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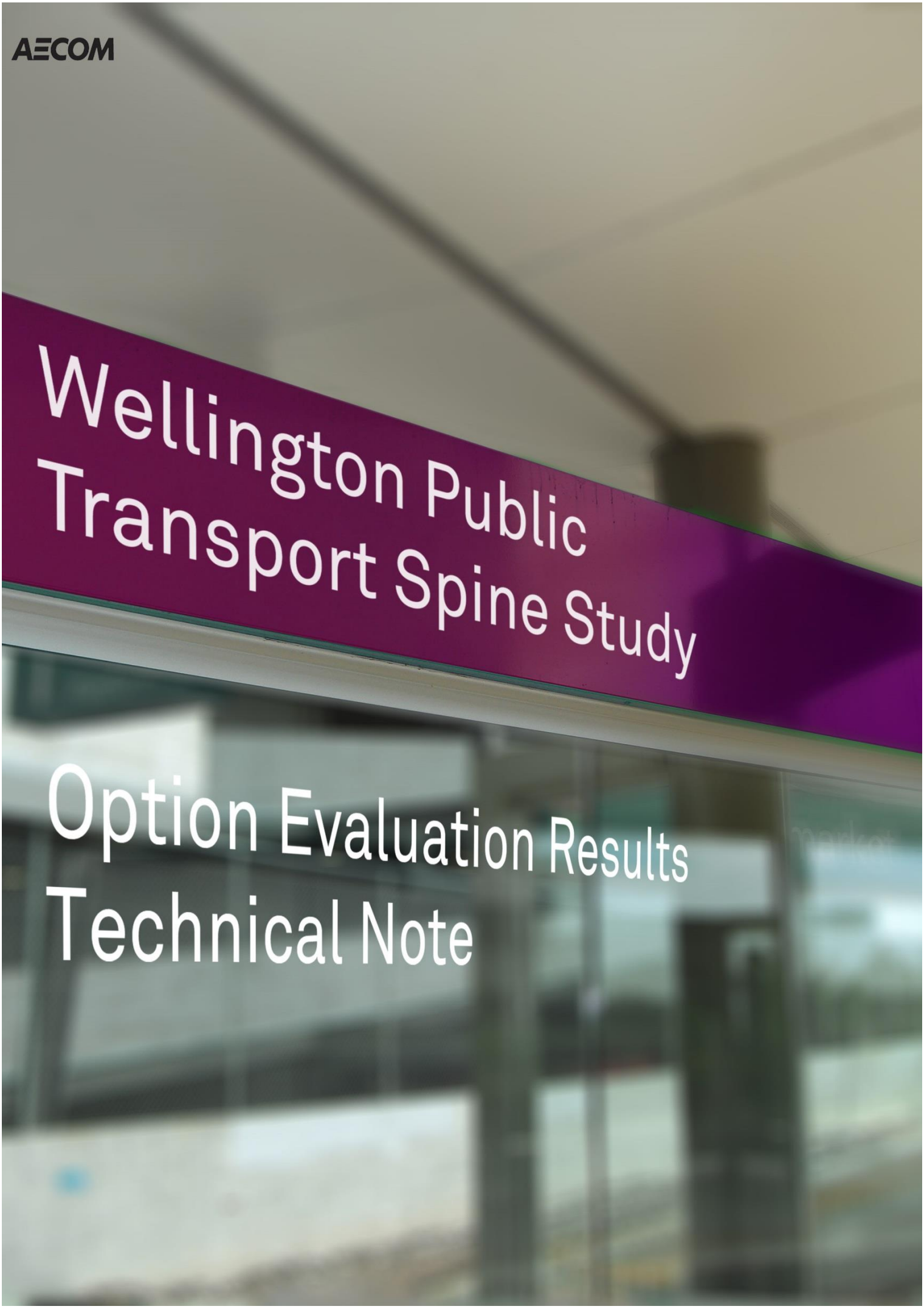

Option Evaluation Results Technical Note

Option Evaluation Results

Prepared for

Greater Wellington Regional Council

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Glossary

Abbreviation	Definition
Alignment	A series of corridors that make up the main public transport Spine for public transport through a specific area of the city (e.g. central, eastern, southern)
BBC	Treasury's Better Business Case Framework
BCR	Benefit Cost Ratio
BP	Bus Priority
BRT	Bus Rapid Transit
CBD	Central Business District
Corridor	A section of road with a fairly consistent cross section width
Cross Section	The layout of a portion of road, including lane configurations and widths. These are often represented in this report by a cross section diagram
EEM	Economic Evaluation Manual
EMME/2	Multimodal Equilibrium (Modelling Package)
GIS	Geographical Information Systems
Golden Mile	The section of Wellington CBD between the Bee Hive and the Embassy Theatre
GPS	Government Policy Statement
Greater Wellington	Greater Wellington Regional Council
HOV	High-Occupancy Vehicle
KPI	Key Performance Indicator
LOS	Levels of Service
LRT	Light Rail Transit (e.g. tram)
LTMA	Land Transport Management Act
LU	Land Use
MCA	Multi-Criteria Assessment
Mode	The main vehicle type that will be applied to the public transport Spine. These are Bus, Bus Rapid Transit or Light Rail Transit
MoT	Ministry of Transport
MRT	Mass Rapid Transit (heavy rail)
N2A	Ngauranga to Airport Corridor Plan

Abbreviation	Definition
NZTA	New Zealand Transport Agency
NZTS	New Zealand Transport Strategy
PPM	Parry People Mover
PT	Public Transport
PTSS, the Study	Public Transport Spine Study
RLTS	Regional Land Transport Strategy
RMA	Resource Management Act 1991
RoNS	Roads of National Significance
RPTP	Regional Public Transport Plan
RTN	Rapid Transit Network
SATURN	Simulation and Assignment of Traffic to Urban Road Networks
SES	Social Environmental Screen
SWOT	Strengths, Weaknesses, Opportunities, Threats
TDM	Travel Demand Management
TOD	Transit Orientated Development
TSD	Transit-Supportive Development
TWG	Technical Working Group
UD	Urban Design
ULT	Urban Light Transit
WCBR	Wellington City Bus Review
WCC	Wellington City Council
WPTM	Wellington Public Transport Model
WTSM	Wellington Transport Strategy Model

1.0 INTRODUCTION

The Wellington Public Transport Spine Study (PTSS) is about determining what a future public transport solution for Wellington might be – one that is high quality, modern and meets the future aspirations and demands of this city.

This Technical Note is one of a suite of technical documents that informs the PTSS. It describes the option evaluation results for three preferred short listed options:

- Bus Priority
- Bus Rapid Transit
- Light Rail Transit.

A list of the other Technical documents that have informed the Study are listed in Appendix A.

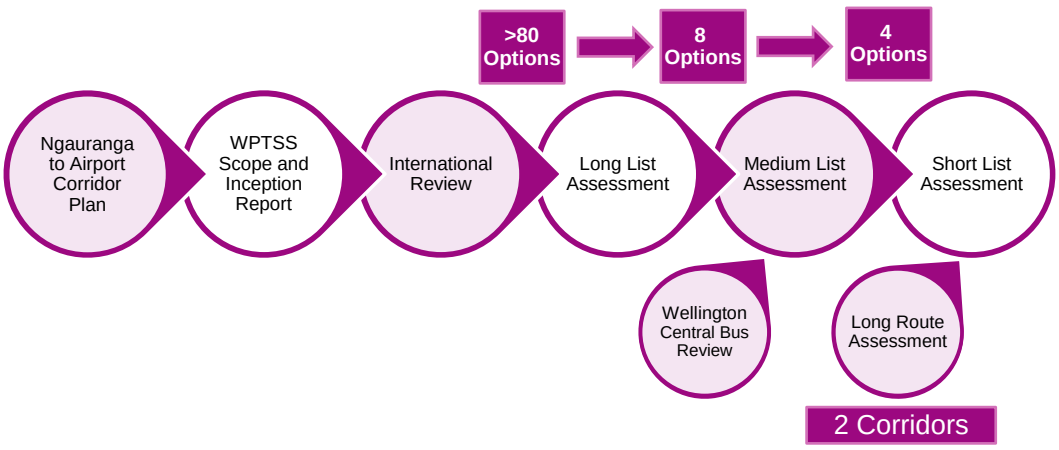
2.0 OPTION EVALUATION PROCESS

2.1 Introduction

2.1.1 Process

The study process is illustrated in Figure 1. The PTSS approach has progressively narrowed down the number of options (Long List Assessment, Medium List Assessment and Short List Assessment), with each stage providing a more detailed analysis of those options. This report explains the evaluation results for the Short List Assessment. The results of the Long List and Medium List Assessment are presented in separate Technical Notes.

Figure 1 Study process



2.2 Short List Evaluation Approach

The Short List Assessment provides a detailed feasibility assessment of the three short listed Bus Priority, Bus Rapid Transit and Light Rail Transit options. The approach includes the following assessment methods:

- **Cross sections for each alignment and corridor.** Cross sections were developed to provide a level of certainty that the proposed options could be constructed as well as identify key constraints and limitations. The cross sections represent potential options for implementation. They are not intended as a detailed design but rather concepts to be taken further in subsequent stages. The concept design for each option is presented in Appendix C.
- **A suite of regional transport models.** Transport models were developed to test the latest land use and transport forecasts, inform the testing of options, provide quantification of the impacts of each option and provide input into the economic evaluation. Details of the modelling approach are contained in the Greater Wellington Regional Council Modelling Report.
- **Planning, social and environmental.** This assessment included impacts on businesses and residential property owners and aspects such as loss of parking and disruption to everyday business. The Planning, Social and Environmental approach is contained in Appendix C.
- **Staging.** This outlined how each option could be staged in line with demand projections, other capacity improvements (e.g. Basin Reserve) and option operational characteristics. It also took into consideration the timing of planning, consultation and other approvals.
- **Cost estimates of constructing and operating the options.** The cost estimates were based on a schedule using rates derived from similar construction works and international reviews. The approach to the

cost estimation is presented in Appendix E. The approach to estimating the cost of operating public transport services is presented in Appendix F.

- **Economic evaluation of each option.** This was based on an Economic Evaluation Manual and behavioural analysis assessment. Sensitivity testing was also undertaken around economics. The economic evaluation approach is presented in Appendix D.

The modelling, cost estimate, and economic approaches were developed, discussed and refined with an independent peer reviewer, prior to the work being undertaken.

3.0 SHORT LIST OPTION DEFINITION

3.1 Short List Option Definitions

Definitions and the key modal characteristics of each of the three short listed modes are presented in Table 1.

Table 1 Modal factors

Bus Priority	
Definition	- An enhanced bus network with greater priority than present at intersections and along key corridors. - Bus vehicles (similar to existing) - Capacity of 64 passengers
Key characteristics	- Provides peak period bus lanes and priority at intersections to bypass congestion on key corridors - Would build on current bus priority lanes - Could be developed incrementally as opportunities arise and resources become available - Limited time needed for planning, consultation end environmental assessments
Bus Rapid Transit	
Definition	- Dedicated BRT lanes as well as other system improvements to enhance frequency and journey times. - Modern low floor articulated or double-decker bus vehicles - Capacity of 100+ passengers
Key characteristics	- Provides new high capacity and high quality buses running on dedicated bus lanes with priority at signals - Flexible in that it would allow local bus services to make use of the facilities provided - Provides corridors with little interaction with traffic except at intersections - Needs careful consideration of staging to allow easy transition between road sections for different vehicle types
Light Rail Transit	
Definition	- Dedicated lanes and tracks as well as interchanges to transfer from other modes - Modern low floor vehicles - Electric powered (issuing overhead wires) - Capacity of 180+ passengers
Key characteristics	- Provides new high capacity and high quality light rail vehicles on dedicated lanes and tracks with priority at signals

	- Buses would be able to use the dedicated Light Rail Transit lanes providing that platform and station configurations are designed accordingly. - Its staging would need to consider how existing bus services would be affected, until the network is fully operational - Not as flexible or resilient as Bus Priority and Bus Rapid Transit due to the fixed nature of the tracks

3.2 Short List Corridors

The core public transport spine was identified from the Wellington Railway Station to Wellington Regional Hospital and Newtown. As part of testing alternatives extending the spine north, west and south were also considered. This was through a review of future (2031) patronage demands. The conclusions from this analysis are outlined below.

3.2.1 For connections to the north

- The average distance for rail users to their final destination from the Wellington Rail Station is short (0.9 km), with the majority of these trips by walking or cycling (90% in the AM peak).
- The majority (86%) of future forecast trips from the north and end in the CBD rather than travelling through. This applies for all modes (including cars) in 2031.
- Public transport already has a high share of trips from destinations to the north (40% - 70%). Replacing heavy rail with an alternative mode is unlikely to increase this significantly.
- Converting the Johnsonville line to Light Rail Transit as a sub-option, has its own costs and challenges:
    - There would be significant costs for conversion (tunnel widening, platform lowering, additional passing loops)
    - Double the number of Light Rail Vehicles would be needed to replace the capacity of the 4 car Matangi holding 490 passengers. This would increase the number of vehicles required and necessitate additional passing loops or double tracks.
    - There would be significant disruption to services for a long period during construction/conversion.

For these reasons, extending the public transport spine to the north was not pursued further in this study. The proposal is to provide on-going train and bus service improvements.

3.2.2 For connections to the west

- There is insufficient demand for a high capacity public transport service from the west as well as topographical constraints. The proposal is to maintain and incrementally improve existing bus services.

3.2.3 For connections to the south and south east

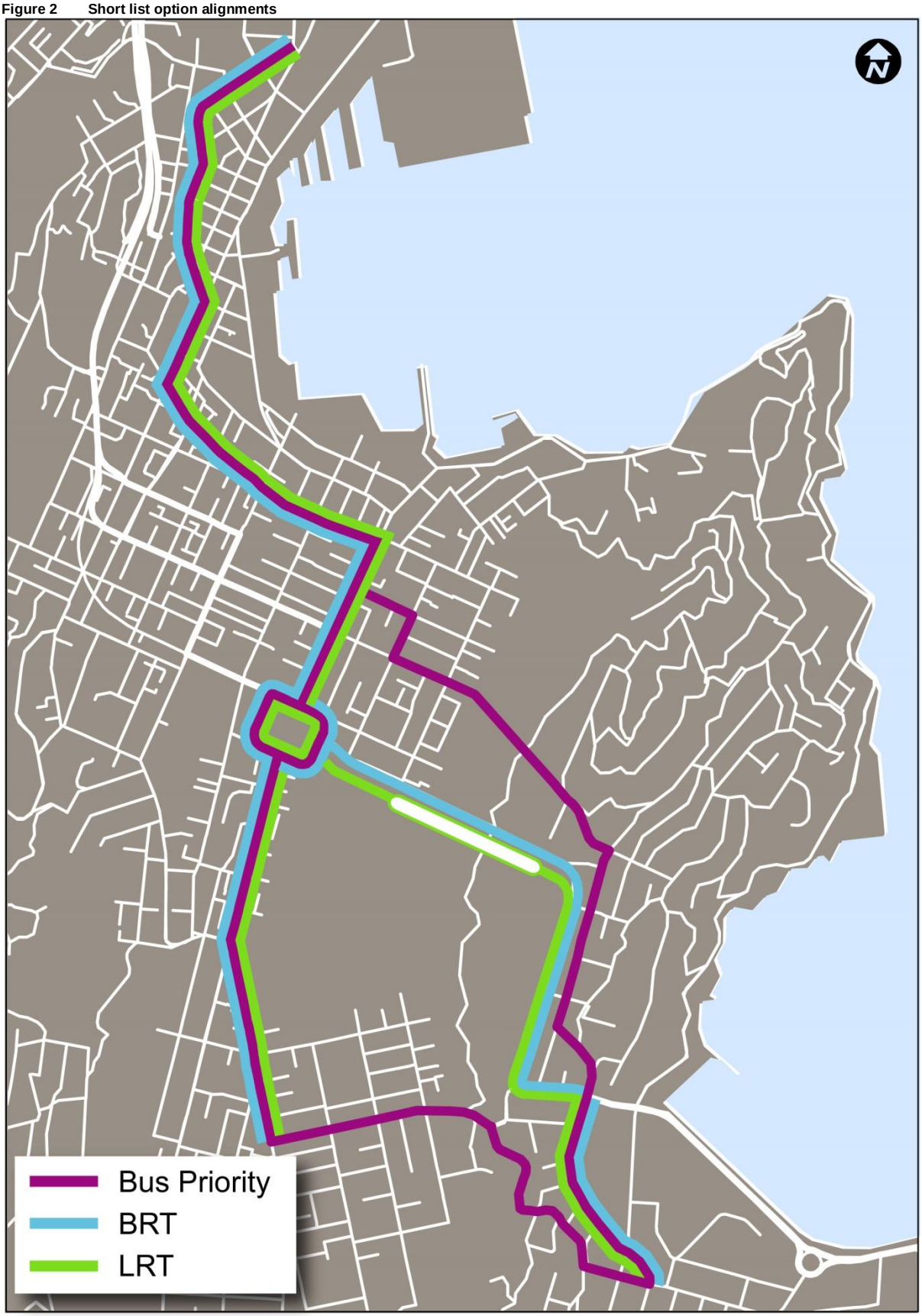
- In contrast to connections to the north public transport to the south and south east has a relatively low (for Wellington) share of AM peak hour trips (30% - 40% to the CBD), so provides a greater opportunity to capture additional passengers.
- The increase in forecast passenger numbers does not justify the extension of a high capacity public transport service, for example, Light Rail Transit from Newtown to Island Bay.
- Extending a high capacity public transport service to Kilbirnie would provide a more direct and quicker service to the CBD and would be justified by forecast passenger numbers. It would also be preferable to other options that may require a modal interchange to complete the journey to the CBD.

For these reasons, extending the primary Bus Rapid Transit, Light Rail Transit to Kilbirnie in the south-east was further considered in the PTSS. The routes considered for Bus Priority, Bus Rapid Transit and Light Rail Transit are illustrated in Figure 2.

As shown, the main southern route alignment option involves a split route from the Basin Reserve with one 'branch' travelling east via the Mount Victoria tunnel to Kilbirnie and the other 'branch' continuing via Adelaide Road to Newtown.

A number of sub-options to link through to the south-east via Newtown were examined and dismissed. These sub-options included using Constable Street and a new tunnel from Newtown to Kilbirnie. Both of these result in longer journey times and have capacity issues due to corridor restrictions.

Figure 2 Short list option alignments



3.3 Cross Sections by Mode

3.3.1 Overview

Cross sections for each alignment and corridor were developed to provide a level of certainty that the proposed options could be constructed and to identify any key constraints and/or limitations. The cross sections represent potential options for implementation and how each option is different to the others. They are not intended as a detailed design but rather concepts to be taken further in subsequent project stages. The concept design for each option is presented in Appendix B and discussed further below.

3.3.2 Bus Priority

The Bus Priority alignment follows the Golden Mile and Manners Street to Courtenay Place. It then travels down Cambridge Terrace and Kent Terrace, heading south towards the Basin Reserve and on to the Wellington Regional Hospital, then east through the Mount Victoria bus tunnel to Kilbirnie.

Central Alignment

On the Wellington (Central) Alignment (see Figure 3), the Bus Priority short list option is similar to the existing situation with the bus lanes provided where buses presently travel on congested roads. Bus lanes would operate in both directions during peak times on Lambton Quay, Willis Street and Manners Street.

On Courtenay Place, Cambridge Terrace and Kent Terrace bus lanes are only required in the morning and evening peaks based on demand in the applicable direction, reverting to parking or general traffic off peak. Buses heading east would continue to use the Mount Victoria bus tunnel.

Southern Alignment

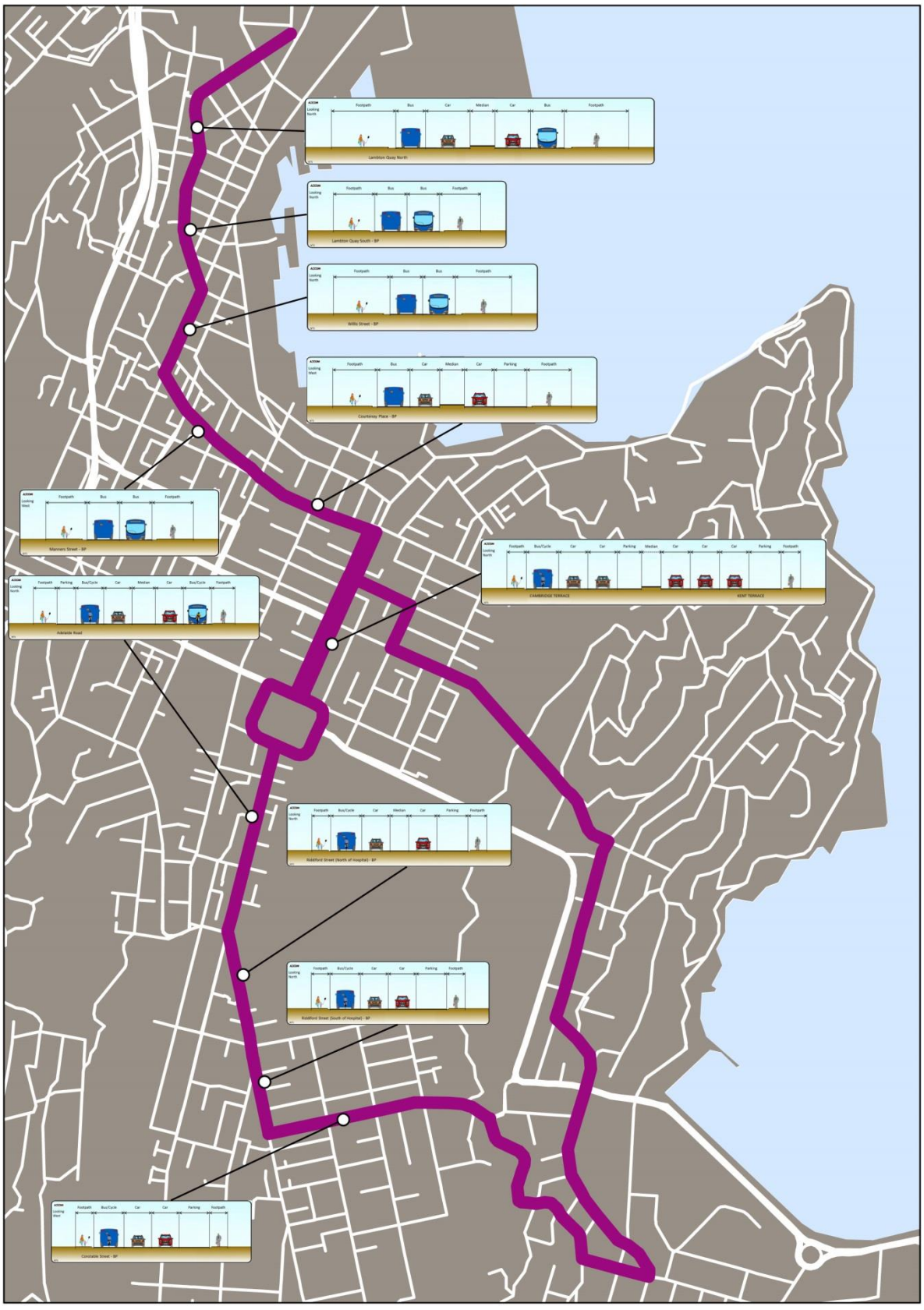
On the Southern Alignment (see Figure 3), the Bus Priority option would utilise the kerb side lanes, sharing with cyclists. This is in line with the planned future layout proposed by Wellington City Council[1].

Eastern Alignment

On the Eastern Alignment (see Figure 3), the Bus Priority option would follow the current bus alignment with bus priority lanes only provided if future traffic congestion results in unreliability. As this is the status quo no cross sections have been provided.

[1] Adelaide Road and John Street intersection upgrade

Figure 3 Bus Priority option (morning peak shown)



3.3.3 Bus Rapid Transit

The Bus Rapid Transit alignment (see Figure 4) differs from the Reference Case in that it has:

Central Alignment

- Four lane sections with one side of the median for Bus Rapid Transit and the other side for general vehicles.
- Roads with three or less lanes would become bus only.
- The current Bus Priority sections will operate only during business hours (7 am to 7 pm).
- The Bus Rapid Transit vehicle would travel adjacent to the median on Cambridge Terrace and Kent Terrace to and from the Basin Reserve.

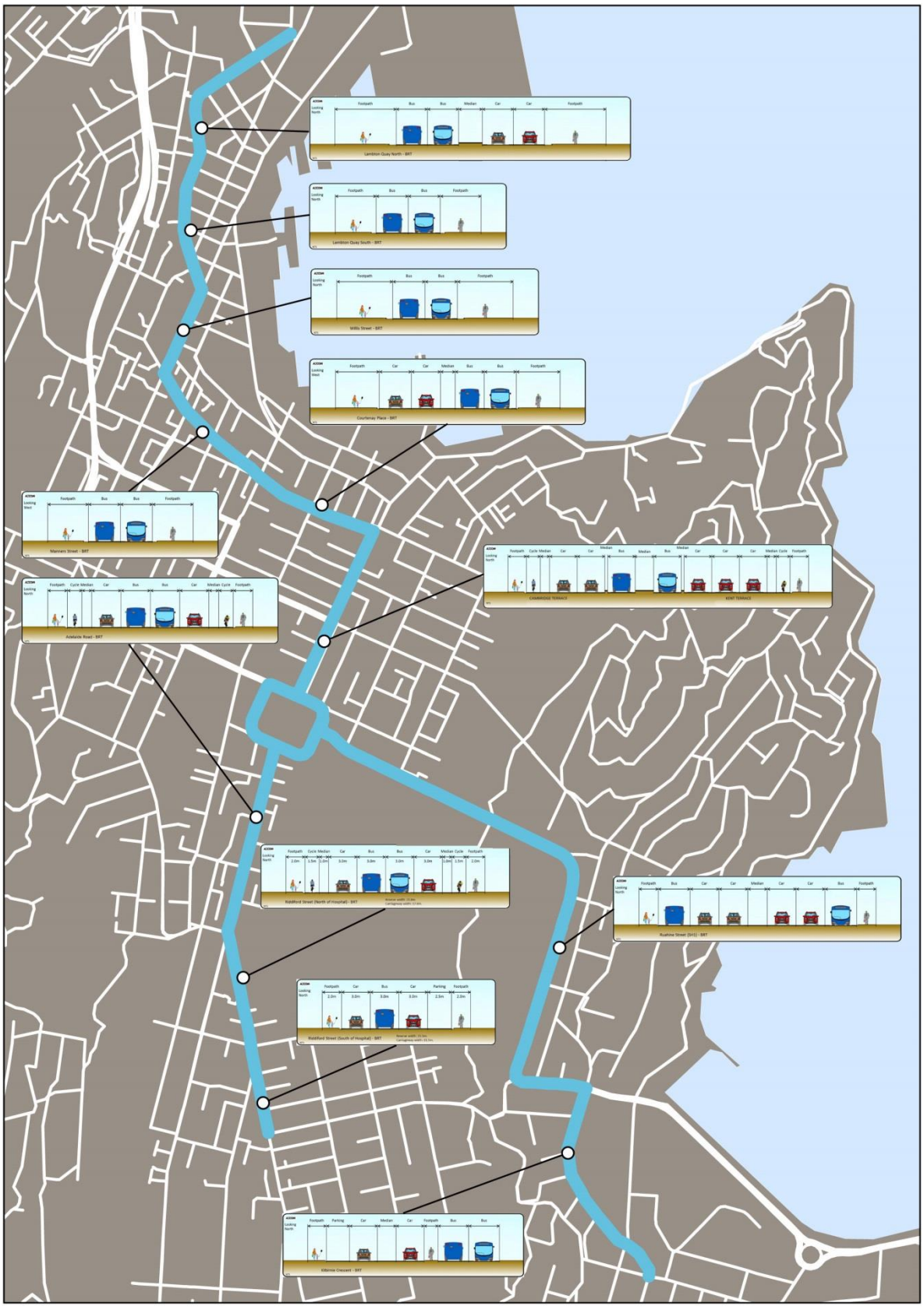
Southern Alignment

- Bus Rapid Transit would replace the central general traffic lanes in each direction from the Basin Reserve to the Hospital, with kerb side cycle lanes.
- Peak directional bus lanes would be provided from the Hospital to Newtown.
- Stations would be provided by removing the median, or removing parking.

Eastern Alignment

- Travels through the new duplicated Mount Victoria Tunnel from the Basin Reserve to Hataitai.
- Provides kerb side bus lanes along State Highway 1.
- The eastern side of Kilbirnie Crescent is a bus only dual carriageway.

Figure 4 Bus Rapid Transit option



3.3.4 Light Rail Transit

The Light Rail Transit alignment (see Figure 5) is similar to the Bus Rapid Transit alignment in that it provides a dedicated corridor. The alignment proposed is:

Central Alignment

- Within four lane sections one side of the median would be for public transport, the other side for general vehicles.
- Within sections with three or less lanes the road would become public transport lanes only.
- Other buses would be able to share the Light Rail Transit lanes.
- Light Rail Transit would travel adjacent to the median on Cambridge Terrace and Kent Terrace to and from the Basin Reserve.

Bus services from the east and south would be replaced by Light Rail Transit, and some services form the north would travel via a secondary spine. As such only limited bus numbers would travel along the Golden Mile.

Southern Alignment

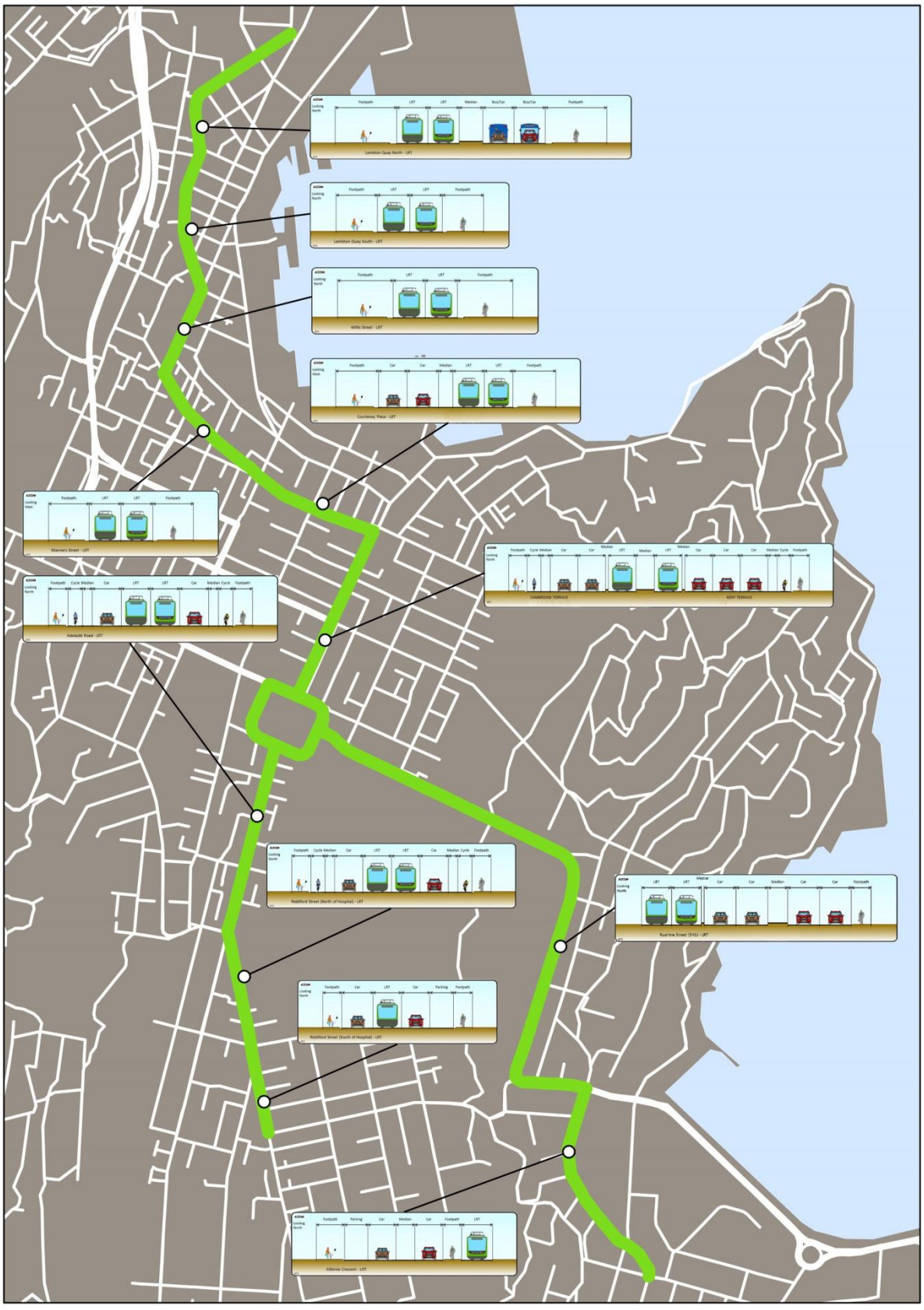
On the Southern Alignment the Light Rail Transit option is similar to the proposed Bus Rapid Transit option:

- Light Rail Transit would replace the central general traffic lanes in each direction from the Basin Reserve to the Hospital.
- Stations would be provided alongside a section of single track (to minimise width) or by providing a central station with tracks either side.

Eastern Alignment

- Travels through new exclusive dual-track tunnel under Mt Victoria. These LRT tunnels are required as there are fire and safety concerns with mixing LRT and general traffic.
- Provides dual tracks alongside the western edge of State Highway 1
- Provides a single Light Rail Transit track on the western side of Kilbirnie Crescent.

Figure 5 Light Rail Transit option



3.4 Summary of Recommended Cross Sections

3.4.1 Central Corridors

The recommended road layouts for each corridor, by section of corridor, are summarised in Table 2, Table 3, and Table 4 for the Central, Southern and Western Corridors respectively.

Table 2 Central Corridors

Current	Bus Priority	Bus Rapid Transit	Light Rail Transit
Lambton Quay North Corridor The northern corridor of Lambton Quay between the Parliament and to Midland Park is a single bus lane and a general traffic lane in each direction with a central raised median and wide footpaths sporadically indented for parking.	Retain the status quo of bus lanes in each direction.	Bus Rapid Transit on west side of the road and general traffic on the east side.	Light Rail Transit on west side of the road and general traffic on the east side.
Lambton Quay South Corridor The southern corridor of Lambton Quay between Midland Park and Willis Street is a bus lane southbound and a general traffic lane northbound. (Widths through Old Bank Arcade restrict a dual Light Rail Transit track)	Replace the northbound general traffic lane with a bus lane.	Bus Rapid Transit lanes in both directions. Bus Rapid Transit lanes go around each side of the Old Bank building	Dual or single tracks replacing traffic lanes
Willis Street Corridor The Willis Street Corridor between Lambton Quay and Manners Street is one bus lane southbound and a general traffic lane northbound.	Replace the northbound general traffic lane with a bus lane.	Bus Rapid Transit lanes in both directions.	Dual tracks
Manners Street Corridor The Manners Street corridor (including Manners Mall) between Willis Street and Taranaki Street is a bus lane in either direction, which merges with general traffic after Cuba Street.	Bus only during peak periods.	Bus Rapid Transit lanes in both directions	Dual tracks
Courtenay Place Corridor The Courtenay Place corridor between Taranaki Street and Cambridge Terrace consists of a general traffic lane with parking in each direction, and a central raised median. Footpaths are wide and several bus shelters are located between Allen Street and Blair Street, on both sides of the road.	Converts the peak direction parking to a bus only lane during the morning and afternoon peak periods.	Two Bus Rapid Transit/Light Rail Transit lanes on the north side of the corridor and two general traffic lanes on the south side with parking retained where possible.	
Cambridge Terrace and Kent Terrace Corridor The Cambridge Terrace and Kent Terrace corridor between Courtenay Place and the Basin Reserve currently consists of three general traffic lanes in each direction, with central median and kerbside parking. During the evening peak kerbside parking on Kent Terrace converts to bus only.	Converts the kerbside parking to peak directional bus lanes. The central parking lane on Kent Terrace is removed to provide wider lanes catering for cyclists.	Bus Rapid Transit/Light Rail Transit lane on each side of the central median. All parking lanes are removed and kerbside cycle lanes are provided in both directions. Central median stations will require specific design.	

Table 3 Southern Corridors

Current	Bus	Bus Rapid Transit	Light Rail Transit
Adelaide Road Corridor Wellington City Council has specified the design to be built for the Adelaide Road corridor between the Basin Reserve and Riddiford Street of a central flush median with a general traffic lane to each side. On the west side there will be a parking and a bus/cycle lane. On the east side there will be a bus/cycle lane.	As per Wellington City Council designed scheme.	Two way Bus Rapid Transit lanes in the centre of the corridor. On each side of the corridor, there is a kerbside cycle lane, a 1.0 m flush median, and then one general traffic lane.	Two way tracks in the centre of the corridor. On each side of the corridor, there is a kerbside cycle lane, a 1.0 m flush median, and then one general traffic lane.
Riddiford Street (North of Hospital) Corridor The northern corridor of Riddiford Street is two general traffic lanes in each direction, with parking on the eastern side of the carriageway.	Kerb side bus lanes which revert to parking outside peak periods, with a 2.0 m flush median for right turning vehicles.	Buses along either side of a centre flush median and kerb side cycle lanes.	Two way tracks along either side of centre flush median and kerb side cycle lanes.
Riddiford Street (South of Hospital) Corridor The southern corridor of Riddiford Street is one general traffic lane in each direction with kerb side parking.	Kerb side peak period bus lanes which revert to parking outside peak periods.	Single contra flow bus lanes in centre of corridor, only running in the peak direction. Parking removed from one side of the road.	One way track with passing bays in the centre of the corridor. Parking removed from one side of the road.
Constable Street	Kerb side peak period bus lanes which revert to parking outside peak periods.	No change	No change

Table 4 Eastern Corridors

Current	Bus	Bus Rapid Transit	Light Rail Transit
Mount Victoria Tunnel Corridor NZ Transport Agency is presently investigating the duplication of the Mount Victoria Tunnel as it is only one general traffic lane in either direction and buses use a single lane bus tunnel through to Hataitai.	Continue to use the present Haitaitai bus tunnel.	Travels through new tunnel with general traffic.	Construction of new dedicated Light Rail Transit tunnels.
Ruahine Street Corridor NZ Transport Agency is presently investigating the duplication the widening of Ruahine Street as part of the Mount Victoria Tunnel duplication. This would result in the corridor being two general traffic lanes in either direction.	Buses travelling on Moxham Avenue, east of Ruahine Street.	Bus lane on either side of the Ruahine Street corridor.	Dual tracks on the western side of the Ruahine Street Corridor.
Kilbirnie Crescent Corridor The Kilbirnie Crescent corridor between Cobham Drive and Rongotai Road is one lane in each direction with kerb side parking and a flush median. The corridor also has wide footpaths.	Priority would only be provided along this corridor if required.	Twin bus lanes on the eastern side of Kilbirnie Crescent. Parking has been retained on one side of the road due to high parking demands. The median has been retained for turning vehicles.	A single track on the eastern side of Kilbirnie Crescent. Parking has been retained on one side of the road due to high parking demands. The median has been retained for turning vehicles.

3.5 Key constraints within the CBD

Key constraints that will impact on the ability for vehicles to travel through the alignments have been assessed. Vehicle tracking curves have been applied along the route through the CBD to ensure that proposed options are feasible. The following is noted:

- Bus Priority is the same as the Reference Case and has no limitations.
- Bus Rapid Transit may involve the use of articulated vehicles which means they are longer and in general have larger turning radii than traditional buses in the City
- Light rail vehicles are also longer than traditional buses and have larger turning radii.

The tracking curves analysis identified two key constraints.

Old Bank Arcade/Hunter Street

Buses currently travel through Old Bank Arcade northbound and Hunter Street / Customhouse Quay southbound. Travelling from Hunter Street to Customhouse Quay is an issue for Light Rail Transit due to the right turn required. Buses travel in the right hand lane on Hunter Street into a bus only lane on Customhouse Quay. For light rail vehicles to traverse this route would likely require alteration to existing buildings.

Providing for two way movement (dual track) through Old Bank Arcade would remove the requirement for light rail vehicles to use Hunter Street. However, the impact of providing dual track would be a loss of usable footpath and potentially removal of overhanging canopies.

Single track Light Rail Transit through Old Bank Arcade providing for two way movement would minimise the loss of footpaths and the impact on buildings. However, the provision of a single track would likely impact on the capacity of the system and would limit the use for buses in the Light Rail Transit option.

Continuation of the existing split alignment is feasible but requires the lanes used by vehicles to be changed. On Hunter Street light rail vehicles would be required to travel in the far left lane in order to turn tight onto Customhouse Quay. This would require changes in the lane configuration and the way in which signals control traffic but does provide a feasible solution.

Manner Street and Willis Street Intersection

The intersection of Willis Street and Manner Street has been identified as a constraint due to the narrowness of the corridor, size of intersection and the sharp turn involved. Traditional buses can traverse this turn. However, for articulated buses and Light Rail Transit there is a constraint. Providing two way movements for Light Rail Transit would most likely require additional widening which would impact on existing buildings.

An alternative option would involve a short section of single track with appropriate signalling and set back. The provision of a single section of track may lead to operational delays for light rail vehicles and buses and impact on the provision of services.

3.6 Cross Sections Philosophy

General Traffic: Where possible general traffic lanes have been retained. However, for the Bus Rapid Transit and Light Rail Transit options, the road layout has been designed to provide full priority. In some cases, particularly through the CBD, the number of general traffic lanes has been reduced. Where general traffic lanes are removed signposting of alternative corridors will be required.

Peak/off peak operation: The Bus Priority option in some areas would operate in the peak direction only. Where these are kerb side bus lanes, and generally outside the Golden Mile, parking would be retained outside peak times.

Pedestrians/Footpaths: It has been a priority to maintain or increase pedestrian facilities. In a small number of cases this has not been possible. In some areas, the existing wide footpath has been slightly reduced in width to accommodate a larger carriageway, while retaining the same road reserve width.

Planted Medians: The medians on Lambton Quay, Kent Terrace and Cambridge Terrace have been retained, but may be impacted on by Bus Rapid Transit / Light Rail Transit stations/stops.

Small raised medians: A 0.3 m raised median separates Light Rail Transit lanes and general traffic for safety purposes. In some corridors this also applies to Bus Rapid Transit lanes.

Raised medians: Central raised medians are located on corridors that do not require priority turning movements into driveways and side roads. For Bus Rapid Transit / Light Rail Transit, these medians would transform into stations, where appropriate.

Flush medians: Central flush medians are located where necessary for turning into driveways and side roads.

Cycle Lanes: Although this is predominantly a public transport project, it has also aimed to deliver sections of the identified cycle routes. The Bus Priority option provides shared bus and cycle lanes on some sections and the Bus Rapid Transit and Light Rail Transit options include cycle lanes in strategic locations. Where there is sufficient road width, a 1.0 m safety buffer would be placed between the kerbside cycle lane and the adjacent traffic lane.

Stations for Bus Rapid Transit / Light Rail Transit: The exact location of stations would be determined at a more detailed stage when a preferred option is chosen. However, it is likely that these can be accommodated within the existing road width. To minimise road widening, elements such as cycle lanes, safety buffers, and medians can be removed from the road cross section at the station location and/or stations staggered.

Parking: Parking would be retained where possible. For Bus Rapid Transit and Light Rail Transit that may require a wider carriageway than the existing, parking removed could be considered to prevent carriageway widening.

Present Bus Lanes: Present bus lanes are retained for the Bus Priority option where appropriate. Off-peak parking in present bus lanes is an option in the Bus Priority option.

Central Bus Rapid Transit / Light Rail Transit: Bus Rapid Transit / Light Rail Transit would be located in the centre of road carriageways to minimise conflict with access to driveways and side roads, parked and service vehicles.

Kerbside Bus Rapid Transit / Light Rail Transit: Bus Rapid Transit / Light Rail Transit lanes would be located together on a single side of the carriageway where no vehicle access is needed on one side of the corridor.

Single Bus Rapid Transit / Light Rail Transit Lanes or tracks: In some corridors there is only space for a single Bus Rapid Transit lane or Light Rail Transit track. These areas will operate with loop detectors and signalised passing bays.

Bus Rapid Transit / Light Rail Transit-only Corridors: Some corridors which previously allowed general traffic access in one direction are now Bus Rapid Transit / Light Rail Transit only. This allows for full priority for the Bus Rapid Transit/Light Rail Transit in both directions.

4.0 OPTION RESULTS

4.1 Introduction

The results of the shortlist evaluation are discussed in this Chapter. The key elements of this evaluation are outlined below:

1. Planning, Social and Environmental

A high level assessment of the potential social and environmental impacts was undertaken. This included an RMA assessment considering the consentability of each option.

2. Patronage

A key goal of the proposed options is to provide better and more attractive public transport links to and from the CBD. Change in patronage for the region and suburbs affected by the options was analysed. This provides an indication of the mode share benefits and the extent to which options provide more attractive public transport alternatives than if the option were not implemented.

3. Level of service

The level of service provided by each option is a key consideration. The level of service was evaluated by analysing travel times along the Spine and for travel to the CBD. Journey time reliability was qualitatively assessed by considering the level of priority, segregation and the number of vehicles within a corridor. The number of transfers forecast for each option was considered so as to provide a measure of connectively and ease of use.

4. Traffic flow

A key goal of the proposed options is to reduce congestion on the Golden Mile during the morning and afternoon peak periods. This was assessed by analysing the decrease in traffic volume along key corridors of the Golden Mile, as well as over the wider network. Overall traffic volume is affected by the uptake of public transport, reducing car volume, and the change in number of public transport vehicles used for each option.

5. Pedestrian impact

The impact of options on pedestrian movement was considered. This included qualitative assessment of the impacts on pedestrian safety, the extent of barriers to pedestrians crossing public transport corridors, and the changes in walk distance of passengers to and from public transport stops.

6. Consistency with future projects

The extent to which options were consistent with future projects was assessed. The future projects included were the Mount Victoria Tunnel Duplication project and the proposed Basin Bridge.

7. Costs and economic assessment

The capital cost and operational cost was estimated for each option. Benefit cost analysis was undertaken, and sensitivity testing was carried out on the resulting benefit cost ratios. Sensitivity tests considered a 20% decrease on the (conservative) construction costs, a cap on parking demand in the CBD, and network improvements as a result of RoNS projects.

The results are discussed in this Chapter.

4.2 Planning, Social and Environmental

This planning assessment provides a high level evaluation of the potential planning, social and environmental impacts of the various public transport options. This planning assessment includes an RMA assessment considering the consentability of the options. No specific assessments such as urban design, acoustic effects or social impact were undertaken.

The options are assessed in three parts:

- The 'Golden Mile'.
- The southern section from Courtenay place to Newtown and Kilbirnie along Kent Terrace, Cambridge Terrace, Adelaide Road, Riddiford Street and Constable Street.
- The eastern section through to Kilbirnie via either the State Highway 1 (Eastern Corridor) or the Hataitai bus tunnel (depending on the option).

4.2.1 District Plan Summary

Golden Mile

Primarily Central Area zoning with areas of Open Space A zoning. There are Heritage Area overlays at Stout Street at the northern end of Lambton Quay, BNZ Centre, Cuba Street around the intersection with Manners Street and Courtenay Place between Tory Street and Cambridge Terrace.

Southern Alignment

The area along Kent and Cambridge Terraces is zoned Central Area, with the area south of the Basin Reserve a mixture of Suburban Centre, Institutional Precinct and Inner Residential zoning. There is a central reservation between Kent Terrace and Cambridge Terrace which has Open Space A zoning. The Basin Reserve, a regional sports facility, also has Open Space A zoning. The Hospital has its own Institutional Precinct Zoning, while there are heritage areas around the John Street intersection and the Newtown shopping centre. Constable Street is Inner Residential to the town belt then residential on Crawford Road through to the Kilbirnie Suburban Centre.

Eastern Alignment

For bus priority the route passes through a primarily Residential environment of Mount Victoria then through the bus tunnel to Hataitai Suburban Centre and then on to Kilbirnie. For Bus Rapid Transit and Light Rail Transit the northern part of the route is bordered by Inner Residential zoning and schools at Paterson Street. The Mount Victoria Tunnel runs through the Inner Town Belt which has its own Open Space C zoning. The Open Space C zoning continues on the western side of SH1 Ruahine Street. The remainder of the corridor is bordered by Outer Residential zoning with the exception of Kilbirnie Park which has Open Space A zoning. Akau-tangi Pa, a noteworthy Maori site of medium significance is located at Kilbirnie Park.

4.2.2 Options

For the Light Rail Transit option, overhead lines are required, which in most places replace the existing trolley bus lines. The effects of this are considered negligible.

4.2.3 Bus Priority

Golden Mile

The Bus Priority option through the Golden Mile effectively mirrors the existing situation, with a series of bus lanes and bus only sections. This option introduces bus lanes southbound on Willis Street and the southern part of Lambton Quay.

This Bus Priority option will require removal of a northbound traffic lane along the southern part of Lambton Quay (Brandon Street to Willis Street) and Willis Street (Lambton Quay to Manners Street) to provide a bus lane. The bus lane could operate in peak hours, business hours, or all day. The introduction of bus priority will lead to a loss of loading zones and accessibility to general traffic for the bus lane operating period. This assessment assumes that traffic can be redistributed without adverse impacts on the network.

There are three loading zones on the western side of Willis Street providing retail and office servicing impacted by the introduction of bus lanes. Buildings on the western side of Willis Street can be serviced via Boulcott Street.

Consequently, the effects of the Bus Priority option through the Golden Mile are negligible with the exception of the southern part of Lambton Quay and Willis Street. In these areas it is considered that there are minor social and environmental effects.

Southern Alignment

Bus priority requires the removal of parking on Kent Terrace. Parking can be retained on Cambridge Terrace. This effectively reflects the existing situation. The proposed NZTA design for the Basin Reserve bridge would accommodate the Bus Priority option without only minor adjustments. Adelaide Road would see the introduction of a peak hour southbound lane which is currently under investigation.

The Bus Priority option requires the removal of peak hour parking on one side of Riddiford Street. The loss of peak hour parking is in an area that has significant demand and limited off street parking. This has the potential to have significant affects around the shopping centre. A small amount of carriageway widening may be required due to constrained widths. This will result in the loss of some existing amenity paving and planting. The loss of parking in particular means that the Bus Priority option has moderate to significant social and environmental effects along Riddiford Street.

Along Constable Street the Bus Priority option requires peak hour bus lanes, which would require carriageway and road reserve widening. The implementation of peak hour bus lanes on Constable Street will result in the loss of on street parking which will have significant social effects on local residents. The opportunity to create off street parking to mitigate the effects is limited. There may also be small impacts on private property. It is therefore considered that the Bus Priority option will have moderate to significant social and environmental effects for the Southern Alignment.

Eastern Alignment

The Bus Priority option follows the existing bus routes via the single lane Hataitai Bus Tunnel. There are very few changes made to the existing configuration and as such very few social and environmental impacts.

4.2.4 Bus Rapid Transit

Golden Mile

The introduction of Bus Rapid Transit through the Golden Mile would require the reallocation of carriageway space. Along the northern section of Lambton Quay, traffic could be relocated to the eastern side of the carriageway with Bus Rapid Transit on the western side. This may require the relocation of the overhead trolley lines. The location of southbound bus stops could be placed in the central median. This may result in the loss of some of the tree and planting amenity that currently exists.

As with the Bus Priority option, Bus Rapid Transit will require the removal of a northbound traffic lane on the southern part of Lambton Quay and Willis Street. There will be an impact on loading zones and loss of accessibility for general traffic; however the majority of offices can be accessed via Boulcott Street, Gilmer Terrace, Victoria, Mercer or Bond Street.

At Courtenay Place the Bus Rapid Transit option utilises the northern two lanes, with general traffic relocated to the southern lanes of the corridor. This will result in the relocation of loading and parking with the loss of some parking. It is assumed that the bus stops required can be accommodated within the middle of the carriageway. It is considered that if the bus stops can be adequately located within the carriageway, the social and environmental effects of Bus Rapid Transit will be no more than minor.

Southern Alignment

The Bus Rapid Transit option requires the removal of parking along either side of the central median between Kent and Cambridge Terraces. Bus stops will be located within the central median or carriageway. Widening of three metres on Kent Terrace between Elizabeth Street and Courtenay Place is required, including intersection improvements. The land uses that will be impacted by the widening are open, ground level car parks. Loss of car parking will impact upon surrounding residential areas which may accommodate spill over. It is also considered that the Bus Rapid Transit option is consistent with the NZTA plans for the Basin Reserve.

Along Adelaide Road, the Bus Rapid Transit option results in the removal of all on street parking, however the effect of this is considered minimal as most businesses have some car parking on site. The Bus Rapid Transit route will run down the centre of Adelaide Road, with widening required to allow for station platforms. The Bus Rapid Transit option will see the loss of the central median which is currently used for property access and right turns into the side streets.

At Riddiford Street, the Bus Rapid Transit option changes to a single lane running through the centre of the road. Again stations will need to be accommodated in the centre of the carriageway, and may be staggered to minimise the carriageway width. All kerbside parking along Riddiford Street will be removed which will have a significant impact on businesses.

South of the Hospital, there will be the removal of at least one parking lane or potentially both if staggered stations are not introduced in the middle of the road. Any potential corridor widening may impact on the heritage areas along Riddiford Street.

It is considered that the Bus Rapid Transit option will result in significant social and environmental effects along the southern corridor.

Eastern Alignment

It is assumed that the Bus Rapid Transit option can travel via the Mount Victoria Tunnel to Ruahine Street (reliant on the tunnel duplication), mixing with general traffic. Along Ruahine Street, the Bus Rapid Transit option requires a bus lane on either side of the street. This would result in road reserve and carriageway widening of seven metres over the NZTA proposal. The major impacts of this would be on the Town Belt and the intersection with Wellington Road.

On Wellington Road, the implementation of Bus Rapid Transit while maintaining three lanes of general traffic would require a further 6.6 metres of widening on top of the NZTA proposal. The area is highly constrained by existing land use already and it is considered that the additional width will make already significant effects even more significant.

For the final section of the corridor on Kilbirnie Crescent, widening is required with two way service located on the eastern or Kilbirnie Park side of the road, a new footpath between the Bus Rapid Transit and the general traffic and the permanent loss of parking on the eastern side. The main issue is the partial or total loss of parking which is heavily utilised on the weekend.

It is considered that there are minimal social and environmental effects during the week and significant effects during the weekend.

4.2.5 Light Rail Transit

Golden Mile

The Light Rail Transit option requires the reallocation of carriageway space throughout the Golden Mile. Traffic is relocated to the eastern side of Lambton Quay, with the Light Rail Transit running along the western side. Southbound stations will be placed in the central median, which may result in the loss of some of the tree and planting amenity that currently exists.

As with the other two options, Light Rail Transit requires the removal of a northbound traffic lane on the southern part of Lambton Quay and Willis Street. There is an impact on loading zones and a loss of accessibility for general traffic. The effects of this is minimised as the majority of offices can be accessed via Boulcott Street, Gilmer Terrace, Victoria, Mercer or Bond Street.

For the southbound right turn manoeuvre on the corner of Hunter and Customhouse Quay, the tracking curve is quite tight. The same issue applies at the Willis Street Manners Street intersection. It is assumed that these issues can be engineered without road reserve or carriageway widening.

On Courtenay Place, the Light Rail Transit option utilises the northern lanes with general traffic relocated to the southern lanes. This will result in the relocation of loading and parking with the loss of some parking. It is assumed that the stations required can be accommodated within the middle of the carriageway. The social and environmental effects will be no more than minor.

Southern Alignment

The Light Rail Transit option requires the removal of parking along either side of the central median between Kent and Cambridge Terraces. Stations will be located within the central median. Widening of three metres on Kent Terrace between Elizabeth Street and Courtenay Place is required, including intersection improvements. The land uses that will be impacted by the widening are open, ground level car parks. Loss of car parking will impact upon surrounding residential areas which may accommodate spill over. The NZTA has confirmed that Light Rail Transit can be provided without requiring redesign of the overbridge piers / columns at the Basin Reserve.

Along Adelaide Road, the Light Rail Transit option results in the removal of all on street parking, however the effect of this is considered minimal as most businesses have car parking on site. At the John Street intersection parking restrictions apply already. The Light Rail Transit track will run down the centre of Adelaide Road, with widening required to allow for station platforms. The Light Rail Transit option will see the loss of the central median which is currently used for property and side road access.

At Riddiford Street, the Light Rail Transit option changes to a single track running through the centre of the road. Stations will need to be accommodated in the centre of the carriageway, and may be staggered to minimise the carriageway width. All kerbside parking along Riddiford Street will be removed which will have a significant impact on businesses.

South of the Hospital, there will be the removal of at least one parking lane or potentially both if staggered stations are not introduced in the middle of the road. Any potential corridor widening may impact on the heritage areas along Riddiford Street.

It is considered that the Light Rail Transit option will result in significant social and environmental effects along the southern corridor.

Eastern Alignment

The Light Rail Transit option requires additional capacity to be provided through a new duplicated tunnel, which is assumed to be double track. This requires additional land from the Town Belt to the south of the existing Mount Victoria tunnel and potentially additional land from the southern side of Paterson Street over and above that required for the Basin Bridge or Mount Victoria Tunnel Projects. The Light Rail Transit option is considered to have considerable effects through this area.

Along Ruahine Street, the Light Rail Transit option requires a double track on the western side of the corridor. This would widen the road reserve and carriageway over and above the NZTA highway widening. The major impact would be on the Town Belt and at the intersection with Wellington Road.

On Wellington Road, the implementation of Light Rail Transit on top of the NZTA proposal would require a further widening. The area is highly constrained by existing land use already and it is considered that the additional width will make already significant effects even more significant.

The Light Rail Transit option on Kilbirnie Crescent introduces a single lane along the eastern side, resulting in the loss of eastern side parking. The main issue is the partial or total loss of parking which is heavily utilised on the weekend.

It is considered that there are significant social and environmental effects along the Eastern alignment.

4.3 Patronage

The assessment of changes in patronage is based upon results from transport modelling and is fully detailed in the Greater Wellington Regional Council Transport Modelling report. The report details the core assumptions which were applied to future year forecasting including forecast increases in development, changes in public transport and the improvements to the road network. Applying the future year assumptions has created a Reference Case against which all options can be compared to show how transport trends may change.

4.3.1 Changes in Regional Patronage

Table 5 displays changes in regional patronage and mode share for the Reference Case. In this evaluation mode share is defined as the mode share between car and public transport use. Changes in regional patronage are small as the options are focussed on connecting the south and east of Wellington to the CBD.

Between 2021 and 2031 there is an overall decrease in the use of public transport during the morning peak period in the Reference Case. The modelled forecast decrease in trips is primarily due to improvements in the highway network which reduce congestion experienced by motorists on key routes.

Introducing the Bus Priority, Bus Rapid Transit and Light Rail Transit options has marginal impact on regional patronage. This reinforces that these are changes to a part of the local network providing for benefits to specific areas, not region wide improvements. All options provide increased patronage, Bus Priority and Light Rail Transit have a similar impacts (+1%) and Bus Rapid Transit increases public transport trips by up to 2.5%.

Table 5 Regional public transport trips (2031 two hour morning peak)

	Reference Case		Bus Priority		Bus Rapid Transit		Light Rail Transit	
Year	Trips	Mode Share	Trips	Growth in Trips	Trips	Growth in Trips	Trips	Growth in Trips
2021	35,600	15.9%	+200	+0.6%	+700	+2.0%	+200	0.6%
2031	34,000	14.4%	+300	+0.9%	+800	+2.4%	+300	0.9%
2041	35,200	14.5%	+300	+0.9%	+900	+2.6%	+400	1.1%

4.3.2 Changes in Patronage in South / East

Table 6 displays changes in the public transport patronage and growth in the south and the east during the morning peak period. Analysis of this subset of trips is important because the proposed options target travel provided improved public transport to the south and east areas. The Reference Case provides a comparison showing how public transport trends are expected to change. Between 2021 and 2031 there is an overall decrease in the use of public transport during the morning peak period but by 2041 the number of public transport trips is greater than 2021.

The Bus Priority and Bus Rapid Transit options increase the number of public transport trips by 3% to 8%, the Light Rail Transit option shows only a marginal increase in trips (1%). When compared to the regional changes in patronage forecast this shows that the southern and eastern areas account for more than 60% of the regional increase in trips for Bus Priority and Bus Rapid Transit. The Light Rail Transit option has only 20% from the area most expected to benefit.

Table 6 Public transport trips from the south and east areas (2031 2 hour morning peak)

	Reference Case		Bus Priority		Bus Rapid Transit		Light Rail Transit	
Year	Trips	Mode Share	Trips	% Increase	Public transport Trips	% Increase	Public transport Trips	% Increase
2021	7,000	21.3%	+ 180	+ 2.6%	+ 400	+ 5.8%	- 40	- 0.6%
2031	6,800	19.5%	+ 200	+ 2.9%	+ 470	+ 6.9%	+ 20	+ 0.3%
2041	7,100	19.3%	+ 220	+ 3.1%	+ 550	+ 7.8%	+ 80	+ 1.1%

4.3.3 Changes in Patronage between Key Locations

A fundamental aim of the proposed options is to provide better and more attractive public transport links to the CBD. An analysis of changes in trips from suburbs affected by the options provides an indication as to the benefits of the options and the extent to which they provide a more attractive alternative to the Reference Case.

Table 7 displays a comparison of the options for the 2031 morning peak period.

Table 7 Local growth in patronage to the CBD (2 hour 2031 morning peak)

Year	Area	Reference Case		Bus Priority		Bus Rapid Transit		Light Rail Transit	
		Trips	Mode Share	Trips	Mode Share	Trips	Mode Share	Trips	Mode Share
2031	Miramar	1,320	43%	+ 60	45%	+ 170	47%	-70	42%
	Kilbirnie Lyall	680	36%	+ 40	38%	+ 80	39%	+ 90	40%
	Mt Vic / Hataitai	790	33%	+ 20	34%	-50	32%	-40	32%
	Island Bay	1,140	43%	+ 20	44%	+ 100	46%	-60	42%
	Newtown	790	31%	+ 30	32%	+ 90	34%	+ 40	32%
	Total	**4,710**	**38%**	+ 170	**39%**	+ 400	**40%**	-30	**38%**

For Bus Priority

- There is a 4.0% increase in public transport trips.
- Largest increase is in trips from Miramar.
- All areas show consistent but low increase in patronage due to nature of option (continuation of current).
- The smallest increase is from Mount Victoria / Hataitai and Island Bay.

For Bus Rapid Transit

- There is an 8.5% increase in public transport trips.
- Largest increase is in trips from Miramar and this reflects improved services.
- There is a decrease in trips from Hataitai, this is due to a reduced number of buses travelling via the Hataitai bus tunnel.
- Overall the mode split for all areas increases to 40.0%.

For Light Rail Transit

- Reductions in patronage from areas where services require transfers or there is a reduction in bus services such as Hataitai.
- Increases in patronage from Newtown and Kilbirnie where direct services provide fast travel times.

4.4 Level of Service

4.4.1 AM Peak Travel Time along Corridors

The options have been developed to minimise the travel time along the Spine through the provision of infrastructure providing priority and segregation. The Bus Priority option allows buses to bypass car based congestion but buses remain travelling unsegregated from general traffic. Bus Rapid Transit and Light Rail Transit provide a corridor providing segregated priority for public transport modes. Between Kilbirnie and the Rail Station the major difference in the options is that the Reference Case and Bus Priority continue to use the Hataitai bus tunnel whilst Bus Rapid Transit uses the current and duplicated Mount Victoria tunnel alignment and Light Rail Transit travels via new tunnels.

Table 8 and Figure 6 show that when travelling from Kilbirnie to the Wellington Rail Station:

- The time taken to travel the route in the Reference Case is approximately 25 minutes.
- Bus priority shows a small but consistent improvement compared to the Reference Case (a saving of three minutes) with the majority of travel time savings between Courtenay Place and the Rail Station. This shows that existing and future planned bus priorities will be in place by 2031 and therefore this option provides small improvements.
- Bus Rapid Transit and Light Rail Transit show a significant saving, halving the travel time when compared to the Reference Case (a saving of 12 minutes). The greatest improvement is between Kilbirnie and Elizabeth Street. This represents the benefit of the high level of priority and segregation and the alternative route via the State Highway network.

Table 8 Comparison of travel time savings against Reference Case: Kilbirnie to Rail Station (2031 morning peak)

From Kilbirnie To	Reference Case	Bus Priority	Bus Rapid Transit	Light Rail Transit
Elizabeth Street	**13.9**	-1.1	-7.6	-7.9
Courtenay Place	**14.7**	-1.1	-8.1	-8.4
Willis Street	**19.3**	-1.5	-9.5	-9.8
Rail Station	**24.5**	-2.7	-11.2	-11.5

Figure 6 Travel time: Kilbirnie to Wellington Rail Station (2031 morning peak)

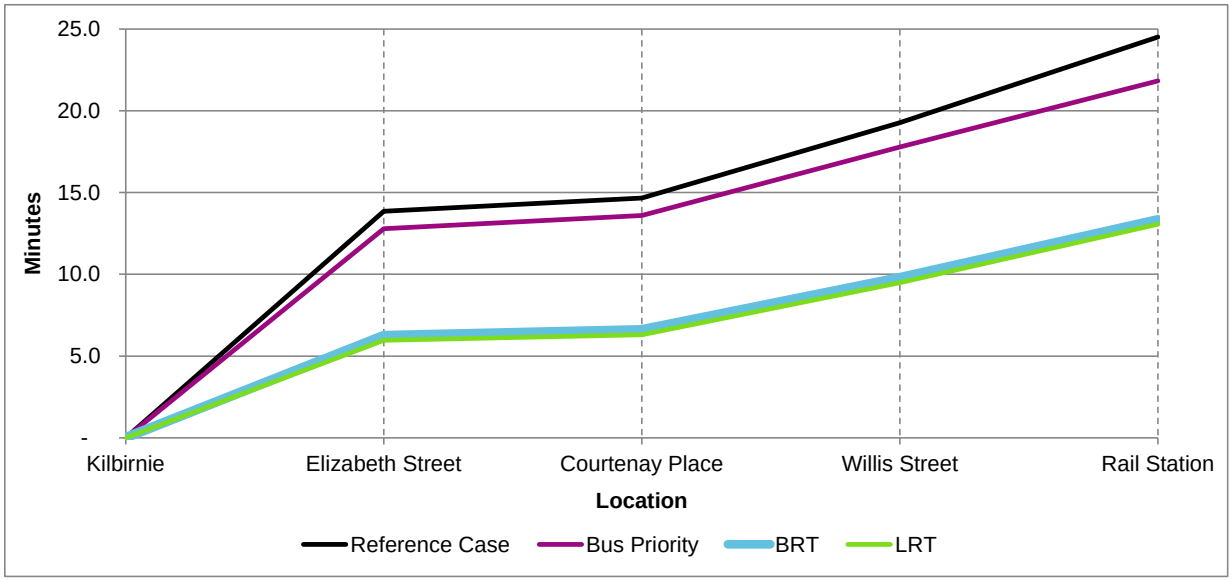


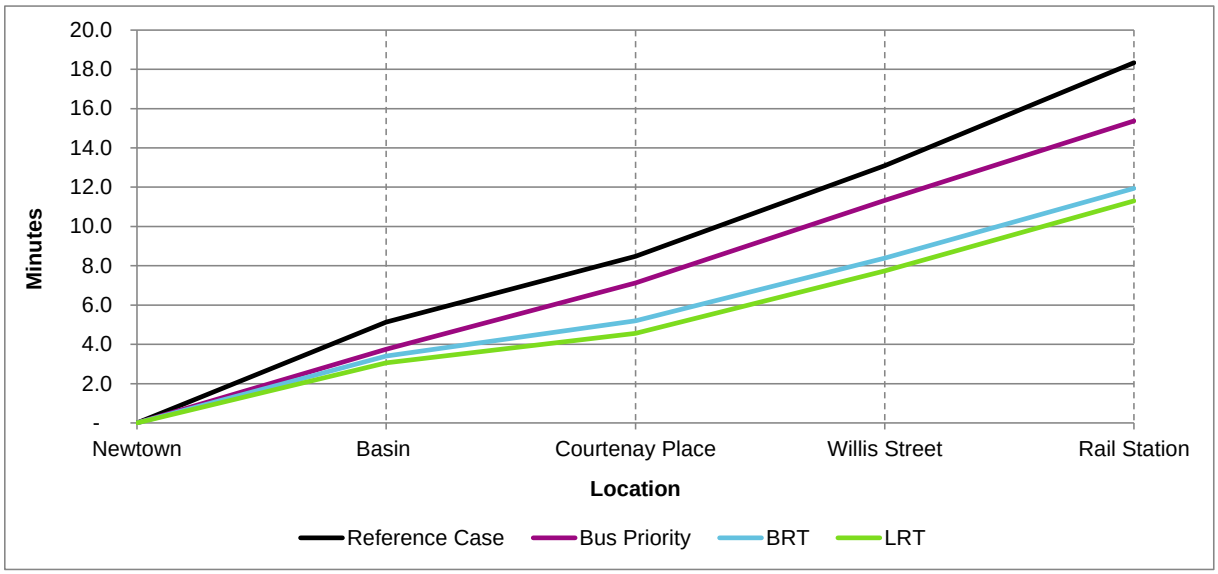
Table 9 and Figure 7 show that when travelling between Newtown and the Wellington Railway Station:

- The time taken to travel the route in the Reference Case is approximately 18 minutes.
- Bus Priority show a consistent improvement compared to the Reference Case indicating the benefit of bypassing car based congestion along the entire route saving three minutes
- Bus Rapid Transit and Light Rail Transit show a significant saving, reducing travel time by approximately a third when compared to the Reference Case (a saving of six minutes). The greatest improvement is between Newtown and Elizabeth Street. This represents the benefit of the high level of priority and segregation and the alternative route via the State Highway network.

Table 9 Comparison of travel time savings against Reference Case: Newtown to Wellington Rail Station (2031 morning peak)

From Newtown To	Reference Case	Bus Priority	Bus Rapid Transit	Light Rail Transit
Basin	**5.1**	-1.4	-1.7	-2.1
Courtenay Place	**8.5**	-1.4	-3.3	-3.9
Willis Street	**13.1**	-1.8	-4.7	-5.4
Rail Station	**18.3**	-3.0	-6.4	-7.0

Figure 7 Travel time: Newtown to Rail Station (2031 morning peak)



4.4.2 Travel Times between key locations and the CBD

The ability of the options to provide reliable travel times can be measured through an assessment of the level of priority and segregation provided and by the improvements in travel time to a destination from a range of origins. Table 10 displays changes in travel times from selected locations to the CBD during the 2031 morning peak period. This differs from an analysis of travel time along the corridor in that it takes into account the components of a trip including the time spent transferring and waiting for services. Overall, this shows that for all options there is a decrease in the time taken to travel to the CBD compared to the Reference Case during the 2031 morning peak period for the areas affected by the options. Overall, Bus Rapid Transit provides the greatest decrease in travel time for passengers due primarily to the level of priority and segregation afforded to it and the services provided which do not require transfers.

Table 10 Reductions in 2031 morning peak travel time

From	Bus Priority		Bus Rapid Transit		Light Rail Transit	
	Minutes	Percentage	Minutes	Percentage	Minutes	Percentage
Miramar	-5	-13%	-13	-35%	-11	-29%
Seatoun	-3	-9%	-4	-12%	-2	-6%
Airport	-2	-5%	-5	-12%	-5	-12%
Island Bay	-1	-3%	-5	-14%	-4	-11%
Newtown	-3	-12%	-7	-28%	-4	-16%
Hataitai	-1	-3%	-1	-3%	-1	-3%
Kilbirnie	-5	-16%	-11	-36%	-11	-36%

An analysis of the interpeak period shows that the Bus Priority option provides no greater benefit than the Reference Case. This is due to the bus priorities being morning peak only. Light Rail Transit and Bus Rapid Transit provide similar but smaller travel time savings (compared to the morning peak) as there is less congestion on the road network and the level of segregation provides less benefits.

4.4.3 Journey Time Reliability

Journey time reliability is a measure of how reliable the journey time between origins and destinations experienced by a traveller is. The previously discussed travel time savings are a best measure of the likely benefits of the options but do not forecast the range of travel times that may be experienced. A qualitative assessment of reliability is based on an assessment of the level of priority, segregation and the number of vehicles within a corridor.

The Bus Priority option increases reliability by providing targeted bus priorities in locations which are congested. However, the Bus Priority option does not segregate buses from traffic and does not lead to a reduction in the buses travelling through the Golden Mile. For travel to/from the east through the Hataitai bus tunnel, buses mix with general traffic in residential streets which are unlikely to include bus priorities.

The Bus Rapid Transit / Light Rail Transit options provide a greater level of reliability because they are far more segregated from traffic and through the CBD the number of vehicles on the Golden Mile decreases. This is likely to reduce the incidence of 'public transport congestion' with stopped public transport vehicles creating a bottleneck. Furthermore for trips to/from the east the Bus Rapid Transit/Light Rail Transit options travel through the State Highway corridor. Light Rail Transit has a higher level of segregation as it travels through Light Rail Transit only tunnels whilst Bus Rapid Transit travels with general traffic. Because of this high level of segregation and priority Light Rail Transit is likely to provide the highest level of journey time reliability.

4.4.4 Need to Transfer

All passenger transport systems require the ability to transfer between modes and services to ensure complete network coverage. In the case of trips by rail there is an absolute necessity to transfer to a different mode if the end destination is beyond a comfortable walking distance.

The analysis of regional trips in Table 11 shows that the Bus Priority option has negligible effect on the number of transfers within the region. Bus Rapid Transit increases transfers by 16% and Light Rail Transit by 41%.

Table 11 Morning peak region wide transfers

	Reference Case	Bus Priority	Bus Rapid Transit	Light Rail Transit
2021	10,360	-110	+ 1,540	+ 4,010
2031	9,730	-90	+ 1,530	+ 3,940
2041	10,070	-100	+ 1,610	+ 4,120

Table 12 displays the number of transfers occurring at the termini of the Spine. The Bus Rapid Transit option has increased transferring with the majority of the increase in the CBD, suggesting that Bus Rapid Transit services provide a better interchange with existing rail services. The Light Rail Transit option displays the greatest number of additional transfers with more than half of these outside of the CBD. This suggests that to use public transport from the south or east in the Light Rail Transit option requires a higher proportion of users to transfer than previously.

Table 12 2031 morning peak transfers in selected areas

	Bus Priority	Bus Rapid Transit	Light Rail Transit
Kilbernie/Lyall Bay	+ 10	+ 50	+ 1,180
Newtown	+ 10	+ 100	+ 970
CBD	- 90	+ 1,300	+ 1,790

Table 13 shows the percentage of passengers requiring a transfer between services in order to reach their final destination in the CBD during the morning peak. This shows that more transfers are required for Light Rail Transit and, to a lesser extent, for Bus Rapid Transit. Overall, the proportion of transfers is 30% of total trips under the Reference Case and the Bus Priority option, 36% under the Bus Rapid Transit option, and 45% under the Light Rail Transit option.

Bus Priority requires a similar proportion of transfers. Bus Rapid Transit requires moderate increases in proportion of transfer trips originating from Kilbirnie, Island Bay, and Newtown. This is due to some services being truncated and now operating as feeder services to allow interchange with the core BRT routes. Light Rail Transit requires significant increases in proportion of transfer trips originating in Miramar (89%), Kilbirnie (46%), and Island Bay (90%). As with Bus Rapid Transit, this is due to the some buses being truncated at the main interchanges and feeding onto the Light Rail Transit network. The significant increase in transfers is a perceived dis-benefit for Light Rail Transit. A fully integrated transport system with timed transfers will be required to create convenience for people that travel to and from Miramar, Kilbirnie, and Island Bay.

Table 13 Percentage of trips to CBD requiring a transfer

	Reference Case	Bus Priority	Bus Rapid Transit	Light Rail Transit
Miramar	11%	17%	21%	89%
Kilbirnie	2%	8%	36%	46%
Mount Vic /Hataitai	3%	5%	4%	5%
Island Bay	8%	11%	29%	90%
Newtown	0%	4%	14%	6%
CBD	0%	0%	0%	0%
Rest of Wellington	17%	17%	25%	31%
Rest of Region	57%	57%	62%	66%
Overall Average	**29%**	**30%**	**36%**	**45%**

4.5 Traffic Flow

4.5.1 Golden Mile

Each option affects the vehicle and public transport passenger volumes along the public transport spines. The changes in vehicle and passenger volumes on the Golden Mile and the Second Spine are shown in Figure 8 and Table 14. The data shows:

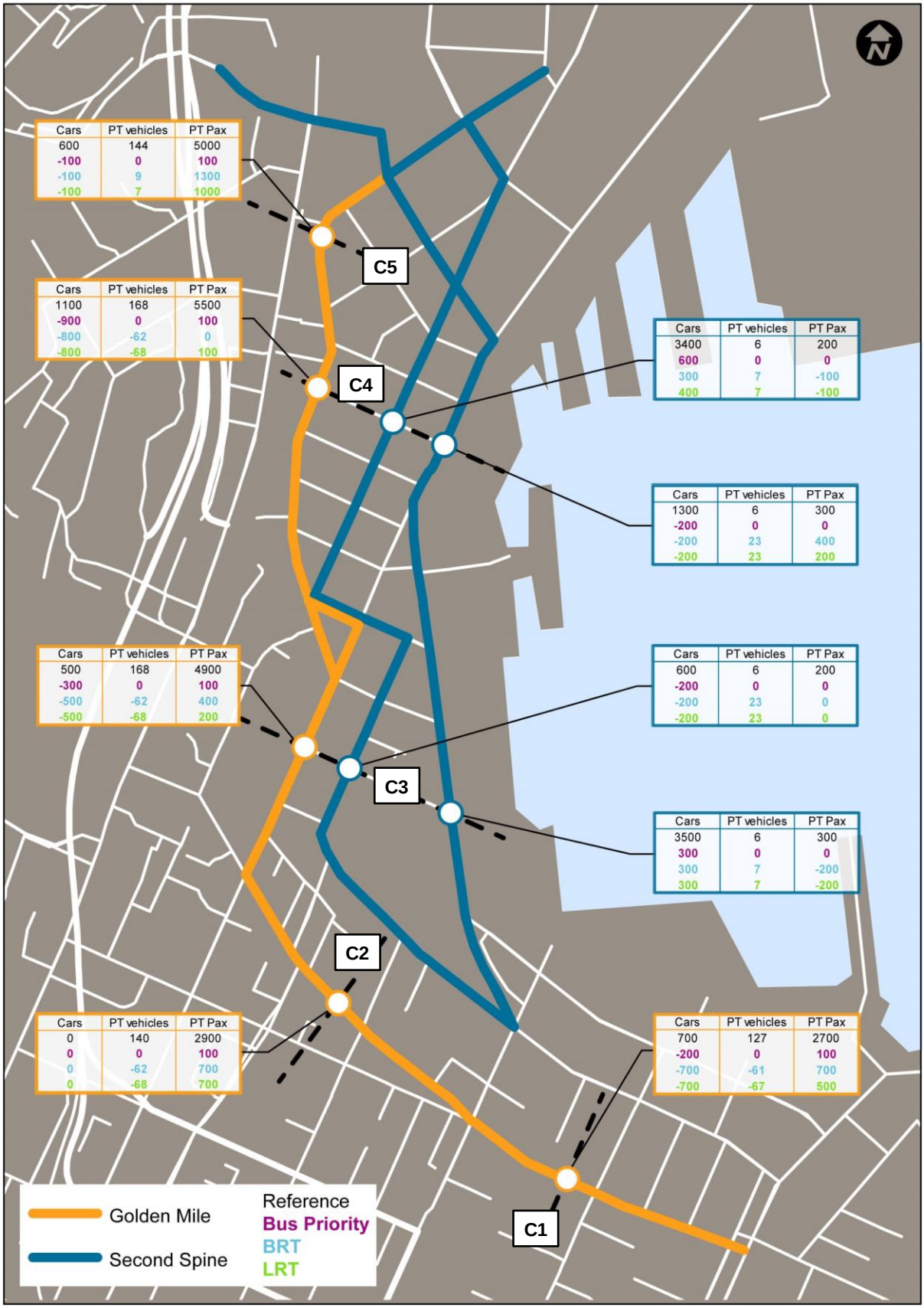
- Bus Priority is similar to the Reference Case. There is no reduction in the number of public transport vehicles on the Golden Mile
- Bus Rapid Transit and Light Rail Transit transfer some bus services (mostly from the north) onto a second Spine, this combined with higher capacity vehicles reduces public transport vehicles on the Golden Mile
- Despite the reduction in public transport vehicles on the Golden Mile for Bus Rapid Transit and Light Rail Transit, these options both have increased patronage on the Golden Mile

Table 14 Changes to car and public transport vehicle volumes along Spines (2031 one hour)

Screenline	C1		C2		C3		C4		C5*	
Number of	Cars	Public transport vehicles	Cars	Public transport vehicles	Cars	Public transport vehicles	Cars	Public transport vehicles	Cars	Public transport vehicles
Reference Case	**700**	**127**	**0**	**140**	**4500**	**180**	**5800**	**180**	**600**	**144**
Bus Priority	-200	0	0	0	-200	0	-500	0	-100	0
Bus Rapid Transit	-700	-61	0	-62	-400	-32	-700	-32	-100	+9
Light Rail Transit	-700	-67	0	-68	-400	-38	-600	-38	-100	+7

*Screenline C5 does not include the Secondary Spine

Figure 8 Vehicle and passenger volumes along public transport Spines



4.5.2 Changes on the Wider Network

Patronage

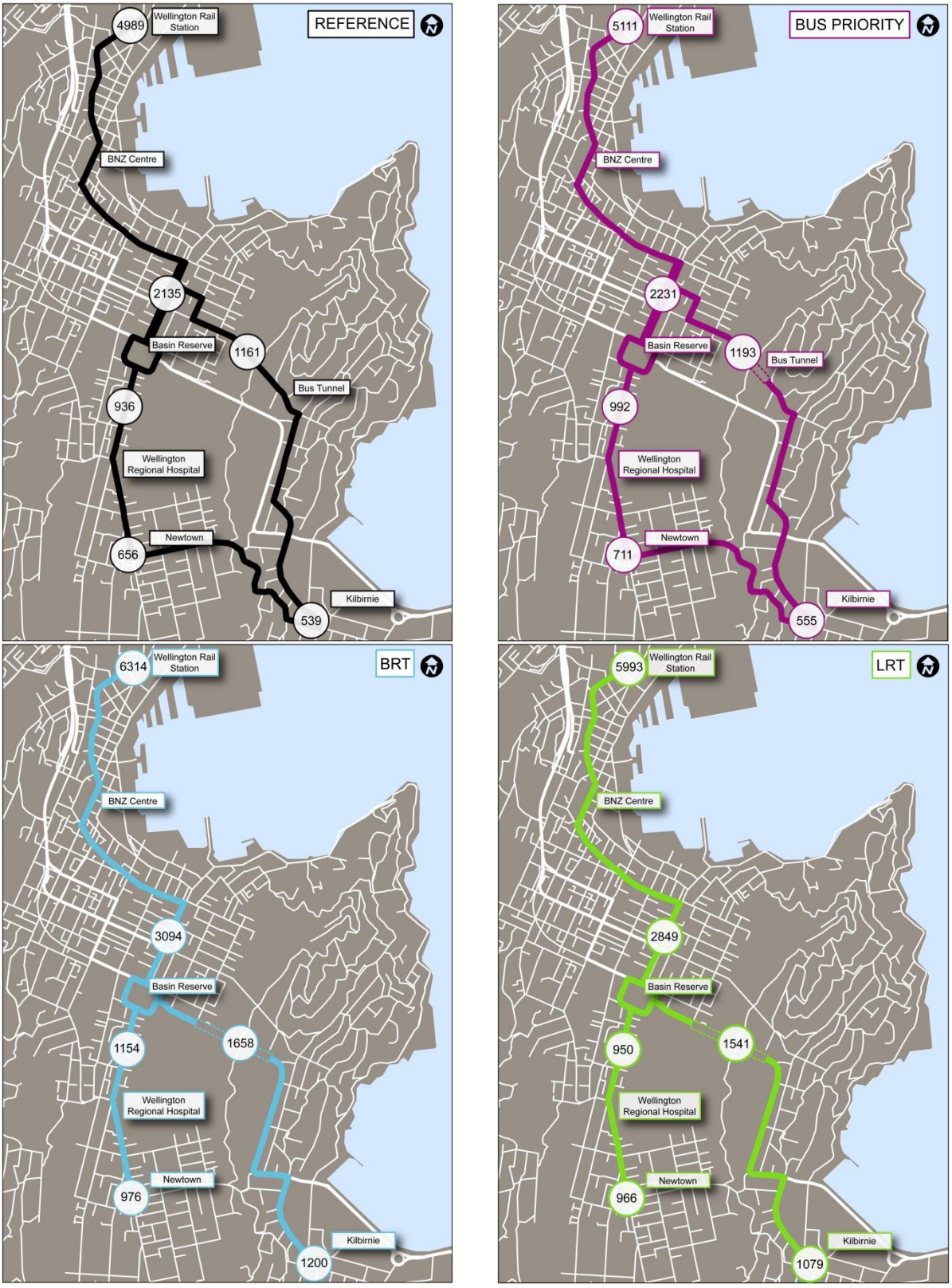
Figure 9 displays the patronage for the Reference Case and each of the options. Bus Priority has slightly more patronage than the Reference Case. Bus Rapid Transit and Light Rail Transit have substantially more patronage than the Reference Case. The Bus Rapid Transit and Light Rail Transit options differ from the Reference Case in the following aspects:

- Despite less public transport vehicles on some corridors, there is increased public transport patronage on all analysed corridors except in the Hataitai Tunnel.
- On Lambton Quay at the Rail Station, Light Rail Transit has 340 more passengers northbound and 670 more passengers southbound per hour. Bus Rapid Transit has 530 more passengers northbound and 800 more passengers southbound per hour.
- Despite reducing the number of public transport vehicles by half on Manners Street, patronage has increased by 200 to 450 passengers per direction per hour.
- There is an overall increase in patronage through the Hataitai / Victoria Tunnels of up to 470 passengers northbound and 60 passengers southbound per hour. This indicates the change in route does not adversely affect patronage.
- Patronage doubles on Kilbirnie Crescent northbound to the city centre.

Table 15 Public transport patronage changes from Reference Case (2031 peak hour)

Corridor	At intersection with	Northbound				Southbound			
		Ref	BP	BRT	LRT	Ref	BP	BRT	LRT
Lambton Quay North	Wellington Rail Station	**550**	30	530	340	**4,440**	100	800	670
Manners Street	Victoria Street	**2,050**	100	450	280	**900**	10	210	380
Kent/Cambridge Terrace	Vivian Street	**1,830**	90	630	410	**310**	0	330	300
Adelaide Road	Drummond Street	**820**	60	170	-20	**110**	0	50	30
Riddiford Street	Constable Street	**590**	50	310	300	**70**	0	10	10
Hataitai Tunnel	-	**1,050**	30	-1,040	-1,040	**110**	0	-90	-90
Victoria Tunnel	-	**0**	0	1,510	1,410	**0**	0	150	130
Kilbirnie Crescent	Kilbirnie Park	**420**	20	610	510	**120**	0	50	30

Figure 9 Patronage on wider network



Public transport vehicles

Table 16 Public transport vehicles changes from the Reference Case (2031 peak hour)

Corridor	At intersection with	Northbound				Southbound			
		Ref	BP	BRT	LRT	Ref	BP	BRT	LRT
Kent/Cambridge Terrace	Vivian Street	**43**	0	-10	-17	**30**	0	-4	-3
Adelaide Road	Drummond Street	**19**	0	-3	-7	**15**	0	-7	-3
Riddiford Street	Constable Street	**16**	0	6	2	**16**	0	-2	2
Hataitai Tunnel	-	**24**	0	-22	-22	**15**	0	-11	-11
Victoria Tunnel	-	**0**	0	15	12	**1**	0	15	12
Kilbirnie Crescent	Kilbirnie Park	**22**	0	-1	-4	**21**	0	4	1

Table 16 shows the number of public transport vehicles on selected corridors during the morning peak. The Bus Priority option does not differ from the Reference Case. The Bus Rapid Transit and Light Rail Transit options differ from the Reference Case in the following aspects:

- The number of public transport vehicles is reduced on Kent Terrace, Cambridge Terrace and Adelaide Road.
- Most public transport vehicles are diverted from the Hataitai Tunnel onto the Victoria Tunnel. Only the Flyer (91) continues to use the Hataitai Tunnel.
- Light Rail Transit sees slightly less northbound public transport vehicles than Bus Rapid Transit from Riddiford Street to Manners Street.
- Conversely, Light Rail Transit sees slightly more southbound public transport vehicles than Bus Rapid Transit from Manners Street to Riddiford Street.

Public transport capacity

Table 17 shows the public transport capacity of each option compared with the Reference Case. The calculated capacity for each option has been based upon the capacity of representative vehicles multiplied by the frequency of vehicles. The assumed capacities are based upon information from the International Review and the 2006 ATC urban guidelines.

Bus 64 Passengers

BRT Vehicle 100 Passengers

LRT Vehicle 180 Passengers

Table 17 Public transport capacity changes from Reference Case (2031 peak hour)

Corridor	At intersection with	Northbound				Southbound			
		Ref	BP	BRT	LRT	Ref	BP	BRT	LRT
Kent/Cambridge Terrace	Vivian Street	**2,800**	0	500	1,700	**1,900**	0	600	2,600
Adelaide Road	Drummond Street	**1,200**	0	400	900	**1,000**	0	-200	1,200
Riddiford Street	Constable Street	**1,000**	0	1,000	1,500	**1,000**	0	200	1,500
Hataitai Tunnel	-	**1,500**	0	-1,400	-1,400	**1,000**	0	-700	-700
Victoria Tunnel	-	**0**	0	1,500	2,200	**0**	0	1,500	2,100
Kilbirnie Crescent	Kilbirnie Park	**1,400**	0	500	1,100	**1,300**	0	800	1,500

The Bus Priority option does not differ from the Reference Case. Bus Rapid Transit has more capacity along most corridors, and Light Rail Transit has even more capacity. The Bus Rapid Transit and Light Rail Transit options differ from the Reference Case in the following aspects:

- Bus Rapid Transit and Light Rail Transit have more capacity from Kent Terrace, Cambridge Terrace to Riddiford Street, except for Bus Rapid Transit on Adelaide Road southbound.
- As with public transport vehicles, most public transport capacity is diverted from the Hataitai Tunnel on the local road network to the Victoria Tunnel.
- Despite less public transport vehicles on some corridors, Light Rail Transit has increased public transport capacity on all analysed corridors, except in the Hataitai Tunnel.

Available public transport capacity

Table 18 shows the percentage of filled public transport capacity. Compared against the Reference Case:

- Bus Priority has the same or slightly higher filled capacities than the Reference Case.
- There is no consistent trend in Bus Rapid Transit and Light Rail Transit filled capacities compared with the Reference Case.
- Bus Rapid Transit generally has higher filled capacities than Light Rail Transit.
- Bus Rapid Transit is at full capacity northbound through the Victoria Tunnel, whereas Light Rail Transit is at 65% capacity.
- Bus Rapid Transit and Light Rail Transit filled capacity has dropped considerably in the Hataitai Tunnel northbound. This suggests low demand for the local buses that would continue to use the Hataitai Tunnel.
- Bus Rapid Transit shows a substantially higher filled capacity on Kilbirnie Crescent northbound.
- Across the analysed corridors, the Reference Case has an average filled capacity of 50% northbound and 20% southbound. Bus Priority and Bus Rapid Transit have similar filled capacities. Light Rail Transit has lower filled capacities of 37% northbound and 16% southbound.

Table 18 Public transport percentage capacity filled

Corridor	At intersection with	Northbound				Southbound			
		Ref	BP	BRT	LRT	Ref	BP	BRT	LRT
Kent/Cambridge Terrace	Vivian Street	**66%**	70%	76%	50%	**16%**	16%	25%	13%
Adelaide Road	Drummond Street	**68%**	72%	62%	37%	**12%**	12%	20%	7%
Riddiford Street	Constable Street	**57%**	63%	45%	35%	**7%**	7%	6%	3%
Hataitai Tunnel	-	**68%**	70%	3%	7%	**12%**	12%	9%	9%
Victoria Tunnel	-	**-**	-	101%	65%	**0%**	0%	10%	6%
Kilbirnie Crescent	Kilbirnie Park	**30%**	31%	55%	37%	**9%**	9%	8%	5%
Average	-	**50%**	**53%**	**54%**	**37%**	**20%**	**21%**	**23%**	**16%**

4.6 Impact on Pedestrians and Cyclists

Through the development of options, alignments and cross sections it would be necessary to maintain, add or increase pedestrian and cycle facilities.

The Bus Priority, Bus Rapid Transit and Light Rail Transit options do not include any physical barriers to movement along, or across roads and intersections for pedestrians. However, public transport priority lanes with vehicles moving at a different speed to general traffic may create safety issues for crossing pedestrians.

Adequate medians and separation distances between general traffic and public transport vehicles would be required in any subsequent detailed designs.

In a small number of cases the footpath has been reduced in width to accommodate a larger carriageway without the need for road reserve widening. In these instances the reductions are small and typically in areas with wide footpaths.

Central raised medians are located on corridors that do not require priority turning movements into driveways and side roads. For Bus Rapid Transit / Light Rail Transit, these medians transform into stations where appropriate. These medians could act as pedestrian refuges and assist pedestrians in crossing the road.

The exact location of stations is not detailed in this study. However, it is envisaged that there will be a consolidation of existing bus stops, in particular on the Golden Mile. This consolidation of bus stops is not however specific to the options proposed and could be implemented in the Reference case to minimise bus congestion. The additional walk distance that this may create for some passengers is not considered to be an impact of the options.

Although this is predominantly a public transport project, it has also aimed to deliver sections of the identified cycle routes. The Bus Priority option provides shared bus and cycle lanes on some sections and the Bus Rapid Transit and Light Rail Transit options include cycle lanes in strategic locations. Where there is sufficient road width, a 1.0 m safety buffer placed between the kerbside cycle lane and the adjacent general traffic lane. Cycle lanes are provided on Adelaide Road, Kent Terrace and Cambridge Terrace.

4.7 Travel times of motorists to CBD

The short list options, particularly Bus Rapid Transit and Light Rail Transit, require capacity to be taken from general traffic at key points on the network to provide for public transport infrastructure and priority measures. These capacity reductions result in slightly longer travel times for some motorists. Table 19 shows car travel times for travel into the CBD during the morning peak. Car travel time under each option is compared against the Reference Case.

In the Bus Rapid Transit and Light Rail Transit options, the greatest increases in car travel time are from Newtown, Island Bay and Karori. The increases for Newtown and Island Bay are due to capacity reductions at intersections in Newtown. Closure of section of the Golden Mile to general traffic affects trips from northern and western suburbs such as Karori.

These results show that travel times for some car users will increase by up to 1.5 minutes as a result of the short list options. Such increases are minimal and could be considered within the bounds of day-to-day variability in travel times. The increased travel time would be imperceptible to most road users. Despite reduced highway capacities, the decrease in car trips appears to cancel out major changes to car travel time.

It is likely that if an option is progressed, detailed design would optimise the highway network so that the increased car travel times would be reduced.

Table 19 Change in car travel time to the CBD (minutes)

Origin	Reference Case	Bus Priority	Bus Rapid Transit	Light Rail Transit
Miramar	**24.7**	-0.3	-0.9	0.2
Seatoun	**27.4**	-0.3	-0.9	0.2
Airport	**25.7**	-0.3	-0.9	0.2
Island Bay	**23.9**	0.0	0.5	0.6
Newtown	**21.6**	1.0	0.8	1.1
Hataitai	**20.0**	-0.3	0.5	0.6
Kilbirnie	**22.6**	0.2	-0.1	0.1
Karori	**24.2**	1.3	1.0	1.2
Brooklyn	**20.8**	0.0	0.8	1.1

4.8 Consistency with Future Projects

4.8.1 Mount Victoria Tunnel Duplication

Both the Bus Rapid Transit and Light Rail Transit options travel from the Basin Reserve to Kilbirnie through tunnels. The Bus Rapid Transit option would use the additional capacity provided by the Mount Victoria tunnel duplication project with buses travelling with general vehicles through the tunnels. The Light Rail Transit option would require the construction of additional tunnel(s) to provide a route through to Kilbirnie.

Bus Rapid Transit includes bus priority lanes along Ruahine Street which will require additional widening beyond that currently envisaged for the entire length. Buses would merge with general traffic before entering the tunnel west bound. The current concept design for Bus Rapid Transit does not include detail of the transition to/from Bus Rapid Transit lanes. This will need to be assessed in detail during subsequent investigations.

Light Rail Transit includes dual track on the western side of Ruahine Street. Travelling on the western side of Ruahine Street ensures minimal interaction between State Highway traffic and light rail vehicles. The biggest impact will be additional tunnels through Mount Victoria. Concept designs and vehicle tracking curves have confirmed that there is a feasible route that can be implemented but it will be necessary at a detailed design stage to understand how Light Rail Transit wil transition to/from the Basin Reserve. Basin Reserve

All of the options travel around the Basin Reserve, bus priority lanes have already been provided for in the proposed design along the edge of the reserve in the right hand lane. For bus priority this will require buses to move from the left lane on the approaches to the basin across to the right hand lane around the Basin and then exit to the left hand lane again. This will require changes to traffic signals to allow buses to enter and exit the priority lanes and is in line with the current design for the Basin Reserve.

Bus Rapid Transit and Light Rail Transit vehicles travel along the median on Adelaide Road and Kent/Cambridge Terrace when approaching the Basin Reserve. This simplifies transition to the priority lanes around the Basin Reserve as vehicles are not required to cross general traffic lanes. For Light Rail Transit the ability for a vehicle to negotiate the Basin Reserve has been tested and is able to operate in both directions as single split track, either side of the Basin Reserve.

4.9 Costs

4.9.1 Capital Costs

Costs for the options were based on rates derived from similar projects, and using recent unit rates for major infrastructure requirements such as tunnelling. A full breakdown of costs is detailed in Appendix E.

Table 20 displays the estimated costs of each of the projects. Bus Priority is the lowest with Bus Rapid Transit three times higher and Light Rail Transit fifteen times higher. The increasing costs between options relate to the increase in the amount of fixed infrastructure involved and the level of segregation provided.

Table 20 Capital costs

Option	Km	Estimated cost	Cost / km
Bus Priority	10.3 km	$ 58.6	$ 5.7 m
Bus Rapid Transit	9.5 km	$ 207.1	$ 21.8 m
Light Rail Transit 2 Tunnel Option	10.7 km	$ 938.0	$ 87.7 m

4.9.2 Operational Costs of Options

The operational costs of the options were developed based upon per hour and kilometre costs. The Reference Case and option service time and distance totals were taken from the Wellington Public Transport Modal (WPTM) model for bus, Bus Rapid Transit and Light Rail Transit vehicles. The costs were then derived by applying hourly and per kilometre rates. The resulting annual costs are shown below. Bus priority is similar to the Reference Case, this is as the total kilometres in service remains the same but there are time savings. Bus Rapid Transit has a lower cost, which is due to the optimisation of routes and services that is possible due to having more consistent travel times. Light Rail Transit has a marginally higher cost, this is due to the inclusion of track maintenance and that total bus kilometres have not reduced enough to offset the growth in Light Rail Transit kilometres.

Table 21 Operating costs (millions)

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

4.9.3 Cost savings associated with reduced car park provision

A benefit of increased public transport patronage is in reduced demand for parking in the CBD as people change mode to public transport. To capture this benefit the cost saving of not providing additional car parks was calculated based on a cost of $ 5,000 per annum per car park space.

4.10 Economic Assessment

4.10.1 Overview

The economic evaluation assessed the viability of the Bus Priority, Bus Rapid Transit and Light Rail Transit options against the Reference Case. The specification of the Reference Case and Options, the model inputs and the method of evaluation were discussed with the peer reviewer (Ian Wallis). The evaluation was underpinned by a number of key assumptions, of which the most significant are:

- **Evaluation period** – 30 years assumed from the first year when major expenditure occurs;
- **Real prices expressed in a constant price for all costs and benefits** – discounted to the base date of 1 July 2012;
- **Real discount rate** – 8.0% as per current New Zealand Treasury guidance; and
- **Year Zero** – 2012/13.

The analysis was carried out at a feasibility level. This is because the sources of benefits were restricted to the outputs of the traffic modelling detailed in the Greater Wellington Regional Council Transport Modelling Report. These outputs were limited to the annual travel time cost and vehicle operating cost for the years 2021, 2031 and 2041 only. This approach therefore did not include the exploration of other potential benefit sources (e.g. accidents, cycling, walking).

The estimates of the option costs were high level. Nevertheless, since many of the potential benefit sources were not explored, the results of this economic evaluation can be considered highly conservative.

The evaluation was broadly carried out using the procedures developed by the NZTA and presented in the *Economic Evaluation Manual*.

Table 22 displays the assumed construction timeline for options. These timeframes provide a basis from which Benefit Costs Ratios (BCR) have been developed and provides a base from which to make comparisons. The dates differ from those assumed for staging which rely on other projects to be completed (Basin Reserve and Mount Victoria Tunnel Duplication) which is not an issue for this comparative test. The BCR evaluation does not consider the incremental benefits that each option may accrue as stages are implemented but rather a full implementation benefit given the likely period of construction.

Table 22 Construction period for options

Option	First year of construction	Construction period (years)
Bus Priority	2014/15	2
Bus Rapid Transit	2014/15	3
Light Rail Transit	2015/16	4

For each option the time stream of economic resource cost savings were estimated in constant price terms to exclude inflation, bringing together the cost savings for public transport users from the Wellington Public Transport Modal (WPTM) and road users from the Wellington Transport Strategic Model (WTSM). These savings were then compared with the corresponding stream of capital investment costs. The resulting stream of net benefits and costs offered by the alternative options over the Reference Case formed the basis for the appraisal.

4.10.2 Source of Benefit Calculations

Data was obtained from the WTSM for highway benefits and the WPTM for public transport user benefits. The outputs from the models were given as single figures of benefits compared against the Reference Case. The derivation of benefits is detailed in the Greater Wellington Regional Council Modelling Report.

The data obtained from the models provided annual costs (in dollars per year) of travel time and vehicle operation for the Reference Case and the options for three time horizons - years 2021, 2031 and 2041. The travel time costs included the cost of congestion.

4.10.3 Wider Economic Benefits

Wider economic benefits (WEB's) describe the productivity advantages that arise from the close spatial concentration of economic activity. There is a strong link between transport provision and the benefits that arise

from the spatial concentration of economic activity. The contribution of the Bus Priority, Bus Rapid Transit and Light Rail Transit options to the upgrading of the Wellington public transport system qualifies for the wider economic benefits to be taken into consideration.

For the purpose of this economic evaluation the WEB's were assumed at 25.0 % of all other benefits. Such a figure is consistent with the amount of WEB's of similar projects.

Benefits

Table 23 presents the public transport and highway benefits extracted from the transport models and discounted over the period 2014/15-2044/45 to obtain the Net Present Value of benefits. This shows that highway benefits are negative for all options. This is due to the small delays created by reductions in road capacity impacting on many vehicles.

Table 23 Benefits

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
Public Transport User Benefits	$ 34.7	$ 95.5	$ 56.0
Highway Benefits	-$ 18.2	-$ 23.6	-$ 31.6
Discounted Benefits ($ million)	$ 16.5	$ 71.9	$ 24.4
Wider Economic Benefits (25%)	$ 4.1	$ 18.0	$ 6.1
Total NPV Benefits	$ 20.6	$ 89.9	$ 30.5

4.10.4 Costs

Table 24 presents the discounted net present value of costs based on construction of the options and the operational cost of the public transport services. The savings in cost from not providing car parks is shown as a negative cost.

Table 24 Costs

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

4.10.5 Benefit Cost Analysis

Benefit Cost Ratio (BCR) is the ratio of the value of discounted benefits to the value of discounted costs. The BCR's for each option based on discounted benefits and costs are shown in Table 25.

Table 25 Benefit Cost Ratio calculation

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

4.10.6 Sensitivity Analysis

Sensitivity analysis provides an understanding of the relative sensitivity of each option to changes in the calculation of costs, benefits, base assumptions and the process that is used to calculate the BCR. Three sensitivity testing regimes have been considered.

- Sensitivity testing of changes in core assumptions in the model and the response to these changes. This is a test of the sensitivity and relativity of option results to changes in fares, transfer cost and road capacity reductions. Results from the modelling sensitivity tests are documented in the Greater Wellington Regional Council Modelling Report.
- Sensitivity testing of the assumptions which have been used in the calculation of benefits and costs and the changes to the BCR. These are detailed in the following section.
- Sensitivity testing of scenario input assumptions and the way in which they affect the uptake of public transport and the resulting BCR. These are detailed in the following section.

Sensitivity Tests - Calculating BCR

These sensitivity tests reveal how changes to the process of calculating the BCR and the costs and benefits that are included affect the BCR. These tests included:

- Reduced construction costs – these were tested for a cost decrease of 20%, an increase was not considered as the costs are considered conservative.
- 6% discount rate and 40 year evaluation period, recognising the long term strategic nature of the options.
- An alternative “behavioural cost” evaluation which uses perceived costs as the value of time. Traveller cost is based on the perceived value of time used in the transport model in calculating the total cost of travel.This is fully documented in the Greater Wellington Regional Council Modelling Report.

Table 26 displays the results of the sensitivity tests. Overall the sensitivity tests reveal that the BCR for each test increases but the relativity between options remains the same.

Table 26 BCR sensitivity analysis

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

Sensitivity Tests – Base Assumptions

These sensitivity tests provide an indication of how changes to selected assumptions in future year scenarios affect the BCR. Table 27 displays the sensitivity tests for which revised BCR’s have been calculated.

Table 27 Model Scenario Tests

Aspect	Base Assessment	Details
Parking	Future year costs and unrestricted parking	Cap the demand for total parking in the CBD to recognise that parking provision will not continue without limits. This is implemented based upon the adjustment of parking costs.
Network Improvements	Planned investment program	Removal of RoNS projects - Petone to Grenada, Transmission Gully, Mount Victoria Tunnel Duplication

Parking

Future year forecasts assume that the decision to travel by car to the CBD is based upon the relative costs of travel by each mode including parking. There is no limitation on the number of car trips that can be made to the CBD, the implication is that parking will increase to meet demand. This sensitivity test forecasts the implications on public transport patronage and the BCR of placing a finite cap on the number of car parks within the CBD coupled with implementing the Bus Rapid Transit and Light Rail Transit options.

This has been applied in the future year forecasts by increasing the cost of parking until the number of commuter trips reach the assumed parking cap. The application of this methodology is fully documented in the Greater Wellington Regional Council Modelling Report.

The effect of introducing parking constraint in the Bus Rapid Transit and Light Rail Transit options has a significant effect, increasing 2031 AM peak patronage by 1,600 – 2,100. This indicates that there are significant trips by car to the CBD which could be carried by public transport if parking spaces are not increased to meet demand. The change in the BCR also highlights that the options provide significant benefits to users compared to the Reference Case with the BCR for Bus Rapid Transit exceeding 1.0 and the BCR for Light Rail Transit doubling.

Table 28 Changes due to parking constraint

	Reference Case	Bus Rapid Transit	Light Rail Transit
Base public transport Trips	34,000	+ 800	+ 300
Revised public transport Trips	-	+ 2,100	+ 1,600
Base BCR	-	0.87	0.05
Revised BCR	-	1.29	0.12

Network Improvements

The future forecasts of travel in the Reference Case shows an increase in public transport patronage between 2011 and 2021 with a decrease between 2021 and 2031. This is due to the inclusion of substantial investment in the State Highway Network (RoNS) which is included in the 2031 assumptions. Projects such as the Mount Victoria Tunnel duplication, Petone to Grenada and Transmission Gully projects provide significant additional road capacity. This increase in road capacity leads to the forecast decrease in public transport patronage after 2021 as there are decreases in travel times for journeys by car.

Table 29 indicates that whilst deferring the RoNS results in increased public transport patronage it does not change the relativity between the options and the Reference Case. The inclusion of the options increases the patronage by the same amount, suggesting that they provide similar benefits across a range of base assumptions.

The deferral of the RoNS provides a lower BCR for both options, suggesting that the additional capacity provided by the investment in roading projects offsets the reductions in road capacity which is represented in the options.

Table 29 Changes in 2031 AM patronage with the RoNS deferred

	Reference Case	Bus Rapid Transit	Light Rail Transit
Base public transport trips	34,000	+ 800	+ 300
Revised public transport trips	34,400	+ 800	+300
Base BCR	0.57	0.87	0.05
Revised BCR	-	0.70	0.02

4.10.7 Economics Summary

The economic evaluation has been assessed against three alternate cases.

- The first alternate case assumes that key RoNS projects are not constructed.
- The second core case assumes that these RoNS projects proceed as planned.
- The third alternate case assumes a future cap on the parking demand in the CBD.
- For the cases without a parking cap, Bus Rapid Transit has the highest BCR, followed by Bus Priority and then by Light Rail Transit. For the cases that assumes a parking cap, Bus Priority has the highest BCR (1.42), followed by Bus Rapid Transit (1.29) and then by Light Rail Transit (0.12).

Transport modelling sensitivity tests were performed on the second core case (RoNS projects proceed as planned and there is no parking cap in the CBD). For all sensitively tests, Bus Rapid Transit maintained the highest BCR, followed by Bus Priority and then by Light Rail Transit. Light Rail Transit gave the highest deviation from its base BCR, doubling from 0.05 to 0.10. Bus Rapid Transit gave the lowest deviation, rising 42% from its base BCR of 0.57. Bus Rapid Transit gave a deviation of 72% above its base BCR of 0.87.

Table 30 BCR summary

Assessment	Bus Priority	Bus Rapid Transit	Light Rail Transit
Base Assessments			
No RoNS + Options	0.32	0.70	0.02
RoNS + Options	0.57	0.87	0.05
RoNS + Options + Parking Cap	1.42	1.29	0.12
Sensitivity Tests – On RoNS + Options			
Decreased costs (-20%)	0.78	1.27	0.06
Discount rate and evaluation period	0.81	1.49	0.05
Alternative Approach	0.67	1.55	0.10
Deviation from Base BCR	0% to +42%	0% to +72%	0% to +100%

4.11 Resilience

Resilience of options is based upon consideration of:

- Infrastructure requirements.
- Power or fuel requirements.
- Ability to adapt dynamically to changing network operating conditions.
- Ability to recover from and/or operate during natural disasters.

This definition of resilience has been adopted so as to highlight issues not associated with transport system capacity, operational and capital costs.

Bus Priority

Buses provide a high level of resilience as they are not based around fixed infrastructure or a network system. Independently powered they do not rely on fixed infrastructure (except for roads), or the requirement to follow fixed routes. The existing trolley buses an exception as they rely on overhead cables. Wellington has a mix of diesel and trolley buses providing a core network of routes and the flexibility and independence of diesel buses which can respond to changes in network operation dynamically. A key aspect is the ability for buses to bypass obstacles such as parked vehicles and be able to be rerouted should road construction or natural disasters close key corridors.

Trolley or hybrid buses would be potentially less affected by availability of fuel and rising fuel costs in the future, especially if renewable energy sources are used. However, reliance on fixed lines for power reduces the resilience of trolley buses to operate during power outages, significant disruptions on the road network or during natural disasters which affect the power lines.

Bus Rapid Transit

Bus Rapid Transit combines the flexibility of a bus based system with the benefit of having sections of the network fully segregated from general traffic. Although Bus Rapid Transit is reliant on infrastructure to provide a high level of priority and segregation during normal operation it also includes the flexibility of individual vehicles which can move away from this fixed infrastructure as necessary. A by-product of a segregated network is that it can provide a priority route for emergency vehicles allowing them to bypass traffic.

Light Rail Transit

Light Rail Transit is reliant on fixed infrastructure for both motive power and for operation. Overhead power lines provide power whilst rails are required for operation. Disruptions to either of these render parts of the network inoperable.

A single line is proposed through the CBD branching off at the Basin Reserve to the south and east. There is not an alternative Light Rail Transit network or route which would be able to be used should a central section of the line be rendered inoperable. Short term impacts of loss of service could only be reduced through the use of buses as replacements.

Light Rail Transit is particularly prone to impacts from natural disasters or construction. There is no ability to quickly reroute or bypass locations, meaning the passenger transport system would only recover once full reconstruction has been completed. The time taken to re-establish Light Rail Transit should major disruption to infrastructure occur would therefore be longer compared to other modes.

In the future Light Rail Transit is likely to be less affected by availability of fuel and rising fuel costs in the future due to the use of electricity.

4.12 Staging

Optimal timing and staging of the projects is guided by:

- Demand based assessment to identify timing;
- Ability of options to be provided incrementally.

Other contributing factors to the staging are the time required for planning, consultation and environmental approval, pre-construction and procurement activities. Experience of other similar sized road construction projects suggests this may take between two to five years.

4.12.1 Assessment of Demand for Bus Rapid Transit and Light Rail Transit

Table 31 displays forecast patronage (AM peak hour direction) from WPTM for Bus Rapid Transit and Light Rail Transit for Adelaide Road and the Mount Victoria Tunnel approaches to the Basin Reserve. This is the point at which the south and east alignments converge. These figures suggest that the demand through the Mount Victoria tunnel is adequate to trigger both Bus Rapid Transit and Light Rail Transit by 2021 (Bus Rapid Transit 100% capacity, Light Rail Transit 65%) for the assumed public transport services in the model. Adelaide Road has a lower demand for both Bus Rapid Transit and Light Rail Transit.

Table 31 Public transport demand

Year	Corridor	Patronage (peak Direction)			% Capacity			Headway		
		Ref Case	Bus Rapid Transit	Light Rail Transit	Ref Case	Bus Rapid Transit	Light Rail Transit	Ref Case	Bus Rapid Transit	Light Rail Transit
2021	Adelaide Road	775	942	805	64%	59%	37%	3.0	4.0	5.0
2031		807	963	837	66%	60%	39%	3.0	4.0	5.0
2041		843	1035	885	69%	65%	41%	3.0	4.0	5.0
2021	Mount Victoria Tunnel	1090	1517	1419	71%	101%	66%	2.5	4.0	5.0
2031		1048	1508	1414	68%	101%	65%	2.5	4.0	5.0
2041		1082	1582	1483	70%	105%	69%	2.5	4.0	5.0

4.12.2 Ability of Options to be Staged Incrementally

Table 32 displays the ability of Bus Rapid Transit / Light Rail Transit to be staged in isolation and the impacts that this would have. This shows that whilst sections of the Bus Rapid Transit could be incrementally staged there is a reliance on State Highway projects at the Basin Reserve and Mount Victoria to progress to the east, staging through the Golden Mile and to the south could occur incrementally and not be wholly reliant on other projects. The assessment of Light Rail Transit shows that incremental development of the option creates issues of integration with remaining services and the ability to provide a holistic network without requiring the need to transfer for short trips. This underlines that Light Rail Transit provides benefits when it is a complete package.

Table 32 Assessment of Stageability

	Bus Rapid Transit	Light Rail Transit
Golden Mile		
Ability to implement in isolation	Yes (infrastructure only)	Limited as does not provide a complete solution
Benefits to providing in isolation	Improved travel time for buses along Golden Mile	Limited as over a short distance, will require transfers to/from bus at Courtenay Place
Design issues	None	Redesign of bus interchanges at Courtenay Place
Reliance on other projects	No	
Impact on other projects	No	
Southern Corridor		
Ability to implement in isolation	Yes	Limited as does not provide a complete solution
Benefits to providing in isolation	Improved travel time from Newtown	Limited as will require transfer to/from bus at Newtown and Courtenay Place
Reliance on other projects	Basin Reserve provides ability to implement priorities around Basin	
Impact on other projects	Supersedes bus priorities on Adelaide Road Requires integration with Basin approaches to Mount Victoria Tunnel	
Eastern Corridor		
Ability to implement in isolation	Yes	Limited as does not provide a complete solution
Benefits to providing in isolation	Improved travel times from Kilbirnie	Limited as will require transfer to/from bus at Kilbirnie and Basin Reserve
Reliance on other projects	Basin Reserve Bridge provides ability to implement priorities around Basin Reserve Mount Victoria Tunnel provides route to/from the east.	Basin Reserve bridge provides ability to implement priorities around the Basin Reserve
Impact on other projects	Mount Victoria tunnel - corridor width on Ruahine Street	

4.12.3 Optimal Staging

Bus Priority Staging

Bus Priority is able to be developed incrementally as opportunities arise and as resources are available. Staging would follow the direction given by the Wellington City Council bus priority plan, which starts in the CBD along the Golden Mile and works outwards along key corridors. In addition, opportunities to construct priority bus lanes as part of other planned road construction projects would be taken wherever possible. This includes the Basin Reserve bridge and Adelaide Road upgrade projects.

Limited time would be needed for planning, consultation and environmental assessment along most parts of the route as there is very limited impact on properties and businesses.

Constable Street is likely to be the last stage of development as it is of lesser overall priority due to low passenger demand.

Bus Rapid Transit Staging

Bus Rapid Transit is reliant on other road construction projects to provide the additional capacity and priority required to provide the complete option network. The completion of the Basin Reserve bridge project is currently 2016, and the Mount Victoria Tunnel duplication is 2022. The Bus Rapid Transit route to Kilbirnie cannot be developed until these projects are in place. Demand forecasts suggest that full implementation by the opening of the Mount Victoria Tunnel is justified.

Building to the full option by 2022 could occur in sections with implementation through the Golden Mile as the first stage extending beyond to include Kent/Cambridge Terrace for the opening of the Basin Reserve bridge project (2016) and beyond to Adelaide Road. Completion of the option to provide services to the east would be developed in conjunction with the Mount Victoria Tunnel duplication. However, the maximum benefits of Bus Rapid Transit are only realised when a complete system is operational and as such the ideal staging would be for the entire network to be developed in one phase.

Leading towards this timeframe, there are some measures that should be considered for early action:

- Purchase of any land parcels required.
- Ensuring that the Bus Rapid Transit option is factored into the planning and design of relevant RoNS projects and other land use and transport planning projects.

Experience of similar sized road projects indicates that approximately three to five years would be required for planning, consultation and environmental approvals, and two years for preconstruction and procurement activities.

Light Rail Transit Staging

As this option requires dedicated Light Rail Transit lanes to be placed in a different road layout, its staging needs to consider how existing bus services will be affected, until the network is fully operational. It is also integrally linked to the timing of other road construction projects such as the Basin Reserve bridge (2016) and Mount Victoria Tunnel duplication (2022). The route to Kilbirnie, which requires a new separate tunnel through Mount Victoria, would ideally be developed in the same timeframe as these projects to minimise cost and disruption. Demand forecasts suggest that full implementation by the opening of the Mount Victoria Tunnel would see adequate patronage to justify the level of service proposed.

Whilst an incremental development of the Light Rail Transit option could be considered, at a minimum this would have to provide for the construction of one complete ‘branch’ of the Light Rail Transit route. This would be the route from the Wellington Rail Station to Kilbirnie, which has the highest forecast patronage. Providing a short section of Light Rail Transit through the CBD would not be successful as this would require bus passengers to transfer close to their final destination.

However, an incremental development approach would likely reduce the level of service for bus passengers, providing an incomplete system and requiring transfer to Light Rail Transit close to the CBD. The maximum benefits of Light Rail Transit are only realised when a complete system is operational, and both ‘branches’ of the Light Rail Transit option are operational, providing a two and half minute frequency of service through the CBD, and allowing passengers to transfer in suburban locations. Taking these factors into account the optimal staging and timing for the Light Rail Transit option is to be implemented in its entirety by 2022.

Leading towards this timeframe, there are some measures that should be considered for early action:

- Construction of dedicated public transport lanes in the Light Rail Transit option layout from Wellington Rail Station to Courtney Place. These can be developed independently of the other sections of the route.
- Purchase of any land parcels required.

- Ensuring that the Light Rail Transit option is factored into the planning and design of relevant RoNS projects and other land use and transport planning projects.
- Early development of a tunnel solution as part of joint project with NZTA for the Mount Victoria Tunnel duplication.

5.0 SUMMARY OF EVALUATION RESULTS

The key results from the option evaluation are outlined in the table below.

Table 33: Summary of Evaluation Results

		Reference Case	Bus Priority	Bus Rapid Transit	Light Rail Transit
Option	km of dedicated route		10.0	9.0	10.2
	New vehicles			40	22
	New Depots				1
	Headway of service on Kent/Cambridge (mins at peak)	1.5	1.5	1.8	2.3
Cost (millions)	$ CAPEX	-	59	207	938
	$ OPEX per annum	88	88	83	89
Benefits	Passenger numbers: AM peak (in an hour)				
	2021 (regional)	35,600	35,800	36,300	35,800
	2031 (regional)	34,000	34,300	34,800	34,300
	2041 (regional)	35,200	35,500	36,100	35,600
	From Locations to CBD				
	Miramar	1,320	1,380	1,490	1,250
	Kilbirnie	680	720	760	770
	Mount Victoria / Hataitai	790	800	740	750
	Island Bay / Berhampore	1,140	1,170	1,240	1,080
	Newtown	790	820	880	830
	Travel Measures (2031 morning peak)				
	Travel times on corridors				
	From Kilbirnie	25	22	13	13
	From Newtown	18	15	12	11
	Transfers				
	Kilbirnie	160	280	210	1,340
	Newtown	50	60	150	1,020
	CBD	7,790	7,700	9,100	9,580
Economic Assessment (BCR)	EEM	-	0.57	0.87	0.05
	Alternative	-	0.67	1.55	0.10

Environmental and social assessment	Widening		Constable Street	Ruahine Street	Ruahine Street Paterson Street
	Parking		Peak Period	Removal in some locations	Removal in some locations
	Property Access CBD		Impacts during Peak period	Impacts during Working Hours	Impacts during Working Hours
	Planning, environmental and social impacts		Marginal	Significant	Very Significant
Potential broader impacts	Typical property price increase *(Source: International Review)*	-	Little attraction	Up to 20%	Up to 25%

Appendix A

Other Technical Documents

Appendix A: Other Technical Documents

The following suite of documents was prepared for this study:

Engagement Report, December 2011

This report details the process and results from the engagement on what makes public transport systems high quality. This was sourced from appreciative inquiries, focus groups, on-line survey, market research street surveys, letters seeking feedback from individual stakeholders.

Inception and Scoping Report, February 2012

This report confirmed the study scope and methods. It specifically set out the modelling approach, development of the study vision and problem definition, feedback from targeted stakeholder engagement, market surveys and guidance on how best to apply the Treasury Business Case framework.

International Review of Public Transport Systems, February 2012

The purpose of this report is to learn from the implementation of public transport systems overseas. Thirty-five case studies from across the globe were investigated to inform the PTSS. The report covered modal attribute, property uplift values due to public transport change, key success factors, design and operational factors. Outcomes from the investigation have been used to inform all subsequent stages in the study.

Land Use Planning, Citywide and Corridor Review, MRCagney, April 2012

The report focuses on the review drivers of land use change at a citywide level, determining the maximum development capacity in the study area and identifying opportunities for Transit Supportive Development. In particular, it helped inform the Long List Option Evaluation stage.

Option Evaluation Long List, April 2012

This report looked at the first sieve of modal and alignment options at a strategic level. It sieved 88 potential options to eight based on an assessment of each option / alignment around a range of multi-criteria including: ability to support land use development/intensification, accessibility, attractiveness to user, engineering feasibility, ability of mode to move the forecast demand, financial viability and environmental.

Option Evaluation Medium List, August 2012

This report looked at a more detailed analysis of the eight options from the Short List evaluation. It assessed each option at a more detailed level. This included concept design, social and environmental assessment, urban planning / design assessment, statutory planning assessment, traffic modelling and operational and capital cost estimates to inform the scoring of a multi-criteria assessment. This stage resulted in the preferred options of Bus Priority, Bus Rapid Transit and Light Rail Transit being recommended for the final short list assessment. It also expanded the extent of the study area to the south and south-east due to limitations in the primary spine being between just Wellington Railway Station to Wellington Regional Hospital.

Transport Modelling Report, June 2013, Greater Wellington Regional Council

This report outlines the modelling approach and brings together all the modelling results that underpin the study analysis.

Option Evaluation Results, June 2013

This report provides details of the Short List evaluation. It includes Appendices that are in themselves Technical Notes covering the planning assessment, economic evaluation, capital costs and operational cost estimates. This report clearly outlines the final results for the preferred short listed options Bus Priority, Bus Rapid Transit and

Light Rail Transit in terms of benefits, staging and development, costs, economics and planning, social and environmental assessment. It also sets out the results from number of sensitivity tests to assess how the options fare under a range of different scenarios. These include commuter parking availability and cost, the geographic distribution of population growth, timing of the RoNS programme, public transport fare levels.

Summary and Key Findings Report, June 2013

This sets out the overall key findings from the study and in affect is an Executive Summary to the Option Evaluation Report.

Appendix B

Short List Cross Sections

Appendix C

Planning Assessment (Incite Ltd)

Appendix D

Economic Evaluation (John Bolland Consulting Ltd)

Appendix E

Option Cost Methodology

Appendix F

Public Transport Opex Methodology