steer davies gleave

Phase 2
Evaluation Report

UBC Line Rapid Transit Study

August 2012

Final Report

SNC·LAVALIN

UBC Line Rapid Transit Study

Phase 2 Evaluation Report

Report

August 2012

Prepared for:
Province of BC & South Coast British Columbia
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.

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CONTENTS

EXECUTIVE SUMMARY I

1 INTRODUCTION AND OVERVIEW 1

Introduction 1

Purpose of the Report 3

Report Structure 3

2 CORRIDOR CONTEXT 4

Transit Service 4

Traffic 7

Goods Movement 7

Parking, Servicing & Access 8

Physical Environment 8

Demographics 10

Activity Centres 11

Corridor Policies 14

3 EVALUATION METHODOLOGY OVERVIEW 16

Introduction 16

Project Problem Statements 16

Project Vision, Mission and Objectives 19

Alternative Development and Assessment Process 20

Multiple Account Evaluation Framework 20

Evaluation Process 27

4 PHASE 2 RAPID TRANSIT ALTERNATIVES 28

Introduction 28

Phase 1 Evaluation 28

Phase 2 Preliminary Evaluation 28

Phase 2 Consultation 29

Phase 2 Preliminary Evaluation Conclusions 31

Phase 2 Alternative Optimisation 33

Description of Final Phase 2 Alternatives 33

5 TRANSPORTATION ACCOUNT 43

Introduction 43
Transportation Efficiency – Transit Users 44
Transportation Efficiency – Non-Transit Users 52
Transit System/Network Accessibility 58
Reliability 61
Capacity and Expandability 62
Transportation Account Key Points 68
6 FINANCIAL ACCOUNT 70
Introduction 70
Total Capital Cost 70
Operating Costs 73
Cost Effectiveness 79
Financial Account Key Points 90
7 ENVIRONMENT ACCOUNT 91
Introduction 91
Emissions 91
Noise and Vibration 94
Biodiversity 96
Water Environment 98
Effects on Parks/Public Open Space 100
Environmental Account Key Points 101
8 URBAN DEVELOPMENT ACCOUNT 102
Introduction 102
Land Use Integration 102
Land Use Potential 103
Property Requirements 104
Urban Design 105
Urban Development Account Key Points 107
9 ECONOMIC DEVELOPMENT ACCOUNT 108
Introduction 108
Construction Effects 108
Operating Effects 109

Taxes 109
Goods Movement 110
Economic Development Account Key Points 112
10 SOCIAL COMMUNITY ACCOUNT 113
Introduction 113
Health Effects from Active Modes 113
Low Income Population Served 114
Safety 115
Community Cohesion 120
Heritage and Archaeology 122
Social Community Account Key Points 123
11 DELIVERABILITY ACCOUNT 124
Introduction 124
Constructability 124
Impacts from Construction 125
Acceptability 133
Deliverability Account Key Points 137
12 SENSITIVITY TESTING 139
Introduction 139
Modelling & Forecasting Sensitivity Tests 139
Economic Sensitivity Tests 148
Sensitivity Test Key Points 154
13 SUMMARY AND KEY CONCLUSIONS 155
Trade-offs and Considerations 159
Next Steps 160

FIGURES

Figure 1-1 Context Map 2
Figure 2-1 99 B-Line Peak Passenger Volumes (Main to Cambie) 5
Figure 2-2 99 B-Line Observed Journey Times (Westbound) 6
Figure 2-3 Truck Routes in Vancouver 9

Figure 2-4	Regional Employment in Town Centres	10
Figure 2-5	Corridor Population and Employment Forecasts	11
Figure 2-6	Key Activity Centres in the Study Area	13
Figure 3-1	Alternative Development and Assessment Process	21
Figure 4-1	Best Bus Map	39
Figure 4-2	BRT Route Map	39
Figure 4-3	LRT1 Route Map	40
Figure 4-4	LRT2 Route Map	40
Figure 4-5	RRT Route Map	41
Figure 4-6	Combination 1 Route Map	41
Figure 4-7	Combination 2 Route Map	42
Figure 5-1	Regional Mode Share (AM Peak Hour, 2041, Unconstrained)	49
Figure 5-2	Corridor Mode Share (AM Peak Hour, 2041, Unconstrained)	50
Figure 5-3	Rapid Transit Capacity and Loadings (AM Peak Hour, 2041)	64
Figure 5-4	Transportation Account Summary	69
Figure 6-1	Capital Cost Estimates (2010 $m)	72
Figure 6-2	Life Cycle Costs (Present Value, 2010 $m)	81
Figure 6-3	Life Cycle Benefits (Present Value, 2010 $m)	84
Figure 6-4	Financial Account Summary	90
Figure 7-1	Environmental Account Summary	101
Figure 8-1	Urban Development Account Summary	107
Figure 9-1	Economic Development Summary	112
Figure 10-1	Fatalities per Billion Passenger Kilometres (USA, 2002-2007)	116
Figure 10-2	Injuries per Billion Passenger Kilometres (USA, 2002-2007)	117
Figure 10-3	Collisions, Derailments and Running Off The Road Incidents per Million Vehicle Kilometres (USA, 2002-2007)	117
Figure 10-4	Social Community Account Summary	123
Figure 11-2	Deliverability Account Summary	138
Figure 12-1	LRT1 Modelling & Forecasting Sensitivities – Peak Load Impacts	142
Figure 12-2	LRT1 Modelling & Forecasting Sensitivities – Weekday Boardings	142
Figure 12-3	RRT Modelling & Forecasting Sensitivities – Peak Load Impacts	143
Figure 12-4	RRT Modelling & Forecasting Sensitivities – Weekday Boardings	144

Figure 12-5 Discount Rate Sensitivity Tests 150
Figure 12-6 Opening Year Sensitivity Test 151
Figure 12-7 Annualisation Sensitivity 152
Figure 12-8 Post-2041 Growth Sensitivity 153

TABLES

Table 3.1 Phase 2 Multiple Account Evaluation (MAE) Framework 22
Table 3.2 Qualitative Assessment Matrix 27
Table 4.1 BAU Bus Service Assumptions 35
Table 4.2 Rapid Transit Technology Summary 36
Table 4.3 Summary of Rapid Transit Alternatives 38
Table 5.1 Travel Time Comparisons 45
Table 5.2 Weekday Pass-Up Benefits Summary 46
Table 5.3 Mode Share Forecasts (2021, unconstrained) 48
Table 5.4 Mode Share Forecasts (2041, unconstrained) 48
Table 5.5 Weekday Ridership Forecasts 51
Table 5.6 Passenger Kilometres (Annual) 52
Table 5.7 Transportation Efficiency Non-Transit users 53
Table 5.8 Intersection Restrictions, Street Closures and Vehicle Lane Impacts .. 54
Table 5.9 On-Street Parking Impacts (Broadway/10th) 56
Table 5.10 North-South Movements-Average Vehicle Delay (2021 AM Peak Hour) 57
Table 5.11 East-West Movements-Average Vehicle Delay (2021 AM Peak Hour) ... 58
Table 5.12 400m Walk Catchment Analysis 59
Table 5.13 800m Walk Catchment Analysis 59
Table 5.14 System Access Assessment 60
Table 5.15 Reliability Assessment 61
Table 5.16 2021 AM Peak Hour Rapid Transit Load and Capacity 62
Table 5.17 2041 AM Peak Hour Rapid transit Load and Capacity 63
Table 5.19 Capacity and Expandability Assessment 66
Table 6.1 Vehicle Requirements (including 15% spare Ratio) 70

Table 6.2 Capital Cost Estimates (2010 $m) 71
Table 6.3 Assumed Unit Operating Costs for Rapid Transit 73
Table 6.4 99 B-Line Existing Headway Patterns 74
Table 6.5 Operating Cost per Alternative (2021) 75
Table 6.6 Operating Cost per Alternative (2041) 75
Table 6.7 Total Rapid Transit Operating Costs 76
Table 6.8 BAU and Best Bus Service Assumptions 77
Table 6.9 Operating Cost Summary By Bus Service (2010 $m) 78
Table 6.10 Operating and Maintenance Costs by Alternative 78
Table 6.11 Life Cycle Costs (Present Value at 6% discount rate, 2010 $m) 80
Table 6.12 Greenhouse Gas Emissions by Mode 82
Table 6.13 Life Cycle Benefits (Present Value, 2010 $m) 83
Table 6.14 Cost (2010 $) Per Additional Transit User and Auto Trip Removed 85
Table 6.15 Cost (2010 $) Per Additional Transit Passenger Kilometre 86
Table 6.16 Cost (2010 $) Per Hour of Travel Time Saved 87
Table 6.17 Net Present Values (2010 $m) and Benefit Cost Ratios 88
Table 6.18 Cost-Effectiveness Summary 89
Table 7.1 Greenhouse Gas Emissions from Transit Operation (2020-2049) 92
Table 7.2 Evaluation Period Greenhouse Gas Emissions 93
Table 7.3 Evaluation Period Change in Criteria Air Contaminants (tonnes) 93
Table 7.4 Noise and Vibration in operation Assessment Summary 95
Table 7.5 Biodiversity Assessment Summary 97
Table 7.6 Water Environment Assessment Summary 99
Table 7.7 Park and Open Space Impacts 100
Table 8.1 Land use integration assessment summary 103
Table 8.2 Land Use Potential Assessment 104
Table 8.3 Property Requirements Assessment 105
Table 8.4 Urban Design Assessment Summary 106
Table 9.1 Economic Development from Construction Assessment 108
Table 9.2 Tax Assessment 109
Table 9.3 Goods Movement Assessment 111
Table 10.1 Reduction in Auto Trips 114

Table 10.2	Low Income Catchment Analysis (2021)	115
Table 10.3	Security Perception Assessment	119
Table 10.4	Safety Assessment Summary	120
Table 10.5	Vehicle, Bicycle and Pedestrian Restrictions	121
Table 10.6	Community Cohesion Assessment Summary	121
Table 11.1	Technical Constructability Assessment	125
Table 11.2	Financial Impacts from Construction Assessment	126
Table 11.3	Transportation Impacts from Construction Assessment	127
Table 11.4	Resource Requirements by Alternative	129
Table 11.5	Environmental Impacts from Construction Assessment	130
Table 11.6	Economic Development Impacts from Construction Assessment	131
Table 11.7	Social Community Impacts from Construction Assessment	132
Table 11.8	Constructability Summary Assessment	132
Table 11.9	Acceptability Survey Results	133
Table 11.10	Funding Assessment ($m 2010)	137
Table 12.1	Modelling & Forecasting Sensitivity Tests	140
Table 12.2	TDM Sensitivity Test	145
Table 12.3	Capacity Implications of RRT and Combination 1 Phasing	147
Table 12.4	Partially Grade separated inputs	148
Table 12.5	Partially Grade separated Results	148
Table 12.6	Net Present Values (2010 $m) and Benefit Cost Ratios – 10% Discount Rate	149
Table 12.7	Net Present Values (2010 $m) and Benefit Cost Ratios – 3% Discount Rate	150
Table 13.1	Project Summary Assessment	155
Table 13.2	Summary of Selected measures	158

APPENDICES

A EVALUATION PARAMATERS AND ASSUMPTIONS

B BEST BUS RESULTS

C DESIGN PRINCIPLES

D FORECASTING ASSUMPTIONS AND RESULTS

E RUN TIME MODEL SUMMARY

F ACCEPTABILITY SURVEY REPORT

Executive Summary

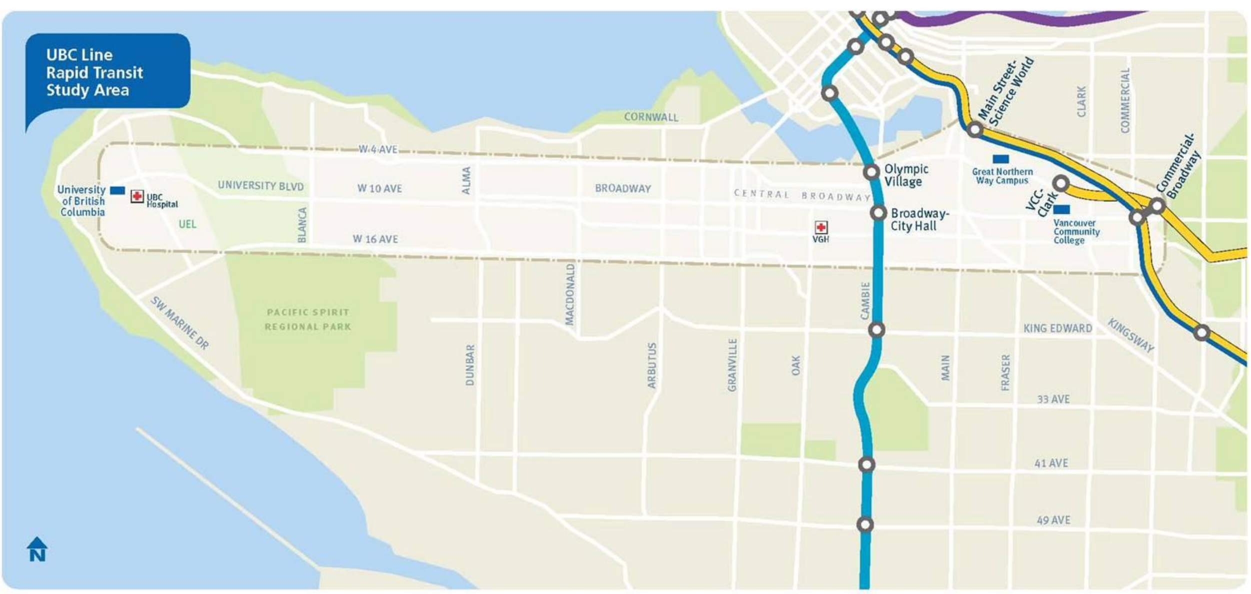
Introduction

TransLink and the Province of British Columbia sponsored a multi-phase study to evaluate alternatives for rapid transit service in the Broadway corridor between Commercial Drive and the University of British Columbia. The City of Vancouver, UBC, University Endowment Lands, Metro Vancouver and Musqueam Indian Band were partners in the study.

Since the 1990s, plans have identified expansion of rapid transit in the Broadway corridor as a priority. One of the region's busiest bus corridors with over 100,000 weekday passenger trips, Broadway is regionally important as it connects major population, job and institutional centres. Central Broadway and the University of British Columbia are the most important transit destinations in the region outside of downtown Vancouver. Existing corridor transit services do not provide sufficient capacity or reliable service, with frequent pass ups during peak periods and unpredictable travel times. With the growth projected in the corridor, the demand for the service will grow. However with buses every one to two minutes in the peak period, the corridor is reaching the limits of the capacity that can be provided by buses in mixed traffic, even with curb side bus lanes. Local, regional and provincial governments have established transportation and greenhouse gas related goals and targets and improving transit service is viewed as necessary to realizing these targets.

In March 2009, Steer Davies Gleave was retained to examine a range of rapid transit technology and alignment alternatives to serve the study area which extends from the University of British Columbia (UBC) in the west to Broadway and Commercial, where the Expo and Millennium SkyTrain lines meet, in the east, generally via 10th Avenue and Broadway as shown below.

Study Area



The UBC Line Rapid Transit Study is being undertaken in three phases and Steer Davies Gleave has led the technical work of the first two phases.

- Phase 1 - Shortlist Identification: technology and alignment alternatives are identified and screened in order to arrive at a shortlist of alternatives for further development in Phase 2.
- Phase 2 - Alternatives Development and Evaluation: shortlisted alternatives are further developed and evaluated to support a decision on a preferred alternative.
- Phase 3 - Design Development: after selection of a preferred alternative, further design development and costing is undertaken. Phase 3 will establish a budget, timeline and phasing for the project and provide the basis for project definition, securing funding and procurement.

The study has involved stakeholder and public consultation at each step and this has informed the study process and outcomes.

Evaluation Process and Alternatives Considered

The study team undertook a corridor assessment of the current and expected conditions and synthesized problem statements in order to ensure that the rapid transit solutions identified and evaluated address the underlying needs and issues.

Problem Statements

- Existing transit services do not provide sufficient capacity or reliable enough service to the major regional destinations and economic hubs within the Broadway Corridor;
- Transit trips and mode share need to increase to reduce vehicle kilometres travelled (VKT) and GHG and CAC emissions, both directly and by supporting the Regional Growth Strategy and other regional objectives;
- Affordability - the limitation on regional funding for transit and the need to balance a range of investment priorities – was also identified as a regional problem for consideration; however, affordability requires understanding other regional needs and cannot be assessed within a single corridor study.

An evaluation framework was developed to assess the rapid transit alternatives. The study employed a Multiple Account Evaluation (MAE) approach, which provides a qualitative and quantitative evaluation across a wide range of factors or “accounts” to identify the benefits and impacts of each alternative in a structured format.

The UBC Line MAE framework consists of seven accounts. For each account an objective and a set of evaluation criteria were developed. The table below summarizes the accounts, objectives and criteria employed with the evaluation including a mix of quantitative and qualitative measures.

Evaluation Criteria

Account	Objective	Criteria
Economic Development	A service that encourages economic development by improving access to existing and future major regional destinations and local businesses by transit while continuing to facilitate goods movement	Construction effects, tax effects and goods movement
Environment	A service that contributes to meeting wider environmental sustainability targets and objectives by attracting new riders, supporting changes to land use and reducing vehicle-kilometres travelled	Emission reductions, noise and vibration, biodiversity, water environment, parks and open space
Financial	An affordable and cost-effective service	Capital cost, operating cost, cost-effectiveness
Social and Community	A safe, secure and accessible service that also improves access to rapid transit for all and brings positive benefit to the surrounding communities, including managing impacts of rapid transit	Health effects, low income population served, safety, community cohesion, heritage and archaeology
Transportation	A fast, reliable and efficient service that meets current and future capacity needs, supports achieving transportation targets and integrates with and strengthens the regional transit network and other modes	Transit user effects, non-transit user effects, transit network/system access, reliability, capacity and expandability
Urban Development	A service that supports current and future land use development along the Corridor and at UBC and integrates with the surrounding neighbourhoods through high quality urban design	Land use integration, land use potential, property requirements, urban design potential
Deliverability	A service that is constructible and operable	Constructability, acceptability, funding and affordability

Three rapid transit technologies were considered (BRT, LRT and RRT) are described below.

Rapid Transit Technologies Considered

Bus Rapid Transit (BRT) 	Low-floor articulated buses (running on diesel or electricity) running in their own right-of-way and separated from other traffic by a curb, and with stations located within the street.
Light Rail Transit (LRT) 	Driver-operated rail vehicles powered from overhead wires running in their own right-of-way and separated from other traffic by a curb, and with stations located within the street.
Rail Rapid Transit (RRT) 	Driver operated or driverless rail technology that is powered by electricity. In Metro Vancouver RRT (SkyTrain) is driverless and automated and operates fully separated from other traffic in a tunnel or on elevated track, and with stations accessed by escalators, stairs and elevators.

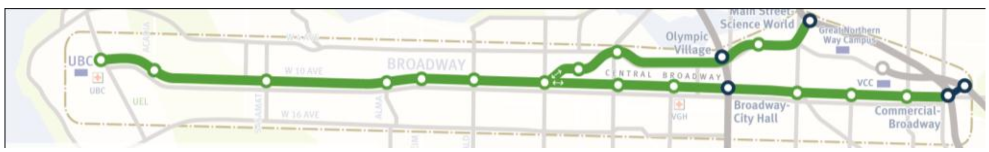
A long list of over 200 possible alternatives was screened to a shortlist according to the evaluation framework above. The shortlist was confirmed through public consultation and seven alternatives were advanced for more detailed study. Design concepts and a multiple account evaluation were developed for each alternative and these were brought forward for public consultation. Based on the input received and further technical work, the designs and evaluations were refined and the final results documented in this report.

UBC Line Alternatives

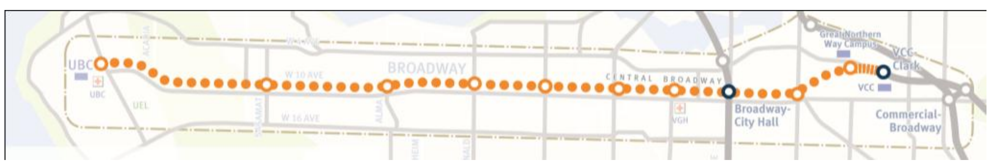
BRT - At-grade BRT route from UBC to Commercial-Broadway via University Blvd, West 10th Ave and Broadway using diesel articulated buses[1].

LRT1 - At-grade LRT route from UBC to Commercial/Broadway via University Blvd, West 10th Ave and Broadway.

LRT2 - combines LRT1 with a second branch from Broadway/Arbutus to Main Street-Science World via the CPR right-of-way, the City of Vancouver Streetcar route and Main St.



RRT - Mainly tunnelled route via University Blvd, West 10th Ave, Broadway, Great Northern Way as an extension of the existing Millennium Line SkyTrain from VCC-Clark.

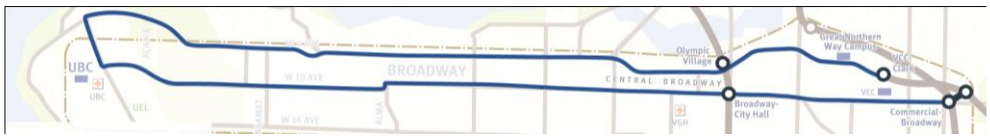


Combination Alternative 1 - Combination of RRT from VCC Clark to Arbutus with the portion of the LRT2 route operating from UBC to Main Street/Science World.

[1] A trolley option was also assessed as having a higher capital cost and greater environmental benefits than the diesel option. For the purposes of this evaluation a diesel option was assumed. If BRT is pursued further this subject could be revisited.

Combination Alternative 2 – a combination of RRT from VCC Clark to Arbutus with the BRT alternative using diesel buses.

Best Bus - represents the best that can be achieved relying on conventional buses in the study area and demonstrates the impacts and benefits of bus service improvements within the corridor including local, semi-express (B-Line) and express bus services.



All alternatives were evaluated against a Business As Usual (BAU) case as a point of reference. The BAU assumes that the study area would continue to be served by buses with service increases consistent with past trends and population and employment growth and no rapid transit investment. A neutral rating means that an alternative would perform no better or worse than "business as usual". These assessments have been summarized on a five point scale, represented as follows:

Evaluation Results

The performance of each alternative within each account is summarized in the table below followed by an account by account description of the findings for each account. "Lifecycle" assessments were based on 30 years of operations of each alternative.

Evaluation Summary

Account	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Transportation	◒	◔	◕	◕	●	●	◕
Financial	◔	◒	◒	◔	◒	◒	◒
Environment	◒	◒	◕	◕	●	◕	◕
Urban Development	◒	◕	◕	◕	◕	◕	◕
Economic Development	◒	◒	◕	◕	●	◕	◕
Social Community	◒	◕	◕	◕	●	◕	◕
Deliverability (affordability not considered)	◒	◒	◒	◒	◒	◒	◔

The **Transportation Account** measures the benefits and impacts to transportation network users. Alternatives with LRT and RRT provide sufficient capacity and can accommodate demand beyond forecast with RRT providing the greatest opportunity for expansion. The Best Bus, BRT and Combo 2 alternatives do not have sufficient capacity to meet forecast demand. All alternatives increase corridor transit trips and mode share, with RRT alternatives having the greatest impact (3.1 percentage points in 2041). At a regional level the impact on mode share ranges from 0 percentage points (Best Bus) to .3 percentage points (RRT and Combination 1) in 2041. RRT and Combination alternatives provide the shortest travel times and greatest reliability improvements, followed by LRT alternatives. Alternatives with LRT and BRT reduce road capacity and introduce turn restrictions which have impacts on traffic, parking, local access and goods movement.

The **Financial Account** measures capital and operating costs as well as cost-effectiveness. Capital costs range from $120 million for the Best Bus alternative to $3.0 billion for the RRT alternative. Over the lifecycle, operating costs for all alternatives are small in relation to capital costs. Except Best Bus, all alternatives have benefit-cost ratios greater than 1, with RRT having the highest ratio. BRT, the Combination alternatives and RRT are most cost-effective in generating additional transit users; BRT only has capacity for these passengers during off-peak periods, and in the off-peak direction. LRT2 is higher cost and less cost-effective than LRT1 on all accounts indicating that the branch along the former rail right-of-way lowers the financial performance of LRT2 relative to LRT1.

The **Environment Account** considers a range of environmental measures including emissions reduction, noise and vibration, biodiversity, and parks and open space. RRT and combination alternatives result in the greatest shift from cars and have the greatest auto emissions reductions. The scale of reduction for all alternatives ranges from 0.01% to 0.30% of the regional total. The RRT alternative results in the greatest reduction in noise and vibration from transit services followed by the LRT alternatives. None of the alternatives are expected to adversely impact biodiversity and water during operations.

The **Urban Development Account** considers the benefits and impacts on local land uses and the urban environment. All alternatives serve four or five major activity centres, with RRT and Combo alternatives serving the fifth, the Great Northern Way Campus. All alternatives require some properties, ranging between 13–30 properties.

The **Economic Development Account** addresses the economic benefits generated by construction activity, impact on taxes as well as goods movement. Alternatives with higher capital costs and longer construction periods have greater increases in employment and GDP and therefore RRT and Combination Alternative 1 generate the greatest benefits. Road capacity reductions and turning restrictions for alternatives with LRT and BRT may cause goods movement delays.

The **Social and Community Account** addresses a wide range of social and community benefits and impacts, including health effects associated with active living, safety and security, community cohesion and others. RRT and the Combination alternatives deliver the greatest health benefits associated with active transportation since they increase transit use, and thus walking and biking to transit, the most. All rapid transit alternatives improve safety and security with greater separation from other road users and rapid transit station designs. Alternatives with BRT and LRT reduce community cohesion due to vehicular restrictions at intersections.

The **Deliverability Account** looks at potential issues associated with implementing the alternative, including the ease with which it can be constructed, construction impacts, funding requirements and public acceptability. No technical issues would prevent any alternative from being constructed. All rapid transit alternatives will have construction impacts, similar in scale. Market research indicates that RRT, LRT1, LRT2, and Combination 1 are all more acceptable to the public than Business as Usual, while the other alternatives are not. RRT receives the highest acceptability rating. There is a wide range in capital and lifecycle costs; affordability cannot be assessed through this study as the sources and alternative uses of funds at a regional scale have not been identified.

Based on this evaluation and considering the transportation problems identified for the corridor, the following conclusions can be drawn:

Capacity and Reliability: Existing transit services do not provide sufficient capacity or reliable enough service to the major regional destinations and economic hubs within the Broadway Corridor

The Best Bus, BRT and Combination 2 alternatives do not have the capacity to meet forecast demand. All other alternatives provide sufficient capacity to meet forecast demand (2041) and expand beyond. RRT provides the greatest opportunity for expansion.

To varying degrees, all of the rapid transit alternatives improve reliability. The RRT alternative provides the greatest improvement because it is fully separated from other road users. Alternatives with LRT also provide reliability improvements because they operate in their own rights of way and receive priority over other vehicles at intersections but to a lesser degree than RRT because LRT’s street-level operation introduces variability. Best Bus, BRT and the BRT section of Combination 2 have less priority over other traffic and therefore deliver lower reliability improvements.

Transit Trips and Mode Share: Transit trips and mode share need to increase to reduce vehicle kilometres travelled (VKT) and GHG and CAC emissions, both directly and by supporting the Regional Growth Strategy and other regional objectives

All alternatives increase transit trips and mode share. At a corridor level, alternatives with RRT increase mode share the most and result in the greatest increase in transit trips. For all the alternatives, the number of new transit trips generated is small relative to the number of trips shifted from bus to rapid transit and the total number of transit trips in the region. Therefore, at a regional scale, and when considered in isolation, none of them would achieve mode share targets. The impact on regional mode share ranges from a 0.0% to a 0.3% increase in transit mode share. Demand-side measures such as road pricing or tolling may complement rapid transit expansion to further increase transit mode share, but they were not evaluated in-depth in the study.

The table below summarizes quantitative measures for the original problem statement and their costs along with the “Business as Usual” case for comparison.

Summary of Selected measures

Measure	BAU	Best Bus	BRT	LRT	LRT2	RRT	Combo 1	Combo 2
Capacity and Reliability								
2041 Forecast Peak Load (passengers per hour per direction, pphpd)	2,700	2,500	6,400	5,200	4,700	12,500	11,000 (RRT) 3,300 (LRT)	11,700 (RRT) 3,500 (BRT)
Assumed Capacity** (pphpd)	2,400	2,400	3,000	7,200	5,800	13,000	13,000 (RRT) 3,600 (LRT)	13,000 (RRT) 3,000 (BRT)
Transit Trips and Mode Share								
UBC Line Weekday Ridership (2041)	102,000	121,000***	117,000	160,000	166,000	322,000*	349,000*	339,000*
New Weekday Transit Trips (2041)	-	2,000	7,000	11,000	13,000	54,000	44,000	43,000
Lifecycle Reduction in Auto Vehicle Kilometres Travelled (million km)	-	90	806	1,014	1,000	2,361	1,915	2,021
Lifecycle GHG Emissions Reductions (Kilo Tonnes)	-	-17 (increase)	128	235	203	335	309	238
Transit Mode Share (Regional/Corridor, %)	16.3%/ 29.3%	16.3%/ 29.5%	16.4%/ 30.0%	16.4%/ 30.1%	16.4%/ 30.1%	16.6%/ 32.4%	16.6%/ 31.7%	16.5%/ 31.6%
Costs								
Capital Cost ($ million, 2010)	-	120	410	1,110	1,330	3,010	2,670	1,970
Net PV of Lifecycle Costs ($ million, 2010)	-	120	180	620	790	1,740	1,490	1,110

** Boardings include through passengers on the Millennium Line*

*** The assumed capacity is the level of capacity used for the purposes of evaluation and costing. RRT capacity can be further expanded to 26,000 pphpd. LRT can be further expanded beyond 7,200 with reduction in speed and reliability due to reduced transit priority*

*** Includes bus routes 84, 99 B Line, 984 and 999

Trade-offs and Considerations

It is worth highlighting the following trade-offs and considerations further to those identified as part of the problem statement.

Acceptability

There is a range in the acceptability of the alternatives. Market research on the acceptability criterion reveals that based on the current designs and evaluation, LRT1, LRT2, Combination 1 and RRT are more acceptable than the BAU and with RRT receiving the highest acceptability rating. Best Bus, BRT and Combination 2 are less acceptable than the Business as Usual alternative.

Affordability

There is a large range in capital and lifecycle costs for the alternatives. Of the alternatives that meet the forecast demand for the corridor, capital costs range from $1.1 billion for LRT1 to $3.0 billion for RRT. An assessment of affordability will be made outside this study by considering regional investment needs relative to available funding.

Phasing

The Combination alternatives and RRT could be built in phases through, for example, extending SkyTrain to Broadway and Arbutus as an interim stage towards extending rapid transit to UBC. This would spread out the capital requirements over a longer period of time. Implementation of rapid transit to UBC would be delayed which could result in on-going crowding in the western segment of the corridor and would require a commitment to bus service to meet demand. This would create local impacts such as a requirement for a major interchange with bus layover space at Arbutus. BRT and LRT1 are less suited for consideration for phasing due to the lower capital costs. LRT2 could be built in phases with an initial phase connecting UBC with either Main Street or Commercial-Broadway. A full MAE of phased options was not undertaken.

Speed

The RRT and Combination alternatives include a Millennium Line extension and provide travel time savings through avoiding a transfer at Commercial–Broadway Station for Millennium Line users. RRT is fully segregated from other traffic and therefore provides the shortest travel times. LRT1 and LRT2 and the LRT segment of Combination 1 operate at street level in their own rights of way and receive priority over other vehicles at intersections, providing travel time improvements to a lesser degree than fully segregated RRT. Partially grade separating (i.e. tunnelling) segments of the LRT would improve its speed and reliability. Best Bus, BRT and the BRT[2] section of Combination 2 have less priority over other traffic and therefore provide fewer travel time benefits than the other alternatives.

[2] BRT has lower priority relative to LRT because signal priority is not as effective at the service levels assumed in the BRT alternatives (2 minute headway)

Street-level Impacts

Street-level operation of BRT or LRT would have impacts on traffic, parking, local access, and goods movement and other impacts associated with turning restrictions and reduced road capacity for vehicles[3]. Segments could be built in a tunnel which would reduce the street-level impacts and shorten travel times at additional cost. RRT would be primarily in a tunnel and therefore would not have street-level impacts.

Next Steps

The results of the Phase 2 evaluation will help to inform the selection of a preferred alternative. The selection of an alternative will take place within a regional context, to allow the consideration of funding availability for this project and other regional transportation investment needs.

Once a preferred alternative has been identified, Phase 3 would advance the planning and design of that alternative, and carry out further public consultation to aid in design development. The technical scope would include more detailed design of the alignments and intersection layouts, station locations, station area planning and urban design, transit service integration, and environmental study and identification of any mitigation measures.

[3] The multiple account evaluation has addressed the scale and nature of the expected impacts. The specific impacts would be determined through detailed design if a BRT or LRT alternative is selected to be implemented.

1 Introduction and Overview

Introduction

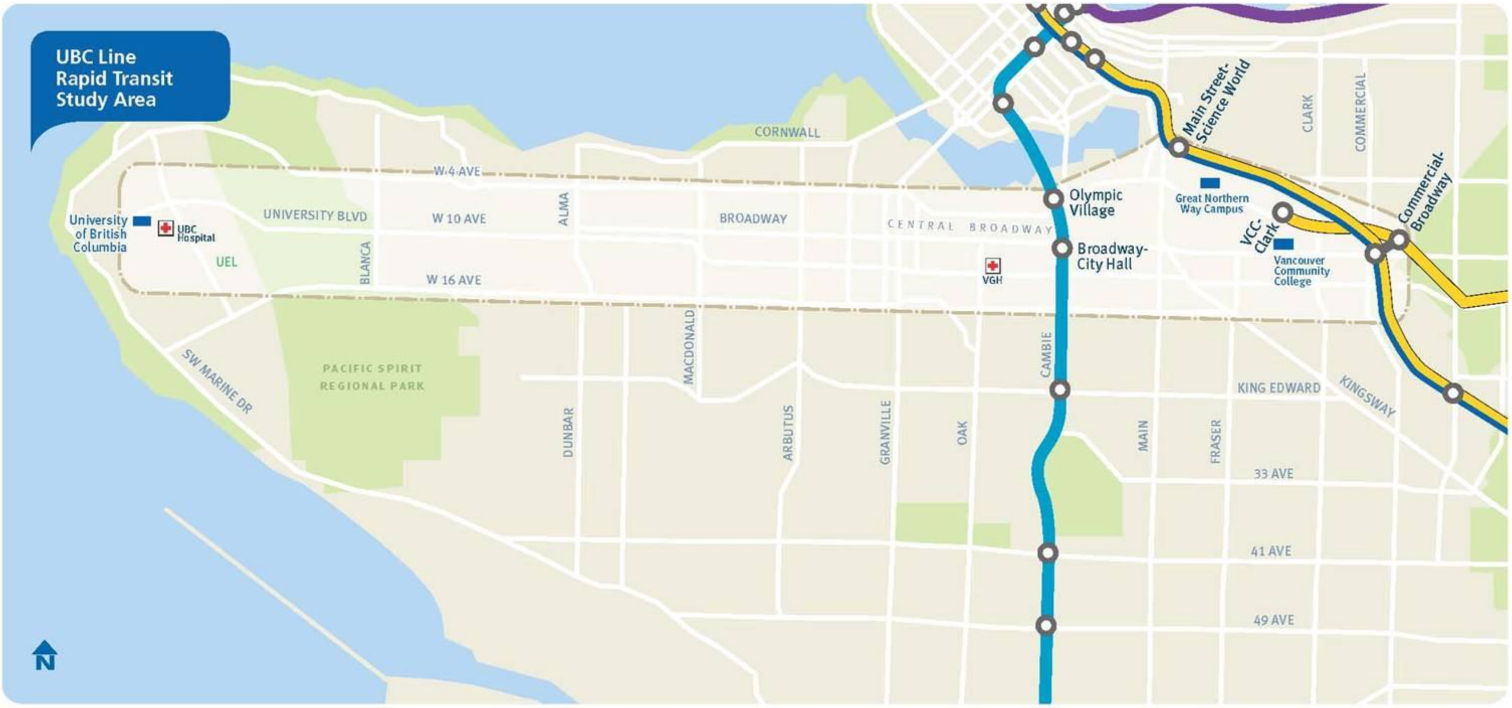
1.1 In March 2009, Steer Davies Gleave was retained by the South Coast British Columbia Transportation Authority (TransLink) and the BC Ministry of Transportation & Infrastructure (MOTI) (the *Project Sponsors*) to examine a range of rapid transit technologies and alignment alternatives to serve the Broadway Corridor – the *UBC Line Rapid Transit Study*. The work has been advised by the City of Vancouver, Metro Vancouver, University of British Columbia (UBC), University Endowment Lands (UEL) and Musqueam (the *Partner Agencies*). Stakeholder and public consultation has informed the process throughout the study.

1.2 For reference, while the complete UBC Line Rapid Transit Study is being undertaken in three phases, the Steer Davies Gleave contract is only for the first two phases. The full project includes:

- **Phase 1 - Shortlist Identification:** technology and alignment alternatives are identified and screened in order to arrive at a shortlist of plausible alternatives for further development in Phase 2.
- **Phase 2 - Alternatives Development and Evaluation:** shortlisted alternatives are further developed and evaluated to support a decision on a preferred alternative.
- **Phase 3 - Design Development:** after selection of a preferred alternative, further design development and costing is undertaken. Phase 3 will establish a budget, timeline and phasing for the project and provide the basis for project definition, securing funding and procurement.

1.3 Figure 1-1 illustrates the Broadway corridor, and shows it in the context of this study.

FIGURE 1-1 CONTEXT MAP



Purpose of the Report

1.4 This report provides the Phase 2 evaluation results and includes the final conclusions of the technical study undertaken and next steps for the project.

Report Structure

1.5 This report includes the following chapters:

- Executive Summary;
- Chapter 1 – Introduction and Overview;
- Chapter 2 – Corridor Context;
- Chapter 3 – Evaluation Methodology Overview;
- Chapter 4 – Rapid Transit Alternatives;
- Chapter 5 – Transportation Account;
- Chapter 6 – Financial Account;
- Chapter 7 – Environment Account;
- Chapter 8 – Urban Development Account;
- Chapter 9 – Economic Development Account;
- Chapter 10 - Social Community Account;
- Chapter 11 – Deliverability Account;
- Chapter 12 – Sensitivity Testing; and
- Chapter 13 – Summary and Key Conclusions.

1.6 The following are attached as appendices to the report:

- Appendix A – Evaluation Parameters and Assumptions;
- Appendix B – Best Bus Results;
- Appendix C – Design Principles;
- Appendix D - Forecasting Assumptions and Results;
- Appendix E – Run Time Model Summary; and
- Appendix F – Acceptability Survey Report.

2 Corridor Context

2.1 This chapter provides an overview of the existing and future conditions in the study corridor including travel patterns, population and employment forecasts and activity centres.

Transit Service

2.2 Frequent east-west service is currently provided by a mix of local and express buses on Broadway and parallel routes. The 99 B-Line is the highest frequency route with up to 22 buses per hour which, when combined with the local services, provides up to 40 buses per hour (per direction) in the Corridor during the peak periods.

2.3 With over 100,000 weekday bus trips, this is the region's busiest bus corridor and the ridership matches some of the region's existing rapid transit lines. The 99-B Line carried about 52,000 on an average weekday in late 2009, an increase of almost 70% over the previous 5 years. Ridership in the UBC Line corridor is comparable to ridership on the Canada Line and exceeds ridership on the Millennium Line.

2.4 While the 99 B-Line weekday ridership shows peak patterns (westbound in the AM and eastbound in the PM), there is also considerable demand in the inter-peak with over 1,000 passengers in the westbound direction at 10:30 and in the eastbound at 14:30 as shown in Figure 2-1. Based on capacity of 1,300 (13 buses at 100 passengers/bus), this results in 75% occupancy on 99 B-Line buses outside peak periods.

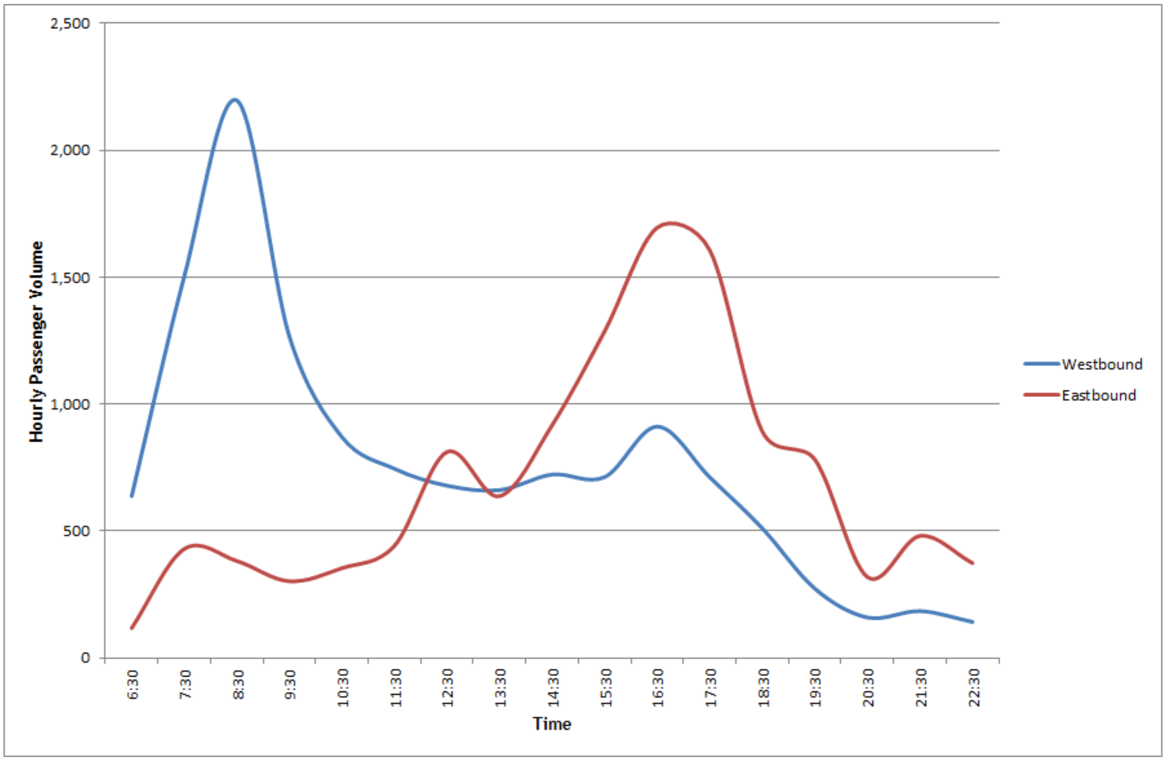
2.5 The University of British Columbia contributes considerable demand in the westbound direction outside the regional AM peak hour (7:30-8:30). At UBC the peak alighting time is between 08:30-09:30, 25% higher than alightings observed between 7:30-8:30 at that location.

2.6 Vancouver General Hospital, medical and dental offices ancillary to VGH, and Vancouver City Hall also generate transportation demand outside of the peak periods due to patient, employee and visitor use.

2.7 The peak load point in the AM Peak is between Main Street and Cambie (westbound) and the PM Peak load point is between Willow and Cambie Street (eastbound).

2.8 The high level of demand on the 99 B-Line results in a large number of pass ups, where a full bus 'passes up' waiting passengers. A survey was undertaken in November-December 2009 at all westbound stops between Commercial and Granville (inclusive) between 6:30 and 9:30, and at Cambie and Willow between 16:30 and 18:30 to count the number of passengers left behind during the AM peak and PM peak periods. The survey counted more than 2,000 passengers who were not able to board the first B-Line to arrive. Pass-ups are observed most frequently at Broadway and Commercial Drive in the AM peak and Broadway and Cambie Street in the PM peak.

FIGURE 2-1 99 B-LINE PEAK PASSENGER VOLUMES (MAIN TO CAMBIE)



Transit Travel Times

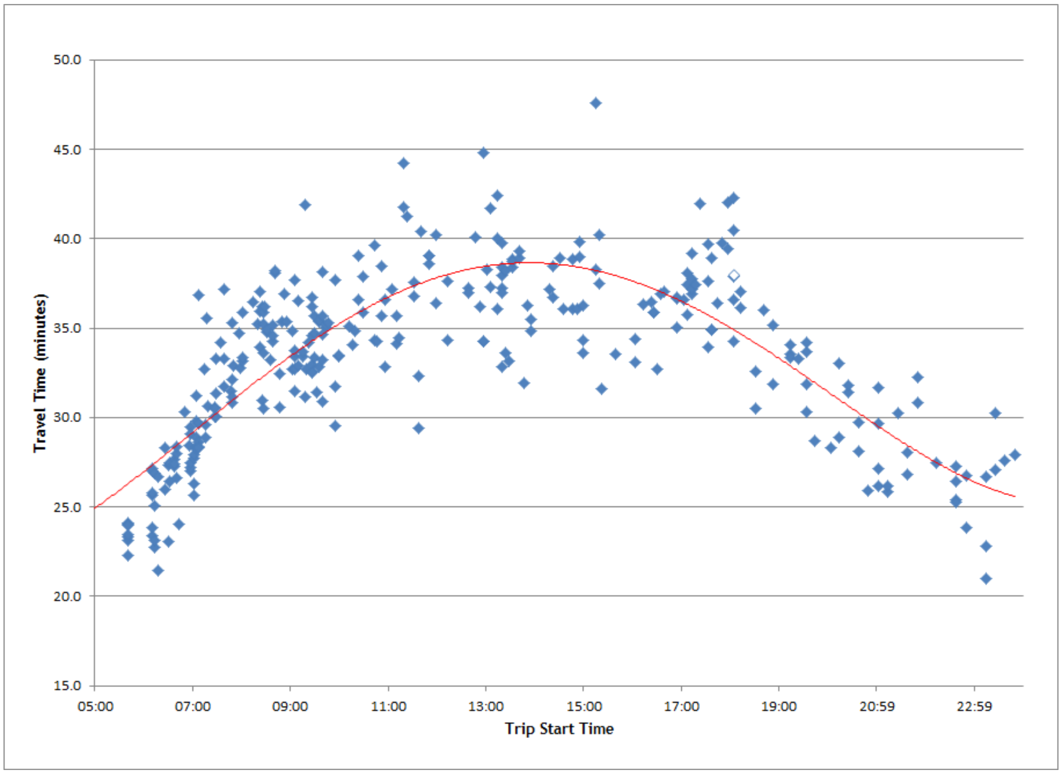
2.9 Transit travel times on the 99 B-Line vary between the AM peak, midday and PM peak periods based on a sample collected from TransLink's Automatic Passenger Count (APC) system from mid-September to end of October 2009. Buses are generally slowest in the midday and PM peak and fastest in the AM peak westbound:

- Average AM peak (7:30-8:30) period WB trip – 33.5 min (Commercial Drive to UBC);
- Average PM peak (16:30-17:30) EB trip– 36.8 min (UBC to Commercial Drive); and
- Average midday trip (10:30-14:30) (WB/EB) – 34.8 min /36.5 min (between UBC and Commercial Drive).

2.10 Transit travel speeds are slower through the eastern segment of the corridor (including Central Broadway) than through the western sections of the corridor. During the AM peak period, westbound trips average 24.8 km/h between Commercial and Arbutus and 39.1 km/h between Arbutus and UBC. Similarly, eastbound trips in the PM peak period average 33.8 km/h between UBC and Arbutus and 17.7 km/h between Arbutus and Commercial with the number 9 being a particularly slow service.

2.11 Variation in actual travel times increases in the midday and PM (eastbound) peak with a six minute difference between the fastest and slowest buses in the AM (westbound) peak (from 31 to 37 minutes with standard deviation of 2.3 minutes) increasing to 15 minutes in the midday (from 32 to 47 minutes with standard deviation of 2.9 minutes) and 12 minutes in the PM peak eastbound (from 31 to 43 minutes with standard deviation of 2.4 minutes). Figure 2-2 illustrates the journey times and service variation of the 99 B-Line throughout the day.

FIGURE 2-2 99 B-LINE OBSERVED JOURNEY TIMES (WESTBOUND)



2.12 This pattern is, in part, explained by the parking restrictions that are in place during the AM and PM peak periods which provide an additional transit travel lane. In addition, traffic levels and congestion are generally worse during the midday and afternoon peak periods.

2.13 An assessment of origins and destinations from TransLink's 2008 trip diary survey was undertaken and the key points include:

- The majority of auto and transit trips destined to the corridor in the AM peak originate from other parts of Vancouver/UEL (34,000 trips), followed by Richmond/Delta (13,000) and New Westminster/Burnaby (under 10,000). This pattern is also reflected for outbound trips in the PM peak with the rest of Vancouver/UEL as the main destination with 37,000 trips (47%); and

- There are two primary transit destinations in the corridor: UBC and Central Broadway, the two largest transit destinations in the region outside of the downtown, accounting for approximately 60,000 transit trips each day. Approximately one quarter (19,100) of AM peak hour transit trips include Central Broadway out of a total of 72,800 AM peak hour transit trips within the region.

2.14 A closer look at transfers between the existing rapid transit network and limited stop bus services (99 B-Line and 84) reinforce the importance of UBC and Central Broadway. The Broadway Corridor Origin-Destination Study (2010) revealed that:

- 70% of passengers boarding the 99 B-Line at Commercial-Broadway Station have transferred from SkyTrain;
- Approximately 90% of passengers boarding the 99 B-Line at Commercial-Broadway Station are going to either UBC (44%) or Central Broadway (47%);
- 82% of passengers boarding the #84 at VCC-Clark Station in the morning have transferred from SkyTrain; and
- Two-thirds (65%) of #84 passengers (boarding at VCC-Clark) are travelling to UBC.

Traffic

2.15 A review was undertaken of the current road conditions to better understand the current east-west traffic volumes across the study area, as well as the types of traffic using the route and their relative travel speeds. The review revealed the following key details:

- Volume and Composition:
  - Highest traffic volumes are on Broadway between Burrard Street and Commercial Drive, averaging 2,600 vehicles per peak hour, and the lowest volume is on University Boulevard/10th Avenue between UBC and Alma, averaging 500 vehicles per peak hour;
  - Level of Service (LoS) during the AM peak, when the most data is available, is highest (A/B) on Broadway/10th Avenue/12th Avenue west of Burrard while Central Broadway shows LoS C. The lowest LoS (C/D) across the entire corridor occurs on 4th/6th/2nd Avenues and east of Burrard on 12th Avenue;
  - Traffic volumes are fairly consistent over the day and there is little difference between the volumes or the composition of eastbound and westbound traffic. Midday flows exceed peak period flows in a number of locations.
- Travel Speeds:
  - Vehicle speeds in the AM peak westbound average about 30 km/h between Burrard Street and Commercial Drive and 40 km/h west of Burrard Street; and
  - Vehicles are generally travelling between 10-30% faster than the average speeds of 99 B-Line buses (including stops).

Goods Movement

2.16 The corridor has a broad range of goods movement needs which vary considerably with the businesses and other premises along its length. Some characteristics of the corridor that are of particular significance to goods movement are the presence of on-street parking for much of the corridor together with curbside bus lane restrictions between Commercial Drive and Arbutus Street in the AM and PM peak periods.

2.17 At the eastern end, from around Commercial to the vicinity of Main Street there is less retail, service or office activity compared to the section from Main Street to Arbutus. There are also more 'through movements' towards the eastern end of the corridor. This is confirmed by survey data showing the highest number of trucks here; trucks comprise 6% of all traffic in the busiest section between Main Street and Commercial Drive (representing around 800 trucks every weekday in that section).

2.18 Broadway is a designated truck route (one of four east-west routes serving the west side of the City of Vancouver) and the next nearest routes are on 4th/6th/2nd Avenues and 41st Avenue as shown in Figure 2-3.

2.19 The roads in the corridor, and the wider Vancouver city area, are built in a grid network. Many of the nodes of development along the corridor are located at the intersections of north-south truck routes and Broadway, including at Alma, Macdonald, Burrard, Granville, Main, Cambie and Oak.

Parking, Servicing & Access

2.20 A review of public parking in the Corridor was undertaken and identified that there is a significant amount of on-street, metered parking on Broadway and that this pay parking is well utilized (about an 80% average utilization throughout the day).

2.21 The review also identified that servicing is from back lanes for the majority of the Corridor and that some of the larger commercial/retail sites have their own access points as well as on-site loading.

2.22 In order to facilitate faster and more reliable peak period bus journey times, the curbside lane in each direction is reserved for buses between 7:00 and 9:30am and 3:30 to 6:00pm (between Commercial Drive and Arbutus Street). These bus lanes were generally installed where parking was already restricted during peak periods.

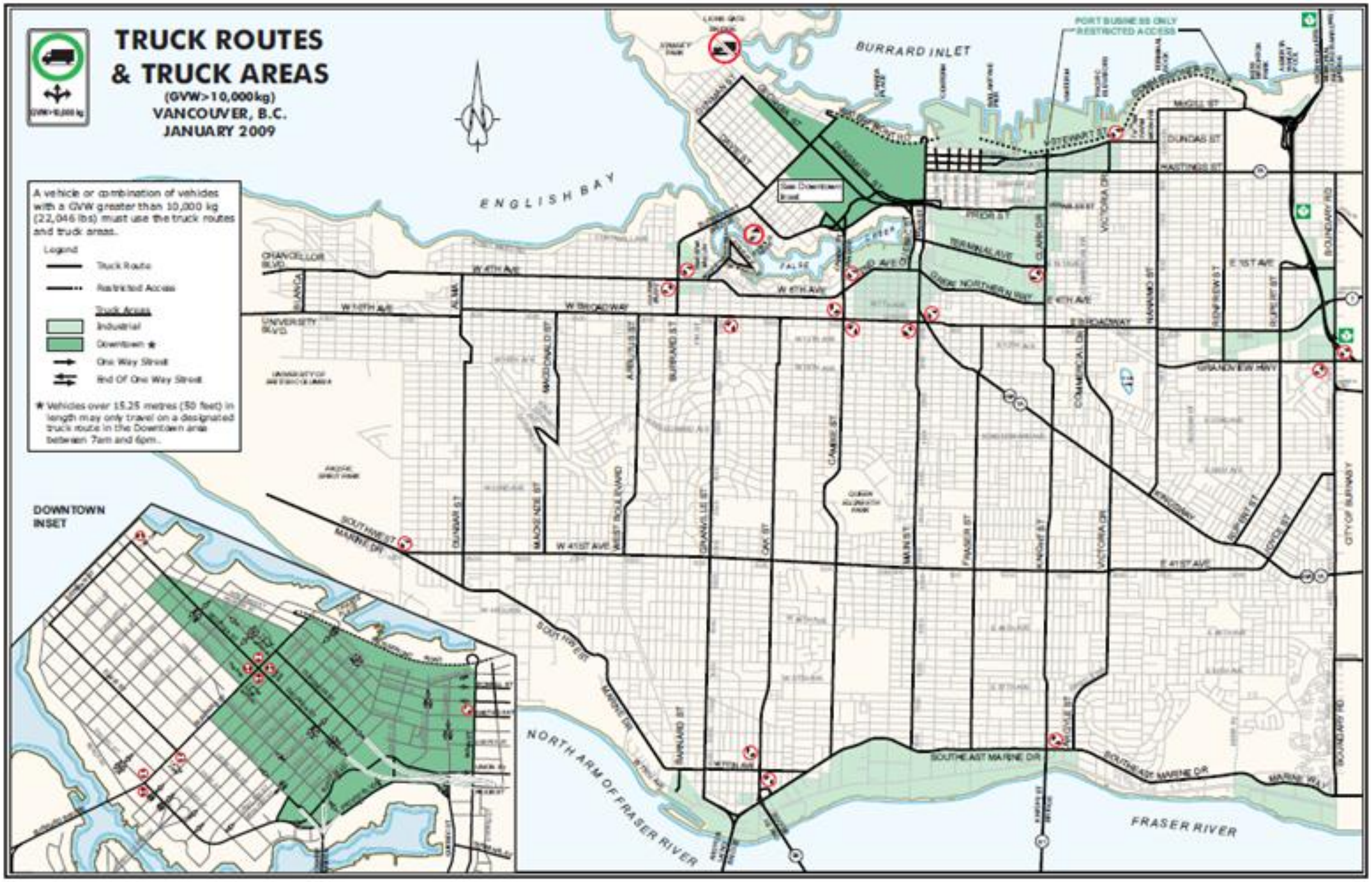
Physical Environment

2.23 The Corridor right-of-way (ROW) from property line to property line ranges from a minimum of 23.8 m to a maximum of 30.5 m. The eastern end of the corridor is generally 30.2 m while the section between Macdonald and Alma is 26.3 m. Narrow sections include east of Main (23.8 m although it widens to 25 m west of Kingsway), 24.3 m on West 10th Avenue between Blanca and Alma and 26.2 m between Main and Yukon. The area from UBC to Blanca has the widest ROW with a consistent 30.5m.

2.24 The steepest gradient along the Broadway Corridor is approximately 8%, located in the vicinity of Wallace Street on West 10th Avenue between Blanca Street and Alma Street. This gradient is not steep enough to preclude any rapid transit technologies from operating along this section[4].

[4] RRT would be tunnelled, allowing grades to be reduced to 6%, as required by this technology.

FIGURE 2-3 TRUCK ROUTES IN VANCOUVER



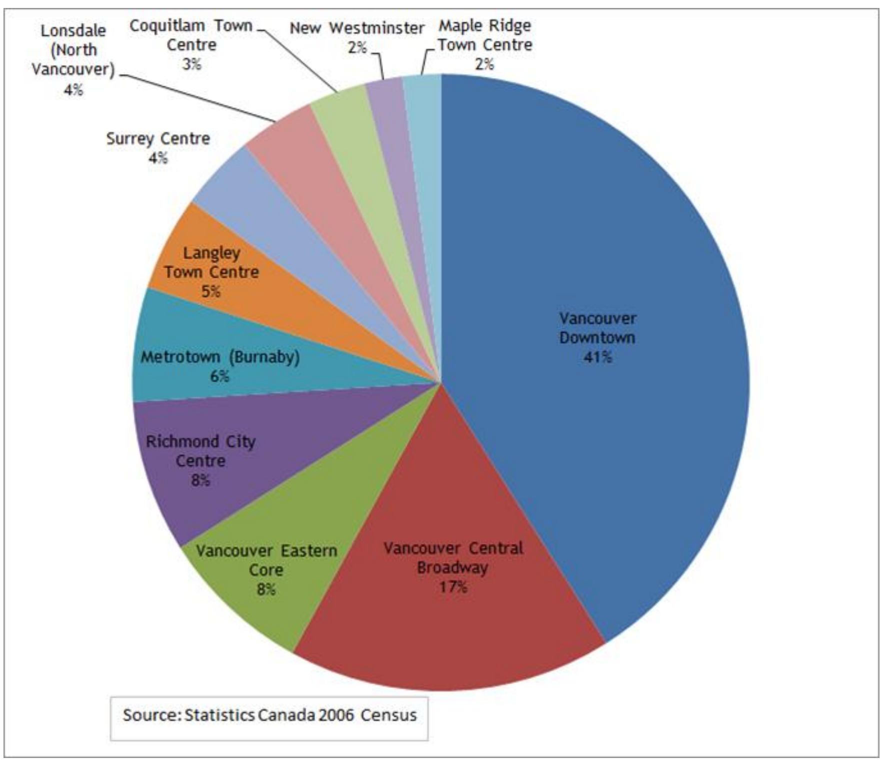
Demographics

2.25 The existing population of the study area (as shown in Figure 1-1) is over 100,000 people with existing employment of around 95,000 jobs.

2.26 Growth forecasts for 2041 have been prepared by Metro Vancouver, in consultation with City of Vancouver and UBC planning staff, as part of the Regional Growth Strategy and these include further growth in the Corridor to over 140,000 people by 2041, increasing the density to over 150 people per hectare (pph). East of Alma Street the corridor is today a medium to high density residential area with an average population density of 120 pph and a total population of over 85,000 people. The western segment from UBC to Alma Street will have over 30,000 people with medium densities of 80-90 pph.

2.27 The Central Broadway segment (from Burrard Street to Main Street), which includes Vancouver City Hall, the Uptown Office District, Vancouver General Hospital and associated ancillary medical/dental offices, has 58,000 employees and is expected to grow by 16% resulting in an employment density of 240 employees per hectare (eph) by 2041. It will continue to be the highest density employment hub of the Corridor and the second largest employment area in Metro Vancouver outside of the downtown. Central Broadway is home to 17% of jobs located in regional town centres, as illustrated by Figure 2-4.

FIGURE 2-4 REGIONAL EMPLOYMENT IN TOWN CENTRES

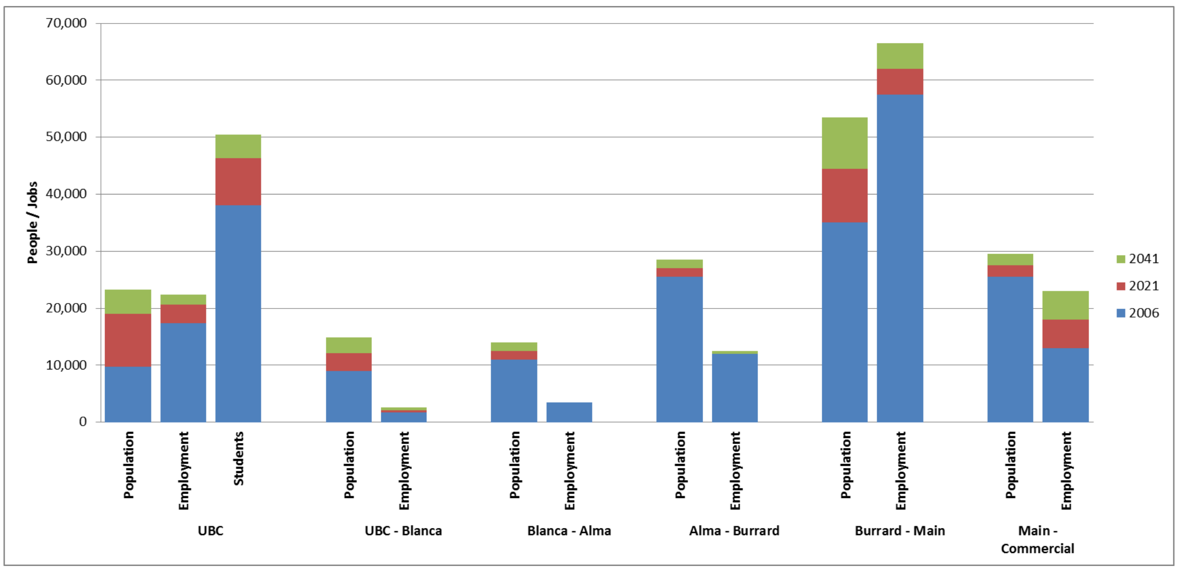


2.28 Outside the Central Broadway area there will be a notable amount of employment throughout the rest of the Corridor with medium density employment levels of over 50 eph for much of its length by 2041. Overall, there are forecast to be over 115,000 employees working in the study area by 2041.

2.29 Growth at UBC is also considerable, from 38,000 students in 2008, to 46,000 by 2021 (21% increase) and a further 4,000 students added between 2021 and 2041 (9% increase from 2021). The number of jobs at UBC is expected to increase from 19,000 in 2008 to 20,000 by 2021, with a further 1,500 jobs added between 2021 and 2041.

2.30 Figure 2-5 shows the forecasts of population and employment along the corridor, from west to east. It shows that the population is expected to grow by 23% (27,000 persons) between 2006 and 2021, and a further 15% (21,000 persons) between 2021 and 2041. The number of jobs is expected to increase by 10% (11,000 jobs) between 2006 and 2021 and a further 10% (11,800 jobs) between 2021 and 2041.

FIGURE 2-5 CORRIDOR POPULATION AND EMPLOYMENT FORECASTS



Source: Metro Vancouver 2040: Shaping Our Future, a Regional Growth Strategy adopted July 29, 2011

Activity Centres

2.31 There are a number of trip generators in the Corridor. On the eastern end, Commercial-Broadway SkyTrain Station is the busiest transportation hub in the network, connecting passengers to destinations along the corridor as well as for passengers interchanging between the Expo and Millennium SkyTrain lines.

2.32 Central Broadway, the segment between Burrard and Main streets, has two significant trip generators, both of which have high employment and visitor use: Vancouver General Hospital (VGH), the largest hospital in the province; and Vancouver City Hall. Medical and dental offices ancillary to VGH also have high trip rates throughout the day due to patient and employee use.

2.33 Both UBC and UBC Hospital are situated at the western end of the Corridor and are major trip generators and destinations within the study area with over 60,000 daytime attendees including faculty, staff and students. Transit trips to UBC have tripled since 1997, particularly since the implementation of U-Pass in 2003.

2.34 In addition, the majority of the length of Broadway has ground floor retail, including several large grocery stores, restaurants, clothing stores, etc., that create an active street generating trips throughout the day, seven days a week. Other shopping areas within the study area include 4th Avenue (from Granville Street to Alma Street), 10th Avenue (from Tolmie Street to Discovery Street); and Granville Street, Cambie Street, Main Street and Commercial Drive near their intersections with Broadway.

2.35 Granville Island, which adjoins and therefore generates trips through the corridor, is an important centre for retail, entertainment, as well as institutional activities and it attracts more than 10 million local and tourist visits annually and is home to over 2,500 employees.

2.36 While the other post-secondary institutions in the Corridor – Vancouver Community College (VCC) with 6,000 students and Great Northern Way Campus (GNWC) with 200 students - have lower enrolments compared to UBC, they are both developing expansion plans for the future that will significantly increase the scale of activity on the eastern end of the Corridor. Notably, plans for the 18.5 acre site at Great Northern Way Campus are under development and are anticipated to include significant residential, retail as well as institutional development.

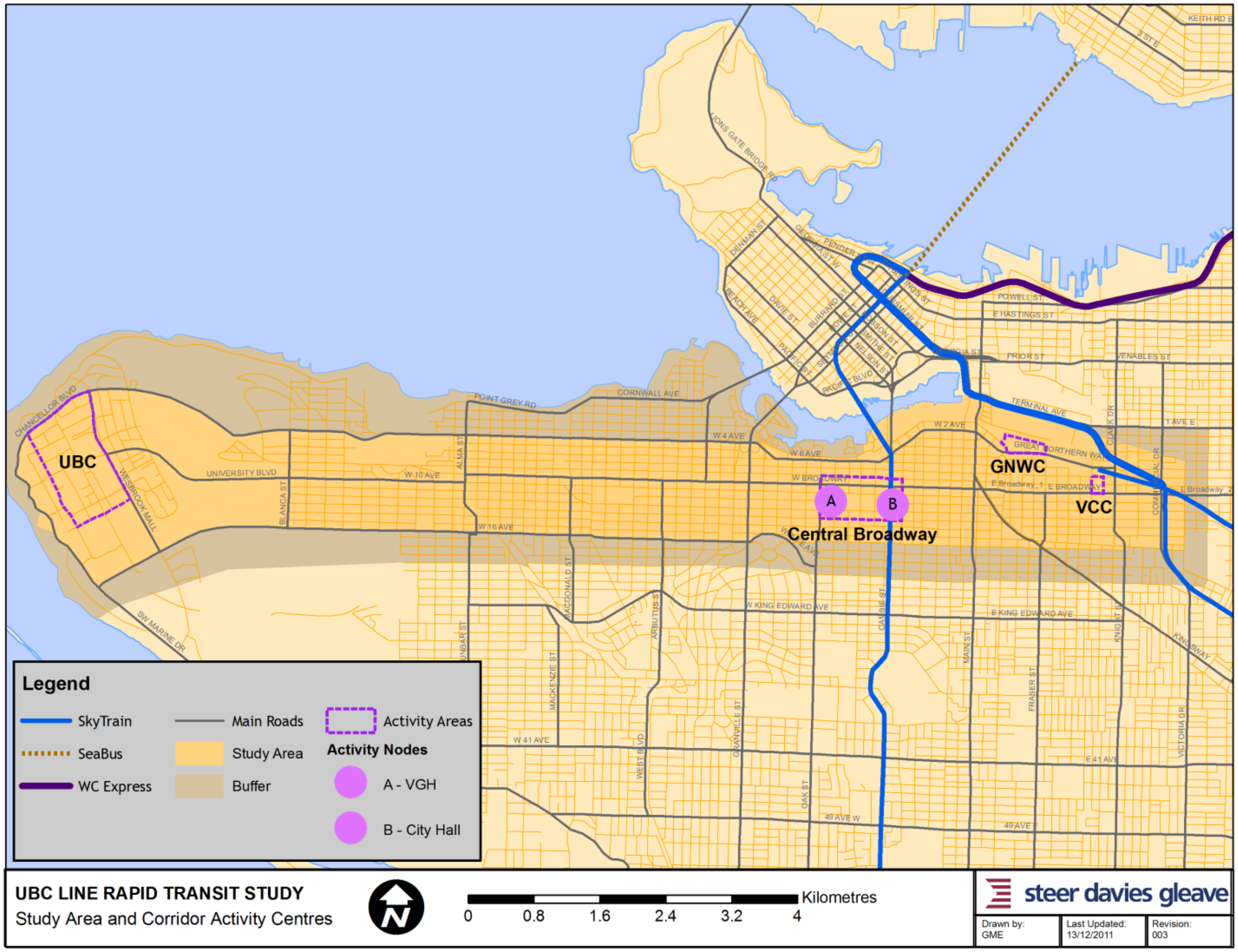
2.37 Public community facilities, including community centres and libraries, are distributed across the study area. There are four community centres and four libraries in the study area.

2.38 Park land accounts for 188 hectares of the study corridor with Pacific Spirit Regional Park making up most of the total at 140 hectares.

2.39 There are 748 buildings on the City's Heritage Register in the corridor with the two segments stretching from Alma Street to Main Street containing almost 80% (598) of the Corridor's heritage sites, with 44% (329) between Alma Street and Burrard Street and 36% (269) between Burrard Street and Main Street.

2.40 The key activity centres in the study area are shown in Figure 2-6.

FIGURE 2-6 KEY ACTIVITY CENTRES IN THE STUDY AREA



Corridor Policies

2.41 The Province and TransLink have established travel mode share targets with the aim of significantly reducing car trips. The Province's target is focused on increasing the transit mode share to 17% by 2021 and 22% by 2030 (from 12%). TransLink's target addresses all non-car related modes and is to more than double the existing sustainable (non-car) travel mode share so that more than half of all trips are made by sustainable modes by 2040 (up from 24% currently).

2.42 The City of Vancouver has 2021 transit mode share targets for the city as well as two key areas in the study area (Central Broadway and UBC). Their targets were set in 1997 and have already been achieved. The targets for Central Broadway were almost met by 2008 with a mode share of 24% (based on trip diary information) compared to a 2021 target of 25%. The transit mode share targets to UBC were exceeded soon after the implementation of the U-Pass. In 1992 the transit mode share to UBC was 14% and by 2010 this had risen to 49%. The 2010 value is higher than the 2021 target of 33%. New targets are now being developed as part of the City's Transportation Plan update. The City of Vancouver has a stated aim to achieve 50% of all trips by non-auto modes by 2020.

2.43 In addition to the mode share targets, all levels of government have set objectives for reducing greenhouse gases. Approximately 40% of GHG emissions result from transportation in this region. Following are Provincial, regional and City goals for GHG reductions:

- BC: "By 2020, B.C. will reduce its greenhouse gas emissions by 33 per cent, compared to 2007 levels. In addition, legally binding targets will be set this year for 2012 and 2016. By 2050, GHG emissions in the Province will be reduced by at least 80 per cent below 2007 levels." Climate Action Plan
- Metro Vancouver: "Reduce regional greenhouse gases 15 percent by 2015 and 33 percent by 2020 from 2007 levels." (Metro Vancouver Integrated Air Quality and Greenhouse Gas Management Plan)
- City of Vancouver: "Reduce community-based greenhouse gas emissions by 33% from 2007 levels" by 2020 Greenest City 2020 Action Plan.

2.44 Transit provision is viewed as important to achieving these targets. Table 2.1 summarizes relevant policies related to mode share.

TABLE 2.1 MODE SHARE POLICIES (ALL TRIPS)

Agency	Current	Medium Term Targets	Long Term Targets
Province of BC	Transit Mode Share: Metro Vancouver- 12.5% (2008)	Transit Mode Share (2020): Metro Vancouver - 17%	Transit Mode Share (2030): Metro Vancouver - 22%
TransLink	Sustainable (non-auto) Mode Share: Metro Vancouver- 25% (2008)	n/a	Sustainable (non-auto) Mode Share (2040): Metro Vancouver- 50%+
City of Vancouver	Transit Mode Share: Central Broadway- 24% (2008) UBC- 49% (2010) City Of Vancouver– 17% (2008)	Transit Mode Share: Central Broadway: 25% UBC: 33% (achieved) Majority of trips (over 50%) on foot, bicycle and public transit by 2020	n/a

Sources: 2008 Regional Trip Diary, UBC Trek, TransLink's *Transport 2040* (2008), City of Vancouver *Transportation Plan Progress Report* (2006) and *Vancouver 2020: A Brighter Green Future* (2009), BC *Provincial Transit Plan* (2009).

3 Evaluation Methodology Overview

Introduction

3.1 The study employed a Multiple Account Evaluation approach, which provides a qualitative and quantitative evaluation across a range of factors or "accounts" to identify the benefits and impacts of each alternative in a structured format.

3.2 This chapter describes the process used to develop the evaluation tools and criteria that were used to compare the rapid transit alternatives.

Project Problem Statements

3.3 Based on the issues identified through the Corridor Context Assessment, the study team synthesized problem statements. The purpose of the Problem Statements is to help clarify the rationale for the project and to help ensure that the rapid transit solutions identified and evaluated address the underlying needs and issues.

Identifying the Challenges

3.4 A set of opportunities and challenges were first identified and grouped into those that were either regional or corridor level issues.

3.5 The regional challenges included the need to provide transit service for a growing region (population and employment) and to meet regional and corridor targets while balancing the infrastructure and service needs across the region with the funds available. There is also a need to coordinate and integrate regional transit investments and land use development to reduce vehicle kilometres travelled (VKT), greenhouse gases (GHGs) and criteria air contaminants (CACs).

3.6 The challenges at the Corridor level included the need to provide transit capacity to meet the existing and future demand and to improve the travel time reliability of transit in the Corridor.

3.7 The challenges were then synthesized into the following three problem statements – each of which spans both the regional and Corridor levels:

- *Existing transit services do not provide sufficient capacity or reliable enough service to the major regional destinations and economic hubs within the Broadway Corridor;*
- *Transit trips and mode share need to increase to reduce vehicle kilometres travelled (VKT) and GHG and CAC emissions, both directly and by supporting the Regional Growth Strategy and other regional objectives; and*
- *Regional funding for transit is limited and needs to balance a range of rapid transit investment priorities.*

3.8 Each 'problem' is discussed in greater detail in the following sections.

Existing transit services do not provide sufficient capacity, or reliability to the major regional destinations and economic hubs within the Broadway Corridor

Transit Capacity

3.9 As noted in the previous chapter, there are a number of bus routes that serve all or part of the Corridor; however the 99 B-Line, with limited stops, frequent service and articulated vehicles, is the only one providing a rapid, direct link between Commercial-Broadway Station, Central Broadway and UBC. The rapid routes on parallel roads, including routes 44 and 84 along 4th Avenue, as well as route 43 to UBC along 41st Avenue, provide limited stop service, but at a lower frequency and capacity than the 99 B-Line. The other routes in the Corridor provide local service with frequent stops and, for the most part, do not provide service over the entire length of the Corridor.

3.10 The 99 B-Line is over capacity during the peak periods with over 2,000 passengers being 'passed up' during the AM period (6:30-09:30). While in the off-peak period it currently operates within capacity (average occupancy levels are up to 75% in certain periods) there are some instances when specific services are over capacity.

3.11 With the growth projected in the Corridor, the demand for the service is also projected to grow. However, due to operational and practical constraints (e.g. size of terminal facilities, space for boarding and alighting, traffic signal timings, interaction with other transit vehicles, etc.) there are limits to increasing capacity through shorter headways (i.e. more buses per hour) and, as a result, the service will remain over capacity.

Speed and Reliability of Services

3.12 As noted in the previous chapter, there is a high level of travel time variability on the 99 B-Line with speeds generally slower in the midday (around 38 minutes) and PM peak (37 minutes) periods than in the morning peak (34 minutes).

3.13 Variation in actual travel times increases in the midday and PM (eastbound) peak with a six minute difference between the fastest and slowest buses in the AM (westbound) peak (from 31 to 37 minutes with standard deviation of 2.3 minutes) increasing to 15 minutes in the midday (from 32 to 47 minutes with standard deviation of 2.9 minutes) and 12 minutes in the PM peak eastbound (from 31 to 43 minutes with standard deviation of 2.4 minutes).

3.14 With significant crowding on the vehicles as well as variability in trip time, the quality of the passenger experience and attractiveness of transit for users of the corridor is diminished.

Transit trips and mode share need to increase to reduce vehicle kilometres (VKT) and GHG and CAC emissions, both directly and by supporting the Regional Growth Strategy and other regional objectives

3.15 Both the Project Sponsors and each of the Partner Agencies have made commitments to reducing transportation emissions in order to help address issues of climate change.

A key component in achieving this goal will be the reduction in the number of vehicle kilometres travelled (VKT) by private vehicles.

Policies and Targets

3.16 Each of the Project Sponsors and Partner Agencies has developed their own targets for mode share (see Table 2.1) and the reduction of vehicle-related emissions although these are currently in the process of being updated by TransLink and the City of Vancouver. Achieving these targets will significantly reduce VKT and transportation-related air emissions but will require investments in transit, walking and cycling infrastructure and demand management measures to encourage the mode shift to the less polluting alternatives.

3.17 Moving more people on transit generally emits lower emissions than by single-occupant private vehicles, however high demand transit corridors with diesel bus service can still create a high level of emissions, particularly locally. Transit technologies using cleaner power sources (such as electricity) can contribute towards achieving emissions targets.

Land-Use and VKT

3.18 Supportive land use is also needed to move towards mode share and emissions targets. The Metro Vancouver Regional Growth Strategy (*Metro Vancouver 2040: Shaping Our Future*, a Regional Growth Strategy adopted July 29, 2011) states a goal to create a compact urban area with transit-oriented development focused in centres and along corridors to help reduce greenhouse gas emissions and pollution and support an efficient transportation network with transportation choice.

3.19 The regional transportation network plays a role in serving and shaping regional development by providing linkages between communities. Providing fast, frequent and reliable transit along the Corridor will improve access to major regional destinations, further support transit-oriented development and increase the attractiveness of transit more generally.

Regional funding for transit is limited and needs to balance a range of rapid transit investment priorities

3.20 The final challenge identified was the need for TransLink and the Province to fund and operate transit services within the entire region with a limited amount of funding. The existing policy documents (e.g. Transport 2040 and the Provincial Transit Plan) contain a number of transit investment and expansion projects including the UBC Line, Surrey Rapid Transit as well as the RapidBus BC Network, none of which has full funding allocated for either construction or operations.

3.21 The transit solution pursued for this Corridor will therefore need to account for regional affordability. While affordability cannot be assessed in the context of a corridor study, without the context of other regional investment needs and available funding, the results of corridor studies will be inputs to regional discussions on rapid transit investment needs.

Project Vision, Mission and Objectives

3.22 While the *Problem Statements* identified the need for rapid transit planning and investment, the *Project Vision* explains the overall aim or purpose of the UBC Rapid Transit Line, the *Project Mission* then explains how the planning will be done and what outcomes the line should achieve and finally the *Project Objectives* provide detail on how the alternatives should be measured. The Vision, Mission and Objectives were developed and agreed through a series of workshops with the Project Sponsors and Partner Agencies and presented to the public through the consultation process.

Project Vision

A rapid transit service that serves and shapes a great region and communities and strengthens its livability and sustainability by providing a viable alternative to the private car.

Project Mission

To plan a rapid transit service that is accessible, convenient, safe, reliable and environmentally and financially sustainable that integrates with the regional transportation system and contributes to the achievement of transportation, environmental and land use objectives and targets.

Project Objectives

- *A fast, reliable and efficient service that meets current and future capacity needs, supports achieving transportation targets and integrates with and strengthens the regional transit network and other modes;*
- *An affordable and cost-effective service;*
- *A service that contributes to meeting wider environmental sustainability targets and objectives by attracting new riders, supporting changes to land use and reducing vehicle kilometres travelled;*
- *A service that supports current and future land use development along the Corridor and at UBC and integrates with the surrounding neighbourhoods through high quality urban design;*
- *A service that encourages economic development by improving access to existing and future major regional destinations and local businesses by transit while continuing to facilitate goods movement;*
- *A safe, secure and accessible service that also improves access to rapid transit for all and brings positive benefit to the surrounding communities, including managing impacts of rapid transit;*
- *A service that is constructible and operable.*

Alternative Development and Assessment Process

3.23 The development and evaluation of alternatives is an iterative process designed to assist the shaping and refinement of the alternatives and is not a single step process. Figure 3-1 summarises the alternative development and assessment process used to move from a full set of all possible alternatives (in Phase 1), to a shortlist of the higher performing alternatives (Phase 2) and through to eventual identification and definition of a single preferred alternative (in Phase 3).

3.24 The study started with a long list of potential alternatives and then progressively reduced the number of alternatives using a phased process of design development and evaluation where, as the list of alternatives was reduced, the detail in which the alternatives were assessed increased, thereby concentrating analysis on alternatives that were more likely to be taken forward. At each step, the alternatives were assessed using a Multiple Account Evaluation (MAE) framework.

Multiple Account Evaluation Framework

3.25 Multiple Account Evaluation framework and criteria were assembled using a combination of the requirements the Government of Canada and the Province of British Columbia as well as detailed inputs received from the Project Sponsors, Partner Agencies, public and stakeholders from June 2009 – January 2010 with the final set of criteria agreed by all parties in July 2010. Note that some minor modifications in the evaluation methodology have occurred since 2010.

3.26 The full evaluation framework is set out in Table 3.1 and includes seven broad accounts that represent the high-level public policy goals against which the alternatives have been assessed and are included, along with the related project objective.

3.27 In applying the framework, no explicit weightings are given to the criteria or accounts. Individual decision makers/agencies will consider the implications and understand the potential effect of implicitly or explicitly applying different weightings.

FIGURE 3-1 ALTERNATIVE DEVELOPMENT AND ASSESSMENT PROCESS

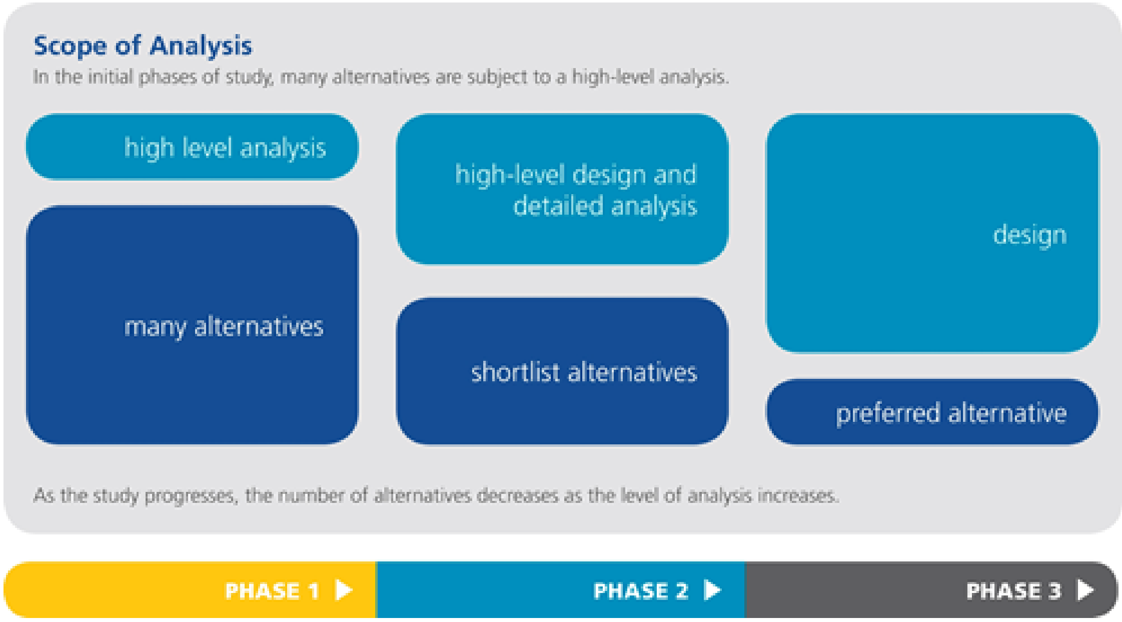


TABLE 3.1 PHASE 2 MULTIPLE ACCOUNT EVALUATION (MAE) FRAMEWORK

Project Objective	MAE Account	Criteria/Input	Role / Description	Measure
A fast, reliable and efficient service that meets current and future capacity needs and integrates with the regional transit network and other modes	Transportation	Transit User Effects	Ridership and journey time benefits demonstrate the effectiveness of the alternative across the system and mode share demonstrates the contribution the alternative will have to meeting mode share targets.	Average journey time benefit per rider Total ridership, boardings and passenger km Transit and non-transit mode share Travel time competitiveness
		Non-Transit User Effects	Changes in VKT demonstrate the change in modelled km travelled by vehicle across the region and subsequent changes in vehicle operating costs and collisions, while the journey time benefits/disbenefits illustrate the effect that the intervention will have on vehicle drivers and passengers.	Vehicle operating costs changes Changes in vehicle collisions Journey time (dis)benefits for road users Street closings and turn restrictions, diverted traffic and parking
		Transit Network/ System Access	Demonstrates the relative accessibility of the alternatives for residents, employees, students, and other users of the corridor. The specifics of the system technology and design can also have an effect on accessibility and integration with pedestrian and cycling facilities (at-grade, elevated/underground, station locations).	Catchment analysis within 400m and 800m of a rapid transit stop Qualitative assessment of system access, including intermodal integration
		Reliability	Levels of segregation and intersection priority have effects on the relative reliability of the rapid transit alternatives.	Qualitative assessment based on % of route segregated and intersection priority[5] Travel time variability from microsimulation outputs

[5] Segregation refers to sections of route (excluding intersections) where only rapid transit is allowed and intersection priority refers to number of intersections that would be affected

Project Objective	MAE Account	Criteria/Input	Role / Description	Measure
		Capacity and Expandability	Crowding (and capacity constraints) are disincentives to using transit and predicted load factors and system utilization rates will help differentiate between the alternatives. The ability of the system to be the basis of future rapid transit lines.	Qualitative assessment of capacity/crowding and capacity issues System utilization rates (2041 ridership divided by capacity) to demonstrate system expandability Qualitative assessment of the system to be expanded or incorporated into a larger network consistent with local context.
An affordable and cost-effective service	Financial	Capital Cost	A like-for-like comparator of the full costs to construct the alternatives – including any mitigation, urban realm improvements, property, renewal costs and utility relocation costs in addition to fleet and operations and maintenance facility requirements.	Full alternative capital cost
		Operating Cost	Operating costs of the full transit network (including maintenance) as well as any savings from reduction/elimination of other services.	Net operating cost of the transit network
		Cost-Effectiveness	Relative value for money of the alternatives.	Benefit:Cost ratio Cost per new rider Cost per passenger km Cost per hour of travel saved
A service that contributes to meeting wider environmental sustainability targets and	Environment	Emission Reductions	Total GHG and CAC emissions reduced through reductions in VKT and including changes in transit emissions and construction.	Reduction in vehicle kilometres travelled (VKT) Reduction in net greenhouse gas (GHG) emissions Reduction in net common air contaminants (CAC) emissions

Project Objective	MAE Account	Criteria/Input	Role / Description	Measure
objectives by attracting new riders, supporting changes to land use and reducing vehicle kilometres travelled		Noise and Vibration	Rapid transit alternatives may have different noise and vibration effects both during construction and operation.	Qualitative assessment based on quantitative precedents
		Biodiversity	Rapid transit alternatives may have different effects on the natural environment and biodiversity both during construction and operation.	Qualitative assessment
		Water Environment	Rapid transit alternatives may have different effects on waterways and from surface run-off both during construction and operation.	Qualitative assessment
		Parks & Open Space	Depending on alignments and technology alternatives, there may be a need to take either parks or other public open space to build or operate the rapid transit line.	Total hectares of parks or public open space lost/gained
A service that supports current and future land use development along the corridor and at UBC and integrates with the surrounding neighbourhoods through high quality urban design.	Urban Development	Land Use Integration	Activity centres are places that people want to go - either to work, shop, go to school, eat, recreate or socialize – and are typically large generators of transit trips.	Number of existing major activity centres within 200m of stations– including distance from major regional attractors Number of future major activity centres within 200m of stations
		Urban Design Potential	Different alternatives will provide different opportunities/effects on the urban realm including the sensitivity/quality of design of new infrastructure to the surrounding buildings and communities.	Potential impacts of infrastructure on the urban realm, including sidewalk widths
		Land Use Potential	Rapid transit alternatives and stop locations have effects on the potential to deliver outcomes of re-zoning, additional density and TOD.	Assessment from City of Vancouver's planning team.

Project Objective	MAE Account	Criteria/Input	Role / Description	Measure
		Property Requirements	Depending on alignments and technology alternatives, there may be a need to take property to build or operate the rapid transit line.	Number of private dwellings and commercial properties required to construct/operate rapid transit line Identification of effects of property loss and qualitative assessment of its significance
A service that encourages economic development by improving access to existing and future major regional destinations and local businesses by transit while continuing to facilitate goods movement	Economic Development	Construction Effects	The construction of rapid transit will create both direct and indirect income and employment.	Incremental employment, income and GDP
		Tax Effects	The construction and operation of the rapid transit line may increase the federal and provincial tax base. This will be assessed and if relevant quantified.	Effect/increased provincial and federal taxes
		Goods movement	The Broadway Corridor is an important east-west goods movement corridor and alternatives may impact on available road space.	Qualitative assessment of the impacts to goods movement/ goods routes in the corridor.
A safe, secure and accessible service that also improves access to rapid transit for all and brings positive benefit to the surrounding	Social-Community	Health Effects	Improved transit services typically generate more walking and cycling trips as well – both to access the system but also as a result of better transportation and land use design – and these have health benefits to the broader community.	Quantitative assessment of health effects of active transportation using the reduction in car trips as a proxy for increased transit, walk and bicycle use.
		Low Income Population Served	Consideration of those who may receive greatest benefit from the transit investment due to current barriers to travel and opportunities for them.	Catchment analysis for social groups (low income and minority census tract) within 400m/800m

Project Objective	MAE Account	Criteria/Input	Role / Description	Measure
communities		Safety	Safety of the system includes both operational safety (i.e. collisions between transit vehicles and cars, cyclists, pedestrians) as well as personal safety of using the system (perceived and real).	Qualitative assessment of the operating environment of each alternative based on precedent data Qualitative assessment of security and CPTED measures
		Community Cohesion	Rapid transit alternatives, depending on their design, can impose varying levels of community severance and visual intrusion.	Number of restricted cross traffic locations for pedestrians, cyclists and vehicles Qualitative assessment on the effects of visual intrusion, quantitative in terms of linear distance and number of properties.
		Heritage and Archaeology	Effects on any properties with local/regional heritage value, architectural merit or community facilities and any known archaeological site as a result of construction or operation.	Number (and type) of heritage properties affected Identification of any known archaeological sites/resources impacted on or near the route
A service that is constructible, operable and supportive of federal, provincial, regional and local transportation, environmental and land use targets and objectives.	Deliverability	Constructability	Generally a review of 'show stoppers' including geotechnical, archaeological, environmental remediation measures and physical challenges (gradients, physical constraints, system expandability, etc) that would pose barriers to building/operating. This also includes non-environmental construction impacts.	Qualitative assessment
		Acceptability	Description of the likely level of public acceptance of the alternative.	Qualitative assessment informed by public and stakeholder process and market research
		Affordability	Required funding to build and operate the alternative.	Not assessed

Evaluation Process

3.28 Each of the Phase 2 alternatives was assessed using the criteria in Table 3.1 and was compared against the Business as Usual (BAU) scenario. The BAU scenario assumes that the study area would continue to be served by buses with service increases consistent with past trends and population and employment growth. The costs and benefits were assessed over a 30 year (plus construction) period and the key evaluation assumptions are contained in Appendix A.

3.29 Where practical, the individual effects were quantified however, where qualitative scoring was used, it was based on the following seven-point scale:

- Significant benefit (✓✓✓)
- Moderate benefit (✓✓)
- Slight benefit (✓)
- Neutral (-)
- Slightly adverse (×)
- Moderately adverse (××)
- Significantly adverse (×××)

3.30 Qualitative assessments are, by their nature, subjective and were undertaken by qualified professionals exercising expertise and judgment to determine the likely, comparative effects of the various alternatives using the assessment matrix presented in Table 3.2.

TABLE 3.2 QUALITATIVE ASSESSMENT MATRIX

Qualitative Assessment Matrix		**Number of people or instances affected by the benefit/effect**			
		Majority	**Moderate**	**Isolated**	**None**
Scale of benefit/effect	**Significant**	*Significant*	*Significant*	*Moderate*	*Neutral*
	Moderate	*Significant*	*Moderate*	*Slight*	*Neutral*
	Slight	*Moderate*	*Slight*	*Slight*	*Neutral*
	None	*Neutral*	*Neutral*	*Neutral*	*Neutral*

3.31 Finally, the assessments were summarized on a five point scale for consultation purposes to aid representation as follows:

4 Phase 2 Rapid Transit Alternatives

Introduction

4.1 This chapter summarizes the Phase 1 process to arrive at a shortlist and explains the process used to develop the Phase 2 Rapid Transit Alternatives including a summary description of each of the final alternatives evaluated.

Phase 1 Evaluation

4.2 In Phase 1 of the study, the MAE framework was applied in a high level analysis to identify a shortlist for more detailed study.

4.3 It included a two-step process – a 'Pre-Sift' to reduce the long list of nearly 200 route alternatives to a set of 29 'in scope' alternatives and then a 'Sift' stage that used a larger number of more detailed criteria to select a shortlist of six alternatives to progress to Phase 2. In general the alternatives that performed the best were those that provided a direct route and served current and future centres of activity, population and employment.

4.4 A Public and Stakeholder consultation process was undertaken in Spring 2010 to confirm the shortlisted alternatives. Through 2,300 online questionnaires, 240 comments submitted online and five community workshops with 400 attendees, six alternatives were confirmed and one additional alternative - the Combination Alternative 2 using bus rapid transit and rail rapid transit - was identified. The UBC Line Phase 1 Final Consultation Summary Report is available on the TransLink website.

Phase 2 Preliminary Evaluation

4.5 Once the shortlist had been confirmed, initial designs were developed and a preliminary evaluation was undertaken in order to enable a comparative assessment of the alternatives using:

- A common reference case against which each alternative was compared (the BAU);
- A consistent level of detail across the criteria that was commensurate with the level of project information available; and
- A disaggregated scoring system that enabled the level of impact to be differentiated between alternatives.

4.6 The alternatives considered through Phase 2 Preliminary Evaluation are described below. As described earlier, the alternatives were evaluated against a Business As Usual (BAU) scenario which included road and transit committed infrastructure improvements (including Evergreen Line) and corridor bus network assumptions as per Table 4.1.

- **Bus Rapid Transit (BRT)** - at-grade BRT route from UBC to Commercial-Broadway via University Blvd, West 10th Ave and Broadway using either diesel or electric trolley articulated buses;

- **Light Rail Transit (LRT) 1 -** at-grade LRT route from UBC to Commercial/Broadway via University Blvd, West 10th Ave and Broadway with two sub-options at the eastern end:
  - **LRT1A** – remains on Broadway all the way to Commercial-Broadway Station;
  - **LRT1B** – turns north off Broadway onto Quebec and then along East 2nd, Great Northern Way, East 7th, Grandview Hwy North to Commercial-Broadway Station;
- **LRT2 -** combines LRT Option 1 (either LRT1A or 1B) with a second branch from Broadway/Arbutus to Main Street/Science World via the CPR right-of-way, the City of Vancouver Streetcar route and Station St;
- **Rail Rapid Transit (RRT) -** completely grade separated route linking UBC to Commercial-Broadway via University Blvd, West 10th Ave and Broadway with two sub-options at the eastern end:
  - **RRT 1A** – completely underground route via University Blvd, West 10th Ave and Broadway, independent of the existing SkyTrain;
  - **RRT 1B** – completely grade separated route via University Blvd, West 10th Ave, Broadway, Great Northern Way as an extension of the existing Millennium Line SkyTrain from VCC-Clark;
- **Combination Alternative 1 -** a combination of the VCC-Clark to Arbutus section of RRT1B with the portion of LRT2 route from UBC to Main Street/Science World; and
- **Combination Alternative 2** – a combination of the VCC-Clark to Arbutus section of RRT1B with the BRT alternative using diesel buses (though trolley buses could also be employed). This alternative was added following feedback received in the Spring 2010 public consultation

4.7 In addition to these six rapid transit alternatives, a **Best Bus alternative** was developed and evaluated to demonstrate the benefits and impacts of bus service improvements across multiple corridors and determine whether future demand in the corridor could be met with buses alone. Specifically, it included:

- New peak direction, peak period "super-limited-stop" services from Main Street - Science World (984) and Commercial-Broadway (999) stations to UBC; and
- A total of 54 additional (over the BAU) services per hour in each direction during the peak period by 2021, and 72 additional services by 2041. This represented a 34% and 40% increase in east-west capacity by 2021 and 2041 respectively. These additional services were on east-west routes between False Creek and 49th Avenue.

Phase 2 Consultation

4.8 A public and stakeholder consultation process was undertaken in March and April 2011 to discuss the designs of the seven alternatives and their evaluation across the multiple accounts. The consultation was designed to help the study team update the designs and finalize the evaluation. The full consultation summary report *UBC Line Rapid Transit Study - Report on March/April 2011 Public Consultation (July 2011)* provides a complete summary of the input received and is summarised in the following sections.

Consultation Objectives

4.9 The objectives of the consultation were to support the technical study by:

- Presenting preliminary designs and evaluation of the seven alternatives for public input;
- Providing information/education to support the public in learning about the alternative designs, benefits and impacts;
- Enabling discussion and input on the designs and evaluation; and
- Communicating next steps.

4.10 Four in-person workshops, an online webinar, seven small group meetings and two drop-in sessions were held. Approximately 540 people participated in these events. Input was received and tracked through more than 1,500 feedback questionnaires submitted and workshop minutes. Additional comments on the Buzzer blog posts and direct correspondence were also recorded.

Feedback on the Designs

4.11 Design assumptions were made for each of the seven alternatives that included horizontal and vertical alignment, station locations and how road space is shared between transit and other uses. The workshops and feedback questionnaire asked participants their level of agreement with the design assumptions for each alternative and specific feedback on changes to help the study team update the designs. Feedback by alternative included:

- BRT: design assumption changes suggested included changes to station locations in addition to general comments related to concerns over road user impacts, use of trolley vs. diesel buses, safety of pedestrian crossings, capacity limitation and insufficient improvements over existing service;
- LRT1: design assumption changes suggested included reviewing a tunnelled alignment and changes to station locations in addition to general comments related to pedestrian and driver safety, road user impacts, retail parking/loading impacts, insufficient improvement over existing service and potential opportunities for streetscape/land use improvements;
- LRT2: generally similar comments to LRT1 with additional comments related to reviewing the station locations between Olympic Village and Main Street-Science World and support for use of existing rail corridor;
- RRT: support for using a tunnelled alignment and some suggestions to use an elevated route along University Boulevard and suggestions to review/reduce the station locations in the eastern and western-most segments of the corridor. Support for its integration with the existing system and lack of impacts to road users. Concerns over the construction impacts and costs;
- Combination 1: support for improving overall network coverage. Concerns with redundancy of stops and alignments;

- Combination 2: similar to Combination 1 with additional concerns related to road space impacts and redundancy of the service; and
- Best Bus: general comments focussed on travel time competitiveness, road space allocation and network capacity concerns.

4.12 In terms of overall design trade-offs, 45% of respondents indicated sidewalk widths were the highest road space priority, while 18% indicated travel lanes and 19% parking. One-third of respondents did not agree with restricting left-turns for the surface alternatives.

Feedback on the Evaluation

4.13 The workshops and feedback questionnaire asked participants:

- Their level of agreement with the evaluation of the alternatives;
- Whether the full range of benefits and impacts had been captured, and whether other criteria should be considered to help finalize the evaluation; and
- If they had advice for decision makers on what is important when considering the evaluation.

4.14 Key themes to the responses were:

- Transportation themes such as ensuring service efficiency, reliability, safety, connectivity and accessibility;
- Support for investing for the long-term, especially with respect to underground infrastructure despite the costs involved;
- Balance local neighbourhood needs with transportation needs, and
- Learn from past experience to mitigate construction impacts.

Phase 2 Preliminary Evaluation Conclusions

4.15 No definitive conclusions were made following the Preliminary Phase 2 Evaluation and Public Consultation and none of the seven alternatives were removed from further consideration. However, a number of preliminary conclusions were made and are summarised in the following sections.

BRT

4.16 The BRT alternative does not provide sufficient capacity to meet projected demand in the corridor.

4.17 Two sub options – a diesel service and a trolley service - were evaluated through the Phase 2 Preliminary Evaluation. The trolley option generated greater environmental benefits at an additional capital cost of approximately $70-80 million. The final Phase 2 evaluation is based on the diesel based option but this conclusion should be revisited should BRT be selected as the preferred alternative.

LRT1

4.18 Two sub-options were considered – LRT1A which runs on Broadway and LRT1B which diverts off Broadway to serve the Great Northern Way Campus – and following the Preliminary Evaluation, no definitive conclusions could be drawn. Further work was undertaken to refine the results and this concluded that LRT1A should progress to the final evaluation as it generates greater transportation benefits for a lower capital cost than LRT1B.

LRT2

4.19 The LRT2 alternative combined LRT1A or LRT1B with a second LRT branch to Main Street-Science World. In line with the conclusions of the LRT1A/1B assessment, it was recommended and agreed that LRT2 would use the LRT1A alignment for the final evaluation.

RRT Alternative

4.20 Two sub-options were considered – RRT1A and RRT1B. RRT1B generates nearly double the transportation benefits for $300 million less in capital investment. It was therefore recommended and agreed that no further work be undertaken on RRT1A.

Combination 1

4.21 No specific conclusions were made regarding Combination 1 and it was therefore recommended and agreed that it would progress to the final evaluation.

Combination 2

4.22 No specific conclusions were made regarding Combination 2 and it was therefore recommended and agreed that it would progress to the final evaluation.

Best Bus

4.23 The Best Bus alternative assumed improvements in east-west bus services in the study area to deliver the highest-capacity service possible with changes to routes, frequencies and service patterns, and minimal investment in fixed infrastructure.

4.24 The purpose of the Best Bus alternative was to determine whether widespread improvements in bus services across multiple, parallel corridors would 'solve' the transportation problems in the Corridor by diverting trip growth to parallel corridors. The conclusion from the evaluation was that it did not divert significant volumes of trips and that transit services on Broadway would still be at or over capacity in the long term. Therefore it would only provide a near term capacity measure.

4.25 In addition, because the Best Bus alternative involved bus improvements across an area much bigger than the study area, it generated exogenous transportation benefits making a direct comparison against any of the rapid transit alternatives very difficult e.g. the benefits provided to eastbound passengers outside the corridor (on 41st Avenue for example) could be provided with any of the rapid transit alternatives. It was therefore recommended and agreed that for the purposes of the final Phase 2 evaluation, the Best Bus alternative should only include service improvements within the study area. Improvements in other corridors can be considered through separate planning efforts.

4.26 The analysis of the various Best Bus alternatives is included in Appendix B.

4.27 It is worth noting that for the purposes of evaluation, bus routes currently served using trolley buses are assumed to continue to use trolley buses and likewise, routes currently served by diesel buses would continue to use diesel buses. However, this conclusion could be revisited[6].

Phase 2 Alternative Optimisation

4.28 As noted previously, the designs and assumptions used for the Preliminary Phase 2 Evaluation were generally consistent across all alternatives in order to provide a consistent point of comparison as the starting point. For example, all alternatives included the same stop locations as the current 99 B-Line service and had the same (or very similar) complementary bus networks.

4.29 It was therefore recommended and agreed that further work be undertaken to refine and optimize a number of the alternatives. This included:

- Review of stop locations;
- Review of parking and loading impacts;
- Review of turning and cross-traffic restrictions;
- Updates to the land-use forecasts (provided by Metro Vancouver); and
- Review of the performance, speed and reliability of surface rapid transit.

4.30 The conclusions of each of these pieces of work were reviewed and agreed as being 'fit for purpose' and have been included in the final Phase 2 alternatives as described in the following section. A Design Principles document provides information on alternative alignment and design assumptions (in Appendix C) and the associated costs of the changes (e.g. off-street parking, changes to stop numbers/locations) have been included in the cost estimates described in Chapter 6.

Description of Final Phase 2 Alternatives

4.31 The Phase 2 final evaluation updates the earlier Phase 2 Preliminary evaluation for each of the remaining shortlisted alternatives. These include six rapid transit alternatives (BRT, LRT1, LRT2, RRT, Combinations 1 and 2) and Best Bus. Each alternative is assessed against the Business As Usual (BAU) case summarised in Table 4.1 and a summary of the specification of each transit technology type is shown in Table 4.2.

4.32 All alternatives serve the UBC campus, run along Broadway and interchange with the Canada Line at Broadway-City Hall. Some alternatives provide an interchange with SkyTrain at Commercial-Broadway (for the Millennium and Expo lines) while others connect to the Millennium Line at VCC-Clark and directly serve the Great Northern Way Campus.

[6] For reference, the incremental cost (infrastructure and vehicles) of converting a high frequency route (2 minute headway) from diesel to trolley is approximately $5 million per kilometre (i.e. the difference between the Phase 1 BRT diesel service and BRT trolley service was $75m for the 14km route).

4.33 Figures 4-1 to 4-7 illustrate the routing and stop locations with the key details of the alternatives summarised in Table 4.3. Subsequent chapters describe the performance of each alternative within each account.

TABLE 4.1 BAU BUS SERVICE ASSUMPTIONS

Bus Service (*)		AM Peak Headways (minutes) 2021 BAU	AM Peak Headways (minutes) 2041 BAU	Route Km (**)	AM Peak Journey Time (min) (**)
9g	Boundary-Granville (bidirectional)	10	9	17.3	61
9u	Boundary-UBC (bidirectional)	8	7.5	34.0	103
17wb	CBD-UBC	9	9	12.0	34
17eb	UBC-CBD	10	10	12.0	36
25wb1	Brentwood-UBC	9	8	23.6	69
25wb2	Nanaimo-UBC	9	8	17.1	46
25eb	UBC-Brentwood	9	8	23.6	76
33	29th Av-UBC (bidirectional)	13.5	12	34.6	106
41i	Joyce-UBC	5.5	5	19.3	47
41ou	UBC-Joyce	6.5	5.5	19.3	50
43wb	Joyce-UBC	7	6	19.3	41
43eb	UBC-Joyce	7	6	19.3	49
44i	UBC-SeaBus	16	14.5	13.0	35
44o	SeaBus-UBC	8	7.5	12.6	32
49i	Metrotown-UBC	5.5	4.5	23.2	56
49o	UBC-Metrotown	6.5	5	23.2	51
84	VCC-UBC (bidirectional)	7	6.5	26.6	60
99wb	Commercial-UBC	2.5	2.5	13.6	37
99eb	UBC-Commercial	6.5	5.5	13.6	39

Note: * Routes serving more than two termini or with asymmetrical service levels are broken down in more detail with codes for each combination of termini and/or direction
** Distances and times are round-trip for routes marked as “bidirectional”

TABLE 4.2 RAPID TRANSIT TECHNOLOGY SUMMARY

Technology	Illustrative Example	Characteristics	UBC Line Specific Assumptions
Bus Rapid Transit (BRT)		Driver-operated, low-floor articulated buses: Frequency: up to every 2 minutes Average speed: 30 kilometres per hour (including stopped time at stations and intersections). Power source: either hybrid buses running on diesel fuel or electricity. Right of way: normally street-level in the centre, in its own right-of-way, separated from other traffic by a curb. Stations: are typically located within the street and connect to both sides of the street with pedestrian crossings.	Vehicle dimensions: 18m x 2.5m articulated bus Capacity per vehicle: 100 passengers Intersection priority: no Stop dimensions: side platforms (40m x 3m)
Light Rail Transit (LRT)		Driver-operated rail technology: Frequency: up to every 2 minutes. Depending on the frequency of the service, signal priority may be provided at intersections. Average speed: 30 kilometres per hour (including stopped time at stations and intersections). Power source: electrically-powered from overhead wires Right of way: normally street-level in the centre, in its own right-of-way, separated from other traffic by a curb. Stations: typically located within the street and connect to both sides of the street with pedestrian crossings.	Vehicle dimensions: 40m x 2.65 m Light Rail Vehicle (LRV) Capacity per vehicle: 240 passengers Capacity per train: 480 (2 LRVs coupled) Intersection priority: 100% priority at minor intersections Stop dimensions: side platforms (80m x 3m) and centre platforms (80m x 4m)

Rail Rapid Transit (RRT)		Driver operated or driverless rail technology. For this study, assumed to be automated and driverless. In this region RRT is called SkyTrain. Frequency: up to every 1.5 minutes Average speed: 40 kilometres per hour including stopped time at stations. Right of way: typically operates in a tunnel or on an elevated track. Surface level operation is possible but automated systems must be fully segregated and protected by fencing. Stations: In cases where RRT runs underground, the station entrances are at ground-level and the platforms are accessed by elevators, escalators and stairs.	Vehicle dimensions: 20m x 2.65 m SkyTrain cars Capacity per vehicle: 130 Capacity per train: 390-650 passengers (3-5 cars coupled together) Intersection priority: N/A Stop dimensions: 80m x 9.3 m

TABLE 4.3 SUMMARY OF RAPID TRANSIT ALTERNATIVES

Alternative Name	Technology	Route/Alignment	Route Length (km)	Stops	End-to-End Runtime (min)	Peak Hour Headway (min)	Vehicles per Unit	
							2021	2041
BAU*	Bus (B-Line)	UBC-Commercial/Broadway	13.3	13	38.0	2.6	1	1
BRT	Bus (BRT)	UBC-Commercial/Broadway	13.3	14	33.4	2	1	1
LRT1**	LRT	UBC-Commercial/Broadway	13.5	14	28.1	4	2	2
LRT2**	LRT	UBC-Commercial/Broadway UBC-Arbutus-Main St/Science World	13.5 12.0	14 12	28.1 24.2	5 7.5	2 1	2 1
RRT***	RRT	UBC-VCC	12.4	11	17.3	3	4	5
Combination 1***	RRT LRT	Arbutus-VCC UBC-Arbutus-Main St/Science World	5.1 12.0	7 14	7.6 24.2	3 4	4 1	5 1
Combination 2***	RRT Bus (BRT)	Arbutus-VCC UBC-Commercial/Broadway	5.1 13.3	7 14	7.6 33.4	3 2	4 1	5 1
Best Bus	Bus	UBC-Commercial/Broadway + Various	-	-	-	-	1	1

NOTE: ** 2041 runtime is considerably longer than current conditions (see paragraph 2.9) due to projected increases in congestion*

*** The LRT route length is approximately 200m longer than the BRT Section due to location and length of longer terminal facilities*

**** The RRT components for RRT1, Combination 1 and Combination 2 represent Millennium Line extensions from VCC*

FIGURE 4-1 BEST BUS MAP

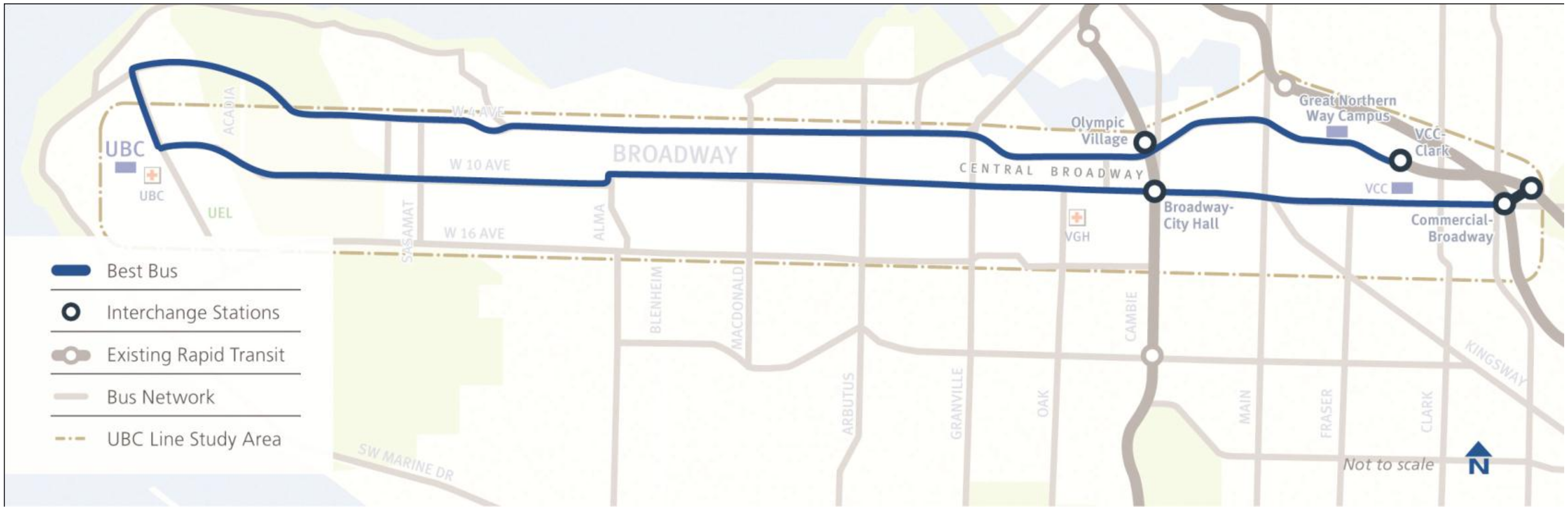


FIGURE 4-2 BRT ROUTE MAP

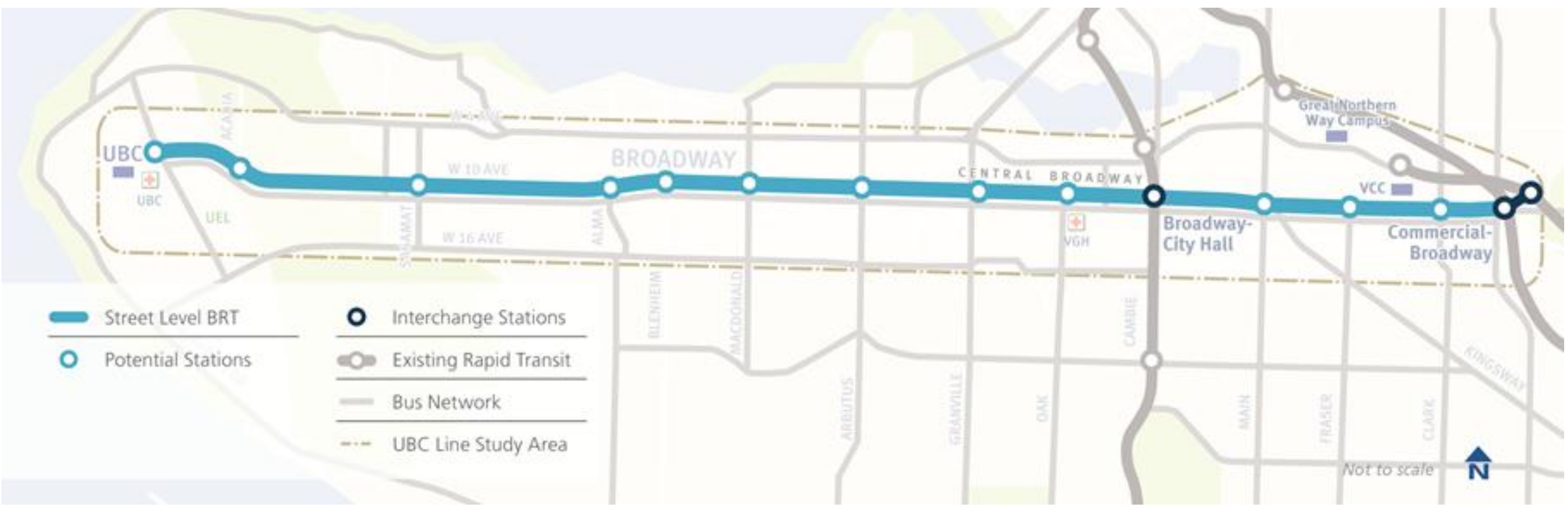


FIGURE 4-3 LRT1 ROUTE MAP

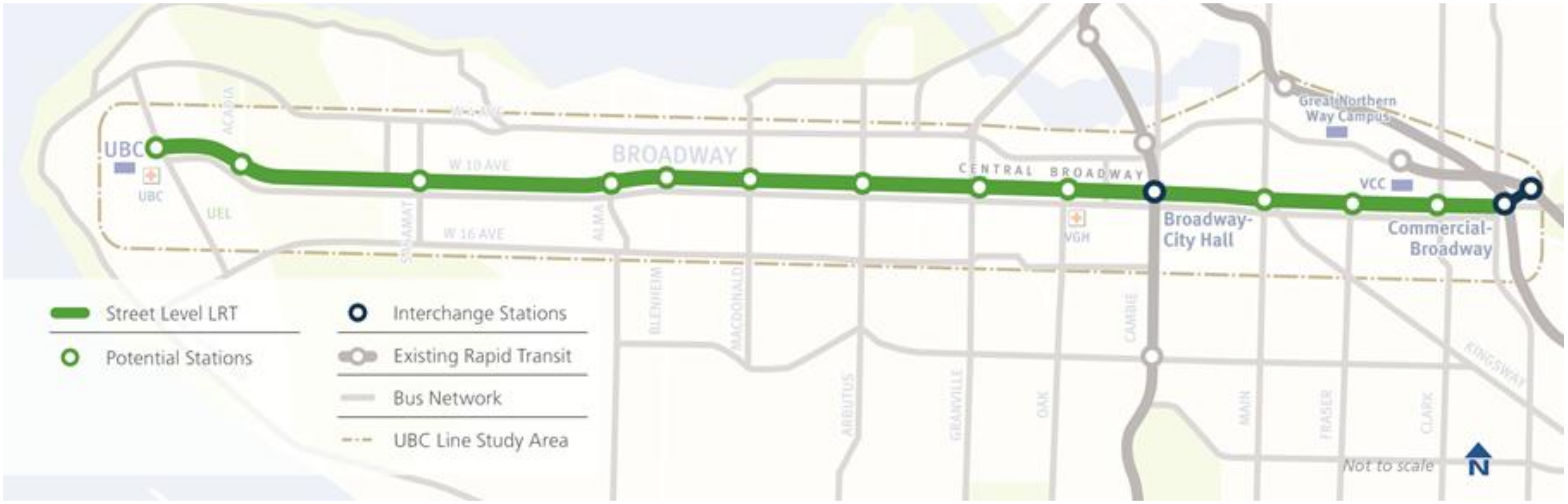


FIGURE 4-4 LRT2 ROUTE MAP

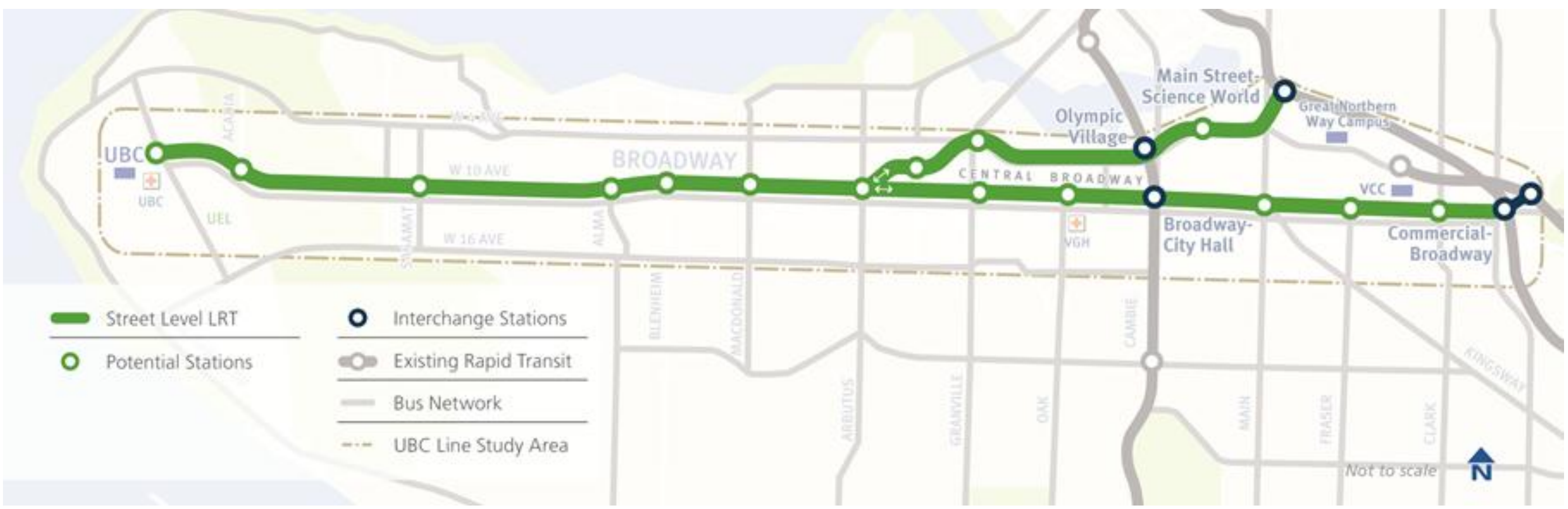


FIGURE 4-5 RRT ROUTE MAP

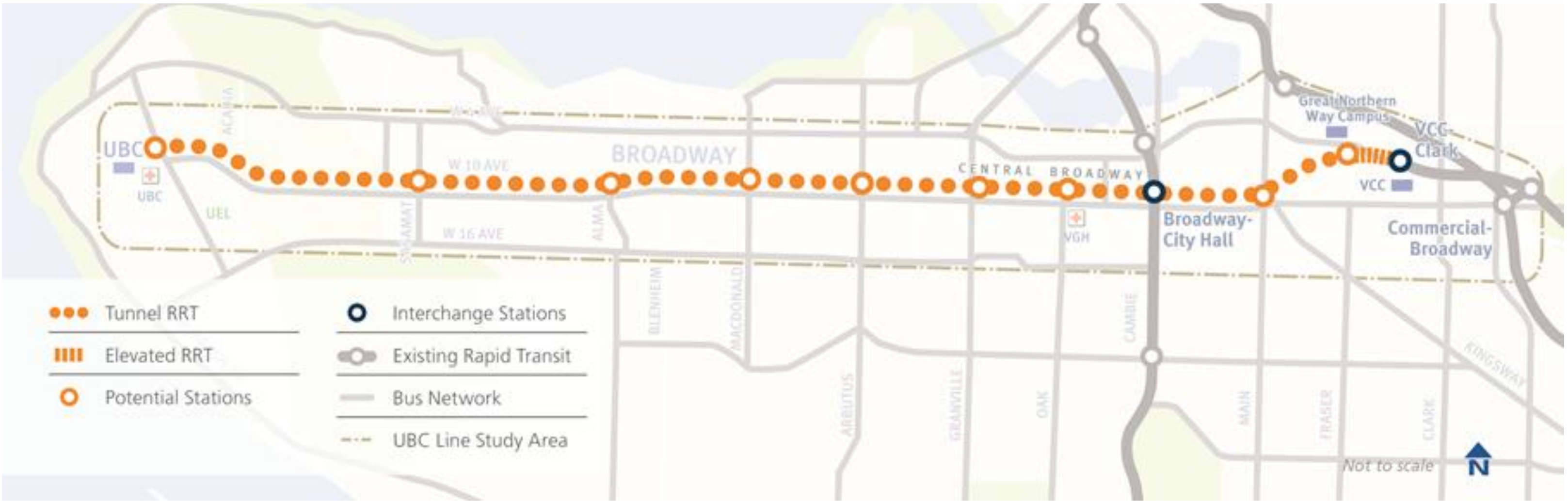


FIGURE 4-6 COMBINATION 1 ROUTE MAP

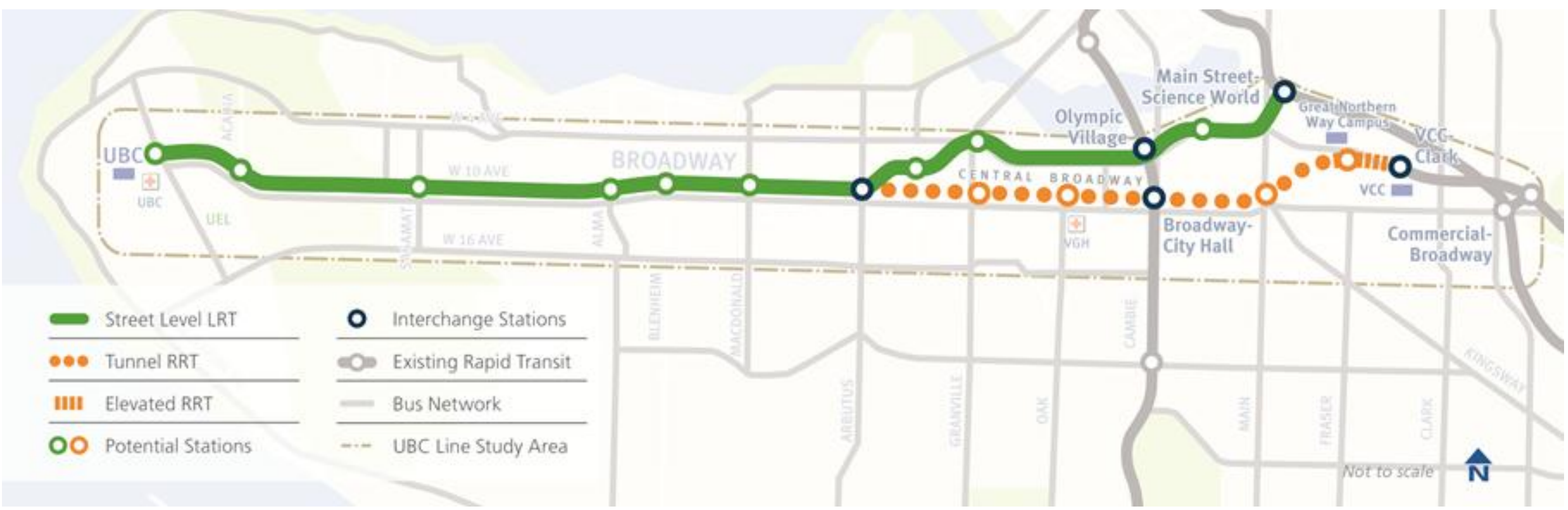
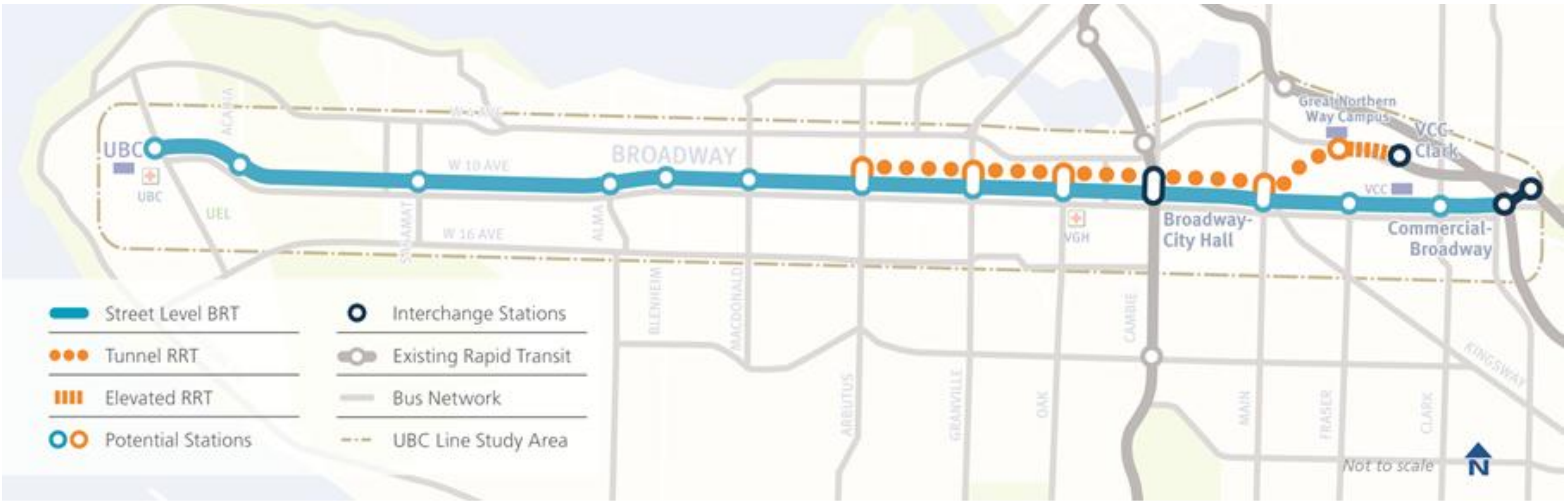


FIGURE 4-7 COMBINATION 2 ROUTE MAP



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5 Transportation Account

Introduction

5.1 The transportation account assessed the extent to which each alternative provides a fast, reliable and efficient service that meets current and future capacity needs, as well as the extent to which it supports achieving transportation targets and integrates with and strengthens the regional transit network. This account covers the following criteria:

- Transportation efficiency savings for transit and non-transit users;
- Transit System/Network Accessibility;
- Reliability; and
- Capacity and Expandability.

5.2 The Rapid Transit Projects Model 2008 (RTPM08) was used to estimate ridership, mode share, travel time savings, decongestion benefits and vehicle kilometres travelled. RTPM08 is a four-stage EMME multi-modal forecasting model representing the Metro Vancouver region. It is an AM peak hour (7:30-8:30) model calibrated to 2008 conditions with 2021 and 2041 forecast years. Future year population and employment forecasts are driven by the Regional Growth Strategy (RGS) as provided by Metro Vancouver and approved by all municipalities. Model outputs include auto, transit and walk/cycle demand and Appendix D describes RTPM08 model assumptions and results. Model results were expanded to average weekday and annual figures using expansion factors, as described in Appendix D, Table 2.5.

5.3 The EMME model does not constrain forecasts based on capacity. A number of adjustments have been made to the benefits to represent the impacts of services that are forecast to be over their assumed capacity in peak periods i.e. the rapid transit service cannot deliver the full modelled demand forecast or travel time benefits. Adjustments to some model outputs, notably total regional trips and mode shares, could not be readily adjusted and so are reported as “unconstrained.” The adjustments were applied to the following alternatives:

- **BRT** is forecast to be overcapacity by 2021. As a result, the peak travel time benefits were reduced in 2021 by 40% and then capped at 2021 levels in 2022 and subsequent years. In this calculation, 53% of all passengers are assumed to travel in the off-peak and 47% in peak periods 07:00-10:00 and 15:00-18:00 on weekdays), based on analysis of boarding and alighting patterns on the 99 B-Line. The service is expected to be at capacity even in the off-peak by 2031 and hence for 2032 onwards, all benefits are capped at 2031 levels.
- **Combination 2** shows the BRT section of the alternative is 20% overcapacity by 2041. Therefore peak period benefits have been reduced accounting for the 47% of the peak period demand and for 60% of the route length as the RRT section does not have capacity issues.

- **Best Bus** benefits have not been adjusted as they are only slightly overcapacity by 2041 with an insignificant impact on the assessment of benefits.

Transportation Efficiency – Transit Users

Travel Time Savings

5.4 Travel time savings refers to perceived (or generalized) travel time, which incorporates weighted access time, weighted wait time (and associated reliability factor), in-vehicle time, interchange penalties and monetary costs (converted to generalized minutes using the value of time). These savings are estimated by the difference between each rapid transit alternative and the BAU travel times as estimated by RTPM08. The transit travel time savings include changes to bus journey times caused by lane reductions or increases/decreases in congestion as well as decreases to journey times for those who use faster rapid transit services.

5.5 A run time model was used to develop end-to-end journey times for each of the alternatives and, for LRT1, these times were validated using a VISSIM microsimulation model of the corridor. A summary of the run time model assumptions is included as Appendix E.

5.6 RRT alternatives provide the greatest reductions in transit journey times at under half the journey time of the BAU (B-Line) service and 44% shorter than the BRT and 34% shorter than the LRT between Commercial-Broadway and UBC. In addition, the RRT and the Combination alternatives provide through travel opportunities onto the UBC Line corridor for Millennium Line passengers, providing additional journey time benefits by avoiding transfers.

5.7 Table 5.1 shows the run time for trips from either Commercial/Broadway or VCC-Clark to UBC and to Broadway at Cambie (i.e. Central Broadway) as well as resulting generalized time savings, where generalized time represents the sum of the monetary and non-monetary costs of a trip. Non-monetary costs include perceived journey time; which incorporates in-vehicle time, weighted access and egress time (factored by 1.75), weighted wait time (factored by 2.25 and allowing for different reliability factors of 1.2 for bus, 1.1 for LRT and 0.8 for RRT) and transfer impact (4 minute penalty assumed). Monetary costs include fares.

TABLE 5.1 TRAVEL TIME COMPARISONS

Alternative	Peak run time (mins) VCC Clark to:		Peak run time (mins) Commercial/ Broadway to:		Travel time benefit per rapid transit rider (generalized mins[7], 2041)	Transit Travel Time Saved (generalized hours, weekday)	
	UBC	Cambie	UBC	Cambie		2021	2041
BAU	30.0	7.0	38.0	8.9	-	-	-
Best Bus	25.5	6.0	30.4	6.4	0.6	840	1,210
BRT	-	-	33.4	8.9	4.9**	7,190**	9,560**
LRT1	-	-	28.1	8.1	8.6	17,630	22,930
LRT2	-	-	28.1	8.1	8.5	18,280	23,520
RRT	17.3	4.4	18.5	5.5	19.4	82,130	104,110
Combo 1	28.1*	4.4	29.3*	5.5	14.8	63,640	86,090
Combo 2	29.7*	4.4	31.7	5.5	11.7**	48,950**	66,110**

*NOTE: * Trips include an interchange at Arbutus (for which a four minute 'interchange penalty' has been applied, consistent with RTPM08 assumptions and reflecting the inconvenience of transferring services). Wait time for UBC bus service is additional to that estimate*

*** Savings capped as described in paragraph 5.3*

5.8 Table 5.1 shows the largest travel time benefits for the fastest alternatives with RRT providing a travel time 20 minutes faster than the B Line under the BAU. Combos 1 and 2 result in slightly lower benefits as RRT only extends to Arbutus and requires a transfer for UBC-bound passengers.

5.9 The following additional benefits were added to current transit user journey time savings from the RTPM08 model under rapid transit alternatives:

- Additional time savings for inter-peak users, since bus journey times along the corridor are currently greater in the midday than in the AM peak due to the bus lanes being peak-only. This is not reflected in the RTPM08 model as it is an AM peak only model. We have assumed that 75%[8] of rapid transit users see a 5 minute journey time saving (which corresponds to 6 minutes of perceived time under the RTPM's weighting of 1.2 for in-vehicle time in buses) as a result of full-time separation of the rapid transit alternatives from other traffic.

- Rapid transit provides improved journey time reliability through full grade segregation (RRT), dedicated road space (BRT/LRT) and traffic signal priority (LRT). This refers to the variation of journey times for the same time of travel (as opposed to the variation across the day). An uplift of 15% on journey time savings

[7] Generalized time represents the sum of the monetary and non-monetary costs of a trip

[8] Assumed that 50% of the passengers travel the entire route and 50% travel half the route

for existing users was applied to represent reliability benefits consistent with SDG's international experience and accepted factor from the UK's Department of Transport. With physical segregation but no signal priority, BRT would only achieve a fraction of the additional reliability (compared to LRT). Therefore, for the purposes of this preliminary evaluation, this uplift was not applied to the BRT benefits.

- Mode specific quality benefit to represent the user perceived attractiveness of rapid transit compared to the bus, such as passenger amenities, ride quality and comfort, personal safety and seat availability. Benefits of 2 minutes/trip for BRT and 4 minutes/trip for LRT and RRT were applied, in line with values used in other jurisdictions such as the US Federal Transit Administration and Transport for London[9].
- Time savings due to elimination of pass-ups (riders left at the bus stop after the buses have departed due to overcrowding) on the 99 B-line as described below.

5.10 Pass-up volumes (passengers left behind at stops) and wait times were derived from surveys undertaken along the 99 B-Line in December 2009, where the average waiting time of those who are passed up was 3.1 minutes in the AM peak and 2.8 minutes in the PM peak. The assumed total time savings for the alternatives that provide additional capacity (i.e. all alternatives other than the BRT and Best Bus) are shown in Table 5.2.

TABLE 5.2 WEEKDAY PASS-UP BENEFITS SUMMARY

	2021	2041
AM peak pass-up numbers (riders in thousands)	3.7	4.2
AM peak wait time (hours)	45.4	51.7
PM peak pass-up numbers (riders in thousands)	1.1	1.4
PM peak wait time (hours)	13.1	17.1
Total wait time (hours)	58.5	68.8
Total perceived wait time (Annual hours in Thousands)	**132**	**155**

[9] Note recent work on the Expo Line Upgrade Strategy identified benefits associated with passenger comfort, capacity, station safety and security, station precinct and accessibility which are linked to the benefits indicated above and based on local Stated Preference surveys. The Demand Performance of Bus Rapid Transit by Graham Currie (see Journal of Public Transportation Volume 8 No.1, 2005) examined how passengers valued trip attributes for on-street bus, BRT, LRT and heavy rail systems, compiling information from a range of studies and sources. The conclusion was that BRT, LRT and heavy rail are all favoured relative to conventional bus. Based on Currie's analysis, LRT mode constants could be up to 20 minutes relative to conventional bus.

Ridership and Mode Share

5.11 Total ridership and incremental passenger-km, derived from RTPM08 are indicators of the overall transit network usage. Transit mode shares have also been derived from the ridership forecasts to illustrate the relative attractiveness of each rapid transit alternative with the CoV/CBD and corridor mode share representing the proportion of all trips from and within these areas made using transit. Note these represent 'linked' trips (origin to final destination).

5.12 The ridership and mode share results for 2021 and 2041 are shown in Tables 5.3 and 5.4 respectively. Note that 'Broadway Corridor' refers to EMME model zones within the study area as defined in Figure 2-6.

TABLE 5.3 MODE SHARE FORECASTS (2021, UNCONSTRAINED)

Alternative	AM Peak Regional Transit Trips	AM Peak Regional Total Trips	Transit Mode Share (AM Peak)		
			Regional	CoV and CBD	Broadway Corridor
BAU	116,143	817,415	14.2%	26.8%	27.1%
Best Bus	116,241	817,421	14.3%	26.9%	27.2%
BRT	116,709	817,444	14.3%	27.1%	27.6%
LRT1	116,614	817,433	14.3%	27.0%	27.6%
LRT2	116,732	817,444	14.3%	27.1%	27.7%
RRT	118,803	817,462	14.5%	27.8%	29.8%
Combo 1	118,398	817,483	14.5%	27.6%	29.3%
Combo 2	118,355	817,490	14.5%	27.6%	29.2%

TABLE 5.4 MODE SHARE FORECASTS (2041, UNCONSTRAINED)

Alternative	AM Peak Regional Transit Trips	AM Peak Regional Total Trips	Transit Mode Share (AM Peak)		
			Regional	CoV and CBD	Broadway Corridor
BAU	154,648	950,570	16.3%	29.7%	29.3%
Best Bus	154,796	950,563	16.3%	29.7%	29.5%
BRT	155,380	950,584	16.4%	29.9%	30.0%
LRT1	155,330	950,576	16.4%	29.9%	30.1%
LRT2	155,413	950,577	16.4%	30.0%	30.1%
RRT	157,934	950,614	16.6%	30.7%	32.4%
Combo 1	157,309	950,641	16.6%	30.5%	31.7%
Combo 2	157,283	950,649	16.5%	30.5%	31.6%

5.13 When considering the forecast mode shares, it should be noted that the following targets have been set:

- Province of British Columbia – Double provincial transit ridership by 2020;
- TransLink – Achieve non-auto mode share of 50% by 2040; and

- City of Vancouver – Achieve a 50% non-auto mode share by 2020.

5.14 Given the large number of trips taken regionally, no investment on a single corridor would be expected to have a significant impact on mode share at the regional scale. Therefore it is not surprising that the impact on mode share for all the alternatives at the regional scale is small and none of the rapid transit alternatives is forecast to achieve the targets relating to non-auto mode share. RRT provides a greater improvement than the other alternatives (a 0.3% increase in regional transit mode share and a 3.1% increase in corridor transit mode share in 2041). In 2021 and 2041, the RRT and Combination Alternatives attract the highest transit ridership leading to the highest transit mode shares. This is to be expected given the lower journey times and fewer transfers for those alternatives with RRT i.e. they include extensions of the Millennium Line.

5.15 Figures 5-1 and 5-2 provide the 2041 regional and corridor mode share data with the absolute values in Appendix D. Note that walking and cycling trips are generally more challenging to forecast and caution should be applied to those estimates.

FIGURE 5-1 REGIONAL MODE SHARE (AM PEAK HOUR, 2041, Unconstrained)

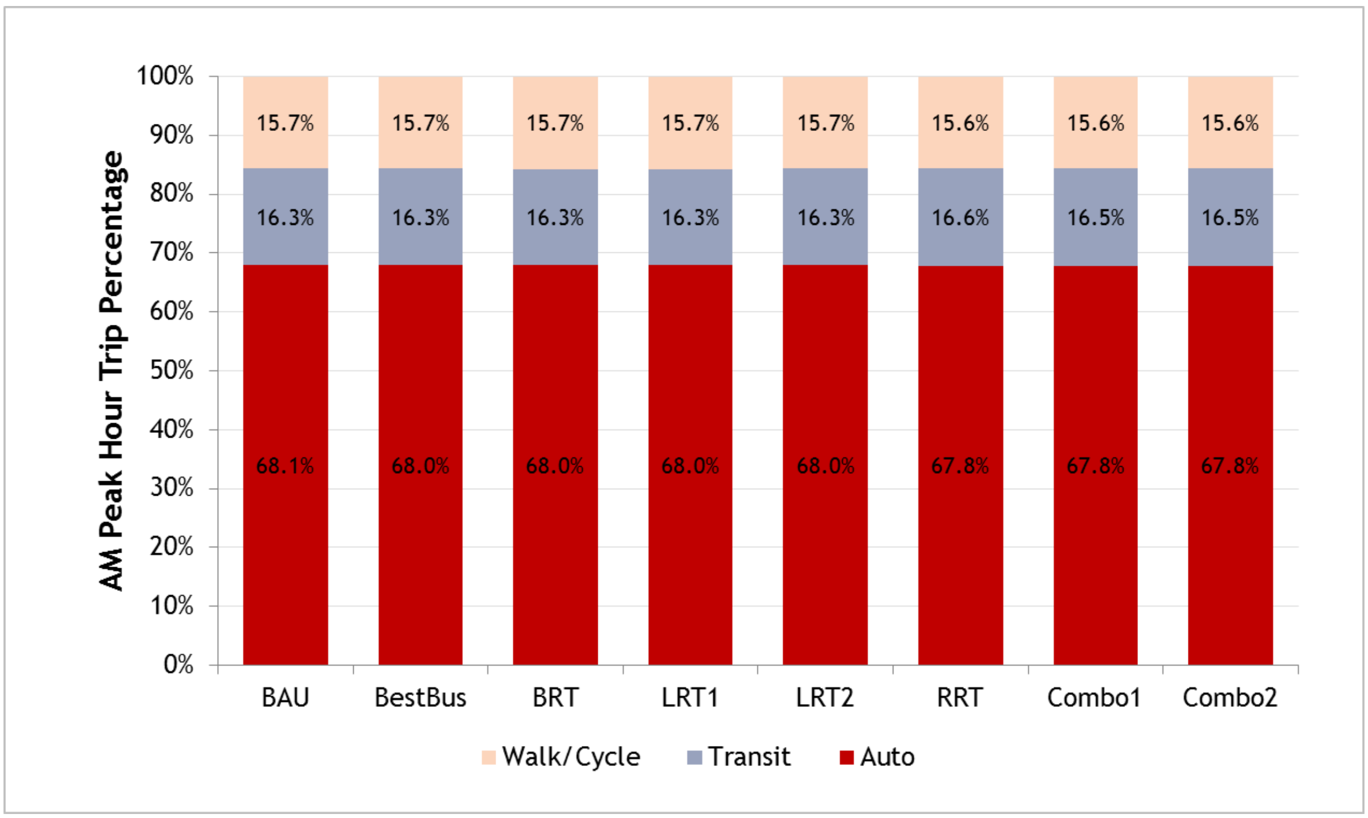
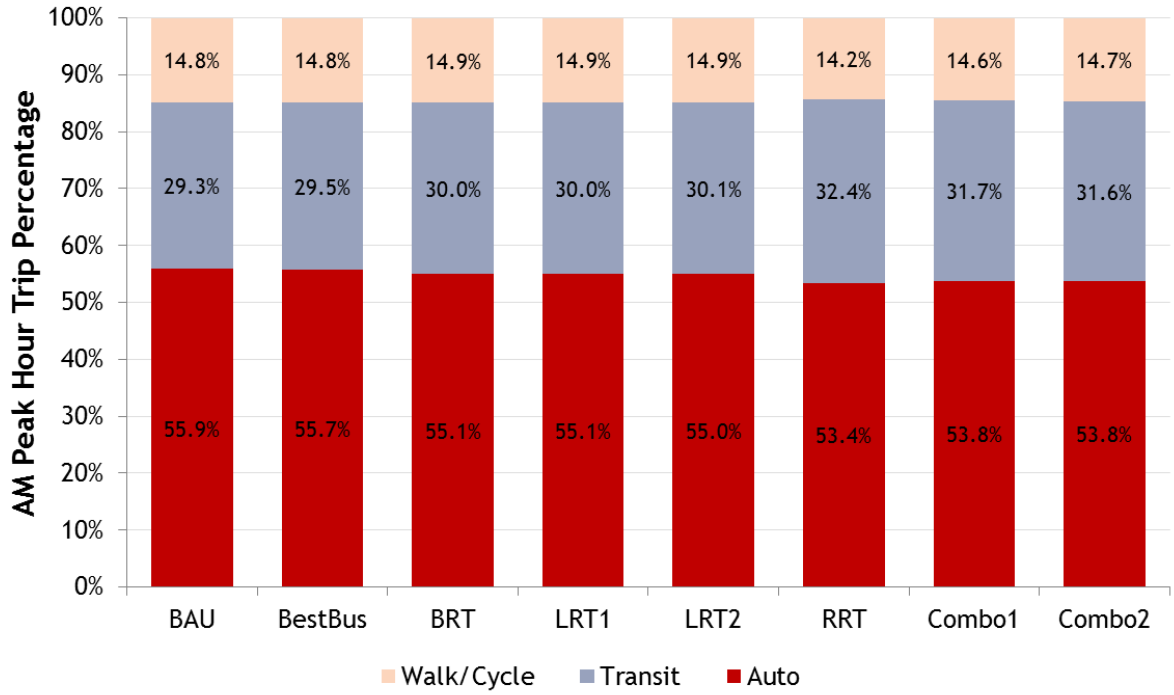


FIGURE 5-2 CORRIDOR MODE SHARE (AM PEAK HOUR, 2041, Unconstrained)



5.16 Combination 1 combines the journey time advantages of RRT with the increased catchment area of LRT2. However users travelling west of Arbutus from VCC-Clark and elsewhere on the Millennium Line are penalized by the need to interchange.

5.17 Combination 2, combining RRT and BRT shows lower ridership than Combination 1 due to both slower journey times from Arbutus to UBC and a smaller catchment area.

5.18 The number of weekday rapid transit boardings (unlinked trips) for each alternative is set out in Table 5.5, together with the total weekday trips (linked). Detailed AM peak route profiles for each alternative are contained in Appendix D.

5.19 Table 5.5 demonstrates that alternatives involving extensions of the Millennium Line have higher boarding numbers. Combo alternatives also show high boarding numbers as some passengers will board twice - RRT and LRT/BRT - as part of their trip.

TABLE 5.5 WEEKDAY RIDERSHIP FORECASTS

Alternative	Corridor Rapid Transit Boardings (unlinked, 000s)		Regional Transit Trips (linked, 000s)			
	2021	2041	**2021**	**BAU Increment**	**2041**	**BAU Increment**
BAU	69*	73*	1,911	-	2,544	-
Best Bus	84**	121**	1,912	+2	2,546	+2
BRT	88***	117***	1,920	+9	2,556	+12
LRT1	123	160	1,918	+8	2,555	+11
LRT2	129	166	1,920	+10	2,557	+13
RRT*	254	322	1,954	+44	2,598	+54
Combo 1	258	349	1,948	+37	2,588	+44
Combo 2	251****	339****	1,947	+36	2,587	+43

*NOTE: * Includes bus routes 84 and 99 B-Line*
*** Includes bus routes 84, 99 B-Line, 984 and 999*
**** Boardings (but not regional trips) capped as described in paragraph 5.3*
***** Boardings include through passengers on the Millennium Line*

5.20 The rapid transit alternatives have different effects on the incremental passenger kilometres travelled using transit which are displayed in Table 5.6 below. All show an increase over the Business as Usual although the capacity constraints of the BRT alternative result in it having the lowest increase in passenger kilometres. The largest increases in transit passenger kilometres come with alternatives involving a SkyTrain extension, where transit becomes more attractive to passengers making longer trips from further east on the Millennium Line into the corridor. As a result, RRT performs the best under this criterion followed by Combinations 1 and 2.

TABLE 5.6 PASSENGER KILOMETRES (ANNUAL)

Alternative	2021		2041	
	Passenger Km	Change in Passenger Km From BAU	Passenger Km	Change in Passenger Km From BAU
BAU	769,892	-	1,042,935	-
Best Bus*	771,228	1,336	1,045,359	2,424
BRT	786,732	16,840	1,065,384	22,449
LRT1	791,172	21,280	1,073,295	30,360
LRT2	792,164	22,272	1,073,286	30,351
RRT	849,090	79,198	1,144,136	101,201
Combo 1	833,456	63,564	1,129,683	86,748
Combo 2*	826,495	56,603	1,119,994	77,059

*NOTE: * Forecasts capped as described in paragraph 5.3*

Transportation Efficiency – Non-Transit Users

5.21 Each rapid transit alternative would also affect non-transit users in terms of changes in vehicle operating costs, collision costs and journey time benefits or disbenefits. In addition, the surface rapid transit alternatives would also lead to increases in turning restrictions, a loss of parking spaces and displaced traffic. Finally, all alternatives would also lead to temporary disruptions during construction which have been captured in the Deliverability account.

Private Vehicle Operating Costs, Collision Costs and Journey Time Changes

5.22 Changes in private vehicle operating costs were estimated from the changes in forecast vehicle kilometres travelled (VKT) from RTPM08. The assumed unit rate of $0.162 (2010 prices) per km includes the fuel, maintenance and operational costs directly linked with vehicle usage. The rate is assumed to remain constant in real terms.

5.23 The cost savings due to a reduction in auto collisions were calculated for each alternative using assumed average costs for different collision types as provided by MoTI - fatal collisions ($7.14m), non-fatal collisions ($0.12m) and property damage ($5,606) in 2010 prices. These were assumed to remain constant in real terms over time and estimated to an average cost of $0.12 per vehicle km as detailed in Appendix A. This factor was applied to the reduction in VKT from RTPM08 to estimate the total auto collision cost differences.

5.24 Both the operating cost savings and collision cost savings are based on VKT from the RTPM08 model, so the best performing alternatives are those which encourage the most users to transfer from auto to transit. The RRT and Combination alternatives are the most effective at encouraging this mode shift and hence these are the alternatives where cost savings and collision savings are highest.

5.25 The reallocation of road space – either towards transit for the surface rapid transit alternatives or back to general traffic for the RRT alternatives – would have an impact on both non-transit and transit users' journey times from changing levels of congestion. In addition, modal shift from auto to transit would result in some decongestion (time saving) benefits for the remaining auto users. Table 5.7 summarizes a number of impacts for non-transit users.

TABLE 5.7 TRANSPORTATION EFFICIENCY NON-TRANSIT USERS

Alternative	Reduction in auto VKT (millions, 2020-2049)	Operating cost savings for Private Vehicles ($m PV 2010)	Collision cost savings ($m PV 2010)	Non-transit user travel time saving (2021, million hours)	Non-transit user travel time saving (2041, million hours)	Journey time benefit per road user in 2041 (minutes)
Best Bus	90	4	3	0.3	0.1	0.00
BRT*	806	35	27	-0.9	-0.9	-0.01
LRT1	1,014	43	33	-0.5	-0.8	-0.01
LRT2	1,000	41	31	-1.0	-0.7	-0.01
RRT	2,361	101	77	4.1	5.9	0.09
Combo 1	1,915	79	60	2.1	3.7	0.06
Combo 2*	2,021	83	63	1.4	2.8	0.05

*NOTE: * Savings capped as described in paragraph 5.3*

Turning Restrictions and Closures

5.26 The assumptions for road space reallocation for each alternative are identified in the Design Principles document in Appendix C and summarized here for convenience.

5.27 All alternatives with BRT or LRT involve closing at least one minor street (to provide full length platforms) as well as the conversion of a number of intersections to right-in-right-out along with additional left turn restrictions in order to ensure reliability of rapid transit journey times. Table 5.8 below summarizes the impact by alternative and the Design Principles document in Appendix C contains the detailed information by intersection.

TABLE 5.8 INTERSECTION RESTRICTIONS, STREET CLOSURES AND VEHICLE LANE IMPACTS

Alternative	No. of intersections with additional vehicle turn restrictions/ intersections crossed	No. of street closures	Description
Best Bus	0/73	0	No intersection impacts
BRT	67/73	2	<u>Vehicle Lanes:</u> East of Arbutus there would be two travel lanes in each direction; peak-period bus lanes would be removed. West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. <u>Turn Restrictions:</u> Most of the new restrictions would be at minor intersections (about 50 intersections). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections.
LRT1	67/73	3	<u>Vehicle Lanes:</u> East of Arbutus there would be two travel lanes in each direction; peak-period bus lanes would be removed. West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. <u>Turn Restrictions:</u> Most of the new restrictions would be at minor intersections (about 50 intersections). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections.

Alternative	No. of intersections with additional vehicle turn restrictions/ intersections crossed	No. of street closures	Description
LRT2	80/93	4	Vehicle Lanes: East of Arbutus there would be two travel lanes in each direction; peak-period bus lanes would be removed. West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. Turn Restrictions: Most of the new restrictions would be at minor intersections (about 50 intersections). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections.
RRT	0/73	0	No vehicle lane or intersection impacts
Combo 1	43/55	2	Vehicle Lanes: West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. Turn Restrictions: All of the new restrictions are at minor intersections (about 15 intersections with new restrictions). There are no new restrictions at major intersections. Cyclist and pedestrian crossings would continue to be permitted at all intersections.
Combo 2	67/73	2	Vehicle Lanes: East of Arbutus there would be two travel lanes in each direction; peak-period bus lanes would be removed. West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. Turn Restrictions: Most of the new restrictions would be at minor intersections (about 50 intersections). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections.

Parking Impacts

5.28 All alternatives with BRT or LRT also result in reductions in available on-street parking spaces in the Corridor. For reference the numbers presented in Table 5.9 include the provision of 193 off-street parking spaces in the central area of the corridor to compensate for this. Note that east of Stephens Street, 2 lanes are retained in each direction but curb lane loading is permitted in the off-peak.

TABLE 5.9 ON-STREET PARKING IMPACTS (BROADWAY/10TH)

Alternative	Existing Peak period parking spaces (a)	Peak period parking spaces removed (b)	Existing Off Peak period parking spaces (c)	Off Peak period parking spaces removed (d)	On Street spaces replaced off-street (e)	Future Peak period option parking spaces (a-b+e)	Future Off Peak period option parking spaces (c-d+e)
Best Bus	1,026	0	1,676	0	0	1,026	1,676
BRT	1,026	882	1,676	1,532	193	337	337
LRT1	1,026	882	1,676	1,532	193	337	337
LRT2	1,094	950	1,744	1,600	193	337	337
RRT	1,026	0	1,676	0	0	1,026	1,676
Combo 1	900	756	900	756	88	232	232
Combo 2	1,026	882	1,676	1,532	193	337	337

5.29 It is recommended that these assumptions be reviewed if any of the surface rapid transit alternatives is progressed to Phase 3 of the study. The development of area wide traffic management plans will also be required.

Displaced auto traffic and delays

5.30 The RTPM08 EMME model was used to assess the likely diversion of traffic as a result of each alternative. The modelled results show approximately a 35% reduction in Broadway traffic (2021 AM peak hour) for LRT1, taken as a proxy for the effect of surface level alternatives and the reduction in road capacity on traffic.

5.31 Traffic reductions on Broadway result in increases elsewhere in the road network. The AM peak model shows a reduction in east/west traffic on Broadway at Burrard of 590 fewer vehicles (-37% compared to the BAU scenario) and in 2021 results in:

- Increase in 115 vehicles (+7% compared to the BAU) on 4th Av;
- Increase in 105 vehicles (+7% compared to the BAU) on 12th Av;
- Increase in 50 vehicles (+4% compared to the BAU) on 16th Av.

5.32 In addition to those increases there is a shift towards transit from private cars and shifts to other east/west routes further south of the corridor.

5.33 A VISSIM model for the 2021 AM peak hour for the LRT1 alternative was developed to test the impacts of a surface alternative on turning movements and delays for auto users in the corridor (both east-west and north-south) and these are described below.

Impacts on North-South Movements

5.34 For each intersection, left turn restrictions may be required, either Northbound (NB), Southbound (SB), Eastbound (EB), Westbound (WB) or a combination of them all). Table 5.10 presents the corridor intersection categorised by the type of left turn bans once LRT is implemented, together with the average delay in seconds per vehicle per intersection on the north/south legs.

TABLE 5.10 NORTH-SOUTH MOVEMENTS-AVERAGE VEHICLE DELAY (2021 AM PEAK HOUR)

Type of Restriction	Number of Intersections	North-South Average Delay Per Vehicle (s.)		
		BAU	LRT	Difference
None	6	27.3	34.6	7.3
EB/WB Left Turn ban	15	15.8	24.6	8.8
EB Left Turn ban	7	27.5	35.8	8.3
WB Left Turn ban	3	21.1	28.7	7.6
All (Right-in/Right- out)	20	16.5	6.4	-10.0

NOTE: VISSIM model included 51 (out of 73) intersections on the LRT1 corridor due to data limitations. Delay statistics presented represent the average values for those 51 intersections, the remaining intersections would become Right-in/Right-out.

5.35 At intersections where east-west left turns are banned in the LRT alternative, the average delay for north-south traffic has decreased by almost 10 seconds compared to the base scenario. This reduction occurs since left turning traffic, particularly on the north-south routes, is assigned to alternative intersections.

Impacts on East-West Movements

5.36 A similar analysis to the above was also undertaken which examined the average delay experienced as a result of banning left turns from Broadway (either banning both eastbound and westbound or just one of the turns). Table 5.11 presents the type of intersection categorised by the type of left turn bans, together with the average delay in seconds per vehicle on Broadway by each intersection type.

5.37 Where both east and west left turns are banned in the LRT option, the average delay for Broadway east/west traffic has decreased slightly compared to the base scenario. This reduction occurs since left turning traffic is assigned to alternative intersections and is no longer impeding through traffic.

TABLE 5.11 EAST-WEST MOVEMENTS-AVERAGE VEHICLE DELAY (2021 AM PEAK HOUR)

Type of Restriction	Number of Intersections	East-West Average Delay Per Vehicle (sec)		
		BAU	LRT	Difference
None	6	26.9	49.1	22.1
EB/WB Left Turn ban	15	19.0	15.6	-3.4
EB Left Turn ban	7	24.7	40.0	13.6
WB Left Turn ban	3	30.1	32.3	2.1
All (Right-in/Right- out)	20	8.4	11.4	3.0

NOTE: VISSIM model included 51 (out of 73) intersections on the LRT1 corridor due to data limitations. Delay statistics presented represent the average values for those 51 intersections, the remaining intersections would become Right-in/Right-out.

5.38 Intersections where there are no left turn restrictions from Broadway experience an increase in delay for east/west movements. This is partly because there is a reassignment of left turning vehicles onto these intersections and also because east-west LRT movements have priority in the corridor. Similarly, intersections with eastbound or westbound left turns banned from Broadway result in an increase in delay. There is also a slight delay increase in the LRT scenario where all left turns are banned at a particular intersection. This is mainly due to the effect of reducing the number of lanes on Broadway from 3 to 2.

5.39 In summary a trip along the entire length of the corridor would be delayed by 4 minutes i.e. 6 intersections at 22 second incremental, 15 intersections with a 3.4 second saving, 7 intersections with 13.6 second incremental, 3 intersections at 2.1 second incremental and 20 intersections at 3 second incremental (note that intersections not included in the VISSIM model will likely result in improvement in travel times as cross traffic is removed).

Transit System/Network Accessibility

5.40 Two aspects of transit system and network accessibility were assessed:

- Catchment of population and employment within a 400m and 800m radius of rapid transit stops; and
- Qualitative assessment of the physical accessibility of each alternative.

Catchment Analysis

5.41 Proximity to a transit stop is a key indicator of accessibility. 400m and 800m catchment areas (indicative of 5 and 10-minute walking trips respectively) were defined, and the forecast number of people and jobs within each was calculated for both 2021 and 2041.

5.42 These results, presented in Table 5.12 and 5.13, demonstrate that alternatives travelling directly along Broadway between Commercial Drive and Main Street are accessible to a greater number of people than alternatives travelling by way of VCC-Clark/Great Northern Way and that the highest catchments are for LRT2 and the Combination Alternatives due to their multiple alignments and highest station numbers.

TABLE 5.12 400M WALK CATCHMENT ANALYSIS

Alternative	# of Proposed Stations	Population ('000s)		Employment ('000s)	
		2021	2041	2021	2041
Best Bus	-	N/A	N/A	N/A	N/A
BRT	14	47	52	49	54
LRT1	14	47	52	49	54
LRT2	21	59	69	68	73
RRT	11	38	42	49	55
Combo 1	20	55	64	69	76
Combo 2	16	51	56	55	61

Source: SDG analysis of Metro Vancouver Regional Growth Strategy data

TABLE 5.13 800M WALK CATCHMENT ANALYSIS

Alternative	# of Proposed Stations	Population ('000s)		Employment ('000s)	
		2021	2041	2021	2041
Best Bus	-	N/A	N/A	N/A	N/A
BRT	14	126	140	106	115
LRT1	14	126	140	106	115
LRT2	21	139	157	121	133
RRT	11	114	126	109	120
Combo 1	20	129	146	122	134
Combo 2	16	130	144	113	124

Source: SDG analysis of Metro Vancouver Regional Growth Strategy data

Physical Accessibility

5.43 In addition to the analysis of catchment numbers, a qualitative assessment was undertaken on the physical accessibility of the alternatives with the results shown in Table 5.14. This assessment took into account whether surface alternatives would be median or curb running as well as specific physical access issues for tunnel or elevated stops.

TABLE 5.14 SYSTEM ACCESS ASSESSMENT

Alternative	Assessment	Commentary
Best Bus	-	The new and upgraded stops for Best Bus operation would not have any material difference in accessibility than existing bus stops.
BRT	✓	The vehicles would be low floor to provide step-free access onto the system and would allow boarding through all doors, providing an improvement over the BAU. The majority of the BRT alignment is centre-running which makes the stations slightly more difficult to access than on a curb-running system. However the stops would be designed with ramps and pedestrian crossings at one end of each platform.
LRT1 LRT2	✓✓	The LRT vehicles would be low-floored, with two to three times more doors than the BRT vehicles and would allow step-free access from the platforms, providing an improvement over BAU and BRT. The LRT platforms are also longer and offer ramped access to pedestrian crossings at both ends, reducing walking distances. Like BRT, most of the alignments are centre-running or off-street.
RRT	×	Access is more difficult for grade-separated systems particularly with bored tunnel systems where the under street centre-platform stations require longer and more complicated access since a mezzanine level and multi-stage vertical circulation are essential. The provision of elevators and escalators reduces but does not eliminate the negative impacts.
Combo 1 Combo 2	-	The two combination alternatives include the positive accessibility delivered through on street systems offset by the slightly negative aspects of a grade separated system.

Reliability

5.44 The reliability of transit travel times is dependent on levels of priority and segregation relative to other traffic. The assessment is presented in Table 5.15 and included:

- Quantitative assessments of the proportion of route segregated and of the number of intersections with/without signal priority;
- Use of the VISSIM traffic model to verify the run times of the BRT and LRT alternatives and to help quantify the reliability/variability of run times;
- Analysis of the vertical and horizontal alignments with the assumption that grade-separated alternatives are the most reliable and that for surface alternatives, centre running alternatives are more reliable than curb running alternatives due to reduced interaction with local servicing access and right turns.

TABLE 5.15 RELIABILITY ASSESSMENT

Alternative	Assessment	Commentary
Best Bus	-	The bus alignments are the same as today with limited priority over other traffic.
BRT	✓	The BRT vehicles would operate in their own right of way and would be primarily centre-running, providing an improvement in journey time reliability over the BAU. No intersection priority would be provided due to the service frequency required to maximize capacity and so there would still be variability in journey times.
LRT1 LRT2	✓✓	LRT alignments operate in their own ROW, with signal priority at intersections, so this would provide a significant improvement in journey time reliability. In addition the alignments are mostly centre-running or off-street, which also contributes to improved reliability. The VISSIM model showed that in the westbound direction, the mean LRT run time is 28.5 minutes with an absolute minimum of 26.7 minutes and absolute maximum of 32.2 minutes. In the eastbound direction it showed that the mean LRT run time is 27.4 minutes with an absolute minimum of 25.6 minutes and absolute maximum of 30.3 minutes.
RRT	✓✓✓	The RRT alignment has no interaction with traffic and hence provides the most reliable journey times possible.
Combo 1	✓✓	The combination of RRT and LRT gives a very reliable journey time. However the requirement to transfer from RRT to LRT reduces this advantage somewhat.
Combo 2	✓	The RRT section of the alignment can be expected to be very reliable and the BRT less so due to the lack of intersection priority or grade separation. Millennium Line passengers interchanging onto the BRT at Arbutus may face additional variability in wait times since mid-route service regulation would be more difficult for the BRT.

Capacity and Expandability

5.45 Based on RTPM08 transit route profiles, passenger loading charts were produced to show where capacity becomes critical for different forecast years. These represent how well the system has been tailored to accommodate forecast demand and when or if additional capacity would be required.

5.46 The following analyses were carried out:

- System expandability was assessed by providing a commentary on the potential for increasing capacity (e.g. reducing headways, increase vehicle length) and the likely effects of each on the alternatives (e.g. on cost and operations); and
- The demand forecasts were used to generate system utilization numbers (for the assumed levels of service) and enable an assessment of the level of crowding on the service(s).

5.47 Tables 5.16 and 5.17 show the 2021 and 2041 AM peak hour peak loads, capacities and load factors (peak load divided by capacity) for each rapid transit alternative. These demand estimates are unconstrained by capacity, so load factors can exceed 1. The 2041 numbers are then illustrated in Figure 5-3 where green shows demand within an alternative's capacity, blue shows remaining capacity, and red represents demand not met due to insufficient capacity. This figure demonstrates that Best Bus, the BRT alternative and the BRT portion of Combination 2 are over capacity by 2041.

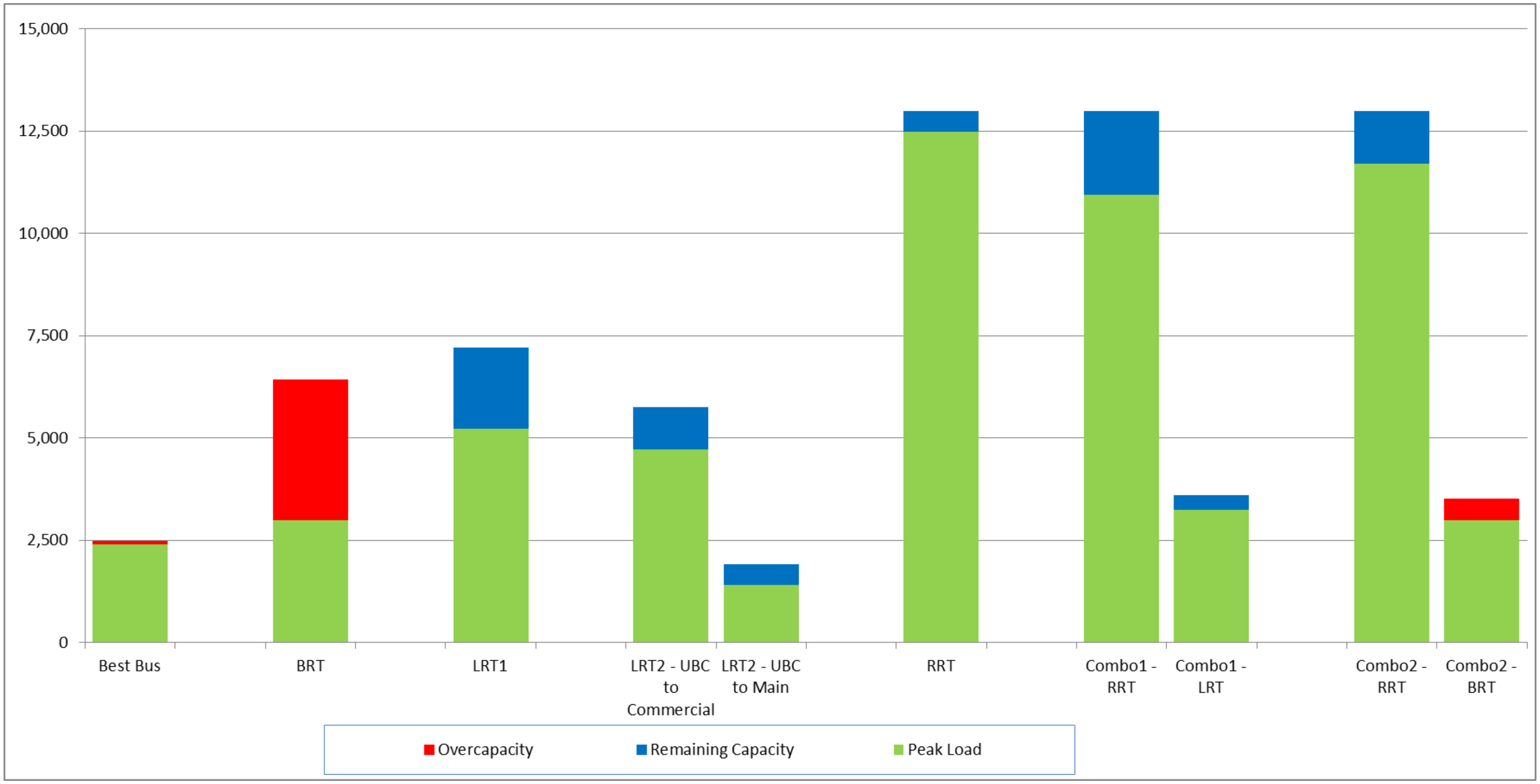
TABLE 5.16 2021 AM PEAK HOUR RAPID TRANSIT LOAD AND CAPACITY

Alternative	Service	Peak Load	Assumed Capacity	Peak Load Factor(volume / capacity)
BRT	-	4,575	3,000	1.53
LRT1	-	3,975	7,200	0.55
LRT2	Broadway service	3,575	5,760	0.62
	CP Rail RoW service	1,025	1,920	0.53
RRT	-	9,075	10,400	0.87
Combo 1	LRT	1,925	3,600	0.53
	RRT	7,700	10,400	0.74
Combo 2	BRT	2,050	3,000	0.68
	RRT	8,250	10,400	0.79

TABLE 5.17 2041 AM PEAK HOUR RAPID TRANSIT LOAD AND CAPACITY

Alternative	Service	Peak Load	Assumed Capacity	Peak Load Factor(volume / capacity)
BRT	-	6,425	3,000	2.14
LRT1	-	5,225	7,200	0.73
LRT2	Broadway service	4,725	5,760	0.82
	CP Rail RoW service	1,400	1,920	0.73
RRT	-	12,475	13,000	0.96
Combo 1	LRT	3,250	3,600	0.90
	RRT	10,950	13,000	0.84
Combo 2	BRT	3,525	3,000	1.18
	RRT	11,700	13,000	0.90

FIGURE 5-3 RAPID TRANSIT CAPACITY AND LOADINGS (AM PEAK HOUR, 2041)



NOTE: Best Bus refers to the 99 B-Line

LRT1 could be further expanded with reduction in speed and reliability due to reduced transit priority. RRT could be further expanded to 26,000 pphpd

5.48 The analysis presented above was based on rapid transit only. Bus route 9 also runs on the corridor and the total transit load and capacity on the corridor for 2041, is presented in Table 5.18. Recognizing some of the challenges of modelling how much of the demand will be carried on local or rapid transit services, the table also presents the peak load factor if both local and rapid transit demand were carried on rapid transit as a further test of capacity. Full details can be found in Appendix D.

TABLE 5.18 2041 AM PEAK HOUR TRANSIT LOAD AND CAPACITY (ALL LOCAL BUS RIDERS USING RAPID TRANSIT)

	Westbound Peak Load			Capacity (rapid transit only)	Peak Load Factor (volume/capacity)
	Route 9	Rapid Transit	Total		
BAU	670	2,735	3,405	2,400	1.42
Best Bus	654	2,642	3,296	2,400	1.37
BRT	367	6,431	6,798	3,000	2.27
LRT1	386	5,225	5,611	7,200	0.78
LRT2	448	4,749	5,197	5,760	0.90
RRT	365	12,487	12,852	13,000	0.99
Combo 1	347	10,959	11,306	13,000	0.87
Combo 2	279	14,260	14,539	16,000	0.91

5.49 The assessment for Capacity and Expandability is shown in Table 5.19.

TABLE 5.19 CAPACITY AND EXPANDABILITY ASSESSMENT

Alternative	Assessment	Commentary
Best Bus	-	The Best Bus operation provides a limited improvement in capacity in the corridor by adding two limited stop services. It would be difficult to expand capacity any further within the study area.
BRT	×	Operating at 2 minute headways, unconstrained forecasts for BRT show that services would be 50% overcapacity in 2021 and more than 100% over capacity by 2041. Although further reduction in headways is possible and buses could be run in 'platoons' in peak periods, in practice the BRT is difficult to expand significantly compared to the BAU. An initial assessment has also been undertaken reviewing the possible use of bi-articulated buses. This is not viewed as a practical solution as these vehicles a) require a wider right-of-way due to a larger dynamic envelope as result of additional vehicle axles and length b) typically provide 20-30% more capacity (which still is not enough to meet demand)[10].
LRT1	✓	LRT1 offers over twice the capacity of BRT and the modelled forecast demand is below the assumed capacity. Evaluation is based on two car trains operating at 4 minute headways. This appears to be the most frequently that trains could operate with full signal priority. While headways could be reduced to 2-3 minutes, this would result in longer journey times (and reduced reliability) for the LRT, due to reduced priority at intersections.
LRT2	✓	Like the LRT1 alternative, the modelled forecast demand is below the assumed capacity The capacity on each branch is limited by the minimum headway of 4 minutes west of Arbutus, if full signal priority is to be provided. There is flexibility to adjust headways and train lengths between the two branches to increase capacity and, as with LRT1, reduce the level of priority in order to reduce headways.

[10] Van Hool articulated AG300 carries 100 passengers while Van Hool double-articulated AGG300 carries 125 passengers

Alternative	Assessment	Commentary
RRT	✓✓	The RRT alternative provides a considerable improvement in capacity over the BAU case. Forecast demand is below the assumed capacity. With five-car trains (at 3-min headways) some crowding is to be expected by 2041. There is scope for expansion beyond the service modelled as the headways can be reduced (to circa 90-120 seconds), giving a theoretical capacity of 26,000 passengers per direction. As this service is connected to the Millennium Line, any changes in train configurations and/or altering headways would have greater costs (capital and operating) and other impacts beyond this portion of the line.
Combo 1	✓✓	The forecast demand for the RRT section is below the assumed capacity. It would be relatively crowded in the peak hour however as with the RRT alternative there would be the possibility to reduce headways and expand capacity to 26,000 pphpd. The forecast demand for the LRT segment is below the assumed capacity and is not expected to be crowded but could have capacity expanded in future as needed by provision of additional cars and/or headway reductions.
Combo 2	-	The forecast demand for the RRT section is below the assumed capacity. The RRT section would be relatively crowded in the peak hour, and the BRT is expected to be over capacity by 2041. The RRT section could have its capacity extended by reducing the headways, however overall this alternative does not score positively because of the limited ability to expand the capacity of the BRT section of the route.

Transportation Account Key Points

- The RRT and Combination alternatives include extensions to the existing SkyTrain system and provide the shortest journey times and as a result, they deliver more transportation benefits than the other alternatives with RRT providing the highest level of benefits.
- Alternatives with LRT and RRT provide sufficient capacity to meet forecast demand and have the opportunity to accommodate increased demand beyond forecast with RRT providing the greatest opportunity for expansion. Alternatives with BRT (BRT and Combination 2 alternatives) and the Best Bus Alternative do not provide sufficient capacity to meet the forecasted passenger demand.
- The capacity of LRT can be expanded beyond the assumed capacity of 7,200 passengers per hour per direction (pphpd) with reduction in speed and reliability due to reduced transit priority. RRT can be further expanded to 26,000 pphpd.
- All alternatives increase transit trips and mode share with RRT having the greatest impact (3.1 percentage points in 2041). For all the alternatives, the number of new transit trips generated is small relative to the number of trips shifted from bus to rapid transit and the total number of transit trips in the region. At a regional scale and when considered in isolation, none of the alternatives achieve mode share targets and they all have a similar impact on regional mode share ranging from 0 percentage points (Best Bus) to .3 percentage points (RRT and Combination 1) in 2041.
- Alternatives with LRT and BRT reduce road capacity and introduce turn restrictions which have impacts on traffic, parking, local access and goods movement.
- Most alternatives offer similar population and employment catchments within 400m and 800m of stations. LRT2 and the Combination alternatives (with larger networks) providing access to a slightly larger catchment.
- The alternatives with RRT are fully separated from traffic and provide the greatest improvement to reliability followed by the LRT alternatives which have their own right of way with full signal priority. Alternatives with BRT (BRT and Combination 2 alternatives) and Best Bus provide lower reliability improvements as they have limited priority.
- Figure 5-4 provides the summary scores for the Transportation Account.

FIGURE 5-4 TRANSPORTATION ACCOUNT SUMMARY

Criteria	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Transit Users	◑	◑	◕	◕	●	●	●
Non-Transit Users	◑	○	○	○	●	◔	◔
Transit Network/System Access	◑	◑	◕	◕	◔	◑	◑
Reliability	◑	◑	◕	◕	●	●	◕
Capacity & Expandability	◑	◔	◕	◕	●	◕	◑
Summary Score	◑	◔	◕	◕	●	●	◕

6 Financial Account

Introduction

6.1 All alternatives were evaluated in terms of their ability to provide an affordable and cost-effective service. This section provides the detailed results of the financial account evaluation, including assessment of:

- Total capital cost;
- Total operating cost; and
- Cost effectiveness.

Total Capital Cost

6.2 The capital cost of each alternative was estimated using a ‘bottom up’ approach based on a number of categories and unit rates of construction. As design details are developed and the concept progresses the costs may vary, resulting in either an increase or decrease in the actual costs incurred.

6.3 Rapid transit vehicle costs were estimated based on each alternative’s vehicle requirements which are driven by service run time, headway, vehicle consist (as detailed in Table 4.3) and a 15% spare ratio and are summarized below in Table 6.1.

TABLE 6.1 VEHICLE REQUIREMENTS (INCLUDING 15% SPARE RATIO)

Alternative	2021			2041		
	Bus	LRT	RRT	Bus	LRT	RRT
BRT	42	-	-	42	-	-
LRT1	-	36	-	-	36	-
LRT2	-	36	-	-	36	-
RRT	-	-	89 (*)	-	-	104 (*)
Combination 1	-	16	57 (*)	-	16	64 (*)
Combination 2	42	-	57 (*)	42	-	64 (*)

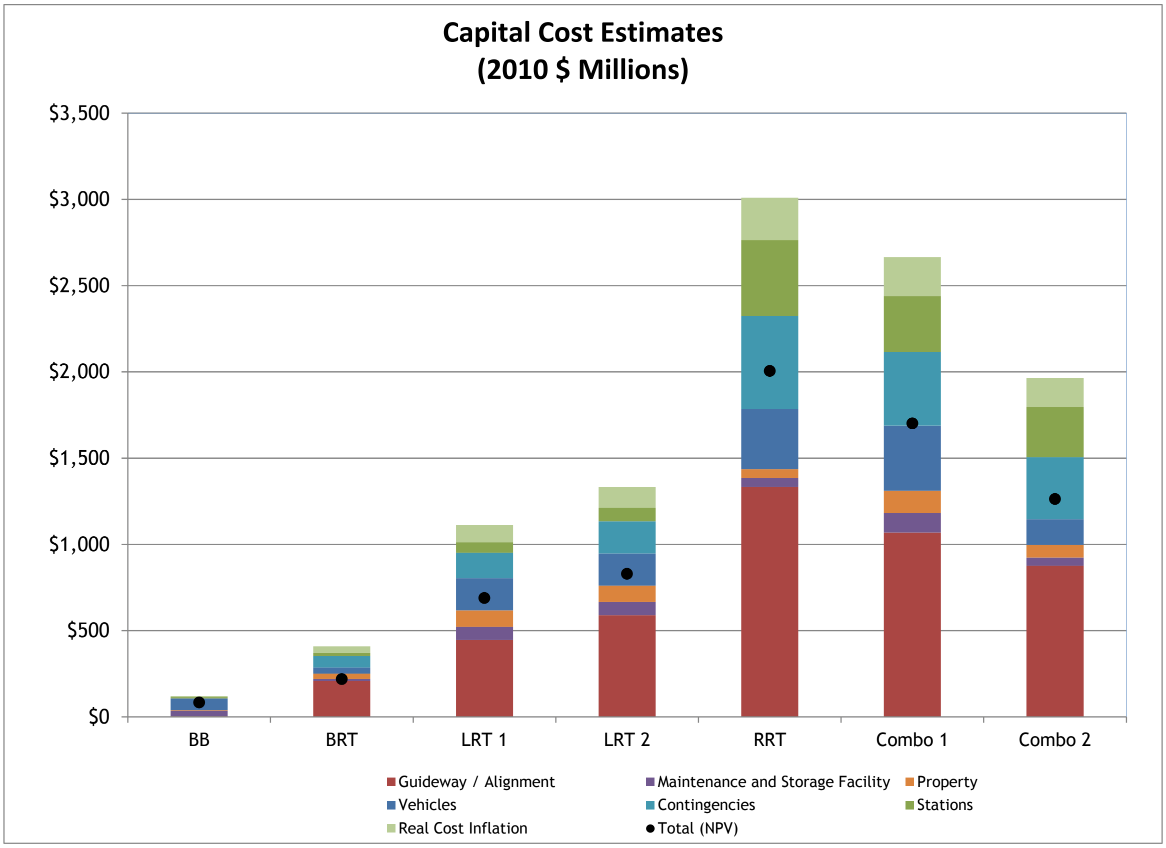
* *These figures include 29 cars required to meet the increased demand (2500 - 3000 passengers/hour increase at peak point) on the Millennium Line resulting from through service with the UBC Line.*

6.4 The breakdown of costs are presented in Table 6.2 in 2010 dollars as incurred in 2010 and then a separate row includes ‘real’ inflation (increases over and above CPI) to produce the *Real 2010 Prices* to reflect inflation over the construction period.

TABLE 6.2 CAPITAL COST ESTIMATES (2010 $M)

Capital costs ($ million 2010 Prices)	Best Bus	BRT	LRT1	LRT2	RRT	Combo 1	Combo 2
Guideway / Alignment	4	208	446	589	1,333	1,069	876
Stations	7	17	61	78	440	323	292
Maintenance/Storage Facility	32	12	76	76	52	112	47
Property	3	31	96	96	51	130	74
Vehicles	69	36	186	186	350	378	149
Base Cost Sub-Total	**115**	**304**	**865**	**1,026**	**2,226**	**2,012**	**1,438**
Contingencies	0	66	148	187	539	427	359
Base Cost with Contingencies	**115**	**370**	**1,013**	**1,213**	**2,765**	**2,439**	**1,797**
Real Inflation (increase over and above CPI)	6	39	99	119	245	227	169
TOTAL CAPITAL COST	**121**	**409**	**1,112**	**1,332**	**3,010**	**2,666**	**1,966**

FIGURE 6-1 CAPITAL COST ESTIMATES (2010 $M)



6.5 The construction period assumed and resulting cost profile was dependent on the technology of each alternative, with alternatives using RRT technology assumed to be constructed over seven years, LRT over five years and BRT over four years with all alternatives assumed to have an opening year of 2021.

Renewal Costs

6.6 In undertaking a life-cycle evaluation of each alternative, it has been necessary to include allowances for mid-life and end-of-life renewal of the vehicles and infrastructure. These costs include a system-extent based estimate to cover typical renewal of facilities as well as vehicle renewal costs.

- Bus and BRT vehicles – renewed every 17 years; and
- LRT and RRT vehicles – refurbished after 20 years at one third of the capital cost, renewed every 40 years (beyond the evaluation period).

6.7 Where additional LRT or RRT vehicles are required beyond 2021 to meet the 2041 demand levels, it was assumed that 50% of the costs would be incurred in 2030, with the remaining 50% incurred in 2040 to reflect a phased capacity expansion.

Operating Costs

6.8 Operating costs for both the rapid transit alternatives as well as the complementary bus network were calculated using an operating cost model. Details of the calculations and costs for each element are provided within Table 6.3 and in the sections that follow.

Rapid Transit Operating Costs

6.9 Rapid transit operating costs were based on the following assumptions provided by TransLink and based on local and North American data:

- Unit costs per service hour, covering wages and administration (time based);
- Unit costs per service km, covering fuel/power and vehicle maintenance (distance based); and
- Unit costs per track or lane km, covering non-vehicle maintenance (extent based).

TABLE 6.3 ASSUMED UNIT OPERATING COSTS FOR RAPID TRANSIT

Costs ($ 2010)	Basis	BRT	LRT	RRT
Vehicle Operations- wages	/hour	$53.15	$53.15	$21.06
Vehicle Operations- fuel/power	/service km	$0.71	$0.20	$0.22
Vehicle Maintenance	/service km	$0.96	$1.80	$0.52
Administration	/hour	$14.27	$14.27	$14.27
Distance-based subtotal	/service km	$1.67	$2.00	$0.75
Time-based subtotal	/hour	$67.42	$67.42	$35.33
Extent-based (Non-vehicle maintenance)	One way /track or lane km	$19,380	$102,097	$245,310

6.10 The total operating hours and service kilometres for each alternative were calculated using route lengths, vehicles per unit, run times, AM peak headways and layovers. A service annualisation factor of 3,450 was used to convert the number of services in the AM peak into an annual total. This was calculated from the existing 99-B line headway pattern shown in Table 6.4 and an assumed service on 250 regular weekdays and 115 weekend days and public holidays per year.

TABLE 6.4 99 B-LINE EXISTING HEADWAY PATTERNS

Period	From	To	Headway (minutes)		Round-trips	
			Weekday	Weekend	Weekday	Weekend
Off Peak	05:30	06:30	7	-	26	-
AM Peak	06:30	09:30	3	15	60	12
Midday	09:30	16:00	5	10	78	39
PM Peak	16:00	19:00	3	10	60	18
Evening	19:00	00:00	12	12	25	25
Night	00:00	02:00	20	20	6	6
Weekday	-	-	-	-	255	100

6.11 Although the headways on the rapid transit alternatives differ from one another, all are assumed to have the same ratio of service numbers at different times of day.

6.12 For the purpose of vehicle capital cost estimation, a three minute layover was assumed for the peak hour to maximize fleet utilization. However it is likely to be undeliverable on an all-day basis and therefore an average layover of five minutes per service was assumed to estimate operating costs. We note that, in reality, layover may differ according to the vehicle technology and operating plan and hence these assumptions should be refined in Phase 3 as appropriate.

6.13 The estimates of vehicle service km, service hours (including layover) and resulting costs (as identified in Table 6.3) for each alternative are shown in Tables 6.5 and 6.6 for 2021 and 2041 respectively. Note that operating costs for options with RRT increase between 2021 and 2041 as a result of additional vehicle kilometres from moving from 4-car to 5-car trains.

TABLE 6.5 OPERATING COST PER ALTERNATIVE (2021)

Alternative	Annual Total		Annual Operating Cost ($m 2010)			
	Vehicle Km (1000s)	Service Hrs (1000s)	Distance based (see 6.9)	Time based (see 6.9)	Extent based (see 6.9)	Total
BRT	2,695	133	4.5	8.9	0.5	14.0
LRT1	2,695	57	5.4	3.9	2.7	11.9
LRT1 in LRT2	2,156	46	4.3	3.1	2.7	10.1
LRT2 in LRT2	663	27	1.3	1.8	2.5	5.6
RRT	6,799	51	5.1	1.8	6.0	12.9
LRT2 in Combo 1	1,244	51	2.5	3.4	2.5	8.3
RRT in Combo 1 & 2	2,819	29	2.1	1.0	2.5	5.6

TABLE 6.6 OPERATING COST PER ALTERNATIVE (2041)

Alternative	Annual Total		Annual Operating Cost (2010 $m)			
	Vehicle Km (1000s)	Service Hrs (1000s)	Distance based (see 6.9)	Time based (see 6.9)	Extent based (see 6.9)	Total
BRT	2,695	133	4.5	8.9	0.5	14.0
LRT1	2,695	57	5.4	3.9	2.7	11.9
LRT1 in LRT2	2,156	46	4.3	3.1	2.7	10.1
LRT2 in LRT2	663	27	1.3	1.8	2.5	5.6
RRT	8,499	51	6.4	1.8	6.0	14.2
LRT2 in Combo 1	1,244	51	2.5	3.4	2.5	8.3
RRT in Combo 1 & 2	3,524	29	2.6	1.0	2.5	6.2

6.14 The total operating costs of each alternative in 2021 and 2041 are set out in Table 6.7. The figures presented are for the rapid transit alternative only and exclude the changes to the bus network which are summarized later in Table 6.8.

TABLE 6.7 TOTAL RAPID TRANSIT OPERATING COSTS

Alternative	Total Operating Cost 2021 (2010 $m)	Total Operating Cost 2041 (2010 $m)
BRT	14.0	14.0
LRT1	11.9	11.9
LRT2	15.7	15.7
RRT	12.9	14.2
Combo 1	14.0	14.5
Combo 2	19.6	20.1

6.15 The operating costs for LRT2 and the Combination alternatives are highest as they involve multiple alignments. Combination 2 is particularly expensive to operate because of the high costs involved with the BRT service with two-minute headways in combination with the RRT service.

Bus Network Operating Costs

6.16 Operating costs were estimated for buses in the study area for all services where changes were assumed between the Business as Usual, Best Bus and the Phase 2 alternative. Table 4.1 provided the headways for the BAU and Table 6.8 summarises the changes assumed for the Best Bus alternative and includes the two express bus services created in the Best Bus alternative (the 984 and 999) which are assumed to run in peak hours and peak direction only. These were developed in consultation with the study working group and were based on matching future levels of demand with capacity.

TABLE 6.8 BAU AND BEST BUS SERVICE ASSUMPTIONS

Bus Service		AM Peak Headways (minutes)				Route Km	AM Peak Journey Time (min)
		2021 BAU	2021 Best Bus	2041 BAU	2041 Best Bus		
009g	Boundary-Granville	10	10	9	9	17.3	61
009u	Boundary-UBC	8	8	7.5	7.5	34.0	103
084	Commercial-UBC	7	6	6.5	5	28.2	66
099wb	Commercial-UBC	2.5	2.5	2.5	2.5	13.6	37
099eb	UBC-Commercial	6.5	5	5.5	4	13.6	39
984	Main-UBC	0	6	0	4	12.4	24.3
999	Commercial-UBC	0	6	0	4	13.6	30.4

6.17 For the purposes of a comparative evaluation, the same bus operation is assumed in each rapid transit alternative as in the Business as Usual case, with the exception of routes 99 and 84 where:

- 99 B-Line: does not run in the rapid transit alternatives;
- Route 84: assumed to be extended from VCC-Clark to Commercial-Broadway in the BAU and Best Bus. For all rapid transit alternatives, it is assumed to be truncated to provide a local service between Commercial-Broadway and Willow.

6.18 More detailed bus integration planning would be required once a preferred alternative is selected for implementation

6.19 Bus network operating costs were calculated for annual service hours and kilometres for each scenario (BAU and Best Bus) assuming operation on 250 regular weekdays, 52 Saturdays and 63 Sundays and public holidays per year in 2021 and 2041. The unit costs per hour and per kilometre presented in Table 6.6 were then applied to calculate the total costs of the bus network which are presented in Table 6.9.

TABLE 6.9 OPERATING COST SUMMARY BY BUS SERVICE (2010 $M)

Route	2021			2041		
	BAU	Best Bus	Rapid Transit	BAU	Best Bus	Rapid Transit
84	3.7	4.3	1.1	4.0	5.2	1.2
99	10.1	11.4	-	10.9	12.9	-
984	-	0.5	-	-	0.8	-
999	-	0.6	-	-	1.0	-
Total	13.8	16.8	1.1	14.9	19.9	1.2

Operating and Maintenance Cost Summary

6.20 A summary of the total operating costs for 2021 and 2041 for each alternative is shown in Table 6.9. The table shows the higher operating costs for options with extensive bus operations (Best Bus) and where RRT and BRT are combined (Combination 2).

TABLE 6.10 OPERATING AND MAINTENANCE COSTS BY ALTERNATIVE

Alternative	2021 Operating Cost (2010 $m)			2041 Operating Cost (2010 $m)		
	Bus network	Rapid transit	Total	Bus network	Rapid transit	Total
BAU	13.8	-	13.8	14.9	-	14.9
Best Bus	16.8	-	16.8	19.9	-	19.9
BRT	1.1	14.0	15.1	1.2	14.0	15.2
LRT1	1.1	11.9	13.0	1.2	11.9	13.1
LRT2	1.1	15.7	16.8	1.2	15.7	16.9
RRT	1.1	12.9	14.0	1.2	14.2	15.4
Combo 1	1.1	14.0	15.1	1.2	14.5	15.7
Combo 2	1.1	19.6	20.7	1.2	20.1	21.3

6.21 Operating costs in other years of operation (within the appraisal period) were calculated by interpolation/extrapolation of the trend defined by these two years.

Cost Effectiveness

6.22 In order to evaluate the cost effectiveness of an alternative, the life-cycle costs and benefits are estimated to derive cost-effectiveness measures.

6.23 The measure of cost effectiveness includes a range of indicators:

- *Cost per new transit user;* to demonstrate how cost effective the alternative is in encouraging modal shift;
- The *cost per passenger-km;* illustrates the effectiveness in carrying passengers, with consideration to the average journey length;
- *Cost per hour of travel time saving/saved;* represents the cost efficiency of the project's travel time savings;
- *Annualized Cost;* represents the annual combined capital and operating cost in a given year, including the cost of financing the initial capital.
- *Net Present Value (NPV);* calculated by subtracting the net project costs from the net project benefits over the 30 year evaluation period using a discount rate of 6% in line with provincial guidance.[11]
- *Benefit:Cost Ratio;* to demonstrate how the full costs of an alternative compare against the benefits it provides. Alternatives with a BCR>1 provide more benefits than they cost to build and operate. The BCR is calculated using the following formula:

$$\frac{\text{Total journey time benefits + vehicle operating costs savings + reduction in vehicle collisions + emission benefits + journey time (dis)benefits for road users + other disbenefits during construction}}{\text{Full alternative capital cost + full alternative renewal cost + net operating cost of the transit network}}$$

6.24 As indicated previously the evaluation assumptions and parameters are contained in Appendix A and discussion of overcapacity issues was presented in paragraph 5.3.

Life Cycle Costs

6.25 The previous section described how the life-cycle present value costs were developed and a summary of these costs are set out in Table 6.11 and Figure 6-2. They show that:

- The overall life cycle Present Value Costs (PVC) ranges from around $120 million PV (Best Bus) to $1.75 billion PV (RRT);

[11] Discounting is the technique used to compare costs and benefits that occur over time and is based on the principle that, generally, people prefer to receive goods and services now rather than later. The discount rate is used to convert all costs and benefits to 'present values', so that they can be compared on a common basis. Calculating the present value of the differences between the streams of costs and benefits provides the net present value (NPV) of an option

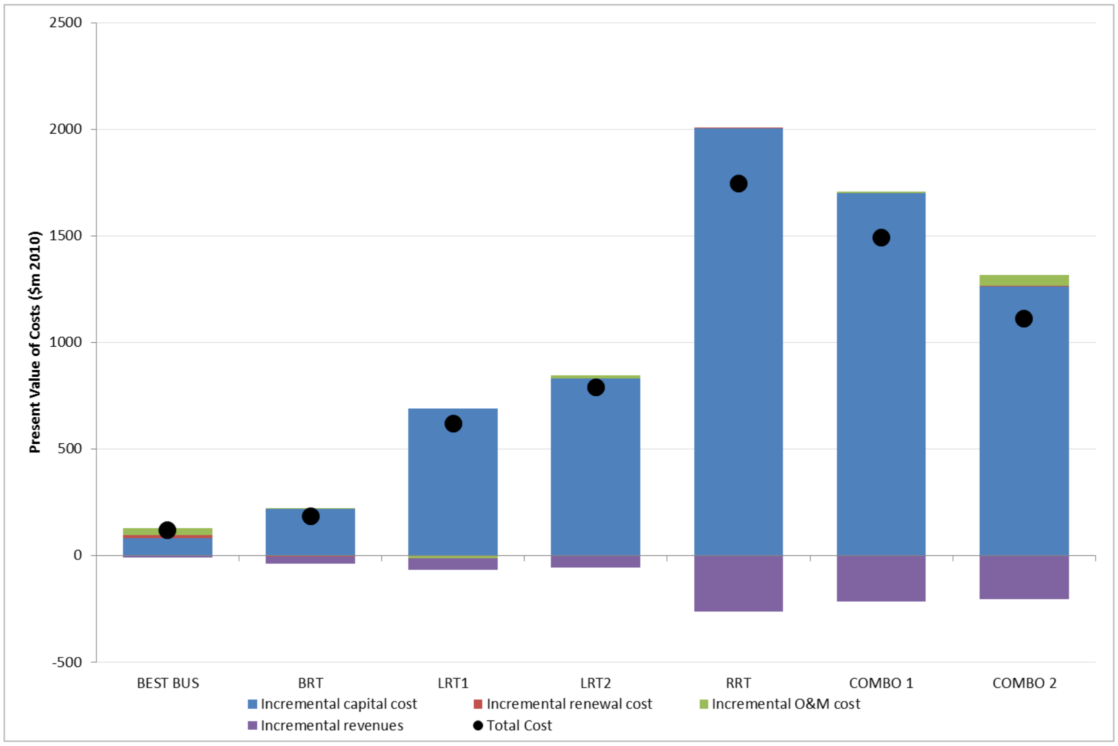
- The relative costs (or savings) from renewals and operating and maintenance (O&M) costs for the rapid transit alternatives are minor compared to the large capital costs;
- In all alternatives there is a net increase in revenue from transit from modal shift (from auto to transit);
- The cost savings and additional revenues contribute to offset the initial capital cost outlay.

TABLE 6.11 LIFE CYCLE COSTS (PRESENT VALUE AT 6% DISCOUNT RATE, 2010 $M)

Alternative	Total Capital Cost	Incremental Renewal Cost	Incremental O&M Cost	Incremental Farebox Revenue*	Total Cost
Best Bus	83	13.0	32	9	**119**
BRT**	219	-4.1	3	34	**184**
LRT1	689	-0.2	-14	54	**621**
LRT2	830	-0.2	16	57	**789**
RRT	2,005	0.8	-1	260	**1,745**
Combo 1	1,701	-0.7	5	214	**1,491**
Combo 2**	1,263	2.5	51	204	**1,112**

*NOTE: * Incremental revenue is presented as a positive number*
*** Fare revenue estimates capped as described in paragraph 5.3*

FIGURE 6-2 LIFE CYCLE COSTS (PRESENT VALUE, 2010 $M)



Monetized Benefits

6.26 Evaluation of the total benefits of each alternative required conversion of the following benefits to monetary terms:

- Journey time savings for transit users (existing and new);
- Journey time savings for car users;
- Auto operating cost savings;
- Collision cost savings; and
- Reduction in greenhouse gas emissions.

6.27 Details on how the travel time savings and auto operating and collision cost benefits were derived are included in Chapter 5.

6.28 Journey time savings from the RTPM08 model were monetized using MOTI's value of time of $12.17/hour (2007 prices) and real growth of 1.2% per year as shown in Appendix A. This resulted in values of time in 2010 prices of $15.03/hour in 2021 and $19.07/hour in 2041.

6.29 The reduction in vehicle kilometres travelled from RTPM08, together with changes in transit vehicle km taken from the operating cost model, were used to estimate the reduction in greenhouse gas emissions as a result of each alternative. The assumed emissions rate for each transit mode are shown in Table 6.12, and the Pacific Carbon

Trust's estimated carbon cost of $25/tonne was used to convert the total emissions savings into monetary terms.

TABLE 6.12 GREENHOUSE GAS EMISSIONS BY MODE

	CO_2 equivalent emissions (g/km)		
Mode	**2007**	**2021**	**2041**
Bus	1,920	1,823	1,827
BRT	1,920	1,823	1,827
LRT (per car)	202	191	192
RRT (per car)	93	88	88
Auto	287	201	164

Source: Metro Vancouver, TransLink

6.30 The present values of the benefits for each alternative are shown in Table 6.13 and Figure 6-3.

TABLE 6.13 LIFE CYCLE BENEFITS (PRESENT VALUE, 2010 $M)

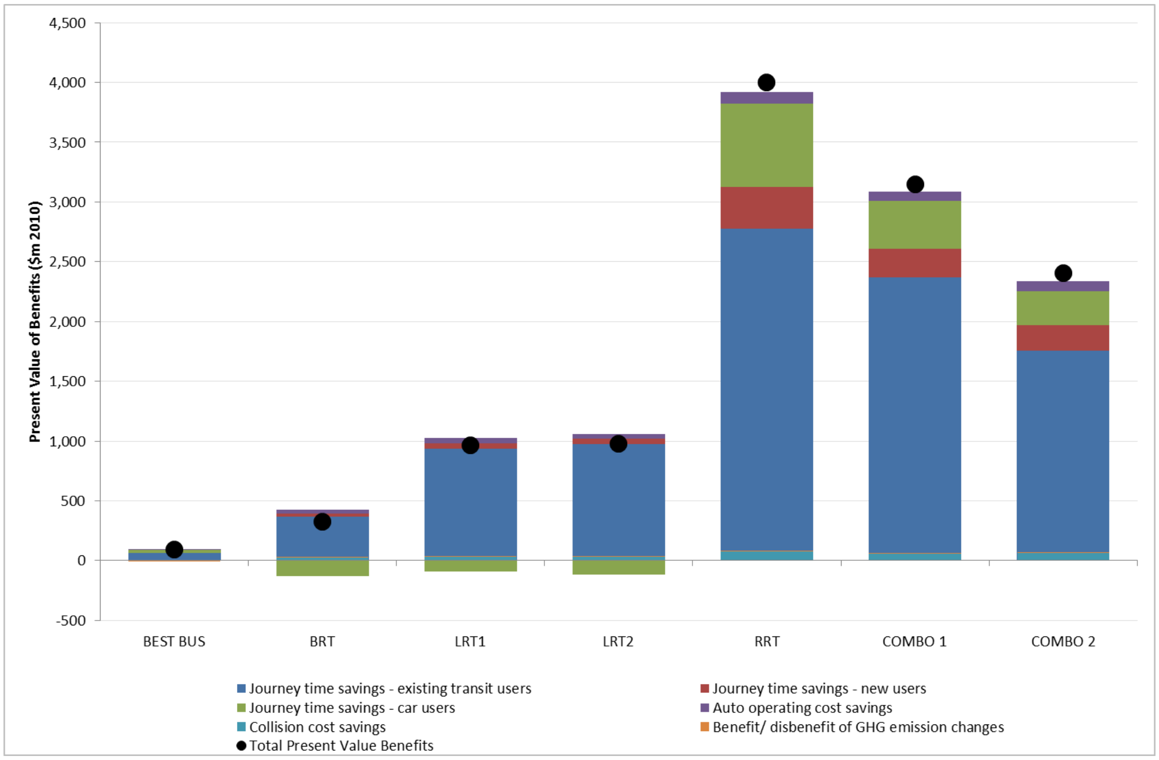
Alternative	Journey time savings - existing users*	Journey time savings - new users**	Journey time savings - car users	Auto operating cost savings	Collision cost savings	Benefit/ disbenefit of GHG emission changes	Total Present Value Benefits
Best Bus	61	1	25	4	3	-0.1	**93**
BRT***	367	23	-128	35	27	1.0	**325**
LRT1	936	46	-93	41	31	2.0	**962**
LRT2	972	45	-119	43	33	2.1	**977**
RRT	2,774	353	693	101	77	3.8	**4,002**
Combo 1	2,372	235	400	79	60	3.2	**3,150**
Combo 2***	1,754	213	289	83	63	2.3	**2,404**

*NOTE: * Includes reliability and pass up benefits*

*** New users through modal shift from non-transit modes (auto, walk/cycle) and generated trips*

**** Savings capped as described in paragraph 5.3*

FIGURE 6-3 LIFE CYCLE BENEFITS (PRESENT VALUE, 2010 $M)



Cost Per New Transit User

6.31 Tables 5.3 and 5.4 showed all alternatives attract additional transit riders, predominately from automobiles, which increases the overall transit mode share and aids the region in moving towards its overall mode share targets.

6.32 The cost per new transit rider and cost per auto trip removed measures how cost effective it is to encourage modal shift. Table 6.14 sets out the 2041 annualized cost which includes an annualized capital cost (accounting for the 6% discount rate, 30 year evaluation period and renewal costs based on average asset life) and incremental O&M costs for 2041 as well as the additional annual transit riders and reduction in auto trips in 2041.

6.33 The table shows that overall, the Combination 2 alternative is the most cost effective in attracting new users and reducing car travel because of its use of RRT for the highest demand Central Broadway portion of the corridor and lower (relative) capital cost BRT for the less intensely used western section. The RRT and Combination 1 alternatives also perform well because they attract the high demand and the through trips offered by RRT improve accessibility for potential SkyTrain users travelling to the corridor. BRT performs well due to its lower cost compensating for the smaller number of riders it attracts.

TABLE 6.14 COST (2010 $) PER ADDITIONAL TRANSIT USER AND AUTO TRIP REMOVED

Alternative	2041 Annualized Cost ($m)	2041 Additional Transit Trips (millions)	Cost per Additional Transit Rider ($ per Trip)	2041 Reduction in Auto Person Trips (millions)	Cost per Auto Person Trip Removed ($ per Trip)
Best Bus	$10.9	0.74	$14.7	0.66	$16.4
BRT*	$24.6	2.31	$10.6	2.07	$11.9
LRT1	$65.8	3.39	$19.4	3.75	$17.6
LRT2	$82.5	3.80	$21.7	4.09	$20.2
RRT	$161.7	16.33	$9.9	11.44	$14.1
Combo 1	$141.3	13.22	$10.7	10.32	$13.7
Combo 2*	$112.5	12.24	$9.2	9.49	$11.9

*NOTE: * Forecasts capped as described in paragraph 5.3*

Cost per Passenger-Kilometre

6.34 The cost per passenger kilometre illustrates the effectiveness in carrying passengers, with consideration to the average journey length. Table 6.15 summarizes the 2041 annualized cost and the additional annual transit passenger kilometres forecast in 2041 providing the 2041 average cost per additional transit passenger kilometre.

6.35 The results show that BRT, RRT and the Combination alternatives are the most cost effective at providing incremental transit passenger kilometres.

TABLE 6.15 COST (2010 $) PER ADDITIONAL TRANSIT PASSENGER KILOMETRE

Alternative	2041 Annualized Cost ($m)	2041 Additional Transit Passenger Kilometres (million)	$ per Additional Transit Passenger Kilometre
Best Bus	$10.9	12.0	$0.90
BRT*	$24.6	69.7	$0.35
LRT1	$65.8	150.8	$0.44
LRT2	$82.5	150.8	$0.55
RRT	$161.7	502.8	$0.32
Combo 1	$141.3	431.0	$0.33
Combo 2*	$112.5	357.8	$0.31

*NOTE: * Forecasts capped as described in paragraph 5.3*

Cost per Hour of Travel Time Saved

6.36 Cost per hour of total travel time (including walking and waiting) saved represents the cost efficiency of the project's travel time savings and does not include the other aspects of a Benefit:Cost Ratio such as collision reductions and decongestion benefits on the road.

6.37 The forecast reduction in transit passenger hours and the cost per hour are presented in Table 6.16. It shows that in terms of passenger time savings Best Bus results in the highest cost per hour of time saved, with the Combination alternatives, RRT and LRT1 having the lowest costs per hour saved.

TABLE 6.16 COST (2010 $) PER HOUR OF TRAVEL TIME SAVED

Alternative	2041 Annualized Cost (2010 $m)	2041 Passenger Hours Reduced (millions)	Cost per Hour of Time Saved ($ per Passenger Hour Reduced)
Best Bus	$10.9	0.67	$16.17
BRT*	$24.6	2.53	$9.74
LRT1	$65.8	8.80	$7.47
LRT2	$82.5	8.81	$9.36
RRT	$161.7	26.68	$6.06
Combo 1	$141.3	23.65	$5.97
Combo 2*	$112.5	15.90	$7.07

*NOTE: * Forecasts capped as described in paragraph 5.3*

Net Present Value and Benefit:Cost Ratio

6.38 The Net Present Value (NPV) measures the total net benefits of a project and is calculated by subtracting the Present Value Costs (PVC) from the Present Value Benefits (PVB).

6.39 Table 6.17 summarizes the PVB, PVC and NPV for each alternative. It shows that, with the exception of Best Bus, all alternatives have positive Net Present Values which means that their benefits are greater than their costs over the evaluation period.

6.40 Also included in Table 6.17 is the Benefit:Cost Ratio (BCR), which is calculated by PVB divided by PVC (A BCR value greater than 1 means that benefits outweigh the costs). These present a similar story to the NPVs with RRT and the Combination alternatives performing best.

TABLE 6.17 NET PRESENT VALUES (2010 $M) AND BENEFIT COST RATIOS

Alternative	Present Value Benefits ($m)	Present Value Costs ($m)	Net Present Value ($m)	Benefit Cost Ratio
Best Bus	93	119	-26	0.8 : 1
BRT*	325	184	142	1.8 : 1
LRT1	962	621	341	1.5 : 1
LRT2	977	789	187	1.2 : 1
RRT	4,002	1,745	2,257	2.3 : 1
Combo 1	3,150	1,491	1,659	2.1 : 1
Combo 2*	2,404	1,112	1,292	2.2 : 1

*NOTE: * Forecasts capped as described in paragraph 5.3*

Cost Effectiveness Summary

6.41 A summary of the performance of each alternative under each cost-effectiveness measure is set out in Table 6.18.

TABLE 6.18 COST-EFFECTIVENESS SUMMARY

Alternative	Net Present Value ($m, 2010)	Benefit: Cost Ratio	2041 Cost per Additional Transit Rider ($ per trip)	2041 Cost per Auto Trip Removed ($ per trip)	2041 Cost per Additional Transit Passenger Kilometre ($ per passenger kilometre)	2041 Cost per Hour of Time Saved ($ per passenger hour reduced)
Best Bus	-$26	0.8 : 1	$14.7	$16.4	$0.90	$16.17
BRT*	$142	1.8 : 1	$10.6	$11.9	$0.35	$9.74
LRT1	$341	1.5 : 1	$19.4	$17.6	$0.44	$7.47
LRT2	$187	1.2 : 1	$21.7	$20.2	$0.55	$9.36
RRT	$2,257	2.3 : 1	$9.9	$14.1	$0.32	$6.06
Combo 1	$1,659	2.1 : 1	$10.7	$13.7	$0.33	$5.97
Combo 2*	$1,292	2.2 : 1	$9.2	$11.9	$0.31	$7.07

*NOTE: * Forecasts capped as described in paragraph 5.3*

Financial Account Key Points

- The capital costs range between approximately $120 million (Best Bus) and $3.0 billion (RRT). The bus-based options have lower capital costs and the rail rapid transit options have higher capital costs as they involve large scale engineering works such as tunnelling and underground stations;
- While some alternatives result in annual operating cost savings, overall the lifecycle operating costs for all alternatives is small in relation to the lifecycle capital costs;
- With the exception of Best Bus, all of the alternatives have positive net present values and benefit:cost ratios greater than one-to-one, indicating that the benefits they provide are greater than the life cycle costs;
- RRT delivers the highest net benefits and benefit cost ratio;
- BRT, Combination 1, Combination 2 and RRT are more cost effective in generating additional transit users in terms of boardings and passenger kilometres. BRT only has capacity for these additional passengers during off-peak periods and in the off-peak direction;
- LRT2 (which provides LRT along Broadway/10^{th} Avenue between Commercial Drive and UBC as well as along the former rail right of way between Main Street and Arbutus) is higher cost and less cost-effective than LRT1 on all accounts indicating that the branch along the former rail right-of-way lowers the financial performance of LRT2 relative to LRT1, which only has LRT on Broadway/10^{th} Avenue between Commercial Drive and UBC.
- Figure 6-4 provides the summary scores for the Financial Account.

FIGURE 6-4 FINANCIAL ACCOUNT SUMMARY

Criteria	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Capital Cost	◒	◒	◔	◔	○	○	○
Operating Cost	◔	◒	◒	◒	◒	◒	◔
Cost Effectiveness	◒	◕	◕	◒	●	●	●
Summary Score	◔	◒	◒	◔	◒	◒	◒

7 Environment Account

Introduction

7.1 The environment account assessed each alternative on the extent to which it would contribute to meeting wider environmental sustainability targets and objectives by attracting new transit riders through mode shift, supporting changes to land use and reducing vehicle kilometres travelled. The specific issues and impacts assessed were:

- Emissions;
- Noise and vibrations;
- Biodiversity;
- Water environments; and
- Parks and open spaces.

Emissions

7.2 All rapid transit alternatives would have impacts on the overall environmental emissions during construction (from the construction and materials used to build the alternative) and operation (from reduced car travel and from changes in transit vehicle operations). Emissions, such as particulate matter, NOx and SOx, can also lead to an impact on health. It should be noted that this section of the report focuses on the greenhouse gas impacts from emissions and health implications have not been considered in the Phase 2 evaluation.

During Construction

7.3 Construction of rapid transit infrastructure would lead to emissions and these impacts are considered under the Deliverability account. The impacts of construction on greenhouse gases are however quantified here so that the net whole life emissions resulting from each alternative can be compared.

During Operation

7.4 During operation, the key impacts on emissions are likely to be from:

- Reduction in auto journeys due to modal shift; and
- Alternate power sources, energy consumption and emissions of transit vehicles.

7.5 Reductions in the auto distance travelled across the network would reduce the greenhouse gas (GHG) and criteria air contaminants (CAC) emissions. The RTPM08 model has forecast the changes in vehicle-kilometres travelled (VKT) which were then used to estimate the reduction in GHGs and CACs over the evaluation period and monetize the GHG emission changes.

7.6 The emissions associated with transit vehicles depend on the types of vehicles used and the total vehicle kilometres operated. These were estimated using the total vehicle kilometres of rapid transit service provided. The resulting incremental GHG emissions (over and above the BAU) from transit operation over the 30-year appraisal period are shown in Table 7.1.

7.7 The results show a marked difference between the alternatives involving diesel BRT vehicles and all other rapid transit options, since the emissions rate per km for diesel buses is considerably higher than that of electric vehicles (used for LRT and RRT). Note that a trolley BRT would perform better on this measure and would incur a higher capital cost.

TABLE 7.1 GREENHOUSE GAS EMISSIONS FROM TRANSIT OPERATION (2020-2049)

Alternative	GHG emissions from transit operation in tonnes (incremental from BAU)
Best Bus	32,560
BRT	-5,023
LRT1	-137,121
LRT2	-136,406
RRT	-131,854
Combo 1	-136,855
Combo 2	3,583

7.8 Tables 7.2 and 7.3 show the calculation of the evaluation period GHG and CAC emissions for each alternative. These were calculated by subtracting the emissions produced during construction from the total, 'undiscounted' savings over 30 years of operation.

7.9 In summary, the results show that:

- The Best Bus alternative increases the overall GHG and CAC emissions while the other alternatives deliver reductions.
- Alternatives which achieve the highest levels of modal shift (RRT and the Combination Alternatives) deliver the highest levels of GHG and CAC reductions from reduced distance travelled by auto.

TABLE 7.2 EVALUATION PERIOD GREENHOUSE GAS EMISSIONS

Alternative	Change in net transit GHG emission during operation (Kilo Tonnes)	Reduction in Total Auto VKT (million km)	Change in net auto GHG emission during operation (Kilo Tonnes)	Total GHGs emitted from construction (Kilo Tonnes)	Net Evaluation Period GHG Emissions Reductions (Kilo Tonnes)
Best Bus	33	*90*	-16	0	+17
BRT*	-5	*767*	-142	19	-128
LRT1	-137	*1,014*	-176	78	-235
LRT2	-136	*1,000*	-176	109	-203
RRT	-132	*2,361*	-414	211	-335
Combo 1	-137	*1,915*	-334	162	-309
Combo 2*	4	*2,021*	-351	110	-238

*NOTE: * Forecasts capped as described in paragraph 5.3*

TABLE 7.3 EVALUATION PERIOD CHANGE IN CRITERIA AIR CONTAMINANTS (TONNES)

Alternative	CO	NH3	NOx	PM10	PM2.5	SOx	VO
Best Bus	-781	0	116	10	10	11	11
BRT*	-7,378	-50	-452	-15	-15	-8	-8
LRT1	-9,485	-89	-1,302	-70	-70	-61	-61
LRT2	-9,362	-88	-1,295	-70	-70	-61	-61
RRT	-21,805	-171	-2,015	-93	-93	-72	-72
Combo 1	-17,731	-144	-1,780	-85	-85	-68	-68
Combo 2*	-18,489	-125	-1,095	-36	-36	-17	-17

*NOTE: * Forecasts capped as described in paragraph 5.3*

Noise and Vibration

7.10 The noise and vibration effect from the operation of rapid transit is influenced by the alignment (whether on the ground, underground or elevated) together with technology used.

During Operation

7.11 The key determining factor of noise and vibration impacts during operation is expected to be associated with the vehicle mode. The evaluation summary is set out in Table 7.4 (note: During Construction conditions are assessed in the Deliverability Account contained in Section 11.13) and the conclusions are:

- The BRT alternative is unlikely to change noise and vibration significantly;
- The LRT alternatives would use quieter vehicles but generate additional noise and vibration from the wheel/rail interface; and
- Underground RRT would reduce local noise (from removal of on-street buses) but may induce vibration.

7.12 Mode shift from car to transit is unlikely to have a material effect on noise and vibration as the mode shift is relatively small for all alternatives.

TABLE 7.4 NOISE AND VIBRATION IN OPERATION ASSESSMENT SUMMARY

Alternative	Assessment	Commentary
Best Bus	-	While the Best Bus alternative adds buses to the local road network, the number of additional buses (in relation to total traffic and buses) is not significant and is therefore assessed as having a neutral impact.
BRT	-	The BRT alternative (with 2-min headways) is only a small increase in buses through the corridor
LRT1	✓	The LRT alternatives have both positive and negative impacts. The positive impacts are derived from replacing diesel buses with fewer, electrically powered and quieter running LRVs. Some new noise and slight vibration is likely from the steel wheel/rail interface – particularly at corners and switches/crossovers on the route. This additional impact was viewed as less severe than the benefits derived from removing the diesel buses.
LRT2	✓	
RRT	✓✓	The RRT alternative has both positive and negative impacts. The positive impacts are derived from replacing diesel buses with electrically powered, quieter and underground running RRT vehicles. Some new noise and slight vibration is likely from operation of the vehicles and their steel wheel/rail interface – particularly at switches/crossovers on the route. Given that the routes are entirely underground and relatively deep, these negative impacts were assessed as being less significant than the positive impacts.
Combo 1	✓	Combination Alternative 1 combines LRT and RRT technology and with a full corridor of LRT included, it was viewed that the impacts from this alternative were more similar to those of LRT
Combo 2	-	Combination Alternative 2 combines BRT and RRT technology and with a full corridor of BRT included, it was viewed that the impacts from this alternative were more similar to those of BRT

Biodiversity

7.13 A qualitative assessment of the impact on biodiversity was undertaken based on the technology and vertical alignment of each alternative.

7.14 As most of the alternatives operate through urban areas, on streets that currently experience large volumes of traffic, the impacts of implementing any of the alternatives are not expected to be significant.

7.15 There is the potential for loss of habitat due to land take and physical damage may occur due to the construction works. Noise caused by the works could also disturb birdlife in the vicinity of False Creek/Charleson Park and the University Golf Club/Pacific Spirit Park. Pollution during construction could possibly further damage habitats.

7.16 The key effects on ecology that may occur during operation include:

- Injury to or death of wildlife due to collisions with transit vehicles;
- Damage to habitats from increased air pollution from vehicle emissions, or contaminated run-off; and
- Disturbance from increased noise levels due to transit vehicles.

7.17 It is not anticipated that the alternatives considered would lead to any significant effects in terms of air or water pollution, or from noise. On this basis, it may also be concluded that during operation, there is unlikely to be any significant damage to ecological habitats from noise or pollution.

7.18 It is unlikely that the additional transit vehicles on-street on segregated routes would significantly increase the risk of injury or death for wildlife present in the route corridor.

7.19 The evaluation summary is set out in Table 7.5 and the conclusions are:

- Any increase in risks to biodiversity along the corridor from collisions or pollution is considered small, particularly during operations;
- Construction of the LRT2 alignment along 6th Avenue poses a slightly higher risk due to the proximity to Charleson Park and False Creek during construction, but these impacts are not expected to be significant and would likely be mitigated through construction methods; and
- The relocation/reallocation of grassland and small trees/shrubs on University Blvd may have some localized negative impacts.

TABLE 7.5 BIODIVERSITY ASSESSMENT SUMMARY

Alternative	Assessment	Commentary
Best Bus	-	Other than a small amount of additional bus layover capacity required at the UBC campus, no additional land take or construction required, therefore it is deemed 'neutral'.
BRT	-	Development of the BRT corridor may have an impact on ecology through the University Golf Club/Pacific Spirit Park but this is not expected to be significant.
LRT1	-	Development of the LRT corridor may have an impact on ecology through the University Golf Club/Pacific Spirit Park but this is not expected to be significant.
LRT2	×	Development of the LRT corridor may have an impact on ecology through the University Golf Club/Pacific Spirit Park but this is not expected to be significant. The route south of False Creek and Charleson Park is more sensitive to construction impacts.
RRT	-	The tunnelling of the RRT alternative would not materially affect biodiversity other than impacts during construction, such as transportation of construction materials.
Combo 1	×	Development of the LRT corridor may have an impact on ecology through the University Golf Club/Pacific Spirit Park but this is not expected to be significant. The route south of False Creek and Charleson Park is more sensitive to construction impacts.
Combo 2	-	The development of BRT and RRT sections may have minor impacts during construction, but overall this is not expected to be significant.

Water Environment

7.20 As with impacts on biodiversity, there are likely to be impacts on the water environment, however they are likely to be quite similar between alternatives and, given the level of design at this stage of the project, no significant impacts were identified.

7.21 However, potential sources of damage to the water environment that may occur during construction and that would require mitigation could be:

- Contaminated run-off during construction works;
- Contamination of ground water resources during excavation/piling etc;
- Groundwater drawdown due to infiltration to excavation works; and
- Disposal of contaminated water from dewatering of excavation works.

7.22 The potential for adverse effects on the water environment during operations could come from the increased contaminated run-off due to increases in areas of impermeable surfaces where the transit vehicles use segregated track. This is not considered significant given the relatively small amount of additional impermeable surface involved in the alternatives considered.

7.23 It is also assumed that, where appropriate, the new structures would be equipped with adequate and modern drainage, and would incorporate necessary measures to protect the water environment (e.g. oil traps) as a matter of course. In this case, it is unlikely that there would be any significant impacts on the water environment, other than in the case of accidental spillage of large quantities of fuel and/or lubricants. Even in this event, the mitigation measures incorporated into modern drainage systems should be able to prevent significant and long-lasting damage.

7.24 The evaluation summary is set out in Table 7.6 and the conclusions are:

- In general, electrically powered vehicles are less prone to leaking oil than diesel/gas powered vehicles.
- The Best Bus, BRT and LRT1 alternatives would not materially affect the water environment either during construction or in operation;
- The LRT2 alternative requires construction south of False Creek and poses a slightly higher risk from contaminated run-off which could require mitigation;
- LRT alternatives that include large portions of grass track could help reduce/manage surface water run-off; and
- The RRT alternatives require significant excavation works and impacts to ground water would need to be managed.

TABLE 7.6 WATER ENVIRONMENT ASSESSMENT SUMMARY

Alternative	Assessment	Commentary
Best Bus	-	The Best Bus alternative requires additional land at UBC for increased bus operations which may have an impact on the local surface water drainage but mitigation measures can be put in place if required.
BRT	-	The BRT alternative does not materially change the urban surface area.
LRT1	-	The LRT alternative includes some grass-track providing additional vegetated surface area to assist the absorption of rainfall, thereby easing the pressure of the local surface water drainage system. However, this was viewed as a small benefit offset by the potential impacts during construction.
LRT2	-	The LRT alternative includes some grass-track providing additional vegetated surface area to assist the absorption of rainfall, thereby easing the pressure of the local surface water drainage system. However, this was viewed as a small benefit offset by the potential impacts during construction.
RRT	-	Given the elevation above sea level for the majority of the Broadway corridor, impacts of ground water resource contamination are not expected to be significant.
Combo 1	-	This alternative combines both impacts of RRT and LRT but has no material impact.
Combo 2	-	This alternative combines both impacts of RRT and BRT but has no material impact.

Effects on Parks/Public Open Space

7.25 A quantitative assessment of the area of parks and public open space lost or gained was carried out alongside a description of the characteristics of the space lost/gained.

7.26 The assessment identified losses to the following areas (dependent on alternative):

- University Boulevard central median – approximately 0.7 hectares
- CPR right-of-way – approximately 0.4 hectares
- Thornton Park – approximately 0.1 hectares

7.27 In addition to the quantitative assessment, a qualitative assessment was undertaken looking at the type and current use of land impacted on where:

- LRT alternatives impact on the central median of University Boulevard which results in a net increase in green space (through grass track);
- LRT2 and Combination 1 require relocation of the community gardens along West 6th Avenue to adjacent space in the CPR right-of-way.
- Impacts to Thornton Park for the terminus station (for LRT2 and Combination 1) could be mitigated through design, by either moving part/all of the station into the existing roadway (albeit at the expense of general traffic or parking) or through integrated park /station planning.

TABLE 7.7 PARK AND OPEN SPACE IMPACTS

Alternative	Hectares Impacted	Qualitative Assessment
Best Bus	-	-
BRT	0.7	×
LRT1	0.7	-
LRT2	1.2	×
RRT	-	-
Combo 1	1.2	×
Combo 2	0.7	-

Environmental Account Key Points

- The RRT and Combination alternatives result in the highest modal shift from car and as a result have the greatest auto emissions reductions. The AM peak hour VKT reduction (and therefore emissions reductions) for all alternatives ranges from 0.01% to 0.30% of the regional total.
- BRT does not generate significantly different levels of noise and vibration from the BAU. LRT with fewer, quieter vehicles, and RRT underground would both provide improvement.
- The biodiversity and water environment are not expected to be adversely affected by rapid transit operation and any impacts from construction can likely be managed and mitigated.
- Figure 7-1 provides the summary scores for the Environmental Account.

FIGURE 7-1 ENVIRONMENTAL ACCOUNT SUMMARY

Criteria	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Appraisal Period GHG Emission Reductions (kilo-tonnes)	-17	128	235	203	335	309	238
Noise and Vibration	◒	◒	◕	◕	●	◕	◒
Biodiversity	◒	◒	◒	◒	◒	◒	◒
Water Environment	◒	◒	◒	◒	◒	◒	◒
Parks & Open Space	◒	◒	◒	◔	◒	◔	◒
Summary Score	◒	◒	◕	◕	●	◕	◕

8 Urban Development Account

Introduction

8.1 Each alternative was assessed in terms of its contribution to Urban Development, in particular the extent to which services would support current and future land use development along the corridor and at UBC as well as the integration with the surrounding neighbourhoods through high quality urban design. This section covers the following criteria:

- Land use integration;
- Land use potential;
- Property requirements; and
- Urban design.

Land Use Integration

8.2 Land use integration was assessed by reviewing the connection of local trip attractors (activity centres) with each other and with local population centres. Chapter 2 also presented demographic information for the corridor, with medium to high density residential area east of Alma (120 people per hectare (pph)) and the western section from UBC to Alma Street with lower densities at around 80-90 pph. Growth forecasts for 2041 assume further growth in the corridor increasing the density to over 150 pph.

8.3 The Central Broadway segment (from Burrard Street to Main Street), which includes Vancouver City Hall, the Uptown Office District, Vancouver General Hospital and associated ancillary medical/dental offices is expected to reach an employment density of 240 employees per hectare (eph) by 2041 and continue as the second largest employment area in Metro Vancouver outside of the downtown.

8.4 Growth at UBC is also considerable, with 8,000 additional students by 2021 and a further 9% (4,000 students) between 2021 and 2041. The number of jobs at UBC is expected to increase by 6% (1,000 jobs) between 2006 and 2021 and a further 8% (1,500 jobs) between 2021 and 2041.

8.5 There are a number of major activity centres along the corridor and these were illustrated earlier in Figure 2-6. Many of these are within 200 metres (roughly two city blocks) of each station for each alternative. The following five locations were agreed by the study team as being the major activity centres within the study area:

- University of British Columbia;
- Vancouver General Hospital;
- City Hall/City Square;
- Vancouver Community College; and

- Great Northern Way Campus.

8.6 All of the rapid transit alternatives serve UBC, Vancouver General Hospital, City Hall/City Square and VCC. The RRT and Combination alternatives also directly serve the Great Northern Way Campus. The summary assessment of land use integration is set out in Table 8.1. Note that the Best Bus alternative, while it serves these locations, does not serve them with rapid transit so was given a neutral rating.

TABLE 8.1 LAND USE INTEGRATION ASSESSMENT SUMMARY

Alternative	Activity Centres Connected	Assessment
Best Bus	0	-
BRT	4	✓
LRT1	4	✓
LRT2	4	✓
RRT	5	✓✓
Combo 1	5	✓✓
Combo 2	5	✓✓

Land Use Potential

8.7 Each alternative was evaluated in terms of the projected built area at each station on the route. The built area figures were calculated by the City of Vancouver Planning Department and are based on 400 metre buffers around station areas and should not be confused with projected built areas within the entire study area.

8.8 These numbers include the 2041 projections of floor areas and do not represent an overall ‘build out’, but rather the projected growth to 2041 based on a variety of factors which include:

- Built projects that were anticipated to have been completed between 2006 (upon which the model data is based) and 2010;
- Projects currently approved for development;
- Established rates of development by zone and an enhanced rate of development due to proximity of rapid transit stations;
- Assumptions for the redevelopment of large sites (e.g. Great Northern Way Campus); and
- Estimated changes to allowable density based on approved and emerging Council policy as of October 2009 (such as Broadway C-3A, Mount Pleasant Plan).

8.9 The potential for Transit Oriented Development (TOD) was also evaluated qualitatively based on numbers and locations of stations as well as the impacts from land take (i.e. where the alternative requires land take for construction, the remaining land provides opportunity for TOD).

8.10 The estimated built floor area (combined residential and retail) and the assessment on TOD potential is set out in Table 8.2.

TABLE 8.2 LAND USE POTENTIAL ASSESSMENT

Alternative	Stations	2041 Built Floor Area (millions sq.ft2 within 400 m of stations)	Potential for TOD
Best Bus	-	Not assessed	-
BRT	14	52.2	✓
LRT1	14	52.2	✓
LRT2	21	70.1	✓✓
RRT	11	50.5	✓
Combo 1	20	68.5	✓✓
Combo 2	16	58.1	✓

8.11 Investment in rapid transit can also bring about changes in land values adjacent to stations, reflecting the increased convenience of public transportation. These impacts should be considered as the project progresses.

Property Requirements

8.12 Based on the alignment design of the alternative, the numbers of private dwellings and commercial properties required to construct and operate the line were identified.

8.13 In addition, a qualitative assessment was undertaken on the likely difficulty in acquiring the properties, the relative amenity that each property provides to the community and the relative 'value' of the property (qualitatively linked to the style, fit with the community etc. with the monetary value captured in the financial evaluation).These assessments are summarized in Table 8.3.

TABLE 8.3 PROPERTY REQUIREMENTS ASSESSMENT

Alternative	Residential Properties Impacted	Commercial Properties Impacted	Qualitative Assessment	Commentary
Best Bus	-		-	Not assessed
BRT	0	17	××	All of the properties required are small to medium sized businesses.
LRT1	0	17	××	
LRT2	0	22	××	
RRT	3	13	××	All of the properties required are small to medium sized businesses plus three residential properties.
Combo 1	0	22	××	All of the properties required are small to medium sized businesses.
Combo 2	0	30	××	All of the properties required are small to medium sized businesses.

Urban Design

8.14 The introduction of rapid transit and the revision of major traffic movements along a route provide an opportunity for improving the overall urban realm of the transit corridor. Horizontal and vertical alignments, as well as transit modes and their design, can have an effect on the urban realm – particularly where integrated streetscape design and planning is included in the designs and costs (note that the assessment is based on the assumed budgets and designs of the alternatives presented).

8.15 New rapid transit stops will become activity generators providing the impetus to create a new pedestrian-focused urban realm. There are also opportunities to use the stop locations as hubs around which development and the urban form is centred. This can improve the environment for local residents and businesses, and provide better conditions for pedestrians, cyclists, and public transit users. An enhanced urban realm also can improve the potential for redevelopment of existing areas and new development in underdeveloped areas.

8.16 The assessment considered the following factors in evaluating the urban design improvements within each alternative:

- **Pedestrian experience** - consisting of:
  - Buffer (effects on interaction between traffic and pedestrian activity);
  - Sidewalk impacts (changes in sidewalk widths); and
  - Scale of street (connectivity between both sides of the road);

- **Placemaking potential** - consisting of:
  - Station design (improvements related to introduction of new station facilities); and
  - Effect of streetscape (potential street improvements including landscaping and design).

8.17 A summary of the assessment is presented in Table 8.4.

TABLE 8.4 URBAN DESIGN ASSESSMENT SUMMARY

Alternative	Assessment	Commentary
Best Bus	-	With no major capital investment, the Best Bus alternative was assessed as having a 'neutral' impact.
BRT	✓✓	The BRT alternative improves the pedestrian scale of the street with crossing distances reduced due to pedestrian refuges being introduced at station locations. However there is the removal of the buffer between traffic and pedestrians (as a result of the removal of parking lanes) and slight reductions in sidewalk widths. There is opportunity for station design improvements, together with road reconstruction opportunities and design potential at two locations where property purchase is required.
LRT1	✓✓	The LRT alternative improves the pedestrian scale of the street with crossing distances reduced due to pedestrian refuges being introduced at station locations. However there is the removal of the buffer between traffic and pedestrians (as a result of the removal of parking lanes) and reductions in sidewalk widths in some places and increases in others. There is opportunity for station design improvements, together with road reconstruction opportunities and design potential at two locations where property purchase is required. Compared with the BRT there is less impact on sidewalk width (due to a slightly narrower right of way) and longer platforms providing more scope for urban design and pedestrian connectivity.
LRT2	✓✓	Same assessment as LRT1. Most of the additional route east of Arbutus is off street and would have limited impact on pedestrians and sidewalk widths. There is opportunity for design and landscaping improvements through sections of the former CPR alignment between Granville Island and 6th Avenue.
RRT	✓	The RRT alternative has limited impact on urban design integration between stations due to its underground guideway. The station houses provide opportunities for urban realm improvements. Implementation of the RRT would reduce road space requirements for transit and present the opportunity to change the street configuration (wider sidewalks, reduced lanes, etc), however the impacts of a revised configuration have not been included in the evaluation as they would incur costs that would not otherwise be incurred.
Combo 1	✓✓	This alternative's combination of LRT and RRT (on different routes on the eastern end of the corridor) provides a larger number of stations and therefore offers greater scope for station design improvements and road reconstruction opportunities.

Alternative	Assessment	Commentary
Combo 2	✓✓	This alternative's combination of BRT and RRT (on different routes on the eastern end of the corridor) provides a larger number of stations and therefore offers greater scope for station design improvements and road reconstruction opportunities.

Urban Development Account Key Points

- All of the rapid transit alternatives serve four of five major activity centres with RRT and the Combination alternatives also serving the fifth, the Great Northern Way Campus.
- To varying degrees, all rapid transit alternatives provide an opportunity to improve urban design, particularly at station locations depending on the design and quality of materials. The opportunity is greater for street-level alternatives because they provide opportunities along the entire corridor rather than just at stations; RRT provides potential urban realm improvements that are outside the project scope.
- All alternatives require the acquisition of commercial and residential properties with the differences between the alternatives ranging between 16 and 30 properties.
- Figure 8-1 provides the summary scores for the Urban Development Account.

FIGURE 8-1 URBAN DEVELOPMENT ACCOUNT SUMMARY

9 Economic Development Account

Introduction

9.1 The economic development account assessed the economic impacts of the alternatives as well as reviewing the impacts to goods movement in the corridor(s) and considered:

- Construction effects;
- Operating effects;
- Taxes; and
- Goods movement.

Construction Effects

9.2 The assessment of the economic effects was based on benchmarked values to ensure that a consistent set of values are used for this project (consistent with other rapid transit planning and construction projects in Metro Vancouver). The project costs were then used as inputs to the British Columbia Input Output Model (BCIOM) in order to estimate both construction and operational related benefits.

9.3 The construction effects focused on the scale of the employment opportunities created, specifically the direct and indirect benefits in various sectors of the economy. Since the BC economy is considered as a whole, any transfer of production from one part of the province to another will not result in a net difference. The effects are summarized in Table 9.1.

TABLE 9.1 ECONOMIC DEVELOPMENT FROM CONSTRUCTION ASSESSMENT

Alternative	Additional Employment (Person Years)	Additional GDP ($m 2010 Prices)	Summary score
Best Bus	-	-	-
BRT	2,700	171	✓
LRT1	6,875	480	✓
LRT2	8,600	614	✓
RRT	24,300	1,632	✓✓✓
Combo 1	18,875	1,247	✓✓
Combo 2	13,675	987	✓✓

Operating Effects

9.4 The economic impacts and effects of linking activity centres along the corridor have not been assessed through this study but the assessment of the economic effects from operation was planned to be undertaken. However, with limited information available regarding the contracting model or the precise split of operating staff (drivers, maintenance workers, etc.) and any additional administrative staff required, it was agreed that the alternatives would not be assessed in this way.

9.5 It is worth noting that the number of staff employed to operate and maintain transit vehicles and facilities under each alternative may differ considerably, for example according to the number of service hours, maintenance requirements and station staffing arrangements. A larger employee base may lead to increased contributions to the economy in terms of spending and taxation.

Taxes

9.6 The implementation of rapid transit will create changes in provincial and federal tax receipts. These include the effects of increased employment salaries (largely from construction) and reductions in fuel duty as a result of modal shift from car to transit. The results of the assessment are presented in Table 9.2.

TABLE 9.2 TAX ASSESSMENT

Alternative	Project and supplier industry tax during construction ($m)	Incremental tax from fuel duty reduction ($m 2041)	Summary Score
Best Bus	-	-0.09	-
BRT	29	-0.97	✓
LRT1	75	-1.19	✓
LRT2	93	-1.08	✓
RRT	264	-2.51	✓✓
Combo 1	203	-2.16	✓✓
Combo 2	152	-2.23	✓

Goods Movement

9.7 Chapter 2 discussed the 'Goods Movements' and 'Parking, Servicing and Access' conditions in the corridor. It indicated that Broadway is a truck route, that the busiest section is between Main Street and Commercial Drive (where trucks represent 6% of all traffic) and that servicing is from back lanes for the majority of the corridor, while some of the larger commercial/retail sites have their own access points (driveways) as well as on-site loading.

9.8 This assessment has considered the following:

- **Travel Conditions** – A qualitative assessment based on the effect on road capacity. The assessment was done qualitatively because the importance of congestion will vary from business to business and by section of the corridor with non-transit users impacts described in Chapter 5 applied.
- **Physical Access** – An assessment of the ability to access premises for loading/unloading. These needs and impacts vary along the corridor and by the nature of the business. Two different examples are the needs of a supermarket compared to those of a small flower shop or a 'dollar' store. In the case of the former access is generally outside regular hours and is made easier with large parking areas and loading areas. In the case of the latter, access from the street will be important. The assessment of this factor also took account of the ability of 'clients' (e.g. customers, patients, etc.) to access premises, as ultimately in the case of retail, the purchase of goods is the final goods movement step in a supply chain.

9.9 Table 9.3 summarizes the Goods Movement evaluation.

TABLE 9.3 GOODS MOVEMENT ASSESSMENT

<table>
<tr><th>Alternative</th><th>Travel Conditions</th><th>Physical Access</th><th>Summary Assessment</th></tr>
<tr><td>Best Bus</td><td>Alternative increases the number of buses on the road but reduces slightly the number of vehicles and there is an overall marginal decrease in traffic congestion.</td><td>Remains unchanged.</td><td>-</td></tr>
<tr><td>BRT</td><td rowspan="3">Alternatives remove road capacity and may lead to increases in congestion. Restricted turns will have effect, particularly left turns. (See Tables 5.8 to 5.11).</td><td rowspan="3">Lane access and on-street loading bays maintained.</td><td rowspan="3">××</td></tr>
<tr><td>LRT1</td></tr>
<tr><td>LRT2</td></tr>
<tr><td>RRT</td><td>No road capacity affected and removal of B-Line buses will provide some additional capacity in the corridor and possible reduction in bus lane restrictions.</td><td>Lane access and on-street loading bays maintained.</td><td>✓</td></tr>
<tr><td>Combo 1</td><td>Alternative removes road capacity and may lead to increases in congestion, but only the section west of Arbutus would be affected while RRT benefits apply east of Arbutus.
Added turn restrictions would have effects, particularly on left turns (Table 5.11) but not in the Central Broadway section.</td><td>Lane access and on-street loading bays maintained.</td><td>-</td></tr>
<tr><td>Combo 2</td><td>Alternatives remove road capacity and may lead to increases in congestion. Added turn restrictions would have effects, particularly on left turns. (See Tables 5.8 to 5.11).</td><td>Lane access and on-street loading bays maintained.</td><td>××</td></tr>
</table>

Economic Development Account Key Points

- The construction of rapid transit is expected to generate benefits associated with employment and increases in GDP; these benefits are correlated with the capital costs and the length of the construction periods and therefore RRT and Combination 1 generate the greatest benefits.
- Reductions in road capacity and turning restrictions for alternatives with BRT and LRT will have impacts on general truck movements in the study area and potentially cause delays.
- Figure 9-1 provides the summary scores for the Economic Development Account.

FIGURE 9-1 ECONOMIC DEVELOPMENT SUMMARY

Criteria	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Construction Effects	◑	◑	◕	◕	●	●	◕
Tax Effects	◑	◑	◕	◕	●	●	●
Goods Movement	◑	◔	◔	◔	◕	◑	◔
Summary Score	◑	◑	◕	◕	●	◕	◕

10 Social Community Account

Introduction

10.1 A wide range of social and community issues are influenced by the transit alternatives. Each alternative was assessed in terms of its contributions to safe, secure and accessible transit services, improved access to rapid transit for all and benefits to the surrounding communities, including managing the impacts of rapid transit.

10.2 Specifically, the social issues covered in this section are impacts on:

- Health;
- Low income population served,
- Safety and security;
- Community cohesion; and
- Heritage and archaeology.

Health Effects from Active Modes

10.3 The range of health outcomes influenced by physical activity is considerable and any increases in walking and cycling trips will assist all levels of government in reaching their broader public health goals and targets. While the RTPM08 forecasts pedestrian and bicycle trips, it is not a reliable estimate for these modes.

10.4 Where alternatives promote mode shift from car to public transit, there are increased levels of physical activity which are linked to enhanced health for transit users. In an article published in the American Journal of Preventive Medicine[12] researchers concluded that construction of a rapid transit system resulted in "*increased physical activity (walking) and subsequent weight loss by people served by the LRT*". Review of the rapid transit in Charlotte, North Carolina researchers found that using, LRT in this instance, resulted in reductions in body mass index equivalent to a relative weight loss of 6.45 lbs for a person who is 5'5". Rapid transit users were also 81% less likely to become obese over time.

10.5 Consequently, alternatives that promote the largest modal shift from car to other modes are expected to deliver the highest levels of health benefits associated with active modes. Table 10.1 summarizes the modelled reduction in auto trips in the 2021 and 2041 AM peak hours. It shows that RRT and the Combination Alternatives are more effective in encouraging modal shift and delivering the associated health benefits.

[12] http://www.ajpmonline.org/webfiles/images/journals/amepre/AJPM_Light_Rail_Usage_PR.pdf

TABLE 10.1 REDUCTION IN AUTO TRIPS

Alternative	Reduced Auto Trips (AM Peak Hour)	
	2021	2041
Best Bus	75	133
BRT*	397	484
LRT1	604	754
LRT2	693	824
RRT	1,907	2,302
Combo 1	1,585	2,077
Combo 2*	1,657	2,186

*NOTE: * Forecasts capped as described in paragraph 5.3*

Low Income Population Served

10.6 Land-use and census data provided information on how different social groups are distributed along the corridor. In particular, UBC students, low income groups and certain land uses that are typically more dependent on transit to access local employment and amenities such as:

- Healthcare (hospitals, dentists);
- Education institutes (schools, colleges);
- Retail (grocery stores); and
- Leisure facilities (sports centres, community centres).

10.7 By using GIS tools and the 2006 Census, the number of low-income households in each catchment area was calculated. The low-income cut-off was defined as the after-tax income level where families spend 20 percentage points more of their after-tax income than the average family on food, shelter and clothing. The cut-off is differentiated by size of family and area of residence.[13]

10.8 Table 10.2 sets out the estimated low income population based on low income population proportion from Census data and the 2021 population catchment forecast. Overall, the percentage of low income population does not vary significantly between alternatives (12-14% within a 400m catchment), although alternatives with a higher number of stops capture a larger low income population (e.g. LRT2 and the Combination Alternatives).

10.9 It should also be noted that significant numbers of low income users of the corridor commute to UBC but do not necessarily reside within the catchment area. Such users will see benefits from the provision of rapid transit, although the difference in level of benefit between alternatives would be small.

[13] See: http://www12.statcan.gc.ca/census-recensement/2006/ref/dict/fam019-eng.cfm

TABLE 10.2 LOW INCOME CATCHMENT ANALYSIS (2021)

Alternative	400m Catchment (000s)			800m Catchment (000s)		
	Estimated Low Income Population	Forecast Population	Percentage	Estimated Low Income Population	Forecast Population	Percentage
BRT	6.6	47	14%	16.5	126	13%
LRT1	6.6	47	14%	16.5	126	13%
LRT2	7.8	59	13%	19.0	139	14%
RRT	4.9	38	13%	14.6	114	13%
Combo 1	6.8	55	12%	17.4	129	14%
Combo 2	7.3	51	14%	17.1	130	13%

Safety

10.10 While it is assumed that all alternatives will be designed to be safe, a qualitative assessment was undertaken on the operational safety of each including road and passenger safety

10.11 In addition to operating safety, a qualitative assessment of perceived passenger security was undertaken including a review of how any risks (perceived or real) could be mitigated through crime prevention through environmental design (CPTED) measures.

Operating Safety Assessment

10.12 Statistics available from the United States Federal Transit Administration (FTA) to 2007[14] provide an insight into the relative levels of operating safety of different transit modes. In analysing this data, we considered three measures of safety, as follows:

- Annual fatalities per billion passenger kilometres
- Annual injuries per billion passenger kilometres
- Annual collisions, derailments and running off the road incidents per million vehicle kilometres

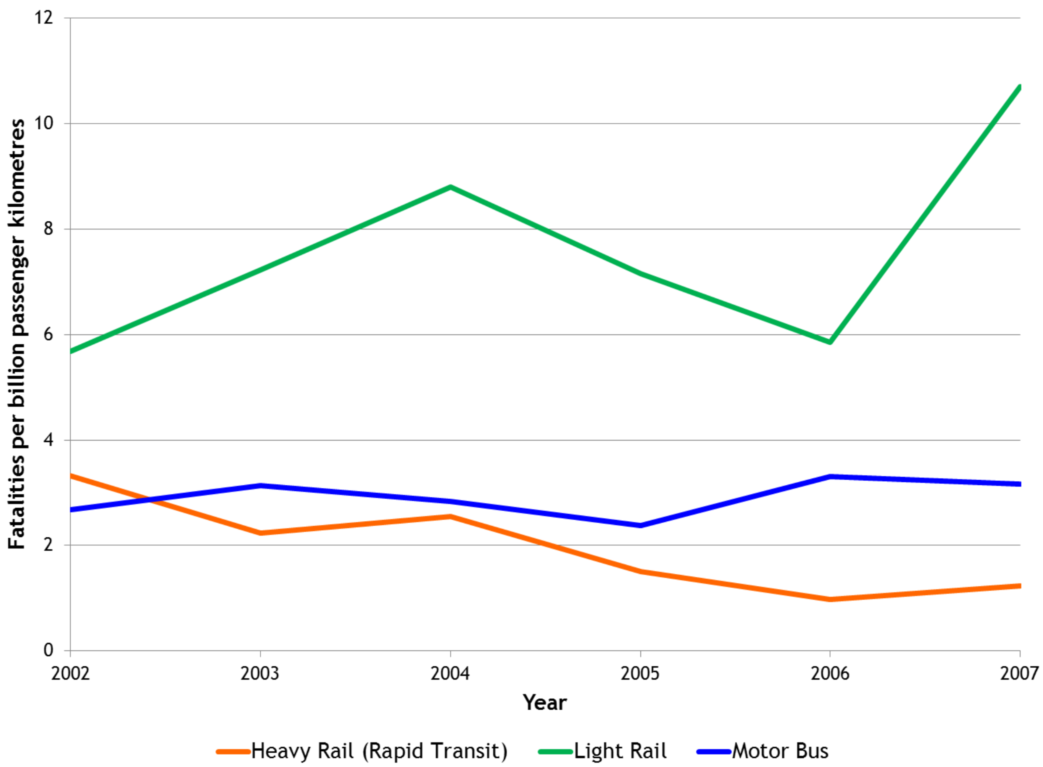
10.13 Figures 10-1 to 10-3 show the performance of heavy rail (rail rapid transit), light rail and buses in the USA under these three measures between 2002 and 2007. All three measures suggest that rail rapid transit is the safest of the three modes, given that these vehicles operate on an exclusive right of way with no interaction with the roadway, and tend to have high usage levels.

10.14 Although the historic injury rate on buses is higher than on light rail systems, the rates of fatalities and operational incidents are considerably lower. When considering these statistics, the following points should be noted:

[14] Transit Safety and Security Statistics and Analysis (formerly SAMIS): http://transit-safety.volpe.dot.gov/Data/Samis.asp

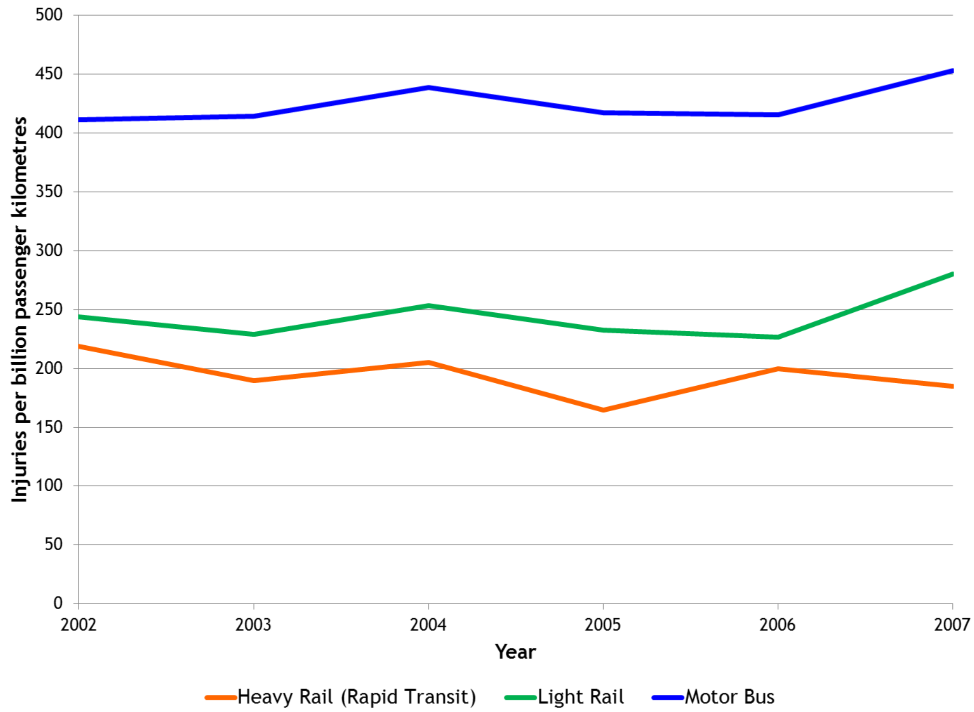
- The bus statistics quoted above are for buses operating on roadways rather than segregated guideways and hence a lower rate of collisions would be expected on a BRT system; and
- Most injuries and fatalities related to LRT systems are outside the vehicle and typically relate to other road users disobeying traffic control devices.

FIGURE 10-1 FATALITIES PER BILLION PASSENGER KILOMETRES (USA, 2002-2007)



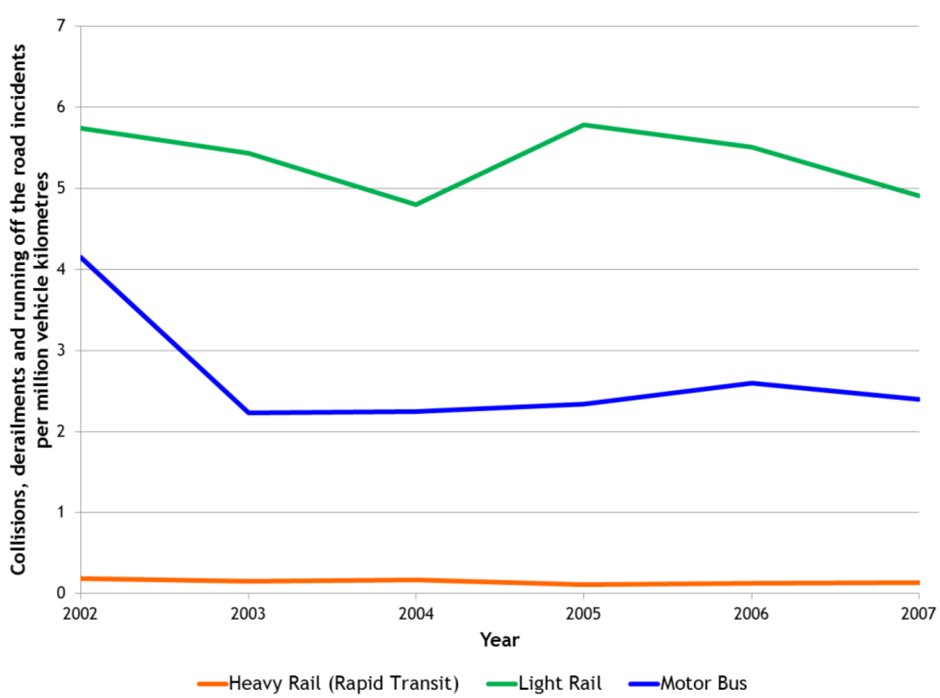
Source: US Federal Transit Administration

FIGURE 10-2 INJURIES PER BILLION PASSENGER KILOMETRES (USA, 2002-2007)



Source: US Federal Transit Administration

FIGURE 10-3 COLLISIONS, DERAILMENTS AND RUNNING OFF THE ROAD INCIDENTS PER MILLION VEHICLE KILOMETRES (USA, 2002-2007)



Source: US Federal Transit Administration

Safety Perception Assessment

10.15 There have been a number of studies into passenger personal safety perception in the USA and UK over the past decade, including quantitative and qualitative surveys by the UK Department for Transport (DfT) in 1996, 2002[15] and 2008[16] and a study of women's fear of transportation environments by the Mineta Transportation Institute in 2009[17].

10.16 The 1996 and 2002 DfT surveys consider the perception of safety of the following, in daylight and after dark:

- Waiting at bus stops, train stations and underground stations; and
- Travelling on bus, train and underground.

10.17 The surveys revealed that people perceived underground vehicles and stations as less safe than those above ground. This is discussed in the survey report, which states that

> *"Subways and long flights of stairs are… often identified as places where people feel less secure, mainly because of a fear of entrapment, but also because they are also often poorly lit and dingy. Recesses and concealed corners, where another person could be hiding, also contribute to people's heightened sense of risk."*

10.18 The survey also shows that people feel safer at bus stops and on buses than at train stations and on trains, though this is less marked amongst men than women. However it is important to note that the trains in question operate on heavy rail lines which are almost always away from streets, and so this does not form an adequate comparator for the LRT alternatives under consideration. There is no evidence to suggest that an LRT station or train should be perceived as inherently less secure than a bus stop, and instead believe that the relative difference between BRT and LRT will depend on the specific features of the vehicles and stops.

10.19 TransLink's quarterly customer service survey has revealed similar findings in Metro Vancouver. The Customer Service Performance Quarter 3 Survey found average ratings of 8.4 for "Feeling Safe from Crime at the Bus Stop and Transit Exchange" for Vancouver bus routes, and 8.1 for "Feeling Safe from Crime Inside the SkyTrain Station".[18]

10.20 The features of vehicles and stops/stations identified[19] as important to passengers' feelings of security include:

- Staff presence;

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[15] "People's Perceptions of Personal Security and Their Concerns About Crime on Public Transport": http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/crime/ps/perceptions/researchfindings

[16] "Experiences and perceptions of anti-social behaviour and crime on public transport": http://webarchive.nationalarchives.gov.uk/20081230052355/http://www.dft.gov.uk/pgr/statistics/datatablespublications/trsnstatsatt/antisocialcrime

[17] "How to Ease Women's Fear of Transportation Environments: Case Studies and Best Practice": http://www.transweb.sjsu.edu/MTIportal/research/publications/documents/2611-women-transportation.pdf

[18] Customer Service Performance Quarter 3 2011: http://www.translink.ca/~/media/Documents/bpotp/translink_listens/customer_surveys/Customer_Service_Performance_Research/Bus_SeaBus_SkyTrain/Q3_2011.ashx

[19] http://www.dft.gov.uk/webtag/documents/expert/unit3.4.2.php

- CCTV coverage;
- Lighting of stops/stations;
- Proximity of stops and stations to the street;
- Visibility of stops and stations from the street;
- Help points on stops/stations and in vehicles;
- Real-time travel information in stops/stations;
- Cleanliness and general good condition of stops/stations and vehicles; and
- Landscaping features (design, plants, etc).

10.21 An initial security perception assessment of the three rapid transit modes plus the Best Bus alternative is shown in Table 10.3.

TABLE 10.3 SECURITY PERCEPTION ASSESSMENT

Measure	Best Bus	BRT	LRT	RRT
Staff presence in vehicles	Driver only	Driver and occasional revenue protection staff	Driver (in separate cabin) and occasional revenue protection staff	No driver, occasional revenue protection staff
Staff presence – at stops	No	Occasional	Occasional	Likely
CCTV coverage at stops	Possible	Yes	Yes	Yes
Proximity of stops to the street	All stops on or very close to main roads	All stops on or very close to main roads	All stops on or very close to main roads	All stops situated underground
Help points at stops	No	Yes	Yes	Yes
Real time travel information in stops	At key stops	Yes	Yes	Yes
Landscaping features	No	Possibly	Possibly	Limited to stations

10.22 In assessing each of the alternatives, the key findings are as follows:

- Tunnelled or elevated alternatives would be the safest in terms of collisions, with the on-street alternatives more prone to collisions with other road users (cars, bikes, pedestrians)
- Street level alternatives are perceived as the safest/most secure while tunnelled and elevated alternatives are perceived as less safe/secure by passengers (due to the isolation of the platforms); and
- Perceived security could be mitigated through crime prevention through environmental design (CPTED) measures.

10.23 Table 10.4 summarizes the safety assessment taking into account the operational safety for users, non-users as well as the perceived safety of users.

TABLE 10.4 SAFETY ASSESSMENT SUMMARY

Alternative	Operational Safety	Passenger Perceived Security	Potential CPTED opportunities	Overall Assessment
Best Bus	-	-	-	-
BRT	✓	-	✓	✓
LRT1	✓	-	✓	✓
LRT2	✓	-	✓	✓
RRT	✓✓	×	✓✓	✓✓
Combo 1	✓	×	✓	✓
Combo 2	✓	×	✓	✓

Community Cohesion

10.24 The assessment of community cohesion considered the number of restricted cross-traffic locations for pedestrians, cyclists and vehicles as a proxy for the level of community 'severance'.

10.25 The assessment assumed that closed vehicular crossings would have fewer negative impacts on local community cohesion than closed pedestrian or cycle crossings, given the nature of local trips. In some instances closed vehicle crossings could increase cohesion by limiting cut-through traffic, while the diversion of traffic may also reduce community cohesion. There could potentially be increased traffic signal cycle lengths although the impact of this on community cohesion would be small. The impact in terms of crossing restrictions out of a total of 73 intersections is shown in Table 10.5.

TABLE 10.5 VEHICLE, BICYCLE AND PEDESTRIAN RESTRICTIONS

Alternative	Vehicle Cross Traffic Restrictions	Pedestrian or Cyclist Restrictions
Best Bus	0	0
BRT	31	0
LRT1	32	0
LRT2	36	0
RRT	0	0
Combo 1	20	0
Combo 2	31	0

10.26 Visual intrusion was assessed qualitatively assuming that the effects would be greatest for those alternatives that have elevated guideways or overpasses as well as any that re-introduce transit to the disused Canadian Pacific Railway right-of-way. The visual impacts have been assessed based on the likely effects on the local community's perception. This is shown in Table 10.6.

TABLE 10.6 COMMUNITY COHESION ASSESSMENT SUMMARY

Alternative	Severance	Visual Intrusion	Overall Assessment
Best Bus	-	-	-
BRT	×	-	-
LRT1	×	-	-
LRT2	×	×	×
RRT	-	×	-
Combo 1	×	××	×
Combo 2	×	×	×

Heritage and Archaeology

10.27 A quantitative assessment was carried out on the number of heritage properties and archaeology sites affected. The impacts to heritage buildings on the City of Vancouver's Heritage Register were assessed using a GIS layer. Similarly, the impacts to archaeological sites were assessed using information provided by the Archaeology Branch via the Ministry of Transportation and Infrastructure.

10.28 The conclusion of these reviews was that, given the level of design and nature of the corridor, no impacts were identified and that all alternatives would be assessed as having a neutral impact. Through the detailed design phase of the preferred alternative, it is suggested that these impacts be carefully monitored as more information about station locations and construction impacts are identified. In particular, the alternatives with RRT technology (the RRT and combination alternatives) have greater potential to disturb archaeological sites that may not have been identified due to ground excavation associated with tunnelling. This will be further considered as designs are refined. In addition, engagement with First Nations will continue.

Social Community Account Key Points

- The RRT and Combination alternatives deliver the greatest shift from auto to active modes of transportation and therefore generate the greatest health benefits from increased physical activity.
- LRT2 and the Combination alternatives provide the greatest catchment of low income population but otherwise the alternatives perform similarly.
- All of the rapid transit alternatives would provide an improvement to safety and security due to greater separation from other road users and rapid transit station design.
- The BRT and LRT alternatives result in reduction in community cohesion as a result of vehicular restrictions at intersections.
- Figure 10-4 provides the summary scores for the Social Community Account.

FIGURE 10-4 SOCIAL COMMUNITY ACCOUNT SUMMARY

Criteria	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Health Effects	◑	◕	◕	◕	●	●	●
Low Income Population Served	◑	◕	◕	●	◕	●	●
Safety	◑	◕	◕	◕	●	◕	◕
Community Cohesion	◑	◔	◔	◔	◑	◔	◔
Heritage & Archaeology	◑	◑	◑	◑	◑	◑	◑
Summary Score	◑	◕	◕	◕	●	◕	◕

11 Deliverability Account

Introduction

11.1 The deliverability evaluation considered each alternative first in terms of its technical constructability, the impact of construction on transportation, the environment, local economy, social and community issues. The operability of each alternative was then considered in terms of its acceptability and requirements for funding and affordability.

Constructability

Constructability -Technical Considerations

11.2 While all of the alternatives will have engineering challenges of construction and these will need to be identified, quantified and mitigation measures developed (in Phase 3), all of the alternatives evaluated appear to be technically constructible.

11.3 The tunnelled and elevated RRT sections are more technically challenging compared to at-grade construction, but there is a track record in the region of delivering and expanding the transit network including SkyTrain. Therefore, no major risks or uncertainties which affect the constructability of those alternatives were identified.

11.4 There are no major legal issues known to affect the construction of any alternative.

11.5 The overall assessment of the technical constructability is set out in Table 11.1.

TABLE 11.1 TECHNICAL CONSTRUCTABILITY ASSESSMENT

Alternative	Qualitative Assessment	Commentary
Best Bus	-	No major construction required other than additional layover facilities for buses and depot expansion.
BRT	×	Requires the construction of an at-grade segregated alignment along an existing road including drainage and road reconstruction.
LRT1	×	Requires the construction of an at-grade segregated rail alignment along an existing road including drainage, road reconstruction and overhead wires.
LRT2	×	
RRT	××	Requires the construction of a tunnelled alignment and station boxes along an existing road, interchange at Broadway-City Hall station and an elevated section to integrate with the VCC-Clark SkyTrain station.
Combo 1	××	Requires the construction of a tunnelled alignment and station boxes along an existing road, interchange at Broadway-City Hall station and an elevated section to integrate with the VCC-Clark SkyTrain station. Requires the construction of an at-grade segregated rail alignment along an existing road corridor and former railway including drainage, road reconstruction and overhead wires.
Combo 2	××	Requires the construction of a tunnelled alignment and station boxes along an existing road, interchange at Broadway-City Hall station and an elevated section to integrate with the VCC-Clark SkyTrain station. Also requires the construction of an at-grade segregated alignment along an existing road including drainage and road reconstruction.

Impacts from Construction

11.6 The construction of each alternative is expected to be short term however each will have its own unique set of impacts. As the other accounts capture the impacts of the rapid transit in service, there is a need to consider the impacts of construction separately under the Constructability category of Deliverability.

11.7 The impacts from construction are examined qualitatively against each account in turn.

Financial

11.8 The capital cost estimates produced for this evaluation include an allowance for contingencies which could also capture some of the direct site specific impacts during construction. However, there may be other capital and operating costs indirectly associated with the construction.

11.9 The construction of LRT and BRT alternatives is expected to require traffic lanes being taken out in sections over a three year period, while the construction of station boxes for the RRT alternatives would require closures of sections of Broadway around stations for up to 9 months (duration and/or severity could be reduced but this would increase costs). The financial implications of this construction may include:

- The construction works along Broadway are expected to generate local congestion and increased journey times for buses. Depending on the delays there may be a need to deploy additional buses to maintain the same passenger capacity, and that would have capital and operating cost implications. In addition there are likely to be additional infrastructure costs to the bus network for moving/replacing overhead trolley wires during construction.
- If there are any construction disruptions to the existing B-Line, Canada Line or Expo/Millennium lines it may result in some transit riders shifting to auto and/or a reduction in the total number of transit journeys made which would result in a loss in transit revenues.
- Finally, there would be a cost associated with the public communication of alternate transit and traffic arrangements (e.g. if transit services are diverted or removed) although this is largely assumed to be covered under the consultation elements of the capital costs.

11.10 The findings from this assessment are set out in Table 11.2.

TABLE 11.2 FINANCIAL IMPACTS FROM CONSTRUCTION ASSESSMENT

Alternative	Qualitative Assessment	Commentary
Best Bus	-	No material financial impacts during implementation of additional service or maintenance facilities
BRT	×	Impacts on congestion during construction (reduced traffic lanes) may lead to increased capital and operating costs to deliver sufficient capacity on transit services along Broadway
LRT1	×	
LRT2	×	Impacts on congestion during construction (reduced traffic lanes) may lead to increased capital and operating costs to deliver sufficient capacity on transit services along Broadway
RRT	×	Impacts on congestion during construction (closure of parts of Broadway to construct station boxes) may lead to increased capital and operating costs to deliver sufficient capacity on transit services along Broadway.
Combo 1	×	Impacts on congestion during construction (reduced traffic lanes and closure of parts of Broadway between Arbutus and Main to construct station boxes) may lead to increased capital and operating costs to deliver sufficient capacity on transit services along Broadway.
Combo 2	×	

Transportation

11.11 The expected transportation impacts include:

- The construction works would generate local congestion and increase journey times for existing transit users along the corridor. Congestion not only affects the average journey time but also reduces the reliability of journey times and the likelihood of uneven headways and capacity issues unless impacts are mitigated through the provision of additional transit services or priority measures (which would have additional financial impacts).
- If there are construction disruptions to the Canada or Expo/Millennium lines it may also lead to extended journey times for users of those services;
- Increased congestion through construction works and any temporary turning restrictions or temporary parking restrictions (for works sites) along Broadway would affect road users;
- Road (and transit) users on parallel and perpendicular corridors are also likely to suffer increased journey times from congestion as traffic slows and is diverted off the main construction route; and
- Road works may also result in temporary barriers which reduce the transit system access and connectivity with the urban environment.

TABLE 11.3 TRANSPORTATION IMPACTS FROM CONSTRUCTION ASSESSMENT

Alternative	Qualitative Assessment	Commentary
Best Bus	-	No material impacts on transportation during implementation
BRT	×	Impacts on congestion during construction (reduced traffic lanes on Broadway) and turn restrictions may lead to increase in transit and auto journey times. Access to transit may be hindered. LRT requires more involved construction and so has higher impacts.
LRT1	××	
LRT2	××	The impacts above would be replicated for this alternative with similar activity occurring on the False Creek branch (where impacts would be lower since much of the branch runs in its own right-of-way)
RRT	××	Impacts on congestion during construction (from station box construction) may lead to increases in transit and auto journey times. Access to transit may be hindered.
Combo 1	××	The impacts of this alternative are similar to those of the RRT alternatives and the LRT2 alternatives.
Combo 2	×××	In addition to the impacts identified above, the construction of two alternatives in the same corridor is likely to result in greater traffic, transit, parking and related negative impacts.

Environment

11.12 The construction of the rapid transit alternatives, like most construction initiatives, would have a number of short-term environmental impacts. These were highlighted under the Environment Account and summarized below.

Noise and Vibration During Construction

11.13 During construction of the rapid transit alternatives, there could be noise and vibration effects from:

- Site clearance and excavation;
- Piling;
- Materials handling;
- Compacting fill material;
- Operation of plant and equipment;
- Movement of plant and vehicles;

11.14 At this stage of project development, there is very little information on likely construction methods and programme. However, given the close proximity of residential areas, there is a strong likelihood that noise impacts may occur, particularly from piling and excavation near proposed stations for the RRT and Combination alternatives.

11.15 Potential measures to avoid, minimize and mitigate noise impacts during the construction works, would include restrictions on working hours and acoustic screening of plant and equipment.

Greenhouse Gas and Criteria Air Contaminants

11.16 It is expected that air contaminants would be generated from:

- Site clearance;
- Excavation and earthworks;
- Concrete batching and materials handling;
- Movement of plant and vehicles; and.
- Gaseous emissions from powered plant and vehicles.

11.17 The extent and magnitude of air quality impacts would depend on the selected location of worksites. It is likely that mitigation of impacts from the generation of contaminants would be required.

11.18 GHG emissions from the production of the materials required to construct the alternatives presents a negative impact for all alternatives, particularly from constructing tunnelled and elevated sections as well as station boxes. The resource summaries for each alternative are summarized in Table 11.4. Note that these impacts were captured under the emissions 'Whole Life Cycle Impacts' in the Environment Account and are offset, in most cases, by reductions in emissions from modal shift from auto to transit (see Table 7.2).

TABLE 11.4 RESOURCE REQUIREMENTS BY ALTERNATIVE

Alternative	Concrete (m3)	Steel (tonnes)	Asphalt (tonnes)
Best Bus	Not Assessed		
BRT	25,000	5,000	69,000
LRT1	117,000	23,000	38,000
LRT2	164,000	33,000	44,800
RRT	329,000	57,000	5,800
Combo 1	249,000	45,000	33,000
Combo 2	168,000	29,000	74,000

Water Environment and Biodiversity

11.19 The key potential sources of damage to the water environment that may occur during construction in the Broadway corridor would be:

- Contaminated run-off during construction works;
- Contamination of ground water resources during excavation/piling, etc;
- Groundwater drawdown due to infiltration to excavation works; and
- Disposal of contaminated water from dewatering of excavation works.

11.20 However, given the level of design and the location of the construction sites, the construction of the alternatives are not expected to result in any significant impacts on water environment and biodiversity provided that standard construction mitigation measures are put in place (as would be required through the environmental permitting process).

Environmental Impact from Construction Summary

11.21 Table 11.5 summarizes the key environmental impacts from constructing each rapid transit alternative. In cases other than Best Bus, the GHG and CAC emissions would be offset over the life cycle of the rapid transit system due to changes in transit operations and mode shift reductions.

TABLE 11.5 ENVIRONMENTAL IMPACTS FROM CONSTRUCTION ASSESSMENT

Alternative	Qualitative Assessment	Commentary
Best Bus	-	Limited environmental impacts associated with the construction of additional bus layover facilities at UBC
BRT	×	The construction of the segregated alignment would lead to additional noise, vibration and air contaminants over the construction period. The use of concrete would result in GHG emissions, while additional construction vehicles and slower traffic speeds would also result in an increase in CAC and GHG emissions.
LRT1	××	The construction of the segregated alignment would lead to additional noise, vibration and air contaminants over the construction period. The use of concrete would result in additional GHG emissions, while additional construction vehicles and slower traffic speeds would also result in an increase in CAC and GHG emissions.
LRT2	××	
RRT	×××	The construction of the RRT alignment would lead to additional noise, vibration and air contaminants over the construction period. In particular, excavation and piling adjacent to stations and along the elevated section would have adverse noise and vibration impacts. The significant use of concrete would result in GHG emissions, while additional construction vehicles, (in particular the trucks required to remove excavated materials) and slower traffic speeds would also result in an increase in CAC and GHG emissions.
Combo 1	×××	
Combo 2	×××	As with the RRT and Combination Alternative 1, Combination Alternative 2 has significant negative impacts to traffic as well as from tunnelling, excavation, noise and vibration and would have the additional negative impacts from constructing transit both below and on Broadway.

Economic Development

11.22 The construction of a rapid transit corridor may have short term localized impacts on economic development. The key potential impacts include:

- The stimulation of redevelopment along the corridor in anticipation of improved transit accessibility;
- Local businesses may be temporarily affected as their premises become less attractive to customers due to congestion and on-street parking impacts associated with construction. This may lead to a temporary reduction in employment, income and productivity for business along the corridor. However, other areas in the City may benefit from additional revenues as there would be a transfer of business activity; and
- The construction works are likely to result in increased and more irregular journey times for goods movements due to increased congestion or diversions.

TABLE 11.6 ECONOMIC DEVELOPMENT IMPACTS FROM CONSTRUCTION ASSESSMENT

Alternative	Qualitative Assessment	Commentary
Best Bus	-	No significant impacts anticipated
BRT	××	The construction of the segregated alignment on Broadway would lead to a temporary adverse impact on local businesses due to congestion and-on street parking impacts. Surface alternatives would result in disruption the length of the corridor that would be of shorter duration and less intensity than the more focussed and longer duration RRT station construction. At this stage of project development the overall impacts appear to be similar across all the alternatives and shall be reviewed in the context of the development of any more detailed construction planning in Phase 3.
LRT1	××	
LRT2	××	
RRT	××	
Combo 1	××	
Combo 2	××	

Social Community

11.23 Currently there are no known temporary impacts of construction to Heritage or Archaeology but these would need to be revisited as the detailed design of station locations and accesses are identified. Other impacts may include:

- Increased health and safety risks to residents, pedestrians, cyclists and motorists adjacent to sites of construction activity; and
- Reduced community cohesion as a result of severance and visual intrusion associated with construction works.

TABLE 11.7 SOCIAL COMMUNITY IMPACTS FROM CONSTRUCTION ASSESSMENT

Alternative	Qualitative Assessment	Commentary
Best Bus	-	No significant impacts anticipated
BRT	××	Construction works on Broadway may lead to increased health and safety risks to residents, pedestrians, cyclists and motorists adjacent to sites of construction, increased severance and visual intrusion. Surface alternatives would result in disruption the length of the corridor that would be of shorter duration and less intensity than the more focussed and longer duration RRT station construction. At this stage of project development the overall impacts appear to be similar across all the alternatives and shall be reviewed in the context of the development of any more detailed construction planning in Phase 3.
LRT1	××	
LRT2	××	
RRT	××	
Combo 1	××	
Combo 2	××	

Constructability – Summary Assessment

11.24 Table 11.8 summarizes the overall assessment against the Constructability criteria.

TABLE 11.8 CONSTRUCTABILITY SUMMARY ASSESSMENT

Alternative	Qualitative Assessment	Commentary
Best Bus	-	No major impacts over and above the BAU
BRT	×	Traffic impacts resulting in increased congestion, parking and goods movement delays as well as relatively minor impacts from GHGs due to the production of the materials needed for construction.
LRT1		
LRT2		
RRT	××	Traffic impacts resulting in increased congestion, parking and goods movement delays as well as additional noise and vibration impacts from station construction and larger impacts from GHGs due to the production of the materials needed for construction.
Combo 1		
Combo 2	×××	Impacts across the same corridor both above and below grade would result in significant impacts including increased congestion, parking and goods movement delays as well as additional noise and vibration impacts from station construction and larger impacts from GHGs due to the production of the materials needed for construction.

Acceptability

11.25 To assess the acceptability of each of the alternatives, market research was undertaken in early 2012 through an online survey via the TransLink Listens panel (see Appendix F for full results). Respondents were provided high level information about each alternative and asked to indicate the acceptability of each alternative relative to continuing to serve the corridor with buses i.e. Business as Usual. Respondents were provided with a 5 point scale for their responses:

- Very Acceptable (5)
- Somewhat Acceptable (4)
- Neither Acceptable nor Unacceptable (3)
- Somewhat Unacceptable (2)
- Very Unacceptable (1)
- Don't know/Unsure

11.26 There were 1,828 respondents from across Metro Vancouver. The results were further segmented by those that live in the City of Vancouver and those that live or travel in the study area. There were no significant differences between the results provided by these segments relative to the overall sample. Table 11.9 provides a summary of results of the research which are further summarized in Figure 11-1. The research revealed that based on the current designs and evaluation:

- Best Bus, BRT and Combination 2 are less acceptable than the Business as Usual alternative;
- LRT1, LRT2, Combination 1 and RRT are all more acceptable than the BAU with RRT receiving the highest acceptability rating.

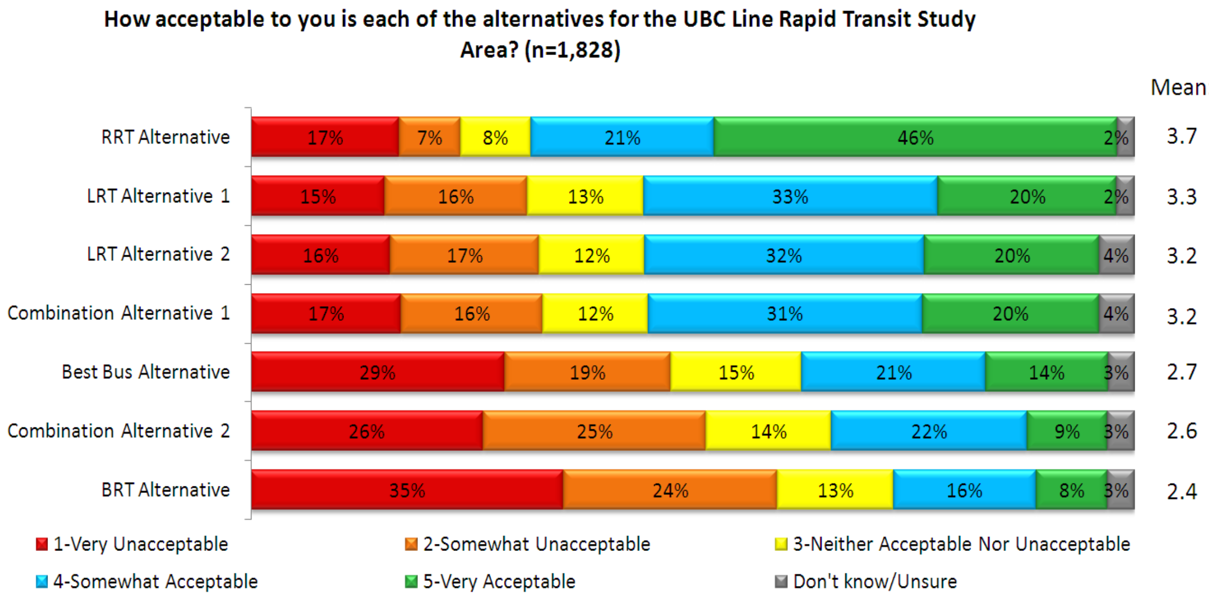
TABLE 11.9 ACCEPTABILITY SURVEY RESULTS

Alternative	% very or somewhat acceptable	% very or somewhat unacceptable	Mean Score (on a scale of 1-5)	Factors influencing rating
Best Bus	35%	48%	2.7	Of those who rated somewhat/very acceptable: ▪ Affordability (25%) Of those who rated somewhat/very unacceptable: ▪ Capacity (32%) ▪ Emissions (10%) ▪ Value for Cost (6%) ▪ Speed (5%)

Alternative	% very or somewhat acceptable	% very or somewhat unacceptable	Mean Score (on a scale of 1-5)	Factors influencing rating
BRT	24%	59%	2.4	Of those who rated somewhat/very acceptable: - Affordability (17%) Those who rated somewhat/very unacceptable: - Capacity (29%) - Impacts on road users (14%) - Lack of improvement (7%) - Speed (7%) - Value for cost (6%)
LRT1	53%	32%	3.3	Of those who rated somewhat/very acceptable: - Affordability (12%) - Capacity and expandability (7%) Of those who rated somewhat/very unacceptable: - Impacts on road users (24%) - Appearance and noise (12%) - Affordability (10%) - Cost-effectiveness (8%) - Capacity (7%) - Speed (7%)
LRT2	52%	33%	3.2	Of those who rated somewhat/very acceptable: - Affordability (10%) - Capacity and expandability (8%) Of those who rated somewhat/very unacceptable: - Impacts on road users (19%) - Appearance and noise (11%) - Expense (10%) - Cost-effectiveness (7%) - Capacity (6%) - Speed (5%)

Alternative	% very or somewhat acceptable	% very or somewhat unacceptable	Mean Score (on a scale of 1-5)	Factors influencing rating
RRT	66%	24%	3.7	Of those who rated somewhat/very acceptable: - Speed (18%) - Capacity and expandability (15%) - Improvement to vehicle traffic (12%) - Reduced emissions (6%) - Cost effectiveness (6%) - Appealing look (6%) Of those who rated somewhat/very unacceptable: - Affordability (53%) - Construction (12%)
Combination 1	50%	33%	3.2	Of those who rated somewhat/very acceptable: - Ease of expanding system (8%) - Extent of coverage (5%) Of those who rated somewhat/very unacceptable: - Affordability (23%) - Impacts on road users (10%) - Speed (5%) - Value for cost (5%)
Combination 2	31%	51%	2.6	Of those who rated somewhat/very acceptable: - Ease of expansion (11%) - Affordability (9%) Of those who rated somewhat/very unacceptable: - Capacity (19%) - Affordability (13%) - Cost-effectiveness (8%) - Impacts on road users (8%) - Extent of coverage (6%) - Appearance (5%) - Duplication of service (5%)

FIGURE 11-1 ACCEPTABILITY RATINGS FROM MARKET RESEARCH



Affordability

11.27 While there is currently no funding allocated to the UBC Line, the initial capital and annual operating costs (in 2010$) assists the identification of the likely costs that would require funding and is set out in Table 11.10. However an assessment of affordability must consider the alternatives in the context of other regional investment needs and available funding and cannot be undertaken within a single corridor study.

TABLE 11.10 FUNDING ASSESSMENT ($M 2010)

Alternative	Real	Present Value				
	Total Capital Cost	Total Capital Cost	Incremental Renewal Cost	Incremental O&M Cost	Incremental Farebox Revenue*	Total Cost
Best Bus	122	83	13.0	32	9	**119**
BRT**	409	219	-4.1	3	34	**184**
LRT1	1,112	689	-0.2	-14	54	**621**
LRT2	1,332	830	-0.2	16	57	**789**
RRT	3,010	2,005	0.8	-1	260	**1,745**
Combo 1	2,666	1,701	-0.7	5	214	**1,491**
Combo 2**	1,966	1,263	2.5	51	204	**1,112**

NOTE: * Incremental revenue is presented as a positive number
** Fare revenue estimates capped as described in paragraph 5.3

Deliverability Account Key Points

- There are no technical engineering issues which would prevent any of the alternatives from being constructed.
- All rapid transit alternatives would have construction impacts. In scale, these impacts are not significantly different. Alternatives including BRT and LRT would have construction impacts over their full length. These would be of a shorter duration than the RRT tunnel and station construction which would be more intensive and occur largely at station sites with little impact between them.
- Market research on acceptability reveals that, based on the current designs and evaluation:, LRT1, LRT2, Combination 1 and RRT are more acceptable than the BAU with RRT receiving the highest acceptability rating. Best Bus, BRT and Combination 2 are less acceptable than the Business as Usual (BAU).
- The BRT alternative has the lowest lifecycle costs and the RRT alternative has the highest lifecycle costs.
- Figure 11-1 provides the summary scores for the Deliverability Account.

FIGURE 11-2 DELIVERABILITY ACCOUNT SUMMARY

Criteria	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Constructability	◒	◒	◔	◔	◔	◔	○
Acceptability	◔	◔	◕	◕	●	◕	◔
Affordability	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Summary Score	◒	◒	◒	◒	◒	◒	◔

12 Sensitivity Testing

Introduction

12.1 The Phase 2 rapid transit alternatives and the evaluation presented in this report were developed using an agreed set of assumptions that included:

- Design assumptions – stops, horizontal and vertical alignment, vehicle lengths, train consists (see the Design Principles in Appendix C for the assumptions for each alternative);
- Operating assumptions – rapid transit and bus network headways, daily, weekly and annual operating patterns, end-to-end run times;
- Economic and Financial assumptions – values of time, inflation, discount rates; and
- Land use and Policy assumptions – location, scale and timing of population/employment growth, costs and availability of parking, road network changes.

12.2 Together these assumptions represent the ‘central’ case which, in simple terms, is the ‘most likely’ future scenario. There will always be a degree of uncertainty surrounding some of these assumptions and sensitivity tests have therefore been undertaken to understand the scale of impact that changes in some of the assumptions may have on the final evaluation. The tests included modelling and forecasting (using RTPM08) and economic evaluation assumption tests.

Modelling & Forecasting Sensitivity Tests

12.3 Nine modelling and forecasting sensitivity tests were undertaken and are summarised in Table 12.1. Further commentary explaining the rationale for the values selected is provided in the sub-sections that follow. Tests were only undertaken for the 2041 forecast year and only for the LRT1 and RRT alternatives to demonstrate the scale of the impact.

TABLE 12.1 MODELLING & FORECASTING SENSITIVITY TESTS

Test	LRT1	RRT	Commentary/ Rationale
Travel Time Increase	+20%	-	
Headway (minutes)	6	1.5 and 6	
Surrey Rapid Transit	RRT extension from King George to Langley with BRT on 104th Avenue and King George Boulevard		RRT was selected from the alternatives considered in the Surrey Rapid Transit Study because it has the greatest potential impact on UBC Line demand.
Traffic Lane removed	-	✓	
Slower/Faster Land Use Growth	✓		Slow down/advance 2041 forecasts by 10 years
Interchange penalty	2.5min		Reduced from 4 minutes and applied to the rapid transit line only
TDM Impact	150% increase to vehicle operating costs and parking		Percentage increase based on previous analysis
Phased RRT Extensions	-	✓	To Cambie and Arbutus
LRT Partial Grade Separation	✓	-	Impact of LRT1 running underground through Central Broadway

Travel Time Increase

12.4 The central case assumption for the LRT1 travel time was 28.1 minutes from Commercial/Broadway to UBC. This travel time was calculated using a run time model and was further tested using a corridor VISSIM model. However, to understand the potential impacts of not achieving this run time, a 20% slower run time of 33.7 minutes was also tested. It is worth noting that this is slower than the predicted run time of the BRT alternative which includes no signal priority and slower than the maximum run time projected by the VISSIM model.

Headway

12.5 The central case assumption for LRT1 was a 4-minute headway and a 3-minute headway was assumed for the RRT. A series of tests were run to understand the impacts of running less frequent service on the LRT1 and RRT (6-minutes) as well as running at the maximum frequency possible using SkyTrain technology for the RRT alternative (90 seconds). It is worth noting that while 90 seconds is normally technically feasible on RRT, constraints elsewhere on the Millennium Line may mean it is not be achievable on the UBC Line without additional capital investment.

Surrey Rapid Transit

12.6 Any investment or expansion of the regional rapid transit network is likely to have wider impacts outside of the immediate area of expansion. With the Project Sponsors also engaged in rapid transit planning elsewhere in the region, a sensitivity test was undertaken to understand what impact rapid transit expansion in Surrey may have on demand forecasts for the UBC Line. For the purposes of this test, it was assumed that this would include a SkyTrain extension to Langley from King George Station along Fraser Highway, as well as BRT on 104th Avenue and King George Boulevard – not because this was viewed as the preferred alternative, but because the SkyTrain extension alternative was forecast to generate the highest numbers of boardings (and therefore have the greatest potential impact on the UBC Line).

Traffic Lane Removed

12.7 The surface rapid transit alternatives reallocate road space from other vehicles to provide dedicated, segregated transit ways. The RRT alternative, on the other hand, is designed to operate underground with no interaction with other traffic. In addition, with the introduction of underground rapid transit, it is likely that many of the remaining local buses on the street would no longer be required and that the existing peak period bus lanes could be reallocated. The central case assumed that this road space would be made available to private cars and a test was therefore undertaken on the RRT alternative to test the impacts of removing a lane of traffic from the corridor.

Slower / Faster Land Use Growth

12.8 As noted earlier, the land use forecasts used in the demand forecasting were provided by Metro Vancouver and were developed through the updated Regional Growth Strategy. However, to understand the impacts of different future land use scenarios, two alternatives were tested – a slower growth scenario and a faster growth scenario. Both forecasts were developed by Metro Vancouver in consultation with City of Vancouver Planning and UBC Campus and Community Planning. These forecasts either slowed or accelerated 2041 growth in the corridor by 10 years.

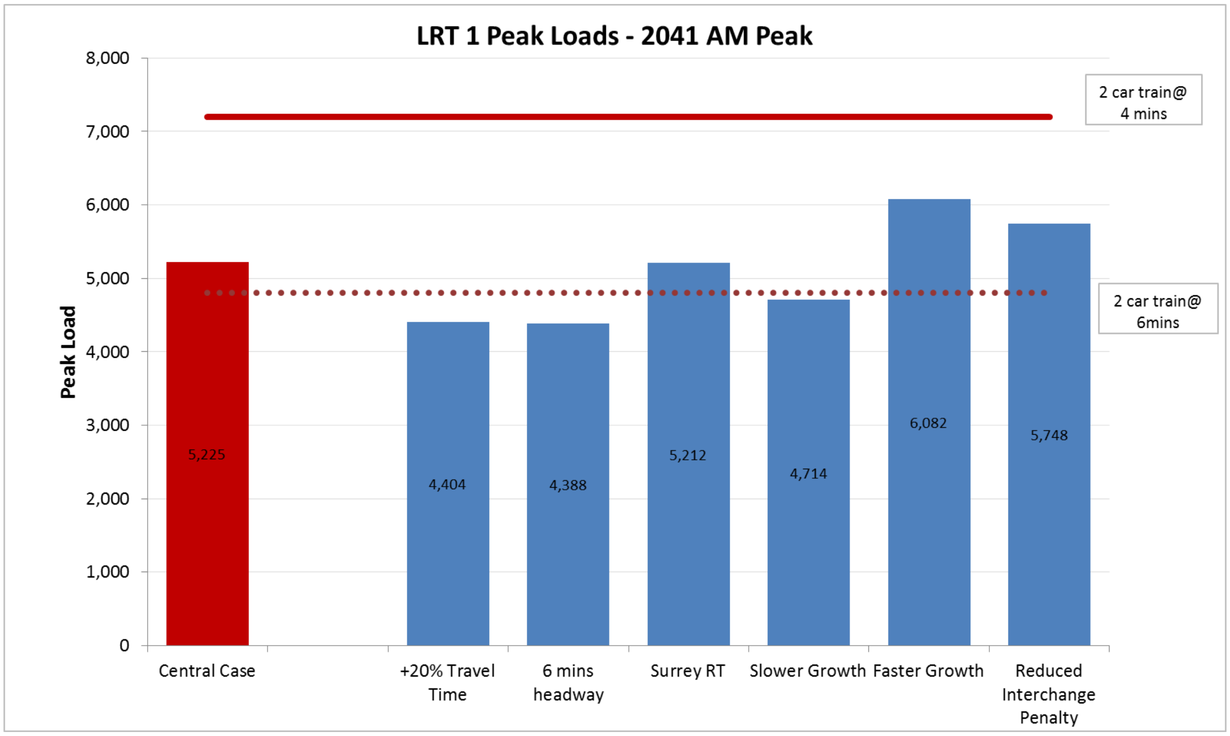
Reduced Interchange Penalty

12.9 As described earlier, the RTPM08 model was used to forecast travel in the region including transit trips on the rapid transit line. The model was developed and calibrated using an agreed set of parameters including an ‘Interchange Penalty’. The interchange penalty was set at 4-minutes based on matching observed travel patterns in the region and represents the perceived penalty or inconvenience that transit riders incur when forced to change between two services. To understand the impacts that this penalty has on rapid transit ridership, a lower rate of 2½ minutes was tested for the rapid transit line only (i.e. the penalty was left at 4-minutes network wide but reduced to 2½ minutes on the UBC Line).

Modelling and Forecasting Test Results

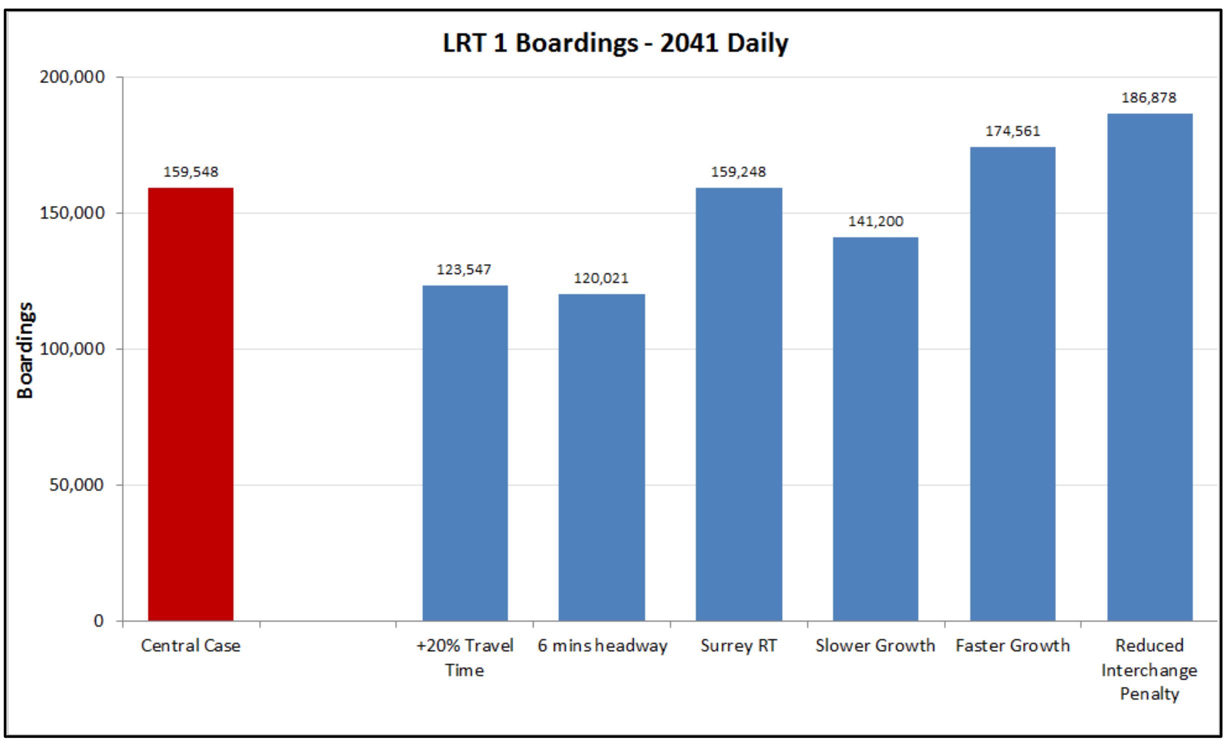
12.10 Figures 12-1 and 12-2 present the impacts on the peak loads and weekday boardings of each of the tests on the LRT1 alternative and then Figure 12-3 and 12-4 present the same information for the RRT forecasts.

FIGURE 12-1 LRT1 MODELLING & FORECASTING SENSITIVITIES – PEAK LOAD IMPACTS



NOTE: LRT capacity could be further expanded with reduction in speed and reliability due to reduced transit priority

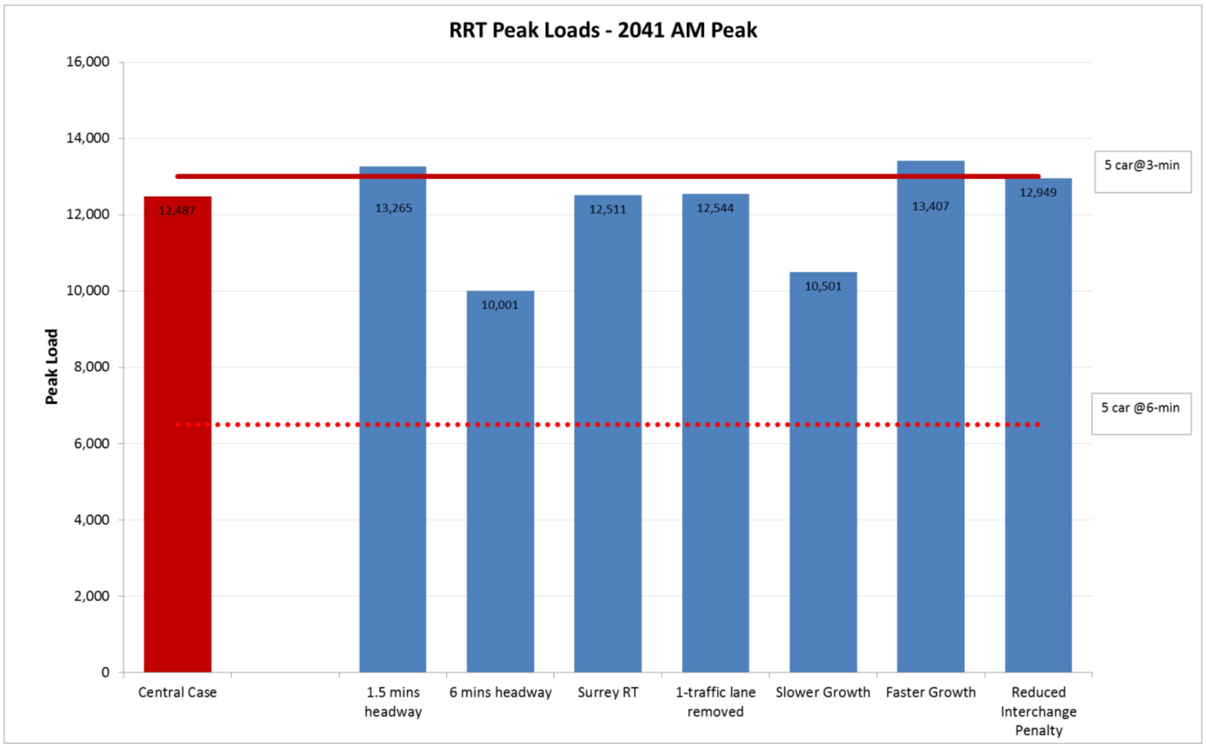
FIGURE 12-2 LRT1 MODELLING & FORECASTING SENSITIVITIES – WEEKDAY BOARDINGS



12.11 Figures 12-1 and 12-2 show that the forecasts for the LRT are quite sensitive to total journey times with either the slower journey time or the increased headway resulting in a loss of approximately 20% of passengers and similarly reductions in the total journey time (represented by the decreased interchange penalty), results in an increase in ridership of approximately 10%.

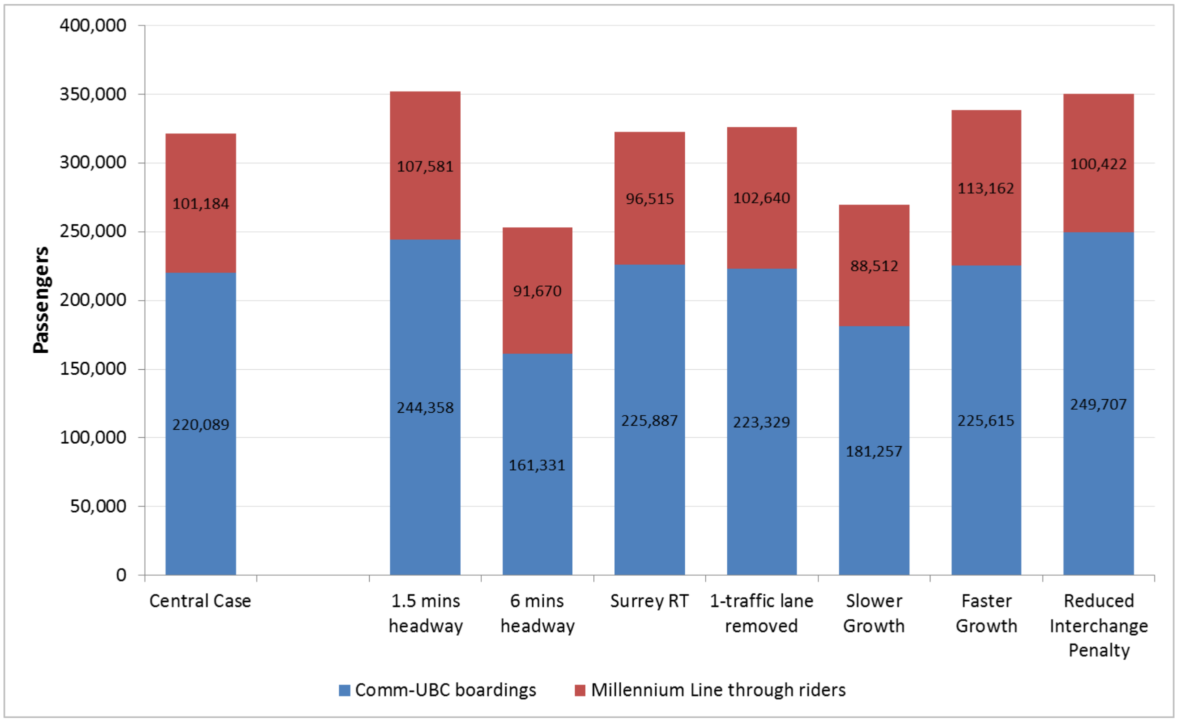
12.12 The figures also show the limited impact that Surrey rapid transit has on the UBC Line (with virtually no impact on ridership) and that by slowing down or speeding up growth in the corridor, ridership goes up or down by approximately 10%.

FIGURE 12-3 RRT MODELLING & FORECASTING SENSITIVITIES – PEAK LOAD IMPACTS



Note: Theoretical capacity RRT of 26,000 assuming a 90 second headway and 5 car train

FIGURE 12-4 RRT MODELLING & FORECASTING SENSITIVITIES – WEEKDAY BOARDINGS



12.13 Figures 12-3 and 12-4 show a similar pattern to Figures 12-1 and 12-2 with the results being quite sensitive to total journey times where increased headways resulted in a loss of approximately 20% of passengers and similarly reductions in the total journey time (represented by either reduced headways or a decreased interchange penalty), resulted in an increase in ridership of just under 10%. The figures also show the same limited impact of the Surrey rapid transit project on the UBC Line (with virtually no impact on ridership).

12.14 The results are slightly different for the slower or faster growth scenarios for the RRT where the slower growth results in a loss of approximately 20% of weekday boardings but the faster growth generates less than 10% more ridership.

12.15 As might be expected, the removal of a traffic lane has a limited impact on the ridership forecasts but would have a more significant impact on the overall economic case. For reference, of the $4 billion in present value benefits generated by the RRT alternative (see Table 6.13), $693 million of those come from savings to car users from reduced congestion while the LRT alternative (which reduces road capacity by one lane) includes $93 million in extra costs (disbenefits) to car users. The Benefit:Cost ratio (BCR) impact of removing the traffic lane on the RRT would be to reduce benefits from $4.0 billion to $3.31 billion and therefore reduce the BCR from 2.29 to 1.90.

Transportation Demand Management Impacts

12.16 As noted in Chapter 5, none of the alternatives has a significant impact on the regional transit mode share and none of the alternatives in isolation meets the regional or Provincial targets for transit/non-auto mode shares by 2041. This is not unexpected as this project is only a single line in a large region with diverse travel patterns. A test was therefore undertaken to understand the impacts on ridership if the targets were met using changes in transportation policy (i.e. how much demand would the UBC Line need to carry if the regional mode share targets were achieved). To test this impact, the RTPM08 model was used and the vehicle operating costs (VOC) and parking charges were increased as a proxy for some form of regional demand management measures. From previous modelling experience, the RTPM08 requires quite large increases in auto costs to force modal shifts and, in this instance, an increase of 150% was used for both VOC and parking costs.

12.17 It is worth noting that there are limitations in the available modelling tools to assess this directly. The current model has not been calibrated to accurately forecast changes of this magnitude and therefore the 150% increase should not be assumed as the value required to meet the regional targets.

12.18 The results of this test show that, within the model, there is a significant reduction in regional VKT with the average trip length reducing by over 30%. This is a result of the increased costs of long journeys and the reallocation of trips from long distance to shorter distance trips and within those trips, a reallocation from auto trips to transit and walk/cycle trips.

12.19 Table 12.2 presents the impacts on auto and transit demand for both LRT1 and RRT along with the forecast peak loads on the services. It shows a decrease in the peak loads as a result of people making shorter trips (typically using local services) which reduces the need (slightly) for regional rapid transit services.

TABLE 12.2 TDM SENSITIVITY TEST

2041 AM Peak Hour	LRT1		RRT	
	Central Case	TDM Test	Central Case	TDM Test
Regional Auto Demand	646,040	601,808	644,567	600,040
Regional Transit Demand	155,409	183,405	157,934	186,002
Regional Walk/Cycle Demand	149,165	165,437	148,139	164,664
Regional Transit Mode Share	16.4%	19.3%	16.6%	19.6%
Average vehicle trip (km, regional)	12.4	9.9	12.4	9.9
Peak Load	5,225	4,562	12,847	11,637

LRT Capacity Constraints

12.20 While the TDM test did not increase the peak loads on the LRT, the results from the earlier sensitivity tests showed that by either increasing the rate of population and/or employment growth in the corridor, or by reducing the interchange penalty, both the number of boardings and the peak loads would increase. A further test was therefore run combining these two sensitivities to understand the likely ability of the LRT alternative to carry the resulting demand. The results showed that the peak loads in this test increased from 5,225 to 6,650 which increases the volume:capacity ratio from 0.73 to 0.95 indicating that if both of these scenarios were to materialise that the system would be nearing modelled capacity in the peak hour in 2041. As noted earlier, it is possible to reduce the headways on the LRT alternative below the modelled 4-minutes but that would likely result in increases in journey time due to reduced signal priority. This may provide a solution in the longer term for the 'peak-of-the-peak' if demand exceeds 7,200 where running 2 or 3-minute headways could increase the LRT system capacity by 50-100% at the expense of an increase in end-to-end journey time of approximately 3-4 minutes.

Phased RRT Extensions

12.21 The Combination alternatives and RRT could be built in phases through, for example, extending SkyTrain to Broadway and Arbutus as an interim stage towards extending rapid transit to UBC which would spread out the capital requirements over a longer period of time. BRT and LRT1 are not as likely to be phased due to the lower capital costs; the LRT alternatives would require an LRT operations and maintenance centre; a minimum route length is typically needed to warrant such a facility making the phasing of LRT1 unlikely. LRT2 could be built in phases with an initial phase connecting UBC with either Main Street or Commercial-Broadway.

12.22 A sensitivity test was undertaken to understand the impacts of building RRT in two phases with the first phase built to either Cambie or Arbutus. The analysis was high level and a full multiple account evaluation was not undertaken.

12.23 For this assessment, both the 2021 and 2041 model years were forecast to enable a full 'lifecycle' assessment of phasing. It included updated capital costs estimates – approximately $1 billion to Cambie and $1.5 billion to Arbutus (which includes an additional $100m to account for additional construction and phasing costs) – and included an assessment of the impacts to the wider bus network (i.e. the 99 B-Line).

12.24 The assessment showed that for an extension to Cambie the 99 B-Line bus services would remain over capacity and this is therefore not viewed as providing a short or long term solution to the transportation (capacity) problems in the corridor as shown in Table 12.3.

12.25 The extension to Arbutus appears more viable in the near to medium term. More detailed analysis would be required to understand more precisely when the 99 B-Line from Arbutus to UBC would be at capacity. The high level assessment of phasing RRT suggests that, based on current forecasts, capacity issues would emerge by 2041 depending on how quickly demand to UBC grows. The analysis also suggested that the assumed 99 B-Line service from Arbutus to UBC would result in no increase in required layover/recovery space at UBC; at Arbutus no more than two-thirds of the layover space now provided at Commercial would be required.

12.26 The economic assessment of phasing RRT is positive with a benefit:cost ratio of 2.7, vs. 2.3 if built to UBC initially.

TABLE 12.3 CAPACITY IMPLICATIONS OF RRT AND COMBINATION 1 PHASING

99 B Line	WB from Cambie	WB from Arbutus
Regional Model AM Peak (7:30-8:30)		
2021 Peak Load (pax)	2,146	1,562
2021 Volume/Capacity	0.89	0.65
2041 Peak Load	2,576	1,764
2041 Volume/Capacity	1.07	0.74
UBC AM Peak (08:30-09:30)		
2021 Peak Load (pax)	2,673	1,945
2021 Volume/Capacity	1.11	0.81
2041 Peak Load	3,208	2,197
2041 Volume/Capacity	1.34	0.92

Partial Grade Separation

12.27 LRT1 assumed that LRT would run at-grade for the entire route. Running LRT1 underground through the Central Broadway section would speed up services, increase reliability, and reduce the impact on road traffic. However, capital costs, station construction impacts and station access times would increase. Two options were tested with key statistics as shown in Table 12.4. In order to minimize impacts, bored tunnels (with cut-and-cover stations) have been assumed for cost estimates. Cut-and-cover tunnels would reduce incremental costs by 10-15%.

- PGS Option 1 – 1.7 km tunnel between Willow/Heather and Brunswick Street/Prince Edward Street (Cambie and Main stations underground).
- PGS Option 2 – 4.5 km tunnel between Yew Street/Vine Street and Brunswick Street/Prince Edward Street (Arbutus, Granville, Oak, Cambie and Main stations underground).

TABLE 12.4 PARTIALLY GRADE SEPARATED INPUTS

	LRT1 Original	PGS 1	PGS 2
Tunnel length (km)	0	1.7	4.5
Underground stations	0	2	5
Travel time Commercial – UBC (min)	28.1	26.8	25.9
Fleet requirements (2041, cars)	36	34	32
Costs ($m) – Bored tunnel for PGS	$1,112	$1,379	$1,837
Peak Load (WB peak hour, 2041)	5,225	5,442	5,549
Volume/Capacity ratio (2041)	0.73	0.75	0.77
Corridor transit mode share	30.0%	30.2%	30.2%

12.28 As can be seen in Table 12.4, the shorter travel times resulting from partially tunnelling the line result in reductions in the fleet requirements of up to four LRT cars in 2041. This reduction is possible as the number of additional passengers attracted by the faster service does not increase the peak load enough to require a more frequent service. The travel time benefits to users, as well as reduced disbenefits to road users, result in overall travel time savings relative to the base LRT1 alternative.

12.29 The analysis of the costs and benefits of the PGS options are shown in Table 12.5. This analysis is based on 2041 modelling only, with 2021 ridership interpolated. The additional costs of PGS 1 are almost equivalent to its additional benefits while for PGS 2 the benefits exceed the cost by a greater margin and so lead to a better Benefit:Cost ratio for PGS 2 than for the base LRT1 alternative.

TABLE 12.5 PARTIALLY GRADE SEPARATED RESULTS

	Total Benefits		
	LRT1 Original	LRT1 - PGS 1	LRT1 - PGS 2
Benefits ($m, PV)	$962	$1,813	$2,445
Costs ($m, PV) – Bored tunnel for PGS	$621	$967	$1,146
Net Present Value ($m)	$341	$538	$763
Benefit:Cost Ratio	1.55 : 1	1.56 : 1	1.67 : 1

Economic Sensitivity Tests

12.30 A number of economic evaluation sensitivity tests were undertaken on a variety of assumptions contained in appendix A:

- Discount Rate – the central case used a 6% discount rate and tests were undertaken using 3% and 10% rates;
- Opening Year – adjustments to the opening year of the rapid transit line;
- Annualisation – impacts of using a lower value; and
- Post-2041 growth – effects of assuming growth after the last forecast year (2041).

Discount Rate

12.31 The central case assumption for the evaluation uses a 6% per year discount rate over 30 years to calculate present value costs and benefits. This is the rate typically used by the Province of BC and is appropriate for a large-scale construction project like the UBC Line (with an operational life of 60 years or more), as there will be a long stream of future benefits to recover the initial cost outlay.

12.32 The Federal Government prescribes a discount rate of 10%, which reflects both the period in which they expect an investment to give a return as well as the level of certainty in future benefits and costs.

12.33 A sensitivity test has been undertaken to illustrate how the NPV and BCR would be affected by employing a discount rate of 10%. The results in Table 12.6 show that in all cases the NPVs and BCRs are significantly worse, with only the RRT and the Combination alternatives showing BCRs greater than 1:1.

TABLE 12.6 NET PRESENT VALUES (2010 $M) AND BENEFIT COST RATIOS – 10% DISCOUNT RATE

Alternative	PVB ($m)	PVC ($m)	NPV ($m)	BCR
Best Bus	43	74	-31	0.6 : 1
BRT*	153	147	6	1.0 : 1
LRT1	440	496	-56	0.9 : 1
LRT2	447	615	-168	0.7 : 1
RRT	1,851	1,458	393	1.3 : 1
Combo 1	1,435	1,216	219	1.2 : 1
Combo 2*	1,104	906	198	1.2 : 1

*NOTE: * Forecasts capped as described in paragraph 5.3*

12.34 A further sensitivity test was undertaken to illustrate how the NPV and BCR would be affected by employing a much lower discount rate of 3% - a rate more typical of other national governments. The results in Table 12.7 show that in all cases the NPVs and BCRs are significantly improved, with all alternatives showing BCRs greater than 1:1 and the RRT and the Combination alternatives delivering more than three times more benefits than costs (i.e. BCRs greater than 3:1).

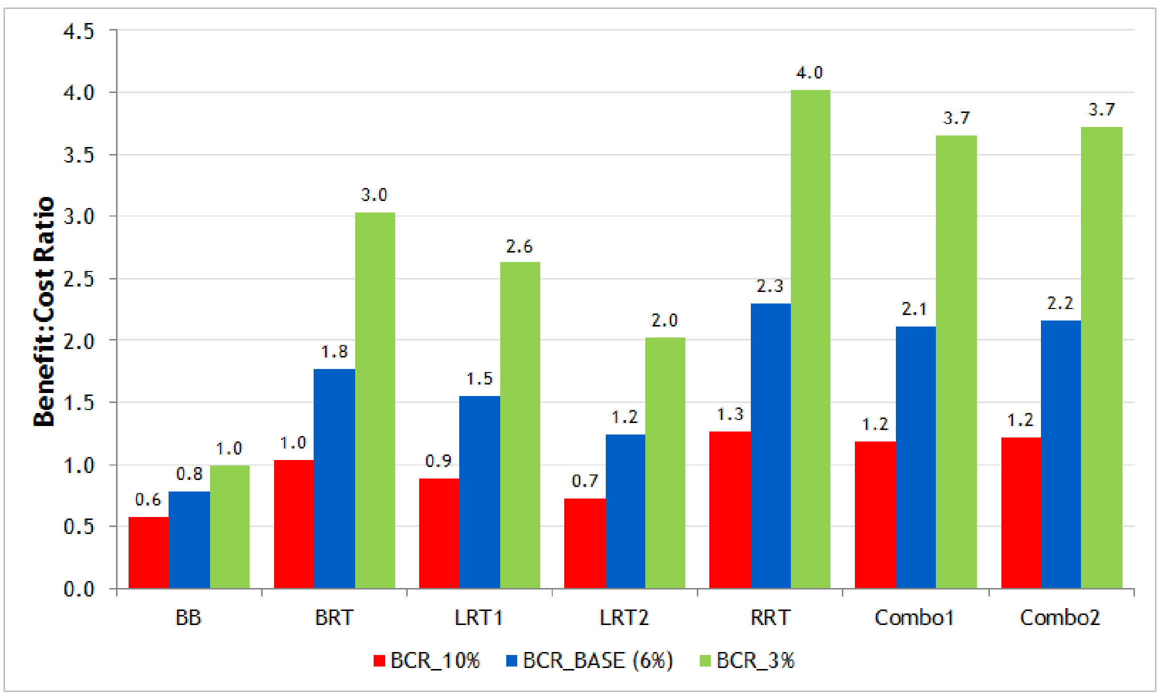
TABLE 12.7 NET PRESENT VALUES (2010 $M) AND BENEFIT COST RATIOS - 3% DISCOUNT RATE

Alternative	PVB ($m)	PVC ($m)	NPV ($m)	BCR
Best Bus	181	182	-1	1.0 : 1
BRT*	621	205	415	3.0 : 1
LRT1	1,882	717	1,165	2.6 : 1
LRT2	1,909	945	964	2.0 : 1
RRT	7,760	1,930	5,830	4.0 : 1
Combo 1	6,182	1,693	4,489	3.7 : 1
Combo 2*	4,689	1,259	3,429	3.7 : 1

*NOTE: * Forecasts capped as described in paragraph 5.3*

12.35 Figure 12-5 then shows the central case and the upside (3%) and downside (10%) discount rate sensitivities.

FIGURE 12-5 DISCOUNT RATE SENSITIVITY TESTS



Opening Year

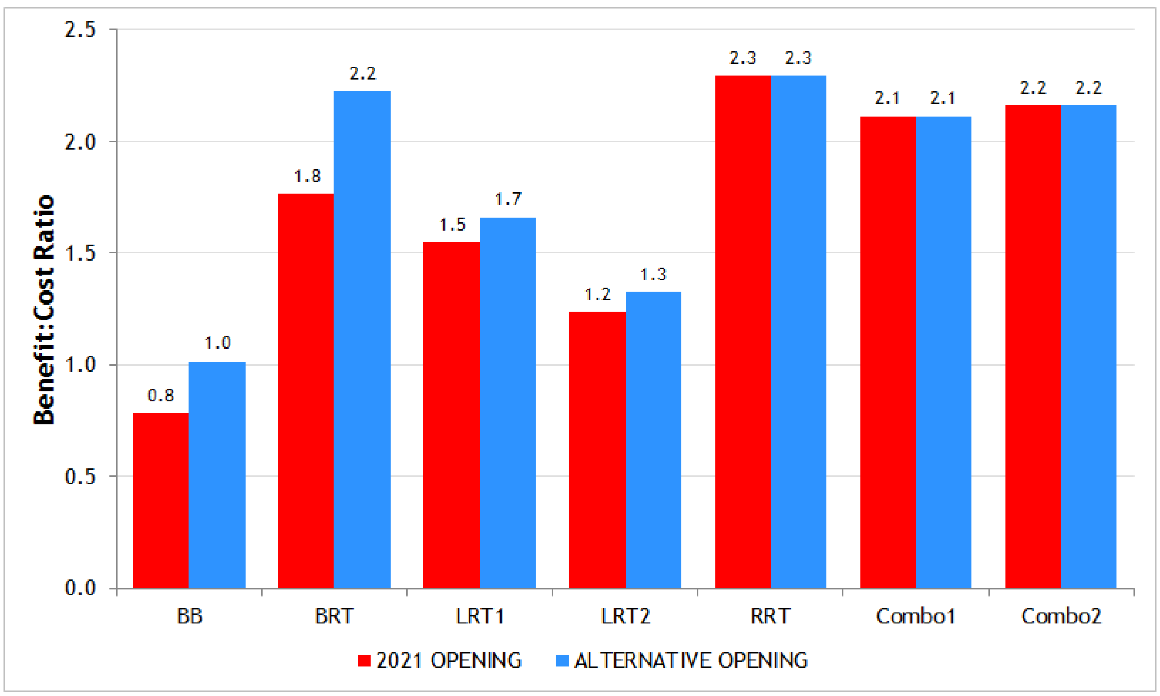
12.36 The central case assumption was that all rapid transit alternatives would open in the same year in 2021. However, for many large infrastructure projects design and construction work begins immediately after they are announced. The result of this alternative approach is that alternatives that take less time to design and construct could be open sooner than others.

12.37 The following opening years were selected for the sensitivity tests, assuming a decision in 2014 and the construction durations given in paragraph 6.5:

- 2015 – Best Bus;
- 2017 – BRT;
- 2019 – LRT1 and LRT2; and
- 2021 – RRT, Combination 1 and Combination 2.

12.38 Figure 12-6 illustrates the impacts that the earlier opening years (for Best Bus, BRT and the LRT alternatives) has on the Benefit Cost ratios for these alternatives. This test illustrated that the BCRs of the faster to construct options (Best Bus BRT, LRT and LRT2) improved and were unchanged for those that have longer construction periods (RRT and Combinations 1 and 2). The relative performance of BRT improves relative to the other alternatives providing the second highest BCR in this test.

FIGURE 12-6 OPENING YEAR SENSITIVITY TEST

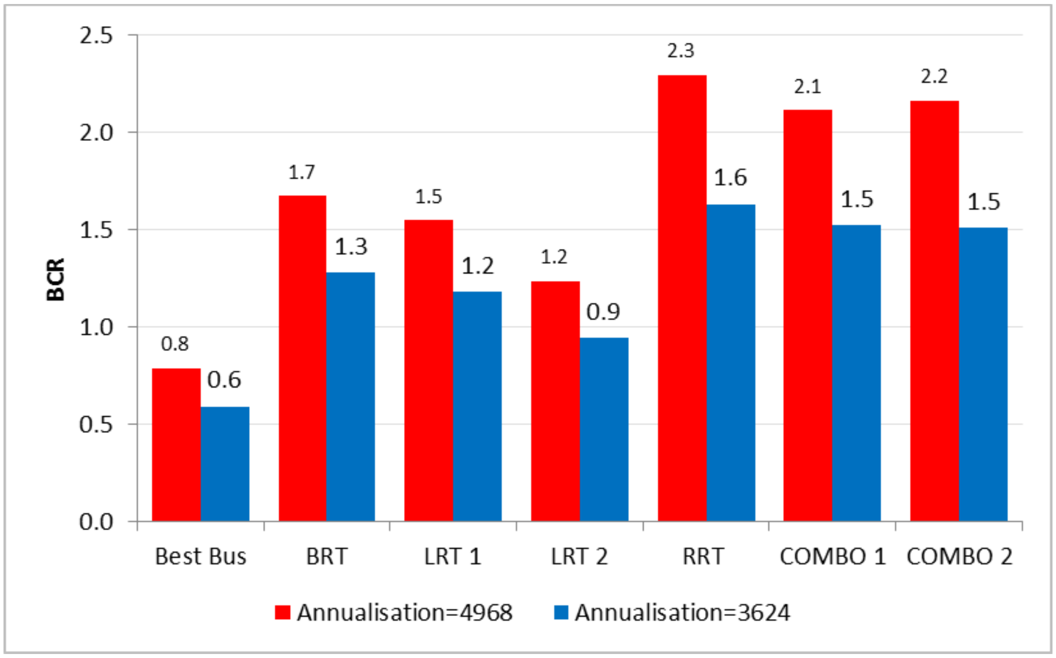


Annualisation

12.39 The annualisation factor of 4,968 (from AM peak hour to annual) in Appendix A was estimated from transit demand for screenline 116 (UBC) from the 2008 regional screenline data. The higher than typical value reflects the fact that the modelled AM peak hour (7:30-8:30) does not coincide with the actual peak hour in terms of demand travel at UBC (8:30-9:30).

12.40 APC data for the 99 B-Line between September-November 2011 was analysed suggesting a value of 3,624 which was applied to the sensitivity tests. Figure 12-7 shows that the reduced annualisation reduces the BCR for all alternatives but has no effect on the relative performance of the alternatives.

FIGURE 12-7 ANNUALISATION SENSITIVITY

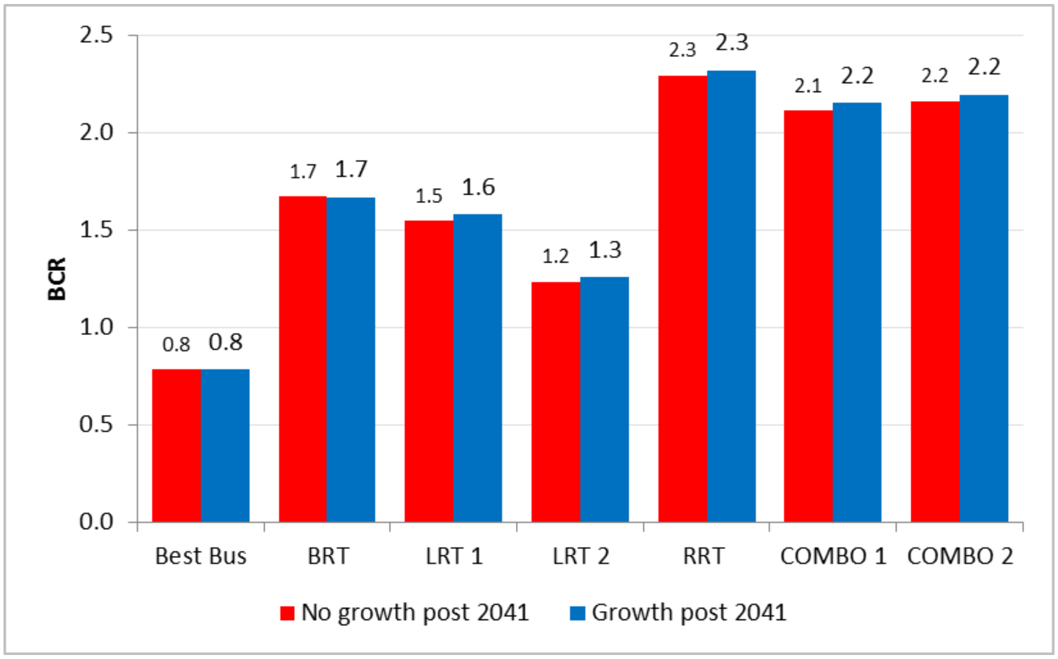


Post-2041 Growth

12.41 Appendix A shows no growth in benefits beyond 2041 (the last modelled forecast year) to account for the uncertainty associated with long term forecasting. This test assumed that the pattern of growth continued after 2041 with results shown in Figure 12-8.

12.42 The figure shows that increasing the growth after 2041 has minimal impact as only the 2042 to 2049 period is affected and a high level of discounting is applied to those benefits.

FIGURE 12-8 POST-2041 GROWTH SENSITIVITY



Sensitivity Test Key Points

- The modelling sensitivity tests demonstrated that the ridership forecasts are sensitive to changes in journey times and increases/decreases in forecast population or employment (with ridership changing by +/- 10-20%). Phasing the RRT alternative increases the benefit:cost ratio over building the full route at once. Phasing construction to an interim terminus at Cambie results in the 99 B-Line being over capacity, while an interim terminus at Arbutus results in the 99 B-Line having sufficient capacity in the near to medium-term but capacity issues would emerge by 2041.
- Phasing the RRT alternative increases the benefit:cost ratio over building the full route at once. Phasing construction to an interim terminus at Cambie results in the 99 B-Line being over capacity, while an interim terminus at Arbutus results in the 99 B-Line having sufficient capacity in the near to medium-term but capacity issues would emerge by 2041.
- The analysis shows that grade separating LRT in a tunnel for part of the route would provide additional benefits over the base case LRT1 alternative and these benefits equal or exceed the additional associated costs, depending on the extent of the tunnelled section.
- The economic and financial sensitivities demonstrate how changes in a single assumption can impact the overall ‘case’ for the project with benefit:cost ratios decreasing by more than 40% with higher discount rates, or nearly doubling with a lower discount rate. They also show that alternatives that are higher in cost or take longer to construct, the Combination Alternatives and RRT, are generally more sensitive to changes in economic or financial assumptions.
- While the sensitivities all have impacts on the evaluation, in almost all tests the relative performance of the alternatives remains the same. None of the decreases or increases in forecast ridership result in any of the alternatives going over capacity (with the exception of Best Bus, BRT and Combination 2 which are over capacity in the central case), nor do they result in extra vehicles or significant changes in capital costs, indicating that the central case assumptions are sound and that the overall evaluation results provide a good indication of the likely relative performance of the alternatives.

13 Summary and Key Conclusions

13.1 A project summary assessment is provided in table below for reference and described in the paragraphs below.

TABLE 13.1 PROJECT SUMMARY ASSESSMENT

Account	Alternative						
	BB	BRT	LRT1	LRT2	RRT	Combo1	Combo2
Transportation	◑	◔	◕	◕	●	●	◕
Financial	◔	◑	◑	◔	◑	◑	◑
Environment	◑	◑	◕	◕	●	◕	◕
Urban Development	◑	◕	◕	◕	◕	◕	◕
Economic Development	◑	◑	◕	◕	●	◕	◕
Social Community	◑	◕	◕	◕	●	◕	◕
Deliverability (affordability not considered)	◑	◑	◑	◑	◑	◑	◔

13.2 **The Transportation** Account measures the benefits and impacts to transportation network users. Alternatives with LRT and RRT provide sufficient capacity and can accommodate demand beyond forecast with RRT providing the greatest opportunity for expansion. The Best Bus, BRT and Combo 2 alternatives do not have sufficient capacity to meet forecast demand. All alternatives increase corridor transit trips and mode share, with RRT alternatives having the greatest impact (3.1 percentage points in 2041). At a regional level the impact on mode share ranges from 0 percentage points (Best Bus) to .3 percentage points (RRT and Combination 1) in 2041. RRT and Combination alternatives provide the shortest travel times and greatest reliability improvements, followed by LRT alternatives. Alternatives with LRT and BRT reduce road capacity and introduce turn restrictions which have impacts on traffic, parking, local access and goods movement.

13.3 **The Financial Account** measures capital and operating costs as well as cost-effectiveness. Capital costs range from $120 million for the Best Bus alternative to $3.0 billion for the RRT alternative. Over the lifecycle, operating costs for all alternatives are small in relation to capital costs. Except Best Bus, all alternatives have benefit-cost ratios greater than 1, with RRT having the highest ratio. BRT, the Combination alternatives and RRT are most cost-effective in generating additional transit users. BRT only has capacity for these passengers during off-peak periods and in the off-peak direction. LRT2 is higher cost and less cost-effective than LRT1 on all accounts indicating that the branch along the former rail right-of-way lowers the financial performance of LRT2 relative to LRT1.

13.4 **The Environment Account** considers a range of environmental measures including emissions reduction, noise and vibration, biodiversity, and parks and open space. RRT and combination alternatives result in the greatest shift from cars and have the greatest auto emissions reductions. The scale of reduction for all alternatives ranges from 0.01% to 0.30% of the regional total. The RRT alternative results in the greatest reduction to noise and vibration from transit services followed by the LRT alternatives. None of the alternatives are expected to adversely impact biodiversity and water during operations.

13.5 **The Urban Development Account** considers the benefits and impacts on local land uses and the urban environment. All alternatives serve four or five major activity centres, with RRT and Combo alternatives serving the fifth, the Great Northern Way Campus. All alternatives require some properties, ranging between 13-30 properties.

13.6 **The Economic Development Account** addresses the economic benefits generated by construction activity, impact on taxes as well as goods movement. Alternatives with higher capital costs and longer construction periods have greater increases in employment and GDP and therefore RRT and Combination alternative 1 generate the greatest benefits. Road capacity reductions and turning restrictions for alternatives with LRT and BRT may cause goods movement delays.

13.7 **The Social and Community Account** addresses a wide range of social and community benefits and impacts, including health effects associated with active living, safety and security, community cohesion and others. RRT and the Combination alternatives deliver the greatest health benefits associated with active transportation since they increase transit use, and thus walking and biking to transit, the most. All rapid transit alternatives improve safety and security with greater separation from other road users and rapid transit station designs. Alternatives with BRT and LRT reduce community cohesion due to vehicular restrictions at intersections.

13.8 **The Deliverability Account** looks at potential issues associated with implementing the alternative, including the ease with which it can be constructed, construction impacts, funding requirements and public acceptability. No technical issues would prevent any alternative from being constructed. All rapid transit alternatives will have construction impacts, similar in scale. Market research indicates that RRT, LRT1, LRT2, and Combination 1 are all more acceptable to the public than Business as Usual, while the other alternatives are not. There is a wide range in capital and lifecycle costs; affordability cannot be assessed through this study as the sources and alternative uses of funds at a regional scale have not been identified.

13.9 Based on this evaluation and considering the transportation problems identified for the corridor in section 3.7, the following conclusions can be drawn:

Capacity and Reliability

13.10 Existing transit services do not provide sufficient capacity or reliable enough service to the major regional destinations and economic hubs within the Broadway Corridor. The Best Bus, BRT and Combination 2 alternatives do not have the capacity to meet forecast demand. All other alternatives provide sufficient capacity to meet forecast demand (2041) and expand beyond. RRT provides the greatest opportunity for expansion.

13.11 To varying degrees, all of the rapid transit alternatives improve reliability. The RRT alternative provides the greatest improvement because it is fully separated from other road users. Alternatives with LRT also provide reliability improvements because they operate in their own right of way and receive priority over other vehicles at intersections but to a lesser degree than RRT because LRT’s street-level operation introduces variability. Best Bus, BRT and the BRT section of Combination 2 have less priority over other traffic and therefore deliver lower reliability improvements.

Transit Trips and Mode Share

13.12 Transit trips and mode share need to increase to reduce vehicle kilometres travelled (VKT) and GHG and CAC emissions, both directly and by supporting the Regional Growth Strategy and other regional objectives

13.13 All alternatives increase transit trips and mode share. At a corridor level, alternatives with RRT increase transit mode share the most and result in the greatest increase in transit trips. For all the alternatives, the number of new transit trips generated is small relative to the number of trips shifted from bus to rapid transit and the total number of transit trips in the region. Therefore, at a regional scale, and when considered in isolation, none of them would achieve mode share targets. The impact on regional mode share ranges from a 0.0% to a 0.3% increase in transit mode share. Demand-side measures such as road pricing or tolling may complement rapid transit expansion to further increase transit mode share, but they were not evaluated in-depth in the study.

13.14 Table 13.2 summarizes quantitative measures for the original problem statement and their costs along with the “Business as Usual” case for comparison.

TABLE 13.2 SUMMARY OF SELECTED MEASURES

Measure	BAU	Best Bus	BRT	LRT1	LRT2	RRT	Combo 1	Combo 2
Capacity and Reliability								
2041 Forecast Peak Load (passengers per hour per direction, pphpd)	2,700	2,500	6,400	5,200	4,700	12,500	11,000 (RRT) 3,300 (LRT)	11,700 (RRT) 3,500 (BRT)
Assumed Capacity** (pphpd)	2,400	2,400	3,000	7,200	5,800	13,000	13,000 (RRT) 3,600 (LRT)	13,000 (RRT) 3,000 (BRT)
Transit Trips and Mode Share								
UBC Line Weekday Ridership (2041)	102,000	121,000***	117,000	160,000	166,000	322,000*	349,000*	339,000*
New Weekday Transit Trips (2041)	-	2,000	7,000	11,000	13,000	54,000	44,000	43,000
Lifecycle Reduction in Auto Vehicle Kilometres Travelled (million km)	-	90	806	1,014	1,000	2,361	1,915	2,021
Lifecycle GHG Emissions Reductions (Kilo Tonnes)	-	-17 (increase)	128	235	203	335	309	238
Transit Mode Share (Regional/Corridor, %)	16.3%/ 29.3%	16.3%/ 29.5%	16.4%/ 30.0%	16.4%/ 30.1%	16.4%/ 30.1%	16.6%/ 32.4%	16.6%/ 31.7%	16.5%/ 31.6%
Costs								
Capital Cost ($ million, 2010)	-	120	410	1,110	1,330	3,010	2,670	1,970
Net PV of Lifecycle Costs ($ million, 2010)	-	120	180	620	790	1,740	1,490	1,110

** Boardings include through passengers on the Millennium Line*

*** The assumed capacity is the level of capacity used for the purposes of evaluation and costing. RRT capacity can be further expanded to 26,000 pphpd. LRT can be further expanded beyond 7,200 with reduction in speed and reliability due to reduced transit priority*

*** Includes bus routes 84, 99 B- Line, 984 and 999

Trade-offs and Considerations

13.15 It is worth highlighting the following trade-offs and considerations further to those identified as part of the problem statement.

Acceptability

13.16 There is a range in the acceptability of the alternatives. Research on the acceptability criterion reveals that based on the current designs and evaluation, RRT, LRT1, LRT2, and Combination 1 are all more acceptable to the public than Business as Usual, while the other alternatives are not. RRT receives the highest acceptability rating.

Affordability

13.17 There is a large range in capital and lifecycle costs for the alternatives. Of the alternatives that meet the forecast demand for the corridor, capital costs range from $1.1 billion for LRT1 to $3.0 billion for RRT. An assessment of affordability will be made outside this study by considering regional investment needs relative to available funding.

Phasing

13.18 The Combination alternatives and RRT could be built in phases through, for example, extending SkyTrain to Broadway and Arbutus as an interim stage towards extending rapid transit to UBC. This would spread out the capital requirements over a longer period of time. Implementation of rapid transit to UBC would be delayed which could result in on-going crowding in the western segment of the corridor and would require a commitment to bus service to meet demand. This would create local impacts such as a requirement for a major interchange and bus layover space at Arbutus. BRT and LRT1 are less suited for consideration for phasing due to the lower capital costs. LRT2 could be built in phases with an initial phase connecting UBC with either Main Street or Commercial-Broadway. A full MAE of phased options was not undertaken.

Speed

13.19 The RRT and Combination alternatives include a Millennium Line extension and provide travel time savings through avoiding a transfer at Commercial – Broadway Station for Millennium Line users. RRT is fully segregated from other traffic and therefore provides the shortest travel times. LRT1 and LRT2 and the LRT segment of Combination 1 operate at street level in their own rights of way and receive priority over other vehicles at intersections, providing travel time improvements to a lesser degree than fully segregated RRT. Partially grade separating (i.e. tunnelling) segments of the LRT would improve its speed and reliability. Best Bus, BRT and the BRT[20] section of Combination 2 have less priority over other traffic and therefore provide fewer travel time benefits than the other alternatives.

[20] BRT has lower priority relative to LRT because signal priority is not as effective at the service levels assumed in the BRT alternatives (i.e. 2 minute headway).

Street-level Impacts

13.20 Street-level operation of BRT or LRT would have impacts on traffic, parking, local access, goods movement and other impacts associated with turning restrictions and reduced road capacity[21] for vehicles. Segments could be built in a tunnel which would reduce the street-level impacts and shorten travel times at additional cost. RRT would be primarily in a tunnel and therefore would not have street-level impacts.

Next Steps

13.21 The results of the Phase 2 evaluation will help to inform the selection of a preferred alternative. The selection of an alternative will take place within a regional context, to allow the consideration of funding availability for this project and other regional transportation investment needs.

13.22 Once a preferred alternative has been identified, Phase 3 would advance the planning and design of that alternative, and carry out further public consultation to aid in design development. The technical scope would include more detailed design of the alignments and intersection layouts, station locations, station area planning and urban design, transit service integration, and environmental study and identification of any mitigation measures.

[21] The multiple account evaluation has addressed the scale and nature of the expected impacts. The specific impacts would be determined through detailed design if BRT or LRT is selected to be implemented.

CONTROL SHEET

Project/Proposal Name	UBC Line Rapid Transit Study
Document Title	Phase 2 Evaluation Report
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SDG Project/Proposal No.	22106506

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0.1	15/11/2011	Draft for Initial TransLink Review
0.3	16/12/2011	Revised Draft
1	6/03/2012	Draft Report (stakeholder comments)
2	23/05/2012	Final Draft Report
3	9/08/2012	Interim Draft Report (TransLink comments)
4	31/08/2012	Final Report
5	09/01/2013	Final Report (with corrections)

REVIEW

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DISTRIBUTION

Client:	Province of BC & South Coast British Columbia Transportation Authority (TransLink)
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APPENDIX

A

EVALUATION PARAMATERS AND ASSUMPTIONS

A1 EVALUATION PARAMETERS AND ASSUMPTIONS

A1.1 There are a number of fundamental parameters and assumptions required to undertake the evaluation of the monetized and quantified effects of the Phase 2 UBC Line Rapid Transit study. These have been split into two different categories:

- **Project assumptions** – the assumptions that relate to the specific nature of the project in terms of its program and characteristics; and
- **Evaluation parameters** - discussing the basis and ranges on which the assessment is undertaken so that it is consistent with other investment opportunities being considered by TransLink and the Provincial Government (MOTI).

A1.2 The project assumptions are set out in Table A1 and evaluation assumptions are set out in Table A2. Note that any economic value is based in real terms i.e. any cost or parameter increase is assumed to be over and above the inflation rate.

A1.3 Where appropriate a range of values which could be applied and the implications of the different values have been included.

TABLE A1 PROJECT ASSUMPTIONS

Factor	Description	Proposed Value (Source)	Implications
Opening Year	Year of project opening	2020	Benefit and revenue stream dependent on this opening date.
Project construction	Years of project construction	BRT - 4 years LRT – 5 years RRT – 7 years	The longer the construction period, the longer it will take for benefits and revenues to start accruing. The sooner the construction period, the less capital costs will be discounted.
Benefit and revenue ramp up	Time for passengers to adjust their behaviour to new route choices	Years 1 to 3: 90%, 95%, 100% (previous evaluation experience)	The more established the corridor and demand patterns are, the less marked the ramp up will be. For UBC corridor considered strong transit market in place and limited build up. Affects benefits incurred in the early years (which are less discounted). However negligible as percentage out of 30 years or so.
Annualisation Factors (Person trips)	Conversion of peak hour forecasts to annual results	AM peak hour to annual: Car 5,855 Transit 4,968 Walk 4,968 Cycle 4,968 (RTPM08)	The higher the value the more benefits assumed. Can have a significant effect on the benefits case but factors applied in models based on observed data.
Forecast year(s)	Years for which revenues and benefits estimated	2021 and 2041 (RTPM08 and land use forecast years)	At least 2 forecast years required to enable interpolation of data between forecast years. The more forecast years, the more detailed revenue and benefit profile can be developed. It can also identify when additional capacity may be required.
Demand Growth profile	Growth assumptions beyond forecast model year	No growth post 2041 (previous evaluation experience).	Demand growth is typically capped at capacity. However, the effect in evaluation is very limited due to large discounting factor applied to benefits in the distant future.
Capacity Assumptions	Mode specific capacity	BRT – 100 passengers/bus LRT – 240 passengers/veh RRT – 130 passengers/veh (RRT1B, Combo 1 and Combo2) or 160 passengers/veh (RRT1A) (Technology Backgrounder technical note)	System crowding being considered in MAE criteria (under Transportation Account) and capacity assumptions will impact assessment.

TABLE A2 EVALUATION PARAMETERS

Factor	Description	Proposed Value (Source)	Implications
Evaluation period	Period for which costs and benefits accounted for.	30 years operation plus construction period (MOTI guidance has 2-5 yrs for small projects, 15-20 yrs for medium and 35-40 for large)	Appraisal period should be sufficiently long to reflect the scale of the investment, related to its lifecycle, and hence the 'pay-back' period. There is limited merit in having unduly long appraisal period if it is accompanied by a discount rate that means values are negligible prior to the end of the assessment period.
Discount Rate	Rate applied to discount all future costs and benefits	6% (Province of BC)	The higher the discount rate the more appropriate it is to have a shorter assessment period.
Value of Time (VoT)	Value applied to convert time into monetary units	$12.17 (MOTI, 2007$ and based on weighted average of age, driver, trip purpose and vehicle type), equivalent to $12.72 in 2010$	The higher the VoT, the higher the monetary valuation of the time savings. Generally based on half the average wage rate.
Value of Time Growth	Growth factor to apply to VoT	1.2% per year real price increase based on GDP per capita increases (based on 2% GDP growth and population estimates from Metro Vancouver) 2021 – $15.03 2041 - $19.07 (2010 $)	The higher the VoT growth, the higher the monetary valuation of future time savings.
Consumer Price Index (CPI)	Inflation	2.0% per year (Bank of Canada target rate)	The higher the CPI, the higher the fare revenues.
Cost Increases	Construction and Goods/Services real price increases	Goods and services: 2010-2019 – 2% nominal, 0% real Construction: 2010, 2011, 2013-2019 – 3% nominal, 1.0% real 2012 – 5% nominal, 3.0% real (TransLink 10 Year Plan for nominal rates, CPI for inflation) After 2019 assume no real price increase	The higher the real price cost increases, the higher the project costs and lower BCR.

Factor	Description	Proposed Value (Source)	Implications
Average Collision Cost	Monetary value of collision costs	$0.12 per vehicle km Fatal: $7.14m Non fatal: $0.12m Property: $5,606 (2010$) (Collision Statistics: 2004 Canadian Motor Vehicle Traffic Collision Statistics, TP3322 Vehicle Kilometres: Statistics Canada, Catalogue No. 53-223-XIE, "Canadian Vehicle Survey" Accident Costs: MOTI)	Estimation based on vehicle kilometres removed. The higher the cost per collision, the higher the collision cost savings.
Greenhouse Gas (GHG)	Amount of GHG emitted by road traffic	Auto CO2 equiv: 2007: 287 g/km 2021: 201 g/km 2041: 164 g/km (Metro Vancouver[1]) Hybrid bus/BRT CO2 equiv: 2007: 1920 g/km 2021: 1823 g/km 2041: 1827 g/km (Translink rates, with profiling from Metro Vancouver estimates) Trolley bus/BRT CO2 equiv: 2007: 62 g/km 2021: 59 g/km 2041: 59 g/km (Translink rates, with profiling from Metro Vancouver estimates) Trolley bus emission rates scaled by vehicle length to estimate emission rates for LRT and RRT	Estimation based on vehicle kilometres removed. GHG aggregated into CO2 by applying GHG - CO2 equivalent factors (CO2: 1; CH4: 21; N2O: 310)

[1] Based on proposed BC Tailpipe Emission Standards starting model year 2011 through to 2016 and BC Renewable Fuel Standard of 5% (ethanol and biodiesel) starting 2010 (regulation currently in development).

Factor	Description	Proposed Value (Source)	Implications
Common air contaminants (CAC) Emissions	Amount of CAC emitted by road traffic	Auto (g/km, values for 2007/ 2021/ 2041): CO - 9.8/7.1/ 6.7; NH3 – 0.061/ 0.062/0.062; Nox - 0.63/0.28/0.21; PM - 0.017/0.016 /0.015; PM10 - 0.017/ 0.016/0.015; PM2.5 – 0.008/0.007/0.007; Sox – 0.005/0.004/ 0.003; VOC – 0.775/ 0.339/0.293 (Metro Vancouver[2]) Diesel bus/BRT (g/km, constant over time): CO - 2.6, NH3 – 0.32, Nox – 9.2, PM – 0.6, PM10 – 0.6, PM2.5 – 0.6, Sox – 0.6, VO – 0.6. (Transport Canada)	Based on: - Implementation of BC Tailpipe Emission Standards (equivalent to California Pavley I standards, starting in 2009 through to 2016) - Implementation of the BC Renewable Fuel Standard of 5% (ethanol and biodiesel) starting 2010
Average Cost of CO2	Monetary value of CO2 equivalent emissions reduced	$25/tonne (Pacific Carbon Trust estimate)	The monetization of CO2 emissions can potentially be contentious with some stakeholders. Wide ranging values according to source referred to.
Auto Operating Costs	Monetary value of vehicle kilometre driven	2008 – $0.16/km 2021 - $0.16/km 2041 - $0.16/km (2008 CAA calculation of average driving costs and includes fuel, operating and tires)	Sensitivity for increasing auto operating costs as a proxy for likely oil price increases (although counterbalanced somewhat by increased fuel efficiency), road pricing and off street parking costs increases and/or limit on off street parking supply.

[2] These factors were developed by Metro Vancouver in 2008 for another study and some of the assumptions may no longer be valid. However, they are considered sufficient for planning and comparative purposes.

APPENDIX

B

BEST BUS RESULTS

steer davies gleave

memo

To	TransLink		
Cc			
From	Dan Gomez-Duran		
Date	26th March 2012		
Project	UBC Rapid Transit Line	**Project No.**	22106506

Subject Best Bus Summary

Background and Summary of Findings

As part of the modelling and evaluation of shortlisted options in Phase 2 of the UBC Rapid Transit Line Study, the Best Bus network was developed to provide a 'low cost' alternative to compare against the various rapid transit options evaluated. The Best Bus option serves to illustrate:

- whether demand can be met by investing in bus service on multiple parallel corridors
- what benefits can be achieved by investing in bus service, short of investing in rapid transit. That is, it assists in illustrating the incremental benefit of investing in rapid transit relative to bus.

This document reviews the assumptions and results for the various Best Bus scenarios tested and the rationale applied to reach the final Best Bus option.

The analysis illustrates (with the current model and land use assumptions) a Best Bus option, confined to the study area or involving improvements on multiple corridors does not have capacity to meet forecast demand.

Network Definition

The 'original' Best Bus network was defined and agreed following discussions between the various project stakeholders (TransLink, City of Vancouver and UBC) during the summer of 2010. Initially it considered broad improvements inside and outside of the study area in order to assess whether demand could be met by investing in bus service on multiple corridors. The routes and headways for the BAU and Best Bus networks are summarised in Table 1. Changes consisted primarily of headway improvements on existing east-west routes between False Creek and 49th Avenue and two express routes:

- Route 999 – a 99 B Line express service stopping only at Cambie (Canada Line)
- Route 984 – an 84 express service, starting at Main St SkyTrain, stopping only at Cambie (Canada Line)

Improvements to route 9 were not assumed due to the high level of provision provided (with no observed capacity issues) on Broadway (around 4 minutes between Boundary and Granville) and the additional express services included.

TABLE 1 BAU AND 'ORIGINAL BEST BUS' ROUTE ASSUMPTIONS – AM PEAK HEADWAY (MINUTES)

Service	2021		2041	
	BAU	Best Bus	BAU	Best Bus
9g (Boundary-UBC)	10	10	9	9
9u (Boundary-UBC)	8	8	7.5	7.5
25wb1 (Brentwood-UBC)	9	8	8	6
25wb2 (Nanaimo-UBC)	9	8	8	7
25eb (UBC-Brentwood)	9	6	8	5
33 (29th Av-UBC)*	13.5	6	12	6
41wb (Joyce-UBC)	5.5	5	5	5
41eb (UBC-Joyce)	6.5	5	5.5	5
43wb (Joyce-UBC)	7	7	6	5
43eb (UBC-Joyce)	7	6	6	5
44i (UBC-SeaBus)	16	5	14.5	5
44o (SeaBus-UBC)	8	7	7.5	6
49i (Metrotown-UBC)	5.5	4	4.5	3
49o (UBC-Metrotown)	6.5	6	5	5
84 (VCC-UBC)*	7	6	6.5	5
99eb (UBC-Commercial)	6.5	5	5.5	4
99wb (Commercial-UBC)	2.5	2.5	2.5	2.5
984 (Main-UBC)**	-	6	-	4
999 (Commercial-UBC)**	-	6	-	4

*NOTE: * Bi-directional, ** Peak direction (WB) only*

Best Bus Network Review

Following initial evaluation work carried out in April 2011, results for the 'Original Best Bus' suggested an 'unequal' comparison of alternatives, where the Best Bus generated benefits across a much wider area than the study corridor and included improvements outside of the study area that did not address the problem statement. A subsequent Best Bus network ('Best Bus Test') was developed to isolate the benefits within the study area by applying only the Best Bus changes related to corridor bus routes (routes 99, 999, 84 and 984). Table 2 shows the proposed headways for this 'Best Bus Test'.

TABLE 2 BEST BUS OPTION SERVICE ASSUMPTIONS

		2041 AM Peak Headway (minutes)		
Bus Service		BAU	Original BB	BB Test
025wb1	Brentwood-UBC	8	6	8
025wb2	Nanaimo-UBC	8	7	8
025eb	UBC-Brentwood	8	5	8
33	29th Av-UBC (bidirectional)	12	6	12
041i	Joyce-UBC	5	5	5
041ou	UBC-Joyce	5.5	5	5.5
043wb	Joyce-UBC	6	5	6
043eb	UBC-Joyce	6	5	6
044i	UBC-SeaBus	14.5	5	14.5
044o	SeaBus-UBC	7.5	6	7.5
049i	Metrotown-UBC	4.5	3	4.5
049o	UBC-Metrotown	5	5	5
84	VCC-UBC (bidirectional)	6.5	5	5
099wb	Commercial-UBC	2.5	2.5	2.5
099eb	UBC-Commercial	5.5	4	4
984	Main-UBC	-	4	4
999	Commercial-UBC	-	4	4

Grey cells refer to source of 'BB Test' headway

Results

Results of this analysis were summarized in a memo dated 1st June 2011 ('Marginal Alternatives Modelling Results') and the results from the memo are presented here for reference. Note that analysis was done for 2041 only and results for bus route 9 have been added to the June 2011 memo results.

Table 3 provides the peak load factors for the two options. It generally shows an increase in peak loads for buses outside the corridor as headway reductions in the 'Best Bus Test' result in lower bus capacity. There is also a slight increase in 99 B-Line westbound v/c, but routes 984 and 999 provide alternatives for some of those trips. This is also reflected in the corridor[1] statistics which show a slight reduction in transit ridership (and mode share) compared to the Original BB scenario as shown in Table 4.

[1] UBC Line study corridor defined between 4th and 16th Avenues and between UBC and Broadway-Commercial SkyTrain station.

TABLE 3 BEST BUS 2041 SERVICE AM PEAK HOUR LOAD FACTOR

Service		Original BB v/c (June 2011)	BB Test v/c (June 2011)
9g	Boundary-Granville	1.00	1.00
9u	Boundary-UBC	1.04	1.06
025wb1	Brentwood-UBC	0.64	0.76
025wb2	Nanaimo-UBC	0.52	0.61
025eb	UBC-Brentwood	0.78	0.86
33	29th Av-UBC (bidirectional)	0.52	0.36
041i	Joyce-UBC	0.66	0.75
041ou	UBC-Joyce	0.79	0.93
043wb	Joyce-UBC	0.17	0.23
043eb	UBC-Joyce	0.54	0.67
044i	UBC-SeaBus	0.88	0.68
044o	SeaBus-UBC	0.29	0.33
049i	Metrotown-UBC	0.60	0.77
049o	UBC-Metrotown	0.29	0.33
84	VCC-UBC (bidirectional)	0.45	0.52
099wb	Commercial-UBC	0.75	0.77
099eb	UBC-Commercial	0.38	0.47
984	Main-UBC	0.30	0.30
999	Commercial-UBC	0.30	0.30

** eb = eastbound, wb = westbound, o = outbound, i = inbound*

Important to note is that the original Best Bus scheme was not effective in drawing demand away from the study area routes with the highest v/c ratios, as can be seen by only a 0.02 change in v/c for the 99 and 9u between the scenarios. Note also that the modelled speed of the 9 services (9g and 9u) was later found to be excessive in relation to their observed speeds relative to the 99 services. This was corrected in later model runs and resulted in a reduced v/c (see Table 6).

TABLE 4 BEST BUS CORRIDOR STATISTICS (2041 AM PEAK HOUR)

Trips	BAU	Original BB	BB Test	Mode Share		
				BAU	Original BB	BB Test
Walk / Cycle	8,890	8,865	8,887	11.1%	11.0%	11.1%
Auto	45,767	45,369	45,631	56.9%	56.4%	56.8%
Transit	25,757	26,193	25,886	32.0%	32.6%	32.2%
Total	80,415	80,428	80,405	-	-	-

A review of travel time savings was also carried out and is shown in Table 5. The analysis showed that the improvements in corridor only services resulted in limited time savings compared to improvements in all east-west routes (corridor services only represented 11% of travel time benefits compared to the Original BB test).

This suggested that all the improvements in parallel routes (which are considerable – increase in 35 buses per hour for non-Broadway services) appear to be the main drivers of the benefits for the BB Original option and also are not diverting enough trips to address the capacity issues on Broadway. The study team therefore decided to make the BB Test the 'new' Best Bus.

TABLE 5 BEST BUS TRAVEL TIME BENEFITS (2041 AM PEAK HOUR)

Travel Time Benefits	Original BB	BB Test
Existing users transit time savings (person-min)	29,710	3,397
New users transit time savings (person-min)	1,548	104
Total Benefits	31,258	3,501

Final Forecasts

Following the re-definition of Best Bus, a revised set of forecasts was developed based on revised land use forecasts received from Metro Vancouver in May 2011 and reduced speed of Route 9 to better match observed rather than scheduled travel times. These results are summarised in Table 6.

TABLE 6 BEST BUS SERVICE PEAK LOAD FACTORS (2041 AM PEAK HOUR)

Service		Final BB v/c (Sept 2011)*	Original BB v/c (Sept 2011)*
9g	Boundary-Granville	0.76	0.73
9u	Boundary-UBC	0.60	0.58
025wb1	Brentwood-UBC	0.67	0.69
025wb2	Nanaimo-UBC	0.80	0.55
025eb	UBC-Brentwood	0.92	0.85
33	29th Av-UBC (bidirectional)	0.49	0.51
041i	Joyce-UBC	0.61	0.56
041ou	UBC-Joyce	0.98	0.80
043wb	Joyce-UBC	0.23	0.19
043eb	UBC-Joyce	0.71	0.55
044i	UBC-SeaBus	1.13	1.31
044o	SeaBus-UBC	0.20	0.21
049i	Metrotown-UBC	0.81	0.61
049o	UBC-Metrotown	0.35	0.34
84	VCC-UBC (bidirectional)	1.25	1.29
099wb	Commercial-UBC	1.10	1.03
099eb	UBC-Commercial	0.51	0.45
984	Main-UBC	0.35	0.32
999	Commercial-UBC	0.40	0.37

** Revised land use and reduce bus route 9 speed*

Results show a general increase in the v/c for all bus routes (compared to BB Test) as result of the increase in population and employment assumed in the new land use forecasts (which focussed on UBC). With the latest land use and Final Best Bus scenario, a number of routes are at or over capacity (041ou, 044i, 84 and 099wb) and there is a big reduction in demand levels on route 9 as result of the reduced speed.

We have also included the results of running the Original BB with the latest version of the model for reference. That shows lower v/c figures on the majority on the non-corridor routes (vs. Final BB) as a result of higher service levels on these routes in the Original BB, although in some selected cases there is an increase, e.g. bus route 044i. Capacity issues on the 99 B Line in the westbound direction remain in place for both scenarios.

APPENDIX

C

DESIGN PRINCIPLES

UBC Line Rapid Transit Study

Design Principles

Report

August 2012

Prepared for:
South Coast British Columbia Transportation Authority (TransLink) and the Province of British Columbia
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CONTENTS

1 OVERVIEW 1
2 BUS RAPID TRANSIT ALTERNATIVE 3
3 LIGHT RAIL TRANSIT ALTERNATIVES 12
4 RAIL RAPID TRANSIT ALTERNATIVE 23
5 COMBINATION ALTERNATIVES 30
6 STREET RUNNING ALTERNATIVES INTERSECTION ASSUMPTIONS 36

FIGURES

Figure 2.1 EXAMPLE OF BRTWAY - NANTES, FRANCE 3
Figure 2.2 EXAMPLE OF BRT STOP – EUGENE, OREGON 4
Figure 2.3 BRT VISUALIZATION - BROADWAY/WILLOW (ILLUSTRATIVE CONCEPT DESIGN) 9
Figure 2.4 BRT ALTERNATIVE – KEY MAP AND STOP LOCATION 10
Figure 2.5 BRT ALTERNATIVE – INTERSECTION MAP 11
Figure 3.1 EXAMPLES OF GRASS TRACK 12
Figure 3.2 EXAMPLES OF LRTWAY 13
Figure 3.3 EXAMPLES OF LRT STOPS 13
Figure 3.4 LRT VISUALIZATION – BROADWAY/BLENHEIM (ILLUSTRATIVE CONCEPT DESIGN) 17
Figure 3.5 LRT VISUALIZATION – BROADWAY/OAK (ILLUSTRATIVE CONCEPT DESIGN) 18
Figure 3.6 LRT ALTERNATIVE 1 – KEY MAP AND STOP LOCATIONS 19
Figure 3.7 LRT ALTERNATIVE 1 – INTERSECTION MAP 20
Figure 3.8 LRT ALTERNATIVE 2 – KEY MAO AND STOP LOCATIONS 21
Figure 3.9 LRT ALTERNATIVE 2 – INTERSECTION MAP 22
Figure 4.1 UNDERGROUND RRT TUNNEL 23
Figure 4.2 EXAMPLE OF RRT STATION PLATFORM 24
Figure 4.3 RRT VISUALIZATION – BROADWAY AND OAK (ILLUSTRATIVE CONCEPT DESIGN) 27
Figure 4.4 RRT ALTERNATIVE – KEY MAP AND STATION LOCATIONS 28

Figure 4.5 RRT ALTERNATIVE – INTERSECTION MAP 29

Figure 5.1 COMBINATION ALTERNATIVE 1 – KEY MAP AND STATION LOCATIONS ... 31

Figure 5.2 COMBINATION ALTERNATIVE 1 – INTERSECTION MAP 32

Figure 5.3 COMBINATION ALTERNATIVE 2 – KEY MAP AND STATION LOCATIONS . 33

Figure 5.4 COMBINATION ALTERNATIVE 2 – INTERSECTION MAP 34

1 Overview

1.1 This appendix provides the design principles and assumptions applied in developing conceptual designs for the six design alternatives of Phase 2 of the UBC Line Rapid Transit Study. The six design alternatives are:

1. Bus Rapid Transit (BRT) Alternative - BRT from UBC to Broadway/Commercial via West 10th Avenue and Broadway.
2. Light Rail Transit Alternative 1 - UBC to Broadway/Commercial via West 10th Avenue and Broadway
3. Light Rail Transit Alternatives 2 - LRT Alternative 1 **plus** an LRT branch from Broadway and Arbutus to Main Street/Science World Station via the Arbutus rail corridor and the Downtown Streetcar alignment.
4. Rail Rapid Transit Alternative - UBC to Broadway/Commercial via West 10th Avenue and Broadway
5. Combination Alternative 1 - LRT from UBC to Main Street/Science World (using the LRT Alternative 2 branch alignment) **plus** RRT from Broadway/Arbutus to VCC-Clark
6. Combination Alternative 2 - BRT from UBC to Broadway/Commercial (using the BRT Alternative alignment) **plus** RRT from Broadway/Arbutus to VCC- Clark

Purpose of the Report

1.2 Phase 1 of the UBC Line Rapid Transit Study reviewed a long list of route and transit technology permutations. The volume of options (over 200) required a relatively coarse level of analysis that was sufficient to shortlist route and transit technology options. These are now the subject of the Phase 2 program and are listed above.

1.3 In order to undertake the detailed assessment of each alternative in Phase 2, initial concept designs are needed to identify the likely range of impacts that each alternative could generate. These concept plans provide the detail required to undertake, for example, cost estimating, ridership forecasting and initial assessments of the likely impacts to other vehicle traffic and parking, as well as to identify areas where wider benefits may be achievable.

1.4 In order for the design team to develop a set of concept designs that were consistent across all the alternatives (in terms of the design philosophy and approach), a set of design principles were defined and agreed for each transit mode. These were then used to determine the design parameters to be applied when developing the designs for each alternative. The initial alignment designs have been prepared to a level of detail that allows the identification and documentation of a range of factors including: cross-section impacts, revisions to traffic lane layouts, intersection arrangements and those requiring transit signal priority, urban development opportunities, pedestrian and cycle improvement opportunities and the scope to improve the urban realm.

1.5 The report contains key plans for each route option and an introduction that describes the transit mode and its related design principles.

1.6 The designs were developed to a conceptual level of detail to support the high-level evaluation of alternatives. Future work will develop more detailed designs of preferred alternative(s) that will define specific local benefits and impacts with more certainty and support consultation on the designs.

2 Bus Rapid Transit Alternative

2.1 This section provides an overview of the Bus Rapid Transit (BRT) Alternative that is being considered in Phase 2 of the UBC Line Rapid Transit Study. This alternative includes BRT from UBC to Broadway/Commercial via West 10th Avenue and Broadway

Bus Rapid Transit (BRT) - Alignment Concept

2.2 The alignment design is based upon the centre running of the BRT within the corridor from UBC to Commercial/Broadway with a significant number of minor intersections along the route converted to right-in, right-out access only and some additional restrictions at major intersections. These restrictions are required to prevent uncontrolled crossings of the BRT alignment, including by left turning traffic. Pedestrian/cyclist crossings are maintained at all intersections. Intersection assumptions are summarized in Chapter 6.

2.3 The alignment is assumed to be an exclusive BRT right of way which at this initial stage of design is assumed to be a raised BRT alignment (where appropriate) within the road with an angled curb to deter road users from driving onto or over the alignment. Emergency vehicles are able to mount the curb, if required, to cross the alignment or to use it to bypass stationary traffic.

FIGURE 2.1 EXAMPLE OF BRTWAY - NANTES, FRANCE

Stops

2.4 While the exact positioning of each stop will require more work (during Phase 3 of the study for the preferred alternative), the stop locations for this initial design are largely based on the replication of the existing 99 B-Line stop locations.

2.5 The BRT stop platform length is a minimum of 40 metres long to provide for two 18 metre long articulated buses to use the stop simultaneously. The platform width is a minimum of three metres with the stop platforms generally staggered on either side of an intersection.

FIGURE 2.2 EXAMPLE OF BRT STOP– EUGENE, OREGON

High Level Design Principles: Bus Rapid Transit

2.6 The proposed design principles for the corridor are set out in the following table.

Design Element	Design Principle	Comments
Vehicle	Length ≈ 18 metres Width ≈ 2.5 metres	
Alignment	Two way running width of ≈ 6.6 metres, widening through curves. Running at grade. Central or side running.	
Segregation	High level of segregation. Reallocation of road space for the exclusive use of the LRT system, whilst retaining appropriate levels of road capacity to meet the differing local needs along the length of the route. Movements at intersections are under "signal protection" such that while the BRT has right-of-way movements that conflict with the BRT (including left turns and pedestrian/cyclist crossings at right-in, right-out intersections) are not permitted.	The City of Vancouver Transportation Plan recommends where appropriate streets or sections of streets assume a more clearly defined transit role. The Broadway corridor is identified as a street where transit would be given higher priority.
Signal Priority	None provided due to high service frequency required to meet demand projections. BRT signals would be activated concurrent with scheduled non-conflicting traffic phases.	

Design Element	Design Principle	Comments
Intersections	Balance the need to maintain car traffic accessibility versus rapid transit speed and reliability. There are four main types of intersections • Right-in right-out, where left turns to and from Broadway/10th Avenue for motor vehicles as well as crossing movements are banned. Signal protected pedestrian and cyclist crossings are provided. • Crossing movements are permitted but left-turns from Broadway/10th Avenue are banned. Signal protected pedestrian, cyclist and vehicular crossings are provided. • All movements are allowed; left turns from Broadway or 10th Avenue across the BRT way can only be made from dedicated left-turn lanes and signals. Signal protected pedestrian, cyclist and vehicular crossings are provided. • Some left turns are allowed, with a left-turn lane and signal provided for either the eastbound or westbound direction. Signal protected pedestrian, cyclist and vehicular crossings are provided.	Chapter 6 presents the intersection assumptions for street running alternatives.
Stops	Length ≈40 metres Width ≈ 3 metres, side platform The majority of stops will feature eastbound and westbound platforms staggered across intersections.	Length to accommodate two vehicles
Stop Infrastructure	Stop facilities to be enhanced but utilising standard TransLink stop furniture where possible. The stop infrastructure would include the following kit of parts, with levels of provision provided in line with the passenger demand. Dedicated stop infrastructure elements to include: • Shelters; • Seating; • Ticket machines; • Passenger Information; • Real Time Service Information; • Branding.	

Design Element	Design Principle	Comments
Roadway	The development of the route will, where possible, minimise impacts to parking and access. Alternative arrangements will be provided where required. The design will seek to minimise cross corridor traffic impacts, though a number of more minor intersections may need to be converted to right-in, right-out to provide greater lengths of segregated running or to reduce “rat running” traffic.	

FIGURE 2.3 BRT VISUALIZATION - BROADWAY/WILLOW (ILLUSTRATIVE CONCEPT DESIGN)

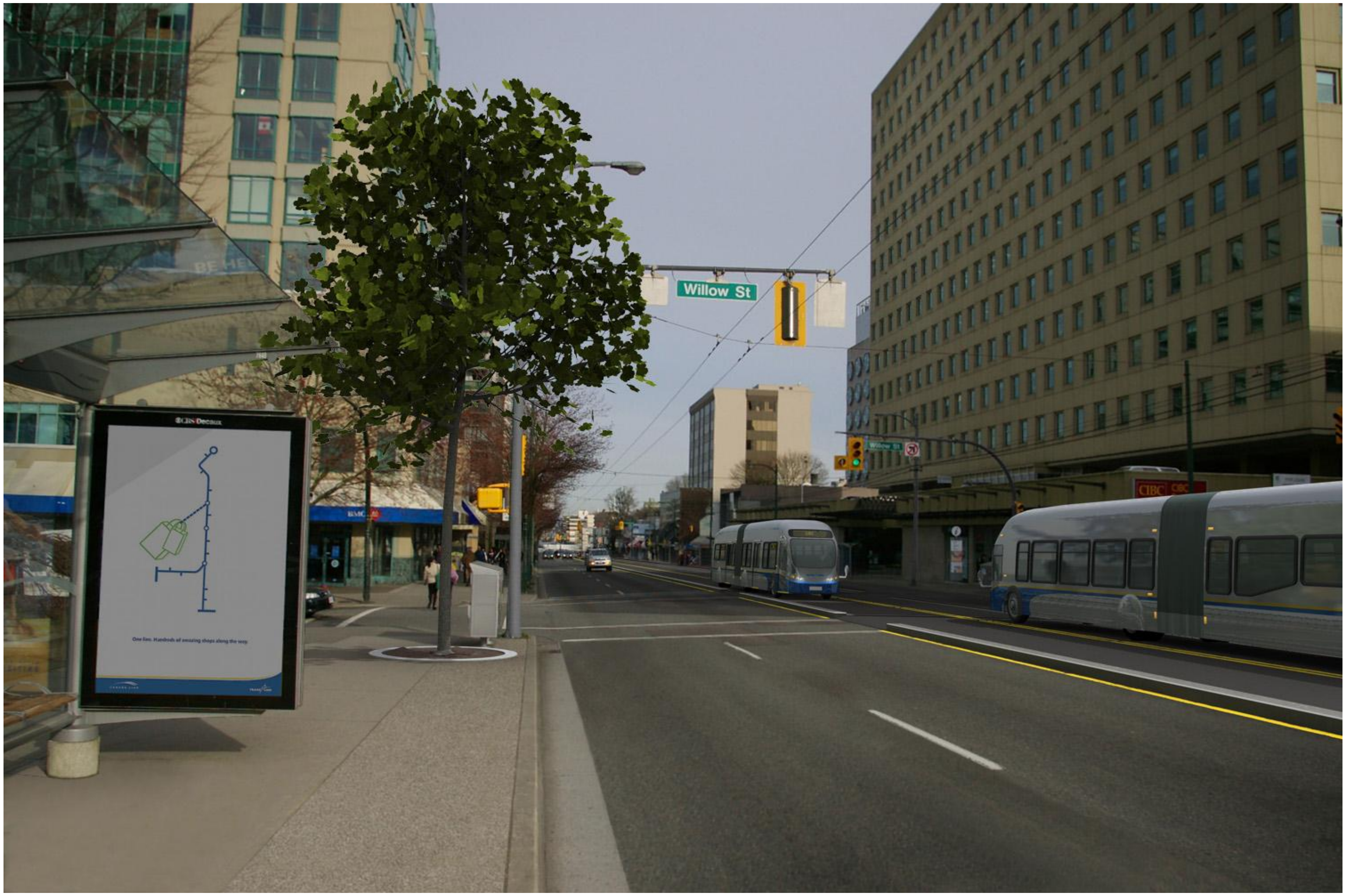


FIGURE 2.4 BRT ALTERNATIVE - KEY MAP AND STOP LOCATION

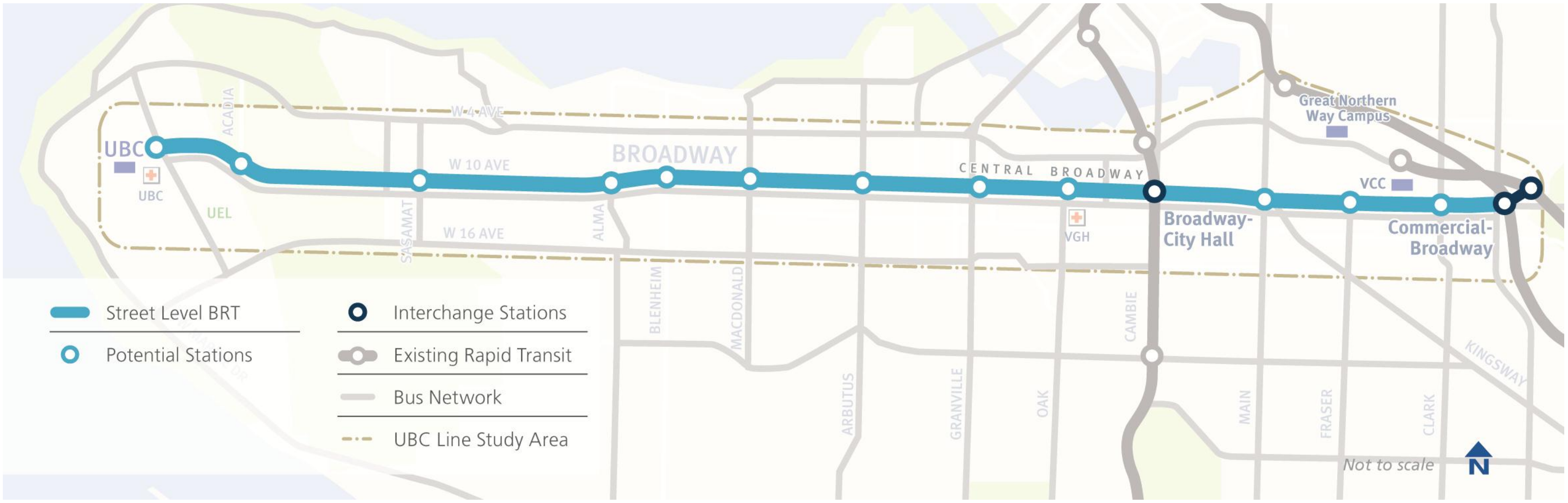
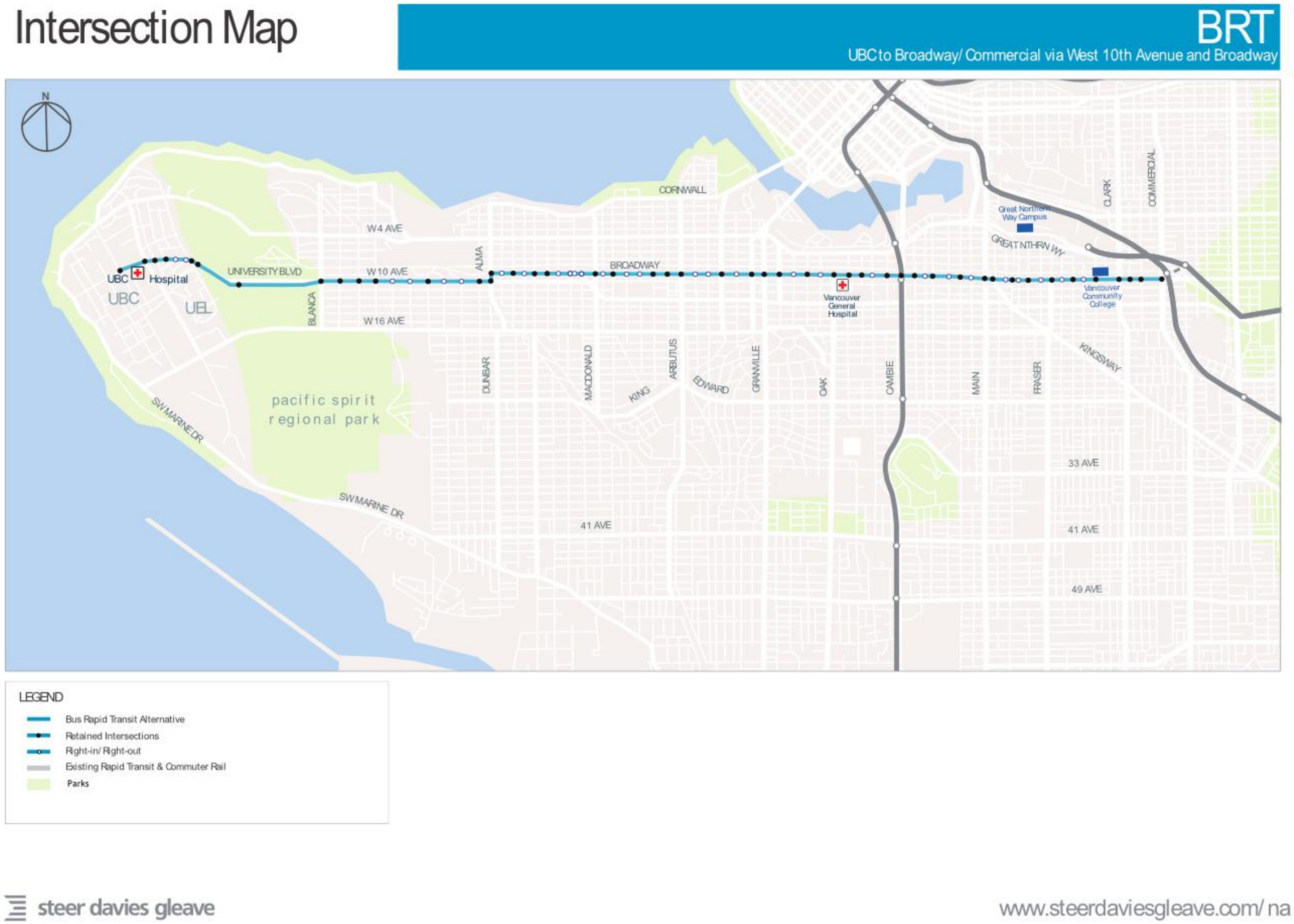


FIGURE 2.5 BRT ALTERNATIVE - INTERSECTION MAP



3 Light Rail Transit Alternatives

3.1 This section provides an overview of the Light Rail Transit (LRT) Alternatives that are being considered in Phase 2 of the UBC Line Rapid Transit Study.

3.2 There are two Light Rail Transit (LRT) Alternatives included in this study:

- LRT Alternative 1: UBC to Broadway/Commercial via West 10th Avenue and Broadway
- LRT Alternatives 2: LRT Alternative 1 **plus** an LRT branch from Broadway at Arbutus to Main Street/Science World Station via the Arbutus rail corridor and the Downtown Streetcar alignment

Light Rail Transit (LRT) - Alignment Concept

3.3 The alignment design is based upon centre running LRT within the West 10th Avenue and Broadway corridor. High levels of segregation have been provided for the LRT alignment, with a significant number of minor intersections along the route converted to right-in, right-out for vehicular traffic and some additional restrictions at major intersections. These restrictions are required to prevent uncontrolled crossings of the LRT alignment, including by left turning traffic. Pedestrian/cyclist crossings with signal protection are maintained at almost intersections, with exceptions noted in the text. Intersection assumptions are summarized in Chapter 6.

3.4 The alignment is assumed to be either grass track (where appropriate) or LRT way (a raised LRT alignment within the overall road width with an angled kerb to deter road users from driving on to or over the alignment. Emergency vehicles can, if required, mount the kerb and cross the alignment or use it to bypass stationary traffic where paved.

FIGURE 3.1 EXAMPLES OF GRASS TRACK

FIGURE 3.2 EXAMPLES OF LRTWAY

Stops

3.5 While the exact positioning of each stop will require more work (during Phase 3 of the study for the preferred alternative), the stop locations for this initial design are largely based on the replication of the existing 99 B-Line stop locations.

3.6 The LRT stop platform length is a minimum of 80 metres long to provide for the coupled operation of two 40 metre LRT low floor vehicles or a longer single vehicle. The platform width is typically four metres for centre platforms and three metres for side platforms.

FIGURE 3.3 EXAMPLES OF LRT STOPS

High Level Design Principles: Light Rail Transit

3.7 The proposed design principles for the corridor are set out in the following table.

Design Element	Design Principle	Comments
Vehicle	Length Up to 40 metres coupled in pairs Width ≈ 2.65 metres	
Alignment	Alignment width of ≈ 6.6 metres, widening through curves. Running at grade. Central or side running. Min curve radius of 25 metres Max gradient 8%	Maximum gradient of the alignment is 7.3% on West 10th west of Highbury.
Segregation	High level of segregation (reserved space within the road). Reallocation of road space for the exclusive use of the LRT system, whilst retaining appropriate levels of road capacity to meet the differing local needs along the length of the route. Movements at intersections are under "signal protection" such that while the LRT has right-of-way movements that conflict with the LRT (including left turns and pedestrian/cyclist crossings at right-in, right-out intersections) are not permitted.	The City of Vancouver Transportation Plan recommends where appropriate streets or sections of streets assume a more clearly defined transit role. The Broadway corridor is identified as a street where transit would be given higher priority.
Signal Priority	Signal priority is granted to rapid transit at all intersections. Automatic Vehicle Location System employed to provide priority through signalled intersections.	AVLS and signal priority will help facilitate reduced journey times and provide greater journey time reliability.

Design Element	Design Principle	Comments
Intersections	Balance the need to maintain car traffic accessibility versus rapid transit speed and reliability. There are four types of intersections • Right-in right-out, where left turns to and from Broadway/10th Avenue for motor vehicles as well as crossing movements are banned. Signal protected pedestrian and cyclist crossings are provided. • Crossing movements are permitted but left-turns from Broadway/10th Avenue are banned. Signal protected pedestrian, cyclist and vehicular crossings are provided. • All movements are allowed; left turns from Broadway or 10th Avenue across the LRT way can only be made from dedicated left-turn lanes and signals. Signal protected pedestrian, cyclist and vehicular crossings are provided. • Some left turns are allowed, with a left-turn lane and signal provided for either the eastbound or westbound direction. Signal protected pedestrian, cyclist and vehicular crossings are provided.	Chapter 6 presents the intersection assumptions for street running alternatives.
Stops	Length ≈80 metres Width ≈ 3 metres, side platform ≈ 4 metres, island platform The locations of stops would be integrated with the existing pedestrian crossings at intersections as appropriate. Platforms will face each other, where possible, to provide a more vibrant public space.	Stop length would limit train lengths to 80 metres assumed to be 2 x 40 metre cars at this stage of the development.

Design Element	Design Principle	Comments
Stop Infrastructure	Stop facilities would provide a distinct image for the system with the stop infrastructure built up from a standard kit of parts to meet the expected demand. Dedicated stop infrastructure elements will include: Shelters; Seating; Ticket machines; Passenger Information; Real Time Information; CCTV; Help Points; Passenger Announcements; Branding.	
Roadway	The development of the route will, where possible, minimise impacts to parking and access or provide alternative arrangements where required and possible. The design will minimise cross corridor traffic impacts, though a number of more minor intersections may need to be converted to right-in, right-out to provide greater length of segregated running or to discourage “rat running” traffic.	

FIGURE 3.4 LRT VISUALIZATION – BROADWAY/BLENHEIM (ILLUSTRATIVE CONCEPT DESIGN)

FIGURE 3.5 LRT VISUALIZATION – BROADWAY/OAK (ILLUSTRATIVE CONCEPT DESIGN)

FIGURE 3.6 LRT ALTERNATIVE 1 - KEY MAP AND STOP LOCATIONS

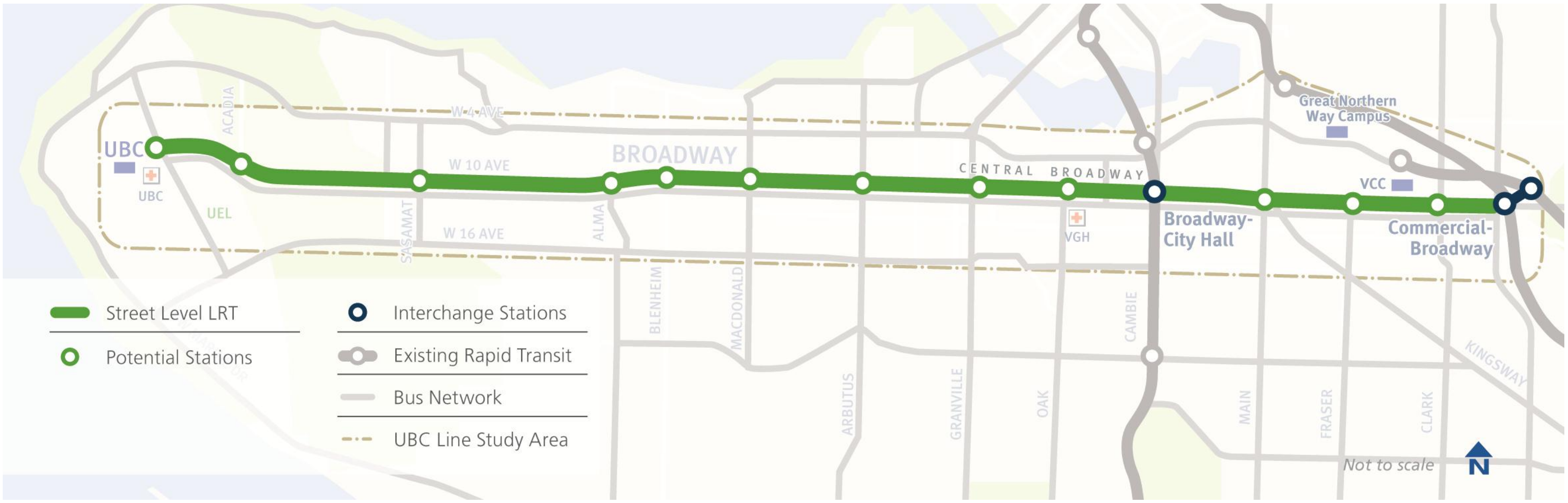


FIGURE 3.7 LRT ALTERNATIVE 1 – INTERSECTION MAP

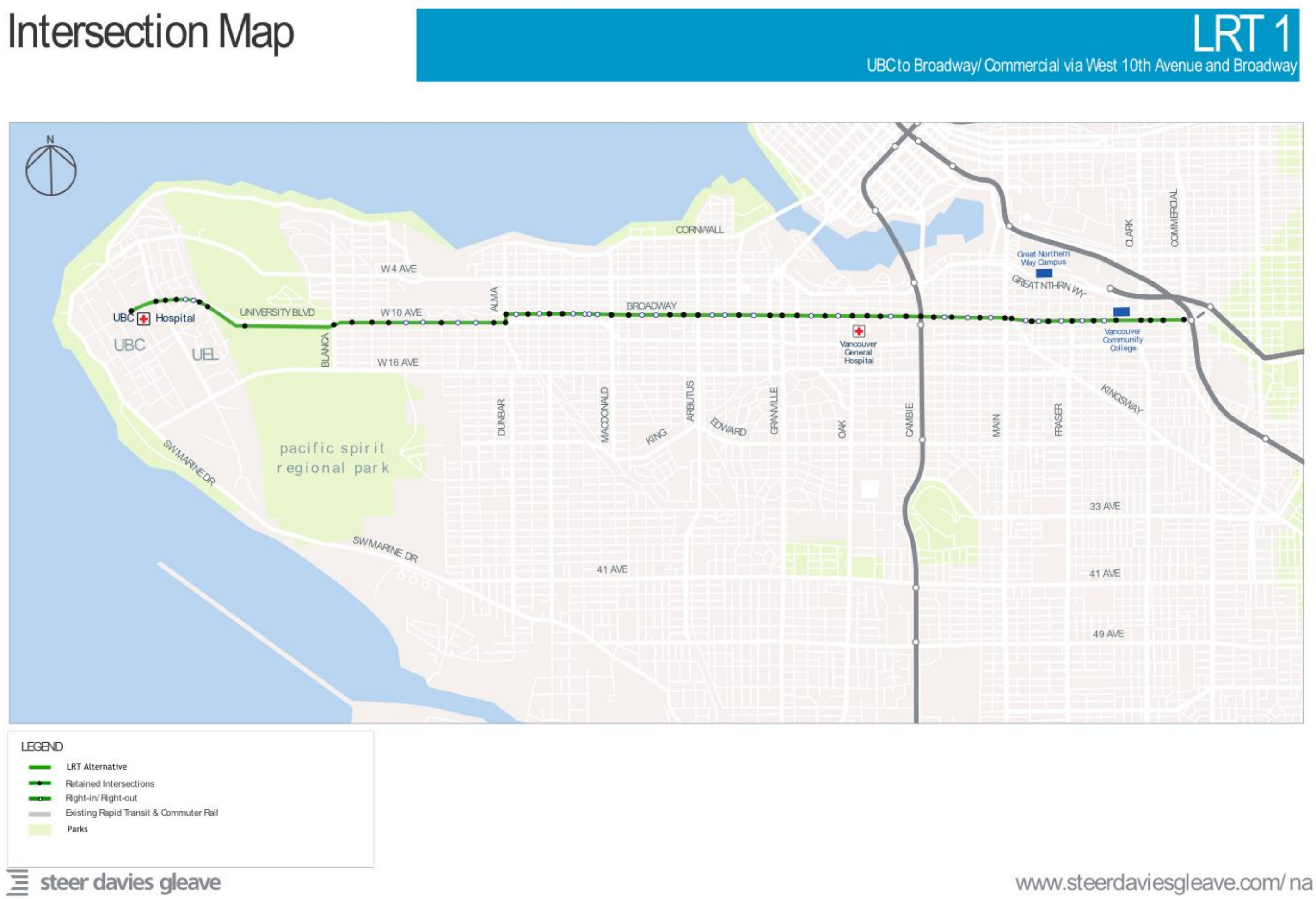


FIGURE 3.8 LRT ALTERNATIVE 2 - KEY MAP AND STOP LOCATIONS

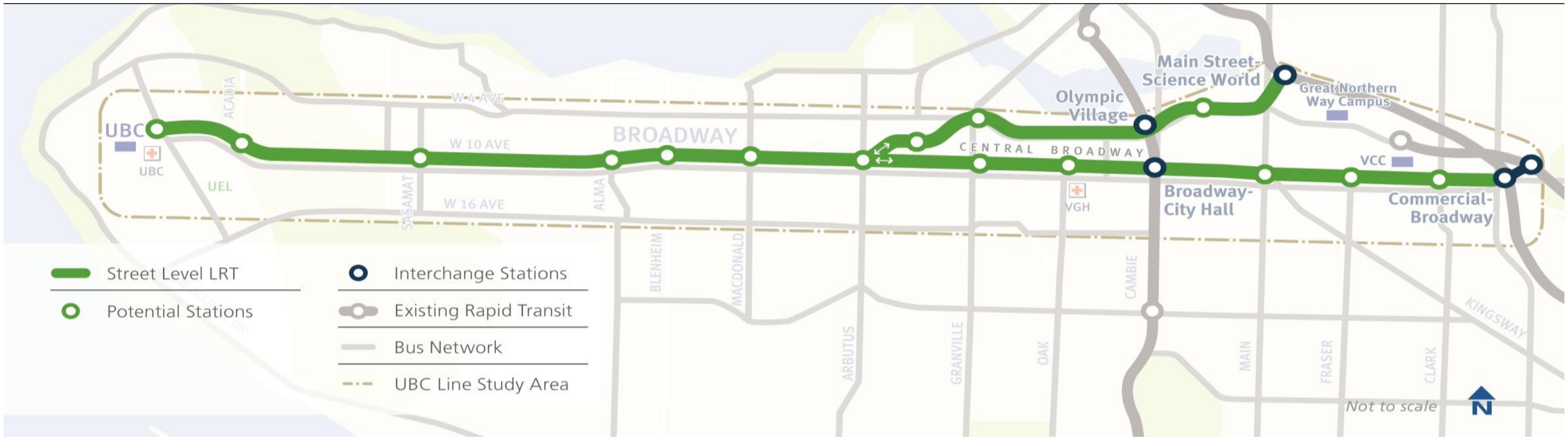
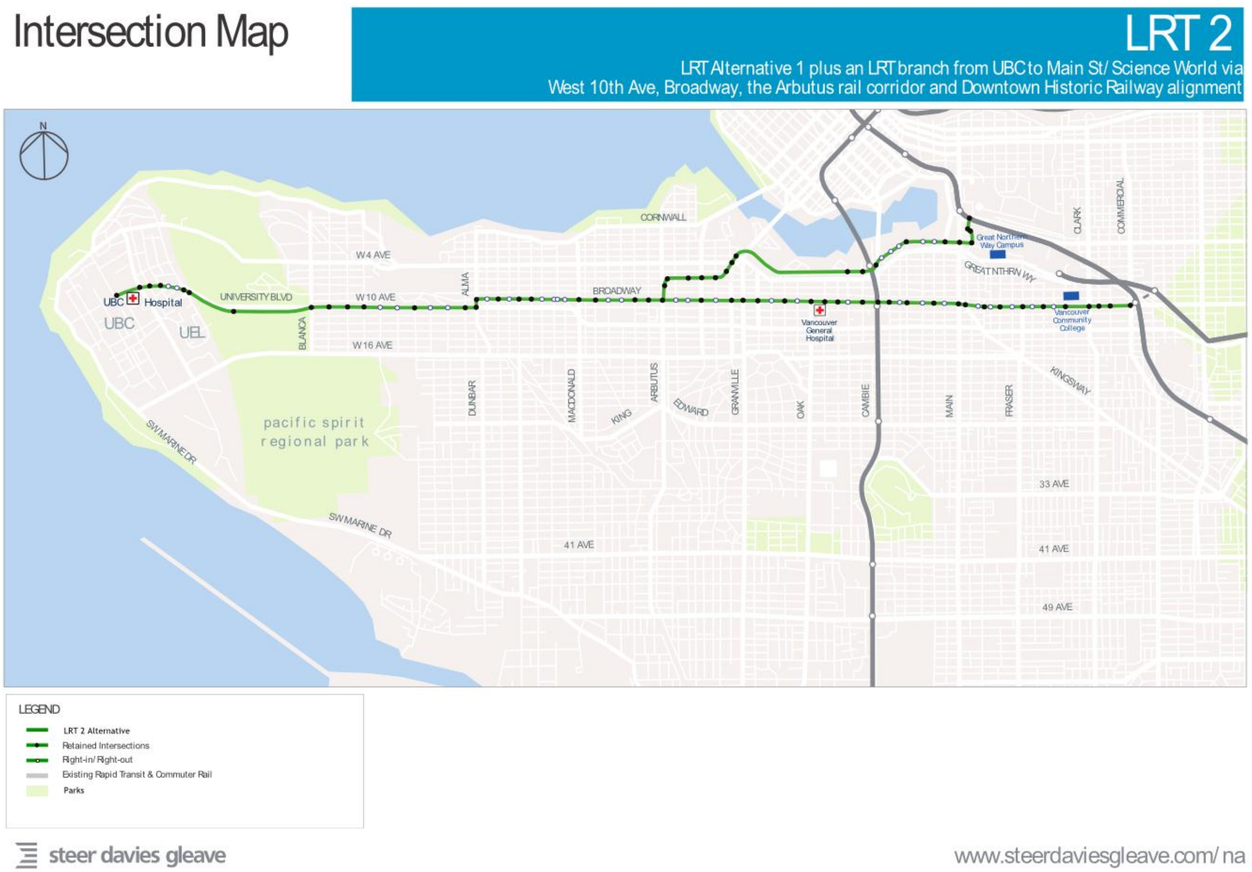


FIGURE 3.9 LRT ALTERNATIVE 2 - INTERSECTION MAP



4 Rail Rapid Transit Alternative

4.1 This section provides an overview of the Rail Rapid Transit (RRT) Alternative that is being considered in Phase 2 of the UBC Line Rapid Transit Study. This alternative includes RRT service from UBC to VCC-Clark Station via West 10th Avenue and Broadway. The RRT alternative uses SkyTrain technology which will allow through service to the Millennium Line.

Rail Rapid Transit (RRT) - Alignment Concept

4.2 The alignment design is based on a fully grade-separated rail rapid transit system. It is assumed the tunnel type used is of twin bored tunnel design, similar to that used on the Canada Line between Olympic Village Station and Waterfront Station.

4.3 At the eastern end of the corridor the RRT alternative will tie-in to the existing elevated VCC-Clark SkyTrain Station.

FIGURE 4.1 UNDERGROUND RRT TUNNEL

Stations

4.4 While the exact positioning of each station will require more work (during Phase 3 of the study for the preferred alternative), the station locations for this initial design are largely based on the replication of the existing 99 B-Line station locations.

4.5 The platform length is 80 metres long to provide for the operation of SkyTrain technology and ensure consistency with Expo/Millennium line platforms. The platform width is nine metres and all will be centre platforms.

FIGURE 4.2 EXAMPLE OF RRT STATION PLATFORM

High Level Design Principles: Rail Rapid Transit

4.6 The proposed design principles for the corridor are set out in the following table.

Design Element	Design Principle	Comments
Vehicle	Length ≈ max train length (first to last door) of 80 metres Width ≈ 2.65 metres	This will allow for 5 car SkyTrain consists
Alignment	Internal tunnel diameter of ≈ 5.5 metres. Maximum Gradient 6% Minimum curve radius 80m Tunnel ventilation would be integrated within the right of way or existing built streetscape environment. Emergency access and egress shafts would be integrated within the existing built streetscape. Integrated where possible with potential development opportunities.	
Segregation	The system would be 100% segregated, driverless with moving block signalling.	

Design Element	Design Principle	Comments
Stations	An 80 metre active platform face to accommodate a five car train length. Stations would feature cut and cover ticketing concourses above the platforms and below street level. Entrances would be integrated within the streetscape, where property is required this would provide development opportunities where feasible. At major stations two entrances would be provided either at the opposite corners of an intersection or the opposite sides of a street. Step free elevator access would be provided as a minimum from the main entrance. Stations will provide: • Entrances; • Concourse; • Ticketing facilities; • Elevators and Escalators; • Seating; • Passenger Information; • Real Time Information; • CCTV; • Help Points; • Passenger Announcements; • Fire equipment; • Emergency exit;	
Roadway	No impact on road capacity following construction.	

FIGURE 4.3 RRT VISUALIZATION – BROADWAY AND OAK (ILLUSTRATIVE CONCEPT DESIGN)

FIGURE 4.4 RRT ALTERNATIVE - KEY MAP AND STATION LOCATIONS

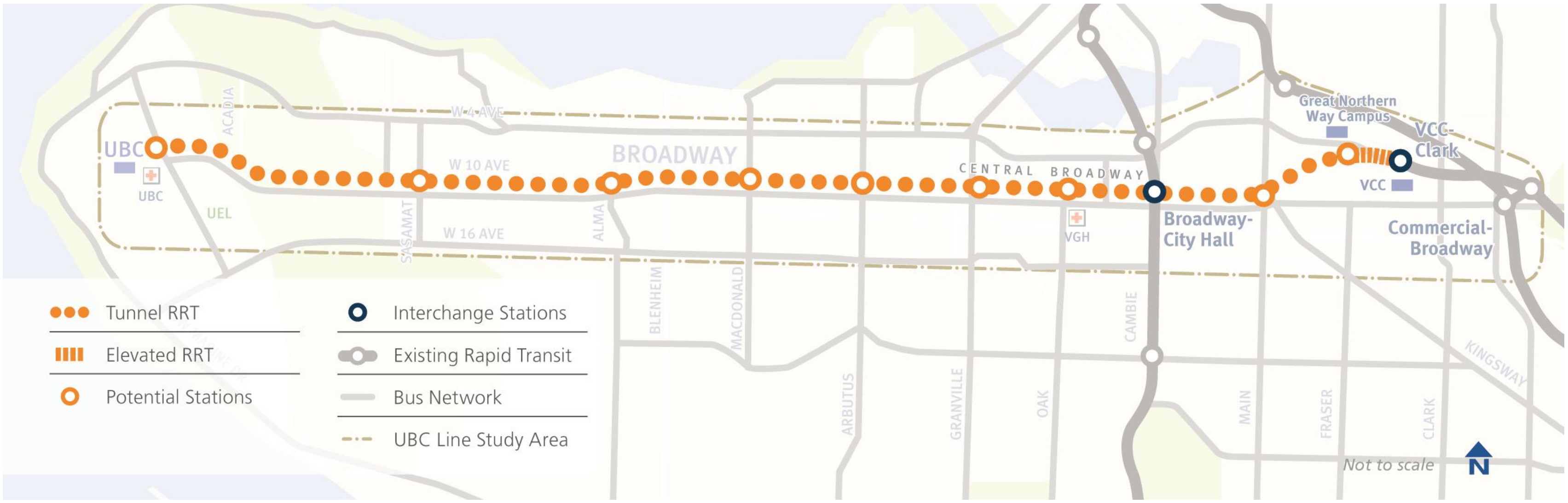
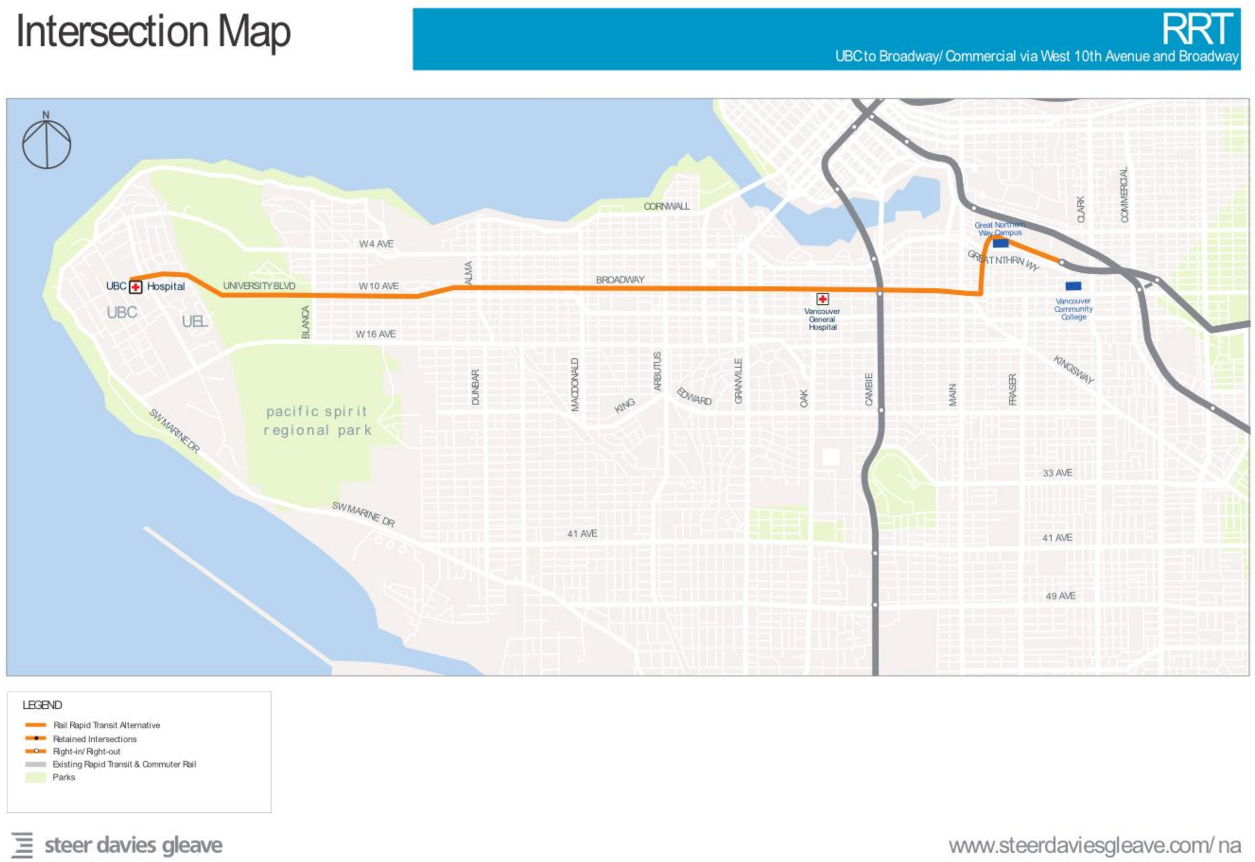


FIGURE 4.5 RRT ALTERNATIVE – INTERSECTION MAP



5 Combination Alternatives

5.1 This section provides an overview of the two Combination Alternatives that are being considered in Phase 2 of the UBC Line Rapid Transit Study.

5.2 There are two Combination Alternatives included in this study:

1. Combination Alternative 1: LRT from UBC to Main Street/Science World (using the LRT Alternative 2 alignment) **plus** RRT from Broadway/Arbutus to VCC/Clark (using the RRT Alternative 1b alignment)
2. Combination Alternative 2: BRT from UBC to Broadway/Commercial (using the BRT Alternative alignment) **plus** RRT from Broadway/Arbutus to VCC/Clark (using the RRT Alternative 1b alignment)

Alignment Concept

5.3 The combination alternatives combine portions of the LRT, BRT, and RRT alternatives. Detailed assumptions and concept notes for each constituent mode can be accessed in their respective sections.

Stops

5.4 While the exact positioning of each stop will require more work (during Phase 3 of the study for the preferred alternative), the stop locations for this initial design are based on the replication of the existing 99 B-Line stop locations.

5.5 Further mode specific stop information can be accessed in the LRT, BRT, and RRT sections of this document.

FIGURE 5.1 COMBINATION ALTERNATIVE 1 - KEY MAP AND STATION LOCATIONS

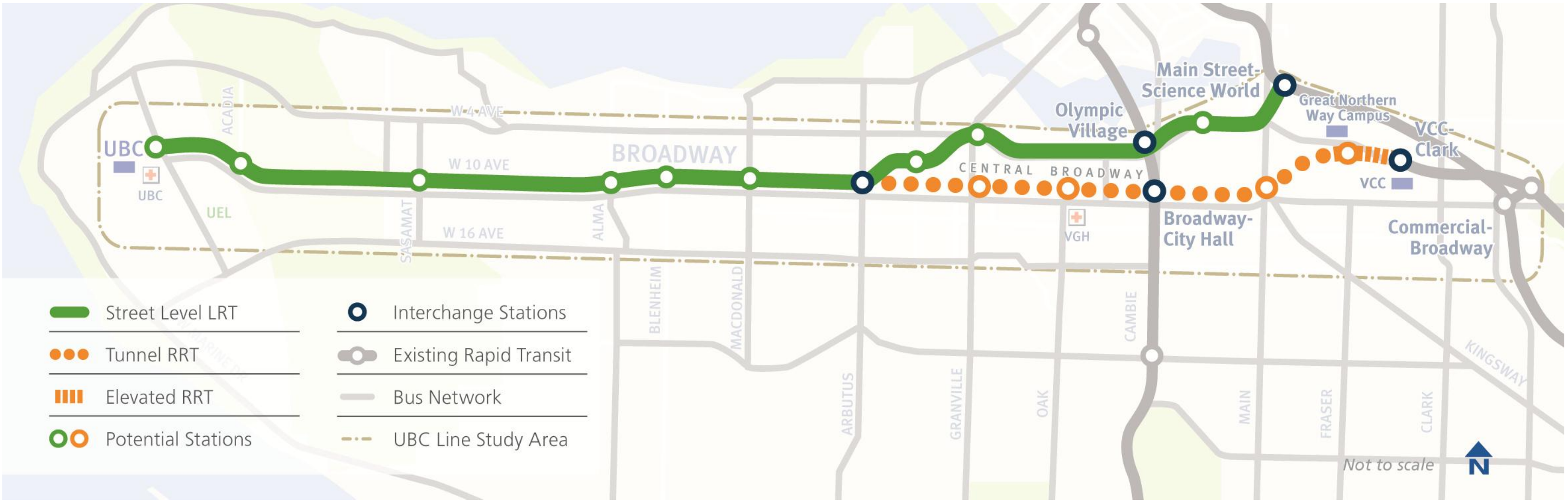


FIGURE 5.2 COMBINATION ALTERNATIVE 1 – INTERSECTION MAP

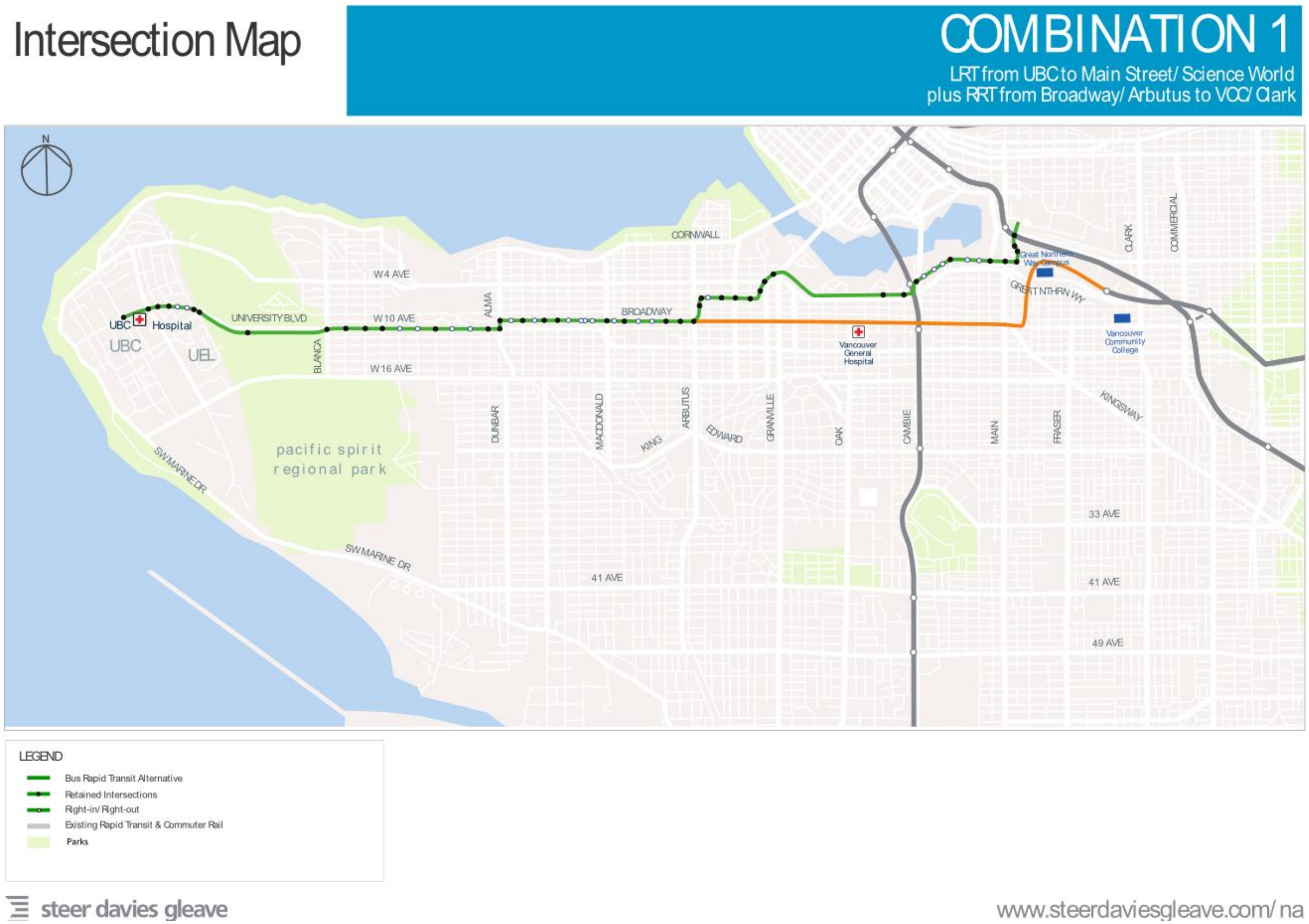


FIGURE 5.3 COMBINATION ALTERNATIVE 2 – KEY MAP AND STATION LOCATIONS

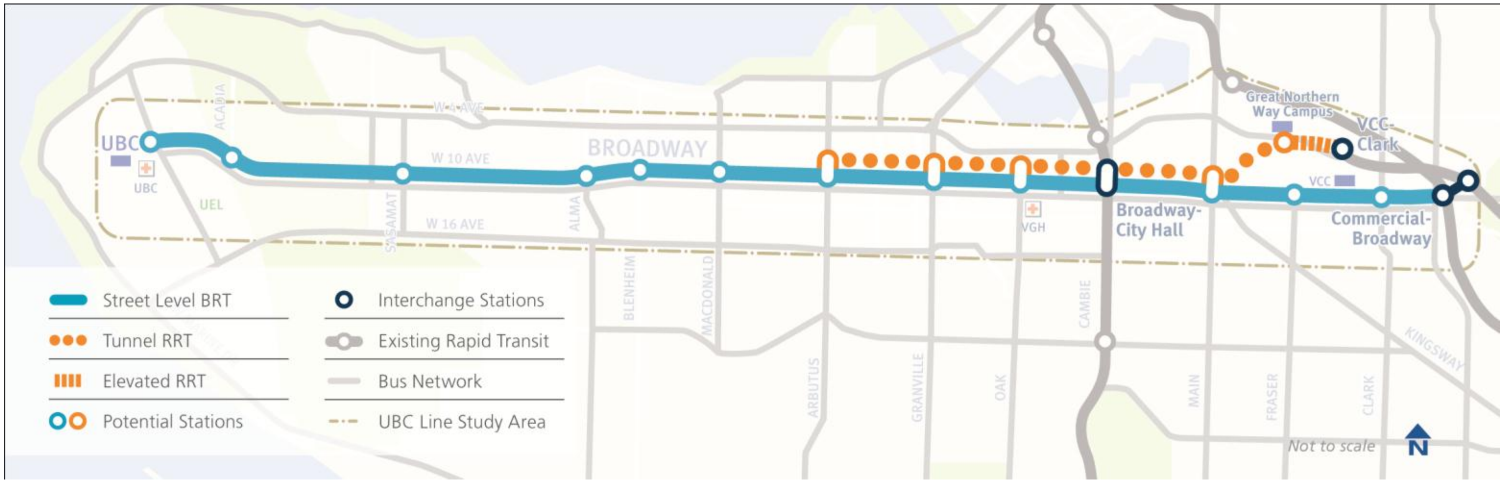
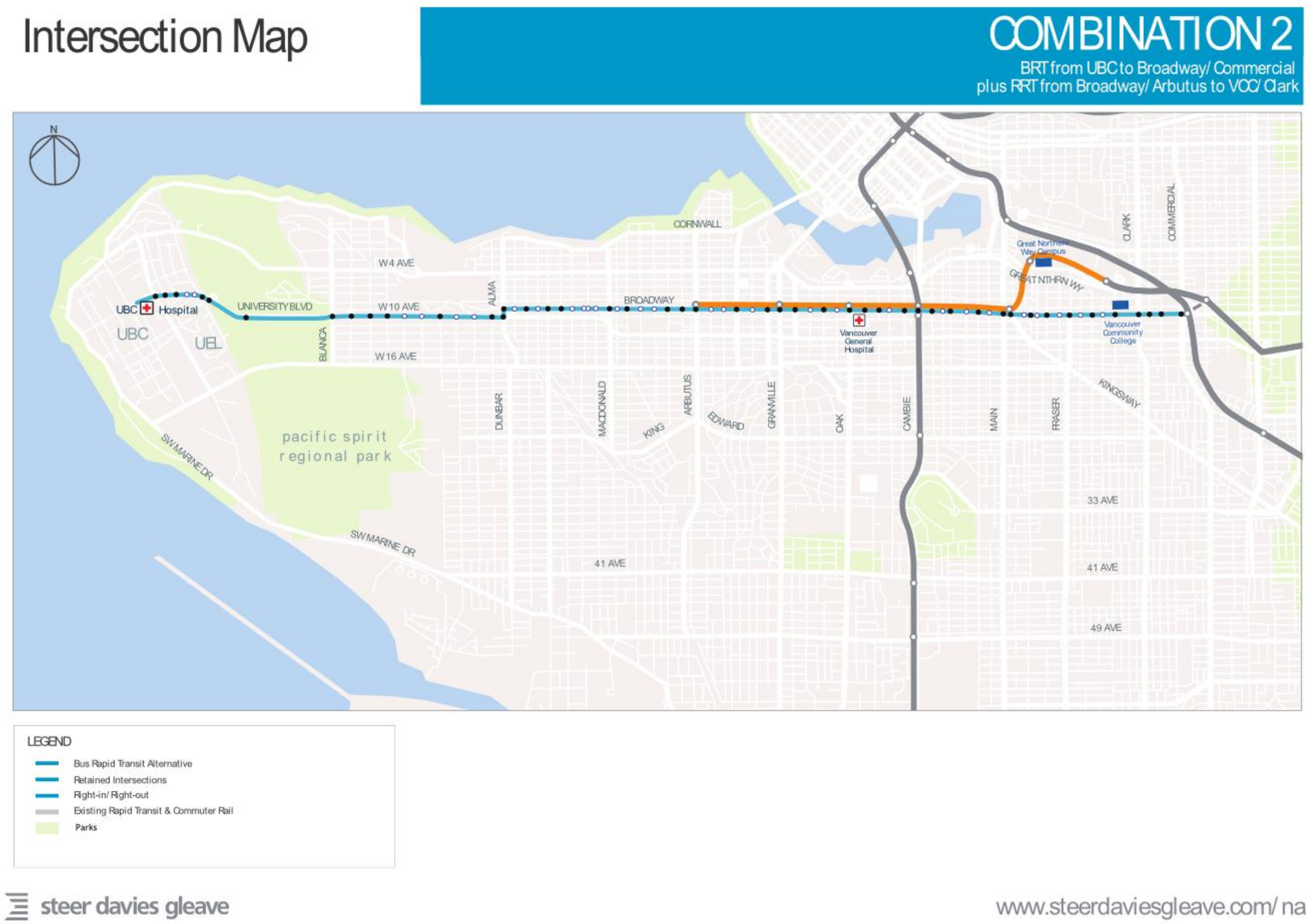


FIGURE 5.4 COMBINATION ALTERNATIVE 2 - INTERSECTION MAP



6 Street Running Alternatives Intersection Assumptions

6.1 Table below presents the intersection assumptions for the various street running alternatives

Intersection	10th Av/Broadway			
	Right In-Right-Out	Crossing	Some Lefts	All Moves
Wesbrook Mall				x
Western Pkwy		x		
Allison Rd		x		
Dalhousie Road	x			
Acadia Rd		x		
Toronto Rd		x		
Blanca St			x	
Tolmie St		x		
Sasamat St				x
Trimble St		x		
Discovery St	x			
Courtenay St	x			
Camosun St		x		
Crown St	x			
Wallace St	x			
Highbury St		x		
W. 10th Ave/Alma				x
Alma/Broadway				x
Dunbar St	x			
Collingwood St		x		
Waterloo St	x			
Blenheim St		x		
Trutch St		x		
Balaclava St	x			
Bayswater St	x			
Carnarvon St	x			
Mackenzie St	x			
Macdonald St				x
Stephens St	x			
Trafalgar St		x		
Larch St	x			
Balsam St	x			
Vine St		x		
Yew St		x		
Arbutus St			x	
Maple St	x			
Cypress St	x			
Burrard St			x	
Pine St	x			
Fir St		x		
Granville St			x	
Hemlock St		x		
Birch St	x			
Alder St		x		
Spruce St	x			
Oak St			x	
Laurel St	x			
Willow St		x		
Heather St	x			
Ash St		x		
Cambie St			x	
Yukon St		x		
Alberta St	x			
Columbia St		x		
Manitoba St	x			
Ontario St		x		
Quebec St	x			
Main St		x		
Kingsway		x		
Brunswick St	x			
Prince Edward St		x		
Guelph St	x			
St George St		x		
Carolina St	x			
Fraser St			x	
Prince Albert St	x			
St Catherines St		x		
Windsor St	x			
Glen Dr		x		
Clark Dr				x
McLean Dr	x			
Woodland Dr		x		
Commercial Dr			x	

Intersection	LRT Alignment - Main St to Broadway				
	Closed	Right In-Right-Out	Crossing	Some Lefts	All Moves
W 8th	x				
Maple St			x		
Cypress St					x
Burrard St				x	
Pine St					x
W 5th			x		
W 4th					x
Anderson			x		
Alder crossing					x
Spruce St					x
Heather St					x
Ash St					x
Cook St			x		
Manitoba St			x		
Ontario St			x		
Quebec St			x		
Main St				x	
Industrial Av	x				
Northern St	x				
Main St				x	

NOTE:

Right In-Right Out: Vehicle traffic cannot cross the LRT tracks/BRT alignment
Same pedestrian crossings as currently in place

Crossing: Vehicle traffic can cross the LRT tracks/BRT alignment
Same pedestrian crossings as currently in place

Some Lefts: Some left turn bans in place
Same pedestrian crossings as currently in place

All Moves: All traffic movements allowed across intersection
Same pedestrian crossings as currently in place

APPENDIX

D

FORECASTING ASSUMPTIONS AND RESULTS

UBC Rapid Transit Line

Forecasting Assumptions and Results

Technical note

July 2012

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CONTENTS

1 INTRODUCTION 1

Background 1

Note Structure 1

2 ASSUMPTIONS 2

Land Use Assumptions 2

Model Input and Assumptions 3

Expansion Factors 4

3 RAPID TRANSIT OPTIONS 6

4 MODEL OUTPUTS 10

Regional Statistics 10

Peak Loads 11

Transit Regional Flows 14

Rapid Transit Demand Profiles 18

FIGURES

Figure 4.1 2041 AM Peak Hour Transit Flows - BAU (unconstrained) 15

Figure 4.2 2041 AM Peak Hour Transit Flows - Best Bus (unconstrained) 15

Figure 4.3 2041 AM Peak Hour Transit Flows - BRT (unconstrained) 16

Figure 4.4 2041 AM Peak Hour Transit Flows - LRT1 (unconstrained) 16

Figure 4.5 2041 AM Peak Hour Transit Flows - LRT2 (unconstrained) 17

Figure 4.6 2041 AM Peak Hour Transit Flows - RRT (unconstrained) 17

Figure 4.7 2041 AM Peak Hour Transit Flows - Combination 1 (unconstrained) 18

Figure 4.8 2041 AM Peak Hour Transit Flows - Combination 2 (unconstrained) 18

Figure 4.9 2041 AM Peak Hour - BRT Demand Profile WB 19

Figure 4.10 2041 AM Peak Hour - LRT1 Demand Profile WB 20

Figure 4.11 2041 AM Peak Hour - LRT2 (CO-BW to UBC) Demand Profile WB 21

Figure 4.12 2041 am peak hour - LRT2 (MA-SW to UBC) demand Profile EB 22

Figure 4.13 2041 AM Peak Hour - RRT Demand Profile WB 23

Figure 4.14 2041 AM Peak Hour - Combination 1 (LRT) Demand Profile WB 24

Figure 4.15 2041 AM peak hour – Combination 1 (RRT) Demand Profile WB......... 25
Figure 4.16 2041 AM Peak Hour – Combination 2 (BRT) Demand Profile EB 26
Figure 4.17 2041 AM peak hour – combination 2 (RRT) Demand Profile WB 27

TABLES

Table 2.1 Regional Growth Strategy Forecasts (May 2011)............................2
Table 2.2 UBC Student Forecasts (May 2011)..3
Table 2.3 Model Inputs...3
Table 2.4 Model Parameters 4
Table 2.5 Expansion Factors 5
Table 3.1 Rapid Transit Service Assumptions 6
Table 3.2 BRT and LRT1 Service Characteristics 7
Table 3.3 RRT Service Characteristics 8
Table 3.4 LRT Service: Main St/Science World-UBC LRT Service.....................9
Table 4.1 2021 Mode Split (AM Peak Hour).. 10
Table 4.2 2041 Mode Split (AM Peak Hour).. 10
Table 4.3 2021 Regional Statistics (AM Peak Hour) 11
Table 4.4 2041 Regional Statistics (AM Peak Hour) 11
Table 4.5 2021 AM Peak Hour Peak Loads (unconstrained) 12
Table 4.6 2041 AM Peak Hour Peak Loads (unconstrained) 13

1 Introduction

Background

1.1 The Rapid Transit Projects Model 2008 (RTPM08) was developed as an analytical tool for the UBC Rapid Transit Line, Rapid Transit Strategic Network Review and Surrey Rapid Transit Alternatives Analysis projects.

1.2 RTPM08 is a four-stage EMME multi-modal forecasting model representing the Metro Vancouver region and largely based on the Metro Vancouver Model (MVM). It is an AM peak hour (7:30-8:30) model calibrated to 2008 trip diary and regional screenline data with 2021 and 2041 forecast years. Future year population and employment forecasts are driven by the Regional Growth Strategy (RGS) as provided by Metro Vancouver and approved by all municipalities.

1.3 The model represents the road and transit network of Metro Vancouver region and model outputs include ridership, mode share, travel time savings, decongestion benefits and vehicle kilometres which have provided the basis for the evaluation calculations.

Note Structure

1.4 Following this introductory section, Section 2 describes the model's main inputs and assumptions, Section 3 presents the rapid transit alternatives while Section 4 summarizes the UBC Rapid Transit Line study ridership outputs.

2 Assumptions

Land Use Assumptions

2.1 Metro Vancouver's Regional Growth Strategy population and employment forecasts from May 2011 were applied. The table below summarizes this data.

TABLE 2.1 REGIONAL GROWTH STRATEGY FORECASTS (MAY 2011)

District	Population		Employment	
	2021	2041	2021	2041
West Vancouver	55,991	65,485	25,508	30,096
North Vancouver	153,926	182,017	67,000	80,000
CBD	108,662	128,930	182,729	201,634
Rest of Vancouver/UEL	579,462	631,714	276,268	301,799
Burnaby/New Westminster	356,193	450,777	206,098	250,006
North East Sector	286,272	368,757	110,820	144,477
Richmond	226,682	280,579	154,007	180,325
Delta South	53,562	57,686	49,883	58,481
Delta North/Surrey	541,913	680,766	196,092	256,497
Surrey South/White Rock	118,430	156,229	45,097	61,387
Pitt Meadows/Maple Ridge	117,128	156,061	42,201	57,297
Langley	176,882	242,237	93,415	128,175
Fraser Valley North	64,602	81,252	25,412	32,577
Fraser Valley South	276,511	341,709	133,462	157,770
TOTAL	3,116,216	3,824,199	1,607,992	1,940,521

2.2 Metro Vancouver's Regional Growth Strategy also contains estimates on the number of students and resident students at and UBC and these are included below.

TABLE 2.2 UBC STUDENT FORECASTS (MAY 2011)

	2021	2041
UBC enrolment	46,306	50,432
Resident student	9,283	13.221

Model Input and Assumptions

2.3 Table 2.3 provides a range of model input assumptions.

TABLE 2.3 MODEL INPUTS

Parameter	2008	2021	2041
Vehicle Operating Cost – Car	$0.16/km		
Vehicle Operating Cost – LGV	$0.24/km		
Vehicle Operating Cost – HGV	$0.56/km		
Transit Fares (average)	$1.68 for 1 zone $2.27 for 2 zones $2.76 for 3 zones WCE: $5.95-$11.05		
Parking Costs	$0.43-$4.48		
Toll Costs – Car	-	$2.50	$2.50
Toll Costs – LGV	-	$5.00	$5.00
Toll Costs – HGV	-	$7.50	$7.50
Average Hourly Income ($ per hour)	$20.90	$23.71	$30.09
Value of Time ($ per hour)	$10.45	$11.86	$15.04
Value of Time – LGV ($ per hour)	$29.55	$33.52	$42.55
Value of Time – HGV ($ per hour)	$41.90	$47.62	$60.61

2.4 The key macroeconomic assumption underlying the RTPM's forecast year is real growth in GDP per capita (i.e. without the effect of inflation). Observed annual GDP per capita growth rate of -1.70% for British Columbia has been applied for the base year (2008) to represent effects of the economic slowdown, based on the GDP statistics available from the Government of British Columbia. However a longer term annual growth rate of 1.20% has been adopted for the years beyond 2008. This was derived from historical BC GDP statistics over the past 10 years (1999 – 2008) and 2009-2010 GDP forecasts prepared by the Conference Board of Canada, together with Metro Vancouver population forecasts.

2.5 These growth rates have been applied to update the base year hourly incomes and VOTs to the forecast year values. The other costs (vehicle operating costs, transit fares, parking costs and toll costs) are assumed constant in real terms over the years.

2.6 There are also a number of model parameters. These are included in table below.

TABLE 2.4 MODEL PARAMETERS

Parameter	Description	Value
Interchange Penalty	Time in minutes applied to any transferring transit trip	4
Wait Factor	Factor applied to wait time	2.25
Walk Factor	Factor applied to walk time	1.75
Reliability	Mode specific factor applied to wait time to reflect service reliability	Bus=1.2 LRT=1.1 BRT=1.1 RRT=0.8 WCE=0.8

Expansion Factors

2.7 Factors were estimated to enable to expand AM peak hour model outputs to daily and annual estimates. Data was collected from auto and transit screenline data and provided for both the region and for UBC due to the different travel characteristics between both areas.

2.8 This is the particularly the case for the UBC peak hour to daily transit factor which was estimated from UBC screenline (number 116) to reflect UBC's later AM peak patterns (8:30-9:30 rather than 7:30-8:30) and high inter-peak ridership.

2.9 The auto daily to annual factor values were based on City of Vancouver auto counts. The lack of regional annual traffic profiles means that this value has been applied to the region.

TABLE 2.5 EXPANSION FACTORS

	Hourly to Daily	Daily to Annual	Hourly to Annual
Auto (regional)	15.07	343	5,175
Auto (UBC screenline and City of Vancouver)	13.64	302	4,113
Transit (regional)	11.65	302	3,518
Transit (UBC screenline)	16.45	302	4,968

2.10 Model data between 2021 and 2041 forecast years was estimated based on a straight line interpolated and there was no growth assumed after 2041.

3 Rapid Transit Options

3.1 The operating characteristics of the various rapid transit options are summarized in the table below. Travel times were developed using a spreadsheet run-time model, supplemented by VISSIM simulations for the LRT1 alternative.

TABLE 3.1 RAPID TRANSIT SERVICE ASSUMPTIONS

Alternative	Service	Length (km)	Headway (min)	Travel time (min)	Speed (km/hr)
BRT	BRT (CO-BW to UBC)	13.1	2.0	33.4	23.5
LRT1	LRT (CO-BW to UBC)	13.1	4.0	28.1	28.0
LRT2	LRT (CO-BW to UBC)	13.1	5.0	28.1	28.0
	LRT (MA-SW to UBC)	11.8	7.5	24.2	29.3
RRT	RRT (CO-BW to UBC)	13.2	3.0	18.5	42.8
Combo 1	RRT to Arbutus	6.1	3.0	9.1	40.2
	LRT (MA-SW to UBC)	11.8	4.0	24.2	29.3
Combo 2	RRT to Arbutus	6.1	3.0	9.1	40.2
	BRT (CO-BW to UBC)	13.1	2.0	33.4	23.5

3.2 For Broadway and 10th Avenue options (BRT and LRT1), the rapid transit services were coded with the following characteristics.

TABLE 3.2 BRT AND LRT1 SERVICE CHARACTERISTICS

Stops	Distance (km)	Travel time (min)			
		BRT		LRT1	
		Station to station	Cumulative	Station to station	Cumulative
Commercial-Broadway	0	0	0	0	0
Clark	0.63	2.1	2.1	1.6	1.6
Fraser	0.71	2.5	4.6	2.3	3.9
Main	1.02	2.2	6.7	2.1	6.0
Cambie	0.86	2.2	8.9	2.1	8.1
Oak	0.87	2.4	11.4	2.1	10.2
Granville	0.82	2.5	13.9	2.0	12.2
Arbutus	1.23	3.4	17.2	2.2	14.4
Macdonald	0.99	2.4	19.6	2.3	16.7
Blenheim	0.63	1.8	21.5	1.5	18.3
Alma	0.6	2.3	23.7	1.4	19.6
Sasamat	2	3.9	27.6	3.6	23.2
University Blvd	1.95	3.8	31.5	3.0	26.2
UBC	0.76	1.9	33.4	1.9	28.1
TOTAL	**13.1**	**33.4**	**-**	**28.1**	**-**

3.3 The operational characteristics for the RRT service from Commercial-Broadway to UBC are summarized below.

TABLE 3.3 RRT SERVICE CHARACTERISTICS

Stops	Distance (km)	Travel Time (min)	
		Station to station	Cumulative
Commercial-Broadway	0	0	0
VCC-Clark	0.95	1.2	1.2
Great Northern Way	0.54	1.2	2.4
Main	0.8	1.4	3.8
Cambie	1.19	1.7	5.5
Oak	0.71	1.3	6.0
Granville	0.88	1.5	8.3
Arbutus	0.99	1.6	9.9
Macdonald	1.17	1.7	11.7
Alma	1.11	1.7	13.4
Sasamat	1.82	2.3	15.6
UBC	3.04	2.9	18.5
TOTAL	**13.2**	**18.5**	**-**

3.4 The operational characteristics for the LRT service between Main Street-Science World and UBC are summarized below.

TABLE 3.4 LRT SERVICE: MAIN ST/SCIENCE WORLD-UBC LRT SERVICE

Stops	Distance (km)	Travel Time (min)	
		Station to station	Cumulative
Main St-Science World	0	0	0
Quebec	1.15	2.4	2.4
Olympic Village	0.66	1.5	4.0
Granville Island	1.86	3.7	7.7
Burrard	0.51	1.3	9.0
Arbutus	0.69	1.6	10.6
Macdonald	0.99	2.3	12.8
Blenheim	0.63	1.5	14.4
Alma	0.6	1.4	15.7
Sasamat	2	3.6	19.3
University Blvd	1.95	3.0	22.3
UBC	0.76	1.9	24.2
TOTAL	**11.8**	**24.2**	**-**

4 Model Outputs

Regional Statistics

4.1 Tables 4.1 and 4.2 present the 2021 and 2041 mode split for each alternative. Note that auto trips includes auto driver and auto passenger.

TABLE 4.1 2021 MODE SPLIT (AM PEAK HOUR)

	Regional			Corridor		
	Auto Trips	Transit Trips	Walk/Cycle Trips	Auto Trips	Transit Trips	Walk/Cycle Trips
BAU	568,993	116,143	132,279	54,839	25,632	14,083
Best Bus	568,919	116,241	132,262	53,367	27,761	13,696
BRT	568,316	116,709	132,419	54,222	26,142	14,195
LRT1	568,390	116,614	132,430	54,228	26,153	14,207
LRT2	568,301	116,732	132,411	54,148	26,231	14,185
RRT	567,086	118,803	131,572	53,021	28,282	13,723
Combination 1	567,408	118,398	131,676	53,304	27,673	13,781
Combination 2	567,337	118,355	131,798	54,751	25,711	14,085

TABLE 4.2 2041 MODE SPLIT (AM PEAK HOUR)

	Regional			Corridor		
	Auto Trips	Transit Trips	Walk/Cycle Trips	Auto Trips	Transit Trips	Walk/Cycle Trips
BAU	646,869	154,648	149,053	57,261	30,025	15,160
Best Bus	646,736	154,796	149,031	57,101	30,173	15,161
BRT	646,043	155,380	149,161	56,466	30,770	15,259
LRT1	646,115	155,330	149,131	56,487	30,769	15,258
LRT2	646,046	155,413	149,118	55,075	33,359	14,674
RRT	644,567	157,934	148,113	55,293	32,567	14,969
Combination 1	644,792	157,309	148,540	55,248	32,444	15,061
Combination 2	644,683	157,283	148,683	57,261	30,025	15,160

4.2 Tables 4.3 and 4.4 present the regional travel statistics for each alternative for 2021 and 2041.

TABLE 4.3 2021 REGIONAL STATISTICS (AM PEAK HOUR)

	Transit pass km	Transit Hours	Auto vehicle km
BAU	769,892	128,141	4,748,066
Best Bus	771,228	128,208	4,748,527
BRT	786,732	128,625	4,741,204
LRT1	791,172	128,589	4,742,988
LRT2	792,164	128,623	4,741,566
RRT	849,090	129,700	4,733,109
Combination 1	833,456	129,535	4,737,361
Combination 2	826,495	129,591	4,737,406

TABLE 4.4 2041 REGIONAL STATISTICS (AM PEAK HOUR)

	Transit pass km	Transit Hours	Auto vehicle km
BAU	1,042,935	172,821	5,567,807
Best Bus	1,045,359	172,897	5,567,096
BRT	1,065,384	173,370	5,560,888
LRT1	1,073,295	173,368	5,559,765
LRT2	1,073,286	173,398	5,560,907
RRT	1,144,136	174,581	5,551,279
Combination 1	1,129,683	174,251	5,553,429
Combination 2	1,119,994	174,356	5,552,180

Peak Loads

4.3 The peak loads for the Broadway corridor transit services under each option are summarized in the tables below.

TABLE 4.5 2021 AM PEAK HOUR PEAK LOADS (UNCONSTRAINED)

	Route	Peak Load EB	Peak Load WB	Headway	Capacity	V/C	All demand on Rapid Transit	Capacity	V/C
	099eb	401	0	6.50	923	0.43	1,334	923	1.45
	099wb	0	2,589	2.50	2,400	1.08	3,209	2,400	1.34
	009g	417	321	10.00	360	1.16			
BAU	009u	516	299	8.00	450	1.15			
	099eb	583	0	5.00	1,200	0.49	1,465	1,200	1.22
	099wb	0	2,260	2.50	2,400	0.94	2,806	2,400	1.17
	009g	406	256	10.00	360	1.13			
Best Bus	009u	476	290	8.00	450	1.06			
	L-1a	2,314	3,976	4.00	7,200	0.55	4,362	7,200	0.61
	009g	295	182	10.00	360	0.82			
LRT1	009u	368	204	8.00	450	0.82			
	L-1a	1,588	3,578	5.00	5,760	0.62	3,991	5,760	0.69
	L-2	1,019	440	7.50	3,840	0.27			
	009g	317	194	10.00	360	0.88			
LRT2	009u	393	219	8.00	450	0.87			
	B-1	2,082	4,575	2.00	3,000	1.53	4,913	3,000	1.64
	009g	284	161	10.00	360	0.79			
BRT	009u	346	177	8.00	450	0.77			
	996mN	3,854	9,077	3.00	13,000	0.70	9,445	13,000	0.73
	009g	266	181	10.00	360	0.74			
RRT	009u	332	187	8.00	450	0.74			
	996mN	3,111	7,698	3.00	13,000	0.59	8,088	13,000	0.62
	L-2	1,925	1,865	7.50	3,840	0.50			
Combo1	009g	267	176	10.00	360	0.74			

	Route	Peak Load EB	Peak Load WB	Headway	Capacity	V/C	All demand on Rapid Transit	Capacity	V/C
	009u	334	214	8.00	450	0.74			
	996mN	3,190	8,264	3.00	13,000	0.64	10,476	13,000	0.81
	B-1	2,045	1,880	2.00	3,000	0.68			
	009g	233	135	10.00	360	0.65			
Combo2	009u	291	197	8.00	450	0.65			

TABLE 4.6 2041 AM PEAK HOUR PEAK LOADS (UNCONSTRAINED)

	Route	Peak Load EB	Peak Load WB	Headway	Capacity	V/C	All demand on Rapid Transit	Capacity	V/C
	099eb	530	0	5.50	1,091	0.49	1,589	1,091	1.46
	099wb	0	2,735	2.50	2,400	1.14	3,405	2,400	1.42
	009g	498	320	9.00	400	1.25			
BAU	009u	561	350	7.50	480	1.17			
	099eb	766	0	4.00	1,500	0.51	1,752	1,500	1.17
	099wb	0	2,642	2.50	2,400	1.10	3,296	2,400	1.37
	009g	508	309	9.00	400	1.27			
Best Bus	009u	478	345	7.50	480	1.00			
	L-1a	3,231	5,225	4.00	7,200	0.73	5,611	7,200	0.78
	009g	331	182	9.00	400	0.83			
LRT1	009u	395	204	7.50	480	0.82			
	L-1a	2,201	4,749	5.00	5,760	0.82	5,197	5,760	0.90
	L-2	1,406	555	7.50	3,840	0.37			
	009g	360	211	9.00	400	0.90			
LRT2	009u	431	237	7.50	480	0.90			

	Route	Peak Load EB	Peak Load WB	Headway	Capacity	V/C	All demand on Rapid Transit	Capacity	V/C
	B-1	3,046	6,431	2.00	3,000	2.14	6,798	3,000	2.27
	009g	311	174	9.00	400	0.78			
BRT	009u	370	193	7.50	480	0.77			
	996mN	5,130	12,487	3.00	13,000	0.96	12,852	13,000	0.99
	009g	295	159	9.00	400	0.74			
RRT	009u	353	206	7.50	480	0.74			
	996mN	4,284	10,959	3.00	13,000	0.84	11,306	13,000	0.87
	L-2	3,135	2,543	7.50	3,840	0.82			
	009g	293	148	9.00	400	0.73			
Combo1	009u	351	199	7.50	480	0.73			
	996mN	4,453	11,699	3.00	13,000	0.90	14,539	13,000	1.12
	B-1	3,205	2,561	2.00	3,000	1.07			
	009g	241	127	9.00	400	0.60			
Combo2	009u	288	152	7.50	480	0.60			

Transit Regional Flows

4.4 Figures below provide an indication of the transit volumes along the UBC corridor and how these compare to transit volumes in the region. Note these represent EMME model outputs and are unconstrained to capacity.

FIGURE 4.1 2041 AM PEAK HOUR TRANSIT FLOWS – BAU (UNCONSTRAINED)

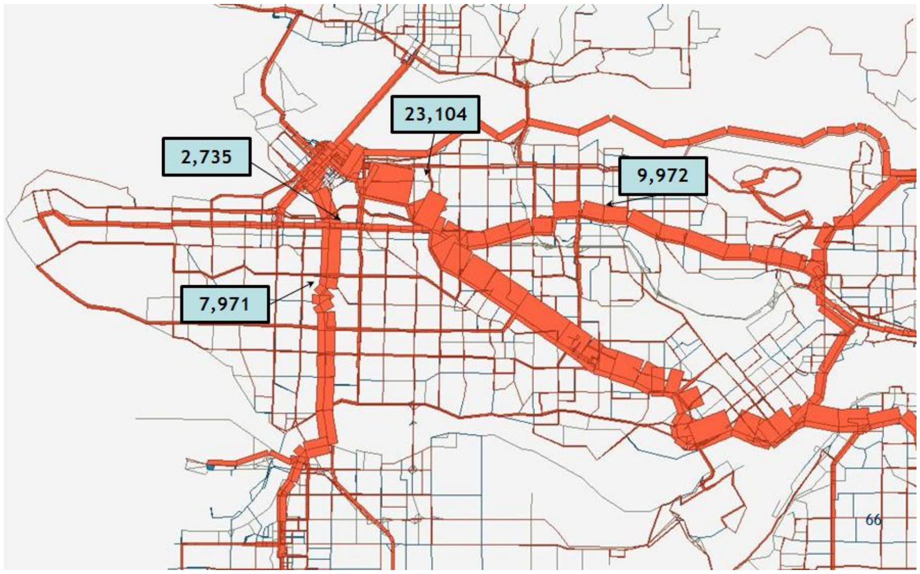


FIGURE 4.2 2041 AM PEAK HOUR TRANSIT FLOWS – BEST BUS (UNCONSTRAINED)

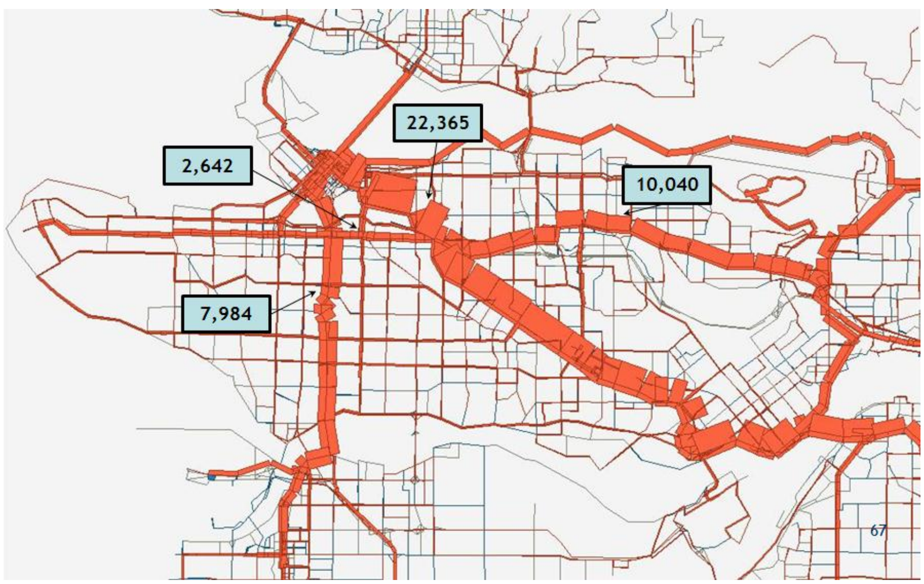


FIGURE 4.3 2041 AM PEAK HOUR TRANSIT FLOWS – BRT (UNCONSTRAINED)

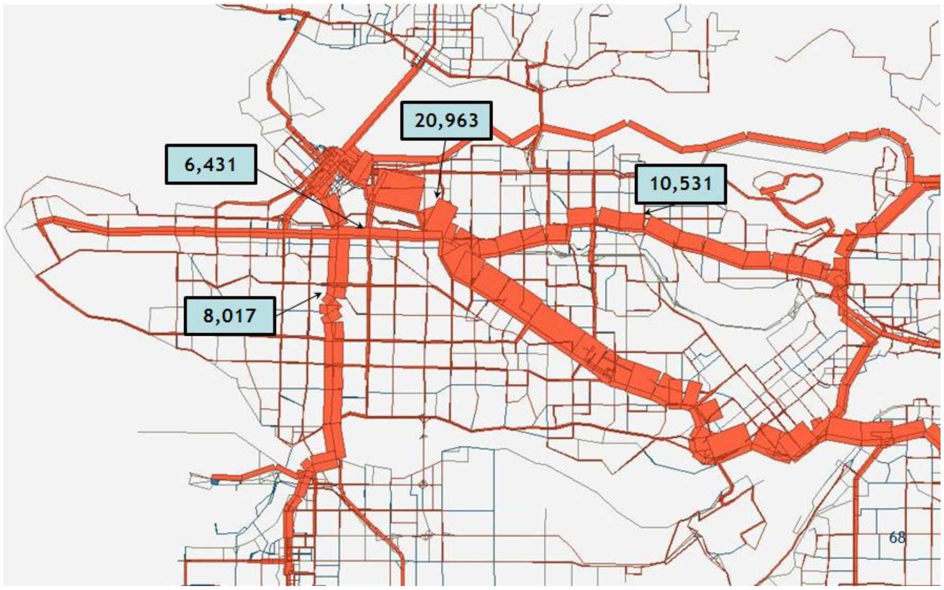


FIGURE 4.4 2041 AM PEAK HOUR TRANSIT FLOWS – LRT1 (UNCONSTRAINED)

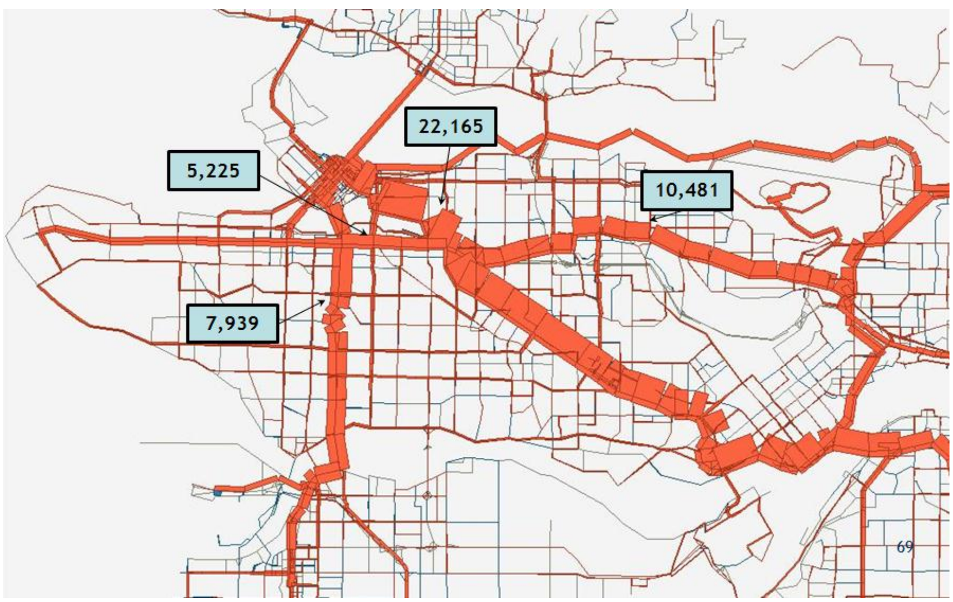


FIGURE 4.5 2041 AM PEAK HOUR TRANSIT FLOWS – LRT2 (UNCONSTRAINED)

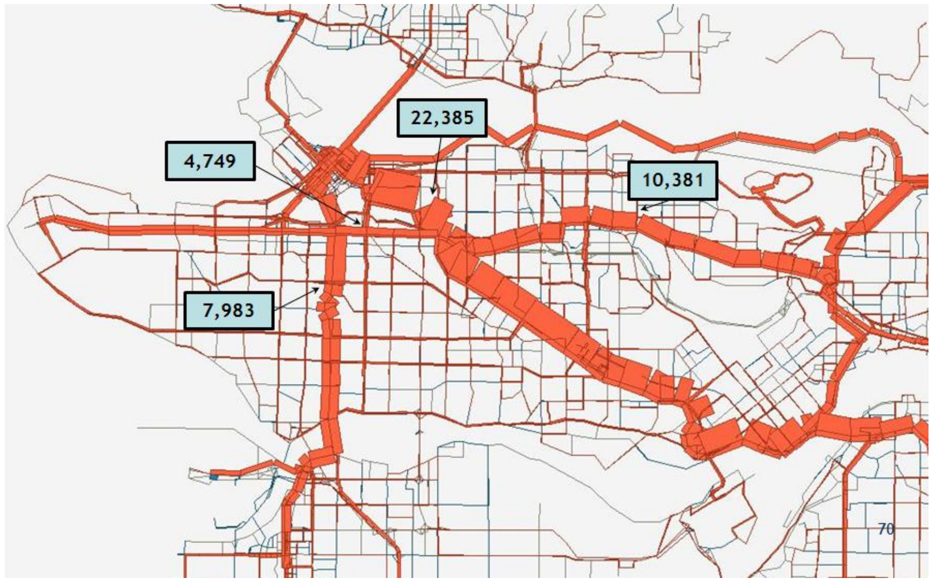


FIGURE 4.6 2041 AM PEAK HOUR TRANSIT FLOWS – RRT (UNCONSTRAINED)

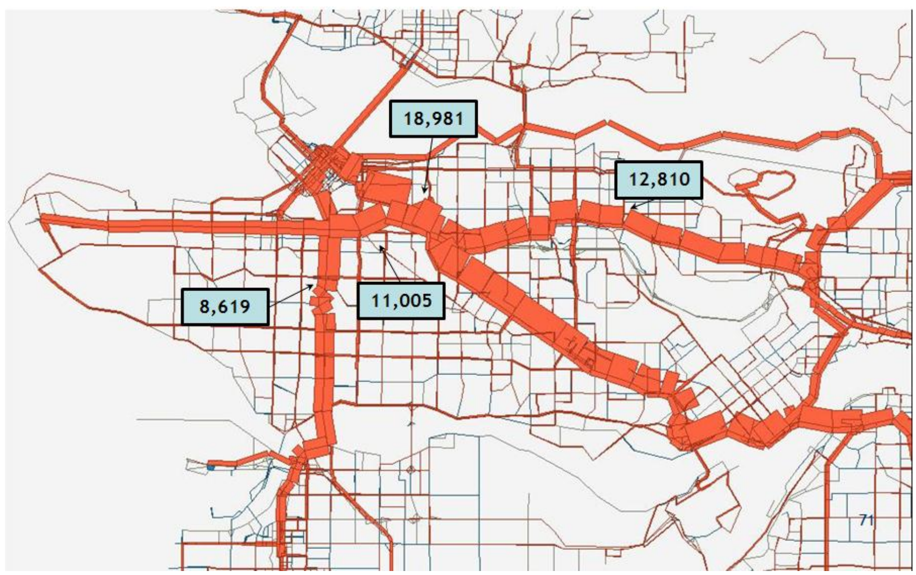


FIGURE 4.7 2041 AM PEAK HOUR TRANSIT FLOWS – COMBINATION 1 (UNCONSTRAINED)

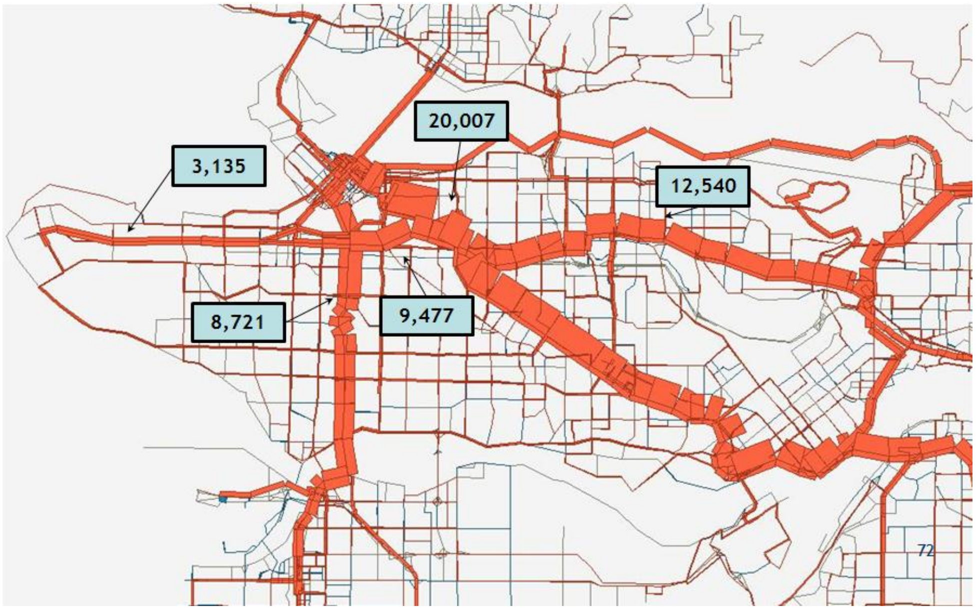
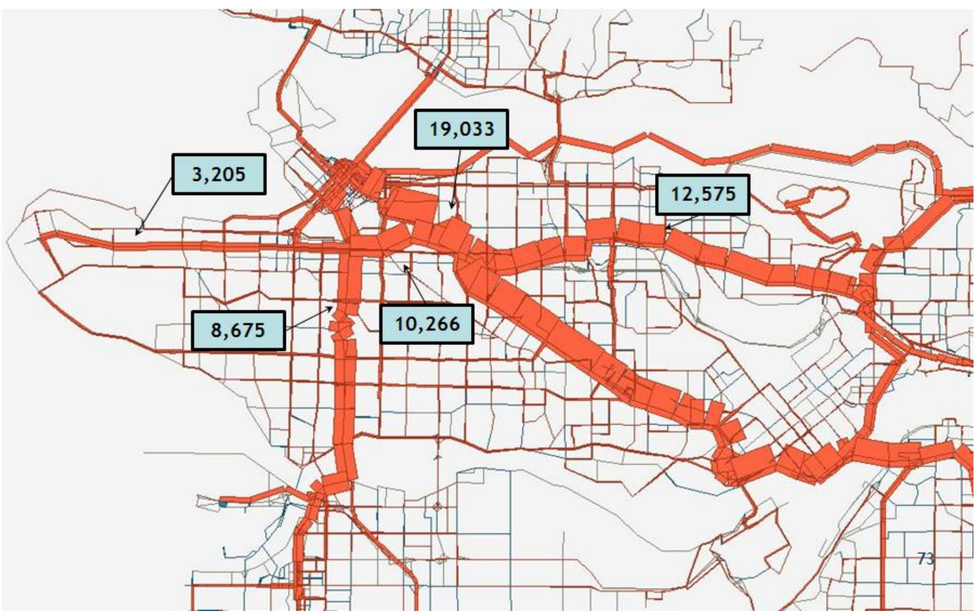


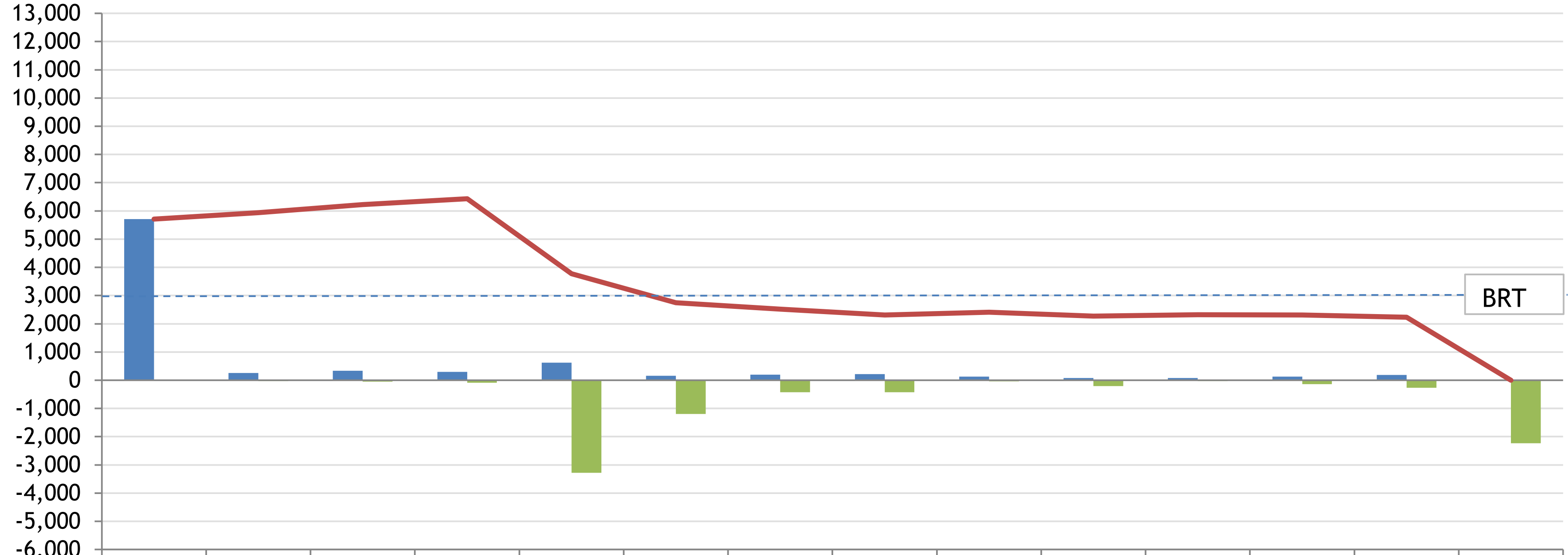
FIGURE 4.8 2041 AM PEAK HOUR TRANSIT FLOWS – COMBINATION 2 (UNCONSTRAINED)



Rapid Transit Demand Profiles

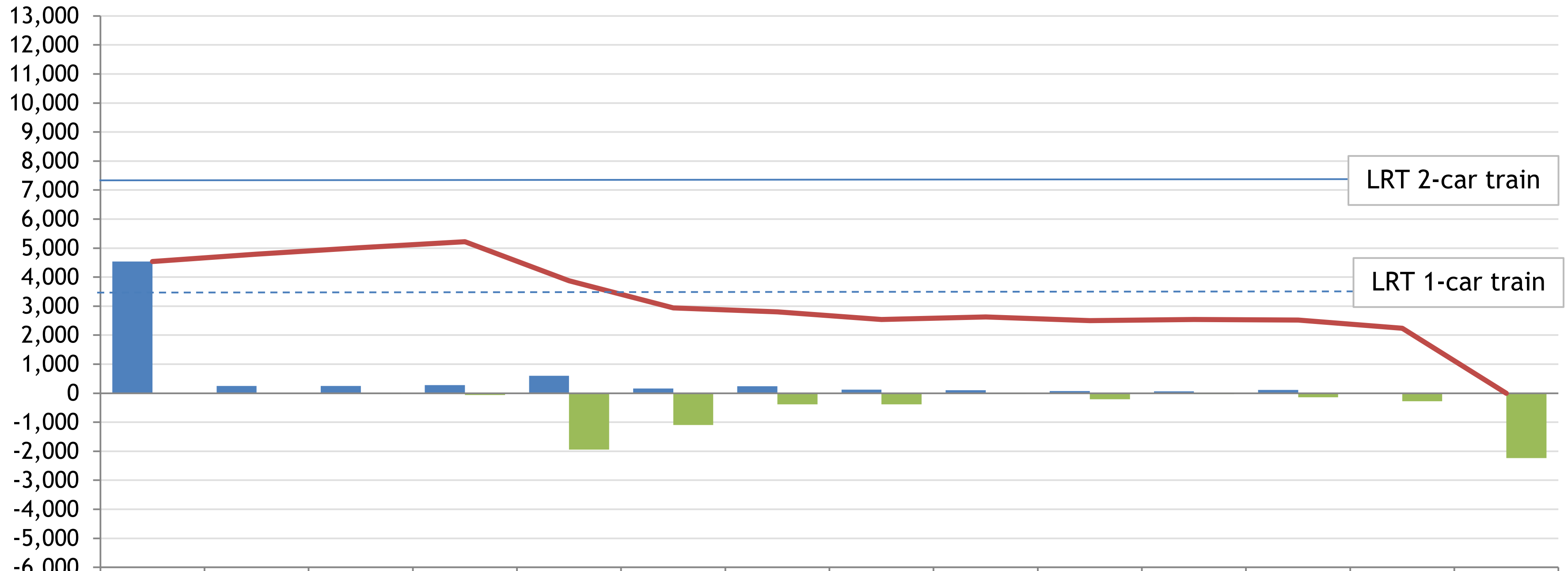
4.5 Boardings, alightings and line loads for each rapid transit option are presented below, together with horizontal lines representing the assumed capacity of each alternative.

FIGURE 4.9 2041 AM PEAK HOUR - BRT DEMAND PROFILE WB



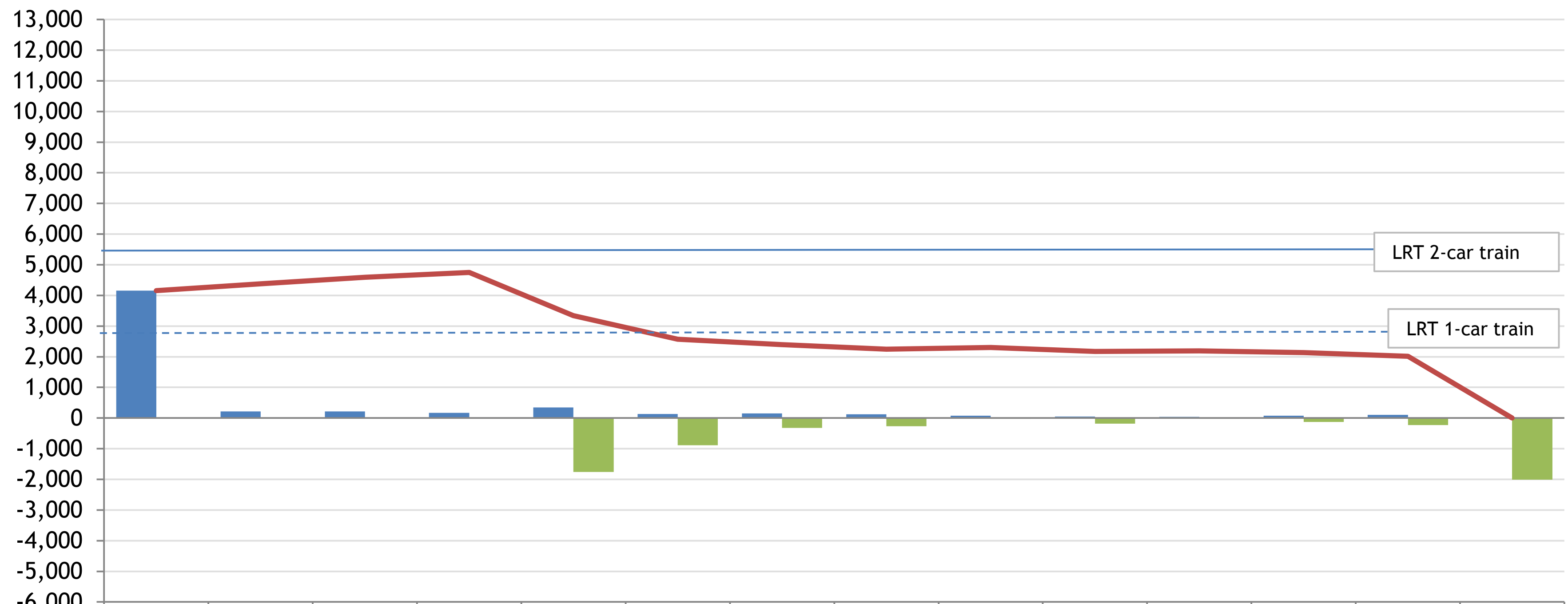
	Commercial	Clark	Fraser	Main	Cambie	Oak	Granville	Arbutus	Macdonald	Blenheim	Alma	Sasamat	University Blvd	UBC
Boardings	5,711	256	335	294	627	161	199	217	130	77	79	124	191	0
Alightings	0	-28	-52	-85	-3,282	-1,190	-429	-420	-38	-211	-25	-140	-269	-2,233
Volumes	5,711	5,939	6,222	6,431	3,776	2,747	2,517	2,314	2,407	2,273	2,326	2,311	2,233	0

FIGURE 4.10 2041 AM PEAK HOUR - LRT1 DEMAND PROFILE WB



	Commercial	Clark	Fraser	Main	Cambie	Oak	Granville	Arbutus	Macdonald	Blenheim	Alma	Sasamat	University Blvd	UBC
Boardings	4,534	254	249	276	599	162	242	123	105	76	62	117	0	0
Alightings	0	0	-23	-65	-1947	-1097	-379	-382	-20	-205	-28	-136	-281	-2236
Volumes	4,534	4,788	5,014	5,225	3,876	2,941	2,804	2,545	2,630	2,501	2,536	2,517	2,236	0

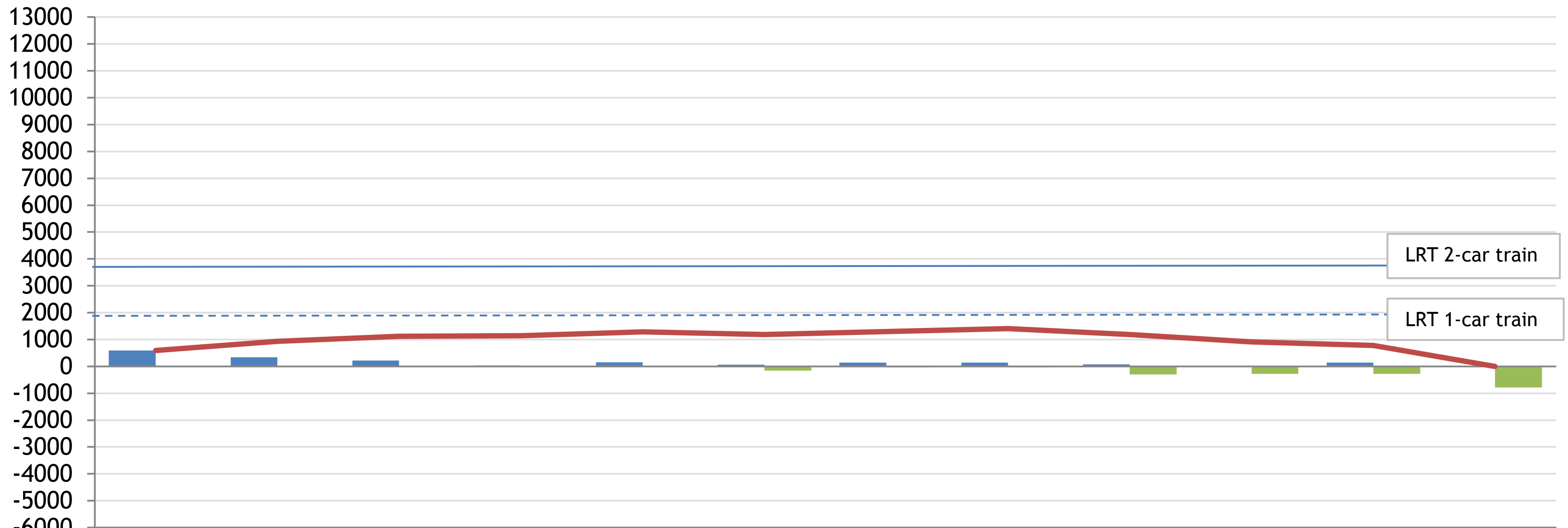
FIGURE 4.11 2041 AM PEAK HOUR – LRT2 (CO-BW TO UBC) DEMAND PROFILE WB



	Commercial	Clark	Fraser	Main	Cambie	Oak	Granville	Arbutus	Macdonald	Blenheim	Alma	Sasamat	University Blvd	UBC
Boardings	4,160	220	213	166	345	128	149	119	81	47	41	73	107	0
Alightings	0	0	-1	-8	-1757	-891	-326	-270	-21	-183	-24	-125	-229	-2013
Volumes	4,160	4,380	4,592	4,749	3,337	2,574	2,397	2,246	2,306	2,170	2,187	2,135	2,013	0

Boardings Alightings Volumes

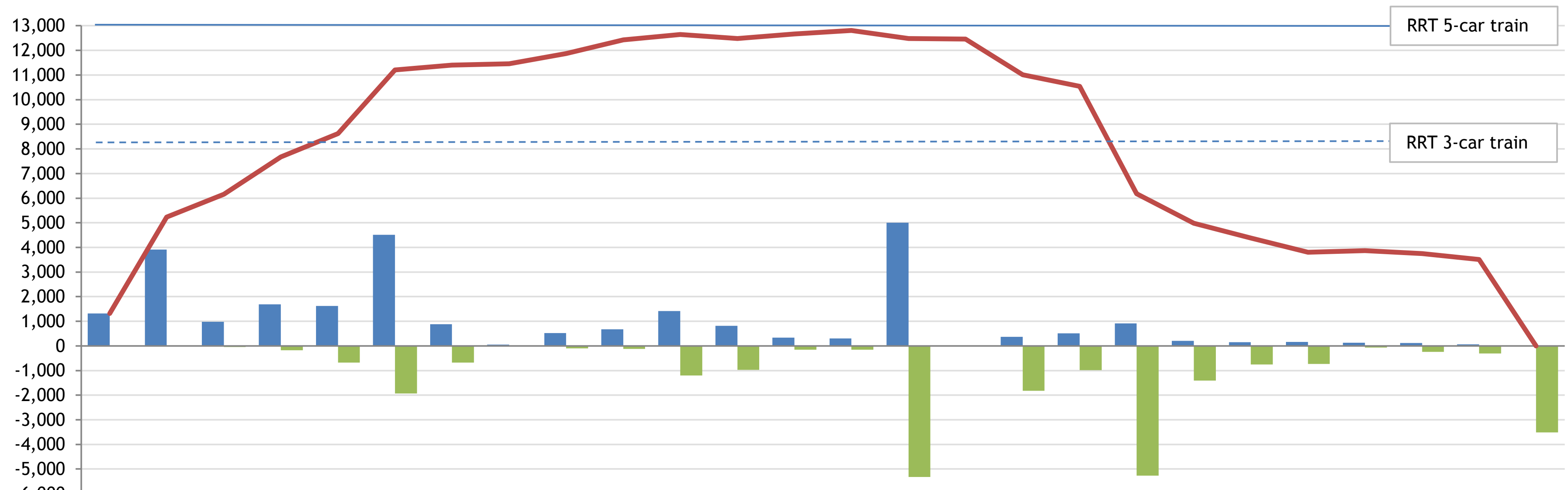
FIGURE 4.12 2041 AM PEAK HOUR - LRT2 (MA-SW TO UBC) DEMAND PROFILE EB



	UBC	University Boulevard	Sasamat	Alma	Blenheim	Macdonald	Arbutus	Burrard	Granville Island	Olympic Village	Thornton Park	Main St/Science World
Boardings	593	336	221	29	153	59	145	145	78	0	144	0
Alightings	0	0	-26	-10	-15	-157	-34	-33	-295	-281	-273	-779
Volumes	593	929	1124	1143	1281	1182	1294	1406	1189	907	779	0

Boardings Alightings Volumes

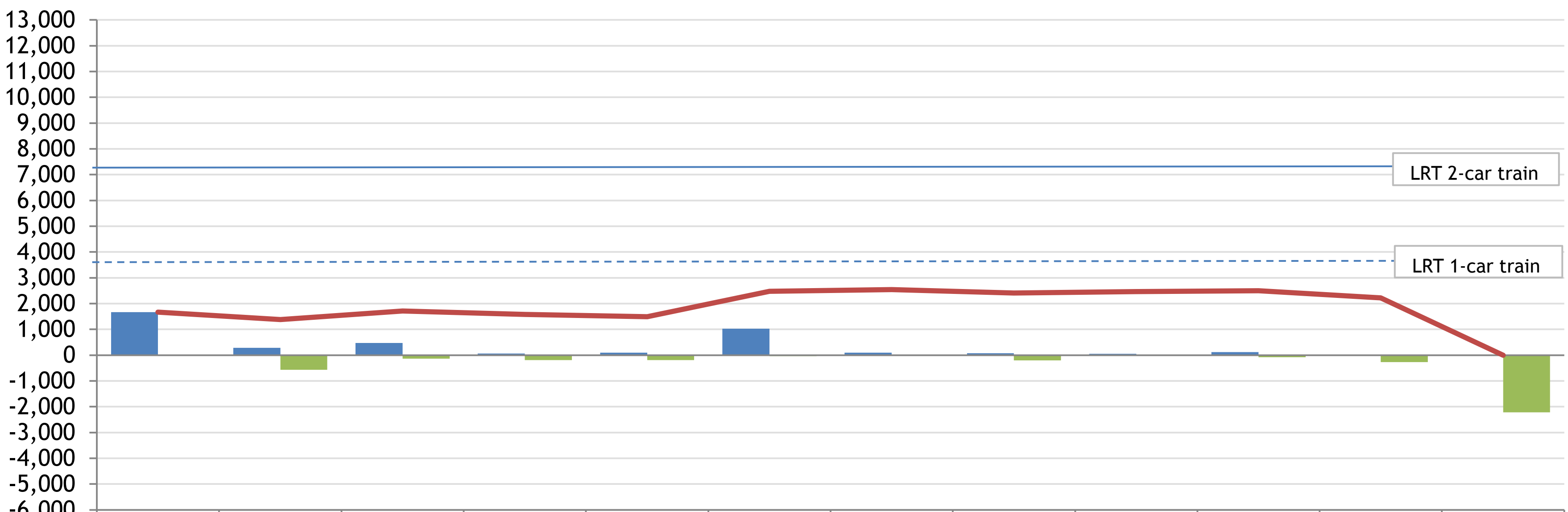
FIGURE 4.13 2041 AM PEAK HOUR – RRT DEMAND PROFILE WB



	Douglas College	Coquitlam Central	Ioco	Port Moody	Clarke Rd	Lougheed	Production	Lake City	Sperling	Holdom	Brentwood	Gilmore	Rupert
Boardings	1,317	3,917	979	1,690	1,624	4,510	877	51	525	679	1,412	811	338
Alightings	0	0	-49	-179	-677	-1,929	-677	0	-105	-125	-1,198	-969	-155
Volumes	1,317	5,234	6,164	7,675	8,622	11,203	11,403	11,454	11,874	12,428	12,642	12,484	12,667

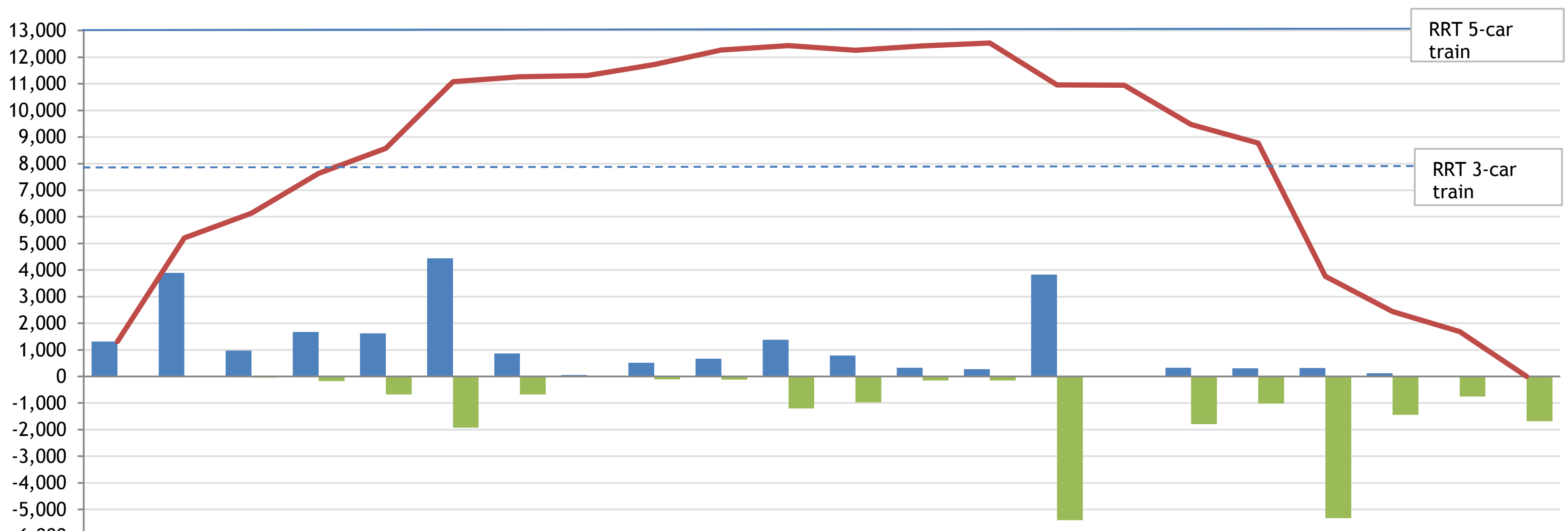
	Renfrew	Broadway Station 2	VCC-Clark	Great Northern Way	Main	Cambie	Oak	Granville	Arbutus	Macdonald	Alma	Sasamat	UBC
Boardings	300	4,998	0	366	516	909	206	155	165	132	117	61	0
Alightings	-157	-5,321	-26	-1,822	-982	-5,266	-1,407	-758	-735	-69	-237	-303	-3,509
Volumes	12,810	12,487	12,461	11,005	10,539	6,182	4,981	4,378	3,808	3,871	3,751	3,509	0

FIGURE 4.14 2041 AM PEAK HOUR - COMBINATION 1 (LRT) DEMAND PROFILE WB



	Main St/ Science World	Thornton Park	Olympic Village	Granville Island	Burrard	Arbutus	Macdonald	Blenheim	Alma	Sasamat	University Boulevard	UBC
Boardings	1,662	286	475	64	94	1,028	98	75	56	116	2	0
Alightings	0	-574	-140	-189	-190	-42	-29	-207	-6	-82	-273	-2,223
Volumes	1,662	1,374	1,708	1,583	1,487	2,474	2,543	2,411	2,461	2,494	2,223	0

FIGURE 4.15 2041 AM PEAK HOUR – COMBINATION 1 (RRT) DEMAND PROFILE WB

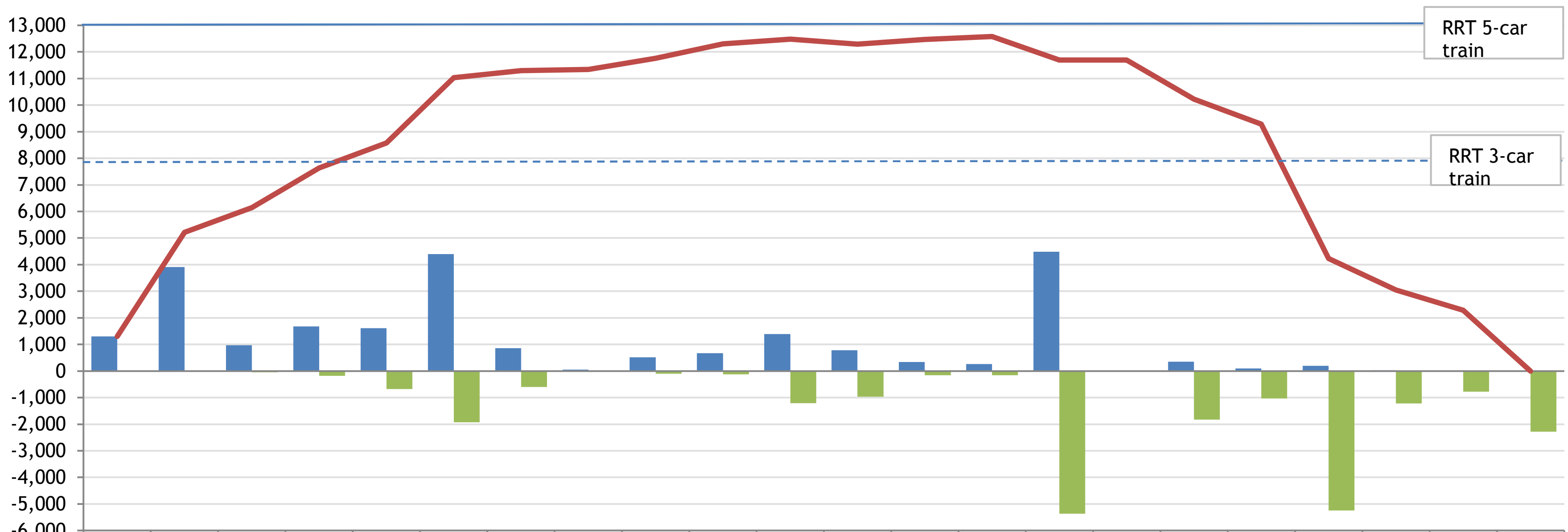


	Douglas College	Coquitlam Central	Ioco	Port Moody	Clarke Rd	Lougheed	Production	Lake City	Sperling	Holdom	Brentwood	Gilmore	Rupert	Renfrew	Broadway Station 2	VCC-Clark	Great Northern Way	Main	Cambie	Oak	Granville	Arbutus
Boardings	1,311	3,899	975	1,674	1,615	4,437	863	50	515	670	1,379	789	327	270	3,823	0	331	311	320	120	9	0
Alightings	0	0	-49	-179	-677	-1,930	-678	0	-105	-125	-1,205	-974	-156	-157	-5,404	-14	-1,799	-1,020	-5,328	-1,444	-758	-1,688
Volumes	1,311	5,211	6,137	7,632	8,570	11,077	11,262	11,312	11,722	12,267	12,441	12,256	12,428	12,540	10,959	10,945	9,477	8,768	3,760	2,437	1,688	0

FIGURE 4.16 2041 AM PEAK HOUR - COMBINATION 2 (BRT) DEMAND PROFILE EB

	UBC	University Boulevard	Sasamat	Alma	Blenheim	Macdonald	Arbutus	Granville	Oak	Cambie	Main	Fraser	Clark	Commercial
Boardings	1,455	879	579	93	440	161	7	54	198	62	5	7	24	0
Alightings	0	75	94	36	36	630	1,121	769	279	533	211	66	73	43
Volumes	1,455	2,259	2,744	2,801	3,205	2,736	1,622	907	826	356	150	92	43	0

FIGURE 4.17 2041 AM PEAK HOUR – COMBINATION 2 (RRT) DEMAND PROFILE WB



	Douglas College	Coquitlam Central	Ioco	Port Moody	Clarke Rd at Como Lake Av	Lougheed	Production	Lake City	Sperling	Holdom	Brentwood	Gilmore	Rupert	Renfrew	Broadway Station 2	VCC-Clark	Great Northern Way	Main	Cambie	Oak	Granville	Arbutus
Boardings	1,305	3,909	974	1,681	1,608	4,394	859	50	519	668	1,387	777	334	264	4,485	0	355	90	190	32	9	0
Alightings	0	0	-49	-180	-677	-1,932	-598	0	-105	-125	-1,206	-971	-155	-157	-5,361	0	-1,828	-1,029	-5,242	-1,218	-773	-2,285
Volumes	1,305	5,214	6,139	7,640	8,571	11,034	11,294	11,345	11,759	12,302	12,483	12,288	12,467	12,575	11,699	11,699	10,226	9,287	4,234	3,049	2,285	0

Boardings Alightings Volumes

CONTROL SHEET

Project/Proposal Name	UBC Rapid Transit Line
Document Title	Forecasting Assumptions and Results
Client Contract/Project No.	Click here to enter text.
SDG Project/Proposal No.	22106506

ISSUE HISTORY

Issue No.	Date	Details
1 (v2)	24 May 2012	May 2012 report
2 (v3)	27 July 2012	Includes 2021 and 2041 corridor data and mode share info

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DISTRIBUTION

Client:	TransLink/MoTI
Steer Davies Gleave:	

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APPENDIX

E

RUN TIME MODEL SUMMARY

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Runtime Model & Phase 2 Alternatives Results

UBC Line Rapid Transit Study

AUGUST 2010

SNC·LAVALIN

UBC Line Rapid Transit Study

Runtime Model and Phase 2 Alternatives Results

Technical note

August 2010

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CONTENTS

1 INTRODUCTION 1

Background 1

Overview 1

2 RUNTIME MODEL 2

Model Input Data Used for UBC Line Rapid Transit Study 2

3 RUNTIME MODEL OUTPUTS 4

BRT Alternative 4

LRT Alternative 1a 7

LRT Alternative 1b 10

LRT Alternative 2 13

RRT Alternative 1a 16

RRT Alternative 1b 19

4 SUMMARY OF RESULTS 23

TABLES

Table 3.1 BRT Alternative Runtime 5
Table 3.2 BRT Alternative Fleet Requirements 5
Table 3.3 BRT Alternative Stop to Stop Runtimes 6
Table 3.4 LRT Alternative 1a Runtime 7
Table 3.5 US LRT System Average Speeds 8
Table 3.6 LRT Alternative 1a Fleet Requirements 9
Table 3.7 LRT Alternative 1a Stop to Stop Runtimes 9
Table 3.8 LRT Alternative 1b Runtime 10
Table 3.9 LRT Option 1b Fleet Requirements 11
Table 3.10 LRT Option 1b Stop to Stop Runtimes 12
Table 3.11 LRT Alternative 2 Runtime 13
Table 3.12 LRT Alternative 2 Fleet Requirements 14
Table 3.13 LRT Alternative 2 Stop to Stop Runtimes 15
Table 3.14 RRT Alternative 1a Runtime 16
Table 3.15 RRT Alternative 1a Fleet Requirements 17
Table 3.16 RRT Alternative 1a Stop to Stop Runtimes 18
Table 3.17 RRT Alternative 1b Runtime 19
Table 3.18 rRT Alternative 1b Fleet Requirements 20
Table 3.19 RRT Alternative 1b Stop to Stop Runtimes 21
Table 4.1 Summary of Results 23

APPENDICES

A OVERVIEW OF RUNTIME MODEL

1 Introduction

Background

1.1 Steer Davies Gleave has been retained by the South Coast BC Transportation Authority (TransLink) and the BC Ministry of Transportation and Infrastructure (MOTI) (the Project Sponsors) to develop rapid transit options for the UBC Line Rapid Transit Project.

1.2 The study is being undertaken in three phases with Steer Davies Gleave's current contract covering the first two phases. At the conclusion of Steer Davies Gleave's commission, a single preferred rapid transit alternative will be selected.

Overview

1.3 To assist in the evaluation of the rapid transit alternatives, a series of Design Workbooks have been developed that include indicative alignment options by alternative for the phase 2 alternatives, following the phase 1 initial short listing process.

1.4 Steer Davies Gleave, using its spreadsheet based Runtime Model, has developed runtimes (journey times) for each of the rapid transit alternatives included in Design Workbook 2 (issued July 2010). This technical note provides details of the assumptions used as inputs to the model and provides the detailed outputs generated including end-to-end journey times and fleet requirements.

1.5 Runtimes were developed in an eastbound direction for each of the following Design Workbook 2 alternatives:

- BRT Alternative
- LRT Alternative 1a
- LRT Alternative 1b
- LRT Alternative 2
- RRT Alternative 1a
- RRT Alternative 1b

2 Runtime Model

2.1 Steer Davies Gleave's spreadsheet based runtime model (RTCM) is part of a suite of spreadsheets designed to develop runtimes during the development of transit projects. The tool has been developed and refined over a number of years and has been successfully used on a large number of rapid transit projects. The model has been benchmarked against a number of operating systems, including SkyTrain, and has proved to accurately represent the achieved runtimes of these systems

2.2 The model has been developed to provide a tool to calculate runtimes during rapid transit project development. The model inputs include the route characteristics and vehicle operating data, to provide runtime for the alternatives being considered. An overview of the model is provided in Appendix A.

Model Input Data Used for UBC Line Rapid Transit Study

2.3 The model allows the inputs to be set to best represent the characteristics of the proposed system being developed/tested. The following sections describe the inputs used to develop the runtimes for each of the alternatives for the UBC Line Rapid Transit Study.

BRT Inputs

2.4 The model developed for the UBC Line Rapid Transit Study includes data compiled from a number of manufactures as well as through benchmarking the model against actual bus performance on BRT systems, including against the existing performance of the 99B Line service.

2.5 The current parameters used to generate the UBC Line runtime estimates are:

- Vehicle = Generic articulated bus (18 metre vehicle)
- Profile = Speed limited to below identified speed limit
- The vehicle speed into stops is limited to 20kph
- The current maximum speed used is 60kph and 50kph east of Blanca Street
- Speed limits are imposed for alignment geometry and sight lines
- Speed limit of 30kph is used across intersections
- Pedestrian only crossing (Transit assumed to have priority operating to speed limit)
- Service Braking = 0.8 m/s2
- Station Dwell Time = 20 seconds

LRT Inputs

2.6 The model developed for the UBC Line Rapid Transit Study includes data compiled from a number of manufacturers as well as through benchmarking the model against actual performance from a number of North American and European LRT systems.

2.7 The current parameters used to generate the UBC Line runtime estimates are:

- Vehicle = Alstom Citadis 401 (40 metre vehicle)
- Characteristics = AW4 with worn wheels (all seat occupied & 4 people/m2)
- Profile = Speed limited to below identified speed limit
- The vehicle speed into stops is limited to 30kph
- The current maximum speed used is 70kph and 50kph east of Blanca Street
- Speed limits are imposed for track geometry, switches, crossings and sight lines
- Speed limit of 30kph used across intersections
- Pedestrian only crossing (Transit assumed to have priority operating to speed limit)
- Service Braking = 1.0 m/s2
- Station Dwell Time = 20 seconds

RRT Inputs

2.8 The model developed for the UBC Line Rapid Transit Study includes data compiled from a number of light metro/automated rail rapid transit vehicles manufactures as well as through benchmarking the model against actual performance from the existing SkyTrain system.

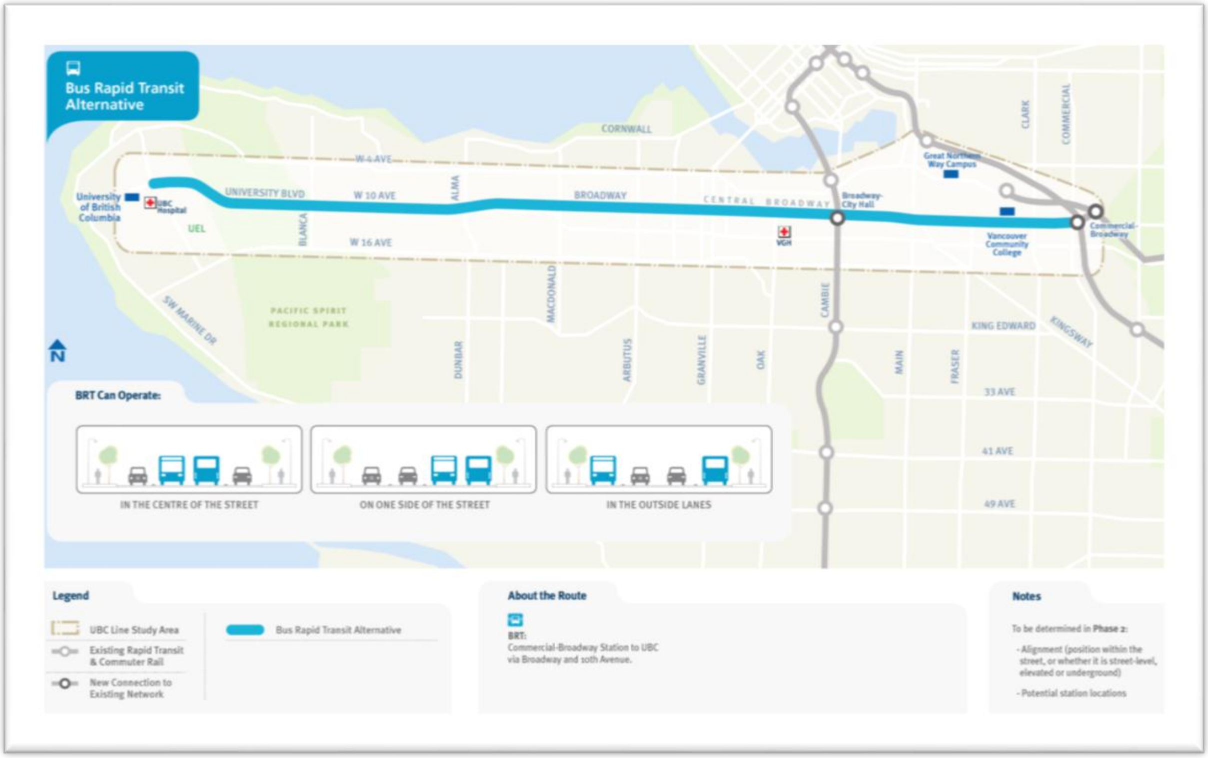
2.9 The current parameters used to generate the UBC Line runtime estimates are:

- Vehicle = SkyTrain The vehicle speed into stops is limited to 30kph)
- The current maximum speed employed is 80kph
- Speed limits are imposed for track geometry, switches, crossings and sight lines
- Service Braking = 1.0 m/s2
- Station Dwell Time = 20 seconds

3 Runtime Model Outputs

3.1 This Chapter provides the detailed outputs of the runtime models developed for each of the rapid transit alternatives for the UBC Line Rapid Transit Study.

BRT Alternative



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3.2 The runtime developed for the BRT Alternative is summarised in Table 3.1.

TABLE 3.1 BRT ALTERNATIVE RUNTIME

Data	
Length	13.0km
Stops	13
Stop to Stop Distance (Average)	1.01km
Intersection Priority Assumption	Varies by location, assumed high level of priority
End to End Journey Time	28.5 minutes
Average Operating Speed	27.4 kph
Layover Time	3 minutes
Vehicle Consist	1 x 18 metre articulated bus

Commentary on Results

3.3 The existing 99B line bus service in the AM peak provides a 34 minute end to end journey time, an average speed of 22.9 kph.

TABLE 3.2 BRT ALTERNATIVE FLEET REQUIREMENTS[1]

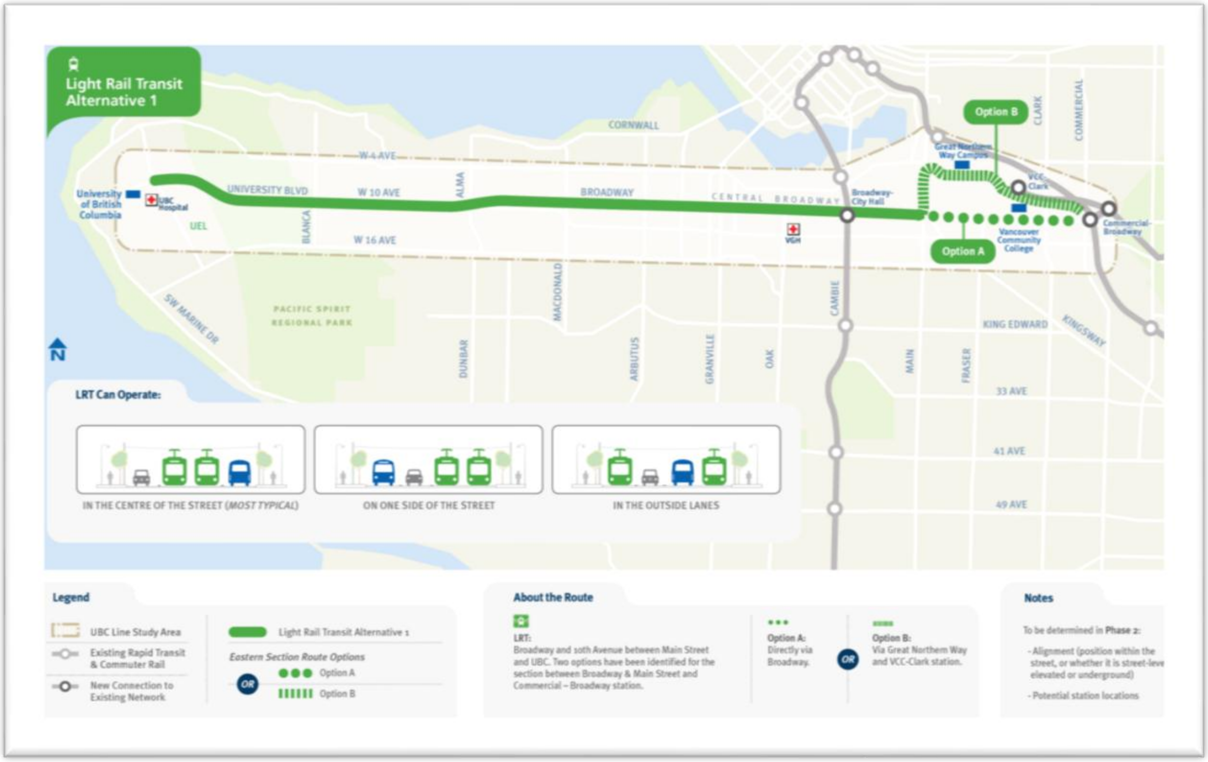
Service Frequency	Service Vehicles	Spares (15%)	Fleet
2 minutes	32	5	37
3 minutes	21	4	25
4 minutes	16	3	19
5 minutes	13	2	15
6 minutes	11	2	13
10 minutes	7	2	9

[1] Increased service frequency could increase end to end journey time due to reducing transit priority at intersections

TABLE 3.3 BRT ALTERNATIVE STOP TO STOP RUNTIMES

Stop	Distance	Runtime	Dwell
UBC			
University Boulevard	680	1:41	0:20
Sasamat	2060	3:00	0:20
Alma	1800	3:05	0:20
Macdonald	1250	2:34	0:20
Arbutus	1110	1:46	0:20
Granville	1120	2:36	0:20
Oak	870	1:50	0:20
Cambie	870	1:48	0:20
Main	920	1:35	0:20
Fraser	950	1:34	0:20
Clark	840	1:50	0:20
Commercial & Broadway	590	1:28	
Totals	13.0 km	24:50	3:40

LRT Alternative 1a



3.4 The runtime developed for the LRT Alternative 1a is summarised in Table 3.4.

TABLE 3.4 LRT ALTERNATIVE 1A RUNTIME

Data	
Length	13.0km
Stops	13
Stop to Stop Distance (Average)	1.01km
Intersection Priority Assumption	Varies by location, assumed high level of priority
End to End Journey Time	26.5 minutes
Average Operating Speed	29.4 kph
Layover Time	3 minutes
Vehicle Consist	2 coupled 40 Metre LRT vehicles

Commentary on Results

3.5 The end to end journey time for the LRT alternatives are faster than BRT due to, the use of a fixed rail vehicle, which can achieve higher acceleration and deceleration rates, operate into stops at a higher speed, and on dedicated alignments (University Boulevard) achieve a higher maximum speed.

3.6 As noted in Table 3.4, a high level of intersection priority has been assumed in the development of the system run times. This means that for this option, the LRT service would get priority at all minor intersections but would stop (and wait) at all major intersections. These include: Alma, Macdonald, Arbutus, Burrard, Granville, Oak, Cambie, Clark and Commercial.

3.7 A sensitivity has been tested where the LRT would stop at all signalled junctions (i.e. the nine listed above plus a further 13 more) to determine a 'worst case' run time for a surface running LRT system. The run time under this scenario would be 31.4 minutes (approximately 18% longer). Similarly, a run time was developed where the LRT has full priority (i.e. it does not stop and wait at any intersections) and the resulting run time was estimated at 25.1 minutes.

3.8 APTA data quotes an average speed of 15mph for LRT systems in the US, equating to 24kph. The APTA data although titled average LRT speed is actually "Annual vehicle revenue miles operated / Annual vehicle revenue hours". The revenue hours include timetabling and layover. A comparison of a number of US LRT systems is shown in Table 3.5.

TABLE 3.5 US LRT SYSTEM AVERAGE SPEEDS

System	APTA Data (where available)	Actual Average Speed *(Route length and timetabled journey time)*
Charlotte	25 kph	36.9 kph
Minneapolis	24 kph	29.7 kph
Phoenix	Not Available	29.0 kph

TABLE 3.6 LRT ALTERNATIVE 1A FLEET REQUIREMENTS[2]

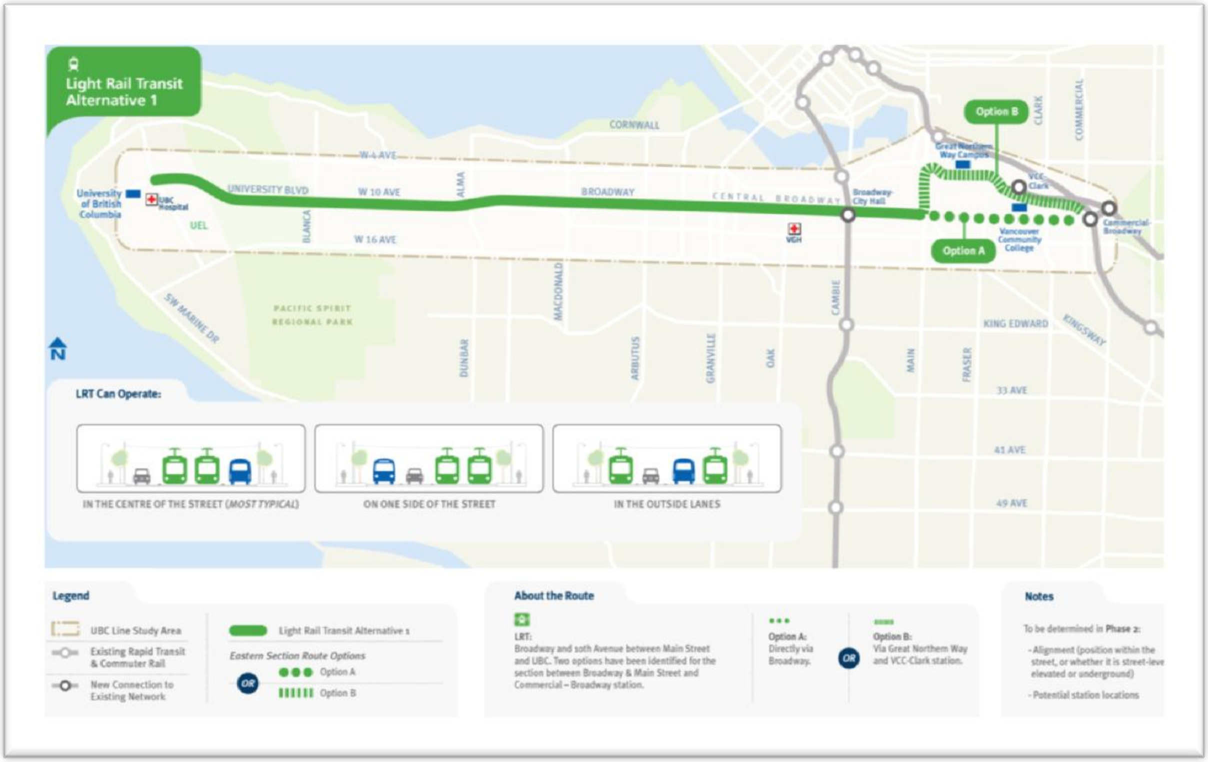
Service Frequency	Service Vehicles	Spares (15%)	Fleet
2 minutes	60	9	69
3 minutes	40	6	46
4 minutes	30	5	35
5 minutes	24	4	28
6 minutes	20	3	23
10 minutes	12	2	14

TABLE 3.7 LRT ALTERNATIVE 1A STOP TO STOP RUNTIMES

Stop	Distance	Runtime	Dwell
UBC			
University Boulevard	760	1:23	0:20
Sasamat	1950	2:15	0:20
Alma	2010	3:22	0:20
Macdonald	1210	2:09	0:20
Arbutus	990	1:35	0:20
Granville	1230	2:38	0:20
Oak	820	1:38	0:20
Cambie	870	1:43	0:20
Main	860	1:23	0:20
Fraser	1020	1:36	0:20
Clark	710	1:34	0:20
Commercial & Broadway	630	1:28	
Totals	13.0 km	22:50	3:40

[2] Increased service frequency could increase end to end journey time due to reducing transit priority at intersections

LRT Alternative 1b



3.9 The runtime developed for the LRT Alternative 1b is summarised in Table 3.8.

TABLE 3.8 LRT ALTERNATIVE 1B RUNTIME

Data	
Length	14.0km
Stops	14
Stop to Stop Distance (Average)	1.01km
Intersection Priority Assumption	Varies by location, assumed high level of priority
End to End Journey Time	28.7 minutes
Average Operating Speed	29.3 kph
Layover Time	3 minutes

Vehicle Consist	2 coupled 40 Metre LRT vehicles

TABLE 3.9 LRT OPTION 1B FLEET REQUIREMENTS[3]

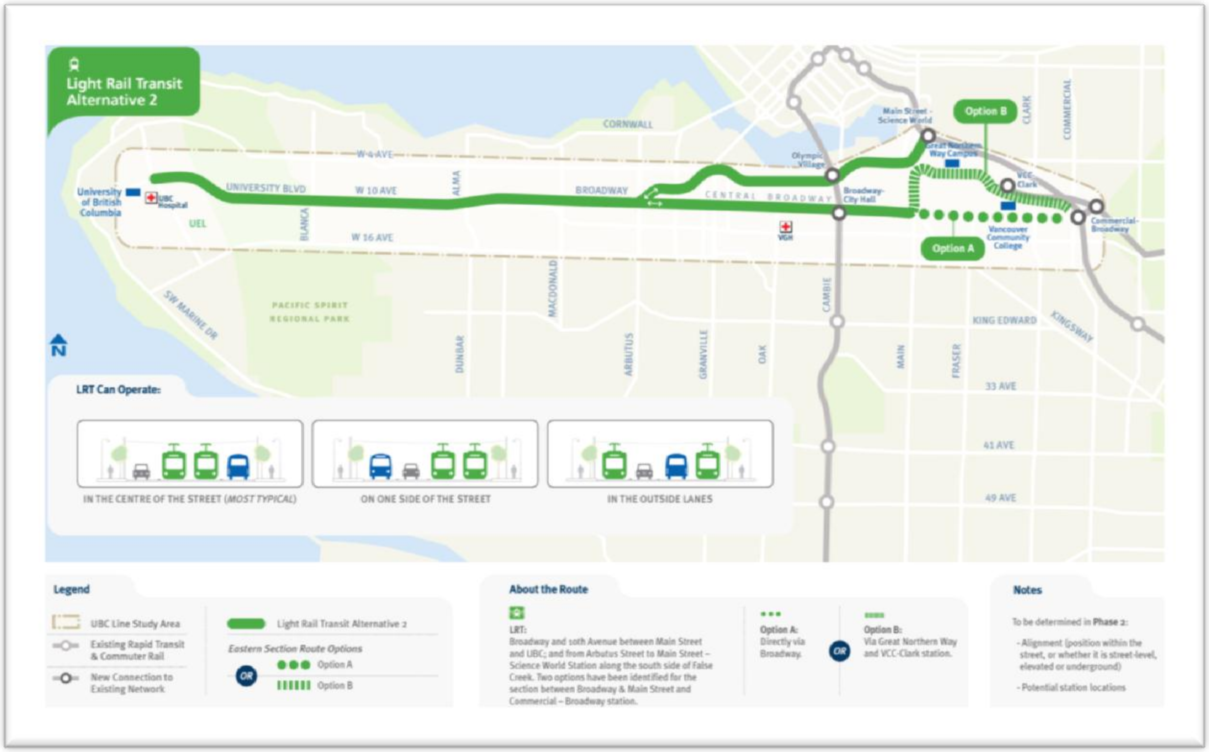
Service Frequency	Service Vehicles	Spares (15%)	Fleet
2 minutes	64	10	74
3 minutes	44	7	51
4 minutes	32	5	37
5 minutes	26	4	30
6 minutes	22	4	26
10 minutes	14	3	17

[3] Increased service frequency could increase end to end journey time due to reducing transit priority at intersections

TABLE 3.10 LRT OPTION 1B STOP TO STOP RUNTIMES

Stop	Distance	Runtime	Dwell
UBC			
University Boulevard	760	1:23	0:20
Sasamat	1950	2:15	0:20
Alma	2010	3:22	0:20
Macdonald	1210	2:09	0:20
Arbutus	990	1:35	0:20
Granville	1230	2:38	0:20
Oak	820	1:38	0:20
Cambie	870	1:43	0:20
Ontario	700	1:08	0:20
Lornie	1070	1:59	0:20
GNW Campus	490	0:53	0:20
VCC	950	1:29	0:20
Commercial & Broadway	1010	2:33	
Totals	14.0 km	24:40	4:00

LRT Alternative 2



3.10 The runtime developed for the LRT Alternative 2 is summarised in Table 3.11.

TABLE 3.11 LRT ALTERNATIVE 2 RUNTIME

Data	
Length	12.0km
Stops	13
Stop to Stop Distance (Average)	1km
Intersection Priority Assumption	Varies by location, assumed high level of priority
End to End Journey Time	24.7 minutes
Average Operating Speed	29.1 kph
Layover Time	3 minutes
Vehicle Consist	2 coupled 40 Metre LRT vehicles

TABLE 3.12 LRT ALTERNATIVE 2 FLEET REQUIREMENTS[4]

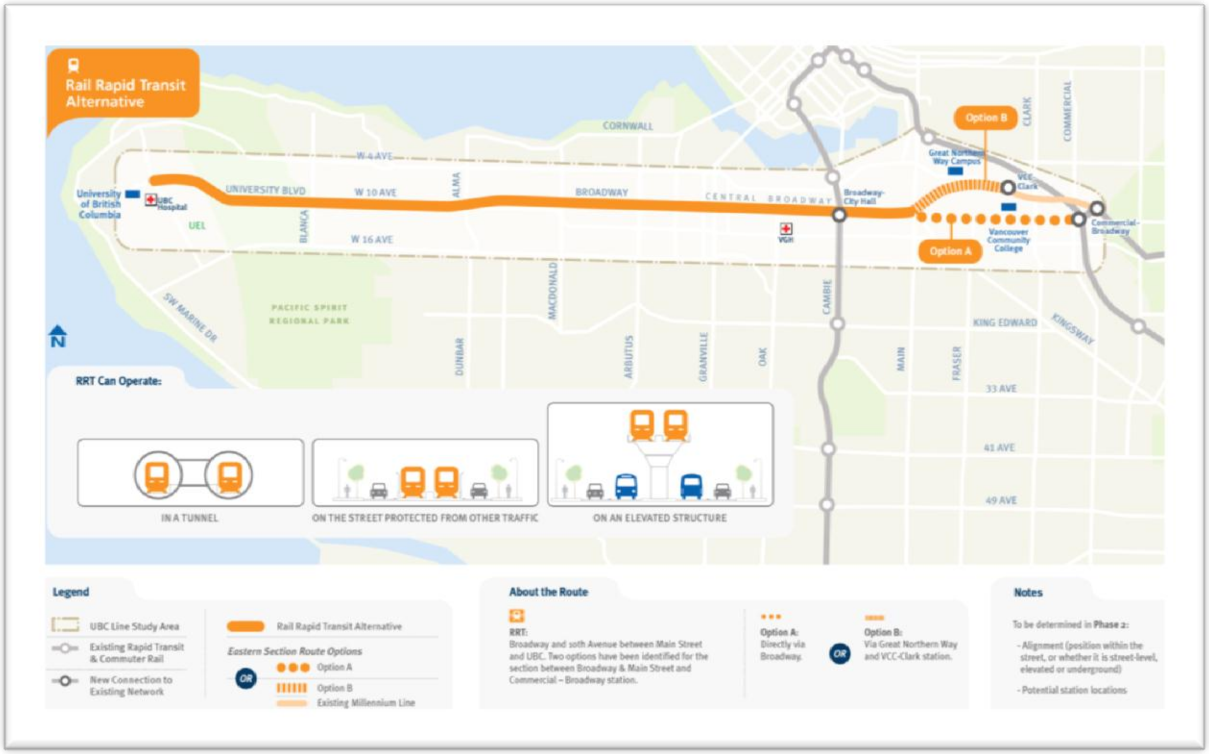
Service Frequency	Service Vehicles	Spares	Fleet
2 minutes	56	9	65
3 minutes	38	6	44
4 minutes	28	5	33
5 minutes	24	4	28
6 minutes	20	3	23
10 minutes	12	2	14

[4] Increased service frequency could increase end to end journey time due to reducing transit priority at intersections

TABLE 3.13 LRT ALTERNATIVE 2 STOP TO STOP RUNTIMES

Stop	Distance	Runtime	Dwell
UBC			
University Boulevard	760	1:23	0:20
Sasamat	1950	2:15	0:20
Alma	2010	3:22	0:20
Macdonald	1210	2:09	0:20
Arbutus	1170	1:50	0:20
Burrard	690	1:54	0:20
4th Avenue / Granville Island	510	1:00	0:20
Spruce	910	1:35	0:20
Olympic Village	950	1:16	0:20
Creekside	660	1:20	0:20
Quebec	500	0:56	0:30
Main Street	650	1:38	
Totals	12.0 km	21:00	3:40

RRT Alternative 1a



3.11 The runtime developed for the RRT Alternative 1a is summarised in Table 3.14.

TABLE 3.14 RRT ALTERNATIVE 1A RUNTIME

Data	
Length	13.2km
Stops	13
Stop to Stop Distance (Average)	1.01km
Intersection Priority Assumption	Varies by location, assumed high level of priority
End to End Journey Time	20.1 minutes
Average Operating Speed	39.4 kph
Layover Time	2 minutes
Vehicle Consist	4 coupled 20 Metre RRT vehicles

Commentary on Results

3.12 The average speed of the existing Expo SkyTrain line is 41.5 kph, with an average stop spacing of 1.5 km.

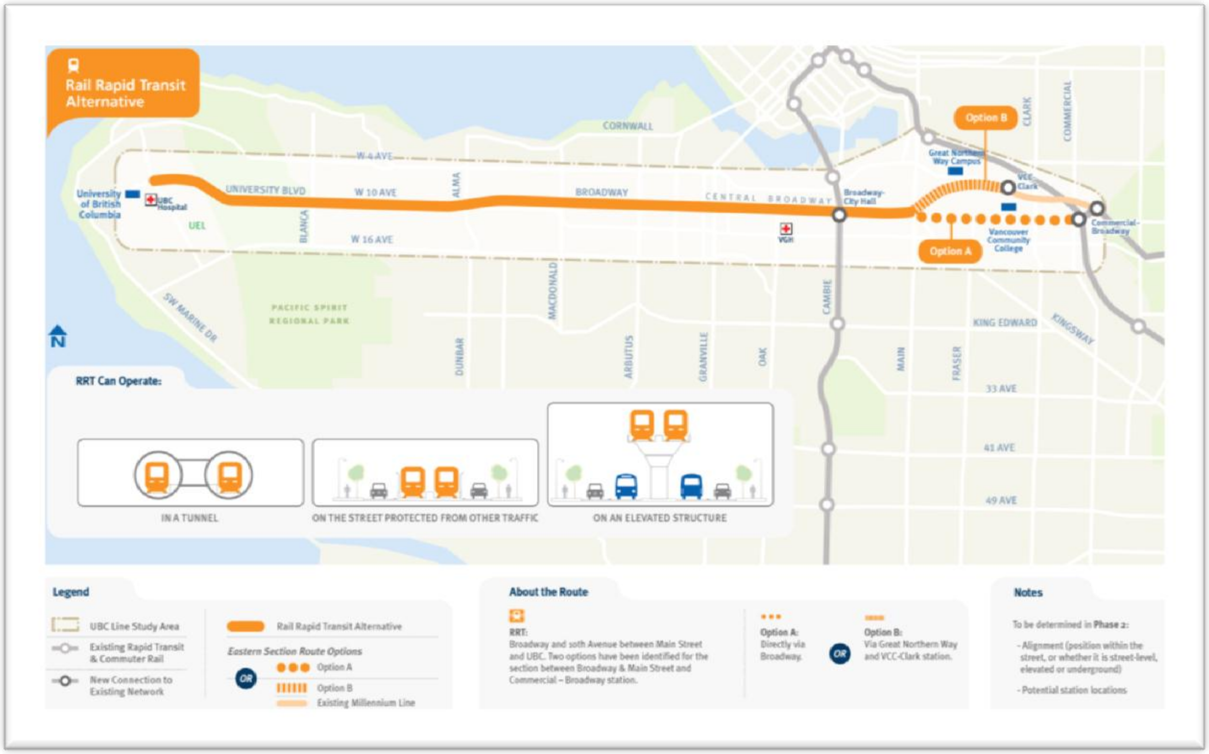
TABLE 3.15 RRT ALTERNATIVE 1A FLEET REQUIREMENTS

Service Frequency	Service Vehicles	Spares	Fleet
2 minutes	92	14	106
3 minutes	60	9	69
4 minutes	48	8	56
5 minutes	36	6	42
6 minutes	32	5	37
10 minutes	20	4	24

TABLE 3.16 RRT ALTERNATIVE 1A STOP TO STOP RUNTIMES

Stop	Distance	Runtime	Dwell
UBC			
University Boulevard	1150	1:24	0:20
Sasamat	1970	2:02	0:20
Alma	1820	1:55	0:20
Macdonald	1110	1:22	0:20
Arbutus	1170	1:25	0:20
Granville	990	1:17	0:20
Oak	880	1:11	0:20
Cambie	710	1:04	0:20
Main	1190	1:26	0:20
Fraser	820	1:09	0:20
Clark	770	1:06	0:20
Commercial & Broadway	710	1:04	
Totals	13.2 km	16:30	3:40

RRT Alternative 1b



3.13 The runtime developed for the RRT Alternative 1b is summarised in Table 3.17.

TABLE 3.17 RRT ALTERNATIVE 1B RUNTIME

Data	
Length	12.3km
Stops	12
Stop to Stop Distance (Average)	1.1km
Intersection Priority Assumption	Varies by location, assumed high level of priority
End to End Journey Time	18.5 minutes
Average Operating Speed	39.9 kph
Layover Time	2 minutes
Vehicle Consist	5 coupled 18 Metre RRT vehicles

TABLE 3.18 RRT ALTERNATIVE 1B FLEET REQUIREMENTS

Service Frequency	Service Vehicles	Spares	Fleet
2 minutes	100	15	115
3 minutes	65	10	75
4 minutes	50	8	58
5 minutes	40	6	46
6 minutes	35	6	41
10 minutes	20	3	23

TABLE 3.19 RRT ALTERNATIVE 1B STOP TO STOP RUNTIMES

Stop	Distance	Runtime	Dwell
UBC			
University Boulevard	1150	1:24	0:20
Sasamat	1970	2:02	0:20
Alma	1820	1:55	0:20
Macdonald	1110	1:22	0:20
Arbutus	1170	1:25	0:20
Granville	990	1:17	0:20
Oak	880	1:11	0:20
Cambie	710	1:04	0:20
Main	710	1:26	0:20
GNW Campus	800	1:17	0:20
VCC Clark	540	0:58	
Totals	12.3 km	15:10	3:20

4 Summary of Results

4.1 The resulting runtime data for the UBC Line alternatives are summarised in Table 4.1.

TABLE 4.1 SUMMARY OF RESULTS

Data	99 B-Line	BRT	LRT 1A	LRT 1B	LRT 2	RRT 1A	RRT 1B
Length	13.0km	13.0km	13.0km	14.0	12.0 km	13.2 km	12.3km
Stops	13	13	13	14	13	13	12
Stop to Stop Distance (Average)	1.01 km	1.01 km	1.01 km	1.01 km	1.0 km	1.01 km	1.1km
End to End Journey Time	34.0 min	28.5 min	26.5 min	28.7 min	24.7 min	20.1 min	18.5 min
Average Operating Speed	22.9 kph	27.4 kph	29.4 kph	29.3 kph	29.1 kph	39.4 kph	39.9 kph
Layover Time	3 min	3 min	3 min	3 min	3 min	3 min	2 min

APPENDIX

A

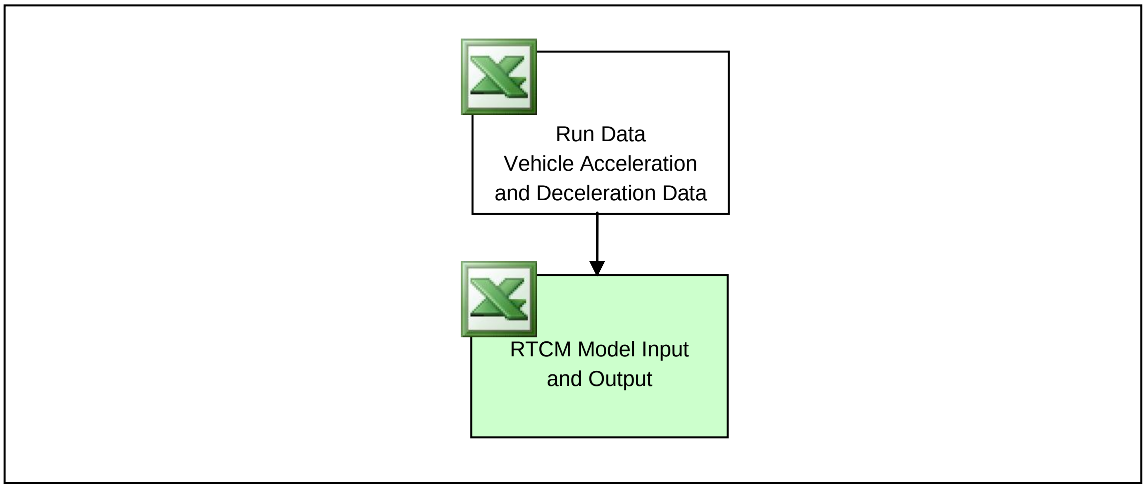
OVERVIEW OF RUNTIME MODEL

A1 OVERVIEW OF RUNTIME MODEL

4.2 Steer Davies Gleave's spreadsheet based runtime model (RTCM) is part of a suite of spreadsheets designed to develop runtimes during the development of transit projects. The tool has been developed and refined over a number of years and has been successfully used on a large number of rapid transit projects. The data, assumptions and the outputs produced have been benchmarked against a number of operating systems, including SkyTrain.

4.3 The basic structure of the model is set out in Figure 2.1.

FIGURE 1 RUNTIME MODEL STRUCTURE



RTCM Input Output Module

4.4 The model has been developed to provide a flexible tool to calculate runtimes during rapid transit project development. The main module is used to input the route characteristics into the model and is built up of three main elements: System, Routes and Links. The system is first split up into routes and then the routes area split into links.

4.5 The characteristics of a section of alignment (stops, level of segregation, intersections) is entered into a link with further links used to compile the characteristics for a whole route.

4.6 The links are then combined into routes to produce runtimes for a route. Links can be interchanged to evaluate different route characteristic and the performance of different options. The run data assumptions can also be changed to evaluate different vehicle performance characteristics.

Link Sheet Inputs

4.7 The link sheets are input with the characteristics for each section of the route, these include:

- Description of element (stop, section, road crossing, etc.)
- Start chainage

- End chainage
- Length (calculated)
- Unit type (e.g. Level of Segregation)
- Speed limit
- Stop dwell time
- Junction (Intersection) delay

4.8 The typical input criteria from a link sheet are shown in Figure 2.3.

FIGURE 2 TYPICAL LINK SHEET INPUT CRITERIA

Route Description	Start Chain	End Chain	Units / Length	Unit Type	Speed	Value / Units	UT Code	Dwell	Junction Delay
UBC Stop	0	0	0	Stop	0		5	1	
To Western Parkway	0	86	86	Segregated	30		4		
Western Parkway Intersection	86	102	16	Segregated	30		4		
To Alison Rd	102	203	101	Segregated	30		4		
Alison Rd Intersection	203	224	21	Segregated	30		4		
To Acadia Rd	224	486	262	Segregated	30		4		
Acadia Rd Intersection	486	513	27	Segregated	30		4		
To Univsersity Blvd Stop	513	630	117	Segregated	30		4		
Track Through Stop	630	680	50	Segregated	30		4		
University Blvd Stop	0	1	1	Stop	30		5		
To Blanca St	680	2297	1617	Segregated	60		4		
Blanca St Intersection	2297	2325	28	Segregated	30		4		
To Tolmie St	2325	2525	200	Segregated	50		4		
Tolmie St Intersection	2525	2546	21	Segregated	50		4		
To Sasamat Stop	2546	2694	148	Segregated	50		4		
Track through Stop	2694	2744	50	Segregated	30		4		
Sasamat Stop	0	1	1	Stop	0		5		

Key Parameters Used To Input the Route Section Characteristics

4.9 The development of the accurate runtimes depends greatly on the quality and detail of the input to the spreadsheet. These are acquired through a combination of an understanding of the local physical and operating conditions, transit operating and design experience and benchmarked industry data for vehicle operating and performance characteristics.

4.10 The primary operating characteristics used as inputs to the model include:

- Section speed limits based on the characteristic of section (segregated, on street, etc.)
- Speed limits through stops
- Dwell times at stops
- Intersection delay (based upon the advanced notice of oncoming tram)
- Speed limits/restrictions across intersections
- Speed limits/restrictions due to geometry
- Speed limits/restrictions due to switch's and crossings

Link Output

4.11 Using the specified inputs described in the previous section, the model generates outputs for each link. These include the total runtime, dwell time, average dwell, junction delay and average speed. A sample is shown in Figure 2.4.

FIGURE 3 LINK OUTPUTS

Start Location		Finish Location		Include Cost		Runtime	Av Speed	J Delay	Dwell Time	Av Dwell
UBC		Sasamat		0		4.6	35.8	0.0	40.0	20

CONTROL SHEET

Project/Proposal Name	UBC Line Rapid Transit Study
Document Title	Runtime Model and Phase 2 Alternatives Results
Client Contract/Project No.	
SDG Project/Proposal No.	22106505

ISSUE HISTORY

Issue No.	Date	Details
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REVIEW

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APPENDIX

F

ACCEPTABILITY SURVEY REPORT

UBC Line Rapid Transit Study
Draft Report

May 2012 – DRAFT 3

Prepared by:
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Table of Contents

Summary........ 3
Method........ 15
Participants........ 16
Weighting........ 17
Results........ 19
UBC Line Rapid Transit Study Awareness and Area Familiarity Profiles........ 19
Factors to Consider in Rapid Transit Expansion in Study Area........ 26
Overall Reactions to Rapid Transit Technology Options in Study Area........ 32
Reactions to Specific Rapid Transit Expansion Options........ 41
Appendix: Demographics........ 59
Appendix: Survey........ 65

Background

- TransLink conducted a survey with residents of the Metro Vancouver region to better understand their opinions about potential rapid transit expansion within the UBC Line Rapid Transit Study Area.
- The specific research objectives were as follows:
  - Profile the awareness and familiarity of the UBC Line Rapid Transit Study among Metro Vancouver residents, and profile travel within the study area and familiarity with the existing transit in the area.
  - Gauge Metro Vancouver residents' overall support of the UBC Line Rapid Transit Study, in terms of importance for Metro Vancouver, the City of Vancouver and the UBC area, and personally.
  - Determine study area residents' and users' reactions to three possible rapid transit technologies (BRT, LRT, and SkyTrain) that may be used for rapid transit expansion in the study area.
  - Understand residents' and users' level of acceptance of seven different rapid transit expansion options for the study area.
- The survey was conducted using the *TransLink Listens** online panel from March 20th through March 29th, 2012. The results were weighted to reflect the known age, gender, region, and main transportation mode parameters of the Metro Vancouver region.**

*The TransLink Listens panel includes a disproportionately high representation of transit users that, with weighting by age, gender, municipality and main mode to duplicate Census and other data, may not adjust for attitudinal differences. TransLink Listens panelists are more critical overall of all transportation services, giving lower ratings than ongoing telephone tracking research. When parallel studies using the same questionnaire are run on the panel and on an independent research supplier's telephone survey, results parallel each other in terms of order of priority or support or opposition, but TransLink Listens' panelists results tend to be more positive or more negative, even with weighting, because of their deeper engagement with transit and transportation.
** Known from a combination of census data and prior demographic studies.

UBC Line Rapid Transit Study Awareness and Area Familiarity Profile

- As of the time of the fielding of this survey, over one-half (54%) of panelists are aware of the UBC Line Rapid Transit Study, while 38% are not aware and 8% are unsure.
- Including those who say they were not aware of the study before completing the survey, 42% are not at all familiar with the study and another 22% are not very familiar. Five percent are very familiar with the study, and 23% are somewhat familiar.
- Generally speaking, most Metro Vancouver panelists say that investing in rapid transit along the Broadway corridor is very important not only to the City of Vancouver, UBC, and the University Endowment Lands (95%), but also for the entire Metro Vancouver region (81%). Personal importance of investing in rapid transit for the corridor is not as high, with 51% saying that such investment is important to them personally (though transit users and those living in the City of Vancouver are understandably more likely to rate this investment as personally important).
- Nearly three-quarters (73%) of Metro Vancouver panelists have travelled to, from, or within the UBC Line Rapid Transit Study area within the past six months. One-third of panelists (34%) are very familiar with existing transit service in the study area, and another four in ten (39%) are somewhat familiar.

Factors to Consider in Rapid Transit Expansion in Study Area

- Respondents were presented with some of the factors that TransLink considers when evaluating rapid transit projects. Of the fourteen factors presented, all are considered either very or somewhat important by more than one-half of panelists.
- Of all the factors, two factors come out on top in terms of importance (based on the percentage who rate each as very important):
  - Reliability: Whether the system offers consistent travel times and is there when expected (77% very important)
  - Capacity and expandability: Whether the system has the capacity to meet forecasted demand and can be upgraded or expanded as demand grows (70% very important)
- Another five factors are rated as very important by more than one-half of all panelists:
  - Speed: Whether the system offers fast, competitive travel times (66% very important)
  - Cost Effectiveness: The level of transportation and other benefits relative to the costs (60% very important)
  - Ridership Attracted: The number of new users attracted to the system and ridership of the overall transit network (59% very important)
  - Affordability: The costs of building and operating the system (59% very important)
  - Environmental Impacts: Impacts on the natural environment, such as air emissions, effects on waterways, parks and open space (53% very important)
- Three factors settle out as the least crucial (based on the percentage who rate each as very important), though still somewhat important overall:
  - Construction Impacts: The level of disruption caused during construction of the system (37% very important)
  - Economic Development Potential: The economic benefits of building and operating the system, such as job creation, effects on goods movement and GDP, etc. (35% very important)
  - Potential for phasing: The ease of implementing the system in phases, such as starting with a smaller initial system (26% very important)

Overall Reactions to Rapid Transit Technology Options in Study Area

- Respondents were presented with three different technologies which could be used for rapid transit expansion within the study area. These three options are as follows, in order of acceptability:

Rail Rapid Transit (SkyTrain): An automated, driverless rail technology that is powered by electricity. SkyTrain can run as frequently as every 2 minutes. SkyTrain travels at an average speed of 40 kilometers per hour. SkyTrain typically operates in a tunnel or on an elevated track; in the case of this study, it is assumed to operate on an elevated track above the centre of the street.

Light Rail Transit (LRT): A driver-operated, electrically-powered rail technology that typically operates at street level. LRT can run as frequently as every 2 minutes. LRT travels at an average speed of 30 kilometers per hour. LRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

Bus Rapid Transit (BRT): A driver-operated, low-floor articulated bus technology that typically operates at street level. BRT can run as frequently as every 2 minutes. BRT travels at an average speed of 30 kilometers per hour. BRT vehicles would run on modern, clean diesel fuel. BRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

- Each of the three technology options is rated as acceptable by at least one-half of participants, and each option is seen as having unique positives and negatives. Specific reactions to each of the three alternative technologies are described on the following slides.

Reactions to Rapid Transit Technology Options – Rail Rapid Transit (SkyTrain)

- Rail Rapid Transit (SkyTrain) technology is considered *very or somewhat acceptable* by 75% and considered *very or somewhat unacceptable* by 17%.
- Those who consider this technology acceptable are likely to mention speed (19%), the appealing look (18%), and a reduction in traffic (13%) as positive factors. Reliability (13%) and capacity and expandability (12%) are also seen as positives of RRT technology. However, some of those who find this technology acceptable mention concerns with affordability (18%), disruptive construction impacts (7%), and noise and appearance of the technology (5%).
- The cost of implementing the RRT technology is a major factor against the technology for six in ten (60%) of those who find it unacceptable. Urban design impacts (23%), construction impacts (22%), and extent of coverage (10%) are other factors cited for why RRT technology is unacceptable.

Reactions to Rapid Transit Technology Options – Light Rail Transit (LRT)

- Light Rail Transit (LRT) technology is considered *very or somewhat acceptable* by 64% and considered *very or somewhat unacceptable* by 26%.
- Reasons for considering this technology acceptable include the appealing look (13%), the perception that the technology works well in other cities (13%), and affordability (9%). Reliability (9%), ease of use (6%), speed (6%), and reduced emissions (5%) are also seen as positive factors of LRT technology. That said, some of those who rate the technology as acceptable are concerned about impacts on other road users (12%), in addition to noise and unattractive appearance (5%).
- Those who consider this technology unacceptable believe that it will have a negative impact on other road users (47%). Many also express concerns about noise and appearance (22%), speed (16%), pedestrian safety issues (8%), affordability (9%), extent of rapid transit coverage (6%), reliability (5%), and ability to meet future demand (6%).

Reactions to Rapid Transit Technology Options – Bus Rapid Transit (BRT)

- Bus Rapid Transit (BRT) technology is considered *very or somewhat acceptable* by 47% and considered *very or somewhat unacceptable* by 40%.
- Reasons for finding this technology acceptable include affordability (13%), an appealing look (6%), ability to expand (6%), and minimal construction disruption (5%). That said, negative impacts on other road users (9%) and the perceived slow speed of the technology (7%) are also mentioned by many panelists who rate the technology as acceptable, particularly those who find BRT *somewhat acceptable* as opposed to *very acceptable*.
- Reasons for finding this technology unacceptable include the negative impact on other road users (32%), concerns about the noise and appearance of the technology (21%), that it represents little or no improvement over existing service (20%), and the perceived slow speed of the technology (16%). Some are also concerned about the ability of the technology to meet future demand (13%) and the reliability of the technology (7%).

Overall Reactions to Rapid Transit Alternatives

- Respondents were presented with seven different alternatives being considered for the UBC Line Rapid Transit Study area. These alternatives are as follows, in order of acceptability (based on percent who rate each very or somewhat acceptable):

Acceptable Alternatives

- **RRT Alternative**: SkyTrain extending the Millennium Line from VCC-Clark to UBC along Broadway.
- **LRT Alternative 1**: LRT along Broadway from Commercial/Broadway to UBC.
- **LRT Alternative 2**: LRT along Broadway from Commercial/Broadway to UBC and along the former rail corridor between Arbutus and Main Street/Science World.
- **Combination Alternative 1**: SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and LRT along the former rail corridor between Arbutus and Main Street/Science World and along Broadway from Arbutus to UBC.

Unacceptable Alternatives

- **Best Bus Alternative**: No rapid transit along the corridor, but improve bus services with additional limited stop service and transit priority measures.
- **Combination Alternative 2**: SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and BRT along Broadway from Commercial/Broadway to UBC.
- **BRT Alternative**: BRT along Broadway from Commercial/Broadway to UBC.

- Specific reactions to each of the alternatives are described on the following slides.

Reactions to Potential Rapid Transit Alternatives – RRT Alternative

- The RRT Alternative is considered *very or somewhat acceptable* by 66% and considered *very or somewhat unacceptable* by 24%. Of note, this option is selected as the most acceptable by 40% of panelists.
- Those who consider this alternative acceptable are likely to mention speed (18%), capacity and expandability (15%), improvements to vehicle traffic (12%), reduced emissions (6%), cost effectiveness (6%), and appealing look (6%) as positive factors. Another 8% simply say this is the best option presented. However, 25% of those who find this alternative acceptable mention concerns with affordability.
- The cost of implementing the RRT alternative is the major deterrent for 53% of those who find the alternative unacceptable. Urban construction (12%) and design (11%) impacts are other factors cited against the alternative.

Reactions to Potential Rapid Transit Alternatives – LRT Alternative 1

- LRT Alternative 1 is considered *very or somewhat acceptable* by 53% and considered *very or somewhat unacceptable* by 32%.
- Those who consider this alternative acceptable are likely to mention affordability (12%) in addition to capacity and expandability (7%) as points in favour of the alternative. That said, the impact on other road users (7%) is cited as a potential issue with the alternative.
- Those who find this alternative unacceptable also mention concerns about impacts on other road users (24%). As well, the appearance or noise (12%), affordability (10%), cost effectiveness (8%), ability to meet future demand (7%), and perceived slowness (7%) are also cited as potential problems with this alternative.

Reactions to Potential Rapid Transit Alternatives – LRT Alternative 2

- LRT Alternative 2 is considered *very or somewhat acceptable* by 52% and considered *very or somewhat unacceptable* by 33%.
- Those who consider this alternative acceptable are likely to mention affordability (10%), capacity and expandability (8%), and the extent of rapid transit coverage (8%) as positive factors of the alternative. That said, the impact on other road users (7%) is cited as a concern for this group.
- Those who find this alternative unacceptable also mention concerns about impacts on other road users (19%). As well, the noise and appearance (11%), expense (10%), cost effectiveness (7%), extent of rapid transit coverage (5%), ability to meet future demand (6%), and speed (5%) are also mentioned as potential problems with this alternative.

Reactions to Potential Rapid Transit Alternatives – Combination Alternative 1

- Combination Alternative 1 is considered *very or somewhat acceptable* by 50% and considered *very or somewhat unacceptable* by 33%.
- Those who consider this alternative acceptable are likely to mention ease of building on to the system (8%) and the extent of rapid transit coverage (5%) as positive factors. However, those who find this alternative acceptable also cite affordability (8%) and impacts on other road users (6%) as areas of concern with the alternative.
- Those who find this alternative unacceptable also mention concerns about affordability (23%) and impacts on other road users (10%). Other areas of concern include speed (5%) and limited value for the cost (5%).

Reactions to Potential Rapid Transit Alternatives – Best Bus Alternative

- The Best Bus Alternative is considered *very or somewhat acceptable* by 35% and considered *very or somewhat unacceptable* by 48%. Notably, this option is selected as the least acceptable option by 42% of respondents.
- Those who consider this alternative acceptable see affordability (25%) as the main advantage of the alternative. However, 9% of those who find this alternative acceptable mention concerns with the ability to meet future demand using the Best Bus Alternative.
- The inability to meet future demand (32%) is also the major concern for those who find the alternative unacceptable. High emissions (10%), value for cost (6%) and slow speed affected by traffic (5%) are other negative factors of this alternative. That said, 5% of those who find the alternative unacceptable do mention affordability as a positive factor.

Reactions to Potential Rapid Transit Alternatives – Combination Alternative 2

- Combination Alternative 2 is considered *very or somewhat acceptable* by 31% and considered *very or somewhat unacceptable* by 51%.
- Those who consider this alternative acceptable are likely to mention ease of expansion (11%) and affordability (9%) as benefits of this alternative. That said, some of those who find this alternative acceptable also are concerned with the ability to meet future demand (7%).
- Those who find this alternative unacceptable also mention concerns about ability to meet future demand (19%). Other concerns include affordability (13%), cost effectiveness (8%), impacts on other road users (8%), extent of rapid transit coverage (6%), noise and appearance (5%), or duplication of service (5%).

Reactions to Potential Rapid Transit Alternatives – BRT Alternative

- The BRT Alternative is considered *very or somewhat acceptable* by 24% and considered *very or somewhat unacceptable* by 59%.
- Those who consider this alternative acceptable are likely to mention affordability (17%) as the predominant positive factor. However, those who find this alternative acceptable also cite concerns about ability to meet future demand (7%) and impacts on other road users (5%) as potential issues with the alternative.
- Those who find this alternative unacceptable also mention concerns about ability to meet future demand (29%) and impacts on other road users (14%). As well, the view that the alternative presents little or no improvement (7%), perceived slowness (7%), affordability (6%), and limited value for cost (6%) are also potential problems with this alternative. That said, 5% of those who find the alternative unacceptable do think that BRT would be affordable compared with other options.

Reactions to Potential Rapid Transit Alternatives – Most and Least Acceptable

- When asked to choose which alternative is most acceptable overall, 40% select the RRT alternative. Several alternatives share major similarities (for example, LRT 1, LRT 2 and Combination 1 all have LRT west of Arbutus) so there is a chance that “vote-splitting” occurred between these alternatives.
- When asked to choose the least acceptable option, four in ten panelists choose the Best Bus Alternative (42%). RRT is the second-least acceptable option, selected by 18% as the least acceptable option overall.

Method

Data Collection & Weighting

Participants

- TransLink Listens panelists were invited to complete a survey titled "Give your input on rapid transit for the Broadway Corridor." A soft launch involving 500 panelists was conducted on March 20, 2012. The full launch started on March 21; an additional 4426 panelists were invited to complete the survey at that time. The survey was open until 11:59pm on March 29.
- Two reminder emails were sent, on March 26 and March 28, to increase the response rate.
- Out of 4926 panelists who were invited to participate, 2210 started the survey – a click-through rate of 44.9%. Of the 2210 who started the survey, 363 did not reach the end of the survey, and a further 19 were disqualified from the study for residing outside of Metro Vancouver (including Abbotsford and Mission). A total of 1828 reached the end of the survey (a completion rate of 37.1%).
- Of the 1828 who completed the survey, 830 surveys were completed by residents of the City of Vancouver. South of Fraser residents (including those living in Surrey, Richmond, Delta, White Rock, and Langley) accounted for 430 completed surveys, while 257 surveys were completed by residents of Burnaby and New Westminster. The Northeast region (including Anmore, Port Coquitlam, Port Moody, Coquitlam, Pitt Meadows, and Maple Ridge) had 196 completed surveys, and the remaining 115 were completed by residents of the North Shore.
- The data in this study were weighed to more closely represent the age, gender, municipality and main transportation mode of Metro Vancouver residents. The weighting methodology is described on the following two slides.

Weighting

Weighting the data occurs in two steps, based on the RIM weighting process:

Step 1: Calculating Sex-Age by Region weights

- Using 2006 Canada Census data, the appropriate proportions of Sex (male and female) and Age (16-34, 35-54, 55+) groups by region are determined for Vancouver, Burnaby/ New Westminster, South of Fraser, Northeast, and North Shore.
- This results in a 6 (Sex-Age groups) by 5 (Regions) matrix of proportions that sum to 1.00 (a sample row for Vancouver is shown below).
- The obtained proportions for those same matrix cells are then calculated based on the survey results.
- By dividing the obtained proportions into the parameter proportions, weights for each group are obtained. Each case is up- or down-weighted in accordance with its under- or over-representation in the sample.

	M 16 - 34	M 35 - 54	M 55+	F 16 - 34	F 35 - 54	F 55+
Vancouver (Parameter)	0.049	0.054	0.037	0.051	0.055	0.043
Vancouver (Obtained)	0.088	0.106	0.080	0.048	0.080	0.051
Vancouver (Weight)	0.555	0.511	0.460	1.055	0.684	0.831

Step 2: Correcting for Main Mode of Transportation after applying the first weights.

- Parameters for Main Mode are obtained using the results of a 2008 TransLink Metro Vancouver telephone survey, with responses broken out by region.
- Using these parameters, weighting factors are calculated for each mode.
- The original weights are then multiplied by the Main Mode weighting factor to obtain the final weights (a sample row for Vancouver is shown below).
- The second weights slightly offset the initial corrections, but because of the over-representation of transit users on *TransLink Listens*, and the under-representation of vehicle users, particularly those whose main mode is to drive alone (SOV), it is an important correction to make when extrapolating to the population of Metro Vancouver.

	SOV	Rideshare	Transit	Other
Vancouver (Parameter)	0.107	0.031	0.105	0.047
Vancouver (Obtained)	0.079	0.026	0.260	0.089
Vancouver (Weight)	1.356	1.190	0.402	0.524

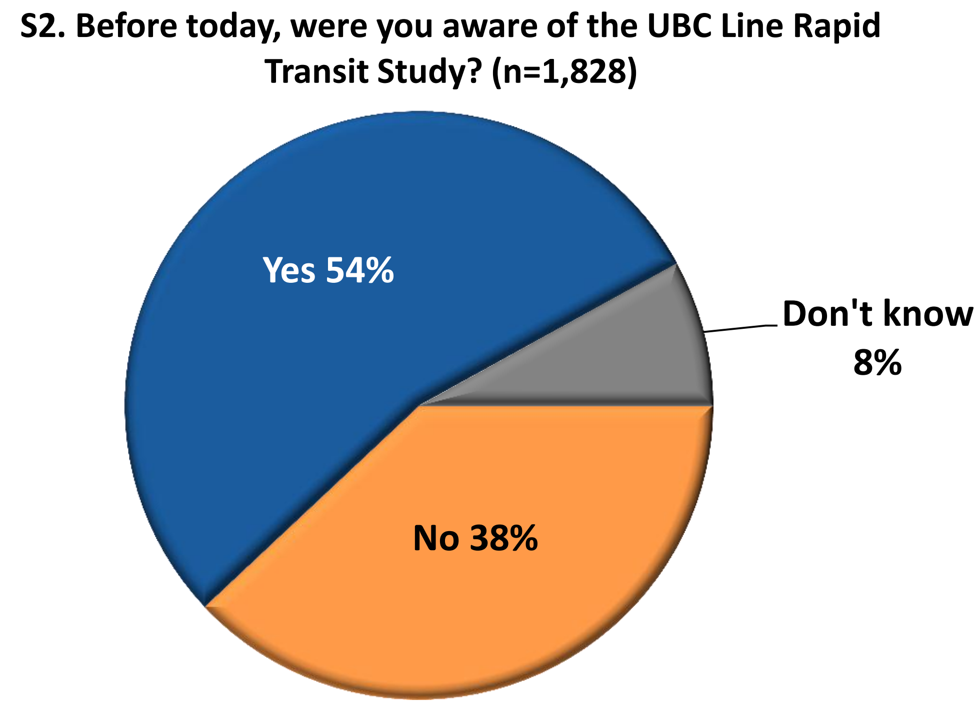
Results

UBC Line Rapid Transit Study Awareness, Opinion, and Familiarity Profiles

Note: In some cases, the summary statistics (e.g., the total percent acceptable) when compared to the sum of the individual percentages of the *very* and the *somewhat* may not appear to be added correctly (i.e., off by +/- 1 percentage point). However these differences are due to rounding and the percentages shown are correct.

- All respondents were first asked which of the Metro Vancouver municipalities they live in. Those living outside of Metro Vancouver were disqualified from completing the survey; those residing in Metro Vancouver were asked whether they were aware of the UBC Line Rapid Transit Study, and if so, how familiar they are with the study.
- Respondents were then shown a map of the study area and informed of the purpose of the UBC Line Rapid Transit Study. Following this, the respondents were asked how important investing in rapid transit along the Broadway Corridor is for the overall Metro Vancouver region, for the City of Vancouver (along with UBC and the University Endowment Lands), and for the respondent personally.
- Respondents were also asked whether they have travelled to the UBC Line Rapid Transit Study area within the past six months, as well as how familiar they are with existing transit service in the UBC Line Rapid Transit Study area.

Awareness of UBC Line Rapid Transit Study



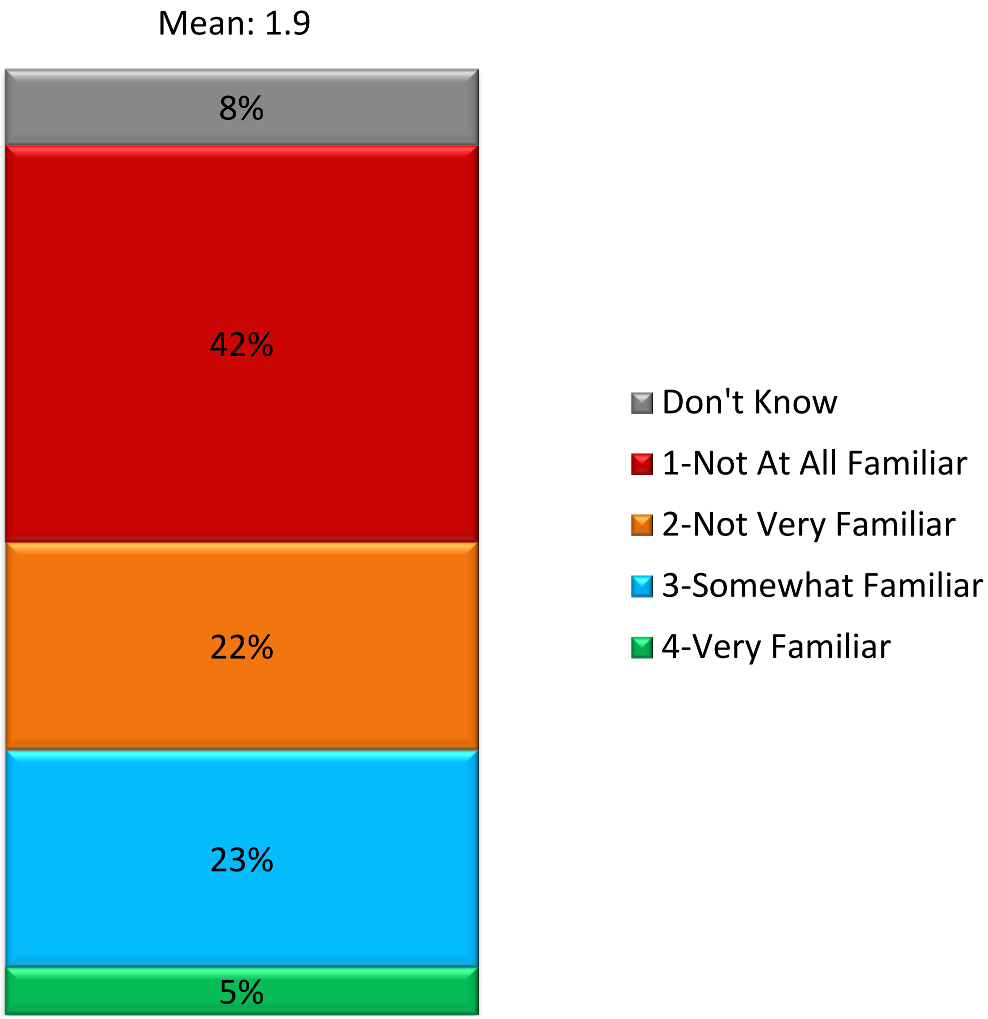
- Of the 1,828 people asked (including residents of any municipality within the Metro Vancouver region), 54% were previously aware of the UBC Line Rapid Transit Study.
- Those living in the City of Vancouver (59%) are more likely than those in the Northeast Sector in particular to be aware of the UBC Line Rapid Transit Study.
- As well, those aged 16-34 (62%) are more likely than their counterparts to be aware of the study, and males are also more likely than females to be aware of the study (61% versus 43%).
- Not surprisingly, those who travel to, from, or within the study area are more likely to be aware of the study than those who do not (60% versus 33%).

Base: All Participants

Familiarity with UBC Line Rapid Transit Study

- Three in ten Metro Vancouver residents (28%) are very or somewhat familiar with the UBC Line Rapid Transit Study, while 64% are either not very familiar or not at all familiar with the study.
- As with overall awareness of the study, those in the City of Vancouver (33% very or somewhat familiar) are slightly more familiar with the study than those in other areas.
- Again mirroring overall awareness, those aged 16-34 are particularly likely to be familiar with the study (40% of those in this age group are very or somewhat familiar). Males are also more familiar with the study than females (36% very or somewhat familiar versus 16%).
- Those who travel within the study area are understandably more familiar with the study than those who do not (33% very or somewhat familiar versus 16%).

S3. How familiar are you with the UBC Line Rapid Transit Study? (n=1,828)

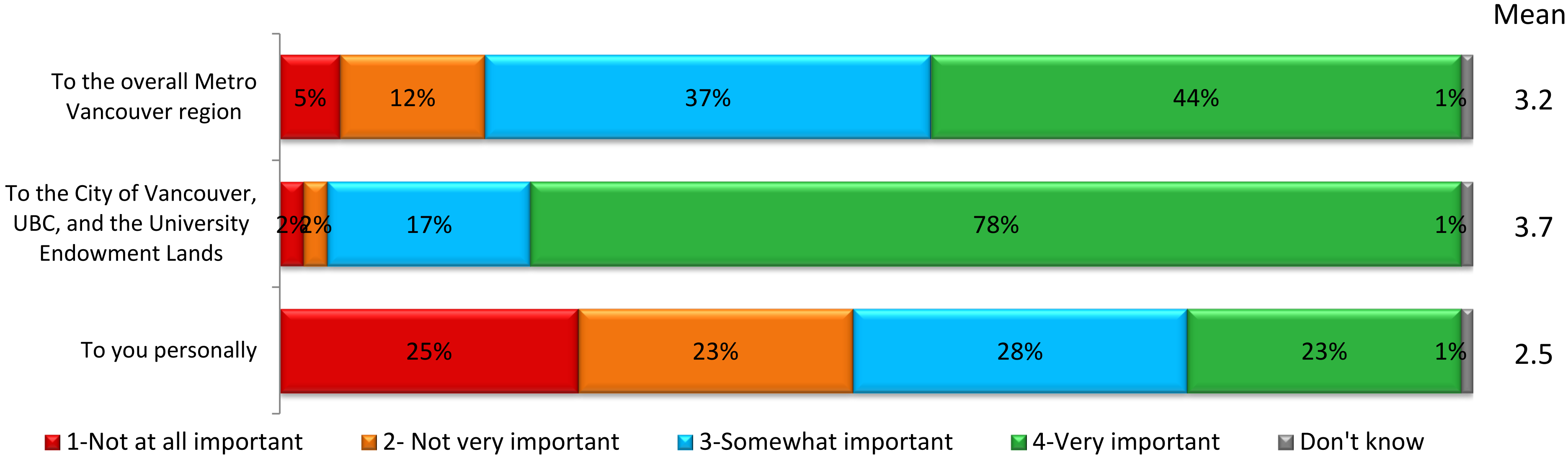


Base: All Participants

enrg RESEARCH GROUP

Importance of Investing in Rapid Transit for the Corridor

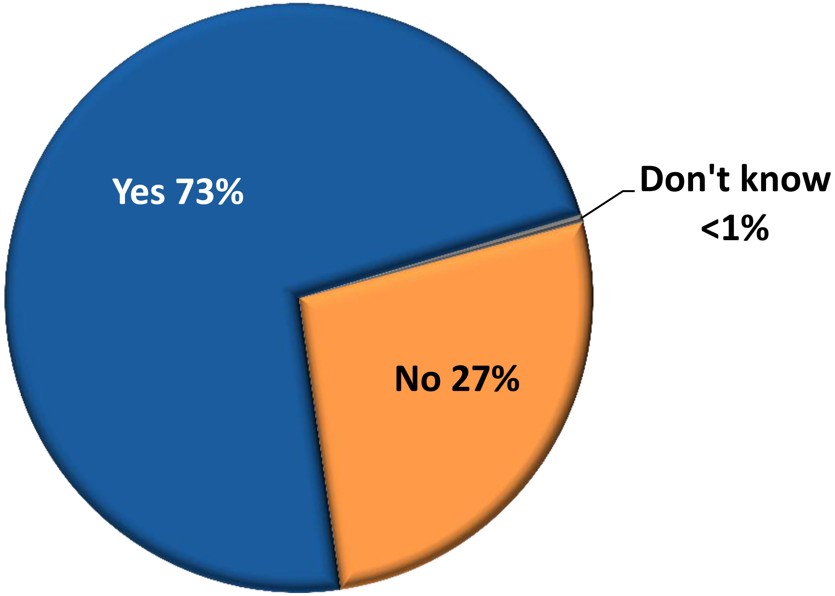
S4. Based on what you have read, seen or heard, how important would you say investing in rapid transit along this corridor is... ? (n=1,828)



- More than eight in ten (81%) Metro Vancouver residents say that investing in rapid transit along the Broadway corridor is very or somewhat important to the overall Metro Vancouver region (ranging from 68% of those living South of the Fraser to 89% in Vancouver), and nearly all (95%) say that it is very or somewhat important to the City of Vancouver, UBC, and the University Endowment Lands.
- That said, just over one-half (51%) of Metro Vancouver residents say that investing in rapid transit along the Broadway corridor is either very or somewhat important to them personally.
- Those who consider investing in rapid transit important to any one of these three groups are also likely to consider the study important to the other groups (though this effect is less pronounced for personal importance). Those living in the City of Vancouver, not surprisingly, are more likely to consider this rapid transit expansion important personally (72% very or somewhat important) or to the Metro Vancouver region (89%) than those in other parts of Metro Vancouver. Transit users are also more likely to consider the study important to Metro Vancouver (91%) or the areas along the Broadway corridor (97%) than those who use a single-occupancy vehicle as their main mode of transport, and they are particularly more likely to consider rapid transit expansion personally important (70%) than their counterparts using any other mode of transport.

Base: All Participants

S5. Have you travelled to, from, or within the UBC Line Rapid Transit Study area in the past six months? (n=1,828)



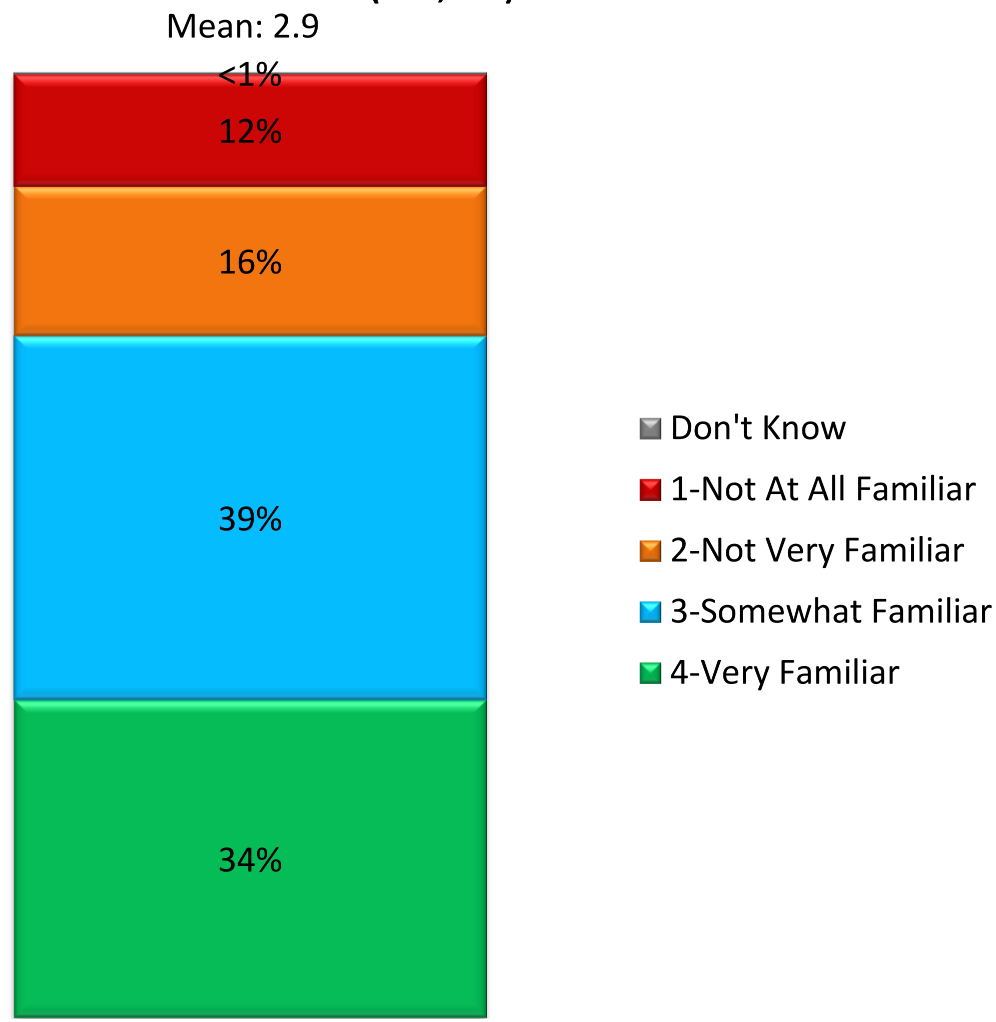
- Three-quarters (73%) of all Metro Vancouver residents have travelled to, from, or within the UBC Line Rapid Transit Study area within the past six months.
- As might be expected, those living in the City of Vancouver are the most likely to have travelled within the study area (90%), though many of those in Burnaby/ New Westminster (73%) and the North Shore (68%) have also travelled to, from, or within the region within the past six months.
- Those aged 16-34 (84%) and those whose main mode of transportation is transit (87%) are more likely than their counterparts to have travelled to, from, or within the study area.

Base: All Participants

Familiarity with Existing Transit Service

- More than seven in ten (73%) Metro Vancouver residents say they are very or somewhat familiar with the existing transit service in the UBC Line Rapid Transit Study area. Conversely, around three in ten (27%) say they are either not very familiar or not at all familiar with transit service in the area.
- Once again, those living in the City of Vancouver (90% very or somewhat familiar) or in Burnaby/ New Westminster (70%) are more likely than those in other regions to be familiar with existing transit service in the study area.
- As well, those whose main mode of transportation is transit (88%) and those aged 16-34 (87%) – a group that tends to have a high proportion of transit users – are particularly likely to be familiar with existing transit service in the study area.
- Those who travel within the study area are understandably more familiar with transit in the study area than those who do not (86% very or somewhat familiar versus 37%).

S6. How familiar would you say you are with the existing transit service in the UBC Line Rapid Transit Study Area? (n=1,828)



Base: All Participants

Results

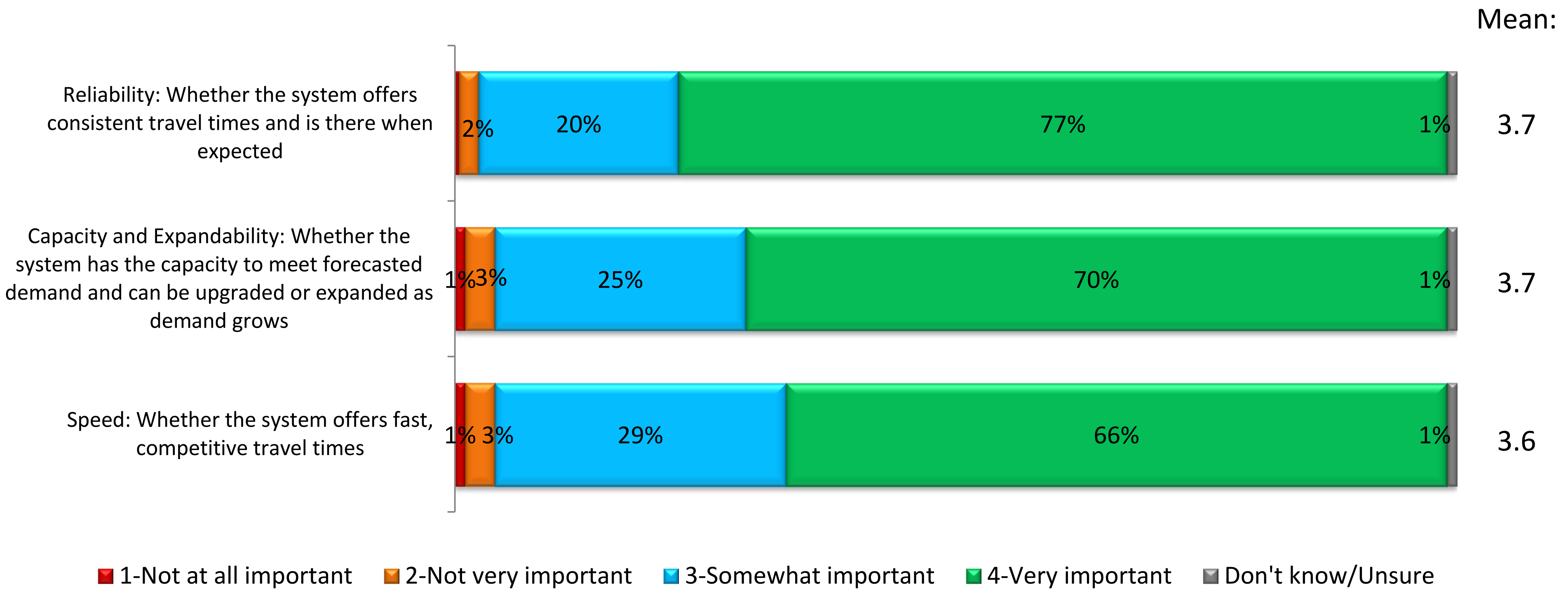
Factors to Consider in Rapid Transit Expansion in Study Area

Factors to Consider in Rapid Transit Expansion in Study Area

- Panelists were next asked to rate the importance of each of a number of factors that TransLink considers when planning rapid transit projects. These factors include:
  - Speed
  - Reliability
  - Capacity and Expandability
  - Cost Effectiveness
  - Affordability
  - Economic Development Potential
  - Environmental Impacts
  - Safety and Personal Security
  - Urban Development
  - Potential for Phasing
  - Ridership Attracted
  - Impacts on Other Road Users
  - Urban Design Impacts
  - Construction Impacts

Importance of Factors Considered in Making Rapid Transit Decisions

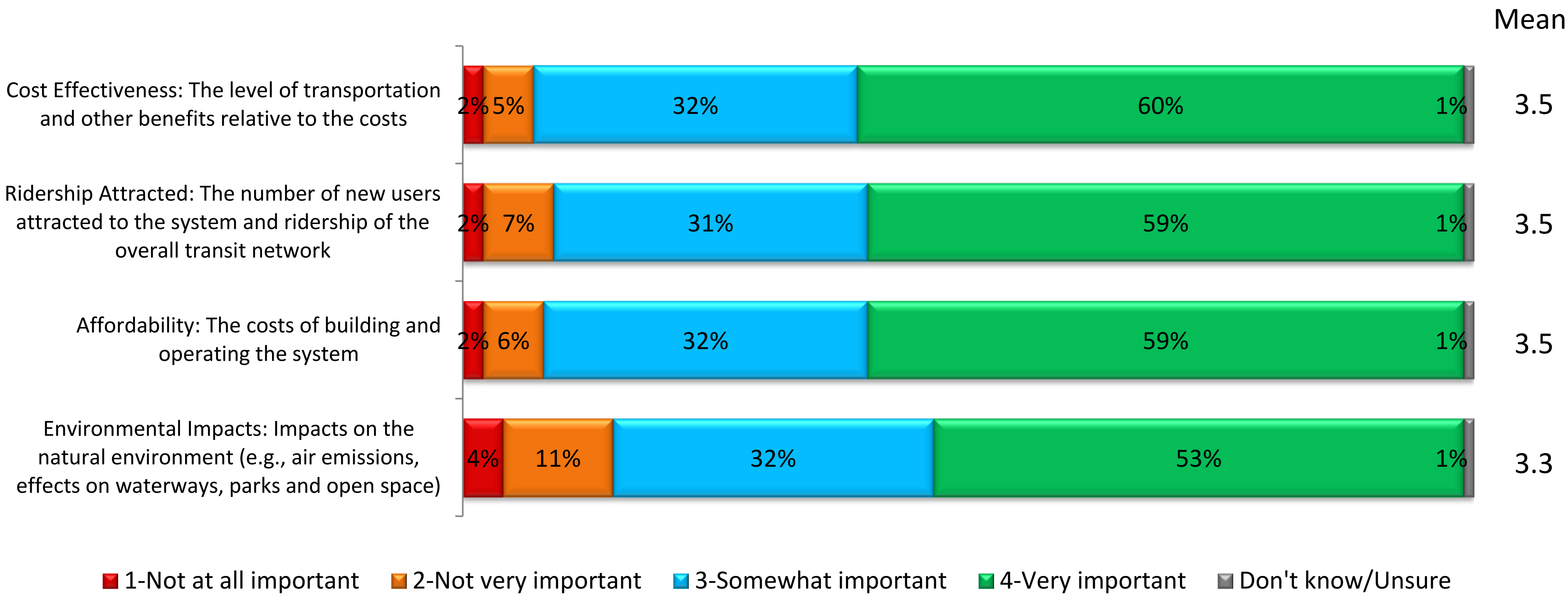
Q1. How important are the following factors when planning and making decisions about rapid transit in the UBC Line Rapid Transit Study area? (n=1,828)



- The most important factor to consider, rated very important by three-quarters (77%), is reliability. This is followed closely by capacity and expandability (70%) and speed (65%).
- As a general rule, those who consider rapid transit expansion along the Broadway corridor important (especially to Metro Vancouver, or to UBC and the University Endowment Lands) also tend to rate the importance of each factor higher than people who do not consider rapid transit expansion in the area to be as important as to these groups.

Base: All Participants

Q1. How important are the following factors when planning and making decisions about rapid transit in the UBC Line Rapid Transit Study area? (n=1,828)

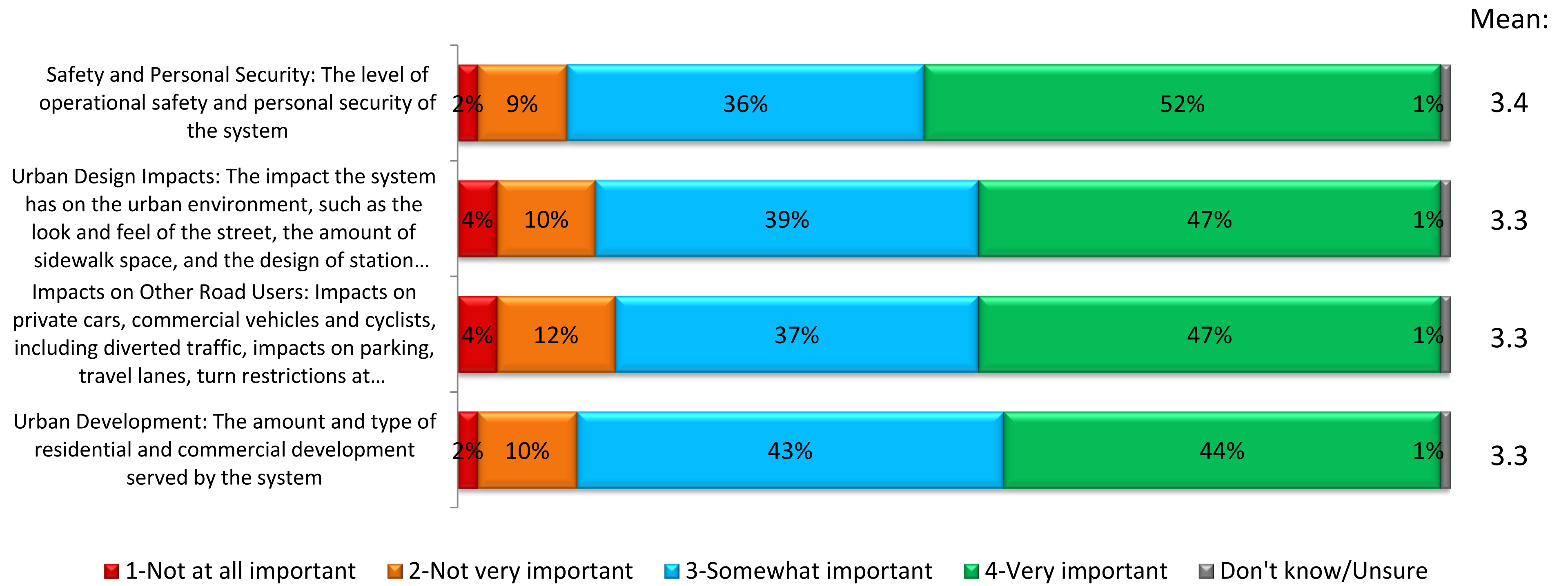


- Other important factors to consider include cost effectiveness (60% rate it as very important), followed closely by ridership attracted (59%), affordability (59%), and environmental impacts (53%).

Base: All Participants

Importance of Factors Considered in Making Rapid Transit Decisions

Q1. How important are the following factors when planning and making decisions about rapid transit in the UBC Line Rapid Transit Study area? (n=1,828)



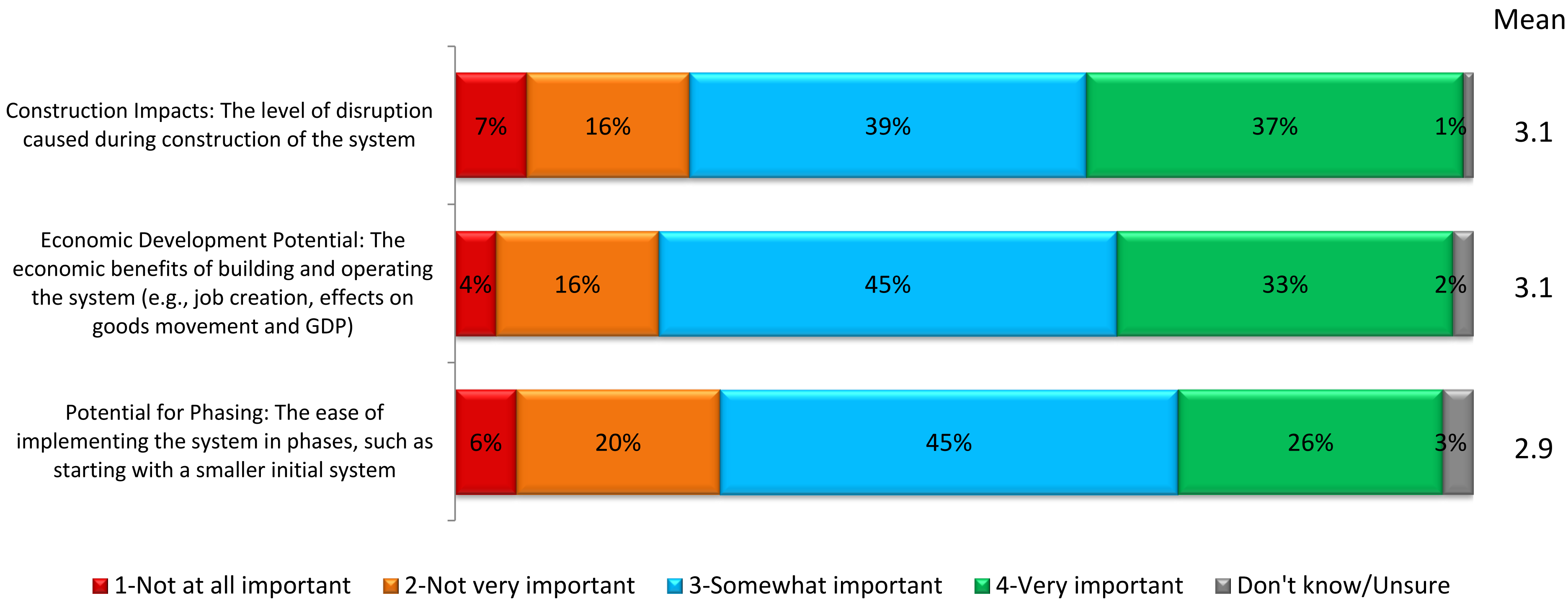
- One-half of panelists consider safety and personal security (52%) to be very important. More than four in ten each also consider urban design impacts (47%), impacts on other road users (47%), and urban development (44%) to be very important.

Base: All Participants

nrg RESEARCH GROUP

Importance of Factors Considered in Making Rapid Transit Decisions

Q1. How important are the following factors when planning and making decisions about rapid transit in the UBC Line Rapid Transit Study area? (n=1,828)



- Rounding out the list of factors to consider when planning and making decisions about rapid transit in the UBC Line Rapid Transit Study area are construction impacts (37% rate it as very important), economic development potential (33%), and the potential for phasing (26%).

Base: All Participants

Results

Overall Reactions to Rapid Transit Technology Options in Study Area

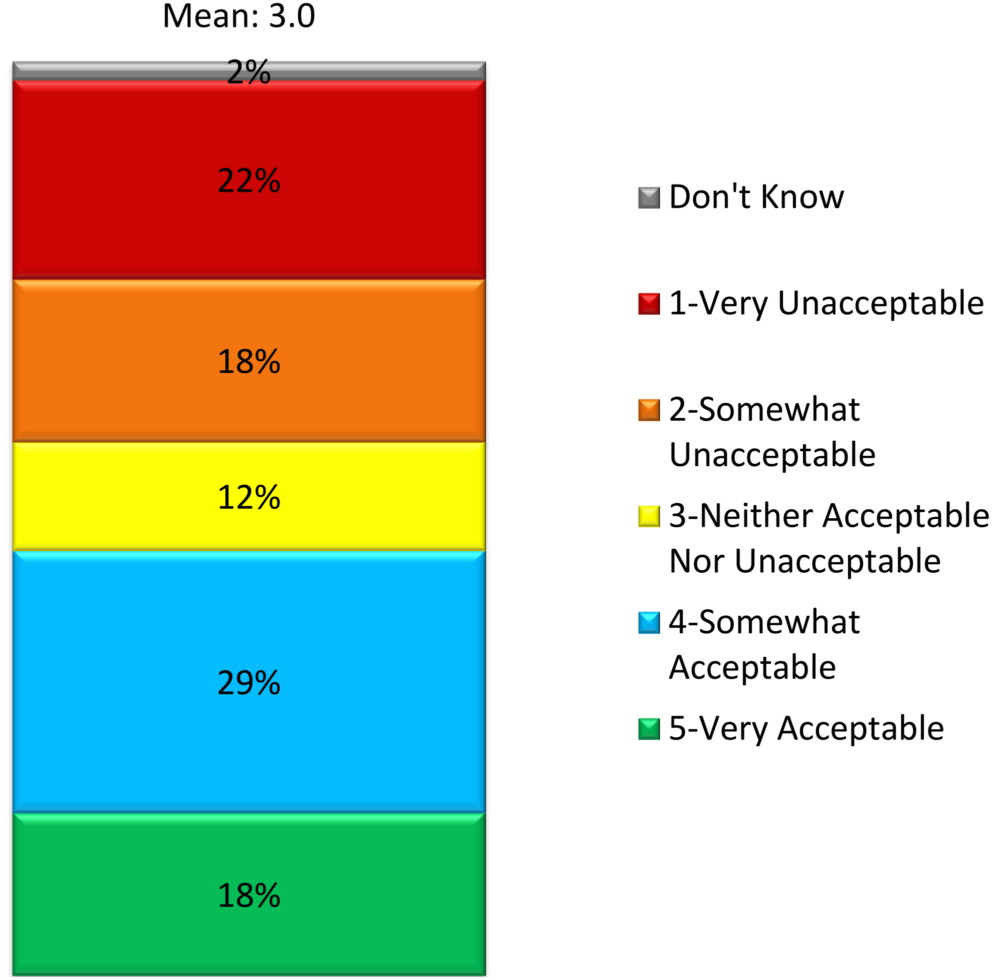
Overall Reactions to Rapid Transit Technology Options in Study Area

- All panelists were asked to rate the acceptability of three different rapid transit technologies being considered for the UBC Line Rapid Transit Study. Respondents were given a description of each of the options, including information on technology, alignment, and station type. These rapid transit technologies are:
  - Bus Rapid Transit (BRT) – a driver-operated, low-floor articulated bus technology that typically operates at street level.
  - Light Rail Transit (LRT) – a driver-operated, electrically-powered rail technology that typically operates at street level.
  - Rail Rapid Transit (RRT or SkyTrain) – an automated, driverless rail technology powered by electricity.
- Panelists were then asked to provide reasons for their ratings of each option, regardless of whether they consider each rapid transit technology option to be somewhat or very acceptable, somewhat or very unacceptable, or neither acceptable nor unacceptable.
- Note that at this stage, panelists were provided with general information about each technology; however, they were not provided with any information about these technologies in the context of specific alternatives for the Broadway corridor.

Acceptability of BRT Technology

- Though the lowest-rated of the three technologies described, BRT technology is still rated as somewhat or very acceptable by roughly one-half of panelists (18% very acceptable, and 29% somewhat acceptable).
- One in five (22%) say that BRT technology is very unacceptable, and 18% say that it is somewhat unacceptable.
- Those under 35 years of age (50%) and males (45%) are more likely than their counterparts to find BRT unacceptable. Students are also particularly likely to find BRT unacceptable (60%), including those who attend school at UBC (47%).
- Those who were previously aware of the study (42%) and those who travel in the study area (43%) are also more likely than their counterparts to find BRT technology unacceptable.
- There are few differences by region when it comes to the acceptability of BRT technology.

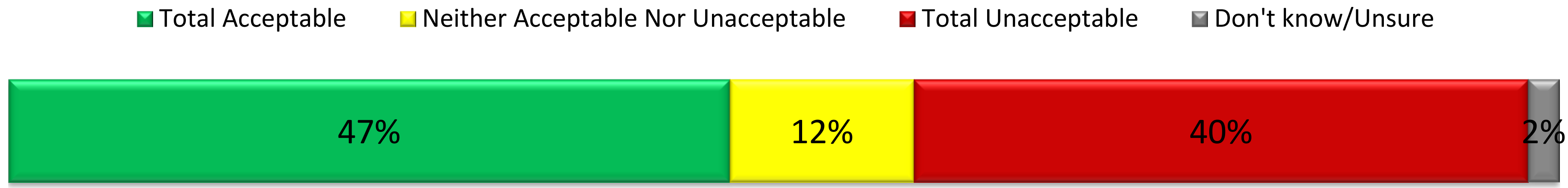
Q2a. Based on the information provided, how acceptable is BRT technology as one of the technologies considered for the UBC Line Rapid Transit Study area? (n=1,828)



Bus Rapid Transit (BRT) – a driver-operated, low-floor articulated bus technology that typically operates at street level. BRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

Base: All Participants

Comments on BRT Technology



Q2b. Why is the BRT Technology (somewhat/very) acceptable to you?	Total (n=861)
Affordability/ Cheap (positive)	13%
Impacts on other road users/ Insufficient road space (negative)	9%
Speed/ Slow/ Affected by traffic (negative)	7%
Urban design impacts/ Looks appealing (positive)	6%
Capacity and expandability/ Easy to build on (positive)	6%
Urban design impacts/ Noisy/ Ugly (negative)	6%
Construction impacts/ Quick to build/ Less disruptive (positive)	5%

Q2b. Why is the BRT Technology neither acceptable nor unacceptable to you?	Total (n=245)
No or little improvement over existing service (negative)	20%
Impacts on other road users/ Insufficient road space (negative)	16%
Urban design impacts/ Noisy/ Ugly (negative)	13%
Speed/ Slow/ Affected by traffic (negative)	8%
Capacity and expandability/ Will not meet future demand (negative)	7%
Affordability/ Cheap (positive)	6%

Q2b. Why is the BRT Technology (somewhat/very) unacceptable to you?	Total (n=722)
Impacts on other road users/ Insufficient road space (negative)	32%
Urban design impacts/ Noisy/ Ugly (negative)	21%
No or little improvement over existing service (negative)	20%
Speed/ Slow/ Affected by traffic (negative)	16%
Capacity and expandability/ Will not meet future demand (negative)	13%
Reliability (negative)	7%
Environmental impacts/ Higher emissions (negative)	6%

Bus Rapid Transit (BRT) – a driver-operated, low-floor articulated bus technology that typically operates at street level. BRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

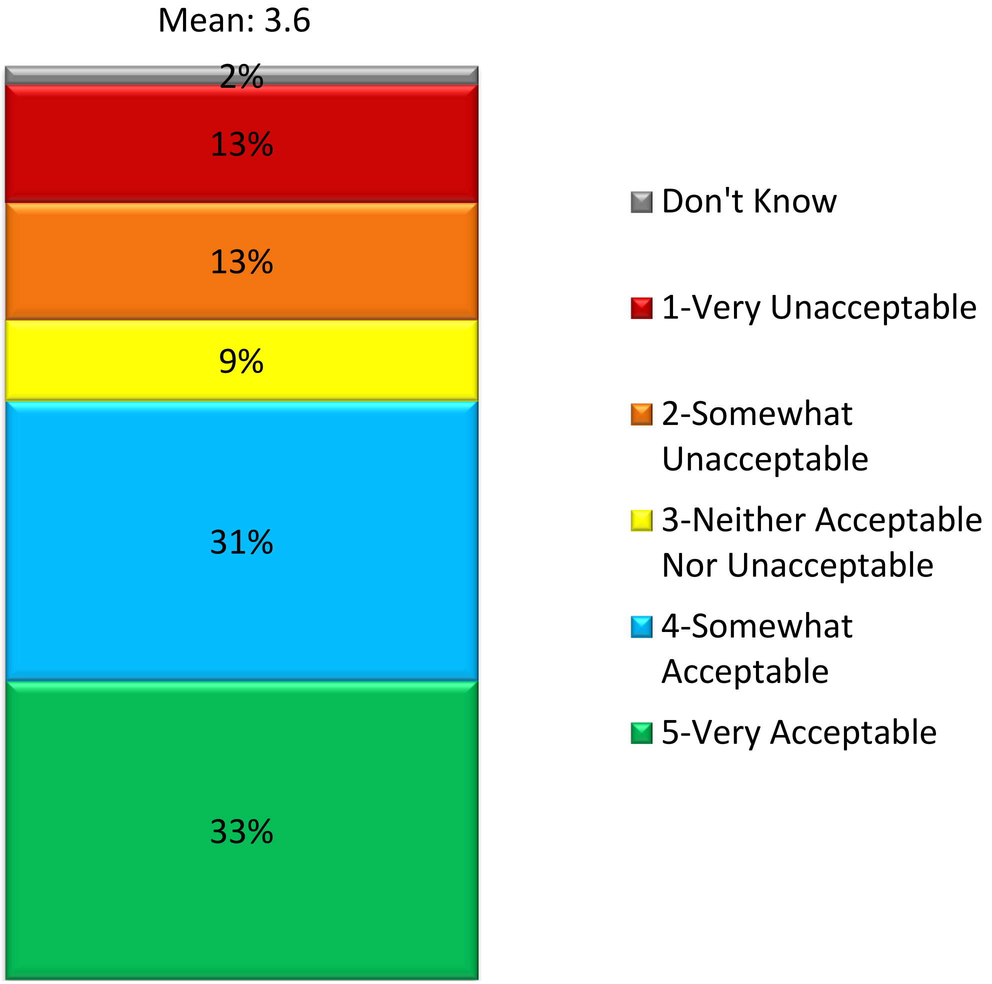
nrg RESEARCH GROUP

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of LRT Technology

Q3a. Based on the information provided, how acceptable is LRT technology as one of the technologies considered for the UBC Line Rapid Transit Study area? (n=1,828)

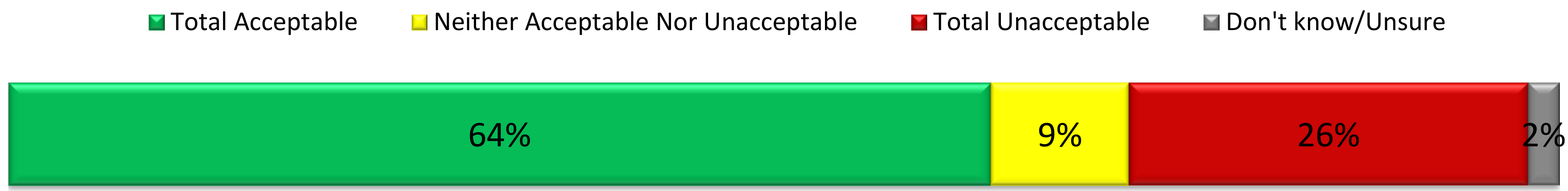
- LRT is considered very or somewhat acceptable by nearly two-thirds of panelists. One-third (33%) rate LRT technology as very acceptable, and another three in ten (31%) consider it somewhat acceptable.
- An equal proportion of panelists (13%) consider LRT technology to be very unacceptable or somewhat unacceptable.
- Males are more likely than females to rate the LRT technology as very or somewhat unacceptable (29% versus 21%).
- As with BRT technology, there are few differences by region in terms of the acceptability of LRT technology.



Light Rail Transit (LRT): A driver-operated, electrically-powered rail technology that typically operates at street level. LRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

Base: All Participants

Comments on LRT Technology



Q3b. Why is the LRT Technology (somewhat/very) acceptable to you?	Total (n=1164)
Urban design impacts/ Looks appealing (positive)	13%
Works well in other cities (positive)	13%
Impacts on other road users/ Insufficient road space (negative)	12%
Affordability/ Cheap (positive)	9%
Reliability (positive)	9%
Ease of use (positive)	6%
Speed (positive)	6%
Environmental impacts/ Reduced emissions (positive)	5%
Cost effectiveness/ Bang for buck (negative)	5%
Urban design impacts/ Noisy/ Ugly (negative)	5%
Capacity and expandability/ Will not meet future demand (negative)	5%

Q3b. Why is the LRT Technology neither acceptable nor unacceptable to you?	Total (n=195)
Impacts on other road users/ Insufficient road space (negative)	31%
Urban design impacts/ Noisy/ Ugly (negative)	17%
Speed/ Slow/ Affected by traffic (negative)	13%
Safety and personal security/ Pedestrian safety concerns (negative)	7%
Affordability/ Expensive (negative)	6%
Extent of rapid transit coverage/ Will not serve my area (negative)	5%

Light Rail Transit (LRT): A driver-operated, electrically-powered rail technology that typically operates at street level. LRT operates primarily in the centre of the street. It is in its own right-of-way, separated from other traffic by a curb with signal priority at intersections.

Q3b. Why is the LRT Technology (somewhat/very) unacceptable to you?	Total (n=469)
Impacts on other road users/ Insufficient road space (negative)	47%
Urban design impacts/ Noisy/ Ugly (negative)	22%
Speed/ Slow/ Affected by traffic (negative)	16%
Affordability/ Expensive (negative)	9%
Safety and personal security/ Pedestrian safety concerns (negative)	8%
Extent of rapid transit coverage/ Will not serve my area (negative)	6%
Capacity and expandability/ Will not meet future demand (negative)	6%
Reliability (negative)	5%
Does not work well in other cities (negative)	5%

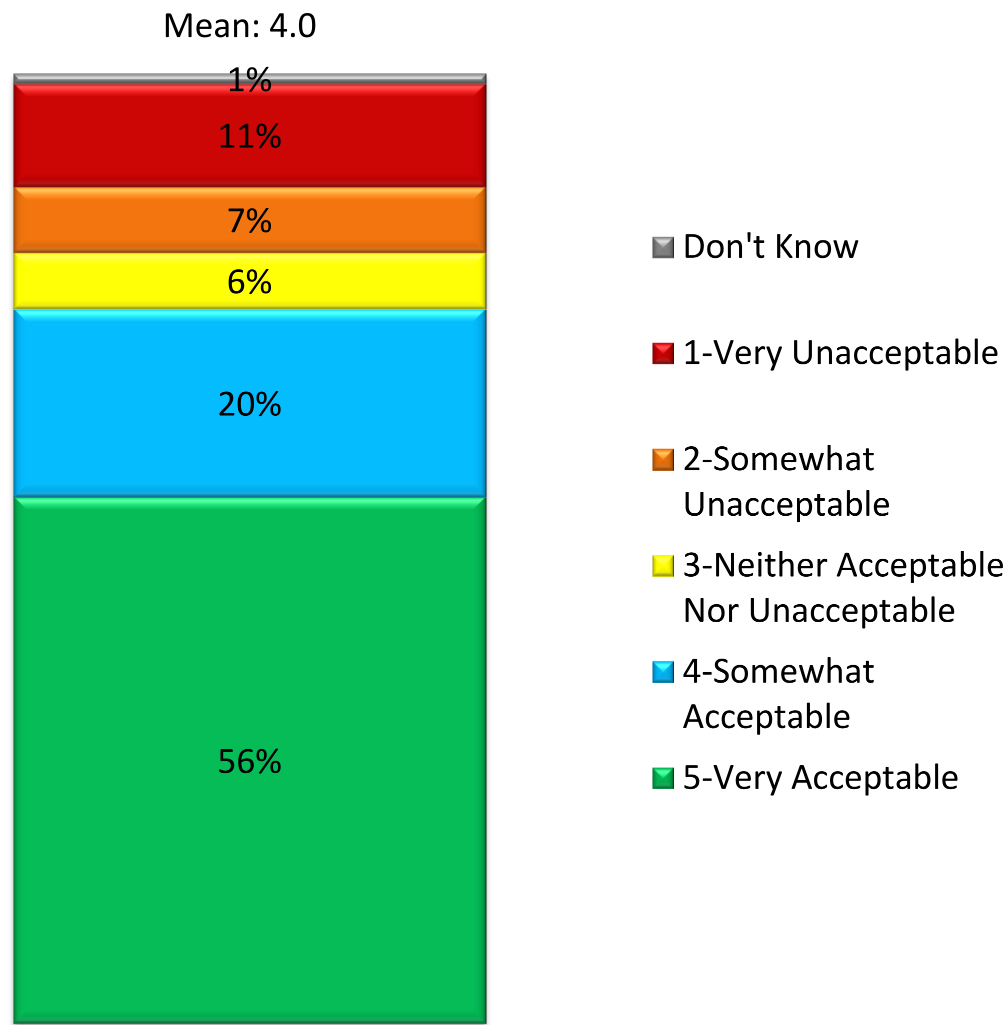
Base: All Participants

NOTE: Only responses mentioned by 5% or more are shown

Acceptability of RRT Technology

- Three-quarters of panelists consider RRT technology to be acceptable (56% very acceptable, and 20% somewhat acceptable).
- Eleven percent consider RRT technology to be very unacceptable, and 7% consider RRT to be somewhat unacceptable.
- Those under 35 years of age are more likely than their older counterparts to find RRT technology acceptable (90% compared with 76% of those 35-54 and 66% of those 55+).
- Panelists residing in Burnaby/ New Westminster (77%) and the Northeast (77%) areas and the City of Vancouver (80%) are more likely than those in the other two regions to rate RRT technology as very or somewhat acceptable. Within the study area, though on small sample sizes, those who attend school in the Broadway corridor (91%) and those who work in the Broadway corridor (87%) show the strongest support for this technology.
- Those who travel in the study area (78%), as well as those who consider investment in rapid transit important to Metro Vancouver (81%), the City of Vancouver and UBC (78%), and personally (85%) are also more likely than their counterparts to find RRT technology acceptable.

Q4a. Based on the information provided, how acceptable is RRT technology as one of the technologies considered for the UBC Line Rapid Transit Study area? (n=1,828)



Rail Rapid Transit (SkyTrain): An automated, driverless rail technology that is powered by electricity. SkyTrain typically operates in a tunnel or on an elevated track; in the case of this study, it is assumed to operate on an elevated track above the centre of the street.

Base: All Participants

Comments on RRT Technology

Q4b. Why is the RRT Technology (somewhat/very) acceptable to you?	Total (n=1399)
Speed (positive)	19%
Affordability/ Expensive (negative)	18%
Urban design impacts/ Looks appealing (positive)	18%
Impacts on other road users/ Improve vehicle congestion (positive)	13%
Reliability (positive)	13%
Capacity and expandability/ Easy to build on (positive)	12%
Integration with the regional transit network (positive)	7%
Construction impacts/ Too long to build/ Disruptive (negative)	7%
Urban design impacts/ Noisy/ Ugly (negative)	5%

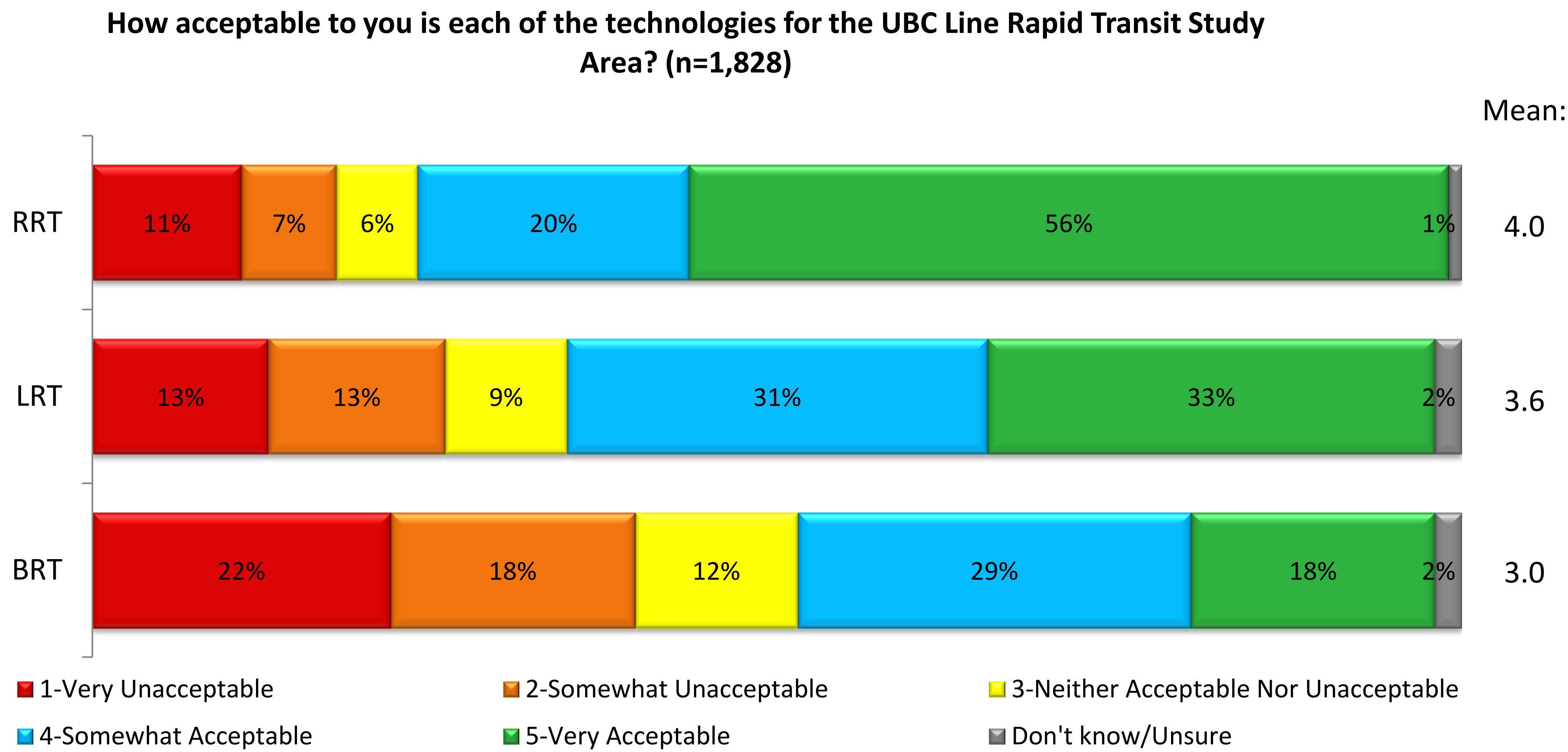
Q4b. Why is the RRT Technology neither acceptable nor unacceptable to you?	Total (n=121)
Affordability/ Expensive (negative)	28%
Construction impacts/ Too long to build/ Disruptive (negative)	9%
Extent of rapid transit coverage/ Will not serve my area (negative)	8%

Q4b. Why is the RRT Technology (somewhat/very) unacceptable to you?	Total (n=308)
Affordability/ Expensive (negative)	60%
Urban design impacts/ Noisy/ Ugly (negative)	23%
Construction impacts/ Too long to build/ Disruptive (negative)	22%
Extent of rapid transit coverage/ Will not serve my area (negative)	10%

Rail Rapid Transit (SkyTrain): An automated, driverless rail technology that is powered by electricity. SkyTrain typically operates in a tunnel or on an elevated track; in the case of this study, it is assumed to operate on an elevated track above the centre of the street.

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of Technologies for the UBC Line Rapid Transit Study Area



- Of the three technology options presented for the Broadway corridor, RRT is the most acceptable overall (55% very and 20% somewhat) and BRT is the least acceptable overall (18% very and 29% somewhat). That said, all three options are acceptable to at least one-half of panelists and all three options garner more acceptable than unacceptable ratings.

Results

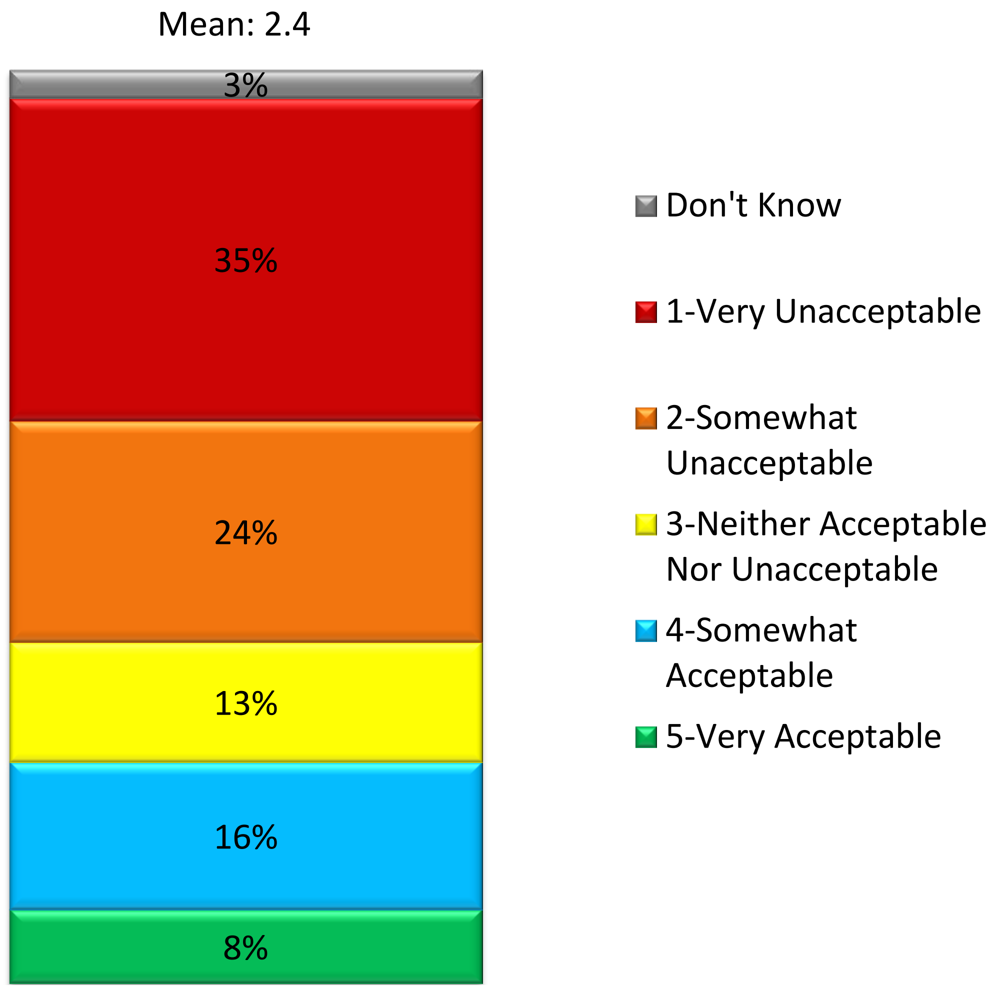
Reactions to Specific Rapid Transit Expansion Options

Reactions to Specific Rapid Transit Expansion Options

- All respondents were provided with information about seven different options for transit expansion in the UBC Line Rapid Transit Study area. These details included a map showing the routing of the service as well as charts comparing each alternative to the other six in terms of average travel times, capital costs, forecasted ridership (including the alternative's capacity to handle the forecasted ridership), effects on greenhouse gas emissions, and potential to attract new ridership. As well, a summary of the results of the initial evaluation of the alternative was presented for each alternative.
- After viewing the details for each alternative, respondents were then asked to rate the acceptability of those alternatives for the UBC Line Rapid Transit Study area. Respondents were also asked to provide the reasons for their rating of each alternative.
- Finally, after rating the acceptability of each alternative and providing reasons for their ratings, respondents were asked to choose the *most* acceptable and *least* acceptable option for the corridor.

- The BRT Alternative is not very acceptable overall. This alternative is rated as somewhat or very unacceptable by nearly six in ten (35% very unacceptable, and 24% somewhat unacceptable).
- Less than one in ten (8%) say that the BRT Alternative is very acceptable, and 16% say that it is somewhat acceptable.
- Those under 35 years of age (72%) are more likely than their counterparts, especially those aged 55 or older (52%), to find the BRT Alternative unacceptable.
- There are few differences by region when it comes to the acceptability of the BRT Alternative; that said, those in the City of Vancouver are slightly more opposed to the BRT Alternative than those living South of the Fraser (64% very or somewhat unacceptable, compared with 51% South of the Fraser).
- Those who were previously aware of the study (62%) and those who travel in the study area (63%) are also more likely than their counterparts to find the BRT Alternative unacceptable, as are those who consider investing in rapid transit important personally (65%) and to the City of Vancouver and UBC (60%).

Q5a. How acceptable is the BRT Alternative to you compared to continuing to serve the corridor with buses only? (n=1,828)



BRT Alternative: BRT along Broadway from Commercial/Broadway to UBC.

Base: All Participants

Comments on BRT Alternative

Q5b. Why is the BRT Alternative (somewhat/very) acceptable to you?	Total (n=456)
Affordability/ Cheap (positive)	17%
Capacity and expandability/ Will not meet future demand (negative)	7%
Impacts on other road users/ Insufficient road space (negative)	5%

Q5b. Why is the BRT Alternative neither acceptable nor unacceptable to you?	Total (n=291)
Capacity and expandability/ Will not meet future demand (negative)	14%
Affordability/ Cheap (positive)	9%
Impacts on other road users/ Insufficient road space (negative)	9%
No or little improvement over existing service (negative)	8%
Speed/ Slow/ Affected by traffic (negative)	5%

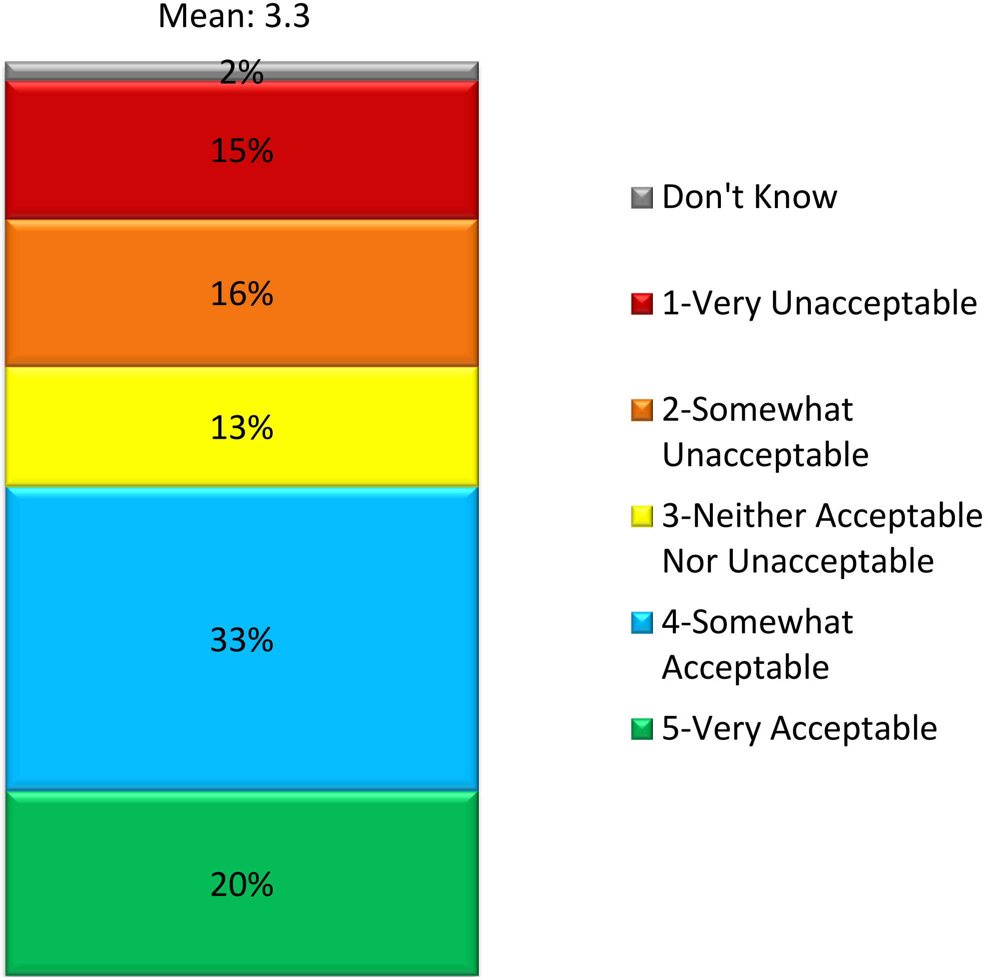
Q5b. Why is the BRT Alternative (somewhat/very) unacceptable to you?	Total (n=1081)
Capacity and expandability/ Will not meet future demand (negative)	29%
Impacts on other road users/ Insufficient road space (negative)	14%
No or little improvement over existing service (negative)	7%
Speed/ Slow/ Affected by traffic (negative)	7%
Affordability/ Expensive (negative)	6%
Affordability/ Cheap (positive)	5%
Cost effectiveness/ No value for cost (negative)	5%

BRT Alternative: BRT along Broadway from Commercial/Broadway to UBC.

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

- LRT Alternative 1 is rated as somewhat or very acceptable by just over one-half of panelists (20% very acceptable, and 33% somewhat acceptable).
- Three in ten (32%) say that LRT Alternative 1 is unacceptable (15% very unacceptable, and 16% somewhat unacceptable).
- Males are more likely than females to find the LRT Alternative 1 unacceptable (36% versus 26%).
- Those who live, work, go to school or have a business in the Broadway corridor find the LRT Alternative 1 (35% unacceptable) more unacceptable than do people with connections to UBC or the University Endowment Lands (27%) or people with other or no connections to the study area (31%).
- As well, there are very few notable differences between groups based on familiarity with the study or the study area, or the importance placed on rapid transit expansion within the study area.

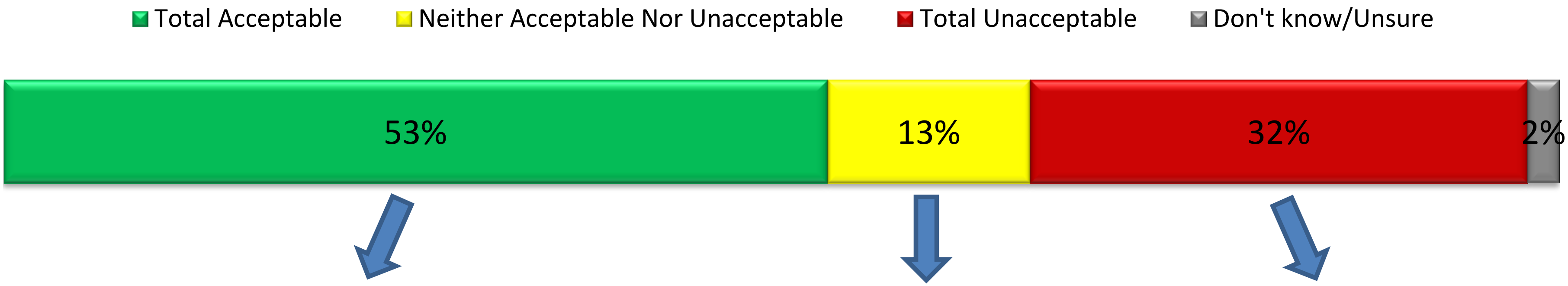
Q6a. How acceptable is LRT Alternative 1 to you compared to continuing to serve the corridor with buses only? (n=1,828)



LRT Alternative 1: LRT along Broadway from Commercial/Broadway to UBC.

Base: All Participants

Comments on LRT Alternative 1



Q6b. Why is LRT Alternative 1 (somewhat/very) acceptable to you?	Total (n=976)
Affordability/ Cheap (positive)	12%
Capacity and expandability/ Easy to build on (positive)	7%
Impacts on other road users/ Insufficient road space (negative)	7%

Q6b. Why is LRT Alternative 1 neither acceptable nor unacceptable to you?	Total (n=279)
Impacts on other road users/ Insufficient road space (negative)	12%
Speed/ Slow/ Affected by traffic (negative)	7%
Urban design impacts/ Noisy/ Ugly (negative)	6%

Q6b. Why is LRT Alternative 1 (somewhat/very) unacceptable to you?	Total (n=573)
Impacts on other road users/ Insufficient road space (negative)	24%
Urban design impacts/ Noisy/ Ugly (negative)	12%
Affordability/ Expensive (negative)	10%
Cost effectiveness/ No value for cost (negative)	8%
Capacity and expandability/ Will not meet future demand (negative)	7%
Speed/ Slow/ Affected by traffic (negative)	7%

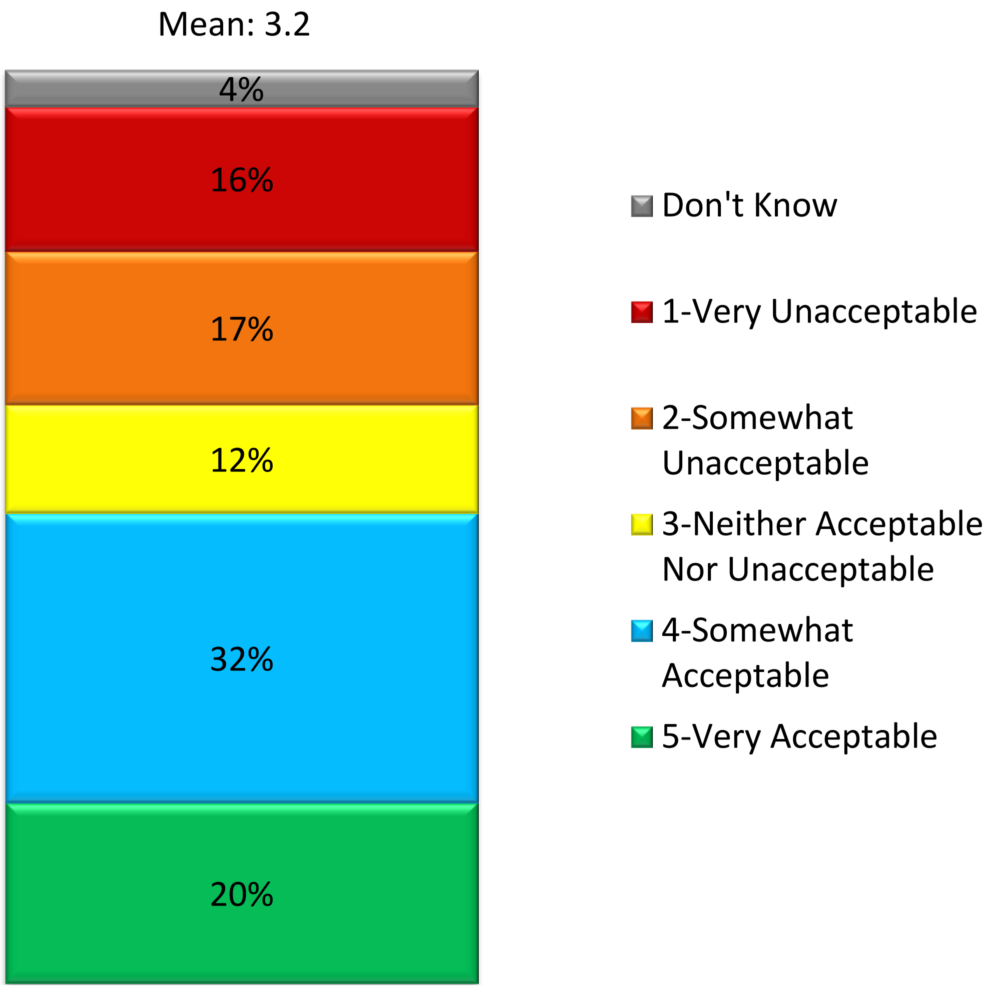
LRT Alternative 1: LRT along Broadway from Commercial/Broadway to UBC.

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of LRT Alternative 2

- LRT Alternative 2 is rated as somewhat or very acceptable by more than one-half (20% very acceptable, and 32% somewhat acceptable).
- Sixteen percent say that LRT Alternative 2 is very unacceptable, and 17% say that it is somewhat unacceptable.
- Females are more likely than males to find the LRT Alternative 2 acceptable (56% versus 49%).
- Those living in the City of Vancouver and the Burnaby/ New Westminster area (both at 34%) are slightly more likely to consider LRT Alternative 2 unacceptable than those in other regions. Those with ties to the Broadway corridor (35%) are also more likely to consider this alternative unacceptable than those with ties to UBC and the University Endowment Lands (24%).
- There are few notable differences between groups based on familiarity with the study or the study area, or the importance placed on investment in rapid transit within the study area. Those who travel within the study area are more likely than those who do not to find LRT Alternative 2 acceptable (53% versus 47%).

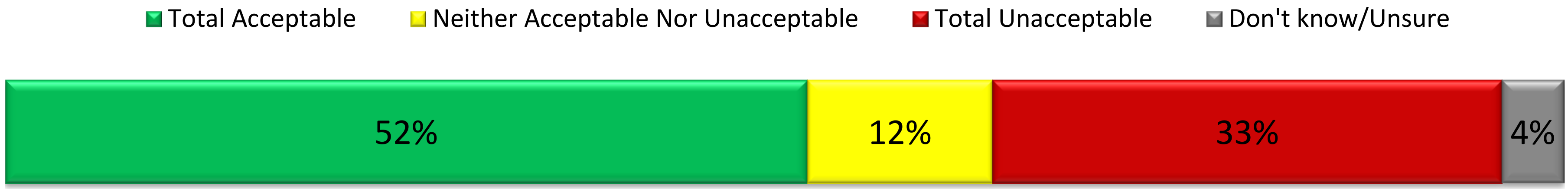
Q7a. How acceptable is LRT Alternative 2 to you compared to continuing to serve the corridor with buses only? (n=1,828)



LRT Alternative 2: LRT along Broadway from Commercial/Broadway to UBC and along the former rail corridor between Arbutus and Main Street/Science World.

Base: All Participants

Comments on LRT Alternative 2



Q7b. Why is LRT Alternative 2 (somewhat/very) acceptable to you?	Total (n=959)
Affordability/ Cheap (positive)	10%
Capacity and expandability/ Easy to build on (positive)	8%
Extent of rapid transit coverage/ Serves more areas (positive)	8%
Impacts on other road users/ Insufficient road space (negative)	7%

Q7b. Why is LRT Alternative 2 neither acceptable nor unacceptable to you?	Total (n=296)
Urban design impacts/ Noisy/ Ugly (negative)	10%
Impacts on other road users/ Insufficient road space (negative)	8%
Cost effectiveness/ No value for cost (negative)	7%
Affordability/ Expensive (negative)	6%
Affordability/ Cheap (positive)	5%

Q7b. Why is LRT Alternative 2 (somewhat/very) unacceptable to you?	Total (n=573)
Impacts on other road users/ Insufficient road space (negative)	19%
Urban design impacts/ Noisy/ Ugly (negative)	11%
Affordability/ Expensive (negative)	10%
Cost effectiveness/ No value for cost (negative)	7%
Capacity and expandability/ Will not meet future demand (negative)	6%
Extent of rapid transit coverage/ Will not serve my area (negative)	5%
Speed/ Slow/ Affected by traffic (negative)	5%

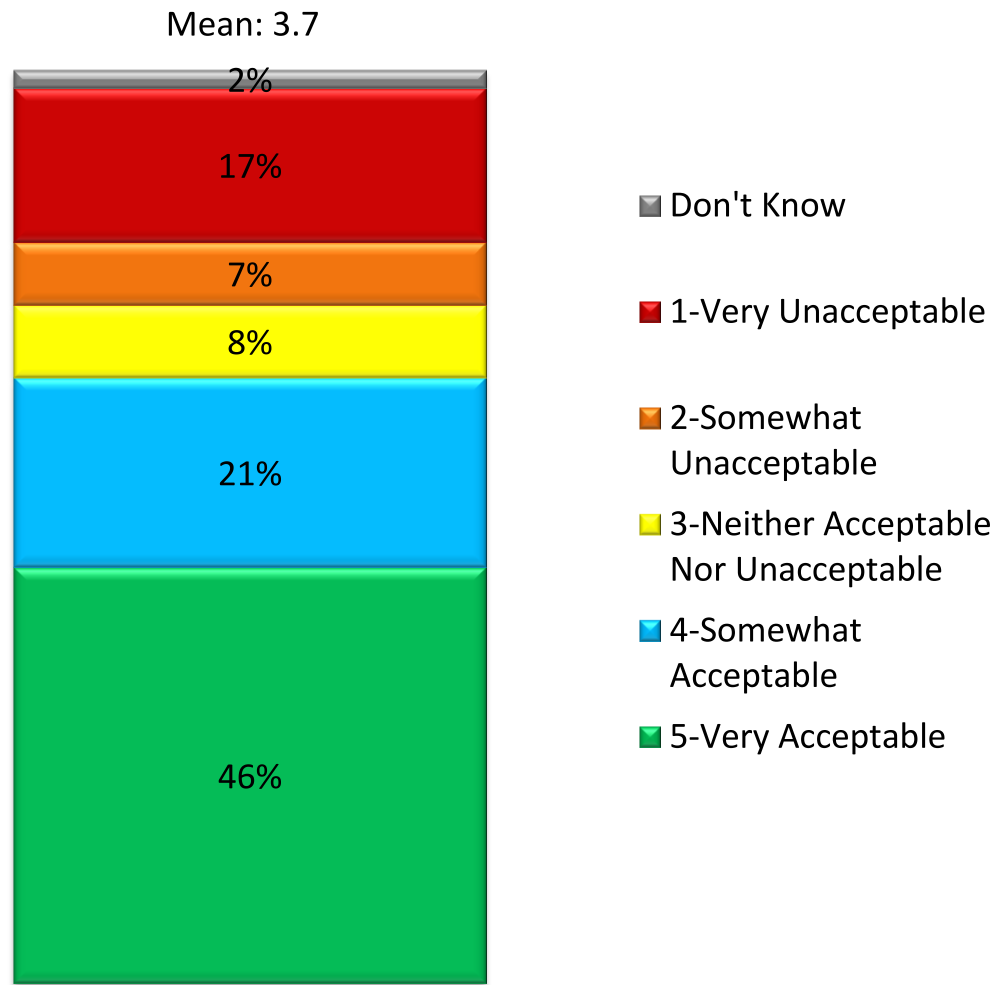
LRT Alternative 2: LRT along Broadway from Commercial/Broadway to UBC and along the former rail corridor between Arbutus and Main Street/Science World.

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of RRT Alternative

- The RRT Alternative is rated as somewhat or very acceptable by nearly two-thirds of panelists (46% very acceptable, and 21% somewhat acceptable).
- One in six (17%) say that this alternative is very unacceptable, and 7% say that it is somewhat unacceptable.
- Those under 35 years of age (83%) are even more likely to find the RRT Alternative acceptable than those aged 35-54 (68%) or 55+ (55%).
- There are notable differences by region when it comes to the acceptability of the RRT Alternative. Those in Vancouver (72%) and Burnaby/ New Westminster (68%) find this alternative more acceptable than those who live in other parts of Metro Vancouver.
- As well, those who travel within the study area (71%) are more likely than those who do not (55%) to consider the RRT Alternative acceptable. Those who consider investment in rapid transit for the corridor to be important are also more likely to find the RRT Alternative acceptable (for example, 73% acceptable for those who believe this investment is important for Metro Vancouver compared with 39% acceptable for those who do not think this investment is important for Metro Vancouver).

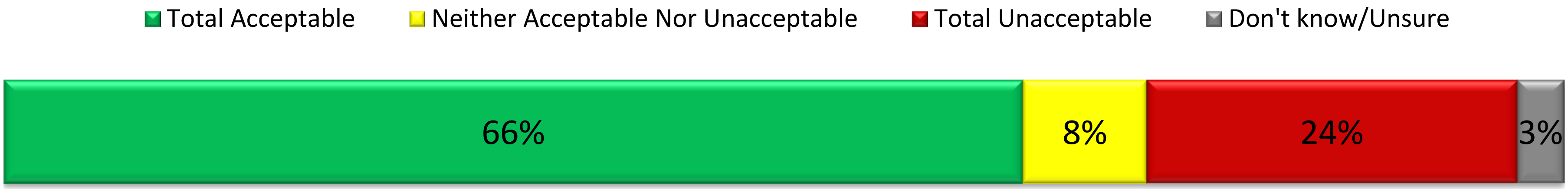
Q8a. How acceptable is the RRT Alternative to you compared to continuing to serve the corridor with buses only? (n=1,828)



RRT Alternative: SkyTrain extending the Millennium Line from VCC-Clark to UBC along Broadway

Base: All Participants

Comments on RRT Alternative



Q8b. Why is the RRT Alternative (somewhat/very) acceptable to you?	Total (n=1248)
Affordability/ Expensive (negative)	25%
Speed (positive)	18%
Capacity and expandability/ Easy to build on (positive)	15%
Impacts on other road users/ Improve vehicle congestion (positive)	12%
Best option (positive)	8%
Environmental impacts/ Reduced emissions (positive)	6%
Cost effectiveness/ Bang for buck (positive)	6%
Urban design impacts/ Looks appealing (positive)	6%

Q8b. Why is the RRT Alternative neither acceptable nor unacceptable to you?	Total (n=168)
Affordability/ Expensive (negative)	36%
Speed (positive)	5%
Capacity and expandability/ Easy to build on (positive)	5%

Q8b. Why is the RRT Alternative (somewhat/very) unacceptable to you?	Total (n=412)
Affordability/ Expensive (negative)	53%
Construction impacts/ Too long to build/ Disruptive (negative)	12%
Urban design impacts/ Noisy/ Ugly (negative)	11%
Extent of rapid transit coverage/ Will not serve my area (negative)	5%

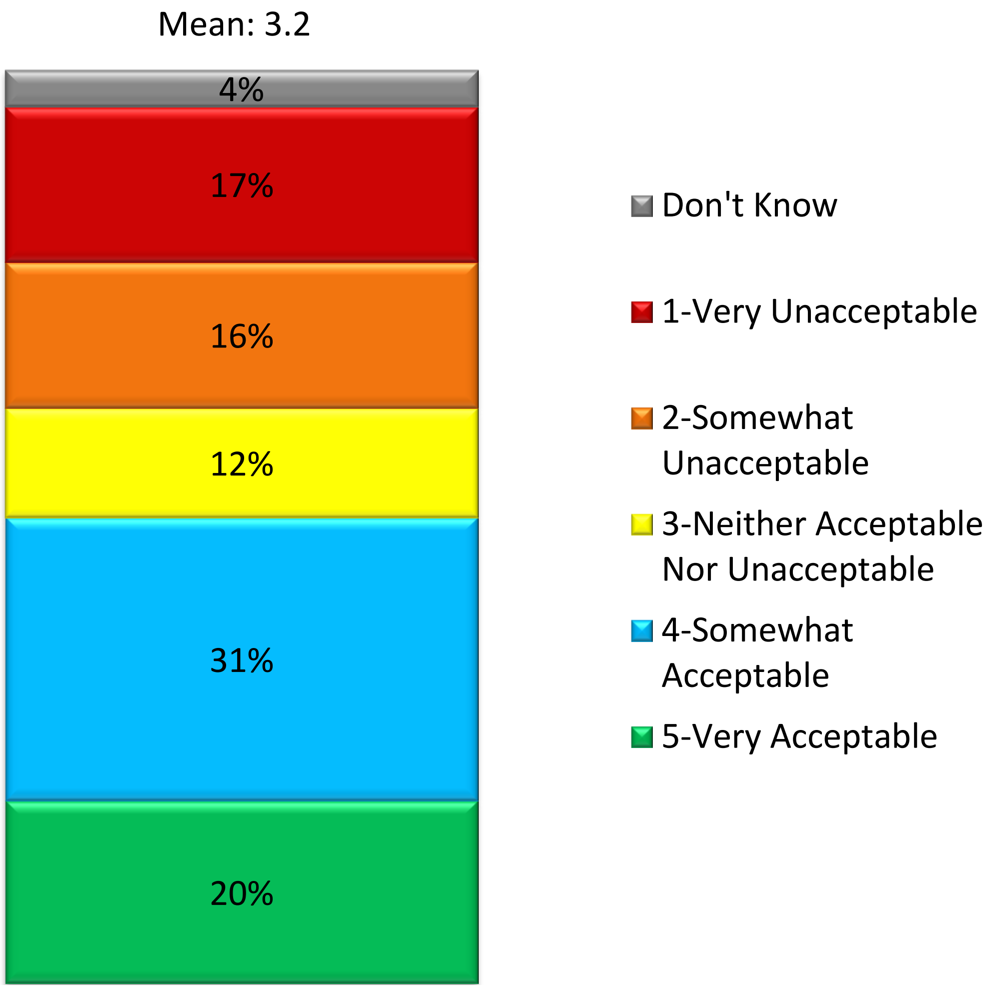
RRT Alternative: SkyTrain extending the Millennium Line from VCC-Clark to UBC along Broadway

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of Combo Alternative 1

- Combination Alternative 1 is rated as acceptable by about one-half of panelists (20% very acceptable, and 31% somewhat acceptable).
- One-third (33%) say that this alternative is unacceptable (17% very and 16% somewhat unacceptable).
- Those 55 years of age and older (39%) and males (36%) are more likely than their counterparts to find this alternative unacceptable.
- There are subtle differences by region when it comes to the acceptability of Combination Alternative 1. Those in Vancouver (54%) and the Northeast areas (56%) are more likely than those in the South of Fraser (45%) region to find this option acceptable.
- As well, those who are aware of the study (53%) as well as those who travel in the study area (54%) and those who are familiar with transit in the study area (55%) are more likely than their counterparts to find this alternative acceptable.
- Those who consider investment in rapid transit important are also more likely than those who do not consider such investment important to rate this alternative as acceptable.

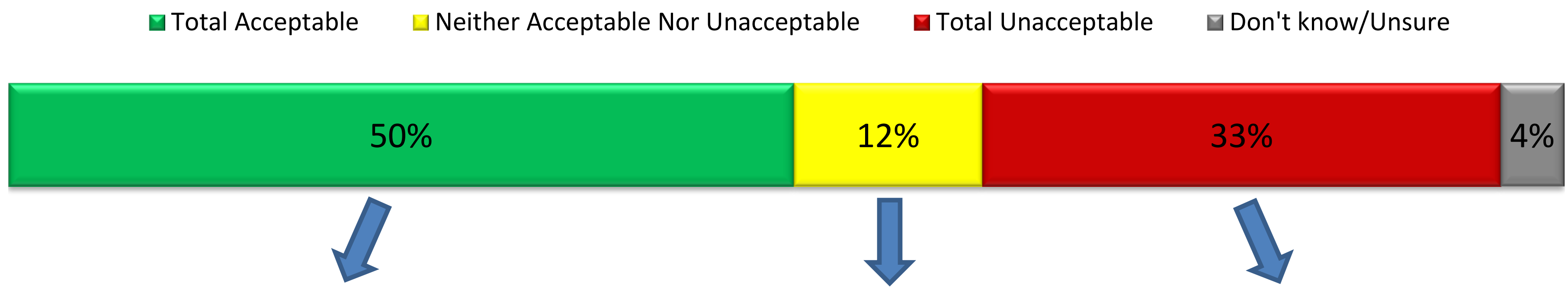
Q9a. How acceptable is Combo Alternative 1 to you compared to continuing to serve the corridor with buses only? (n=1,828)



Combination Alternative 1: SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and LRT along the former rail corridor between Arbutus and Main Street/Science World and along Broadway from Arbutus to UBC.

Base: All Participants

Comments on Combo Alternative 1



Q9b. Why is Combo Alternative 1 (somewhat/very) acceptable to you?	Total (n=949)
Affordability/ Expensive (negative)	8%
Capacity and expandability/ Easy to build on (positive)	8%
Impacts on other road users/ Insufficient road space (negative)	6%
Extent of rapid transit coverage/ Serves more areas (positive)	5%
Affordability/ Cheap (positive)	5%

Q9b. Why is Combo Alternative 1 neither acceptable nor unacceptable to you?	Total (n=295)
Affordability/ Expensive (negative)	13%
Impacts on other road users/ Insufficient road space (negative)	9%
Speed/ Slow/ Affected by traffic (negative)	5%

Q9b. Why is Combo Alternative 1 (somewhat/very) unacceptable to you?	Total (n=584)
Affordability/ Expensive (negative)	23%
Impacts on other road users/ Insufficient road space (negative)	10%
Speed/ Slow/ Affected by traffic (negative)	5%
Cost effectiveness/ No value for cost (negative)	5%

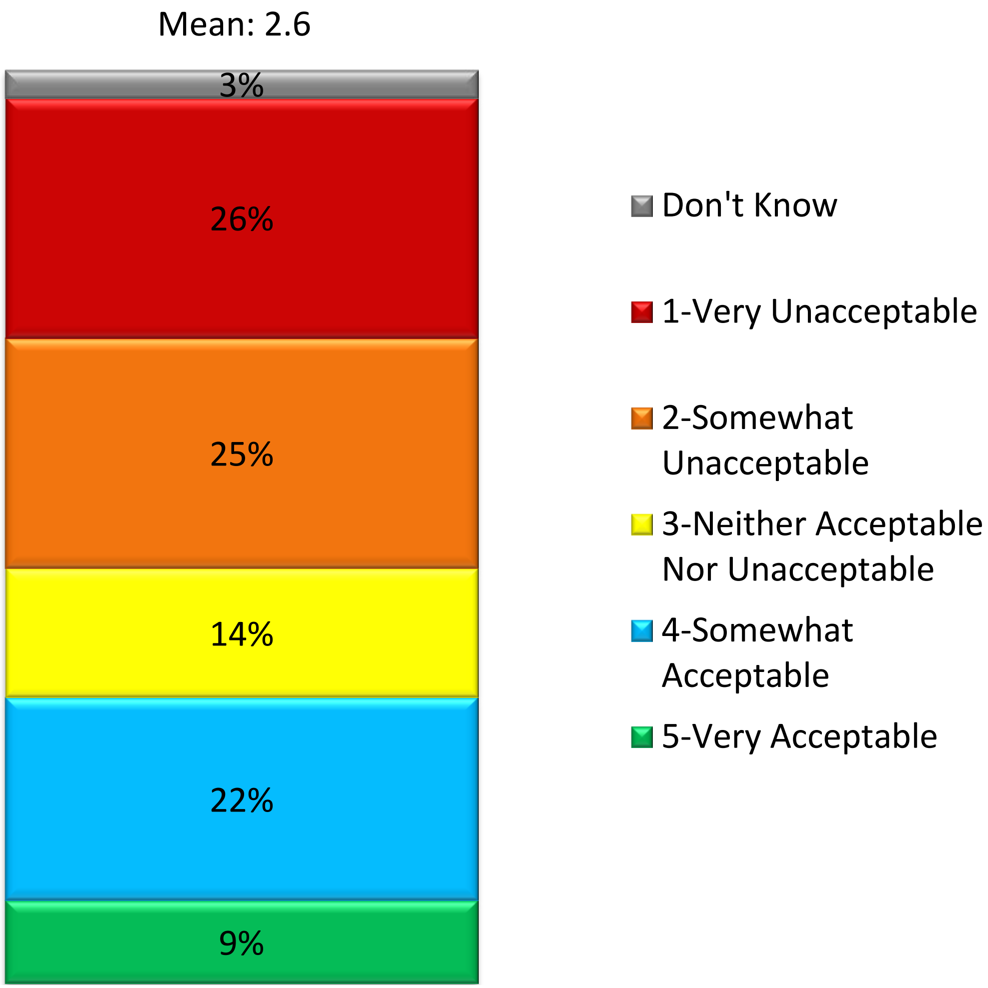
Combination Alternative 1: SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and LRT along the former rail corridor between Arbutus and Main Street/Science World and along Broadway from Arbutus to UBC.

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of Combo Alternative 2

- Combination Alternative 2 is rated as somewhat or very unacceptable by one-half of panelists (26% very unacceptable, and 25% somewhat unacceptable).
- One in ten (9%) say that Combination Alternative 2 is very acceptable, and 22% say that it is somewhat acceptable.
- There are few differences by region when it comes to the acceptability of this alternative; that said, those who live in the City of Vancouver are more likely than those in other regions to find this alternative unacceptable (55%). Those who live at UBC, though on a small sample size, are also very likely to oppose this alternative (83% very or somewhat unacceptable).
- There are few notable differences between groups based on familiarity with the study or the study area, or the importance placed on rapid transit expansion within the study area. Those who travel in the study area are slightly more likely to find this alternative unacceptable than those who were not previously aware (53% versus 46%).

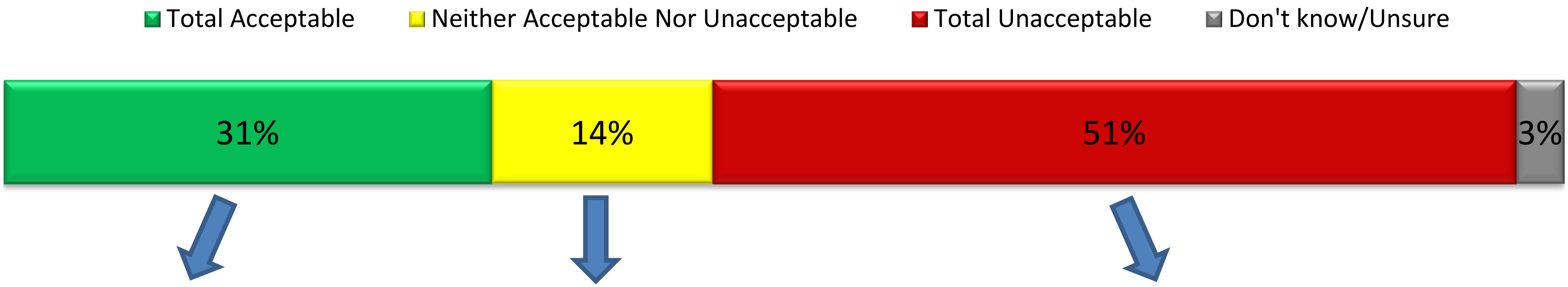
Q10a. How acceptable is Combo Alternative 2 to you compared to continuing to serve the corridor with buses only? (n=1,828)



Combination Alternative 2: SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and BRT along Broadway from Commercial/Broadway to UBC.

Base: All Participants

Comments on Combo Alternative 2



Q10b. Why is Combo Alternative 2 (somewhat/very) acceptable to you?	Total (n=570)
Capacity and expandability/ Easy to build on (positive)	11%
Affordability/ Cheap (positive)	9%
Capacity and expandability/ Will not meet future demand (negative)	7%
Extent of rapid transit coverage/ Will not serve my area (negative)	5%

Q10b. Why is Combo Alternative 2 neither acceptable nor unacceptable to you?	Total (n=332)
Affordability/ Expensive (negative)	9%
Capacity and expandability/ Will not meet future demand (negative)	8%

Q10b. Why is Combo Alternative 2 (somewhat/very) unacceptable to you?	Total (n=926)
Capacity and expandability/ Will not meet future demand (negative)	19%
Affordability/ Expensive (negative)	13%
Cost effectiveness/ No value for cost (negative)	8%
Impacts on other road users/ Insufficient road space (negative)	8%
Extent of rapid transit coverage/ Will not serve my area (negative)	6%
Urban design impacts/ Noisy/ Ugly (negative)	5%
Duplication of service (negative)	5%

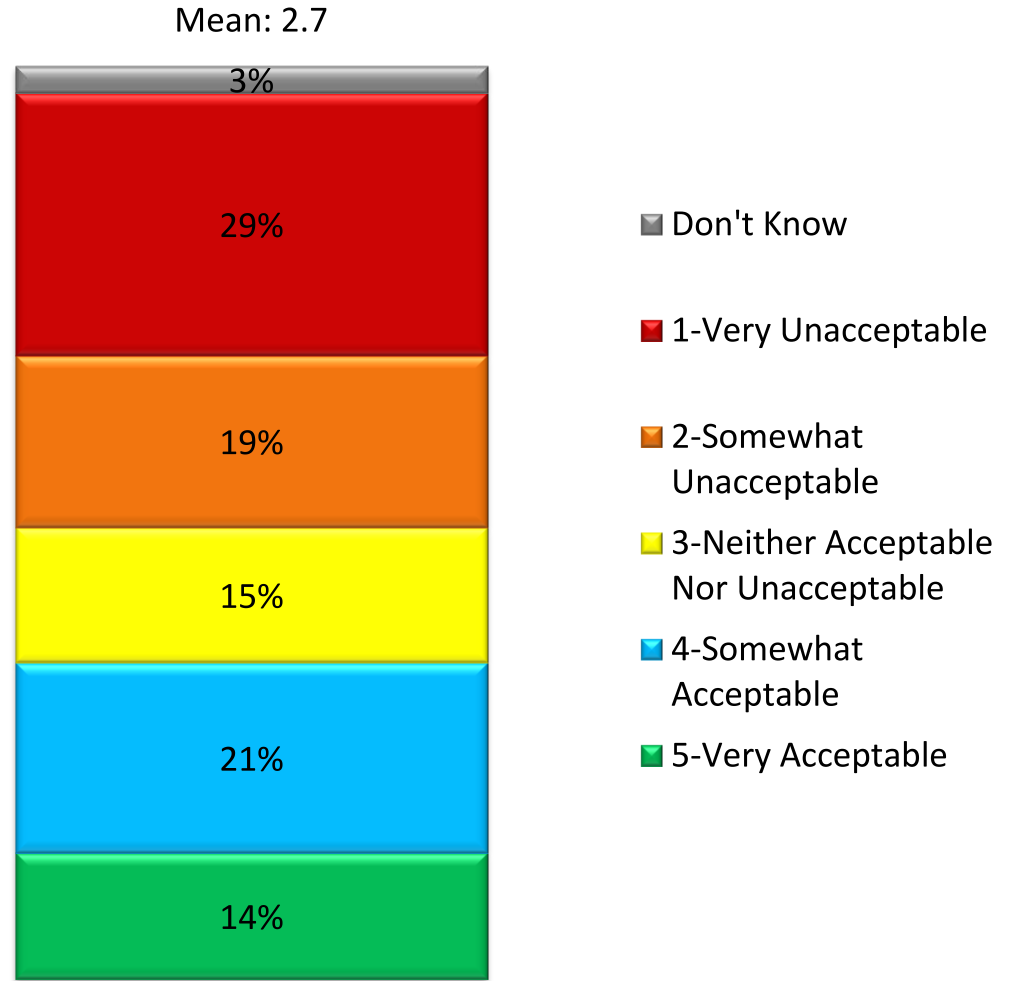
Combination Alternative 2: SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and BRT along Broadway from Commercial/Broadway to UBC.

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

Acceptability of Best Bus Alternative

- The Best Bus Alternative is rated as somewhat or very unacceptable by about one-half of panelists (29% very unacceptable, and 19% somewhat unacceptable).
- One in seven (14%) say that the Best Bus Alternative is very acceptable, and 21% say that it is somewhat acceptable.
- Those under 55 years of age (61% for those under 35, 48% for those 35-54) and males (53%) are more likely than their counterparts to find this alternative unacceptable.
- Those living in the City of Vancouver are more likely to find this option unacceptable (54%) than those in other regions; those with ties to UBC and the University Endowment Lands are also more likely to find this option unacceptable (58%) than those with ties to the Broadway corridor (54%) or no ties to the study area (45%).
- There are a number of differences between groups based on familiarity with the study or the study area, or the importance placed on rapid transit expansion within the study area. Those who are aware of the study (55%) and familiar with the study (59%), as well as those who travel in the study area (51%) and are familiar with existing transit in the area (53%) are all more likely than their counterparts to consider this alternative unacceptable.
- As well, those who consider the study important, whether to Metro Vancouver (51%), the City of Vancouver and UBC (49%) or personally (57%) are also more likely to consider the Best Bus Alternative unacceptable.

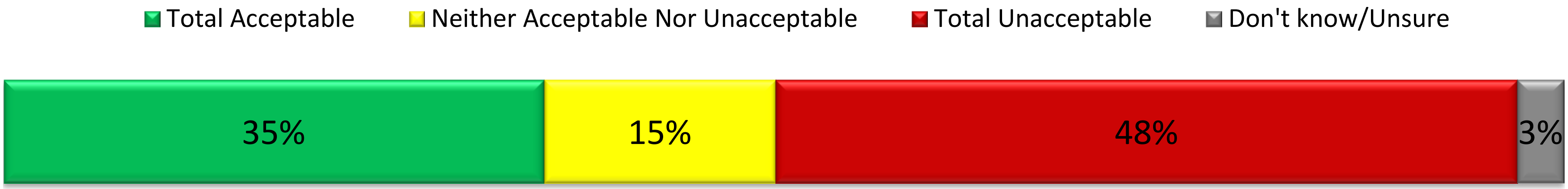
Q11a. How acceptable is the Best Bus Alternative to you compared to continuing to serve the corridor with buses as today with service improvements consistent with past trends? (n=1,828)



Best Bus Alternative: No rapid transit along the corridor, but improve bus services with additional limited stop service and transit priority measures.

Base: All Participants

Comments on Best Bus Alternative



Q11b. Why is the Best Bus Alternative (somewhat/very) acceptable to you?	Total (n=600)
Affordability/ Cheap (positive)	23%
Capacity and expandability/ Will not meet future demand (negative)	9%
Capacity and expandability/ Will not meet future demand (negative)	6%
Cost effectiveness/ Bang for buck (positive)	5%
Best option (positive)	5%

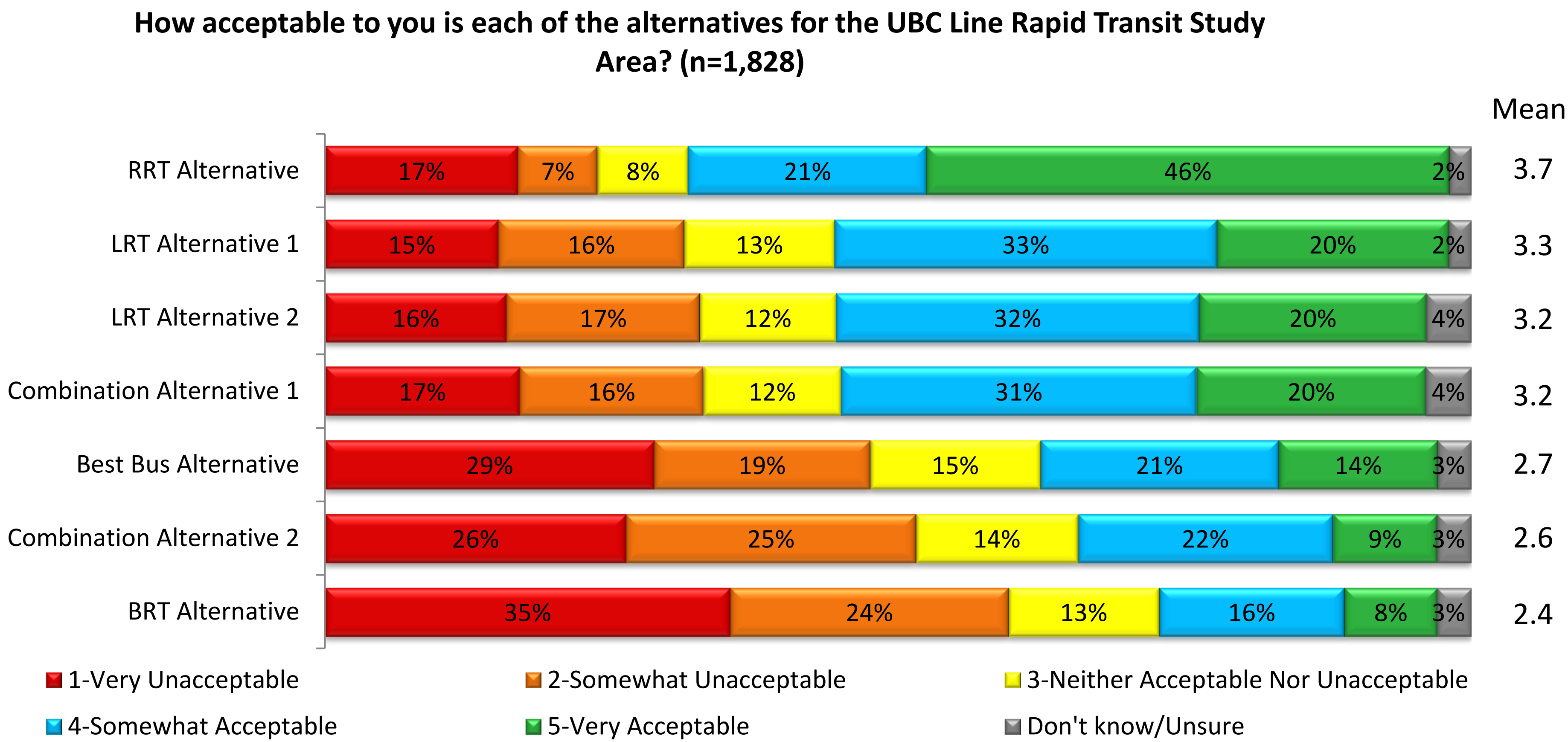
Q11b. Why is the Best Bus Alternative neither acceptable nor unacceptable to you?	Total (n=313)
Capacity and expandability/ Will not meet future demand (negative)	14%
Affordability/ Cheap (positive)	9%
Environmental impacts/ Higher emissions (negative)	5%

Q11b. Why is the Best Bus Alternative (somewhat/very) unacceptable to you?	Total (n=928)
Capacity and expandability/ Will not meet future demand (negative)	32%
Environmental impacts/ Higher emissions (negative)	10%
Cost effectiveness/ No value for cost (negative)	6%
Affordability/ Cheap (positive)	5%
Speed/ Slow/ Affected by traffic (negative)	5%

Best Bus Alternative: No rapid transit along the corridor, but improve bus services with additional limited stop service and transit priority measures.

Base: All Participants
NOTE: Only responses mentioned by 5% or more are shown

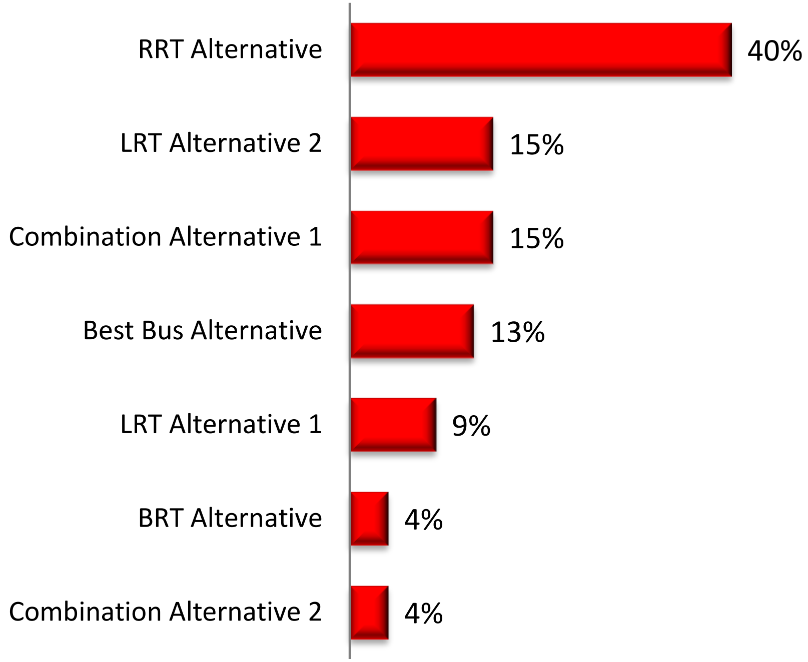
Acceptability of Alternatives for the UBC Line Rapid Transit Study Area

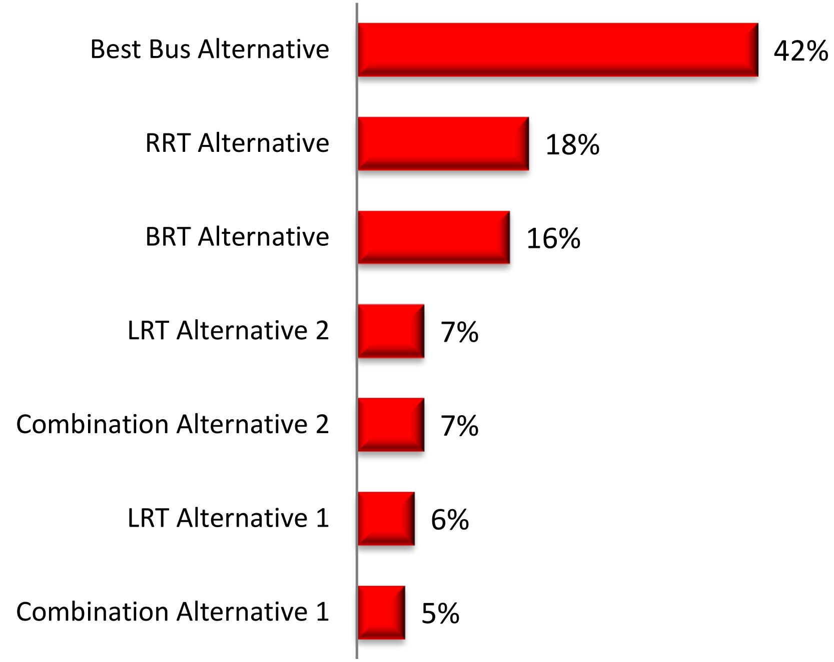


- Of the seven alternatives presented for the Broadway corridor, the RRT alternative is the most acceptable overall (46% very and 21% somewhat).
- LRT Alternative 1, LRT Alternative 2, and Combination Alternative 1 are moderately acceptable alternatives for the Broadway corridor, with roughly one-half of panelists supporting each alternative.
- The BRT Alternative is the least acceptable overall (8% very and 16% somewhat). The Best Bus Alternative and Combination Alternative 2 are also considered unacceptable overall.

Base: All Participants

Most/Least Acceptable Alternatives for UBC Line Rapid Transit Study Area





- When choosing the most acceptable option of the seven presented, the RRT alternative comes out on top with 40% of votes. Those in Vancouver (44%) and Burnaby/ New Westminster (43%) are particularly likely to choose this option as the most acceptable, as are those with ties to the Broadway corridor (47%), and those under 35 years of age (53%).
- Several of the alternatives share major similarities—i.e., three alternatives have an LRT component and two have an RRT component—so there is a chance that "vote-splitting" occurred between these alternatives.
- On the other hand, when asked to choose the least acceptable option, four in ten panelists choose the Best Bus Alternative (42%). This option is least acceptable among those in Vancouver (47%), those with ties to UBC and the University Endowment Lands (52%), and those under 35 years of age (54%). Interestingly, RRT is the second-least acceptable option, selected by 18% as the least acceptable option overall.

Base: All Participants

Appendix
Demographics

In which of the following areas do you live?	Unweighted (n=1828) %	Weighted (n=1828) %
South of Fraser	**24**	**23**
Delta – South Delta (includes Ladner and Tsawwassen)	2	2
Delta – North Delta	1	<1
Langley City	1	<1
Langley Township	3	4
Richmond	6	6
Surrey	10	10
White Rock	1	1
Burnaby/ New Westminster	**14**	**14**
Burnaby	10	9
New Westminster	4	5
Vancouver	**45**	**45**

Appendix – Demographics

In which of the following areas do you live?	Unweighted (n=1828) %	Weighted (n=1828) %
North Shore	**6**	**7**
Bowen Island	<1	<1
Lions Bay	<1	<1
North Vancouver – City	2	2
North Vancouver – District	3	3
West Vancouver	1	2
Northeast	**11**	**11**
Anmore/Belcarra	<1	<1
Coquitlam	4	3
Maple Ridge	2	2
Pitt Meadows	<1	<1
Port Coquitlam	2	2
Port Moody	2	2

Do you have access to a car, van, or truck for your own use on a regular basis?	Unweighted (n=1828) %	Weighted (n=1828) %
Yes	69	83
No	31	17
Don't know	<1	<1

What mode of transportation do you use most often to travel to work, school or your other frequent trips in Metro Vancouver?	Unweighted (n=1828) %	Weighted (n=1828) %
SOV	24	51
Rideshare	9	13
Transit	54	24
Walk/ Cycle/ Other	13	12

Appendix – Demographics

Age/ Gender	Unweighted (n=1828) %	Weighted (n=1828) %
M 16-34	17	13
M 35-54	23	26
M 55+	19	22
F 16-34	9	8
F 35-54	18	17
F 55+	13	14

What is your present employment status?	Unweighted (n=1828) %	Weighted (n=1828) %
Employed full time (30 or more hours per week)	60	61
Employed part time (less than 30 hours per week)	11	11
Student	7	5
Retired	16	17
Not employed	4	4
Homemaker	2	2

Which of the following best describes your total household income before taxes for 2010?	Unweighted (n=1828) %	Weighted (n=1828) %
Under $35,000	17	14
$35,000 to under $65,000	21	20
$65,000 to under $95,000	17	18
$95,000 or over	23	25
Don’t know/ Refused	22	22

Appendix

Survey

UBC Line Rapid Transit Study Acceptability Questionnaire
Final Draft March 21, 2012

FIELD DATES: Soft launch March 20th. Full Launch March 21st.

REMINDERS: March 26th and 28th

SAMPLE: All panelists living in Metro Vancouver [i.e., exclude if PQ municipality variable equals 1, 11 or 22]

QUESTION FORMAT: Flat.

E-MAIL INVITATION

Subject: Give your input on rapid transit for the Broadway Corridor

Dear On-Line Advisor,

TransLink and the Province of British Columbia have partnered with the City of Vancouver, University of British Columbia, University Endowment Lands, and the Musqueam Indian Band to conduct a multi-phase study evaluating a number of rapid transit alternatives for the Broadway Corridor between Commercial Drive and the University of British Columbia and we would like your feedback on the subject.

As this survey will take about 15-20 minutes to complete, and to encourage participation, you will be entered into draw for six prizes of $50.

Please click the link below to complete this survey by March 29, 2012.

[%LINK%]

Thank you,

TransLink Listens

Contest Rules

TransLink
1600 - 4720 Kingsway
Burnaby, BC V5H 4N2

1

[QUESTIONNAIRE]

[Screening Questions]
Thank you for agreeing to participate in the survey. Your opinions are very important to us.

The survey should take about 15-20 minutes to complete. Your responses will be kept strictly confidential.

If at any time you wish to stop this survey and complete it at a later time, please close the questionnaire window. To return to the survey please use the same URL provided in the invitation we sent you. You will return to the same section of the survey where you left off.

S1. To begin, in which of the following areas do you live?
[SINGLE RESPONSE]

1. Anmore/Belcarra
2. Burnaby
3. Bowen Island
4. Coquitlam
5. Delta—North Delta
6. Delta—South Delta (Ladner/Tsawwassen)
7. Langley—City
8. Langley—Township
9. Lions Bay
10. Maple Ridge
11. New Westminster
12. North Vancouver –City
13. North Vancouver—District
14. Pitt Meadows
15. Port Coquitlam
16. Port Moody
17. Richmond
18. Surrey
19. Vancouver
20. West Vancouver
21. White Rock
22. Outside of Metro Vancouver (not in above list) [GO TO THANK AND TERMINATE]

[Thank and Terminate if S1=22]
Thank you, but this survey is intended for Metro Vancouver residents.

2

[NEW SCREEN]
S2. Broadway is a regionally important and growing corridor connecting major population, job and institutional centres. Central Broadway (including Vancouver General Hospital) and the University of British Columbia are two of the most important transit destinations in the region. Existing transit services in the Broadway corridor do not provide sufficient capacity or reliability, with frequent pass-ups during peak periods and unpredictable travel times.

To address these issues, TransLink and the Province of British Columbia have partnered with the City of Vancouver, UBC, the University Endowment Lands, and the Musqueam Indian Band to conduct a multi-phase study evaluating a number of rapid transit alternatives along the Broadway corridor between Commercial Drive and UBC.

Before today, were you aware of the UBC Line Rapid Transit Study?
[SINGLE RESPONSE]

1. Yes
2. No
3. Don't know/Unsure.

[NEW SCREEN]
[ASK IF S2=1] [IN DATA PROCESSING IMPUTE S2=2 AS "NOT AT ALL FAMILIAR" AND S2=3 AS "DON'T KNOW/UNSURE"]
S3. How familiar are you with the UBC Line Rapid Transit Study?
Please choose one response.
[SINGLE RESPONSE]

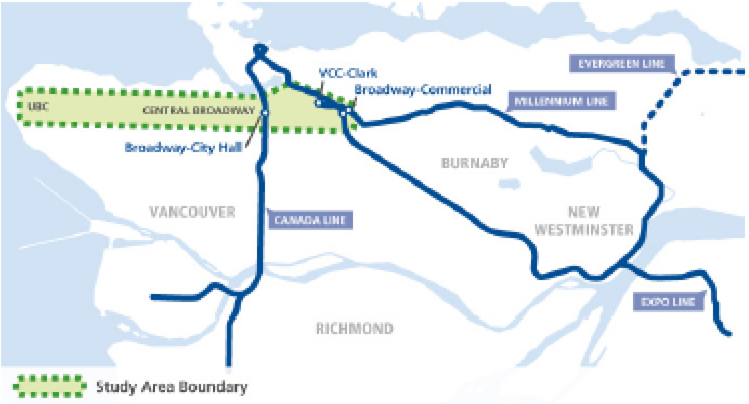
1. Very familiar
2. Somewhat familiar
3. Not very familiar
4. Not at all familiar
5. Don't know

[NEW SCREEN]
S4. The study is considering a range of rapid transit technologies along the Broadway corridor which runs between UBC and the Commercial-Broadway SkyTrain station and includes all streets north to 4th Avenue and south to 16th Avenue (see map below).

Seven alternatives are being evaluated in detail to assess their costs, benefits and impacts. The results will support decision-makers in determining a preferred alternative and in making investment decisions on future rapid transit in the region.

[INSERT MAP OF STUDY AREA: image=ubcline_backgroundmap_prf03.jpg]

3



Based on what you have read, seen or heard, how important would you say investing in rapid transit along this corridor is…

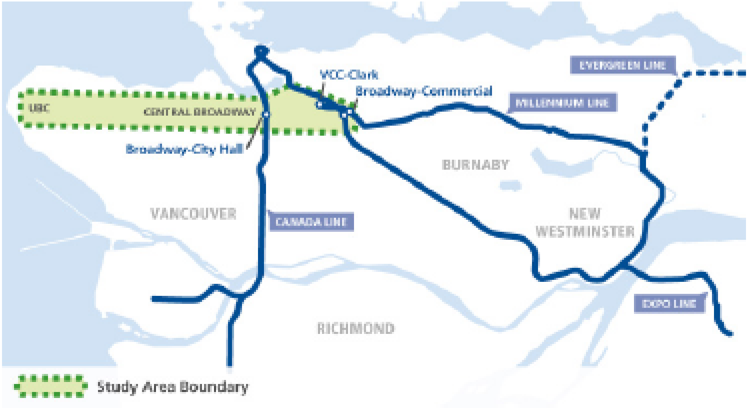
Please choose one response per row.

	Very important	Somewhat important	Not very important	Not at all important	Don't know/Unsure
To the overall Metro Vancouver region					
To the City of Vancouver, UBC and the University Endowment Lands					
To you personally					

4

[NEW SCREEN]
S5. Have you travelled to, from, or within the UBC Line Rapid Transit Study area in the past six months?
[SHOW STUDY AREA MAP BELOW QUESTION: image=ubcline_backgroundmap_prf03.jpg]
[SINGLE RESPONSE]

1. Yes
2. No
3. Don't know



S6. How familiar would you say you are with the existing transit service in the UBC Line Rapid Transit Study area?
Please choose one response.
[SINGLE RESPONSE]

1. Very familiar
2. Somewhat familiar
3. Not very familiar
4. Not at all familiar
5. Don't know

5

[Main Questionnaire—ASK ALL]

[NEW SCREEN]
Q1. How important are the following factors when planning and making decisions about rapid transit in the UBC Line Rapid Transit Study area?

[RANDOMIZE ORDER OF FACTOR LIST]

FACTOR	Very important	Somewhat important	Not very important	Not at all important	Don't know/ Unsure
Speed: Whether the system offers fast, competitive travel times.					
Reliability: Whether the system offers consistent travel times and is there when expected.					
Capacity and Expandability: Whether the system has the capacity to meet forecasted demand and can be upgraded or expanded as demand grows.					
Cost Effectiveness: The level of transportation and other benefits relative to the costs.					
Affordability: The costs of building and operating the system.					
Economic Development Potential: The economic benefits of building and operating the system (e.g., job creation, effects on goods movement and GDP).					
Environmental Impacts: Impacts on the natural environment (e.g., air emissions, effects on waterways, parks and open space).					
Safety & Personal Security: The level of operational safety and personal security of the system.					
Urban Development: The amount and type of residential and commercial development served by the system.					
Potential for Phasing: The ease of implementing the system in phases, such as starting with a smaller initial system.					

6

FACTOR	Very important	Somewhat important	Not very important	Not at all important	Don't know/ Unsure
Ridership Attracted: The number of new users attracted to the system and ridership of the overall transit network.					
Impacts on Other Road Users: Impacts on private cars, commercial vehicles and cyclists, including diverted traffic, impacts on parking, travel lanes, turn restrictions at intersections, etc.					
Urban Design Impacts: The impact the system has on the urban environment, such as the look and feel of the street, the amount of sidewalk space and the design of station locations.					
Construction Impacts: The level of disruption caused during construction of the system.					

[NEW SCREEN]

There are three rapid transit technologies being considered for the UBC Line Rapid Transit Study: Bus Rapid Transit (BRT), Light Rail Transit (LRT) and Rail Rapid Transit (RRT or SkyTrain).

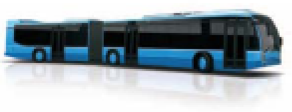
We want to know how acceptable each technology is to you.

Next we will give you a brief explanation of each of the three technologies, and then ask you a few questions about each one.

7

[RANDOMIZE ORDER OF Q2A/B, Q3A/B AND Q4A/B. SHOW EACH BLOCK ON SAME SCREEN—E.G., Q2a and Q2b together]
[NEW SCREEN]
Q2a. Bus Rapid Transit (BRT)

Technology
BRT is a driver-operated, low-floor articulated bus technology that typically operates at street-level.



BRT can run as frequently as every 2 minutes.
In high demand corridors like Broadway, signal priority may not be possible for BRT due to the high frequency of the service, reducing average speed and reliability.

BRT travels at an average speed of about 30 kilometres per hour (similar to Light Rail Transit, but slower than Rail Rapid Transit's 40 km/h). Average speeds include stopped time at stations and intersections.

BRT vehicles could either be hybrid buses running on clean diesel fuel or be powered by electricity.

Alignment
BRT normally operates in the centre of the street, in its own right-of-way, separated from other traffic by a curb.

To fit BRT in the street requires adjusting how road space is shared with other users (e.g. pedestrians, cyclists, transit, cars) and may require reducing the number of vehicle lanes, and on-street parking spaces, introducing new turning restrictions and increasing or decreasing sidewalk widths.

Station Type
BRT stations are typically located within the street and connect to both sides of the street with pedestrian crossings. Stations are sheltered and typically feature ticket vending machines, closed circuit TV for security, seating, real-time schedule information and wayfinding.

8

Based on the information above, how acceptable is BRT technology as one of the technologies considered for the UBC Line Rapid Transit Study area?
[SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q2b. Please explain fully, your rating of the BRT technology.
Feel free to provide examples of your experiences elsewhere. If you don't have any comments, click on the NEXT button to continue.
[OPEN-END – NOT REQUIRED]

[NEW SCREEN]
Q3a. Light Rail Transit (LRT)

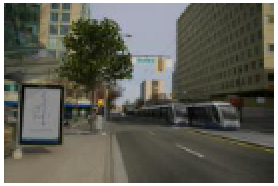
Technology
LRT is a driver-operated, electrically-powered rail technology that typically operates at street-level.

LRT can run as frequently as every 2 minutes.

Depending on the corridor and the frequency of the service, signal priority may be provided at intersections.

LRT travels at an average speed of about 30 kilometres per hour (similar to Bus Rapid Transit, but slower than Rail Rapid Transit's 40 km/h). Average speeds include stopped time at stations and intersections.

Alignment
LRT operates primarily in the centre of the street, in its own right-of-way, separated from other traffic by a curb.



To fit LRT in the street requires adjusting how road space is shared with other users (e.g. pedestrians, cyclists, transit, cars) and may require reducing the number of vehicle lanes, and on-street parking spaces, introducing new turning restrictions and increasing or decreasing sidewalk widths.

Station Type
LRT stations are typically located within the street and connect to both sides of the street with pedestrian crossings. Stations are sheltered and typically feature ticket vending machines, closed circuit TV for security, seating, real-time schedule information and wayfinding.

Based on the information above, how acceptable is LRT technology as one of the technologies considered for the UBC Line Rapid Transit Study area?
[SINGLE RESPONSE - REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q3b. Please explain fully, your rating of the LRT technology.
Feel free to provide examples of your experiences elsewhere. If you don't have any comments, click on the NEXT button to continue.

[OPEN-END – NOT REQUIRED]

[NEW SCREEN]
Q4a. Rail Rapid Transit (RRT)

Technology
RRT (i.e. SkyTrain) is an automated, driverless rail technology powered by electricity.

RRT can run as frequently as every 1.5 minutes.

RRT travels at an average speed of about 40 kilometres per hour (compared to 30 km/h for Bus Rapid Transit and Light Rail Transit). Average speeds include stopped time at stations.

Alignment
RRT typically operates in a tunnel or on an elevated track. Surface level operation is possible; however, automated systems must be fully segregated and protected by fencing. In the case of the Broadway corridor, it would operate almost entirely in a bored tunnel, avoiding interactions with other traffic.

Station Type

In cases where RRT runs underground, the station entrances are at ground-level and the boarding areas are accessed by elevators, escalators and stairs. Stations feature ticket vending machines and faregates, closed-circuit TV for security, seating, real-time schedule information and wayfinding.

Based on the information above, how acceptable is RRT technology as one of the technologies considered for the UBC Line Rapid Transit Study area?
[SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q4b. Please explain fully, your rating of the RRT technology.
Feel free to provide examples of your experiences elsewhere. If you don't have any comments, click on the NEXT button to continue.

[OPEN-END – NOT REQUIRED]

[Acceptability of Alternatives]
[NEW SCREEN]
The UBC Line Rapid Transit study team identified seven alternatives that were evaluated in detail.

Next we will present you with details on each of the seven UBC Line Rapid Transit Study alternatives and ask you whether the alternative is acceptable or not, and why.

For each alternative we are interested in knowing how acceptable it is to you relative to continuing to serve the study area with buses only; this assumes that future bus service improvements will continue to be made, and that the level of improvements will be consistent with past trends and account for population and employment growth in the area.

The details of each alternative will include:

- A map showing the routing of the service.
- A set of charts which compare each alternative to the other six in terms of: the average travel time between key destinations in the study area; the capital cost of the project; forecasted ridership in the year 2041; its effect on GHG emissions; and its potential to attract new riders to the transit system relative to its cost.
- A summary of the results of the initial evaluation of the alternative.

For each alternative, bus service would continue to operate in the study area. Bus service that duplicates the rapid transit service would be eliminated (e.g. 99 B-Line).

11

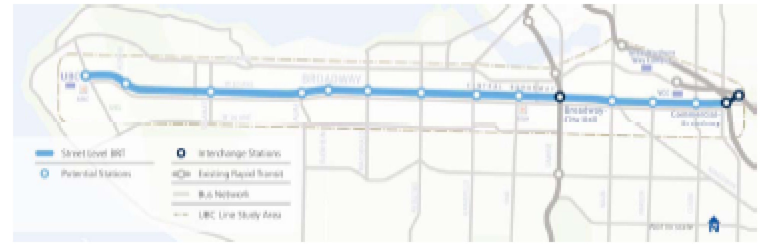
[RANDOMIZE ORDER OF QUESTION BLOCKS Q5 THROUGH Q11]

[NEW SCREEN]
[BUS RAPID TRANSIT ALTERNATIVE]

Q5intro. The Bus Rapid Transit (BRT) Alternative, which is shown in blue on the map below, would run along Broadway between Commercial-Broadway Station and UBC.

BRT Alternative

[INSERT MAP OF BRT ALTERNATIVE: image= UBC Line Maps_Feb2012_for_brt_prf03.jpg]



On the next screen you will be given more information about this alternative and then asked several questions.

[NEW SCREEN]

Listed below are some of the results from the study team's evaluation of the BRT Alternative. The charts below compare the alternative to the others being considered in terms of expected ridership, costs, travel times and effect on greenhouse gas emissions.

Once you have read through both pieces of information please answer the questions that follow.

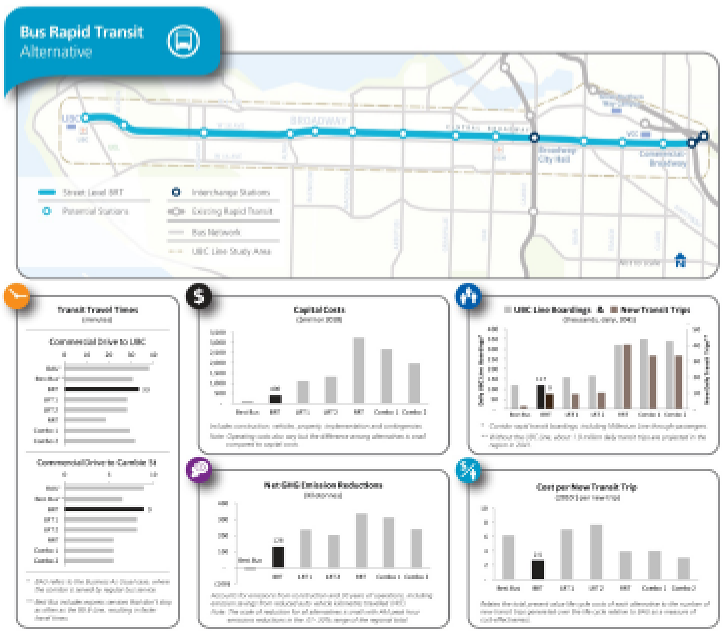
- BRT would cost $400 million to construct and would have roughly 120,000 daily boardings in 2041, providing a travel time of 33 minutes from Commercial Drive to UBC.
- BRT does not have the capacity to meet forecasted demand in 2021 and the boardings shown below reflect these capacity limitations.
- BRT would operate in its own right-of-way, improving reliability and travel time, but to a lesser degree than the other rapid transit alternatives because the frequency required to maximize the capacity of BRT makes it impossible to provide signal priority at intersections.
- BRT would require changes for traffic, parking, local access, and goods movement. For example:
  - East of Arbutus there would be two travel lanes in each direction; peak-period bus lanes would be removed.
  - West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. In places where left-turns are permitted, left-turn bays would be provided.
  - About 90% of intersections would have restrictions to varying degrees. Most of the new restrictions would be at

12

minor intersections (about 50 intersections). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections.
- On-street parking would be reduced by up to 90% or 1,500 spaces with 200 new spaces provided in off-street replacement parking. Additional replacement parking may be identified through detailed design.
- Sidewalk widths would be changed, decreased in some places and increased in others.
- The specific impacts would be refined through detailed design if BRT is implemented.

- BRT increases transit mode share by 0.7 percentage points in the corridor and 0.1 percentage points regionally by 2041 and reduces GHG emissions. At a regional scale these impacts are small.
- All rapid transit alternatives will have construction impacts. In scale, these impacts are not significantly different between the alternatives.

If you are having trouble reading the image below, click on it and it will open in a separate browser window which you can make larger. [INSERT DASHBOARD FOR BRT: image= BRT_v4.jpg]



Q5a. How acceptable is this alternative to you compared to continuing to serve the corridor with buses only?

[SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

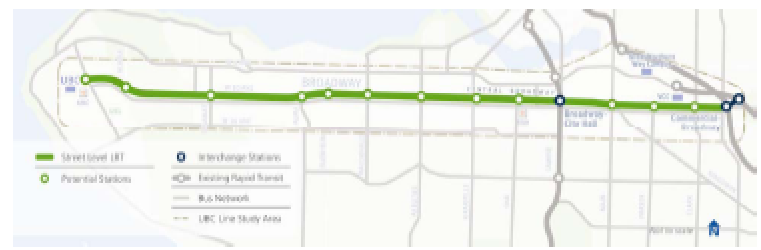
Q5b. Please explain fully, your rating of the <u>BRT Alternative</u>.
If you don't have any comments, click on the NEXT button to continue.

[OPEN-END – NOT REQUIRED]

[NEW SCREEN][LIGHT RAIL TRANSIT ALTERNATIVE 1]
Q6intro. <u>Light Rail Transit (LRT) Alternative 1</u>, shown in green on the map below, would run along Broadway between Commercial-Broadway Station and UBC.

LRT Alternative 1

[INSERT MAP OF LRT ALTERNATIVE 1: image=UBC Line Maps_Feb2012_for_web-lrt1_prf03.jpg]



On the next screen you will be given more information about this alternative and then asked several questions.

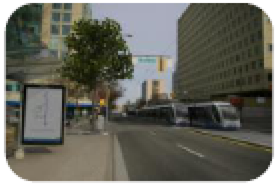
[NEW SCREEN]

Listed below are some of the results from the study team's evaluation of <u>LRT Alternative 1</u>. The charts below compare the alternative to the others being considered in terms of expected ridership, costs, travel times and effect on greenhouse gas emissions.

Once you have read through both pieces of information please answer the question that follows.

- LRT 1 would cost $1.1 billion to construct and would have roughly 160,000 daily boardings in 2041, providing a travel time of 28 minutes from Commercial Drive to UBC.

- LRT 1 has the capacity to meet forecasted demand in 2041 with room for further growth.
- LRT 1 would operate in its own right of way with signal priority at intersections, improving reliability and travel time but to a lesser degree than alternatives with RRT because the LRT interacts with other vehicles at intersections.
- LRT 1 would require changes for traffic, parking, local access, and goods movement. For example:
  - East of Arbutus there would continue to be two travel lanes in each direction; peak-period bus lanes would be removed.
  - West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. Where left-turns are permitted, left-turn bays would be provided.
  - About 90% of intersections would have restrictions to varying degrees. Most of the new restrictions are at minor intersections (about 50 intersections with new restrictions). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections. On-street parking would be reduced by up to 90% or 1,500 spaces with 200 new spaces provided in off-street replacement parking. Additional replacement parking may be identified through detailed design.
  - Sidewalk widths would be changed, decreased in some places and increased in others.
  - The specific impacts would be refined through detailed design if LRT is implemented.

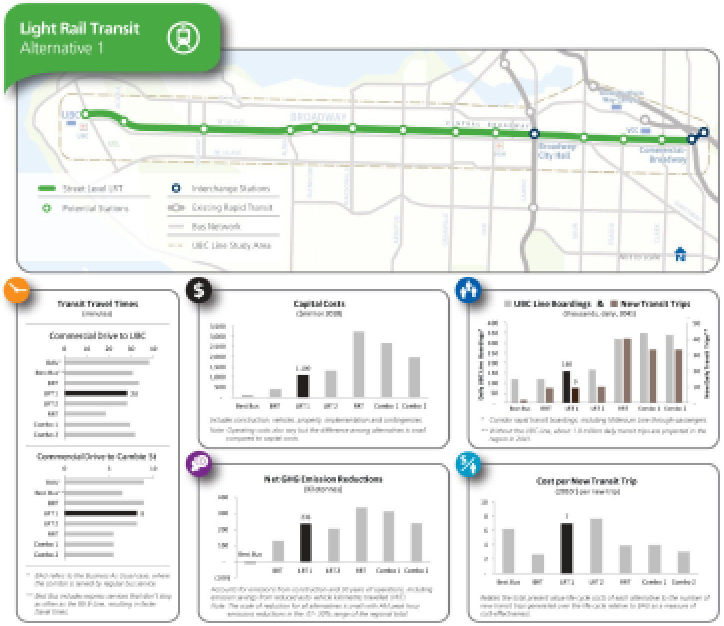


- LRT 1 increases transit mode share by 0.8 percentage points in the corridor and 0.1 percentage points regionally by 2041 and reduces GHG emissions. At a regional scale these impacts are small.
- All rapid transit alternatives will have construction impacts. In scale, these impacts are not significantly different between the alternatives.

If you are having trouble reading the image below, click on it and it will open in a separate browser window which you can make larger.

[INSERT DASHBOARD FOR LRT1: image= LRT1_v4.jpg]

15



Q6a. How acceptable is this alternative to you compared to continuing to serve the corridor with buses only? [SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q6b. Please explain fully, your rating of the LRT Alternative 1.
If you don't have any comments, click on the NEXT button to continue.

[OPEN-END – NOT REQUIRED]

16

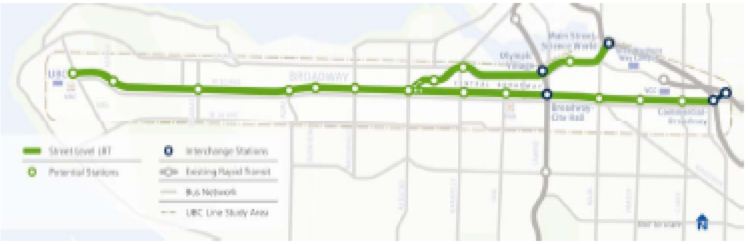
[NEW SCREEN][LIGHT RAIL TRANSIT ALTERNATIVE 2]

Q7intro. Light Rail Transit (LRT) Alternative 2 is split into two routes east of Arbutus Street. As shown by the green lines in the map below:

- All trains serve UBC; east of Arbutus Street the service is split between a segment along the old CPR railway line to Main Street-Science World Station and a segment serving Commercial-Broadway Station via Broadway.

LRT Alternative 2

[INSERT MAP OF LRT ALTERNATIVE 2: image=UBC Line Maps_Feb2012_for_web-lrt2_prf03.jpg]



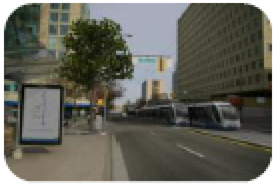
On the next screen you will be given more information about this alternative and then asked several questions.

[NEW SCREEN]

Listed below are some of the results from the study team's evaluation of LRT Alternative 2. The charts below compare the alternative to the others being considered in terms of expected ridership, costs, travel times and effect on greenhouse gas emissions.

Once you have read through both pieces of information please answer the question that follows.

- LRT 2 would cost $1.3 billion to construct and would have roughly 170,000 daily boardings in 2041, providing a travel time of 28 minutes from Commercial Drive to UBC.
- LRT 2 has the capacity to meet forecasted demand in 2041 with room for further growth.
- LRT 2 would operate in its own right of way with signal priority at intersections, improving reliability and travel time but to a lesser degree than alternatives with RRT because the LRT interacts with other vehicles at intersections.
- LRT 2 would require changes for traffic, parking, local access, and goods movement. For example:
  - East of Arbutus there would continue to be two travel lanes in each direction; peak period bus lanes would be removed.
  - West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. Where left-turns are permitted, left-turn bays would be provided.

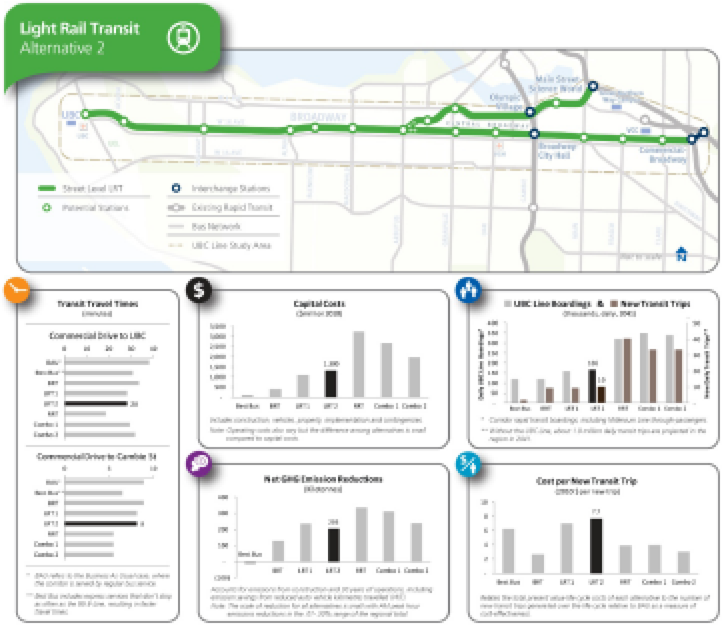


  - About 90% of intersections would have restrictions to varying degrees. Most of the new restrictions are at minor intersections (about 50 intersections with new restrictions). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections. On-street parking would be reduced by up to 90% or 1,600 spaces with 200 new spaces provided in off-street replacement parking. Additional replacement parking may be identified through detailed design.
  - Sidewalk widths would be changed, decreased in some places and increased in others.
  - The specific impacts would be refined through detailed design if LRT2 is implemented.
- LRT 2 increases transit mode share in the corridor by 0.8 percentage points and 0.1 percentage points regionally by 2041 and reduces GHG emissions. At a regional scale these impacts are small.
- All rapid transit alternatives will have construction impacts. In scale, these impacts are not significantly different between the alternatives.

If you are having trouble reading the image below, click on it and it will open in a separate browser window which you can make larger.

[INSERT DASHBOARD FOR LRT 2: image=LRT2_v4.jpg]

18



Q7a. How acceptable is this alternative to you compared to continuing to serve the corridor with buses only? [SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q7b. Please explain fully, your rating of the LRT Alternative 2?

If you don't have any comments, click on the NEXT button to continue.
[OPEN-END – NOT REQUIRED]

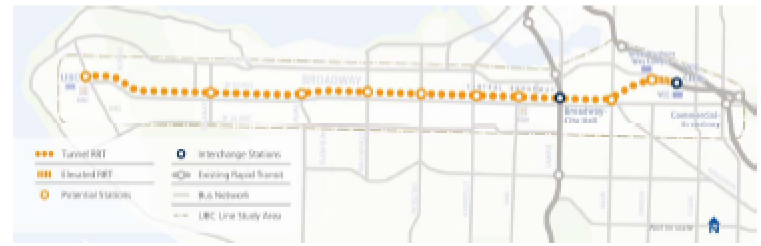
[NEW SCREEN][RAIL RAPID TRANSIT ALTERNATIVE]

19

Q8intro. The Rail Rapid Transit (RRT) Alternative (i.e. SkyTrain) would operate as an extension to the existing Millennium Line from VCC-Clark Station to UBC. It is assumed to operate in a bored tunnel with an elevated section between Great Northern Way and VCC-Clark Station and a section of tunnel under University Boulevard built using the "cut and cover" method.

RRT Alternative

[INSERT MAP OF RRT ALTERNATIVE: image= UBC Line Maps_Feb2012_for_web-rrt_prf03.jpg]



On the next screen you will be given more information about this alternative and then asked several questions.

[NEW SCREEN]

Listed below are some of the results from the study team's evaluation of the RRT Alternative. The charts below compare the alternative to the others being considered in terms of expected ridership, costs, travel times and effect on greenhouse gas emissions.

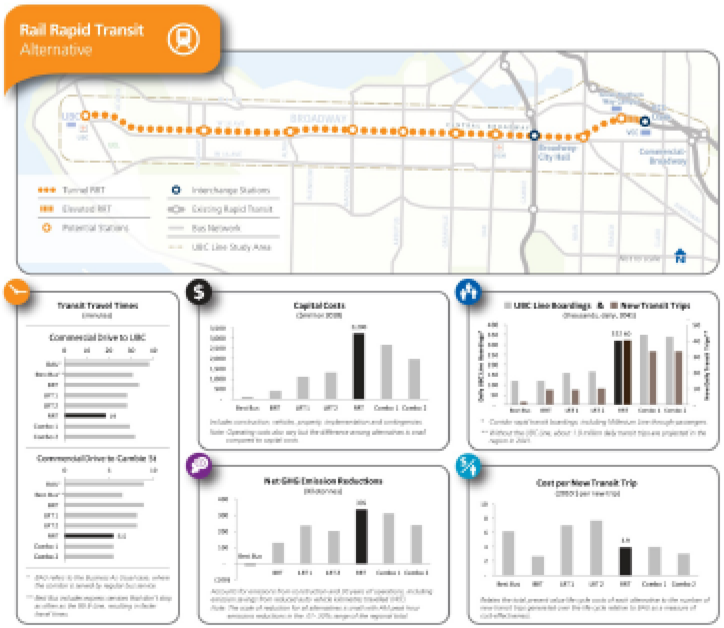
Once you have read through both pieces of information please answer the question that follows.

- RRT would cost $3.2 billion to construct and would have roughly 320,000 daily boardings in 2041, providing a travel time of 19 minutes from Commercial Drive to UBC.
- RRT has the capacity to meet forecasted demand in 2041 with the greatest room to expand capacity.
- RRT would have no interaction with traffic since it operates primarily underground, with an elevated section to connect with the existing Millennium Line SkyTrain at VCC-Clark, thereby maximizing travel time and reliability improvements.
- RRT would not involve any turning restrictions or reductions in road capacity.
- RRT increases transit mode share by 3.1 percentage points in the corridor and 0.3 percentage points regionally by 2041 and reduces GHG emissions. At a regional scale these impacts are small.
- All rapid transit alternatives will have construction impacts. In scale, these impacts are not significantly different between the alternatives.

If you are having trouble reading the image below, click on it and it will open in a separate browser window which you can make larger.

20

[INSERT DASHBOARD FOR RRT: image= RRT_v4.jpg]



Q8a. How acceptable is this alternative to you compared to continuing to serve the corridor with buses only? [SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q8b. Please explain fully, your rating of the RRT Alternative.

If you don't have any comments, click on the NEXT button to continue.
[OPEN-END – NOT REQUIRED]

21

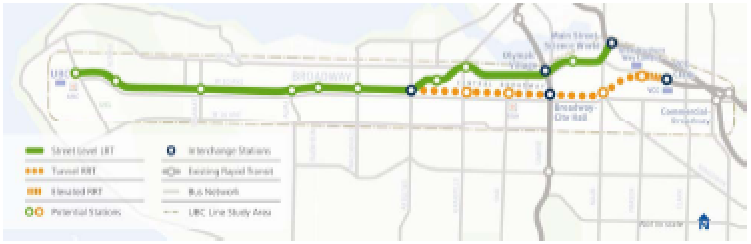
[NEW SCREEN][COMBINATION ALTERNATIVE 1]

Q9intro. Combination Alternative 1 combines one Light Rail Transit (LRT) route and one Rail Rapid Transit (RRT) route. Both of these routes are shown in the map below:

- The LRT service (shown in green) would operate between UBC and Main Street-Science World Station primarily in the centre of the street with a section of University Boulevard that runs on the south side. Between Arbutus Street and Main Street-Science World Station it would operate along the old CPR railway line.
- The RRT service (i.e. SkyTrain, shown in orange) would operate as an extension to the Millennium Line from VCC-Clark Station to Arbutus Street. It is assumed to operate in a bored tunnel with an elevated section between Great Northern Way and VCC-Clark Station.

Combination Alternative 1

[INSERT MAP OF COMBINATION ALTERNATIVE 1: image=UBC Line Maps_Feb2012_for_web-combo1_prf03.jpg]



On the next screen you will be given more information about this alternative and then asked several questions.

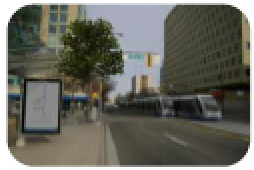
[NEW SCREEN]

Listed below are some of the results from the study team's evaluation of Combination Alternative 1 (Combo 1). The charts below compare the alternative to the others being considered in terms of expected ridership, costs, travel times and effect on greenhouse gas emissions.

Once you have read through both pieces of information please answer the question that follows.

- Combo 1 would cost $2.7 billion to construct and would have roughly 350,000 daily boardings in 2041, providing a travel time of 29 minutes from Commercial Drive to UBC.
- Combo 1 has the capacity to meet forecasted demand with room for further growth.
- The RRT portion of Combo 1 would have no interaction with traffic since it operates primarily underground, with an elevated section to connect with the existing Millennium Line SkyTrain at VCC-Clark, thereby maximizing reliability and travel time improvements.

- The LRT portion of Combo 1 would operate in its own right of way with signal priority at intersections, improving reliability but to a lesser degree than RRT because the LRT interacts with other vehicles at intersections.
- The LRT portion of Combo 1 would require changes for traffic, parking, local access, and goods movement. For example:
  - West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. Where left-turns are permitted left-turn bays would be provided.
  - West of Arbutus, about 85% of intersections would have restrictions to varying degrees. All of the new restrictions are at minor intersections (about 15 intersections with new restrictions). There are no new restrictions at major intersections. Cyclist and pedestrian crossings would continue to be permitted at all intersections.
  - Along the LRT portion of the route, on-street parking would be reduced by up to 85% or 750 spaces with 90 new spaces provided in off-street replacement parking. Additional replacement parking may be identified through detailed design.
  - Sidewalk widths would be changed, decreased in some places and increased in others.
  - The specific impacts would be refined through detailed design if Combo 1 is implemented.



- Combo 1 increases transit mode share by 2.4 percentage points in the corridor and 0.3 percentage points regionally by 2041 and reduces GHG emissions. At a regional scale these impacts are small.
- All rapid transit alternatives will have construction impacts. In scale, these impacts are not significantly different between the alternatives.

If you are having trouble reading the image below, click on it and it will open in a separate browser window which you can make larger.

[INSERT DASHBOARD FOR Combo1: image=Combo1_v4.jpg]

Q9a. How acceptable is this alternative to you compared to continuing to serve the corridor with buses only? [SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q9b. Please explain fully, your rating of the Combination Alternative 1.

If you don't have any comments, click on the NEXT button to continue.
[OPEN-END – NOT REQUIRED]

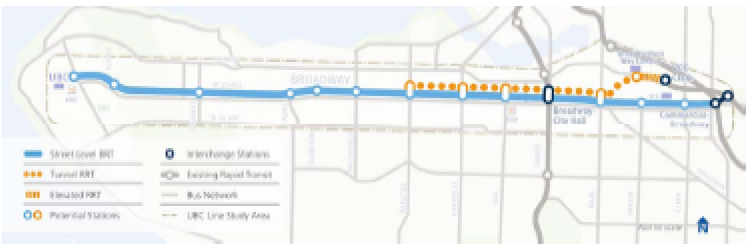
[NEW SCREEN][COMBINATION ALTERNATIVE 2]

Q10intro. Combination Alternative 2 includes one Rail Rapid Transit (RRT) route and one Bus Rapid Transit (BRT) route; both of these are shown in the map below:

- The RRT service (i.e SkyTrain, shown in orange) would operate as an extension to the Millennium Line from VCC-Clark Station to Arbutus Street. It is assumed to operate in a bored tunnel with an elevated section between Great Northern Way and VCC-Clark Station
- The BRT service (shown in blue) would run along Broadway between Commercial-Broadway Station and UBC

Combination Alternative 2

[INSERT MAP OF COMBINATION ALTERNATIVE 2: image=UBC Line Maps_Feb2012_for_web-combo2_prf03.jpg]



On the next screen you will be given more information about this alternative and then asked several questions.

[NEW SCREEN]

Listed below are some of the results from the study team's evaluation of Combination Alternative 2 (Combo 2). The charts below compare the alternative to the others being considered in terms of expected ridership, costs, travel times and effect on greenhouse gas emissions.

Once you have read through both pieces of information please answer the question that follows.

- Combo 2 would cost $2.0 billion to construct and would have roughly 340,000 daily boardings in 2041, providing a travel time of 32 minutes from Commercial Drive to UBC.
- **The BRT portion of Combo 2 does not have capacity to meet forecasted demand in 2041** and the boardings shown below reflect these capacity limitations.
- The RRT portion of Combo 2 would have no interaction with traffic since it operates primarily underground, with an elevated section to connect with the existing Millennium Line at VCC-Clark, thereby maximizing reliability and travel time improvements

- The BRT portion of Combo 2 would operate in its own right of way improving reliability and travel time, but to a lesser degree than the other rapid transit alternatives because the frequency required to maximize the capacity of BRT makes it impossible to provide signal priority at intersections.

- The BRT portion of Combo 2 would require changes for traffic, parking, local access, and goods movement. For example:
  - East of Arbutus there would continue to be two travel lanes in each direction; peak period bus lanes would be removed.
  - West of Arbutus, vehicle lanes would be reduced from two lanes to one in each direction. Left-turn bays would be provided where left-turns are permitted.
  - About 90% of intersections would have restrictions to varying degrees. Most of the new restrictions are at minor intersections (about 50 intersections with new restrictions). At Major intersections, current peak period turn restrictions become full-time and there would be new left turn restrictions at about three locations. Cyclist and pedestrian crossings would continue to be permitted at all intersections. On-street parking would be reduced by up to 90% or 1,500 spaces with 200 new spaces provided in off-street replacement parking. Additional replacement parking may be identified through detailed design.
  - Sidewalk widths would be changed, decreased in some places and increased in others
  - The specific impacts would be refined through detailed design if Combo 2 is implemented.

- Combo 2 increases transit mode share in the corridor by 2.3 percentage points and 0.2 percentage points regionally and reduces GHG emissions. At a regional scale these impacts are small.
- All rapid transit alternatives will have construction impacts. In scale, these impacts are not significantly different between the alternatives

If you are having trouble reading the image below, click on it and it will open in a separate browser window which you can make larger.

[INSERT DASHBOARD FOR Combo2: image=Combo2_v4.jpg]

Q10a. How acceptable is this alternative to you compared to continuing to serve the corridor with buses only? [SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable
6. Don't know/Unsure

Q10b. Please explain fully, your rating of the Combination Alternative 2.
If you don't have any comments, click on the NEXT button to continue.

[OPEN-END – NOT REQUIRED]

27

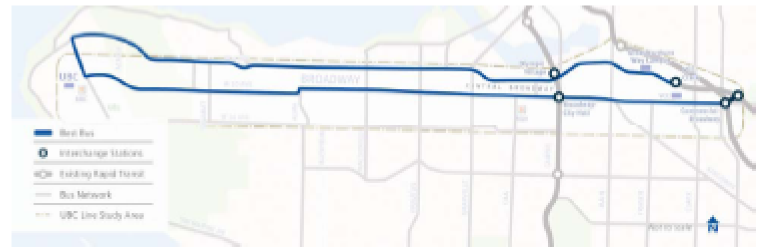
[NEW SCREEN][BEST BUS ALTERNATIVE]

Q11intro. The Best Bus Alternative further improves bus service on Broadway and parallel streets throughout the study area with service improvements *exceeding* past trends and population and employment growth in the area. Improvements are achieved through a range of measures, including:

- Increasing bus frequency on existing routes (e.g. #99 B-Line, #84)
- Adding new limited stop services on Broadway and 4th Avenue
- Improving transit priority measures (e.g. bus lanes, signal priority), and
- Adding amenities such as real-time information displays.

Best Bus Alternative

[INSERT MAP OF BEST BUS ALTERNATIVE: image=UBC Line Maps_Feb2012_for_web-bestbus_prf04.jpg]



On the next screen you will be given more information about this alternative and then asked several questions.

[NEW SCREEN]

Listed below are some of the results from the study team's evaluation of the Best Bus Alternative. The charts below compare the alternative to the others being considered in terms of expected ridership, costs, travel times and its effect on mode-share and greenhouse gas emissions.

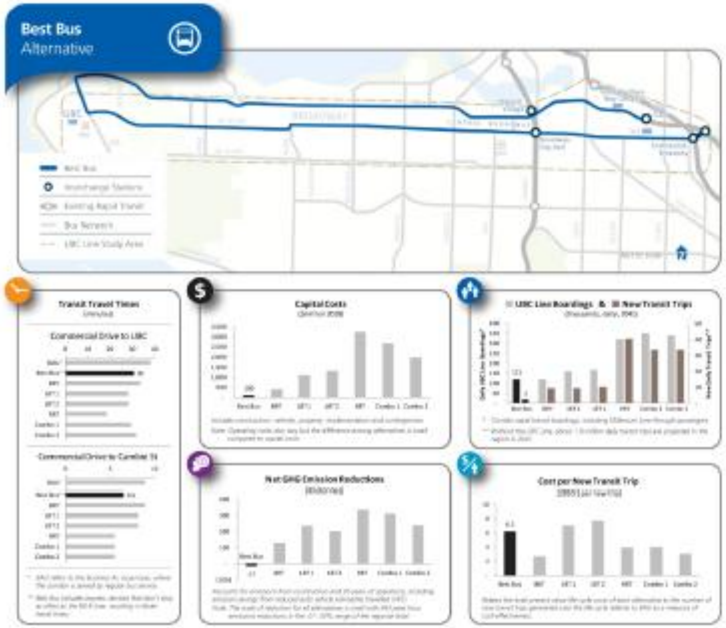
Once you have read through both pieces of information please answer the question that follows.

- Best Bus would cost $100 million to implement and would have roughly 120,000 daily boardings in 2041 on the transit services in the study area, providing a travel time of 30 minutes from Commercial Drive to UBC.
- Best Bus could improve service, reliability and partially address capacity issues in the near-term; by 2041 it would not have the capacity to meet forecasted demand and the boardings shown below reflect these capacity limitations.
- Best Bus increases transit mode share in the corridor by 0.2 percentage points and 0.0 percentage points regionally by 2041; it increases total emissions because of the number of additional buses involved, which outweighs the benefits of car users shifting to transit. At a regional scale impacts on transit mode share and GHG emissions are small.
- Best Bus does not have any construction impacts.

28

If you are having trouble reading the image below, click on it and it will open in a separate browser window which you can make larger.

[INSERT DASHBOARD FOR BEST BUS: image=BestBus_v4.jpg]



Q11a. How acceptable is the Best Bus alternative to you compared to continuing to serve the corridor with buses as today with service improvements consistent with past trends and according to population and employment growth in the area?
[SINGLE RESPONSE--REQUIRED]

1. Very Acceptable
2. Somewhat Acceptable
3. Neither Acceptable nor Unacceptable
4. Somewhat Unacceptable
5. Very Unacceptable

6. Don't know/Unsure

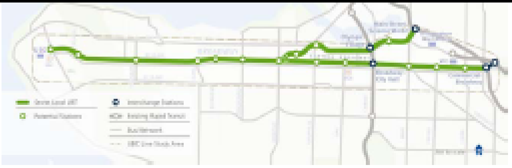
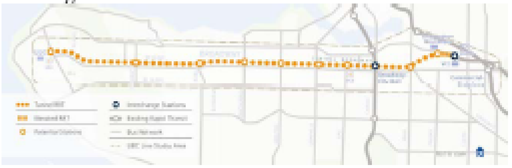
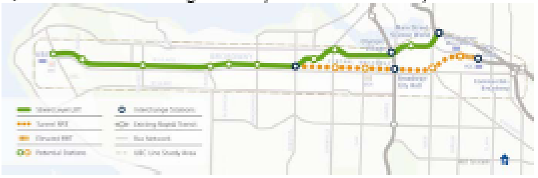
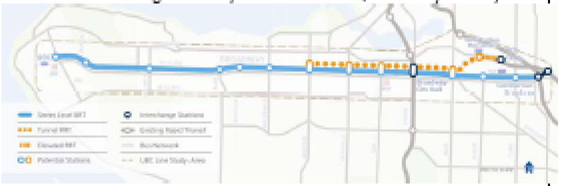
Q11b. Please explain fully, your rating of the Best Bus Alternative.

If you don't have any comments, click on the NEXT button to continue.
[OPEN-END – NOT REQUIRED]

[NEW SCREEN]
Q12a. Below is the full list of the seven alternatives that we've been discussing. Which one in the list is the most acceptable and which one is the least acceptable to you?

Please choose only one option per column.
[RANDOMIZE ORDER][ALLOW RESPONDENT TO CLICK ON THUMBNAIL IMAGE TO MAKE LARGER]

List of Alternatives	Most Acceptable	Least Acceptable
Best Bus (No rapid transit along the corridor, but improve bus services with additional limited stop service and transit priority measures) 		
BRT (BRT along Broadway from Commercial/Broadway to UBC) 		
LRT 1 (LRT along Broadway from Commercial/Broadway to UBC) 		
LRT 2 (LRT along Broadway from Commercial/Broadway to UBC and along the former rail corridor between Arbutus and Main St/Science World)		

List of Alternatives	Most Acceptable	Least Acceptable
		
RRT (SkyTrain extending the Millennium Line from VCC-Clark to UBC along Broadway) 		
Combo 1 (SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and LRT along the former rail corridor between Arbutus and Main St/Science World and along Broadway from Arbutus to UBC) 		
Combo 2 (SkyTrain extending the Millennium Line from VCC-Clark to Arbutus and BRT along Broadway from Commercial/Broadway to UBC) 		

[NEW SCREEN]
[DEMOGRAPHICS]
Finally we have a few questions about you that will help us properly categorize your responses.

D1. Which, if any, of the following best describes you?
Please check all that apply.
[MULTI- RESPONSE--REQUIRED]

1. I live in the Broadway corridor
2. I work in the Broadway corridor
3. I go to school in the Broadway corridor
4. I own a business in the Broadway corridor
5. I live at UBC or in the University Endowment Lands
6. I work at UBC or in the University Endowment Lands
7. I go to school at UBC's main campus
8. Other (please specify):
9. None of the Above

D2. Do you have access to a car, van, or truck for your own use on a regular basis?
[SINGLE RESPONSE--REQUIRED]

Yes
No
Don't Know

[ASK ALL – NEED FOR WEIGHTING PURPOSES]
D3. What mode of transportation do you use most often to travel to work, school or your other frequent trips in Metro Vancouver?
[SINGLE RESPONSE--REQUIRED]

Car/truck – driven alone
Car/truck – more than one person/carpool or vanpool (vehicle with driver and one or more passenger)
Bicycle
Walk
Transit (Bus, SeaBus, SkyTrain, West Coast Express, HandyDART)
Motorcycle, scooter
Other (*please specify*)

D4. What is your present employment status?
[SINGLE RESPONSE--REQUIRED]

Employed full-time (30 or more hours per week)
Employed part-time (less than 30 hours per week)
Student

Not employed
Homemaker
Retired

D5. Which of the following best describes your total household income before taxes for 2011?
[SINGLE RESPONSE--REQUIRED]

Under $15,000
$15,000 to under $25,000
$25,000 to under $35,000
$35,000 to under $45,000
$45,000 to under $55,000
$55,000 to under $65,000
$65,000 to under $75,000
$75,000 to under $85,000
$85,000 to under $95,000
$95,000 or over
Don't Know
Prefer Not to Say

QSOFT. [SOFT LAUNCH ONLY] Was there anything about the questionnaire that you found confusing or difficult to answer? If yes, please provide a detailed explanation, if not, click NEXT to continue.

[OPEN END – NOT REQUIRED]

QFEEDBACK. Just before we finish:

Is there anything else you would like to share with us on any of the topics covered in this survey? [OPEN END – NOT REQUIRED]

[Closing Screen]
Those are all our questions today, thank you for participating! Your input will be very valuable in helping to narrow the alternatives for the next phase of the study.

Your responses have been recorded. You may now close this window.

Sincerely,
TransLink Listens

DEMOGRAPHIC VARIABLES TO IMPORT FROM PANELIST'S PROFILING QUESTIONNAIRE

- Age
- Gender
- Full Postal Code

33