precast units would be used for the majority of construction because of issues with getting concrete trucks into the site and along constructed busway sections. Some sections would need to be boxed and poured because of site constraints and geometry. Because of the steep topography it is likely that some form of safety fencing would need to be constructed over substantial lengths to ensure safety of the workforce. Because of these sorts of issues, the construction timeframes above are indicative and assume that there are no major issues with construction. A detailed analysis and risk assessment would need to be undertaken in the future to confirm these timeframes.

Overall, the disruption due to construction of the busway would be significant over the section between Johnsonville and Hutt Road. The disruption could last up to 24 months with staged operation optimistically possible after 12 months from Ngaio through to Hutt Road. As for any major infrastructure projects, these timeframes are heavily dependant on the conditions encountered and could push out further. More detailed analysis would need to be undertaken to confirm these timeframes. However, the disruption would to a large degree be mitigated by the replacement services operating on-street in a very similar way to the bus-on-street scenario. The short term level of service provided would be similar to that provided by the bus on-street scenario in the longer term, however the replacement services would be of a temporary nature and require a number of iterations during construction which may cause some confusion for the public. For these reasons, the disruption during construction was scored worse than the bus on-street and enhanced rail scenarios.

D.2.5 Scenario 4 – Light Rail Scenario Construction Disruption

Under the Light rail scenario, the construction of new passing loops to cater for a 10 minute timetable on the Johnsonville Line section and the construction of the new CBD section would result in significant disruption. The works to facilitate the LRT system would likely take place in 2007/08 and 2008/09 so that Light Rail could begin operation in 2008/09 when the economic lives of the English Electric Units are programmed to end.

Similarly to the ER2 scenario above, 3 sets of passing loops would need to be constructed to facilitate a 10 minute timetable. Weekend closures of the existing rail services would be utilized to construct the passing loops adjacent to existing tracks prior to stopping the rail services. Offline works could be undertaken during normal operations with speed restrictions and defined / separated working areas. It was estimated that the programme of works could be implemented over a 12 month duration, with the utilisation of a combination of weekend closures and extended partial line closures. In addition to these closures, a continuous closure of 2 - 3 months would be required to make changes to the power supply and overhead catenery system to cater for the new LRVs.

During the time that rail units were not operating a replacement bus service would need to be put into place to maintain a reliable, attractive service during construction. The replacement buses would operate in a very similar way to the bus on-street scenario. It is unlikely that temporary bus priority measures could be put in place economically for the construction period and all buses would be subject to general traffic congestion through Hutt Road to the Lambton Interchange.

Because no new buses would be required for the permanent solution, buses for operation during construction could not be provided by early purchase of new vehicles. Additional buses would need to be sourced for a short period of time to provide the rail replacement services which could prove difficult.

A major information and promotional campaign would be required to inform people of the changes, educate them on the short term usage of uses on-street and the longer term operation of the busway.

The procurement timeframes for obtaining LRVs could become an issue, particularly with the small order proposed. Typically procurement can take up to 3 years to spec units, have them built and delivered. The specification for the new EMU units is well underway at present and a procurement process being followed to ensure the units can be delivered by 2008/09. By contrast it would be some time before a decision on Light Rail was confirmed and the procurement and specification process begun. If an “off the shelf” unit could be specified and added to another order, procurement timeframes would be less of an issue.

Installation of the new tracks within the CBD would cause significant disruption to both general traffic and bus services. Service relocation would have to take place to divert services out from under the new tracks. A concrete slab foundation would then need to be constructed and the tracks cast into this. The construction of the tracks through the CBD could take in the order of 18 – 24 months. The overhead catenary system would follow on behind and would lag by approximately 3 months to commissioning.

To provide room for service relocation, new tracks and working areas would require large sections of the available road space. This means that significant temporary traffic diversions as well as bus service diversions would need to take place. This raises particular difficulties with rerouting trolley buses which are constrained by the extent of the overhead wire network as to how far away and where they can be diverted. It is likely that there would be significant disruption to traffic, public transport services, pedestrians and CBD retailers.

The construction timeframes above are indicative and assume that there are no problems during construction. A detailed analysis and risk assessment would need to be undertaken in the future to confirm these timeframes.

For this scenario, it was considered that the disruption due to construction would continue for some time and be significant for the Johnsonville Line section and particularly significant for the CBD section. It is likely to take up to 24 months to complete construction and would disrupt general traffic, bus routes and retailers.

D.2.6 Assessment of Construction Disruption

Based on the discussions above, Table 5-13 sets out the assessment of construction disruption for the scenarios being considered.

A score of 0 is the least disruption which is no worse than disruption attributable to the base case which involves the work anticipated by ONTRACK. A score of XXX is when services have continued high level of disruption for more than 12 months, with lesser alternatives being provided.

- **Table 5-13: Assessment of Construction Disruption**

Scenario	Sub-scenario	Johnsonville Line Section	CBD Section	Score
Base		▪ 3 weeks of extended night bus replacement ▪ 2 x 1week extended bus replacement	▪ N/A	0
Scenario 1 – Enhanced Rail	**ER1**	▪ 3-4 months of weekend bus replacement ▪ 2 X 1week extended bus replacement	▪ N/A	0
	ER2	▪ 12 months of weekend and extended 3 week bus replacements	▪ N/A	X
Scenario 2 – Bus on-street with Walking and Cycling		▪ Minor off peak road and lane closures ▪ 2 month bus replacement Raroa to Johnsonville	▪ Off peak road and lane closures. ▪ Possible large short term disruption to some intersection in CBD	0
Scenario 3 - Busway		▪ 18-24 months rail replacement bus services ▪ Ngaio to Wellington section could optimistically be operating within 12 months	▪ Off peak road and lane closures ▪ Possible large short term disruption to some intersection in CBD	XX
Scenario 4 – Light Rail		▪ 12 months of weekend bus replacement ▪ 2 – 3 months extended bus replacement	▪ 24 months disruption to general traffic, buses and retailers in CBD (all bus routes)	XXX

D.3 Travel Times (journey times)

The impact on travel times was measured using the average AM peak private vehicle and public transport (PT) journey times from the northern suburbs to key destinations (weighted by the base trip demands). The journey time for public transport includes walk time, waiting time, any transfer time and in-vehicle time.

In general public transport journey times to key destination remain constant or improve (Table 5-14 and Figure 5-8, Figure 5-9). Vehicle travel times remained very similar to the base because of the marginal impact on vehicle trips. The PT journey times reduce in general for all the scenarios. Services in the busway scenarios have a longer distance to travel via the Johnsonville corridor compared to the bus on-street scenario which travels via the road network. Under the busway scenarios more services travel via the corridor. The travel time from Johnsonville to the CBD forecast by the model for 2016 was less via the road than via the busway. The road travel times were based on the assumed 2016 road network which included the improvements anticipated in the RLTS. These improvements improve conditions for travel from the northern suburbs into the CBD. Refer to Appendix J for details of the improvements included.

Sensitivity tests were undertaken to see if an improvement in the assumed operating speeds of the busway would have a large impact. Even with a 2 minute reduction in the travel time on the busway, the average journey time only reduces slightly.

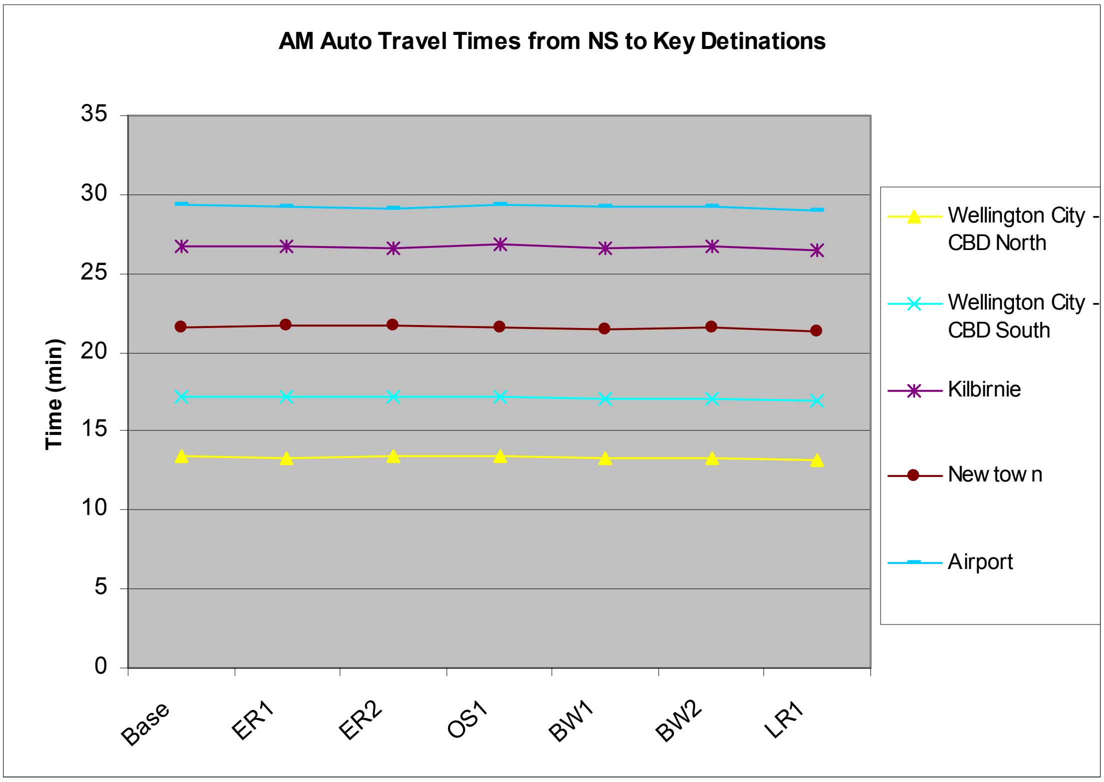
It was acknowledged that journey times over the road network would be less reliable and this issue is addressed in the PT network reliability Section D.6.

Table 5-14 includes the resulting scores for the measure. All scenarios were scored as having a minor positive impact.

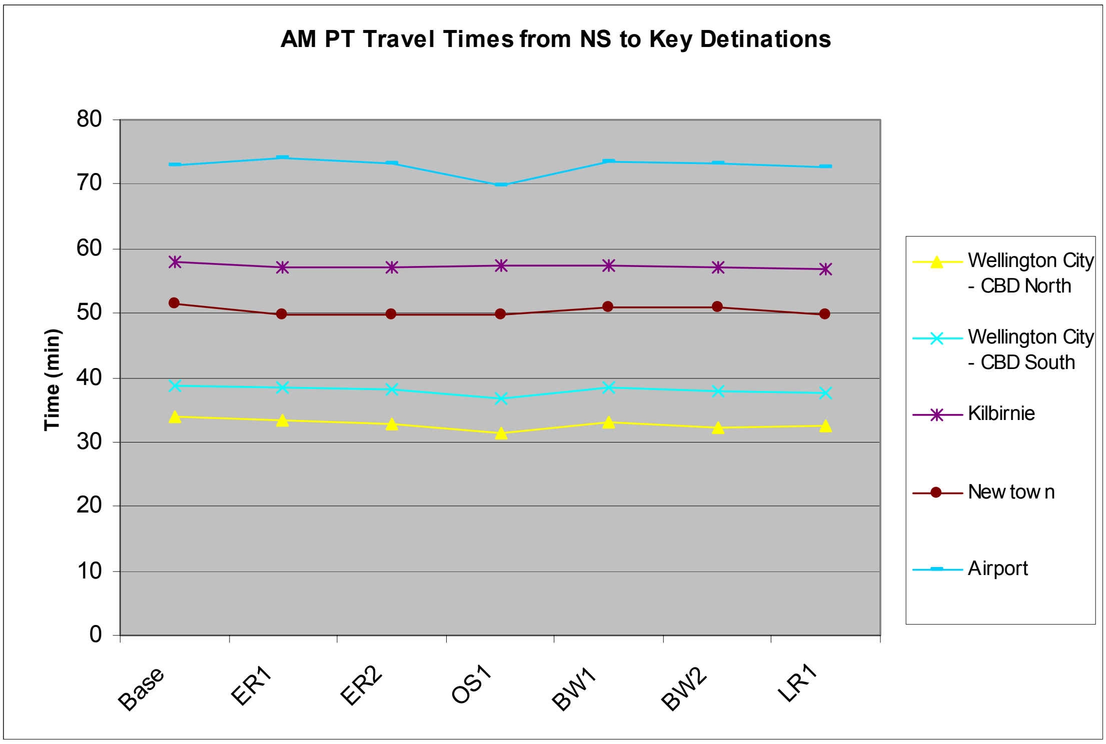
- **Table 5-14: Journey Times from the Northern Suburbs to Key Destinations on the Growth Spine (AM peak) (min)**

Auto Trips From NS	**Base**	**ER1**	**ER2**	**OS1**	**BW1**	**BW2**	**LR1**
Wellington City - CBD North	13.4	13.4	13.4	13.4	13.3	13.3	13.2
Wellington City - CBD South	17.1	17.1	17.1	17.2	17.1	17.1	16.9
Kilbirnie	26.7	26.7	26.6	26.8	26.6	26.7	26.5
Newtown	21.6	21.7	21.7	21.6	21.5	21.5	21.3
Airport	29.3	29.2	29.1	29.4	29.2	29.3	29.0
Average (weighted by base demands)	15.8	15.8	15.8	15.9	15.8	15.8	15.6
PT Trips From NS							
Wellington City - CBD North	33.84	33.48	32.68	31.44	32.93	32.35	32.48
Wellington City - CBD South	38.63	38.33	38.05	36.65	38.37	37.91	37.59
Kilbirnie	57.82	57.22	57.05	57.50	57.41	57.10	56.76
Newtown	51.36	49.82	49.65	49.87	51.01	50.76	49.65
Airport	72.89	73.93	73.08	69.88	73.51	73.14	72.58
Average (weighted by base demands)	36.77	36.39	35.82	34.60	36.15	35.63	35.53
Average %	100%	99%	97%	94%	98%	97%	97%
Score	**0**	√	√	√	√	√	√

- **Figure 5-8: Auto Journey Times from the Northern Suburbs to Key Destinations on the Growth Spine (AM peak) (min)**



- **Figure 5-9: PT Journey Times from the Northern Suburbs to Key Destinations on the Growth Spine (AM peak) (min)**



D.4 Vehicle Speeds

The criteria of vehicle speeds was measured using average private vehicle and public transport vehicle speeds within the northern suburbs and CBD corridor.

Average private vehicle and public transport speeds are shown in Table 5-15 and Figure 5-10. As expected because of the marginal impact on vehicle trips, the auto speeds remain relatively constant across the scenarios. The auto speeds include all vehicles on links within the corridor from the northern suburbs through the CBD. Therefore, it includes vehicles using the Ngauranga Gorge motorway which results in a relatively high average speed.

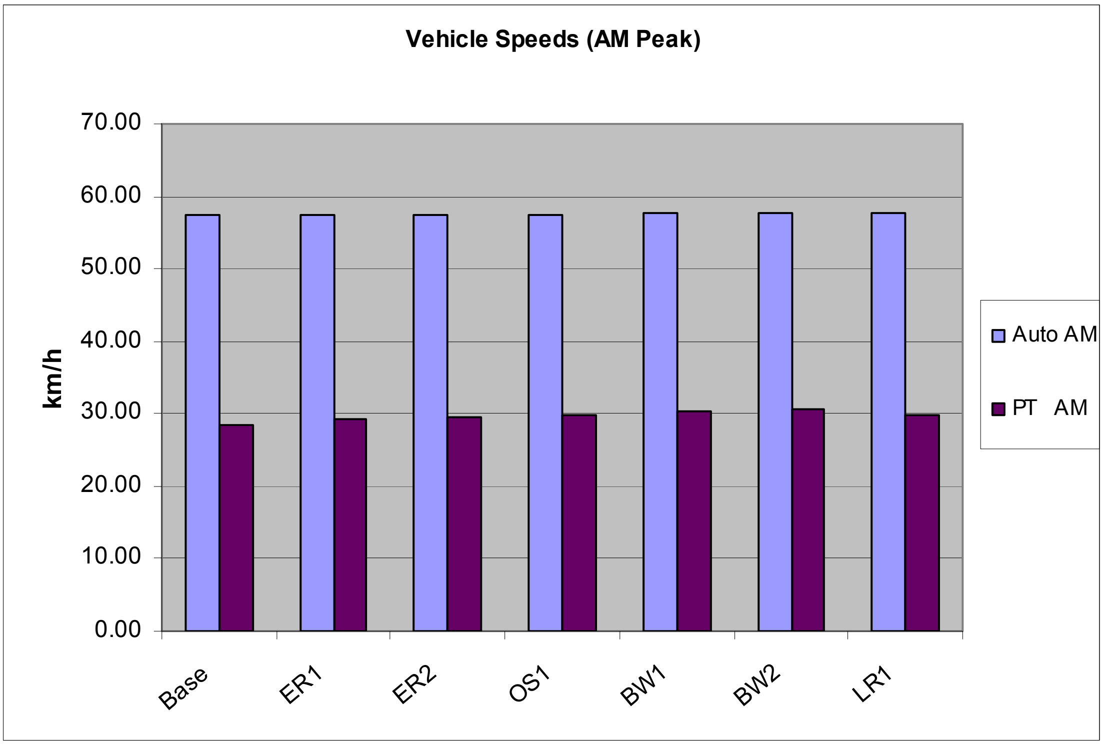
The PT speeds shown here include waiting time in the calculation so that the whole journey is taken into account and increases in PT service frequency are therefore incorporated in this measure. Increases in vehicle speeds in the order of 3 – 8% are experienced under all the scenarios.

Table 5-15 includes the resulting scores for the measure. All scenarios were considered to have a minor positive impact compared to the base and were all scored the same.

- **Table 5-15: Average Vehicle Speeds in the Northern Suburbs and CBD (AM peak) (km/h)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Auto AM	57.37	57.39	57.40	57.45	57.72	57.71	57.60
Auto AM %	100.0%	100.0%	100.0%	100.1%	100.6%	100.6%	100.4%
PT AM	28.40	29.28	29.53	29.79	30.27	30.63	29.76
PT AM %	100.0%	103.1%	104.0%	104.9%	106.6%	107.9%	104.8%
Score	**0**	√	√	√	√	√	√

- **Figure 5-10: Average Vehicle Speeds in the Northern Suburbs and CBD (AM peak) (km/h)**



D.5 Level of Congestion and Network Reliability

The level of congestion and network reliability was measured using:

- the level of congested vehicle-kilometres in the northern suburbs and CBD corridor, where congested was defined as volume/capacity >0.8, and
- volume/capacity at identified key locations

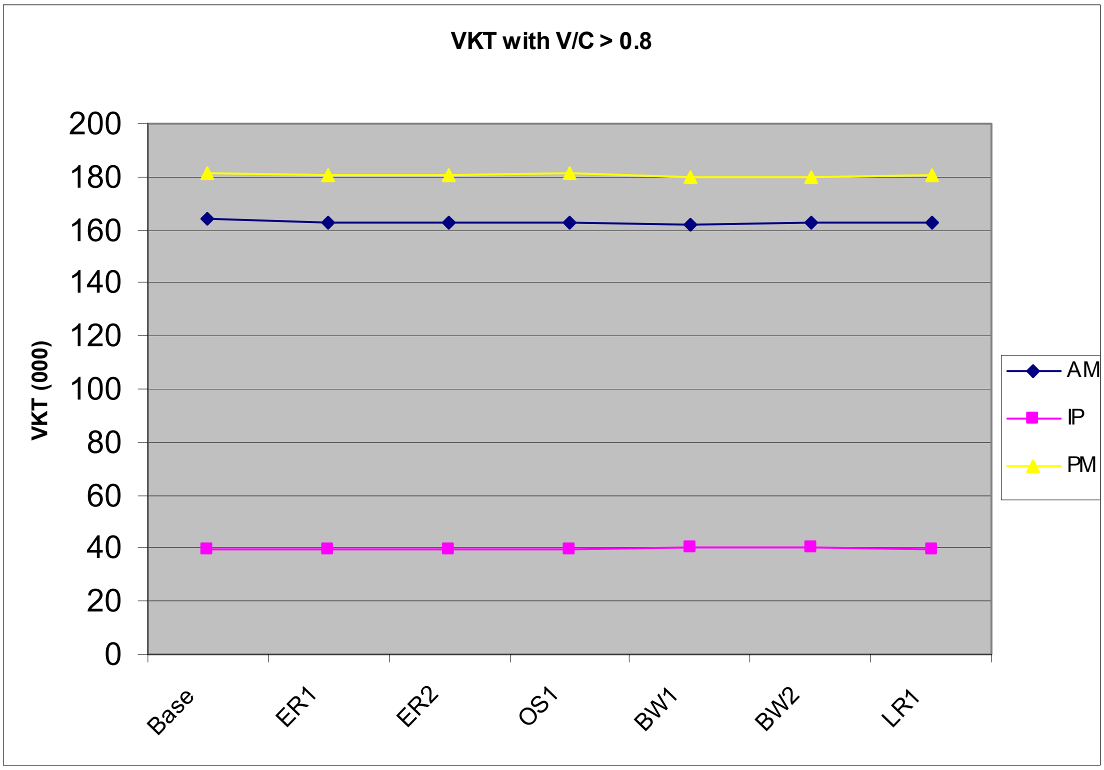
D.5.1 Level of Congested Vehicle-km

The impact on the level of congestion was measured by considering the amount of congested VKT (Table 5-16 and Figure 5-11), where congested was defined as having a volume/capacity ratio >0.8. Due to the limited impact on vehicle trips, there was no significant impact on congested VKT and all scenarios were scored the same (Table 5-16).

- **Table 5-16: Congested VKT in the Northern Suburbs and CBD (VKT with V/C > 0.8) (000 km)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
AM	164	163	163	163	162	163	162
IP	40	40	40	39	40	40	40
PM	181	180	180	181	180	180	180
Total %	100.0%	99.3%	99.3%	99.5%	99.0%	99.2%	99.2%
Score	0	0	0	0	0	0	0

- **Figure 5-11: Congested VKT in the Northern Suburbs and CBD (VKT with V/C > 0.8) (000 km)**



D.5.2 V/C at Key Locations

Table 5-17 gives the volume to capacity ratio at selected key locations in the morning peak and highlights the number of key locations where the V/C <1. Figure 5-12 shows the volume to capacity ratio at identified key locations for each scenario graphically.

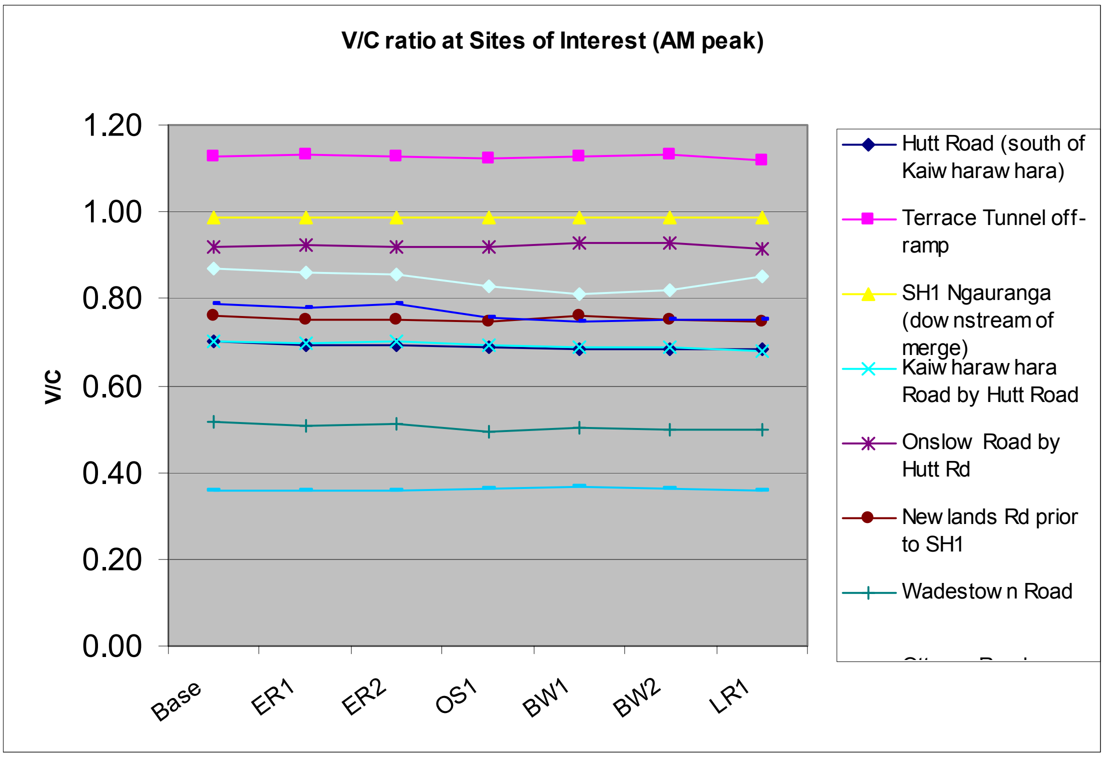
The locations identified do not generally experience large amounts of congestion. Of the locations identified, only the Terrace Tunnel, the SH1 Ngauranga Gorge motorway, Onslow Road and Moorefield Road show V/C ratios greater that 0.8, over which congestion becomes an issue. Because of the limited impact the number of vehicle trips, there was no significant impact on V/C at any of the key locations. V/C does reduce on Moorefield road under the bus on-street and busway scenarios, however the other locations are generally unaffected.

Table 5-17 includes the resulting scores for the measure. These scenarios are not aimed at reducing congestion and have a limited impact so they have all been scored as 0.

- **Table 5-17: V/C at Key Locations (AM peak)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Hutt Road (south of Kaiwharawhara)	0.70	0.69	0.69	0.69	0.68	0.69	0.68
Terrace Tunnel off-ramp	1.13	1.13	1.13	1.12	1.13	1.13	1.12
SH1 Ngauranga (downstream of merge)	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Kaiwharawhara Road by Hutt Road	0.70	0.70	0.70	0.69	0.69	0.69	0.68
Onslow Road by Hutt Rd	0.92	0.92	0.92	0.92	0.93	0.93	0.91
Newlands Rd prior to SH1	0.76	0.75	0.75	0.75	0.76	0.75	0.75
Wadestown Road	0.52	0.51	0.51	0.50	0.50	0.50	0.50
Ottawa Road	0.79	0.78	0.79	0.75	0.75	0.75	0.75
Johnsonville on ramp	0.36	0.36	0.36	0.36	0.37	0.36	0.36
Moorfield Road	0.87	0.86	0.86	0.83	0.81	0.82	0.85
Score	0	0	0	0	0	0	0

- **Figure 5-12: V/C at Key Locations (AM peak)**



D.5.3 Level of Congestion and Network Reliability Summary

One aspect that has not been considered above is the impact of level crossings. All scenarios except the busway retain level crossings of the Johnsonville corridor at Fraser Avenue, Station Road and at Simla Crescent. At present with approximately 3 trains per hour each way, these are triggered a limited number of times. If substantially more services were to operate, this could lead to disruption to general traffic. This would particularly be the case with the busway operating with express services which could reduce headways between the services significantly against the base, triggering the crossings very regularly. The 10 minute timetables for the rail and light rail would also experience increases but these would not be as significant as the busway. Station Road has the highest traffic volumes and could lead to disruption with queuing leading back and impacting on Burma Road.

The resulting overall score for the measure Level of Congestion and Network Reliability is shown in Table 5-18. There is little impact as a result of any of the scenarios and the have all been scored as having no significant impact.

Table 5-18: Level of Congestion and Network Reliability Score

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Congested VKT in the Northern Suburbs and CBD (VKT with V/C > 0.8) (000 km)	0	0	0	0	0	0	0
V/C at Key Locations (AM peak)	0	0	0	0	0	0	0
Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**

D.6 Public Transport Network Reliability

The reliability of the public transport network can have a large impact on the attractiveness of the services and peoples propensity to use the system. One of the major reasons given for not using public transport is that people cannot be confident that they will arrive at their destination on time. The characteristics of the scenarios mean they could perform differently in this respect.

GWRC collects information about the reliability of the existing bus and rail services in the northern suburbs. The following information about reliability of the existing rail services was provided for all services throughout the day.

Table 5-19: Average Time Keeping – on time within 3 minutes, arrivals and departures to Wellington Station

Period	% on time within 3 minutes
Jan-06	97.60%
Feb-06	95.00%
Mar-06	94.20%
Apr-06	92.10%
May-06	90.80%
Jun-06	86.20%
Jul-06	89.20%
Average	**92.16%**

GWRC passenger transport staff have advised that the majority of delays on the Johnsonville Line are the result of rolling stock issues and not signalling and power supply issues and in the recent past there were issues with weather.

GWRC recently undertook surveys of bus services between Johnsonville and Lambton Quay using the SH1 motorway down the Ngauranga Gorge and bus services from Khandallah to Lambton Interchange via the Ngaio Gorge and Onslow Road during the weeks of 19 and 26

July 2006. These surveys indicate that travel times in the AM peak from Johnsonville to the Lambton interchange are on average 6 minutes longer than those timetabled (22 minutes vs 16 minutes). This average reduces significantly down to 18 minutes when two days where incidents occurred resulting in very long travel times are excluded. There was a large degree of variability in the travel times on this route with individual travel times ranging between 11 minutes and 40 minutes.

Significant improvements to the road network are anticipated in the RLTS. This includes improvements such as additional lanes along the Aotea section of the motorway, the Petone – Grenada Link and tidal flow at the Terrace Tunnel. These improvements will reduce travel times and improve reliability on the road network and have been included in the networks used in the scenario modelling.

The measure Public Transport Network Reliability was considered in two ways:

- Assessment of public transport network reliability
- Person-km on a dedicated right of way

D.6.1 Assessment of Public Transport Network Reliability

A review was undertaken to identify the issues which may have an impact on the reliability of the public transport network. Using this review as a basis an assessment of the relative reliability of the different scenarios was undertaken.

D.6.1.1 Scenario 1 – Enhanced Rail Scenario Network Reliability

Rail Service Reliability – Johnsonville to Wellington Station

The enhanced rail scenario has a dedicated right of way between the Johnsonville Station and Wellington Station. This means that services are not impacted by general traffic congestion and therefore results in a high level of operational reliability over this length.

Rail provides a parallel alternative route between Johnsonville and the CBD. This means that if the road or rail network was to become incapacitated, there is an alternative route for passengers to take which would not be affected.

Because of the steep topography there is only one track for most of the length of the Johnsonville Line. This means that train services operating in opposite directions can only pass at dedicated passing loops which are currently provided at Khandallah, Ngaio and Wadestown. Operation requires trains travelling in opposite directions to meet one another at these passing loops. If one train is delayed, the other train is delayed as it waits at the passing loop. Isolated disruption to one service can put the timing of all services out, which has a flow on effect resulting in delays to all services.

Under the 13 minute frequency scenario, the number of passing loops would remain the same as at present. Under the 10 minute scenario there would be 3 additional sets of passing loops. Because there are additional passing loops available at reduced intervals under the ten minute frequency, this provides greater flexibility in operating the line and provides increased operational reliability.

There are a number of other factors which could influence reliability of rail services over this section:

Mechanical Faults with EMUs - The existing English Electric Units are over 50 years old and utilise outdated technology. Mechanical faults with new EMUs would be greatly reduced over the existing rolling stock because of the new technology used and undeteriorated componentry.

Signal Faults - No improvements to the signalling system on the Johnsonville line are proposed which are outside the general maintenance programme undertaken by ONTRACK. The current signalling system is dated and under current planning would remain so, indicating that disruption due to signal faults would remain similar to the existing situation.

Power Supply Faults - Failure of the power supply system including substations, and overhead catenery system can cause disruption to services. Under current plans, no upgrades of the motive power supply system on the Johnsonville Line are proposed. As part of wider improvement for the whole Wellington Network, upgrades of the major substations are proposed. The marginal cost of the improvements attributable to the Johnsonville line would be minor and have not been accounted for as these changes would be required even if the Johnsonville Line was abandoned.

It is anticipated that disruption due to power supply systems would remain similar to the present rail services or improve.

Derailments - Derailments of rail vehicles occur when trains are driven at speeds greater than allowable or due to track or switching gear faults. Very few derailments occur on the network as a whole. Two minor derailments were reported on the Johnsonville Line recently, however this only disrupted services for a short period of time. During sustained heavy rain, a slip came down onto the track and derailed the front wheels of a train. At the same time slips closed adjacent roads in the Ngaio Gorge and through Wadestown. Derailments are not considered to have a major impact on the reliability of the Johnsonville rail line.

Public Actions - Public actions such as suicides (through jumping from structures or in front of vehicles) and public placing objects on the rail tracks can cause delays. These issues occur at times, however are not considered to be major factors in determining the reliability of this scenario.

Bus Service Reliability – Remainder of the Northern Suburbs and Wellington Station to Courtenay Place

Bus services would run on the existing road network and be subject to general traffic congestion. Their operational reliability would likely worsen in the future as congestion increases. Refer to the bus on-street section above for further discussion.

Over the section between Wellington Station and Courtenay Place, passengers either walk or transfer to bus. It was assumed that incremental general bus priority measures would be put in place to maintain existing levels of service for buses over this section in the future. This would be as part of general bus priority works undertaken by WCC and GWRC to benefit all services operating from access the region. No cost allowance was attributed directly to this scenario for these improvements. This approach differs from that noted in the Scenarios Report. To be fair to all options, only costs for works required to maintain a similar level of services to the existing (in addition to assumed general bus priority works), were allowed for under each scenario.

D.6.1.2 Scenario 2 - Bus on-street and Walking and Cycling Network Scenario Reliability

Bus Service Reliability – Northern Suburbs to Lambton Interchange

The bus on-street scenario does not have a dedicated right of way between the Johnsonville Station and Wellington Station. This means that all services would be affected by general traffic congestion which results in reduced operational reliability. Under this scenario there would not be a parallel alternative route for passengers if the road network was to become blocked.

There are a number of factors which could influence the reliability of buses operating on-street over this section:

Road Accidents - Road accidents and incidents can close roads and reduce the number of available lanes which can significantly affect the reliability of bus services. The effects of an accident in key locations can have flow on effects that impact on the whole road network. For example, when an accident closes sections of the SH1 motorway, vehicles reroute onto the local road network having a large effect on journey times. Road accidents reduce the reliability of road based buses.

General Traffic Congestion - Traffic congestion can affect the reliability of journey times for general traffic and therefore buses where they operate using the same infrastructure. As the road network nears capacity small changes can have a large impact and the journey time reliability of the network is reduced.

In general, trip time reliability reduces when volume to capacity ratios (V/C) increase above 0.8. In Section D.5, V/C ratios in key locations were extracted from the WTSM model. From these it can be seen that V/C ratios at key locations on bus routes down the Ngauranga Gorge, Onslow Road and Moorefield Road are forecast to be higher than 0.8 in 2016.

The bus on-street scenario allows for installation of bus priority measures on the approach to the Kaiwharawhara Rd / Hutt Road intersection and installation of bus lanes along Hutt Road and Thorndon Quay from Kaiwharawhara Rd intersection to the Lambton Interchange. Because a dedicated facility is provided, buses are less affected by general traffic and reliability is improved.

Mechanical Faults with Buses - Mechanical faults with buses are of limited impact on overall reliability. Breakdowns are relatively infrequent, do not hold up following services and passengers can be transferred on to other buses.

Public Actions - Public actions such as suicides (through jumping from structures or in front of vehicles) and public placing objects on the road network can cause delays. These issues occur at times, however are not considered to be major factors in determining the reliability of this scenario.

Bus Service Reliability – Lambton Interchange to Courtenay Place

In addition to the general factors noted above for bus service operational reliability, the section between Lambton Interchange and Courtenay Place provides particular issues:

As a result of the bus on-street scenario there will be an increase of approximately 21 buses per hour along the CBD bus route over the base in the AM peak.

CBD Bus Route Capacity - General bus priority measures are anticipated in the future to maintain existing levels of service for the CBD bus route (not as part of this study). This scenario would however add a significant number of additional buses operating along this route during peak times. At present this route is near capacity the way it and the associated stop and ticketing infrastructure is configured. In addition to competing with general traffic, there is significant bus self-congestion exacerbated by the inability of trolley buses to pass one another. Additional bus services could reduce reliability through this section.

Investigations into the CBD bus route capacity and the potential of bus priority measures for the route were undertaken as part of the Ngauranga to Airport Strategic Study. That study has determined that up to 200 buses per hour could be accommodated on the route with "enhanced" bus priority measures in place. Some general bus priority measures are required to provide an acceptable level of service for buses from across the region even if no changes were made in the northern suburbs. We have assumed some additional costs for this scenario for additional bus priority measures required to maintain the existing level of service through the

CBD with additional buses as a result of this scenario. No detailed investigations were undertaken and would be required to confirm the nature and scale of the works required before progressing with this scenario.

Power Supply and Signal Failures - Power failures in the CBD can be an issue. Disabled trolleys impede all bus flows because of limited opportunities for buses to overtake buses. The new trolley buses being procured would be able to travel short distances without power so should be able to clear congestion points if power was last. Traffic signal faults can also occur as a result or power or equipment failures. These are reasonably rare occurrences and are unlikely to have a large impact on reliability.

Street Marches - Occasionally WCC permits street marches etc or closes streets for special events. It is expected that these events are planned with alternative routes for buses. However, generally there would be greater unreliability resulting from such events as the alternatives are never as good.

D.6.1.3 Scenario 3 – Busway Scenario Network Reliability

Busway Service Reliability - Johnsonville to Hutt Road

This scenario has a dedicated right of way between the Johnsonville Station and Hutt Road. This means that services which travel on the busway over this length would not be affected by general traffic congestion resulting in improved operational reliability over this length than if they were to travel on-street. Under this scenario there would be a parallel alternative route over this length if the road network was to become blocked.

Because of the steep topography there is only room to construct a one direction busway for most of the length of the Johnsonville corridor and buses would only operate in one direction. Buses would operate one behind the other and only be able to pass each other at dedicated passing bays (at busway stations and at a number of other emergency passing opportunities constructed along the route).

If a bus was to become incapacitated at some point it would block the route for all services which were following it and they could divert to the road network where possible. It was assumed that special recovery vehicles would be purchased which could operate on the busway and would be required to retrieve incapacitated buses. All buses in front of the stopped bus would have to leave the busway before the recovery vehicle could enter the busway travel in the counter peak direction to reach and recover the vehicle. These sorts of incidents could have a large impact on the operational reliability of the busway.

Delays to buses on-street before they enter the busway would effect service reliability of the busway section. The buses would need to access the busway at Johnsonville and Hutt Road.

Delays in getting to these accesses, or bunching of buses at the entrances would effect service reliability.

The number of buses on the busway in the morning peak would be in the order of 66 per 2-hours. This equates to an average headway of just under 2-minutes, however peaking will reduce this at critical times.

As a result of the busway scenarios there will be an increase of approximately 21 buses per hour along the CBD bus route over the base in the AM peak.

There are a number of factors which could influence the reliability of buses operating on a busway:

Mechanical Faults with Buses - Mechanical faults with buses while operating on the busway would have a large impact on the operational reliability of the busway. Breakdowns are relatively infrequent, but would hold up buses which were following. From this perspective the busway would be less reliable than the bus on-street scenario. There would also be a lot more buses than trains operating on the busway so the probability of breakdowns would be larger.

Steps would be taken to ensure that mechanical breakdowns were as infrequent as possible. For example in Adelaide, in the event of tyre damage on the front axle, the wheels are equipped with a metal inner tyre that prevents full deflation, allowing a loaded bus with deflated tyres to be driven up to 16km at a speed of 50km/h.

Accidents / Derailments on the Busway - Derailments of buses on the guideway occur when they are driven at speeds greater than allowable or due to guideway faults. Because buses would be controlled by drivers, driver error would be a large factor in accidents occurring on the busway. Drivers would be directly in control of speeds which would need to be adjusted constantly along the route.

The buses would be relatively closely spaced on the busway and it was assumed that minimum spacing requirements would be enforced. It is proposed that moving block signalling would be used to maintain separation (particularly through blind tunnels) where visibility would be reduced. However, the tight geometric alignment and steep topography mean that forward safe stopping sight distances may be difficult to maintain at speed. This raises the possibility of nose to tail type accidents. While this has not been an issue in other applications, the specific site constraints of the Johnsonville corridor may result in this becoming a problem.

As was experienced recently, land slips onto the Johnsonville line corridor can occur and could close the busway.

Few derailments and accidents could be expected, however due to the large number of buses, the probability of a bus derailing is increased over rail.

Public Actions - Public actions such as suicides (through jumping from structures or in front of vehicles) and public placing objects on the guideway could cause delays. These issues occur at times, however are not considered to be major factors in determining the reliability of this scenario.

Buses Service Reliability – Remainder of the Northern Suburbs and Hutt Road to Courtenay Place

For those sections of bus routes that operate on-street, the impact of general traffic congestion and accidents would be similar to that set out for the bus on-street section above.

There would also be similar issues associated with additional buses using the CBD bus route.

D.6.1.4 Scenario 4 - Light Rail Scenario Network Reliability

Light Rail Service Reliability – Johnsonville to Wellington Station

The light rail scenario has a dedicated right of way between the Johnsonville Station and Wellington Station. This means that services over this length would not be affected by general traffic congestion resulting in improved operational reliability over this length. Under this scenario, there would be a parallel alternative route over this length if the road network was to become blocked.

Similarly to the 10 minute rail scenario, light rail services operating over this length in opposite directions can only pass at dedicated passing loops which would be provided at Fraser, Khandallah, Box Hill, Ngaio, Wadestown and the Wellington yards. Because of the additional passing loops available at reduced intervals, this provides greater flexibility than the existing rail in operating the line and provides increased operational reliability.

There are a number of factors which could influence the reliability of the light rail network over this length:

Mechanical Faults with Light Rail Vehicles - Mechanical faults with Light Rail Vehicles (LRVs) could have a large impact on operational reliability. Mechanical faults would be greatly reduced over the existing rollingstock because the units would be newer and utilise newer technology.

Signal Faults - No major changes to the signalling system on the Johnsonville Line are proposed for the operation of LRVs over this length. The current signalling system is dated and under current planning would remain so indicating that disruption due to signal faults would remain similar to the existing situation.

Power Supply Faults - Failure of the power supply system including substations, and the overhead catenery system can cause disruption to services. As part of the conversion to light rail, renewal of outreach arms and re-registration of the overhead catenery system is proposed but it was assumed that dual voltage LRV's could be used. As part of wider improvement for the whole Wellington Network, upgrades of the major substations are proposed. The marginal cost of the improvements attributable to the Johnsonville line would be minor and have not been accounted for as it is likely that these changes would be required anyway without the Johnsonville Line operating.

It was considered that disruption due to power supply systems is likely to remain similar to the present rail services or improve.

Derailments - Derailments of light rail vehicles occur when LRVs are driven at speeds greater than allowable or due to track or switching gear faults. Very few derailments occur on light rail networks and are not considered to have a major impact on the reliability of the Johnsonville rail line. Derailments due to slips could be more of an issue with light rail that the existing heavy rail because of the weight difference of the units.

Public Actions - Public actions such as suicides (through jumping from structures or in front of vehicles) and public placing objects on the line could cause delays. These issues occur at times, however are not considered to be major factors in determining the reliability of this scenario.

Light Rail Service Reliability –Wellington Station to Courtenay Place

On the section between Wellington and Courtenay Place, light rail would run on-street. Where possible priority would be provided for light rail, however the LRVs would still be affected by general and bus traffic congestion.

The Light Rail Feasibility Study (Works / MVA) anticipated that light rail would run mixed with general traffic. Other proposals include operating the Lambton Quay section of the route in a dedicated "transitway" for buses and light rail with northbound general traffic removed and southbound traffic operating in a series of one way loops for access. Either way, light rail would be subject to general traffic or bus delays over lengths where dedicated running way could not be provided. Reliability would be similar to buses where LRT shared road space with buses or slightly better than buses where LRT has its own facilities.

There are a number of factors which could influence the reliability of the light rail network over this length:

Signal Faults - Signals would be incorporated with the existing traffic signals and the LRVs could operate on line of sight where priority was not provided. Signal faults are unlikely to have a significant impact on operational reliability over this length.

Power Supply Faults - Power supply infrastructure would be newly constructed as would the overhead catenery system. Power supply faults can occur at times in the CBD but are unlikely to be a major factor in operational reliability over this length.

Derailments / LRV Accidents - Derailments of light rail vehicles occur when LRVs are driven at speeds greater than allowable or due to track or switching gear faults. Collisions with other vehicles can cause light rail derailments. Because LRVs are sharing road space in over this section, there is potential for impact on operational reliability from accidents and derailments.

General Traffic Congestion and Road Accidents - For this section that operates on-street, the impact of general traffic congestion and accidents would be similar to that set out for the bus on-street section above.

Street Marches - Occasionally WCC permits street marches etc or closes streets for special events. It is expected that these events are planned with alternative routes for buses but this would not me practical for light rail. There would be greater unreliability resulting from such events.

Bus Service Reliability – Remainder of the Northern Suburbs and Wellington Station to Courtenay Place

For the remainder of the Northern Suburbs, bus services would run on the existing road network and be subject to general traffic congestion. Their operational reliability would likely worsen in the future as congestion increases. Refer to the bus on-street section above for further discussion.

Bus services from across the region operate through the CBD and would be impacted by the installation of Light rail. There would be three different modes (light rail, bus and general traffic) competing for the same roadspace and priority. Additional vehicles along this route could reduce reliability of travel times for all services. We have assumed some additional costs for this scenario for bus / LRT priority measures required to maintain the existing level of service through the CBD for this scenario. No detailed investigations were undertaken and would be required to confirm the nature and scale of the works required before progressing with this scenario.

D.6.1.5 Assessment of Public Transport Network Reliability

Based on the discussions above, Table 5-20 notes the major differences between the scenarios and sets out the qualitative professional assessment of operational reliability for the scenarios being considered.

A score of √√√ indicates a vast improvement over the operational reliability of the base case. A score of 0 indicates an operational reliability consistent with the base case. A score of XXX indicates a vastly lower level of operational reliability than the base case.

Table 5-20: Assessment of PT Network Reliability

Scenario	Sub-scenario	Rail Catchment	Remainder of Northern Suburbs	CBD through to Courtenay Place	Score
Base		▪ Dedicated right of way (not subject to general traffic congestion) ▪ Subject to signal faults	▪ Subject to general traffic congestion and accidents	▪ Subject to general traffic congestion and accidents (similar to existing)	0
Scenario 1 - Enhanced Rail	**ER1**	▪ Dedicated right of way (not subject to general traffic congestion) ▪ Significantly improved rail vehicle reliability ▪ Subject to signal faults	▪ Subject to general traffic congestion and accidents (similar to existing)	▪ Subject to general traffic congestion and accidents (similar to existing)	√
	ER2	▪ Dedicated right of way (not subject to general traffic congestion) ▪ Significantly improved rail vehicle reliability ▪ Improved reliability due to additional passing loops ▪ Subject to signal faults	▪ Subject to general traffic congestion and accidents (similar to existing)	▪ Subject to general traffic congestion and accidents (similar to existing)	√

Scenario 2 – Bus on-street and Walking and Cycling		▪ Subject to general traffic congestion and accidents	▪ Subject to general traffic congestion and accidents (similar to existing)	▪ Subject to general traffic congestion and accidents ▪ Additional buses through the CBD could impact on CBD bus route reliability	XX
Scenario 3 – Busway		▪ Dedicated right of way (not subject to general traffic congestion) ▪ Susceptible to stoppages (large number of services - increased likelihood of mechanical faults and accidents/derailments)	▪ Express services have dedicated right of way (not subject to general traffic congestion) ▪ Express services susceptible to stoppages (large number of services) ▪ Non-express services subject to general traffic congestion and accidents (similar to existing)	▪ Subject to general traffic congestion and accidents (similar to existing) ▪ Additional buses through the CBD could impact on CBD bus route reliability	√
Scenario 4 – Light Rail		▪ Dedicated right of way (not subject to general traffic congestion) ▪ Significantly improved rail vehicle reliability ▪ Improved reliability due to additional passing loops ▪ Subject to signal faults	▪ Subject to general traffic congestion and accidents (similar to existing)	▪ Subject to general traffic congestion and accidents ▪ Running with buses could reduce bus reliability	√

SKM

D.6.2 Passenger-km on a Dedicated Right of Way

As noted above, providing an alternative route that is not subject to general traffic congestion or delays is an important aspect of public transport network reliability. The resilience of the public transport network is a measure of how badly services are affected by disruption on the road network such as accidents or general traffic congestion. This could be considered in terms of the person-km of travel that takes place on a dedicated right of way, and is therefore likely to be more reliable.

The person-km of travel on a dedicated right of way in the northern suburbs is shown in Table 5-21 and is displayed in Figure 5-13. Obviously there are no person-km on a dedicate right of way for the bus on-street scenario.

Person-km of travel increase significantly for the busway and light rail scenarios. BW1 has higher passenger-km than BW2, because the majority of services operate via the busway. For the BW2 scenario, services from the east of the State Highway continue to use the motorway network.

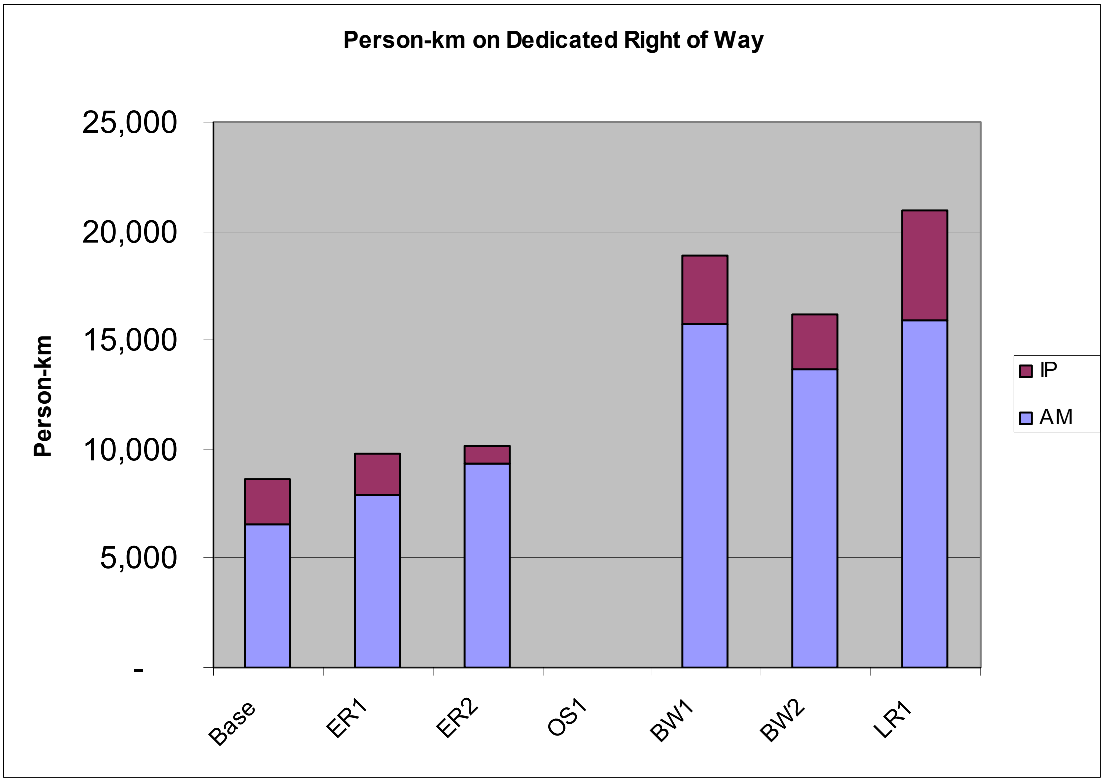
Light rail performs the best of these scenarios with a 143% increase over the base. The rail scenarios show the lowest increase because only the Johnsonville Line catchment uses the corridor.

In the scoring evaluation (Table 5-21), an increase in person-km was seen as a positive impact on reliability because more passenger-km of travel would not be affected by general traffic congestion. The rail scenarios were considered to have a minor positive impact, while the busway and light rail scenarios were considered to have a moderate positive impact. The on-street bus scenario was considered to have a moderate negative impact.

- **Table 5-21: Person-km Travelled on a Dedicated Right of Way in the Northern Suburbs**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
AM	6,576	7,927	9,354	-	15,755	13,649	15,954
IP	2,096	1,905	785	-	3,101	2,493	4,976
AM %	100%	121%	142%	0%	240%	208%	243%
Score	0.00	√	√	XX	√√	√√	√√

- **Figure 5-13: Person-km Travelled on a Dedicated Right of Way in the Northern Suburbs**



D.6.3 PT Network Scenario Reliability Summary

The resulting overall score for the measure PT Network Reliability is shown in Table 5-22. Each of the scenarios include aspects that have potential for positive and negative impacts on reliability. All scenarios are considered to have a positive impact on the reliability of the PT network, except for the bus on-street scenario. The bus on-street scenario would have a moderate negative impact, largely because all services would be subject to general traffic congestion. The busway and light rail scenarios were scored the highest with moderate positive impacts because they provide increased reliability for people to the east of the State Highway over services which currently run via the Ngauranga Gorge route - which has the most inconsistent journey times.

- **Table 5-22: PT Network Reliability Score**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Public Transport Network Reliability Assessment	0	√	√	XX	√	√	√
Person-km Travelled on a Dedicated Right of Way in the Northern Suburbs	0	√	√	XX	√√	√√	√√
Score	0	√	√	XX	√√	√√	√√

D.7 Access to Public Transport (proximity)

Access to public transport in terms of how far people have to travel from their homes to access public transport was measured in terms of the population in the northern suburbs that live within a comfortable walking catchment of the PT services envisaged. 400m catchments for road based bus or 800m catchments for modes with fixed right of way e.g. rail, busway and light rail stations were used. Population was measured using indicative stop locations and GIS to sum the populations of meshblocks within the catchments. Meshblocks are small geographical units defined by Statistics New Zealand containing a median of approximately 90 people in 2001.

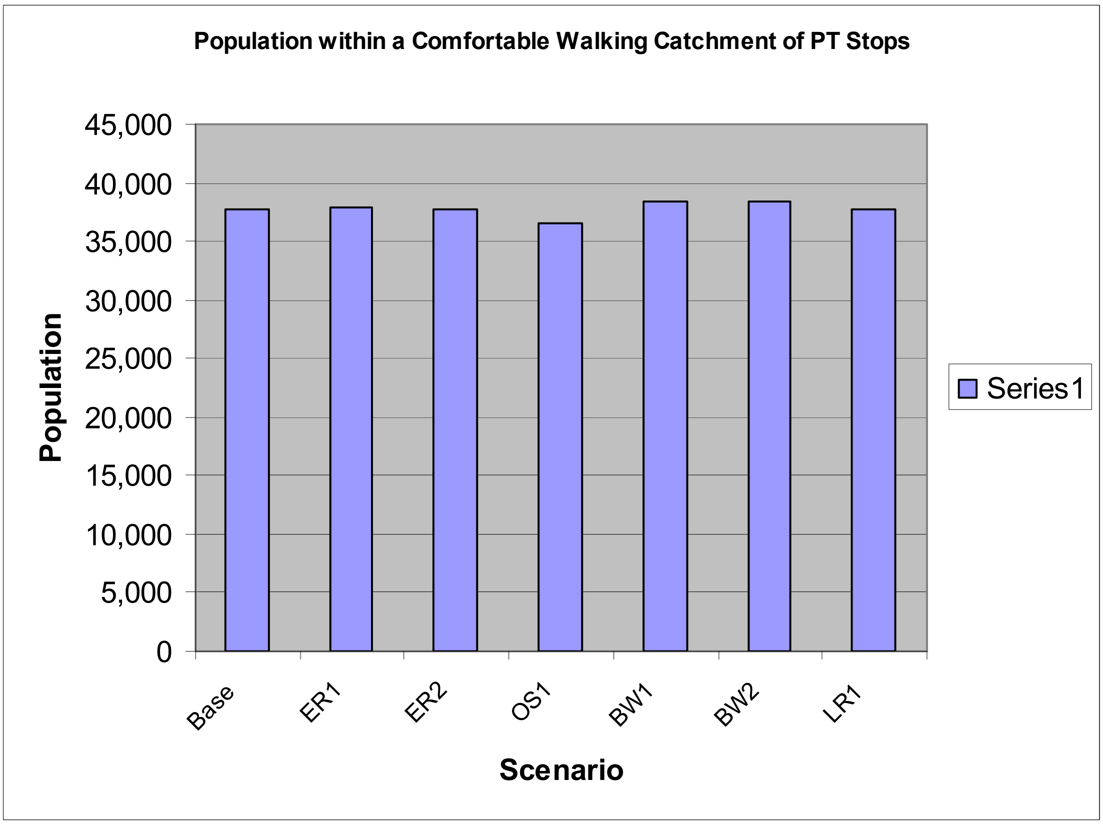
The population within a comfortable walking catchment of PT services is shown in Table 5-23 and is displayed in Figure 5-14. The bus on-street performs the worst because it does not have any fixed infrastructure and therefore the walking catchments are considered to be slightly reduced.

In the scoring (Table 5-23) evaluation, an increase in the population within an easy walking catchment was considered to be positive. All scenarios have marginal impacts and so were all scored as 0. 400m walking catchments could have been used for all modes, however this would have had a minimal impact and all scenarios would have continued to be scored as 0.

- **Table 5-23: Population within a Comfortable Walking Catchment of PT stops**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Population	37,785	37,814	37,787	36,612	38,407	38,407	37,787
% of Base	100.0%	100.1%	100.0%	96.9%	101.6%	101.6%	100.0%
% of Northern Suburbs Pop	97.2%	97.2%	97.2%	94.1%	98.8%	98.8%	97.2%
Score	0	0	0	0	0	0	0

- **Figure 5-14: Population within a Comfortable Walking Catchment of PT stops**



D.8 Public Transport Integration (seamlessness of service)

The more integrated a public transport service is, the easier it is for passenger to travel to their destination, either because the number of interchanges between services is reduced, or because the interchanges that are provided, are of a high quality and promote interchange with minimal disruption to travel.

Integrated ticketing could improve interchange between modes by ensuring that a journey could be made without the need to purchase multiple tickets or pay large penalties for doing so. Greater Wellington have advised that integrated ticketing for both rail and bus services is being investigated at present and is expected to be put in place in the future. It is expected that when it is introduced, fares would be similar to the new zone based system and be related to distance travelled, not by mode or service provider.

For all scenarios, integrated automated electronic ticketing machines are assumed to be installed at all stations.

For the scenarios proposed, interchange is to be improved through the design and implementation of any new stations / stops in the Johnsonville corridor. Where services meet, their timetables would be co-ordinated where possible and interchange provided for through measures like shared or adjoining platforms.

Irrespective of the scenario, interchange improvements are proposed at Johnsonville as part of the Mall improvements which are currently being investigated by the Mall owners and WCC and GWRC Councils. At present, interchange between bus and rail is provided for at Johnsonville. While the physical facilities are of a poor quality, the timetables are co-ordinated and distance between the platforms is minimal. In practice there is a very limited amount of interchange between the modes.

Interchange between bus services and between bus and rail is provided for at the Lambton Interchange and a similar level of interchange would be provided for all scenarios. It could be argued that interchange between bus and rail is more difficult at Lambton because of the larger distance between the bus platforms and the rail platforms compared to a bus - bus interchange.

A measure of public service integration is the number of interchanges or transfers that are required under each scenario for trips from the northern suburbs to key destinations on the growth spine. The number of transfers required is shown in Table 5-24.

For people in the existing Johnsonville line catchment, the on-street, busway and light rail scenarios would reduce the number of transfers required to reach the southern part of the CBD because unlike the rail scenarios, they continue through to Courtenay Place.

People in the remainder of the northern suburbs already have a seamless service to the south of the CBD provided by existing bus services. If only patrons using services which run in the Johnsonville line corridor were considered, the busway would be more seamless than the light rail, as there would be no need for people from the northern part of the northern suburbs to transfer at Johnsonville.

In the scoring (Table 5-24) evaluation, a reduction in the number of transfers required was considered to have a positive impact. All scenarios except rail show a reduction in the number of transfers required. They were scored as having a minor positive impact.

- **Table 5-24: Number of Transfers required from the Northern Suburbs to Key Destinations**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Johnsonville Line Catchment							
Wellington City - CBD North	0	0	0	0	0	0	0
Wellington City - CBD South	1	1	1	0	0	0	0
Kilbirnie	1	1	1	1	1	1	1
Newtown	1	1	1	1	1	1	1
Airport	1	1	1	1	1	1	1
Remainder of the Northern Suburbs							
Wellington City - CBD North	0	0	0	0	0	0	0
Wellington City - CBD South	0	0	0	0	0	0	0
Kilbirnie	1	1	1	1	1	1	1
Newtown	1	1	1	1	1	1	1
Airport	1	1	1	1	1	1	1
Remainder of the Northern Suburbs if using the Johnsonville Line Corridor							
Wellington City - CBD North	1	1	1	0	0	0	1
Wellington City - CBD South	2	2	2	0	0	0	1
Kilbirnie	2	2	2	1	1	1	2
Newtown	2	2	2	1	1	1	2
Airport	2	2	2	1	1	1	2
Score	0	0	0	√	√	√	√

D.9 Vehicle Comfort and Condition

The comfort and condition of vehicles is a factor in people using public transport services. Rail rolling stock is generally anticipated to have a functional life of 30 years. The current

English Electric units that operate of the Johnsonville line are well past their economic lives and utilise technology that is over 50 years old. As such they provide a poor quality of ride and despite a recent cosmetic refurbishment do not provide an attractive service.

Existing bus services are operated with a range of vehicles that meet the requirements of specified performance requirements. As new units are purchased to replace buses that are at the end of their economic lives or to cater for additional demand they are replaced by modern low floor uses. While not a requirement recent larger buses purchased by Stagecoach have included air-conditioning.

The scenarios all assume replacement of the English Electric units with vehicles that are within their expected economic lives. The age of vehicles as a measure of their attractiveness was therefore not considered in detail. This was because the relative age of vehicles would change as vehicles are purchased and refurbished. As the expected life of a bus is in the order of 15 years and refurbishment of trains would take place every 15 years, there would be little difference in condition due to age.

The ride quality of vehicles is related to the surface or tracks that they run on. In general the ride quality of a train is better than a bus due to the fixed nature of the track which reduces small deviations. Trains also speed up and slow down less than buses because they do not have to interact with general traffic and generally only stop and start from stations or passing loops. Modern trains use air suspension and provide a high quality of ride on well constructed and maintained tracks. The Johnsonville line is made up of a tight horizontal and vertical geometry with a large number of bends and the tracks themselves are poorly aligned after many years of use. The ride quality of new or refurbished units would be significantly improved over the existing English Electric units but would not be as smooth as that experienced on high quality rail services internationally. New units which could be operated on the line would be expected to me more comfortable than refurbished units because of the improved technology used. It was assumed that new or refurbished rail units would include heating and air-conditioning systems.

Light rail units would perform similarly to heavy rail except that they would provide a better ride quality through the CBD than bus services. Buses running on a busway would have improved ride quality over buses running on-street because the fixed guideway. There would be a similar number of turns as the horizontal and vertical alignments would be similar. Buses would also not have to alter their speeds to interact with traffic, however because of the high bus frequency may have to do so to maintain adequate separation between buses.

Another issue for passenger comfort is noise levels within the vehicles. The motive systems of electric rail units are generally quiet with some compressor noise from breaking. The level of noise within the car would be reduced with improvements to the standard of acoustic insulation over the older the train. Typical new train performance specifications (from the UK for a Class 375 EMU) would require that interior noise levels do not exceed 63db(A) SPL when stationary and 71db(A) SPL under power or breaking conditions.

In the case of buses, engine noise dominates at speeds below 50km/hr and above this road noise dominates. Diesel buses would be louder for passengers than trains or light rail.

D.9.4 Assessment of Vehicle Comfort and Condition

Based on the discussions above, Table 5-25 notes the major differences between the scenarios and sets out the qualitative assessment of vehicle comfort and condition for the scenarios being considered.

A score of √√√ indicates a vast improvement over the comfort and condition of the refurbished Ganz Mavag rail units anticipated in the base. A score of 0 indicates a vehicle comfort and condition consistent with these. A score of XXX indicates a vastly lower level of comfort and condition.

- **Table 5-25: Assessment of Vehicle Comfort and Condition**

Scenario	Sub-scenario	Score
Base		0
Scenario 1 - Enhanced Rail	**ER1**	0
	ER2	0
Scenario 2 – Bus on-street and Walking and Cycling		XX
Scenario 3 – Busway		X
Scenario 4 – Light Rail		√

D.10 Public Transport Frequency

Access to public transport was measured above in terms of peoples proximity to services. Another measure is the frequency of services for people in the northern suburbs. This was measured in terms of the average waiting time for trips to and from the northern suburbs. The average waiting time for trips from the northern suburbs is shown in Table 5-26 and is displayed in Figure 5-15 for the AM peak.

The average AM and IP percentage shown is a raw average of the data displayed and is not weighted by trips, but provides an indication of performance. In general the average waiting times reduced for all scenarios as a result of the increased frequencies experienced.

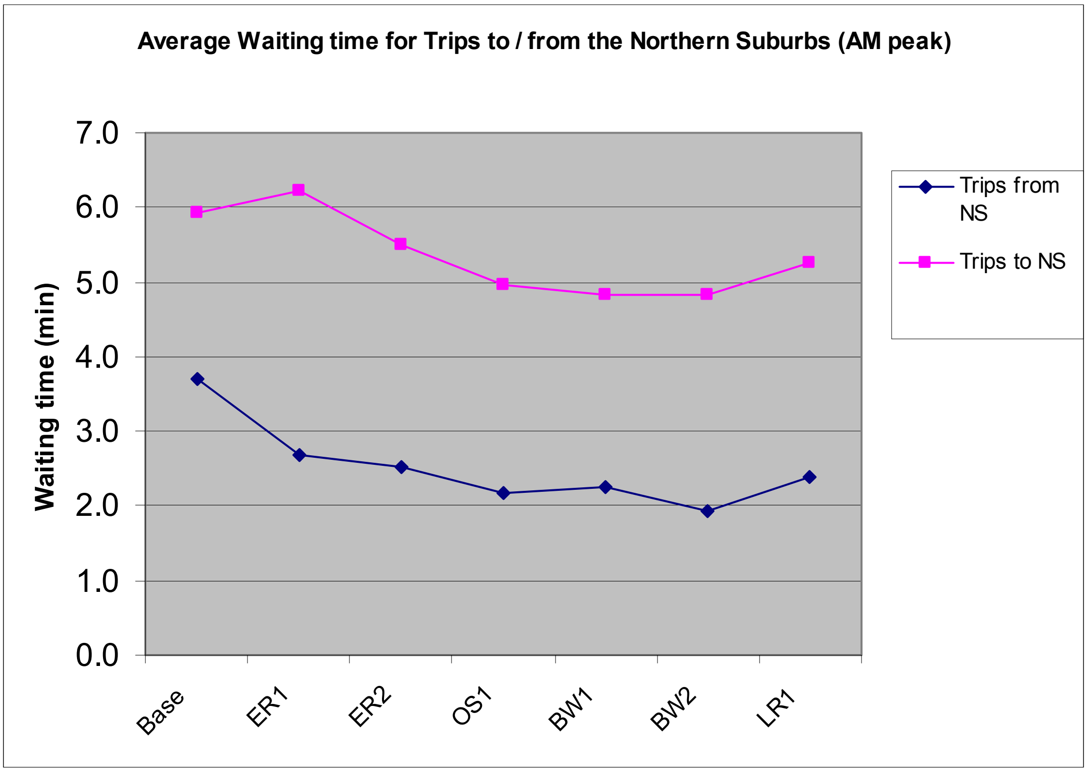
Waiting time for trips **from** the northern suburbs is the most important measure because it is the area we are most interested in and where the improvements are made. For example average waiting time for trips **to** the northern suburbs actually increased from the base to ER1. This was due to induction of more trips that come from outside the northern suburbs with longer weighting times.

In the scoring (Table 5-26), a reduction in waiting time was scored as positive with the rail scenarios having a minor positive impact and the remainder of the scenarios having a moderate positive impact.

- **Table 5-26: Average Waiting Time for PT Trips to / from the Northern Suburbs**

AM	**Base**	**ER1**	**ER2**	**OS1**	**BW1**	**BW2**	**LR1**
Trips from NS	3.7	2.7	2.5	2.2	2.3	1.9	2.4
Trips to NS	5.9	6.2	5.5	4.9	4.8	4.8	5.3
Average AM %	100%	92%	84%	74%	74%	70%	79%
IP							
Trips from NS	7.4	5.8	6.2	4.7	4.1	3.9	4.5
Trips to NS	6.8	5.1	5.2	4.1	4.5	4.5	4.4
Average IP %	100%	77%	80%	62%	61%	60%	62%
Score	0.0	√	√	√√	√√	√√	√√

- **Figure 5-15: Average Waiting Time for PT Trips to / from the Northern Suburbs (AM peak)**



D.11 Other Considerations

D.11.1 Access to Westpac Trust Stadium

At present access to the Westpac Stadium for events is provided by rail. A large factor in the decision to locate the Stadium in the Wellington Rail and port area was the accessibility that could be provided to it by the Wellington rail network. Access to rail platforms including the Johnsonville Line platform is provided directly from the Fran Wilde Walk access structure and that mean that patrons leaving the Stadium can get directly onto trains which have the ability to bring and take home large numbers of people in a relatively quick and efficient manner.

For events at the Stadium Tranz Metro operate all the normal services and also provide additional trains to cope with the extra volume of people. These additional trains run a few minutes ahead of scheduled services and, for the journey home, they run at frequent intervals to clear the backlog of people. If the enhanced rail or light rail scenarios were to be taken forward, access to the Stadium could continue in a similar way.

If buses operating on-street were to be used to provide access to the Stadium, additional services would be put on to get people into the stadium and patrons would have to walk between the Stadium the Lambton Interchange. This would be less desirable than the direct access provided at present.

There would be additional issues with a busway because of the one-way operation. For an evening event starting at 7:30pm, patrons would generally want to be at the Stadium half an hour before the start at say 7:00pm. At his time the busway would still be operating from Wellington towards Johnsonville to take commuters home. It would be very difficult to change the direction of operation only on event days and would cause considerable confusion. Additional services taking people to the Stadium would need to operate on-street. Additional services taking people back to the northern suburbs after the event would be able to use the busway. Again, patrons would have to walk between the Stadium the Lambton Interchange to access services.

D.11.2 Long Term Capacity

The scenarios were considered in terms of ability to provide for the forecast levels of demand in 2016. While growth forecast after this time are low for the Wellington region, there is the potential that in the future as the result of additional growth or changes in travel patterns as the result of other factors such as fuel prices or peak oil effects could increase substantially.

Under the enhanced rail scenario, the maximum peak direction carrying capacity for the line would be approximately 3,640 assuming a planning capacity of 202 per new two car unit, ten minute frequencies and the extension of platforms and passing loops to cater for six car trains. This figure equates to a 150% increase in patronage on the railway line over the forecast 2016 patronage in the AM peak.

The ultimate capacity of buses operating on-street is really only controlled by the capacity of the road network. If there was a large switch to public transport in the future it is likely that there would be more capacity on the road network due to the reduction in vehicle trips and scenarios such as the installation of bus lanes on the Ngauranga Gorge would become viable. This would allow buses operating on-street to cater for the additional capacity required.

Assuming a practical maximum frequency for buses operating in one direction on the busway is in the order of 1 minute implies a maximum peak flow frequency of 60 buses per hour. 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).

For light rail, a peak planning capacity of 1,400 passengers per hour can be achieved on the Johnsonville railway section assuming a planning capacity of 230 people per 2-car unit with a 10-minute service frequency. This limited capacity could become an issue in the long term because it is assumed that only 2-car sets (approximately 60m long) would operate on the

Johnsonville Line section. This is because 60m long units are expected to be the maximum that could effectively operate through the CBD. If say 3-car sets were contemplated they would be approximately 90m long requiring lengthening of platforms on the Johnsonville Line section and requiring the units to separate once they reached the CBD section. That would mean that people in the front units would continue their journey before the following unit.

D.11.3 Access to Johnsonville Mall

The Johnsonville Mall is included as a centre of intensification in WCC's Urban Development Strategy. As such it is anticipated that it will become a more important retail and economic centre. All scenarios provide access to the centre, however the level of access changes between the scenarios. A rail system with fixed infrastructure and a high quality regular service in the counter peak direction provides a higher level of accessibility which may promote retail and recreational usage of the facilities provided. Bus based scenarios would not provide as attractive counter peak service for shopping or recreation.

D.11.4 Station Relocation and Access to Schools

Relocation of Raroa Station and removal of Box Hill Station is required for the 10-minute frequency rail scenario ER2. Moving the station to Fraser Avenue would have an adverse impact on accessibility because the station would be further away from the majority of its current catchment.

If Box Hill 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[8] at the station (both directions) over the entire day. Therefore, it is considered that removal of the station would have only a minor impact on accessibility.

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. This would continue under the rail or light rail scenarios. Under the busway scenario, 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.

Under the bus on-street scenario, the routes utilised are the same as the busway counterpeak services so access to Onslow college would be provided in this way.

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[8] From Rail Survey March 2002

D.11.5 Legibility

The legibility or understandability of services is an issue that will affect infrequent users of a public transport service. The majority of the scenarios would operate in a consistent manner throughout the day.

A busway would however operate it in the peak direction only. 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. 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

D.11.6 Flexibility

The fixed infrastructure of the rail and light rail does not provide much flexibility to alter routes to cater for demand over the Johnsonville Corridor. The light rail scenario does provide the flexibility to extend routes to the south – potentially to the airport, while this is unlikely to be feasible for heavy rail. Buses running on street are flexible and routes can be change to meet demand easily. The busway could be operated in a number of different ways and provides the opportunity to extend services to the north or south. Although the busway itself is fixed, buses could be routed off the busway and connect with the busway when full.

D.12 Improve Access, Mobility & Network Reliability Summary

Table 5-27 shows the overall score for the objective Improve Access, Mobility & Network Reliability, where each of the measures was given equal weighting. All scenarios show a marginal positive impact. .

The measures *impact on travel*, *level of congestion, network reliability* and *access to PT (proximity)* do not change significantly between the scenarios or against the base. This is due to the marginal impact on vehicle trips and the fact that the majority of the northern suburbs catchment is already catered for by public transport. The scenarios all perform very similarly under the measure *vehicle speeds* and *travel times*, with all having a minor positive impact.

The two rail scenarios score similarly, with the ER1 scenario performing slightly better than ER2 in respect of reduced construction disruption impacts.

The two busway scenarios perform similarly. Despite the busway scenarios performing better than the rail scenarios under *frequency*, *PT Integration* and *PT network reliability*, this is offset by the larger construction disruption associated with the busway scenarios and poorer performance under *vehicle comfort and condition*. Hence they score similarly overall.

The bus on-street scenario performs slightly worse than the rail scenarios overall. Improvements in regard to frequency and seamlessness of the services are offset by reduced network reliability as a result of on-street running and consequential delays due to congestion, and poorer vehicle comfort and condition. The bus on-street performs slightly worse than the busway scenarios overall, as the busway offers better performance under *network reliability* and *vehicle comfort and condition* due to the guideway, albeit offset by the large construction disruption which this scenario entails.

Light rail performs similarly to the heavy rail and busway scenarios overall. While light rail could offer improved network reliability and interpeak frequencies over the rail and improved vehicle comfort over the busway, these gains are offset by the significant disruption during construction.

- **Table 5-27: Improve Access, Mobility & Network Reliability Score**

3) IMPROVE ACCESS MOBILITY AND NETWORK RELIABILITY (Better Connected / More Liveable)	Base	ER1	ER2	OS1	BW1	BW2	LR1
Impact on Travel	0	0	0	0	0	0	0
Construction disruption	0	0	X	0	XX	XX	XXX
Travel times (journey times)	0	√	√	√	√	√	√
Vehicle speeds	0	√	√	√	√	√	√
Level of congestion and network reliability	0	0	0	0	0	0	0
PT network reliability	0	√	√	XX	√√	√√	√√
Access to PT (proximity)	0	0	0	0	0	0	0
PT integration (seamlessness of service)	0	0	0	√	√	√	√
Vehicle Comfort and Condition	0	0	0	XX	X	X	√
PT Frequency	0	√	√	√√	√√	√√	√√
Average	**0**	**0+**	**0+**	**0**	**0+**	**0+**	**0+**

Appendix E Objective 4: Protect and Promote Public Health (Healthier)

The objective of Protect and Promoting Public Health was measured in three ways:

- Effects on local air quality;
- Effects of noise and emissions on people; and
- Amount of active travel (walking and cycling)

E.1 Effects on Local Air Quality

Effects on air quality were measured in two ways:

- Estimates of general traffic emissions
- Assessment of relative local emissions from public transport

E.1.1 Estimates of General Traffic Emissions

As a result of the public transport improvement, there would be a change in the use of private vehicles as people shift between modes. This shift has a corresponding impact on the performance of the road network. Estimates of vehicle emissions were used to identify the relative impacts of these changes.

Estimates of vehicle emissions, nitrous oxides (NOx), particulates (Part), and volatile organic compounds (VOC), for the northern suburbs and CBD corridor were used to assess the impacts on air quality. The data is adequate for this strategic study, but it should be recognised that it does not relate to emissions guidelines, take account of dispersion effects, consider the effect on people or localised effects.

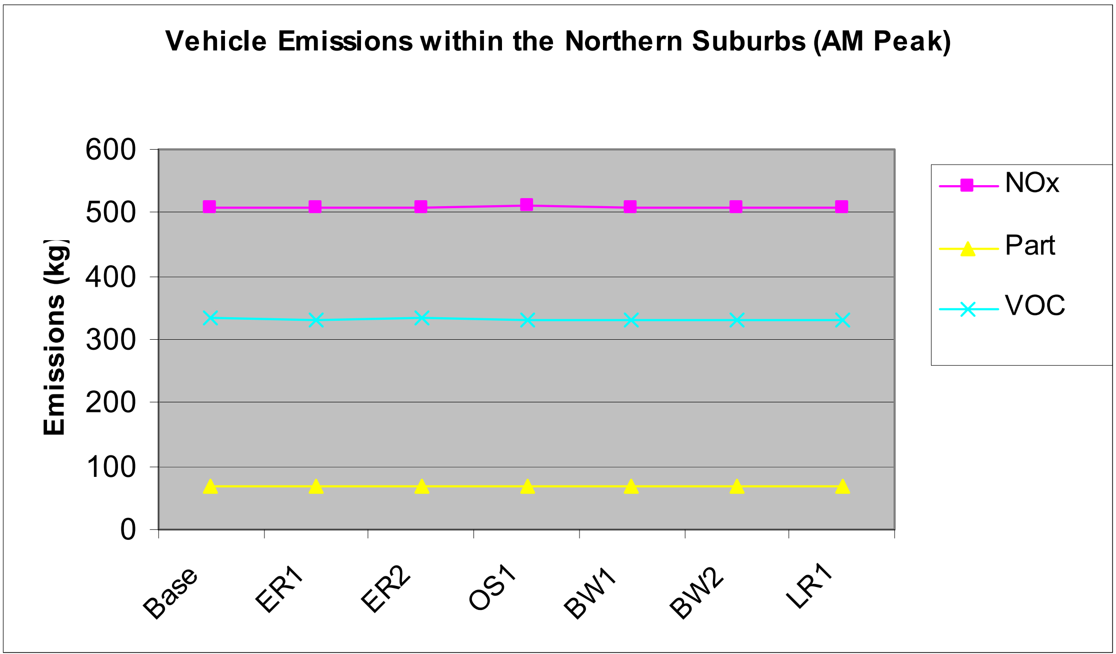
The vehicle emissions were estimated with the same procedures and emissions factors used in the Western Corridor Study as provided by GWRC. Table 5-28 gives the estimate of the three emissions for each of the modelled time periods and Figure 5-16 shows those for the AM peak period.

Table 5-28 includes the resulting scores for the indicator vehicle emissions. The measure was scored such that the lower the emissions, the higher the score. All scenarios perform similarly and have almost no impact.

- **Table 5-28: Vehicle Emissions within the Northern Suburbs (kg)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
AM							
NOx	508	508	508	510	508	509	508
Part	68	68	68	68	68	68	68
VOC	336	332	332	332	331	331	331
IP							
NOx	477	478	478	479	479	479	478
Part	67	67	67	67	67	67	67
VOC	205	205	205	205	206	206	205
PM							
NOx	493	495	495	499	497	497	494
Part	65	65	65	66	65	65	65
VOC	338	337	337	340	337	337	337
Score	0	0	0	0	0	0	0

- **Figure 5-16: Vehicle Emissions within the Northern Suburbs (kg) (AM Peak)**



E.1.2 Assessment of Relative Local Emissions from Public Transport

In terms of emissions from public transport services themselves, the differential local air quality effects of the scenarios proposed would only be an issue at the local level and it is unlikely that a substantial difference would be noticeable to residents. With the exception the Bus on-street Scenario, all scenarios considered continue to use the Johnsonville Line transport corridor and in general the corridor is separated some distance from residential properties. The remainder of the northern suburbs would continue to be served by bus and the air quality effects on those areas would be broadly similar to existing.

E.1.2.1 Rail Emissions

The motive power used for Electric Multiple Units (EMUs) and Light rail vehicles is electricity. This means that there are limited local air quality impacts related to rail because the energy is generated remotely. There may be very small ozone emissions that result from sparking of overhead wires and electric motors, however this was not considered to be significant.

Air quality at the generation source may be impacted by electricity usage. The Sustainability Assessment detailed in Section Appendix F discuses the potential and forecast electric power generation scenarios for the future. Clearly, where renewable energy sources such as hydro, geothermal or wind farms are used to generate electricity there would not be an issue with emissions at the generation site. If the electricity was to be generated by gas-fired turbine equipment and oil or coal-fired external combustion, this would become more of an issue. However, because generation sites are generally some distance from population centres, there is likely to less impact on public health and our assessment has focused on emissions in the northern suburbs.

E.1.2.2 Bus Emissions

It was assumed that new diesel buses would be purchased to provide the rail replacement services operating on-street and on the busway. Diesel buses produce a number of emissions, the most important in terms of local air quality are:

- Particulate matter less than 10 microns in size (PM_{10})
- Carbon monoxide (CO) and
- Volatile organic compounds (VOC).
- Oxides of nitrogen (NOX)
- Sulphur dioxide (SO_2)

Until recently, diesel fuel in New Zealand had large amounts of sulphur in it. As noted above diesel vehicles produce sulphur oxides and particulates which increase with the sulphur content of the fuel. Both sulphur oxides and particulates have been linked to several health problems, especially respiratory problems.

Many new vehicles emissions technologies require lower sulphur diesel in order to operate. These new technologies help to reduce several harmful emissions and increase engine efficiency. Therefore, in January 2006 the sulphur content of diesel was regulated to reduce from 500ppm to 50ppm. It is intended to regulate a further reduction to 10 – 15 ppm by 2009/10.

Modern diesel engine technology combined with exhaust filtering technology can significantly reduce the emissions of diesel buses. Bus operators in New Zealand are currently ordering Euro 3 compliant buses which have reduced emissions in line with European standards. Lower emission Euro 4 rated buses are currently available in the European market, however the New Zealand market usually lags behind the European market by 2 – 3 years.

Trolley buses are electrically powered and similar to rail vehicles would not have any local emissions. Trolley buses have not been considered because of the additional overhead infrastructure that would be required. For the busway, all bus routes in the northern suburbs would need to converted to trolley bus replacing the whole fleet at substantial additional cost and wiring large areas. Even if only the new rail replacement buses were to be trolley buses, the one-way operation of the busway would require the wiring of the counterpeak route along the State Highway and / or local roads. Trolley buses have therefore not been considered as an scenario in this strategic assessment.

Lower emission hybrid electric/gas vehicles, fuel cell vehicles and electric/diesel vehicles are also potential alternatives. Examples such as the hybrid Shuttle constructed in New Zealand can operate on battery and LPG turbine and has been trailed successfully in some applications recently. Hydrogen fuel cell buses are being developed and could be available economically in the short to medium term. These types of buses could prove to be viable options for the northern suburbs in the future as the bus fleet reached the end of their economic lives and were replaced greatly reduce the local air quality impacts.

Air quality issues are unlikely to be a determining factor in this strategic assessment, therefore in our analysis we have assumed that the more efficient Euro 3 / 4 type buses would be provided and that the local air quality impacts of increased diesel bus usage would be minor.

E.1.2.3 Scenario 1 – Enhanced Rail Scenario Local Emissions Assessment

Local emissions on the Johnsonville corridor would be similar to the base case. Bus improvements in the rest of the northern suburbs would increase the local emissions of from buses to some extent, however it was not considered this would be substantial.

E.1.2.4 Scenario 2 – Bus on-street Local Emissions Assessment

The use of diesel buses in place of electrically powered rail vehicles would have an adverse impact on local air quality. The number of additional bus journeys in the northern suburbs which would result from the bus on-street scenario is however unlikely to have any major effect on public health. If new modern buses with Euro3 / 4 type technology buses were purchased to operate in the northern suburbs, the impact on air quality would be minor If older technology buses were to be used the impact would be greater.

Operation of additional buses through the CBD bus route would increase the local air quality impacts on public health along this route, particularly if there was increased bus congestion along this route with increased stopping and starting.

Buses operating from Wellington to Johnsonville would have more emissions than vehicles travelling in the opposite direction due to grade. Buses which operate on-street are required to stop and start on a regular basis (i.e. at stops, intersections and due to traffic congestion). This stopping and starting has an adverse impact on emissions and therefore local air quality compared to buses operating on a busway.

E.1.2.5 Scenario 3 - Busway Local Emissions Assessment

The use of diesel buses in place of electrically powered rail vehicles would have an adverse impact on local air quality. The number of additional bus journeys in the northern suburbs which would result from the busway scenario is however unlikely to have any major effect on public health.

Buses on a busway would have their own right of way and would only need to stop and start at station stops for rail replacement services or potentially not at all for express services. This more constant running would have a positive effect on air quality compared to buses operating on-street.

Buses operating from Wellington to Johnsonville would have more emissions than vehicles travelling in the opposite direction due to grade. Because the busway would be constructed on the existing rail alignment which has a maximum grade of approximately 2.8%, the impact for that scenario would be less than for the bus on-street scenario which would need to negotiate steeper grades.

Local emissions also dissipate quickly with increased distance from the source. This is highly dependant on factors like weather conditions and topography, however under the busway scenario most residences are some distance from the Johnsonville Corridor and residents are unlikely to notice any significant impacts.

Operation of additional buses through the CBD bus route would increase the local air quality impacts on public health along this route, particularly if bus congestion increases.

E.1.2.6 Scenario 4 – Light Rail Local Emissions Assessment

Similarly to the enhanced rail scenario, the motive power used for Light Rail Vehicles (LRVs) is electricity. For the Johnsonville line section, the impacts would be largely the same as for the enhanced rail described above.

Light rail would also operate through the CBD. It is not proposed to sever existing bus routes, so the number of buses operating over this length would be broadly similar to existing (although they may travel on alternative parallel roads). Therefore, there is likely to be little difference in local air quality impacts compared to the existing situation

Based on the discussions above, Table 5-29 sets out the assessment of local air quality impacts due to public transport services for the scenarios being considered.

A score of √√√ indicates a vast reduction in local air quality impacts compared to the base case. A score of 0 indicates local emission impacts consistent with the base case. A score of XXX indicates a vast increase in adverse local air quality impacts over the base case.

- **Table 5-29: Assessment of Local Air Quality Impacts**

Scenario	Score
Base	0
Scenario 1 - Enhanced Rail	0
Scenario 2 – Bus on-street and Walking and Cycling	X
Scenario 3 – Busway	X
Scenario 4 – Light Rail	0

E.1.3 Effects on Local Air Quality Summary

Table 5-30 shows the overall score for the criteria of Effects on Local Air Quality where each of the measures was given equal weighting.

All scenarios have no significant impact on general traffic emission. The difference between the scenarios relates to whether diesel buses (which have local emissions) or electric rolling stock (which have zero local emissions) are used. While alternatives to diesel buses may be available economically in the future, the bus based scenarios were scored as having a minor negative impacts overall.

- **Table 5-30: Effects on Local Air Quality Summary Score**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Vehicle Emissions within the Northern Suburbs (kg)	0	0	0	0	0	0	0
Assessment of Local Air Quality Impacts	0	0	0	X	X	X	0
Score	0	0	0	X	X	X	0

E.2 Effects of Noise on People

The second criteria for this objective is the impact of noise on people which was evaluated in two ways:

- Sum of traffic volumes on about 20 selected links in residential areas
- Qualitative assessment of relative noise emissions from public transport

E.2.1 Sum of Traffic Volumes

The sum of traffic volumes on about 20 selected links in residential areas was used to measure the impacts that changes in vehicle volumes as a result of the scenarios have on adjoining residents. This makes the simple assumption that traffic volumes and these impacts are directly related and ignores localised spatial effects and the effects of individual vehicles.

The traffic volumes are given in Table 5-31 along with the resulting scores and the volumes are shown graphically in Figure 5-17.

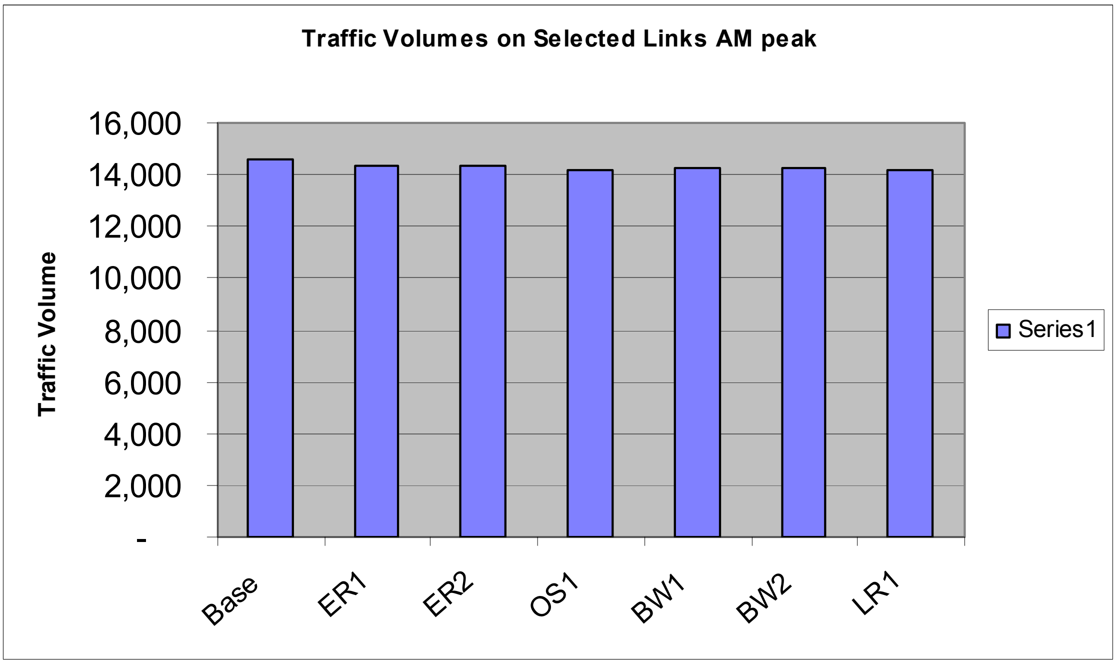
All scenarios show a reduction in traffic volumes and hence reduced noise and emission impacts on people. These reductions would be slight in real terms, especially given the logarithmic variation in noise with distance.

All scenarios perform similarly with only small reductions over the base. They have all therefore been scored as 0.

- **Table 5-31: Sum of Traffic Volumes on approx. 20 Selected links (AM peak)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Sum of Traffic Volumes	14,612	14,370	14,356	14,213	14,266	14,220	14,192
% difference	0.0%	-1.7%	-1.7%	-2.7%	-2.4%	-2.7%	-2.9%
Score	0	0	0	0	0	0	0

- **Figure 5-17: Sum of Traffic Volumes on approx. 20 Selected links (AM peak)**



E.2.2 Assessment of Relative Noise Emissions from Public Transport

The noise impacts of the public transport services themselves were assessed in a qualitative way. Noise impacts are extremely localised, and for this reason it is difficult to assess specific noise impacts without a detailed micro level evaluation. The evaluation set out below was undertaken at a strategic level and is intended to highlight the general differences in noise impacts for the different scenarios proposed. The scale of the differences identified is not large and the resulting impact is low. A detailed evaluation of the noise impacts would be required in the next stage of investigation.

There are a number of factors that influence the noise impacts. These include:

- Maximum noise level at any point in time (compared to the background noise level)
- The equivalent continuous noise level – the steady level of noise equivalent to the average of fluctuating sound levels
- Frequency of the noise source – how often the noise is heard
- Time the noise occurs – noise at night has a larger impact because background noise is reduced and people are sleeping

With the exception Scenario 2 – Bus on-street, all scenarios considered continue to use the Johnsonville Line corridor and in general the corridor is separated some distance from residential properties. Given the logarithmic variation in noise with distance, this would limit the noise impacts of these scenarios.

E.2.2.1 Scenario 1 – Enhanced Rail Noise Assessment

The noise signature of a train service is determined by a number of factors including:

- Vibration (local effect transmitted through the ground)
- Wheel / track interface
- Compressor noise (for breaking)

Because of the heavy nature of rail vehicles, the vibration profile generated by the trains would be felt very locally by residents and this impact is likely to be larger than for buses operating in the same area.

Train services carry more people and are therefore less frequent than buses carrying an equivalent number of passengers. The frequencies of the train services reduce to approximately half hour services through the evening with limited services after midnight on weekends.

Rail services currently operate along the Johnsonville Line and the community has developed in an environment where noise from trains is an accepted part of the areas character. As such, it is unlikely that noise from trains could be considered to have a large detrimental impact.

ER1 – 13 Minute Timetable

The noise impacts of trains running on the 13 minute timetable would be broadly similar to the existing train services. New units would result in a marginal decrease in the absolute noise level for each train, while the additional service each hour would have a small negative impact.

ER2 – 10 Minute Timetable

The noise impacts of the 10 minute timetable would be worse than the existing situation because of the increased number of services. New units would result in a marginal decrease in the absolute noise levels for each train.

E.2.2.2 Scenario 2 – Bus on-street Scenario Noise Assessment

The noise signature of bus services are determined by a number of factors including:

- Tyre / road interface
- Engine and exhaust

The tonal component of bus noise would change dependant on speed. At lower speeds (<50km/hr) the engine noise predominates and at higher speeds, tyre noise predominates.

The bus on-street scenario would mean that more buses are travelling on local roads which are adjoined by residential properties – resulting in minor negative noise impacts on those residents. There would be a positive impact for residents adjacent to the existing rail corridor because the noise associated with train services would be removed. The scale of this benefit is likely to be minor because train noise is an accepted part of the character of the area and people have chosen to live in this area knowing that trains operate on the Johnsonville Line.

The ambient noise levels on these roads would be higher than the rail corridor because of existing traffic flows and the majority of the routes carry buses and other heavy vehicles at present. The number of additional buses per day is small compared to the general traffic volumes. At sections where the on-street bus routes combine (i.e. Burma Road), there may be up to 18 additional bus services an hour during peak times. While this number of additional buses may be noticeable, they are unlikely to have a significant noise impact considering the existing background noise of the road. Due to the steep topography of the area, northbound buses would have to operate on significant grades at times and the engine tonal component on those sections is likely to be more significant. Services in the evening would reduce to approximately half hourly for many services and therefore are unlikely to have a significant impact over this period.

E.2.2.3 Scenario 3 – Busway

The noise signature of buses using the guided busway would be similar to that of standard buses as described in Scenario 2 above. In addition to the factors noted above there may also be some noise component as the result of the guidance system. Maximum noise levels quoted for the guided busway in Leeds are in the order of 73db at 9m.[9].

For adjacent residents, buses running on the busway are likely to have less absolute noise impact per bus than the existing train services because of reduced vibration profile and lower road/rail interface noise. Buses would however have a higher engine noise component than trains (which do not) and would stand out more. The grades on the Johnsonville line corridor are relatively shallow (maximum 2.8%) because it was constructed for rail. Bus engines would however be under constant load heading uphill to the north and the engine tonal component on those sections is likely to be more noticeable as a result.

More buses would also operate on a more frequent basis, resulting in a negative impact. It is expected that in the order of 66 buses would use the busway in the morning peak 2 hours, compared with the current 6 trains. If the option of operating the majority of northern suburbs buses down the busway was implemented, the combined frequency of these services would have a larger noise impact on residents.

[9] Cambridgeshire Guided Busway Order: Inspector's report

Mitigation measures such as noise wall and bunds have been accepted internationally to address noise impacts of busways. It was assumed that where local issues require, noise mitigation measures could be provided.

E.2.2.4 Scenario 4 – Light Rail Scenario

Over the existing Johnsonville Line section, the noise impacts of light rail would be broadly similar to those described above for ER2, however the absolute noise impacts would be slightly less because of the reduced vibration profile because of the units lighter weights.

Over the CBD section, the noise impact of Light Rail Vehicles (LRVs) would be less significant that in residential areas because the background noise levels are higher. There would however be a negative impact because of the new services operating on-street. Redistribution of bus routes and rearrangement of traffic lanes may have an impact but this is unlikely to be significant.

Wheel and track screech on tight radii found in the CBD would contribute to noise impacts of LRVs over this section, however this impact is likely to be minor.

E.2.2.5 Construction Impacts

Construction noise impacts would result from all scenarios. The construction noise impacts are likely to be worst for the busway because of the significant heavy civil construction works required and would last for long duration (18 – 24 months for some sections).

The enhanced rail (10 minute timetable) and LRT scenarios require significant physical works and would have the next highest construction noise impact on the Johnsonville line section for a duration of months. Some works would happen on weekends and at night to restrict the duration of full closures - any works during these times would have larger impact on residents trying to sleep or during recreation time.

Again for the other enhanced rail scenario (13 minute timetable), some works would take place in the weekends and at night, resulting in noise impacts for adjacent residents.

Construction noise impacts through the CBD would be largest for LRT because of the significant civil and electrical construction works that would be required. The bus on-street scenario would have minimal construction noise impacts.

Because the construction noise impacts are for a limited duration, less weighting was given to them compared to long term operational noise impacts.

E.2.2.6 Assessment of Noise Impacts from Public Transport

The overall scale of public transport noise in the northern suburbs is not large and focused around peak periods. Any changes between scenarios are likely to have minor impacts.

In terms of absolute noise emissions per vehicle, heavy rail is likely to have the most noticeable noise emissions, followed by light rail (broadly similar to rail), busway buses and then buses. Rail noise is however an accepted part of the environment and new or refurbished units are likely to be significantly quieter than the existing units. Buses operating on grade would have a more noticeable engine tonal component and be much more frequent than trains. Their effects wouls be concentrated into the Johnsonville corridor under the busway scenarios.

Noise impacts are greatest at night, when the background noise levels are lowest. Trains currently run at limited frequencies through the night and it is not anticipated that a substantial increase in service numbers would be require for any of the scenarios over this period.

Based on the discussions above, Table 5-32 sets out the assessment of noise impacts for the scenarios being considered.

A score of 0 relates to noise impacts that are no worse than base case noise impacts. A score of XXX is when services have a large noise impact which can not easily be mitigated. A score of √√√ is when noise impacts age significantly reduced over the base case.

- **Table 5-32: Assessment of Noise Impacts from Public Transport**

Scenario	Sub-scenario	Score
Base		0
Scenario 1 – Rail	ER1	0
	ER2	X
Scenario 2 – Bus on-street		X
Scenario 3 – Busway		XX
Scenario 4 – Light Rail		0

E.2.3 Effects of Noise Summary

The resulting overall score for the measure Effects of Noise is shown in Table 5-22. There is little impact on noise emissions as a result of changes to general traffic volumes so this was not considered to be important. The difference between noise impacts of the scenarios is the noise emissions from public transport. The differences were related to increased frequency of services. The busway scenarios were scored as having moderate negative impacts because they concentrate a large number of services into the Johnsonville corridor and the bus on-street and ER1 were scored as having minor negative impacts. The remaining scenarios were considered to have similar noise impacts to the base.

- **Table 5-33: Effects of Noise Score**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Sum of Traffic Volumes	0	0	0	0	0	0	0
Assessment of Noise Emissions from Public Transport	0	0	X	X	XX	XX	0
Score	**0**	**0**	**X**	**X**	**XX**	**XX**	**0**

E.3 Amount of Active Travel

The number of trips made by active modes (walking and cycling) is not dealt with well in the model. With the exception of the bus on-street with walking and cycling scenario (where a new walking and cycling facility is provided), none of the scenarios would have a large impact on people walking and cycling.

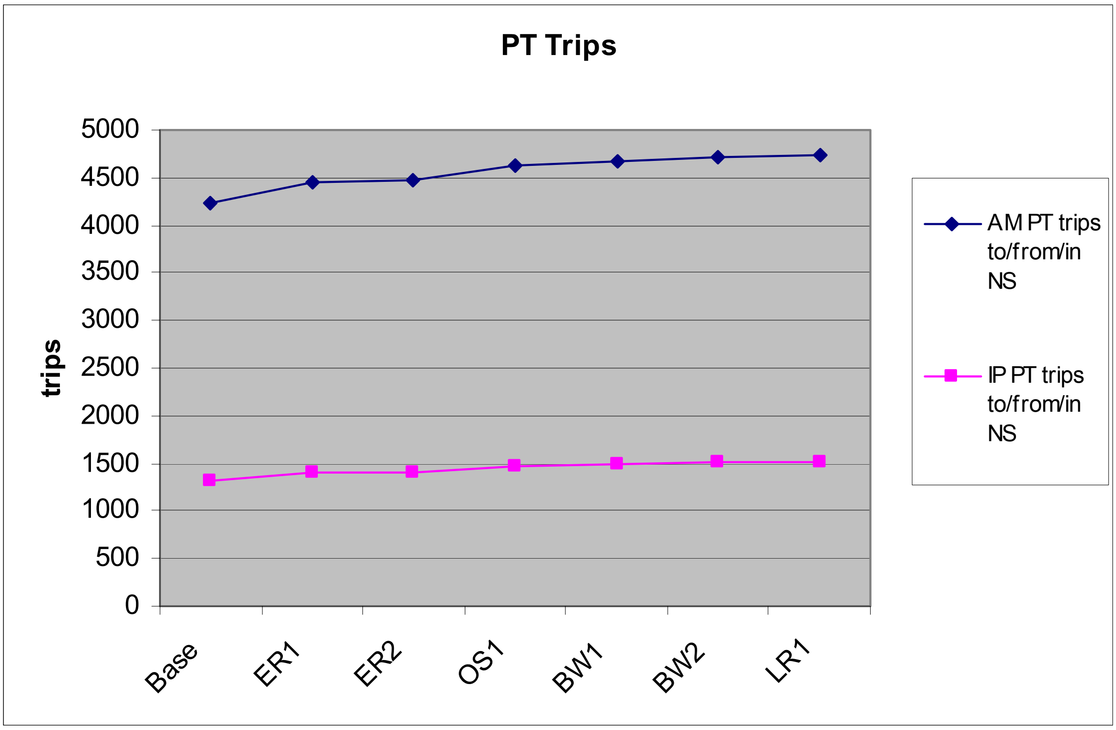
Public transport usage is a useful measure of active travel because there is often a walking component of the trip between the PT stop / station and the origin / destination. PT trips are given in Table 5-34 and are shown graphically in Figure 5-18. Improved cycle sparking was allowed for all scenarios at stations in the Johnsonville Corridor except the bus on-street scenario. The bus on-street with walking and cycling scenario includes pulling up the Johnsonville rail tracks and use of the Johnsonville corridor as a recreational walking and cycling facility. This would have benefits in terms of additional walking and cycling use.

All scenarios show increases in PT usage that could have a minor positive impact on public health. Table 5-31 includes the resulting score for PT usage and also for ability to impact on general walking and cycling. All scenarios were scored the same except for the bus on- street scenario which was score higher because it provides better walking and cycling facilities.

- **Table 5-34: Walking and Cycling and PT trips in the Northern Suburbs and CBD Corridor**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
AM PT trips to/from/in NS	4243	4456	4479	4621	4671	4715	4733
IP PT trips to/from/in NS	1322	1408	1405	1476	1493	1504	1507
PT Total %	100%	105%	106%	110%	111%	112%	112%
PT Score	0	√	√	√	√	√	√
Walk Cycle Score	0	0	0	√√	0	0	0
Score	0	√	√	√√	√	√	√

- **Figure 5-18: PT trips in the Northern Suburbs and CBD Corridor**



E.4 Protect and Promote Public Health Summary

Due to the marginal impact on vehicle trips, there is little impact on forecast emissions from private vehicles.

The difference between the scenarios relates to whether diesel buses, which have local emissions, or electric rolling stock, which have zero local emissions are used. While alternatives to diesel buses may be available economically in the future, the bus based scenarios were scored as having a minor negative impact overall.

The differences between the scenarios related to noise arise chiefly from increased frequencies. The busway scenarios were scored as having moderate negative impacts because they concentrate a large number of services into the Johnsonville corridor. The bus on-street and ER2 scenarios were scored as having minor negative impacts. The remaining scenarios were considered to have similar noise impacts to the base.

All scenarios show increases in PT usage that could have a minor positive impact on the amount of walking and cycling. Public transport usage is a useful measure of active travel because there is often a walking component of the trip between the PT stop / station and the origin / destination. All scenarios were scored the same under this measure except for the bus on-street scenario which was scored higher because it provides better walking and cycling facilities by reusing the Johnsonville corridor as a walking and cycling track.

Table 5-35 shows the overall scores for the objective Protect and Promote Public Health, where each of the measures was given equal weighting. Overall, ER1 has a small positive impact and performs slightly better than ER2 because it has less noise impacts as a result of lower frequencies. Light rail performs similarly to ER1 overall. Despite having higher frequencies, the absolute noise emissions from each train are expected to be lower.

The bus on-street scenario has no net impact overall, as improvements due to the walking and cycling facilities provided are offset by increases in emissions and noise impacts. The busway scenarios have a small negative impact overall due to increased emissions and noise impacts.

- **Table 5-35: Protect and Promote Public Health Score**

4) PROTECT AND PROMOTE PUBLIC HEALTH (Healthier)	**Base**	**ER1**	**ER2**	**OS1**	**BW1**	**BW2**	**LR1**
Effects on local air quality	0	0	0	X	X	X	0
Effects of noise	0	0	X	X	XX	XX	0
Amount of active travel (walking and cycling)	0	√	√	√√	√	√	√
Average	**0**	**0+**	**0**	**0**	**0-**	**0-**	**0+**

Appendix F Objective 5: Ensure Environmental Sustainability (More Sustainable / More Compact) (Sense of Place)

The objective Ensure Environmental Sustainability was measured in terms of:

- Climate change
- Energy use
- Ability to provide for residential intensification along transport routes including the CBD
- Retention of cultural heritage
- Contribution to quality urban space

The investigations described below were undertaken at a high level. Sustainability is an important but complex issue and there are a large number of factors to be considered. Undertaking further investigations into sustainability was considered unnecessary by the Study's management team due to the strategic results showing little difference between the scenarios.

F.1 Climate Change

Impact on climate change as a result of modal switch between private vehicle and public transport was measured using:

- Estimates of greenhouse gas emissions from general traffic
- Estimates of greenhouse gas emissions from public transport vehicles

F.1.1 Greenhouse Gas Emissions from General Traffic

Greenhouse gas emissions from general traffic were measured using estimates of carbon dioxide emissions in the CBD and northern suburbs extracted from the model. The estimates of annual CO2 emissions are given in Table 5-36 and shown graphically in Figure 5-19.

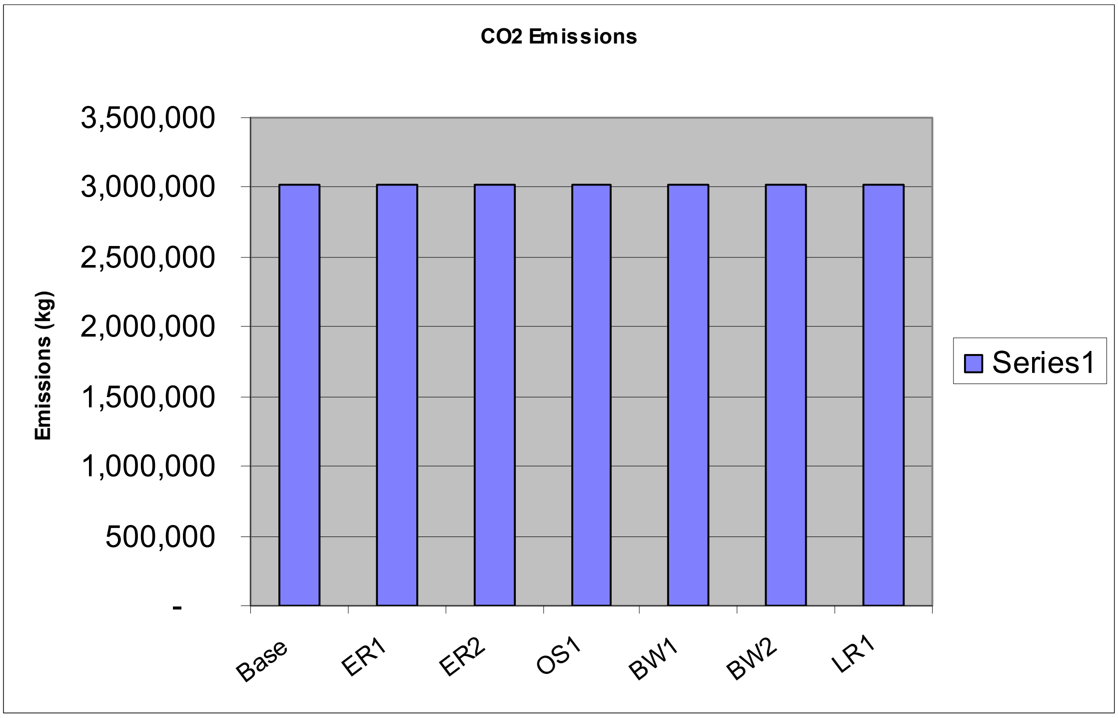
All scenarios have reduced CO2 emissions compared with the base case but these are all extremely small as a result of the marginal impact the scenarios have on vehicle trips. Because none of the scenarios affect the number of vehicle trips made significantly, there is little difference in CO2 emissions.

In the scoring (Table 5-36) all scenarios were considered to have no significant impact on greenhouse gas emissions compared with the base.

- **Table 5-36: General Traffic Emissions of Carbon Dioxide (annual) (kg) from the Northern Suburbs and CBD Corridor**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Annual CO2	3,021,734	3,020,531	3,020,372	3,019,702	3,019,252	3,018,833	3,019,033
Score	0	0	0	0	0	0	0

- **Figure 5-19: General Traffic Emissions of Carbon Dioxide (annual) (kg) from the Northern Suburbs and CBD Corridor**



F.1.2 Greenhouse Gas Emissions from Public Transport Vehicles

The level of greenhouse gas emissions from public transport would be determined by whether vehicles are powered directly by fossil fuels (diesel bus) or alternatively by electricity. Electricity can be generated from renewable recourses such as wind or hydro which would have no greenhouse gas emissions. Alternatively, electricity could be generated from non-renewable sources such as coal or combined cycle gas turbines which produce greenhouse gas emissions.

A limited number of public transport vehicles and services would be required in the northern suburbs under any of the scenarios and the majority of the northern suburbs would continue to be serviced by diesel buses. As such, changes to these services were not assumed to have a significant impact on regional greenhouse gas emissions or contribute significantly to New

Zealand's Kyoto Protocol responsibilities. Therefore, in this assessment all scenarios were scored as having no impact.

Undertaking further investigations into public transport greenhouse gas emissions considering different energy futures, generation technologies, vehicle technologies and embedded energy etc. was considered unnecessary by the Study's management team due to the strategic results showing little difference between the scenarios.

F.1.3 Climate Change Summary

Emissions from private vehicles are not expected to change significantly under any of the scenarios because of the marginal impact on vehicle trips. Changes to public transport services were not assumed to have a significant impact on regional greenhouse gas emissions or contribute significantly to New Zealand's Kyoto Protocol responsibilities. Additional investigations into sustainability impacts were not considered appropriate for a strategic study of this nature.

Table 5-37 shows the overall score given to climate change. There is little difference from the base or between the scenarios, so they have all been scored as 0.

Table 5-37: Climate Change Summary Score

	Base	ER1	ER2	OS1	BW1	BW2	LR1
General Traffic Emissions of Carbon Dioxide (daily) (kg) from the Northern Suburbs and CBD Corridor	0	0	0	0	0	0	0
PT Emissions of Carbon Dioxide (daily) (kg) from the Northern Suburbs and CBD Corridor	0	0	0	0	0	0	0
Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**

F.2 Energy Use

Energy use was measured in a number of ways:

- General traffic fossil fuel use
- Public transport fuel usage

F.2.1 General Traffic Fossil Fuel Use

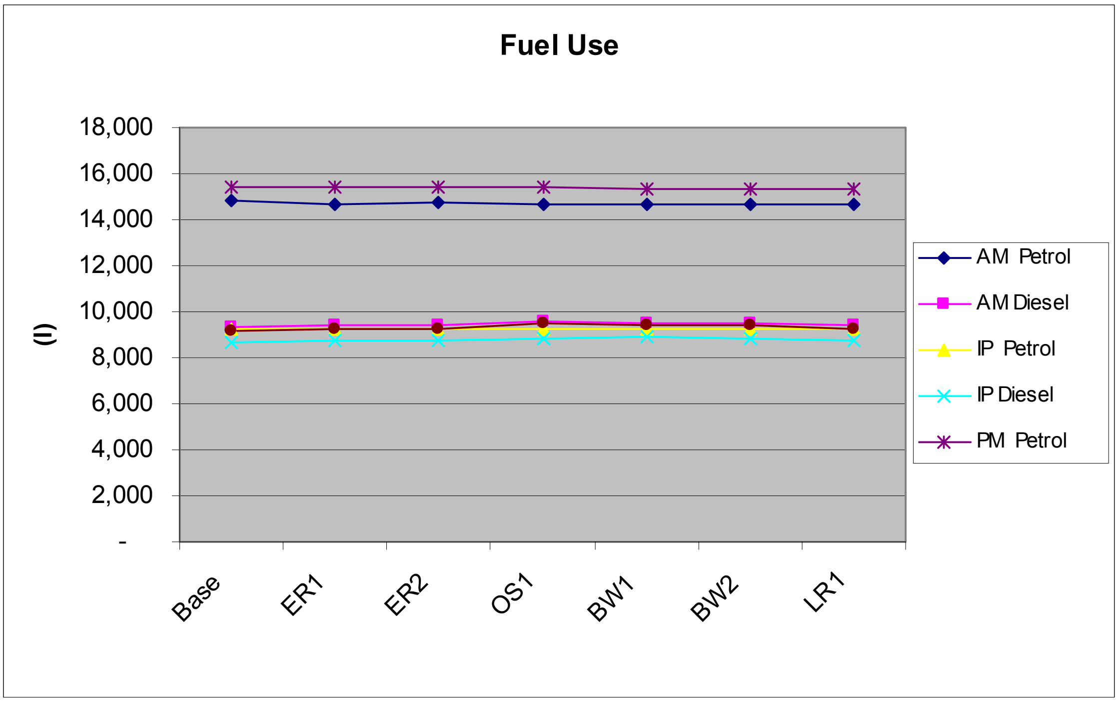
Estimates of general traffic fossil fuel use were extracted from the model as petrol and diesel usage. These are given for the three modelled periods along with the resulting scores in Table 5-36, and then shown graphically in Figure 5-19.

All scenarios show very small reductions in fossil fuel usage compared with the base case, and all perform similarly. Hence all scenarios were scored equally as having an insignificant impact on fuel usage.

- **Table 5-38: General Traffic Fossil Fuel Use (I)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
AM Petrol	14,834	14,707	14,711	14,658	14,647	14,636	14,642
AM Diesel	9,371	9,427	9,432	9,580	9,474	9,488	9,444
IP Petrol	9,260	9,246	9,246	9,222	9,229	9,226	9,228
IP Diesel	8,684	8,791	8,791	8,875	8,883	8,867	8,769
PM Petrol	15,448	15,399	15,395	15,439	15,348	15,356	15,363
PM Diesel	9,146	9,252	9,256	9,483	9,435	9,440	9,276
Total %	100.0%	100.1%	100.1%	100.8%	100.4%	100.4%	100.0%
Score	0	0	0	0	0	0	0

▪ **Figure 5-20: General Traffic Fossil Fuel Use (l)**



F.2.2 Public Transport Fuel Usage

Given the limited number of public transport services operated in the northern suburbs, public transport is unlikely to have a significant impact on fossil fuel usage - be it direct through diesel bus or through electricity generation.

The majority of the northern suburbs would continue to be serviced by diesel bus under any of the scenarios, so the difference between the scenarios would be limited.

Table 5-39 shows the scores given to the criteria PT fuel use. There is little difference form the base or between the scenarios, so they have all been scored as 0.

Undertaking further investigation into public transport energy use was considered unnecessary by the Study's management team due to the strategic results showing little difference between the scenarios.

▪ **Table 5-39: PT Fuel Use**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Score	0	0	0	0	0	0	0

F.2.3 Energy Use Summary

Table 5-40 shows the overall score given to the criteria Energy Use. In terms of the whole of the study area, there is little difference form the base or between the scenarios, so they have all been scored as 0. Detailed investigations into energy uses were not considered appropriate for a strategic study of this nature.

Table 5-40: Energy Use Summary Score

	Base	ER1	ER2	OS1	BW1	BW2	LR1
General Traffic Fossil Fuel Use (l)	0	0	0	0	0	0	0
PT energy use	0	0	0	0	0	0	0
Score	**0**	**0**	**0**	**0**	**0**	**0**	**0**

F.3 Ability to Provide for Residential Intensification Along Transport Routes

Agglomeration or densification along public transport routes was considered to be a benefit because more trips can be made sustainably by public transport. BML investigations into the potential for additional intensification including infill housing did not identify any significant potential for densification in any location other than around the Johnsonville Town Centre. Planning measures could be put in place to incentivise or permit intensification around particular nodes to promote intensification but it is uncertain how the market would respond.

Studies on land use development along public transport routes provide little help in undertaking a quantifiable assessment. It is generally considered that fixed transport modes such as rail, light rail and busways are more effective in promoting intensification because they are considered permanent. Of these modes, light rail has the most proven impacts and amenity and image benefits. Busway are considered to be the least permanent of the modes because buses can be removed from a guideway and utilised elsewhere. Significant intensification is being experienced around busways in Ottawa and Brisbane.

In general, light rail is considered to have the largest impacts on land use development adjacent to a corridor where stations are closely spaced and there are town centres and community facilities immediately adjacent to stations. Heavy rail is considered to have a larger impact adjacent to the corridor where stations are spaced more widely and include larger employment destinations. Busways are considered more appropriate when key centres are dispersed widely from the central spine of the busway.

A detailed assessment of this issue is being undertaken as part of the review of urban development issues and will feed into the decision making process in the future. A high level assessment is included in Table 5-44.

- **Table 5-41: Assessment of Ability to Provide for Residential Intensification Along Transport Routes**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Score	0	0	0	X	0	0	√

F.4 Retention of Cultural Heritage

In general, scenarios which maintain the historically significant Johnsonville Line as a rail based corridor are considered to perform better in relation to retention of cultural heritage. A detailed assessment of this issue is being undertaken as part of the review of urban development issues and will feed into the decision making process in the future. A high level assessment is included in Table 5-42.

- **Table 5-42: Retention of Cultural Heritage Score**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Score	0	√	√	0	0	0	√

F.5 Contribution to Quality Urban Space

Scenarios which have fixed infrastructure are likely to have the largest positive impact on quality urban space by providing opportunity to concentrate large numbers of people. Light rail has the potential to form an integral feature of urban space through the development of transit malls in the CBD. The on-street busway however provides the opportunity for a walking and cycling track through the urban area.

A detailed assessment of this issue is being undertaken as part of the review of urban development issues and will feed into the decision making process in the future. A high level assessment is included in Table 5-43.

- **Table 5-43: Contribution to Quality Open Space Score**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Score	0	√	√	0	√	√	√√

F.6 Ensure Environmental Sustainability Summary

There is little impact under *climate change* or *energy use* for any of the scenarios.

Rail or guideway based scenarios encourage land use development because the fixed infrastructure provides a level of permanence that encourages adjacent investment. Light rail provides minor opportunities to increase intensification along the corridor because of amenity and image benefits while the bus on-street scenario reduces this potential because the fixed infrastructure along the corridor would be lost.

The rail based scenarios (ER1, ER2 and LR1) have improved potential to retain the cultural heritage of the existing railway line because they maintain a rail use.

All the scenarios have a positive impact in contributing to quality urban space except for the bus on-street which removes the fixed infrastructure. Light rail has a moderate positive impact because it provides the opportunity to form an integral part of urban spaces through the development of transit malls in the CBD.

The two rail scenarios perform identically with a small positive impact overall. Compared to light rail, they perform worse overall because of light rail's improved ability to provide for intensification and contribute towards quality urban space. The busway scenarios do not perform as well as the rail or light rail scenarios because they were not considered to contribute effectively to retention of cultural heritage. Bus on-street performs the worst of the scenarios because of the lack of fixed infrastructure.

Table 5-44 shows the overall score for the objective Ensure Environmental Sustainability, where each of the measures was given equal weighting. Table 5-44: Ensure Environmental Sustainability Score

5) ENSURE ENVIRONMENTAL SUSTAINABILITY (More Sustainable / More compact)	**Base**	**ER1**	**ER2**	**OS1**	**BW1**	**BW2**	**LR1**
Climate Change	0	0	0	0	0	0	0
Energy Use	0	0	0	0	0	0	0
Ability to provide for residential intensification along transport routes including the CBD	0	0	0	X	0	0	√
Retention of Cultural Heritage	0	√	√	0	0	0	√
Contribution to Quality Urban Space	0	√	√	0	√	√	√√
Average	**0**	**0+**	**0+**	**0**	**0**	**0**	√

Appendix G Objective 6: Consider Economic Efficiency and Affordability

The objective Consider Economic Efficiency and Affordability was measured using the following criteria:

- Consider economic efficiency
- Consider affordability
- Procurement and implementation staging

G.1 Cost Estimates

Rough order cost estimates were produced for the scenarios at a strategic level in line with the Transit NZ Costs Estimation Manual SM014. Both capital and operating costs were developed for the scenarios:

G.1.1 Capital Cost Estimates

Capital costs include all infrastructure improvements such as new tracks, busways, bus priority measures etc. In the case of the rail and light rail scenarios, the capital cost also includes the purchase of rolling stock. This is because GWRC would need to purchase the units to be operated and maintained by a service provider. The costs of refurbishing units after 15 years was included as a capital cost.

The cost of purchasing buses was not included in the capital cost. This is because the capital cost for buses is included in the bus service contract costs. No residual value was assumed for buses because they are paid for in the annual operating costs. Costs for recovery vehicles were included as a capital cost where appropriate.

No allowance was made for any land purchase costs that could result from a need to purchase the Johnsonville Line corridor from ONTRACK.

G.1.2 Operating Cost Estimates

Operating cost estimates were produced for the scenarios. The operating costs were developed based on current public transport contract costs in the Wellington region and on international experience. On advice from GWRC, an allowance of 2% pa increase in the real cost of PT operating contracts was included.

For rail and light rail, operating costs included vehicle and infrastructure maintenance (stations, signalling operation and monitoring), drivers, management costs and operator returns.

For bus services, operating costs include for all costs associated with providing the services such as drivers, management costs, vehicle capital and finance costs, depoting facilities and operators return. Under the busway, the operating costs also include for maintenance of the busway infrastructure (busway, station stops, signalling operation and monitoring).

G.2 Consider Economic Efficiency

Economic efficiency was measured by way of a comparison of economic benefits, revenues and costs of the scenarios. The economic assessment was carried out in line with the Land Transport New Zealand Economic Evaluation Manual, Volume 2, as required for any scheme which may require government funding.

Table 5-45 illustrates the range of scenario benefits and costs in economic terms and the costs are total costs to the nation. The costs include a risk component developed as detailed in Section H.1.4. The figures presented are Net Present Values (NPV) discounted at 10% over a 25 year evaluation period.

The benefits are derived from the following:

- Public transport user benefits
- Vehicle operating cost benefits
- Accident cost benefits

Costs include capital and operating costs and are expressed in terms of the absolute cost as well as the difference between the costs for the base case and the scenarios (i.e. additional to the base). The BCR (relative to the base) therefore provides an indication of the economic performance of the scenarios, based on the additional expenditure over that which is assumed for the base.

"The deficit between the change in revenues…and the service provider costs is the amount that needs to be funded by local and central government if the proposal is to proceed. The amount that requires funding by local and central government is the 'funding gap'." (LTNZ Economic evaluation manual, Volume 2). The funding gap is a representation of the annual government contribution required for each scenario, taking into account the revenues generated by the various options. It is calculated as the annual payment required to give an NPV of 0 with an internal rate of return of 12%.

Table 5-45: Benefits and Costs ($m)

	Benefit	Cost (additional to base)	BCR	Cost absolute	Funding Gap (pa)	Score
Base	$0	$0	0.00	$128	$9	0
ER1	$9	$55	0.17	$182	$13	XX
ER2	$10	$70	0.14	$198	$14	XX
ER1 (New Units)	$11	$71	0.15	$198	$14	(XX)
ER2 (New Units)	$13	$92	0.14	$219	$17	(XX)
OS1	$14	$25	0.56	$153	$9	X
BW1	$16	$93	0.17	$221	$15	XX
BW2	$19	$85	0.23	$213	$14	XX
LRT	$21	$257	0.08	$385	$24	XX

In Table 5-45 the economic costs for ER1 and ER2 using both refurbished Ganz Mavag units and new units are included. The remainder of the evaluations detailed in this report assume refurbished units and if the new units were to be considered, the rail scenarios would perform better under the other objectives.

In the economic analysis the residual value of the rail and light rail units was accounted for at the end of the 25 year evaluation period. Units older than 15 years at that time were assumed to have a residual value of 20% and units younger than 15 years were assumed to have a residual value of 40%.

Details of what is included in each scenario is included in Section 2. The bus on-street option is more expensive than the base case because it includes general bus improvements (set out in Section 2.1.2), bus priority measures in the northern suburbs, new bus shelters and stop facilities (passenger information systems etc), removal of the rail infrastructure and construction of a walking and cycling track, CBD bus priority measures and an allowance for risk. By comparison the base case initially assumes refurbished rail units operating on the existing timetable, minimum infrastructure improvements and bus services the same as the existing.

Economic evaluations of this type must be undertaken on a project specific basis. This evaluation was undertaken using the costs and benefits directly attributable to the northern suburbs in line with LTNZ policy which does not allow benefits (or costs) attributable to other schemes to be included in the economic analysis. Under the rail scenarios, the costs attributable to the northern suburbs include refurbishment of the Ganz Mavag units and replacement of the Ganz Mavag units after 15 years with new units.

There is an argument that the initial economic cost of the refurbished rail units is actually the cost of purchasing new units. This is because new units would need to be purchased to run on the wider network to replace the refurbished units that would operate on the Johnsonville Line during the peak. This is not appropriate because the costs of new units would be attributed to the scenario but the trains would operate on other services and the benefits would accrue to other projects. These include:

- Operating costs savings generated by the new units
- Patronage benefits
- Vehicle operating cost savings (on the wider road network)
- Reliability benefits
- Any externalities and non-monetised benefits associated with the new units but not experienced on the Johnsonville Line.

It would be unfair to assign the cost of these units to the Johnsonville Line without attributing their benefits. We also believe it is fair to assign the cost of a unit to the section of line where it will be operating, and the cost of a new unit should only be included if it is operating on the Johnsonville Line. These benefits to the wider network cannot be quantified here without undertaking a review of the whole rail network, but would be significant.

In considering the scale of the benefits the new units would provide for the wider network, it is useful to note that the 25-year NPV of the capital costs for the ER1 scenario would only increase by approximately $17.4m if new units were used. However, it was calculated that by providing new units on the Johnsonville Line for the ER1 option the operating costs would be reduced by approximately $2m (NPV). In addition, when the benefits were calculated using new units, there was an increase in benefits of approximately $1.4m (NPV).

Given that the new unit cost would be similar to the above but they would actually operate on the wider network on much longer routes, the operating cost savings and additional benefits on the wider network would be significantly more than calculated for the Johnsonville Line. In addition, because more new units would be available, they would be used on all services during the offpeak period in place of older units, further reducing the operating costs and increasing benefits. These savings and benefits would go a considerable way to offsetting the cost of the new units. We believe the approach of assigning costs and benefits to the Johnsonville Line as they accrue is robust.

Table 5-45 includes the resulting scores for economic efficiency. None of the scenarios have economic benefits in excess of the additional costs above the base case costs. None of the scenarios are economically viable as stand alone projects. The performance of the light rail scenario is affected by the large risk value applied to it. If the risk value was in line with the other rail scenarios the BCR would increase but still be under 1.

The bus on-street is the most economically efficient scenario but is still not economically viable with costs outweighing benefits. The benefits are in the same order as the busway and light rail scenarios, however the costs are significantly less. Changes at the margin to assumptions about infrastructure provided, costs and risks associated with the OS1 or base case could affect the overall efficiency of the OS scenarios.

The BCRs of the rail and busway scenarios are in the same order (between 0.1 and 0.23) and so have been scored as having moderately negative impacts. The light rail scenario performs poorly at around 0.08 and has also been scored as having a moderately negative impact.

G.3 Consider Affordability

A benchmark for what is affordable to the region is the amount of funding currently identified in Greater Wellington's Long Term Council Community Plan (LTCCP) for public transport improvements in the northern suburbs. The amount of funding identified in the LTCCP includes anticipated rates increases over the plan's 10-year period and it is therefore unlikely more money would be available.

The public transport improvements that were included in the "funding envelope" are those identified for improvements on the Johnsonville railway line as set out in Table 5-46 and a small component of limited region wide bus service improvement funding. The LTCCP funding assumes running refurbished Ganz-Mavag units on the Johnsonville railway line, however, the affordability calculations used to determine the funding envelope assumes new units.

- **Table 5-46: Northern suburbs passenger transport improvements allowed for in the Greater Wellington LTCCP**

Improvement	Timing	Cost
Minor Johnsonville Station refurbishment	06/07	$0.2m
Infrastructure improvements to allow the new larger trains to operate on the Johnsonville railway line (Tunnel Lowering)	07/08	$3.0m
Increased length of passing loops at Wadestown and Khandallah to accommodate longer car lengths	07/08	$9.0m
Replacement of the existing English Electric trains which run on the Johnsonville railway line with new EMUs (12 units) or refurbished Ganz-Mavag units	08/09	$42m
Minor station refurbishments	12/13 – 13/14	$1.3m
New EMUs to meet demand (4 units)	11/12	$12m
Total		**$67.5m**

Note: These values are in nominal dollars and include capital costs only. They are therefore not comparable with NPV values used elsewhere.

The twenty-five year affordability envelope for public transport in the northern suburbs is anticipated to be in the order of $105m, with $65m available over the next ten years. In accordance with existing Land Transport NZ funding criteria, the total regional contribution would be $60m, with $35m contributed over the next ten years as part of the current LTCCP[10]. The balance would be funded by Land Transport NZ. The affordability cost calculations are different to the economic cost calculations as they account for fare box revenues and are based on GWRC borrowing money to fund capital items which smoothes out the cash flow and includes financing costs.

Table 5-47 shows the 10 and 25-year NPV costs to government as a whole and the GWRC cost component. The scoring was undertaken on the basis of what is affordable to GWRC over the next 10 years which is the duration of their LTCCP. The base case is less than the LTCCP because it is assumed in the LTCCP that new units will be used, additional infrastructure and station works will be required and an additional train per hour will operate from 2011/12.

The bus on-street scenario scored the same as the base because it is very similar to the base. ER1 and the two busway scenarios were considered to have a minor negative impact on affordability while ER2 was considered to have a moderate negative impact. The capital costs

[10] These figures are expressed in today's equivalent dollars (NPV) and are based on the infrastructure improvements detailed above, information provided on current bus and rail subsidy costs and a percentage of the bus improvement funds available for the region. Affordability calculations were done over a 25 year analysis period with any capital or operational expenditure outside of the 25 year analysis period not incorporated in the calculations.

associated with the light rail scenario are substantial and this scenario significantly exceeds the anticipated level of funding. It was therefore scored as having a significant negative impact.

- **Table 5-47: Affordability Compared to LTCCP Funding**

	Total				GWRC Contribution				Score
	NPV [10]	NPV [10] %	NPV [25]	NPV [25] %	NPV [10]	NPV [10] %	NPV [25]	NPV [25] %	
LTCCP	65	100%	106	100%	37	100%	59	100%	N/A
Base	44	67%	76	72%	26	71%	45	75%	0
ER1	59	90%	109	103%	37	101%	66	112%	X
ER2	65	100%	123	116%	40	110%	73	123%	XX
ER1 (New Units)	67	0%	120	113%	40	110%	71	119%	(XX)
ER2 (New Units)	75	0%	137	129%	45	123%	80	134%	(XX)
OS1	42	65%	81	77%	25	69%	49	82%	0
BW1	62	95%	114	107%	37	102%	68	115%	X
BW2	60	91%	109	103%	36	98%	65	110%	X
LRT	102	156%	184	173%	61	168%	107	179%	XXX

Table 5-47 includes the affordability costs if new units were to be used for options ER1 and ER2. Refurbished units have been assumed for all other evaluations detailed in this report. If new units were to be considered, the rail options would perform better under the other objectives.

G.4 Procurement and Implementation Staging

Scenarios which allow for staged construction or implementation provide the opportunity to defer investment. Deferred investment was considered to be beneficial because while allowing for short term demand to be catered for, the full costs do not have to be committed up front reducing financing charges and allowing funds to be utilised elsewhere. This section considered the possibilities for staged construction of the scenarios.

G.4.1 Scenario 1 – Rail Scenario Procurement and Implementation Staging

ER1 – 13 minute timetable

The minor refurbishment of the English Electric Units which has recently been undertaken is expected to add 3 – 5 years to the life of the units. Refurbishment began in 2005/06, meaning the units will reach the end of their operational lives between 2008/09 and 2010/11.

There is therefore limited opportunity for staged construction for this scenario, as the improvement works would need to be completed before the operational life of the English Electric units is exhausted. Construction works could be pushed out two years to 2009/10 at the latest.

ER2 – 10 minute timetable

As for ER1 above, construction works to enable the 13 minute timetable could be pushed out two years to 2009/10 at the latest.

The works to facilitate the 10 minute timetable would likely take place in 2010/11 so that additional new units delivered in 2011/12 could begin operation allowing for additional capacity as patronage grows. This provides the opportunity for staging construction of the works required for the 10 minute timetable and deferring this investment if desired or if patronage does not increase as predicted.

G.4.2 Scenario 2 – Bus on-street Procurement and Implementation Staging

Construction works could be pushed out to 2009/10 at the latest to utilise the full extended lives of the English Electric units.

There is limited opportunity for staged construction or deferring investment as all buses would be required from the beginning of operation and bus priority measures would be required to ensure an acceptable level of service.

Construction of the walking and cycling track could be postponed indefinitely by leaving the rail corridor as it is.

G.4.3 Scenario 3 – Busway Procurement and Implementation Staging

New buses would be required immediately to provide the on-street rail replacement services during construction of the busway. The whole busway would presumably be constructed at the same time to ensure that it could provide the expected level of benefits at the start of implementation and enjoy scales of economy for construction. As noted in D.2.4, some staging during construction could be provide but this was not anticipated to have a long term impact.

One strategy might be to implement the on-street bus services initially, but to defer investment in the busway infrastructure. If it was determined that on-street bus services could provide an acceptable level of service initially, services could run on the road network allowing the Johnsonville line rail services to be abandoned. In the future, when bus services became more effected by road congestion or if on-street bus services did not attract the patronage anticipated, either the Johnsonville Line could be reinstated or alternatively a busway could be constructed. The busway could also be staged so that only sections where significant time savings could be gained were constructed initially - constructing the section between Ngaio and Hutt Road before the remained of the busway for example. This would have limited benefit as the busway would not cater for buses from the north of the study which would continue to operate via the Ngauranga Gorge.

G.4.4 Scenario 4 – Light Rail Scenario Procurement and Implementation Staging

Construction works could be pushed out two years to begin 2009/10 at the latest to utilise the full extended lives of the English Electric units.

Construction of the Light Rail System could be staged and investment deferred by only constructing the Johnsonville Line section of the proposed Light Rail route initially in 2007/08. This would mean that LRVs could replace the English Electric units at the end of their operational lives, and the CBD section could then be constructed at a later date.

Because of the small order of LRVs and the small length of operation, the costs for purchasing and operating new LRVs on just the Johnsonville section is likely to be significantly more expensive on a per unit basis. LRVs do not provide a strategic fit with current proposals for the remainder of the Wellington network. Therefore, staging the construction in this manner was not considered appropriate unless there was some commitment to extending the LRT network into the CBD or converting the wider Wellington Network to Light Rail in the future.

Construction of the Light Rail scenario would provide the opportunity for staged extension of the line to the south of the CBD along Wellington City's proposed growth spine to the Airport in the future.

It should be noted that the procurement timeframes for obtaining LRVs could become an issue, particularly with the small order proposed. Typically procurement can take up to 3 years to spec units, have them built and delivered. The specification for the new EMU units is well underway at present and a procurement process being followed to ensure the units can be delivered by 2009/10. By contrast it would be some time before a decision on Light Rail was confirmed and the procurement and specification process begun. If an "off the shelf" unit could be specified and added to another order, procurement timeframes would be less of an issue.

G.4.5 Procurement and Implementation Staging Assessment

Based on the discussions above, Table 5-48 notes the major differences between the scenarios and sets out the assessment of potential for procurement and implementation staging for the scenarios being considered.

A score of √√√ indicates a large potential to stage procurement and implementation. A score of 0 indicates no opportunity to stage procurement or implementation.

- **Table 5-48: Assessment of Procurement and Implementation Staging**

Scenario	Sub-scenario	Comments	Score
Base		▪ N/A	0
Scenario 1 - Enhanced Rail	**ER1**	▪ New or refurbished units required to replace existing units in 2009/10 ▪ Works to cater for larger units required as soon as new or refurbished units begin operation. ▪ New units required to cater for additional patronage around 2012	0
	ER2	▪ New or refurbished units required to replace existing units in 2009/10 ▪ Works to cater for larger units required as soon as new or refurbished units begin operation. ▪ New units required to cater for additional patronage around 2012	0
Scenario 2 – Bus on-street and Walking and Cycling		▪ New buses required to replace existing units in 2009/10 ▪ Bus priority works required at the beginning of operation to ensure acceptable level of service ▪ Walking and cycling track could be postponed	√
Scenario 3 – Busway		▪ Potential to operate bus on-street following abandonment of rail services and defer investment in busway infrastructure ▪ Potential for staging construction of the busway	√
Scenario 4 – Light Rail		▪ Potential to stage construction of CBD section after LRT operating on the Johnsonville Line	√√

G.5 Consider Economic Efficiency and Affordability Summary

Table 5-49 shows the overall score for the objective Economic Efficiency and Affordability.

The impacts on economic efficiency are negative for all scenarios compared to the base. None of the scenarios have economic benefits which outweigh the additional costs associated with providing the improvements. The bus on-street is the most economically efficient scenario by a considerable margin with a Benefit Cost Ratio (BCR) of 0.56, however it is not economically viable with costs outweighing benefits. It was scored as having a minor negative impact. The benefits are in the same order as the busway and light rail scenarios, however the costs are significantly less. This scenario also performed best when an incremental BCR analysis was undertaken.

The BCR of the rail and busway scenarios are in the same order (between 0.1 and 0.23) and so have been scored as having moderately negative impacts. The light rail scenario performs poorly at around 0.08 and has been scored as having a moderately negative impact. Light rail has the highest benefits compared to the other scenarios, but also has very high costs.

When compared against the anticipated funding allowed for in the LTCCP over the next ten years, relative to the base all scenarios except the bus on-street scenario had negative impacts on affordability. The bus on-street scenario scored the same as the base. ER1 and the two busway scenarios had minor negative impacts on affordability while the ER2 scenario had moderate negative impacts. The capital costs associated with the light rail scenario are substantial and this scenario significantly exceeds the anticipated level of funding. It was therefore scored as having a significant negative impact on economic efficiency and affordability.

The ability to stage construction and defray financial costs was considered a financial and economic benefit. There is little opportunity to stage construction of the rail scenarios because new rolling stock and associated infrastructure improvements would be required before the operational life of the existing units is exhausted in the near future.

The on-street bus scenario could be staged with construction of the walking and cycling track taking place after abandonment of the rail line. It was therefore scored as having a minor positive impact.

The busway scenarios could require the new buses to operate on-street for a considerable period before the busway was completed. It is estimated that the busway would take between 18 and 24 months to complete. Construction of the busway could be staged with sections completed incrementally. The busway scenarios were therefore scored similarly to the bus on-street scenario as having a minor positive impact. Light rail provides the largest scope for staging construction by allowing the CBD section to be completed in the future, potentially as part of a wider light rail network.

Overall, the rail scenarios perform similarly, with the ER1 scenario performing slightly better overall due to performing better under the affordability criteria. The busway scenarios perform similarly to ER1 but have more potential for implementation staging. The bus on-street scenario performs the best overall due to the smallest negative economic impact and potential for staging. The light rail option performs poorly in terms of economic and affordability impacts.

- **Table 5-49: Consider Economic Efficiency and Affordability Score**

6) CONSIDER ECONOMIC EFFICIENCY AND AFFORDABILITY	Base	ER1	ER2	OS1	BW1	BW2	LR1
Consider Economic Efficiency	0	XX	XX	X	XX	XX	XX
Consider Affordability	0	X	XX	0	X	X	XXX
Procurement and Implementation Staging	0	0	0	√	√	√	√√
Average	**0**	**X**	**X-**	**0**	**0-**	**0-**	**X**

Appendix H Risk

The criteria Risk was measured using the following criteria:

- Risk scores
- Consentability

H.1 Risk Scores

Each of the scenarios present a range of risks and opportunities as transport strategies. As part of this study, a facilitated one day risk workshop was held in Wellington on the 1st March 2006 to identify the size and nature of these risks. Details of the risk process undertaken are included in the report *Wellington City Northern Suburbs Passenger Transport Services Study Comparative Risk Report*, SKM, June 2006.

Given the early stage and strategic level of the study, the workshop did not attempt to determine the finite value of the risks but established a comparative base between the more significant scenarios. Due to time constraints it was not possible to assess all scenarios during the workshop, however enough detail regarding two of the most extreme but realistic scenarios were obtained which provided a base for assessing the remaining scenarios. The two scenarios assessed for risk levels were:

- Enhanced timetable - New EMUs; and
- Busway

The remaining scenarios were scored by SKM staff following the workshop based on the risks identified for the scenarios above at the workshop and in line with the scoring undertaken for them.

Identification of any potential "show stoppers" using the risk assessment approach is now possible by reviewing the tabulated data presented in the risk tables. These are presented in a range of ways that allow comparison of the risks as well as presentation of the full data as it was reviewed during the workshop.

The first two of the following three bases for presenting the results of the risk analysis are provided in this summary.

1) Identifying those risks that differentiate one scenario from another scenario
2) Identifying those risks that are high or extreme for all scenarios
3) Recognising the risks that are neither significant nor affect the decision process but none the less require some level of mitigation and manage control. These risks are retained in the risk register located in the appendices.

H.1.1 Risk Assessment Methodology

The method used during the risk workshop was based on the Transit New Zealand document "Risk Management Process Manual, AC/MAN/1, ISBN 0-478-10560-6. This manual describes both a general and an advanced approach to risk assessment. The general approach was used for the purposes of this workshop.

Eleven strategic level risks were analysed for the transport scenarios. These were:

1) Technical risks associated with the design scenario.
2) Procurement difficulties.
3) Over or under demand for the chosen scenario.
4) Legislative limitations.
5) Failure to meet stakeholder or community expectations.
6) Constructability difficulties.
7) Project capital cost escalation.
8) Inability to obtain funding.
9) Inability to obtain consents.
10) Operational issues.
11) Interface difficulties with existing infrastructure.

The specific risks under each of these general headings were scored against the likelihood and consequence criteria set out in Table 5-50 and Table 5-51. These were then multiplied for the risks to determine their risk score as set out in Table 5-52 and Table 5-53.

Table 5-50: Consequence Criteria

Rating	Descriptor	Health & Safety (H&S)	Image / Reputation (Rep)	Environment (Env)	Stakeholder Interest (Stk)	Cost (Fin)	Delay (Del)
100	Substantial	Multiple fatalities	International media cover	Permanent widespread ecological damage	Commission of Inquiry	>$10m	Many years
70	Major	Several fatalities	Substantial national media cover	Heavy ecological damage, costly restoration	Ministerial Inquiry	$1m to $10m	Years
40	Medium	Serious injuries	Regional media cover or short term national cover	Major but recoverable ecological damage	Ministerial questions or 3rd party investigation	$100k to $1m	Months
10	Minor	Minor injuries	Local media cover	Limited but medium-term negative impacts	Official Information Request	$10k to $100k	Weeks
1	Negligible	Slight injuries	Brief local media cover	Short term damage	Minor Complaint	<$10k	Days

Table 5-51: Likelihood Criteria

Rating	Category	Description	Probability (short term)	Frequency (long term)
5	Likely	The threat can be expected to occur OR a very poor state of knowledge has been established on the threat.	>50%	Greater than once per year.
4	Quite common	The treat will quite commonly occur OR a poor state of knowledge has been established on the threat.	20% - 50%	Once per 1 - 5 years.
3	Unlikely	Threat may occur occasionally OR a moderate state of knowledge has been established on the threat.	10% - 20%	Once per 5 - 10 years.
2	Unusual	The threat could infrequently occur OR a good state of knowledge has been established on the threat.	1% - 10%	Once per 10 - 50 years.
1	Rare	The threat may occur in exceptional circumstances OR a very good state of knowledge has been established on the threat.	<1%	Less than once per 50 years.

Table 5-52: Risk Analysis Matrix

LIKELIHOOD					
5	5	50	200	350	500
4	4	40	160	280	400
3	3	30	120	210	300
2	2	20	80	140	200
1	1	10	40	70	100
CONSEQUENCE	1	10	40	70	100

The colours in the above matrix refer to the following bands of risk:

Table 5-53: Risk Bands

Risk Rank	Level	Typical Mitigation Action
500 to 350	Extreme threat	Avoid
300 to 200	Very high threat	Avoid
200	Very high threat	Avoid or transfer
160	Very high threat	Avoid
140	High threat	Avoid or transfer
120	High threat	Accept actively or transfer
100	High threat	Avoid or transfer
80	High threat	Accept actively or transfer
70	High threat	Avoid or transfer
50 to 40	Moderate threat	Accept actively
30	Moderate threat	Accept actively
20 to 10	Low threat	Accept actively or transfer
5	Low threat	Accept actively
4	Low threat	Accept actively
3	Negligible threat	Accept passively
2	Negligible threat	Accept passively
1	Negligible threat	Accept passively

H.1.2 Differentiating Risk Scores

The scenarios assessed at the risk workshop also included the scenario of using new rail rolling stock as well as refurbished rolling stock to identify if there was any significant difference between them. The following table shows only those risk scenarios where there is a difference in the risk scores between the scenarios. Whilst it is not technically correct to simply add these scores together it does provide a qualitative assessment of the relative risks. Note that the table does not address the relative opportunities for each scenario. The fill colour is used to highlight which of the scenarios carries the higher risk. The colour used in these cells reflects the band of risk as defined in the risk matrix. Each risk was considered against a number of risk types including health and safety (H&S), delay (Del), cost (Fin), image / reputation (Rep), environmental (Env) and stakeholder interest (Stk).

Table 5-54: Differentiating Risks Scores

Scenarios	Risk Type	Most Likely Risk						
		Base Timetable		Enhanced Timetable		Bus way	Bus on street	Light rail
		New EMU	Refurbished EMU	New EMU	Refurbished EMU			
Constructability difficulties.	Del	160	160	160	160	500	20	400
Failure to meet stakeholder or community expectations.	Del	30	30	30	30	120	160	400
Inability to obtain funding.	Del	280	280	280	280	280	160	400
Constructability difficulties.	Fin	160	160	160	160	280	20	400
Constructability difficulties.	Rep					120	20	
Constructability difficulties.	Stk	160	160	160	160	30	20	280
Failure to meet stakeholder or community expectations.	Fin						160	
Failure to meet stakeholder or community expectations.	Rep	20	20	20	20	160	160	160
Failure to meet stakeholder or community expectations.	Stk	20	20	20	20	280	160	120
Inability to obtain consents.	Fin	3	3	3	3	40	40	280
Inability to obtain consents.	Stk	40	40	40	40	40	40	160
Inability to obtain funding.	Fin	40	40	40	40	40	30	160
Inability to obtain funding.	Rep					30	30	
Inability to obtain funding.	Stk	40	40	40	40	30	30	160

Scenarios	Risk Type	Most Likely Risk						
		Base Timetable		Enhanced Timetable		Bus way	Bus on street	Light rail
		New EMU	Refurbished EMU	New EMU	Refurbished EMU			
Interface difficulties with existing infrastructure.	Del	120	120	120	120	160	160	400
Interface difficulties with existing infrastructure.	Fin	120	120	120	120	160	210	400
Interface difficulties with existing infrastructure.	Stk	30	30	30	30	160	160	280
Legislative limitations.	Del					280	350	350
Legislative limitations.	Fin					40	280	280
Legislative limitations.	Fin						280	
Legislative limitations.	Rep					40		280
Operational issues.	Del	30	30	30	30		120	160
Operational issues.	Fin	30	30	30	30	160	120	280
Operational issues.	Rep						30	
Operational issues.	Stk	120	120	120	120	160	120	120
Over or Under demand for the chosen option.	Fin	160	160	160	160	160	160	160
Over or Under demand for the chosen option.	Rep	80	80	80	80	120	120	120
Over or Under demand for the chosen option.	Stk	80	80	80	80	160	160	160
Procurement difficulties.	Del	160	160	160	160	160	160	400
Procurement difficulties.	Fin	40	160	280	160	160	160	280
Procurement difficulties.	Stk	40	40	40	40	160	160	160
Project capital cost escalation.	Fin	280	280	280	280	280	40	280
Project capital cost escalation.	Rep	40	40	40	40	120	40	160
Project capital cost escalation.	Stk	40	40	40	40			160
Technical risks associated with the design option.	Del	160	160	160	160	200	200	350
Technical risks associated with the design option.	Fin	280	280	280	280	200	200	500

Scenarios	Risk Type	Most Likely Risk						
		Base Timetable		Enhanced Timetable		Bus way	Bus on street	Light rail
		New EMU	Refurbished EMU	New EMU	Refurbished EMU			
Technical risks associated with the design option.	H&S					20		
Technical risks associated with the design option.	Rep						160	
Technical risks associated with the design option.	Stk	40	40	40	40	200	200	200
TOTAL RISK SCORE		**2803**	**2923**	**3043**	**2923**	**4640**	**5050**	**8400**

Since the risk workshop was undertaken, further investigations were undertaken into the scenarios. One issue which arose was the risks associated with operating a one way busway on the tight Johnsonville alignment. There is poor forward sight distance available and the frequencies anticipated increased such that there would be very small headways (in the order of 1 – 2 minutes) between the buses. Moving block signalling was therefore included in the costing for this option. There is no experience of operating a one way busway on such a tight geometric alignment, therefore the risks associated with this option were assumed to be more significant than first anticipated. No alteration has been made to the scoring above, however a more significant health and safety risk should be included under operational issues for the busway scenarios.

H.1.3 Significant Risks

Those risks that were consistently ranked with the same extreme or very high ranks regardless of the study scenario were identified. These risks are not useful for differentiating between scenarios but must be mitigated during the project management, design and implementation stages of the project. The issues noted below were identified during the workshop and require action to fully assess the risk of the scenario. Adjustments to the ranking may occur once this is completed.

The significant risks identified were:

- Technical issues associated with the design scenario
- Procurement difficulties
- Under or over demand for the chosen scenario

- Constructability difficulties
- Project capital cost escalation

H.1.4 Financial Risks

Only those risks with a financial impact were subsequently modelled using a Monte Carlo simulation to establish the likely effect, those with a delay, environmental, health and safety, reputational or stakeholder impact have not been assessed in the Monte Carlo model. Given the relatively subjective nature of the input information in terms of the likelihood and range of cost, this is however preliminary at this stage. As an example, an extreme risk of a 500 signifies a likelihood of 50-100% of a cost impact of greater than $10 million [with no upper threshold]. To this end a preliminary assessment has had to be made to establish the risk parameters.

- **Table 5-55: Financial Risk Assessments ($m)**

	Base	ER1	ER2	OS1	BW1	BW2	LR1
Mean	14	14	14	21	39	39	120
P95	20	20	20	27	52	52	151

There are however a couple of fundamental risks which have not been assessed in the risk model due to the nature of the original model.

Two most significant risks, absent from the financial Monte Carlo assessment are the uncertainty around the base cost estimate (given that it is based on very preliminary information), and the risk associated with the use of the rail corridor for non-rail purposes. Whilst the risk associated with the uncertainty around the estimates would apply to a similar level to all of the scenarios the risk associated with the use of the corridor once it ceases to be a rail route would only be applicable to the bus on-street and bus way scenarios. This issue is discussed further in Section H.2.

H.1.5 Risk Score Summary

The analysis above was used to score the performance of the scenarios in terms of construction and operational risks. Table 5-56 shows the number of extreme risks and the total risk scores. Whilst it is not technically correct to simply add these scores together it does provide a qualitative assessment of the relative risks.

The risks associated with the rail scenarios are consistent with the base and were scored as 0. The busway and bus on-street scenarios have a higher level of risk and were scored as having a moderate negative impact. Light rail was scored as having a significant negative impact on risk.

- **Table 5-56: Risk Scores**

	Base Timetable - New EMU	Base Timetable - Refurbished EMU (ER1)	Enhanced Timetable – New EMU	Enhanced timetable – Refurbished EMU (ER2)	Bus on-street (OS1)	Busway (BW1 & BW2)	Light Rail (LR1)
No. of Extreme and Very High Risks	9	10	10	10	20	21	22
Risk Total	2803	2923	3043	2923	4640	5050	8400
Score	0	0	0	0	XX	XX	XXX

H.2 Consentability

This section reviews the anticipated planning, consenting and approvals process that would be required for the implementation of the scenarios being considered. Only significant planning and approval issues were highlighted here, with a brief overview of the process involved. Many of these processes are unclear because they have not been undertaken in this context previously and a detailed legal opinion would be required to clarify them. GWRC and WCC have decided that it would be inappropriate to undertake a review of this nature at this stage.

H.2.1 Existing Situation

A preliminary review of the planning status of the existing Johnsonville line corridor was undertaken. Under the operative District Plan, the Johnsonville Line corridor (from Thorndon Quay to Johnsonville Station) is designated as a rail corridor (designation reference R1) for *Railway Purposes including tunnels and bridges*. The underlying zoning for the corridor is primarily Open Space A or B, although Johnsonville Station is within Suburban Centre. The Wellington Rail yards are also designated for Railway Purposes (reference R5) and have an underlying Central Area zoning.

As such, rail transport activities and associated structures and work, are permitted activities under the existing designation of the Operative Wellington City District Plan.

However, it is noted that any works which require regional consent under the Regional Plans require approval from the Greater Wellington Regional Council as such works are not permitted with the scope of designations.

H.2.2 GWRC Approvals Process

The recommendations of this study would need to be considered by the Regional Passenger Transport Committee (PT Committee) and they would need to recommend the proposals to the Regional Council for formal adoption. The PT committee and the Regional Council meet every 6 weeks so this process could be completed in a number of months if both accept the recommendations.

Subsequently, GWRC would need to include the proposals in the GWRC LTCCP (including any funding requirements) by February or March to meet consultation requirement which would be completed by 30 June. Therefore, depending on when the proposals were adopted, this process could take up to two years for any scenario.

H.2.3 LTNZ Funding Approvals

Following inclusion of proposals in the LTCCP, GWRC would need to apply to Land Transport New Zealand (LTNZ) for funding through the Funding Allocation Process (FAP). It was assumed this process could take approximately 1 year for any scenario but could take place concurrently with other consenting processes.

H.2.4 Scenario 1 – Enhanced Rail Consentability

The Johnsonville Line currently operates through the corridor which is designated for rail use. Consequently, no change to the designation of the corridor would be required to continue operation of the rail line, either in its existing format or with modifications to allow for improved timetabling. While no design has yet been undertaken for the additional passing loops and station removals / relocations, it was assumed that they could be constructed within the existing designation. In respect of Johnsonville Station, any works would likely fall within the existing designation, or otherwise need to comply with the underlying Suburban Centre zoning. Additionally, it was assumed that no earthworks of sufficient scale to trigger regional consents would be required.

Park ‘n’ ride facilities may need resource consent approval from WCC and proposals for encouragement of intensification around Johnsonville could require a District Plan Change. However, these measures are not essential to the operation of the enhanced rail scenarios and could take place while the upgrades were being undertaken.

H.2.5 Scenario 2 – Bus on-street Consentability

This scenario would essentially require buses to operate on existing roads. Some bus priority measures would be required. However, it is expected that these could be undertaken substantively within the existing road reserve and without the need for large amounts of earthworks. It was anticipated that any structures (such as bus shelters) on road reserve would require resource consent as a discretionary activity. Careful consideration would need to be given to the location of any structures with preference being to utilise any existing stops thereby reducing the need to apply for resource consent.

As part of this scenario, it is envisaged that the Johnsonville Line corridor would be revised to provide a walking and cycling track and possibly for recreational amenity. This is a change in use of the Johnsonville line corridor from rail to recreation, requiring removal of the designation, to allow the underlying Open Space zoning to apply, and as such would trigger a number of planning considerations. The Operative District Plan does not designate open space areas and there appears little merit in pursuing a recreation designation for the revised corridor given the underlying permissive Open Space zoning which would allow the walkway and cycleway as a permitted activity.

In respect of Johnsonville Station, any works would likely comply with the underlying Suburban Centre zoning. The same applies for any works within the Central Area.

There are potentially significant construction works including earthworks, removal of the railway line and modifications to bridges etc. along the length, and therefore some Regional Consents for earthwork or working near to watercourses may be required. Depending on the scale of the activity, these are not in themselves considered to be problematic.

A removal of designation process would need to be undertaken under the Resource Management Act 1991 (RMA) and is a relatively straight forward process. Section 182(1) allows a requiring authority to give notice that it no longer wants a designation or part of a designation in a district plan. Section 182(2) states that the territorial authority "shall, without further formality amend its district plan" to show the removal of a designation or part of a designation. General notification or the calling for submissions is not required. However, notice must be given to "Every other person who, in the opinion of the requiring authority, is likely to be affected by the designation". The wording indicates that the complete removal of a designation should be an administrative task, not requiring analysis, or the involvement of territorial authority decision makers. Given the known level of support for rail from some sectors of the community, it would be reasonable to expect that there would be an appeal made against this removal of designation. Because no submissions process is required, it is likely that this would have to go to the High Court for a Judicial Review.

The rail line could simply be abandoned and not used for a walking and cycling track. This would mean that buses could operate on-street and no removal of designation would be required. Agreement would however need to be reached over who would be responsible for safety and maintenance if for example the tunnels fell into disrepair. ONTRACK may no longer wish to be financially responsible for the corridor if it were not used for rail purpose and as such, a new requiring authority would need to take over responsibility for the designation.

ONTRACK have advised that it believes that, under the Rail Network Bill that was introduced in 2005, the use of the Johnsonville Line for non-rail uses would require the permission of the

Minister of Transport. The exact process that would be required is unclear. However, it would be reasonable to assume that this would include a review by the Ministry of Transport and production of Ministerial briefing papers.

Change of ownership issues are also raised by this change in use. WCC would need to acquire the land for use as a walking and cycling track and the New Zealand Railways Corporation may be bound to dispose of the land via a competitive tendering process in which WCC would have to bid. It is likely that WCC would need to approve the adoption of this corridor as GWRC cannot by statute pay for, own or maintain a walking and cycling track.

ONTRACK have advised that it believes that if the corridor was no longer to be used for rail purposes, the land would have to be offered back to the original owners and this could involve claims to the land by local iwi. Should this be the case, there could be a significant delay to the process while settlements were reached and there could be a large financial implication for the scenario.

WCC and GWRC have chosen not to seek a legal opinion on the process and possible "buy-back" provisions as the Rail Network Bill is before Parliament. It is felt that, until the Bill has been enacted, it would be premature to commission an opinion. In consultation with GWRC and WCC it was decided to assume that it could take between 1 and 2 years to obtain the approvals required from central government.

The GWRC LTCCP currently anticipates the purchase of new rail units to operate on the Johnsonville Line. The operation of buses on-street and construction of a walking and cycling track in the Johnsonville corridor is a large change, but the removal of the rail designation itself is not considered problematic from a legislative processing perspective. The public's attitude to the removal of the railway line is a separate issue.

H.2.6 Scenario 3 – Busway Consentability

This scenario would require the Johnsonville rail line to be converted into a guided busway from Johnsonville Station through to the Hutt Road overbridge. This is a change in use of the Johnsonville line corridor from rail to a busway use and as such would likely trigger a number of planning considerations.

There are essentially two planning options –

1) The removal of the Railway Corridor designation; or,
2) Changes to the designation itself.

For option one, the withdrawal process under Section 182 of the Resource Management Act would apply as outlined above for the bus on-street scenario. The corridor would revert to its underlying Opens Space zoning. The use for a guided bus way is then potentially permitted as the plan provides for "the upgrade and maintenance of existing formed road and access ways" however it could be argued that this concept was never envisaged by these words. From a resource management perspective, this is the more viable option. Given the known level of support for rail from some sectors of the community it is reasonable to expect that there would be an appeal made against this removal of designation. Because no submissions process is required, it is likely that this would have to go to the High Court for a Judicial Review.

Option two would require the removal of the designation, and application for a new designation (Notice of Requirement (NOR) under Section 168 of the RMA). The new body financially responsible for the guided busway, being the "Requiring Authority" would need to make this application. It is noted that there are no similar designations currently in the District Plan.

This raises issues over which organisation would have financial responsibility for a busway, who can or would own and maintain the infrastructure and land and the classification of the busway (as a road etc.). It should be noted that GWRC is permitted to have an interest in passenger transport infrastructure but not roads. These issues would need to be addressed, agreed and formally adopted by Councils.

Sections 168 to 171of the RMA set out the procedures for processing a notice of requirement. The procedure is similar to that for a notified resource consent in that the process involves the request for further information, submissions, and hearing procedures. However, following the hearing, the territorial authority is required to make a recommendation on the notice of requirement, of which the requiring authority then accepts or rejects.

The NOR would need to include a detailed Assessment of Environment Effects (AEE) which would describe all potential impacts and how these would be mitigated, consideration of alternatives, consultation details and detail on other consents required. The preparation of the NOR itself could take up to 6 months, depending on the scale of works required. Given a one-way guided busway is a new concept for New Zealand, a significant level of information would be required and a feasibility study would need to be undertaken which could take 6 months to 1 year. The submission, hearing and decision process could take between 6 months and 1 year.

If at this time the application is successful, there is a period of 6 weeks for appeals to the decision to be lodged. Appeals would be held in the Environment Court and given the level of community interest, it is likely that some form of appeal would be lodged against the abandonment of a railway line. While the new NOR is likely have a positive outcome, there is the potential for the public to use the process to object to the abandonment of the rail line. The timeframe to schedule and hear an appeal in the Environment Court is likely to be in the order of 18 – 24 months.

Section 181(3) of the RMA provides for alterations to a designation, provided that there is no more than a minor change to the effects on the environment or if it only involves minor changes or adjustments to the boundaries of the designation or requirement. This option requires further consideration, but an initial interpretation is that the nature of the changes are such that the changes would give rise to more than minor effects.

Additionally, there are significant construction works including modifications to bridges etc. along the length, therefore some regional consents for earthwork or working near to watercourses may be required. Depending on the scale of the activity, these are not in themselves considered to be problematic.

It is anticipated that the Busway Scenario would have the same ownership, "buy-back", iwi and Ministerial approval issues and timeframes as described above for the Bus on-street scenario.

Some bus priority measures would be required. However, it is expected that these could be undertaken substantively within the existing road reserve and without the need for large amounts of earthworks. Therefore, no significant consenting or planning hurdles are envisaged for the bus operation for the on-street sections.

The GWRC LTCCP currently anticipates the purchase of new rail units to operate on the Johnsonville Line. The construction and operation of a busway is a large change and it is likely that there would be a delay while WCC and GWRC approvals were obtained.

Because a busway would be a new mode for New Zealand, LTNZ would need to provide safety approval and develop regulations for its use. This could take more than 1 year but could run in parallel with the consenting process.

H.2.7 Scenario 4 – Light Rail Consentability

The Johnsonville Line currently operates through the corridor which is designated for rail use. As Light Rail is still a rail based technology, it was assumed that no change to the designation of the corridor would be required to continue operation of the line using light rail technology. This would need to be confirmed by a detailed review of the planning status of the Johnsonville rail corridor and a legal opinion.

If an alteration to the designation is required, it is submitted that this could be undertaken as an alteration in accordance with Section 181(3) of the RMA. Provided that there is no more than a minor change to the effects on the environment or if it only involves minor changes or adjustments to the boundaries of the designation or requirement, and both the territorial authority and the requiring authority agree with the alteration, the alteration can be made without the formal process of notification and submissions required for a new designation.

Given the level known level of support for bus based services from some sectors of the community, it is reasonable to expect that there would be an appeal made against this alteration of designation. Because no submissions process is required, it is likely that this would have to go to the High Court for a Judicial Review. An application would also need to be made under Section 180 of the RMA for the transfer of rights and responsibilities for the designation from the existing Requiring Authority (being ONTRACK) to the new body that is financially responsible for the light rail line. This raises issues over which organisation would have financial responsibility for a light rail line, who can or would own the infrastructure and land. These issues would need to be addressed, agreed and formally adopted by the Councils.

While no design has yet been undertaken for the additional passing loops and station removals / relocations, it was assumed that they could be constructed within the existing designation. Additionally, it was assumed that no earthworks of sufficient scale to trigger regional consents would be required.

This scenario also requires significant works to be undertaken on the section between Wellington Station and Courtenay Place. The works would be undertaken largely within the existing road reserve, and based on the Central Area zoning, would not likely trigger any resource consent requirements. There may however be road stopping requirements. A feasibility study would need to be undertaken to confirm the viability of Light Rail which could take 6 months to 1 year.

As this scenario involves major alterations to the way traffic and parking would operate and impacts on retailers in the CBD, there would be large issues to be considered by WCC. More detailed investigations into the feasibility of the scenario and preliminary design work would need to be undertaken which could take 6 – 12 months. It is possible that WCC hearings would be required and it is anticipated that this could take between 4 months and 1 year.

The GWRC LTCCP currently anticipates the purchase of new rail units to operate on the Johnsonville Line. The construction and operation of a Light Rail scheme is a large change and it is likely that there would be a delay while WCC and GWRC approvals were obtained.

Because a light rail system would be a new mode for New Zealand (tourist trams operate in Christchurch), LTNZ would need to provide safety approval and develop regulations for its use. This could take more than 1 year but could run in parallel with the consenting process.

H.2.8 Assessment of Consentability

An assessment of the difficulty of obtaining planning, consenting and Council approvals was undertaken. A score of 0 relates to approvals and consents reasonably being able to be obtained within 3 years (related to the estimated remaining economic life of the refurbished EEMUs). A score of XXX relates to approvals and consents reasonably only being able to be obtained after 5 years.

Scenario	Council Approvals / Further Investigations	LTNZ FAP	Change of Designation	Change of ownership / buyback / Ministerial approvals issues	Regional Council Consents	LTNZ Safety and Regulation Issues	Score
Base	▪ GWRC PT Committee, GWRC Council approvals and LTCCP submissions	▪ Yes	▪ N/A	▪ No	▪ No	▪ No	0
Scenario 1 - Rail	▪ GWRC PT Committee, GWRC Council approvals and LTCCP submissions	▪ Yes	▪ N/A	▪ No	▪ Unlikely	▪ No	0
Scenario 2 – Bus on-street	▪ GWRC PT Committee, GWRC Council approvals and LTCCP submissions ▪ WCC adoption of walking and cycling track approvals / hearings	▪ Yes	▪ Yes - removal ▪ Possible appeal to High Court	▪ Yes	▪ Possibly - minor	▪ No	X
Scenario 3 - Busway	▪ GWRC PT Committee, GWRC Council approvals and LTCCP submissions ▪ Feasibility Study ▪ Investigation and WCC / GWRC busway adoption approvals / hearings	▪ Yes	▪ Yes – removal or new designation ▪ Appeal to Environment Court or High Court (for point of law) highly probable	▪ Yes	▪ Yes – earthworks etc.	▪ Yes	XXX

Scenario 4 – Light Rail	▪ GWRC PT Committee, GWRC Council approvals and LTCCP submissions ▪ Feasibility Study ▪ Investigations and WCC / GWRC Light Rail adoption approvals / hearings ▪ WCC approvals / hearings on CBD alterations	▪ Yes	▪ Possibly – change to existing designation ▪ Possible appeal to High Court	▪ Unlikely	▪ Possibly - minor	▪ Yes	XX

SKM

H.3 Least Risk Summary

Table 5-57 shows the overall score for the measure of Risk, where each of the measures was given equal weighting.

The two rail scenarios perform in a similar way to the base and each other, having the best overall score which is similar to the base case risks. Bus on-street performs the next best having a moderately negative impact. The major risks for the bus on-street scenario are associated with failure to meet community expectations, resulting under demand for the services, and difficulties interfacing with existing infrastructure through the CBD. Compared to light rail it performs better overall because of the risks associated with consenting and construction of the light rail line. Light rail and the busway perform similarly overall. However, both have substantial risks. The risks associated with the busway in terms of construction and implementation are less than the light rail due to light rails large construction requirements through the CBD. This difference is offset by the additional consenting issues associated with the busway scenario.

- **Table 5-57: Risk Score**

7) Least Risk	Base	ER1	ER2	OS1	BW1	BW2	LR1
Risks associated with implementation and operation	0	0	0	XX	XX	XX	XXX
Consentability	0	0	0	X	XXX	XXX	XX
Average	**0**	**0**	**0**	**X-**	**XX-**	**XX-**	**XX-**

Political risk related to adverse public reaction to the chosen option has not been included in this assessment.

Appendix I Sensitivity Tests

I.1 Light Rail for Johnsonville Only

Implementation of light rail only on the Johnsonville line section was not considered appropriate for a number of reasons including the fact that it would require a small number of unique units which would not provide a strategic fit with the remainder of the regions public transport network.

Intuitively, additional capacity would need to be provided over the CDB section between the Wellington Station and Courtenay Place to cater for patronage for trips taking place wholly within the CBD. There may be some additional demand for these trips generated, however the majority would currently take pace on bus services and would result in a modal shift.

The focus of this study is on providing PT services for the northern suburbs. A test was undertaken to identify how light rail might perform if it continued to provide a seamless service from Johnsonville to Courtenay Place but did not provide additional frequency services through the CBD.

A best case scenario was tested where all benefits achieved for the CBD section were maintained, revenues were maintained, however the costs associated with operating the additional CBD services were removed.

This had the impact of increasing the BCR for the project and improving performance against the affordability criteria. The relative BCR increased from 0.08 to 0.10. The % of the 10 year LTCCP funding reduced from 168% to 148%. While having a beneficial impact on the economic performance of the scenario, the test shows that only allowing for costs associated with the northern suburbs did not change its relative performance compared to the other scenarios, and would not impact on the scoring overall.

I.2 Impact of Construction Disruption

Because of the extended scale and duration of disruption under some scenarios, there may be a longer term impact on patronage. Once people have shifted back to the use of private vehicles, the public transport “habit” is broken and it can be difficult to attract them back out of their cars and it would take some time to build up patronage to the levels forecast in the long term.

The impact that this type of extended disruption can have on public transport service patronage was highlighted by the sustained patronage loss experienced by Tranz Metro following track temperature problems in the past. Trans Metro have advised that once the problems were addressed it took a considerable time before patronage returned to the levels experienced before the problem. Equally, it could be argued that a new or improved service would attract patronage immediately as people would want to try the improved facilities and service.

In order to address this issue, sensitivity tests were carried out on the economic performance of those scenarios which have large scale or extended construction durations. The revenues for the first year of implementation were reduced by 30%. These are ramped up to the forecast levels linearly over the next two years. A 20% reduction in benefits for the first two years of operation and a 10% reduction in benefits of the third year is assumed for the busway and light rail as a sensitivity test. These changes were found to have a very small impact on the economic performance of the options overall.

I.3 Impact of Additional Patronage / Assumed Growth Rates

The model used for this evaluation was calibrated against the observed patronage and vehicle flows from 2001. Since this time there have been changes in the use of public transport which can in part be attributed to recent fuel price increases. The use of the model is appropriate to determine the relative performance of the options. Actual current patronage figures for the Johnsonville line are not available and there is anecdotal evidence that the number of passenger using the Johnsonville line at present could be more than forecast using the model. This could have an impact on the viability of services.

To address this issue, the demand, patronage, benefits and revenues forecast for 2016 were applied from 2008/9 through to 2016 in the economic analysis. This has the effect of accounting for additional benefits and revenues etc. in the first few years which is where they would have the biggest impact due to the discount rate of 10% used. Experience with forecasts for future demand in Wellington indicates that there is limited growth expected after 2016 and there is expected to be an upper limit to the public transport mode share achievable in the study area.

Sensitivity tests changing the growth rates between 2006 and 2016 and after 2016 were undertaken. Because the model output is for 2016, this year was fixed, and various growth rates were extrapolated forward beyond 2016, and backwards to 2006. Changes to the assumed growth rates had little impact on the overall economic performance of the different scenarios.

I.4 Bus Cost Increases

This assessment has been undertaken using costs for bus services that are based on GWRC expected contract costs, current contract costs and New Zealand experience. One of the unit rates applied is an amount per peak bus required per year. This amount is intended to cater for fixed costs associated with the bus including insurance etc. The way that bus contracts operate is that the capital cost of purchasing and funding the buses are covered in the operating costs and should be included in the peak bus unit rate. The rates experienced in Wellington are extremely low and would not cover the cost of purchasing a bus (depreciated over 15 years) and the cost of financing. This could be a result of the bus companies working hard to utilise the buses for charter or off peak commercial services and therefore spreading the cost.

If a large number of additional buses were required for the peak periods only, it is unlikely that additional services could be found for the buses or drivers off-peak to help offset the purchase costs. This could result in the cost of bus services increasing substantially. GWRC have advised that for some contracts they are experiencing large cost increases over expected inflation which are claimed to be the result of increase wage and fuel bills.

To test the impacts of increased bus operating costs we have undertaken a test to increase the per bus operating costs by approximately 250%.

All scenarios performed very similarly despite the cost increases. In terms of financial performance, the BCR for the scenarios decreased slightly (in the order of 0.02 – 0.03 for all options except OS1 which has a 0.2 reduction) and did not effect the scoring given to the scenarios under economic efficiency.

I.5 Impact of Bus Improvements Only

General bus improvements are set out in Section 2.1.2 and these by themselves (without changes to the Johnsonville Line) could have an effect on the performance of public transport in the study area.

A test was undertaken using the rail services used in the base case (13-minute,13-minute, 26-minute timetable using Ganz Mavag Units), but the general bus improvements that were anticipated under the majority of the scenarios were also included.

- **Table 5-58: AM Peak Patronage – Bus Improvements Only Sensitivity Test**

	Base 2016	ER-1	Base + Bus Improvements
% of Base	100.0%	104.4%	102.5%

Table 5-58 shows that a large proportion of the additional patronage (approximately 58%) could be achieved through improved bus services alone. This is because the bus service improvements were generally targeted at areas which are not served by rail. As seen with other scenarios, improvements to one mode take patronage from the other.

I.6 Impact of Busway Travel Times

Assumptions were made about travel times on the busway. Detailed investigations and design work would be required to determine travel times. It was assumed that travel time from Johnsonville to Lambton interchange would be comparable with rail - 21-minutes for services that stopped at all stations. This was reduced by 2-minutes to 19-minutes for non-stopping express services.

Tests were undertaken where the travel time was reduced by 2-minutes over the assumed travel time for all services.

For the reduced travel time tests, the busway performed similarly to the base busway options. In terms of financial performance, the BCR increased in the order of 0.01. This does not however affect the relative performance of the busway against the other scenarios or the way there would have been scored.

Table 5-59 sets out the changes in patronage as the result of the alternative travel times. Reductions in travel times on the busway had only a limited impact on the performance of the option. Significant reductions would be required to have a meaningful impact on the busway option's performance.

- **Table 5-59: AM Peak Patronage – Alternative Busway Travel Times Sensitivity Test**

	Base 2016	BW1 +2min	BW-1	BW1 – 2min
Travel time	n/a	23min	21min	19min
% of Base	100.0%	103.9%	106.2%	107.3%

I.7 Mode Specific Constant Impacts

In the model, a factor is applied to the in-vehicle travel times of the current modes to represent differences between them that cannot be attributed to other quantifiable attributes (such as waiting time, fares etc). The base WTSM model has factors of 1.0 for existing bus and 0.9 for existing rail; that is, rail times are reduced by 10% over the actual modelled times, whereas bus times are not. These factors were determined during the calibration of the base year (2001) model.

In introducing a new or improved mode the factors may be changed to reflect a change in the relative attractiveness of both the mode (eg condition of vehicles, comfort) and the associated facilities (stations, signage, information, lighting, etc). These changes are often referred to as mode specific constants.

Based on experience and a review of practice within New Zealand, the constants in Table 5-60 were applied in the modelling of the options for this study. The factors are relative to an existing mode, in this case bus, which has a factor of 1.0.

- **Table 5-60: Mode Specific Constants Applied in Option Modelling**

	Travel Time Factor
Bus (on-street)	1.00
New Heavy Rail	0.80
Refurbished Heavy Rail	0.88
Light Rail (on rail corridor)	0.80
Light Rail (on-street)	0.90
Busway (on own corridor)	0.90

A sensitivity test was undertaken, by applying a factor of 0.8 instead of a factor of 0.9 to the services operating on the busway.

- **Table 5-61: AM Peak Patronage – Change to Mode Specific Constant for The Busway**

	Base 2016	BW1 – 0.8	BW-1
Modal Constant	n/a	0.8	0.9
% of Base	100.0%	107.3%	106.2%

Table 5-61 shows that changes to the mode specific constant to bring it in line with that used for heavy rail had only limited impact on the forecast patronage. It is therefore considered that mode specific constant assumptions would not have a significant impact on the performance of the scenarios.

I.8 Impact on General Traffic in the CBD

The strategic nature of the model means that it is not appropriate for investigating detailed changes to the network at a local level. In modelling the scenarios, it was assumed that the level of service and travel times experienced by public transport on the CBD bus route would remain constant for bus or light rail as the result of bus priority or LRT priority measures put in place. This approach did not include for the potential adverse impacts on general traffic as a result of the priority works.

A worst case scenario was tested where all through traffic was banned from using Lambton Quay (and other roads e.g. Courtney Place) with only vehicle access to properties catered for. This test was carried out on the Light Rail scenario, but is indicative of the impact that would be experienced with the busway or bus on-street scenarios if traffic was banned on some streets.

Table 5-62: Changes to Vehicle Travel times (min) from Johnsonville as the result of Banning General Traffic in the CBD

Destination	Base 2016	LR-1	LR1 + CBD Closure
Average Auto %	100%	99%	99%

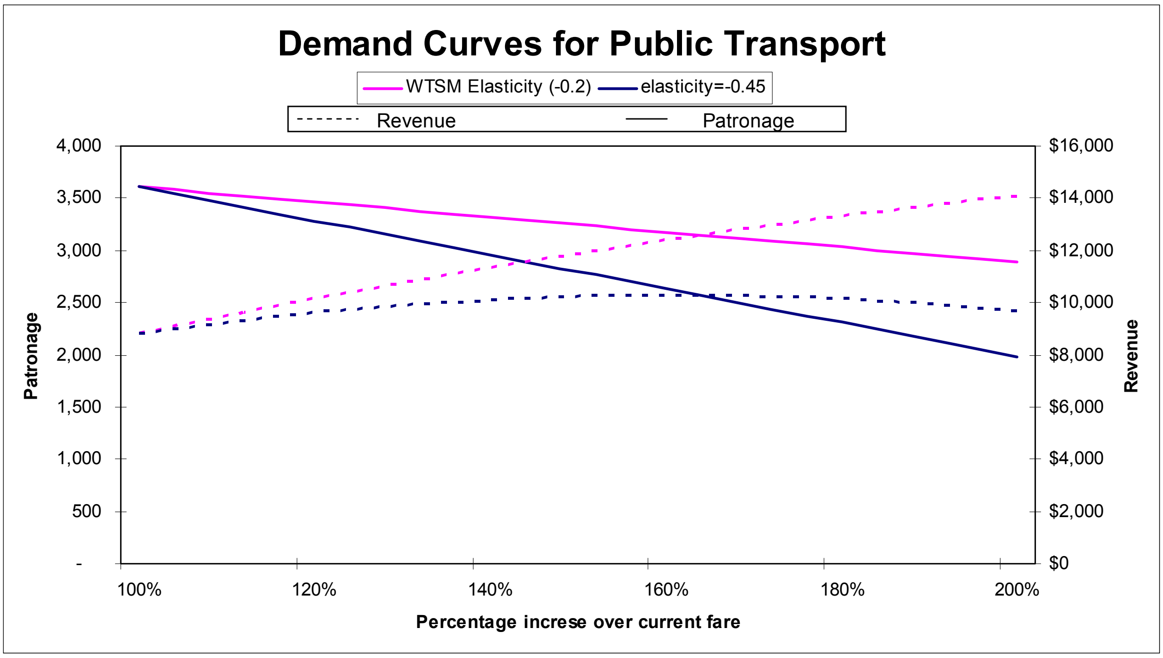
From this test we can see that while there could be adverse impacts on general traffic, these even in a worst case, would be minor.

I.9 Fare Increase

The assessments undertaken have been on the basis of the fare structure remaining similar to that recently adopted by GWRC. If fares are increased, the revenues generated are higher and the contribution by government becomes less. Another result is that PT patronage will reduce as people move away from public transport because of the increased costs.

A sensitivity test has been carried out to identify what impact this may have on peak patronage and affordability (Figure 5-21). Initial fare price and patronage are based on those obtained from the 2016 Base model. A -0.2 elasticity value was used to create the demand profile for the WTSM model based upon those set out in the *Wellington Transportation Strategy Model TN22.1 Validation Report (July 2003).* The -0.45 elasticity value investigated is in line with other fare elasticises in NZ.

- **Figure 5-21: Fare Price Elasticity**



There is a large difference between the sensitivities. The WTSM elasticity shows that a 50% increase in fares would result in a 10% loss of demand. Alternatively using the higher end -0.4 elasticity, a 50% increase in fares would result in a 22% loss of demand. There is a risk of significant patronage loss as the result of increases in fares and in practice it would be hard to justify the loss of significant patronage on economic grounds as benefits would also reduce.

I.10 Impact of Increase Vehicle Travel Times

The travel time for private vehicles from the northern suburbs into the CBD is considerably shorter than for public transport. The travel times assumed in the model are forecast assuming significant improvements such as the Ngauranga - Aotea 8 laning, Terrace Tunnel improvements and Inner City Bypass etc, which result in improved performance of the network. It is possible that because of increased congestion, the actual travel time in the future could be longer and may result in a modal shift from private vehicles onto public transport.

A sensitivity test has been carried out to identify what impact increase travel times on the road network may have on patronage. Initial patronage is based on those obtained from the 2016 Base model. A -0.07 elasticity value was used to create the demand profile for the WTSM model based upon those set out in the *Wellington Transportation Strategy Model TN22.1 Validation Report (July 2003)*. A -0.25 elasticity value was also investigated which is in line with other travel time elasticises in NZ.

We assumed that the reduction in private vehicle demand is all transferred onto public transport. For a 20% increase in private vehicle travel times, the WTSM elasticity resulted in a 1% increase in patronage. Using the -0.25 elasticity, the greatest increase was 5%; ie 3600 to 3800. This indicates that moderate travel time changes on the road network are unlikely to have a large effect in determining the preferred scenario.

Appendix J Model Development and Testing Procedures

J.1 Model Overview

The Wellington Transport Strategy Model (WTSM) is a multi-modal transport model used to evaluate integrated transport packages within the Wellington region at the strategic level. WTSM is based on Emme/2, a transportation modelling package used by over 645 government and private organisations worldwide.

J.1.1 Model Development

The current version of WTSM was developed jointly by Beca Carter Hollings & Ferner and SKM between 2001 and 2003. This allowed the latest demographic information on the region from the 2001 Census to be used as a base, detailing population, household and employment distribution. Specific additional information for sub-model development and validation included:

- Household Travel Survey (2500 households, 7000 people, 36000 trips)
- Other Surveys: Rail (5100 people), School (3900 students), External Screenline (7200 people)
- Road screenline traffic counts
- Public Transport boarding and screenline counts
- Bus speed and car travel time surveys

The development process and delivered version of WTSM has been peer reviewed by Arup Australia.

J.1.2 Model Structure

WTSM is a traditional four-stage model, covering trip generation, mode choice, trip distribution and assignment.

The Wellington region is divided into 225 internal and 3 external transport zones based on land use and demographic factors, so that each zone is relatively homogeneous. The number of trips produced in and attracted to each zone is derived from each zones' characteristics and relationships observed in the 2001 data, and is calculated within the trip distribution stage.

The generalised travel costs are combined with geographically and modally stratified constants, which indicate the relative appeal of origin-destination combinations and preferences between modes. Thus, the perceived aspects of travel are included. Trip distribution and mode choice are undertaken using these perception adjusted values of travel cost to give trips by mode.

Trips are assigned to the road or public transport networks, where the decision of which route to take is based on the generalised cost of travel. Each trip (person) in the assignment chooses the route that minimises their cost of travel (not just time).

The mode choice, distribution and assignment stages are successively iterated, using the previous iterations travel costs, until the model converges.

J.1.3 Generalised Cost

The generalised cost of travel represents the cost to a traveller of making a particular trip by their chosen mode. For trips made by private vehicles it consists of travel time, vehicle operating costs, parking charges and any toll payments required. For public transport trips the generalised cost comprises travel time, walk time, wait time, boarding penalty, transfer penalty and fare. Monetary based attributes are converted before being added to the travel times.

J.1.4 Time Periods

WTSM models three time periods on an 'average' weekday:

- AM (7.01 – 9.00 am)
- Inter-peak IP (9.01 am – 4.00 pm)
- PM (4.01 – 6.00 pm)

Trips are calculated for the three periods and then adjusted for trip retiming, where trips are deferred out of the peak periods into the inter-peak. This peak spreading is a response to increasing travel costs in the peak periods.

J.1.5 Trip Purpose

Trips are calculated for seven purposes within the model, each with their own characteristics, including value of time:

- Home Based Work: Trips between home and work - commuters
- Home Based Education: Trips between home and educational sites
- Home Based Shopping: Trips between home and shopping locations
- Home Based Other: Trips between home and other locations
- Non- Home Based Other: Trips between two locations neither being home
- Employers Business: Trips made for work purposes

- Heavy Commercial Vehicle Trips

J.1.6 Network

The modelled network includes all major roads in the region, with greater detail within regional CBDs, and all public transport (rail, bus, cable car and ferry) services.

J.1.7 Future Years

Transport demands are driven by land use and demographics. Trip demand in modelled future years is derived from demographic projections based on Statistics NZ growth assumptions.

Alterations are made to the road network and public transport services to model the changes anticipated to occur between 2001 and the relevant future year.

The future years currently modelled by WTSM are 2016 and 2026.

J.1.8 Policy Testing

Policies are tested by making changes to the 2001 or future year models. These changes can include modifications to the network, public transport services, travel perceptions and costs such as parking charges and tolls.

Assessment of the policy option impact is measured by changes in travel patterns and costs.

J.1.9 Model Outputs

WTSM calculates travel times and vehicle numbers on each part of the modelled road network, and passenger numbers on each link of every public transport service. A wide variety of outputs are available, including trip numbers, vehicle counts, PT patronage, trip times, etc.

Policies are evaluated against a range of criteria derived from the LTMA, with the model providing some quantitative outputs. LTNZ's Project Evaluation Manual procedures are used to calculate:

- Travel time costs for vehicle occupants and PT passengers, including additional congestion frustration costs;
- Vehicle operating costs, including additional congestion costs; and
- Additional costs/benefits due to traffic induction (people shifting mode due to improved traffic conditions).

Ambient air emissions (Carbon Monoxide, Nitrogen Oxides, Volatile Organic Compounds and Particulate Matter), fuel use and Carbon Dioxide emissions are also output.

J.1.10 Further Information

Documentation of WTSM development, calibration and validation process is available in a series of 25 Technical Notes produced between 2001 and 2003.

J.2 WTSM Use in the NWPTS

WTSM was used to forecast the performance of the scenarios. The original version of the model had a base year of 2001, with associated planning data, networks and other model inputs along with a specification and model validation (which was formally documented) and a User Guide.

Since it's delivery a number of potential changes were investigated and others implemented in the model by GWRC. Some of the changes were incorporated into the model used for the Western Corridor Study. These changes were reviewed and the following were implemented by the study team:

- small base year network corrections implemented by GWRC;
- incorporate the latest GDP growth forecasts used by GWRC; and
- the revised model iteration procedures.

J.3 Forecasting Scenarios

The forecast years and future networks and other inputs were discussed and agreed with GWRC.

The forecast year is 2016 and was chosen to be consistent with other GWRC strategic modelling undertaken. The land use inputs (population, employment, etc) are generally the same as currently used by GWRC. As part of the study, BML undertook a review of: the land uses in the study area; the Northern Growth Management Framework (NGMF); and the UDS growth spine concept, and made an assessment of the potential for infill housing and new development. These projections are detailed in the Appendix A of the *North Wellington Public Transport Study Scenarios Report*, NWPTS Project Team, June 2006, and were used to modify the land use projections in the model for 2016.

The 2016 network specifically includes:

- Lindale Station
- Raumati Station
- WC Rail Option 3
- Rail Freq improvements north of Plimmerton
- Adelaide Rd Upgrade

- Basin Reserve
- Dowse / SH2 Grade Separation
- Haywards / SH2 Grade Separation
- Inner City Bypass
- Korokoro / SH2 Partial Grade Separation
- MacKays Crossing
- Ngauranga - Aotea 8 laning
- Petone - Ngauranga HOT Lane
- Terrace Tunnel Tidal Flow
- Transmission Gully
- Western Link Road Stage I
- Western Link Road Stage II
- Whitford Brown / SH1 Grade Separation
- Otaihanga Grade Separation
- Mana Interim Improvement Removal
- Paekakariki Hill Adjust Back
- Petone-Newlands-Grenada/Tawa Link
- Western Link to Te Moana Cutoff
- Western Link Free Speed set to 55 km/h
- Paekakariki Traffic Signals

The results from the model are routinely extracted on a region wide basis. Because the study area only accounts for a small proportion of the regional network, results at a regional level show little overall change, indicating that the changes proposed are not significant at a regional level. Where appropriate, the results were extracted for either the northern suburbs by themselves of for the corridor from the northern suburbs through the CBD in order to identify difference between the scenarios at a more local level.

J.4 Assumptions and Estimates

The model and modelling process use a range of assumptions and predictions or estimates (many of which are intrinsic to the model calibration and development), including the following:

- The growth in population and employment and their location within the region (used as inputs into the numbers of trips generated),
- Future car ownership levels (input into the model's car ownership model),

- Future economic growth (future GDP is used, along with future land use estimates, in estimating growth in commercial vehicle traffic),
- Car occupancies, which remain constant in forecasting (used for estimating cars from persons in cars),
- The sensitivity of peak spreading to changes in travel costs (an input to the peak spreading model),
- The future roading and PT networks assumed to be in place in the forecast year(s) (see above),
- Future fuel costs, which are assumed to remain constant over the forecast period (an input into private vehicle operating costs and then generalised costs),
- Future values of time, which remain constant over the forecast period (an input into the private vehicle generalised costs),
- PT attributes and weightings, such as: the weightings applied to access, egress and waiting times, the time penalty applied to transfers, the relationship between waiting time and service headway (inputs into PT generalised costs).