BEYOND THE B-LINE:
BROADWAY/LOUGHEED RAPID TRANSIT LINE
PHASE II - COMMERCIAL DRIVE WEST

Executive Summary

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BROADWAY/LOUGHEED RAPID TRANSIT STUDY PHASE II

Introduction

Between May and December, 1999, three partner agencies—the City of Vancouver, TransLink and Rapid Transit Project 2000 Ltd. (a Provincial company)—jointly funded and directed a $200,000 rapid transit study.

Assisted by transportation and land use professionals, the consultant team examined how public transit could be upgraded along part of the "Broadway corridor". Currently, a combination of the #99 B-Line (articulated limited stop) plus #9 (regular local) buses serve the corridor.

Corridor of Interest

Today a new SkyTrain line (called "Phase I") is being built by the Province through New Westminster and Burnaby. This new line (Figure 1) will follow the Lougheed Highway before entering Vancouver by following the Burlington Northern Santa Fe rail right of way into the Grandview Cut.

The new line passes underneath the existing SkyTrain line at Commercial Drive and Broadway, site of the existing Broadway SkyTrain station and a major transit interchange. As proposed, the SkyTrain extension would continue in a tunnel west along Broadway. The western end point has not been determined.

This Phase II study focuses on that portion of the corridor from Commercial Drive to the University of British Columbia (UBC), a distance of 13.4 km. (Figure 2).

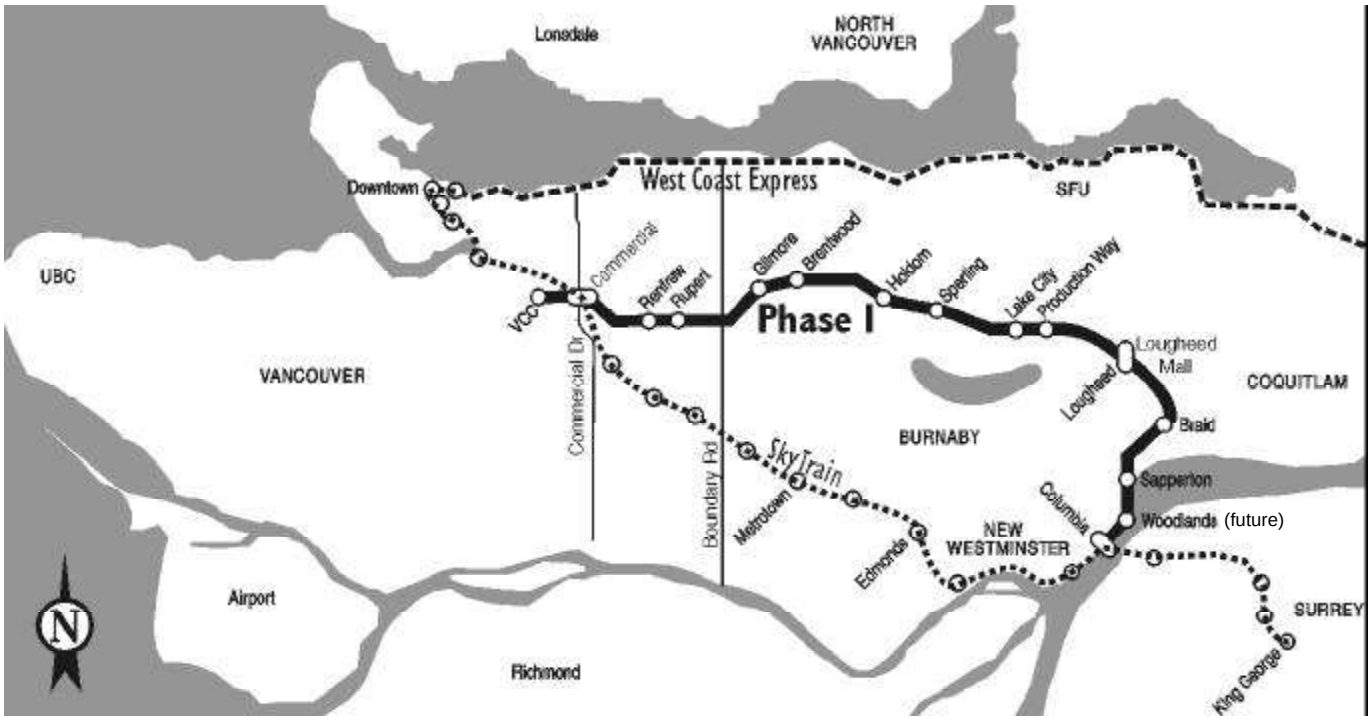
The corridor features local retail and commercial buildings, single family and multi-family dwellings, recreational facilities such as the University Golf Club, and major regional destinations such as UBC and the Vancouver General Hospital. Broadway is also the main street of Greater Vancouver's second largest business district. Accordingly, a wide variety of users must be served, whether they are travelling locally or making long journeys from other parts of the City and Region.

Questions Addressed by the Study

For this corridor, the study looks ahead 20 years and answers the following questions:

- **What combination of technologies should be considered?** Consider that different technologies could work best in different parts of the corridor, and recognize that causing passengers to transfer between transit vehicles will deter some of them.
- **How do these alternatives compare?** Alternatives are compared for customer service, system operation, cost and cost effectiveness, environmental and community impacts, and urban design and land use.
- **What is the contribution each alternative makes to the urban environment and land use in the corridor?**

Figure 1



Rapid Transit Technologies

The three technologies have different characteristics. The following is a description of the concept for each technology used in the study, for comparative purposes.

Rapid Bus is an enhanced version of the current #99 B-Line, operating on-street, using articulated, low-floor, multiple-door vehicles for fast loading. Either diesel or electric trolley buses could be used.

- As for LRT and SkyTrain below, fares are paid off-vehicle (e.g. via curbside ticket machines).
- Service is every 2 minutes or less in peak periods, 5 to 7 minutes midday and on Saturdays, and 10 minutes evenings and on Sundays.
- Designated bus lanes allow top speeds of 50 km/hour and average speeds of 25 km/hour.
- Rapid Bus has limited stops, and is supplemented by local bus.
- "Queue jumpers" lead the bus to the head of the traffic queue for green signals.
- Stations have distinctive shelters, improved signing and information, increased lighting, and other amenities attractive to riders.

Light Rail Transit (LRT) systems range from slower streetcars (trams) moving in mixed traffic to faster, tunnelled or elevated versions. In this study, the LRT concept uses electric rail vehicles, operated in two-car trains on the surface of the street.

- Tracks lie mainly in the centre of the current roadway, on a raised median separate from other traffic with trains given preferential treatment at signalized intersections.
- Pedestrian activated signals are converted to full traffic signals; minor unsignalized streets and mid-block access driveways become right-in/right-out only, to prevent uncontrolled crossing of tracks.
- For other traffic, two continuous through travel lanes are available each way east of Trafalgar. West of Trafalgar, a single travel lane is open each way. Left turn lanes are provided at major intersections.
- At all stations, on-street parking is removed. In many sections parking would be eliminated or reduced to one side of the street, but is retained on both sides between Trafalgar and Alma. Sidewalks, parking, traffic lanes, track beds, and station platforms, are squeezed to a minimum width.
- Acquisition of property is needed for at least two station locations along the alignment (Cambie and Main/Kingsway).
- Service is every 3 minutes in peak hours, 5 - 10 minutes midday, evenings, and Saturdays;10 - 15 minutes for late nights and on Sundays.
- Maximum speed of the system would be 50 km/hour, average 25 km/hour.
- Stations are every 2 to 3 blocks east of Arbutus and 6 to 8 blocks to the west.

SkyTrain, totally automated, is separated from other traffic.

- In this study, SkyTrain is almost entirely underground.
- It operates as an extension of the Phase I Lougheed/ Broadway line now under construction, i.e. from the planned end of Phase I at Vancouver Community College.
- SkyTrain continues to function as a line-haul regional system with quite widely spaced stations, and therefore is complemented by local parallel bus service.
- Service can be as frequent as 90 seconds apart, but service will be less frequent than this in practice and would be determined by the passenger volumes on the Lougheed section of the line.
- Average speed is 35 km/hour. Maximum speed of the system would be 80 km/hour.

Combinations Considered

The study considered six alternative combinations of the three technologies, shown graphically in Figure 2.

The Steering Committee chose these 6 combinations as the ones that were most practical for the transit rider (i.e. fewer transfers along the route) and the transit provider (i.e. cost effective). For example:

A - SkyTrain from Commercial to UBC is theoretically possible, but, for cost reasons, not likely to be constructed further west than Arbutus.

B - If we change technologies in the corridor (e.g. from SkyTrain to LRT), it is preferable to do so only once; three technologies (ie multiple transfers) in one corridor is very inconvenient; for that reason, the LRT concept assumes LRT covers the full length of the corridor from Commercial to UBC.

Alternative 1 (i.e. Rapid Bus) and Alternative 2 (LRT) follow the same route for the length of the corridor. These are single-mode options that do not require a transfer for trips traveling the length of the study corridor. The route follows Broadway from Commercial Drive to Alma Street, Alma Street from Broadway to 10th Avenue, 10th Avenue from Alma to Blanca Street, and University Boulevard to the UBC transit loop.

Alternatives 3, 4, 5, and 6 (SkyTrain plus Rapid Bus) differ by their terminus point for SkyTrain and the transfer point to Rapid Bus.

Evaluation, Findings and Conclusions

The study offers findings and conclusions, without a recommendation. The public's input will be solicited before Vancouver City Council advises TransLink and the Province of its preferred technology combination and therefore the end point for SkyTrain in the corridor.

The performance and costs of the six alternative combinations are shown on the charts on page 6.

Costs and Ridership

LRT from Commercial to UBC (Alternative 2) has the highest capital cost and annual operating cost. It is also by far the most expensive way of attracting new riders to transit. Rapid Bus (Alternative 1) has the lowest capital cost and is the cheapest way to attract new transit riders. SkyTrain to Arbutus (plus Rapid Bus to UBC; Alternative 6) has an intermediate capital cost and an operating cost comparable to Rapid Bus. It has the highest number of new riders and is between Rapid Bus and LRT in terms of cost per new rider. SkyTrain alone is the most expensive technology on a per km basis; however, when combined with Rapid Bus to UBC, the combination costs less than LRT.

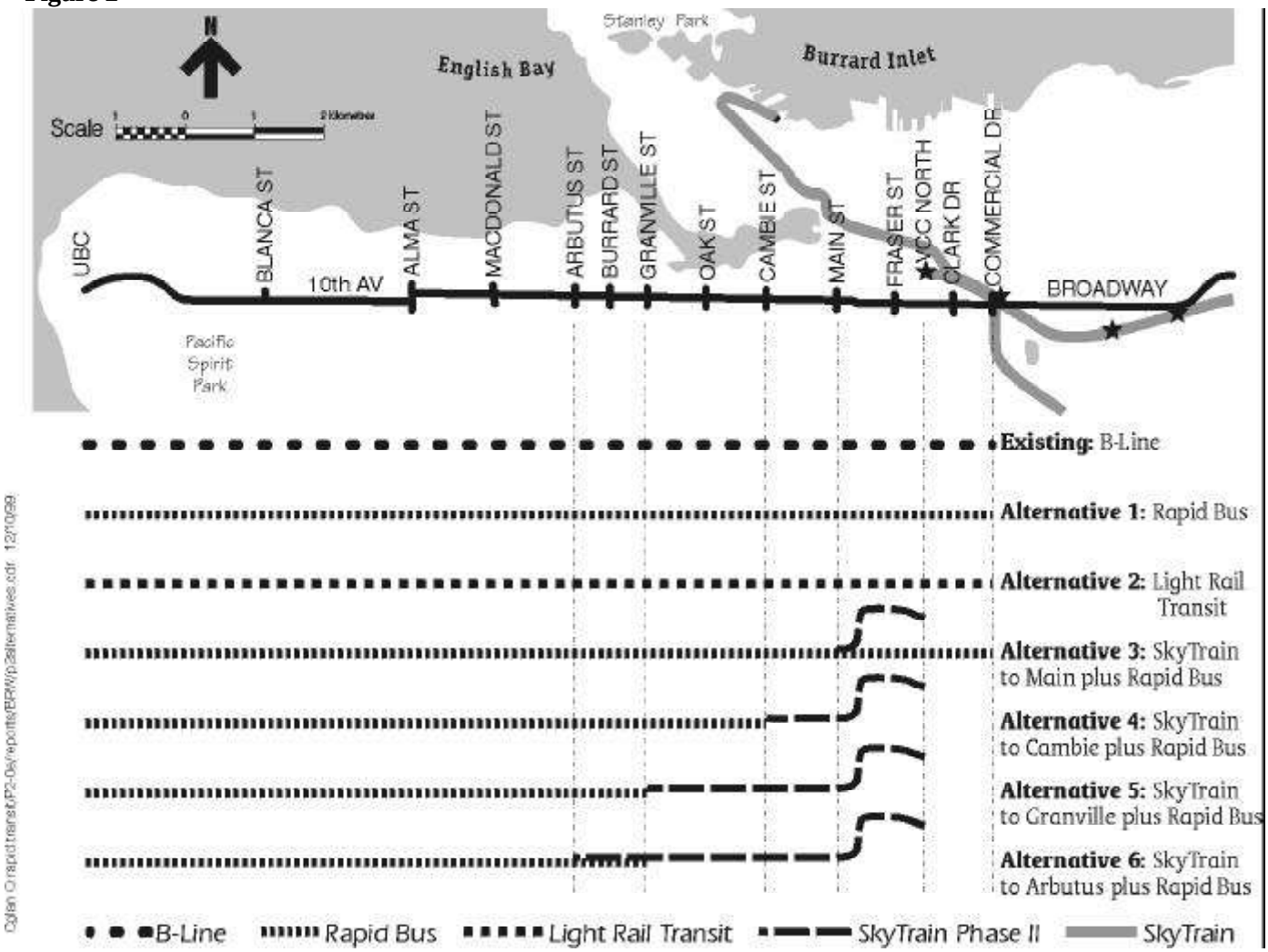
Community Impacts and Ridership

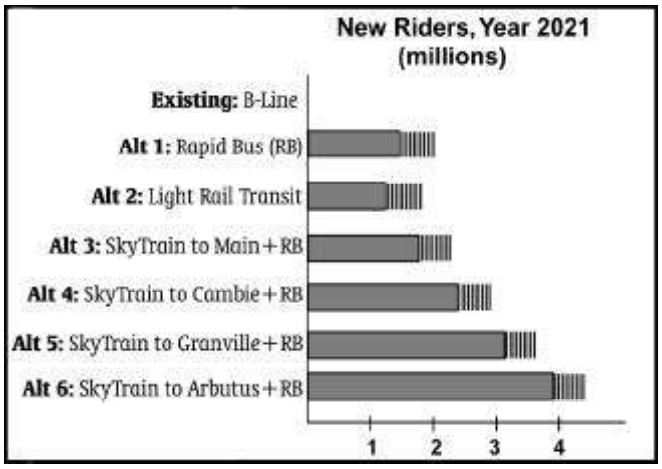
Overall, the study finds that while LRT is high in ridership, if it is designed for competitive operating speed it introduces the greatest impacts by displacing traffic, parking, access and pedestrians. LRT also has the greatest construction impact. Close station spacing in Central Broadway gives easy access for many people and produces high ridership.

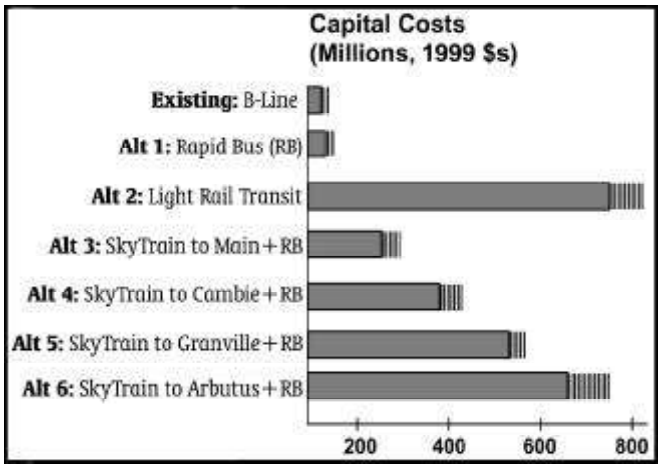
The alternatives involving SkyTrain (numbered 3 through 6) produce high ridership while having the least impact on the current transportation system. To deliver its maximum benefit, SkyTrain would have to extend west of Cambie to either Granville or Arbutus.

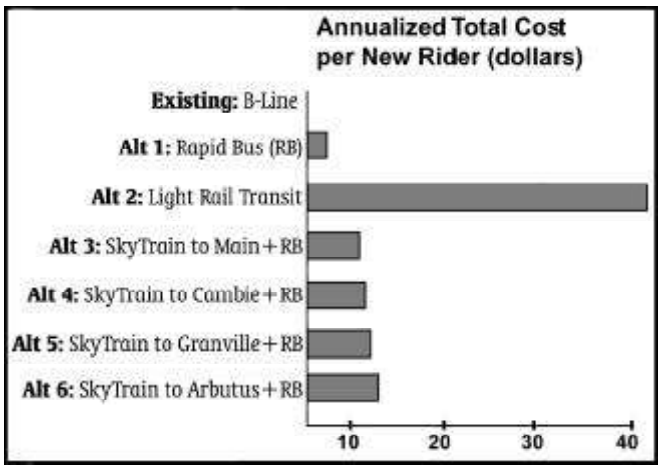
Rapid Bus may be viewed as an effective interim solution; however, over time it could evolve to a more "separated" operation and resemble LRT in terms of its impact on traffic, parking and other uses of the corridor. Further, its capacity will be tested in 15-20 years.

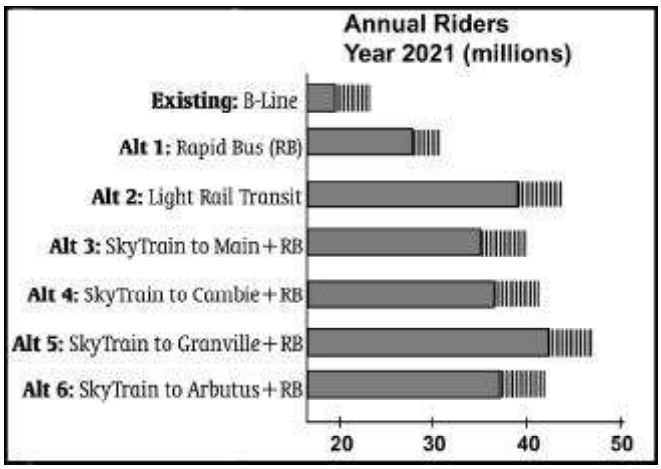
Figure 2

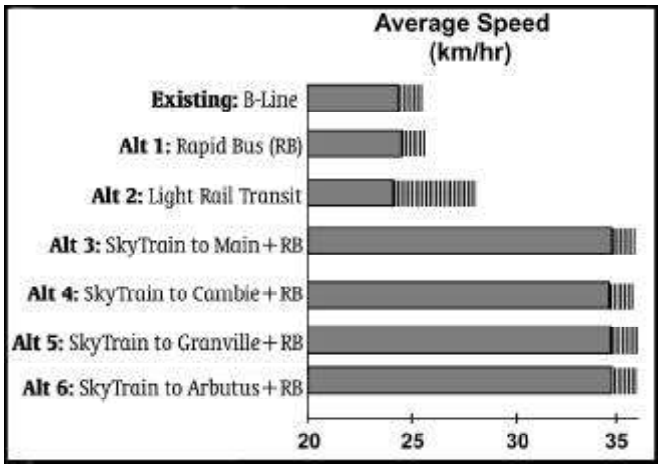


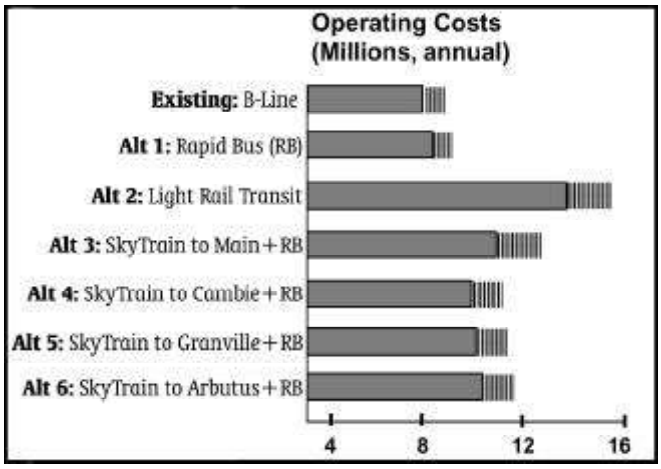












* Alternatives 3~6: Average speed is for the SkyTrain portion of the alternative only.

The **future implementation of Travel Demand Management (TDM)** is an unknown in this study. TDM comprises a variety of techniques to encourage transit use and discourage solo-commuting in cars (e.g. by higher gas taxes and parking fees). Local government policy in Greater Vancouver calls for these measures, but they are yet to be implemented. The study assumes that this will happen within the study timeframe; projected (higher) transit ridership reflects this assumption.

Consistency with City and Regional Plans and Policies

The study concludes that the further west SkyTrain is extended, the greater the probability of influence on meeting land use, transportation and livability goals and policies. Though Rapid Bus is not inconsistent with land use and livability goals, the study views this technology as least effective in supporting and achieving them.

The SkyTrain Alternative 3 (Main) should be dropped from further consideration as it involves considerable expense yet provides few additional benefits that are not otherwise available through implementation of the Rapid Bus alternative.

Uncertainty of a Richmond to Downtown Rapid Transit Corridor and Technology

Before doing much more work on the east-west Broadway corridor, it is important to better define the north-south **Vancouver-Richmond rapid transit corridor.** So far no long-term decisions have been made on such a north-south link, i.e. as to technology, routing (e.g. Cambie, Granville, Arbutus) or timing.

The north-south intersection with Broadway would create an important transit interchange. The study acknowledges that the north-south intersection is uncertain. As far as possible, it **tests the Broadway alternatives irrespective of the exact location of the north-south intersection**. However, since the computer simulations used to predict transit ridership require a specific assumption, this study assumes a north-south link on Cambie with SkyTrain-type performance.

Cost Sharing

The study does not **address financing, or who would pay** for any upgrades of transit. It does estimate the total costs of the alternatives for comparison, irrespective of who pays for them. The study notes, however, that the Province has agreed to pay 67% (TransLink will pay the remaining 33%) of the cost of extending Phase 1 SkyTrain west along the Broadway corridor, as far as Granville.

The Province has not agreed to pay for any other technology – in other words, the Province has not agreed to contribute to the cost of the Rapid Bus or LRT alternatives.

This executive summary was prepared with the assistance of Martin Crilly, an independent advisory member of the study's Steering Committee.

The complete report, as well as conceptual illustrations of the rapid transit technologies, are available from the Community Services Group - Planning Reception - Maps & Publications, City of Vancouver, East Wing, 2675 Yukon Street 3rd Floor.

BROADWAY/LOUGHEED RAPID TRANSIT LINE PHASE II - COMMERCIAL DRIVE WEST

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This study was funded by the City of Vancouver, TransLink, and Rapid Transit Project 2000, Ltd.

Figure 1 - Vicinity Map

I. Introduction

A. Study Purpose

Vancouver, British Columbia, boasts an extensive public transit system that is currently comprised of a network of bus lines, West Coast Express (a commuter rail line), Sea Bus and a SkyTrain line, which runs between Surrey and downtown Vancouver. On June 24, 1998, the Province of British Columbia announced its intention to proceed with an extension of the SkyTrain system. The extension was proposed in two phases: Phase I, currently under construction, is approximately 21 km long and connects the suburban municipalities of New Westminster and Burnaby with Vancouver. Phase II of the system extension involves two sections. One section provides a connection of the Phase I project with the City of Coquitlam. The second section begins at the western terminus of Phase I at Vancouver Community College and continues west to the Central Broadway area to a terminal location that is yet to be decided. The latter section of the system, from Commercial Drive to the west, is the subject of this study. In order to study the full implications of a variety of rapid transit technology options, the corridor has been defined to extend west to the University of British Columbia (UBC) campus.

This study's purpose is threefold:

- Review the range of alignment and technology alternatives previously identified as candidates for implementation in the corridor, and select a limited number of the most effective solutions for a more detailed investigation.

- Conduct a thorough evaluation of the limited number of alternatives and provide findings and conclusions regarding the alignment and technology applications.

- Identify opportunities to use each of the selected alternatives to enhance the urban environment through which it would pass.

B. Study Objectives

The following objectives were identified as key components in the comparison and evaluation of the identified alternatives:

1. Provide improved transit access and service for local, through-routed and UBC-bound trips.

2. Consider system-wide cost effectiveness measured by speed, type and amount of ridership, cost-per-unit of service, and including off-line facilities.

3. Preserve, to the extent possible, transportation service in the corridor including pedestrian, vehicular loading, parking, and goods movement.

4. Desirable system characteristics include:
   - Minimize transfers
   - Maximize new transit riders
   - Minimize increase in SOV trips
   - Maximize flexibility, reliability, expandability, and durability

5. Allow for integration with future capital and demand management investments.

6. Improve the urban form; how it works for people using the system.

7. Support City and regional land use plans and policies.

8. Minimize construction impacts.

C. Study Organization

The consultant team is under contract through the City of Vancouver Rapid Transit Office. Project direction and oversight are provided by a Technical Advisory Committee (TAC) and a Steering Committee. The TAC is comprised of senior staff members representing the Province (Rapid Transit Project 2000), TransLink, and the City of Vancouver. The Steering Committee is comprised of senior management from the same jurisdictions, in addition to two transportation and land use professionals who serve as independent advisors.

D. Study Scope

The Consultant team's scope of work was developed as a three-part effort, with each part reflecting the three study purposes outlined above.

Part 1. Review the existing system and previous reports to determine the technology and general alignment options that would best serve the transportation requirements from Commercial Drive west to UBC. A recommended list of alternatives selected by the Steering Committee was advanced to the next step.

Part 2. Further define the selected alternatives and evaluate the alternatives against a series of agreed-upon criteria. The results of the alternatives evaluation to be recorded in a report, which will be used in part as the basis for a recommended alignment and technology alternative.

Part 3. Focusing on the area between Main Street and Arbutus Street, the team will review the selected option and provide illustrations, design guidelines, and other measures that could help to effectively integrate the alternatives into the urban environment.

This report summarizes the results of Part One and presents the results of Part Two work.

Part I - Purpose

- Review of Prior Studies
- Review of the Existing System
- Determine which technology combinations and alignments would best serve:
  - Commercial to UBC
  - North/South connections

II. Background

A. Part 1 - Findings and Conclusions

The purpose of Part 1 was to review prior studies with a focus on the Broadway/Lougheed corridor, review the existing system and committed extensions, and recommend a short list of alignment and technology options to be carried forward for further review.

Given the many views regarding the appropriate transit technology and alignments for the Commercial to UBC corridor, it was important to identify the adopted public policies that establish guidance in evaluating the long list of available options. A review of current City and Regional policies indicates that established transportation policies support five themes:

- Encourage public transit use
- Discourage single occupancy vehicle use
- Invest in pedestrian, cycling, and public transit solutions
- Invest in transportation projects that support land use strategies
- Encourage transportation demand management initiatives

With these policies as the basis, the consultant team began an effort to identify an appropriate list of alternatives which:

1) Reflect the range of technology options appropriate to the Commercial to UBC corridor, and
2) Address the above policies in a favorable way

Recognizing that numerous studies of the corridor have been conducted, and the broad range of opinion regarding appropriate solutions within the corridor, the consultant team adopted the following approach to develop a recommendation:

Step back from the details.
An abundance of information exists regarding a full range of alternatives; adding to it may further impede the ability to focus on the broader policy implication of each alternative.

Focus on the mode's ability to support policy objectives.
Each technology alternative supports or detracts from accomplishing adopted policy objectives to differing degrees.

Limit evaluation to a few critical factors.
In conducting an initial screening of alternatives, information is required on a limited set of criteria. For the initial narrowing of options, the following criteria were used:

- Connectivity/system integration
- Operational efficiency
- Capital costs
- Support of land use/transportation policies
- Implementation impacts
- Traffic and parking impacts
- Operations costs
- Ridership

Recognize that there is a range of options that could meet projected demand.
Previous studies have established that any of the three technology options under consideration (Rapid Bus, Light Rail, and SkyTrain) can generally meet the ridership demand anticipated west of Commercial.

There are no absolutes…right or wrong.
The given range of technology and alignment options are all capable of accomplishing the basic transportation objectives; they each do it in varying degrees with differing advantages and disadvantages, costs and impacts, and levels of policy support.

Apply best judgement to which alternative best serves long-term policies and objectives.
Each of the alternatives represents a significant and long-term investment which should be evaluated by how well it accomplishes the long-term vision for the corridor.

From an initial list of 12 options, five were selected for evaluation against the criteria identified above. These options are:

Option 1	Rapid Bus, from Commercial Drive to UBC
Option 2	SkyTrain extension to Cambie; Rapid Bus from Cambie to UBC
Option 3	SkyTrain extension to Granville; Rapid Bus from Granville to UBC
Option 4	Light Rail, from Commercial to UBC
Option 5	Light Rail, from Commercial to Granville or Arbutus; Rapid Bus to UBC

A summary of how each of these options ranked against the evaluation criteria was produced for review. Based on discussions of the TAC and the Steering Committee, the following alternatives were advanced to Part 2 for a more detailed assessment:

Option 1	Rapid Bus, from Commercial Drive to UBC
Option 2a	SkyTrain extension to Cambie
Option 2b	SkyTrain extension to Granville
Option 3	Light Rail, from Commercial Drive to UBC

B. Definition of Technologies

The three technology options under consideration are briefly described below.

Rapid Bus

Rapid Bus is an on-street bus service designed to attract and accommodate heavier passenger loads than regular bus service by offering improved passenger amenities and faster travel times. Station spacing is less frequent than conventional bus service; however, the Rapid Bus would stop at all designated stations. Bus priority measures, such as designated lanes and queue jumps, would be provided to improve travel times. Off-vehicle fare collection results in reduced dwell times. For purposes of this study, vehicles are assumed to be low-floor articulated trolley buses with a total capacity of approximately 100 passengers. Improved stations would provide distinctive shelters, improved signing and information, increased lighting, and other amenities attractive to riders. At a frequency of a bus every 2 minutes, the Rapid Bus line would be capable of carrying 3,000 passengers per hour through a single point.

Light Rail Transit (LRT)

LRT systems consist of electrically powered rail vehicles capable of operating singularly or as multiple units. Such systems operate in a wide range of applications, from streetcar-type mixed traffic operations to fully separated operations, including tunnel and elevated applications. In developed urban areas, LRT generally operates within existing street right of way or on existing rail right of way. In-street designs generally restrict operating speeds to that of the adjacent roadways. Some level of preference at signalized intersections is usually provided. For purposes of this study, vehicles would be low-floor articulated units with a capacity of approximately 160 passengers. With two car trains operating at 3-minute headways, the light rail system could accommodate 6,400 passengers per hour through a single point.

SkyTrain

SkyTrain is a totally automated system with a third rail traction electric power supply, which requires the system to be separated from pedestrian and vehicular traffic. Although some opportunities exist to operate at grade, most frequently in developed urban environments the system is either elevated or in a tunnel section. SkyTrain can operate with headways as low as 90 seconds. System platform lengths have been established at 80 metres, which will allow for 6-car trains with the existing Mark I fleet, and 5-car trains of the new Mark II fleet. Passenger capacity with the Mark I car is 80 passengers and 130 with the Mark II car. A 5-car Mark II train operating at 3-minute headways is capable of carrying 13,000 passengers per hour through a single point.

C. Modified List of Alternatives

On June 25, 1999, shortly after the project Steering Committee adopted the four alternatives identified in Section IIA, the Province and TransLink jointly announced an agreement in principle for cost sharing and construction of SkyTrain expansion in the Lower Mainland. This agreement establishes funding conditions for segments of an expanded SkyTrain system east and west of Vancouver Community College (VCC). Specifically:

- The Province will pay for the completion of the partial T-line (New Westminster - Lougheed Mall - Coquitlam Centre - VCC), with TransLink contributing $650 million on opening day or 2005, whichever comes later.

- The Province will pay for 67% of Phase II (VCC to no further west than Granville), provided SkyTrain technology is used.

- The City was given the opportunity to recommend a preferred alignment between Broadway/Commercial and VCC by July 31, 1999.

The Technical Advisory Committee and Steering Committee met on July 20, 1999, to assess the impact of the agreement on the study and each alternative under consideration. They determined that the study should proceed, based on a sound technical approach, and that financial and political considerations should not limit the examination of options. A key question was whether or not to retain an LRT option. The decision was to retain LRT as an option. The LRT alternative would run on Broadway from Commercial Drive to Alma, then along 10th Avenue and University Boulevard to UBC. Between Main and Arbutus, stations would be closely spaced , but west of Arbutus stations would be located primarily at major streets.

The Steering Committee also concluded that VCC North should be used as the western terminus of the Phase I SkyTrain extension. For the Rapid Bus and LRT alternatives, Commercial Drive would be the effective eastern terminus. For Phase II SkyTrain, the western terminal locations would be either Main, Cambie, Granville, or Arbutus. Table One summarizes the final list of alternatives to be evaluated.

Table 1 - Final List of Alternatives to be Evaluated

Option	Mode	East Terminus	West Terminus
1	Rapid Bus	Commercial	UBC
2	Light Rail	Commercial	UBC
3	Skytrain/ Rapid Bus	VCC (North) Commercial	Main UBC
4	Skytrain/ Rapid Bus	VCC (North) Cambie	Cambie UBC
5	Skytrain/ Rapid Bus	VCC (North) Granville	Granville UBC
6	Skytrain/ Rapid Bus	VCC (North) Granville	Arbutus UBC

D. The Merge Option

The consultant team was asked by the City of Vancouver to review the feasibility of physically connecting the Phase I SkyTrain extension with the existing line in the vicinity of the Broadway Station. Referred to as the “merge” option, this concept would provide for a direct ride to the downtown area for passengers whose trips originate east of Commercial Drive along the Phase I portion of the Broadway/Lougheed corridor. The merge option offers the advantage of avoiding the substantial number of transfers that otherwise will be required at the Broadway Station. However, construction of a merge option would be difficult and would introduce operational complexities. The merge option review, completed in September 1999, addressed the following question:

If current investment decisions to extend the Broadway/Lougheed line to the west of Commercial Drive were not in place, would the option of physically connecting the two SkyTrain lines in the vicinity of the Broadway Station be recommended?

The consultant team’s response to this question was twofold, depending upon the timing of other investments in the region’s high-capacity transit system:

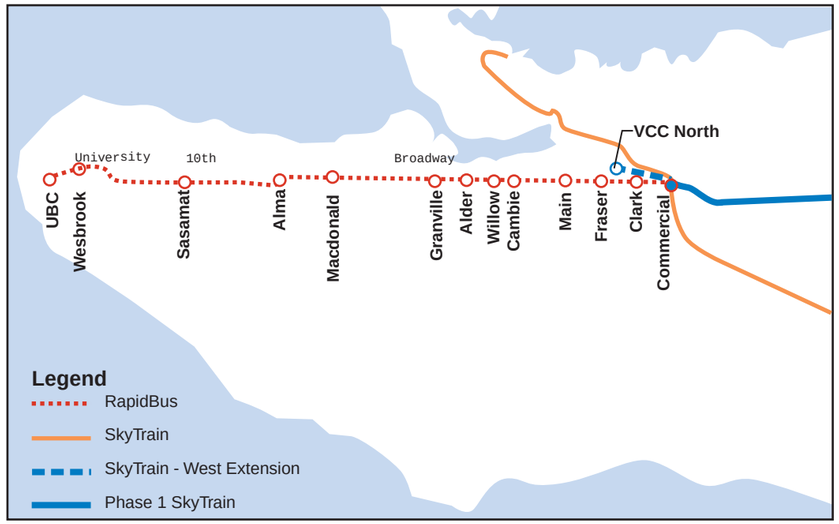
1) If the west extension of the Broadway/Lougheed line to a point of interface with a high-capacity north/south line is 10 years or more in the future, then the merge option would appear to represent a better investment than a stub line to VCC, Finning, or Main & Broadway. In this case, we recommend implementation of a merge option. In summary, the merge option presents an opportunity to continue the SkyTrain legacy of offering superior passenger service, versus operating for an extended period of time under less desirable conditions.

2) If commitments are in place to extend the Broadway/Lougheed line west to intercept a committed north/south line within a 5 to 10 year time frame, the basis for investing in the merge option is weakened and would be difficult to justify. Under these circumstances, we would not recommend the merge option be implemented.

The entire merge option review is included with this report in Appendix A.

Figure 2

Option 1: RapidBus



III. Description of Alternatives

A. Rapid Bus

Figure 2 illustrates the Rapid Bus alternative this study evaluated. The following paragraphs and illustrations provide a more detailed description of the Rapid Bus alternative.

Service Concept - The Rapid Bus alternative between Commercial and UBC would build on the highly successful service provided by the 99B Line. The segment between Commercial Drive and Arbutus Street would operate as a rapid transit service designed to serve trips to Central Broadway with high quality service. This would be accomplished by providing more frequent stops than the B Line service, but fewer than the current local Line 9 service. The added time required by additional stops is offset by off-vehicle fare collection, use of low floor buses with multiple door loading, improved amenities at station areas, signal priority treatment and peak hour queue jumps, and curb side bus lanes. The segment between Arbutus Street and the UBC Loop would operate in a similar fashion to the existing B Line service. Stops would be less frequent than in the Central Broadway section, with travel time improved through signal priority and queue jumps at strategic locations.

While Rapid Bus has a fairly low impact on the urban environment, it does benefit from several physical improvements to the roadway. Like Light Rail, the Rapid Bus would receive signal priority at signalized intersections, to help the buses clear the intersection prior to a station. In addition, queue jumps would be installed at several intersections. Queue jumps allow the bus to "jump" to the head of a queue waiting for the green light at a signal. One method is to sign a lane as "Right Turn Only Except Bus," which effectively allows the bus to move through an intersection without much delay.

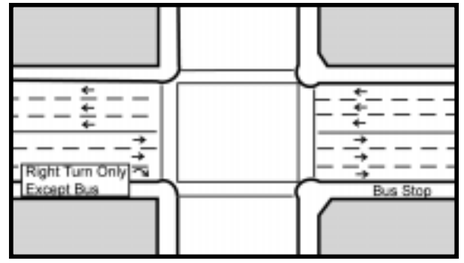
Alignment - The Rapid Bus option would operate on Broadway between Commercial Drive and Alma, on 10th from Alma to Blanca, and on University Boulevard from Blanca to the west terminal on the UBC campus. The following maps identify the specific routing.

Stations - Stations would be provided at Commercial, Clark, Fraser, Main, Cambie, Willow, Alder, Granville, Macdonald, Alma, Sasamat, Wesbrook, and the UBC Loop. The station areas would be designed to provide enhanced rider amenities, including information systems, covered waiting areas, and lighting. Proof-of-payment fare collection would require stations to be equipped with ticket vending machines and validators. From Commercial Drive to Arbutus, all stops would be "far-side" complemented by queue jumpers. From Arbutus to the UBC terminus, stations would be "near-side" with curb extensions to provide priority for buses.

Operations - The Rapid Bus would operate from Commercial to UBC, stopping at all stations. If modeling indicates it would be advantageous, consideration would be given to providing a loop in the Granville area to accommodate short turns between Commercial and Granville. Headways would be in the 2 minute range during peak periods, 5 to 7 minutes midday and on Saturdays, and 10 minutes in the evenings and on Sundays. The proof-of-payment fare collection system would allow loading at all doors, reducing the required dwell time at stations. Top speed would be 50 km/hour when operating in the bus lane, matching the posted speed of adjacent traffic.

Vehicles - The Rapid Bus line is proposed to use articulated, low-floor trolley buses. Trolley buses have a number of advantages over diesel buses in this type of application, including quicker acceleration and higher speeds on grades under fully loaded conditions. The electric buses are quieter and less intrusive in a corridor with extensive pedestrian activity and adjacent land uses. The entire Rapid Bus route is currently supplied with trolley overhead; adding a second set of wires to the existing overhead is less expensive than the cost of installing an entirely new trolley bus system. The more compact design of the latest electric propulsion systems allows a low-floor height over the full length of the vehicle without dedicating space to a large engine enclosure, thereby increasing passenger capacity and interior circulation.

Figure 3 Queue Jump



Although electric buses offer the advantages outlined above, the service could also be effectively implemented utilizing diesel articulated low-floor buses. Such an option would avoid the costs associated with electrifying the service and the added cost of articulated trolleys. Use of diesel technology would also avoid the complexity introduced by express and local trolley lines operating on the same street.

Connecting and Local Transit Service - The Rapid Bus alternative would connect to North-South Rapid Transit service (Richmond to Vancouver CBD) either at Cambie (SkyTrain), Granville Rapid Bus or Arbutus (LRT). Parallel local service between Boundary and Granville would be provided by Route 9. West of Granville, Routes 9 and 10 would continue to provide local service. Route 16 would continue to provide local service on Broadway between Granville and Arbutus. Routes 7, 8, 15, 17, 42, 50 and 51 would provide additional connecting local service.

Traffic, Parking, and Access - The current Broadway traffic configuration would remain as it exists today, including left-turn lanes at all major intersections. All existing right turns would also be permitted. During peak periods, Rapid Bus would operate east of Arbutus in the curb lane as an exclusive operation with the exception of right turns. This operation would require continuation of the removal of parking during peak periods between Arbutus and Kingsway, and the expansion of parking removal between Kingsway and Commercial Drive in both the morning and evening peak periods. The only other parking loss would be the permanent loss of a few spaces west of Arbutus at Rapid Bus station locations where bus bulges are provided at near-side stops. All minor street and property accesses would remain under the Rapid Bus alternative.

Right of Way and Property - The Rapid Bus alternative operates within current public right of way and requires taking only a minor amount of additional property to be implemented.

MATCH LINE
SEE BELOW RIGHT

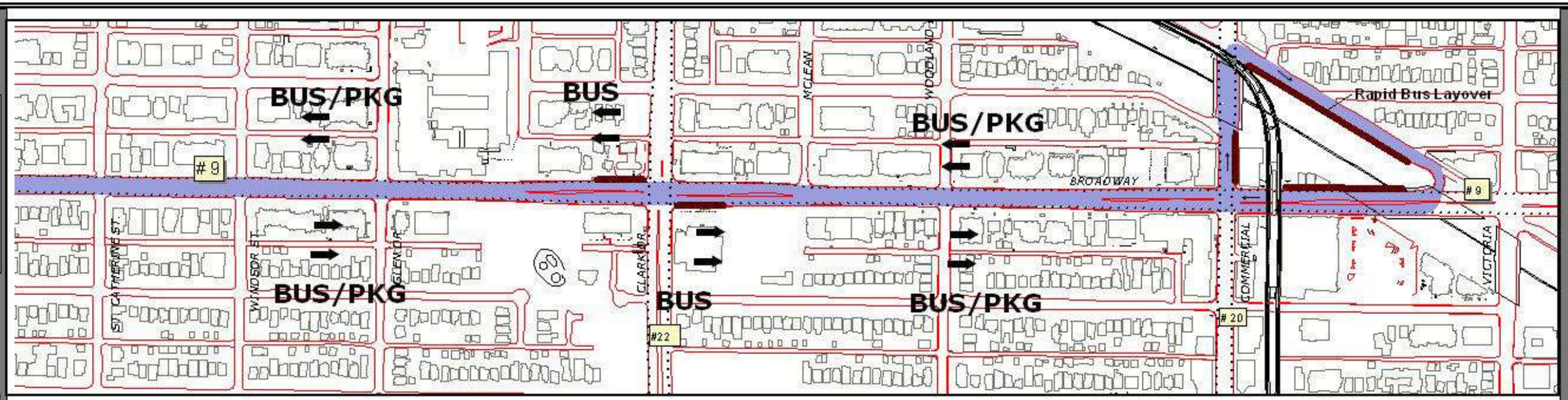
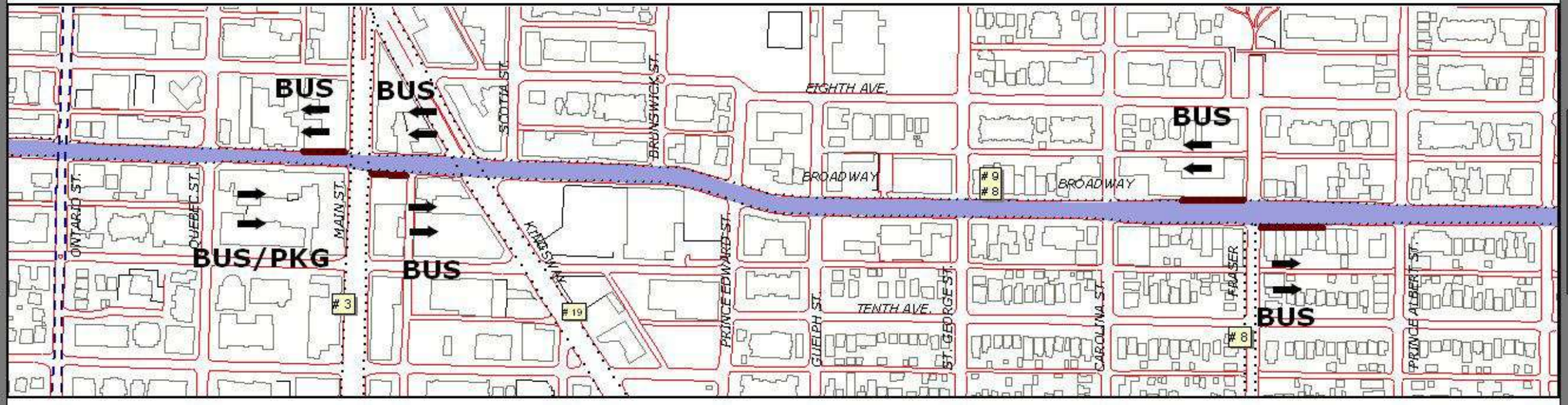


ILLUSTRATION REFERENCE

Section: Commercial to Arbutus *Typical Section: Cambie* *Section: Commercial to Arbutus*



MATCH LINE
SEE SHEET RB2

MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION REFERENCE

Section: Commercial to Arbutus *Typical Section: Cambie* *Section: Commercial to Arbutus* *Typical Section: Cambie*

BRW
A DAVIES & MOORE GROUP COMPANY

Sheet RB1
12/99
p:/08630/011/cadd/maps/corridormap

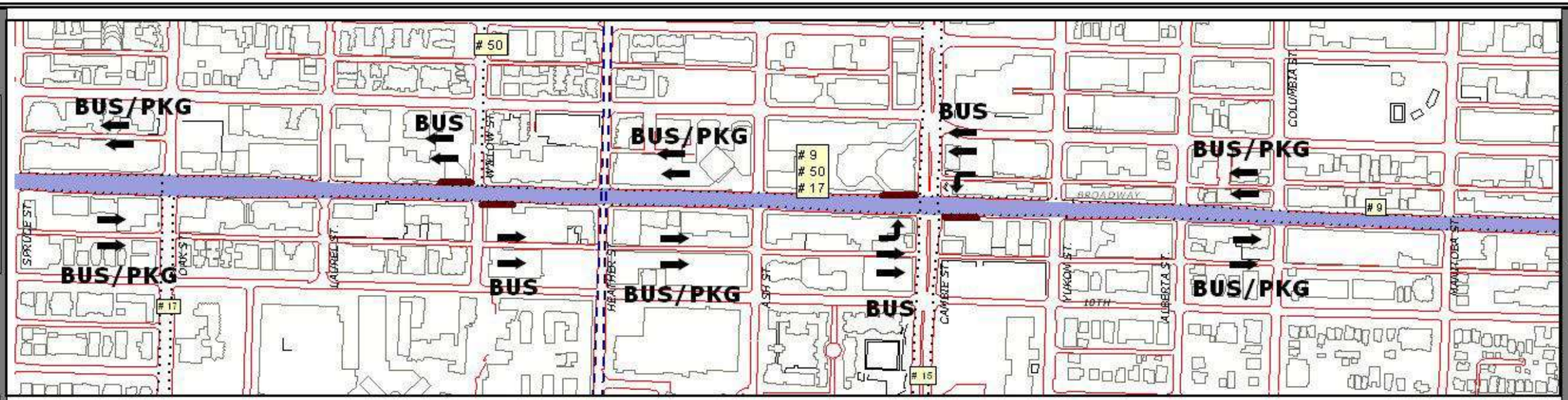
UMA
Lloyd D. Lindley, ASLA
Davidson Yuen Simpson Architects

Rapid Bus Corridor Map

BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

RapidBus Alignment
Travel Lane
BUS Transit Lane
BUS/PKG Peak Transit/Off-Peak Parking Lane
Bikeways
Local Bus Route
Station

MATCH LINE
SEE BELOW RIGHT



MATCH LINE
SEE SHEET RB1

ILLUSTRATION REFERENCE

Section: Commercial to Arbutus | *Section: Cambie St.* | *Section: Commercial to Arbutus*

See Station Plan

MATCH LINE
SEE SHEET RB3

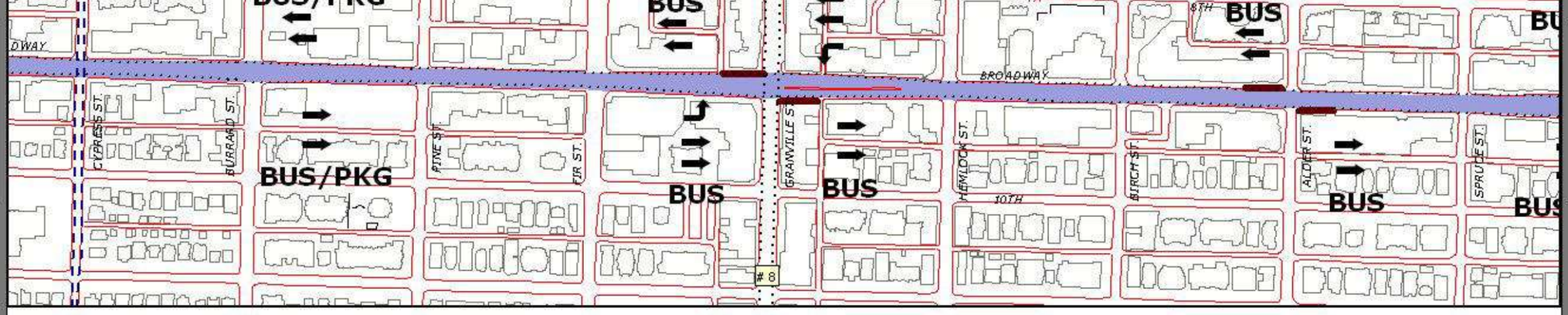


ILLUSTRATION REFERENCE

Section: Commercial to Arbutus | *Section: Cambie St.* | *Section: Commercial to Arbutus*

MATCH LINE
SEE ABOVE LEFT

BRW
A DAVIES & MOORE GROUP COMPANY

Sheet RB2
12/99
p:/08630/011/cadd/maps/corridormap

UMA
Lloyd D. Lindley, ASLA
Davidson Yuen Simpson Architects

Rapid Bus Corridor Map

BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

RapidBus Alignment
BUS ← Travel Lane
BUS Transit Lane
BUS/PKG Peak Transit/Off-Peak Parking Lane
Bikeways
Local Bus Route
Station

MATCH LINE
SEE BELOW RIGHT

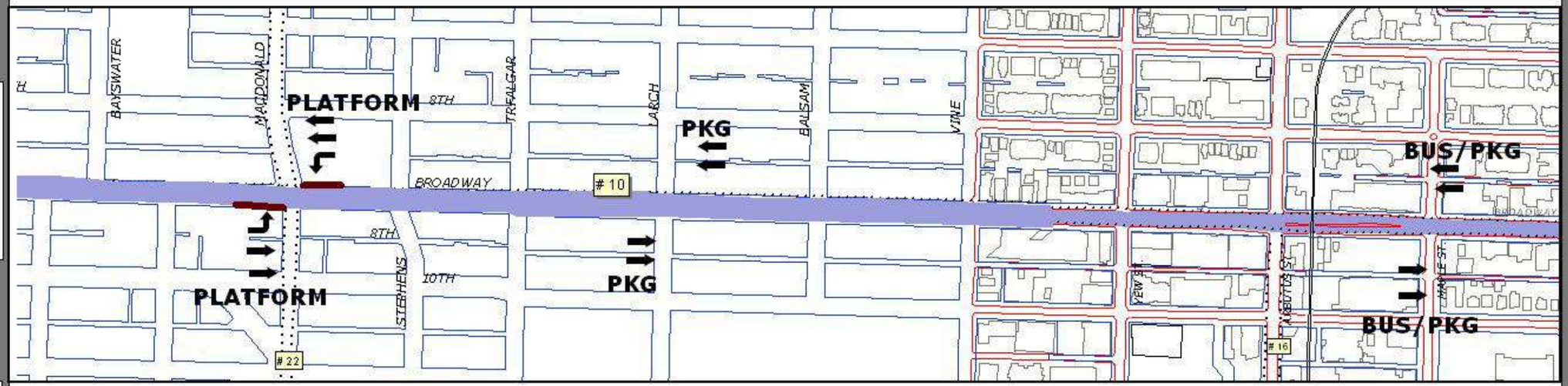
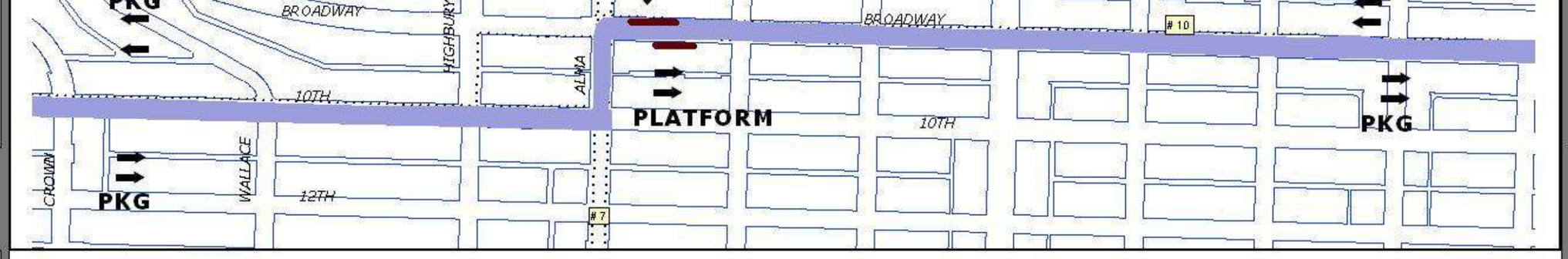


ILLUSTRATION REFERENCE

Section: Macdonald

Section: Arbutus to Alma

Section: Commercial to Arbutus



MATCH LINE
SEE SHEET RB2

MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION REFERENCE

Section: Arbutus to Alma

Section: Arbutus to Alma

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Sheet RB3
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p:/08630/011/cadd/maps/corridormap

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Rapid Bus Corridor Map

BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

RapidBus Alignment
Travel Lane
BUS Transit Lane
BUS/PKG Peak Transit/Off-Peak Parking Lane
Bikeways
Local Bus Route
Station

MATCH LINE
SEE BELOW RIGHT

BIKE

BIKE

10
4

10TH

PLATFORM

PLATFORM

BLANCA

12TH

TOLMIE

SASAMAT

TRIMBLE

DISCOVERY

COURTENAY

12TH

PKG

10TH

10

PKG

CAMOSUN

MATCH LINE
SEE SHEET RB3

ILLUSTRATION
REFERENCE

Typical Section: Macdonald

Section: Arbutus to Alma

Continues to
UBC Transit Station

UNIVERSITY ENDOWMENT LANDS

10
4

UNIVERSITY BLVD.

MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION
REFERENCE

BRW
A DAVIES & MOORE GROUP COMPANY

Sheet RB4
12/99
p:/08630/011/cadd/maps/corridormap

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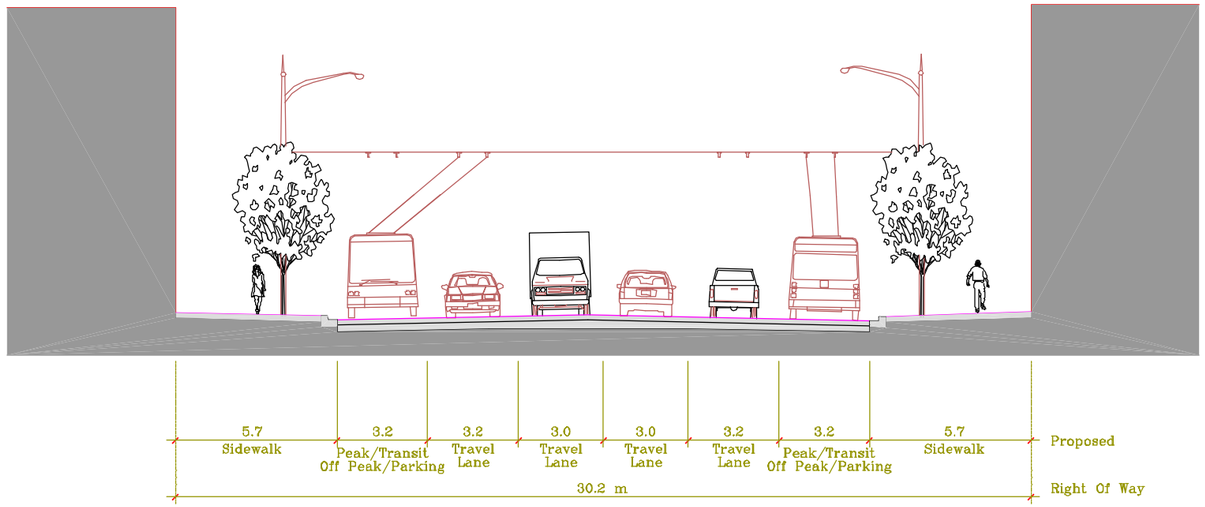
Rapid Bus Corridor Map

BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

RapidBus Alignment
Travel Lane
BUS Transit Lane
BUS/PKG Peak Transit/Off-Peak Parking Lane
Bikeways
Local Bus Route
Station

XREF'S
011BDR-2
LTscale: 1
PSscale: 1
ViaRetn: 1



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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II - Commercial Drive West

Rapid Bus Illustrations
Broadway Mid-block Section
Between Commercial St. And Arbutus St.

not to scale | 08630-011 | 011com19 p2brw_11.dwg

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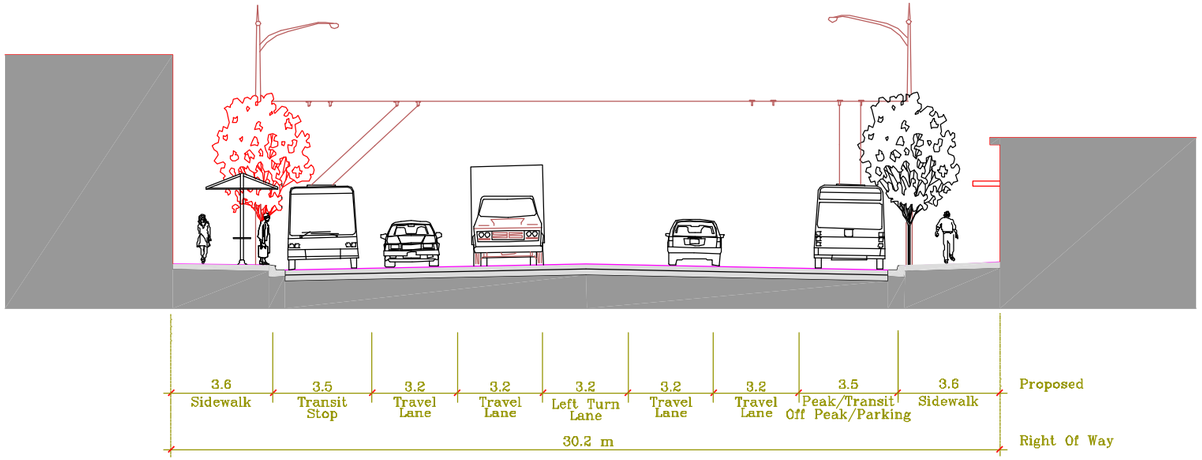

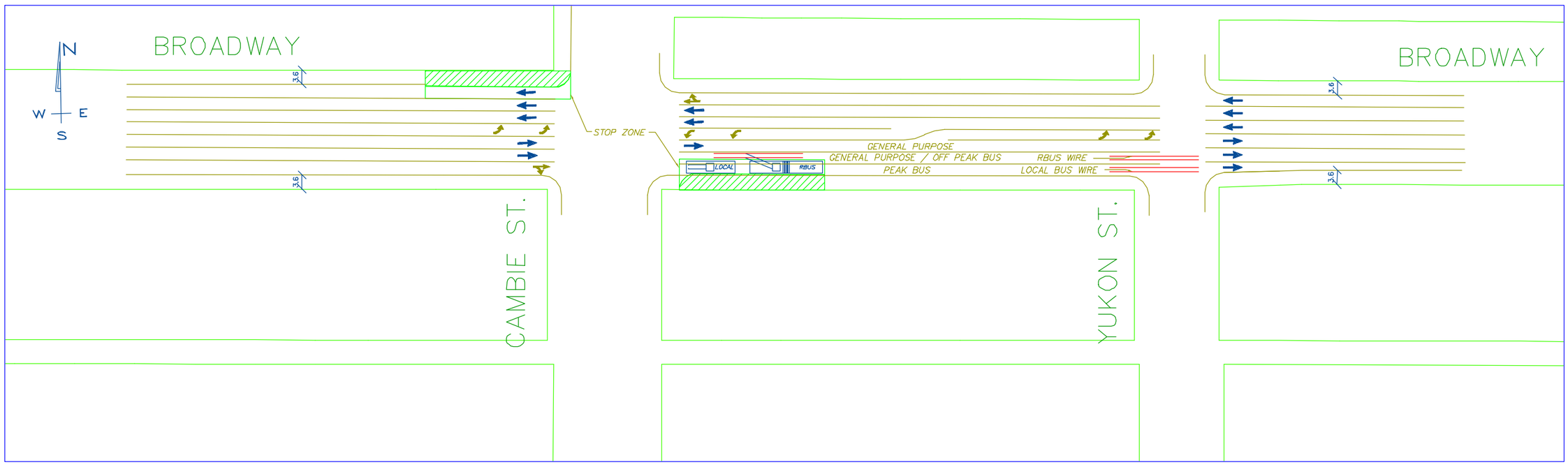

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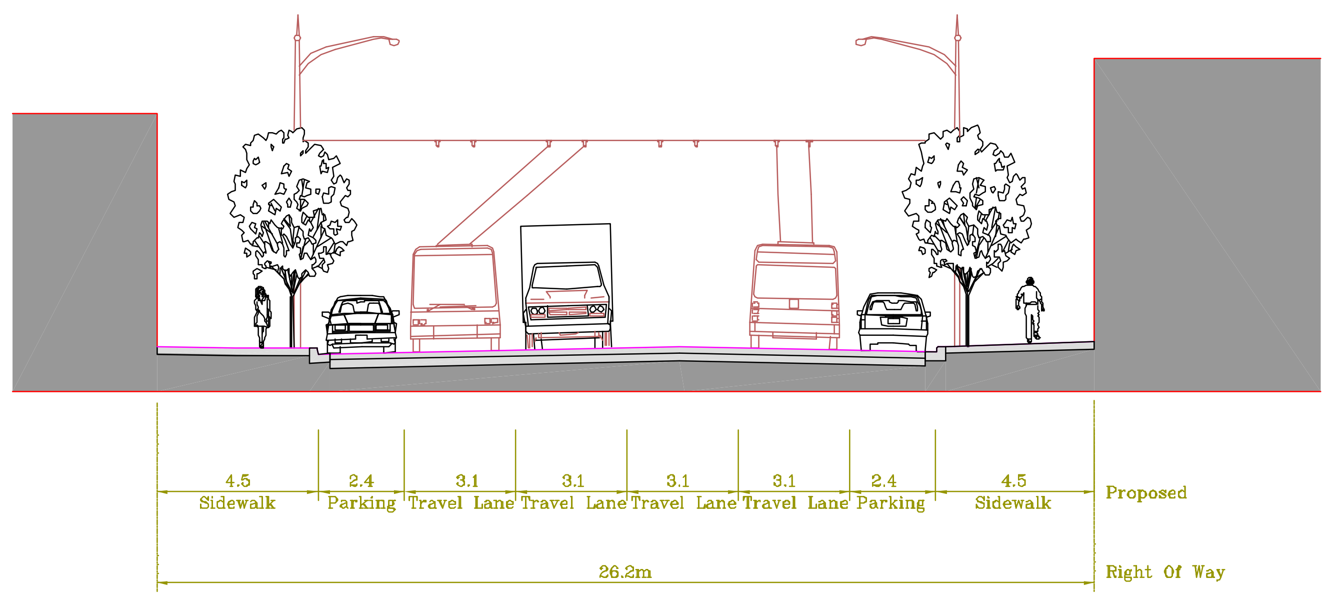
Davidson Yuen Simpson Architects

BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Rapid Bus Illustrations
Broadway Section At Cambie St.
Cambie St. Station

not to scale | 08630-011 | 011com12 p2brw_12.dwg



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BROADWAY/LOUGHEED
RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Rapid Bus Illustrations
Broadway Mid-block Section
Between Alma St. and Macdonald St.

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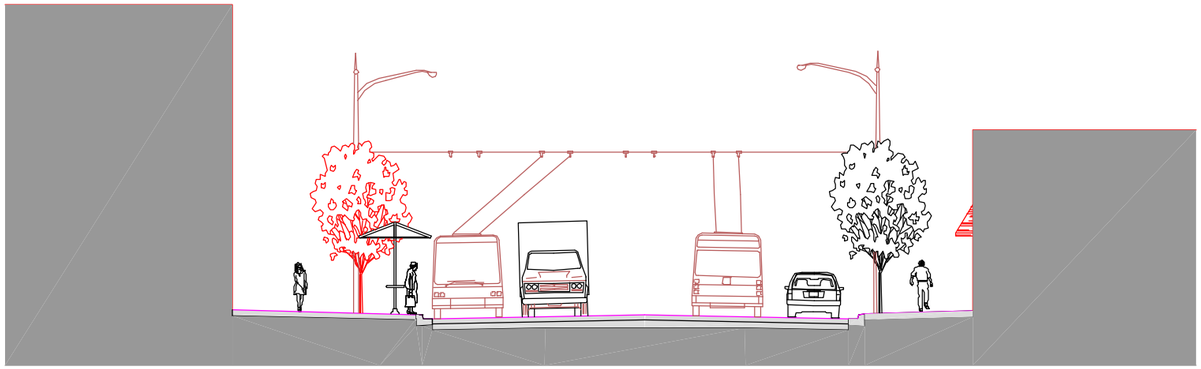

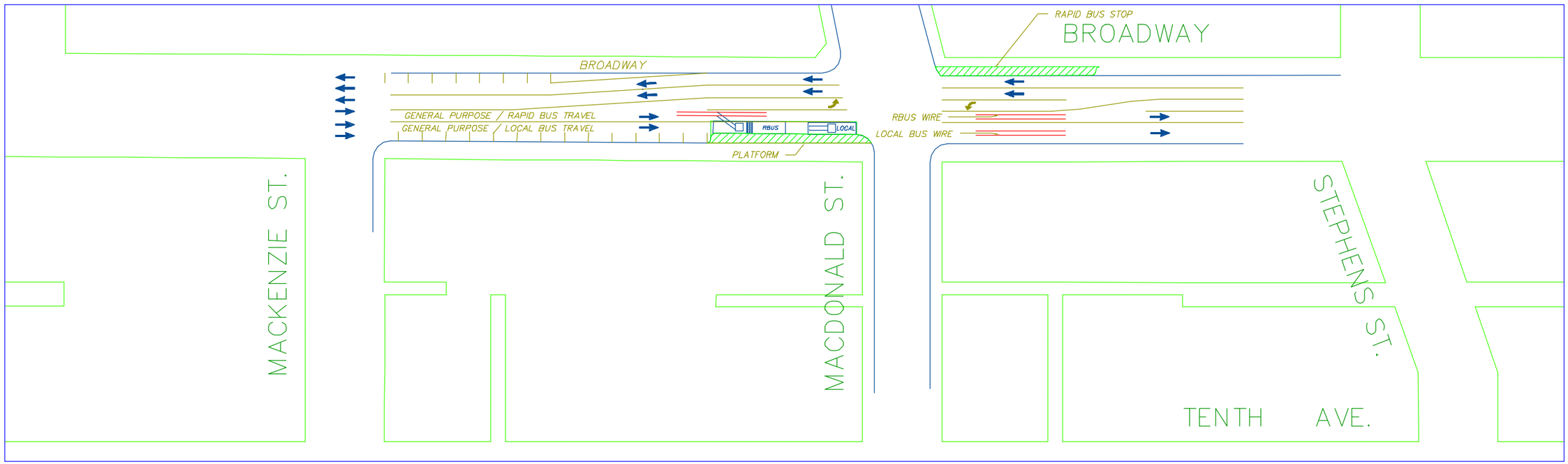

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Rapid Bus Illustrations
Broadway Section at Macdonald Station
Macdonald Station Plan

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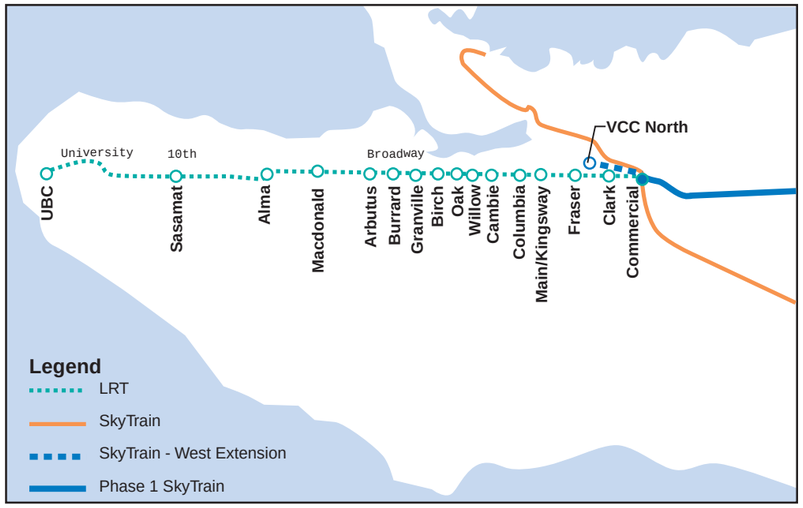
Figure 4

Option 2: LRT



B. Light Rail Transit (LRT)

The LRT alternative evaluated in this study is a fair representation of the range of LRT designs that meet the planning objectives of the City and Region, but is not meant to be the preferred LRT design concept. This alternative was developed under a set of parameters provided by the project TAC and Steering Committee. These included development of an LRT concept generally contained within the current right-of-way, and in some instances within the existing curb-to-curb envelope. Other guidance included retention of two through travel lanes in each direction west of Macdonald, and retention of left turn lanes at major intersections. Should LRT be selected as the preferred technology, a more detailed study and comparison of LRT options will be undertaken. Specific design elements requiring resolution include the width of station platforms at the Commercial, Columbia, Willow, Oak, and Granville stations. Station platforms located at Fraser and Sasamat will require special attention, due to the grades in these areas. The transition from Broadway to 10th at Alma Street warrants added exploration of options to accommodate the auto, bus, pedestrian, and LRT requirements in this area.

Service Concept - The LRT alternative is designed to serve the dual function of serving regional trips headed to major destinations within the Broadway/Lougheed corridor, and also to provide local circulation within the Central Broadway area. Station spacing will average 400 metres east of Arbutus (2 to 3 blocks), while station spacing west of Arbutus will be much less frequent (6 to 8 blocks). While operating at street level within a mixed automobile and pedestrian environment, the light rail alternative would employ a number of measures to make operations as time-competitive as possible. These measures include a raised rail median to provide separation from auto traffic in order to allow the trains to operate without interacting with encroaching traffic. At signalized intersections, the trains would receive preference in terms of either advancing or holding signals to allow trains to proceed without significant delay. Proof-of-payment fare collection would allow all-door loading on one side, thereby reducing station dwell time. The use of low-floor vehicles would also foster faster loading, further reducing the stop dwell times.

Alignment - The LRT alignment alternative evaluated would operate on Broadway between Commercial and Alma, on Alma between Broadway and 10th, on 10th between Alma and Blanca, and on University Boulevard from Blanca to the west terminal on the UBC campus. The alignment on Alma, although geometrically possible, would impact traffic substantially, suggesting that other options, including a diagonal alignment through the block east of Alma, be explored if LRT were to be pursued. (See linear maps that follow.)

Stations - Stations would be located at Commercial, Clark, Fraser, Main, Columbia, Cambie, Willow, Oak, Birch, Granville, Burrard, Arbutus, Macdonald, Alma, Sasamat and UBC. Due to the constrained right of way available to accommodate sidewalks, parking, auto lanes, the rail alignment, and station platforms, some areas required that minimum widths be used. The Columbia Station may need to be moved or property acquired to provide added platform width. Platforms were laid out in a number of configurations, including single center platforms, dual side-by-side platforms, near side or far side platforms, and offset or shadowed platforms. The platform widths vary, although attempts were made to provide greater widths at major transfer points. High frequency service will somewhat offset the need for greater platform width. Given the median rail alignment, platforms will require designs that protect passengers from adjacent traffic as well as to prevent spray from passing traffic. To accommodate a proof-of-payment system, platforms would be equipped with ticket vending machines and validators, as well as sheltered waiting areas, information systems, and lighting.

Operations - The LRT alternative would operate between Commercial to UBC with each train making all stops. Service would be provided by two-car trains during most hours, although single-car operation may be sufficient during some periods. Two-car trains provide a practical capacity in the range of 320 passengers. During peak hours, 3 minute headways would be provided, with 5 to 10 minute service midday, evenings, and Saturdays; and 10 to 15 minute service during late nights and on Sundays. The proof-of-payment system would allow use of all doors for loading, resulting in an average dwell time of 20 seconds. Maximum speed of the system would be 50 km/hour.

Vehicles - To size the system and establish vehicle capacity, this study assumed commonly used North American light rail vehicles. The standard width of light rail cars is 2.65 metres; lengths vary with most cars in the range of 26 to 28 metres. Low floor cars are recommended because they reduce the loading time at stops for all passengers. Narrower vehicles in the range of 2.4 metres are potentially available, although not common in the North American market. The advantage of narrower vehicles is the reduced space required, in the range of .8 metres, for a two-track alignment. Such space could be allocated to wider platforms or sidewalks. The disadvantage of the narrower cars is the loss of seating and on-board circulation space. The latter is a particularly important consideration for service with relatively frequent stops and high levels of on and off riders.

Connecting and Local Transit Service - The LRT alternative would connect to North-South Rapid Transit service either at Cambie (SkyTrain from Richmond to downtown Vancouver) or Arbutus (LRT from Richmond to downtown Vancouver). Parallel local service would be provided between Boundary and Main by Route 9. Route 10 would provide local service between Granville and UBC. Given the LRT station spacing, Route 9 service would be discontinued between Main and Granville. Routes 42, 3, 20, 51, 16, 17, 19, 15, 50, and 8 would provide additional connecting local bus service.

Traffic, Parking and Access - The LRT alternative would provide for two continuous through travel lanes in each direction between Commercial and Trafalgar. Between Trafalgar and UBC the design retains a single travel lane in each direction, with left turn lanes at major intersections. At all station locations, on-street parking would be removed to accommodate auto lanes, rail right of way, station platforms, and sidewalks. In many sections parking would be eliminated or reduced to one side of the street. Parking would be retained on both sides of Broadway between Trafalgar and Alma. Minor, unsignalized streets and mid-block access driveways would be converted to right-in and right-out in order to prevent uncontrolled crossing of the rail alignment. The following drawings illustrate the light rail alignment, travel lane configuration, and parking and access restrictions. Conceptual design of light rail platform layouts follow for several station locations.

Right of Way and Property - The LRT conceptual alternative would require acquisition of property at two locations along the alignment, otherwise the alignment will be built within current public right of way. These locations are on the south side of Broadway between Kingsway and Main, and on the southeast quadrant of the Broadway and Cambie intersection. In addition, property will be required to accommodate a maintenance and operations facility, which will include the storage of vehicles.

MATCH LINE
SEE BELOW RIGHT

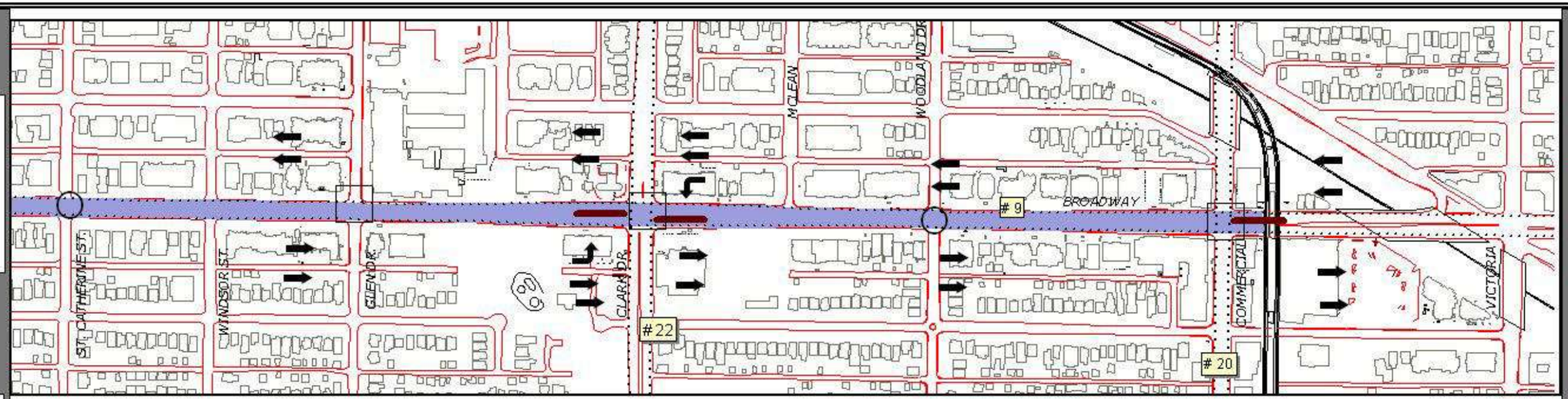


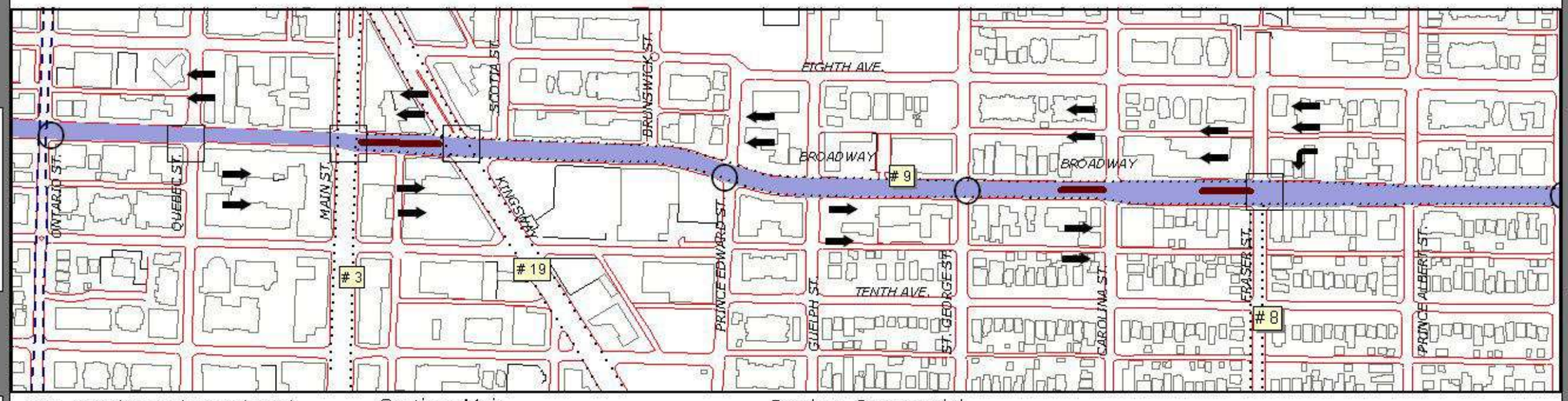
ILLUSTRATION REFERENCE

Typical Section:
Commercial to Prince Edward

Section: Commercial to Prince Edward

See Station Plan

MATCH LINE
SEE SHEET LRT2



MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION REFERENCE

Typ. Section: Prince Edward to Cambie

Section: Main & Kingsway

See Station Plan

Section: Commercial to Prince Edward

See Station Plan

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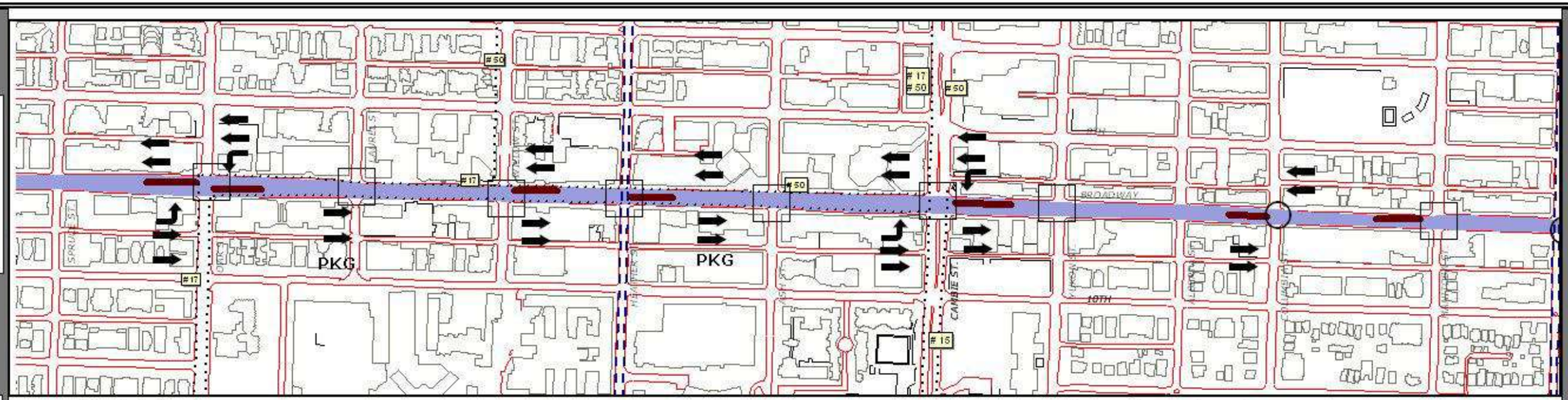
Light Rail Corridor Map

LRT 1
BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

- Light Rail Alignment
- Travel Lane
- PKG Parking Lane
- Station
- Bikeway
- Local Bus Route
- Fully Signalized Intersections To Remain
- Pedestrian Signals To Become Full Signals
- * Unmarked intersections to become right-in, right-out

MATCH LINE
SEE BELOW RIGHT



MATCH LINE
SEE SHEET LRT1

ILLUSTRATION REFERENCE

Typical Section: Granville Station

Section: Cambie to Vine

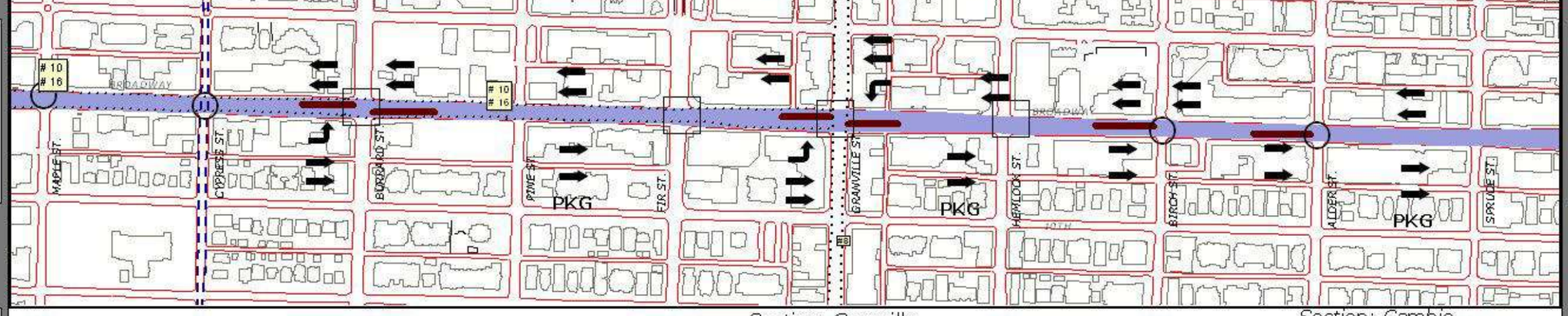
See Station Plan

Section: Prince Edward to Cambie

Section: Columbia Station

See Station Plan

MATCH LINE
SEE SHEET LRT3



MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION REFERENCE

Section: Cambie to Vine

Section: Granville Station

Section: Cambie to Vine

See Station Plan

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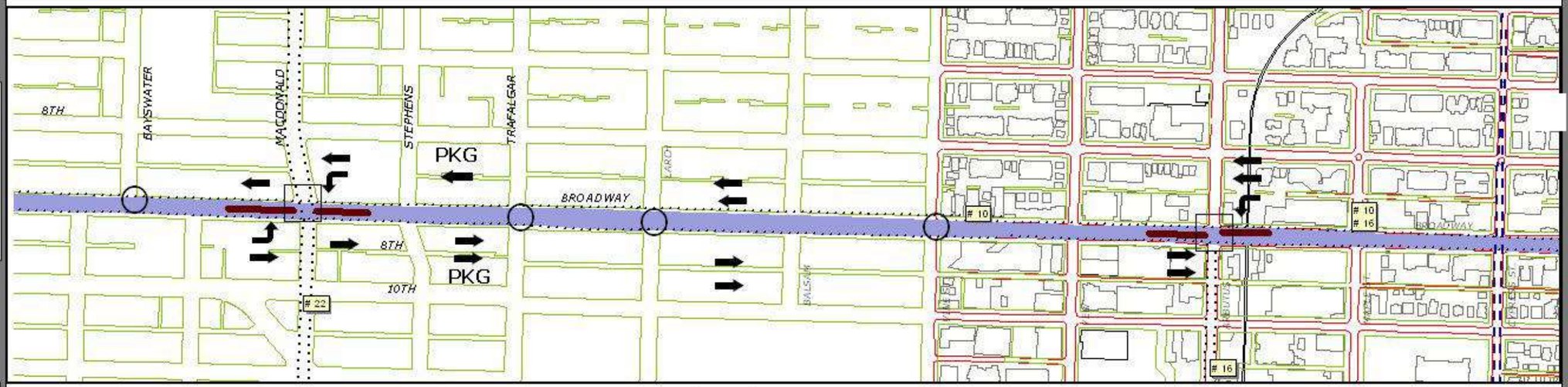
Davidson Yuen Simpson Architects

Light Rail Corridor Map

LRT 2
BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

- Light Rail Alignment
- Travel Lane
- **PKG** Parking Lane
- Station
- Bikeway
- Local Bus Route
- Fully Signalized Intersections To Remain
- Pedestrian Signals To Become Full Signals
- * Unmarked intersections to become right-in, right-out

MATCH LINE
SEE BELOW RIGHT



MATCH LINE
SEE SHEET LRT2

ILLUSTRATION REFERENCE

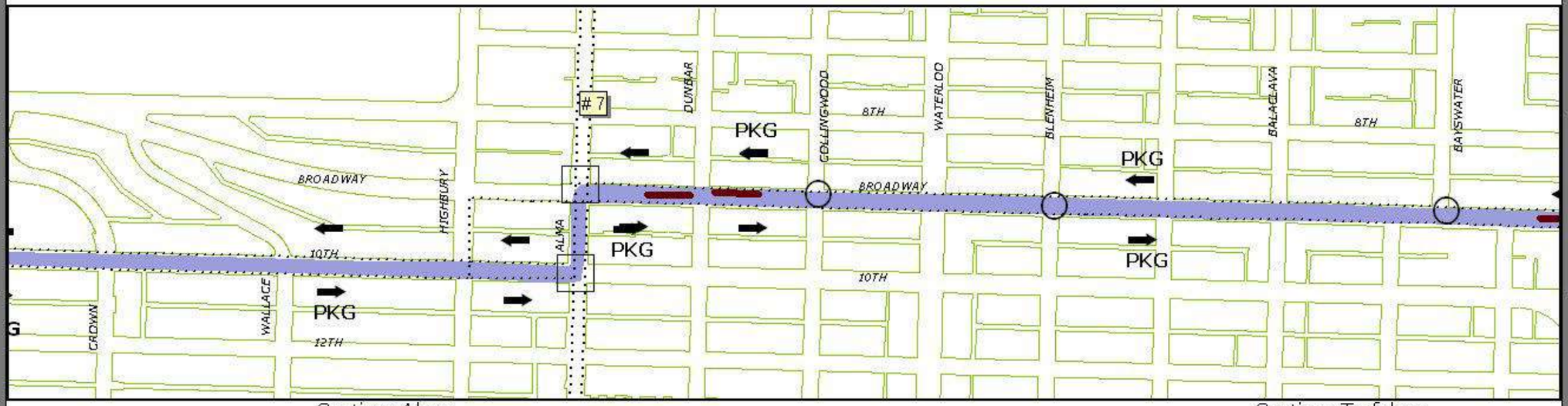
Section: Macdonald Station

See Station Plan

Section: Vine to Trafalgar

See Station Plan

MATCH LINE
SEE SHEET LRT4



MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION REFERENCE

Section: Alma to Blanca

See Station Plan

Section: Trafalger to Alma

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Light Rail Corridor Map

LRT 3
BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

Light Rail Alignment
Travel Lane
PKG Parking Lane
Station
Bikeway
Local Bus Route
Fully Signalized Intersections To Remain
Pedestrian Signals To Become Full Signals
* Unmarked intersections to become right-in, right-out

MATCH LINE
SEE BELOW RIGHT

BIKE

BIKE

10TH

BLANCA

12TH

TOLMIE

SASAMAT

TRIMBLE

DISCOVERY

COURTENAY

10TH

12TH

CAMOSUN

PKG

CROWN

MATCH LINE
SEE SHEET LRT3

ILLUSTRATION REFERENCE

Section:
University Blvd.

Section: Sasamat Station

See Station Plan

Section: Alma
to Blanca

Continues to UBC
Transit Station

University Endowment Lands

BIKE

UNIVERSITY BLVD.

BIKE

MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION REFERENCE

Section: University
Blvd.

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Light Rail Corridor Map

LRT 4
BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

Light Rail Alignment
Travel Lane
PKG Parking Lane
Station

Bikeway
Local Bus Route
Fully Signalized Intersections
To Remain

Pedestrian Signals To
Become Full Signals

* Unmarked intersections
to become right-in, right-out

XREF'S
011BDR-2
ALIGN
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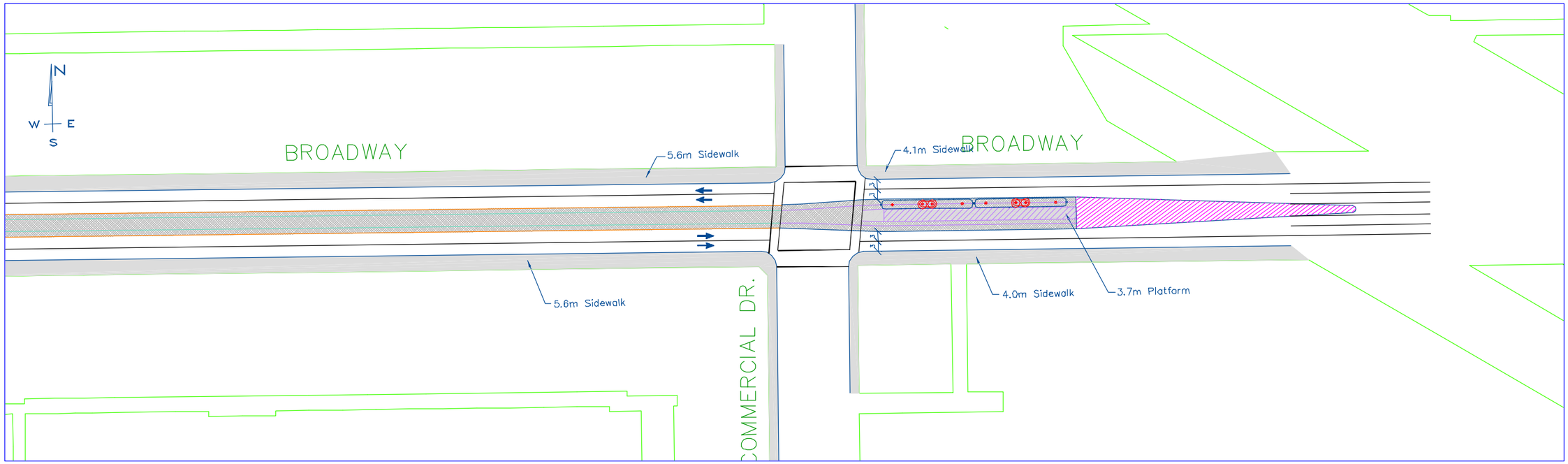
PSscale: 1
VisRetn: 1



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Davidson Yuen Simpson Architects

BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Commercial Street Platform
Plan

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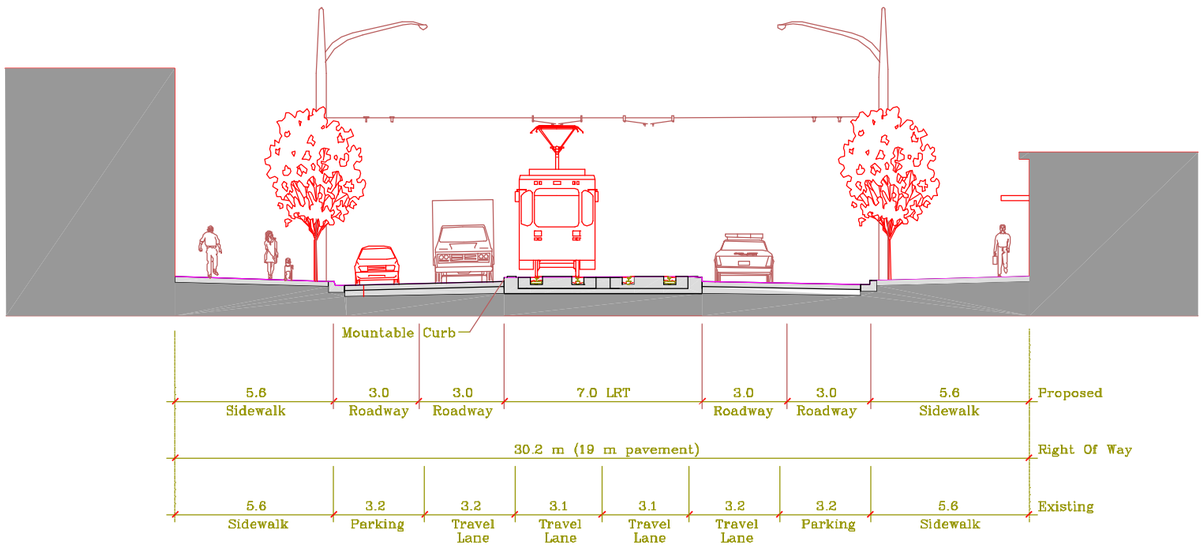

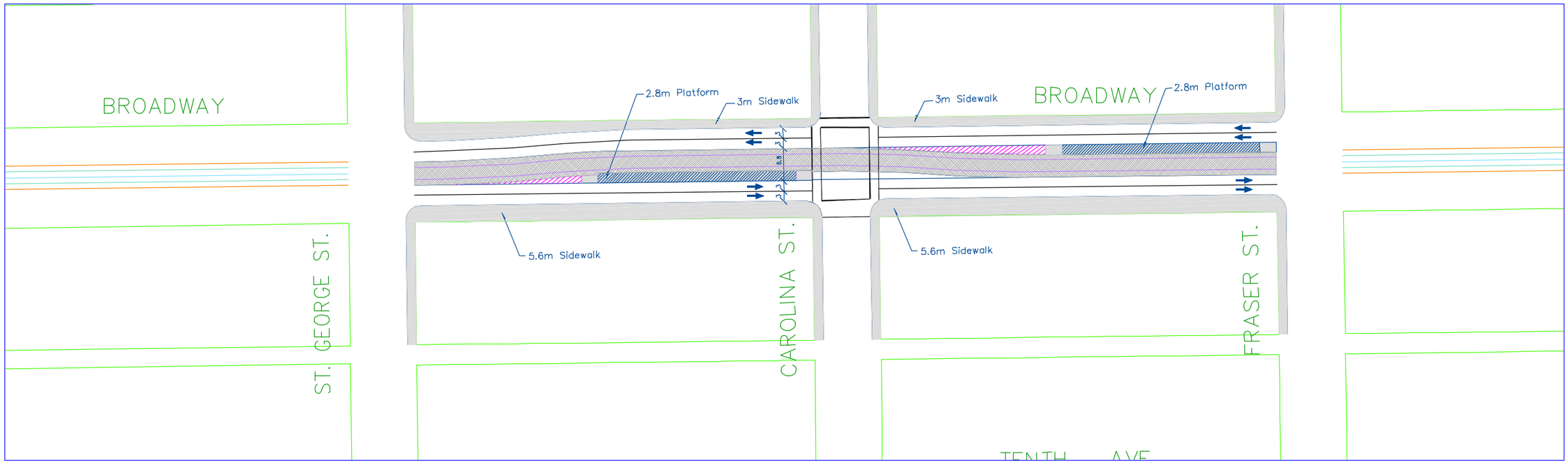

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Mid-block Section between Commercial and Prince Edward St. / Fraser Station Plan

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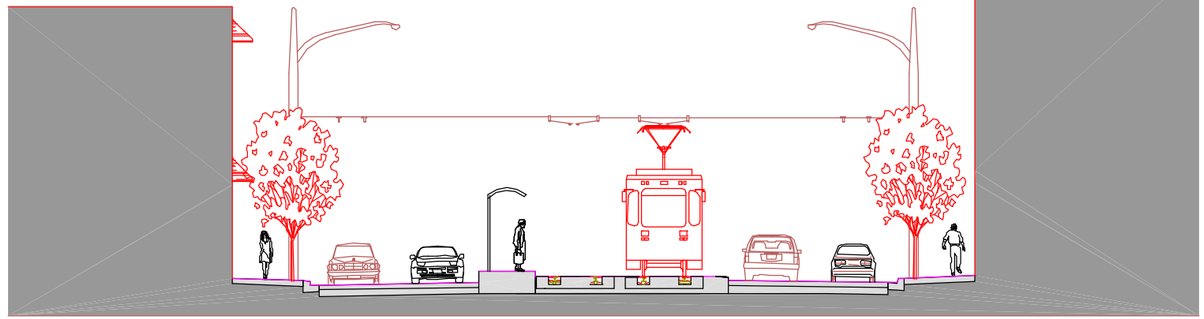

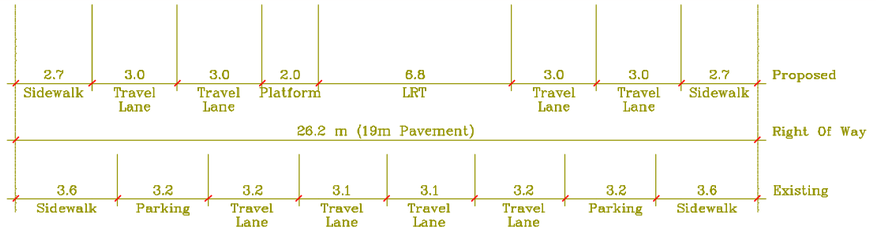

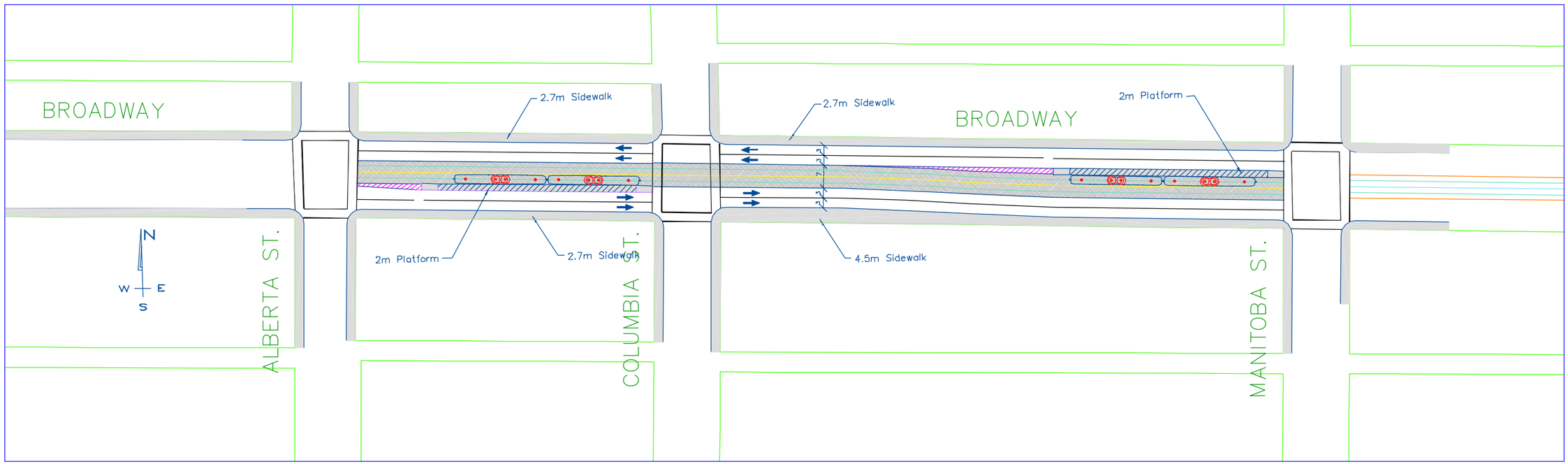

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Section at Columbia St.
Columbia Station Plan

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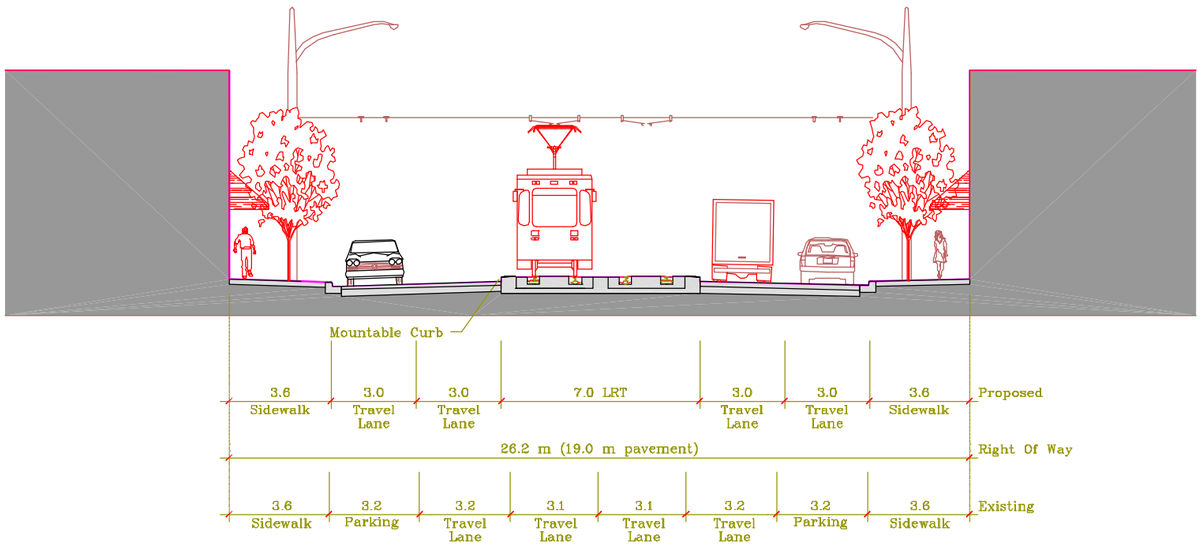

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Mid-block Section
Between Prince Edward St. and Cambie St.

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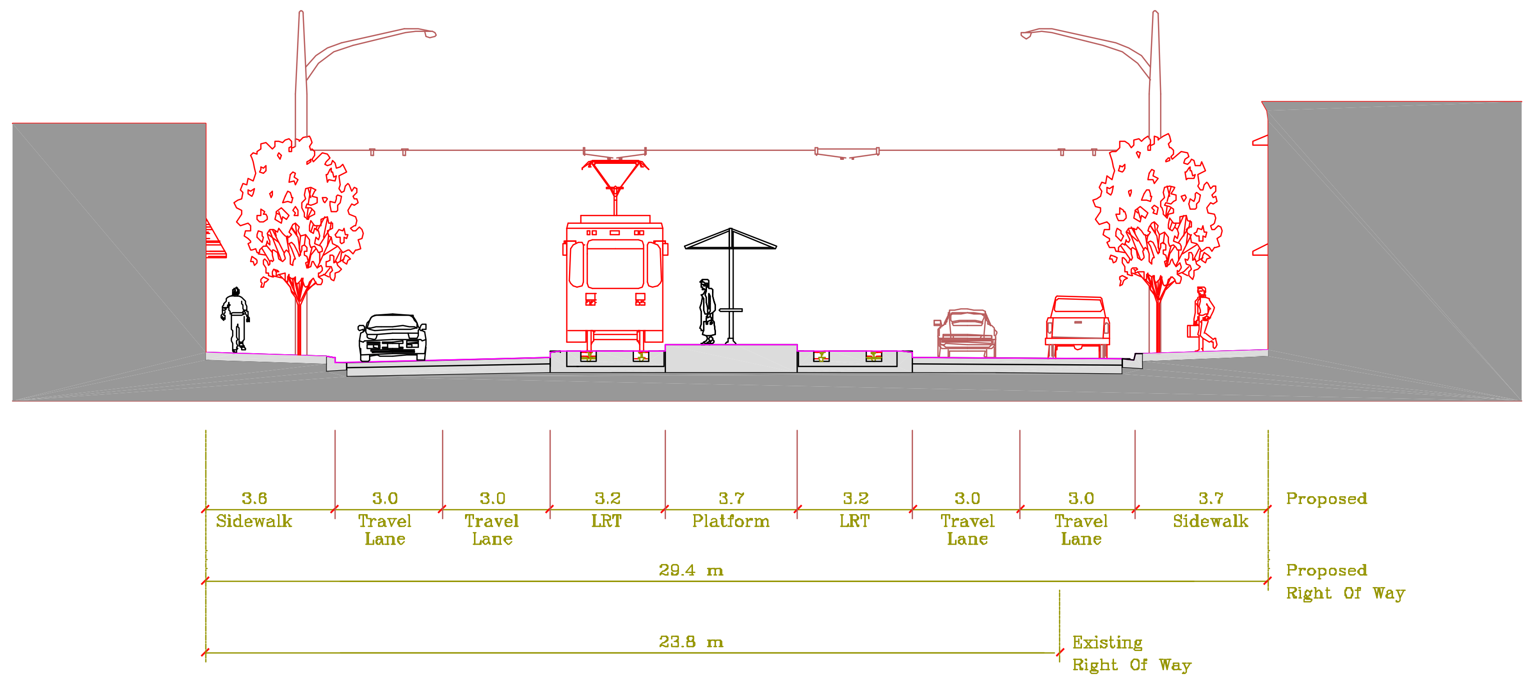

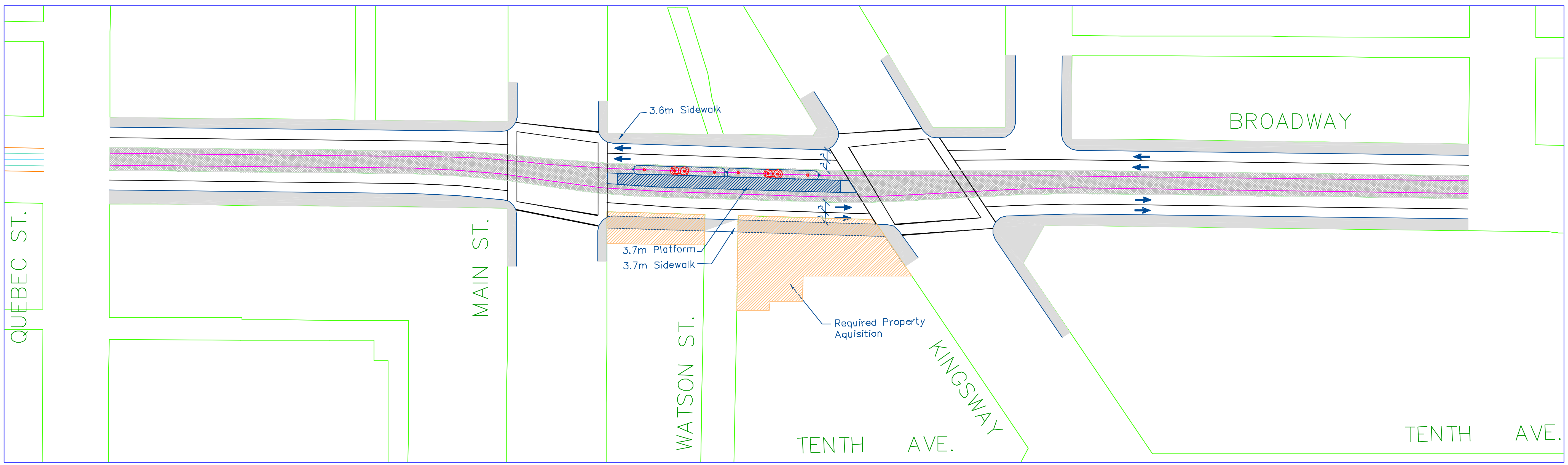

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BROADWAY/LOUGHEED
RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Section at Main and Kingsway Platform
Looking East / Station Plan at Main and Kingsway

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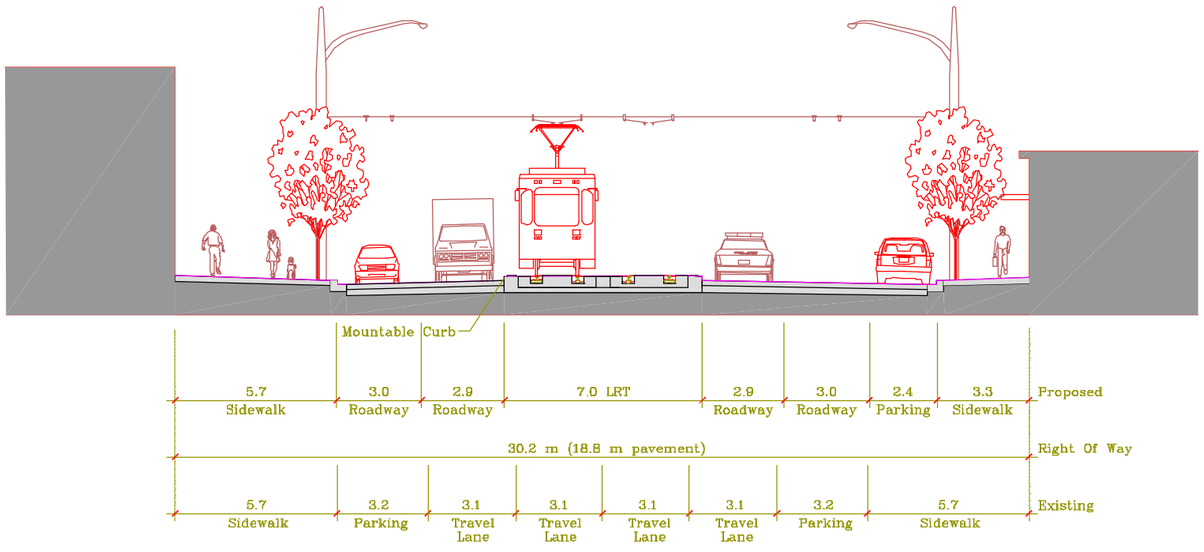

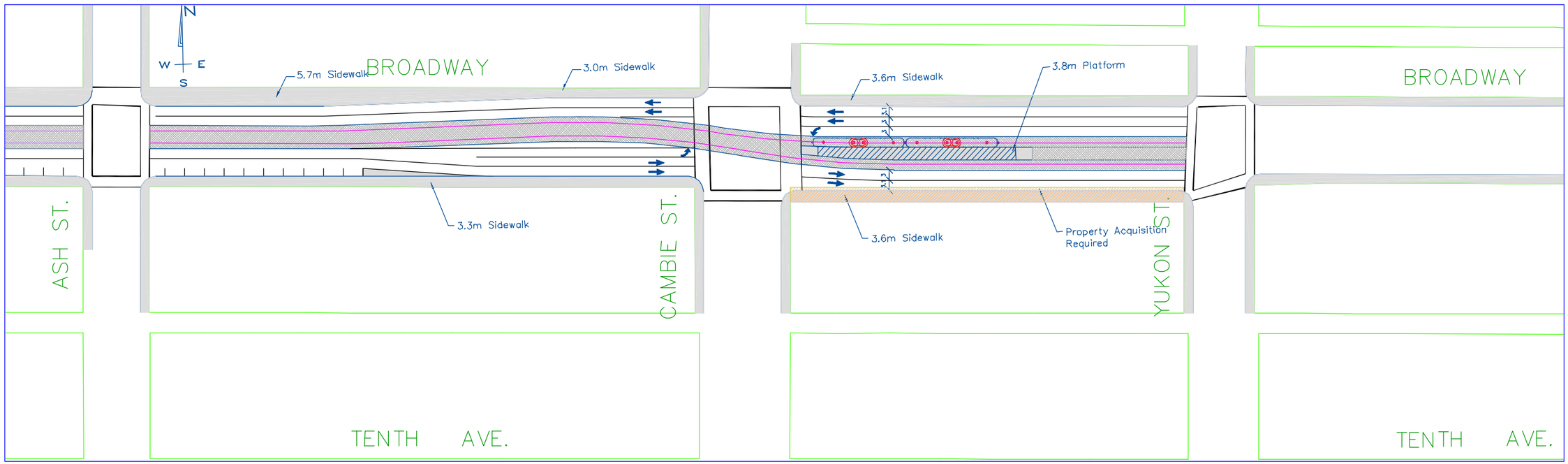

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PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Mid-block Section betwwen Cambie St. and Vine St / Cambie Station Plan

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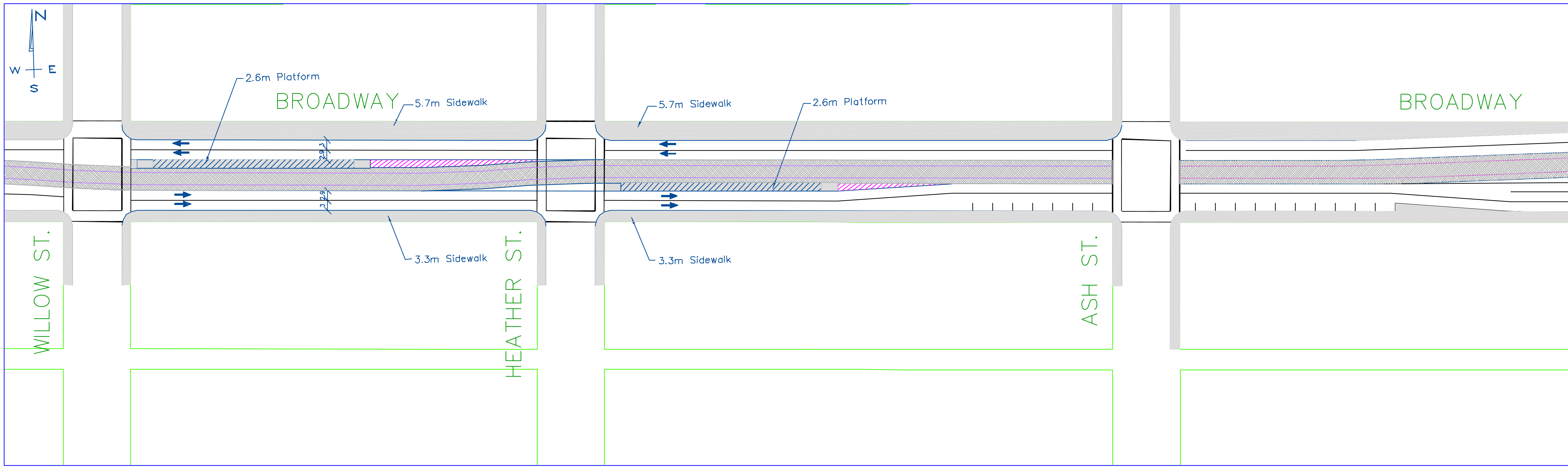

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PHASE II – Commercial Drive West

Light Rail Illustrations
Willow Street Platform Plan

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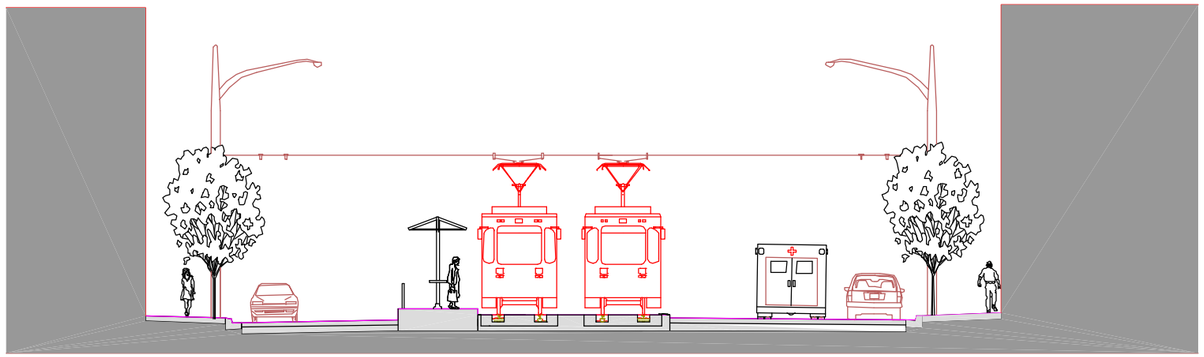

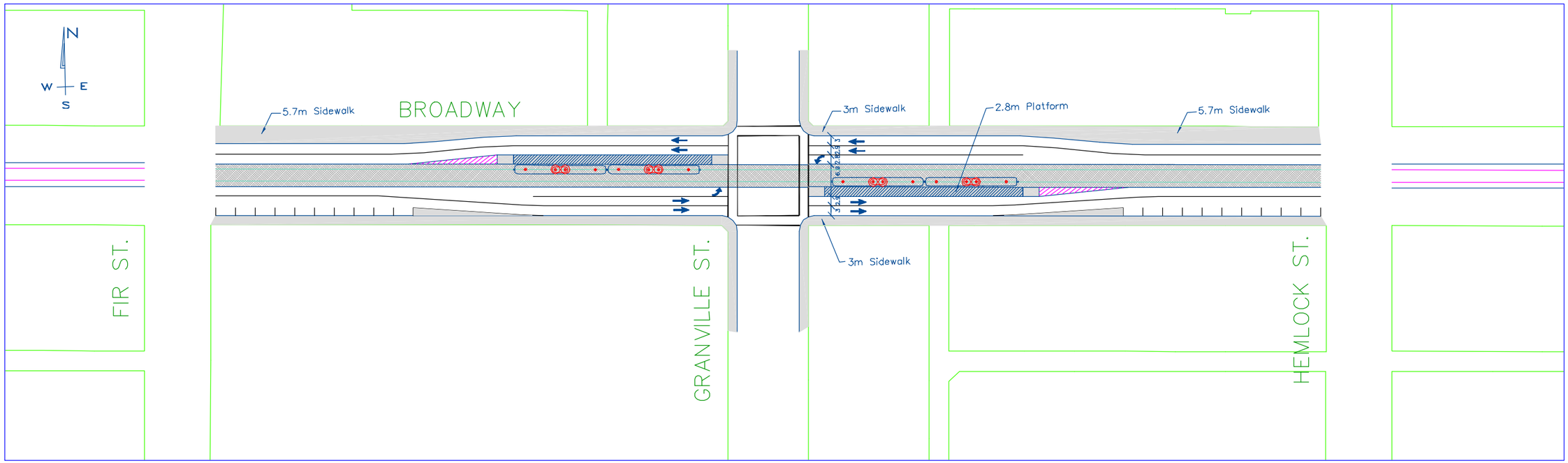

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Section at Granville Platform
Granville Station Plan

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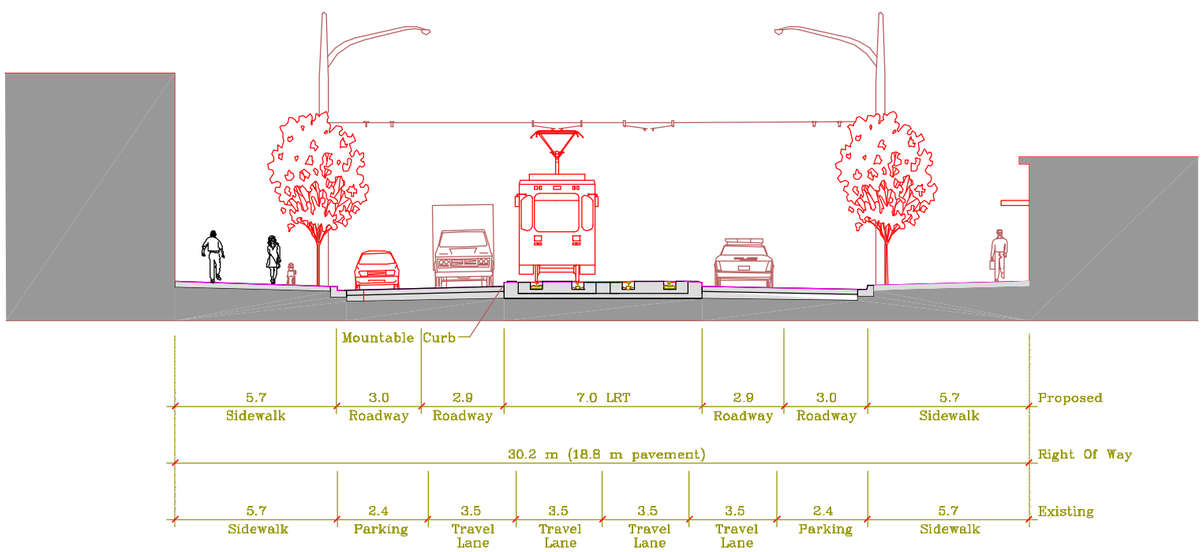

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Mid-block Section
Between Vine St. and Trafalgar St.

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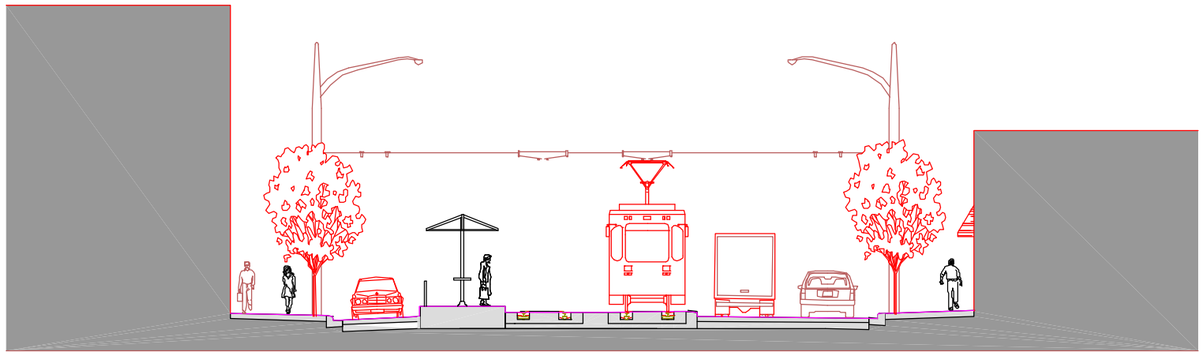

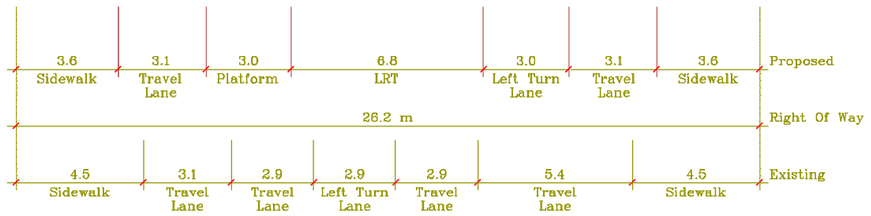

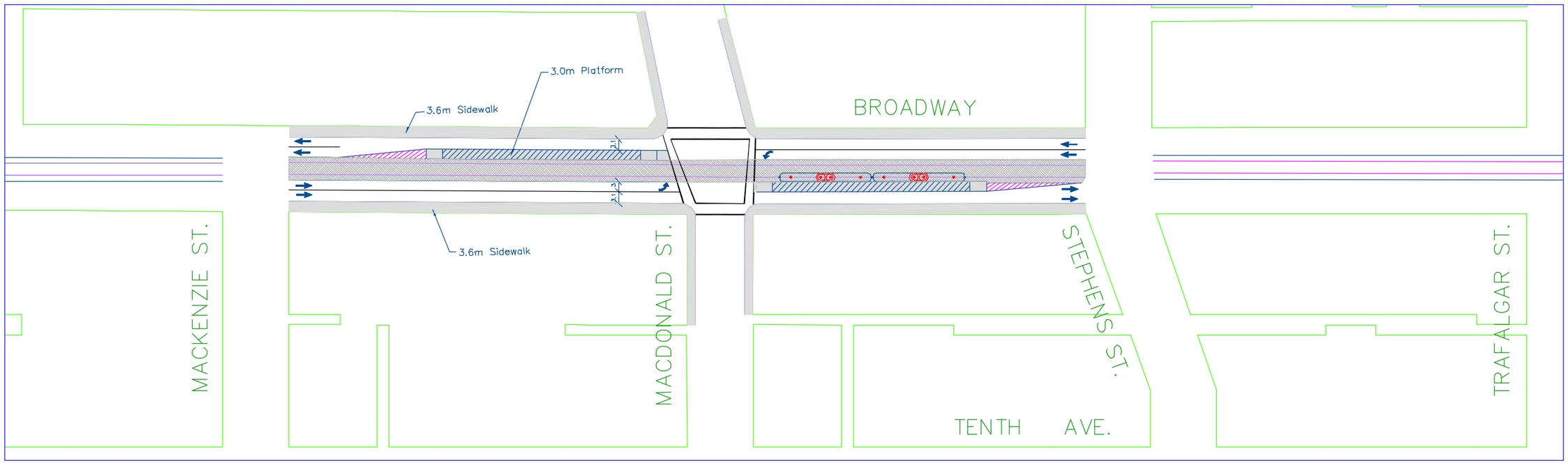

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Section at Macdonald Platform
Macdonald Station Plan

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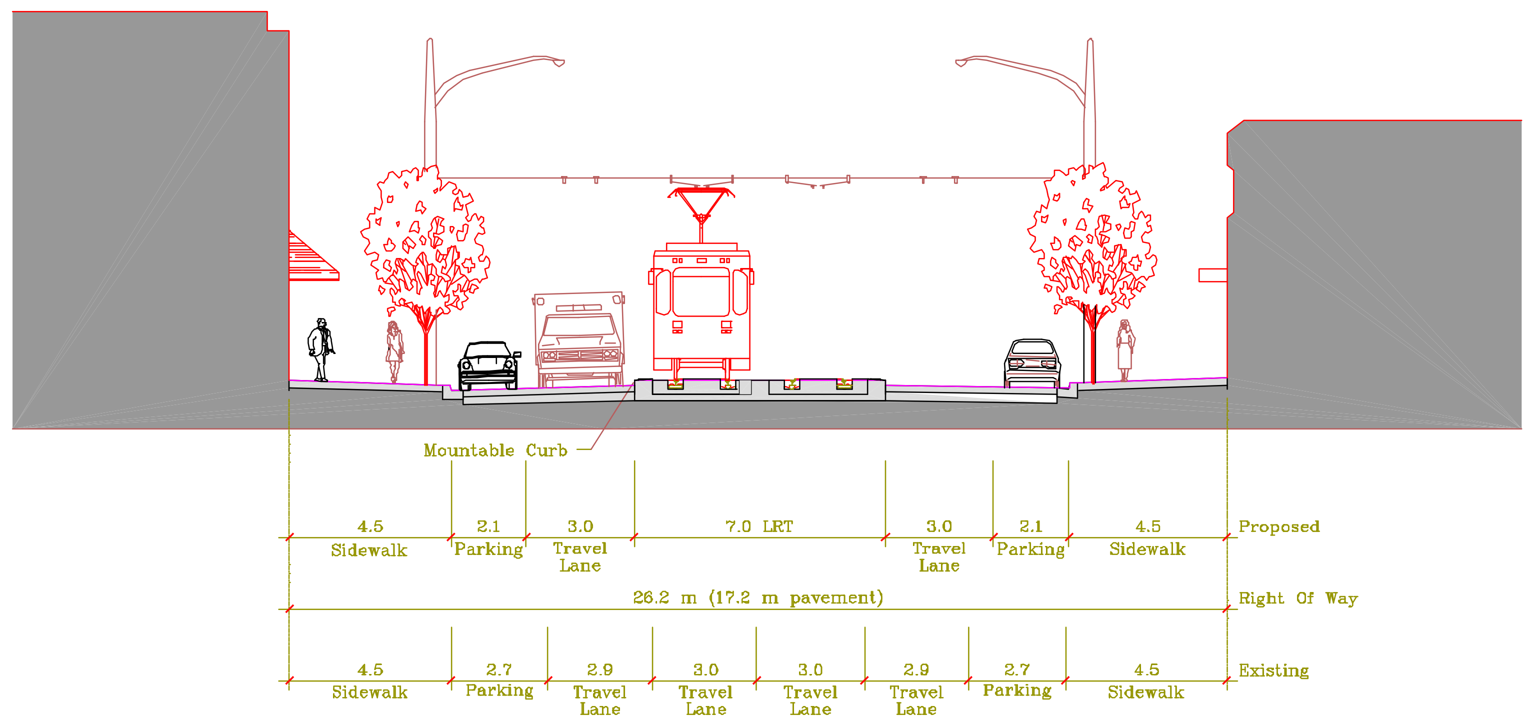

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RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Broadway Mid-block Section
Between Trafalgar St. and Alma St.

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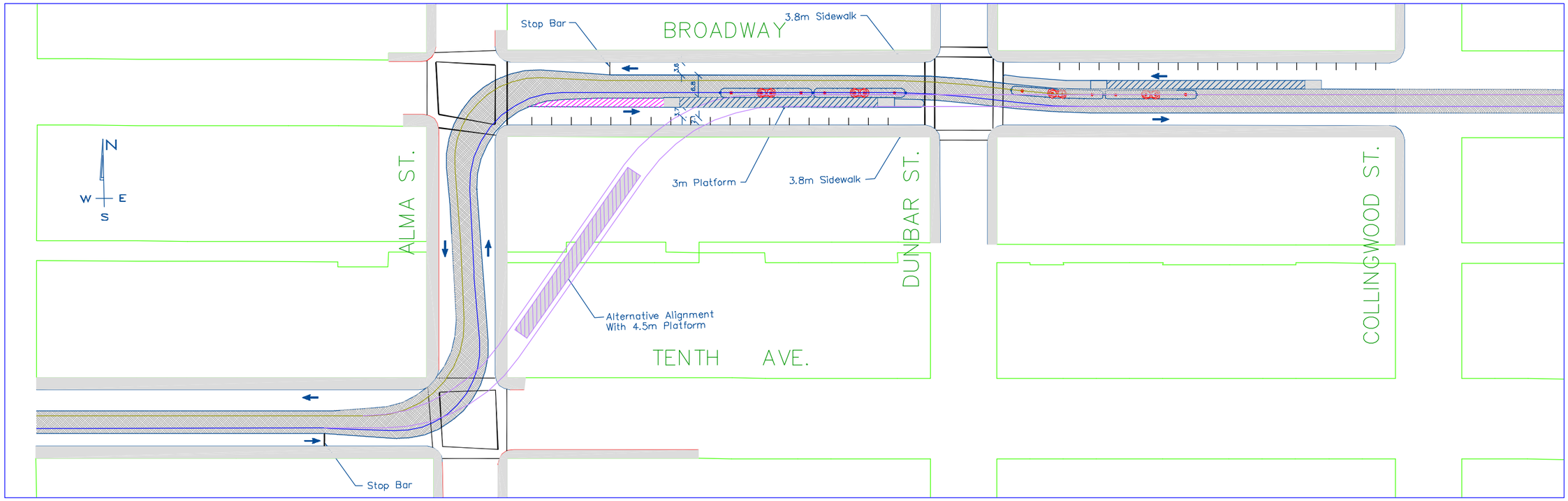

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BROADWAY/LOUGHEED RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
Alma Street Platform
Plan

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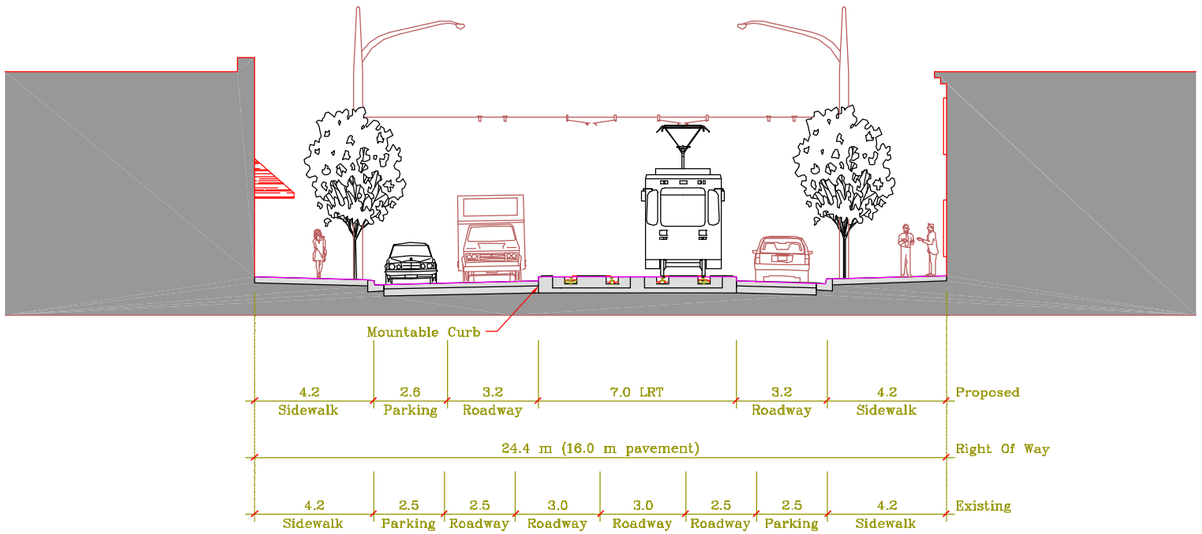

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BROADWAY/LOUGHEED
RAPID TRANSIT LINE

PHASE II – Commercial Drive West

Light Rail Illustrations
10th Av Mid-block Section
Between Alma St and Blanca St

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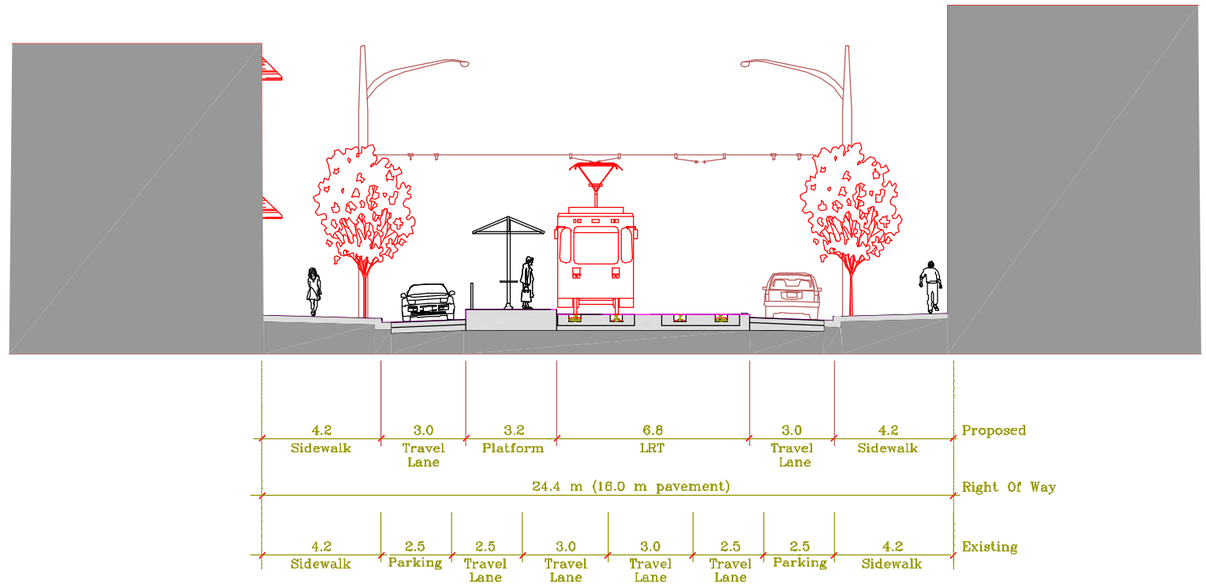

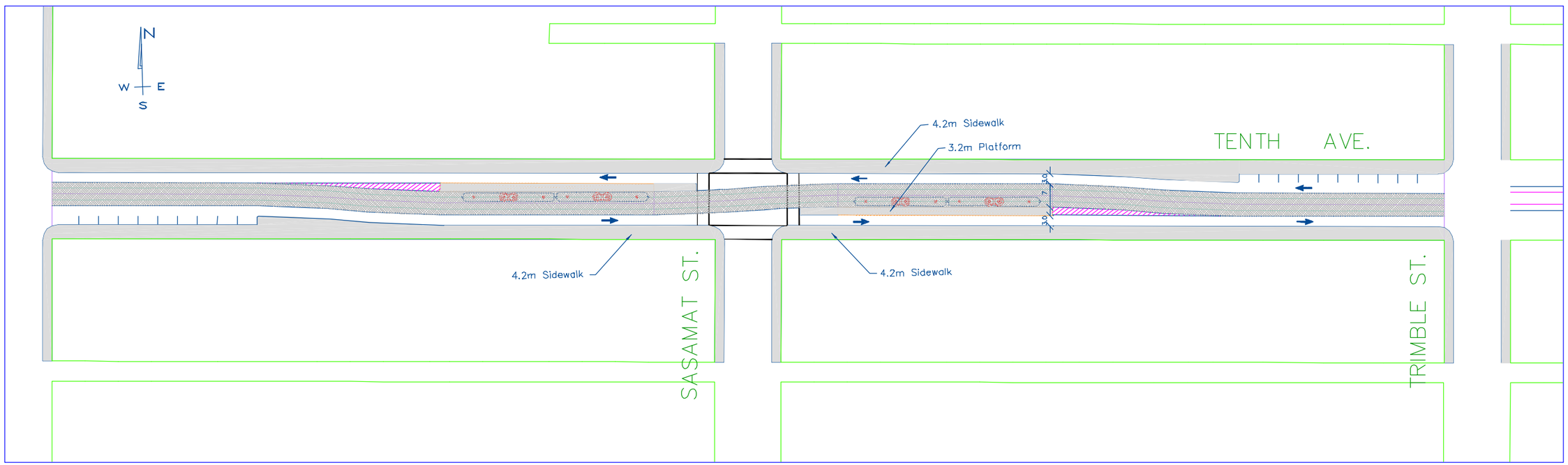

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PHASE II – Commercial Drive West

Light Rail Illustrations
10th Av. Section at Sasamat Platform
Sasamat Station Plan

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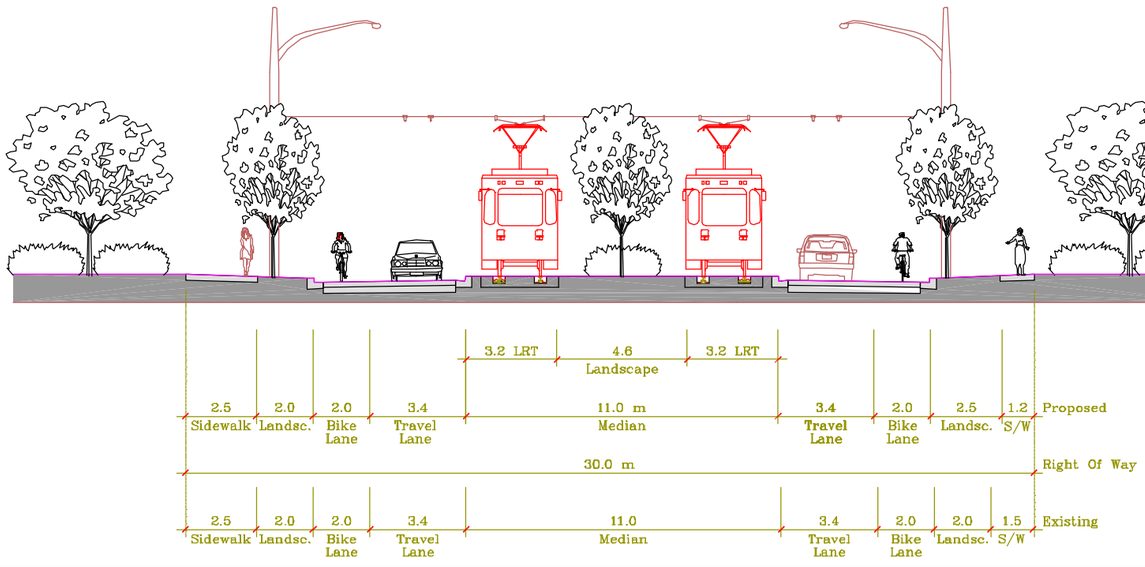

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PHASE II – Commercial Drive West

Light Rail Illustrations
University Blvd.
Section

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C. SkyTrain/Rapid Bus

Figure 5 -

Option 3: SkyTrain to Main

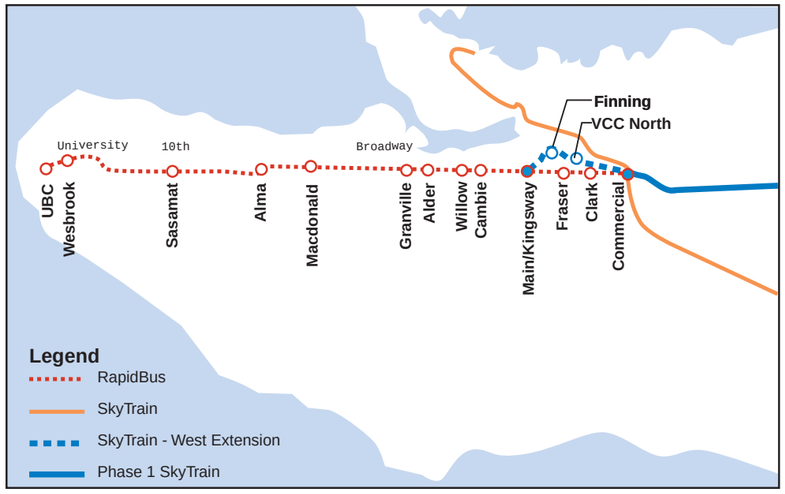
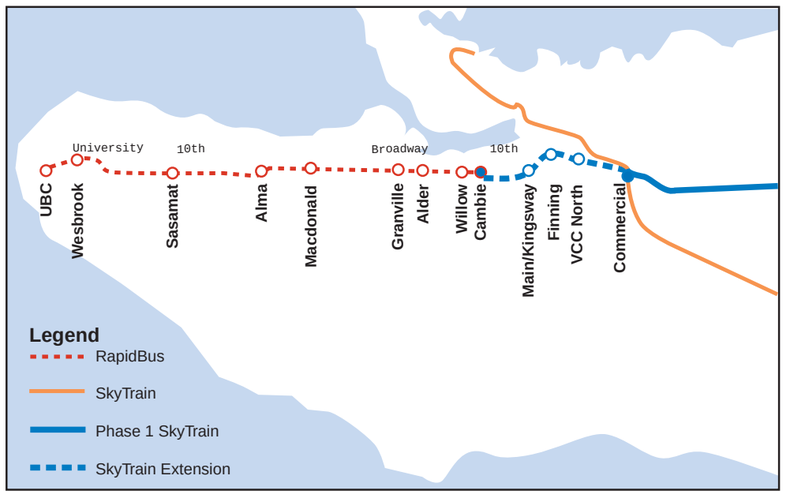


Figure 6 -

Option 4: SkyTrain to Cambie



Figures 5 through 8 illustrate the four SkyTrain alternatives under consideration in this study. Each shares a common east terminus of the VCC (north) station. The four alternatives differ in the location of the west terminus of SkyTrain, which are Main, Cambie, Granville, and Arbutus. For each of the four alternatives the SkyTrain west terminus to the UBC section is covered by a Rapid Bus solution.

Service Concept - Each of the four SkyTrain alternatives would function as a westward extension of the Broadway/Lougheed Phase I corridor. The SkyTrain alternative would continue to function as a line-haul regional system with more widely spaced stations. Preference would be to continue current practices of providing high-frequency service. SkyTrain's wider station spacing would be coupled with retention of a local bus service on Broadway to accommodate local trips and connections for passengers arriving at SkyTrain stations. Each SkyTrain alternative would differ substantially in how it serves the Central Broadway area and how it connects to other transit lines. The corridor maps that follow illustrate the concept.

Main/Kingsway - A SkyTrain west terminus at this location would provide direct service to the surrounding area. Connections to local north-south Lines 3, 8, and 19 would be available. The connecting Rapid Bus from UBC would provide the primary access to the west. The Rapid Bus line would be extended east to Commercial to accommodate trips destined to either the north or south on the existing SkyTrain line. A Main/Kingsway terminus would not provide a direct connection to a north-south rapid transit line on either Cambie, Granville or Arbutus.

Cambie - A SkyTrain west terminus at Cambie would provide direct service to the City Hall complex and surrounding development. If a north-south SkyTrain line is built on Cambie, trains from Lougheed Mall could turn north to provide a direct (non-transfer) trip to downtown Vancouver. Connecting service to the west, including UBC, would be provided by a local line on Broadway and the Rapid Bus extension. Rapid Bus would terminate in the vicinity of Cambie via a surface street loop. Service to Vancouver General Hospital (VGH) could be supplemented by a short shuttle bus route.

Granville - A SkyTrain west terminus at Granville would directly serve the substantial office and retail development in the vicinity of Granville and Broadway. A terminus here would intersect a north-south Rapid Bus line from Richmond to downtown Vancouver as well as service on Cambie and Main/Kingsway. Direct service to VGH could be provided by a station at Oak. Rapid Bus service to UBC would terminate in the vicinity of Granville via a surface street loop.

Arbutus - The primary purpose of extending SkyTrain to Arbutus would be to either provide connection to a north-south service if it were developed on the existing rail right of way, or to provide an off-street transfer point between SkyTrain and the Rapid Bus service to the west.

Alignment - The SkyTrain alignment for all options would begin at a Vancouver Community College (VCC north) station and proceed west into the Finning lands to a below-grade station at the west end of the Finning site just north of Great Northern Way. The tracks would then swing south, passing below Great Northern Way and follow underneath Prince Edward Street in a tunnel. The alignment remains below grade and heads west upon reaching 10th Avenue, with stations at Main/Kingsway, Cambie, Oak, Granville, and Arbutus, depending upon the location of the west terminus.

Stations - Station amenities, information systems, ticketing, and security are assumed to be consistent with the Phase I design of the SkyTrain extension. Stations are designed to accommodate either Mk I or Mk II vehicles. Single center platforms are assumed, with a 9m to 10m width and 80m length. Station entries for all stations would be coordinated with both existing and planned development. Given the importance of connections to local bus service, and in particular the Broadway Rapid Bus to UBC, particular attention will need to be paid to providing the most direct path possible between the SkyTrain entry and the Rapid Bus stop.

Operations - The SkyTrain alternative would operate as an extension of the line from Lougheed Mall to VCC (north). Trains would stop at all stations, with train lengths determined by ridership demand. The maximum train length would be 5 Mk II vehicles, which represents a total capacity of approximately 650 passengers. Headways as close as 90 seconds can be operated; however, considerations such as ridership east of the Broadway Station and the configuration of a Cambie Station if a north-south Cambie SkyTrain line is implemented will be key determinants of the frequency of service.

Vehicles - Initial operations assume use of the SkyTrain Mk II vehicles, which are 17.5m in length. Mk I (12.5m) vehicles could also be used in the corridor. Future orders could result in vehicles of greater length, although the working assumption is that any future vehicles would need to function within the constraints of the 80m platforms, as is the case throughout the system.

Figure 7 -

Option 5: SkyTrain to Granville

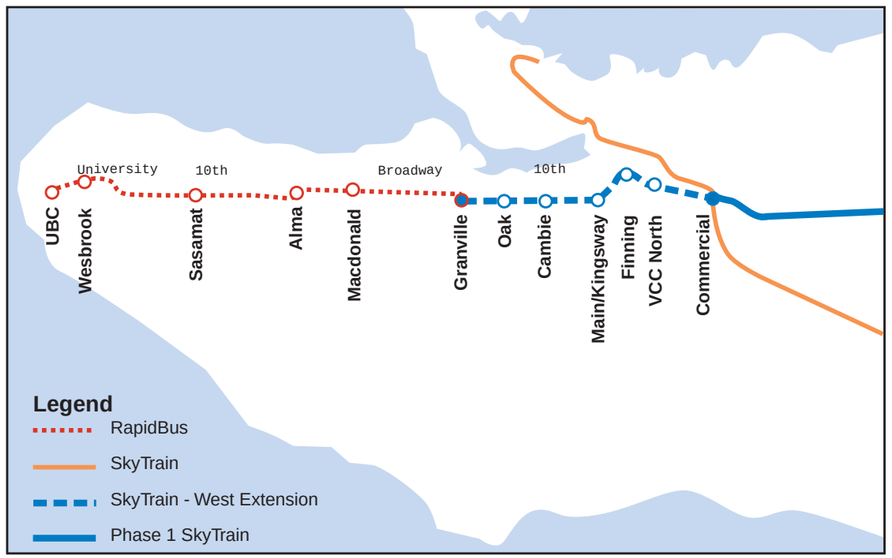
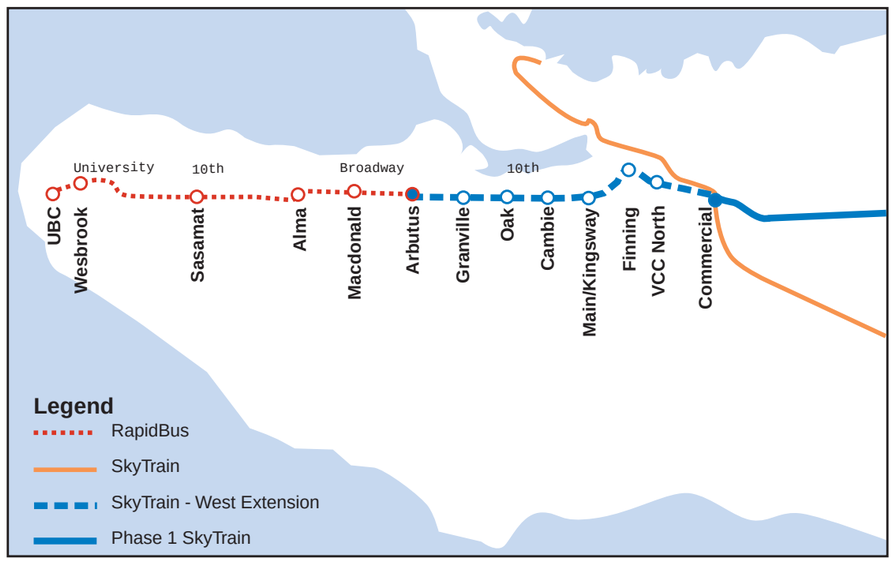


Figure 8 -

Option 6: SkyTrain to Arbutus



Connecting and Local Transit Service - All of the SkyTrain alternatives would be coupled with a Broadway/10th/University Rapid Bus to provide a high-capacity service from the west terminus of Sky Train to UBC. All the alternatives would also be coupled with a local service on Broadway/10th/University. The following table summarizes the regional and local transit connections to each SkyTrain alternative.

Table 2
SkyTrain Connecting Transit Services

Skytrain Terminus	Local Routes	North South High Capacity Transit Connection	Connections to Broadway - West via Local
Main/Kingsway	3, 8, 19	None	Rapid Bus, 9
Cambie	3, 8, 19, 17, 15, 50	Cambie Sky Train	Rapid Bus, 9
Granville	3, 8, 19, 17, 16, 15, 50, 51	Cambie Sky Train or Granville Rapid Bus	Rapid Bus, 9, 10
Arbutus	3, 8, 19, 17, 16, 15, 50, 51	Arbutus LRT, Cambie Sky Train or Granville Rapid Bus	Rapid Bus, 9, 10

Traffic, Parking, Access - The SkyTrain alternative will be in a tunnel section from the Finning/Great Northern Way Station west, and therefore will have little impact on existing traffic, parking, access drives and cross streets. Exceptions would be in the vicinity of stations with traffic generated by passenger pick up and drop off. In addition, the Cambie and Granville terminus alternatives would require an on-street terminal loop for the connecting Rapid Bus service to UBC. In these cases, some loss of on-street parking and possible channelizing of existing traffic lanes will likely be required.

Right of Way and Property - With the exception of a short segment through the Great Northern Technology Park, the SkyTrain alternatives west of VCC (North) will be in tunneled sections. The underground SkyTrain section will require property be acquired to accommodate station houses, emergency exits, and ventilation and emergency communications equipment. Each of these functions may be partially accommodated on public right of way, but will require some acquisition of private property.

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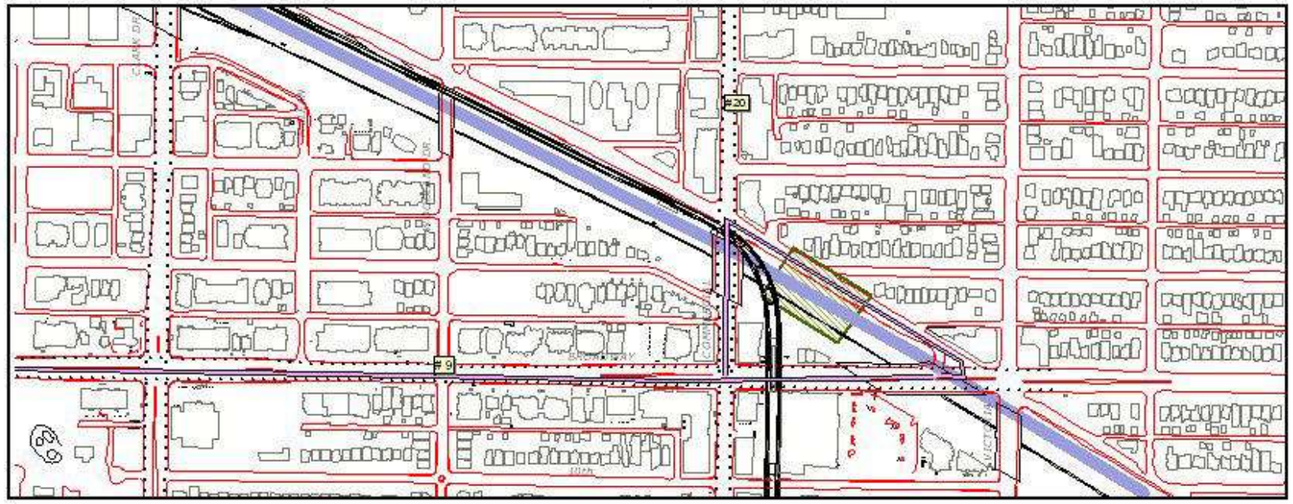
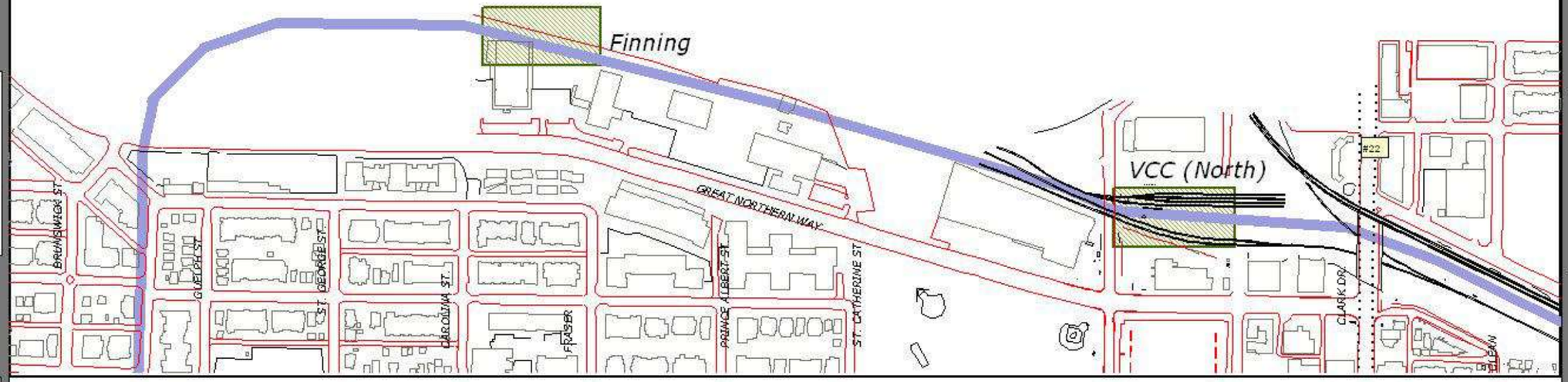


ILLUSTRATION REFERENCE

SkyTrain Phase I alignment above grade in the Grandview Cut

MATCH LINE
SEE SHEET ST2



MATCH LINE
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ILLUSTRATION REFERENCE

SkyTrain alignment in bored tunnel

SkyTrain surface alignment

SkyTrain Phase I

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Sky Train Corridor Map

BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

RapidBus Route
Bikeways
Local Bus Route
Station
SkyTrain Alignment

MATCH LINE
SEE BELOW RIGHT

15
9
50
17
9
19
3

Option 4: SkyTrain western terminus

Option 4: Rapid Bus eastern terminus

Option 3: SkyTrain western terminus

Option 3: Rapid Bus connection, continues to Commercial

MATCH LINE
SEE SHEET ST1

ILLUSTRATION REFERENCE

SkyTrain alignment in bored tunnel

MATCH LINE
SEE SHEET ST3

Option 5: Rapid Bus eastern terminus

Option 5: SkyTrain western terminus

17

MATCH LINE
SEE ABOVE LEFT

ILLUSTRATION REFERENCE

SkyTrain alignment in bored tunnel

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Sheet ST2
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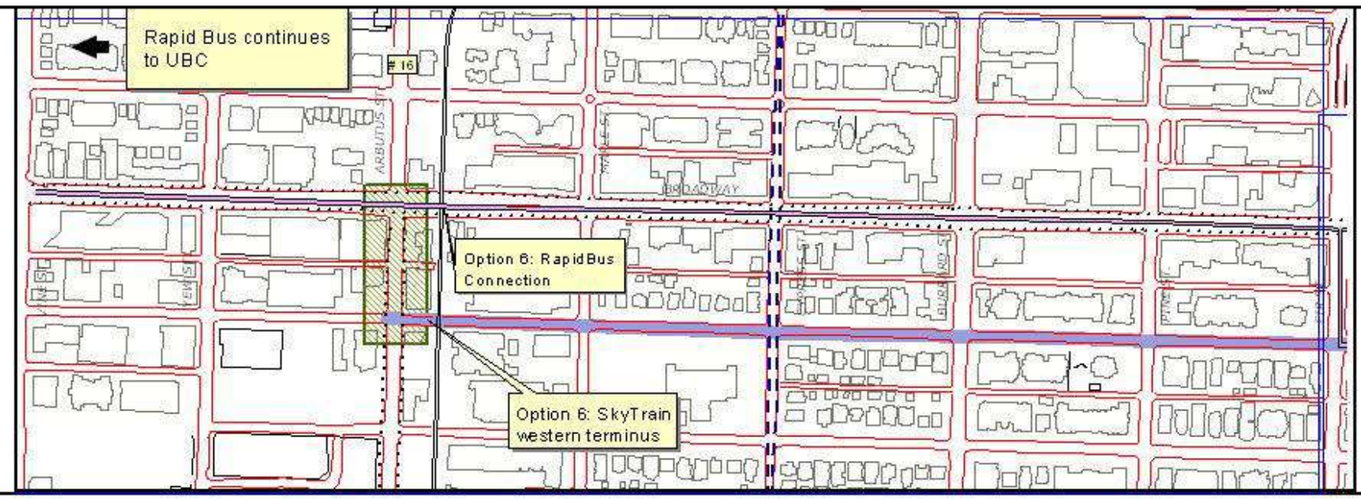
Sky Train Corridor Map

BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

RapidBus Route
Bikeways
Local Bus Route
Station
SkyTrain Alignment

MATCH LINE
SEE BELOW RIGHT



MATCH LINE
SEE SHEET ST3

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Sky Train Corridor Map

BROADWAY/LOUGHEED
RAPID TRANSIT LINE
PHASE 1 - Commercial Drive West

RapidBus Route
Bikeways
Local Bus Route
Station
SkyTrain Alignment

IV. Evaluation of Alternatives

This section provides a summary evaluation of the six alternatives selected by the Steering Committee for further assessment. The evaluation measures were also the subject of a review by the Technical Advisory and Steering Committees. The evaluation measures are intended to help define the ability of each alternative to meet project objectives as well as differentiate between the alternatives. Wherever possible, the evaluation measures are stated quantitatively; however, there are a number of the measures that by definition require a qualitative assessment. In the latter cases, the attempt will be to objectively evaluate the alternatives without interjecting a modal bias.

A. Evaluation Criteria

Each of the Broadway/Lougheed corridor alternatives will be assessed in terms of a series of evaluation criteria. The following provides a brief description of each criterion and the measures used to describe the consequences of each. Table 3 provides a summary description of the evaluation criteria and specific measures to be used in evaluating the options.

Capital Costs - Capital costs for all alternatives will be presented in 1999 dollars. Costs will include all direct construction costs including civil construction, systems elements, maintenance facilities, land acquisition, vehicles, and an allowance for general and administrative costs and contingency. To provide a more direct comparison of options, costs will also be developed on a cost-per-kilometre basis. Vehicle costs reflect year 2011 fleet requirements. Each SkyTrain alternative includes the identification of the costs required to provide RapidBus service from its western terminus to UBC.

Operating Costs - Annual operating costs in 1999 dollars will be developed for each option. Costs will reflect direct operating and maintenance costs. The costs will not include amortization of major equipment components such as vehicles. Calculations will identify offsets for savings from reduced local bus operations.

Cost Effectiveness - Cost effectiveness will be measured by operating costs per passenger. Two additional measures will be developed to further define differences between alternatives. Operating cost per passenger kilometre will introduce the added element of effectiveness of alternatives in accommodating the average passenger trip length. The final cost effectiveness measure will be the total cost per new passenger relative to a base which is defined as the B-Line service. The measure is an indicator of the effectiveness of the total expenditure of net operating costs and annualized project capital costs in attracting new passengers to public transit, as opposed to moving passengers from one public transit mode to another.

Table 3 Evaluation Criteria and Measures

Account	Evaluation Criteria	Descriptions/Consequences
Financial	Capital Cost	Capital Cost/Capital cost per kilometre
Financial	Operating Cost	Operating Costs
Financial	Cost Effectiveness	Operating cost per passenger
		Operating cost per passenger kilometre
		Cost per new passenger relative to base
Customer Service	Ridership	Annual boardings
		Annual passengers new to transit (Year 2021)
Customer Service	Connectivity (ease of transfers)	Qualitative comparison of a series of typical trips via each alternative
System Operation	System Performance	Average travel speed
		Travel Time
		-UBC to Commercial
		-Granville to Commercial
		-Cambie to Commercial
System Operation	System flexibility, reliability, and expandability	
		Ease or difficulty of integrating each alternative with a future north-south line, adding capacity and new stations
		Fleet availability and on-time performance
		Ability to expand the system to meet future demand
Urban Design/ Land Use	Consistency with City and Regional Plans and Policies	
		Support of Regional and City livability goals
		2021 mode split compared to targets of 38% for Central Broadway and 36% for UBC
		2021 population and employment within 500m of stations
Urban Design/ Land Use	Contribution to the pedestrian and bicycle environment	Qualitative evaluation of each alternative's contribution to the pedestran and bicycle environment and increase or decrease in confilcts
		Personal safety
Urban Design/ Land Use	Ability to generate positive land use changes	Assess ability to attract desired development, reduce commercial turnover, support existing development
Urban Design/ Land Use	Effects of construction on the community	Extent of traffic lane, parking and sidewalk closures/restrictions
		Number of bussiness loading zones affected
		Duration of costruction
Environmental / Community Impact	Contribution to clean air and noise environments	Number of autos in Central Broadway area (annual vehicles/km in millions)
		Positive or negative contribution to current noise levels
Environmental / Community Impact	Effects on vehicular traffic	Total vehicle delay
		Traffic diverted to alternative routes
		Ability of alternate arterial routes to accomodate displaced traffic
		Access restrictions to adjacent properties
		Streets with restricted turniing properties
		On-street parking lost

Ridership - Ridership will be reported as projected annual passengers. Projections will be generated utilizing the Emme/2 model. Also presented will be the number of annual passengers new to transit.

Connectivity (Ease of Transfers) - The ease of transferring within the transit system is a significant factor in potential users' acceptance and use of the system. This criterion will assess the total transfers and average time required to make a series of hypothetical trips via each alternative. A cross-platform transfer between two high-frequency transit lines is a relatively small factor compared to a one-block walk between lines. The above review will be summarized into a qualitative assessment of each alternative's (low, medium, and high) ease of transfers.

System Performance - System performance will be presented in terms of the average travel speed for the primary technology of each of the alternatives being evaluated. In addition, the scheduled travel time between major destinations served by each of the alternatives will be presented to further illustrate the difference in the performance of the alternatives. Selected destinations include:

- Commercial to UBC
- Commercial to Granville
- Commercial to Cambie

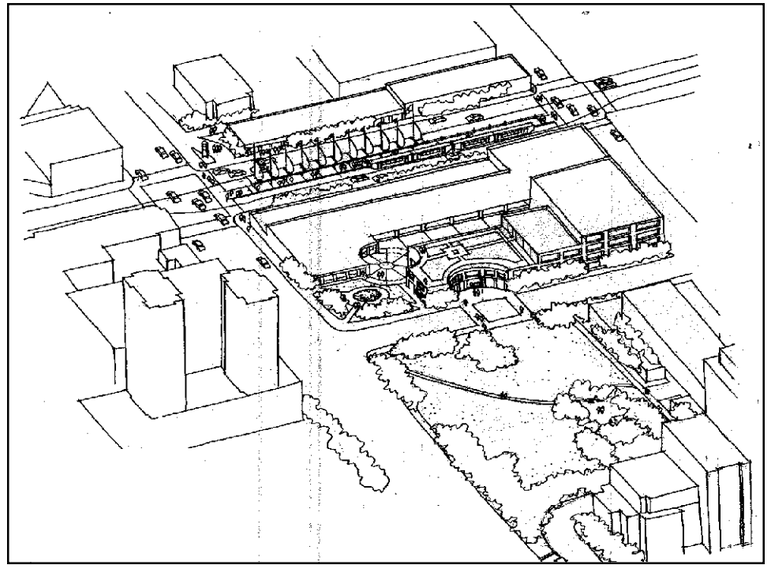
System Flexibility, Reliability and Expandability - The system will be evaluated with respect to the ease or difficulty of providing convenient passenger connections with the future north-south line, adding or maintaining capacity, and the ability to locate new stations in response to development. Reliability will be measured by each technology's record regarding fleet availability and service interruptions, as well as increased susceptibility to traffic and pedestrian interaction, accidents, and weather-related interruptions. If available, on-time performance will be used as a measure and if not available, a qualitative ranking of the alternatives will be used. The ease or difficulty of expanding the system to meet increased demand over time will also be evaluated.

Consistency with City and Regional Plans and Policies - Providing effective measures that distinguish each alternative's ability to support City and Regional land use and transportation plans and policies is difficult, partially because each technology option was selected for its ability to support plans and policies. To help distinguish the alternatives, three measures will be used:

1) For each alternative, the consistency with City and Regional plans and policies will be evaluated.
2) The mode 2021 split for each alternative will be compared with the Regional targets of 38 percent for Central Broadway, and 36 percent for UBC.
3) Population and employment within 500 metres of stations will be generated as an indication of the alternative's ability to enhance accessibility, providing stations that support development, and the ability to encourage transit as an alternative to automobiles.

Contribution to the Pedestrian and Bicycle Environments - A qualitative assessment of each alternative's contribution to the pedestrian and bicycle environment will be provided. The evaluation will be based in part on the reduction or increase in pedestrian/bicycle conflicts with traffic, ability to provide improved pedestrian/bicycle facilities, and pedestrian/bicycle access restrictions created. Personal safety will also be considered in terms of station location and design.

Ability to Generate Positive Land Use Changes - An evaluation will be conducted of the alternatives in terms of local community acceptability, potential for positive development impacts, and contribution to the City and Regional Land Use serving and shaping goals. The focus will be on the Central Broadway area, with each alternative rated on its potential to attract desired development, support existing development, reduce commercial turnover, and to otherwise enliven the Central Broadway area.



Effects of Construction - Each alternative will have different construction impacts. For each alternative, impacts will be described in terms of the overall duration of construction, the sequence of construction activity, and impacts on businesses, pedestrians, traffic, parking, and loading zones.

Contribution to Clean Air and Noise Environments - This study is not intended to develop detailed assessments of the before and after air and noise environment. As an indication of the project's contribution to air quality, each alternative will be described in terms of the reduction of the number of automobiles in the Central Broadway area against a base case of retaining the existing service on Broadway. Noise will be evaluated in terms of whether or not each alternative increases or decreases the current levels of noise experienced.

Effects on Vehicular Traffic - Each alternative is anticipated to impact vehicular traffic within the corridor differently. The impacts will be described as follows:

- Total vehicle delay as generated by the Emme/2 model.
- Level of traffic diverted to alternative routes and an assessment of the ability of those routes to accommodate the added traffic.
- On-street parking lost.
- Identification of access restrictions, including the number of driveways impacted and the number of minor (unsignalized) streets that will have restrictions in terms of turning movements.

B. Evaluation Results

The following paragraphs and matrix provide a summary of the evaluation of each of the six alternatives advanced for detailed evaluation. The matrix provides a quick method of arraying a substantial amount of material in a convenient format. The matrix also assists in understanding the relative strength and weaknesses of each of the alternatives and is the primary basis for the findings and conclusions for this review of the high capacity transit options for the Phase II (West) Broadway/Lougheed Corridor Study.

Capital Costs - Appendix B provides a summary of the estimated capital costs for each of the six alternatives. All costs are presented in 1999 dollars. The estimates are based on the available conceptual level of design and represent reasonable "order of magnitude" cost estimates, which provide the basis for comparisons between the various alternatives. For each of the alternatives, costs have been developed within the general categories of civil and systems, right of way, vehicles and interim financing and GST. In addition, for the SkyTrain options, none of which extend the full distance from Commercial Drive to UBC, an added category reflecting the cost of extending Rapid Bus service from the western terminus of SkyTrain to UBC is included. For each alternative, a total cost estimate is developed for the base option and for the full Commercial Drive to UBC distance. To provide an additional comparative basis, cost per metre tabulations are also provided for each alternative.

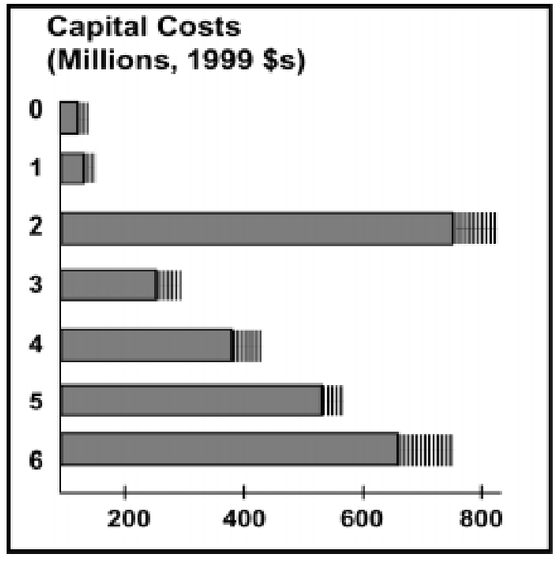
Costs of vehicles for each alternative are based on estimates of fleet requirements for year 2011, reflecting fleet required for startup plus a reasonable number of years of ridership growth. For all alternatives, identical add-on allowances were utilized to reflect the accepted local practices. The allowances are: design at 5%; project management at 7%; construction management at 6.5%; insurance at 1%; and contingency applied at 20%. Right of Way allowance is 5%; vehicle margin is 0.5%; interim financing is 5% per year and the GST is 3% on all costs.

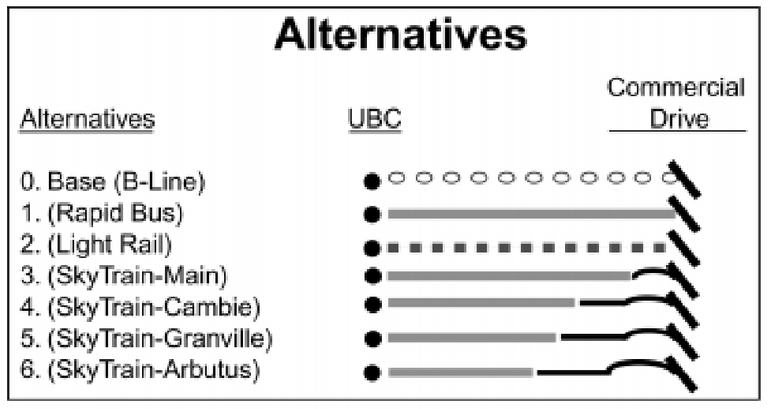
Cost estimates for the Rapid Bus and Light Rail alternatives are based on the conceptual designs described in Section III of this report. The consultant team developed estimates for these alternatives based on the cost experience with similar designs on other projects as well as the cost experience within the Vancouver area. The estimates for the SkyTrain alternatives were supplied by the Rapid Transit Project 2000 office, based on preliminary design work completed for the VCC west portion of the Broadway/Lougheed corridor by Baker McGarva Hart.

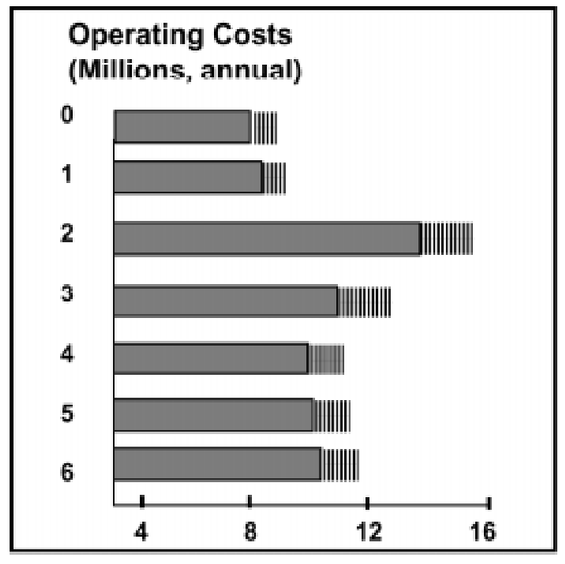
Also developed were the costs of implementing the RapidBus alternative utilizing diesel bus technology verses electric trolleys. Such a shift would reduce the costs of the RapidBus alternative by approximately $24 million, represented primarily by saving in the cost of diesel articulated buses verses electric and the elimination of the costs associated with the modification of the overhead system on Broadway, Alma, 10th and University.

Operating Costs – Operating cost estimates were developed for each of the six alternatives. For each of the SkyTrain alternatives (Alternatives 3, 4, 5, and 6) estimates were developed for both the VCC to western terminus segment and the RapidBus extension to UBC. The costs reflect the anticipated direct operating and maintenance expenses required to perform the service. The estimates do not include general administrative expenses or the amortization of equipment.

For each alternative service, frequencies were developed for weekday, Saturday and Sunday/Holidays. Peak hour headways for each of the alternatives were compared to the results of the EMME/2 modeling to determine if the originally inputted frequencies were adequate to handle the projected AM peak direction ridership. The review indicated that the headways for both the Light Rail (3 min.) and SkyTrain (2.75 min.) alternatives were adequate for the projected ridership volumes. A headway of 1.5 minutes is marginal to handle the projected ridership under the currently defined RapidBus alternative as well as to provide sufficient capacity to meet the projected demand under SkyTrain alternatives 5 (Granville) and 6 (Arbutus). Under SkyTrain alternative 3 (Main), the number of peak hour buses would need to be increased to approximately 50 buses (1.2 minute headways) to address the projected demand. Headways in this range would likely result in bunching of buses as they are impacted by signal cycle times and experience delays at individual stops.



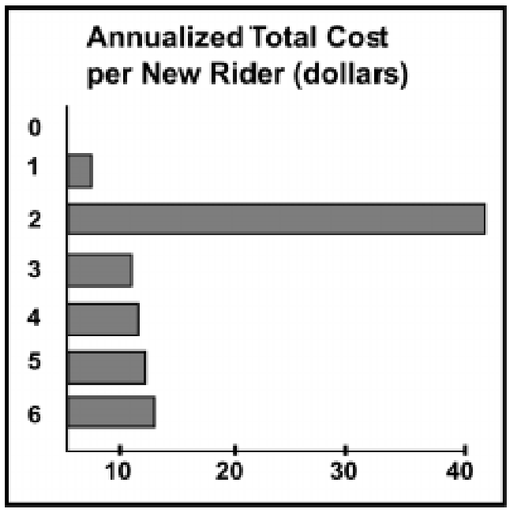




The projected levels of ridership suggest that if the TDM measures incorporated into the modeling process do have the results the model forecasts, the RapidBus alternative, as defined for purposes of this study, may be unable to address the projected demand within the 20-year time frame without a significant redefinition, which could involve a more exclusive operation coupled with substantial modification of the signal system.

Costs for the SkyTrain service were based on applying a rate of $1.57 per vehicle/km to the estimated annual vehicle km. For the RapidBus alternative a rate of $70.00 per service hour was applied to the estimated annual vehicle hours. Both of the above rates are based on operating experience in the Vancouver market. For the Light Rail alternative two methods were used to establish the operating costs. The first method was to utilize data from Calgary, which indicates
direct costs at a rate of $113.00 per service hour. The second method was to utilize the more traditional basis of estimating rail transit operating by costs by applying a cost per vehicle/km, in this case at a rate of $4.75.

Cost Effectiveness - Cost effectiveness is presented by three indices, which are intended to illustrate the differences between the alternatives. The first measure is operating cost per boarding passenger. The reader should recognize that the passenger projections are for year 2021 and the costs are stated in 1999 dollars. The resultant numbers serve to help compare the alternatives as opposed to stating the cost the system would experience to board one passenger. As anticipated, the SkyTrain alternatives are the most efficient in terms of carrying the volume of passengers projected. The RapidBus alternative, given its lower operating costs, performs better than the Light Rail alternative.

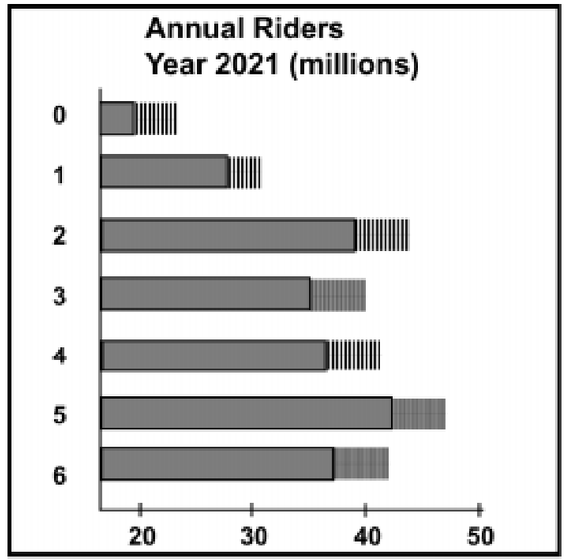


The operating cost per passenger kilometre measures results in the same relationship between the alternatives as the operating cost per passenger, with the SkyTrain alternatives performing best. The measure of total cost per new passenger is an indicator of the effectiveness of annualized capital dollar expenditures and annual operating expenditures in attracting new passengers to public transit, as opposed to moving passengers from one public transit mode to another. New passengers were determined by comparing each scenario to the base scenario which featured SkyTrain to VCC North and the existing B-Line service on Broadway, 10th and University. The comparison is on a full regional basis. Given its modest cost, the RapidBus (Alternative 1) performs best; while the Light Rail alternative, with its greater cost and slower travel times, is the least effective against this measure.

Ridership – Ridership estimates were developed for each of the six alternatives using the EMME/2 model. For each alternative, multiple model runs were conducted to gain a full understanding of the impact of differing assumptions regarding the average operating speed on projected ridership levels. All the modeling runs have the following features in common:

- All modeling runs were for the morning peak hour in year 2021.
- Annual figures for ridership were obtained by multiplying the morning peak hour figure by 3,187.
- The land use data used in the modeling is the same as that used in the RTPO work with two exceptions:
    a. The City of Vancouver provided updated 2021 projections for zones within the City.
    b. UBC enrollment was projected to grow at a 1% per annum verses the 0% utilized in the RTPO work.
- For modeling purposes, a north-south rapid transit corridor was assumed as SkyTrain technology on Cambie.

As specified by the project Technical Committee, the modeling incorporated use of a "partial" Transportation Demand Management (TDM) program. Included were assumptions regarding increases in the Gas Tax sufficient to raise vehicle operating costs by 17% through 2006 and by 33% by 2021 and increases in parking cost by 25% for 2006 and 50% by 2021. No tolls were assumed. These assumptions increase the ridership levels on all the transit alternatives. The surface alternatives benefit significantly from the projected decreases in auto volumes in the corridor. For the reported ridership levels inputted average speeds of 25 km/hr were utilized for the Rapid Bus and Light Rail alternatives. For the SkyTrain alternatives, an average speed of either 35 or 36 km/hr as generated by the model is utilized. The average speed for the SkyTrain alternatives is reflective of the closer station spacing on this segment of the system.



The following are the EMME/2 model outputs for AM peak hour/peak direction loads and headways as well as the planned headways. The planned headways for the SkyTrain alternatives are dictated by the estimated load factors on the line segment east of the Broadway Station. The model is assigning transit volumes that would necessitate RapidBus headways in the range of 90 seconds. The model is indicating that level of demand will exist, whether or not the alternative can accommodate it. Of course, if the TDM measures are less effective than the model suggests, the peak volumes will decline and the RapidBus option would require a less intense service level.

	Alt. #1	Alt. #2	Alt. #3	Alt. #4	Alt. #5	Alt. #6
Peak one-way load	4,580	6,050	2,210	5,260	6,580	6,440
Model generated headway (min.)	1.4	3.2	15.3	6.4	5.2	5.3
Planned headway (min.)	1.5	3.0	2.75	2.75	2.75	2.75

Connectivity – The RapidBus and Light Rail alternatives do not require a transfer to traverse the UBC to Commercial Drive corridor. They both do require a transfer to occur at Commercial to access the existing SkyTrain service. All the SkyTrain alternatives do require a transfer to occur in order to traverse the entire length of the corridor. The number of annual transfers varies with each SkyTrain alternative. The EMME/2 model projected 7.3 million transfers for the Main terminus, 10.8 million for the Cambie terminus, 7.0 at Granville and 8.4 at Arbutus. In terms of traversing the length of the corridor the two surface alternatives offer the advantage of a no transfer trip.

In terms of connecting to the numerous local transit services which run both parallel and intersect the Broadway, 10th, and University alignments, the Light Rail alternative performs best given its more frequent station locations in the corridor. RapidBus would intersect the next highest amount of local service with the SkyTrain alternatives 4, 5, and 6 providing the least number of connections. The SkyTrain alternatives do offer the opportunity to improve the quality of some transfers by reducing the number of surface street crossings required by transferring passengers. Connections to a north-south Cambie SkyTrain line would best be accommodated by the SkyTrain alternatives 4, 5 and 6. SkyTrain alternative 3 (Main Street terminus) would not connect directly to the Cambie line, requiring a double transfer and therefore represents the least effective of all the alternatives. Direct connections to the substantial service on Granville are provided by the RapidBus, Light Rail and SkyTrain alternatives 5 and 6.

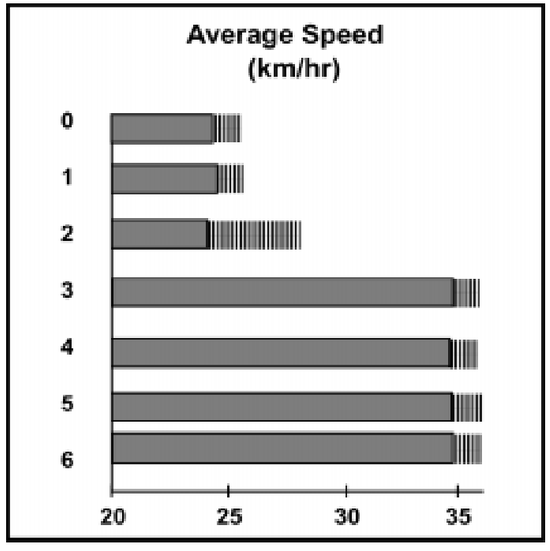
System Performance - System performance is measured in terms of the average speed for each of the alternatives and the average travel time required to travel between major destinations served by the alternatives. The modeling process was used to generate information regarding varying average speeds for each of the alternatives. The EMME/2 model generates an estimated travel speed based on station spacing, station dwell-time values and vehicle acceleration/deceleration characteristics. Also impacting the travel speed are assumptions regarding implementation of TDM measures such as added parking fees and the level of gas taxes. For each of the alternatives, the model establishing an average travel speed is as follows:

Alternative	Avg. Speed
RapidBus	31 km/hr
Light Rail	30 km/hr
SkyTrain (Main)	35 km/hr
SkyTrain (Cambie)	36 km/hr
SkyTrain (Granville)	35 km/hr
SkyTrain (Arbutus)	35 km/hr

Based on a further evaluation of the operating environment on 10th, Alma, and Broadway, a decision was made to utilize a 25 km/hr speed for the RapidBus and Light Rail alternatives for purposes of this evaluation.

Data was also produced for travel times between major destinations within the corridor (UBC to Commercial, Granville to Commercial and Willow to Commercial). The travel time information is summarized in the evaluation matrix. A note regarding the reported travel time is that for some of the RapidBus and SkyTrain examples the model is assigning trips to the parallel local service (#9 or #10) which may have closer stops, therefore shorter walking distance and in some cases an overall time advantage. In all cases the Light Rail alternative has slightly longer travel time, primarily due to the more frequent station spacing in the Central Broadway area.

System Flexibility, Reliability and Expandability – Each alternative was evaluated with respect to how well passenger connections with future north-south high capacity transit service could be accommodated. If the north-south line is a subsurface SkyTrain line on Cambie, alternatives 4, 5 and 6 would offer the possibility of either a cross-platform transfer or a non-surface platform to platform connection, neither of which would require passenger connections to occur on the surface streets. Alternatives 4, 5 and 6 would also present the opportunity to reduce surface conflicts between transferring passengers and automobile traffic. Alternative 3 (SkyTrain to Main) would essentially function the same as the Rapid Bus and LRT options from a transfer perspective. However, with an added transfer required at Main, this alternative is substantially disadvantaged compared to the other alternatives. If the north-south line were an Arbutus LRT line, the alternative that would offer the connection with the least conflicts would be the SkyTrain



Arbutus Alternative 6, which would offer the opportunity for the access points to be located in a manner which lessens the number of pedestrian/auto conflicts. In terms of adding capacity and new stations the Rapid Bus alternatives would have an advantage over the other options in terms of both the ease and the cost of adding both capacity and stations.

Each of the technologies evaluated has a good history of fleet availability to provide the scheduled service and operating on schedule. With each fleet involving electric propulsion systems, it can be anticipated that all will experience excellent availability records as measured by sufficient vehicles being available to completely fill the daily scheduled fleet requirements. It can be anticipated, based on operating experience with SkyTrain and numerous LRT operations, that these alternatives would experience slightly higher levels of availability than the RapidBus trolleybus alternative (Alternative 1).

The on-time performance of any transit mode is a function of the dependability of the equipment and the absence of auto and pedestrian movements which conflict or potentially conflict with the operation of the transit line. The SkyTrain alternatives, with segregated right of way for operations and a solid dependability record, are anticipated to perform better than the other options in terms of on-time performance. The Light Rail alternative with separated center running can be anticipated to have an advantage over the Rapid Bus in terms of having fewer conflicts with automobile and pedestrian traffic. The Light Rail alternative also would have all crossing and turning traffic controlled by signals as opposed to the Rapid Bus alternative which would be subject to some interruptions due to conflicting auto turning movements. In terms of the entire alignment from Commercial to UBC it is anticipated Alternatives 2 (LRT) and Alternative 6 (SkyTrain to Arbutus) would perform best in terms of overall performance.

The ability of the alternative technologies to be expanded to meet future demand differs in terms of ease or difficulty of implementation, cost, and ability to secure added equipment. The Rapid Bus technology is clearly the most flexible and inexpensive in terms of extending or expanding the system. SkyTrain technology would represent the most expensive and potentially the most time consuming option to expand.

Urban Design and Land Use - The urban design/land use evaluation focused on the central part of the Broadway corridor, between Main and Arbutus Streets. It addressed a broad range of considerations which are summarized in the evalu-

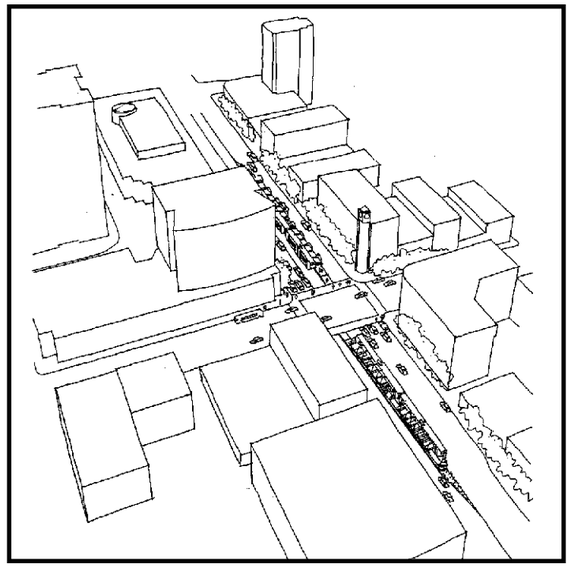
ation matrix under four categories:

- Consistency with City and Regional Plans and Policies
- Contribution to the Pedestrian and Bicycle Environment
- Ability to Generate Positive Land Use Changes
- Effects of Construction on the Community

The accompanying matrix summarizes the entire list of considerations the urban design team addressed. The alternatives are defined as described in the previous sections of this report. As an additional clarification, for this evaluation each SkyTrain station is assumed to have one passenger entry/ exit point (station house), and a second emergency-only exit. Secondary station entry points may be added in conjunction with adjacent property redevelopment by either the public or private sectors. The station house assumptions are as follows:

- Main/Kingsway: Southeast corner of Broadway and Kingsway
- Cambie: East side of Cambie Street between Broadway and 10th
- Oak: Southeast corner of Oak and 10th
- Granville: Mid-block on the east side Granville between Broadway and 10th
- Arbutus: South side of Broadway immediately east of the Arbutus rail alignment

For each of the six alternatives, more than thirty urban design criteria were assessed. Seven major categories of assessment were considered:



1. Supports regional/city livability goals
2. Supports zoning and corridor vitality
3. Potential to enliven central Broadway
4. Effect on neighborhood livability
5. Effect on commercial vitality
6. Promotion of station place
7. Support for modal transfers

As one tool in the evaluation of the alternatives in central Broadway, the results of the urban design evaluation are summarized and graded from lighter to darker as the assessment of each alternative shifts from better to worse. On balance, each of the three technology options is a positive addition to the urban fabric of Central Broadway. Each has its own set of advantages and disadvantages. Each option can be improved at the stage of detailed design. Conversely, detailed design can reduce or even eliminate anticipated benefits. Input from the public consultation process will be an important factor in assessing each option and maximizing benefits.

Of the criteria evaluated, less than half of the criteria showed a difference between the options of more than one position on the scale from "better to worse". In other words, where one option was seen to have an advantage the other options also tended to have an advantage, even if there was a slightly different magnitude. While the chart does not weight any individual criterion as more important than another, it is recognized that every person will have their own point of view for relative importance of the criteria. The summary chart represents the collective opinion of the consulting team on these items, without the weighting of individual items.

SkyTrain

Not surprisingly, when more SkyTrain stops are provided in central Broadway the evaluation finds greater urban design benefits, and the greatest support

Central Broadway (Main to Arbutus): Urban Design and Land Use Evaluation Summary

The table below is a subjective and value-based evaluation from the urban design and land use perspective of implications in central Broadway (Main to Arbutus) for each proposed technology and route option. It is intended to serve as a starting point for public discussion. Details in Appendix C.

Criteria	Rapid Bus	LRT	SkyTrain/ RapidBus			
	SkyTrain West Terminus		Main	Cambie	Granville	Arbutus
1. Supports regional/city livability goals	◠	○	◠	◠	○	○
2. Supports existing zoning and corridor vitality	◠	○	◠	◠	◠	◠
3. Potential to enliven central Broadway						
.1 Effect on Broadway pedestrian traffic	●	▬	●	▬	▬	▬
.2 Contribution to traffic calming (off-peak)	◠	●	◠	▒	▒	▒
.3 Effect of parking changes on street life (peak)	▬	▒	▬	▒	▒	▒
.4 Effect of parking changes on street life (off-peak)	▒	●	▒	▒	▒	▒
.5 Noise and vibration effects	▒	◠	▒	◠	◠	◠
4. Effect on neighbourhood livability						
.1 Minimizes residential impacts	▬	▬	▬	▒	▒	▒
.2 Low impact on heritage sites	▒	▒	▒	▬	▬	▬
.3 Protection of existing mature trees	▬	▒	▬	▬	▬	●
.4 Reduces local reliance on automobiles	○	○	○	○	○	○
.5 Improved transit access to the region	◠	◠	◠	○	○	○
.6 Aesthetic and safety benefits of new streetscapes	▒	○	▒	▒	▒	▒
.7 Probable interest in enhanced security staffing	▒	▒	▬	●	●	●
.8 Crime Prevention Th. Environmental Design needs	▒	▒	▬	▬	▬	▬
.9 Neighbourhood construction impact	▒	●	▬	▬	▬	▬
.10 Supports N-S activity across Broadway (walk, auto, cycle)	▒	▬	▒	▒	▒	▒
.11 Wheelchair accessibility to transit system	◠	●	◠	◠	◠	◠
5. Effect on commercial vitality						
.1 Construction effect on businesses	▬	●	▬	▬	▬	▬
.2 Enhances business for existing premises	◠	◠	◠	○	○	○
.3 Serves existing employment centres	◠	○	◠	◠	○	○
.4 Effect on goods delivery	▒	▬	▒	▒	▒	▒
.5 Catalyst for area redevelopment (500 m radius)	◠	◠	◠	◠	◠	◠
.6 Opportunity for new major projects	◠	○	◠	○	○	○
6. Promotion of station place						
.1 Promotes pedestrian street life at stations	◠	○	◠	○	○	○
.2 Opportunity to enhance station areas	◠	◠	◠	○	○	○
.3 Promotes neighbourhood identity at stations	◠	○	◠	◠	◠	◠
.4 Ability to serve pedestrians at station entry	●	●	●	▒	●	●
.5 Opportunities for public art at stations	◠	○	◠	◠	◠	◠
.6 Opportunity for shops/street vendors at stations	▒	◠	◠	○	○	○
.7 Effect of venting & emergency exits at stations	▒	▒	▬	▬	▬	▬
7. Support for modal transfers						
.1 Link to local bus routes	▒	○	▬	▒	▒	▒
.2 Link from SkyTrain to Rapid Bus	▒	▒	▒	◠	▬	▬

COMPARED TO EXISTING: ***Key:*** ○ Better ◠ to ▒ ▬ ● Worse

for regional and city livability goals. A terminus at Main has modest benefits, while extending SkyTrain to Granville or Arbutus maximizes connectivity of central Broadway to the regional transit network, and has the most potential to act as a catalyst to new development.

SkyTrain to Arbutus keeps the most options open for N-S rapid transit links, and offers advantages for station enhancement and commercial development benefits. One key disadvantage found for SkyTrain is the probable interest of neighborhood residents and businesses in enhanced security staffing in underground passageways and stations. From Cambie west, the SkyTrain station construction may threaten mature trees on 10th Avenue, depending on construction techniques chosen.

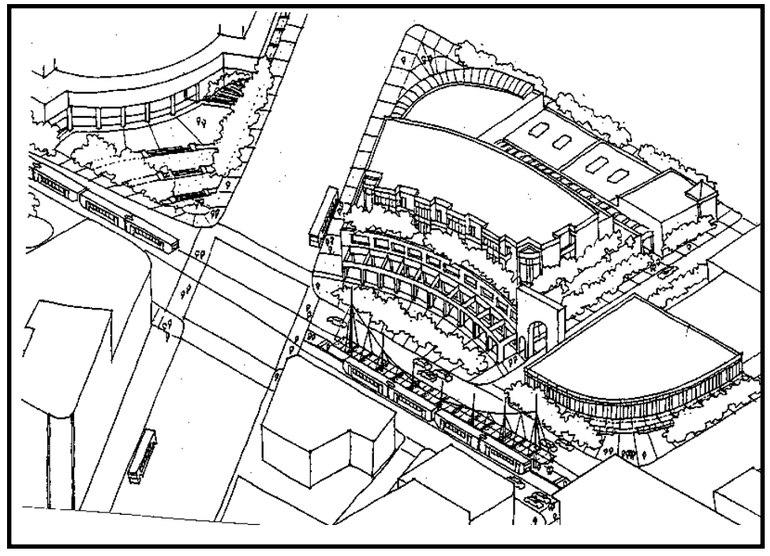
A decision on a preferred north-south rapid transit route is essential to choosing a western terminus for the Broadway SkyTrain to maximize local and regional benefits. For example, a terminus for SkyTrain at Main offers no connection to the three options for north-south rapid transit. A decision to terminate SkyTrain at Cambie, followed by a choice of Arbutus or Granville as the north-south connection to downtown would similarly fail to maximize the benefits of linking the rapid transit routes. From this perspective, it is preferable to decide on a north-south routing of rapid transit in Vancouver prior to choosing a western terminus for SkyTrain. In the interim, planning for a terminus at Arbutus is the only SkyTrain choice that preserves all three options for north-south linkages.

LRT

LRT has advantages over other options for enlivening Broadway between major arterials, and connecting to a potential north-south LRT line at Arbutus or to the Granville RapidBus. It also shares with SkyTrain the benefit of significantly supporting livability goals of the region and city. LRT, as proposed, receives a low rating in the urban design analysis from the permanent reductions proposed in on-street parking. First, these reductions fail to contribute to traffic calming. Second, the removal of on-street parking in favour of retaining four general-purpose traffic lanes also impacts merchants and all users of the sidewalk environment. LRT is at a comparative disadvantage in providing for wheelchair accessibility because of narrow platform widths. It also interferes with cross-Broadway movements by all modes, and construction impacts may be substantial on adjacent retailers, businesses and residents from the reconstruction of the entire street bed. On the other hand, reconstruction of the sidewalk and streetscape from property line to property line has the potential to enhance the commercial vitality of central Broadway through investment in new sidewalks, lamp posts, landscaping and other street furniture elements.

RapidBus

Like the other technologies, RapidBus supports explicit livability goals of the region and city. RapidBus continues the elimination of on-street parking at peak hours with negative impacts on adjacent sidewalk comfort. It also suffers with LRT and SkyTrain at Granville from difficulty serving anticipated pedestrian volumes along the constrained sidewalk widths, particularly at intersections with left-turn bays. In general, the RapidBus option offers few major advantages or disadvantages over the two train technologies.



Light Rail Concept at Main & Kingsway

Opportunities to Enhance the Alternatives

Each technology can be improved upon detailed design, and detailed examination of station zones. For example, several SkyTrain stations have good opportunities for secondary entries if adjacent sites were to redevelop and construct direct access to the SkyTrain stations; assuming security, safety and operational concerns of TransLink and the City can be met. With only one direct entry, the evaluated SkyTrain proposal provides poor access to users of the No. 3 Main Street bus, the employment node at Vancouver Hospital, and to people boarding the RapidBus at Granville.

Widening of selected LRT station platforms would improve transit passenger comfort and safety, especially with regard to wheelchair accessibility, but require building setbacks or right-of-way acquisition outside the scope of this conceptual study. Columbia and Willow stops are particularly constrained by narrow platform widths.

With Rapid Bus, increasing bus volumes and general traffic congestion over time may warrant provision of exclusive bus lanes in selected segments of central Broadway to accommodate increased passenger demand. The RapidBus option may be further enhanced if station and streetscape design were to reflect a level of financial commitment in these budget items comparable to the alternative technologies, taking into account ridership forecasts.

Consistency with City and Regional Plans and Policies – The alternatives were reviewed with respect to the ability of each to support regional and city goals of encouraging public transit use, discouraging single occupancy vehicle travel and making transportation investments which support land use strategies. The Light Rail alternative along with the SkyTrain alternatives which cover the entire Central Broadway corridor (Granville and Arbutus) are seen as the best performers in terms of moving towards accomplishing the above goals. The alternatives were also evaluated in terms of their ability to meet the year 2021 mode split targets for both the Central Broadway area and for UBC. Each of the alternatives meets the established goals during the am peak period. A major element in meeting the goals is the TDM measures. Without the assumed TDM measures the goals for UBC would be marginally met during the peak hours, however the Central Broadway goals would not be met. Also evaluated was the year 2021 employment and population within 500m of stations for each option. Again there is little difference between the

alternatives, although the Light Rail alternative does serve a higher combined total, based primarily on the closer station spacing in the Central Broadway area.

Contribution to the Pedestrian and Bicycle Environment – Several measures were considered to result in a qualitative measure of the contribution each technology can make to the city's bicycle and pedestrian environments.

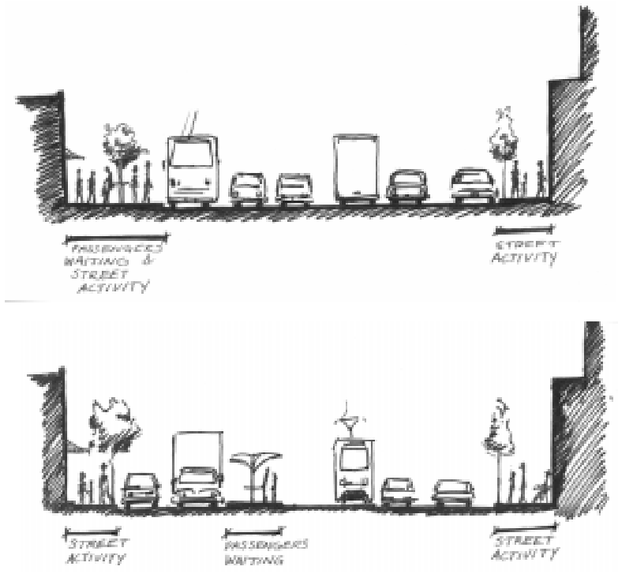
To evaluate the pedestrian environment, a review was conducted of:

- *Variation from the existing sidewalk width.* Addition to or subtraction from the existing sidewalk width could be expressed as a numerical total, but is more informative when considered as a pattern along the entire alignment. For example, while the Light Rail design could widen sidewalks in the Central Broadway area, more often than not the sidewalks (as well as the travel lanes) are narrowed to accommodate the LRT alignment. Rapid Bus and SkyTrain, on the other hand, can be accommodated with minimal disruption of the existing sidewalk.

- *Platform location in relation to the sidewalk.* This measure addresses both how the platform activity will relate to the sidewalk activity as well as the potential for auto conflicts with pedestrians accessing the platform. The different modes exhibit clear differences in this category. The LRT platforms are located in the center of the street, away from sidewalk activity. While this separation may ease pedestrian congestion on the sidewalk in busy areas, the waiting passengers are isolated from the "eyes on the street" in adjacent buildings, and surrounded by city traffic. Accessing these platforms will always involve street crossings, and potential conflicts with through and turning traffic. The RapidBus stops either at the curb or at a curb extension, effectively using the sidewalk as the platform in either case. Potential for pedestrian/auto conflicts is lower. If local bus stops are coordinated with the RapidBus, some transfers could occur without forcing passengers to cross traffic. SkyTrain stations would be underground, directly connecting Broadway and the platform below 10th Avenue. Pedestrians would be forced to cross auto traffic less, but would be more isolated from the street life of Broadway and 10th Avenue, and would have relatively long walks from the surface access points to the platforms.

Current and planned bikeways in the Broadway corridor direct bike traffic onto streets north of Broadway (mostly 7th and 8th). Along the corridor, four designated bikeways cross Broadway, and University Boulevard is striped with bike lanes leading to UBC. Each mode was evaluated by how it impacts these facilities, as well as how it changes the existing conditions for cyclists who chose to ride on Broadway/10th Avenue.

- Both LRT and Rapid Bus will impact the existing cycling environment on Broadway. The street design for LRT on most of Broadway will narrow all travel lanes, including the curb lane where cyclists ride. A narrower lane will increase the possibility of auto/bus/bike conflict. LRT will cross bikeways at four points, which should receive carefully designed intersection treatments to minimize bike/train conflicts. Rapid Bus could potentially have a greater impact on bike traffic, because the buses will run in the curb lane with local buses and general traffic. Bus operator training and clear traffic signage can help alleviate potential conflicts. SkyTrain, on the other hand, will have the least impact on bike traffic, because it is grade separated. If SkyTrain operation results in a decrease in bus or auto traffic, bicycling conditions could be improved.



- Neither the LRT nor the Rapid Bus will impact the University Boulevard bike lanes.

Ability to Generate Positive Land Use Changes – With the possible exception of the Main SkyTrain alternative, all the alternatives are seen as supporting the land use objectives of the Central Broadway area and objectives for revitalizing the area. The rail options and in particular the SkyTrain alternatives present the best opportunity to help attract new major projects. All the alternatives support the existing land use plans and zoning for the area and, with the exception of the Main and Cambie SkyTrain options, they all effectively serve the existing employment centres in the corridor. The more frequent station spacing under the Light Rail option in the Central Broadway area results in more population and employment within walking distance. The location of the access points to the SkyTrain alternatives will be important to providing good access to major employment locations such as VGH.

Effects of Construction on the Community

Rapid Bus

Based upon the conceptual level of design and planning to date, the Rapid Bus alternative would clearly have the least amount of impact on the community during construction. Physical construction would be limited to the area within approximately half a block radius of platforms or curb extensions. In addition to construction impacts, there will be some disruption of trolley bus service while the electrical system is modified to accommodate a second line. Overall construction is anticipated to require less than one year.

LRT

The analysis presented is based on the conceptual level of design and many assumptions are made in order to develop a reasonable approach to construction staging and impacts. It is assumed that access to businesses will be maintained at all times, and through traffic would be provided for during construction. At minimum, one lane per direction of traffic would be maintained on Broadway and 10th. It is also assumed that existing utilities that fall under the trackway in the LRT option will be relocated under a travel lane. All existing utility connections would be reconnected to the new systems and all structures relocated outside of the trackway.

An analysis of the staging and impacts is developed on a per

block basis. The total estimated time for each block is assumed to be six months from the time construction begins to the time all work on the block is complete. Each block would have two primary phases. The first allows the contractor to occupy the center 13 metres of the ROW, providing for the utility relocation, the trackway construction, station area construction, and two travel lanes. It is estimated that this work will take approximately four months to complete. Once this phase is complete, traffic can be diverted to the inside lanes and work on the curbs, sidewalks, pavement, and traction electrification system can begin. All platform amenities can be complete during this phase. The second phase will require approximately two months to complete.

Work for various elements in each phase can overlap from block to block. Typically, work is restricted to a limited area of three blocks at a time. Work could advance to the next block in two-month increments. It is anticipated that construction would be initiated in two or more segments in order to reduce the overall duration of construction.

Impacts to the streets will vary during the construction of each block. The greatest impact will be at the intersections, as the cross-street traffic would have to be maintained. At minor streets, an option of complete intersection closure versus partial intersection closure should be evaluated further to determine impacts to the schedule. Total construction time will depend upon the number of construction zones operating simultaneously that will be allowed. A total of 3 to 3-1/2 years would be normal for such a project.

SkyTrain/RapidBus

The analysis presented here is based on the conceptual drawings provided by the SkyTrain project office and assumes a dual tunnel system would be constructed. Each tunnel will be constructed using a tunnel-boring machine that is capable of traversing 16 metres a day. Station areas will require a block to construct and will be of cut-and-cover type construction after the tunnel boring process has been completed.

There are no significant impacts to the blocks outside the station areas other than construction-related traffic. It will take approximately one month of boring per tunnel to traverse a block, provided soil conditions are adequate.

The station area construction, however, will have a much greater impact on the blocks and intersections. A cut-and-cover approach to tunneling access to the stations will be required. A portion of the street will be excavated to allow ventilation systems to be installed. Utilities will be relocated to allow shaft construction, during which traffic lanes need to be maintained. It is estimated that impacts to the streets will take fourteen months from the time construction begins on the stations until work is contained to the buildings. Total construction would depend upon the length of each alternative.

<u>*Contribution to Clean Air and Noise Environments*</u> – As an indication of the changes the six alternatives would have on the air and noise environment within the corridor, the annual auto vehicle-km were calculated for each alternative and compared to an option of retaining the current auto lane configurations and transit service (B-Line and local) in the corridor. All the alternatives perform better than the base case in terms of reducing the total vehicle-km in the corridor and therefore should see some level of reduction of auto-generated air pollution. The RapidBus and Light Rail perform slightly better, in part because they both to some degree reduce available auto capacity.

The noise levels experienced within the corridor will differ with each alternative. The RapidBus alternative would see some decreased noise if trolley buses are used in service. If diesel technology were to be used, the noise levels would be similar to today, only impacted over time by the increased volume of vehicles. The Light Rail alternative would offer the dual benefit of reducing the overall level of traffic on the street as well as replacing the current B-Line diesels with electric vehicles. The SkyTrain would generate no additional noise at the surface level of the street. The Granville and Arbutus alternatives would result in the current B-Line diesels being removed from the Central Broadway area, which would result in some reduction of noise levels.

<u>*Effects on Vehicular Traffic*</u> – The matrix identifies the total vehicle delay in annual millions of hours for each alternative. The amount of delay is more for the surface alternatives with the Light Rail introducing the greatest amount of impact by a fairly substantial amount over the other alternatives. The impact of the assumed TDM measures results in overall minor reductions for most of the rest of the alternatives. The Light Rail delay is created by restrictions on the number of travel lanes and the number of signalized crossings, which will be modified to accommodate the rail operations. With exception of the Light Rail alternative none of the options result in any significant diversion of traffic to alternative streets. The Light Rail alternative will result in minor diversion of traffic with the exception of western end of the project where 630 AM peak vehicles will be diverted to Sixteenth Avenue east of Blanca. Otherwise, any other locations where a possible diversion of traffic is identified the parallel routes can absorb the traffic. The Light Rail alternative is also the only alternative with any substantial amount of impacted accesses to adjacent properties (90), streets with restricted turning movements (25) and loss of on-street parking (1100). The RapidBus alternative would result in minor loss of on-street parking (60), as would the SkyTrain alternatives, at the western terminus locations where connections to RapidBus (25-30) would occur.

V. Findings and Conclusions

The following is a summary of the key **findings** that result from the current study of alternatives considered for implementation in the Broadway/ Lougheed corridor west of Commercial Drive. This listing is not intended to be exhaustive, rather it identifies the factors that may be of significance while coming to a decision regarding the selection of an appropriate solution to the long-term transportation needs of this corridor. The findings are organized to address the three general technology options under consideration; RapidBus, Light Rail and SkyTrain. The General category is intended to capture findings which relate to all the options.

General

- Identification of a preferred north-south rapid transit solution is an important aspect to both the initial selection and the planning and design of the Commercial Drive west portion of the Broadway/Lougheed corridor.
- Pending identification of an additional north-south rapid transit line, RapidBus on Granville becomes a significant element in the regional system with added importance for direct connections to the high capacity option serving the Commercial Drive west portion of the Broadway/ Lougheed corridor.
- Besides assumptions regarding the average speed each alternative can achieve, ridership modeling results are most significantly impacted by assumptions regarding the implementation of Transportation Demand Management programs designed to discourage automobile use.

RapidBus

- The RapidBus alternative, as well as RapidBus service connecting to each of the SkyTrain alternatives, requires headways of 1.5 minutes or less by 2021.
- By a substantial margin, the RapidBus alternative is the least cost option, however, it also produces the least amount of ridership.
- The RapidBus alternative can be operated using either diesel or electric technology. Electric vehicles offer a less intrusive approach in terms of noise and air impacts within a corridor experiencing heavy pedestrian activity, but do so at the expense of the operating complexities of having both local and express trolley buses on the same street. Diesel vehicles would result in lower capital cost requirements and would avoid the operational conflicts that trolley buses would experience.
- While not inconsistent with land use, transportation and livability goals, RapidBus is viewed as the least effective of the alternatives in supporting or achieving such goals.
- RapidBus introduces the fewest construction impacts of all of the alternatives and would require the shortest duration to complete construction.

Light Rail

- With extensive improvements required the length of the corridor, LRT is the most expensive alternative from a capital cost standpoint.
- In order to develop operating speeds in the 25 to 30 km/hr range, the LRT requires a semi-exclusive median-running design with partial signal preemption and signal progression.
- Of the alternatives, LRT requires the most intense use of the current right-of-way, resulting in loss of auto capacity, on-street parking and limiting of current access points including minor street crossings.
- The frequent station spacing within the Central Broadway area provides direct pedestrian access to a larger base of population and employment resulting in high ridership.
- LRT provides excellent connections to both the local and regional transit network.
- The LRT alternative would result in significant construction impacts in the corridor.
- LRT has sufficient capacity to meet projected demand to year 2021. Additional capacity can be gained by either decreasing headways below three minutes or extending station platforms to accommodate three car trains (the exception would be the Main/Kingsway station, which would either have to be moved or placed under ground).

SkyTrain / RapidBus

- Although the most expensive alternative on a per kilometre basis, when combined with the RapidBus to provide service to UBC, the SkyTrain costs are less than the LRT alternative.
- SkyTrain has sufficient capacity to meet year 2021 ridership projections and can meet demand beyond 2021 through increased service frequency and adding cars to each train.
- If the north-south line is SkyTrain on Cambie, the SkyTrain alternative offers the opportunity for direct cross-platform transfers. Transfers to surface routes and connecting RapidBus service, while requiring more time, can avoid some of the pedestrian/auto conflicts inherent in the other alternatives.
- Construction impacts will be confined primarily to station areas and routes used to haul construction materials and excavation spoils.
- SkyTrain options that travel the length of the Central Broadway corridor (to Granville or Arbutus) are considered to have high probability of generating positive land use changes.
- The SkyTrain alternatives will have the least impact on surface streets such as Broadway, displacing no traffic capacity, access points or parking, with the minor exception of locations providing transfers with the RapidBus extension to UBC.

In addition to the above findings, the following is a listing of **conclusions** developed while evaluating the various options addressed in this study:

- ❖ The lack of definition of the preferred north-south corridor and technology detracts from making a definitive decision regarding the appropriate solution for the Broadway/Lougheed (west of Commercial Drive) corridor.

- ❖ The SkyTrain Alternative 3 (Main/Kingsway) involves considerable expense while providing few benefits to the Central Broadway or UBC that are not otherwise available through implementation of the RapidBus alternative. The alternative should be dropped from further consideration.

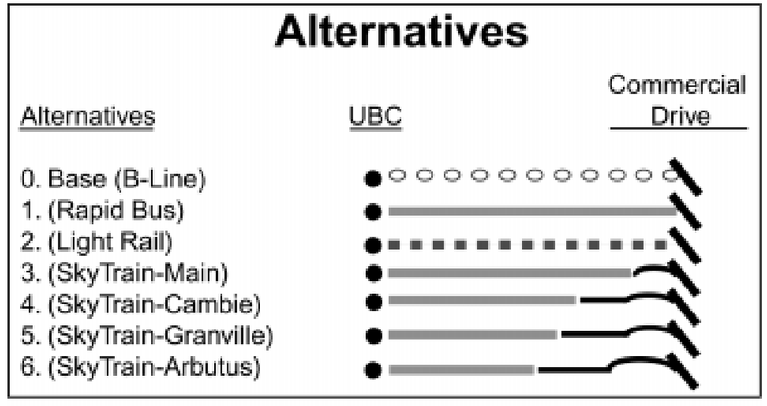
- ❖ The RapidBus alternative may best be viewed as an interim corridor solution unless it evolves over time to a more exclusive operation which would initiate the traffic and displacement impacts associated with the LRT alternative.

- ❖ Although high in ridership, LRT under any design scenario that provides a competitive operating speed introduces the greatest impacts in terms of displacement of current pedestrian, traffic, parking and access uses.

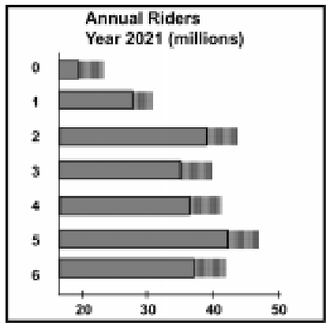
- ❖ The SkyTrain alternatives produce high ridership levels while introducing the least impact on the current transportation system.

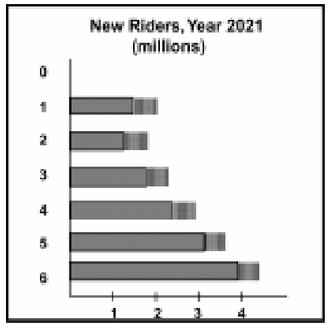
- ❖ In order for the SkyTrain technology to deliver its maximum benefit in meeting the transportation and land use goals of the Central Broadway area, it would have to extend west of Cambie to either Granville or Arbutus.

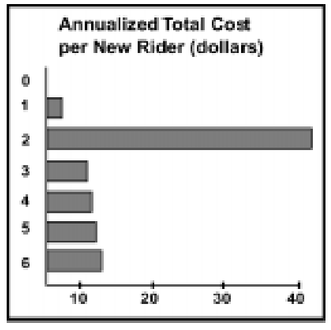
Performance and Cost Summary



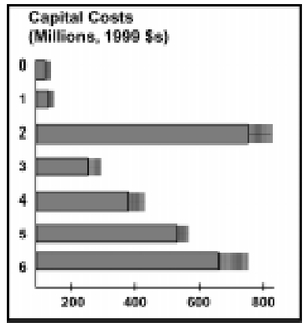
Performance

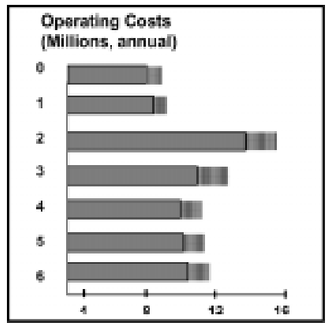


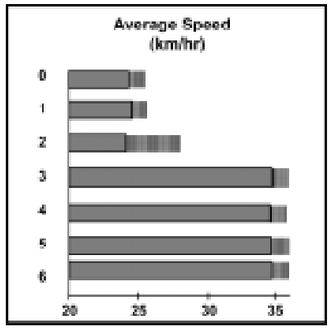




Costs







EVALUATION OF ALTERNATIVES
Broadway/Lougheed Corridor West
Year 2021[2]

		Alternatives					
		Alternative 1	***Alternative 2***	***Alternative 3***	***Alternative 4***	***Alternative 5***	***Alternative 6***
	Mode	Rapid Bus	Light Rail	SkyTrain	SkyTrain	SkyTrain	SkyTrain
	East Terminus	Commercial	Commercial	VCC North	VCC North	VCC North	VCC North
	West Terminus	UBC	UBC	Main	Cambie	Granville	Arbutus
	CRITERIA/DESCRIPTORS			/ With Rapid Bus to UBC	/ With Rapid Bus Extension to UBC	/ With Rapid Bus Extension to UBC	/ With Rapid Bus Extension to UBC
FINANCIAL	**Capital Costs (millions)**	$87.9	$802.7	$191.9 / $277.8	$347.1 / $411.6	$526.8/ $578.8	$663.9 / $709.0
	Capital Costs per kilometre	$6.6	$59.9	$147.6 / $20.7	$150.9 / $30.7	$131.7 / $43.2	$127.7 / $52.9
	Operating Costs (millions)	$9.0	$15.0	$1.8 / $11.9	$3.2 / $9.8	$5.5 / $10.3	$7.2 / $11.3
	Operating Costs - net of local service reductions	$9.0	$12.9	$11.9	$9.8	$10.3	$11.3
	Cost Effectiveness						
	' Operating cost/passenger	$0.31	$0.36	$0.18 / $0.32	$0.14 / $0.25	$0.16 / $0.23	$0.21 / $0.26
	' Operating cost/passenger kilometre	$0.05	$0.07	$0.05	$0.04	$0.04	$0.05
	' Cost/new passenger relative to base[1]	$1.77	$45.39	$10.50	$11.82	$13.15	$16.79
CUSTOMER SERVICE	**Ridership**						
	' Annual boardings, Yr 2021 (million)	29.0	42.0	10.1 / 37.1	22.9 / 39.4	33.5 / 45.1	34.5 / 43.8
	' Annual passengers new to transit, Yr 2021 (millions)	1.6	1.4	2.0	2.5	3.3	3.3
	Connectivity (Ease of Transfers)						
	' Quantitative and qualitative comparison of a series of typical trips via each alternative	Medium - provides good connections to local service, would intercept north-south lines	High - provides best connections to local service and intercepts any north-south line	Low - provides fewest connections to local service and no direct connection to future north-south lines	Medium - would provide excellent connection to a Cambie north-south line, no direct connections to service west of Cambie	High - Excellent connection to a Cambie north-south line and Granville service	High - Excellent connection to a Cambie north-south line and Granville service
SYSTEM OPERATION	**System Performance**						
	' Average travel speed (km/hr, base alternative only)	25	25	35	36	35	35
	' Travel Time (minutes)						
	UBC to Commercial	39	41	39	37	36	36
	Granville to Commercial	13	18	13	15	15	15
	Willow to Commercial	12	17	12	14	14	14
	System Flexibility, Reliability, and Expandability						
	' Ease or difficulty of integrating each alternative with future N/S line, adding capacity and new stations	Simple to integrate with surface options; does result in pedestrian/traffic conflicts. SkyTrain is more complex, can avoid pedestrian/auto conflicts, new stations easy/inexpensive to add.	Simple to integrate with surface options; does result in pedestrian/traffic conflicts. SkyTrain is more complex but can avoid pedestrian/auto conflicts, new stations added at moderate cost.	This option does not offer an opportunity for a direct connection to a north/south line, new stations would be difficult and high cost.	Integration with north/south SkyTrain offers cross platform transforms, surface options are more complex, but can avoid pedestrian/auto conflicts, new stations difficult to add and high cost.	cross platform transfers, surface options are more complex but can avoid pedestrian/auto conflicts, new stations are difficult to add and high cost.	cross platform transfers, surface options are more complex but can avoid pedestrian/auto conflicts, new stations are difficult to add and high cost.
	' Fleet availability and on-time performance	Fleet availability is high, on-time performance less than the other options due to the less exclusive nature of the alignment.	performance is good but somewhat impacted by the adjacent and crossing auto and pedestrian traffic.	performance would be the best of the alternatives due to the exclusive alignment and automated operations.	performance would be the best of the alternatives due to the exclusive alignment and automated operations.	performance would be the best of the alternatives due to the exclusive alignment and automated operations.	performance would be the best of the alternatives due to the exclusive alignment and automated operations.
	' Ability to expand the system to meet future demand	Extension can occur at relatively low cost, high ability to add incremental capacity and moderate ability to add equipment within a reasonable time period.	Extensions at moderate to high cost, capacity added through reduction of headways/eventual platform extensions, long lead time to add fleet with small orders impractical.	Extensions at a high cost, capacity increases available by added frequency and maximizing train lengths, single supplier of equipment results in limited options, local assembly plant a plus.	Extensions at a high cost, capacity increases available by added frequency and maximizing train lengths, single supplier of equipment results in limited options, local assembly plant a plus.	Extensions at a high cost, capacity increases available by added frequency and maximizing train lengths, single supplier of equipment results in limited options, local assembly plant a plus.	Extensions at a high cost, capacity increases available by added frequency and maximizing train lengths, single supplier of equipment results in limited options, local assembly plant a plus.

(1) Base is defined as the B-Line service from Commercial Drive to UBC.

(2) If Transportation Demand Management measures incorporated into the modeling process have the results the model forecasts, the RapidBus option, as defined in this study, may be unable to address the projected demand within the 20-year time frame without a significant redefinition, which could be coupled with substantial modifications to the signal system. Hence, some of the evaluation measures shown here (eg. capital costs, effects on vehicular traffic) may not reflect the impact of a fully functional Rapid Bus system in the year 2021. Nevertheless the evaluation provides a valid comparison with the other options at a conceptual level for a period up to the year 2015.

EVALUATION OF ALTERNATIVES
Broadway/Lougheed Corridor West
Year 2021[2]

		Alternatives					
		Alternative 1	***Alternative 2***	***Alternative 3***	***Alternative 4***	***Alternative 5***	***Alternative 6***
	Mode	Rapid Bus	Light Rail	SkyTrain	SkyTrain	SkyTrain	SkyTrain
	East Terminus	Commerical	Commercial	VCC North	VCC North	VCC North	VCC North
	West Terminus	UBC	UBC	Main	Cambie	Granville	Arbutus
	CRITERIA/DESCRIPTORS			/ With Rapid Bus to UBC	/ With Rapid Bus Extension to UBC	/ With Rapid Bus Extension to UBC	/ With Rapid Bus Extension to UBC
URBAN DESIGN/LAND USE	**Consistency with City and Regional Plans and Policies**						
	Support of regional and city livability goals	Medium-High	High	Medium - High	Medium	High	High
	2021 mode split compared to targets of 38% for Central Broadway and 36% for UBC	Broadway - 41% UBC - 48%	Broadway - 42% UBC - 48%	Broadway - 42% UBC - 51%	Broadway - 41% UBC - 50%	Broadway - 41% UBC - 50%	Broadway - 42% UBC - 50%
	2021 employment within 500m of stations (not incl UBC)	97,604	94,924	29,174 / 110,462	49,102 / 111,119	82,864 / 97,333	90,041 / 97,333
	2021 population within 500m of stations (not incl UBC)	78,950	83,067	23,609 / 88,430	28,286 / 74,404	44,688 / 71,751	53,973 / 71,751
	Contribution to the Pedestrian and Bicycle Environment						
	Qualitative evaluation of each alternative's contribution to the pedestrian and bicycle environment and increase or decrease in conflicts	No significant change in sidewalk width. Bus travel lane during peak periods directly adjacent to sidewalks. Buses share travel lane with bikes. Buses cross 4 N/S bikeways	Decrease sidewalk width in some areas. Several platforms ar narrow; may cause accessibility problems. Trains are separated from E/W bikeways; train crosses 4 N/S bikeways.	No change in sidewalk width required. No interaction with bikes. Enables creation of intense hubs of activity around stations.	No change in sidewalk width required. No interaction with bikes. Station activity is isolated from street activity. Enables creation of intense hubs of activity around stations.	No change in sidewalk width required. No interaction with bikes. Station activity is isolated from street activity. Enables creation of intense hubs of activity around stations.	No change in sidewalk width required. No interaction with bikes. Station activity is isolated from street activity. Enables creation of intense hubs of activity around stations.
	Personal safety	Sidewalk stops increase pedestrian activity, pedestrian and bus activity in close proximity.	Center platforms separate from sidewalk activity & increases # of potential auto/ped conflicts.	Station activity is isolated from street activity. Fewer ped/auto conflicts during transfers.	Station activity is isolated from street activity. Fewer ped/auto conflicts during transfers.	Station activity is isolated from street activity. Fewer ped/auto conflicts during transfers.	Station activity is isolated from street activity. Fewer ped/auto conflicts during transfers.
ENVIRONMENTAL/COMMUNITY IMPACT	**Ability to Generate Positive Land Use Changes**						
	Assess ability to attract desired development, reduce commercial turnover, support existing development, within Central Broadway.	Medium	Medium-High	Medium	Medium-High	High	High
	Effects of Construction on the Community						
	Extent of traffic, land, parking, and sidewalk closures/restrictions	Impact focused on stations west of Cambie. Impact on local trolley bus wires. Minimum impact on traffic and parking.	Phased, partial street closure along entire alignment, substantial traffic, parking, and sidewalk impacts.	Disruption at stations and portal, utility and structure protection along tunnel. Traffic, parking, pedestrian impacts at station location	Disruption at stations and portal, utility and structure protection along tunnel. Traffic, parking, pedestrian impacts at station location	Disruption at stations and portal, utility and structure protection along tunnel. Traffic, parking, pedestrian impacts at station location	Disruption at stations and portal, utility and structure protection along tunnel. Traffic, parking, pedestrian impacts at station location
	Number of business loading zones affected	23	79	23	17	21	25
	Duration of construction	1 year	3-3 1/2 years	2 years	3 years	4 years	4 years
	Contribution to Clean Air and Noise Environments						
	Number of autos in Central Broadway area (annual auto veh-km, in millions), base case of 106	103	103	102	104	105	106
	Increase or decrease in current noise levels	minor decrease	decreased noise levels	no decrease	no decrease	minor decrease	minor decrease
	Effects on Vehicular Traffic						
	Total vehicle delay (annual auto delay-millions of hours), base case of 2.13	2.13	2.52	2.05	1.97	1.93	1.94
	Traffic diverted to alternative routes	minor	minor amounts with exception of 630 am peak vehicles to 16th east of Blanca	none	none	none	none
	Ability of alternate arterial routes to accommodate displaced vehicular traffic	no identified difficulties	possible problem on 16th east of Blanca	no identified difficulties	no identified difficulties	no identified difficulties	no identified difficulties
	Access restrictions to adjacent properties	0	90	0	0	0	0
	Streets with restricted turning movements	0	25	0	0	0	0
	On-street parking lost (all day spaces)	60	1100	60	70	50	50

(1) Base is defined as the B-Line service from Commercial Drive to UBC.

(2) If Transportation Demand Management measures incorporated into the modeling process have the results the model forecasts, the RapidBus option, as defined in this study, may be unable to address the projected demand within the 20-year time frame without a significant redefinition, which could be coupled with substantial modifications to the signal system.
Hence, some of the evaluation measures shown here (eg. capital costs, effects on vehicular traffic) may not reflect the impact of a fully functional Rapid Bus system in the year 2021. Nevertheless the evaluation provides a valid comparison with the other options at a conceptual level for a period up to the year 2015.

Appendices

A. Merge Option Report

B. Cost Estimate

C. Urban Design Table

Appendix A

SkyTrain Merge Option Review

Introduction

The consultant team was requested to review the feasibility of physically connecting the new Phase 1 SkyTrain extension with the existing line in the vicinity of the Broadway Station. Referred to as the "merge" option, this concept would provide for a direct ride to the downtown area for passengers whose trips originate in East Vancouver along the Phase 1 portion of the Broadway/Lougheed corridor. The merge option offers the advantage of avoiding the substantial number of transfers that otherwise would be required at the Broadway Station.

This review was based on existing information regarding development of a physical connection between the two lines. The review is intended to address the following question:

> If current investment decisions to extend the Broadway/Lougheed line to the West of Commercial were not in place, would the option of physically connecting the two SkyTrain lines in the vicinity of the Broadway Station be recommended or not recommended?

The review focused on three primary topics:

1. **Cost Estimates** - Are the cost estimates for implementing the merge option reasonable given industry experience with similar projects?
2. **Schedule** - Are estimates of the duration of construction and disruption to the daily operation of existing SkyTrain service reasonable?
3. **System Capacity** - Is there sufficient system capacity to accommodate the impact of merging the two lines?

Background information available for the review included a memorandum provided the Rapid Transit Project 2000 office. The City of Vancouver provided a set of engineering drawings of the foundations, column locations and foundation sections of the existing SkyTrain in the vicinity of the Broadway Station. A February 26, 1999 report prepared by Ward Consulting Group titled "Transit Ridership Analysis for West Broadway Transit Strategies" provided information regarding the impacts a merge option would have on ridership levels and transfers. Further information was gained from an August 5 conference call involving Teresa Watts, David Ko, and Tom Parkinson of the Project 2000 office, Jane Bird of the City of Vancouver, and Bob Post and Stu Ramsey of the consultant team.

The following is a summary of our review of the merge option and our response to the above posed questions.

Cost Estimates - The review of estimated costs focused on a reported cost of $50 million for the South Merge Option, as defined on page 4 of the RTPO memorandum, and $101 million for the Grandview Cut Merge Option 1, as defined on page 5 of the memorandum.

Conclusion: Based on a preliminary review, the estimates provided by Project 2000 staff are considered reasonable estimates of the costs required to implement the merge options.

Discussion: Detailed cost estimates or cost breakdowns were not provided for review. Project staff provided a rather detailed description of the assumptions used to develop cost estimates. These included anticipated complexities associated with constructing the merge option, while retaining single track operations on the system in the vicinity of the Broadway Station. For purposes of the cost review, the more expensive Grandview Cut Merge Option 1 was reviewed and tested against available unit cost information for similar types of construction. Construction of this merge option is complicated by the necessity of adding structural depth at the points where the lines meet. This is significant because modifications to some of the existing columns would be required. The costs of construction would also be impacted by a difficult construction environment, which includes the steep banks of the cut itself, the operating freight rail line, and accommodation of continued operation of SkyTrain. Based on these factors, and taking into consideration the costs of similar construction, we believe the cost estimates that Project 2000 staff cited above are reasonable preliminary estimates for both the South Merge Option and the Grandview Cut Merge Option 1.

Schedule - The estimated duration for construction of the merge options is approximately one year, during which the existing line would be reduced to single track operation.

Conclusion: The overall duration of construction of the Grandview Cut Merge Option 1 may be underestimated, based on the complexities of the construction environment. However, we believe there are opportunities for creative construction staging to reduce the duration of the required single track operation, particularly with the South Merge Option.

Discussion: For the Grandview Cut Merge Option 1 the duration of the construction phase and the anticipated single track operation are again impacted by a difficult construction environment and the necessity to accomplish the work while retaining the ongoing operation of the system. While in theory the majority of the construction of the structures, rail and special trackwork could occur without impacting the current operation by cutting in the new line over a short time duration, some practical realities suggest otherwise. Project staff have determined that introducing special track work at the junction point will require modification of the spans and the supporting columns to accommodate the added depth and weight of the special track work. Such work would take the line out of service for an extended amount of time. Fortunately, the design of the current line would allow construction to occur independently on the inbound and outbound trackways, thereby allowing a sequencing plan that retains single track service on the track not under construction. An added factor for the outbound track, between the point it passes under the current line east of Commercial to the junction point with the existing line, is the potential disruption of service due to staging some, if not most, of the construction from the Grandview Hwy. This arrangement would cause interruptions whenever work required lifting or performing work over the operating line. The South Merge Option would involve a less complex construction environment, although construction activity in the vicinity of residential units would restrict the hours of construction.

Capacity - There is a concern that the merge option would constrain the system's overall ability to accommodate ridership growth, particularly on the existing SkyTrain line.

Conclusion: The merge option would constrain the future capacity of both the existing line and the Broadway/Lougheed line east of the Broadway Station. The merge option would also advance the date when six-car trains would be required. However, even with the merge option in place, sufficient capacity would exist to accommodate projected ridership on both lines through year 2021.

Discussion: The minimum headway on any portion of the SkyTrain system is in the range of 90 seconds. When lines are split, as would be the case with implementation of a merge option, the service on each line must be closely coordinated to retain the minimum separation between trains. A second key factor that determines system capacity is the passenger load of individual cars and train sets. Current practice is to operate trains in increments of two cars (either 2, 4 or 6 cars). The current Mark I cars have a capacity of 80 persons, 160 for a two-car set. The new generation Mark II cars are larger and will have a capacity of 130 persons, 260 for a two-car set. Also planned is the addition of a third Mark II unit in the middle of a two-car set, resulting in a capacity of 390 persons. The following table outlines the capacity of various potential train combinations that will fit within the station envelope of 80 meters.

TRAIN CAPACITY OPTIONS

Train Consist	Length	Capacity
AA	50 M	320
BB	70 M	520
AAA	75 M	480
BC	87 M*	650

*Exceeds platform length but all doors would be on the platform.

Note: A - Mark I (2 car set) - 25m
B - Mark II (2 car set) - 35m
C - Mark II (3 car set) - 52m

As an example of the capacity that could be provided, the existing line could be operated at a 3 minute headway (20 trains per hour) and the new Broadway/Lougheed service cut in on a 3 minute headway (20 trains per hour). The above service would result in a 90 second headway. The passenger carrying capacity that can be generated with the above level of service for each line and the Broadway Station to downtown segment is indicated in the following table:

Merge Option
Line and System Capacity

Existing Line (20 peak hour trains)	20 x 650 (BC)	=	13,000
Broadway/Lougheed (10 peak hour trains)	10 x 320 (AA)	=	3,200
	10 x 480 (AAA)	=	4,800
			8,000
Broadway Station to Downtown (40 peak hour trains)			21,000

Ridership projections for year 2021 are available from a February 26, 1999, report titled "Transit Ridership Analysis for West Broadway Transit Strategies," prepared by the Ward Consulting Group. The report provides ridership projections for a number of alternatives, including the merge option. More recent projections are also available from the RTP 2000 office. The RTP 2000 projections are based on different land use assumptions than the Ward projections, and generally result in higher ridership projections. Although the latest projections do not include a merge option, it is possible to approximate the merge option ridership levels. From this work, the ridership on the Broadway/Lougheed line is projected to be in the range of 6,500 to 7,900 peak hour trips. The ridership on the existing line is projected in the range of 9,000 to 13,700 peak hour trips. The Broadway Station to downtown section's projected ridership is estimated in the range of 12,800 to 17,900. The preceding tables indicate that capacity can be provided to accommodate the above range of ridership.

In conclusion, sufficient passenger capacity can be provided to operate a merge option for up to 20 years.

Operations Without a Merge Option - Under the current plan to extend the Broadway/Lougheed line west of the Broadway Station to the area of either VCC North, the Finning property, or to Broadway/Main, a substantial portion of the passengers on the line will transfer to the existing SkyTrain line at the Broadway Station in order to access the downtown area. This situation will exist until the Broadway/Lougheed line is extended further west and connects with or is interlined with a Richmond/downtown high capacity line. Estimates indicate that up to two thirds of the passengers on the A.M. peak hour Broadway/Lougheed line will make the transfer, meaning that a nearly full trainload of passengers will arrive on the existing Broadway Station platform looking for space on the downtown service. The station platform will be highly congested and, unless extra trains can be spotted (short-turned) and effectively scheduled to meet the Broadway/Lougheed trains, there will likely be pass ups which quickly lead to passenger dissatisfaction with the service. These complications will be in addition to a time-consuming transfer, which involves substantial vertical and horizontal movement by the passengers.

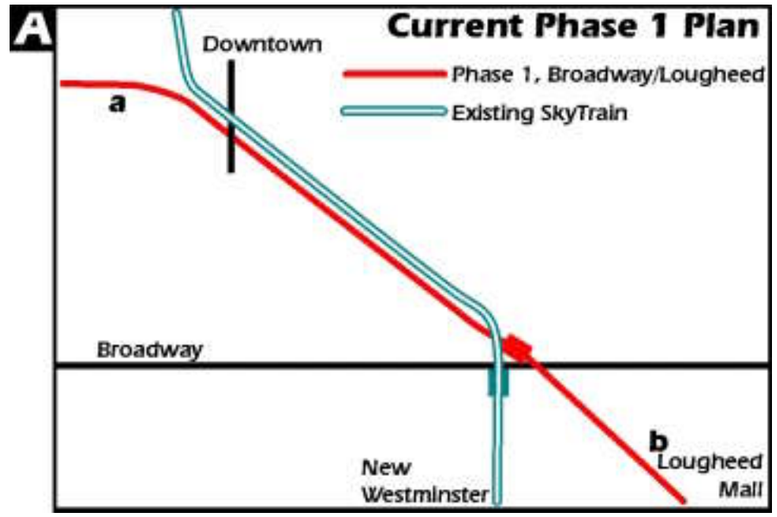
Merge Discussion: Minus an extension to a point of interface with a north/south line, a stub extending west of Commercial to VCC North, Finning, or Main/Broadway has little utility in serving the bulk of the forecasted trips on the system. The vast majority of the trips are destined to downtown and will transfer at the Broadway Station. If the extension to the west is not programmed to occur within the next decade, and is not connected to an effective link to downtown, then a solution that effectively serves the majority of the users should be considered.

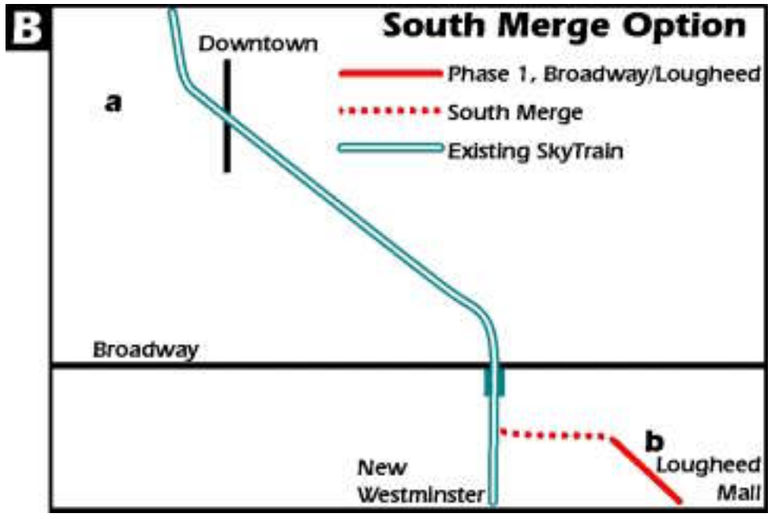
The merge option offers the opportunity to provide direct service to downtown for trips from East Vancouver, reduces the impact of substantial numbers of transfers to the existing line at the Broadway Station, and offers an opportunity to introduce a level of long-term operational flexibility otherwise not available. Implementation of the merge option would require a careful operational balancing of headways, but does offer the opportunity to meet projected travel demand on both lines for up to twenty years under current ridership growth projections.

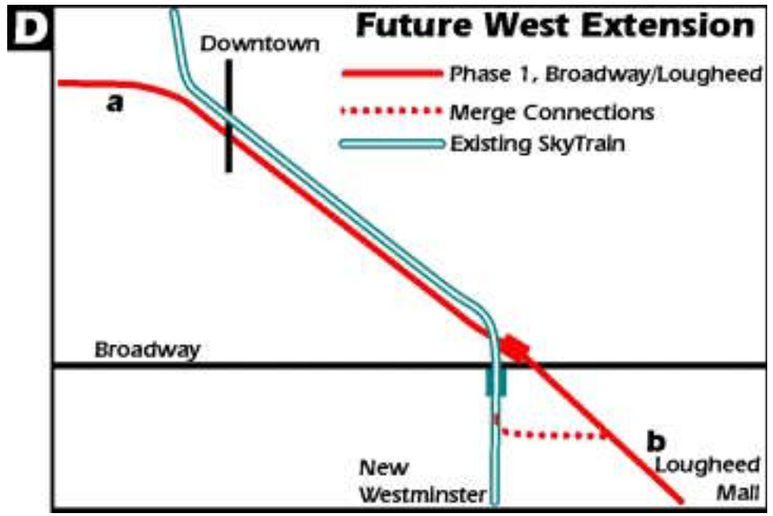
If a merge option were to be pursued, we believe an option that accomplishes the physical connection south of the Broadway Station should be given serious consideration. In addition to being less expensive, such an option offers the advantage of a direct cross-platform transfer between the lines and would simplify transfers to connecting service on Broadway. Construction of a south merge would require some property acquistion. Under this option, when the Broadway/Lougheed line is extended west, the merge connection could stay in place and continue to provide the opportunity to interline some elements of the service. Such a connection would provide flexibility in responding to service interruptions and provide special events or off-peak service flexibility. Prior to implementation of a merge of the two lines, a detailed assessment of each available option would be required, including addressing neighborhood impacts and urban design considerations. The following drawings illustrate the various options, including:

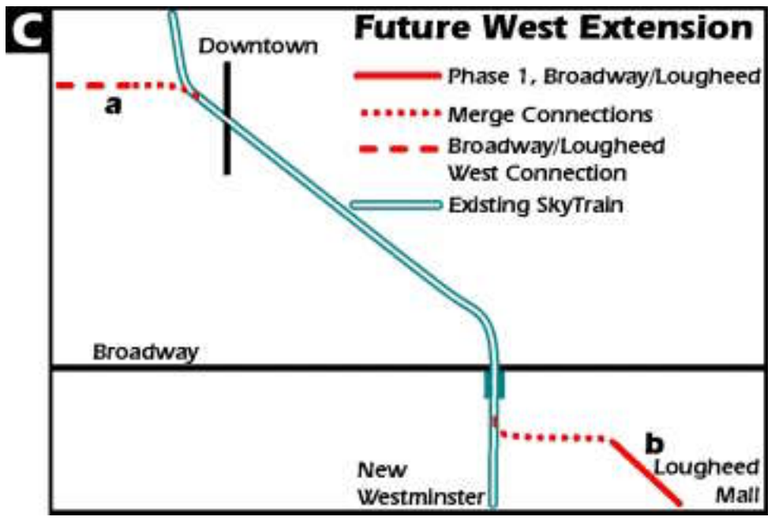
A - The current separated alignments requiring two Broadway Stations
B - South merge option
C - Future alignment separation via a connection to the west in the vicinity of Clark Drive
D - Future alignment separation via the Grandview Cut alignment

Drawing C would likely represent the least expensive option for providing a future separation of the two lines. However, it would restrain the ability to expand the existing line capacity in the future. Option D would use the original Grandview Cut Phase I alignment while retaining the flexibility of interlining some service elements as mentioned above.









Conclusion: In response to the question of whether implementation of a merge option would be recommended, the answer is twofold and would depend upon the timing of other investments in the region's high capacity transit system.

If the west extension of the Broadway/Lougheed line to a point of interface with a high capacity north/south line is a decade or more in the future, the merge option would appear to represent a better investment than a stub line to VCC, Finning or Main/Broadway. In this case, implementation of a merge option would be recommended. In summary, the merge option presents an opportunity to continue the SkyTrain legacy of offering superior passenger service versus operating for an extended period of time under a less desirable solution.

If commitments are in place to extend the Broadway/Lougheed line west to intercept a committed north/south line within a 5 to 10 year time frame, the basis for investing in the merge option is weakened and, under these circumstances, would likely not be recommended.

Appendix B

City of Vancouver B.C. - West Segment

Vancouver West Segment
CAPITAL COST ESTIMATE - SUMMARY
(All Costs 1999 Canadian in millions)

Cost Elements	Rapid Bus	Light Rail	Sky Train / Rapid Bus			
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
	Commercial to UBC	Commercial to UBC	VCC to Main	VCC to Cambie	VCC to Granville	VCC to Arbutus
	13.4 kilometre	13.4 kilometre	1.3 kilometre	2.3 kilometre	4.0 kilometre	5.2 kilometre
Civil and Systems						
Utilities	$1.6	$24.2	$0.5	$1.3	$1.8	$2.4
Street / Roadway Construction	$0.0	$94.1	$1.2	$2.0	$3.2	$5.2
Guideway / Trackway	$0.0	$38.7	$46.9	$78.5	$130.0	$172.3
Trackwork, Power Supply & Distribution	$4.9	$107.2	$10.2	$15.3	$23.6	$32.8
Fare Collection	$1.5	$2.9	$1.0	$2.0	$3.1	$3.8
Train Control, Signal System and Communications	$3.5	$44.5	$4.6	$8.2	$13.3	$17.6
Stations	$5.4	$22.2	$32.0	$74.0	$106.0	$118.5
Maintenance Facility	$5.0	$39.4	$1.0	$1.4	$2.0	$2.8
Subtotal Civil and Systems	$21.9	$373.2	$97.4	$182.7	$283.0	$355.5
Engineering, Management and Contingency	$9.6	$165.8	$44.4	$82.5	$127.5	$160.5
Total: Civil and Systems	$31.6	$539.0	$141.8	$265.2	$410.5	$516.0
Right of Way	$1.0	$9.2	$13.3	$21.7	$25.3	$31.3
Vehicles (Year 2011)	$48.7	$144.6	$13.5	$18.0	$27.0	$36.0
Interim Financing and GST	$6.6	$109.9	$23.3	$42.1	$64.0	$80.6
Subtotal	$87.9	$802.7	$191.9	$347.1	$526.8	$663.9
Cost per kilometre	$6.6/km	$59.9/km	$147.6/km	$150.9/km	$131.7/km	$127.7/km
Rapid Bus UBC Extension	n/a	n/a	$85.9	$64.5	$52.0	$45.1
Total Costs	$87.9	$802.7	$277.8	$411.6	$578.8	$709.0
Cost per kilometre (13.4 kilometre base for all options)	$6.6/km	$59.9/km	$20.7/km	$30.7/km	$43.2/km	$52.9/km

Appendix C

Central Broadway (Main to Arbutus): Urban Design and Land Use Evaluation Comments

The table below is a subjective and value-based evaluation from the urban design and land use perspective of implications in central Broadway (Main to Arbutus) for each proposed technology and route option. It is intended to serve as a starting point for public discussion.

Criteria ***COMPARED TO EXISTING: Key: Better to Worse***	***RapidBus*** ***5 Stops***	***LRT*** ***9 Stops***	***SkyTrain/Rapid Bus*** ***5 Stops, 4 Termini. Bored-tunnel construction for SkyTrain (Main to Arbutus); cut-and-cover or mining of stations. One entry per station plus 1 emergency-only exit. East terminus of RapidBus varies (note d).***	***SkyTrain Terminus*** **M** ain	**C** ambie	**G** ranville	**A** rbutus
Job and Population Growth Assumptions:	Same as LRT.	Job growth of 1.5% p.a. to 2021 vs. region average of 1.9%. Population growth of 0.8% p.a to 2021 versus. region average of 1.9%. Therefore, conservative growth relative to the region, and within current zoning capacity.	Same as LRT.				
1. Supports regional/city livability goals	Supports Regional Context Statement Official Development Plan Sec. 5.2(6) "Supporting the development of a grid of express bus routes". Supports the Livable Region Strategic Plan route for Intermediate Capacity Transit. Builds on 99 B-line success as a region-shaping transit service.	Supports Regional Context Statement Official Development Plan 5.2(5) "Supporting a minimum of three new intermediate capacity transit lines -- the Broadway -Lougheed line..." Supports Vancouver Transportation Plan Policy 3.4.4. Supports the Livable Region Strategic Plan route for Intermediate Capacity Transit. Builds on 99 B-line success, with an urbane service for central Broadway.	Supports Regional Context Statement Official Development Plan 5.2(5) "Supporting a minimum of three new intermediate capacity transit lines -- the Broadway -Lougheed line..." Supports Livable Region Strategic Plan route for Intermediate Capacity Transit. A decision on N-S rapid transit routing is key to the choice of a Broadway West terminus to maximize regional benefits. Low value to central Broadway if SkyTrain terminates at Main, or if the SkyTrain terminus is at Cambie with a N-S rapid transit link at Granville or Arbutus.				
2. Supports existing zoning and corridor vitality	Commercial and residential zoning is compatible with RapidBus. RapidBus can serve forecast development in the corridor. There is an opportunity to promote complementary uses (e.g. small retail) at the development permit stage.	C-3A commercial zoning and residential zoning is compatible with LRT. LRT can accommodate forecast development in the corridor. There is an opportunity to promote complementary uses (e.g. small retail) at the development permit stage. Frequent stops (400 m) encourages positive effects on street life along the entire corridor. In the course of construction LRT may provide an opportunity to incorporate the public realm design guidelines in the current zoning.	Commercial and residential zoning is compatible with SkyTrain. SkyTrain can accommodate forecast development in the corridor. There is an opportunity to promote complementary uses (e.g. small retail) at the development permit stage. Like RapidBus, effects are focused at stations.				
3. Potential to enliven central Broadway							
3.1 Effect on Broadway (Bwy.) pedestrian traffic	Recommend 4.0 to 4.5 m minimum width for a pedestrian- and transit-oriented street. Proposed design proposes to accommodate increased pedestrian and queuing demand with an undesirable level of sidewalk width in peak hours at critical intersections and east of Cambie (note a).	As with Rapid Bus, proposed design continues an undesirable level-of-service to pedestrians on the sidewalks in peak hours at critical intersections and east of Cambie. Adds to an undesirable section on the south side of Broadway, west of Cambie to Arbutus. Low LRT train noise adds potential risk of pedestrian-train collisions. Mid-street platforms relieves some sidewalk demands.	Continues undesirable level-of-service to pedestrians in peak hours at critical intersections. Main terminus equivalent to RapidBus-only option				
3.2 Contribution to traffic calming (off-peak).	Increased bus frequency and use of general purpose lanes slows auto traffic.	Eliminates cross-traffic at unsignalized intersections, thereby increasing off-peak auto speeds.	Main is the same as RapidBus option.				
3.3 Effect of parking changes on street life (peak hours).	Addition of Rapid Bus to the curb lane from Yukon to Main in the AM peak is harmful to pedestrian street comfort.	Addition of curb lane traffic from Yukon to Main in the AM peak is offset by the addition of some peak parking stalls on the south side of the street. No net change to pedestrian comfort.	Minor loss for 3 bus lay-bys at Rapid Bus loop connection to SkyTrain at Granville or Cambie. Main has same rating as RapidBus.				
3.4 Effect of parking changes on street life (off-peak hours).	Current on-street parking is retained off-peak.	Major reduction in on-street parking is harmful to pedestrian comfort on adjacent sidewalks due to traffic running in the curb lane.	Minor loss for 3 bus lay-bys at Rapid Bus loop connection to SkyTrain at Granville or Cambie.				
3.5 Noise and vibration effects	More frequent service in curb lane at peak hours adds vibration. -1. Eliminates 99 B-line diesel. +1.	Eliminates 99 B-line diesel. Vibration reduction assumes vibration-dampening mats are used in LRT track bed where necessary.	Eliminates 99 B-line diesel				
4. Effect on central Broadway neighbourhood livability							
4.1 minimizes residential impacts	Increased bus traffic in curb lane.	Increased auto traffic in curb lane.	Minimal effect as station entries are concentrated at commercial nodes.				
4.2 low impact on heritage sites			Potential ground settlement risk on 10th Ave. (note b).				
4.3 protection of existing mature trees	Moving existing overhead wires to curb lane reduces potential for new trees on Bwy; may affect some existing trees.		Extra costs to construct stations, or trees will need to be removed at Cambie, Arbutus on 10th Ave.				
4.4 Reduces local reliance on automobiles	Improved transit reduces need for auto as secondary or primary means of access for local residents.	Improved transit reduces need for auto as secondary or primary means of access for local residents.	Improved transit reduces need for auto as secondary or primary means of access for local residents. Higher ridership on SkyTrain than alternative technologies. Main terminus offers limited benefits to central Broadway.				

Central Broadway (Main to Arbutus): Urban Design and Land Use Evaluation Comments

The table below is a subjective and value-based evaluation from the urban design and land use perspective of implications in central Broadway (Main to Arbutus) for each proposed technology and route option. It is intended to serve as a starting point for public discussion.

Criteria ***COMPARED TO EXISTING: Better to Worse*** ***Key:***	***RapidBus*** ***5 Stops***	***LRT*** ***9 Stops***	***SkyTrain/Rapid Bus*** ***5 Stops, 4 Termini. Bored-tunnel construction for SkyTrain (Main to Arbutus); cut-and-cover or mining of stations. One entry per station plus 1 emergency-only exit. East terminus of RapidBus varies (note d).***	**SkyTrain Terminus** **M**	**C**	**G**	**A**
4.5 Improved transit access to the region	Increased bus frequency adds to local neighbourhood access to regional job options.	Improved access to regional transit increases local access to regional job opportunities	Direct link by SkyTrain to Lougheed/New Westminster and Coquitlam increases local access to regional destinations such as Brentwood town centre, Lougheed industrial employment zones, Coquitlam town centre.				
4.6 Aesthetic and safety benefits of new streetscapes	Minor positive changes to streetscape at station stops.	Major reconstruction of streetscape from property-line to property-line adds opportunities to improve street landscape and improve sidewalk safety for persons with developmental disabilities.	Minor positive changes to streetscape at station stops.				
4.7 Probable interest in enhanced security staffing			Underground stations, with long circuitous corridors from station to surface, especially at Granville likely to increase local resident and business interest in enhanced security staffing of underground stations.				
4.8 Crime Prevention Through Environmental Design(CPTED) needs	Stations need transparency.	Stations need transparency.	Need for specialized lighting, preference for high ceilings, open design with minimal columns, issue of minimizing circuitous corridors.				
4.9 Neighbourhood construction impact	Rewiring of existing trolley lines and station construction.	Reconstruction of street disrupts all traffic, business and community activities in the central Broadway corridor, in block-by-block sections.	Cut & cover station zones have impacts on 10th Ave. Construction access concerns at Arbutus, Granville, Oak stations. Probable concerns of 10th Ave. residents of ground movement during construction, risk to heritage homes, trees. Decision on N-S link will affect construction impact at Cambie. Construction effect of trucking tunnel spoil on city streets (e.g. Arbutus, Main, Knight?) .				
4.10 Supports N-S activity across Broadway (walk, auto, cycle)		Eliminates three crossings of Broadway from Main to Arbutus.					
4.11 Wheelchair accessibility to transit system	More transit service accessible to wheelchairs.	Narrow platform widths on side platforms (e.g. Columbia, Willow) are sub-standard for safe wheelchair access. Cambie platform is tight for anticipated volumes.	More transit service accessible to wheelchairs.				
5. Effect on commercial vitality							
5.1 Construction effect on businesses	Negative impact from station and complete overhead wire relocation.	Negative effect on street businesses for several months per block during street regrading and reconstruction.	Tunneling on 10th minimizes effects on Bwy. Commercial. Exceptions at stations at Main, Cambie (Cancer agency), Granville. Assumes no major closure of major N-S arteries during construction.				
5.2 Enhances the business climate for existing premises	Increased ridership adds to customer base.	Increased ridership with closely spaced stations contributes to a healthy retail and business climate throughout central Broadway. Less convenience for auto users; loss of parking will affect retail uses.	Concentrates increased ridership at 5 points. Impact on central Bwy. greatest when line extends to Arbutus. Increased ridership adds to total customer base, with major construction at station houses creating new opportunities for adjacent private business				
5.3 Provides service to existing employment centres	Improves access to major employment nodes from Granville to Cambie.	Improves access to jobs in the entire central Broadway corridor.	Improves access to jobs, especially in the vicinity of stations. A terminus at Main has limited job access benefits to central Broadway. At Cambie, a single entry along Cambie would limit benefits to hospital zone.				
5.4 Effect on goods delivery		Reduces left-turn access across Broadway, cross Broadway connections.					
5.5 Catalyst for area redevelopment (500 m radius).	There are redevelopment opportunities within the existing zoning at several locations	Redevelopment opportunities within the existing zoning at several locations	Same opportunities as Rapid Bus. Opportunities for additional entries to be added at extra cost with transportation and livability benefits (e.g. Main St., Cambie to VGH, Oak at Broadway).				
5.6 Opportunity for new major projects	Some sites at Main, Cambie.	Some sites at Main, Cambie, Arbutus.	Potential with station development. Limited with Main terminus.				
6. Promotion of Station Place							
6.1 Promotion of pedestrian street life at stations.	Increased ridership adds to station life.	Frequent stops every other block (400 m) adds to pedestrian street life.	Contributes to street life at station entries, and through higher transit ridership.				
6.2 Opportunity to enhance station areas	Good potential for streetscape development at Cambie and Main stops due to public land ownership/purchase.	Good potential for streetscape development at Cambie and Main stops due to public land ownership/purchase.	Significant potential at all stops, especially Cambie, Main. Depends on willingness to acquire surface rights, private development initiatives and ridership volumes.				
6.3 Promotes neighbourhood identity at stations.	Possible, if stations are more than basic bus shelters.	Good potential at Cambie and Main stops. Less potential at stations with narrow r/w. Potential to use public land for community-enhancing uses. Opportunity for distinctive design at 9 stations.	Good potential at all 5 station houses, if station entry points are visible. Excellent potential at Cambie. Less stops than LRT.				

Central Broadway (Main to Arbutus): Urban Design and Land Use Evaluation Comments

The table below is a subjective and value-based evaluation from the urban design and land use perspective of implications in central Broadway (Main to Arbutus) for each proposed technology and route option. It is intended to serve as a starting point for public discussion.

Criteria	***RapidBus***	***LRT***	***SkyTrain/Rapid Bus***	**SkyTrain Terminus**			
COMPARED TO EXISTING: Better to Worse ○ ◠ ● ◡ ● ***Key:***	***5 Stops***	***9 Stops***	***5 Stops, 4 Termini. Bored-tunnel construction for SkyTrain (Main to Arbutus); cut-and-cover or mining of stations. One entry per station plus 1 emergency-only exit. East terminus of RapidBus varies (note d).***	**M**	**C**	**G**	**A**
6.4 Ability to serve pedestrians at station entry	Recommend 6.3 m minimum width at station. Undesirable level-of-service where stations are restricted to current Broadway right of way (Granville, Alder, Willow). ●	Undesirable sidewalk width within current right-of-way. Tight platform width at all stops. ●	Continues undesirable sidewalk width at the main station entry on the east side of Granville Street.	●	●	●	●
6.5 Opportunities for public art at stations	Good potential at Cambie and Main stops. ◠	Good potential on 9 stations, and on guideway. ○	Good potential at 5 station houses.	◠	◠	◠	◠
6.6 Opportunity for shops/street vendors at stations	Some potential at Cambie and Main. Need to re-think typical bus stop design. ●	Some potential at Cambie and Main stations. ◠	Most disturbance outside road r/w, therefore most potential to develop complementary shops and vendors in plazas, entry passages.	◠	○	○	○
6.7 Effect of venting & emergency exits (inc. NFPA 130) at stations	●	●	Architectural challenge to manage aesthetics and minimize negative impact of vacant walls. Potential localized air quality concerns from the volumes, noise, and chemistry of vented air.	◡	◡	◡	◡
7. Support for modal transfers							
7.1 Link to local bus routes.	●	Maintains surface links to existing N-S local bus routes ○	Kingsgate station house is 1 block east of the busy No. 3 local bus on Main St.	◡	●	●	●
7.2 Link from SkyTrain to Rapid Bus	●	●	With Main as terminus, Rapid Bus carries on to Commercial Drive, therefore no SkyTrain benefit. Cambie terminus has good alighting and boarding integration with SkyTrain, but awkward left-turn for Rapid Bus westbound on Broadway from Cambie. Granville terminus has an extra block of Rapid Bus looping, a less convenient boarding location than at present and requires walking along a tight sidewalk on the east side of Granville for westbound RapidBus transfers from SkyTrain. With an Arbutus terminus of SkyTrain RapidBus continues to Granville, so the Granville comments also apply to Arbutus.	●	◠	◡	◡

Note a: Sidewalk widths have been reduced where left-turn bays have been added at major intersections on Broadway.
Note b: Risks to heritage structures or trees is dependent on geological conditions
that will be subject to more detailed investigations outside the scope of this study.
Note c: transportation engineering, costing and operational evaluation criteria are evaluated separately.
Note d: RapidBus runs from UBC to the SkyTrain Commercial Drive station in the RapidBus-only option, or if SkyTrain terminates at Main.
The east terminus of RapidBus is at Cambie if SkyTrain terminates at Cambie, and at Granville if SkyTrain terminates at either Granville or Arbutus.