SCHEDULE 6

RICHMOND • AIRPORT • VANCOUVER

AMENDED AND RESTATED PROPOSAL EXTRACTS

For the Richmond • Airport • Vancouver Rapid Transit Project

INDEX

VOLUME A

INCORPORATED APPROVED CHANGES

Approved Changes

Introduction

Pursuant to the written agreement (the "Approved Changes Agreement") dated March 29, 2005 between RAVCO and the Concessionaire on "Approved Changes" (as defined in that written agreement) RAVCO has exercised its discretion and given notice to the Concessionaire to implement four of the Approved Changes as follows:

(a) Approved Change 1 - 2nd Avenue Station;

(b) Approved Change 6 – Bicycle Bridge

(c) Approved Change 7 – Relocation of King Edward Station

(d) approved Change 8 – Relocation of Richmond Terminus Station

Accordingly the Approved Changes Agreement is modified by deleting the above four Changes, and these Changes are hereby incorporated into this Agreement on the terms and conditions described below:

1. 2ND AVENUE STATION

1.1 Scope of Work

Design and Construction of a new underground Station at 2nd Avenue in Vancouver and incorporated as part of the System in general conformance with the conceptual design included in the SNC/Lavalin-Serco BAFO Submission, as indicated on the following drawings, copies of which are included in Schedule 6 Appendix B-1:

Drawing No.	Description
865704-VARI-44DK – A136, Revision 1	2nd Ave Station - Site and Context Plan
865704-VARI-44DK – A137, Revision 1	2nd Ave Station – Grade/Concourse/Platform Plans

The scope includes all changes to the Design, including any and all revisions to E&M Systems and the Train Control Systems, and all Construction required, to accommodate 2nd Avenue Station as an integrated part of the System. The scope also includes remediating the Hazardous Substances contained in the West 6th Avenue and Cambie Street Contamination solely if and to the extent that the activities undertaken by the Concessionaire for the Construction of the 2nd Avenue Station disturb or affect the Hazardous Substances contained in the West 6th Avenue and Cambie Street Contamination and as a result, such Hazardous Substances are or will need to be, as a matter of applicable Law, investigated, handled, treated, remediated or disposed of. For greater certainty, the Concessionaire will not be responsible for Hazardous Substances that are within the portions of West 6th Avenue and Cambie Street

Contamination that are not so disturbed or affected by Concessionaire's activities relating to the Construction of the 2nd Avenue Station. The scope further includes all required site servicing, including relocation as required of Public Utilities and (at RAVCO's cost) Regulated and Other Utilities.

1.2 Assessment of the Change

The Concessionaire will be compensated for the change in accordance with Section 21 of the Concession Agreement (Relevant Events) based on the input costs data shown in Section 1.3.

1.3 Cost Impact of Change

(a) Design and Construction: s.17(1)(e)

The cost of this Approved Change will be a lump sum increase to the Design and Construction Price of (nominal dollars) to be paid as set out below under a "Price Adjustment" Cost Centre pursuant to Section 4.3 of Appendix I to Schedule 11 of the Concession Agreement.

Month	Payment
September 1, 2005	
July 1, 2006	
January 1, 2007	s.17(1)(e)
July 1, 2007	
January 1, 2008	

(b) Operations and Maintenance

An increase in the O&M Cost o

s.17(1)(e)

1.4 Variations to Concession Agreement:

(a) The Design for 2nd Avenue Station will satisfy the requirements of Section 8.3 of Schedule 2 of the Concession Agreement, and in particular will be capable of satisfying the Operation and Maintenance Requirements and Specifications (amended as described below) ;

(b) The Concessionaire has prepared the following, which RAVCO has reviewed:

(1) amendments to Schedule 4 and Schedule 6 of the Concession Agreement to add to the travel times from Terminal Station to Terminal Station to allow for Vehicle stop and dwell at 2nd Avenue Station;

(2) amendments to Appendix A and B (Service Plans) to Schedule 4 and Schedule 6 of the Concession Agreement to reflect the above revised travel times;

(3) amendments to Appendix A (Service Plan) of Schedule 4 and Schedule 6 to the Concession Agreement to adjust service Headways in the Peak

Periods and Mid-Day period and amend other entries to reflect this revised Headway so as to avoid the requirement for an additional Train.

(c) RAVCO has made the following amendments:

(1) amendment to the Base Level Demand forecast in Figure 2.4.2 of Schedule 3 to the Concession Agreement to reflect addition of 2nd Avenue Station; and

(2) amend the Baseline Ridership Forecast attached as Appendix 3 in Schedule 3 to the Concession Agreement.

6. CHANGE NO. 6 - BICYCLE BRIDGE

6.1 Scope of Work

The Design and Construction of bicycle bridge across North Arm of Fraser River in location of Guideway Bridge, as indicated generally on the following drawings, copies of which are included in Schedule 6 Appendix B-1:

Drawing No.	Description
865704-VARI-42DK-1646, Revision 1	North Arm Fraser River -Pedestrian/Cyclist Crossing – Preliminary General Arrangement
865704-VARI-42DK-1647, Revision 0	North Arm Fraser River -Pedestrian/Cyclist Crossing – Preliminary Cross Section

This Approved Change includes lighting for the bridge as reasonably necessary for the safety of persons using the new bridge, and also includes connections to the adjacent public thoroughfares. This Approved Change does not include Operation or Maintenance, which will be performed by others.

6.2 Assessment of the Change

The Concessionaire will be compensated for the change in accordance with Section 21 of the Concession Agreement (Relevant Events) based on the input costs data shown in Section 6.3.

6.3 Cost Impact of Change

(a) Design and Construction: s.17(1)(e)

The cost of this Approved Changes will be a lump sum increase to the Design and Construction Price of (nominal dollars) to be paid generally over the time of performing this Work and included in a "Price Adjustment" Cost Centre pursuant to Section 4.3 of Appendix I to Schedule 11 of the Concession Agreement as follows:

Month	Payment
November 1, 2005	
April 1, 2006	s.17(1)(e)
November 1, 2006	
April 1, 2007	

(b) Operations and Maintenance:

GVTA will assume all responsibility for any required Operations, Maintenance and Repair of the bicycle bridge including lighting installed as reasonably necessary for the safety of persons using the new bridge and so there will be no impact on the O&M Costs.

7. CHANGE NO. 7 – RELOCATION OF KING EDWARD STATION

7.1 Scope of Work

Relocation of the King Edward Station to the location shown on the following drawings, copies of which are included in Schedule 6 Appendix B-1:

Drawing No.	Description
865704-VARI-44DK-A151, Revision 1	King Edward - Site and Context Plan
865704-VARI-44DK-A152, Revision 1	King Edward – Grade Level Plan
865704-VARI-44DK-A153, Revision 1	King Edward – Concourse And Outbound Plan
865704-VARI-44DK-A154, Revision 1	King Edward – Outbound Platform Plan
865704-VARI-44DK-A155, Revision 1	King Edward – Cross Section
865704-VARI-44DK-A156, Revision 1	King Edward – Longitudinal Section

7.2 Assessment of the Change

The Concessionaire will be compensated for the change in accordance with Section 21 of the Concession Agreement (Relevant Events) based on the input costs data shown in Section 7.3.

7.3 Cost Impact of Change

(a) Design and Construction:

s.17(1)(c) The cost of this Approved Change will be a lump sum addition to the Design and Construction Price of (nominal dollars in accordance with the schedule included in the Concessionaire's BAFO Submission, evenly distributed) payable generally over the time of performing this Work and included as payments owing under the "Price Adjustment" Cost Centre as set out in Section 4.3 of Appendix I to Schedule 11 of the Concession Agreement.

(b) Operations and Maintenance:

There will be no impact on the O&M Costs as a result of this Approved Change

8. CHANGE NO. 8 – RELOCATION OF RICHMOND TERMINUS STATION

8.1 Scope of Work

Relocation of the Richmond Terminus Station and Guideway to the location shown on the following drawings, copies of which are included in Schedule 6 Appendix B-1:

Drawing No.	Description
865704-VARI-41DK-1101, Revision 0	Richmond - Plan and Profile
865704-VARI-44DK-A231, Revision 0	Richmond Centre Station-Site & Context Plan
865704-VARI-44DK-A232, Revision 0	Richmond Centre Station-Grade Level Plan
865704-VARI-44DK-A233, Revision 0	Richmond Centre Station-Platform Plan
865704-VARI-44DK-A234, Revision 0	Richmond Centre Station-Cross Section Plan

8.2 Cost Impact of Change

(a) Design and Construction:

There will be no change to the Design and Construction Price as a result of this Approved Change.

(b) Operations and Maintenance:

There will be no impact on the O&M Cost as a result of this Approved Change

1.0 PROPOSED SYSTEM DESIGN

1.1 TECHNOLOGY

The RAV Project Request for Proposals allows alignment options for proponents to propose either at-grade or elevated solutions in Richmond and at-grade or "in-trench" solutions through south Vancouver. The remainder of the alignment is stipulated:

- Vancouver: underground north of 46th Avenue and elevated south of 63rd Avenue
- Richmond: elevated north of Sea Island Way
- Airport Connector: elevated

Selection of at-grade alignment configurations in the optional areas would likely reduce capital costs but would place constraints on technology selection and service plans. Selection of elevated or underground configurations in the optional areas would offer a segregated system at a higher capital cost. Selection of a segregated alignment would also broaden the range of viable technologies.

The SNC-Lavalin/Serco team has taken the view that, operationally, the Canada Line is as an overlay of a Richmond/Vancouver service and an Airport/Vancouver service, with common overlap from Bridgeport station north. With this view, Airport/Vancouver service headways overlay on Richmond/Vancouver service headways through the Bridgeport-to-Waterfront segment. Consequently, headways north of Bridgeport station would be considerably less than headways in either the Richmond or Airport sections. Such an operational arrangement suggests that at-grade operation is feasible in Richmond but that a segregated system will likely be needed within Vancouver to accommodate shorter headways and larger link volumes.

Our team has developed an alternate (Alternate 3) comprised of at-grade alignment in Richmond, combined with a grade-separated alignment in Vancouver, for comparison with a fully grade-separated alignment. From our financial analysis, we concluded that a fully grade-separated alignment was the most advantageous for the following reasons:

- The net present value of the differential ridership revenue credit was greater than the differential capital cost.
- A fully grade-separated system allowed system wide Automatic Train Operation (ATO).
- ATO allowed us to provide higher system capacity via the use of smaller train consists at more frequent intervals.
- Smaller train consists allowed for reduced station costs through the use of short platforms.
- Shorter headways or more frequent service boosted ridership.
- ATO reduced overall operations and maintenance labour cost.

Based on this analysis we selected a fully grade-separated alignment using a metro-type vehicle with ATO servicing the Richmond and Airport segments each on average 6min 20sec headways overlapping to provide average 3min 10sec service from Bridgeport station north. The following summarizes our proposed configuration.

System Operation

Initial fleet	40 vehicles (36regular service plus 4 spares)
System capacity	**Initial6,322 pphpd between Bridgeport Station and Waterfront Station; 3,166 pphpd between Bridgeport Station and Richmond Centre and between Bridgeport Station and YVR 4.** **Ultimate 15,000 pphpd between Bridgeport Station and Waterfront Station; 7,500 pphpd between Bridgeport Station and Richmond Centre and between Bridgeport Station and YVR 4.**
Train control	Automatic Train Control
Platform length	50.0 metres (40.0 metres finished during the Operating Period)

Vehicle Dimensions

Exact vehicle dimensions will be determined during the detailed vehicle design and procurement stage after BAFO. For the purposes of planning and designing the proposed system for BAFO the dimensions shown below were used. Based on bids received from vehicle manufacturers for BAFO, while all of the proposed vehicles do not exactly match the following dimensions, a range of vehicles from various suppliers can still be accommodated within our design parameters for tunnel size and station platform length.

Length (over couplers)	18.0 metres +/-
Width (over thresholds)	3.0 metres +/-
Height (TOR to roof)	3.6 metres +/-
Height (rail to floor)	1.0 metre +/-
Doors per side	3 or 4
Doorway width (clear open)	1.3 metres +/-
Doorway height	1.9 metres +/-

Train Formation

Train consist	2 vehicles (A+B) in semi-permanent pairs, and the capability to insert a 3rd "C" car to accommodate future ridership

Performance

Max. operational speed	80 km/h
Max. acceleration rate	1.1 metres/s²
Braking rate	1.1 metres/s²

Capacity (per vehicle)

The final vehicle layout, including seated and standing capacity, will be determined in consultation with vehicle manufacturers. However, based on vehicle bids received for BAFO, we can state that the minimum total vehicle capacity will be 167, based on a standing density of 4 pass/m² and a minimum seating capacity of 37.

Fare Collection and Compliance

Proof of payment with provision to install fare gates at all stations

Electrical System

Voltage	750 Volts - DC
Power Collection	Third rail

Our proposed technology solution provides optimum flexibility to our team and to RAVCO. In particular, we note the following:

- The vehicle and ancillary systems may be procured from a wide range of suppliers.
- A wide range of operational scalability is available through reduction of headways, plus increases in train consist size.

1.2 ALIGNMENT

Our base proposal employs a fully grade-separated or segregated alignment consistent with the technology selection. Plan and profile drawings are presented in Drawings 865704-CONF-41DK-1101 to 1129 and general arrangement cross sections in Drawings 865704-CONF-41DK-1201 to 1217 included in Appendix B-1. The main features of the alignment are as follows:

- Elevated in Richmond, generally in accordance with the vertical alignment of the reference elevated option but with Richmond Centre Station relocated just south of Saba Road. Horizontally aligned on the east side of Number 3 Road between Richmond Centre station and Cambie Road moving to the centre of Number 3 Road to Bridgeport Road. From Bridgeport Road north, the alignment is generally consistent with the reference horizontal and vertical alignment.
- Elevated from the Airport to Bridgeport station. The horizontal and vertical alignment is generally consistent with the reference alignment.
- Grade separated interchange west of Bridgeport station at the intersection of the Airport and Richmond lines.
- Elevated ramps down from two-point side track access on the mainline into the Operations and Maintenance Centre (OMC) located between River Road and Van Horne Way in Richmond.

- Elevated over the Fraser River North Arm to approximately 63rd Avenue in Vancouver. The horizontal and vertical alignment is generally consistent with the reference alignment.
- Underground in a "stacked" arrangement from 63rd Avenue to approximately 37th Avenue. The horizontal alignment through this area has been shifted east, compared to the reference alignment, to align under the northbound lanes of Cambie Street. The vertical alignment varies from the reference alignment and has been configured to keep the tunnel as close to the surface as possible.
- Underground in a side-by-side arrangement from 37th Avenue round Little Mountain to 30th Avenue
- Underground in a stacked arrangement from 30th Avenue to 12th Avenue.
- Underground in a side-by-side arrangement from 12th Avenue to 2nd Avenue.
- Underground in separated bored circular tunnels from 2nd Avenue to a location between Georgia and Dunsmuir Streets underneath Granville Street.
- Underground in a cut and cover tunnel from midway between Georgia and Dunsmuir Streets to Waterfront Station generally following the alignment.
- The horizontal alignment is generally consistent with the reference alignment. The vertical alignment is higher than the reference alignment and has been configured to keep the tunnels as close to the surface as possible.

The proposed alignment is compliant and substantially the same as the reference alignment. There are, however, three areas of refinement that warrant further discussion:

- The proposed horizontal alignment along Number 3 Road in Richmond.
- The OMC location
- The horizontal and vertical alignment from 63rd Avenue to Waterfront Station.

1.2.1 Richmond Number 3 Road Horizontal Alignment

The reference alignment is in approximately the centre of Number 3 Road. Our team initially developed a similar alignment for both an at-grade and elevated solution. During a review of these alignments, the following features that relate primarily to the elevated solution were noted:

- It was difficult to develop a straight alignment and maintain functionality of Number 3 Road because the centreline of the road varied considerably over its length.
- Station loading was difficult. Initially the station concourses were located in the middle of Number 3 Road with grade access at intersections. By using centre-loading platforms, vertical circulation elements could be maintained within the existing median. While this provided a viable technical solution it had a much less than desirable access configuration.
- Guideway costs and visual impact were high due to the need to bifurcate the guideways at each station. The varying centre of Number 3 Road further exacerbated visual impacts by causing considerable horizontal guideway curvature on a substantially straight roadway.
- Permanent traffic and access impacts were high, in that left-turn bays at intersection and at business access points were difficult to accommodate without developing major and intrusive

structural systems. These conflicts not only created storage and sight-line problems but also caused longer guideway spans, leading to the requirement for more "special structures."

- Construction access would be difficult and construction impacts high because work would have to be carried out in the middle of the existing roadway.

Based on the review, the team considered alignments that located the guideway on one side of Number 3 Road and found that many of the problems noted above could be substantially mitigated, if not eliminated. The final selected arrangement provides the following benefits:

- The horizontal and vertical alignments are much smoother and straighter.
- All stations have side platform configurations with a central at-grade concourse accessible from the side of Number 3 Road. Side-load platforms could not be accommodated within the median or centre lanes of Number 3 Road because of the large out-to-out dimension between vertical circulation elements.
- The guideway has no bifurcations, reducing cost and visual impact.
- Eliminating conflicts with left turn bays reduces traffic impact and guideway costs.
- With all construction located on the side of the road, access is much easier and impacts are reduced. Moreover, the work is more simply staged by relocating utilities and Number 3 Road first to create a work site, then undertaking construction off to the side.

Although utility relocation costs are higher, locating the alignment along the side of Number 3 Road is the most beneficial solution.

1.2.2 OMC Location

The OMC is located in the Bridgeport area of Richmond. It is situated between River Road and Van Horne Way. The existing CP Rail track that runs through this area will be relocated (by RAVCO at its expense) in order to provide sufficient site area to accommodate the yard and the operations and maintenance buildings and facilities.

1.2.3 Alignment 63rd Avenue to Waterfront Station

The reference alignment indicated an option for either trench or at-grade alignments from 63rd Avenue to approximately 46th Avenue, shallow cut-and-cover tunnel from 46th Avenue to approximately 37th Avenue and deep-bored tunnel from 37th Avenue to 2nd Avenue. Horizontally, the alignment was centred approximately on Cambie Street.

The technical team evaluated both trench and underground configurations for the section from 63rd Avenue to approximately 46th Avenue. The trench had a large surface impact and caused significant loss of green space, along with large numbers of utility relocations. An underground configuration could allow the guideway to be beneath the roadway, avoiding both the loss of green space and much of the utility relocation. Both a side-by-side and stacked guideway arrangement were evaluated, with the stacked arrangement being preferred primarily due to its reduced footprint. Overall, our technical team recommended the use of a stacked guideway in this section for the following reasons:

- A stacked underground configuration allowed the horizontal alignment to shift to beneath the northbound lanes of Cambie Street.

- An alignment beneath the northbound lanes of Cambie allowed the Cambie Boulevard to remain untouched.
- The utility relocations were reduced.
- The construction site was easily segregated from the traffic on Cambie. This avoided significant impacts and the difficulty of having the construction site in the middle of the road.
- The stacked underground arrangement costs approximately the same amount as a grade-separated trench arrangement because there are reduced costs for utility relocations, reduced construction disruption and less green space reconstruction.

Our proposed alignment in the 46th Avenue to approximately 37th Avenue section is substantially as shown on the reference alignment except we have maintained a stacked arrangement for much the same reasons as noted above.

Our team has developed an alignment from 37th Avenue to 2nd Avenue that deviates from the reference alignment. In the opinion of our technical team, raising the alignment in this section was critical to the viability of the project because it will reduce costs and increase revenues. Specifically:

- It would reduce the amount of deep-bored tunnelling, thereby reducing associated risks and costs.
- It would allow cut-and-cover construction, which is well understood in the local market, with ample qualified contractors able to compete for the work.
- It would reduce station depths, thereby reducing costs and increasing ridership revenues by reducing access times.

Based on our technical evaluation and ridership modelling by Halcrow/TSI we were able to confirm our belief that this approach would reduce costs and increase revenues. Our alignment is therefore as close as possible to the surface through this section.

In the Little Mountain area, we have chosen to follow the northbound lanes of Cambie Boulevard in a side-by-side configuration to accommodate the crossover and future station at 33rd Avenue, after which the configuration rolls back into the stacked configuration to follow the northbound lanes down to 12th Avenue.

At 12th Avenue the configuration rolls back to side by side in order to pass over the future planned extension of the Millennium Line and the existing interceptor at 8th Avenue. We propose to bridge over the 8th Avenue interceptor in order to minimize construction and other impacts on the interceptor and on the transit system itself. The separation between the tracks then widens ready to enter the bored tunnels that start at Commodore Road.

The bored tunnels follow the reference alignment downtown, taking a tighter horizontal curve from Davie Street to Granville Street, in order to minimize the impacts on the buildings. Once the alignment is under Granville Street, the bored tunnels continue to north of Georgia Street where the cut-and-cover tunnels resume and continue to Waterfront Station.

1.3 TRACK PLAN

A track plan is shown in Drawing 865704-CONF-43DK-1701 in Appendix B-1. This track plan shows special trackwork elements and indicates where the mainline is in an elevated single guideway, elevated dual guideway pre-cast segmental, elevated dual guideway bridge structure, cut-and-cover stacked underground, cut-and-cover, side-by-side underground, cut-and-cover, cast-in-place underground or bored-tunnel underground configuration.

1.4 TRAIN SIMULATIONS

1.4.1 Train Simulation Methodology

RAILSIM Version 7 was used to simulate rail travel times for the Canada Line. RAILSIM is a leading, proven train simulation package used by many leading transit and transport operators, including CN, CPR, TTC, WMATA and KCRC. It is a comprehensive simulation package that allows the user to specify vertical and horizontal alignments, station locations, station dwells, air resistance coefficients and vehicle characteristics. The simulation software suite includes a train performance calculator (TPC), network simulator and load flow analysis.

All station dwells are greater than the minimum 10 seconds required in Schedule 1 section 4.4

Although vehicle manufacturers confirm that acceleration/deceleration rates of 1.3 m/s², along with a maximum speed of 90 km/h are achievable with their vehicles, it was deemed appropriate for scheduling and fleet sizing purposes to undertake train simulations with slightly lower performance characteristics. In this case, acceleration/deceleration rates of 1.1 m/s² and a maximum speed of 80 km/h were assumed. Using lower performance characteristics builds robustness into the schedule and tests the sensitivity of vehicle performance on travel times and fleet size. It is important to note that the results show that lower vehicle performance characteristics alone do not lead to increased fleet requirements. However, changes to the alignment, primarily around Little Mountain, and station locations have lengthened the Waterfront to Richmond trip time enough to add one train to the fleet, as discussed in subsection 1.5.

Table 1.1: Train Performance Calculator Parameters

TPC PARAMETERS	VALUE	UNITS
Track maximum speed:	Obey	
Civil speed limits:	Obey	
Calculated curve speed limits:	Obey	
Velocity smoothing:	None	
Jerk limiting:	1.0	m/s/s/s
Station stopping:	Yes	
System maximum speed:	80	km/h
Make-up time:	10	percent
Station dwell time:	20[1]	seconds
Average passenger weight:	68	kg
Acceleration rate:	1.1	m/s/s
Deceleration rate:	1.1	m/s/s
Passengers per car:	167	
Passenger load:	334	

1.4.2 Train Simulation Results

On the following page, Table 1.2 summarizes the end-to-end travel time results and average speeds for each simulation run, with and without Westminster Station. Tables 1.3 through 1.6 present travel times between each station. These tables include the simulation results for the Waterfront to Richmond Centre alignment without Westminster Station. It is important to note that the station-to-station travel times are meant for use in planning and designing the system and for setting operating schedules. However, as with any model outputs, they may not match the exact trip times between stations during operations. This is important because although the simulation results show that the end-to-end trip time requirement of 30 minutes between Waterfront and Richmond, and 26 minutes between Waterfront and the Airport, can be met, exact station-to-station trip times will not be known until the system is operational.

[1] 20-second dwells were assumed at all stations except Broadway and Bridgeport Stations, which have 25-second dwells.

Table 1.2: Travel Time and Average Speed Summary

	TRAVEL TIME (min)	AVERAGE SPEED (km/h)		
	Simulation Result	Simulation Result		
Waterfront to Richmond (SB)	25.00	34		
Richmond to Waterfront (NB)	25.02	34		
Waterfront to Airport (SB)	25.39	34.5		
Airport to Waterfront (NB)	24.92	34		

The detailed simulation result tables (Tables 1.3 through 1.6) provide the following information:

- Interval time
- Elapsed time
- Distance travelled
- Maximum speed

Table 1.3: Train Simulation Results – Waterfront to Richmond Centre

STATION ID	EVENT	INTERVAL TIME	ELAPSED TIME	DISTANCE
	State	Min:Sec	Min:Sec	Metres
Waterfront	Departure	0.00	0.00	
Robson	Arrival	1.10	1.10	658
Robson	Departure	0.30	1.40	0
Davie	Arrival	1.50	2.90	1054
Davie	Departure	0.30	3.20	0
2nd Avenue	Arrival	1.33	4.53	1001
2nd Avenue	Departure	0.30	4.83	0
Broadway	Arrival	1.10	5.93	431
Broadway	Departure	0.30	6.23	0
King Edward	Arrival	2.07	8.30	1505
King Edward	Departure	0.33	8.63	0
Oakridge	Arrival	2.75	11.38	1842
Oakridge	Departure	0.30	11.68	0
49th Avenue	Arrival	1.27	12.95	809
49th Avenue	Departure	0.30	13.25	0
Marine Drive	Arrival	2.20	15.45	1882
Marine Drive	Departure	0.30	15.75	0
Bridgeport	Arrival	2.10	17.85	1839
Bridgeport	Departure	0.42	18.27	0
Cambie	Arrival	2.23	20.50	1545
Cambie	Departure	0.83	21.33	0
Alderbridge	Arrival	1.50	22.83	845
Alderbridge	Departure	0.83	23.67	0
Richmond Centre	Arrival	1.33	25.00	905
Run Total		**25.00**		**14316**

Note: The Interval Time, Elapsed Time, Station Dwells and Distance between stations may vary as detailed design progresses and the final location of each station is determined. The Run Total will not exceed the maximum run times set out in the Project Essential Elements.

Table 1.4: Train Simulation Results – Richmond Centre to Waterfront

STATION ID	EVENT	INTERVAL TIME	ELAPSED TIME	DISTANCE
	State	Min:Sec	Min:Sec	Metres
Richmond Centre	Departure	0	0	0
Alderbridge	Arrival	1.55	1.55	906
Alderbridge	Departure	0.83	2.38	0
Cambie	Arrival	1.33	3.72	845
Cambie	Departure	1.00	4.72	0
Bridgeport	Arrival	2.17	6.88	1545
Bridgeport	Departure	0.42	7.30	0
Marine Drive	Arrival	2.17	9.47	1847
Marine Drive	Departure	0.20	9.67	0
49th Avenue	Arrival	2.17	11.83	1873
49th Avenue	Departure	0.20	12.03	0
Oakridge	Arrival	1.33	13.37	809
Oakridge	Departure	0.25	13.62	0
King Edward	Arrival	2.83	16.45	1842
King Edward	Departure	0.30	16.75	0
Broadway	Arrival	1.88	18.63	1505
Broadway	Departure	0.30	18.93	0
2nd Avenue	Arrival	1.00	19.93	417
2nd Avenue	Departure	0.30	20.23	0
Davie	Arrival	1.35	21.58	1020
Davie	Departure	0.30	21.88	0
Robson	Arrival	1.58	23.47	1035
Robson	Departure	0.30	23.77	0
Waterfront	Arrival	1.25	25.02	658
Run Total		**25.02**		**14304**

Note: The Interval Time, Elapsed Time, Station Dwells and Distance between stations may vary as detailed design progresses and the final location of each station is determined. The Run Total will not exceed the maximum run times set out in the Project Essential Elements.

Round Trip Time – Waterfront to Richmond Centre

The round trip time between Waterfront and Richmond Centre stations is calculated by adding the one-way travel times and terminal dwells. These calculations are shown below:

Waterfront to Richmond Centre	25.00
Richmond Centre to Waterfront	25.02

Terminal Dwells (3.5+3.4)	6.9
Round Trip Time	56.92

Table 1.5: Train Simulation Results – Waterfront to YVR 4

STATION ID	EVENT	INTERVAL TIME	ELAPSED TIME	DISTANCE
	State	Min:Sec	Min:Sec	Metres
Waterfront	Departure	0.00	0.00	0
Robson	Arrival	1.17	1.17	658
Robson	Departure	0.30	1.47	0
Davie	Arrival	1.50	2.97	1054
Davie	Departure	0.30	3.27	0
2nd Avenue	Arrival	1.33	4.60	1001
2nd Avenue	Departure	0.30	4.90	0
Broadway	Arrival	1.10	6.00	431
Broadway	Departure	0.30	6.30	0
King Edward	Arrival	2.07	8.37	1505
King Edward	Departure	0.33	8.70	0
Oakridge	Arrival	2.75	11.45	1842
Oakridge	Departure	0.30	11.75	0
49th Avenue	Arrival	1.27	13.02	809
49th Avenue	Departure	0.30	13.32	0
Marine Drive	Arrival	2.20	15.52	1882
Marine Drive	Departure	0.30	15.82	0
Bridgeport	Arrival	2.10	17.92	1839
Bridgeport	Departure	0.42	18.34	0
YVR1	Arrival	2.07	20.40	1573
YVR1	Departure	0.33	20.74	0
YVR 2	Arrival	1.57	22.30	991
YVR 2	Departure	0.33	22.64	0
YVR 3	Arrival	1.25	23.89	759
YVR 3	Departure	0.33	24.22	0
YVR 4	Arrival	1.17	25.39	754
Run Total		**25.39**		**15098**

Note: The Interval Time, Elapsed Time, Station Dwells and Distance between stations may vary as detailed design progresses and the final location of each station is determined. The Run Total will not exceed 26 minutes.

Table 1.6: Train Simulation Results – YVR 4 to Waterfront

STATION ID	EVENT	INTERVAL TIME	ELAPSED TIME	DISTANCE
	State	Min:Sec	Min:Sec	Metres
YVR 4	Departure	0.00	0.00	0
YVR 3	Arrival	1.30	1.30	754
YVR 3	Departure	0.33	1.63	0
YVR 2	Arrival	1.17	2.80	764
YVR 2	Departure	0.33	3.13	0
YVR 1	Arrival	1.47	4.60	992
YVR 1	Departure	0.33	4.93	0
Bridgeport	Arrival	2.00	6.93	1583
Bridgeport	Departure	0.42	7.35	0
Marine Drive	Arrival	2.17	9.52	1847
Marine Drive	Departure	0.20	9.72	0
49th Avenue	Arrival	2.17	11.88	1873
49th Avenue	Departure	0.20	12.08	0
Oakridge	Arrival	1.33	13.42	800
Oakridge	Departure	0.25	13.67	0
King Edward	Arrival	2.83	16.50	1342
King Edward	Departure	0.30	16.80	0
Broadway	Arrival	1.88	18.68	1505
Broadway	Departure	0.30	18.98	0
2nd Avenue	Arrival	1.00	19.98	417
2nd Avenue	Departure	0.30	20.28	0
Davie	Arrival	1.35	21.63	1020
Davie	Departure	0.30	21.93	0
Robson	Arrival	1.58	23.52	1035
Robson	Departure	0.30	23.82	0
Waterfront	Arrival	1.10	24.92	658
Run Total		24.92		15,098

Note: The Interval Time, Elapsed Time, Station Dwells and Distance between stations may vary as detailed design progresses and the final location of each station is determined. The Run Total will not exceed 26 minutes.

Round Trip Time – Waterfront to YVR 4

The round trip time calculations between Waterfront Station and YVR 4 are shown below:

Waterfront to YVR 4	25.39
YVR 4 to Waterfront	24.92

Terminal Dwell (2.33 – 3.40)	5.73
Round Trip Time	**56.04**

1.4.3 Turnback Operations at Terminal Stations

The preceding section addressed operations of a single train travelling in a single direction. This section describes turnback operations at the three Terminal stations: Waterfront, Richmond Centre and YVR 4. Each station is dealt with separately below. These descriptions are based on normal train operations during peak periods and throughout the day. Emergency and failure management operations are dealt with separately in Volume C of this proposal.

1.4.3.1 Waterfront Station

The design of Waterfront Station addresses several physical and operational constraints imposed by surrounding structures and the proposed service. These constraints led to a design that accommodates Richmond and Airport-bound trains and provides efficient passenger connections to the SkyTrain Line. When ridership volumes reach the ultimate capacity of 15,000 pphpd in the peak link, train headways between Waterfront and Richmond and between Waterfront and the Airport will need to be reduced from six minutes to four minutes, resulting in a combined two-minute headway between Bridgeport and Waterfront Stations. This service frequency can be accommodated with the proposed station arrangement.

As shown in Figure 1.1 below, a diamond crossover will be located south of Waterfront Station, which is a side platform station. Under normal operations, it is intended that northbound trains from Richmond will travel through the crossover from the northbound to southbound track and will proceed to the Richmond platform to alight passengers, dwell and board passengers. This operation will be similar to SkyTrain turnback operations at Commercial Station.

Northbound trains arriving from the Airport will be routed directly into the station to the Airport platform, where passengers will board and alight. When departing Waterfront Station, southbound trains to the Airport will be routed through the crossover to the southbound track. Figure 1.1 on the following page illustrates this operation.

The simulation results for northbound and southbound trips between Richmond Centre and Waterfront include the proposed turnback operations. As the results indicate, Airport-bound trains departing Waterfront Station from the airport platform require [1:10] (minutes:seconds) to reach Robson Station, compared to [1:06] for southbound trains to Richmond departing from the Richmond platform. This allows time for the Airport-bound train to travel through the crossover to the southbound track.

For northbound trips, Richmond trains traveling into Waterfront Station require [1:15] to travel from Robson Station and through the crossover to the Richmond platform. Northbound airport trains only require [1:06] to travel between Robson and Waterfront Stations, as they travel directly to the Airport platform.

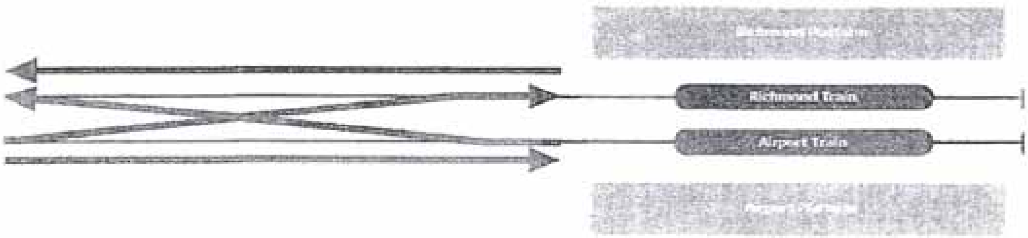


Figure 1.1: Turnback Operations at Waterfront Station

1.4.3.2 Richmond Centre Station

Richmond Centre Station is designed as an elevated side platform station. Turnback operation is accommodated by single crossovers north of the station platform, as shown in Figure 1.2 below.

The proposed solution is for Regular Service trains to be routed directly into the platform where passengers will alight and board. Trains will depart northbound from the same platform and will travel through the crossover to the northbound track. The simulation results include these operations for both north and southbound trips. The results show that southbound trips between Alderbridge and Richmond Centre Stations take 1:20. Northbound trips between these same two stations take 1:33, including time to travel through the crossover.

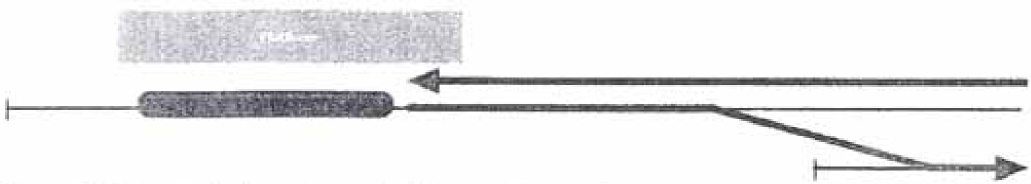


Figure 1.2: Turnback Operations at Richmond Centre Station

1.4.3.3 Airport Terminal Stations

The proposed turnback operations at YVR 4 involve routing southbound trains directly into the Preferred Inbound/Outbound platform where passengers would board and alight. Northbound trains would travel through the crossover to the northbound track between YVR 4 and YVR 3. This arrangement offers the benefit of allowing southbound passengers with luggage arriving at YVR 4 to stand up and prepare to alight without being jostled by travelling through a crossover. Northbound passengers will have time to sit down before their train travels through the crossover. This configuration is illustrated on the following page in Figure 1.3.

The simulation results shown in Table 1.5 include the proposed turnback operation at YVR 4. As the results show, the time required for southbound trains to travel from YVR 3 to the Preferred Inbound/Outbound platform at YVR 4 is 1:10 seconds. Northbound trains must travel through the crossover and will require 1:18 seconds to travel between YVR 4 and YVR 3.

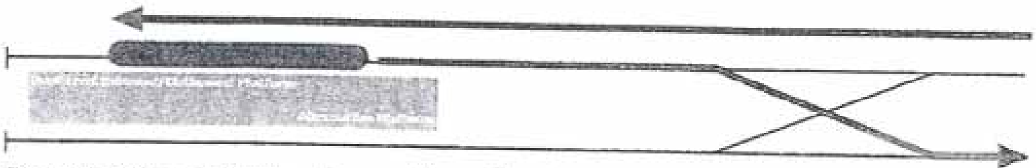


Figure 1.3: Turnback Operations at Airport Terminal Station – YVR 4

1.5 SYSTEM CAPACITY

The RFP Design and Construction Specifications state that proposed solutions must provide sufficient passenger capacity to meet "Base Level Demand." Base Level Demand is defined as a.m. peak hour demand, plus 15%. The following sections demonstrate how SNC-Lavalin/Serco's proposed solution (i.e., combination of vehicle capacity, fleet size and headways) will meet Base Level Demand throughout the Concession period.

1.5.1 Train Length and Passenger Capacity

A range of vehicle lengths is under consideration for the Canada Line. SNC-Lavalin/Serco have worked closely with several vehicle manufacturers during BAFO preparation to develop a list of potential vehicles that meet our performance criteria and are compatible with our infrastructure design. Based on the bids received from manufacturers, the vehicle length is anticipated to be between 17.5 metres and 22.5 metres in length, resulting in two-car trains between 35 metres and 45 metres in length. Passenger capacity is expected to be 167 passengers per vehicle, or 334 passengers per train.

1.5.2 Fleet Size

The tables on the following page show fleet size calculations for Regular Service operations. Calculations were undertaken for both the Richmond to Waterfront line and the Airport to Waterfront line. Each line is proposed to operate at an average 6min 20sec headways throughout the day, providing a combined average 3min 10sec headway between Bridgeport and Waterfront Stations.

Tables 1.7 and 1.8: Fleet Size Calculations

2 CAR CONSIST - RICHMOND TO WATERFRONT		
Headway (minutes)		6.33
Data Inputs		
Number of stations	13	
Passengers per vehicle	167	
Round-trip distance	29	
Station dwell	20	
Terminal dwells	414	
Round trip time (minutes)		56.92
Trains per hour past single point		9.5
Vehicles per train		2
Peak hour trains required		9
Peak hour vehicles required		18
Fleet Size Including Spares		**20**
Capacity pphpd		3,166

2 CAR CONSIST - AIRPORT TO WATERFRONT		
Headway (minutes)		6.33
Data Inputs		
Number of stations	14	
Passengers per vehicle	167	
Round trip distance	30	
Station dwell	20	
Terminal dwells	344	
Round-trip time (minutes)		56.94
Trains per hour past single point		9.5
Vehicles per train		2
Peak hour trains required		9
Peak hour vehicles required		18
Fleet Size Including Spares		**20**
Capacity pphpd		3,166

Based on operations and maintenance needs, one spare train is required for each of the Richmond to Waterfront line and the Airport to Waterfront lines, resulting in a fleet of 40 vehicles (20 trains). [Future growth in ridership would demand a decrease in headways from six to 5.5 minutes in 2035. This would result in two additional service trains being needed, and resulting in a fleet of 44 vehicles (22 trains). To avoid buying these vehicles now, well before their need is confirmed through actual ridership, it is proposed to maintain the average peak period 3 min 10 sec headway throughout the operating period.

The capacity requirements beyond 2037 will be met by allowing a reduction in the 15% margin above forecast demand that is used to determine Base Level Demand. This results in a 11% margin in the last year of operation.

1.5.3 Line Capacities

Based on the anticipated train capacity, fleet size and operating headways described above, the proposed operations can achieve the line capacities shown in Table 1.9 below. In summary, capacity between Bridgeport and Richmond Centre, and between Bridgeport and the Airport is anticipated to be 3,166 passengers per hour per direction (pphpd). These services merge between Bridgeport and Waterfront to provide an anticipated combined capacity of 6,322 pphpd.

Table 1.9 also shows Base Level Demand (baseline plus 15%) maximum a.m. peak hour demand per line segment based on SNC-Lavalin/Serco's proposed solution. These figures include air and non-air passengers.

The results show that the proposed system capacity meets a.m. peak hour Base Level Demand in 2010 and 2021. In other words, based on the demand forecast no changes would be required to headways up to 2021.

Table 1.9: A.M. Peak Hour Maximum Link Volumes by Line Segment

LINE SEGMENT	MAXIMUM LINK VOLUMES PASSENGERS PER HOUR PER DIRECTION - REGULAR SERVICE			
	2010		*2021*	
	Demand	Capacity	Demand	Capacity
Richmond Centre to Bridgeport	1,500	3,166	2,484	3,166
Airport to Bridgeport	961	3,166	1,879	3,166
Bridgeport to Waterfront	3,331	6,322	5,316	6,322

On the following page, Table 1.10 shows projected volumes on the Base Level Demand (baseline plus 15%) heaviest travelled link on the line (King Edward to Broadway) in the a.m. peak hour over the operating period. These figures were calculated based on the compound growth of the maximum link volume (air and non-air passengers) between 2010 and 2021. Table 1.10 also indicates fleet and headway requirements to satisfy the calculated demand. As shown, demand can be met with the initial vehicle fleet throughout the operating period with the margin reduced beyond 2037 as described in Section 1.5.2.

Table 1.10: Mainline A.M. Peak Hour Maximum Link Volume by Year

YEAR	BASE LEVEL DEMAND MAXIMUM LINK VOLUME pphpd	FLEET SIZE FOR REGULAR SERVICE OPERATIONS	HEADWAY PER LINE
2010	3,600 (ramp-up period)	40	6.33
2011	4,100 (ramp-up period)	40	6.33
2012	4,900	40	6.33
2013	4,900	40	6.33
2014	5,000	40	6.33
2015	5,000	40	6.33
2016	5,100	40	6.33
2017	5,100	40	6.33
2018	5,200	40	6.33
2019	5,200	40	6.33
2020	5,300	40	6.33
2021	5,400	40	6.33
2022	5,400	40	6.33
2023	5,500	40	6.33
2024	5,500	40	6.33
2025	5,600	40	6.33
2026	5,700	40	6.33
2027	5,700	40	6.33
2028	5,800	40	6.33
2029	5,800	40	6.33
2030	5,900	40	6.33
2031	6,000	40	6.33
2032	6,100	40	6.33
2033	6,100	40	6.33
2034	6,200	40	6.33
2035	6,300	40	6.33
2036	6,300	40	6.33
2037	6,400	40	6.33

2038	6,500	40	6.33
2039	6,500	40	6.33
2040	6,600 (11% margin)	40	6.33

1.5.4 Ultimate Capacity

The Canada Line must be designed to accommodate an ultimate capacity of 15,000 pphpd on the peak link. Meeting this requirement will require a change to both train length and headways. Tables 1.11 and 1.12 show the calculations of fleet size and headways that will meet the 15,000 pphpd capacity requirement for both the Richmond to Waterfront line and the Airport to Waterfront line.

Tables 1.11 and 1.12: Regular Service Fleet Size Calculations for Ultimate Capacity Requirement

3 CAR CONSIST - RICHMOND TO WATERFRONT		
Headway (minutes)		4.0
Data Inputs		
number of stations	13	
passengers per vehicle	167	
round trip distance	29	
station dwell	20	
terminal dwells	240	
Round trip time (minutes)		56.92
Trains per hour past single point		15
Vehicles per train		3
Peak hour trains required		15
Peak hour vehicles required		45
Fleet Size Including Spares		48
Capacity pphpd		7,515

3 CAR CONSIST - AIRPORT TO WATERFRONT		
Headway (minutes)		4.0
Data Inputs		
number of stations	14	
passengers per vehicle	167	
round trip distance	30	
station dwell	20	
terminal dwell	240	
Round trip time (minutes)		56.04
Trains per hour past single point		15
Vehicles per train		3
Peak hour trains required		14
Peak hour vehicles required		42
Fleet Size Including Spares		48
Capacity pphpd		7,515

The calculation reveals that the original two-car train consists must be expanded to three-car consists. This can be accomplished by splitting the two married cab cars at the articulation and adding a middle vehicle in between. This would increase train capacity to 501 passengers per train (167 * 3). Headways on each line must be reduced from six to four minutes, providing a combined two-minute headway between Bridgeport and Waterfront stations. These changes to vehicle length and headways result in a line capacity of 15,030 pphpd. For the range of vehicles under consideration the three vehicle consist will allow all doors to fit on the proposed ultimate length 50 metre platform. This meets ultimate demand requirement for all line segments, as shown in Table 1.13 on the following page.

Table 1.13: Ultimate Capacity Maximum Link Volumes by Line Segment

LINE SEGMENT	MAXIMUM LINK VOLUMES ULTIMATE CAPACITY	
	Demand	Capacity
Richmond Centre to Bridgeport	6,400	7,515
Airport to Bridgeport	4,200	7,515
Bridgeport to Waterfront	15,000	15,030

1.6 DESIGN AND CONSTRUCTION PRINCIPLE STANDARDS & CODES

The following is a list of principal standards and codes or an equivalent that will be used for the Design and Construction of the Project. The use and applicability of all or any part of these codes and standards in the design and construction of any portion of the work for the Project will be subject to the judgement of the Concessionaires qualified professional personnel responsible for that portion of the work.

CEC Parts I and II

Canadian Standards Association (CSA)

Electro-Federation Canada (EFC)

AASHTO	American Association of State Highway and Transportation Officials - LRFD Bridge Design Specifications, SI Units, Second Edition, 1998.
AASHTO	American Association of State Highway and Transportation Officials: Guide Specifications for Design and Construction of Segmental Concrete Bridge, 1999.
CAN/CSA- S6-00	Canadian Highway Bridge Design Code, 2000
NBCC	National Building Code of Canada, 1995.
BCBC	British Columbia Building Code, 1998.
VBBL	City of Vancouver Building By-law No. 8057, 1999
RTPO	Skytrain Rapid Transit Project 2000 Design Manual
NFPA 130	National Fire Protection Association - fixed Guideway Transit and Passenger Rail Systems NFPA 101 - National Fire Protection Association - Life Safety Code
NEMA	National Electrical Manufacturers Association
ASTM	American Society for Testing & Materials

AREMA	American Railway Engineering and Maintenance-of-Way Association
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
IEEE	Institute of Electrical and Electronics Engineers

International Organization for Standardization, ISO 9000 Quality Management Systems

ANSI C34.2	Practices and Requirements for Semiconductor Power Rectifiers
ANSI C34.14	Low Voltage DC Power Circuit Breakers Used in Enclosures
ANSI C37	Power Switchgear
ANSI C37.90.1	Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
ANSI C37.90.2	Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
ANSI C57	Transformers, Regulators and Reactors
ANSI C114.1	Recommended Practice for Grounding of Industrial and Commercial Power Systems
CSA C9-M	Dry-Type Transformers
CSA C22.2 No 31	Switchgear Assemblies
CSA C22.2 No 107	Rectifier Equipment
CSA C22.2 No 38	Thermoset Insulated Wires And Cables
CSA C22.2 No 239	Control and Instrumentation Cables
CSA C22.2 No 131	Type TECK 90 Cable
CSA C68.3	Shielded and Concentric Neutral Power Cables Rated 5-46kV
CSA FT4	Fire Test (Vertical Flame Test)
CSA C233	Non-Linear Resistor (Valve) Type Lightning Arrestors for Alternating Current Systems
EEMAC G-8-2	Switchgear Assemblies
IEEE No 59	Semi-conductor Rectifier Equipment
IEEE 80	Guide for Safety in AC Substation Grounding
IEEE 242	Recommended Practice for Protection and Co-ordination for Industrial and Commercial Power Systems
IEEE 446	Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

NEMA SG3	Low Voltage Power Circuit Breakers
NEMA SG4	AC High Voltage Circuit Breakers
NEMA SG5	Power Switchgear Assemblies
NEMA SG6	Power Switching Assemblies
NEMA RI9	Silicon Rectifier Units for Transportation Power Supplies
NEMA TR1	Transformers, Regulators and Reactors
NEMA 250	Enclosures for Electrical Equipment (1000V Maximum)
GEN SETS	

ANSI/NEMA, MG1-2003, ISO 8528-5, Class G3

EN 50119	European Standard - Railway Applications, Electric Traction Overhead Contact Lines

Canadian Radio Television and Telecommunications Commission (CRTC)

EN 50126	European Standard - Railway Applications. Demonstration of Dependability, Reliability, Availability, Maintainability and Safety (RAMS)
EN 50128	Railway Applications – Communications, Signalling and Processing Systems
NFPA 72	National Fire Alarm Code
MPT 1327	Trunked Private Land Mobile Radio Systems

Maintainability and Safety (RAMS)

EN 50128	Railway Applications - Software for Railway Control and Protection Systems
ISO 11064	Ergonomic Design of Control Centres
NFPA 70	Electrical Safety Requirements (as amended by Canadian and Local requirements)
NFPA 91	Exhaust Systems for Air Conveying of Vapours, Gases, Mists and Noncombustible Particulate Solids
NFPA 110	Emergency and Standby Power Systems
NFPA 130	Fixed Guideway Transit and Passenger Rail Systems
ANSI/AMCA	210-85 Laboratory Method of Testing Fans for Rating
ANSI/AMCA 300-96	Reverberant Room Method for Sound Testing of Fans

2.0 GUIDEWAY

2.1 PROPOSED GUIDEWAY PLAN

The alignment proposed for the Canada Line by SNC-Lavalin/Serco is based on the Fully Grade Separated Option in accordance with the RFP and complies with the reference alignment as described in Appendix 1 of the RFP. The mainline guideway configuration is presented from south to north, starting at Richmond Centre Station and proceeding to Waterfront Station in Vancouver. The Airport Connector configuration, located to provide access to the new hub proposed between Terminals 4 and 5 by the Airport Authority, is presented starting at Bridgeport Station and proceeding to YVR 4 Station. This section presents general arrangements of the guideway and an overview of the means and methods of construction. For a more detailed discussion of construction methods, please see Section 8.0 of this volume.

2.1.1 *Richmond Mainline*

The Richmond Mainline extends from the south terminal station at Richmond Centre to the south abutment of the Fraser River North Arm crossing. It is entirely elevated, precast concrete segmental construction supported on cast-in-place concrete columns and foundations. Framing plans and elevations are presented in Drawings 865704-CONF-42DK-1501 through 1507, attached in Appendix B-1. The guideway is typically single beam/dual trackway, simply supported beam spans except between Richmond Centre Station and Alderbridge Station and between Cambie Station and Bridgeport Station where single beam/single trackway is used. Spans are typically 36 metres but are varied to suit local site and other structural constraints.

On Number 3 Road the guideway is located along the eastern side of the road alignment, for ease of construction and to enhance the pedestrian and user interface. A road centreline alignment was considered in some detail during the development of our guideway concept but was found to have poor user interface, conflict excessively with vehicular manoeuvres and present construction coordination and access difficulties. Stations have been configured as side platform to enable the guideway and trackways to pass through station areas with a minimum of geometric variation. Centre platform configurations were investigated and found to create more intrusive and expensive guideway arrangements. Side platform arrangements along Number 3 Road were found to have net cost savings, as well as significant improvement in the visual presentation by avoiding tortuous and complicated guideway geometry.

The single trackway north of Cambie Station joins the two track from the Airport, just west of Bridgeport Station.

2.1.2 Fraser River North Arm Crossing

The framing plan and elevation for this structure is shown in Drawings 865704-CONF-42DK-1507 and 1508. The Fraser River North Arm Crossing will be constructed as an extradosed concrete box girder with cable stays using segmental pre-cast concrete elements erected by the balanced cantilever method of construction. The guideway in this location is arranged in a single beam-dual trackway configuration.

The track separation will be established from the pier dimensions. The span lengths and pier locations have been selected to accommodate the clearance requirements for the two navigational channels in the Fraser River and the clearance requirements of the CP Rail tracks. The height of the superstructure is restricted by the airport flight path requirements.

The substructure will be constructed using a combination of steel pipe piles, a pile cap and a cast-in-place column at each pier location. Substructures susceptible to ship/barge collision will have protection systems in general accordance with the RFP requirements.

2.1.3 Vancouver Mainline

The Vancouver Mainline extends from the north abutment of the Fraser River North Arm Crossing to the north terminal platforms at Waterfront Station. The alignment is elevated from the south extent to approximately 64th Avenue, at which point it transitions underground for the balance of the alignment. Drawings 865704-CONF-42DK-1508 and 1509 attached in Appendix B-1 show the framing plan and elevation for the elevated portion of the alignment. The elevated guideway is arranged in a single beam/dual trackway configuration from the north abutment of the crossing to approximately 330 metres south of Marine Drive. At this point the guideway starts to bifurcate to a dual beam/single trackway configuration to accommodate a centre platform arrangement at Marine Drive. The guideway maintains this arrangement north of Marine Drive station as it grade-separates and transitions to a stacked arrangement in a cut-and-cover tunnel. The general arrangement of this "rollover" structure is shown in Drawings 865704-CONF-42DK-1621, 1622 and 1623, attached in Appendix B-1. The elevated guideway terminates at the Cambie portal to the cut-and-cover tunnel at approximately station 105+760.

The rollover transition structure will transform the alignment from an elevated side-by-side configuration into a stacked shallow tunnel configuration. The alignment is set to be under the existing Cambie Street northbound traffic lanes to reduce utility relocations within the Cambie Boulevard and to avoid significant loss of existing green space. The cut-and-cover stacked tunnel configuration starts at approximately station 105+870, maintaining this arrangement to station 108+680, where the guideway transitions back to side-by-side configuration around Little Mountain. The vertical alignment of the stacked cut-and-cover shallow tunnel is maintained as close as possible to the existing grade of Cambie Street in order to reduce excavation and backfill quantities and provide minimum vertical circulation requirements at the stations. In addition, the use of cut-and-cover for a tunnel in this configuration uses well understood construction means and locally available equipment and resources, thereby reducing risks inherent in deep underground mining.

At station 108+680, the stacked arrangement transitions to a side-by-side arrangement through a cast-in-place concrete rollover structure. The side-by-side guideway configuration is constructed as an in-situ tunnel with dividing wall between the tracks, apart from at the crossover. The in-situ construction continues around Little Mountain, through the location of the future station at 33rd Avenue to Station 109+250.

At station 109+250, just north of Queen Elizabeth Park, the side-by-side tunnel arrangement rolls over once again to a stacked shallow tunnel arrangement. This stacked arrangement is maintained along the east side of Cambie from station 109+680 at 29th Avenue to approximately station 111+280 between 12th and 13th Avenues, where it transitions to a side-by-side, shallow, cut-and-cover tunnel arrangement. This shallow side-by-side tunnel arrangement is maintained through Broadway Station northward to the future 2nd Avenue Station cavity, where the alignment is configured to allow deeper bored tunnel construction. The future 2nd Avenue Station cavity is configured to allow for staging of tunnel boring machines for the boring of tunnels under False Creek, north under Davie Street and turning under Granville Street – generally following the reference alignment through to the north of Georgia Street.

2.1.4 Airport Connector Line

Framing plans and elevations for the Airport Connector Line are presented in Drawings 865704-CONF-42DK-1510 through 1516, attached in Appendix B-1. The Airport Connector guideway starts approximately at station 200+360 at the end of the tailtrack west of YVR 4 Station. Following meetings with RAVCO and the Airport Authority, the alignment and guideways have been changed from the reference alignment in the vicinity of YVR 4 and YVR 5 stations to provide a connection into a hub planned by the airport authority between the international and domestic terminals. YVR 4 Station has been located above the road network for circulating traffic and to provide access to both the new hub and the existing terminal, and thus YVR 5 has been removed. The resulting alignment and stations will provide superior passenger service and improved run times.

From YVR 4 the alignment follows the reference alignment to YVR 3, YVR 2 and YVR 1 Stations.

All airport stations, apart from the YVR 1, are configured as centre platform stations with the guideway bifurcating around each. Both the dual beam/single trackway and the single beam/dual trackway arrangements for the Airport Connector Line use the same type of structure as proposed for the Richmond Line. The line proceeds east from YVR1 in an elevated guideway configuration generally following the reference alignment over Grant McConachie Way and the Middle Arm of the Fraser River (discussed in subsection 2.1.5). As noted in subsection 2.1.1 the Richmond Line is configured to allow a grade separation between it and the Airport Connector Line just southwest of Bridgeport Station. At the connection to the Richmond Line, the Airport Connector Line is configured in a dual beam/single trackway configuration to facilitate its grade-separated branching from the mainline. The guideway transitions from a single beam/dual trackway arrangement to a dual beam/single trackway at approximately station 204+065 just west of the grade separated tie-in to the Richmond Line.

2.1.5 Fraser River Middle Arm Crossing

The framing plan and elevation for this structure is shown in Drawing 865704-CONF-42DK-1515 included in Appendix B-1. The Fraser River Middle Arm Crossing will be constructed using segmental precast concrete elements erected by balanced cantilever method of construction. The guideway in this location is arranged in a single beam/dual trackway configuration. The span lengths and pier locations have been selected to accommodate the clearance requirements for the navigational channel in the Middle Arm of the Fraser River. The substructure will be constructed using a combination of steel pipe piles, a pile cap and a cast-in-place column at each pier location. Substructures susceptible to ship/barge collision will have protection systems in general accordance with the RFP requirements.

2.2 ELEVATED GUIDEWAY

Elevated guideways are used for the Richmond and Airport Lines and extend into Vancouver, transitioning to shallow underground tunnel at approximately 64th Avenue. The elevated guideway superstructure will be constructed using match-cast, three-metre-long precast reinforced concrete segments. The form and nature of construction of the elevated guideway is similar to the recently completed Millennium Line. The segments will typically be erected through the use of erection/launching girders and post-tensioned into 36-metre simple span beams supported on bearings located on cast-in-place concrete columns. Span lengths will be varied to minimize utility conflicts, accommodate street crossings, stations and any other physical constraints. Such variations in the typical span length can easily be made, by eliminating a segment and/or varying the length of one or two segments within a span. Where site conditions dictate the need for longer spans, special structures will be constructed by configuring the typical section into three-span continuous structures or by utilizing the variable segment depth continuous structures built by cantilever construction methods. Typical elevated guideway general arrangements are shown in Drawings 865704-CONF-42DK-1601 through 1609 attached in Appendix B-1.

At certain locations where particular constraints occur, such as restricted headroom, pre-stressed beams with an in-situ deck will be used. The beams will have dapped ends and be supported on the crossheads or bents in the usual way.

The substructure elements, comprising single cantilever columns and bents, will be cast-in-place concrete structures constructed concurrently with the production of the precast concrete units.

The substructures and their foundations will be constructed in numerous locations to accommodate the construction schedule and project completion. Foundations on the Richmond and Airport Lines will consist of steel pipe pile groups with pile caps set below grade. Ground conditioning will be undertaken as required at some locations on the Richmond and Airport Connector Lines. Foundations on the Vancouver portion of the Canada Line will consist of cast-in-place, concrete, large-diameter caissons. Typical elevated guideway substructure and foundation general arrangements are shown in Drawings 865704-CONF-42DK-1601 through 1609 attached in Appendix B-1.

2.3 RIVER CROSSINGS

As noted in subsection 2.1, both the Fraser River North Arm and Fraser River Middle Arm crossings are configured to accommodate the navigational clearance requirements set out in the RFP and as subsequently revised by RAVCO.

The North Arm of the Fraser River bridge crossing requires a span of 180 metres to clear the navigation channel. Also, there is a Transport Canada flight path height restriction covering the bridge site. The structure proposed is therefore an extradosed precast segmental concrete box girder with cable stays that serve more as external post-tensioning than traditional cable-stays. The side spans will also be reduced to be consistent with the reduced girder-haunched depth at the pylons.

The Middle Arm of the Fraser River bridge crossing requires a span of 90 metres to clear the navigation channel. Also, there is a Transport Canada flight path height restriction covering the bridge site. The structure proposed is a five-span, variable-depth continuous structure providing a single guideway for the dual trackways.

Both structures are proposed to be constructed using precast concrete segments erected via the use of hoisting winch and traveler systems conceptually similar to the means and methods of construction used for the long-span special structures on the recently completed Millennium Line.

Substructures for the Middle Arm Bridge will consist of cantilever box piers on pile caps, on multiple pipe pile groups. Piers may be either permanently or temporarily fixed to the superstructure to accommodate the cantilever construction. The final general arrangement of the pier and superstructure articulation will be defined in design development. Ground conditioning around the pier foundations will be undertaken as required.

Protection will be provided for the in-water piers in case of ship/barge collision.

Typical general arrangements of both structures showing span lengths, location of piers and navigation clearance envelopes are shown in Drawings 865704-CONF-42DK-1642 to 1645 and pier details in Drawing 865704-CONF-42DK-1610, attached in Appendix B-1.

2.4 UNDERGROUND GUIDEWAYS

The proposed system is underground from approximately 63rd Avenue in Vancouver, north to the north terminal station at Waterfront. The underground construction is of two types: "shallow" tunnel constructed via cut-and-cover and "deep" tunnel constructed via boring or mining. The shallow tunnel extends from 64th Avenue to 2nd Avenue (station 105+760 to 112+130) and from just south of Dunsmuir Street to Waterfront Station. The deep tunnel extends from 2nd Avenue to just south of Dunsmuir Street.

2.4.1 Shallow Underground Tunnels

The shallow underground tunnels are typically configured in a stacked guideway arrangement. Two methods of constructing the stacked tunnel have been investigated, one using precast segmental concrete construction methods and the other using conventional cast-in-place concrete construction methods. The precast method uses match-cast, 2.4-metre-long, pre-cast concrete twin box tunnel segments. These segments will be installed sequentially within an open excavation suspended over a compacted base and skim slab graded to the approximate vertical and horizontal alignment. The void under the aligned segments will be grouted, the excavation backfilled and the surface restored. When installed, the twin box tunnel segments will produce a structure with the tracks in a stacked position. The cast-in-place method will use conventional mechanized and motorized steel jump-forming methods within an open excavation. The cast-in-place sections will have base slabs set to horizontal and vertical alignment including super-elevation. For this proposal we have concluded that the use of the precast segmental tunnel construction method has advantages over certain segments of the alignment and at others the in-situ method provides the flexibility of construction needed to overcome the constraints of maintaining utilities and traffic.

From Broadway Station to 2nd Avenue the tunnel is in a side-by-side arrangement. This configuration allows the tunnel to avoid conflict with the 8th Avenue Interceptor. At this stage it is proposed to expose the sewer and, depending on the condition of the pipe, either bridge over the 8th Avenue Interceptor to avoid impact and allow future replacement, and/or repair without disruption to the transit system, or construct a flume diversion that meets the hydraulic operational requirements.

All stations within this section are proposed to be substantially constructed by open excavation, cut-and-cover or top down construction methods, with excavations completed in advance of the adjacent shallow tunnels.

General arrangements of the shallow underground tunnels are presented in Drawings 865704-CONF-41DK-1207 to 1215 attached in Appendix B-1.

2.4.2 Deep Underground Tunnels

The section of deep underground tunnel is from 2nd Avenue through the downtown core (station 112+134 to 114+277). The Tunnel Boring Machine (TBM) will be set up to operate out of the site at 2nd Avenue/Commodore Road and will bore downtown.

The bored underground section consists of twin-bored tunnels, each approximately 5.5 metres in internal finished diameter. The tunnels are aligned to be in sandstone and glacial till and drift materials, and are to be advanced with a pressure-face TBM. The tunnel excavations will be supported with a "one-pass" bolted and gasketed precast concrete segmental lining, which will then be pressure grouted.

All stations within this section will be constructed substantially by open-excavation, cut-and-cover or top down construction methods, generally with their excavations completed in advance of the TBMs passing through. Should the station excavation not be completed prior to the first pass of the TBM, the lining of the running tunnel will be broken out later as part of the general excavation of the station. General arrangements of the deep underground tunnels are presented in Drawings 865704-CONF-41DK-1216 and 1217 attached in Appendix B-1.

2.5 UNDERGROUND EMERGENCY EVACUATION

Emergency evacuation and exiting is in accordance with NFPA 130. In general, within the underground tunnel sections emergency evacuation from an incident is accommodated by service walkways that run along the entire length of the tunnel. In an emergency, the tunnel ventilation fan system will be activated and fresh air will be supplied to the exit path in order to protect the evacuees. Emergency lighting and handrails mounted on the tunnel wall will assist in demarcating the exit routes. Cross-passages, located at approximately 240-metre intervals along the tunnel are provided to enable evacuees to transfer to the adjacent tunnel if required.

In the stacked tunnel configuration, these transfer points are configured as vertical towers. The evacuation path is connected to the stations, where vertical circulation elements will enable evacuees to exit to the surface. There are Blue Light Stations and exits to the surface at each passenger station. The cross-passages and Blue Light Stations are located in accordance with NFPA 130, typically are not farther apart than 244 metres and are configured as vertical stair towers within the stacked tunnel arrangement, and as horizontal cross passages in the side-by-side tunnel arrangement.

[redacted] 865704-CONF-41DK-1111 to 1122 attached in Appendix B-1.

s.15(1)(l)

s.15(1)(l)

in Drawing 865704-CONF-42DK-1640 and for the side-by-side tunnels in Drawing 865 04-CONF-42DK-1641 attached in Appendix B-1.

Details of the Tunnel Ventilation System, its configuration and operating approach, are provided in subsection 4.6 of this volume.

3.0 STATIONS

3.1 OVERVIEW

Stations and vehicles are the public face of transit. Combined with service reliability, the welcome and comfort they express shape public attitudes about the entire system. This approach is integral to providing a transit system that people will choose as a positive experience, rather than use as an inferior necessity.

Positive opinion has already been shaped through RAVCO's previous public consultation. This momentum must be enhanced through the finalization of design, continued through construction. Transit design, construction and public consultation must therefore be approached in an integrated, strategic manner.

Our concept of Community Partnership is central to the structure and flexibility of SNC-Lavalin/Serco's BAFO submission, and will help accomplish this goal. Community Partnership entails meaningful interaction with stakeholders, conducted within the discipline of a clearly understood process.

We have carefully considered the input from the general public and stakeholders from RAVCO's public process to date. Our initial task is to verify that these BAFO station designs locate station houses and entrances where they can serve the needs of each station precinct for greatest mutual benefit.

Our approach to finalizing station design for the Canada Line is to design stations on an individual and family basis. Richmond, Vancouver and Airport stations will have a distinct character that integrates each segment into its community. Station designs are founded in both elements of continuity and elements of distinction. As with the Millennium Line, this enables the design expression of each station to be best suited to its individual site and context.

The majority of our station designs are founded on four prototypes: two underground and two elevated. The principles of Crime Prevention Through Environmental Design (CPTED) are embodied in their layouts. Station footprints are modest, based on the principle of concentrating pedestrian activity in order to encourage a safe environment, as opposed to dispersing activity. In addition, our stations are "close to the ground," as we have used shallow stations in the underground segments and stations without mezzanines in the elevated segments. Their architecture and finishes will be designed to create warm, clean and safe stations.

Our philosophy regarding development around stations is to support associated development, as opposed to integrated development strategies. We aim to build stations that can be built independently and can function as station entities without reliance upon surrounding developments. In this way we can free station construction from the constraints of schedule related to obtaining potential rezoning and development permits. Provision for future linkages, allowance for adjacent new construction and other measures are strategies that enable the stations to become catalysts for shaping neighbourhoods and communities they serve.

All stations are designed to accommodate demarcation between paid and unpaid fare zones, and if required can be secured from general public non-ticketed access through a fare gate array. Station egress capacity has been sized to provide for the 15,000 pphpd ridership requirement.

The balance of this section describes the design principles and general approach we intend to adopt for the following aspects of station design:

- Station context
- Public consultation and community building
- Urban design
- Station branding
- Station architecture

The section concludes with descriptions of the individual stations, including their neighbourhood context, their location and configuration, and the opportunities that exist with each.

3.2 DESIGN PRINCIPLES AND GENERAL APPROACH

3.2.1 Station Context

Stations are community builders. In both "city-serving" and "city-shaping" capacities their role is larger than movement of transit patrons. This synergy between transit and community is at the core of this proposal. We conceive of station hubs as community catalysts. Customer service is an important baseline, and in response to this we seek to create stations that are clean, well maintained, welcoming and safe. Our aim is to enable opportunities for an expanded range of stakeholders around these station hubs, whose success will reinforce our core business. Thereby, long-term public benefit will be matched by value for the concessionaire and partner agencies.

Effective station design must recognize and balance five main elements:

a) **Transit System:** The overarching goal to provide and maintain a rapid and effective transportation system that is a fundamental lifeline for the healthy communities it serves.

b) **Neighbourhood/station area precinct:** This can be characterized as the synergy of the station with its communities. This varies according to whether the station is city-serving or city-shaping. In either case the transit service is an agent of change to be harnessed for community building. At this level of urban design, the focus is ensuring the station house, entrances and pedestrian pathways are located effectively.

c) **Station Hub:** This concerns itself with the area immediately around the station. Its narrow focus is the intermodal interface functions affecting buses, HandyDART service, passenger drop-off and pick-up, cyclists and pedestrians. Its broader focus is partnership with associated and adjacent development. Effective intermodal transfers will attract ridership and feed the transit system, while a strong station hub providing patron and community amenities will reinforce transit attractiveness for those with transportation choice.

d) **Site Functional Integration:** Good station design begins with a solid functional plan, integrated with access patterns to and through the site. This provides a logical and organized sequence of spaces and functions. They naturally lead the patron through the station and to the platform boarding area. The many facets of good station design are explained more fully in subsection 3.2.5.

e) **Station Building Elements:** At the detailed design level, great emphasis is placed on the design of the stations' systems and elements. Establishing the system's Elements of Continuity and Elements of Distinction provides functional clarity for the user while optimizing context-sensitive design. This takes into consideration long-term lifecycle costs, materials performance and operations and maintenance issues, in addition to the value placed on light, air and landscape by the general public.

3.2.2 Public Consultation and Community Building

Collaboration from the Ground Up – a Vision for Community Partnership

The transit corridor is selected and the alignment largely defined. Station locations and plans have been developed, yet this has been done in relative isolation, missing two key elements: city coordination, which has been limited due to BAFO submission time constraints, and public/stakeholder consultation.

Our Community Partnership approach starts with a strong understanding of the RAV community planning process. Our team members have participated in several technical planning processes for all the line segments. However, integrated dialogue is now needed, at the technical and community levels, so that we can proceed with the optimum balance of all interests.

Our Community Partnership approach is more fully described in Volume D, Third Party Consultations. At its core, this is a dialogue around the opportunities and constraints of design finalization. This direct contact with the design process, and discussion on the consequences of alternatives, will enable the strongest level of consensus to be built and maintained with respect to the project design and its implementation. There are two key filters that will discipline the discussion of options. Both of these are synchronous with the project's public private partnership procurement method:

Budget: The overall budget for stations has been established and the net cost cannot be exceeded.

Schedule: There is a definitive project schedule with critical timelines. The process of decision-making must therefore respect the schedule's milestones, and cannot be permitted to impact critical elements of the overall construction timeline.

Within these parameters, there is flexibility to explore station options. For this BAFO submission, station designs have been developed to provide a clear baseline for the project. Assumptions about property interests will need intensive consideration.

For several stations there are a range of alternative station house locations that can still be considered in the finalization of design provided that any additional land required can be provided by RAVCO at no additional cost to the Concessionaire. This design finalization is seen as a collaborative process with stakeholder input.

Led by a design team with experience in achieving excellence through collaboration, this dialogue will result in choices that will shape each station's design expression. In fact, the more participating stakeholders act integrally with the SNC-Lavalin/Serco project team, the greater is the opportunity to overcome constraints and achieve cost effective creativity.

Our Community Partnership approach is a means of enabling effective public consultation, involving an intensive community design process in the early months of the project. Anchored by the baseline and the discipline of budget and schedule, it will define station planning and urban design.

With the network of communication in place, the detailed design phase will include the parallel elaboration of construction impacts on a block-by-block basis and ongoing communication with affected property owners. This process will create informed understanding of the project and its processes, and identify opportunities for synergy within and beyond the transit envelope.

3.2.3 Urban Design – Community Fit and Catalyst

Made for this Place – a Vision for Community Partnership

The right building in the wrong place is the wrong building. As noted previously, the first priority is to complete the stakeholder dialogue so that, within the project's parameters, each station is located in the right place.

Fit within the community, and the extent to which a station can function as a catalyst for community-building, requires detailed review with the municipalities of Vancouver and Richmond, with the Airport, and with property owners. The urban design objective is for each station to take its "right place" within the evolution of each precinct.

For example, at King Edward, the station will create a fundamentally different "place" than that which exists. Whether the existing commercial zone continues to mark the boundary between multi-family/commercial and single-family development, or whether the station creates a more direct connection to the hospital and Queen Elizabeth Park precincts is a question for the public consultation process. On the other hand, it is assumed that Oakridge will undergo a reorientation, subject to the mall owner's (Ivanhoe Cambridge) timetable for site development.

The station planning and design process generally focuses on accomplishing a legacy of community upon completion of the transit project. The Community Partnership approach also addresses issues related to construction, such as temporary screening, landscaping and alternative parking.

Whichever way the broader city planning decisions unfold, a series of urban design principles underpin the station functional plans developed for the BAFO stage:

a) Elements of Continuity and Elements of Distinction

The architectural success of the Millennium Line was no accident. Individual design expression was brought to the forefront (Elements of Distinction) in the service of coordinated efficiency (Elements of Continuity).

This topic is elaborated further under Station Architecture (subsection 3.2.5). For the Canada Line the architectural design will be guided by key urban design concepts that also acknowledge the pragmatic and visionary complements of continuity and distinction.

b) Creative collaboration to ignite opportunity

The Canada Line requires us to expand into further forms of collaboration. While Millennium Line stations were conceived to be welcoming beacons in transitional industrial districts, the Canada Line generally represents the linkage of established urban areas.

At the largest scale, Bridgeport represents the greatest opportunity and challenge for transformation of its precinct. Accordingly it is at the forefront of our exploration of alternative alignments, technologies and integration with a new municipal station area plan.

Waterfront Station is similarly poised to contribute to a big-picture transformation. In this instance, the station can simply be inserted into the existing urban fabric. However the opportunity of its construction could trigger a broader vision that might otherwise languish for lack of a catalyst. Capitalizing on "leftover" space and infrastructure, an urban hub of international significance could be created to integrate many modes of transportation (including automobiles and parkades, as well as rail, sea and air) with complementary property development.

c) **Urban values – close to the ground**

The urbanism of Vancouver and Richmond is different in detail, but commonly shaped and coloured by street life and landscape. It is conditioned by daylight (nightlight in some instances) and cultural variety and knitted together by a common appreciation of nature. It is inherently a Northwest Pacific style of living – a product of our temperate climate, cultural openness and luxuriant environment.

Unlike in eastern Canada, where extensive underground systems function as primary pathways, in Vancouver sustaining a vibrant street life and maintaining connections to the outside are primary urban design objectives. Buried shopping malls like Pacific Centre go to great lengths to bring light in from the sky. Burrard Station opens into a sunken garden. Consideration of these qualities has led to the concept of bringing Canada Line stations "close to the ground."

Likewise, elevated mezzanine stations can spread their tentacles across a busy roadscape, detracting from pedestrian activity at street level. We seek to keep elevated stations close to the ground, and bring them to the east side of the street, where they can form the framework for urban courtyards that suit Richmond's urban development and redevelopment pattern (as well as at Marine Drive). In this way they function as lookouts in the urban landscape, highlighting transit connectivity, and marking major urban portals for the regeneration of commercial vitality at each station node.

d) **Daylight in a sunken courtyard**

Setting stations at a shallow level, just below grade, results in easier access. For the Vancouver underground station, this means providing concourses in the form of a sunken courtyard, with daylight orientation and high visibility to the street. There is ample opportunity for adjacent commercial activity, while the circulation to the platform level(s) proceeds in a direct line of sight, with the same quality of spatial openness.

e) **Minimal urban incision**

The stacked underground stations respect the enormous treasure that a mature treed landscape represents for Vancouver, especially an environment of rare and visually stunning specimens. The landscape median is safeguarded by a minimal width of cut for a stacked tunnel. This also enables the speediest means of tunnel construction. The wider areas for stations are excavated at street intersections, where the traffic management plan is already in place, further reducing long-term disruption to properties around stations and increasing opportunities for long-term additional connections.

f) **Community service**

The success of the Hub at the existing Commercial Station is testament to the benefits that integrating transit and community development can bring. In addition to serving transit patrons, we envision each station fostering similar commercial partnerships. This station plays a role in the community's daily life that is well beyond transit patronage. This symbiosis will sustain and reinforce the attraction of transit ridership over the long term.

g) **Universal access**

All stations require vertical patron movement. They are also designed for people of all levels of physical ability. This ranges from able-bodied people who can readily walk up and down stairs, to those who require assistance beyond riding an escalator. Patron service extends from those in wheelchairs to those taking bicycles on transit and every level of ability in between. Recognizing that in the large scheme of things, all humans are "temporarily abled," station planning follows principles of universal accessibility. A particular contributor to this is the location of elevators adjacent to main traffic paths, as opposed to their being separated from the amenities of the rest of the station.

In terms of station siting, it is expected that the normalization of universal access will place primary emphasis on pedestrian movements, through and around each station house, focussing on the integration of the station with the public life of the streetscape. In this regard bus interface and vehicular drop-off are designed to integrate the station with the streetscape as opposed to isolate it within a "transit dedicated zone."

h) **Sustainability**

As a major transit infrastructure project, the Canada Line goes well beyond "green" in its contribution to sustainability. We plan to highlight the environmental contribution of this project as an element of public education in the course of the design finalization and community consultation processes. In the context of sustainability, and mindful of the social improvements made at Commercial and Broadway, we also will be highlighting the CPTED and public safety aspects of sustainability. This ranges from the creation of opportunities for eyes on the street to the control of vehicular movements around station precincts.

3.2.4 Station Architecture

The foundation of superior station architecture is the functional plan. The range and depth of issues reflected at the functional level is extensive. Although simple and diagrammatic in appearance the key themes engendered in the functional plan form the catalyst for the expression of the final architecture. Principles embodied in the functional plans for the 16 Canada Line stations include the following:

a **Basic Station Configuration and Site Fit** – The station configuration and its fit on the proposed station site responds to guideway alignment, street right-of-way and property acquisition issues. Although requirements of underground stations differ from elevated stations the general intent has been to identify a good station fit that does not unnecessarily compromise adjacent properties or incur excessive expense through either utility relocation or property acquisition.

Recognizing that the life of a transit system should be measured in centuries, the baseline entrances have been selected to minimize imposition on existing property. For certain stations, such as Robson, a variety of alternate or supplementary station houses could be utilized, depending on negotiation with stakeholders.

b **Stations Access** – Station entrance configurations provide a hierarchy of inter-modal access that gives priority to bus transfers and pedestrian access. HandyDART loading has been located to provide easy access to the elevators where possible. Passenger drop-off and pick-up has been afforded secondary priority at most stations. Preference has been given to using in-street parking for passenger drop-off and pick-up, rather than providing off-street parking at stations. Bike storage has been placed at visibly prominent locations at station entrances in order to deter theft. Up to three service-parking stalls are provided for police and maintenance vehicles.

Resolution of the station access issues is a complex matter that requires extensive dialogue and consultation with the cities, transit agencies and local stakeholders. The SNC-Lavalin/Serco team plans to establish a Station Access Planning Committee that will bring together the key decision makers to facilitate this aspect of the design process.

c **Clarity of Path/Sequence of Movement** – The station's prime function is to be a direct conduit to guide people to and from the trains. There is a basic functional organization through arrival, information provision, ticketing, fare control, travel to platform and waiting for the train. This requires a systematic progression that is easy to follow for the first-time user and is consistent between stations across the system. The station plans have been developed using right-hand rule patron movements. Spaces are oriented to direct decision making as a linear series of single choices. Cross-flow movements have been minimized.

d **Station Balancing** – Patrons tend to wait at the platform in a proximity that corresponds to their optimum point of arrival. It is thereby important for the system to vary the platform entry points from station to station. This approach, termed "station balancing," provides a more even distribution of passengers within the trains.

e **Level of Service** – The stations' spaces and vertical circulation elements have been sized based on level of service standards developed by Dr. J. J. Fruin. Consideration has been given to the fundamental exit capacity requirements required for life safety. In addition, spaces have been sized taking into account level of service standards associated with transit use. For vertical circulation, stairs have been sized such that, if an escalator breaks down, the main transit pedestrian movement can still continue, albeit at a reduced level of service.

f **Crime Prevention Through Environmental Design (CPTED)** – Much like the CPTED principles incorporated into the Millennium Line, the current station designs assume extensive use of glass at the platform level and in elevator shafts to strengthen visual connectivity. Likewise, elevators are located in prominently visible public locations, and not relegated to remote areas visibly disconnected from the general public. These examples illustrate just some of the many strategies adopted and used in the functional planning of these Canada Line stations.

There is an opportunity to develop complementary companion uses in close proximity to the stations, particularly commercial functions that can remain open at night. These have not been indicated on the station functional plans at this time. The exploration of these initiatives is one element to be considered during the design development/public consultation phase of developing the Community Partnership approach.

The more significant CPTED challenge is presented by the underground stations, because their general nature entails the removal of public areas from the public streetscape realm. Our solution has been to create compact stations that are close to the surface, as opposed to being deep underground. Our "closer to the ground" approach enables vertical circulation and connecting concourses to be shorter, and provides greater opportunity to incorporate natural light into the stations. These strategies concentrate patron activity as opposed to dispersing it along greater runs, and provide more opportunity for overlook from the streetscape.

The concentration of patron activity is a core component of our baseline approach. It does not mean that additional access is undesirable; however it is in contrast to large "tentacle" type stations that disperse transit patrons through multiple single purpose underground passages. In addition to being expensive, passages, such as those at [redacted] create unsafe environs that are not well used by passengers. Our Community Partnership approach works with property owners who can benefit from exposure to added commercial traffic and provides "eyes on the street" for secondary entrances and concourses. The end result of improved accessibility can only be achieved through the station finalization process, with its consultative outreach. s.17(1)

g) **Universal Access –** For stations, disabled access incorporates all persons with limiting conditions, from those with impaired movement through to those with cognitive disabilities or impaired senses. Universal access refers to the integration of consideration for disabilities within the mainstream of the design. The station functional plans address some of these issues through the organization of spaces to create clarity of path, and the use of escalators and elevators to assist vertical movement. Other issues for the disabled will be addressed through the detailed station design. The SNC-Lavalin/Serco team will establish a Disabilities Review Committee as part of the Public Consultation Program to coordinate and liaise with the disabled community.

h) **Organization of Ancillary Functions –** The ancillary space functions in elevated and underground stations represent up to 30% of a station's total floor area. They require special planning for spatial and functional relationships to be maintained, and issues such as large equipment removal and location of primary electrical risers are accommodated.

In underground stations the accommodation of tunnel ventilation requirements is essential to the station's layout. Care has been taken to develop tunnel ventilation strategies that will protect the primary paths of exit and station air intakes, from unwanted levels of smoke filled exhaust air from recirculating back into the station, prior to the safe evacuation of passengers.

i) **Construction Method –** The Construction Method is important to the sequencing and scheduling of the work. Key interfaces between guideway and station influence both design and construction methodology.

At elevated stations, given the poor ground conditions common to most sites, it has been necessary for the guideway and station structures to be integrated and share the same foundations. By sharing a common structure, potential differential settlement issues at the boarding interface between platform and vehicle are avoided.

Underground station boxes are located in the street right-of-way to reduce property acquisition costs. To reduce traffic disruption during construction, a top-down excavation method is proposed at selected station locations. This approach relies on establishing a perimeter wall around the station box and then constructing a roof structure for the station. Once the roof structure is in place, the roadway can be reinstated and traffic operations restored. In the meantime, excavation of the station box can take place underneath, with relatively little impact on vehicular traffic.

f. **System-Wide Procurement**

s.17(1)(e)

3.3 PROJECT APPRECIATION

3.3.1 Neighbourhood Character

For the purpose of station design, the Canada Line has been divided into seven distinct segments, each with unique urban characteristics and technical challenges. They can be classified as follows:

- Downtown Urban Core

- Cambie Street Commercial
- Cambie Street Residential
- Industrial/Intermodal
- Richmond Number 3 Road International District
- Richmond Number 3 Road Commercial District
- YVR Support Areas and the Airport Terminals

3.3.2 Location and Site

The rationale utilized for station location, configuration and features is based on critical response to unique community requirements. The neighbourhoods vary dramatically in character, architecture, density and urban fabric, and therefore each site has been carefully considered with regard to station accessibility, visibility and recognition, intermodal transfers, and day and night site security.

3.3.3 Station Prototypes

In response to the variety of contexts through which the Canada Line will operate, four station prototype configurations have been developed: two for elevated stations and two for underground stations. Several stations, such as Broadway, are unique in their configuration and are not prototypical. The four prototypes are as follows:

- Elevated centre platform
- Elevated side platform
- Underground-stacked platform
- Underground centre platform

The elevated centre platform prototype is utilized at the airport stations and at Bridgeport. The elevated side platform prototype is proposed for stations along Number 3 Road in Richmond. The underground-stacked prototype is utilized along Cambie Street to minimize the extent of the station box footprint, while both side and centre platform configurations are utilized in the downtown underground stations.

3.3.4 Downtown Urban Core Stations

- **Waterfront Station**
- **Robson Street Station**
- **Davie Street Station**

Neighbourhood Character

Although located in three distinct precincts of the city, the context of each of the three stations is characterized by intense public activity, commercial growth and ongoing development. Vancouver's downtown is recognized as a vibrant, safe, clean, environment amidst both historical and contemporary architecture. The Waterfront and Robson station designs incorporate the Granville Mall redesign currently being considered by the City of Vancouver.

Station Features

The underground centre platform configuration is utilized in two of the downtown stations in response to the wide track centres associated with either the twin bore tunnels or the special trackwork. Waterfront Station utilizes a side platform configuration in response to the close track centers selected to minimize excavation width in the cut and cover guideway section in this area. The platform and concourse levels are contained within a grand urban room of generous double height space, which will be well lit, and offer opportunities to introduce daylight.

Waterfront Station:

- **Location:** adjacent to Canadian Pacific (CP) Train Station, under a newly configured Granville Street right-of-way, between Cordova Street and Hastings Street. CP Station currently functions as the city's intermodal transit hub; the front doors of this historic building provide direct access to the SkyTrain Expo Line, SeaBus, West Coast Express and a number of retail establishments. The station is ideally located to connect directly into the CP station main hall for passenger transferring to other modes. A south entrance beyond Hastings Street services the majority of a.m. peak Ridership destined for the central business district.
- **Station Configuration and Characteristics:**

s.17(1)(e)

Robson Street Station:

- **Location:** approximately five city blocks south of Waterfront Station within the retail and commercial core of the city. This area of Vancouver consists of large-scale developments such as the Sears department store, Pacific Centre Mall and Vancouver Centre Mall, as well as low-rise commercial developments with sidewalk frontage.

  The location of this station more than any other is subject to public debate. Ideally it should have two entrances: one reaching to Robson Street and the other to Georgia. The current configuration, because of budget constraints, assumes a single entrance on Robson Street. Opportunities exist for the station to make a connection to the Pacific Centre and Vancouver Centre Malls, but this is predicated on the mall owners' substantially paying for the extra station infrastructure needed for the link.

- **Station Configuration and Characteristics:** the general arrangement is illustrated in Drawings 865704-CONF-44DK-A121 to A125 in Appendix B-1. The primary station house on Granville Street is located north of Robson Streetwithin the eastern half of the road right-of-way. A new emergency egress stair at the south end of the platform exits to the street. Potential direct access into the below grade retail link located north of the station box could replace the requirement for the secondary exit route.

Davie Street Station:

- **Location:** the dynamic neighbourhood of Yaletown. Originally developed in the early 1900s, this once-warehouse district is now zoned primarily as CD-1 and HA-3 and is one of the city's most thriving shopping, business, residential and night entertainment precincts. A simple historical building materials pallet of brick, steel and glass, make for a rich architecture, recently restored to its original character. The station must fit into a dense urban fabric: the proposed location at the intersection of Davie Street and Pacific Boulevard provides the opportunity to fit into this context, while straddling the border of a new mixed-use high-density development to the south, adjacent to False Creek.

- **Station Configuration and Characteristics:** the general arrangement is illustrated in Drawings 865704-CONF-44DK-A131 to A135 in Appendix B-1. Access to this underground station is provided via a primary station house in Bill Curtis Plaza. The station entrance at Bill Curtis Plaza is located at the north end in order to achieve the greatest penetration and best serve the local neighbourhood. It utilizes the existing parkade egress pavilion on the southwest corner of Mainland and Davie Streets for elevator access and emergency egress. Reconstruction of the existing stairs and elevator is assumed, in order to serve the functional and security requirements of the station.

Key Site Features, Special Requirements and Opportunities

These three sites offer the possibility of tying into public and civic spaces such as the new Granville Street Mall, connecting to adjacent underground retail, and in the case of Waterfront Station, serving as a catalyst for the stimulation of major redevelopment around the station hub.

- Waterfront Station: renovations to the CP Station over the years have created a series of overlapping components to accommodate intermodal requirements. Marginally functional, these components have resulted in a convoluted and inefficient system of mass public transit interface. In addition, a series of infrastructure upgrades adjacent to the station, phased over many years, have resulted in a complex network of underground spaces, pedestrian links and vehicular right-of ways. The prominence of the CP Train Station location provides multiple opportunities to stitch together and tie into other existing circulation elements and buildings. While it is not the mandate of this project to finance and implement such an undertaking, it is recognized that this new Canada Line station can serve as a catalyst and generator of major change to this key intermodal hub.

There are further opportunities at Waterfront Station to provide cruise ship passenger transfers. The details of this opportunity are discussed in more detail in subsection 10.6 of this volume.

- Robson Station: several tie ins to adjacent existing developments are possible in the proposed location, such as the underground link between Pacific Centre Mall and Vancouver Centre Mall south of Georgia Street. Although the base design provides only one entrance, this site offers prime opportunities to introduce additional retail venues, as well as underground linkage to existing adjacent developments. Such opportunities would be pursued based upon reaching a negotiated agreement with the mall owners.
- Davie Station: reconfiguration of Bill Curtis Plaza, combined with the interface with the underground parking structure, is the primary design issue for Davie Station. Although our entrance configuration has been developed for this BAFO submission, more meaningful discussion with the key property stakeholders will allow us to explore and potentially find a better solution than that currently portrayed in the design drawings.

3.3.5 Cambie Street Commercial

- **Broadway Station**
- **Oakridge Station**

Neighbourhood Character

The Broadway and Oakridge neighbourhood characters are similar, with two and three-storey properties with a retail base and commercial space above. These neighbourhoods are punctuated with major buildings and complexes such as City Hall and Oakridge Centre. Open plazas and other vacant sites offer opportunities to locate station entrances that can be integrated into the community.

Station Features

Broadway Station

- **Location:** approximately centered on 10th Avenue, with the main entrance located in a portion of an existing parking lot on the east side of Cambie Street. The location will allow for future tie-in with the extension of the Millennium Line, which may be located below either 10th Avenue or Broadway. In addition to close proximity to the busy intersection of Cambie Street and Broadway, the proposed station location serves east/west bus traffic, visitors and employees of City Hall and Vancouver General Hospital. Desire for this station to expand and provide multiple entrances with underground connecting concourses is strong. However, considering CPTED-related issues, our preference has been to design compact stations that concentrate pedestrian activity rather than disperse it.

- **Configuration and Characteristics:** the station general arrangement is illustrated in Drawings 865704-CONF-44DK-A141 to A146 in Appendix B-1. Broadway Station is proposed to be an underground side platform station, with an underground ticketing concourse above the platform. The future Millennium Line platform can be accessed from the same mid-level concourse, from the fare-paid zone, thus maintaining the same ticketing threshold for passengers accessing either the Canada Line or Millennium Line platform. The station site plan assumes a rerouting of the existing lane on the north side of the entrance. It is proposed that the lane is turned southwards to connect to 10th Avenue so that in the future, when the City redevelops its land fronting Broadway, an entrance on Broadway can connect directly into the station concourse without involving stairs or escalators.

Oakridge Station

- **Location:** the busy intersection at 41st Avenue and Cambie Street is an ideal location for an underground station. Adjacent to one of BC's most prominent shopping centres, the intersection also functions as a north/south and east/west transit exchange. In this neighbourhood, Cambie Street is flanked on both the east and west sides by commercial development. In addition to the three-storey commercial and retail buildings is a gas station (now closed), located on the northeast corner of the intersection. Access to the Canada Line station is proposed to be from the west side of Cambie Street, south of 41st Avenue. The existing plaza on this corner functions as the basis for tie-in to station entrance and tie into the mall.
- **Configuration and Characteristics:** the general arrangement is illustrated in Drawing 865704-CONF-44DK-A161 in Appendix B-1. Linking into the plaza has been explored in order to create a dynamic public space. The result is a tie-in that benefits the retail component and maintains close proximity to the four in-street bus stops located at this major street intersection. A series of new terraces, planters and green plates define a new amphitheatre court. The court will provide direct access to the station concourse level. Upon entering the fare-paid zone located below the southbound lanes of Cambie Street, one proceeds eastward, under the Heritage Boulevard, directly onto the northbound platform, or descends to the southbound platform located below.

Key Site Features, Special Requirements and Opportunities

- Broadway Station: this station is at a lower elevation than the north end of the new station house; an opportunity exists to connect directly from the southeast corner of Broadway and Cambie to the mid-level concourse of the station. This connection is assumed to be incorporated as part of the City's redevelopment of that block. A knock-out panel at concourse level will enable a simple connection to be made. The location of the proposed street connector is dependent on the status of the B-Class heritage building located just north of the station house. If necessary, an alternate connection that avoids the building can be provided. Locating the proposed pedestrian link under the sidewalk will avoid conflict with the existing heritage building located mid-block between the existing City-owned parking lot and Broadway. The location offers the potential to tie into a future bus loop or passenger pick-up and drop-off zone to the east of the station house in the area of the existing surface parking lots.
- Oakridge Station: Oakridge Shopping Centre is planning significant redevelopment, including major residential expansion. It is known that the mall owners would be interested in a direct link into the mall. The opportunity to add a south entrance would be subject to negotiations with the mall.

3.3.6 Cambie Street Residential

- **King Edward Station**
- **49th Avenue Station**

Neighbourhood Character

This precinct is predominantly zoned as single family residential with some mixed use commercial. The "low-key" character of this area will be maintained by addressing the fit of the station houses within the environment. A similar response to station design is envisioned for these two stations: modestly scaled pavilion-type station houses. Minimal disturbance of the Heritage Boulevard is critical and has been addressed in the layout of the station boxes and their locations below grade.

Station Features

The underground-stacked platform configuration is utilized in three of the Cambie Street stations. The stacked configuration, with the southbound tunnel below the northbound tunnel, reduces the station excavation footprint, thereby reducing site disturbance during construction. Placing the northbound tunnel closer to grade minimizes station access time and thus total travel time, for inbound boarding passengers. Passengers enter this underground station through a single station house, via stairs or an elevator, directly into the ticketing zone of the main concourse below. Passengers may then purchase tickets and proceed into the fare-paid zone. This area provides direct access to the northbound platform and a direct connection via stairs and an ascending escalator with the southbound platform below.

King Edward Station

- **Location:** at the intersection of King Edward and Cambie Street. This intersection demarcates the north extent of the Heritage Boulevard. The boulevard is framed by mature fir trees along its borders and punctuated by a prominent sequoia at its centre. This formally planned segment of the boulevard is highly valued by the public, and every effort has been made in our design to keep it and its trees intact. The station entrance is located on the south east corner of the intersection on the site of an existing residential property.
- **Configuration and Characteristics:** the general arrangement is illustrated in Station Prototype Drawings 865704-CONF-44DK-A151 to A155 in Appendix B-1. Functional plans and sections form the basis of the stacked underground station prototype. The stations at 41st and 49th Avenues assume similar layouts. The station house on the east side of Cambie Street is envisioned as a modestly scaled pavilion within an existing commercial development.

49th Avenue Station:

- **Location:** in close proximity to Langara College, the intersection of 49th Avenue and Cambie Street will provide rapid transit access to a mix of both commuters and students. Predominantly zoned for single-family homes, the character of the area is that of a mature residential neighbourhood. On the southeast corner of the intersection are the Langara Estates, while further to the south is the Langara Golf Course. The proposed station plan locates the station box under the intersection, with an entrance sited on the northeast corner, replacing the existing single-family residence. The residual site area behind the station will be used to locate a surface traction power substation.

- **Configuration and Characteristics:** the station site context plan is illustrated in Drawing 865704-CONF-4DK-A171 in Appendix B-1. The pavilion is located on the northeast corner property at the 49th Avenue and Cambie Street intersection.

  The general configuration of this station is similar to King Edward station, with the main station volume located on the east side of the tunnel. Rather than entering the station house from the north, patrons enter the station house from the south. Stairs or an elevator provide direct access into the ticketing zone of the main concourse below. Passengers may then purchase tickets or proceed into the fare-paid zone. As with King Edward station, this area provides direct access onto the northbound platform and a direct connection via stair and ascending escalator, with the southbound platform below.

Key Site Features, Special Requirements and Opportunities

King Edward Station

- Construction of the King Edward station assumes acquiring the full property on the southeast corner. The station house and Traction Power Substation will fully occupy the residential property.

49th Avenue Station

- At 49th Avenue Station, on the southeast corner of the intersection, mature evergreen trees screen the Langara Estates residences. It may be necessary in the next phase of design to adjust the station box slightly to limit disturbance of existing trees.

3.3.7 Industrial/Intermodal Hubs

- **Marine Drive Station**
- **Bridgeport Station**

Neighbourhood Character

- Marine Drive Station: the neighbourhood around Marine Drive and Cambie Street is a mix of residential and commercial developments straddling the edge of industrial parcels zoned I-2 to the south. This area has potential for more high intensity employment, such as biotech and high-tech, in the future. Due to the width of both Marine Drive and Cambie Street north of the intersection, the perceived character of the neighbourhood is more a vehicular zone than a pedestrian realm. This intersection demarcates the termination of the Cambie Heritage Boulevard; to the south of Marine Drive the right-of-way narrows to a four-lane configuration without a median. The substantial reduction in width alters the character of the street from prominent thoroughfare to secondary arterial.
- Bridgeport Station: the light industrial character of the area is quickly changing into a commercial entertainment precinct. The recently completed extension of Garden City Way has provided direct access to the site, while the new casino located on the north side of River Road has made the neighbourhood a destination location. The adjacent railway lines, spur lines and sidings to the south of the site, paired with the new casino, create a challenging context in which to locate Richmond's largest station and intermodal transit exchange.

Station Features

Marine Drive Station:

- **Location:** to the southeast of the intersection of Marine Drive and Cambie Street is the ICBC site, lush with indigenous plant life; to the southwest are a series of residential two-storey town homes with a two-storey office building on the corner. The north side of this busy intersection is zoned commercial with adjacent residential on both the east and west sides of Cambie Street. On the northwest corner is a gas station, and on the northeast corner a small-scale convenience retail establishment.

  The proposed location for the elevated station is approximately 20 metres south of the southeast corner of the intersection, along the west side of the ICBC site, as shown in Drawing 865704-CONF-44DK-A181. The station facilitates an intermodal exchange with a six-bay bus loop. The site negotiates a change in grade of approximately 5.0 metres, with a landscape buffer along the north side of the property.

- **Configuration and Characteristics:** Site Context Plan and configuration is illustrated in Drawings 865704-CONF-44DK-A181 to A184 in Appendix B-1. Utilization of the topography is a key component in the station design. The ticketing concourse is located along Cambie Street at sidewalk level at the north end of the station. Access is then provided down to the bus loop below or up to the centre-loaded platform. Tight site and alignment constraints are resolved through the use of an offset bent structure for this centre platform station. Locating the bus loop east of the station, at a lower elevation than the ticketing concourse utilizes the station as a screening element for the R-2 properties on the west side of the street. A centre platform is proposed to suit local site conditions and access. Circulation from concourse level to platform level is achieved by stair or escalator oriented in an in-line arrangement.

Bridgeport Station:

- **Location:** the site is to accommodate an elevated station a 15-bay bus loop, a passenger pick-up and drop-off zone (PPUDO) and bicycle storage. The station will function as the interchange station from which southbound trains will route to either the airport or Richmond. The station will also be the merging point for northbound trains from the airport and Richmond. The site is approximately 2.0 metres above sea level in an area that was prone to seasonal flooding prior to the construction of dikes along the Fraser River. This local geography has resulted in a topography that is virtually flat, with sparse natural vegetation. This station is destined to be a catalyst for change. Identification of the preferred station location will be a key aspect of the station precinct planning exercise.

- **Configuration and Characteristics:** the general arrangement of this elevated station is illustrated in Drawings 865704-CONF-44DK-A191 to A195 in Appendix B-1. In developing the general arrangement of this Station, it has been assumed that an elevated pedestrian bridge will be provided between the Station concourse and the parkade structure developed north of the station. This bridge has been considered in the access/egress calculations.

Key Site Features, Special Requirements and Opportunities

- Marine Drive Station: during construction, there is a strong likelihood that much of the existing landscaping along the east side of Cambie Street will be removed, the specific locations of planters and types of plants used will conform to CPTED principles.
- Bridgeport Station: currently barren of landscaping, the site design will require consideration of new planting areas, as well as soft and hard surface treatments. A landscape buffer zone along the south side of the site paired with the inclusion of landscaping within the bus loop plaza are possible site enhancements that will be studied in more detail during the next stage of design. The broader opportunities around the Bridgeport station relate to the redevelopment of the station precinct plan.

3.3.8 Number 3 Road International District

- **Cambie Station**
- **Alderbridge Station**

Neighbourhood Character

Development in this area is escalating with new large-scale projects planned for the near future. Predominantly low-rise commercial development, the neighbourhood is very active and often congested with vehicular traffic. In the baseline proposal, these two stations, as with all the Richmond stations, are elevated and arranged in a side-loaded platform configuration. The elevated guideways will avoid conflict with cross traffic and local public transit. This option avoids conflicts between guideway columns and left-turn lanes on Number 3 Road, and also achieves a relatively straight guideway alignment.

Station Features:

Cambie Station

- **Location:** the proposed site for this station is the southeast corner of Cambie Road and Number 3 Road. Despite a relatively narrow station footprint, two properties must be acquired to adequately site the station.
- **Configuration and Characteristics:** Cambie station is shown in Drawing 865704-CONF-44DK-A201. This station is based on the elevated platform prototype used at Alderbridge.

Alderbridge Station

- **Location:** the proposed site for this station is the southeast corner of Alderbridge Way and Number 3 Road, located along the edge to the Landsdowne Mall parking lot. While certain parking spaces will be lost, the overall positive benefit of the station for the mall will far outweigh the loss of parking.
- **Configuration and Characteristics:** the general arrangements for Alderbridge station are illustrated in Station Prototype Drawings 865704-CONF-44DK-A211 to A214 in Appendix B-1.

  The station structure is designed to minimize the amount of individual footings and foundations in what are considered poor load-bearing soil conditions. The elevated guideway at the station platform location is supported on two cast-in-place concrete bent structures spaced 36 metres apart. An additional bent structure at the 18-metre mid-span works with the guideway structure to support the platform and roof. The proposed structure will result in minimum impact on pedestrian circulation and visual encumbrance.

Roadway realignment will be required at the proposed station locations.

Key Site Features, Special Requirements and Opportunities

The landscape design for areas adjacent to the stations and below the guideway will play an important roll in promoting the use of the space along the east side of Number 3 Road. Opportunity to infill under the station platforms with retail or commercial in the future will assist the City of Richmond in its long-term goal of creating a defined street edge for Number 3 Road.

3.3.9 Number Three Road International District

- **Richmond Centre Station**

Neighbourhood Character

The proposed station location is in Richmond's commercial core, which is zoned primarily as C7 Commercial. The widened right-of-way that accommodates the Number 3 Road busway terminates at Ackroyd Road and results in a narrowing of the street cross-section as one proceeds southward. The character of the precinct quickly changes from greenway to commercial core.

This area of Richmond is zoned as C7, Downtown Commercial Zoning. Public access to retail and commercial developments in this area is primarily by vehicle, which has resulted in the provision of extensive surface vehicular parking along the east and west sides of the right-of-way.

Station Features

Richmond Centre Station:

- **Location:** the terminus station in Richmond is located on the west side of Number 3 Road, just south of Saba Road. The station, in close proximity to Richmond City Hall and numerous retail venues, will function as the southern hub of the Canada Line. The central issue associated with this station is the intermodal bus facility and the extent of property acquisition needed to site the station and bus functions.
- **Configuration and Characteristics:** Drawings 865704-CONF-44DK-A233 and A234 in Appendix B-1 depict the station configuration. Also shown on the drawings is the scheme for the full intermodal bus loop. The design of the Richmond Centre station matches the layout of the Richmond family of stations. Higher ridership demand at this station necessitates wider vertical circulation elements than the other stations in Richmond. Integral to the facility is the intermodal connection to a bus loop. The proposed bus loop location is along the west side of the station.

3.3.10 Sea Island

- **YVR 1 support services station**
- **YVR 2 support services station**

- **YVR 3 terminal serving station**
- **YVR 4 terminus station**

Neighbourhood Character

Apart from the relatively fine grained neighbourhood of Burkeville, Sea Island is characterized by the large structures associated with the airport, which are separated by large, grassed expanses. This low-lying area, located between the tributaries at the mouth of the Fraser River is exposed to the natural elements, especially wind and wind-driven rain, which is a key consideration for the design of the YVR stations.

The airport represents Vancouver in an international perspective through its interface with business travellers and tourists from all over the world. An important point of arrival and regional prominence, its image and branding has been carefully nurtured to reflect the characteristics of this naturally beautiful Northwest Pacific coastal region. Elements distinctive to the area are expressed throughout the Domestic and International Terminal Buildings, in their architecture, their artwork and even retail.

Station Features

The Airport lands are undergoing significant development in response to anticipated growth. Master planning, although not complete, has established locations for the new International Building, and the relocation of long-term parking facilities toward the eastern extent of Sea Island. In mid-2003 Stantec Architecture developed preliminary designs for five airport stations on Sea Island. Subsequent to the RFP submission, the SNC-Lavalin/Serco team has worked with the Airport Authority to evaluate long-term goals for YVR in order to establish an effective strategy for connecting to the Canada Line.

The four stations proposed for the airport are shown in drawings 863704-CONF-44DK-A241 to A274. An overview of each is as follows:

- **YVR 1:** currently planned to be located adjacent to future long-term parking (approximately 600 metres west of the Arthur Laing Bridge south bridgehead)
- **YVR 2:** located adjacent to the Air Canada aircraft maintenance facility (south of the North Service Road between stations 1 and 3)
- **YVR 3:** located west of the future International Terminal Building 3 (east of McDonald Road)
- **YVR 4:** an amalgamation of YVR 4 and 5 located strategically to service both international and domestic terminal buildings.

The airport stations have been planned to optimally serve two distinct functional areas. YVR 1 and YVR 3 will serve primarily arriving and departing passengers at the terminal buildings either now or in the future. YVR stations 1 and 2 are located in support areas and so the character of these stations will be somewhat different. All four stations will be used extensively by airport staff both in getting to and from work, and during the day to travel between buildings.

The stations are to be constructed as part of the baseline to meet the requirements prescribed by the Airport Authority. In addition to these initial requirements, additional requirements prescribed in the

RFP have resulted in the following alterations to the previous designs prepared by Stantec Architecture:

- Circulation components (passenger flow and terminal connectors)
- Security of fare-paid zone (operational)
- Length of platform (technology)

Operationally, it is preferable to have a single threshold defining the fare-paid zone. For stations 2 and 3, relocating future retail space to allow access only from the ticketing zone prevents possible through-flow of non-ticket-holding passengers. For YVR 4, gate arrays (if implemented) are proposed for each end of the platform.

The technology proposed for the trains reduces the platform length from 60 metres to 50 metres. The adjustment of 10 metres in platform length has a positive impact on station layouts, in that this reduces the extent of the footprint and the amount of required support structure.

The general configuration of programmed spaces has been maintained as designed in the previous submission, with the exception of the concourse level of stations 2 and 3. For these stations, end-loaded access versus side-loaded access through ticketing zones is proposed in order to avoid conflict at fare gates and queuing at ticket vending machines. The revised layout also prevents possible security breaches through future retail space.

YVR 1 Station:

- **Location:** YVR station 1 is currently located in the centre of a greenfield site, where future long term parking will be located. This station, being the closest to the Burkeville neighbourhood, will be of greatest interest to the community. The relative position of the station to the neighbourhood and the ease of station access will be key considerations from their standpoint. These desires will have to be balanced with locating the station in the most effective location to serve the airport's plans for long-term parking and other functions associated with that area. While currently shown with the station located approximately 200 metres east of Templeton Street, it is quite likely that detailed planning and public consultation will result in refinement of this station's location.
- **Configuration and Characteristics:**

  The current station plan is based on the elevated side platform end loaded configuration. Since YVR 1 station is not constricted in its width in the same way as the Richmond stations, we propose at the next stage of design to look more closely at the vertical circulation configuration, to shorten the overall station configuration by sliding the escalator and stairs to the outside of the platform and to move the elevators into the concourse area. The relatively low ridership for the station makes it difficult to justify providing both an up and a down escalator for each side platform, and so for this BAFO submission our scheme assumes one escalator per platform but maintains two elevators per platform.

YVR 2 Station:

- **Location:** YVR station 2 is located in front of the main Air Canada maintenance facility, on the thin strip of land between the North Service Road and Grant McConachie Way. This station location has been selected so that the stand of mature trees located on the other side of the North Service Road remains in tact. If the construction of YVR 1 station is deferred, then

YVR 2 will become the local neighbourhood station for the Burkeville community. The station will effectively serve the maintenance facility to its north, the Burkeville community and the service buildings bordering the south edge of Miller Road. It is this southern reach of the station's influence that has resulted in the provision of an elevated pedestrian walkway over Grant McConachie Way to Miller Road. At the urban design level, consideration will have to be given to pedestrian connections to this station, so that tie ins are provided to the existing sidewalk infrastructure. With the provision of a grade-separated pedestrian crossing over Grant McConachie Way, measures will have to be considered to discourage pedestrians from crossing at grade.

- **Configuration and Characteristics**: The narrow land strip, combined with the adjacent pedestrian ramp, makes for a relatively tight fit to available land parcel. The narrower configuration of a centre platform station is ideally suited to these site constraints. The station configuration is based on the elevated centre platform prototype developed for YVR 3.

YVR 3 Station:

- **Location:** YVR 3 station will ultimately serve the future International Terminal Building; however, in the short term its function is to support local ridership. The preferred location of this station needs further consideration in the next phase of the project, because the station must be located where it can serve its immediate function and yet with an eye to the future such that the station is located properly in relation to the future terminal. At present, without a conceptual design for the terminal, there is no collective agreement on the station's best location. With these issues in mind there are two strategies to consider:
    i. Develop conceptual and functional plans for the future International Terminal Building with the intent of establishing a preferred and final location for the station
    ii. Locate the station now to serve only the immediate needs, and plan in future to build a new and separate station for the terminal in the future, assuming that a new segment of guideway will be built and a connection made to the operating alignment

In both scenarios there has to be a general knowledge and understanding of the future terminal building's location and likely elevation. This is required because even under the more flexible second option, the connecting sections that will serve the final station position must consider the likely range of vertical and horizontal transitions. If this is not done at this stage it is possible that the YVR 3 station will be located where the future station cannot be easily tied into the operating alignment. If that were the case it would probably be necessary to decommission that segment of alignment for a considerable time while the existing station was demolished and a new station and alignment constructed. This would not necessarily be such a problem if YVR 3 were the end of the line, but it is not. Any temporary shutdown of service to accommodate YVR 3 would result in YVR 4 being temporarily decommissioned.

- **Configuration and Characteristics**

s.17(1)(e)
s.15(1)(l)

s.17(1)(c)
s.15(1)(L)

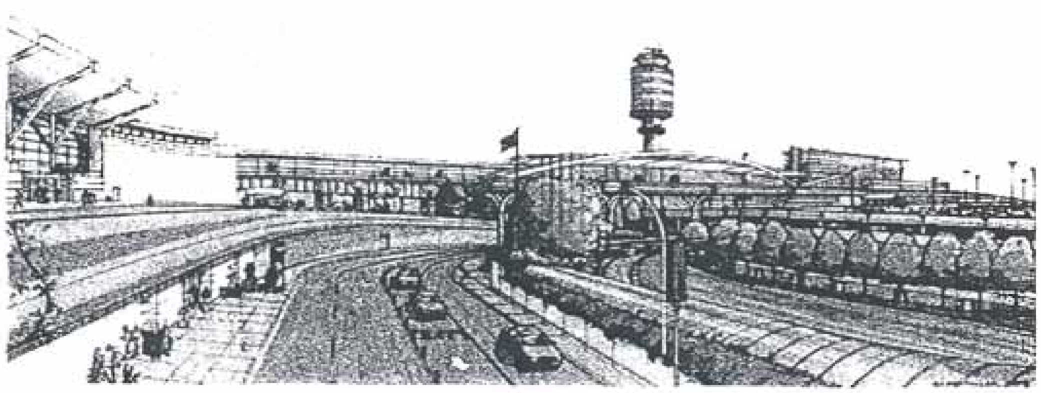
YVR 4 Station:

- **Location:** YVR 4, now reconfigured to function as a grand terminus station that serves both the Domestic and International Terminals, requires that an additional, direct westward connection be provided. The new location of the station is directly in line with the future link building between the two terminals. This provides an opportunity to include a direct pedestrian bridge connection from the west end of the platform level to the new link building scheduled for construction in the near future. The platform and guideways are located above the existing pedestrian bridge between the parkade and the International Terminal Building.

  The prime benefits of this single station option are:

  - Pedestrian connections to the Domestic Terminal are improved because at-grade conflicts with car traffic are avoided, and high-level entry into an already-congested arrivals concourse is avoided. Clarity of path will be improved and decision-making sequenced in a manner that assists passengers.
  - The eastern connection into the International Terminal maintains the existing at-grade and elevated bridge connections. It avoids previously presented options that entered the terminal building at high level.
  - The single YVR station will be more cost-effective than providing two separate stations and connecting alignment.
  - The simple track alignment associated with the proposed YVR 4 station will avoid noise from wheel squealing and increased track maintenance associated with the previous alignment geometry.

Figure 3-1: Architectural Rendering of YVR 4 Station viewed from the pedestrian bridge at the Domestic Terminal



- **Configuration and Characteristics:** Two station configurations have been prepared for YVR 4, in response to the key issues of urban fit and pedestrian functionality.

Drawings 865704-CONF-44DK-A271 to A274 were prepared, based on keeping the guideway's tail tracks furthest away from the existing buildings. This arrangement assumed locating the eastern vertical circulation to the east of the existing pedestrian footbridge. While this approach achieves good set-backs from the surrounding buildings, it does so at the expense of pedestrians' path of travel, making for a longer connection to the link building and a turn-back movement at the eastern end.

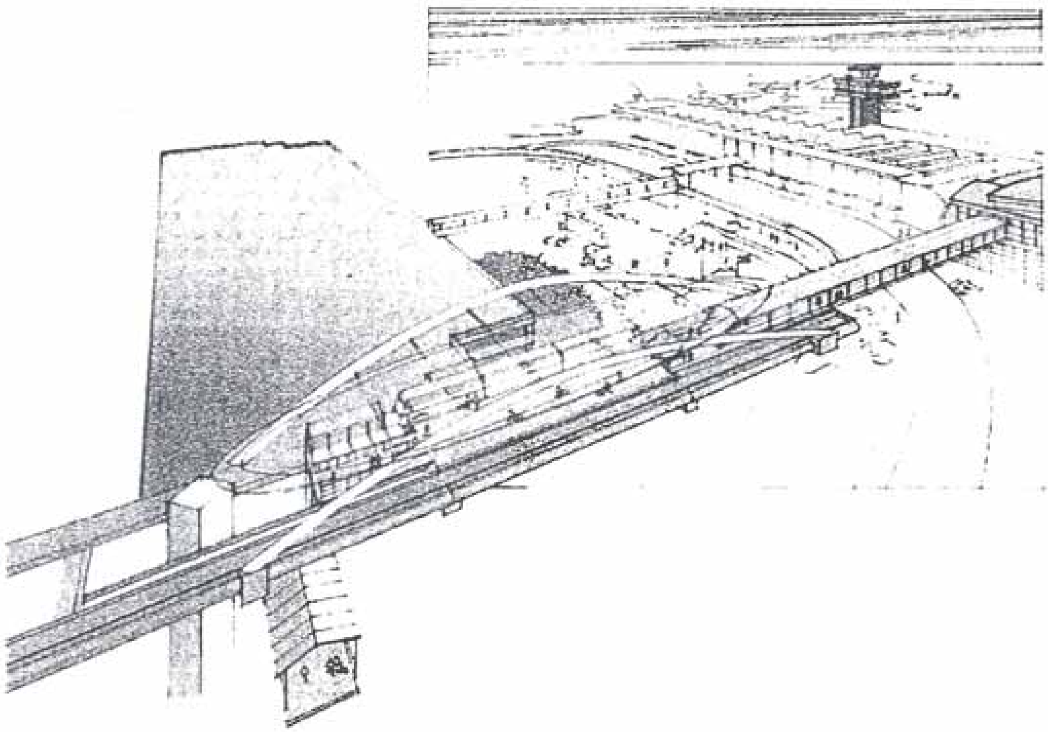
Drawing 865704-CONF-44DK-A275 shows a platform configuration with pedestrian movements optimized. The vertical circulation at the east end has been located to the west side of the pedestrian bridge: this in turn has shifted the station platform and tail tracks westward, which shortens the path of travel to the link building. Although the relative separation between the station and International Terminal Building is reduced (provided this is acceptable to the Airport Authority) it is the better transit solution.

Refinement of the YVR 4 station scheme will take place in the next phase of design. It is anticipated that through close coordination with YVR staff, the scheme will meet the dual requirements of fit and function.

A key feature to this station configuration is the use of higher speed traction elevators, selected to provide access from the east end of the new platform down to the bridge level and at-grade crossings. This configuration preserves existing pedestrian movement patterns and avoids convoluted circulation patterns associated with escalators at this location. The provision of up to four elevators will be sufficient to provide the level of service needed for the anticipated pedestrian volumes.

The exposed location of this station, with its higher elevation, will require due consideration of wind and driving rain. For this reason the station roof structure has been designed to provide broader coverage over the station platform and adjacent guideways. Design advancement will seek to find the natural balance between rain protection offered by a lower roof and desire for a more substantial spatial volume given the architectural significance of this station.

Figure 3-2: Architectural Rendering of YVR 4 Station viewed from above showing simplified pedestrian connectors serving the Domestic and International terminal buildings



4.0 E&M SYSTEMS

The section of "the proposal extracts" describes the E&M systems required to support safe and efficient operation of the Canada Line. Within the context of this section, E&M systems consist of the following major systems:

- Automatic Train Control
- Power Supply and Distribution
  - Traction and Station Substations
  - Power Rail
  - Traction SCADA
- Trackwork
- Communications
  - Public Address
  - Voice Communications and Passenger Alarms
  - Passenger Security
  - Passenger Information
  - E&M SCADA
  - Fibre Optic Transmission
  - Performance Monitoring
  - Passenger Counting
  - Tunnel Ventilation SCADA
  - Platform and Guideway Intrusion
- Fare Collection
- Tunnel Ventilation

The following acronyms and abbreviations are utilized in this section:

ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
CCTV	Closed Circuit TV
CMU	Concrete Masonry Unit
CR	Control Room
CRO	Control Room Operator
DT	Data Transmission
ESB	Emergency Stop Button

FNAGS	Floating Negative Automatic Grounding System
FOTS	Fibre Optic Transmission System
GFDD	Ground Fault Detection Device
GIDS	Guideway Intrusion Detection System
GUI	Graphical User Interface
I/O	Input/Output
ITELs	Information Telephones
LAN	Local Area Network
MC	Master Clock
MTM	Manual Tracked Mode
NMS	Network Management System
OMC	Operations and Maintenance Centre
PABX	Private Automatic Branch Exchange
PC	Personal Computer
PDC	Power Distribution Centre
PIS	Passenger Information System
PS	Power Station
PS&D	Power Supply and Distribution
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
STC	Station Controller Subsystem
SMC	System Management Centre
STTS	Simulation Training and Testing System
TPS	Traction Power Substation
UPS	Uninterruptible Power Supply
VCC	Vehicle Control Centre
VCPA	Voice Communication and Passenger Alarm
VOBC	Vehicle On-Board Controller

4.1 AUTOMATIC TRAIN CONTROL

4.1.1 General

This section describes the ATC system proposed for the Canada Line. While our solution has been developed through a close working relationship with Alcatel and is based on the SelTrac Train Control system it is by no means the only system available within the world market to meet the performance requirements for the Canada Line, both in terms of those specified by RAVCO within the Concession and by the operational needs of SNC-Lavalin and Serco. In order to maintain consistence with our procurement philosophy of maintaining a competitive environment in all our major purchases, we must therefore reserve the right to implement an alternative Train Control solution should this be necessary. This section should therefore be read on the basis that this is a specific description of the Alcatel SelTrac system and not a generic description of our proposed Train Control system, should an alternative be selected this section will be updated with a specific description of that system.

The Canada Line will be equipped with an ATC System based on the proven Alcatel SelTrac S40 communication based moving block system, similar in functionality to the ATC System utilized in the Vancouver SkyTrain transit system. Trainborne-wayside communications will be provided by an inductive loop communications system.

The primary responsibilities of the ATC System will be to:

- Prevent any hazardous conditions from occurring
- Provide automatic train operation
- Provide the capability to optimize the timetable and respond to changes in traffic demands

All Automatic Train Protection (ATP), Automatic Train Operation (ATO), and Automatic Train Supervision (ATS) functions required for the Canada Line application will be performed by the Alcatel SelTrac system using a minimum set of wayside and trainborne hardware. The use of the Alcatel SelTrac system will result in a high performance transit system capable of achieving the desired operating headway.

Safe separation of trains, switch/route interlocking control and train speed enforcement will be implemented with the use of vital (checked redundant) computer systems on board the train and at wayside control locations.

The Alcatel SelTrac moving block system provides the capabilities to:

- Regulate timetables and service
- Control the complete velocity profile
- Provide driverless train operation
- Enforce vital supervision of temporary speed restrictions
- Provide bi-directional operation without additional hardware
- Precise station platform stopping
- Coupling and uncoupling
- Provide centralized monitoring of vehicle systems
- Provide continuous train identification for routing
- Perform a system-wide 'train hold at station' feature
- Perform timetable adjustment and related ATS functions

4.1.1.1 ATC Functional Overview

The ATC System will ensure automatic and driverless operation of trains on the automated portions of the system (including the mainline and depot), except those in Manual Tracked Mode (MTM).

The ATC System will automatically regulate the movement of all trains on the Canada Line, except those in MTM.

The ATC System will control train separation, routing, operating speed, maximum speed, precision stopping, travel direction, vehicle door operation, longitudinal acceleration and jerk, and safety interlocks.

The ATC System will also internally monitor all aspects of its operations.

Drawing 865704-CONF-47DK-2013, the Automatic Train Control System Context Diagram, illustrates the scope of the ATC System.

4.1.1.1.1 Automatic Train Protection

The ATP subsystem will provide for safe train operation, including train separation, maximum speed supervision and route/switch interlocking, and will detect the presence of all operating trains and train consists.

The ATP subsystem will perform the following operational functions:

- Train positioning
- Train detection
- Safe train separation assurance
- Unauthorized train movement detection
- Overspeed and target point overshoot protection
- Loss of train integrity detection
- Train door supervision
- Train speed measurement and zero speed movement detection
- Obstructed train movement protection
- Route and switch interlocking and supervision
- ESB and Guideway Intrusion supervision

4.1.1.1.2 Automatic Train Operation

The ATO subsystem will include the functionality and equipment necessary to automatically perform the following, within the constraints of the ATP subsystem:

- Execution of train stops, station dwell times, and train departures
- Control the operation of the train doors
- Operate trains at assigned speeds within the limits imposed by the ATP subsystem
- Regulate train acceleration and jerk within specified passenger comfort limits

4.1.1.1.3 Automatic Train Supervision

The ATS subsystem will control, monitor, and display most train operations and will provide the most significant interface between the CROs and the ATC System.

The ATS subsystem will provide CROs in the OMC Control Room with the ability to direct train operations, provide timetabled service under normal operating conditions and maintain the best possible service in case of disruptions and emergencies.

The functionality provided by the ATS subsystem will include, but not be limited to, the following:

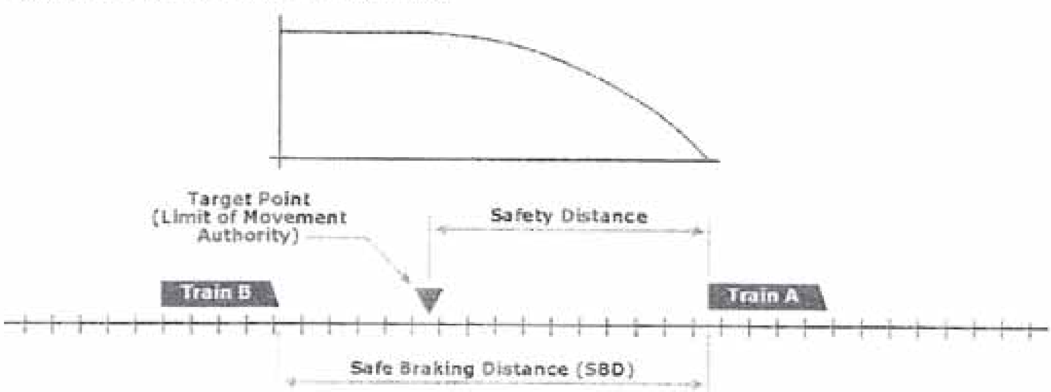
- Command and control of train movements in support of schedules and line assignments, including fleet build-up and reductions
- CRO commands and functionality to permit efficient supervision and management of operations
- Display and logging of all train movements, system performance, and status

4.1.1.2 Moving Block Principles

The Alcatel SelTrac S40 system uses the moving block principle, in which the safe separation of trains is dynamically calculated based on the maximum operating speeds, braking curves and locations of the trains on the guideway. Because of the high resolution of position reporting (6.25 m), a following train may safely close up to within a safe braking distance from the last verified position of the rear of a preceding train, based on the maximum allowed speed in that section of the guideway. In many applications, a significant reduction in headway relative to fixed block systems is possible, since the train need not be stopped at the entrance to an occupied fixed block.

Figure 4.1 below illustrates the principle of the SelTrac moving block safe train separation.

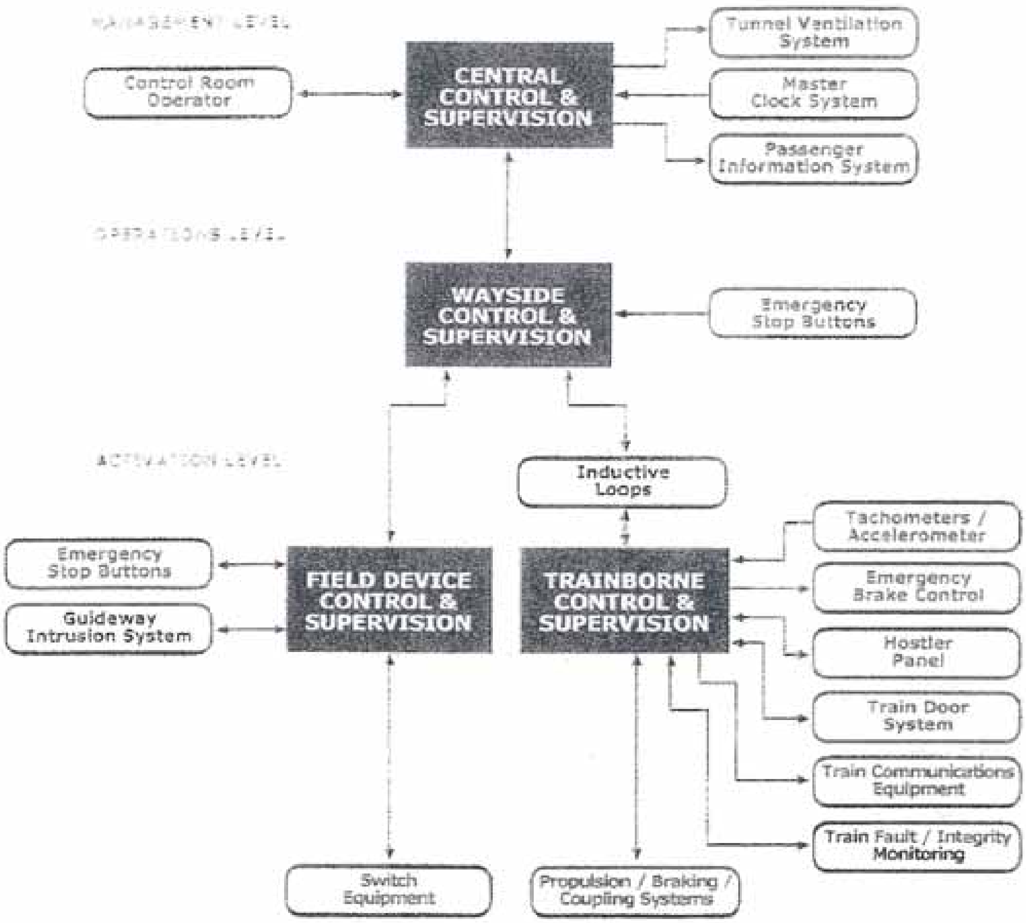
Figure 4.1: SelTrac Safe Train Operation



4.1.2 ATC Levels of Control

The complete SelTrac moving block operational structure is arranged in a three-tier hierarchy, as shown in Figure 4.2 on the following page and described in the following subsections.

Figure 4.2: SelTrac Operational Structure



4.1.2.1 Management Level

The System Management Centre (SMC) will coordinate the overall management of the automated train control system. The SMC performs all of the signalling control and ATS functions but has no intrinsic responsibility for safety.

The SMC will, in conjunction with workstations, provide the following functions:

- Addition or deletion of trains to or from service
- Assignment of routes for trains and requests for the appropriate switch settings in the field, according to pre-stored schedules or through operator input
- Regulation of trains in the system by adjusting train velocity and station dwell time

- Regulation of trains in the yard and selecting those destined for service or storage
- Monitoring status of train performance and collection of other ATO data
- Data exchange with external systems, such as the Tunnel Ventilation System, Passenger Information System (PIS), and the Master Clock (MC) system.

4.1.2.2 Operations Level

Safe operation of the SelTrac moving block system will be the responsibility of the Alcatel Vehicle Control Centres (VCCs). The VCCs ensure safe train separation throughout the system. For each train, the VCC generates a command telegram containing a target point, the maximum permitted vehicle velocity and other commands, based on the following real-time information:

- Last reported train speed and position
- Travel direction
- Last verified position of the preceding train
- Unlocked or unreserved switch ahead on the train's route
- Speed restriction
- Station stop
- Status of wayside devices (e.g. switches, ESBs and Guideway Intrusion status)

4.1.2.3 Activation Level

The following components will be responsible for implementing commands from the operations level: the Vehicle On-Board Controller (VOBC), inductive loops and the Station Controller Subsystem (STC).

4.1.3 System Operation

The operation of the ATC System for the Canada Line will be consistent with the operations plans and requirements described in other sections of this document.

4.1.3.1 ATC Headway Requirements

Subject to any alignment constraints, the ATC System will be capable of the following:

- Operating trains at the design headway
- Maintaining non-interference headways (design headways) which are no more than two thirds of the operational headway throughout the system

The SelTrac moving block system will provide a minimum design headway of 75 seconds or less for the Canada Line ATC System, subject to the final design of the system guideway.

4.1.3.2 Train Operational Modes

An ATC-equipped train will operate in one of the following two modes:

- Automatic Mode

- Manual Tracked Mode

4.1.3.2.1 Automatic Mode

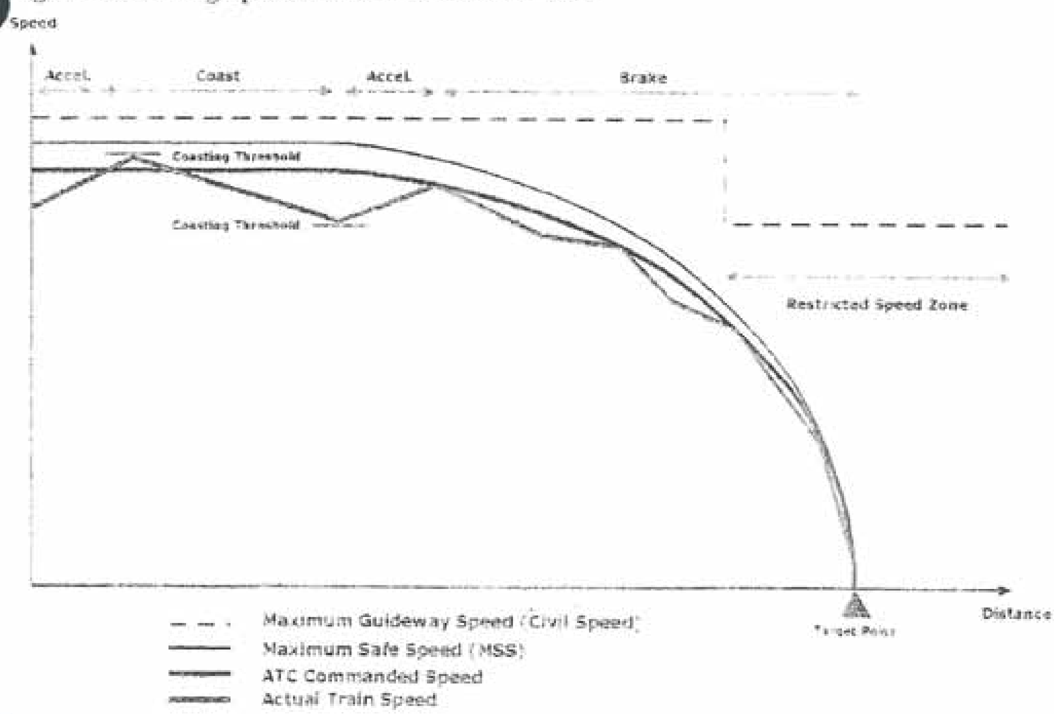
Normal daily system operation will be performed with all trains in automatic mode. In automatic mode, all train functions, including acceleration, coasting, deceleration, and stopping will be automated. Automatic mode operation will be monitored and regulated by the CROs in the OMC Control Room, or by system-automated features executed by the SMC, VCC and VOBC subsystems. Automatic trains may be automatically regulated by the ATS subsystem during timetabled operation. Automatic trains will be driverless and do not require on-board attendants to perform their normal operations.

The doors on the station-platform side of the train will be automatically opened after the train has come to a complete stop and is correctly positioned in the station. Once the train dwell has expired and after the train doors are closed and locked, the train will depart.

An automatic train will accelerate until the predefined coast level speed is reached or the braking parabola speed is reached. When the VCC requires that a train brake to a speed restriction or to a full stop, the VCC will not advance the target point command to the VOBC, which will cause a service braking of the train to the required speed.

Figure 4.3 shows the driving speed profile of a train stopping in automatic mode.

Figure 4.3: Driving Speed Profile in Automatic Mode



4.1.3.2.2 Manual Tracked Mode

The ATC System will support the operation of MTM trains. Each train capable of self-propulsion will be capable of operating in MTM.

This mode will be implemented by means of a permanently installed hostler control panel at each end of the train. MTM will permit maintenance or operations personnel to manually operate all aspects of the train necessary for failure recovery, the movement of trains due to emergency conditions, and the operation of the train doors.

If communicating with the VCCs, a train operating in MTM will be tracked by the system and protected from other trains in the automatic operating mode, but not from other trains operating in the MTM.

If a train is not communicating with the VCCs (for example, due to on-board equipment failure or faults in the communication system), the train attendant and the CRO will be totally responsible for the safe operation of the train. In order to protect such a train traversing the automated guideway, a manual route reservation must be entered by the CRO. A manual route reservation allows the CRO to select and protect a route from A to B. This route can also include switches. Once selected, other automatic trains are prevented from entering the area of the route reservation. Since the failed train is not communicating with the VCC, train movement is not tracked by the ATC System. However, if the train does not violate the bounds of the manual route reservation set by the CRO, protection will be provided by the manual route reservation.

4.1.4 ATP/ATO Overview

The mainline and depot will be equipped with Alcatel's latest SelTrac moving block ATC System technology. Drawing 865704-CONF-47DK-2031, the Automatic Train Control System Overview, shows the location of wayside equipment.

The wayside equipment for the mainline will consist of one VCC unit with associated data transmission equipment. The control and activation system for switches, ESBs and Guideway Intrusion will consist of a number of STC units located in equipment rooms, primarily in stations, along the length of the track.

The wayside equipment for the depot will consist of one VCC unit with associated data transmission equipment. The depot switch control and activation system will consist of a number of STC units located in equipment rooms around the OMC.

Inductive loop communication cable and equipment will be mounted on the mainline track and in the depot to facilitate trainborne-wayside communications.

4.1.4.1 Vehicle Control Centre (VCC)

The Vehicle Control Centre (VCC) will be responsible for the determination of safe train and switch movement. The VCC equipment will be located in the central equipment room at the OMC. The figure below provides the layout of a typical VCC central computer complex.

A VCC will consist of the following equipment:

- VCC Central Computer Rack
- VCC I/O Rack(s)

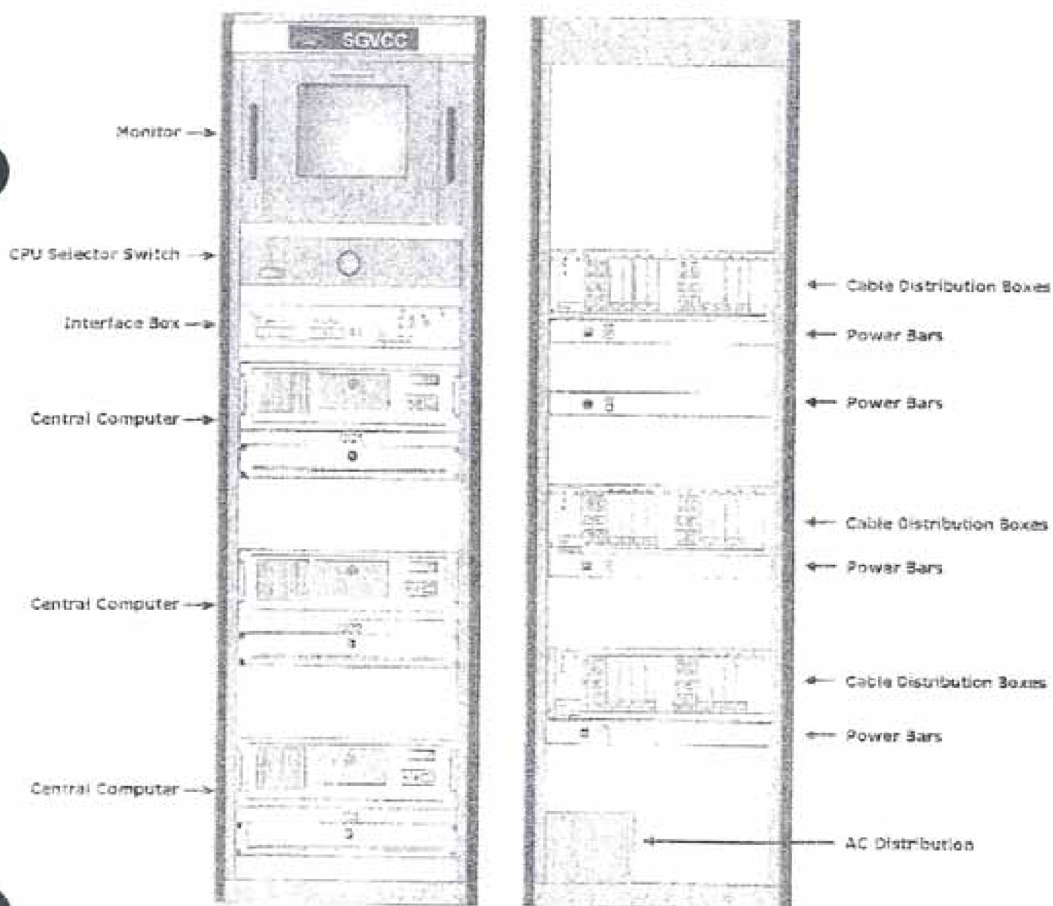
- VCC Data Transmission (DT) Rack(s)
- CRO Terminal
- Emergency Stop Button (ESB) Panel

The VCC equipment controls all trains and switches on the track and reports all system information to the SMC. The VCC racks (Central, I/O & DT) are constructed using standard 19" computer rack enclosures.

The VCC computers use robust industrial grade IBM-compatible computers. Three of the central computers will operate in a triple-checked-redundant manner.

A VCC monitor is provided for maintenance purposes. This monitor is shared by three VCC computers using a three-way switch box located in the rack. Figure 4.4 shows a typical VCC equipment rack.

Figure 4.4: Typical VCC Equipment Rack



4.1.4.2 Station Controller Subsystem (STC)

The STC works in conjunction with the VCC to supplement the ATP and Automatic Train Operation ATO functions of the ATC System. The wayside control functions of the STC are initiated by command telegrams from the VCC during normal operation. All device status information under STC control is conveyed back to the VCC in the form of STC response telegrams.

The STC provides the following vital control and monitoring functions:

- Automatic switch control and supervision
- Monitoring and reporting of guideway intrusion detection
- Monitoring and reporting of platform emergency stop button status

STCs are located in equipment rooms that are in close proximity to switches. The STC controls the interlocking behaviour of the switches. The STC is constructed with redundant CPUs for increased system availability.

4.1.4.3 Inductive Loop Communications

Trainborne-wayside communication will be accomplished using an inductive loop-based transmission system. The inductive loop communications equipment will be located in equipment rooms and at trackside.

The inductive loop communications consist of the following equipment:

- Feed-in devices
- Remote loop boxes
- Inductive loop cable

The inductive loop cable will consist of a stranded copper core with an insulating and unshielded protective outer sheath. The cable serves as both a transmitting and receiving medium for the inductive loop communication system.

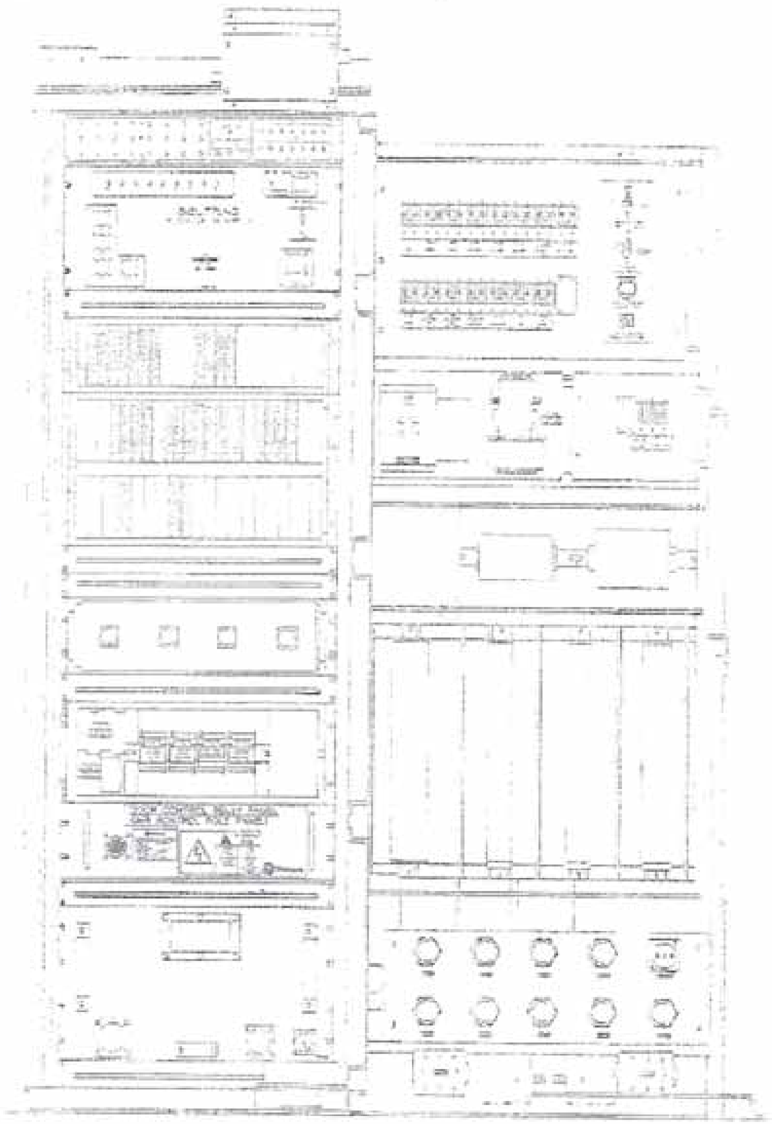
4.1.4.4 Vehicle On Board Equipment

The VOBC will perform the following functions:

- Generate output commands to control the longitudinal motion of the train in response to commands from wayside equipment
- Monitor and generate output commands to control the operation of the passenger doors
- Report vehicle location, speed and other status data to the wayside

Two VOBCs will be provided for each two-car train. The VOBC closets will be located in each of the two-car train. Figure 4.5 on the following page shows a typical VOBC closet arrangement.

Figure 4.5: Typical VOBC Closet Arrangement



The VOBC system provides the interface between the ATC System and the vehicle subsystems.

The primary elements of the ATC on-board equipment (per VOBC) will include the following:

- Electronics Unit (1)
- Interface Relay Unit (1)

- Power Supply (1)
- Peripheral Equipment
- Receive Antennas (2)
- Transmit Antennas (2)
- Accelerometer (1)
- Tachometers (2)
- Vehicle Identity Plug (1)

4.1.5 ATS Overview

4.1.5.1 System Management Centre (SMC)

The SMC will consist primarily of a number of personal computers (PCs) on a Local Area Network (LAN) with a data communication link to the VCCs. The SMC interfaces with all VCCs to provide central control over the entire line.

The primary user interface workstations will be located at the Operations and Maintenance Centre (OMC) Control Room. There is one operator workstation, one supervisor workstation and one spare workstation in the Control Room. From these workstations, the CROs can supervise the system and input commands to control the entire line.

Centralized SMC equipment, such as servers, will be located in the OMC electronic equipment room. For increased system availability, every server will be configured as a redundant pair. Should one server fail, the other will be immediately available as a back up.

4.1.5.1.1 SMC Hardware Description

The SMC will be configured with a dual LAN to provide increased reliability. All of the SMC computers at the OMC will be connected to this LAN.

SMC equipment will be located in one or more commercial grade standard 19" racks.

4.1.5.1.2 ATS Operator Workstations

The ATS workstation will consist of a high-performance commercial PC configured with a keyboard, mouse and a multi-monitor output card.

4.1.5.2 ATS Operator Displays

The ATC System will provide the CRO with a number of facilities for monitoring the status of various systems. These facilities will include, as a minimum, the following:

- SMC line overview display (for overall status of trains, tracks, platforms and switches)
- SMC information display facilities (used to display and print detailed information from the SMC regarding trains in service, schedules, system elements, etc.)
- VCC information display facilities (used to display and print detailed information from the VCC regarding track and train status)

The SMC operator workstations will provide the majority of the information to the CROs, and will provide the CRO the commands and functions to control the entire ATC System via a full-featured graphical user interface (GUI).

4.1.5.2.1 SMC Line Overview Display

The SMC line overview display will be a dynamic representation of the track layout using full-colour workstation monitors and the ATC video wall overview. The workstations and the video wall overviews will display the same information; however, the video wall overviews will not contain items such as screen selection icons and command menus.

The line overview display allows the CROs to monitor the state of the system. The display will show a schematic diagram of the line, on which is depicted the current state of the trains, switches, stations and other line equipment. It will be updated in real time based on status information received from the control system.

The following list is an example of information that can be displayed on the line overview displays:

- Representation of the automated guideway, including the location of all automatic switches, markers, platforms, loop boundaries and transition zones
- Track reservation status, including track travel direction
- Switch designations
- Switch reservations
- Track closure limits
- Train identities
- Train operating mode
- Train status
- Train door status
- Platform intrusion status
- Number of vehicles in a train
- Train and switch malfunctions

4.1.5.2.2 SMC Display Information Facilities

The CRO will be able to obtain information on system elements using the available screens and commands, or through the "print" feature associated with many commands.

Information reports that will be available via the SMC will include as a minimum, the following:

- Available listing of schedules
- Platform information for all platforms
- Listing of failed trains
- Listing of closed tracks
- Listing of temporary speed restriction zones

- Switch information for all switches
- Performance indicator reports

4.1.5.3 Timetable Regulation and Timetable Compiler

The SMC will support a timetable regulation mode to provide regulation and dwell management functions to the line. The timetable regulation system will allow the day's entire timetable to be established from the beginning, and then allow the ATC System to automatically adjust the operation and scheduling of the trains to ensure they meet that timetable.

The timetables will be generated using an off-line timetable compiler and downloaded into the SMC timetable regulation system and enabled when requested.

4.1.5.3.1 Timetable Regulation

In timetable regulation mode, trains will be regulated against the active timetable. A timetable defines the scheduled service for an entire day. A timetable can include scheduled build-ups and reductions in the level of services.

A timetable will consist of a number of run definitions. Each run definition specifies the sequence of station stops that a single train is scheduled to service. For each station stop, the run definition defines the scheduled arrival time, the scheduled dwell, the routing to the next stop and the scheduled travel time to the next stop.

When regulation is active, if a train arrives at a station stop after its scheduled arrival time, the train's dwell will be reduced and/or its velocity increased to minimize the train's lateness. If a train arrives at a station before its scheduled arrival time, its dwell will be increased and/or its velocity reduced to minimize its schedule deviation.

Automatic Timetable Assignment

The SMC can perform automatic timetable assignment based on the current date. The user enters the timetable for each date into a calendar. Each morning, the SMC will automatically assign the designated timetable.

Train Launch

When a timetable calls for a build-up in service, trains need to be launched from the depot and assigned to the additional runs. The SMC will automate this process. The SMC automatically allocates a train waiting in the depot to each additional run for a service build-up. The allocated trains are shown in the launch list display.

Performance Reporting

Reports indicating train type, origin, destination, arrival and departure time of each train at each passenger station will be produced as well as a report indicating the operation time and distance travelled for each vehicle.

4.1.6 Simulation Training and Testing System

The primary purpose of the Simulation Training and Testing System (STTS) will be to train the CROs, verify timetable operations and test the ATC System.

The core of the training system will be the operations simulator that executes the actual VCC software (without the vital input/output components) used in the target system, together with the track and vehicle emulator. The track and vehicle emulator allows the system to simulate indications from trains and from the wayside devices.

Actual SMC and VCC code will be used in the STTS. As such, simulator behaviour will be the same as that of the actual operational system. Since the actual SMC and VCC code will be used, together with a simulator capable of providing wayside and train indications, the actual system and its operations can be accurately emulated.

System perturbations caused by full or partial equipment failures can be introduced. This includes, but is not limited to, all switch failure modes, vehicle propulsion failure, communication failure and VOBC failure. In many cases, the response to a partial failure can be investigated through the system's diagnostic capabilities.

To assist in training, predefined scenarios can be run on the STTS. These scripts may be written off-line by the trainer and used on the operations simulator.

A playback or rerun capability will also be provided. CRO operations, the train operating state and the equipment working state can be reviewed using fast-forward, pause, stop or real-time speed.

4.1.7 Reliability, Availability, and Maintainability

4.1.7.1 Reliability

4.1.7.1.1 General

All major components of the system will have been proven reliable in revenue service in an operational environment similar to the Canada Line.

Failure of a single system component will not cause failure of the complete system.

A reliability analysis will be produced to demonstrate that reliability targets have been achieved.

4.1.7.1.2 Failsafe/Checked Redundancy Design

The ATC System will incorporate failsafe design principles, checked redundancy design principles, or a combination of both into all safety-critical hardware and software components of the system.

A safety analysis will be produced to demonstrate that safety targets have been achieved.

4.1.7.2 Availability

The system will be designed to ensure high availability, in excess of 99.825% (consistent with that experienced on SkyTrain). Availability will be defined as the probability that the system will be operational, without significant degradation, at any point in time under the stated requirements.

A service affecting failure will be defined as, but not limited to, the following:

- Any failure that delays service by a period greater than the operational headway of the area affected by the failure
- The loss of wayside-to-train communications for any one train

The availability requirements will be based on the ATC System being operational for 20 hours per day, seven days per week, 365 days per year.

An availability analysis will be produced to demonstrate that availability targets have been achieved.

4.1.7.3 Maintainability

4.1.7.3.1 General

The system will be designed and constructed for ease of maintenance. The system will be capable of self-diagnostic health analysis, wherever practicable.

Special consideration will be given to such concerns as access to equipment, repair and/or replacement procedures, tools to be used, safety of operation, access doors, panels and hatches, and space around the component being repaired or replaced.

The ATC System will be equipped with self-diagnostic capabilities. All internal faults that are detected will be reported to the CROs and/or to the maintenance personnel. All service affecting faults will be reported to the CROs and to the maintenance personnel. Faults that may lead to a system failure will, where practicable, be identified to the maintenance personnel to enable rectification before complete failure occurs.

The ATC System will be capable of performing remote fault diagnostics on any ATC equipment. It will be possible to perform maintenance (preventative, corrective, upgrades, etc.) to the ATC System while the system remains in revenue service operation, without degradation. All ATC System equipment will be accessible to facilitate preventative maintenance without disruption to the system as a whole and without disruption to other systems.

4.1.7.3.2 Mean Time to Repair

The ATC System Mean Time to Repair (MTTR) – the time required for equipment to be repaired and returned to normal service – will typically be less than 15 minutes.

The MTTR is measured from the start of the troubleshooting/diagnosis process and assumes there are sufficient spare parts available.

4.1.7.4 Design Life

The design life of the ATP subsystem, ATO subsystem and trainborne and wayside components of the system will typically be 30 years. The design life of all other equipment within the system, including the ATS subsystem, will typically be 15 years.

4.1.8 External Interfaces

The ATC System will interface to the following components:

- Trainborne Systems (doors, brakes, propulsion, health monitoring, etc.)

- Guideway Intrusion Detection System (GIDS)
- Passenger Information System (PIS)
- Tunnel Ventilation SCADA System
- Master Clock (MC) System

4.2 POWER SUPPLY AND DISTRIBUTION

The power supply and distribution system (PS&D) will consist of 12.47kVac or 25kVac incoming supplies from the local utility power substations (BC Hydro) to each traction power substation (TPS) and passenger station (PS), the 12.47kVac cables between adjacent underground passenger stations, 25kVac cables between TPS and adjacent PS, the traction power substations themselves, the 750Vdc power rail system, the 600/347Vac power distribution system and miscellaneous systems related to the PS&D.

This section should be read in conjunction with the following drawings:

- Drawings 865704-CONF-47DK-2001, 2002 and 2003 – Power Distribution Single Line Diagram
- Drawing 865704-CONF-47DK-2007 – Typical Underground TPS Single Line Diagram (With Integrated Passenger Station)
- Drawing 865704-CONF-47DK-2008 – Typical Above Ground TPS Single Line Diagram
- Drawing 865704-CONF-47DK-2009 – Typical Underground Passenger Station Single Line Diagram
- Drawing 865704-CONF-47DK-2010 – Typical Above Ground Passenger Station Single Line Diagram
- Drawing 865704-CONF-47DK-2011 – Depot Single Line Diagram
- Drawing 865704-CONF-47DK-2012 – Typical Traction Power Substation Single Line Diagram
- Drawing 865704-CONF-47DK-2014 – Traction Power Supply & Distribution Context Diagram
- Drawing 865704-CONF-47DK-2027 – Typical Underground TPS Substation Layout
- Drawing 865704-CONF-47DK-2032 and 2033 – Typical Power Rail Arrangements

4.2.1 PS&D Requirements

The PS&D system will be designed to handle the capacity of the system fleet as outlined in this document. It will provide a nominal positive voltage of 750Vdc at the power rail with respect to the running rails. The negative return will be via the running rail with the mainline running rails being electrically isolated from ground (floating system). The running rail at the OMC will normally be isolated from the mainline and solidly grounded.

The system is designed to be receptive to regenerated power. If the regenerative power cannot be used by other trains, the excess energy will be dissipated by resistors onboard each vehicle.

The power supply and distribution will also provide 600/347Vac, three-phase, 60 Hz for the passenger stations, tunnel electrical systems, communications, train control equipment and guideway facilities.

All equipment and installation work will conform to the requirements of the latest editions of the applicable standards as well as local codes and regulations.

4.2.2 Electrical Supply

The power source will be received at 12.47kVac (or 25kV in the Richmond area), three-phase, 60 Hz from BC Hydro. Each underground TPS will be supplied by two dedicated feeds via underground power cables and ducts. Each aboveground TPS will be supplied by one dedicated feed via underground power cables and ducts.

At locations where the passenger station is integrated with a traction power substation, the passenger station will be supplied from the TPS. One shared feeder from BC Hydro, as well as an interconnecting supply from an adjacent passenger station or TPS, will supply each standalone underground passenger station. Each standalone aboveground passenger station will be supplied directly at 600/347Vac from BC Hydro or an interconnecting supply from an adjacent TPS.

4.2.3 Power System Demand

The power system demand will be determined after a comprehensive traction power system study has been completed during the preliminary design phase of the project.

At this time, the demand, rating, number and locations of the TPSs have been estimated using vehicle data, alignment details, service headways, service patterns, passenger capacity and train consists detailed in other sections of this proposal.

Tunnel power supply loadings will be determined during the preliminary design phase.

4.2.4 PS&D Security of Supply

The PS&D will be configured for operational reliability against interruptions due to electrical power supply or PS&D equipment failures.

Each underground TPS will be fed via two independent and dedicated 12.47kVac feeders from BC Hydro. A single BC Hydro feeder outage or a fault on one of the 12.47kVac incoming cable supplies will not cause the loss of power to any underground TPS or PS.

Each segment of the 750Vdc power rail system will be fed from two adjacent TPSs. The failure of any single TPS will still allow the operation of the transit system to continue without restriction to traffic or headways.

In addition, each underground TPS will be equipped with two power distribution transformers, which are connected to 12.47kVac switchgear for providing 600/347Vac power feeds to an adjacent passenger station. Each underground standalone passenger station will be supplied by a 12.47kVac supply from the utility as well as a 12.47kVac supply from an adjacent TPS or passenger station. A single failure in a utility power substation, 12.47kVac cable feed, power distribution transformer or 600/347Vac cable feed will not cause the loss of power to passenger stations.

4.2.5 Traction Power Substations

4.2.5.1 TPS Locations

The location of each TPS is determined by many factors, both physical and electrical. During the conceptual design, preferred locations were selected based on the construction phasing, services patterns, passenger loading and train consist as outlined in this document. The physical constraints of the alignment and surrounding structures have also been considered.

The principles followed in selecting locations were as follows:

- Space availability
- Initial installation of only a single rectifier
- Provision for a second rectifier at those TPSs required to meet ultimate capacity for the future

A TPS will be located under (or beside) the guideway when the guideway is elevated. In tunnel areas, each TPS will be located adjacent to a station. The depot will be provided with its own dedicated TPS.

The relative location of each TPS is shown graphically in Drawings 865704-CONF-47DK-2001, 2002, and 2003.

4.2.5.2 Traction Power Substation Buildings

For substations along the underground section of the alignment, the station box will accommodate the substation facility. Along the elevated section of the alignment, the substation equipment will be housed in standalone buildings in the vicinity of the guideway or at passenger stations. All PS&D equipment will be located indoors, with the exception of the pad-mount service transformers supplied by BC Hydro for the aboveground passenger stations. Adequate ventilation will be provided to dissipate heat generated by equipment located in the substations.

The structural framing for the TPS buildings will be reinforced concrete supported by beams and perimeter columns for the roof. Reinforced Concrete Masonry Unit (CMU) infill walls located around the perimeter of the structure will act as the lateral load resisting system. All CMU cavities will be fully grouted to support the loads of wall-mounted equipment.

The substructure will be designed after geotechnical information has been made available.

All cable components will be designed in accordance with the flammability, smoke and fume generation requirements of NFPA 130.

The floor of aboveground TPS buildings will be above the 100-year flood plain level in order to prevent flooding during peak rainfall periods. Where a TPS is part of a passenger station, this will be ensured by the design of the passenger station.

4.2.5.3 Traction Power Substation Equipment

Each TPS will include ac switchgear, transformer-rectifier unit, positive dc switchgear, negative dc switchgear, a blue light relay panel, a 110Vdc battery power system, distribution power transformers and 600/347V, three-phase ac switchboards and a SCADA interface panel. An automatic grounding switch will be provided in the negative dc switchgear at each integrated TPS/Passenger Station as well as at each standalone Passenger Station. The TPS will be designed for unmanned automatic operation with remote control for normal operation and local control for emergency and maintenance purposes. The remote control and monitoring of the TPS will be done via the traction supervisory control and data acquisition (Traction SCADA) system. All TPS equipment, except batteries, will be designed for a minimum operating life of 30 years.

4.2.5.3.1 AC Switchgear

The underground ac switchgear line-ups will consist of one medium-voltage (15kV class) switchboard connected to two independent and dedicated supplies from BC Hydro. Each switchboard will consist of two circuit breakers for accepting the incoming feeds, a metering unit, a rectifier transformer circuit breaker, substation auxiliary power cell, two distribution power transformer load-break switches and the necessary protection and control devices.

The aboveground ac switchgear line-ups will consist of one medium-voltage (12.47kV or 25kV as directed by BC Hydro) switchboard connected to one independent and dedicated supply from BC Hydro. Each switchboard will consist of one circuit breaker for accepting the incoming feed, a metering unit (unless the TPS is sub-fed from an adjacent TPS), a rectifier transformer circuit breaker, substation auxiliary power cell, one or two distribution power transformer load break switch, and the necessary protection and control devices.

The ac switchboards will be freestanding, dead front, metal-clad type with draw-out style, vacuum or SF_6 gas-type circuit breakers. The design of the ac switchgear will provide for the addition of a future rectifier transformer breaker.

4.2.5.3.2 Transformer-Rectifier Units

Transformer-rectifier units will convert 12.47kV or 25kV, three-phase, 60 Hz ac power to nominal 750Vdc power for feeding the traction power distribution system via the dc switchgear. The transformer-rectifier units will be heavy traction power duty, 12-pulse type.

The rectifier transformers will be dry type with the size and secondary winding voltage matching the rectifiers. The rectifiers will be silicon-diode type, freestanding, metal-enclosed, natural air-cooling type. Rated output voltage will be 750Vdc. Each TPS will consist of one 2000kW output unit.

4.2.5.3.3 DC Switchgear

The 750Vdc switchgear will consist of two line-ups, one positive dc switchboard and one negative dc switchboard. The positive dc switchboard will consist of one rectifier breaker cell, one, two or four feeder breaker cells, and the necessary associated protection and control devices. The negative dc switchboard will consist of one rectifier isolator switch cell, negative feeder isolator cell, a floating negative automatic grounding switch where applicable and a ground leakage detection cell.

The dc switchboards will be freestanding, dead front, metal-enclosed type with draw-out trucks for all breaker cells.

Each rectifier isolator switch will operate together with the corresponding rectifier feeder breaker in the positive switchgear to energize and isolate the transformer rectifier unit in accordance with the close and open sequences.

The design of the dc switchgear will provide for the addition of a future rectifier transformer breaker and isolator.

The 750Vdc breakers will be truck-mounted, drawout, single-pole, high-speed circuit breakers. Except for the OMC area switchgear and each end-of-line TPS, four dc feeder breakers will be connected to the following segments of power rails:

- Feeder #1 connected to southbound south power rail segment
- Feeder #2 connected to northbound south power rail segment
- Feeder #3 connected to southbound north power rail segment
- Feeder #4 connected to northbound north power rail segment

The OMC area switchgear will have five feeders supplying the various sections within the yard and one feeder dedicated to the stinger system.

A back-up High Speed Circuit Breaker (HSCB) will be provided at the OMC for emergency DC power via the power rail to the OMC from the mainline and visa versa in the event of supply failure.

4.2.5.3.4 DC Ground Fault Detection Panel

The dc grounding panel will consist of the negative dc bus, dc ground fault detection device(s), lockout relay and the main ground bus. The positive dc switchgear and the 750V rectifier will be isolated from ground. These devices will be grounded via a cable to the main ground bus. Each of these cables will pass through a ground fault detection device. Excess current to ground will be detected and cause a trip and lockout on the dc equipment.

4.2.5.3.5 Floating Negative Automatic Grounding System (FNAGS)

The mainline running rail, which will be isolated from ground, is the return path for the negative of the 750Vdc power distribution system. Cables will be connected between the running rail and the negative dc switchgear at each TPS. The voltage between the negative bus and ground is monitored in the FNAGS panel for each integrated TPS. If the voltage exceeds a preset value an alarm is sent to the control centre via SCADA. If the voltage rises to a preset operating value, selected to be less than the accepted safe step-and-touch potential, the negative dc bus, and thus the running rail, is automatically clamped to ground and a FNAGS operation signal is given via SCADA. FNAGS panels will also be installed at each standalone passenger station.

4.2.5.3.6 Blue Light Relay Panel

The Blue Light Relay Panel is part of the Blue Light System (please refer to Section 4.2.7) that interfaces the pushbutton operation in Blue Light Stations with the 750Vdc switchgear. If the pushbutton in any Blue Light Station is pressed, the corresponding dc feeder breakers will be tripped and the associated power rail segment will be de-energized.

4.2.5.3.7 110Vdc Battery Power System

The 110Vdc battery power system consists of the 110Vdc battery assembly, battery charger, battery disconnect switch and 110Vdc distribution panel. The battery power system will be sized to provide sufficient 110Vdc control power to all TPS equipment for its operation. Under normal conditions the battery charger will provide 110Vdc control power for all TPS equipment as well as battery charging. If the battery charger loses the 120Vac input power supply, the batteries will provide 110Vdc control power to all TPS equipment, for a minimum of eight (8) hours. The batteries will have a minimum operating life of 10 years. The 110Vdc distribution panel will be wall mounted, metal enclosed type with sufficient number of moulded-case circuit breakers for protection of load circuits.

4.2.5.3.8 Distribution Power Transformers and 600/347Vac Switchboards

The distribution power transformers will receive 12.47kVac or 25kVac, three-phase, 60 Hz from the ac switchgear and step it down to 600/347Vac three-phase, 60 Hz, to supply the low voltage Power Distribution Centres (PDCs). Distribution power transformers will be dry type. The 600/347Vac switchboards will be freestanding, metal-enclosed type with a sufficient number of moulded-case circuit breakers.

The distribution power transformers and 600/347Vac switchboards will be sized to provide sufficient 600/347Vac power for TPS building and control, passenger stations, tunnel ventilation system, communications, train control equipment and guideway facilities. The distribution power transformers and 600/347Vac switchboards will be located in TPS buildings or passenger stations.

4.2.5.3.9 SCADA Interface Panel

The SCADA interface panel will provide a termination point for connection of the TPS equipment to the traction SCADA system for remote control, status indication, metering and alarm purposes.

4.2.5.3.10 Protection and Coordination

The 12.47kVac or 25kVac switchgear will be equipped with all necessary protective relays and surge arresters for protection of individual circuits from transient over-voltage, under-voltage, short circuit, over-current and ground fault. The correct relay settings will provide appropriate coordination between incoming circuits and downstream feed circuits that will minimize the ac power outage and equipment damage.

The 750Vdc switchgear will be equipped with rate-rise (di/dt) and over-current relays, reverse current relays in the rectifier breaker cells, line measuring and re-closing relay and surge arresters in feeder breaker cells. The relay settings will provide appropriate protection to the equipment and minimize nuisance breaker trips, dc power outage and equipment damage from voltage surge, short circuits and overloads. The dc grounding panel will provide ground fault protection for the dc equipment within the TPS.

4.2.6 Power Rail System

The power rail system will consist of one conductor rail (positive rail), insulated supports, expansion joints, ramps, insulated coverboard and all associated mounting hardware. The power rail system will be fed from the 750Vdc switchgear in TPSs and provide nominal 750Vdc power, via collector shoes, to the vehicles.

4.2.6.1 Conductor Rail and Insulated Supports

The conductor rail and insulated supports will be designed to withstand operating and transient voltages, vehicle dynamic loads, wear as well as electromagnetic and thermal loads imposed by short circuits. The conductor rail will be of a stainless-steel aluminium composite and will be designed to provide a minimum operating life of 30 years without degradation in performance due to wear or environmental conditions.

Each insulated support consists of an insulator and steel bracket designed for wall or floor mounted applications. The insulated supports will provide the positive conductor rail with solid support and prevent lateral and vertical motion, while allowing longitudinal movement as necessary for thermal expansion.

The conductor rail will be provided with expansion joints to allow for thermal expansion expected over the minimum to maximum operating conditions including ambient temperature, solar gain and current heating. The expansion joints will be designed for minimum collector shoe wear, acoustic noise and arcing. Conductor rail anchors will be provided to prevent the power rail from creeping.

Should icing on any section of power rail effect service or vehicle performance, power rail heating will be provided on the affected power rail section.

4.2.6.2 Power Rail Sectionalizing

The power rail system will be segmented to allow sectionalization of the guideway for isolation, maintenance and other purposes. Sectionalizing via circuit breakers in dc switchgears will route power to both ends of each section of power rail. Under normal operation, all power rail sections will be tied through the dc switchgear. It will be possible to isolate any section of power rail through the operation of the appropriate circuit breakers. A single malfunctioning TPS will be disconnected from the load and the remaining TPSs will have sufficient capacity to carry the load without degradation of performance. Provision will be made for the addition of power rail isolation section bypass switches at those TPSs required to meet the ultimate capacity for the future in a single TPS failure mode.

HSCB will also be provided on the OMC lead tracks for isolation between the mainline and the OMC.

The power rail at rail crossings and track turnouts will also have isolation points for further sectionalizing the power rail for maintenance and failure management purposes. Power disconnect switches will be provided at these isolation points. Appropriate operation of the sectionalizing circuit breakers and power disconnect switches will minimize the loss of track sections and interruption to service.

Grounding devices (Ground Straps) will be located around the system as required for operations and maintenance.

4.2.6.3 Coverboards

As a minimum, coverboards will be provided at the following locations:

- Passenger station platform areas
- Areas where the emergency walkway is on the same side of the track as the power rail
- Areas where the emergency walkway crosses from the centre to the same side of the track as the power rail
- Special trackwork areas

- Power rail in the OMC

The coverboards will prevent accidental contact with the power rail by personnel on the guideway and in the OMC. The insulating material used for coverboards will be flame-retardant or non-combustible, and ultra violet (UV) resistant type. The crosswalk coverboards used where the emergency walkway passes over power rail will be able to sustain the weight of one person plus portable tools.

4.2.7 Blue Light System

The Blue Light System will be provided in accordance with the requirements of National Fire Protection Association (NFPA) 130. The Blue Light System will consist of Blue Light Stations mounted at the ends of station platforms, cross passages in underground guideway and at designated emergency access points along the guideway. A Blue Light relay panel will be located in each TPS. Each Blue Light Station consists of a blue light for indication of the Blue Light Station location, a telephone for communication with the Control Room and a pushbutton. When the pushbutton is operated, the corresponding dc feeder breakers will be tripped and the associated power rail segment will be de-energized.

4.2.8 Grounding Philosophy

Each TPS and passenger station will be provided with a ground grid to which all power equipment within TPS and passenger station will be bonded in accordance with local electrical codes and standards. In addition, the ground grid system design will comply with IEEE Standard 80 – Guide for Safety in ac Substation Grounding to ensure that step-and-touch potentials are limited to safe values.

The rectifier and positive dc switchgear enclosures will be insulated from the floor and individually connected to the dc earth bus via dc ground fault detection devices (GFDD) as described in the section on the dc Ground Fault Detection Panel. When the ground fault occurs on this dc equipment, the corresponding GFDD will pick up the fault signal, initiate mass trip and lockout of all associated feeder breakers, and send an alarm signal to the control centre.

4.2.9 Stray Current Collection and Monitoring

The mainline running rails will be isolated from ground to serve as the negative return for the traction power system. With the system design resulting in the majority of the isolated running rail being installed on underground or elevated guideway, with insulated track fasteners, it is anticipated that stray current will be kept to a minimum and therefore permanent stray current monitoring is not required. A study will be conducted, however, to determine the extent and magnitude of any stray current and stray current monitoring points will be incorporated into the design to allow periodic stray current measurements to be made.

4.2.10 Stinger System

A stinger system will be provided in the OMC maintenance shop to provide auxiliary power only to the vehicles. The stinger system will consist of a dc power distribution centre, stinger power feed assemblies, stinger power connectors and control pushbutton stations. The type, configuration and rating of stinger power connectors will match the power plugs installed on the vehicle.

4.2.11 Passenger Station And Tunnel Power Supply

Underground passenger stations electrical service rooms will receive power from a dual supply via two distribution power transformers and 600/347Vac switchboards.

Aboveground passenger stations will receive power from a distribution power transformer located in an integrated TPS; or, in the case of a standalone passenger station, directly from BC Hydro or adjacent TPS. Each passenger station electrical service room will be provided with an Uninterruptible Power Supply (UPS) System.

4.2.11.1 Uninterruptible Power Supply (UPS) System

The Uninterruptible Power Supply (UPS) System consists of the UPS unit, battery, critical panel and manual transfer switch. The UPS will be sized to provide sufficient 208/120Vac power to all essential equipment and lighting in the passenger station and tunnel where applicable. The UPS unit will be solid-state type. The UPS battery will be sized to provide power for at least two hours following failure of the ac supply. The batteries will be designed to provide a minimum operating life of 10 years. The critical panel will be housed in a metal enclosure with a sufficient number of moulded-case circuit breakers for critical load circuits. The manual transfer switch will be connected to a three phase, four-pole wall receptacle located outside the building for portable generator connection.

4.2.12 Traction SCADA System

The Traction SCADA System will monitor and control the Traction Power and Distribution System throughout the Canada Line from a single operator position and traction overview located at the OMC.

The system will provide the following functionality:

- An overview of 12.47kV (or 25kV), TPS and track network
- Status of power in each traction power section
- Status and control of traction circuit breakers and disconnect switches
- Status and control of 12.47kV (or 25kV) network
- Status of TPS, PS and UPS supplies
- Equipment alarm monitoring and management

Each TPS and passenger station will be provided with a Remote Terminal Unit (RTU) connected to the TPS, power rail switching equipment and passenger station status through a SCADA Interface Panel. The RTU will be powered by a UPS to ensure operation during an ac power failure.

At the OMC a SCADA master station, user interface and overview display will be provided.

4.2.13 Emergency Power Supply Systems

A fixed mounted emergency power supply system (diesel generator set) will be provided for standby purposes only at the OMC. The generator will be connected to the 12.47kVac bus via a circuit breakers and a 600V/12.47kVac transformer in the depot TPS and will be interlocked to prevent back-feed to BC Hydro.

The generator will be rated 750kVA, 600Vac, three-phase and 60Hz. The unit will have standard protection devices for over speed, over/under voltage, frequency, low oil pressure, over temperature, etc. which will be monitored via SCADA. The generator will be capable of operating continuously at 100% load as well as at 110% for one hour in each 12-hour cycle and have fuel capacity for operating six (6) hours at full load.

Two trailer-mounted generator units will be provided for emergency power supply at any passenger station.

4.3 TRACKWORK

Trackwork design for the Canada Line will be based on standard proven rapid transit technology and methodology, as used in various operating systems throughout the world. The design, supply, installation and construction of the complete trackwork system will be in accordance with the applicable internationally recognized standards, including American Railway Engineering and Maintenance of Way Association (AREMA), TCRP Report 57 – Track Design Handbook for Light Rail Transit and International Union of Railways (UIC).

The trackwork design will be undertaken by a fully qualified team of experienced trackwork design specialists, and will be fully integrated with the requirements of the traction power distribution, communications and signalling systems.

Technical specifications, defining exact performance requirements, material properties, and testing and inspection requirements for all components, will be produced. The selection process for trackwork components and materials will take into consideration functionality, ease of construction, minimal maintenance, durability and suitability. Detailed drawings and specifications will be prepared for the installation and construction work, clearly showing the infrastructure constraints and tolerances to which the guideway structure and trackwork will be built to ensure the overall integrity and performance of the operational system.

The installation and construction of trackwork will ensure that the finished product meets the overall performance requirements established in the design process. Track plan, track concepts and proposed general arrangements are shown in Drawings 865704-CONF-43DK-1700 to 1730 in Appendix B-1.

4.3.1 Mainline Track

The trackwork for the mainline will be direct fixation type, and will comprise approximately 16.5 track kilometres of elevated guideway, 4.42 track kilometres of bored tunnel, and 14 track kilometres of cut-and-cover. As discussed in the Section 4.2, Power Supply and Distribution, the mainline running rails will be electrically isolated from ground.

Direct fixation track, except for the special trackwork, will utilize resilient fasteners secured to the concrete trackbed.

Mainline turnouts and crossovers (special trackwork) will be fixed to the guideway via a second pour, cast-in-place concrete slab with steel plates directly bonded to the poured concrete surface using a resilient polyurethane grout mix, supplemented by anchor bolts cast into the second pour concrete slabs.

4.3.2 Operations and Maintenance Centre – Yard Tracks

The yard tracks will consist primarily of ballasted track, except lead tracks connecting mainline with the depot and in the maintenance shop. Ballasted track, except in the special trackwork areas, will utilize pre-stressed concrete and/or timber ties where necessary to install restraining rails in sharp curves. The maintenance shop track will consist of embedded track and/or pit track with special fastening details.

Track in the OMC will be isolated from the mainline and be fully grounded.

4.3.3 Design Concept

The design concept for the trackwork system is based on technology with over 24 years of proven system operational experience, including significant research and development to improve the functionality of the system. The trackwork elements proposed will provide quality, safety, ride comfort, longevity and ease of maintenance.

The trackwork components are an integral part of the overall design of the system, including the civil structures. Therefore, it is imperative that a coordinated and integrated approach be adhered to during design and construction of the civil structure and the trackwork.

- **Richmond and Airport Connector Section:** The Richmond and Airport sections are proposed to be elevated, and consist of precast beam segments and cast-in-place columns. The guideway will be constructed with super-elevation through the horizontal curves. Inserts for direct fixation rail fasteners will be cast into the guideway beam segments. Inserts will be located with sufficient accuracy to ensure compliance with specified trackwork tolerances and as required by the direct fixation fastener design.
- **Fraser River Crossing:** The Fraser River Crossing is proposed to be elevated guideway with the centre span as a special structure. Elevated guideway will utilize precast beams, while the special structure will be cast in place with cast-in-place columns. The trackwork anchorage on the special structure will be installed by the core drill and grout method with sufficient accuracy to ensure compliance with specified tolerances and as required by the direct fixation rail fastener design.
- **Vancouver Elevated:** The Vancouver section has a short section of elevated guideway from the Fraser River Crossing to the start of the underground tunnel section at approximately 63rd Avenue. The trackwork design concept for this area will be identical to that proposed for the Richmond and Airport Sections.
- **Vancouver Shallow Tunnel:** Where the alignment is in a cut-and-cover shallow tunnel under Cambie Street it will consist of match-cast segments. As on elevated guideway, the cut and cover section will be constructed with super-elevation through the horizontal curves. Inserts for direct fixation rail fasteners will be cast into the precast segments. Inserts shall be located with sufficient accuracy to ensure compliance with specified trackwork tolerances and as required by the direct fixation fastener design.

  Rollover transitions from elevated guideway structures to the cut-and-cover sections will be cast-in-place concrete and the final track elevations of direct fixation track will be achieved by the civil contractor. Anchor bolt inserts for direct fixation fasteners will be installed by the core drill and grout method with sufficient accuracy to ensure compliance with specified tolerances and as required by the direct fixation fastener design. Epoxy grout will be used for securing anchor bolt inserts.

Vancouver Bored Tunnel: The track in the bored tunnel will utilize direct fixation fasteners on the invert concrete surface and/or base slab. Anchor bolt inserts for direct fixation fasteners will be installed by the core drill and grout method with sufficient accuracy to ensure compliance with specified tolerances and as required by the direct fixation fastener design. Epoxy grout will be used for securing anchor bolt inserts.

In the event that our design analysis identifies tunnel locations with a need for additional ground born vibration attenuation, a low vibration track (LVT), such as Sonneville's concrete blocks with rubber boots will be implemented on the tunnel invert and/or base slab to reduce vibration to required limits.

4.3.4 Mitigation of Wheel to Rail Noise and Vibration

Trackwork for the Canada Line will be designed with due consideration for the vibration effects and noise resulting from steel-wheel-to-steel-rail contact. The guideway structural design will incorporate features designed to minimize noise generation and propagation, such that the design goals for acoustic and noise control problems relating to the construction and operation of the Canada Line and the environmental assessment can be met. Design based on vibration analysis will be undertaken, with a view to keeping major structural components free from resonance and unacceptable dynamic amplification such that ground- and structural-borne vibration in adjacent buildings and/or pedestrian areas are within required limits.

Recent investigations have shown that the use of bonded rail fasteners with low spring rate values, such as those proposed for this project, significantly reduce noise and vibration levels. All turnouts and crossovers will be designed and installed with due consideration to noise and vibration sensitivities. Polyurethane grout with an average thickness of 30 to 35 mm will be placed between the top of second pour slabs and underside of each direct fixation rail fastener to provide complete support and resiliency.

4.4 COMMUNICATION SYSTEMS

This section outlines the communications systems required to support automatic operation of the Canada Line. The communication systems dispense information to, and provide regular and emergency communications between, CROs staff, passengers, and operations and maintenance personnel.

The systems are described from their functional perspective, or "what" they will do, rather than from an implementation perspective, or "how" they will do it.

The following systems are presented in this section (system descriptions should be read in conjunction with the associated drawings provided in Appendix B-1):

- Public Address System (4.4.1)
- Voice Communications and Passenger Alarms System (4.4.2)
- Passenger Security System (4.4.3)
- Passenger Information System (4.4.4)

- E&M SCADA System (4.4.5)
- Fibre Optic Transmission System (4.4.6)
- Master Clock System (4.4.8)
- Passenger Counting System (4.4.9)
- Tunnel Ventilation SCADA System (4.4.10)
- Platform and Guideway Intrusion Detection System (4.4.11)

4.4.1 Public Address System

4.4.1.1 General Description

The Canada Line will be provided with a Public Address (PA) system covering all passenger stations, vehicles, equipment rooms, substations and the CROs. The PA system will allow routine and emergency announcements to be made to passengers and operations and maintenance personnel. The PA system will provide a number of functions as follows:

- CROs may make announcements to passenger stations, vehicles and staff areas.
- Staff may make announcements in and around a passenger station from that station's PA microphone.
- Staff may make announcements in and around the vehicle from a microphone at the vehicle hostler panel.
- Fire department personnel may make announcements in and around the passenger station from the Fire Command Post. Such an emergency announcement will override all other non-emergency announcements.
- The Fire Alarm System may trigger automated emergency announcements.
- The Passenger Information System may trigger automated announcements of train arrivals, departures and destinations.

The context within which the PA system will operate is shown in Drawing 865704-CONF-47DK-2017.

4.4.1.2 Passenger Stations

Each station will be provided with standalone PA equipment connected to the CROs. PA announcements will be audible throughout the entire station, including platforms, concourses, equipment rooms and ticketing areas. The PA system will have multiple zones so that messages may be routed to specific areas. Most announcements will be made from the CROs, but the PA system will also provide operator positions within each station on the inbound and outbound platforms and at the Fire Command Post. These positions provide a microphone and controls to select the announcement zone within the station.

The design of the speaker network, materials and finishes chosen within the station will be coordinated to minimize the amount of reflection and maximize the audibility of announcements. This is particularly important in underground stations.

4.4.1.3 Vehicles

Each vehicle will be provided with standalone PA equipment connected to the CROs through the Radio System. Announcements will generally be made from the CROs, but a microphone will be provided at the vehicle hostler panel to make announcements from within the vehicle.

4.4.1.4 Traction Power Substations

Each TPS within a station will be provided with PA speakers connected to the PA system at the station. TPSs will be zoned together with other restricted access areas, such as equipment rooms.

4.4.1.5 Automated Announcements

The PA system will allow for the recording of audio messages and the automatic announcement of these messages. Recorded messages may be triggered by a specific event, or made automatically on a regular basis. Interfaces with the passenger information system and the station fire alarm system will allow train arrivals and fire alarms to trigger PA announcements. Automated announcements will include:

- Announcements of train arrivals, departures and destinations
- General safety information and service bulletins to passengers
- Information regarding schedule interruptions
- Specific evacuation information to passengers under emergency situations

4.4.1.6 Ambient Noise Sensing

The PA system will include ambient noise sensing to ensure all announcements can be heard clearly above the background noise in the passenger station or vehicle. Ambient noise sensing also helps to control noise pollution in open-air, aboveground stations.

4.4.1.7 Safety

The PA system will be designed to meet the requirements of NFPA 72 and relevant Canadian Standards pertaining to the use of the PA system for evacuation from underground locations.

4.4.1.8 Interface with Airport PA System

At airport passenger stations, the PA system will be interfaced with the airport PA system so that PA announcements may be made from the airport control centre. Such announcements will be limited to handling of emergency situations in the airport, and will override all regular non-emergency announcements from within the Canada Line PA system.

4.4.1.9 Announcement Priority

S.15(1)(L)

-
-
-
-
-

s.15(1)(l)

4.4.2 Voice Communication and Passenger Alarm System

4.4.2.1 General Description

The Canada Line Voice Communication and Passenger Alarm (VCPA) System will provide services throughout the stations, equipment rooms, cross passages, guideways and vehicles. The VCPA system will use the Canada Line Fibre Optic Transmission System (FOTS) and Radio System, and will therefore not be dependent on any public networks. Passenger alarm functions will be implemented using the telephone system, Radio System and E&M SCADA system working together to provide the following:

s.15(1)(l)

Emergency and passenger assistance telephones will be designed to be accessible to people with physical and mental disabilities.

The context within which the Voice Communication and Passenger Alarm System operates is shown in Drawing 865704-CONF-47DK-2020.

4.4.2.2 Emergency Telephones

Emergency telephones will be provided in the following locations:

- In the Designated Waiting Area of each platform
- At each emergency access point to the guideway, including at the ends of platforms, tunnel portals, and cross passages
- Inside elevators and at elevator landings (outside concourse area)

- In each area of refuge
- At each Blue Light Station
- At each station entrance
- In emergency cabinets in stations
- At fire command posts
- Throughout passenger stations, such that all public areas are within 60 m of an emergency phone

Emergency telephones and intercom panels will be red, to make them highly visible. When an Emergency Phone Handset is lifted, a call to the CROs will be automatically initiated. At the CROs, the incoming emergency call will raise an audible and visual alarm to draw the operator's attention to the call, and provide information regarding the location of the emergency phone. Where video coverage of the emergency phone area is provided, this will also be presented to the CROs Operator. Throughout the duration of the call both video and audio will be recorded.

A system of call routing and queuing will be provided in the CROs to ensure calls are answered as soon as possible. If all operators are busy, the call will be alarmed and placed in a queued to await the first available operator. Emergency calls will take priority over normal calls. All ETEL calls will also be routed to an FCP for communication with the fire department.

4.4.2.3 Passenger Vehicle Intercoms and Alarms

Each passenger vehicle will be provided with the following:

- Passenger silent alarm strips
- Passenger emergency call intercoms
- Smoke detectors
- Attendant hostler panels
- Vehicle health monitoring

Activation of any alarm system will result in an alarm being raised in the CROs, together with information identifying the affected vehicle. Upon answering the call the CROs Operator will be connected, via the telephone and radio systems, to the vehicle. The operator may then opt to monitor conversations on the vehicle before deciding the best course of action, or to establish a two-way connection with the vehicle intercom.

The telephone and radio systems will also be used to pass data on a regular basis from the vehicle health monitoring system for Performance Reporting.

4.4.2.4 Passenger Information Telephones

Passenger Information Telephones (ITELs) will be provided in the following locations:

- On each platform
- Adjacent to each group of TVMs

When an ITEL handset is lifted, a call will be automatically initiated to the Translink Information Centre to provide customer assistance.

4.4.2.5 Administrative Telephones

Regular system telephones will be provided in the following locations:

-
-
-
-
-
-

s.15(1)(L)

Administrative phones with a conventional handset and touch-tone keypad will be provided. These phones will allow users to make calls In public areas, administration telephones will be

s.15(1)(L)

4.4.2.6

The Canada Line will be provided with its own located at the OMC. This will handle all internal emergency, passenger assistance and administrative telephone calls.

s.15(1)(L)

4.4.2.7 Radio System

The Canada Line will be provided with its own private Radio System, covering all stations, tunnels, elevated guideways and depot areas. The primary function of the Radio System is to provide voice and data communication services between CROs, vehicles and staff carrying hand portable radios. Voice communications also support the vehicle PA and emergency call systems. Data communication services support vehicle PIDs, alarms and vehicle equipment monitoring. The Radio System will also be used for voice communication between CROs, maintenance staff and ticket checking staff using mobile handsets. Drawing 86704-CONF-47DK-2029 shows an overview of the radio system.

The Radio System will consist of the following equipment:

-
-
-
-

s.15(1)(L)

-
-

s.15(1)(l)

The Radio System will allow the following types of voice calls:

-
-
-

s.15(1)(l)

4.4.2.8 Voice Recording

Voice recorders will be provided at the CROs for recording conversations. All conversations involving CROs and/or emergency response staff will be recorded. Passenger assistance calls may be recorded for quality of service monitoring. Each conversation will be recorded with date and time information to assist in the investigation and reconstruction of incidents. Recordings will be stored for before being overwritten. This allows sufficient time to investigate incidents and make copies of recordings if required.

s.15(1)(l)

4.4.2.9 Airport Courtesy Phones

Space on airport station platforms and in cable ducts will be allocated for the installation of airport courtesy phones. The supply and installation of such phones, and the associated telephone circuits, is the sole responsibility of YVR.

4.4.2.10 CROs Hotlines

s.15(1)(l)

4.4.3 Passenger Security System

4.4.3.1 General Description

The Canada Line will be provided with passenger security facilities in all stations. The Passenger Security System will provide the following functionality:

- Colour CCTV cameras
-

s.15(1)(l)

-
-
-
-
-
-
-

s.15(1)(L)

The context within which the Passenger Security System will operate is shown in Drawing 865704-CONF-47DK-2021.

4.4.3.2

s.15(1)(L)

4.4.3.3 Surveillance Cameras

Coverage of

s.15(1)(L)

s.15(1)(L

4.4.3.5 CROs Overview

s.15(1)(L)

4.4.3.6 CROs Operator Positions

s.15(1)(L)

4.4.3.7 Video Recording

Video images will be recorded at the stations. Images will be stored at a during normal operation. During emergencies, the frame rate will be Recorded images will be available s.15(1)(L) immediately for review. The use of digital video recorders will allow operators to review recorded images while continuing to record.

Once recorded, images will be stored for before being overwritten. This allows sufficient time to review incidents and make a copy of the images if required. Recordings will be electronically stamped with date, time and camera location to assist with incident investigations.

4.4.3.8

s.15(1)(L)

4.4.3.9 Technology

The Passenger Security System may be based on either an analog or a digital solution. In either case,

s.15(1)(L)

4.4.3.10

s.15(1)(L)

4.4.3.11 Station CCTV Monitor

s.15(1)(L)

4.4.4 Passenger Information System

4.4.4.1 General Description

The Canada Line will be provided with a Passenger Information System to keep passengers informed about train schedules and destinations. The Passenger Information System will provide the following functionality:

- Display of train arrival times and destinations in intermediate passenger stations

- Display of train departure times and destinations in terminal passenger stations
- Display of next station and final destination in vehicles
- Announcement of closing doors in vehicles
- Announcement of the next station and destination in vehicles
- Triggering of automated PA announcements of train arrivals, departures and destinations in passenger stations
- 24-hour telephone information service
- Internet information service

The context within which the Passenger Information System will operate is shown in Drawing 865704-CONF-47DK-2018.

4.4.4.2 Station Passenger Information Displays

Passenger Information Displays (PIDs) will be provided on each platform. PIDs will alternately display the time to arrival, and final destination of incoming trains for that platform, special events, public information items, instructions in emergency situations, and the current time.

Each PID will typically be double-sided, use yellow LED technology, with the ability to show multiple lines of text and graphic characters. The size and number of PIDs will be coordinated with the platform layout such that the PIDs are visible throughout the platform area.

4.4.4.3 Vehicle Passenger Information Displays

Vehicle Passenger Information Displays will be provided inside each vehicle displaying the next station and Exterior displays at the ends and sides of each two car train will display the destination for that train.

4.4.4.4 Interface to ATC System

The Passenger Information System interfaces to the ATC System to receive information regarding the location of trains. The ATC System sends a trigger event each time an announcement is to be given or display is to be updated.

Train arrival, departure events and train destinations will be provided by the central ATC equipment. These events will be communicated to vehicles over the Radio System and to stations via the Fibre Optic Transmission System.

Door-closing indication will be provided directly by the vehicle ATC equipment.

4.4.4.5 Operator User Interfaces

CROs will be provided with a user interface that will allow them to configure the system to display other safety, public information and security information on station and vehicle PIDs. Operators will be able to select the number of incoming trains displayed on PIDs, and configure the content and frequency of other special messages. PIDs will typically be configured to display the time to arrival for the next train to each terminal station.

4.4.4.6 Advertising

The Passenger Information System may be used to deliver advertising of events or products through station and vehicle PIDs. The frequency of advertising will be such that it does not infringe on the delivery of train operation information to passengers.

4.4.4.7 Internet Information Service

A website will provide customers with information on Canada Line service bulletins, schedules, hours of operation, etc. Schedules will also be made available on the TransLink website at http://www.translink.bc.ca.

4.4.4.8 Flight Information Displays

Space will be reserved on each station platform for the installation of a YVR flight information display. The provision and installation of such displays remains the sole responsibility of YVR. Space in cable ducts between the displays and station equipment rooms will be made available for connecting the display to the Fibre Optic Transmission System and the power distribution system.

4.4.4.9 Interface with TransLink Control Centre

The Canada Line Passenger Information System will provide an interface to allow operators at the TransLink Control Centre to configure special messages for display on Canada Line station and vehicle PIDs. TransLink personnel will be able to configure the content and priority of their own messages, but will not be able to configure messages created by Canada Line operators. The use of such messages will be limited to informing passengers about irregularities in TransLink operations. All regularly scheduled messages will be configured through the Canada Line Control Centre.

4.4.5

4.4.5.1 General Description

s.15(1)(l)

4.4.5.2 Security Alarms

s.15(1)(l)

s.15(1)(L)

4.4.5.3 Equipment Alarms

s.15(1)(L)

4.4.5.4 Elevators and Escalators

s.15(1)(L)

4.4.5.5 Operator User Interface

s.15(1)(L)

4.4.5.6 Performance Reporting

s.15(1)(L)

4.4.6

4.4.6.1 General Description

s.15(1)(L)

4.4.6.2 Communications Interfaces

s.15(1)(l)

4.4.6.3 Security

s.15(1)(l)

4.4.6.4 Architecture

s.15(1)(l)

Analog CCTV images may be transported directly to the CROs on point-to-point connections from each station. Spare fibres to each station will be provided to add redundancy in case of a fibre failure.

4.4.6.5 Network Management System

A Network Management System (NMS) will be provided to assist operators with FOTS diagnostics and reconfiguration. Operators will be able to reconfigure network connections to deal with equipment additions or rerouting around failures. Operators will also be able to collect performance data on the network. The NMS will monitor the complete network and advise maintenance staff of failures.

4.4.6.6 Technology

The FOTS will use SONET or similar such as , but not limited to Gigabit Ethernet technology for digital data transmission. Using this type of equipment will ensure availability of compatible replacement equipment in the future.

4.4.6.7 Capacity

The FOTS will be designed with 30% spare capacity over and above the predicted peak traffic on the network. Client systems will be provided with dedicated bandwidth if required for optimal performance.

4.4.6.8 Fibre for YVR Use

A dark, 48-strand single mode fibre optic cable will be provided for YVR's use. This cable will run from YVR 4 passenger station to Bridgeport Station, from Bridgeport station to Richmond Centre Station, and from Bridgeport Station to Waterfront Station. Full 48-fibre termination patch panels will be provided at Richmond Centre, Bridgeport, Waterfront and YVR 4 station. Eight-fibre spur cables will be provided at all other passenger stations. The configuration of the fibre spurs will be determined upon consultation with YVR.

4.4.8 Master Clock System

The Master Clock System maintains a precise time-of-day reference and distributes this to all systems and clocks. The Canada Line system time will be synchronized to UTC time by the Canadian short wave radio broadcast station CHU, or by a GPS receiver. Under failure situations, the Master Clock System will continue to maintain accurate time using its own internal free-running clock. Precise time across all system clocks is required to ensure consistency during incident investigations and accuracy of timetable scheduling and passenger information. The context within which the Master Clock System will operate is shown in Drawing 865704-CONF-47DK-2019.

4.4.9 Passenger Counting System

4.4.9.1 General Description

The Canada Line Passenger Counting System will count the number of passengers entering and exiting each station. Overhead counting sensors will be placed at entrances to the fare paid area of each station. Data will be collected every day for each station and transferred to the central passenger counting system over the FOTS. Passenger counts may be accumulated on intervals as short as two minutes to assist with ridership analysis and schedule planning. The context within which the Passenger Counting System will operate is shown in Drawing 865704-CONF-47DK-2025.

4.4.9.2 CROs Workstation

The Passenger Counting System will have a single CROs workstation for:

- Monitoring PCS equipment
- Analyzing and archiving ridership data
- Generating ridership reports

The Passenger Counting System will use overhead infrared sensors to detect the passing of riders. The system can differentiate between passengers entering and leaving the station. On existing systems, accuracy has been shown to be 98% on daily count. In order to minimize errors, the infrared sensors will be placed in areas where passengers are unlikely to be standing around, or where they are unlikely to cross the sensor multiple times. Suitable locations include above stairs, escalators and elevator doors.

4.4.10 Tunnel Ventilation SCADA System

4.4.10.1 General Description

The Tunnel Ventilation SCADA System monitors and controls fans and dampers in underground stations and guideways. The context within which the Tunnel Ventilation SCADA System will operate is shown in Drawing 865704-CONF-47DK-2026.

S.15(1)(l)

4.4.10.3 Fire Command Post

S.15(1)(l)

4.4.11 Platform and Guideway Intrusion Detection System

4.4.11.1 General Description

The Canada Line will be equipment with a Platform and Guideway Intrusion Detection System that will provide the following functionality:

- Detects the presence of objects or individuals in the guideway
- Raises alarms to the operators
- Notifies the ATC System of an intrusion

The context within which the Platform and Guideway Intrusion Detection System will operate is shown in Drawing 865704-CONF-47DK-2023.

4.4.11.2 Detecting Objects

The Platform and Guideway Intrusion Detection System will utilize a network of sensors located in and around the platform area and guideway, in a similar configuration to that used on SkyTrain, to determine if an object or individual has entered the guideway. The system will detect a person leaving the station on the guideway along the emergency walkway. The system will also detect an individual or object falling onto the guideway in the platform area.

Where required, the system will also be used where there is a risk of direct access to the guideway from public property. In such locations, the primary means of protection will be a suitable fence, and the guideway intrusion detection system will be a secondary safety measure.

4.4.11.3 SCADA Alarms

The system will be monitored through the E&M SCADA System, which will raise alarms to operators located at the OMC. Upon an intrusion alarm, the affected area will be displayed on CCTV monitors for the appropriate operator.

4.4.11.4 ATC

When an intrusion has been detected, the system will S.15(1)(L)

4.5 FARE COLLECTION SYSTEM

4.5.1 General Description

The Fare Collection System for the Canada Line will be supplied, installed and commissioned by GVTA. The Concessionaire will make the following provisions within the design of the Canada Line to accommodate the Fare Collection System:

- Allow for the equipment within the layout of the station.
- Provide cableways and equipment mounting.
- Provide power and associated cabling and protection devices.
- Provide communications and associated cabling between each station and Waterfront (Canada Line).
- Provide communications and associated cabling between Waterfront (Canada Line) and OMC, if required.

- Present communications for onward transmission by GVTA at Waterfront (Canada Line),
- Monitor station fare collection equipment alarms through E&M SCADA system.

4.5.5 Quantities

The following quantities will be used as a basis for design.

STATION	# TVMS	# TVUS	# GATES	# SPECIAL GATES	# AFMS
Waterfront	7	4	8	2	4
Robson	6	2	4	1	2
Davie	3	2	3	1	2
Broadway	5	2	6	1	2
King Edward	3	2	3	1	2
Oakridge	3	2	3	1	2
49th	3	2	3	1	2
Marine Drive	3	2	3	1	2
Bridgeport	5	2	6	1	2
Cambie	2	2	3	1	2
Alderbridge	2	2	3	1	2
Richmond Centre	5	2	4	1	2
YVR 1	2	2	3	1	2
YVR 2	2	2	3	1	2
YVR 3	2	2	3	1	2
YVR 4	6	4	6	2	4
Total	**56**	**36**	**64**	**18**	**36**

4.6 TUNNEL VENTILATION

4.6.1 Introduction

The Canada Line will be provided with a Tunnel Ventilation System throughout the underground portion of the line between Waterfront station and the tunnel portal at around Cambie and 64th. The Tunnel Ventilation System will facilitate general year-round air circulation, to maintain a comfortable environment for passengers and employees during normal and abnormal operations. However, the primary function of the Tunnel Ventilation System will be to provide a tenable environment for passengers and emergency personnel during an evacuation of the tunnel arising from a fire-and-smoke incident. In addition to addressing fire and smoke emergencies the ventilation system will assist in the containment and purging of hazardous gases and airborne contaminants. The Tunnel Ventilation System will therefore provide the following:

S.15(1)(l)

This section should be read in conjunction with the following drawings:

- Drawing 865704-CONF-47DK-2040, 2041, and 2042 Tunnel Ventilation and Emergency Exit Plan and Profiles
- Drawing 865704-CONF-47DK-2043 Tunnel Ventilation Schematic - Blast Relief Mode
- Drawing 865704-CONF-47DK-2044 Tunnel Ventilation Schematic - Cooling Mode
- Drawing 865704-CONF-47DK-2045 Tunnel Ventilation Schematic – Emergency Mode
- Drawing 865704-CONF-47DK-2046 Typical Fan Room Arrangements
- Drawing 865704-CONF-47DK-2026 Tunnel Ventilation Control Context Diagram

4.6.2 Tunnel Configuration

The tunnel will be configured with four emergency fans in each station. These emergency fans will be housed in ventilation shafts located at each end of each station. A system of dampers will permit the ventilating capacity of each ventilation shaft to be supplied to or exhausted from either one or both of the running tunnels. The total pressure rating of the emergency fans and the corresponding horsepower requirements will be functions of both the ventilation shaft design and the design layout of the adjacent station.

Placing the shafts on either side of the station platforms permits the emergency fans to both deliver fresh air to a tunnel-fire site more efficiently and remove smoke from an incident tunnel before it flows into the adjacent station. The location of the ventilation shafts also benefits possible fire scenarios in the stations or their adjacent crossovers/pocket tracks.

Between each station, approximately 220 m apart, will be a cross-passage between the inbound and outbound tunnels. This passage will be used to allow evacuation from the incident tunnel to a place of safety in the adjacent tunnel. In a bored tunnel this evacuation route will be a cross-passage between the bores; in the cut-and-cover section, it will be a transfer door; and in the stacked tunnel section it will be a transfer stairwell with a door. Each passage and door will provide a minimum of 1.5 hours' fire protection and will be provided with an emergency telephone and Blue Light Station.

A pair of jet fans will be provided at the tunnel portal to increase air velocities and provide sufficient airflow.

4.6.3 Modes of Operation

The Tunnel Ventilation System may be configured to suit various operational requirements. Normally the system will be configured to provide blast relief for platforms from train-generated airflows. Should the tunnel temperature rise for any reason, the system can be configured to deliver a supply of fresh air to the tunnel. In an emergency the system will be configured to prevent back-layering and remove smoke and heat emanating from a fire to the atmosphere and deliver fresh air to passengers evacuating from a train.

4.6.3.1 Blast Relief Mode

In blast relief mode the Tunnel Ventilation System will be configured to S.15(1)(c)

To implement this mode the system will be configured as follows:

4.6.3.2 Tunnel Cooling Mode

In tunnel cooling mode, the Tunnel Ventilation System will be configured to To implement this mode, the system will be configured as follows: S.15(1)(c)

4.6.3.3 Emergency Mode

In emergency mode, the Tunnel Ventilation System will be configured to

S.15(1)(c)

To implement this mode, the system will be configured as follows:

s. 15 (1)(L)

4.6.4 Levels of Control

The Tunnel Ventilation System will incorporate a number of levels of control. Generally the

S.15(1)(L)

4.6.5 Performance Modelling

The Tunnel Ventilation System will be analyzed to ensure the performance of the system under all the foreseen normal, abnormal and emergency scenarios in the unique environment of the Canada Line. The modelling will take into account, but not be limited to, the following:

- The heat release rate produced by the combustible load of a vehicle and any combustible materials that could contribute to the fire load at the incident site
- The fire growth rate
- Smoke removal and determination of critical velocity
- Station and guideway geometries
- Station emergency smoke management ventilation
- The system of fans, shafts, and dampers for directing airflow in stations and guideway
- Smoke exhaust re-entrainment study
- SES modelling of tunnel network
- The program of predetermined emergency response procedures capable of initiating prompt response from the OMC in the event of a fire emergency
- The location of fire and direction of evacuation

4.6.6 Equipment Description

The Tunnel Ventilation System will consist of the following major items:

- Ventilation fans
- Dampers
- Silencers
- Fan rooms
- Tube and vent shafts
- Motor control panels and associated PLCs

-
-
-

S.15(1)(L)

The general arrangement of these items is provided in our associated systems drawings and will be developed in greater detail as the project progresses. Particular arrangements for each station are shown in the station drawings.

Ventilation fans will be placed in pairs and sized at 50% of the air quantity required to prevent back-layering of smoke from a train fire. Each fan will be a vane axial reversible unit providing approximately 110,000 to 130,000 cfm. These fans and associated silencers will be located in a sealed fan room, together with electrically interlocked motorized dampers. An access hatch will be provided to facilitate equipment servicing and removal. This will either be to the surface or to an adjacent tunnel.

Associated motor control and SCADA equipment will be located in an adjacent electrical equipment room.

Each fan will be connected to the associated station critical services power supply. The critical services supply will ensure power is continually available from either of two independent BC Hydro supply points, or where no supply is available, a portable generator.

5.0 VEHICLES

5.1 VEHICLE PROCUREMENT APPROACH

The SNC-Lavalin/Serco team is independent of any vehicle supplier and is therefore able to make an informed choice for the Canada Line vehicle. Our approach to vehicle procurement will be one that considers quality and value for money, in conjunction with unit price, to obtain value over the life of the concession for the vehicles supplied. Our team intends to procure an off the shelf vehicle that will be available from a number of suppliers both now and in the future.

The supplier selection procedure for vehicles outlined in this section will form the basis for the selection procedure used for this project.

This process considers the goals of our team, RAVCO and TransLink over the concession period and not simply the short-term goals of a particular manufacturer.

The right vehicle design will be achieved by:

- Integrating Operation and Maintenance team input to specification development and bid evaluation
- Having the Operation and Maintenance team integral to the management of the project
- Undertaking factory inspection by experienced personnel not allied to the manufacturer
- Completing testing and commissioning with the supplier and Operations and Maintenance team to meet the concession requirements
- Enforce the Warranty in the interests of the Concessionaire

Through this approach we will deliver a vehicle for the Canada Line from a selection of leading manufacturers.

5.1.1 Vehicle Specification

The vehicle specification we are using to obtain final prices is a performance-based specification that provides details of our proposed alignment and station locations. This was developed from the technical specification that was used as the basis for our discussions with suppliers during BAFO.

The specification will allow the following objectives to be achieved:

- Incorporate lessons learned on other similar projects
- Promote competition and reduce price
- Allow suppliers to propose standard equipment

The specification was developed in close co-operation with operations and maintenance staff to meet their requirements.

Specification review meetings were conducted to develop the vehicle performance specification which allowed input from operators, maintainers, the project management team and rolling stock technical specialists.

5.2 DETAILS OF THE PROPOSED VEHICLE

The vehicle we will procure for the Canada Line will be based upon, but not constrained by, the criteria laid out in this document. There are some areas of vehicle design that are non-negotiable, such as compliance with safety legislation and the ability to meet the required operational performance. Other areas are, however, more open for discussion. Maintaining flexibility in these areas will allow us to integrate innovative ideas and designs built on previously proven designs within the commitments of our price.

The layout of the vehicle interior will be determined by three major factors:

- The need for passengers to be evenly distributed throughout the vehicle at peak times.
- The need to maintain dwell times during periods of peak passenger usage.
- Accessibility for all passengers.

SNC-Lavalin/Serco have determined that a vehicle capacity of 167 passengers (334 passengers per two-car train) operating at three-minute headways will allow us to meet demand throughout the operating period. Beyond 2037 the capacity requirements will be met by reducing the 15% margin used to calculate Base Demand thus preventing a need to purchase additional vehicles late in the operating period. These trains would have to be expanded to three-car consists to move 15,000 pphpd when operated at two-minute headways (167 passengers * 3 cars per train * 30 trains per hour =15,030 pphpd). Based on the responses we received from vehicle manufacturers during BAFO, several suppliers can provide a vehicle with this capacity, expandability and with a door arrangement that will fit within our station platforms if and when platforms need to be expanded from 40 metres (finished platform length for the operating period) to 50 metres. SNC-Lavalin/Serco will work closely with vehicle suppliers to obtain their input and ideas for designing an optimal layout that balances passenger flow, capacity, disabled passenger needs and vehicle maintenance requirements.

5.2.1 Accommodation of Wheelchairs and Bicycles

Space for wheelchair passengers will be incorporated in the design of the Canada Line vehicle. It is our intention to obtain input from vehicle design specialist to finalize the design of the wheelchair areas in the vehicles. The wheelchair spaces will have passenger emergency call points.

It is our intention to support the use of the system by bicycle users, outside of peak hours only. In order to achieve this, bicycle space will be incorporated into the vehicle design. Bicycle space on each vehicle will be fitted with tip-up seats.

5.2.2 Accommodation of Airport Passenger Baggage and Effect on Passenger Capacity

The bicycle space in the vehicles can also be used by passengers standing with luggage. The presence of luggage on a train will reduce overall capacity, as the space occupied by luggage will reduce the amount of standing room available. This is not anticipated to be a problem in off-peak periods when passenger volumes are low. The storage space provided will be flexible enough to accommodate both bicycle and luggage storage.

734

5.2.3 Performance Specifications

As part of the development of our initial proposal, we reviewed metro and mass transit systems around the world to develop a set of vehicle performance specifications to address the characteristics of the Canada Line. During BAFO we worked closely with several vehicle manufacturers to determine whether our performance specifications can be met. The responses we received confirm that we can procure a vehicle to meet our performance specifications.

5.2.4 Description of Interior and Exterior

The final design of the Canada Line vehicle will consider the specific needs of the Canada Line environment. Based on our understanding of issues associated with transit in the Greater Vancouver area, we will work closely with vehicle suppliers to develop a design that will meet the needs of passengers in order to maximize system ridership.

5.2.4.1 Design Approach – Exterior

The proposed look of the new vehicle will express values of modernity and efficiency, without being over-stylized or ostentatious. The key ingredient of this approach is careful integration of all the major exterior elements, including the doors, windows, lighting units and roof-mounted equipment.

All parts of the vehicle that can be easily seen by the public require equal attention to design.

5.2.4.2 Design Approach – Interior

Vehicle interior design will incorporate accessibility requirements. Overall, our intention is to create an innovative and contemporary look that is both inviting for passengers and easy to maintain and keep clean. This look will be achieved through careful design and detailing, including the use of appropriate materials, finishes and colours.

5.2.4.3 Seating

The seats will be designed for the transit environment. Tip-up seats will be provided in the designated wheelchair areas and bicycle storage areas.

The proposed car will have 2+2 transverse seating, with the exception of tip-up seats as described above.

5.2.4.4 Passenger Comfort

A good design must measure up to the expectation of service quality it creates. This means providing an efficient and comfortable journey for all passengers. Our design will consider the following measures to maximize passenger comfort:

- Comfortable seating
- Adequate provision of high-visibility handholds throughout the vehicle
- Clear presentation of system and journey information
- High standards of cleanliness
- Aesthetically pleasing interiors

- Environmental/temperature monitoring and control

5.2.4.5 Passenger Egress/Doorways

The vehicle design will provide doorways of sufficient width to ease boarding and alighting, and minimize dwell times, particularly at peak hours. Doorway width and spacing will be optimized to even out passenger flow as people enter the vehicle and move through the vehicle. In addition, where feasible space will be allocated at the side of each doorway for standing and/or other uses, without obstructing the clear opening of the doorway. Again, this will aid in passenger circulation and help minimize station dwell times during peak hour.

5.2.4.6 Cleaning, Maintenance and Vandal Resistance

The material content in the vehicle will be limited to those materials with low emissions characteristics (with regard to fire, smoke and fumes), that provide resistance to wear and deliberate acts of vandalism and are easy to clean, refurbish and repair.

6.0 OPERATIONS AND MAINTENANCE CENTRE

The Operation and Maintenance Centre (OMC) for the Canada Line is located in the Bridgeport area of Richmond.

The OMC site is an at-grade on 6.8 ha of land in the Van Horne Industrial park in Richmond. It is roughly bounded by River Drive to the north, Van Horne Way to the east and south and CP railway to the west. The site also is situated where the CP industrial spurs serve the existing industrial park. This necessitates the relocation of the CP industrial spur to the south towards Van Horne Way. The western half of the OMC is underneath Highway 99 Oak Street Bridge. The eastern portion is directly underneath the south approach to the new Bridge over the Fraser River.

The OMC is roughly bisected by the elevated guideway that passes over the intersection of Van Horne Way and River Drive and parallels the CP spur tracks before connecting into Bridgeport Station.

The southeastern portion of the site contains the staff parking, storage and shops and offices that support the repair facility to which they are connected.

The OMC will house all personnel and equipment necessary for the management, maintenance and operation of the Canada Line and its fleet of vehicles. Initial storage for up to 40 cars (2 two-car trains), with room for future expansion up to 114 cars (38 three-car trains) will be provided.

6.1 ADMINISTRATION BUILDING

The Administration Building will be house all operations personnel, administrative functions and critical equipment, including the main control room located on the top floor.

The Administration Building will also house changing rooms.. Training facilities, accounting and management offices are also located in this building.

6.2 MAINTENANCE SHOP

The maintenance shop, which utilizes a parts inventory control system, has a full range of equipment for heavy and routine maintenance of the vehicles, together with a spare parts storage depot. The shop is designed to maximize natural light and provide a safe environment for maintenance tasks. A service bay for the operator's road vehicles is also attached to the maintenance shop.

6.3 WASH FACILITIES

The wash facility is adjacent to the cleaning two tracks, with the tracks passing through a fully automated wash system. Effluent collection and disposal facilities will be included in the design package.

6.4 STORAGE AND OTHER TRACK DESIGN

The functional layout of the OMC is shown in Drawing 865704-CONF-43DK-1702 in Appendix B-1. It has been developed based on the operational experience of our team and tailored to meet the specific needs of the Canada Line.

The north half of the OMC consists of dead-head train storage tracks (four to the west and four to the east) connecting into a central bypass track. These tracks are all automatically operated. The northwestern end of the bypass track connects into two tracks one of which is an auto bypass loop track that goes to a two-track cleaning and inspection shop as well as a train wash facility in the southern half of the site. These three auto tracks connect into a tail track to the east, which then reconnects to the main bypass track through the train storage compound.

The north and south depot leads connect into both tracks of the main guideway.

The other track is a transition track from auto operations to manual operations. The manual tracks go into the maintenance of way track and the three-track maintenance shops next to and south of the cleaning and inspection area. These shop tracks have pits under the tracks for maintenance crew access.

The primary access to vehicles is by means of the northbound and southbound OMC lead tracks and features two No.1:8 crossovers, two 1:8 turnouts and two No. 1:6 lead turnouts on direct fixation slab track. Other special trackwork in the OMC are No. 6 turnouts on ballast.

In general, all OMC track will be on ballast except for the wash track, which will be direct fixation track on slab. Shop building track will have sections of embedded track, including that along the pits and the pedestal track.

6.5 CONTROL CENTRE

The Control Centre is on the second floor of the Administration Building and houses the automated train control system in fully air conditioned and protected rooms, with all required specific fire suppression equipment.

6.6 ACCESS ROADS AND PARKING

A secure access from River Drive leads to the outside storage area and the traction power sub-station and access from VanHorne Way leads to the maintenance building and the main parking. In addition, two other gates (one from River Drive and one from south) will be provided for overflow parking.

Emergency exits will be provided for all buildings and alongside every second track in the storage area.

6.7 SUBSTATION

The OMC substation is located at the southwest corner of the site. Separate feeders from the OMC rectifier are provided for the stinger system in the maintenance buildings, the manual areas of the

OMC, the storage area and the bypass track. The substation contains a generator to power all the critical systems, including the control room. Track in the OMC is fully grounded.

7.0 ROADWORK, TRANSPORTATION INTERFACE FACILITIES, UTILITIES AND LANDSCAPING

7.1 ROADWORKS

7.1.1 Richmond Section – Number 3 Road

The elevated guideway will be predominately located along the east side of Number 3 Road, from Richmond Centre to Bridgeport Road, and from there passing over the Number 3 Road/Beckwith Road intersection, Charles Street and the future Garden City Road to the Highway 99 underpass (Oak Street Bridge) and the Fraser River. Removal of the exclusive bus lanes in the median north of Ackroyd Road, and the reconstruction of Number 3 Road to provide a four-lane divided arterial adjacent to the proposed Canada Line, is proposed. Local traffic will be accommodated on the reconstructed road, leaving a corridor free on the east side for construction of the elevated guideway. The 3.1 km distance between Park Road and Bridgeport Road has 14 signalized intersections, which will be reconfigured to suit the proposed change in operations. Street furniture will be removed and/or relocated to suit the reconfiguration of roadways.

Locating the alignment on the east side of Number 3 Road provides the following benefits:

- It avoids conflicts between the guideway structure and motor vehicle left-turn manoeuvres.
- Because of the significant variations in the width and lane configuration of Number 3 Road along its length, the centreline location varies from block to block in some areas. The east side alignment allows for smoother centreline geometry because the alignment is not constrained to the highly variable centreline of Number 3 Road.
- It allows station concourse and access to be directly under the platform integrated into a pedestrian-oriented zone along the side of Number 3 Road.
- It segregates transit patrons from traffic on Number 3 Road.
- It avoids the need for elevated pedestrian walkways with multiple vertical circulation elements or, alternately, the need to have all patrons traverse across Number 3 Road at grade to a concourse.
- During construction, with the reconstruction of Number 3 Road undertaken first, as it better segregates construction from general traffic.

The upgrading of River Road or early construction of a new two-lane or four-lane street (with wider curb lanes for cycling) along the CPR alignment, between River Road and Number 3 Road (as outlined in Richmond's City Centre Transportation Plan), would be particularly beneficial if undertaken by the City of Richmond prior to reconstruction of Number 3 Road. Temporary closures and diversion routes will be required for cross-street traffic when construction progresses through each main intersection and over Beckwith Road, Charles Street and River Drive.

For details of the Road and Traffic Management Plan for the Number 3 Road corridor please refer to subsection 8.1.6.3, as well as Drawings 865704-CONF-41DK-1471 to 1473 which can be found in Appendix B-1.

SNC-Lavalin/Serco will not be responsible for those portions of the construction/restoration of roadways and associated facilities where and to the extent that such works will be undertaken by others pursuant to Schedule 6 of the Concession Agreement.

7.1.2 Vancouver Section – Cambie Street and Downtown

Elevated guideway will be constructed from the Fraser River to West 64th to 65th Avenue. From the Fraser River Crossing North Approach, the alignment proceeds north along the west side of Cambie, transitioning to the east side of the street south of Marine Drive Station. From the station, the guideway crosses South West Marine Drive to West 64-65th Avenue, where the guideway will transition from elevated to a stacked tunnel configuration located under the existing northbound lanes of Cambie Street. From here to 2nd Avenue it will be built using cut-and-cover techniques. The alignment will follow Cambie Street around Queen Elizabeth Park, and similar cut-and-cover methods will be used to construct the guideway through this area, except between 37th Avenue and 29th Avenue, where it will be in a side-by-side configuration and be cast-in-place rather than precast segmental. The existing three northbound lanes of Cambie Street, where they are removed for excavation and construction of the cut-and-cover tunnel, will be used for construction access to the Doman Sawmill property and OMC site. While construction is in progress, the existing northbound lanes of Cambie Street will not be available for general traffic. Between West 12th Avenue and Broadway, the cut-and-cover tunnel will transition from stacked to side-by-side format, and proceed in this configuration to 2nd Avenue. It will then transition to a bored tunnel under Commodore Road, where there will be a tunnel portal. Upon completion of the Canada Line guideway, Cambie Street will be restored to its pre-construction condition.

Consideration was given to relocating the northbound trolley wires to the west side of Cambie, but temporary detours will be required during certain construction activities, such as excavations for station cavities, and these detours may cause disruptions to the trolley bus service along this corridor. Conventional buses will therefore replace the current trolley bus service, with the northbound and southbound trolley wires removed for the duration of the construction period.

Much of the downtown section of the guideway will be constructed using the bored tunnel method, and consequently disruption to roads will be minimized. However, excavations will be required at each of the three station locations (Davie Street at Pacific Boulevard, Granville at Robson and Granville between Hastings and Cordova). In addition, the cut-and-cover method will be used for the guideway constructed beneath the Granville Mall, North of Georgia Street. Restoration of the roads affected by the station and guideway construction activities will be performed in accordance with City of Vancouver standards.

Trolley wires along the Granville corridor between Smithe Street and Cordova will also be removed for the duration of the construction period, but crossings at intersections will be maintained to the fullest extent possible.

For details of the Road and Traffic Management Plan for the Cambie Street corridor and downtown, please refer to subsections 8.1.6.4 through 8.1.6.7. Drawings 865704-0000-41DK-1474 to 1476 illustrate the traffic management for the Cambie Corridor, and can be found in Appendix B-1.

SNC-Lavalin/Serco will not be responsible for those portions of the construction/restoration of roadways and associated facilities where and to the extent that such works will be undertaken by others pursuant to Schedule 6 of the Concession Agreement.

7.1.3 Airport Section - Grant McConachie Way

The guideway on Airport lands is entirely elevated, and the majority of the guideway construction will not require any major traffic diversions during construction or permanent modifications to existing roadways. Airport and construction traffic will be maintained on existing roads or an alternative route will be provided, and any roads disturbed during construction will be restored to their original condition.

For details of the Road and Traffic Management Plan for the Airport, please refer to subsection 8.1.6.9.

7.1.4 Roadway Design Criteria

Roadway design is based on the TAC Geometric Design Guide for Canadian Roads with British Columbia Supplement and the City of Vancouver and Richmond Design Guidelines current at the time of design and approvals. All roadwork will conform to City of Vancouver and Richmond Standard Specifications – Road Construction, current edition.

Table 7.1 summarizes the design criteria proposed for permanent roadway elements:

Table 7.1: Roadway Design Criteria

ROAD DESIGN ITEM	GEOMETRIC DESIGN GUIDELINE*				
	Number 3 Road	Cambie Street	Grant McConachie Way	Major Cross Roads	Minor Cross Roads
Road Function	Major Road	Major Road	Major Road	Major Road	Minor Road
Design Classification	UAU/UAD	UAU/UAD	UAD/RAD	UAU/UAD	ULU/UCU
Design Speed Minimum (km/h)	60	60	30-60	60	30-50
Proposed Posted Speed (km/h)	50	50	20-40-60	50	30-50
Horizontal Curve					
Minimum Radius (m)	130	130	20-130	130	20-80
Vertical Curves					
Sag - Minimum (K)	8	8	8	8	2-5
- Desirable (K)	9	9	9	9	2-6
Crest-Minimum (K)	10	10	10	10	2-6
- Desirable (K)	13	13	13	13	2-7
Maximum Grade (%)	3	6	3-6	3-6	6-8
Minimum Grade (%) (curbed)	0.3-0.6	0.6	0.3-0.6	0.3-0.6	0.3-0.6
Absolute Maximum Grade through Intersection (%)	3	6	3-6	3-6	6-8
Maximum Super-elevation (e_{max}) (m/m)	0.04	0.04	0.04	0.04	0.04
Lane Width (m)	3.0-3.5	3.5-3.7	3.5-3.7	3.3-3.7	3.0-3.5
Inside (left) Shoulder Width (m)	N/A	N/A	N/A/1.5	N/A	N/A
Outside Right Shoulder Width (m)	N/A	N/A	N/A/3.0	N/A	N/A
Minimum Median Width (m)	N/A/5.0-6.0	5.0-6.0	5.0-6.0	N/A/5.0-6.0	N/A
Minimum Vertical Clearance (m)	5.2	5.2	5.2	5.2	5.2
Minimum Sidewalk Width					
Away from Curb (m)	1.5	1.5	1.5/N/A	1.5	1.5
Against Curb (m)	2.0	2.0	2.0/N/A	2.0	2.0

742

ROAD DESIGN ITEM	GEOMETRIC DESIGN GUIDELINE*				
	Number 3 Road	Cambie Street	Grant McConachie Way	Major Cross Roads	Minor Cross Roads
Design Vehicle	WB 15	WB 15	WB 15	WB 15	B 12

* *Figures in table for preliminary design purposes only.*
Includes the left turn lane.
* *Structures to also accommodate guideway minimum clearances, where applicable. Minimum clearance for pedestrian bridges is 5.3 m over a roadway.*
Shoulder to accommodate barrier offset where required.

Other standard roadway design elements include the following:

- Outside edge rolled curb with 500 mm gutter
- Median edge standard curb with 500 mm gutter or concrete GM barrier
- Concrete GM barrier as shown on plans (curb omitted where barrier used)
- Earthworks – cut and fill slopes are not to be steeper than 3 horizontal to 1 vertical
- Wheelchair ramps are required at all crosswalk locations
- Concrete island/median fill. All islands less than 10 m both short sides. Other islands and medians where less than 3.5 m wide between curbs
- Fencing shall be 1.8 m high chain link

Pavement structures for new roads are the minimum acceptable based on preliminary investigation. Pavement structures are to be engineered during detailed design. Pavement markings will be based on City of Vancouver/Richmond Standards in accordance with the City Signing Policy Manual and the current edition of the TAC Manual of Uniform Traffic Control Devices.

7.1.4.1 Storm Drainage

It is our understanding that preliminary storm drainage analysis for the RAV Corridor improvements has not been carried out. No allowance has been made in the design to handle runoff from adjacent land, beyond the road and guideway right-of-way. A separate drainage analysis, which includes the adjacent areas, will be required prior to detailed design, should drainage from any of these areas be diverted into the RAV Corridor drainage system.

The design of surface and subsurface drainage for the Richmond, Vancouver and Airport sections will be carried out to the City of Vancouver/Richmond Storm Water Management and Design Manual guidelines. Road and guideway drainage will be conveyed to existing storm sewers along the full length of the alignment. Flow attenuation is to be provided wherever possible. Inlet Control Devices in swale catch basins will be used to regulate flow volumes entering the storm system from swales at the back of curbs.

Provision of temporary drainage, erosion and sediment controls, such as silt fencing around catch basins, will be provided throughout the construction duration. Storm sewer will be protected from excessive loading or freezing through the installation of reinforced slabs or suitable insulation as appropriate.

All minor storm drainage systems consisting of sewers, catch basins, inlets and leads, subsurface drainage, manholes and junctions will be designed using the Rational Method.

All major storm drainage systems will be designed as overland systems to handle runoff from extreme rainfall events that are in excess of the minor drainage system.

It is assumed that the existing storm sewer mains are in structurally and hydraulically good condition. Surface runoff from the guideway right-of-way has been included in the overall storm water management plan and therefore does not require separate storm water management.

7.1.4.2 Intermodal Facilities

RAVCO has determined the type and quantity of intermodal facilities to be provided at Canada Line stations. These include: a 1,200-car Park and Ride facility at Bridgeport Station; Passenger Pick Up and Drop Off (PPUDO) zones at all stations in Vancouver and Richmond; bus loop facilities at Richmond Centre, Bridgeport and Marine Drive Stations; bike lockers and on-street bus stops. As part of the station design exercise, SNC-Lavalin/Serco developed concept designs for the Park and Ride facility at Bridgeport Station and the three bus loop facilities. In addition, provision has been made for the required number of bike lockers at each station. As alignment and station design proceeds, and property and right-of-way requirements are more precisely defined – bus stops and PPUDO zones will also be included. Stakeholder and public consultation will play a key role in the final locations and design of all intermodal facilities. Also, like all public facilities designed for the Canada Line, intermodal facilities will be designed in accordance with applicable CPTED principles. These principles are discussed in Section 3.0 of this volume.

In terms of passenger service and function, the following guidelines have been incorporated into the design of Canada Line intermodal facilities:

- Put passengers first
- Provide an enhanced transit station functional design
- Provide efficient bus and vehicle flow, reducing long-term operating costs
- Respect and enhance surrounding neighbourhoods
- Clearly mark vehicle access
- Minimize pedestrian-vehicle conflict
- Reduce conflicts through architecturally celebrated pedestrian entrances
- Provide visual accessibility to parking and concourses

Pedestrian circulation from the last car in the Park and Ride, or bus in the bus loop, to the station entrance, and from that point to the station platform, has to be seamless, clearly defined and easy to follow. A common approach to organizing pedestrian and vehicular circulation in these types of facilities is the use of pedestrian boulevards. Pedestrian boulevards can be used to connect PPUDO zones and bus loops with station entrances. These facilities are typically landscaped, feature good illumination, and can be equipped with emergency call boxes or public phones for security. In addition, they can be easily monitored with CCTV. Aesthetically, the boulevard may be lined with deciduous trees, with tops in view of surrounding neighbourhoods, mitigating the visual impacts of the intermodal facilities, while providing colour changes through the seasons. Where appropriate, pedestrian boulevards and other innovative designs will be implemented to enhance the pedestrian-transit system interface, while minimizing potential pedestrian-vehicular conflicts.

During functional and final design of the park and ride facility, the following geometric design standards will be followed:

- >35 m² per vehicle
- Coefficient of indirectness of <1.4
- One access per 300 vehicles separated from bus access

A highlight of any intermodal facility design is a central location that is easily accessible and with minimal impacts on adjacent neighbourhoods. As a result, loops, PPUDO zones and Park and Ride facilities at stations may have to share access points. A single bus, pedestrian and bicycle access is generally preferred but would not be intended for use by passenger vehicles.

Direct, efficient bus flow is paramount in attracting and maintaining ridership, and has a potential impact on operating costs. Entrances and exits to bus loops have been designed to optimize access from the street and to minimize bus-pedestrian conflicts. The conceptual bus loop designs have sufficient capacity for temporary bus storage during driver breaks and shift changes.

Responsibility for the design and construction of the intermodal facilities (Transportation Interface Facilities) is as defined in Schedule 3 of the Concession Agreement.

7.1.4.3 Lighting and Signals

Street lighting will be designed in accordance with: Illuminating Engineering Society Manual – Roadway Lighting RP8, TAC Guideline for the Design of Roadway Lighting and the City of Vancouver/Richmond Street Lighting Standards and Specifications. The detailed street lighting design will include the detailing of streetlight type, offsets from roadway, locations and spacing of street lights, location of streetlight wire, duct crossings, poles, control cabinets and cross sections to determine the height of pole bases. Where existing lighting has been removed, temporary street lighting will be provided during construction on all portions of road that are open for traffic, where the permanent lighting has not been installed or is not yet operational. Where appropriate, street lighting required for roadways underneath bridges will be fastened to the bridge structures.

Permanent and temporary traffic signals and signs will be to City of Vancouver/Richmond Standards in accordance with the City's Signing Policy Manual and the current edition of the TAC Manual of Uniform Traffic Control Devices. Overhead sign structures are to be designed by the City, based on the City of Vancouver/Richmond Standards and Specifications.

SNC-Lavalin Serco will not be responsible for lighting and signals where and to the extent that such works will be undertaken by others pursuant to Schedule 6 of the Concession Agreement.

7.1.4.4 Detour/Temporary Roadway Design Criteria

Table 7.2 summarizes the design proposed for detours or temporary roadways that may be required during construction of the Canada Line:

Table 7.2: Detour/Temporary Roadway Design Criteria

DETOUR ROAD DESIGN ITEM	GEOMETRIC DESIGN GUIDELINE *		
Location	Number 3 Road	Cambie Street	Grant McConachie Way
Design Speed (km/h)	30-40	30-40	30-40
Proposed Posted Speed (km/h)	30-40	30-40	30-40
Design Vehicle	WB 15	WB 15	WB 15
Maximum Grade (%)	6	6	6
Minimum Grade (%)	0-0.5	0-0.5	0-0.5
Maximum Super-elevation (e_{max}) (m/m)	0.06	0.06	0.06
Vertical Clearance (m)	4.5	4.5	4.5
Lane Width (m)	3.0	3.0	3.0
Shoulder (Open) (m)	R-1.5 L-0.5	R-1.5 L-0.5	R-1.5 L-0.5
Shoulder (Closed by Barrier) (m)	R-2.1 L-1.1	R-2.1 L-1.1	R-2.1 L-1.1
Side Slopes – Maximum (No Barrier)	3:1	3:1	3:1
Pedestrian Access			

** Figures in table for preliminary design purposes only.*
Pedestrian and cycling access to be maintained in the general area where they currently exist.

7.2 URBAN DESIGN AND LANDSCAPE

Urban design and landscaping are key considerations to successfully integrating a transit system into a community. Where tunnelling is used, the long-term impacts on communities are relatively contained around stations and other fixed facilities. The visual presence of elevated guideways creates a lasting legacy, and their interface with buildings, roads and the public realm generally leads to a reshaping of the street's urban character.

As discussed in Sections 1.0 and 2.0 of this volume, SNC-Lavalin/Serco's proposed design places the alignment on one side of Cambie Street and Number 3 Road, rather than in the centre. From an urban and landscape design perspective, this approach offers significant benefits over the reference alignment. These benefits in relation to the alignment are discussed below, whereas the broader urban design issues around stations are described in Section 3.0.

A certified arborist has already been retained as part of the project team and has prepared a Level 1 tree appraisal for the entire alignment. Policy on protecting trees during construction, and determining which trees are suitable for transplantation, will be developed in detail at the next phase.

The following sections provide a commentary on the urban design considerations along the various segments of the alignment. SNC-Lavalin/Serco will not be responsible for landscape features where and to the extent that such works will be undertaken by others pursuant to Schedule 6 of the Concession Agreement.

7.2.1 Downtown

Along the bored tunnel segments of the downtown alignment, the surface impacts will be minimal, whereas at the stations and for the tunnel segment north of Georgia Street, where open cut-and-cover construction will be predominant, large areas of the street will be excavated. In the latter case it will be necessary to restore the street to its former condition, or to an equivalent state.

Two street improvement projects, currently in the planning stages with the City of Vancouver, offer opportunity to synchronize their efforts with that of the project. The two prime benefits are minimal disruption to the public and local stakeholders, and reduced construction expenditure.

The most significant of these projects is the upgrade of Granville Mall. Since the SNC-Lavalin/Serco team proposal involves open cut for large sections between Robson and Cordova Streets, as described above, the opportunity will be to return the street to the form of the proposed new street design. Without knowing at this stage what the final design might be, it is assumed that SNC-Lavalin/Serco's financial exposure would be no greater than returning the street to its former condition. Removal of the pin oaks along Granville Street was already anticipated for the Granville Mall upgrades and so earlier removal of these trees for the purpose of the RAV Project is assumed to be acceptable.

At Davie Station, plans to reconfigure Pacific Boulevard have been assumed to enable the southern tunnel ventilation exhaust shafts to be located in the centre median of the street. This will avoid locating the grille in front of the Engine 374 exhibit, attached to the Roundhouse Community Centre.

Replacement of displaced street trees around the Robson and Davie stations is assumed. Where their condition permits efforts will made to save the trees and replant them after construction.

7.2.2 Cambie Street and Heritage Boulevard

SNC-Lavalin/Serco's proposed tunnel through Vancouver addresses one of the most controversial sections of the Canada Line alignment. Residents throughout Vancouver expressed strong feelings about protecting the Cambie Heritage Boulevard. By constructing a stacked tunnel under the northbound travel lanes of Cambie Street, SNC-Lavalin/Serco can virtually eliminate the need to remove trees and vegetation during Canada Line construction and operations. This will allow the majority of the Heritage Boulevard to remain as it is today, as illustrated in Drawings 865704-1000-41DK-1307 to 1311 included in Appendix B-1.

There are four places along Cambie Street where some landscape impacts to the boulevard will occur. These are: the tunnel portal at 63rd Avenue, and stations at 49th Avenue, Oakridge and King Edward.

At the portal, new landscaped areas in the vicinity of the portal structure will be created to replace all lost green space. The portal itself will extend along the existing boulevard until the alignment transitions to below Cambie, at which location the alignment will turn east under the existing travelled lanes. To replace lost green area the northbound lanes of Cambie Street will be reconfigured to provide a landscaped area on both the east and west sides of the portal. This area will be of sufficient size to facilitate a one-for-one replacement of vegetation. Details and final design of this area in general and the portal in particular will be part of the public consultation and community outreach process.

At station sites we have adopted a strategy of locating the main station structures in the centre of the road intersection, which helps to reduce impact on the median. Tunnel ventilation fan rooms and surface grilles, which have flexibility to be moved along the running tunnel, have been carefully located to preserve significant trees. Grassed areas disrupted during excavation and construction of the tunnel ventilation fan rooms will be reinstated afterwards.

7.2.3 Richmond and Number 3 Road

Richmond is a "Garden City," dedicated to the "greening" of its neighbourhoods and city centre. Introduction of an elevated guideway through the Bridgeport area and along the east side of Number 3 road will have major urban design impact, with significant changes to street configuration, traffic patterns, the pedestrian realm and landscape.

In the Bridgeport area the focus will be on the Bridgeport station hub. The large parking garage and bus loop will lead to large expanses of hard landscaping, which need to be softened and punctuated with a carefully devised landscaping scheme. The landscape concept will be developed in conjunction with the station design.

The east side alignment for the elevated guideway assumes reclamation of the 98 B-Line right-of-way as far south as Ackroyd. For this segment the elevated guideway will be located within the overall street right-of-way and will provide excellent urban design and landscape opportunities along its length.

South of Ackroyd soft landscaping opportunities will reduce as the street right of way narrows. The more continuous softer landscape character to the north is replaced by a harder urban environment articulated by street trees along the sidewalk.

7.2.4 Vancouver Airport

The wide grassed spaces between buildings make routing of the guideway alignment visually less intrusive at the airport than in Richmond and Vancouver. The proposed alignment has been selected to reduce conflicts with trees, and to route the alignment away from the main international and domestic terminals.

Tree removal or transplantation is currently contemplated at YVR 4 station (three trees), YVR 3 station (six to eight trees), and for the segment bordering the northern edge of the surface car park just east of YVR 4 station (10 to 12 trees). It is assumed where size is not cost prohibitive, that most trees affected by guideway columns and foundations will be transplanted to new locations agreed to with YVR staff.

Grass areas will require reseeding and reinstatement where construction activities will have an impact. But in general the overall landscaping impacts are assumed to be insignificant. At an urban design level, crossing of the elevated guideway over Grant McConanchie Way at the approach to Sea Island has special significance as an entry. This segment has been composed as part of the crossing over the Middle Arm of the Fraser River.

7.3 UTILITY CONFLICTS

A detailed review of existing utility information within the project limits was carried out. The RAVCO composite utility base plans, which identify the deep utilities, water, sanitary sewer, combined sewer, storm sewer and gas information, were relied upon but not field-verified. The accuracy of the utility base plans will be verified prior to detailed design. The GVRD profile drawings were also relied upon (where available) and the information was crosschecked to ensure information on potential utility conflicts was as complete and accurate as possible at this time. Information on overhead power, streetlights and related power cabling, and trolley lines was obtained from RAVCO and added to the utility base plans. The companies with shallow utilities, including Telus, Shaw Cable and Terasen Gas, will need to be contacted to confirm the extent of their facilities.

It is anticipated that the project work will necessitate the protection of existing utilities together with, in many instances, their temporary and permanent relocation. With respect to BC Hydro, Telus, Shaw Cable and Terasen facilities, temporary and permanent relocations will be designed and undertaken by the respective utilities. If relocation of municipal or private utilities is required, the relocation will be designed to ambient standards of the existing utility. Sound engineering practice and appropriate duty of care shall be exercised.

Deep utilities crossing the Cambie Street cut-and-cover guideway section will require permanent relocation to avoid the structural elements. For this same section of guideway, certain gravity sewer/storm/combined sewer conflicts may require replacement with inverted siphons or depressed sewers to carry flow under the buried guideway. A conceptual design for large diameter sewer and storm drain siphon has been used for the determination of the estimated construction cost. The typical design, construction and maintenance requirements, which are to be considered, have been summarized below:

- Large diameter siphons will be required to replace gravity pipes that must be relocated for construction of the buried guideway. Hydraulic head losses generated by the siphon will be higher than the headloss in the existing gravity pipe system. To minimize the head loss that would reduce conveyance capacity, it is recommended that the siphon include the use of long radius bends, gradual transition between different conduit cross sections and rounding of all corners at inlets.
- Flow in the existing gravity lines is high and cannot be stopped. This must be considered in the design of connections between the existing and new pipes. It is proposed that junction chambers will be constructed first around the existing pipe. Then, during low flow and with short duration by- pass pumping, the old pipe within the chamber will be cut, removed and a curved slide gate plate will be dropped into an already installed frame. The void behind the gate plate will ultimately be filled with concrete.
- The footprint of the relocated utility will be designed to minimize conflict with other utilities and structures.
- Any required siphon installation will be completed in advance of the buried guideway construction. Structurally, the relocated utility will be designed to allow for any adjacent excavation. Any obstruction that would slow down the guideway excavation will be avoided with sufficient clearance maintained for excavation equipment and shoring.
- The Municipality or the GVRD will be responsible for the maintenance of the siphons. To reduce future maintenance costs several of the following provisions may be incorporated into the design:
  - Stairs will be provided for access to the junction and inspection chambers
  - Effective ventilation system will be installed

- The siphon will consist of at least two independent pipes, each with a provision for closing, inspection and cleaning
- Upstream sluice gates will be automated. During low flows only one siphon will be open to maintain flushing velocity in the pipe. Both gates will automatically open when flow exceeds the capacity of one pipe
- Sediment and inspection will be facilitated with assemblies for lowering submersible pumps and video cameras
- Rock sumps will be installed in the upstream junction chamber to facilitate removal of sediment before it can enter the siphon
- In front of each sluice gate there will be provision for installation of a slide plate and a sump pump so that a double blocking and drain system could be installed should maintenance of the siphon be required

The final determination of the need for siphons can only be finalized once the guideway elevation has been set.

The use of siphons has been proposed to resolve four sewer conflicts along Cambie Street. We have not yet approached the GVRD with this proposal but are confident that this, or a similar proposal, will be acceptable.

We confirm that the cost being carried in our price will be sufficient to cover the relocation work in a manner that is acceptable to the GVRD.

For the elevated sections of guideway, the utility crossing relocations will only be required for avoidance of foundations. All pressurized lines under or over the guideway will be required to be encased. The exception to this will be waterlines 250 mm or smaller.

All parallel utilities in conflict will require relocation to outside the guideway foundation limits, to a location where any potential future maintenance requirements will not impact on the guideway operation. New utilities installations will generally be completed prior to decommission of the conflicting utility. Tables 7.3 to 7.6 on the following pages have been prepared to identify and summarize anticipated conflicts with underground utilities along the alignment during construction of fixed facilities. It should be recognized that the identified conflicts are based on currently available information, and during the detailed design stage other conflicts may be identified as new information becomes known, or conflicts that have been identified may be eliminated as a result of optimization.

S.17(1)(e)

Table 7.3: Underground Utility Conflicts: City of Richmond (CoR)

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(e)

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(e)

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(e)

Table 7.4: Underground Utility Conflicts: City of Vancouver (CoV) Cambie Corridor

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(e)

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(e)

s.17(1)(e)

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

758

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

S.17(1)(e)

Table 7.5: Underground Utility Conflicts: City of Vancouver (CoV) Downtown

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

S.17(1)(e)

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(c)

761

Approx. Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

S.17(1)(e)

Table 7.6: Underground Utility Conflicts: Airport (YVR)

Approx Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(c)

763

Approx Chainage	Location	Parallel	Crossing	Conflict Description	Public	Regulated	Proposed Resolution

s.17(1)(e)

7.3.1 Utility Design Criteria

All storm and sanitary sewer work will be designed and constructed in accordance with the GVRD/City of Vancouver/Richmond Standard Specifications for Sewer Construction, current edition.

All waterworks will be designed and constructed in accordance with the GVRD/City of Vancouver/Richmond Standard Specifications for Waterworks Construction, current edition.

All Municipal utility work shall be in accordance with the GVRD/City of Vancouver/Richmond Design Guidelines and Design Guidelines for Development Permits, Mechanical Site Plans and Solid Waste Services Plans

Existing pipe classes will be reviewed and the need for concrete encasement of utility crossings evaluated and provided for, as required.

Waterlines requiring encasing or replacement will be replaced with PVC pipe. Both existing and new waterlines larger than 250 mm will be installed in an encasing pipe with pipe spacer/restrainers at all pipe joints.

7.3.2 Utility Management Plan, Relocation Plan and Schedule

Before commencing construction, SNC-Lavalin/Serco will pre-locate all underground utilities and structures that may be interfered with by construction, and consult with all public utilities and all regulated and other utilities to pre-locate any underground utilities of which they have records.

A Utility Management Plan will be developed and implemented for the project. This plan will address all the issues inherent in utility management during construction. The plan will document the following for each utility within or adjacent to the work site:

- Utility owner
- Type, size, location and elevation of the utility
- Reported material, existing usage and condition
- Acceptable ground movement
- Projected movement based on ground movement analysis
- Protection plan, including timing, duration and structural details of any proposed temporary or permanent relocation or temporary support system
- Safety program
- Emergency response plan
- Agreement of all affected agencies and authorities to the plan, including public utilities and regulated and other utilities

Utility Relocation Plans and Schedules will be prepared for all those portions of the project involving work on or near travelled roadways and the guideway. The plans will be issued to the responsible municipalities, GVRD, YVR and utility companies for approval well in advance, to reduce negative impacts on the construction schedule. Acceptable Relocation Plans will be agreed upon with the municipalities, GVRD, YVR and utility companies at least 20 working days before the start of any major portion of the work, and will include the following:

- Description of the locations of the work zone, work activities, traffic control measures, and times and dates work will need to be undertaken on the utility
- Utility layouts showing placement, material specifications and arrangement of maintenance access
- Vehicular and pedestrian traffic management as outlined in Section 8.0 of this volume
- Staging strategies and timing of work required to maintain an efficient guideway construction schedule

It is understood that the utility owner will undertake the relocation of regulated utilities and that sufficient notice will be provided as to when the utilities need to be moved. All areas disturbed for the utility relocation work will be restored to their present condition. The timing of the ultimate restoration may be staged to account for advanced utility relocation work.

7.3.3 Specific Utilities Issues

A comprehensive tabulation of the known underground utility conflicts has been provided in subsection 7.3. A number of significant utility conflict issues have been identified, some of which are more fully described below:

Richmond

-

s.17(1)(e)

YVR (Airport)

-

s.17(1)(e)

-

Vancouver - Cambie Corridor

-

s.17(1)(e)

S.17(1)(e)

8th Avenue Interceptor

s.17(1)(e)

Vancouver – Downtown

s.17(1)(e)

8.0 CONSTRUCTION METHOD STATEMENT – GUIDEWAY

The Base Case alignment proposed for the Canada Line by SNC-Lavalin/Serco is based on the Fully Grade Separated Option, in accordance with the RFP, and complies with the reference alignment as described in the RFP Appendix 1. Our proposal uses elevated, cut-and-cover and tunnelled guideway construction methods, each of which is discussed in this section.

SNC-Lavalin/Serco has developed the pricing, design, construction methodology and schedule for our proposed construction methods based on our current understanding and knowledge of the site and economic conditions. We will continue to develop and optimize our design, and improve the methodologies within our commitments to scope, schedule and price, to enable us to adapt it to any changing conditions as they become known.

The current extents of each guideway type, and the configuration of the overall guideway, are presented in Sections 1.0 and 2.0 of this volume. Final types and construction methodologies will be confirmed during detailed design.

8.1 DETAILED METHOD STATEMENTS

8.1.1 Elevated Guideway

8.1.1.1 Characteristics

Characteristics of the typical span arrangements proposed for the elevated guideway are described below.

Simply Supported Dual Guideway, 8.2 Metres Wide, Typical 36-Metre-Long Span

Span length:	36 metres between column centres
Segment depth:	2.1 metres (parapet walls not included)
Segment length:	3 metres for typical segments;
	2.975 metres for end segments
Minimum radius of curvature:	170 metres (for radii of less than 170 metres the span length will be reduced for stability)
Whole span dead load:	335 tonnes
Longitudinal stressing:	combination of internal and external tendons
Joint type:	epoxy joints between precast segments (Type A joints according to AASHTO definition)

Note: The spans have been designed following the AASHTO requirement to have at least 50% of internal tendons in seismic areas. However, recent research carried out by Caltrans (Seismic Performance of Precast Segmental Bridge Superstructures – May 2002) indicated that the use of a combination of external and internal tendons should be avoided in seismic areas. Therefore, the pre-stress arrangement of the simply supported spans will be investigated

770

further at final design stage. The typical span length can vary by multiples of the segment length.

SNC-Lavalin/Serco intends to follow accepted design practices in place at the time of BAFO submission.

Simply Supported Single Guideway, 4.0 Metres Wide, Typical 36-Metre-Long Span

Span length:	36 metres between column centres
Segment depth:	2.1 metres (parapet walls not included)
Segment length:	3 metres for typical segments;
	2.95 metres for end segments
Minimum radius of curvature:	170 metres (for radii of less than 170 metres the span length will be reduced for stability)
Whole span dead load:	260 tonnes
Longitudinal stressing:	combination of internal and external tendons
Joint type:	epoxy joints between precast segments (Type A joints according to AASHTO definition)

Note: The spans have been designed following AASHTO requirement to have at least 50% of internal tendons in seismic areas. However recent research carried out by Caltrans (Seismic Performance of Precast Segmental Bridge Superstructures – May 2002) indicated that the use of a combination of external and internal tendons should be avoided in seismic areas. Therefore the pre-stress arrangement of the simply supported spans will be investigated further at final design stage. The typical span length can vary by multiples of the segment length. The maximum span can be increased to 45 metres by utilizing three-span continuous structures. The typical span length can vary by multiples of the segment length.

SNC-Lavalin/Serco intends to follow accepted design practices in place at the time of BAFO submission.

Long-Span Balanced Cantilever Structures – Three-Span Variable Depth Continuous Structures

Central span length:	up to 60 metres
End span length:	up to 52 metres
Segment depth:	2.1 metres to 3.0 metres (parapet walls not included)
Segment length:	2.75 metres to 3.0 metres according to span arrangement
Minimum radius of curvature:	100 metres
Segment erection method:	balanced cantilever
Longitudinal stressing:	internal tendons
Joint type:	epoxy joints between precast segments (Type A joints according to AASHTO definition)

Fraser River Middle Arm Crossing – Five-Span Continuous Structure

Central span length:	96 metres
End span length:	52 metres
Segment depth:	2.60 metres to 3.0 metres variable depth (parapet walls not included)
Segment length:	2.75 metres to 3.0 metres according to span arrangement
Minimum radius of curvature:	no curvature
Segment erection method:	balanced cantilever
Longitudinal stressing:	internal tendons
Joints:	epoxy joints between precast segments (Type A joints according to AASHTO definition)

Fraser River North Arm Crossing – Five-Span Continuous Structure

Span Arrangement:	52; 139; 180; 139; 52 metres [subject to minor revision during detailed design]
Segment depth:	3.0 metres to 4.5 metres variable depth (parapet walls not included)
Segment length:	3.0 metres according to span arrangement
Minimum radius of curvature:	352 metres
Segment erection method:	balanced cantilever combined with use of extradose cables
Longitudinal stressing:	internal tendons
Stays	individually protected 15.7mm diameter monostrands bundled in a parallel configuration into stays.
Joints:	epoxy joints between precast segments (Type A joints according to AASHTO definition)

8.1.1.2 Elevated Guideway Construction Methods

Elevated guideway will typically be constructed in three linear phases: foundation construction, substructure construction and superstructure construction.

Foundations for the guideway south of the Fraser River will consist of pile groups with pile caps set below grade. Ground conditioning using stone columns will be required for certain pile groups, as determined from analysis. North of the Fraser River, foundations for the elevated guideway will consist of large-diameter caissons. Typically each foundation is constructed by first undertaking any ground conditioning using conventional stone column construction methods, followed by excavation, piling and forming, reinforcing, casting, stripping and backfilling of the pile cap.

Substructures are typically cast-in-place concrete single cantilever columns with portal frames or bents as needed for guideway bifurcations and for avoidance of utilities or other obstructions. The substructure elements will be constructed concurrently with the production of the precast concrete segments, and in numerous locations to accommodate the construction schedule and project completion. The installation of the segments will also proceed in multiple locations in coordination with segment production and column construction activities.

The guideway superstructure will be constructed using match-cast, three-metre-long precast reinforced concrete segments. Typically these segments will be erected and post-tensioned into simply supported 36-metre beams supported on bearings located on cast-in-place columns. Span lengths can easily be adjusted to accommodate site requirements for utility conflicts, street crossings, stations and any other physical constraints. Where site conditions dictate the need for longer spans, special structures utilizing balanced cantilever-type structures or constant-depth, three-span continuous-type structures are proposed. Typical span erection diagrams are presented in Drawings 865704-CONF-42DK-4001 through 4033 and typical precast yard and formwork schematics are shown in Drawings 865704-CONF-42DK-4034 through 4062 in Appendix B-1.

The simply supported superstructure spans are designed in accordance with AASHTO specifications for seismic design: at least 50% of the longitudinal tendons will be bonded to concrete. To minimize the self-weight of the structure, the structure is designed such that two of the six tendons are external. All tendons are anchored in diaphragms located at the ends of each span. The external tendons deviate at three locations along the span. This system considerably simplifies the precasting operations if compared to 100% internal tendons. However, recent research carried out by Caltrans (Seismic Performance of Precast Segmental Bridge Superstructures – May 2002) suggests that the use of a combination of external and internal tendons should be avoided in seismic areas. Therefore, the possibility of using full external pre-stressing for the simply supported spans will be investigated further at the final design stage. External tendons are encased in continuous polyethylene pipes extending through deviators. After erection, the tendons will be grouted and post-tensioning anchorages protected.

Advantages of the segmental construction system:

- Precast concrete segments are widely used and are routinely produced to close dimensional tolerances and to high quality standards
- Flexibility in altering the span lengths
- Flexibility in resolving utility conflicts and other physical constraints
- An efficient method of construction with minimal interruption to traffic and the community
- Simplifies delivery of the precast concrete segments in that normal truck and lowboy trailer units can readily transport them
- Spans can be readily configured to accommodate wide street crossings
- Reduces the work on site and eases congestion
- Easily configured to meet the horizontal, vertical and super elevation track requirements within tight tolerances
- Smooth systems interface for track systems and subsystems (problems such as accurate location of the direct fixation track fastener anchors and excessive voids under the direct fixation track fasteners have been considered and resolved)

8.1.1.3 Fraser River Crossing Segment – Middle Arm Bridge

The Fraser River Crossing (Sta. 203+507 to Sta. 203+899) over the Middle Arm of the Fraser River will be constructed using a segmental balanced cantilever method. The span lengths and pier locations have been selected to accommodate the clearance requirements for the navigational channel in the Fraser River and at the same time recognize the clearance requirements over Grant McConachie Way and a future roadway. This structure will form a gateway entrance to the Airport. The substructure will be constructed using a combination of driven steel or concrete piles, a pile cap and a cast-in-place column at each pier location.

The piers will be cast-in-place reinforced concrete and will be constructed in several vertical lifts depending on their individual heights. Barge-mounted equipment will be utilized in the installation of the driven steel or concrete piles, pile cap forms, pile caps and construction of the cast-in-place piers and superstructure. Installation of the driven steel or concrete pipe piles is proposed to follow the installation of the pile cap form, which will consist of prefabricated steel or precast concrete. The pile cap form will be supported and positioned by temporary piles or "spuds" and once in position, will also serve as a template for the installation of the driven piles. Following the installation of the piles and the verification of the design capacities, the form will be sealed and cleaned, the pile cap reinforcing steel placed, and the form filled with concrete. The pile cap form will remain in place, becoming a permanent part of the completed substructure. Pier protection systems will be installed after access for guideway erection equipment is no longer required. Construction of abutment piers at each end of the crossing will require ground conditioning before the installation of the steel piles and construction of the pile caps. Bank stabilization will be undertaken to comply with design and regulatory requirements.

In areas where ground conditioning is required, the installation of stone columns will precede the installation of the driven piles. The piles will be installed from the existing grade level to minimize the disturbance of subgrade. Following the installation of the specified number of piles at each location and the verification of the design capacities, excavation for the concrete pile caps will be completed. Appropriate pumping and/or dewatering techniques will be utilized to control groundwater conditions. Standard procedures will be employed in the forming, reinforcing and concreting of the pile caps. Work on the columns and bents, and the finishing of exposed concrete, will follow in logical sequence.

The superstructure will be erected with a winch and beam, which travels from end to end of the erected span to erect balanced segment pairs. The procedure is shown in Drawings 865704-CONF-42DK-4051 through 4060 in Appendix B-1 and begins with the winch and beam in the lift position near the pier with the cantilever in balance. Erection of one segment is as follows:

- The segment is brought to the pier location by barge and connected to the winch and beam.
- The segment is lifted clear of the transport barge that is moored to the pier. The trolley is traversed as necessary to centre the load below the trolley before travelling forward.
- The segment is levelled by adjustment of the winches.
- The segment is hoisted and travelled to its erection position.
- Epoxy is then applied to the joints and the segments almost brought into contact with the end of the cantilever. Fine trim for line and grade is then done.
- The temporary post-tensioned bars are snugged up, to assist the mating of the keys and adjustment of the segments with the winches, to bring the tapers to within allowable tolerances.
- The temporary post-tensioned bars are stressed. The lifting beam is then released and the permanent post-tensioning is installed and stressed.

- The winch and beam are then launched to a new position after the completion of stressing of the permanent post-tensioning.

When a new position is reached the process is repeated, moving from pier to pier and completing with closure pours.

Segment erection by winch and beam is not performed in winds exceeding 50 km/h and launching of the winch and beam are not performed in winds exceeding 40 km/h.

Fabrication and delivery of the segments follows a similar sequence to the segmental guideway method as described below.

8.1.1.4 Fraser River Crossing Segment – North Arm Bridge

The Fraser River North Arm Crossing (Sta. 104+440 to Sta. 105+002) over the North Arm of the Fraser River will be constructed using an extradosed segmental balanced cantilever method. The navigation window required for the main channel of the North Arm of the Fraser River has been increased to 150 metres in width. The span length of 180 metres required to clear the window governs the bridge solutions considered. To be consistent with the construction means and methods used for typical elevated guideway structures and preserve the resulting economies, the North Arm crossing will be constructed using an extradosed precast segmental concrete cable stay box girder configuration and are shown in Drawings 865704-CONF-42DK-1642 and 1643.

This North Arm crossing will be constructed separately from the typical land-based guideway construction. It will be constructed substantially in accordance with the balanced cantilever method. This method will be supplemented by the installation of stay cable pylons and stay cables as the balanced cantilever construction approaches the location of the stay cables. Balanced cantilever construction will proceed out from each of the two inner approach piers and the two main pylons. The construction of the approach piers and much of the deck would use land-based cranes. The construction of the main pylons and the extradosed deck would be completed using marine equipment. Close coordination with Coast Guard and Fisheries will be maintained to ensure marine operations satisfy environmental, fish habitat, and navigation constraints.

The foundation for the north pylon could be completed in the dry on the fill placed for ship protection. In this case, piles would be driven through the fill and the pilecap constructed at grade. The foundation for the south pylon could be constructed in the dry using a driven sheet pile cofferdam or a precast float-in cofferdam as a template for pile driving and to contain the pile cap concrete and reinforcing, as described in subsection 8.1.1.3.

Upon completion of the approach piers and the pylon twin walls, the pier segments for each cantilever will be placed. These could be cast-in-place or precast. Once the pier segment connections are made, segments will be alternately lifted, to each end, in a balanced cantilever arrangement, to build out the span. Temporary bar post-tensioning rods will hold the segments into place, and once two segments are erected, the permanent post-tensioning, stay cable pylon and cable stays will be installed to make the span cantilever structurally stable. This process will be repeated until the entire superstructure section is completed at each pier. A cast-in-place closure pour would be done to complete each span. At that time, external continuity post-tensioning will be installed. Track, utilities, access facilities and navigational markings will then be added.

8.1.1.5 Fabrication and Construction Plan

The proposed precast concrete segment manufacturing facility would be located on Kent Avenue at the south end of Fraser Street on the site provided by RAVCO. This site is strategically located and provides convenient access to the Richmond, Airport and Vancouver segments of the alignment without excessive impact on the traffic flow in the area. In addition, it is anticipated that the water access will be utilized for the delivery of sand and aggregates to the facility and for the delivery of segments by barge to the North Arm Fraser River Crossing and to the Middle Arm Fraser River Crossing.

The establishment of the precast yard will be a critical activity in the early stages of construction. Production of the segments will commence well before construction of the yard is completed. At full capacity, a steady rate of production will provide an adequate number of segments for the project to be completed on schedule. Provision has been made in the design of the precast yard for sufficient segment storage space to allow for some interruption of the field installation activities without impacting the segment production process. The possibility of expanding segment storage capacity has been investigated to ensure that the precast yard continues to function smoothly and efficiently.

A drawing of the site developed with the precast yard facility is provided in Drawing 865704-CONF-42DK-4062 in Appendix B-1.

The basic elements of the precast facility are:

- 1 production building having a total area of 6084 m^2
- 6 overhead bridge cranes (in the production building)
- 4 gantry cranes in the segment storage area
- 1 segment pier mould for double guideway
- 5 typical segment moulds for double guideway
- 4 typical segment moulds for single guideway
- 1 segment pier mould for single guideway
- 1 cantilever pier segment mould
- 2 cantilever variable depth casting moulds
- 1 concrete batching plant
- Site offices
- Workshop and stores buildings
- Segment storage area
- Employee parking area

B.1.1.4.1 Operations Methodology for the Precast Yard

The precasting method that will be utilized to fabricate the guideway segments is generally referred to as the "short line match cast" method. The typical precast mould produces segments three (3) metres long. Each segment comprises a complete cross section, with a bottom soffit, web walls, deck and parapet walls. The mould consists of two basic sections, the outer form and the inner core as well as a specially designed jig for the accurate location of the direct fixation track fastener anchor inserts in the deck of the segment. The casting moulds always retain the same orientation. To produce the required geometry for the superstructure, the previously cast segment is accurately positioned into the required geometry relative to the new section that will be cast in the mould. The segment to be produced is cast directly against the properly positioned segment, ensuring a precise fit between the two segments.

The basic fabrication activities are as follows:

- Both the outer form and the inner core are cleaned and lightly coated with form release.
- The reinforcing steel for the segment is fabricated in a jig. The fabrication of the rebar cage occurs in advance of the segment forming/casting.
- The rebar cage is delivered to the mould using the overhead bridge crane and is installed in the exterior form.
- Post-tensioning ducts and anchors are installed and secured as well as the rebar spacers.
- The inner core is moved into position and properly secured.
- The jig with the track fastener anchors is placed in position and secured.
- The jig adjustments for the location of the track fastener anchors are fine tuned to the design location and secured.
- A detailed survey check is conducted, verifying the relative geometry of the match-cast segments.
- The mould is filled with concrete and vibrated to achieve the proper consolidation.
- After a prescribed curing period the compressive strength of the concrete is tested to confirm that the specified strength has been achieved.
- At this point the inner core is extracted from the newly cast segment and the exterior form is retracted clear of the segment. The jig securing the track fastener anchors is also released and removed.
- The segment against which the production segment was match cast is moved from the match cast position into the segment finishing area where it will be inspected for compliance to specifications. The segments meeting the specifications will be then moved to the storage area to await delivery to site, while those with deficiencies will undergo remedial repairs, be re-inspected, and upon acceptance will be moved to the storage area.
- The cycle is then repeated.

8.1.1.4.2 Fabrication and Cycle Times

Once the learning curve is complete and full production is achieved, the following production rates are expected:

- Typical segment – one segment per mould per day
- Typical Pier segment – one segment per mould per day
- Variable depth segment – one segment per mould per day
- Variable depth pier segment – one segment per mould every seven days

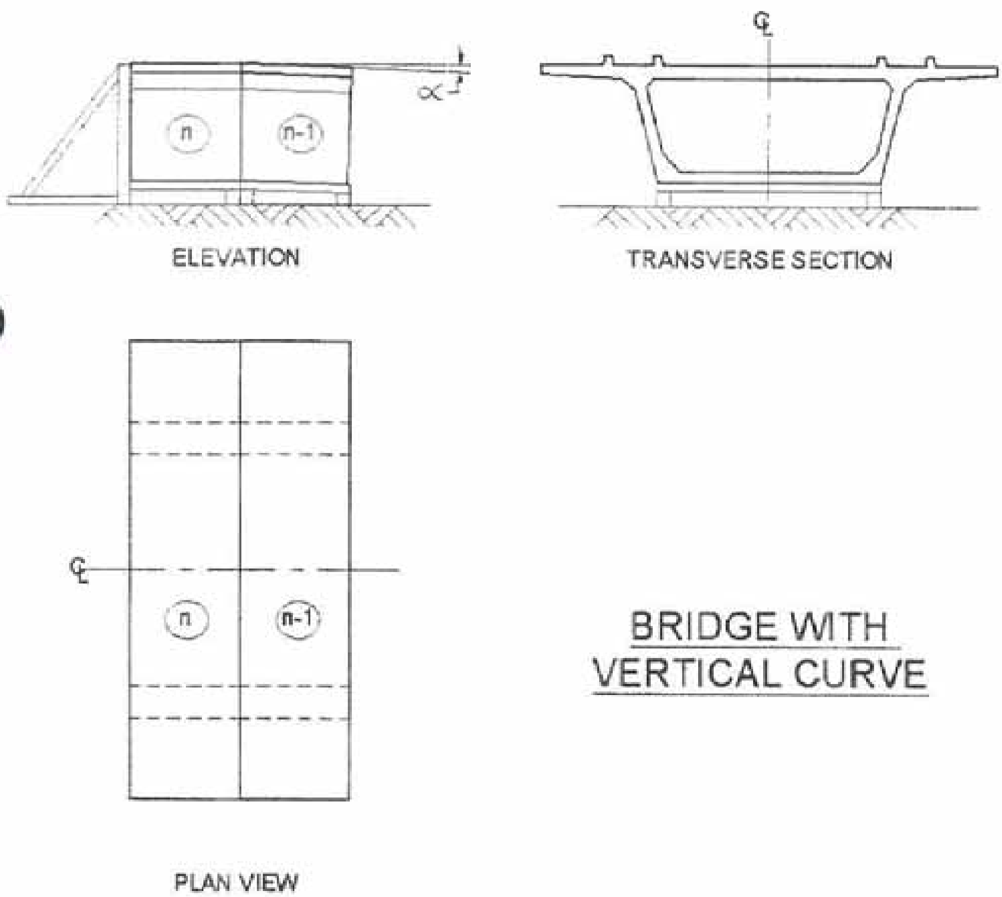
The precast yard will be operational between the hours of 6:00 a.m. and 10:00 p.m., five days a week, and will close for weekends and statutory holidays.

8.1.1.6 Geometry Control – Short Cell Casting

The geometry is dictated by the position of the match-cast segment. The new cast segment is always poured into the same stationary form against a fixed bulkhead. In reality, the new cast segment forms can be slightly manipulated to match the fixed bulkhead on one side and the front of the match-cast segment on the other side.

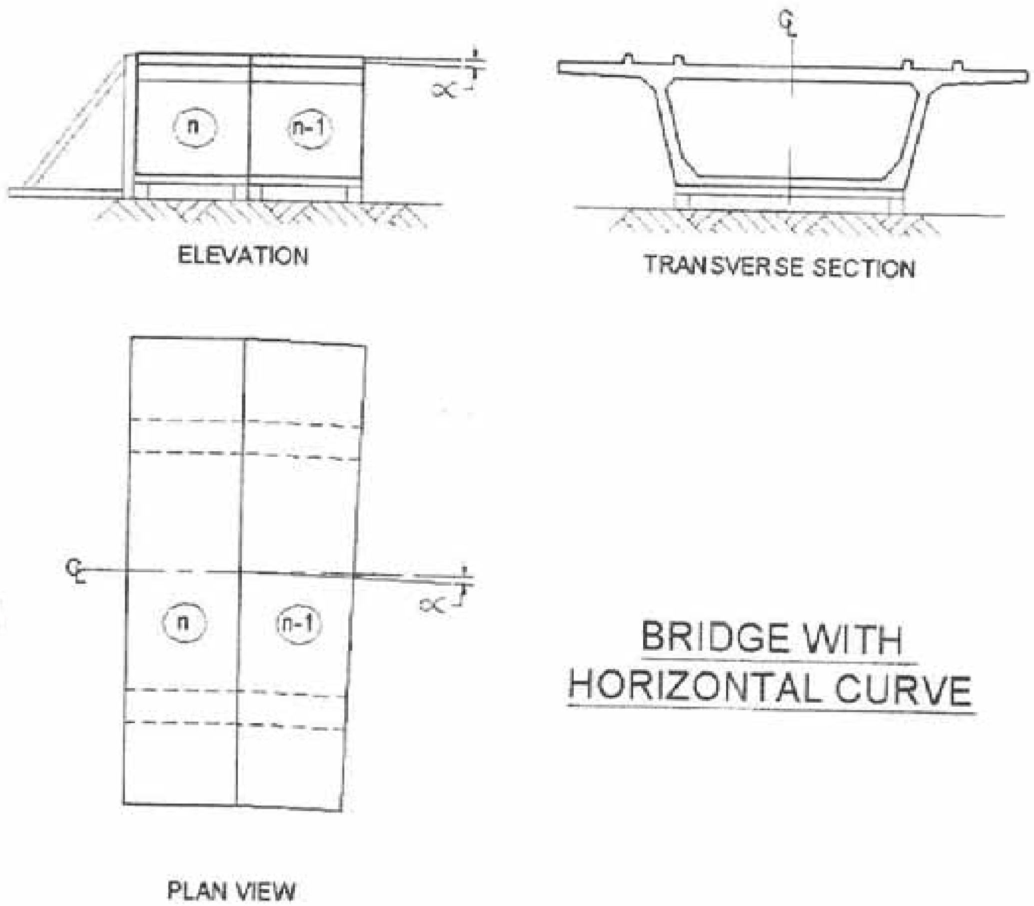
For tangent sections, the segments are simply moved in a straight line from the new cast to the match cast position. For a section with a vertical curve, the segments are first moved in a straight line to the match cast position, then rotated around a horizontal axis parallel to the joints, as shown in the following sketch.

Figure 8.1: Match Casing Elevated Guideway Segments with a Vertical Curve



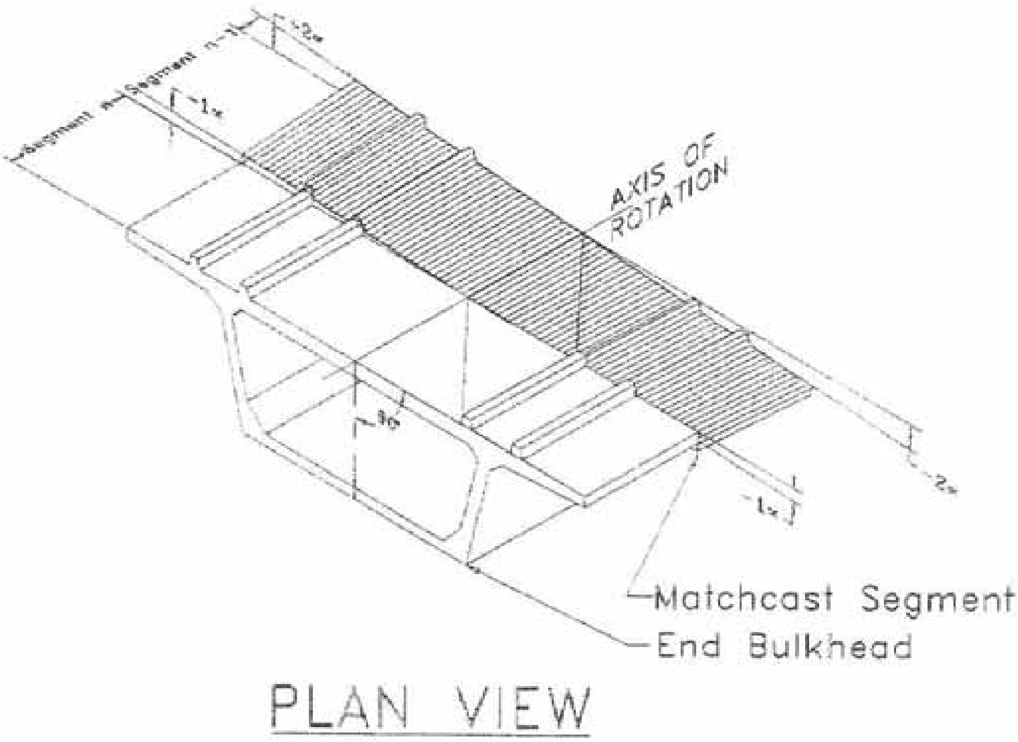
For a section with a horizontal curve without super-elevation variation, the segments are first moved in a straight line to the match cast position, and then rotated around a vertical axis passing through the centreline at the front of the segment, as shown in the following sketch.

Figure 8.2: Match Casting Elevated Guideway Segments with a Horizontal Curve



Variable super-elevation in spiral curve areas will be included in the girder geometry and can also be obtained by rotating the match-cast segment around a horizontal axis perpendicular to the segment joint, as shown in the following sketch.

Figure 8.3: Match Casting Elevated Guideway Segments with Variable Super-Elevation



Short cell casting provides the ability to follow any kind of superstructure geometry in three dimensions. Other advantages of the short cell method are the limited space requirements in the casting yard and the stationary location of the forming system.

The steel moulds used in the production of the precast concrete segments will be fabricated off site at the form supplier's facility and will be transported to the precast yard, where they will be assembled in their designated locations. Well-constructed, robust moulds will be utilized, in recognition of the tight tolerances required and the number of cycles for which they will be used.

8.1.1.7 Segment Delivery and Erection

The precast concrete segmental approach utilizes a span-by-span beam component that weighs only 20 to 40 tonnes, with dimensions of 8.2 metres wide by 3.0 metres long by 2.7 metres high (including parapet walls). The segmental guideway beam is erected using an erection truss or girder, which lifts each segment into its relative position for each beam and after post-tensioning, sets the beam into the final position on the bearings.

The basic erection activities are as follows:

- Individual segments are transported to the launching site using standard truck and lowboy trailer units.

- Segments are hoisted off of the trailer by the erection truss whenever possible. In areas where access is extremely difficult, staging areas will be established where the segments will be hoisted onto a special segment transporter then moved along the guideway. The transporter will deliver the segment to the tail end of the erection truss for installation in its proper location. Segments may also be staged on the ground in advance of the erection truss.
- Segments are held in position by the erection truss, and as the segments are sequentially aligned, epoxy will be applied to the joints and adjacent segments tensioned together using temporary "Dywidag" bars
- The permanent post-tensioning system is then assembled and the beam is stressed. In the initial phase the system is stressed to 50% of design while the beam is being fully supported by the erection truss. In the second phase the beam is lowered onto temporary jacks and the system is stressed to 100% of the design.
- The temporary handrails are installed (safety handrails will remain in place for the duration of all construction activities, including system-wide elements).
- The segments are released from the erection truss, then telescoped to the next span, and the process is repeated.
- The completed beam is adjusted into the final alignment using the temporary jacks, and the bearing pads are grouted with the beam in place.
- The seismic restraints are formed and cast.

Construction of the guideway superstructure will closely follow the critical path throughout the project schedule.

For the Fraser River Crossing the pier segments will be made by a precast concrete shell, erected in advance by crane, geometrically adjusted and then filled with concrete to create a monolithic connection with the column. The remaining span segments weighing 40 to 60 tonnes with dimensions of 8.2 metres wide by 3.0 metres long by 3.2 to 5.1 metres high (including parapet walls), will then be erected in balanced cantilever by using beam-and-winch erection equipment. Cast-in-place closures will be placed at the completion of the erection sequence, out of the critical path. Once the concrete has attained the required strength, the continuity tendons will be stressed.

8.1.2 Cut-and-Cover Guideway

8.1.2.1 Cut-and-Cover Construction Method Statement

A portion of the Canada Line will be constructed as a cut-and-cover tunnel aligned within the northbound lanes of Cambie Street from West 63rd Avenue north to West 2nd Avenue. The guideway in these sections is configured in both a stacked and side-by-side arrangement, with the majority in a stacked arrangement. The general sequence of construction is to relocate conflicting utilities, implement traffic relocation/management measures, excavate, place concrete guideway structure, backfill and reinstate surface conditions. Other systems works will follow within the completed guideway, primarily from within the confines of the existing right-of-way. The concrete guideway will be constructed within a shored trench on multiple headings down Cambie Street with larger confined excavated areas to accommodate the construction of four stations within the cut-and-cover portion of the alignment.

8.1.2.1.1 Typical Excavation and Backfill

Prior to excavating the trench to receive the concrete guideway, the appropriate utility companies will be contacted and, with their assistance, the existing utilities will be located and protected or, where in conflict with the guideway, relocated in agreement with the utility owner. Overhead utilities will be supported and protected during construction to ensure uninterrupted service or, where they are in direct conflict with the work, either temporarily or permanently relocated as agreed with the utility owner.

Construction of the cut-and-cover tunnel will advance south to north from 64th Avenue on Cambie Street. The construction zone will be isolated from the general public utilizing a combination of moveable fencing and precast concrete barriers with controlled entry points for construction traffic. The advance of the construction enclosure along Cambie Street will be coordinated with the progress of the construction sequence and the traffic management plan. The construction enclosure will be of sufficient length to accommodate the completion of the preparatory work, the excavation and installation of the shoring, the delivery of the precast tunnel segments, the launcher installation of the tunnel precast segments and the shoring removal/backfilling operation.

Any existing asphalt and concrete structures identified as requiring removal, such as curbs and sidewalks, will be saw-cut, excavated by small track excavators and then loaded into tandem trucks. The excavated materials will be disposed of in accordance with subsection 9.4 of this volume.

The main excavation will be typically carried out by an EX 1100 excavator, or equivalent, equipped with a long-reach boom and arm in order to achieve the maximum depth of excavation from the original ground level. Trench excavation will be carried out in lift fashion to match the ground conditions and associated support requirements. Subsequent lifts will not proceed until adequate support has been achieved in the previous lift. A small excavator and/or dozer will pull the final grade at the bottom of the trench and feed the large excavator. The large excavator will also place the shoring components. In areas where the depth of the trench prevents the large excavator from rotating effectively, material will be dumped in front of the machine and passed onto a conveyor system that will handle the material directly into the truck box.

The excavated material will be sorted and either utilized within the permanent works or hauled by tandem highway trucks to an approved landfill or ocean dump facility as described in subsection 9.4 of this volume.

The final grade of the trench will be levelled with a bulldozer, Cat D-6 or equivalent, and a mud slab approximately 75 to 100 mm will be placed to protect the final grade and provide an all-weather platform on which to place the precast concrete tunnel segments. The mud slab will also incorporate a precast concrete beam that will form the bottom strut in the shoring system. The spacing of these beams will match the spacing of the vertical members of the shoring system.

The bottom 11.6 metres of the trench will be shored using a continuous multi-panel trench box with rolling interior struts spaced at 5.9 metres on centre. As the precast concrete tunnel segments are placed and the backfilling operation follows, a second large excavator (EX1100) will remove the shoring components for reuse in the excavation area. In areas where the depth of the trench exceeds the depth of the trench boxes, the top lift will be shored by conventional shotcrete shoring or other suitable means.

A schematic concept of the shoring installation sequence is shown in Drawing 865704-CONF-42DK-4073 to 4075 in Appendix B-1.

The guideway will be backfilled using native excavated materials, where possible, with any shortfall made up of appropriate imported granular fill.

The backfill material will be evenly spread out, typically using a Cat D-6 or equivalent, and it will be compacted in layers via a combination of plate tampers and single drum rollers. Compaction tests will be carried out periodically throughout the backfilling operation to ensure the necessary compaction is achieved.

8.1.2.1.2 Concrete Guideway

In the development of our proposal and BAFO, we have considered constructing the cut-and-cover guideway with a segmental precast concrete method and with a cast-in-place method. Based on our work to date, we favour the segmental precast method and have used it as the basis for our design, construction, pricing and scheduling for the BAFO submission. In design development we may consider the cast-in-place method further if warranted.

Option 1 – Precast Concrete Construction Method

This construction method is an extension of the elevated guideway construction method, and is similar in concept, except that the segments are erected on grade (or subgrade in this case). Under this method the guideway will be assembled using match cast, 2.4-metre-long, precast concrete twin box tunnel segments manufactured off site and transported on dedicated specialized haul units to the site. These elements will be match cast using the same methods as for the elevated segmental guideway, to provide for horizontal and vertical alignment, and will be installed using launching trusses. One of the launching trusses will be situated on top of the previously placed and grouted elements to lift and place segments onto a launching truss located within the bottom cell of the box segment. When installed, the twin box tunnel segments will produce a structure with the tracks in a stacked position.

The basic activities for the construction of cut-and-cover tunnel are as follows:

Stage 1:

- Mitigate utility conflicts and implement Traffic Management Plan
- Install safety fencing and precast concrete barriers
- Complete construction survey
- Sawcut, excavate and dispose of pavement and concrete curbs
- Excavate and sort granular road base

Stage 2:

- Excavate and shore the trench to the design grade following the excavation specifications
- Install a mud slab to a tolerance of ±10 mm for placing the precast concrete tunnel segments
- Survey installed mud slabs for:
  - Best-fit alignment
  - Tunnel segment location and elevation

Stage 3:

- Advance the upper launching truss

- Deliver precast concrete tunnel segments to the upper launcher
- Hoist tunnel segments, rotate to vertical position, rotate to alignment, and place on the mud slab – average production will be six segments per day
- Advance lower expandable launching truss through placed tunnel segments
- Align the segments using the hydraulic jacks and locate the segments into their final location
- Survey to confirm that each tunnel segment is in the design location, alignment and elevation
- Grout underside of the placed segments

Stage 4:

- Backfill the excavation after the grouting specifications have been complied with
- Remove shoring as per specifications and recycle to the excavation face
- Reinstate roadworks

Transport vehicles will be located under overhead cranes on the upper launching truss and the segments lifted off and placed in the trench. Once in the trench, the lower launching truss located within previously placed segments will slide through the open ends of the segments and extend a support structure down onto mats on the bottom of the trench.

Each individual segment will then be carried back to the previously placed element to be aligned and joined. Once in place, the elements will be grouted to the invert of the slab to ensure full bearing, and then the process will be repeated.

A schematic concept of the construction erection sequence is shown in Drawing 865704-CONF-42DK-4076 to 4087 in Appendix B-1.

Option 2 – Cast in Place Concrete Construction Method

This construction method uses conventional cast-in-place concrete construction methods. The guideway will be constructed from cast-in-place concrete using conventional placing and finishing equipment in conjunction with travellers, which form the inside face of the guideway. The bottom slab of the guideway, including starter walls to align the traveller, will be poured first. When the bottom slab is cured and the upper rebar placed, the traveller will be collapsed and advanced inside the newly placed rebar cage. Once advanced, the traveller will be expanded out to the correct lines and grades and a bulkhead installed at the leading end to contain the pour.

Once the concrete had been placed and correctly cured, the process will be repeated along the length of the project section. Each traveller will be equipped with a hydraulic system to facilitate the stripping, advancing and setting of the form. Rebar will be assembled in advance of the form on jigs allowing for continuous advancement on each heading.

Excavation and shoring for this method will be similar and use similar equipment to that described for the precast segmental method. Backfilling will follow immediately behind the concrete operation to facilitate the restoration of Cambie Street with the minimum disruption possible.

Restoration Work

As restoration work advances, the barriers and fencing will be removed and traffic returned to normal routing where possible.

8.1.2.1.3 Construction Equipment

The following is a list of the major pieces of plant equipment anticipated to be required for constructing the cut-and-cover portion of the guideway Option 1, Precast Concrete Construction Method:

- 3 ea. 185 CFM Compressors
- 2 ea. 60 T RT Cranes
- 1 ea. 75T RT Crane
- 1 ea. 15 T Boom Truck
- 6 ea. 18,000 Gal Weir Tanks
- 2 ea. D-6 Dozers
- 2 ea. EX 200 Excavators
- 1 ea. EX 600 Excavator
- 2 ea. EX 1100 Excavators
- 3 ea. Concrete Finishing Machines
- 9 ea. 7.5 KW Generator/Light Towers
- 2 ea. CS563E Packers
- 4 ea. Heavy Haul Transport Truck
- 1 ea. Segment Handlers
- 1 ea. Launching Trusses

The following is a list of the major pieces of plant equipment anticipated to be required for constructing the cut-and-cover portion of the guideway Option 2, Cast-in-Place Concrete Construction Method:

- 8 ea. 185 CFM Compressors
- 4 ea. 60 T RT Cranes
- 1 ea. 15 T Boom Truck
- 8 ea. 18,000 Gal Weir Tanks
- 2 ea. D-6 Dozers
- 4 ea. EX 200 Excavators
- 2 ea. Cat 365 Excavators
- 4 ea. Concrete Finishing Machines
- 20 ea. 7.5 KW Generator/Light Towers
- 2 ea. CS563E Packers
- 1 ea. Heavy Haul Transport Truck

8.1.2.1.4 Temporary Works

It is anticipated that in certain areas the ground conditions will require the use of a limited amount of conventional sheet pile walls with beams and struts. These will be driven at grade with a vibratory hammer and the beams and struts installed as the trench is excavated downward.

Another aspect of temporary works is the handling and discharge of groundwater or heavy rainfall that may be encountered within the excavated areas. To maintain the integrity of the bottom of the excavation, a mud slab will be placed immediately after final grade is reached.

In conjunction with the protection placed for the final excavated level, small sumps will be excavated as required along the length of the section and sufficient sized pumps installed to maintain a dry excavation during concreting activities. The pumps will be either electric submersible or portable gas-powered. All necessary precautions to protect the environment will be in place. For example:

- Drip trays will be used to collect any spillage while refuelling and dripping oil
- Spill response kits will be available close to the generators
- Hoses will be regularly checked for leaks

Collected water will be pumped to the surface and discharged into portable weir tanks, where it will be filtered, tested for compliance to regulatory requirements, and then discharged directly into the city storm water sewer system.

8.1.2.1.5 Spoil Disposal

The guiding philosophy for spoil disposal will be to incorporate, to the maximum extent practical, native material into the permanent works in order to minimize the amount of spoil disposal off site and to recycle materials for future use where possible.

It is anticipated that the excavated asphalt will be hauled to a recycling facility. The concrete curbs and other miscellaneous concrete structures will be excavated and hauled to an approved and licensed landfill site or alternatively crushed and incorporated into the backfill material. Sub-base granular materials will be excavated, stockpiled and where possible reused for backfill around the new concrete structures.

Excavated overburden and native materials will be hauled and disposed offsite, either in approved landfill facilities or by ocean dumping.

Any contaminated material will be disposed of in accordance with regulatory requirements.

For more detail on the soil disposal plan refer to Section 9.0 of this volume.

8.1.2.2 Transition Segments

As noted in Sections 1.0 and 2.0, there are four cast-in-place concrete "rollover" structures that transition the guideway to/from a side-by-side arrangement to/from a stacked arrangement as follows:

- At approximately West 63rd Avenue transforming the alignment from an elevated side-by-side configuration into a stacked shallow tunnel configuration
- At approximately West 37th Avenue transitioning from a stacked configuration to a side-by-side configuration before the drill-and-blast excavation around Little Mountain

- On the north side of Queen Elizabeth Park, a transition segment from a side-by-side to a stacked configuration.
- Between West 12th Avenue and West 10th Avenue transitioning from a stacked configuration to a side-by-side configuration before bifurcating for Broadway Station.

All four transition segments are proposed to be constructed using conventional cast-in-place concrete construction methods within a cut-and-cover excavation as discussed in preceding sections.

The guideway section from Broadway station to the future 2nd Avenue station is proposed to consist of a short section of side-by-side cast-in-place concrete construction. The vertical alignment for this shallow tunnel section will follow the existing grade as closely as possible with a nominal cover of 1.2 metres. Due to its short length this section is proposed to be constructed using conventional cast-in-place concrete construction methods.

2nd Avenue Station will be the launching portal for the tunnel boring machines (TBMs), which will drive the twin bore tunnels to Waterfront Station. Upon completion of the tunnels, and in recognition of the need to restore access in this area, the future 2nd Avenue Station cavity will be covered and the surface restored.

8.1.2.3 Advantages of Precast Concrete Tunnel Segments

There are considerable advantages to the international and routinely utilized precast tunnel construction method:

- Produces close dimensional tolerances and high quality standards
- Reduces the length of time for open excavation and minimizes the disruption at grade level
- Reduces congestion onsite, with most of the work performed in a factory environment offsite
- Minimal interruption to traffic and the community during construction
- Improves the interface with future subsystems, providing inserts for E&M systems, walkways and anchors for direct fixation track fasteners, to be accurately installed during the fabrication of the segments
- Items such as systems inserts, walkway brackets and direct fixation track fasteners can be pre-installed into the segments at the fabrication facility
- Reduces schedule in that subsequent systems can be efficiently installed immediately following segment installation
- Reduces the negative impact of unfavourable weather conditions

8.1.2.4 Fabrication and Construction Plan

The precast concrete tunnel segments would be produced in the same manner as the precast elevated guideway segments. They would be produced by and at the same segment precast plant, but in a different production building from the segments for the elevated guideway.

The basic elements required for the production of the precast concrete tunnel segments are as follows:

- 1 production building with a total area of 2,550 m²
- 2 overhead bridge cranes in the production building
- 2 Gantry cranes in the segment storage area

- 6 twin way tunnel segment moulds

The following elements are shared with elevated segment production:

- Site offices
- Workshop and store building
- Employee parking area
- Segment storage area for tunnel segments

8.1.2.5 Operations Methodology for the Production of Tunnel Segments

The short line match cast method will be used to fabricate the tunnel segments. The segments will be cast on their sides for production and shipping convenience and rotated to the vertical position at the time of installation on site. Each segment is 2.4 metres long, consisting of two stacked tunnel sections, the upper and lower track base and the tunnel roof. The mould consists of two basic sections: the outer form and the inner cores. The casting moulds always retain the same orientation. To produce the required geometry for the tunnel, the previously cast segment is accurately positioned into the required geometry relative to the segment that will be cast in the mould. The segment to be produced is cast directly against the properly positioned segment, as in elevated segmental fabrication, to ensure a precise fit between the two segments once they have been installed in their onsite positions, to form the tunnel.

The basic fabrication activities are as follows:

- Both the inner core and the outer form are cleaned and lightly coated with form release.
- The reinforcing steel for the segment is fabricated in a jig. The fabrication and inspection of the rebar cage occurs prior to the segment forming/casting.
- The rebar cage is delivered to the mould using the overhead bridge crane, is installed in the exterior form and properly chaired.
- The inner core is then moved into position and secured.
- The cast-in-place inserts are secured to the inner core by means of fixing bolts.
- The outer form is moved into its proper position and secured.
- A detailed survey check is conducted, verifying the relative geometry of the match-cast segments. Checks are also conducted to ensure the rebar cage is properly chaired. The location of the inserts is fixed and checked.
- The mould is filled with concrete and vibrated to achieve the proper consolidation
- After a prescribed curing period the compressive strength of the concrete is tested to confirm that the specified strength has been achieved
- At this point the inner core is extracted from the exterior form and retracted clear of the segment.
- The segment against which the new one was cast is moved from the match cast location into the segment finishing area, where it is inspected for compliance to specifications. The segments meeting the specifications are then moved to the storage area to await delivery to the

site. Those with deficiencies will undergo remedial repairs, be re-inspected and, upon acceptance, moved to the storage area.

- The whole cycle is then repeated.

8.1.2.6 Fabrication and Cycle Times

Once the learning curve is complete, the production rate for a typical tunnel segment will be one segment per mould, per day.

8.1.2.7 Geometry Control – Short-Cell Casting

The geometry control procedure for the tunnel segments is exactly the same as that used for the elevated concrete segments. Since the segments will be cast on their sides, the vertical and horizontal alignment will be inverted during the definition of alignment data for the fabrication of the segments.

8.1.3 Work Methods – Excavation Around Little Mountain

8.1.3.1 Scope of Work

This work comprises the open-cut excavation along Cambie Street to detour construction around "Little Mountain" and the surrounding parklands from approximately 37th Avenue to 29th Avenue.

Within this stretch of excavation, rock will be encountered within the trench excavation for a length of approximately 298 metres. Removal of this rock will require drilling and blasting.

8.1.3.2 Excavation Methodology

Additional Major Equipment Requirements:

- 1 ea. EX 600 Excavator
- 1 ea. Shotcrete Pump
- 2 ea. Jackleg Drills
- 1 ea. 600 cfm Diesel Compressor

Excavation and Stabilization

Overburden excavation will be undertaken in a manner similar to the overburden excavation for the rest of the project, with the Cat 375 Excavator loading the material directly into street legal haulage trucks for transport to the designated disposal site.

The depth of the overburden varies along this length of the guideway, from 9.0 metres to 1.25 metres, with the average depth being 3.3 metres.

The excavation will be carried out in 2-metre lifts and, upon completion of each lift, shotcrete and soil anchors will be installed to support the excavation prior to commencing the next lift of excavation (see Drawing 865704-CONF-42DK-4088).

8.1.3.3 Excavation Methodology - Rock

Major Equipment Requirements:

- 2 ea. Diesel/Hydraulic Track Mounted Rock Drills
- 1 ea. Cat 966 FEL

Excavation and Stabilization

In order to facilitate the concrete operations for the construction of the guideway, this portion of the trench will be excavated to a width of 12.25 metres through the rock section.

As the rock surface is exposed, drilling operations will commence utilizing the track mounted rock drills.

Pre-shear holes will be drilled along the perimeter of the excavation at spacing of 600 mm, and production blastholes will be drilled on a spacing of 1.82 metres and a burden of 1.63 metres (see Drawing 863704-CONF-42DK-4089). All holes will be drilled 63.5 mm in diameter.

The pre-shear holes will be loaded lightly, either using primacord as the in-hole charge or with trimtex cartridges, depending on the actual rock encountered.

The main blastholes will be loaded with an ANFO product, depending on the explosives supplier chosen for the supply contract, with the top portion of the holes filled with stemming material. All holes will be detonated using non-electric detonators for safety reasons. The anticipated powder factor for the rock excavation is 0.74 kg/m³.

To reduce the effects of vibrations caused by the blasting operations, all blasting will be designed based on the scaled distance factor to produce a peak particle velocity of under 50 mm (this is the normally accepted level where no damage is done to any adjacent structures). Due to the vibration constraints, most of the rock will be excavated in two lifts and the explosive charge in each hole will be "decked" so that the charge will be detonated by two different detonator delays.

Prior to undertaking the blasting operations, a pre-blast survey of the adjacent properties will be conducted by a third party and the results documented and filed to handle any post-blast concerns.

During the course of the work, all blasts will be monitored using an Instatel Seismic Monitor to verify that the Peak Particle Velocity generated from the blasts fall below the 50 mm desired. This will also produce a document trail for future reference.

Surface fly-rock can be generated due to the release of the gases formed in the generation of the explosion. To minimize/eliminate the occurrence of fly-rock, the surface of the blast will be covered in "blasting mats," and the mats then covered by a layer (approximately 600 mm) of granular materials. This confinement will entrap the surface rock and render it benign.

As the rock excavation is benched down, the walls will be scaled for any loose rock, and, if required, slit-set rock anchors will be installed in areas of slabby ground conditions (see Drawing No. 040401-0000-41DK-0050).

All blasted rock will be loaded by the Cat 966 front-end loader into street legal haulage trucks and hauled to the designated disposal recycling site.

8.1.4 Tunnel Boring Machine (TBM) Tunnelling

Twin bore tunnels are proposed from the 2nd Avenue Station area to Granville Street, north of the Pacific Centre Mall Underground Corridors between Georgia and Dunsmuir Street. They will be mined by a pressure-face tunnel boring machine (TBM), and supported using "one-pass" bolted and gasketed precast concrete segmental lining. The tunnels will be driven from the 2nd Avenue/Commodore Road staging area and proceed under False Creek, into downtown Vancouver, and end at the Dunsmuir extraction pit, where cut-and-cover construction will be used for crossovers and pocket track to Waterfront station. The TBMs would proceed through both Davie and Robson stations, which may be excavated and shored in advance, by breaking into, rolling through and re-launching from the shored and excavated station box.

Two types of tunnel boring machine have been considered: the mixshield slurry machine and an earth pressure balance (EPB) machine. Herrenknecht and Lovat have reviewed the geology and following confirmatory boring and investigation the optimum TBM will be selected.

8.1.4.1 General Tunnelling Characteristics

8.1.4.1.1 Anticipated Ground Conditions

Based on our review of project geotechnical data, our proposed alignment will keep the tunnel within two distinct geologic materials along its entire length. These are glacial till and drift (Sta. 112+010 to approximately 113+460) and sedimentary rock (approximately Sta. 113+460 to 114+441).

The glacial till and drift deposits are anticipated to be compact to very dense stratified deposits of silts, sands and gravels, which contain cobble and boulder size particles derived from very strong parent material such as granite and granodiorite. The majority of the fill material is expected to contain enough silt and clay to result in a relatively stable structure, with a low mass permeability. Thus, the majority of this material is expected to exhibit enough cohesion upon excavation to produce ground behaviour ranging from slow ravelling to slow creep, which will permit tunnelling and support installation. However, these deposits also contain zones and lenses of water-bearing granular materials. Without support, such granular deposits will flow upon excavation.

The sedimentary rock is anticipated to consist of a sequence of sandstones, siltstones, and claystones, with less frequent occurrences of conglomerate. Coal seams are commonly found in this unit and volcanic sills and dykes will likely be encountered. UCS test results from rock in this unit show values ranging from as little as 0.6 MPa to as much as 52 MPa. The sandstone unit is highly variable in strength, ranging from uncemented sand to moderately strong rock (UCS strengths averaging about 6.0 MPa). The sandstone is massive and is expected to have a moderate hydraulic conductivity of about 1e-4 cm/sec. The response of this material to excavation will range from flowing to small creep. The siltstones and claystones have a relatively higher average strength (25 to 30 MPa) than the sandstone. This material is expected to show little creep upon excavation, but may invade the tail space faster locally where the strength drops or slickensides adversely affect stability.

Based on the data provided, most of the tunnel is expected to be well below the groundwater table. Due to the presence of a high groundwater table, combined with the varying permeabilities of the soil units to be encountered around False Creek, a tunnelling machine capable of exerting a balancing hyrdrostatic and soil pressure against the tunnel face will be used to control excavation rates, groundwater inflows and maintain the stability of the tunnel face.

Faults could potentially cause difficulty during TBM excavation. Since no faults are known to cross the alignment, none are assumed at this time. Both of the TBM machines proposed can readily handle the full hydrostatic head under False Creek and continue boring through the ground.

8.1.4.1.2 Tunnel Lining Design

The tunnel drives will be supported with a bolted and gasketed precast concrete segmental lining. The proposed lining system includes a 300 mm thick segmental lining with an internal radius of approximately 2,650 mm. A cross-sectional view of one of the bored tunnels is shown in Figure 8.6 on the following page. The separation between the two tunnels, at spring-line, will be around 6,200 mm.

Figure 8.6: Proposed Cross Section of One Bored Tunnel under False Creek and Downtown Vancouver

S.15(1)(L)

This watertight lining system will be designed to withstand construction, ground, hydrostatic, and seismic loads. This type of lining is commonly referred to as "one-pass" since a completed lining is achieved in a single pass.

A black, solid neoprene or HDPE gasket fits around the outer edge of the precast segment and is compressed as the segments are installed in the tunnel to make a watertight seal.

The small difference in diameter between the TBM and the precast segmental lining erected in the tail of the TBM results in an annular void which must be grouted near the TBM tail to ensure intimate contact between the lining and the surrounding ground. This is necessary to prevent unbalanced loading of the segmental lining, and to minimize surface settlements. Available information suggests the majority of the tunnel in the glacial deposits will be able to advance without immediate invasion of the annular space by the surrounding ground prior to grouting. Locations with flowing sands will invade the annular space prior to grouting and result in higher tail shield and face ground loss. Higher surface settlements are possible at such locations. However, this will be mitigated through the use of slurry pressures higher than groundwater pressures and injection of annular backfill grout through the tail shield.

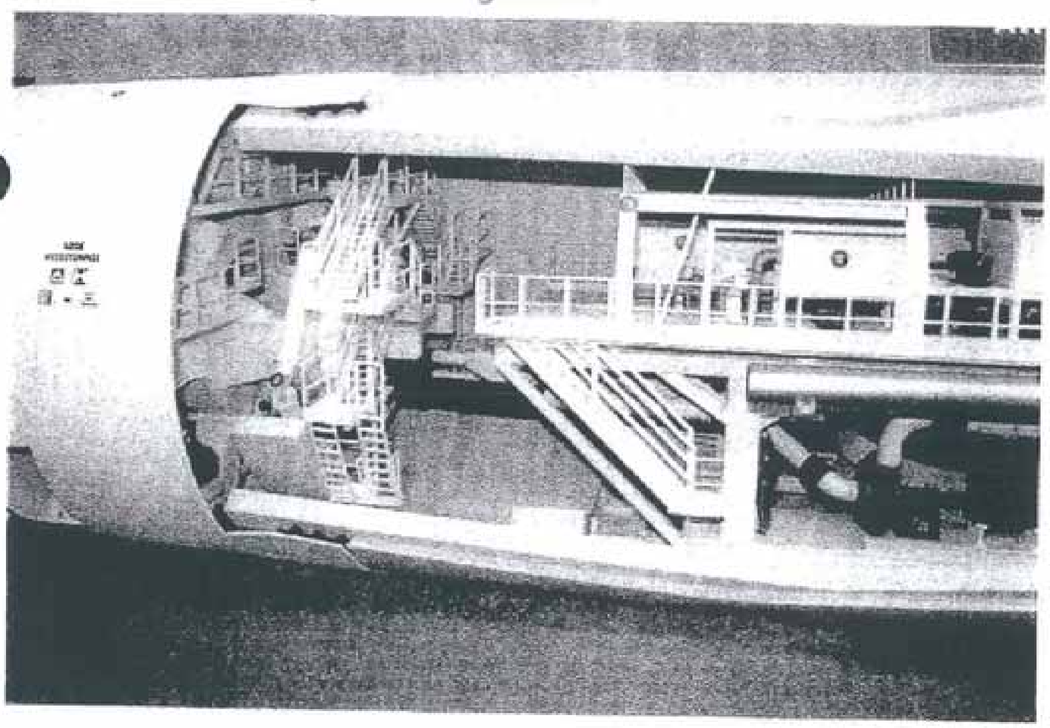
Manufacture of precast concrete segments will be undertaken by specialist personnel with previous experience in this operation. Established quality control/quality assurance programs will be implemented in order to produce a high-quality product.

8.1.4.1.3 Tunnel Boring Machine

As stated above, we propose to use an EPB or a mixshield slurry TBM to drive the tunnel reach from 2nd Avenue to near Dunsmuir Street. These machines will be capable of exerting a balancing pressure against the tunnel face, which will be used to control excavation rates, groundwater inflows and maintain stability of the excavated face.

Figure 8.7 below shows a cut-away model of a mixshield slurry TBM.

Figure 8.7: Mixshield Slurry Tunnel Boring Machine



Mixshield slurry TBMs have been successfully used for 20 years. Their distinguishing feature is a partial bulkhead wall separating the fluid-filled excavation chamber from a pressure chamber containing an air cushion above the slurry surface. This air cushion system effectively eliminates pressure fluctuations that can occur in other pressurized-face TBMs. In cohesive soils or rocky conditions, which do not require such a sensitive support mechanism, mixshields can be used as simple slurry machines.

A mixshield machine provides protection against face inundation and excessive groundwater inflow through the use of a sealed forward chamber and valving on the muck removal system. The material removal rate and the pressure within the plenum is carefully monitored and controlled during machine advance. The goal of this procedure is to exert a pressure that balances and maintains the in-situ ground and groundwater pressures that existed prior to tunnelling. The method is designed to completely balance the in-situ pressures and results in little ground disturbance ahead of and around the advancing machine and therefore minimizes surface settlements.

The mixshield in slurry mode will effectively handle the glacial till zone. In order to deal with the differing conditions in the sedimentary rock, and to obtain increased production, TBM modifications may have to be made. Excavation at the tunnel face is accomplished using a rotating cutterhead equipped with cutting tools to remove the intact ground and draw the loosened material into the cutterhead. The cutterhead will be designed with cutting tools that can excavate through both the soft ground reaches and the bedrock reaches. The cutterhead will include a combination of spades, chisel and drag bits and disc cutters mounted on the surface of the cutterhead. The disc cutters on the TBM will be able to cut large boulders with high intact rock strength, corresponding to granite, which typically has a UCS of up to 270 MPa.

The presence of gravel, cobbles and boulders in the ground may require special treatment. These materials can accumulate in the forward chamber and even block the slurry system. The TBM will have screen and crusher incorporated at the rear of the cutter head. The crusher reduces the size of the spoil so that it is able to pass through the pumps and pipework to the slurry separation plant. This crusher works in parallel with the excavation cycle.

The EPB TBM will have cutters to break the large cobbles and boulders into pieces that pass through a screen into the conveyor system. Gravel and cobbles less than 300 mm in size can readily pass through the conveyor.

Our proposal assumes that the tunnels are non-gassy.

8.1.4.2 TBM Tunnel Construction

Construction will consist of distinct stages: site mobilization, tunnel excavation and lining, and site clean up and restoration. This operation results in the installation of the final lining in one pass during excavation.

8.1.4.2.1 Site Mobilization, Preparation and TBM Procurement

Mobilization at the 2nd Avenue site will start during the 12-month TBM procurement phase. Mobilization will include site clearance, erection of facilities, boundary fencing, delivery of equipment and development of the TBM launch shaft. Material cleared from this exercise will be hauled away for disposal. Contaminated soils are expected to be encountered in this area. Excavations will be minimized to reduce the amount of soil that will require special handling and disposal. It has been assumed that the soil will be of sufficient quality that it can be disposed of in Lower Mainland landfills. Any flora and fauna will be protected where practical.

The site water treatment system (settlement ponds or similar) will be constructed during the mobilization phase. The system will be sized to handle storm water run-off from within the site boundaries. All water destined for discharge will be tested, and treated as necessary, to ensure compliance with the local and national regulations prior to release.

The procurement of the TBM will commence after the commercial closing. Preliminary discussions and design will have taken place prior to the commercial closing to identify the specific TBM requirements and the potential manufacturers. The TBM will be capable of achieving, as a minimum, an average advance rate of 10 metres per day in the type of ground conditions anticipated, and erection of the segmental lining within the specified tolerances.

B.1.4.2.2 Excavation and Lining

Tunnel excavation will commence some following the delivery, erection and commissioning of the TBMs. Once the first pass is complete, the TBM will be dissembled, moved and reassembled at the launch shaft to make the second pass, downtown to Waterfront Station area.

The TBM will be capable of excavation and segmental lining installation concurrently. Excavation will likely be completed in 1,500-mm-long strokes compatible with the segmental lining ring length. A one-month learning curve has been allowed for the TBM, with an average advance rate of 10 metres per day.

Immediately following erection of a full ring of segmental lining, the annular gap will be filled using a grout. This will ensure that the erected ring shape is maintained and that the load from the surrounding ground is transferred into the ring. Each ring will be checked as it is erected to ensure that it is built within the specified tolerances.

Full segmental lining ring sets will be delivered to the TBM in sets. Other components on the segment delivery train will include grout, services (pipes, cables, supplies) and a man-rider car.

Dedicated periods of four hours will be set aside for TBM maintenance at the end of the two 10-hour day shifts. Non-essential maintenance may be carried out over weekends or during periods of planned non-production.

In the case of the slurry TBM, the excavated muck will be removed from the face in suspension with the slurry. Slurry will be batched at the surface and fed to the TBM along supply lines in the tunnel. The slurry/muck suspension will be pumped out of the tunnel to the slurry separation plant on the surface. The separated slurry will be re-circulated into the tunnel for use, while the separated muck will be taken off site for disposal. From the 2nd Avenue/Commodore Road site, this material will be hauled the short distance to the False Creek dock where it will be transferred to barge for ocean disposal.

In the case of the EPB machine, the muck will be removed in muck carts pulled by the train. The carts will dump directly into a staging area, from which it will be loaded into trucks and taken directly off site to a waiting barge.

B.1.4.2.3 Demobilization, Site Clean-Up and Restoration

Upon completion of the first drive, the TBM will be removed at the Dunsmuir End Shaft. The TBM will be reassembled at the 2nd Avenue shaft and re-launched for the second drive. Cleaning of the tunnel and tunnel finishing (removal of services, temporary track, outstanding precast segment repairs, casting of the invert slab, etc.) will then be undertaken prior to handover for systems installation.

After completion of TBM excavation and installation of a continuous circular lining of precast segments, the temporary rail will removed, the invert cleaned, and a flat invert for the permanent rail fixation constructed as reinforced, cast-in-place concrete. The invert will contain any embedded pipe and inlets for track drainage. Invert concrete will be placed, forming 50-metre lengths with a bulkhead form for the construction joint as required.

Placement of the invert will be followed by construction of either a reinforced, cast in-place concrete or a steel safety walkway. Concrete placement for the walkway will require a travelling form, up to 15 metres in length. The safety walkway can be constructed with a cable tray, raceway or with embedded conduits for systems and communications lines. The civil works in this section of the guideway tunnel will terminate with the removal of any temporary utilities.

Upon completion of all tunnel civil works activities, including tunnel finishing, cleaning and removal of services, equipment will be removed, facilities taken down and the entire site area restored to an acceptable condition. Materials and vegetation will be imported as necessary to achieve these conditions. The tunnel will be handed over to systems installation personnel as soon as practical during this stage.

8.1.4.2.4 Cross Passage Construction

The emergency cross passages between the twin guideway tunnels will be excavated in sedimentary rock or glacial till. Cross passages will be constructed using the sequential excavation method, often referred to as the New Austrian Tunnelling Method (NATM). The horizontal spacing between cross passages will be around 240 metres, as per fire code requirements.

Ground improvement for soils may be required as a means of stabilizing the ground to permit open-face excavation. This ground improvement can be in the form of dewatering, grouting, or ground freezing, depending on the localized geotechnical conditions and surface access at each individual cross passage. From the geotechnical information available, substantial ground improvement measures will likely not be required at any of the cross passage locations.

The construction sequence for each cross passage involves the following stages:

- Erection of temporary support for the precast linings, such as with steel ribs, in each tunnel adjacent to the cross passage
- Sawcutting and removal of precast segments at one end of the cross passage entrance
- Excavation of the cross passage with a top heading and bench sequence – excavation will be carried out with mechanical spaders or hoe ram, and as excavation advances, will be supported with steel-reinforced shotcrete lining
- Breakthrough of the cross passage excavation into the other tunnel will require removal of segments at the other tunnel
- Installation of geotextile and a PVC membrane within the crown
- Placement of a cast-in-place concrete final lining from within stick-built (wood) forms
- Installation of cross passage utilities, as required

8.1.4.2.5 2nd Avenue to Waterfront Station Site

Both tunnels will be driven from a working shaft at 2nd Avenue and Commodore Road. The TBM launching area will be from the cut-and-cover tunnel/crossover excavation.

The typical facilities and areas required are:

Shaft, 18 x 50 m	900 m^2
Slurry Separation Plant	4,050 m^2
Segment storage	900 m^2
Settlement ponds	1,600 m^2
Workshops, offices	1,600 m^2
Electrical substation	625 m^2
Stores	400 m^2
Crane bases	100 m^2
Parking (equipment, labour)	1,000 m^2
Sub-Total	**11,125 m^2**

This includes the facility areas above, together with access roads and a section of the cut-and-cover trench. The muck disposal route is expected to be either by truck or conveyor from the slurry separation plant to the barge facility at the east end of False Creek. This same haulage route could be used in a reverse direction for the delivery of precast concrete segments.

8.1.4.2.6 Staging Requirements

There appears to be approximately 2.5 hectares of parking lot to the west of Cambie Bridge available for use as a staging area. There is a second parking lot to the west of this that would provide an additional 1.5 acres. In order to effectively operate two tunnel drives from the 2nd Avenue site, both parking lots would probably be needed to provide sufficient staging areas for the shaft, crane, slurry separation plant, segment storage, water handling facilities, workshop(s), offices, materials storage, cement silo, grout batch plant and construction parking.

The total staging area required (including additional 50% for access, etc.) is 16,670 m^2. This space is available if both parking lots are used as a staging area. The benefit of driving both tunnels from the 2nd Avenue site is that it eliminates duplication of equipment (chiefly slurry separation plant), offers far more efficiency in spoil disposal, allows the tunnel contractor to focus on one working site, and thus allows key personnel to attend to both drives, thereby reducing staff costs (if two TBMs are used to excavate the tunnels concurrently).

8.1.4.2.7 Haulage

The excavated diameter of the tunnels would be approximately 2.0 metres, subject to final selection of the vehicle. The volume of spoil to be separated at separation plant and disposed is estimated to be 90,000 m^3 for each drive (assuming a bulking factor of 1.5). The total volume of muck to be disposed of, including the shaft excavation, would be around 230,000 m^3. Therefore, the average maximum daily volume of spoil per tunnel drive to be disposed of is 850 m^3. This material can be transported from the site to a barge facility on False Creek for disposal. Material handling facilities will be sized to allow for greater sustained advance rates than indicated above.

8.1.4.2.8 Segmental Lining Delivery

Sufficient space will be provided onsite for storage of around one week of TBM advance. For a 15-metre daily advance and a truck capacity of one-half full ring set (ring width of 1.5 metres), 20 truck deliveries per day will suffice to keep segment inventory at required levels. The ability to deliver more lining will be available should TBM production exceed estimates and lining stocks fall below the minimum acceptable levels.

8.1.5 Underground Station and Pocket Track Construction

The construction of the underground stations and pocket tracks will be cover-and-cut, or a combination of cover-and-cut and cut-and-cover cover, as shown in Drawings 865704-CONF-42DK-1648 to 1650. The priority will be to minimize disruption to the City of Vancouver, pedestrians and traffic, as well as to support surrounding structures, and to optimize construction efficiency. The detailed methodology will be finalized during the detailed design phase.

The top-down cover-and-cut method is performed as follows:

- An investigation of the underground utilities is made, and these utilities relocated or protected and supported as appropriate
- In order to provide the space needed for construction work, part or the entire section of the road and sidewalk are blocked off while the utility, initial excavation, diaphragm wall and cover section are installed
- Station walls are installed using the most appropriate technique, such as slurry walls, tangent pile walls or pile and shotcrete infill walls
- Ramps are excavated on the outside of the station box in the direction of the tunnel
- The top slab, where necessary, such as at intersections, will be constructed, with utilities suspended and top surfaces reinstated
- Where required in order to maintain the surface for traffic or access the process of excavation from the top down underneath the reinstated top surface for the station cavity will be used, spoils will be removed from an adjacent access shaft selected to minimize impact on the local community
- Access/egress structures will then be completed and the station fitted out

The cut-and-cover method is performed as follows:

- An investigation of the underground utilities is made and these utilities relocated or protected and supported as appropriate
- In order to provide the space needed for construction work, part or the entire section of the road and sidewalk is blocked off while the utility, initial excavation, diaphragm wall and cover section are installed
- Station walls are installed using the most appropriate technique, such as slurry walls, tangent pile walls or pile or shotcrete infill walls
- Ramps are excavated on the outside of the station box in the direction of the tunnel
- A system of whaler beams and lateral shores are constructed and installed using sections of the permanent structure where possible, both at the surface and the concourse level

- The slabs are constructed, with utilities suspended and top surfaces reinstated only upon completion of the excavation
- Access/egress structures are completed and the station fitted out

8.1.6 Road and Traffic Management Plan (TMP)

8.1.6.1 Traffic Management Strategy

SNC-Lavalin/Serco will develop a traffic management strategy at the outset to ensure that project needs are identified and that traffic management plans are developed to adequately address those needs over the construction period. The traffic management strategy will include the following:

- Preparation of an area-wide traffic model using the Greater Vancouver Regional Transport Model to determine traffic diversion and impacts on adjacent corridors due to capacity reductions (SNC-Lavalin/Serco will identify and implement appropriate mitigation measures)
- Consultation/work with TransLink to develop a plan to maintain current transit service levels to the extent reasonably practicable
- Identification of requirements for maintaining bicycle routes, business access and pedestrian access through the work site
- Assessment of potential traffic infiltration on residential streets and identification of traffic calming measures
- Preparation of a plan for coordination of work with the City, YVR and other contractors working in the vicinity of the Project and adjacent routes

The traffic management strategy and detailed traffic management plans will be prepared in accordance with the requirements contained under Section 13.11, Schedule 2 of the Agreement.

8.1.6.2 Traffic Management Plan

For each stage of construction, SNC-Lavalin/Serco will prepare a detailed traffic management plan (TMP), which will be issued to a Traffic Management Committee for review and acceptance prior to commencement of each construction stage. The Traffic Management Committee will consist of representatives from TransLink, the Airport Authority, the City of Vancouver, the City of Richmond, the Ministry of Transportation and other agencies, as required.

The TMPs will be consistent with a Category 5 project as set out in the Ministry of Transportation's "Traffic Management Guidelines for Work on Roadways," and it will include the following sub-plans:

- Traffic Control Plan
- Public Information Plan
- Incident Management Plan
- Implementation Plan

SNC-Lavalin/Serco will be responsible for implementing the TMP, monitoring TMP performance and modifying or adapting the TMP to improve performance during the construction period, as required.

An outline of SNC-Lavalin/Serco's proposed traffic management plan is described below for the following sections of the corridor:

- Number 3 Road Corridor from Park Road to Fraser River
- Cambie Street Corridor from Fraser River to South West Marine Drive
- Cambie Street from South West Marine Drive to Broadway Avenue
- Cambie Street from Broadway Avenue to Commodore Road
- Downtown Vancouver from Commodore Road to Cordova Street (Waterfront)
- Vancouver International Airport Connector

The outline also covers traffic management for:

- A typical station construction across an intersection (Cambie Street and King Edward Avenue)
- Construction vehicle routes to/from the casting yard and barge loading dock

8.1.6.3 Number 3 Road Corridor from Park Road to Fraser River

8.1.6.3.1 Existing Roadway

Number 3 Road between Park Road and Bridgeport Road has two lanes in each direction, with left-turn lanes at intersections. North of Bridgeport Road, Number 3 Road is a two-lane undivided road. Between Ackroyd Road and Sea Island Way, the lanes are separated by a partially segregated busway along the centre median of the road.

Sidewalks run along both sides of the street. The 98 B-Line and other express buses utilize the busway.

8.1.6.3.2 Construction Work Area and Sequence

Number 3 Road Reconstruction: Between Park Road and Sea Island Way, the elevated guideway will be located on the east side of Number 3 Road over the existing northbound lanes. To provide space for the elevated guideway, Number 3 Road will be permanently reconstructed between Ackroyd Road and Sea Island Way. The road reconstruction will entail removal of the existing busway, shifting of the northbound lanes to the space vacated by the busway and provision of a left-turn lane.

Guideway Construction: Upon completion of the permanent road reconstruction, construction of the foundation and substructure will start at Saba Road and proceed north along Number 3 Road, while at the same time starting at the Fraser River and proceeding south. The launching and erection of the beams will follow behind the foundation substructure construction.

The construction work area for the elevated guideway will be about 10 metres in width and will extend from Park Road to the Fraser River. The work area will be in place for an 18-month period between Saba Road and the Fraser River.

8.1.6.3.3 Traffic Control Plan

Number 3 Road (Park Road to Sea Island Way): The road reconstruction works will be staged to maintain two lanes in each direction on Number 3 Road. Upon completion of the road reconstruction, Number 3 Road will have a permanent five-lane cross section from Park Road to Ackroyd Road, and a permanent four-lane cross section from Ackroyd Road to Sea Island Way.

The construction zone for the guideway will be located along the east side of Number 3 Road outside of the traffic lanes. The permanent four- and five-lane cross-section on Number 3 Road will be maintained during the guideway construction. Conceptual traffic management plans are shown in Drawings 865704-CONF-41DK-1471 through 1473, along with typical cross-sections.

A reduced speed of 40 km/h will be posted through the construction work zone.

A permanent sidewalk will be provided along the west side of Number 3 Road and temporary pedestrian walkways will be provided along the east side of Number 3 Road during construction.

Vehicle accesses to commercial/business premises on the east side of Number 3 Road will be temporarily closed for three to four days when a beam is erected across the access. Vehicles belonging to businesses fronting Number 3 Road will be directed to the back entrance or parallel side road and/or a temporary access will be provided onto Number 3 Road.

The 98 B-Line bus will be routed to Garden City during construction.

Intersections (Park Road to Sea Island Way): The elevated guideway will cross over the east leg of the intersections along Number 3 Road from Park Road to Sea Island Way. During the erection of overhead guideway beams, the east leg of the following intersections along Number 3 Road will be temporarily closed to traffic:

- Westminster Highway
- Ackroyd Road
- Lansdowne Road
- Alderbridge Way
- Alexandra Road
- Leslie Road
- Cambie Road
- Capstan Way
- Sea Island Way

The west, north and south legs of the major intersections will remain open to traffic, but traffic access to and from the east leg will be temporarily closed.

At each crossing, the beam erection will close the road for three to four days. Signage will be strategically placed in advance of the closure to divert vehicle traffic to alternative routes. Only one east-west road will be closed at one time to minimize traffic disruption.

Bridgeport Road to River Drive: From Bridgeport Road to River Drive, temporary road closures will be required at the following road crossings for the beam erection:

- Bridgeport Road
- Number 3 Road
- Charles Street
- Van Horne Way

These minor roads will be temporarily closed for three to four days for the beam erection. Signage will be placed to divert pedestrians, bicycles and vehicles around the road closure via adjacent local roads. To minimize traffic disruption, only one road will be closed at a time.

8.1.6.3.4 Delay Management

Construction will require temporary lane reductions along Number 3 Road and temporary closures of cross-streets. SNC-Lavalin/Serco will investigate and implement measures to mitigate traffic delays, including:

- Modelling of area-wide traffic to determine traffic diversion, identify impacts on adjacent corridors and establish mitigation measures.
- Preparation and implementation of a public communications plan to inform the travelling public of lane reductions/road closures and alternative routes. The communications plan will include signage (static and CMS), newspaper notices, radio announcements and a website.

8.1.6.4 Cambie Street Corridor from Fraser River to South West Marine Drive

8.1.6.4.1 Existing Roadway

Cambie Street between Kent Avenue and South West Marine Drive is a two-lane undivided road.

8.1.5.4.2 Construction Work Area and Traffic Management

North of Kent Avenue, the elevated guideway will run along the west side of Cambie Street for 200 metres, cross over to the east side of Cambie Street, and run along the east side to South West Marine Drive.

Construction of the elevated guideway along the west and east sides of Cambie Street will encroach on the roadway. One lane in each direction and/or single-lane alternating traffic operation will be provided along Cambie Street during construction on the west and east sides.

Construction of the crossover will require temporary closure of Cambie Street for three to four days. Signage will be strategically placed to divert traffic on the section of Cambie Street south of South West Marine Drive to adjacent parallel streets, including Yukon Street and Ash Street. A temporary traffic circulation plan will be prepared to ensure adequate accessibility to local businesses.

At driveway crossings, the beam erection will temporarily close the access for three to four days. Access to business premises will be maintained by way of the back entrance and/or provision of a temporary access.

A conceptual traffic management plan for this section of the corridor is shown in Drawing 865704-CONF-41DK-1473.

8.1.6.5 Cambie Street from South West Marine Drive to Broadway Avenue

8.1.6.5.1 Existing Roadway

Between South West Marine and King Edward Avenue, Cambie Street has a pavement width of 10.4 metres in each direction, with three northbound and three southbound lanes. The lanes are separated by a wide median that varies from 10.7 and 24.0 metres.

Between King Edward Avenue and West 12th Avenue, Cambie Street has six lanes with no centre median. The pavement width varies with a width of 17.6 metres at 24th Avenue and 16.3 metres at 14th Avenue.

Sidewalks run along both sides of Cambie Street. Trolley bus service (Route 15) runs along Cambie Street.

8.1.6.5.2 Construction Work Area and Sequence

The guideway will be elevated along the centre median of Cambie Street between South West Marine Drive and 64th Avenue. It will descend into a tunnel portal just north of 64th Avenue and will then run underground along northbound lanes of Cambie Street to Broadway.

South West Marine Drive to King Edward Avenue: The southbound lanes of Cambie Street will be reconfigured for two-way traffic, and the northbound lanes closed to traffic and designated as a construction zone from South West Marine Drive to King Edward Avenue.

The cut-and-cover guideway construction will start just north of 64th Avenue and proceed north along the northbound lanes of Cambie Street. The active work area for the cut-and-cover construction will have a length of approximately 350 metres and a width of 10.4 metres, which will be contained within the northbound lanes of Cambie Street. Concurrently, tunnel construction will also proceed along the northbound lanes of Cambie Street between 36th and 29th Avenue.

As the construction proceeds north, the trench will be backfilled and the northbound lanes will be partially restored but will remain closed to traffic, except for limited local traffic access and construction vehicle access.

King Edward Avenue to Broadway Avenue: North of King Edward Avenue, the active work area will have a length of approximately 350 metres and a width of about 9 to 10 metres, which will occupy the three northbound lanes and encroach on the southbound lanes. When the cut-and-cover guideway construction is completed up to Broadway Avenue, the northbound lanes of Cambie Street will be reinstated from South West Marine Drive to Broadway Avenue and opened to traffic.

As the construction proceeds north, the trench will be backfilled and the northbound lanes will be partially restored but will remain closed to traffic, except for limited local traffic access and construction vehicle access.

8.1.6.5.3 Traffic Control Plan

Cambie Street: Between South West Marine Drive and King Edward Avenue, traffic in both directions will use the existing southbound lanes of Cambie Street, as construction will occupy the northbound lanes. Two northbound and two southbound lanes will be accommodated by temporarily widening of the existing southbound lanes by 1.5 metres on the median side.

Between King Edward Avenue and Broadway Avenue, traffic will be shifted to the west side of Cambie Street, with one lane in each direction maintained through the construction zone.

Conceptual traffic management plans are shown in Drawings 865704-CONF-41DK-1473 through 1466, and typical cross-sections are shown in Drawings 865704-CONF-41DK-1477 through 1479.

A reduced speed of 40 km/h will be posted through the construction work zone. Left-turn movements from Cambie Street to minor cross-streets will be temporarily prohibited to minimize disruption to traffic flow. As well, parking on Cambie Street will be prohibited.

As the overhead trolley bus lines will be temporarily removed during construction, public transit service using conventional buses is proposed along Cambie Street. The conventional buses will share the curb lanes with other vehicular traffic. Bus stops that are adjacent to the 350-metre active work area will be temporarily relocated. Bus bays will be provided to minimize disruption to traffic flow, where possible.

Sidewalks will remain open on both sides of the street at all times for pedestrian access to residences and businesses. Bicycles will be temporarily diverted to parallel north-south local roads.

Major Intersections: At major intersections along Cambie Street, construction works will be staged to maintain east-west cross-traffic movements. A "top-down" construction method will be employed at Station constructions to shorten the duration of traffic disruption. The major intersections are:

- South West Marine Drive
- 49th Avenue
- 41st Avenue
- King Edward Avenue
- West 16th Avenue
- West 12th Avenue
- Broadway Avenue

The north and south approaches will each contain one or two through-lanes, a separate left-turn lane and right-turn movement shared with the through-lane. There will be temporary lane reductions on the east and west approaches.

Minor Cross-Streets and Property Access: The existing northbound lanes of Cambie Street will be designated as a continuous construction zone between South West Marine Drive and Broadway Avenue. Within the construction zone, access to properties and streets on the east side of Cambie Street will change as cut-and-cover tunnel construction progresses along Cambie Street.

The access conditions along Cambie Street during each period of tunnel construction are shown in Drawing 865704-CONF-41DK-1481. During the pre- and post-construction period, limited local access will be permitted as described in Drawing 865704-10041DK-1481 and summarized as follows:

- Local traffic access to curbside parking, driveways and side streets permitted on the east side of Cambie Street in the northbound direction only
- East-west cross-traffic movements permitted across the construction zone
- Sidewalks maintained on both sides for pedestrian access to properties
- Emergency vehicle access maintained to properties on east side of street

During the construction period, minor cross-streets and driveway accesses on the east side of Cambie Street will be temporarily closed to vehicle traffic until the active work area moves past the cross-street. Signage will be positioned to divert pedestrian, bicycle and vehicle cross-traffic to the nearest open cross-street beyond the active work area.

8.1.6.5.4 Delay Management

During construction, the number of lanes along Cambie Street will be reduced from six to four lanes between 64th Avenue and King Edward Avenue, and from six to two lanes between King Edward

Avenue and Broadway Avenue, which will cause delays to traffic during peak and off-peak hours. SNC-Lavalin/Serco will investigate and implement several measures to mitigate traffic delays:

- Modelling of area-wide traffic to determine traffic diversion, identify impacts to adjacent corridors and establish mitigation measures.
- Preparation and implementation of a public communications plan to inform the travelling public of lane reductions/road closures and route alternatives. The communications plan will include signage (static and CMS), newspaper notices, radio announcements and a website.
- Implementation of a one-way detour route between West 12th Avenue and West 2nd Avenue. Northbound traffic will be routed to West 12th Avenue, Yukon Street, West 2nd Avenue to the Cambie Street on-ramp. Yukon Street will be temporarily designated as a one-way street in the northbound direction and a temporary traffic signal will be installed at the Yukon Street/West 2nd Avenue intersection to facilitate by-pass traffic movements. Southbound traffic will be routed to the Cambie Street off-ramp, West 2nd Avenue, Ash Street and West 12th Avenue. Ash Street will be temporarily designated as a one-way street in the southbound direction.

8.1.6.6 Cambie Street from Broadway Avenue to Commodore Road

8.1.6.6.1 Existing Roadway

Between Broadway Avenue and the approach to the bridge, Cambie Street has six lanes and a narrow centre median. Sidewalks are along both sides of the street.

8.1.6.6.2 Construction Work Area and Sequence

The work area for the cut-and-cover construction will have a width of approximately 10 metres, which will occupy the three northbound lanes and encroach on the southbound lanes. Guideway construction will commence at Broadway Avenue and proceed north to Commodore Road. The active construction work area will have a length of approximately 350 metres. North of Commodore Road, the guideway will be constructed using a tunnel boring machine.

As the construction proceeds north, the trench will be backfilled and the northbound lanes will be partially restored but will remain closed to traffic, except for limited local traffic access and construction vehicle access.

8.1.6.6.3 Traffic Control Plan

Cambie Street: With construction along the east side of Cambie Street, traffic will be shifted to the west side of the road, with one lane in each direction maintained through the construction area. Between West 7th Avenue and West 6th Avenue, where the guideway crosses to the west side of Cambie Street, construction will be staged to maintain one lane in each direction at all times on Cambie Street. When cut-and-cover construction moves off of Cambie Street on the west side, Cambie Street between Broadway Avenue and West 6th Avenue will be fully reinstated and opened to all traffic.

During construction of the guideway from West 6th Avenue to West 2nd Avenue, the two Cambie Street off-ramps to West 2nd Avenue westbound and eastbound will be temporarily closed during construction. Conceptual traffic management plans are shown in Drawing 865704-CONF-41DK-476.

 805

A reduced speed of 40 km/h will be posted through the construction work zone. Left-turn movements from Cambie Street to minor cross-streets will be temporarily prohibited to minimize disruption to traffic flow.

As the overhead trolley bus lines will be temporarily removed during construction, public transit service using conventional buses is proposed along Cambie Street. The conventional buses will share the curb lanes with other vehicular traffic. Bus stops that are adjacent to the 350-metre active work area will be temporarily relocated. Bus bays will be provided to minimize disruption to traffic flow, where possible.

Sidewalks will be maintained on both sides of the street for pedestrian access to businesses. Bicycles will be diverted to parallel north-south local roads.

Major Intersections: At the major intersections of Broadway Avenue and West 2nd Avenue, construction works will be staged to maintain cross-traffic movements. A "top-down" construction method will be employed to shorten the duration of construction.

At the Cambie Street/Broadway Avenue intersection, a through-lane shared with the right-turn movement will be provided on the north and south approaches. There will be lane reductions on the east and west approaches.

Minor Cross-Streets: Minor cross-streets on the east side of the construction zone will be temporarily closed to vehicle traffic during construction. Signage will be erected to divert pedestrian, bicycle and vehicle cross-traffic to the nearest open cross-street beyond the active work area. Drawing 865704-CONF-41DK-1481 shows the access conditions for the section of Cambie Street north of Broadway Avenue.

Accesses: The existing businesses along the east side of Cambie Street have their driveway accesses onto the east-west cross-streets. Access to the cross-streets will be by way of Yukon Street during construction.

8.1.6.6.4 Delay Management

During construction, the number of lanes along Cambie Street will be reduced from six to two between West 12th Avenue and West 7th Avenue, which is expected to cause delays to traffic during peak and off-peak hours. SNC-Lavalin/Serco will develop and implement a public communications plan to inform the travelling public of lane reductions/road closures and alternative routes. The communications plan will include signage (static and CMS), newspaper notices, radio announcements and a website.

In addition, a portion of the traffic will be routed around this section of Cambie Street along a one-way detour route.

8.1.6.7 Downtown Vancouver from Commodore Road to Cordova Street

The section of guideway north of West Georgia Street will be cut-and cover construction, as will the stations at Davie Street, Robson Street and Cordova Street. The open excavation for the cut-and cover tunnelling will require road closures and lane restrictions.

The guideway between Commodore Road and West Georgia Street will be constructed using tunnel-boring machines, which will cause minimal disruption to traffic.

8.1.6.7.1 Cut-and-Cover Construction

Granville Street: Granville Street will be closed to traffic from West Georgia Street to Cordova Street and designated as a construction zone. The construction work area will be approximately 18 metres in width, will occupy the existing two traffic lanes.

Intersections along Granville Street: Where the cut-and-cover guideway and/or stations cross under an intersection, the construction will be staged to maintain through-traffic movements on the cross-streets. The intersections where cut-and-cover construction is planned are:

- Granville Street and Robson Street
- Granville Street and Dunsmuir Street
- Granville Street and Pender Street
- Granville Street and Hastings Street
- Granville Street and Cordova Street

At the intersections, the guideway will be constructed in 7.0-metre segments, using a "top-down" construction method, with a work zone that will occupy two traffic lanes on the cross-street. When the top slab of the 7.0-metre segment is completed, the work zone will be backfilled, and the road will be restored and opened to cross-street traffic. Construction will then proceed on the next 7.0-metre segment of guideway.

Davie Street: The cut-and-cover construction of Davie Street station will be staged to maintain through-traffic movements at Pacific Boulevard. Davie Street will be temporarily closed during the station construction.

8.1.6.7.2 Traffic Control Plan

Granville Street: The construction along Granville Street will require temporary closure of the street from West Georgia Street to Cordova Street. Buses and taxis on Granville Street will be rerouted to Seymour Street and Howe Street. Access to existing parking structures at the Granville Street and Cordova Street intersection will be maintained.

Sidewalks and pedestrian access to businesses along both sides of Granville Street will be maintained during construction by cantilevering the walkway, where necessary.

Intersections along Granville Street: During construction across an intersection, one lane in each direction will be maintained on the cross-street with prohibition of left- and right-turn movements. At Dunsmuir Street, which is a one-way road, two westbound lanes will be maintained with left- and right-turn movement prohibited. A reduced speed of 40 km/h will be posted through the construction work zone.

Along Granville Street, only one construction work area at an intersection will be ongoing at a time to minimize traffic disruption from multiple work areas.

Davie Street: Construction of the Davie Street station will temporarily close Davie Street at Pacific Boulevard. Traffic will be rerouted to adjacent parallel streets with strategic placement of signage to divert traffic away from the work area. The Route 1 bus service along Davie Street will be temporarily diverted.

8.1.6.8 Cambie Street and King Edward Avenue Intersection

Where the cut-and-cover guideway and/or station cross a major intersection, construction will be staged to provide a left-turn lane and at least one through-lane on all intersection approaches. As an example, the construction staging and traffic management at the Cambie Street and King Edward Avenue intersection is described below.

8.1.6.8.1 Existing Intersection

The Cambie Street and King Edward Avenue intersection has three through-lanes on the northbound and southbound approaches with left-turn lanes. It has two through-lanes on the eastbound and westbound approaches with left-turn lanes.

There are bus stops at the intersection for the Cambie Street (Route 15) and King Edward Avenue (Route 25) bus routes. Pedestrian crosswalks are on all approaches.

8.1.6.8.2 Construction Staging and Detours

The cut-and-cover guideway and station will be constructed in four stages, as follows:

Stage 1 – South Half of Station: The construction work area for the south half of the station and ventilation room will occupy the northbound lanes and eastbound lanes. The intersection will be temporarily shifted to the northwest encroaching on the existing commercial building at the northwest corner, which will be demolished for the station. The intersection configuration will maintain one through-lane and a left-turn lane on each approach, as shown in Drawing 865704-CONF-41DK-1470.

Stage 2 – North Half of Station: The construction work area for the north half of the station will occupy the northbound and westbound lanes. The intersection will be temporarily shifted to the southwest. The intersection configuration will maintain one through-lane and a left-turn lane on each approach.

Stage 3 – Cut-and-Cover Guideway Construction: The guideway will be constructed along Cambie Street in a northerly direction. The guideway construction will stop at the south end of the underground station and then continue at the north end of the station.

The construction work area and proposed intersection configuration during construction are shown in Drawing 865704-CONF-41DK-1480. The existing through and turning lanes on the eastbound and westbound approaches will be maintained. The northbound and southbound approaches will be limited to one through-lane in each direction, with left-turn lanes. Once the guideway construction is completed up to Broadway Avenue, Cambie Street will be reinstated to its original six-lane cross-section and opened to traffic.

Stage 4 – Station Concourse: The construction work area for the station concourse will encroach on the southbound lanes. The southbound lanes will be temporarily shifted to the east. The intersection configuration will maintain two through-lanes and a left-turn lane on the northbound and southbound approaches. The existing lanes on the eastbound and westbound approaches will be maintained.

8.1.6.8.3 Buses and Pedestrians

A reduced speed of 40 km/h will be posted through the construction work zone. Where existing bus stops will disrupt traffic flow through the intersection, they will be temporarily relocated upstream or downstream of the intersection. Temporary intersection configurations will maintain pedestrian crosswalks on at least three intersection legs.

8.1.6.9 Vancouver International Airport Connector

The construction of the elevated guideway will start at Bridgeport Station and proceed in a westerly direction to the Domestic Terminal of the Vancouver International Airport. East of the terminal buildings, the majority of the construction work will be located outside of the road right-of-ways, except where the elevated guideway crosses over a road, which will require temporary road closure.

A three- to four-day road closure will be required at each road crossing. Table 8.1 below identifies the road crossings, road closures and the methods used to accommodate traffic. Only one road closure will be implemented at a time. Signage will be strategically placed to divert traffic to alternate routes around the construction area.

Table 8.1: Road Crossing, Road Closures and Methods to Accommodate Traffic

ROAD CROSSING	ROAD CLOSURE	TRAFFIC MANAGEMENT
Grauer Road	Temporary closure	Divert traffic to Templeton Street
Grant McConachie Way (south approach to Arthur Laing Bridge)	No closure	
Templeton Street	Temporary closure	Temporary detour
North Service Road – crossing at east end	Temporary closure	Divert traffic to Connector Road No. 1
Connector Road No. 1	Temporary closure	Divert traffic to Connector Road No. 2
North Service Road – crossing west of Connector Road No. 1	Temporary closure	Divert traffic to alternate routes via Grant McConachie Way and Connector Roads
North Service Road – near to terminal building	Temporary closure	Provide temporary detour
Connector Road No. 2	Temporary closure	Divert traffic to Connector Road No. 1
McDonald Road	Temporary closure	Divert traffic to adjacent road

For the existing land uses on the north side of the guideway alignment, at least one access to each land use will be maintained at all times. Where required, a detour and/or temporary access will be provided when the guideway construction blocks an existing access.

For construction of the guideway adjacent to the terminal buildings, detailed traffic management plans will be developed to micromanage the movement of pedestrians and vehicles around the construction work zone in a safe and efficient manner. The traffic management plans will ensure pedestrian and vehicle access to arrival and departure levels, and parking, at all times.

8.1.6.10 Construction Vehicle Routes

Excavation Haul Route: The material excavated from the cut-and-cover construction along Cambie Street will be hauled to barges on the North Arm of the Fraser River at the foot of Fraser Street. There will be 100 to 150 haul vehicle trips per day to and from the barge loading dock.

The main haul route, with a possible alternate via Yukon Street and South West Marine Drive, is shown in Drawing 865704-CONF-41DK-1481. The loaded haul trucks will travel south along the west side of Cambie Street and east along Kent Avenue and travel east to the barge loading dock. The return route is a reversal of the haul route. The empty haul trucks will travel north on the east side of Cambie Street.

Precast Segment Transport: The precast guideway segments for the cut-and-cover construction along Cambie Street will be transported by low-bed truck from the casting yard on the south side of Kent Avenue at Fraser Street. There will be six to eight transport truck trips per day to and from the work area.

The main transport route, with a possible alternate via Yukon Street and South West Marine Drive, is shown in Drawing 865704-CONF-41DK-1481. The loaded trucks will travel by way of Kent Avenue and the east side of Cambie Street..

8.2 SCHEDULE

8.2.1 Overview

The schedule of activities for the Canada Line project is presented in Schedule 2 of the Concession Agreement.

8.2.2 Critical Path

The most critical path on the project is summarized as follows:

Commercial and Financial Closure
↓
TBM Delivery
↓
Tunnel Boring and TBM Removal
↓
Completion of Rail, Systems, etc.
↓
Completion of System Commissioning and Trial Running

The other major "near-critical" paths involve a number of key issues, including the following:

- Early design and receipt of permits for the Fraser River Crossing, in order to perform in-river works in the fall/winter of 2005/6
- Early possession of the Kent Street precast yard
- Production and placement of the Cambie Street precast
- Vehicle design, delivery, assembly and testing

While other major operations (such as some sections of the elevated guideway) are not critical, they still need to be managed proactively to avoid becoming critical. Please see subsection 8.3 Float, in this volume, for further discussion.

8.2.3 Commercial and Financial Closure Issues

Commercial Closure is scheduled for March 29, 2005, to allow for the necessary preceding legal and financial activities. Financial Closure is scheduled for July 29, 2005, which is the business day preceding August 1, 2005 (a public holiday). The Financial Closure date is determined primarily by receipt of the Environmental Assessment Certificate (EAC), but it is also assumed that major access agreements with the cities will be required.

Several other activities will need to occur prior to either Commercial or Financial Closure in order to achieve the overall schedule and to mitigate risk. The major items are summarized below:

- Mobilize project management and technical departments
- Mobilize all major internal contracts and joint ventures
- Complete a significant amount of preliminary engineering
- Obtain strategic permits
- Obtain strategic properties and access agreements
- Perform extensive traffic modelling and planning
- Conduct extensive public consultation
- Make significant progress on station and guideway design
- Design strategic utility relocations and procure related long-lead items
- Order and commence fabrication of strategic construction equipment (TBM, launching trusses, precast yard buildings and forms)
- Procurement of casting machines for precast yard
- Procurement of launchers for elevated guideway and cut-and-cover guideway
- All permitting required prior to actual construction
- Procurement of shoring system

Note that while no permanent construction work is currently planned to take place until after Financial Closure, there may be certain strategic utility relocations and localized site preparation activities that can be identified after the Preferred Proponent is announced. No onsite work will, however, be undertaken before the receipt of the EAC.

8.2.4 Discussion of Project Schedule by WBS Area

The Project Schedule covers all phases of the project, from design through to construction. It has been produced as a CPM schedule in Primavera P3EC, meaning that all activities have been linked using appropriate network relationships.

The schedule Work Breakdown Structure (WBS) is used to create headings and subheadings in the Project Schedule. The WBS has been developed in such a way that it intuitively reflects the way the project will be managed and constructed. For ease of reference, the following commentary has been structured around the WBS.

General

- The major milestones defined in Section 3.4 of the BAFO Invitation are included and fall on appropriate dates. Additional milestones have been added to indicate additional key dates resulting from the schedule.
- Financial and legal activities show the work involved in achieving Commercial Closure, after which the only activity required to achieve Financial Closure is the receipt of the EAC.
- A significant project management and technical staff will ramp up as soon as Preferred Proponent is announced. The consultation team will also mobilize immediately.
- Preliminary engineering includes the final definition of the alignment, the development and approval of a design manual and the production of definitive descriptive drawings for the stations.
- There will be a project-wide program for the consolidated procurement of standard station components, which will be provided to individual station contractors.
- Throughout the schedule, all design activities are followed by a "review and design completion" activity, allowing for review by RAVCO, followed by completion of the design. These activities are linked to corresponding procurement and/or construction activities.

Major Permits

- Major permits have been grouped by the authority having jurisdiction. Durations have been established through initial discussions with these authorities, taking into account the preliminary work already carried out by RAVCO.
- The most critical items are the EAC and permits related to the Fraser River North Arm Bridge
- It is likely that permits will be required to upgrade the existing barge facility at the YVR Precast Yard.

Access Rights

- These have been grouped by region (Richmond, Vancouver and YVR).
- We have assumed that the City and YVR access agreements must be in place prior to Financial Closure. They are also required for starting any utility relocations.
- Private properties have been grouped into areas that reflect the alignment and the construction program. At each area, a typical sequence of steps has been used from "Finalize Acquisition Requirements" through to "Vacate Property." These have been tied to subsequent utility relocation and construction activities.
- Most of the properties are shown as being vacated as early as possible to mitigate risk, although some vacating of the premises has been postponed where possible.

Traffic, Roadwork and Utility Relocations

- Traffic planning will commence very early, with detailed modelling and strategy development. Major traffic pattern changes have been identified in the schedule at the regional level, with most needing to be implemented by late 2005. This section of the schedule must be read in conjunction with subsection 8.1.6.

- Utility relocations and "pre-construction" roadwork has been shown for each major section of the alignment and at underground stations. Although our approach is generally to perform this type of work as soon as possible, we have postponed some less-urgent activities to spread out the workload.

Precasting

- The Kent Street precasting facility will remain until fall 2008 (see Drawing 865704-CONF-42DK-4062). It will then be decommissioned promptly and handed back to RAVCO.
- The precast production for the bored tunnels is also shown in this section.
- Shop drawings for all precast types needs to be well advanced by January 2006, which means a significant amount of detailed guideway design must be completed several months prior.

Elevated Guideway Substructure

- The substructure will proceed on a number of independent fronts.

Elevated Guideway Superstructure

- The elevated structure will involve the use of two launching systems (LG1 and LG2). Special spans will be erected by crane.
- The current plan is that LG1 will run northward from the Fraser River Crossing to the 64th Avenue Portal. It will then be relocated to Richmond Centre, where it will run northward to Capstan. LG2 will run southward from the Fraser River Crossing to Capstan. It will then move across the Middle Arm Crossing and complete the guideway to YVR #4.

River Crossings

- In-river work for the Fraser River Crossing will be performed prior to the 2006 fishery closure, allowing the bridge to be completed by mid-2007. If this opportunity is lost, the bridge will be delayed a whole year and will become near-critical. A significant effort will be required to ensure that permits and sufficient design are in place by fall 2005.
- The Middle Arm Crossing is less critical, but will still be constructed by mid 2007, even with in-river work occurring in fall 2006.

Elevated Stations

- In most cases the station structures will be constructed after the guideway precast installation. A notable exception is YVR #4, where the station substructure should start earlier to avoid unnecessary delays.
- The station structures will be typically constructed after the guideway has been erected.
- At YVR where the guideway erection occurs later than in Richmond, the station substructures will start in advance of the guideway.
- The stations are also tied to the pulling of power and systems cabling along the guideway, which typically terminates at each station.

Cambie Cut and Cover – Precast Guideway

- The construction operation will commence at the 64th Avenue Portal in early 2006, until it reaches 12th Avenue in fall 2007.
- Timely completion is essential to allow decommissioning of the Kent Street precast yard and also to allow the return of regular traffic patterns on Cambie Street.

Cambie Cut and Cover – Cast-in-Place Guideway

- Construction of the 63rd to 64th Avenue Portal will commence in spring 2006, after the start of the precast guideway installation. This operation will then move to 12th Avenue, where it will proceed on a single front in a northerly direction towards Broadway, and ultimately to 2nd Avenue, by late 2007.
- The Little Mountain bypass structure will be constructed northward on a single front, from early 2006 until mid-2007.
- In a separate operation, the TBM entry pit north of 2nd Avenue will have to be excavated and shored in late 2005, ready to accept the TBM in spring 2006. The permanent guideway structure in the pit will be constructed immediately after the removal of all TBM components and infrastructure in mid-2008.

Cambie Cut and Cover – Stations

- The stations are also tied to the pulling of power and systems cabling along the guideway, which typically terminates at each station.

Bored Tunnels

- This is the primary critical path for the project.
- The TBM must be ordered in March 2005, with delivery to site in March 2006.
- The first tunnel pass is scheduled for completion in May 2007.
- The second tunnel pass is scheduled for completion in May 2008.
- Davie and Robson station boxes must be fully excavated with base slabs for the first pass of the machine. For the second pass, construction at each station will be significantly advanced, although platform slabs and finishes will not have been installed, and an opening will still be left in the roof to access the TBM as it passes through.

Downtown Cut and Cover

- It is envisaged that this work will be contracted as a separate contract, although it may be combined with Waterfront Station.
- The TBM exit pit will have to be ready to accept the TBM in spring 2007. The permanent guideway structure in the pit will be constructed immediately after the removal of all TBM components and infrastructure in mid-2008.
- The balance of the work will proceed from just south of Dunsmuir Street to the south face of the Waterfront Station structure, with completion slated for fall 2007.

Downtown Stations

- Waterfront station is the largest and most complex of the three downtown stations, and although is independent of the TBM, it will still be necessary to award a contract for the work in late 2006.

Trackwork

- The trackwork has been scheduled to proceed radially outwards from the OMC on three fronts (Vancouver, Richmond and YVR). Activities have been broken down into sections of alignment separated by stations.
- Trackwork is on the critical path from 2nd Avenue to Waterfront.

Power and Systems

- Power and systems work has also been scheduled to proceed radially outwards from the OMC on three fronts (Vancouver, Richmond and YVR). Activities have been broken down into sections of alignment separated by stations.
- Power and systems installation is on the critical path from 2nd Avenue to Waterfront.

Vehicle Procurement

- An order for the vehicle needs to be placed soon after Financial Closure.
- The first vehicles are scheduled to arrive in early 2008, ready for the commencement of testing at the OMC. The balance of the vehicles will continue to arrive progressively until early 2009.

OMC and System Commissioning

- The OMC facility buildings and approximately half of the rail loop will be constructed from mid to late 2006 until late 2007. Remaining trackwork and systems work will then be installed, with the OMC ready for vehicle testing in spring 2008.
- Dynamic and integrated system testing on each station will run radially outwards from the OMC, from mid-2008 until mid-2009. A 10-week commissioning period for the whole system will follow.

Completion

- Basic pre-operational activities have been included.
- This section also includes a final 12-week period for test running, pre-trial and trial running leading up to system acceptance.

8.3 FLOAT

Our schedule reflects our assessment of major construction activity production rates. The productivity rates are based on the experience of our team and our participating subcontractors: Walter Construction, Chant Construction and Rizzani de Eccher. Our team and participating subcontractors have significant experience with very similar construction means and methods to those we have proposed for this project. Production rates are based on the application of levelled resources with unrestricted access to schedule float.

Actual progress in all areas of the project will be monitored against the Project Schedule on a weekly basis and immediate remedial action will be initiated if actual progress threatens the overall schedule. The remedial action may involve expediting design, adding additional equipment and labour, or even adding additional headings on site.

In the Project Schedule, float has already been used selectively to spread out work to avoid obvious peaks in resource demands and associated cost implications as well as cost escalations. Even so, many activities in the schedule still show significant float, which must be preserved as a future resource-levelling tool. If activities with float are indiscriminately delayed too early in the project, a dramatic downstream peak in construction resources can often result. In the projected construction climate in the Lower Mainland between 2005 and 2009, this must be avoided unless the reason for postponing such activities is compelling. Another reason to minimize early consumption of float is to preserve the opportunity for achieving early service commencement.

To manage this key issue, we intend to perform a thorough resource loading of the Project Schedule prior to Commercial Close, which will provide a basis for forecasting, avoiding and managing resource peaks through the life of the project.

9.0 ENVIRONMENTAL REQUIREMENTS

9.1 UNDERSTANDING AND APPROACH

9.1.1 *Understanding of the RAVCO/Concessionaire Responsibilities and Reporting Relationships*

The Environmental Requirements for construction of the Canada Line that will be met by SNC-Lavalin/Serco are set out in the following documents:

- Section 6 of the RFP, Section 2.9 of Appendix 3 to the RFP and Sections 11 and 12 of Schedule 2 to Appendix 5 of the RFP
- Section 5 of the BAFO Invitation and Section 3.1.9 of Attachment 2 thereto
- The Design and Construction Requirements document, which is Schedule 2 of Appendix 5 of the BAFO Invitation (Draft Concession Agreement between RAVCO and SNC-Lavalin/Serco), particularly Section 11, Environmental Requirements, and Section 12, Archaeological Requirements
- The RAVCO report entitled "E1 – 30 Environmental Requirements," which is referenced in Section 11.3(b) of Schedule 2 to the Draft Concession Agreement

SNC-Lavalin/Serco further understands from the RFP and BAFO documents noted above, and from discussions between SNC-Lavalin/Serco and RAVCO officials during the BAFO stage, that the relative responsibilities for environmental matters are as follows:

A. RAVCO

1. RAVCO will be responsible for the preparation and submission of the Environmental Assessment Certificate Application (EACA), to be prepared as directed by the order issued to RAVCO by the British Columbia Environmental Assessment Office (EAO) on September 11, 2003, and in accordance with the detailed EACA Terms of Reference – Richmond-Airport-Vancouver Rapid Transit Project (RAVP) issued by the EAO on November 19, 2003. The EACA will also meet the requirements for a screening-level study for the RAVP under the Canadian Environmental Assessment Act (CEAA).

2. RAVCO will be responsible for acquiring the Environmental Assessment Certificate (EAC) for the RAVP to be issued under the British Columbia Environmental Assessment Act (BCEAA) and the approval of the federal Minister of Environment under CEAA. The EAC and the federal CEAA approval (the EA Approvals) will be issued to RAVCO once the EACA has been reviewed and accepted. RAVCO is still targeting the summer of 2005 for the EA Approvals to be acquired.

3. RAVCO will be responsible for the approvals required from the North Fraser Port Authority (NFPA) for the bridge crossings of the North Arm and Middle Arm of the Fraser River, as part of its responsibilities as set out in the RFP and BAFO Invitation to acquire the necessary lands (including water lots where necessary) for the construction and operation of the Canada line.

4. RAVCO will be responsible for acquiring the Fraser River Estuary Management Program (FREMP) approval, as stated in Section 6.2.4 of the RFP.

5. RAVCO will be responsible for undertaking additional preliminary archaeological assessments for any proposed RAVP works in the vicinity of False Creek and for the North Arm of the Fraser River Bridge Crossing, as part of the environmental assessment studies required for the EACA.

6. RAVCO will be responsible for undertaking Stage 1 and Stage 2 preliminary site investigations in accordance with the British Columbia Contaminated Sites Regulations for some of the high-risk lands to be acquired for the proposed alignment of the Canada Line, in order to determine if there are any Undisclosed Environmental Liabilities on those lands that will have to be managed by the Concessionaire in accordance with the terms of the Concession Agreement.

B. SNC-Lavalin/Serco

1. SNC-Lavalin/Serco is responsible for acquiring all permits as defined in the Concession Agreement, except for those set out under A above.

2. SNC-Lavalin/Serco will be responsible for the performance of the Work on the Canada Line in compliance with all Environmental Laws and in accordance with the Environmental Management Plan, the Permits and EA Approval as defined in the Concession Agreement

9.1.2 Understanding of the BCEAA/CEAA Environmental Assessment Process

SNC-Lavalin/Serco has a good understanding of the requirements of the BCEAA/CEAA process for the Canada Line. We have reviewed Sections 10 and 11 and the EACA Terms of Reference for the RAVP. We have met with RAVCO officials during the BAFO Stage and discussed the content of the EACA in general terms. SNC-Lavalin/Serco understands that we may be called upon by RAVCO, once we are chosen as the Preferred Proponent, to assist in some technical areas with the completion of the EACA.

SNC-Lavalin/Serco also understands that, once the EACA is filed and becomes a public document, RAVCO will require SNC-Lavalin/Serco's assistance and support in undertaking third party consultations, during the EACA review period. Details of SNC-Lavalin/Serco's plans for supporting RAVCO during the EACA review are set out in Volume D of this Base Case submission.

SNC-Lavalin/Serco also understands that it will be required to implement a number of conditions in the EACA once it is acquired by RAVCO. SNC-Lavalin/Serco, through SNC-Lavalin's work on other major projects currently underway in British Columbia, such as the Sea-to-Sky Highway Improvement Project and the Brilliant Expansion Power Project, is very familiar with the typical conditions of EACs and the steps needed to be taken to implement those conditions on behalf of the Owner.

9.1.3 Commitment and Approach of the Environmental

SNC-Lavalin/Serco will meet the requirements in the BAFO Invitation for the preparation and implementation of the Environmental Management Plan (EMP).

The requirements for the EMP that are set out in Schedule 2 of the Concession Agreement and the RAVCO report entitled "E1-30 Environmental Requirements" will be addressed in the EMP for Construction (EMPC). A detailed draft outline of the major sections of the EMPC is provided in Section 9.2. The requirements set out in Section 11 of Schedule 2 and the related RAVCO document "E1-30 Environmental Requirements," where applicable, will also be incorporated into the Environmental Management Plan for Operations (EMPO). This is outlined in Section 9.5.

9.2 ENVIRONMENTAL MANAGEMENT PLAN FOR CONSTRUCTION

9.2.1 Introduction

This section provides an overview of the Environmental Management Plan for Construction matters (EMPC) that SNC-Lavalin/Serco will implement for the Canada Line project.

SNC-Lavalin/Serco will implement an EMPC for the Canada Line. The objectives of the EMPC will be to:

- Set out the plan for the protection of valued ecosystem components and socio-economic features during the construction of the new Canada Line
- Outline the construction activities, contractor obligations and mitigation strategies required to complete the construction
- Outline the regulatory requirements, permits, authorizations and environmental standards that will be followed during construction
- Define the role of the Environmental Monitor (EM) in the Canada Line construction work

The EMPC will encompass all work done on the project during the construction phase. The plan will address issues such as environmental awareness training, hazard and risk assessment, storm and wastewater management, materials handling, spill response, air quality, noise mitigation, archaeological resources, habitat compensation and/or mitigation, and quality assurance and quality control (QA/QC) of the EMPC through environmental monitoring.

Existing information from prior assessments, investigations, reports and engineering design works is presented where necessary to provide supporting information relevant to the EMPC.

The EMPC will be dependent on the features and activities related to the project. These include:

- Roadwork and utility relocations
- Tunnelling by boring machine
- Cut-and-cover tunnel construction
- Foundations and substructure works
- Elevated guideway construction
- River and stream crossings
- Station construction
- Track installation

 819

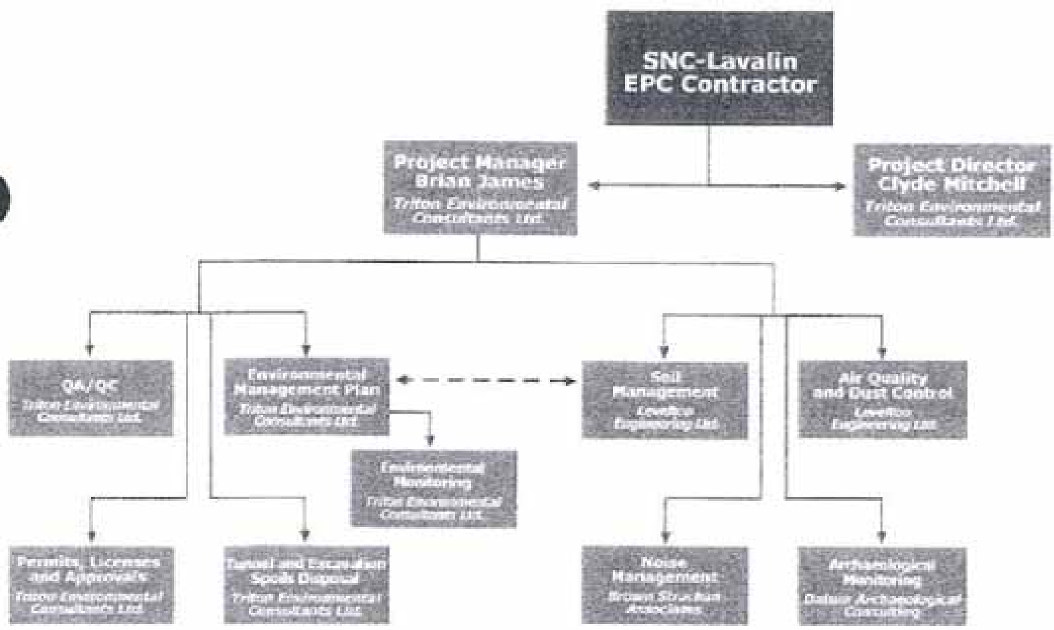
- Electrical substations construction, including interconnections to BC Hydro's system
- Operating systems installation

Details of the construction features and activities are provided in Sections 1.0, 2.0, 7.0 and 8.0 of this volume.

Risk to the environment will be managed and minimized at all stages of construction. A pre-construction hazard and risk assessment will be used to identify tasks, materials and equipment with the potential to impact the environment. Special emphasis will be placed on these tasks, materials and equipment in the various sections of the EMPC, and in the environmental awareness training and orientation programs.

Figure 9.1 below presents the proposed Environmental Management Team structure for construction of the Canada Line:

Figure 9.1: Proposed Environmental Management Team Structure



A proactive approach to environmental management is the best strategy for managing environmental risk. Therefore, environmental awareness training will be a component of the EMPC. Training will help to make construction staff aware of the potential for their activities to affect the environment, such that they take the necessary steps to minimize impacts when they are working on any construction site. An environmental awareness program will educate the employees and contractors about the key environmental principles to be followed by them during construction.

Components of the EMPC (provided in subsections 9.2.3 and 9.3) illustrate the subject matter that must be addressed and the minimum level of detail required in a comprehensive EMPC. Examples of the Construction Environmental Requirements to be developed in the EMPC are provided in Section 9.2.3. Details of Outline Plans, including: Environmental Quality Assurance/Quality Control; Landscape Restoration and Management; Tunnel and Excavation Spoils Disposal; Conceptual Plan for North Arm and Middle Arm Bridges – Engineering Designs, and Staging and Erection; and Permits, Licences and Approvals are presented in subsections 9.3 and 9.4.

9.2.2 Outline of EMPC

The EMPC to be developed will comprise two volumes. Volume I will consist of the Project Background and Environmental Plans and Volume II will provide the Detailed Construction Management Plans. Volume I will include the following sections:

- **Introduction** – will describe the EMPC objectives, outline RAVCO and SNC-Lavalin/Serco project-related commitments, outline the standards used in the EMPC development, and provide an overall outline of the EMPC
- **Background** – will provide project background information and a brief review of the EMPC development process
- **Project Implementation** – will identify project participants, describe administrative procedures to be followed by RAVCO and SNC-Lavalin/Serco during project implementation, define the roles and responsibilities of Environment Project Team members, and list project communications protocols
- **Design and Construction Methods** – will provide an overview of construction methods, activities, and schedules
- **Environmental Plans** – will define environmental plans and construction standards for the protection of environmental resources
- **Glossary** – will provide a glossary of terms used in the EMPC
- **Acronyms** – will provide a list of acronyms used in the EMPC
- **References** – will provide a list of reference materials used in the development of the EMPC
- **Appendices** – will be included as required to document information used in the development of the EMPC

Volume II of the EMPC will provide site-specific management prescriptions for the construction of the entire Canada Line. Map sheets consisting of orthophotos, planimetric maps (developed in CAD), and site profiles (at a scale appropriately selected such that sections of the Canada Line can be effectively presented in an 11"x17" format) will be prepared to depict discrete alignment segments of the Canada Line from Richmond Centre and the Vancouver International Airport to Waterfront station in downtown Vancouver. Environmental management prescriptions will be referenced to site-specific alignment locations. Each alignment segment will be covered in approximately four pages:

- The first page will provide a map overview of the segment of alignment included. This overview will document the segment of trackwork, the physical features of the section, and summarize environmental issues that are expected to be encountered during construction.

- The second page will provide an orthophoto of the segment in landscape across the top half of the page, and a planimetric map (CAD drawing) with site-specific biophysical details and legend across the bottom half of the page.
- The third page will consist of a longitudinal profile of the segment showing alignment detail including line elevation, facility components and various bio-physical features to be considered in the vicinity.
- The fourth page will provide, in tabular form, a summary of the segment code, the segment location, the associated environmental features or issues and the prescriptions or mitigation measures corresponding to each feature.

9.2.3 Construction Environmental Requirements

The Environmental Management Plan will be designed to meet the principles and practices of good environmental stewardship to protect the integrity of the environment through all phases of construction.

The following proposed components of the EMPC have been prepared to demonstrate SNC-Lavalin/Serco's understanding of RAVCO's construction requirements for environmentally sensitive areas, and the Environmental Assessment Certificate Application (EACA) requirements of BCEAA and CEAA:

- Hazard Identification and Risk Analysis
- Contaminated Sites Management
- Air Quality and Dust Control
- Noise Management
- Storm Water Drainage and Sediment Control
- Habitat Compensation/Mitigation
- Imported Soil Sampling
- Excavated Soil Sampling
- Solid Waste Management and Recycling
- Hazardous Materials Management
- Spill Prevention and Emergency Response
- Training and Orientation
- Archaeology Management
- Construction Environmental Management Program
- Residual Environmental Effects Program

Construction environmental requirements for each of the above aspects of the EMPC will form the basis upon which construction activities will be undertaken, and will be adhered to by the various parties involved in the construction of this project. For the Airport Connector segment of the Canada Line, SNC-Lavalin/Serco understands that all construction activities on Sea Island must also comply with the Vancouver International Airport Authority's Environmental Construction Standards. These aforementioned environmental construction requirements will be incorporated into the appropriate plans within Volume I of the EMPC, as well as the Detailed Construction Management Plans to be developed for Volume II of the EMPC.

9.2.3.1 Hazard Identification and Risk Analysis

Prior to the commencement of construction activities, a hazard identification and risk assessment will be completed for the key construction processes, installation tasks and construction sites described in Sections 7.0 and 8.0 of this volume. Specific tasks and equipment will be assessed and material use, transport and storage volumes and areas identified. The process will aim to identify the potential onsite and offsite hazardous tasks and materials, as well as potential consequences for the project in the event of a major or minor incident involving a particular task or substance.

The risk analysis will evaluate the exposure, likelihood, and consequence of each task and material, and categorize each item by its potential to cause environmental impacts:

- **Exposure** evaluates the number of times that a task will be performed during the project and the amount of time expended on the task or the frequency of hazardous material use. Minor exposure describes tasks that will happen once or twice during the course of the project or materials that are seldom used. Moderate exposure describes tasks that will be performed several times during the course of the project or materials that are frequently used. High exposure describes materials or tasks that will be utilized or performed daily during the project.
- **Likelihood** is a measure of the probability that the task or material will result in an environmental incident and considers factors such as procedural safeguards and the history of similar tasks or type of material. Minor likelihood describes tasks or materials that have not been known to cause environmental damage. Moderate likelihood describes tasks or materials that have the potential to cause environmental damage. High likelihood describes tasks or materials where, in the absence of mitigation, there is a reasonably high probability of environmental damage.
- **Consequence**, for a task or material, measures the consequence of an incident and includes factors such as the materials used and their proximity to environmentally sensitive features. Tasks can have minor consequence (i.e. no short-term or long-term negative effects), or they can have moderate consequence (i.e. possible short-term negative effects), or tasks can have serious consequence (i.e. possible long-term damage).

This combination of exposure, likelihood, and consequence allows tasks and materials to be ranked in a logical manner to identify the items with the highest potential for environmental damage, thereby focusing energies on mitigating the hazards and risks of these items or tasks. Training, mitigation and preventative measures will then be prioritized to focus efforts on reducing the risk of incidents with the highest potential for environmental damage.

9.2.3.2 Contaminated Sites Management

It is SNC-Lavalin/Serco's understanding that the Screening Level Contaminated Sites Assessment Study undertaken for RAVCO as part of the first round of study for the Canada Line, and the studies undertaken for the City of Vancouver and provided to RAVCO on the 6th Avenue and Cambie Street parking lot, will form the basis of the contaminated sites management plan section of RAVCO's EACA. The Screening Level Contaminated Sites Assessment focused on identifying areas of potential contamination along the proposed Canada Line corridor and ranked the potential contaminant risks as either "Low Risk," "Moderate Risk," or "High Risk." It is further understood that RAVCO will undertake Stage 1 (and Stage 2 if required) site assessments for the properties required for SNC-Lavalin/Serco's alignment, and those studies will be available to SNC-Lavalin/Serco to reveal possible currently Undisclosed Environmental Liabilities.

The results of the studies noted above will be used by SNC-Lavalin/Serco to develop a Contaminated Sites Management Plan. The plan will address the management of contaminated sites/material during construction and will include provision for:

- Encountering pre-existing contaminated soils and/or groundwater during construction
- Contingency planning to address new contamination that may be caused directly by the construction activities
- Export of contaminated materials from the construction site
- Movement of contaminated material within the construction site
- Prevention of the import of contaminated materials onto the construction site

The plan will conform to applicable provincial regulations and management practices, and will address the following:

- Additional investigation and management plans for sites recently identified by RAVCO as contaminated sites (6th Avenue and Cambie Street parking lot)
- Sampling, testing, analysis and removal procedures
- Monitoring of construction in potentially high risk areas
- Notification protocols following confirmation of a contaminated site
- Suspension of work protocol
- Risk assessment protocol
- Clean-up, remediation, mitigation and/or disposal protocol
- Reporting requirements

General management practices will include, but may not be limited to, handling of:

- Odorous, stained and/or suspected contaminated soil
- Surface drainage
- Suspected contaminated groundwater, if any

9.2.3.3 Air Quality and Dust Control

Air quality may be affected by dust emissions from excavations and soil processing activities, as well as transport and storage of imported and excavated materials. Dust emissions from excavations and soil processing, including rock blasting, crushing or material transfer will be in accordance with applicable site-specific requirements for total particulates in air emissions set by the Ministry of Water, Land and Air Protection (MWLAP), or the Greater Vancouver Regional District (GVRD).

Contractors will be responsible for conducting activities in a manner that reduces the release of airborne particles, including fumes or dust, and meeting any conditions identified in any permits from regulatory agencies. If air quality objectives are not being met, appropriate measures will be implemented to reduce dust emissions. Additional dust suppression activities may be required, or, in special circumstances (high levels of concern), the construction schedule may be adjusted. Dust emissions will be controlled using methods approved by regulatory agencies and the Environmental Monitor (EM).

If required by the appropriate Relevant Authorities, an air quality monitoring protocol will be developed. Air quality monitoring will be conducted in accordance with the procedures described in the *British Columbia Field Sampling Manual for Continuous Monitoring Plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 1996 Edition (Permittee)* or by suitable alternative procedures as authorized by the MWLAP Regional Waste Manager and the EM. If air quality sample analysis were required, it would be carried out in accordance with procedures described in the third edition of *British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials, Supplement #2 to the 1994 Edition: Analysis of Discrete Ambient Air Samples, July 1998* or by suitable alternative procedures as authorized by the Regional Waste Manager and the EM.

9.2.3.4 Noise Management

The need to operate large amounts of heavy equipment for a construction project of this nature will necessitate a certain level of noise. Construction noise varies widely for different activities and equipment, and with time.

The noise control bylaws of Vancouver and Richmond limit construction activities to periods that generally exclude night-time and early morning hours, particularly on weekends and holidays. The bylaws limit noise levels from construction. Contractors will be required to maintain equipment so that bylaws are met, and to reduce noise further where reasonably practicable.

To maintain a positive community attitude, a primary requirement of the contractor will be to advise the local community of the work procedures and schedule, particularly proposed schedule changes (e.g. night work).

Due to the requirements of a large-scale project of this nature, bylaws on occasions may be difficult to meet, e.g. night work may be essential to meet the schedule or to reduce traffic congestion. When necessary, a variance will be sought from the relevant City, as required by the applicable bylaws. The community will be advised accordingly. If required by the relevant authorities, a noise monitoring protocol will be developed for these situations.

To confirm that recognized vibration criteria are met – e.g. for construction methods such as pile driving during construction activities in densely populated areas – the contractor will be required to monitor vibration levels at certain points in time as the work progresses.

9.2.3.5 Storm Water Quality and Sediment Control

Sediment control will be an integral part of the EMPC. Contractors will be required to comply with the recommended guidelines for sediment control outlined in the Land Development Guidelines for the Protection of Aquatic Habitat, Fisheries and Oceans Canada (DFO) and the MWLAP. Care will be taken during all phases of construction to minimize sedimentation in watercourses, ditches, and storm sewers, and to avoid erosion of disturbed areas or runoff from stockpiled materials.

The storm water drainage and sediment control plan will comprise two components:

- Surface water management (i.e. surface rainfall water runoff from the construction site)
- Wastewater management (i.e. treatment and control of wastewater from activities such as tunnel boring, drilling or excavation, dewatering and concrete wash water)

9.2.3.5.1 Surface Water Management

Surface water flow will affect both at-grade and below-grade activities. To manage surface water for the at-grade activities, measures will be employed to minimize erosion of disturbed areas and therefore limit the mobilization of sediments and reduce the accumulation of suspended solids. The sediment control plan may include: covering of stockpiled soils, use of silt fencing and routing of surface water through settling ponds or infiltration galleries to remove suspended solids.

Surface water flow from below-grade activities will be either pumped to the surface to be handled as at-grade surface water, as mentioned above, or discharged directly to a local drainage sump if practical, in which case the surface water discharge will not require treatment; or pumped from the below-grade activity and transported offsite for appropriate treatment and discharge.

It is anticipated that surface water runoff from the at-grade facilities or pumped from the below grade activities will be directed to the Greater Vancouver Regional District (GVRD) storm water drainage system. If possible, all or a portion of the storm water runoff will be directed to the GVRD sanitary sewer system. This portion of the runoff will thus not require treatment prior to discharge. Surface water runoff directed to the GVRD storm water drainage system enters active surface water courses, and this discharge is thus required to meet water quality objectives set to protect the aquatic habitat conditions of the receiving watercourse.

Item 2.5 of Part B of RAVCO's Environment Requirements specifies that runoff water from the construction sites that might enter storm sewers or watercourses directly must comply with the Canadian Council of the Minister of the Environment Canadian Water Quality Guidelines for Freshwater Aquatic Life. Total suspended solids in runoff water that might enter storm sewers or watercourses directly should not exceed 10 mg/L when background-suspended solid concentrations (as measured at representative locations upstream of the discharge source) are equal to or less than 100 mg/L. Suspended solids should not exceed 10 percent of background concentrations when background concentrations are greater than 100 mg/L. However, in the Airport Environmental Construction Standards the relevant limit is 25 mg/L over background levels. Therefore, further discussion on other applicable standards to be adopted in the EMPC is required between SNC-Lavalin/Serco and RAVCO.

Discharge of surface water runoff will be monitored for compliance with regulatory guidelines. Surface water management practices will be adjusted as necessary to accommodate the volumes and flow rates expected based on the size and activity associated with particular construction sites, as well as their point of discharge in proximity to environmentally sensitive features such as fish bearing watercourses.

9.2.3.5.2 Wastewater Management

Wastewater to be discharged to the GVRD sanitary sewer system will not require treatment on site. However, any wastewater to be discharged from a construction site to the GVRD storm water drainage system will be monitored prior to discharge to ensure that suspended solids and pH levels are within acceptable GVRD limits. Any wastewater not meeting these limits will be directed to treatment facilities within the immediate vicinity of the construction activity, or transported from the construction site to nearby facilities for treatment prior to discharge. Records of the discharge monitoring will be maintained in the environmental monitoring reports.

Concrete suppliers will be informed that there will be no discharge of residual concrete or wash water on the construction site from trucks and equipment related to concrete supply, pumping, or placing equipment, except in designated areas. Designated exfiltration areas will be established where appropriate so that concrete wash water will be completely contained and discharge of concrete wastewater will not be permitted from any construction sites.

Wastewater with suspended sediments from drilling or tunnel excavation will be routed either directly to the GVRD sanitary sewer system, or through a sediment control system that may include settling ponds, and infiltration or exfiltration galleries, so that discharges meet suspended solid criteria established by regulatory agencies. The specific size, type and location of sediment control system will be established in detail prior to the commencement of construction activities and may be modified during construction, depending on performance and volumes of wastewater to be processed.

If the level of suspended solids and pH of the wastewater meets the discharge criteria, the wastewater will be discharged through the onsite surface water drainage system. If the water does not meet the suspended solid criteria or the pH criteria it will be pumped to a long-term storage tank and allowed to settle or neutralize. If all of the mitigative measures do not bring the wastewater to an acceptable standard, the water will be hauled away by tanker truck. Where possible, wastewater will also be reused on site.

The storm water drainage program and sediment control plan will also have a shutdown protocol in the event of a system overload or failure. If the rate of precipitation is so extreme that the sediment control system cannot handle the influx of water, or if any sediment control systems fail and cause an overload of the system, affected construction activities will be suspended until the rain and discharge levels subside to acceptable levels.

Water quality sampling activities will follow the procedures described in the *British Columbia Field Sampling Manual for Continuous Monitoring Plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples 1996 Edition (Permittee)* or alternative procedures as authorized by the Regional Waste Manager and the EM. Water quality analysis will be performed by a qualified laboratory or alternative procedures as authorized by the Regional Waste Manager and the EM.

9.2.3.6 Habitat Mitigation and Compensation

Construction of the Canada Line will involve disturbance to existing areas, as well as modification of drainage patterns, and impacts on some vegetation. As part of the Environmental Assessment Office (EAO) pre-application process, the Applicant (RAVCO) has commissioned a number of studies to assess environmental impacts including:

- Fisheries and Aquatic assessment
- Socio-Community/Socio-Economic Assessment
- Screening-Level Contaminated Site Assessment
- Greenhouse Gas Emissions Reduction and Co-Benefits Study
- Tree Inventories and Assessments

During development of the final EMPC, each of these documents will be reviewed for relevant information related to project impacts and recommendations for mitigation, compensation, and remediation of disturbed sites including restoration and planting. Individual recommendations from these reports will ultimately need to be adjusted based on the final design and specific project attributes such as the ultimate size of disturbed areas. These adjustments will also take into account project avoidance guidelines.

The final design for mitigation and compensation of project impacts will be developed in consultation with RAVCO, regulatory agencies and the SNC-Lavalin/Serco Environmental Management Team. This work will also be conducted in recognition of local information, such as the City of Richmond Official Community Plan – Environmentally Sensitive Areas.

Mitigation techniques should be designed to mitigate or eliminate project impacts before they occur. Typical mitigation techniques will be described throughout the EMPC, including handling of fuels and hazardous materials to minimize the risk of spills, and controlling surface water runoff from disturbed areas.

Compensation techniques typically are used where project effects cannot be effectively avoided through mitigation. Examples of some of these effects include the loss of in-stream fish habitat from a bridge pier, loss of riparian habitat from approach causeways, or loss of plant species from construction of an above ground station. It is expected that the majority of the project compensation requirements will be identified in the Environmental Approval Certificate (EAC) and the agreement-in-principle for the two river crossing that RAVCO is currently settling with DFO.

The Environmental Management Team has a wide range of experience with the design and construction of habitat compensation works, site restoration, and rehabilitation. Project habitat compensation designs will be developed so that they address agency concerns, are acceptable to RAVCO and will not adversely impact future operation of the project by creating long-term maintenance requirements.

9.2.3.7 Soil Sampling

9.2.3.7.1 Excavated Soil Sampling

A soil sampling plan will be developed to characterize the excavated material with respect to the absence (or presence) of contaminants, chemical reactivity and its suitability for reuse, or for ocean or land disposal. The plan will outline, at the minimum, the location and number of sampling sites, the number of samples to be collected and the type of analysis to be performed. The plan will need to be reviewed and approved by Environment Canada in the context of the disposal at sea option.

Materials found to contain substances of concern below the regulated or guideline concentrations may be disposed via disposal at sea if land disposal is not practical (see subsection 9.3.3.3). Spoils that are shown to be high in clay content, and without contamination above applicable levels defined by the BC Environmental Management Act (BCEMA), may be received by local municipalities for use in dyke improvements. The feasibility of other land disposal options for clean surplus excavated soils will also be examined.

In the case where disposal at sea is the chosen option and the material is found to contain substances of concern at, or higher than, the regulated or guideline concentrations, toxicity testing will be undertaken to show that it will not cause acute or chronic effects on marine organisms or human health, whether or not arising from their bioaccumulation in marine organisms.

If the soil sampling results show that the material is contaminated to levels unacceptable for land and/or disposal at sea it will be considered contaminated waste and treated as such (see subsection 9.3.3.2).

9.2.3.7.2 Imported Soil Sampling

All contractors delivering soil to the project site will be required, by contract specifications to deliver soils that are clean and not contaminated. Imported soil will be characterized in terms of contaminants, and if contaminated, will not be accepted on site.

9.2.3.8 Solid Waste Management and Recycling

The Construction Waste Management Plan will provide the basis for handling non-hazardous materials onsite. Efforts will be made to reduce the amount of construction material used and disposed of by reducing, reusing, and/or recycling.

Materials likely to be generated onsite due to construction activities will include:

- Used construction lumber, including pallets and concrete forms
- Concrete and metal debris
- Excavated or milled asphalt
- Packing materials, including paper and plastics
- Containers for various construction materials
- Waste and refuse from construction offices

Solid waste management will emphasize the reduction, reuse, and recycling of waste materials, where practicable.

Construction techniques will be designed to minimize the production of waste and will be modified as required through technical reviews in order to reduce the amount of waste produced. Materials will be reused onsite where appropriate, and other materials will be recycled whenever reasonably practicable.

Receptacles for recyclable material and for general waste material will be available and these will be clearly marked. All construction personnel will be informed of the locations of these receptacles and will be encouraged to maximize their use.

Non-recyclable construction wastes will be disposed of in approved containers designed and designated for non-recyclable waste. Any material that cannot be reused or recycled will be sent to appropriate licensed landfills.

9.2.3.9 Hazardous Materials Management

Proper handling of potentially hazardous material will be a key element of the EMPC. The proper handling, storage and transport of potentially hazardous materials will minimize potential for spills. Reducing the possibility of any hazardous material discharge will be given a high level of importance.

9.2.3.9.1 Prevention Measures

Effective prevention of a spill begins with awareness of a potentially hazardous situation. Awareness will be developed in several ways:

- Education of supervisors, subcontractors, equipment operators and site workers as to the hazards and consequences of spills. The education will emphasize methods of correct transfer, transportation, and storage of potentially hazardous materials
- Monitoring of potentially hazardous areas (areas where hazardous materials are being used) throughout the construction site by the Environmental Monitor
- Reporting of potentially hazardous situations to all appropriate parties
- Recommendations for modifications to materials handling procedures based on observations of specific onsite conditions and practices of concern

Prevention of potentially hazardous situations will be achieved by several actions:

- Refuelling according to safe, environmentally sound practices in designated areas
- Storing hazardous materials in approved containers in designated areas
- Using anti-spill devices such as double-wall tanks, impermeable surfaces, interceptor drains, and drip pans
- Storing empty hazardous materials containers in approved and properly labelled waste containers and in designated areas
- Inspecting construction equipment regularly for leaks
- Conducting equipment maintenance in designated areas

9.2.3.9.2 Underground and Aboveground Storage Tanks

During the detailed design phase of the project, the Environmental Management Team will develop a detailed Storage Tank Management System (STMS) for the construction phases of the Canada Line. This system will address the siting, design, construction, installation, operation and decommissioning of underground and aboveground storage tanks containing petroleum or otherwise flammable, combustible or potentially hazardous products. All phases of the STMS will be consistent with local government bylaws and the following regulations:

Federal

- National Fire Code
- CCME: Environmental Code of Practice for Underground Storage Tank Systems Containing Petroleum Products and Allied Petroleum products
- CCME: Environmental Code of Practice for Above Ground Storage Tank Systems Containing Petroleum Products

Provincial

- BC Fire Code, BC Services Act and the BC Fire Regulation

Municipal

- Applicable city bylaws

The design and construction of storage tanks forming part of the permanent works will be consistent with relevant standards and regulations, including, for example, the CAN/ULC-S603 Steel Underground Tanks for Flammable and Combustible Liquids and CAN/ULC-S603.1 Galvanic Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids. The installation of such underground storage tanks will reflect the siting, ground cover, filling, repair, corrosion protection and other requirements of the BC Fire Code. Secondary containment will be designed with a capacity of ≥ 110% of the volume of the largest tank, or 25% of the total volume of containers onsite (whichever is greater). The operational phases of all underground storage tanks will include reasonably frequent inspections to assess the potential for leaks, with less frequent inspections of above ground tanks systems. Operational plans will include detailed descriptions of corrective action to be undertaken when leaks are confirmed. Decommissioning plans for all storage tanks will be submitted to MWLAP, and where required, local governments, to demonstrate that the proposed decommissioning strategies meet relevant standards and regulations.

9.2.3.9.3 Transportation, Storage and Handling of Fuel and Other Hazardous Materials

Dangerous goods or materials whose release into the environment could cause adverse effects will be handled in a manner that gives due regard to the security and safety of both the material and the personnel working with them. The transportation and handling of all dangerous goods and special wastes will be carried out in compliance with standards set by the Ministry of Water Land and Air Protection (MWLAP) or, if not specifically stated, with standards and/or guidelines associated with the British Columbia Transportation of Dangerous Goods Act, Transportation of Dangerous Goods Act (Canada), British Columbia Environmental Management Act and its "Special Waste Regulation," the British Columbia Health Act and Sanitary Regulations, the British Columbia Fire Services Act and the British Columbia Fire Code Regulations. Controlled products will be used, stored or handled in the workplace in compliance with the applicable Workplace Hazardous Materials Information System (WHMIS) requirements concerning labels, identifiers, Materials Safety Data Sheets (MSDS) and worker education and training. The procedures for handling hazardous materials will integrate with the Contingency Emergency Response Plan.

Storage areas for fuel and hazardous substances will be regularly inspected and fuel containers monitored for unexplained losses. All leaks or spills will be isolated, contained and cleaned up to the satisfaction of the Environmental Monitor and regulatory agencies. Spills will be reported to the Environmental Monitor and to the federal and provincial agencies as required by the applicable legislation. Storage sites will be used only for storage of substances or hazardous materials designated for that area. Storage of fuel and other flammable materials will be in accordance with site-specific standards set by the MWLAP or, if not specifically stated, with the standards in the "British Columbia Fire Services Act" and the "British Columbia Fire Code Regulation."

Fuelling or servicing of any mobile construction equipment or vehicle within the riparian management area of a watercourse (minimum 100 metres) will be prohibited unless site-specific conditions allow for complete containment of fuel losses. Trucks and other machinery will be fuelled at designated fuelling locations, such as areas of significant clay till or on a concrete or asphalt surface to allow for containment and clean-up of any spills. Fuel dispensing will be in compliance with the "British Columbia Fire Service Act" and the "British Columbia Fire Code Regulation." All subcontractors will be responsible for containment of fuel losses experienced during fuelling or servicing of excavation and related equipment.

Designated storage sites for waste products, such as waste oils and other special wastes, will be developed and used only for storage of substances or contaminated equipment designated for that area. Storage of waste oil and other special wastes will be in accordance with site-specific criteria set by the MWLAP or, if not specifically stated, with standards in the Special Waste Regulations of the British Columbia Environmental Management Act. Any empty containers identified as hazardous waste will be stored in appropriate storage areas and containers and will be shipped to approved disposal locations. The transportation and disposal of hazardous materials or containers will be performed by a licensed hauler. The hauler will adhere to the manifest system required by the Transportation of Dangerous Goods Act and the British Columbia Special Waste Regulations. Documentation will be maintained by contractors for all hazardous wastes going off site.

9.2.3.10 Spill Prevention and Emergency Response

The emergency response guidelines comprise a detailed program of action to control and/or minimize the effects of an emergency that requires prompt corrective measures beyond normal procedures in order to:

- Protect human life and minimize the risk of injury
- Minimize the loss of controlled or hazardous substances
- Ensure the proper clean-up and reporting of hazardous materials

SNC-Lavalin/Serco is committed to the implementation of a Contingency Emergency Response Plan, including environmental emergency prevention and response procedures for spills of hazardous materials. The plan will protect the health and safety of employees and the public, and the environment.

9.2.3.10.1 Pre-Emergency Planning and Prevention

As part of the hazard identification and risk assessment described in subsection 9.2.3.1, critical tasks and materials will be assessed and categorized with regard to their potential to cause injury or impact the environment. The hazard identification and risk assessment will form part of the pre-emergency plan and be designed so that adequate precautions are implemented to avoid impacts to the environment wherever possible. It will also assist in ensuring that suitable emergency response procedures are developed and can be implemented to address environmental emergencies, and that emergency response equipment is located in a strategic area in close proximity to areas with the highest risk categories.

9.2.3.10.2 Emergency Training

During the environmental awareness training, staff members who have training in responding to emergencies, those who will be involved in responding to any spill, and those who should be notified will be identified. General training for workers in the environmental awareness program will also familiarize them with the location of spill equipment and the need to report spills to the

Environmental Monitor and the construction site manager. The training will include but not be limited to:

- Due diligence to prevent spills
- Safety procedures in the event of a spill
- Characteristics of various materials
- Spill assessments and spill reporting
- Spill containment and recovery as well as roles and responsibilities
- Clean-up procedures
- Documentation

9.2.3.10.3 Prevention Measures

Reducing the possibility of any hazardous material discharge will be given primary importance. Effective prevention of a spill begins with awareness of a potentially hazardous situation, which will be identified through the hazard and risk assessment described in subsection 9.2.3.1, and communicated to workers through the environmental Training and Orientation Plan (subsection 9.2.3.11). In addition, contractors will conduct monitoring of potentially hazardous areas and tasks throughout the construction site on an ongoing basis, and make recommendations for modification of hazardous areas to minimize the risk of any discharge of hazardous materials. Workers will be encouraged to watch for potentially hazardous situations and take steps to rectify them or report them to the appropriate parties.

Prevention of potentially hazardous situations will be addressed by several actions, including procedures identified in the Hazardous Materials Management Plan (subsection 9.2.9).

9.2.3.10.4 Contingency Emergency Response

As part of the final EMPC and based on the results of the hazards and risk assessment (subsection 9.2.3.1), a list of potential sources of spills, potential consequences and clean-up options for each material will be developed and posted at key points throughout construction sites. This information will also be made available to all persons taking the environmental awareness training. In addition, this material will be used to develop a staged response plan for environmental incidents. The Contingency Emergency Response Plan (CERP) will be made available to all persons taking the environmental awareness training and will be posted in conspicuous areas throughout construction sites.

In the event that, despite all due precautions, a spill of hazardous materials occurs, the CERP will be implemented. The CERP will be designed to ensure a state of readiness that will allow for prompt, orderly, safe, and effective response to an environmental emergency during construction.

Upon receiving initial notification of an incident involving release of a hazardous substance into the environment, the individual with on-scene authority will assess the magnitude of the problem and the potential threat to personnel, equipment and the environment.

The person with on-scene authority will collect the information required to complete an initial spill response assessment. This will help the individual to communicate the severity of the incident to the appropriate parties, and determine the corresponding emergency action required.

Information collected as part of the initial spill response assessment will include the following:

- The location of the spill or emergency and the type and volume of material involved
- The nature of worker exposure to any hazardous materials
- Potential risks to worker safety from the hazardous materials
- Potential risks to the public from the hazardous materials
- Proximity of the incident to environmentally sensitive features or watercourses
- Potential risks to the works from hazardous materials
- Actions undertaken or currently being undertaken to clean up the spilled materials

If the situation warrants, the person with on-scene authority to invoke the CERP will activate the plan, notify any other members of the response team closest to the site of the incident, and report to the on-scene coordinator as soon as possible. Situations will continue to be assessed on an ongoing basis to modify the response strategy to ensure that it adequately addresses the severity of the situation.

Some examples of staged environmental responses are included below, although it is expected that this will be modified prior to completion of the final EMPC:

- **Level 1:** Minor spills requiring onsite staff to take corrective actions to eliminate the source and clean up the impacted areas and restore the site to its pre-spill conditions. The Environmental Monitor will be notified and incident report forms completed and submitted to appropriate parties after completion of the operation.
- **Level 2:** Intermediate-level spills requiring response by trained staff but posing no danger to the public. The contractor and/or the Environmental Monitor will notify MWLAP immediately, or as required by regulation. The contractor may also be required to contact environmental remediation contractors for assistance with the incident. The Environmental Monitor will complete and submit incident report forms, conduct a follow-up investigation of the cause of the spill and follow up with various agencies and parties involved.
- **Level 3:** Major spill or incident beyond the resources or capabilities of the trained staff available, or where there is a risk of associated problems that could complicate the situation such as fire, explosion, toxic compounds, or threat to life or property. In these circumstances, assistance will be required from local, regional, and/or provincial organizations. The CERP team will immediately notify and request assistance from all relevant government agencies.

9.2.3.10.5 Resources

This project is taking place in an urban setting; therefore, resources for any level of environmental emergency will likely be available. Should any Level 3 emergency occur, the Provincial Emergency Response Program (PEP) can be a valuable government resource. Fire departments, municipal resources, and private environmental clean up crews are also readily available.

As part of the final EMPC and CERP, a detailed list of internal and external contacts, including emergency contact numbers, will be compiled and posted in strategic locations, and issued to all persons taking the environmental awareness training program. This contact list will be updated and modified as required throughout the duration of the project.

9.2.3.10.6 Communications

For the majority of this project we do not anticipate any communication problems, due to its location in an urban setting. Mobile telephones will be the standard method of communication and will allow for quick and easy communication between construction staff and emergency resources.

However, during tunnel boring activities there are likely to be unforeseen difficulties in communication that may require a specific communication plan. The contractor(s) working on tunnel boring and excavation activities will be required to develop and submit an emergency communication plan that outlines how communications will be maintained and how workers will report construction, environmental or medical emergencies.

9.2.3.10.7 Reporting

In the event of a serious spill or environmental incident, a post-incident review will be conducted to identify weaknesses or strengths in the action plan that was implemented and make appropriate modifications to the CERP, if required. A written incident report will be prepared and filed, describing the source and cause of the incident, the remediation actions taken, quantity of the spill, success of the clean-up, cost of the clean-up. The incident report will make recommendations, if appropriate, to further mitigate the spill, as well as recommendations, if appropriate, to prevent future incidents.

9.2.3.11 Training and Orientation

A proactive approach to environmental management is the best strategy for avoiding potential adverse environmental issues. The success of an EMPC will be measured by the ability of the project staff, including project management staff, engineering personnel, and subcontractors' personnel to comply with environmental procedures and government regulations.

The Environmental Training and Orientation Plan will increase environmental awareness, provide rationale for the protection of the various resources, familiarize employees with common causes of environmental problems and how they can be avoided, and promote environmentally sound construction practices so that compliance is achieved.

Specifically, the training and orientation will include a review of environmental policies and expectations, sediment and drainage control plans, solid waste management and recycling, emergency spill response procedures, air quality monitoring, noise mitigation, archaeological procedures and any other site-specific concerns.

All supervisors, including those of subcontractors, will be required to participate in environmental training and orientation before they start work. The Environmental Training and Orientation Plan will be oriented to assist these workers in protecting the environment through avoidance of environmental incidents, and the prompt and efficient mitigation of any environmental incidents that do occur.

The key environmental principles that relate to construction practices that will be integrated into the orientation and training are as follows:

- Workers will be made aware of the importance of maintaining site runoff water to the acceptable standards.
- Workers will be made aware of preventative measures in place to prevent and mitigate spills of hazardous and other materials to the environment. These include fuelling and maintenance procedures and areas, and material storage areas. Proper maintenance and servicing of machinery, storage of hazardous materials, and application of chemicals will be emphasized.
- Workers will be made aware of the importance of keeping an up-to-date hazardous materials inventory, and complying with all aspects of the Workplace Hazardous Materials Information System (WHMIS), and completing all Material Safety Data Sheets (MSDS).
- Workers will have unrestricted access to MSDS and be expected to be knowledgeable with WHMIS.
- Workers will be instructed in spill prevention techniques, the location of spill prevention and clean-up equipment, and the Contingency Emergency Response Plan.
- Workers will be made aware of expected procedures for noise mitigation.
- Workers will be made aware of the need to control fugitive dust and other airborne emissions where possible.
- The training program will also provide details of the workers or persons who will be involved in responding to any spill. Specifically, training will familiarize the workers with the location of spill equipment and the need to report spills to the Environmental Monitor and the construction site manager. Spill response training will include but not be limited to:
  - Due diligence to prevent spills
  - Safety procedures
  - Roles and responsibilities
  - Characteristics of various materials
  - Spill assessments
  - Spill containment and recovery
  - Site clean-up
  - Documentation

9.2.3.12 Archaeological Monitoring

SNC-Lavalin/Serco will ensure that all archaeological requirements outlined in Section 12 of Concession Agreement Schedule 2, are met during project construction. SNC-Lavalin/Serco will ensure that all permits required by the contractor and the project archaeologist are obtained and managed according to the conditions specified.

The management of impacts to archaeological sites is a requirement of the "Heritage Conservation Act (HCA)" which is administered by the Archaeology and Registry Services Branch at the Ministry of Sustainable Resource Management (MSRM). Through previous investigations, assessments and consultation with First Nations, archaeological sites and the potential for them have been identified.

Management of impacts on archaeological resources will be undertaken following recommendations and approvals from MSRM that were developed during the environmental assessment process. Management recommendations are expected to follow the BC Archaeological Impact Assessment Guidelines (1998), and all archaeological work undertaken will meet the standards outlined in this document. In addition, on Sea Island the Airport Authority's archaeological procedures will apply to this project.

The management of adverse impacts on archaeological resources will be realized through the implementation of a number of management strategies:

- In instances where significant archaeological resources have been identified, impacts to these sites will be avoided or minimized as much as possible. Construction activities may be modified to avoid impacts or reduce the intensity of impact on archaeological sites.
- In some cases, the potential for deeply buried or capped archaeological sites may exist. In compliance with the recommendations from the previous archaeological overview and impact assessments, archaeological monitoring of geotechnical work will be conducted and the samples inspected for cultural remains.
- Onsite surveillance and/or monitoring by a qualified archaeologist during construction excavation for compliance with mitigation measures will be required in high-risk areas, if they exist and are identified. In cases where unanticipated impacts to archaeological sites occur, emergency impact management procedures will be developed in conjunction with the project officer assigned by MSRM. Salvage data recovery will be implemented as required.
- Where required, impact assessments of previously unidentified sites or areas of potential archaeological concern will be carried out.

Where applicable, contractors and workers will be educated and informed as to their responsibilities for reporting newly discovered archaeological sites in compliance with the HCA. The archaeologist will be available to provide guidance and assistance with this process.

First Nations representatives will be invited to contribute to archaeological assessments and participate in monitoring or other fieldwork components. First Nations permitting and protocols will be given consideration, and consultation pertaining to archaeological resources will be coordinated with the First Nations Consultation Plan.

9.2.3.13 Construction Environmental Monitoring Program

The Environmental Monitor (EM) is an objective overseer of construction activities (i.e. independent from the contractors), who is responsible for inspecting construction operations to determine that environmental standards and requirements are followed and that works are in compliance with environmental legislation and regulations. The EM will act with the authority of SNC-Lavalin/Serco, but will report directly to RAVCO, the Ministry of Water Land and Air Protection (MWLAP) and the Department of Fisheries and Oceans (DFO) on all issues related to significant environmental events and incidents of non-compliance. Contractors will be expected to cooperate fully and comply with all directions issued by the EM.

The EM will conduct regular inspections of construction facilities and activities, as well as be present during in-stream work activities to satisfy him/herself that the work is conducted in accordance with the environmental construction specifications. The EM may attend project team meetings and provide input and direction for any environmental concerns. Water intake and discharge facilities will be inspected and approved by the EM prior to operation and the EM will thereafter make periodic inspections throughout the project. Whenever on site, the EM will complete a daily environmental monitoring report for submission to SNC-Lavalin/Serco. This report will document daily site conditions, construction activities, and relevant upcoming project activities, which will facilitate an ongoing assessment of potential environmental concerns of such facilities.

The EM will be assigned with responsibilities, duties, and procedures as outlined in this document. The following key items regarding aspects of the EM's role will be clearly outlined to all contractors:

- **Authority:** In the event of an activity or incident which contravenes regulatory requirements or the construction environmental requirements, the EM will have the authority to suspend all or a portion of any activity which is causing, or may cause, a significant environmental impact.
- **Communications:** The EM will be available for site visits, meetings, or written communication, as necessary to ensure a constant flow of information. The EM will report directly to SNC-Lavalin/Serco's construction project manager, and to appropriate environmental agencies, and will respond to concerns raised by these parties.
- **Reporting:** A regular reporting schedule will be established by the EM so that appropriate mitigative or preventative measures can be implemented in a timely manner to minimize effects.
- **Sampling:** Field protocols (such as those set out in the BC Field Sampling Manual) will be set up to specify the frequency of sampling and type of sampling equipment used in consultation with SNC-Lavalin/Serco and regulatory agencies.

The EM will also be assigned key responsibilities and duties to monitor environmental compliance during construction. These may include:

- Monitoring of compliance with federal, provincial and municipal permits, approvals, guidelines and regulations relating to environmental protection
- Being available throughout the duration of the work to review contractors' performance in matters related to the protection of the environment and, in particular, attending key meetings at which environmental protection measures are scheduled to be discussed
- Liasing with provincial and federal environmental agencies, as well as appropriate local government agencies
- Advising SNC-Lavalin/Serco in a timely matter on potentially controversial issues related to environmental activities on the project
- Attending pre-construction meetings, and other meetings where environmental protection measures are scheduled to be discussed and with regulatory agencies relating to construction activities being carried out in environmentally sensitive areas
- Assisting in developing plans and procedures that minimize environmental risks, avoid environmental problems and resolve conflicts
- Assisting with delivery of environmental awareness training and development of material for delivery to employees and contractors
- Preparing written procedures for construction in environmentally sensitive areas

- Monitoring construction activities that have the potential to adversely affect environmentally sensitive areas
- Monitoring and review of controlled substance (including fuel) delivery, handling, and storage practices
- Coordinating the collection of water samples for analysis, and monitoring suspended solids and other water quality parameters of concern, from storm water and wastewater discharges
- Determining that appropriate emergency spill kits are stored at locations which are identified to employees and contractors
- Stopping work that is threatening, or may threaten, environmentally sensitive areas

The following outline briefly describes the reporting requirements of the EM and the expected deliverables from construction monitoring:

- Daily monitoring report from each site inspection that summarizes activities and actions taken to minimize impacts and describes the effectiveness of mitigation measures. The daily monitoring report will include but not be limited to:
  - Time, date, and weather conditions
  - Description of current construction activities
  - Mitigative actions being taken to meet requirements stipulated in the construction environmental construction requirements, project plans and drawings, or by regulatory agencies
  - Effectiveness of mitigative measures undertaken
  - Condition of any site drainage facilities and results of any water testing
  - Summary of discussions with subcontractors, operations personnel, government agencies, etc.
  - List of relevant information pertaining to any recorded issues
  - Emergency response to unforeseen environmental problems
  - Recommendations for future remedial action
- Written records of meetings pertaining to environmental matters
- Prepare, at a frequency approved by SNC-Lavalin/Serco, environmental progress reports
- Prepare a final report for the SNC-Lavalin/Serco on environmental aspects of construction, including:
  - Explanation of design changes implemented for environmental reasons
  - Photographic documentation of work in environmentally sensitive areas
  - Copies of important communications between contactors, regulatory agencies and stakeholders
  - Summary of environmental concerns encountered, mitigative measures taken, and recommendations

In addition to the EM, efforts will be made to include First Nations personnel who possess the appropriate skills and abilities in the Construction Environmental Monitoring Program in areas specific to their interests. For example, First Nations will be consulted to determine their level of interest and job-specific capabilities for construction environmental monitoring and post-construction monitoring for any habitat restoration or compensation works required to mitigate impacts of the construction of the bridges over the North and Middle Arms of the Fraser River.

9.3 OUTLINE PLANS FOR THE EMPC

A number of Outline Plans will be prepared and attached to the EMPC as schedules:

- Environmental Quality Assurance/Quality Control Plan
- Landscape Restoration and Management Plan
- Tunnel and Excavation Spoils Disposal Plan
- Conceptual Plan for North Arm and Middle Arm Bridges – Engineering Designs, and Staging and Erection Plan
- Permits, Licences and Approvals Acquisition Plan

The Outline Plans included in this proposal will be advanced to the point of implementation when the EA Approvals are in place and the Concession Agreement has been signed. The anticipated content of each of these plans is briefly described in the following sections.

9.3.1 Environmental Quality Assurance/Quality Control Plan

Environmental monitoring and sampling requires careful planning and control in order to obtain valid and representative results. This section outlines the proposed Quality Assurance/Quality Control (QA/QC) Plan developed for the Environmental Management Plan. Note that an accredited laboratory will have its own, separate QA/QC requirements. The Environmental QA/QC plan will be designed and implemented at the following levels:

- Onsite supervision of construction monitoring activities
- Communication
- Field collection of samples (field testing)
- Data processing
- Reporting

9.3.1.1 Quality Management Team

In the context of the Environmental Quality Assurance/Quality Control Plan, the team members and respective duties are expected to be as follows:

Clyde Mitchell, P.Eng., Triton Environmental Consultants Ltd., will serve as the Project Director/ Sponsor of the Quality Management Team. Mr. Mitchell will provide technical advice and review the QA/QC Plan and project reports.

Brian James, P.Eng., Triton Environmental Consultants Ltd., will be the Project Manager of the Quality Management Team. He will coordinate and oversee all aspects of the QA/QC Plan.

Peter Frederiksen, Triton Environmental Consultants Ltd., will serve as an Environmental Monitor. He will participate in the development of the QA/QC Plan, and will conduct onsite environmental monitoring, including activities outlined in subsection 9.2.3.12.

Celine Totman, R.P.Bio., Triton Environmental Consultants Ltd., will be responsible for developing the QA/QC Plan, including documenting project specific QA/QC procedures, outlining ongoing QA/QC monitoring requirements, and preparing for QA/QC meetings. She will also assist with technical support for any water quality issues that may arise during construction.

Michael McArthur, R.P.Bio. Triton Environmental Consultants Ltd., will serve as an Environmental Monitor and will participate in the development of the QA/QC Plan. He will also conduct onsite environmental monitoring, including activities outlined in subsection 9.2.3.12.

9.3.1.2 Testing Program

Any sampling required will be conducted in accordance with standard operating procedures and industry-accepted standards so that the data are defensible and meet regulatory QA/QC requirements. Standards that will be followed include but are not limited to the British Columbia Field Sampling Manual: 2003 – for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment and Biological Samples.

Examples of QA/QC protocols for field procedures include:

- Staff undertaking fieldwork will have certification for specific services (i.e., electrofishing, sediment control, etc.).
- Instrumentation used for in-situ measurements will be calibrated prior to use and at appropriate frequency during the course of the work.
- Utensils used to collect samples will be thoroughly cleaned using laboratory grade detergent and distilled water prior to the collection of the samples.
- Samples collected will be placed in clean sample containers provided by the analytical laboratory. Sample jars will be appropriately labelled and stored under refrigerated conditions prior to submission to the analytical laboratory.
- Appropriate holding time will be considered when shipping the samples to analytical laboratories.
- Samples submitted to analytical laboratories will be accompanied by an appropriately completed Chain-of-Custody form.
- Data associated with the testing program will be placed in appropriately labelled files stored at the SNC-Lavalin/Serco construction management office.
- Soil sampling specifics:
  - Soil samples will be collected either directly from the sidewalls of the excavation (after removal of surface smearing) or from the excavator's bucket (ensuring that the material sampled had not contacted the bucket sidewalls).
  - The bucket of the excavator will be nominally cleaned (and/or washed, if a washer is available at the site) prior to excavation of each test pit.
  - Soil descriptions, location of samples, observations, measurements, etc. will be recorded in waterproof field notebooks. These notebooks will be stored in a safe location prior to

permanent storage.

Examples of QA/QC protocols for laboratory procedures include the following:

- Samples will be submitted directly to analytical laboratories for analysis.
- Samples will be stored under refrigerated conditions, both en-route and at the laboratory, if required.
- The analyses will be conducted in accordance with recognized and approved procedures and techniques appropriate to the analysis (i.e. EPA, ASTM, BCE, etc.).
- The analytical laboratories will analyze laboratory spikes, and where appropriate and available, Standard Reference Materials (SRM) to verify calibration of the equipment. As a minimum, one spike and/or SRM will be analyzed for each 10 samples (of like analysis).
- The analytical laboratories will also analyze blank samples to check for contamination of the equipment. One blank sample will be analyzed for each 10 like samples.
- A minimum of ten (10) percent of the samples submitted for analysis will be duplicate samples obtained in the field. These duplicate samples will determine the repeatability of analyses.
- Laboratory duplicate analyses will also be analyzed in addition to field duplicates to verify analytical repeatability. A minimum of one laboratory duplicate for each 10 samples will be analyzed.
- Field duplicate samples will not be identified to the analytical laboratories at the time of submission. "Dummy" designations for duplicate samples will be used. These designations will only be known to the sampling personnel.
- Analytical and QA/QC results will be analyzed and statistically assessed. Should the statistical analysis of the QA/QC results indicate that the results fall outside normal, acceptable standards (typically greater than 20 percent of the relative standard difference [RSD]), then measures will be taken to identify and rectify the problem. Repeat analysis of the stored samples may be conducted to resolve the issue.

Upon receipt of analytical results, the relative percent differences (RPDs) of field blind duplicate and laboratory replicate analyses will be calculated and their accuracy evaluated.

The accurate and concise compilation of field notes, data, and photographs is essential to the successful completion of the project. Immediately following each field day, field personnel will compile field notes, prepare a preliminary summary of the field findings on hard copy maps, and prepare additional sampling requirement reports if required. This system is designed to ensure that all field information is thoroughly documented while fieldwork is still fresh with the field personnel, and allows for preliminary results to be available as needed.

9.3.1.3 Process Control

Prior to commencement of construction, the QA/QC Team will meet with RAVCO and relevant government agencies to confirm the Environmental QA/QC Plan.

During construction, the Environmental Monitor (EM) will be an objective overseer of construction activities (i.e. independent from contractors) and will be responsible for inspecting operations to ensure that environmental standards and requirements are followed and that works are in compliance with the prepared environmental plans, legislation and regulations. The EM will report directly to RAVCO, the Ministry of Water Land and Air Protection (MWLAP) and the Department of Fisheries and Oceans Canada on all issues with significant environmental effects, and report incidents of non-compliance. Contractors will be expected to cooperate and comply with the reasonable directions issued by the EM.

The EM will conduct regular inspections of construction facilities and activities, as well as be present during in-stream work activities to ensure that work is conducted in accordance with the environmental construction specifications. The EM may attend project team meetings and provide input and direction for any environmental concerns throughout the life of the project. Additionally, periodic QA/QC meetings will be held throughout the construction period to review work done to date and address any potential issues.

Water intake and discharge facilities will be inspected and approved by the EM prior to operation and thereafter the EM will make periodic inspections. Whenever onsite, the EM will complete a daily environmental monitoring report for submission to SNC-Lavalin/Serco, RAVCO and relevant agencies. This report will document site conditions, construction activities, and relevant upcoming project activities, which will facilitate an ongoing assessment of potential environmental concerns.

Details of the key items related to authority, communications, reporting and sampling for the EM and contractors, and the roles, responsibilities and reporting requirements are outlined in subsection 9.2.3.12.

9.3.2 Landscape Restoration and Management Plan

Subsection 7.2 of this volume sets out the landscape restoration and replacement strategy for SNC-Lavalin/Serco's proposal. As noted in this section, the design strives to avoid impacts on existing landscaped areas. In taking this approach, SNC-Lavalin/Serco have been able to significantly reduce the loss of existing landscaped areas and thereby reduce the need for replacement plantings. For example, SNC-Lavalin/Serco have now adopted an alignment that follows the northbound lanes of Cambie Street around Queen Elizabeth Park. This revised base alignment, relative to the base alignment in the RFP, will avoid all of the previously envisioned impacts on Queen Elizabeth Park, and should also avoid future impacts on the park, if a station is built in the vicinity of 33rd Avenue and Cambie Street.

The Landscape Restoration and Management Plan will be developed by a qualified landscape designer and arborist with input from the Environmental Management Team during the design development stage. This plan will be designed to provide no net loss of landscaped area and will include specific actions related to:

- Protection of existing landscape elements to remain
- Relocation, if required, of existing significant trees, provided they can be successfully relocated
- Storage of existing landscape elements for reuse after construction
- Provision of new landscaping and plantings for no net loss of landscaped areas

9.3.3 Tunnel and Excavation Spoils Disposal Plan

SNC-Lavalin/Serco may use land disposal for clean surplus excavation materials (waste) generated by the Canada Line. The majority of the solid waste will be soil and rock material generated during

 843

excavation of the trenches and tunnels. Land disposal for some of these spoils will be explored by the SNC-Lavalin/Serco prior to adoption of a disposal at sea plan.

9.3.3.1 Clean Waste

Excavation spoils found to be free of contamination under the criteria of the Canadian Environmental Protection Act (CEPA) may be disposed via disposal at sea if land disposal is not practical (see subsection 9.3.3.3). Spoils that are shown to be high in clay content, and without contamination above applicable levels defined by the BC Environmental Management Act (BCEMA), may be received by local municipalities for use in dyke improvements. SNC-Lavalin/Serco will examine this and other land disposal options for clean waste prior to finalizing of the plans for disposal at sea.

9.3.3.2 Contaminated Waste

Contaminated wastes are expected to represent a minimal portion of the solid waste generated during the Canada Line. SNC-Lavalin/Serco will develop a testing program and QA/QC measures to identify spoil contamination levels prior to and during excavation.

BCEMA procedures for classification of contaminated waste and Special Waste will be followed in concert with the soil testing program to establish appropriate disposal options. For any waste found to be contaminated, an appropriately permitted receiving facility will be used. Transportation and handling of contaminated waste will also be done in accordance with the BCEMA and associated guidelines, including the use of contractors with the appropriate licences and training for contaminated waste. Records, including waste manifest and waste stream generator will be produced and maintained in accordance with Provincial and Federal requirements and the environmental requirements from RAVCO.

Undisclosed Environmental Liabilities, if present, are more likely to be found in currently or previously industrialized areas around Kent Street at the foot of the Cambie Street and False Creek areas on the alignment of the Canada Line. Hydrocarbons such as those potentially leaching into the Canada Line alignment from off-site sources (e.g. gas station sites) are also a possible source of soil contamination.

9.3.3.3 Disposal at Sea

After consideration of disposal alternatives (subsection 9.3.3.1 and 9.3.3.2), it may be concluded that disposal at sea is the most environmentally preferable and practical alternative.

Disposal at sea is regulated by the Canadian Environmental Protection Act (CEPA) 1999, and its "Disposal at Sea Regulation" and "Regulations Respecting Applications for Permits for Disposal at Sea." Environment Canada administers the Act and its Regulations, and controls all disposals at sea by a system of permits, or "Disposal at Sea Permit," issued under the CEPA 1999.

To obtain a permit SNC-Lavalin/Serco must demonstrate that the materials to be disposed of at sea meet the Disposal at Sea Regulations and the disposal at sea "Interim Contaminant Testing Guidelines."

9.3.3.4 Tunnel and Excavation Spoils Characterization for Disposal at Sea

Environment Canada requires chemical analyses to be performed on any material that might be disposed of by disposal at sea, where there is a lack of chemical data or a reason to believe that contaminants such as selected trace metals or organics are present. Only materials that have been tested and that meet the "Disposal at Sea Regulations" and the disposal at sea "Interim Contaminant Testing Guidelines" will be approved for disposal at sea.

Where disposal at sea is the preferred option for spoil disposal, SNC-Lavalin/Serco will develop a proposed sampling program for submission to the appropriate regional office of Environment Canada for approval prior to commencement of loading or disposal at sea activities. The sampling program will outline site location, number of samples, types of sampling, sampling techniques, analytical methods, parameters of concern and quality assurance. Minimum sampling requirements will be based on the volume of material to be excavated and are presented in the Table 9.1 below.

Table 9.1: Minimum Sampling Requirement

PROJECT QUANTITY (m^3)	# OF SAMPLES	TYPE OF SAMPLING
Less than 10,000	6	Composite of surface native till to 1 metre depth.
10,001 – 30,000	9	Composite of surface native till to 1 metre depth.
30,001 – 60,000	12	Composite of surface native till to 1 metre depth.
More than 60,000	Number of samples to be determined on a project-specific basis.	

Minimum chemical analysis that should be conducted by analytical laboratories accredited and certified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) are provided in Table 9.2 below.

Table 9.2: Minimum Chemical Analysis and Limit of Detection

PARAMETER		LIMIT OF DETECTION
Trace Metals:	Mercury	0.2 ug/g
	Cadmium	0.2 ug/g
Organics:	PAHs	0.1 ug/g
Other:	Total Organic Carbon	not applicable
	Particle Size	not applicable

Following the site history and/or chemical analysis results, Environment Canada can require an increased number of samples and/or analysis of additional metals and/or organics.

Materials found to contain substances of concern at, or higher than, the regulated or guideline concentrations will have to undertake toxicity testing to show that it will not cause acute or chronic effects on marine organisms or human health, whether or not arising from their bioaccumulation in marine organisms.

Additionally the sampling program should include:

- A location map for the dredge or excavation site with the street address of the proposed excavation or dredge site
- A site map showing the proposed excavation or dredge site relative to known landmarks and/or streets
- A nautical chart showing location of loading site
- A list of any known possible contaminant input sources in the vicinity of the proposed works
- A written record of the decision making process used in selecting disposal at sea as the preferred materials disposal option, explaining why other disposal methods are not being used
- A site use history for the site from which the material destined for disposal at sea will originate

9.3.3.5 General Timeline

All proposed disposal at sea projects are reviewed under the "Canadian Environmental Assessment Act;" thus, before a permit is issued by Environment Canada, it is subject to scientific review and public consultation, which may take about two to three months.

A permit is issued by publishing it in Part 1 of the "Canada Gazette," and, under CEPA 1999, operations may not start until 30 days after publication.

Once issued, a permit may remain in effect for a maximum of one year. If operations are still required after one year, another permit is required and may be applied for at any time.

9.3.3.6 Summary of Information Needed for a Permit Application

As a summary the following information will be required for the permit application to be processed:

- Cover letter describing the project in detail
- Identification of material to be disposed
- Applicant name, where, when, how and why disposal will occur
- Nautical chart showing location of loading site
- Comparative assessment of alternatives to disposal at sea
- History of the loading site
- Chemical, physical and biological characteristics of the material to be disposed of
- Location of loading site with respect to potential pollution sources
- Location of disposal site with respect to environmentally sensitive areas

- Mitigation and timing considerations

9.3.3.7 Permit(s)

The obtained disposal at sea permit(s) will set out conditions controlling:

- The type of material to be disposed
- The quantity of the material to be disposed
- The location of the loading site
- The location of the disposal site
- Equipment use and requirements
- Restrictions such as reporting to the Canadian Coast Guard or restrictions on the timing of disposal operations

9.3.4 Conceptual Plan for North Arm and Middle Arm Bridges – Engineering Designs and Staging and Erection

The proposed general arrangements for both of these river crossings are shown in Drawings 42DK-1642 through 1647 in Appendix B-1. Both structures have been developed to provide for all navigational, rail and roadway clearances. General arrangements for each structure are discussed in subsections 2.1.2 and 2.1.5 of this volume and methods of construction are presented in subsections 8.1.3 and 81.4.

9.4 PERMITS, LICENCES AND APPROVALS

9.4.1 Introduction

The numerous permits, licenses and approvals required as part of the Canada Line construction and operation will be dependent on the type of construction and operation facilities and associated features. Specific requirements are referenced in individual sections of this EMPC. SNC-Lavalin/Serco will develop a plan to procure the needed permits and approvals based on the specific requirements listed in the EACA submitted by RAVCO and the resulting EAC issued by the EAO. This plan will consider the results and recommendations of the pre-application studies put forward by RAVCO and the input given by agency representatives involved in the EACA review process. The detailed plans of SNC-Lavalin/Serco's BAFO may require most or all of the permits identified by RAVCO in the EACA. Additional permits to those discussed in the EACA may also be required.

SNC-Lavalin/Serco will ensure some or all of the following permits and approvals are acquired as part of the environmental component of the Canada Line construction and operation. Other sections of the EMPC will discuss the details surrounding the prerequisites and procurement of the permits and approvals needed for the Canada Line.

9.4.2 List of Activities and Associated Permits and Approvals

The following provides an indication of the types of permits and approvals that may be required for selected features of the project.

Fraser River Crossing and Middle Arm Crossing

- Authorization by the Department of Fisheries and Oceans (DFO) under 35(2) of Fisheries Act
  - For fish habitat changes due to installation of new piers
  - Conditions to limit or minimize impacts to fish or fish habitat that could be caused during construction
- Authorization by DFO/Coast Guard under Navigable Waters Protection Act
  - Concerns pier location, design and marine traffic disruption/safety
- Utilities permits
  - For working near telecom, gas or sewer lines

Cut-and-Cover Trenchwork

- Approvals under the BC Environmental Management Act
  - Disposal of any contaminated soils
  - Transportation of any contaminated soils
- Notification and/or Approval under BC Water Act
  - For trenching near top-of-bank or stream crossings
- Authorization under Heritage Conservation Act
  - To address any potential archaeological sites near trench location
- Authorization under Canadian Environment Protection Act
  - For disposal of clean spoils via disposal at sea
- Municipal permits
  - Fill permit for disposal (if needed) of clean fill on land
  - Traffic Permits for road closures, etc.
  - Permits for use of boulevards/city rights-of-way for staging, etc.
  - Tree cutting permits
  - Noise permit (Vancouver Bylaw)
  - Heritage Alteration Permit (City of Vancouver)
- Utilities permits
  - For working near telecom, gas or sewer lines

Drill Tunnel

- Utilities permits
  - For working near telecom, gas or sewer lines
- Approvals under the BC Environmental Management Act
  - Disposal of any contaminated soils
  - Transportation of any contaminated soils
  - Permit to cover dust and noise
- Authorization under Canadian Environment Protection Act
  - For disposal of clean spoils via disposal at sea
- Authorization under Heritage Conservation Act
  - To address any potential archaeological sites near tunnel location
- Municipal permits
  - Fill permit for disposal (if needed) of clean fill on land
  - Traffic permits for road closures, etc.
  - Permits for use of boulevards/city rights-of-way for staging, etc.
  - Tree cutting permits
  - Noise permit (e.g. Vancouver Noise Bylaw)

Station Construction

- Notification and/or Approval under BC Water Act
  - Addressing management of surface water runoff from site
- Authorization and or Letter of Advice by DFO under 35(2) of Fisheries Act
  - Addressing management of surface water runoff from site during construction and during operation

Roadworks

- Authorization of Letter of Advice by DFO under 35(2) of Fisheries Act
  - For any time roadwork is near top-of-bank or crosses a stream
  - Addressing management of surface water runoff from site
- Notification and /or Approval under BC Water Act
  - Addressing management of surface water runoff from site
  - For any time roadwork is near top-of-bank or crosses a stream
- Railway Permit
  - For any trenchwork near rail right-of-ways
- Authorization under Heritage Conservation Act
  - To address any potential archaeological sites near roadway location

- Municipal permits
  - Fill permit for disposal (if needed) of clean fill on land
  - Traffic permits for road closures, etc.
  - Permits for use of boulevards/city rights-of-way for staging, etc.
  - Tree cutting permits
  - Heritage Alteration Permit (City of Vancouver)
- Approvals under the BC Environmental Management Act
  - Disposal of any contaminated soils
  - Transportation of any contaminated soils
  - Permit to cover dust and noise

9.5 ENVIRONMENTAL MANAGEMENT PLAN FOR OPERATIONS (EMPO)

Addendum 3b to the BAFO Instructions revisions to the Environmental Management Plan to "Provide a clear indication of the intention, commitment and approach of the EMPC, and how/who will implement the component parts of the program during Construction and Operation of the RAV Line." In addition to the Environmental Management Plan for Construction, SNC-Lavalin/Serco will develop an Environmental Management Plan for Operations (EMPO) to be ready for implementation prior to testing and commissioning of the various components of the Canada Line. The EMPO will deal with site-specific and system-wide environmental aspects of the Canada Line and will use background information from existing EMPOs including Serco Docklands Limited's light railway in London, UK and TransLink's Expo and Millennium Lines.

The operations and maintenance for the Canada Line will provide the overall framework for environmental management for operations and maintenance activities on the Canada Line, including the operation of the trains, the rail lines, the stations and the Operations and Maintenance Centre (OMC). It will be used by SNC-Lavalin/Serco as the primary document for planning and implementing environmental programs for the Canada Line. The major areas of environmental management include the following:

- Liquid and solid waste management from the stations, offices at the OMC, maintenance and repair facilities for the trains at the OMC and traction power stations
- Resource consumption, including energy, water and paper products
- Pollution prevention, including releases to water from cleaning activities; noise and vibration from operation of the trains, the use of underground and aboveground storage tanks and air emissions from company vehicles

The environmental management organization including responsibilities, lines of authority and communications/reporting procedures will also be included in the EMPO.

SNC-Lavalin/Serco will adopt a proactive approach to environmental management. This will include development and implementation of an environmental awareness and training program for employees and contractors; energy and water conservation programs; development of an emergency preparedness plan to deal with environmental incidents and "reduce, reuse and recycle" protocols.

The plan will be reviewed on an annual basis and updated as required.

A draft Table of Contents for the EMPO is provided in Exhibit 1.

Exhibit 1

Canada Line

Environmental Management Plan for Operations

DRAFT Table of Contents

Appendix B1
Drawings
Pages 1208-1626

Severed in its entirely pursuant to
Section 17 and Section 21
of the BC Freedom of Information &
Protection of Privacy Act

Volume C

TABLE OF CONTENTS

5.17 (1)(d) 5.21

1.0 INTRODUCTION

Volume C of the Canada Line Proposal presents our solution for the Operation and Maintenance (O&M) of the Canada Line and its assets over the concession period, and the preceding preparations for commencement of operations.

The following acronyms and abbreviations are utilized in Volume C:

24/7	24 hours per day, seven days per week
AC	Alternating Current
AFC	Automatic Fare Collection
AQV	Availability, Quality and Volume
ATC	Automatic Train Control
ATO	Automatic Train Operation
CAPEX	Capital Costs
CCTV	Closed Circuit Television
CPA	Crime Pattern Analysis
CSA	Customer Service Assistants
DC	Direct Current
DM	Duty Manager
DMM	Digital Multi Meter
DPU	Designated Policing Unit Officer
E&M	Electrical and Mechanical
ETI	Engineering Technical Issue
FLRT	First Line Response Team
H&S	Health and Safety
HR	Human Resources
IMS	Integrated Management System
ISO	International Standards Organization
IT	Information Technology
KPI	Key Performance Indicators
LMV	Light Metro Vehicle
MMS	Maintenance Management System
O&M	Operation and Maintenance
OMC	Operation and Maintenance Centre

OPCO	Operations Company
OPEX	Operational Costs
PA (1)	Personal Assistant
PA (2)	Public Address
PID	Passenger Information Display
RCM	Reliability Centred Maintenance
RSE	Rolling Stock Engineer
RSM	Rolling Stock Manager
RSS	Rolling Stock Supervisors
RST	Rolling Stock Technician
S&T	Signalling and Telecommunications
SES	Safety Engineering Services
SQ&E	Safety, Quality and Environment
TVM	Ticket Vending Machine
TVU	Ticket Validation Unit
VAC	Volts, Alternating Current
VDC	Volts, Direct Current

2.0 SUMMARY OF OPERATIONS AND MAINTENANCE

2.1 OPERATIONS PHILOSOPHY

Our operating philosophy is based

S.17 (1)(e)
S.21

Figure 2.1: O&M Steady State Organization

S.17(1)(e)
S.21

2.2 PASSENGER FOCUS

S.17(1)(e)
S.21

S.17(1)(e)
S.21

2.4 MAINTENANCE

S.17(1)(e)
S.21

2.5 SAFETY

S.17(1)(e)
S.21

2.6 OPERATIONAL PROCEDURES

S.17(1)(e)
S.21

2.7 PERSONAL SECURITY

S.17(1)(e)
S.21

2.8 INTEGRATION

S.17(1)(e)
S.21

2.9 STAFFING

s.17(1)(e)
s.21

3.0 SERVICE PLANS

3.1 SERVICE PLANS AS DETAILED IN SCHEDULE 4 OF THE CONCESSION AGREEMENT

S.17(1)(e)
S.21

4.0 OPERATIONS AND MAINTENANCE ORGANIZATION PLAN

4.1 INTRODUCTION

S.17(1)(e)
S.21

4.2 SERVICE PROVISION

S.17(1)(e)
S.21

4.2.1 *Use of Subcontractors*

S.17(1)(e)
S.21

s.17(1)(e)
s.21

4.3 ORGANIZATION AND STAFFING

4.3.1 O&M Start-Up Organization

The diagram below depicts the O&M Start-Up Organization

s.17(1)(e)
s.21

Figure 4.1: O&M Start-up Organization Plan

s.17(1)(e)
s.21

s.17(1)(e)
s.21

4.4 MANAGEMENT ORGANIZATION

Figure 4.2: Management Organization

S.17(1)(e)
S.21

4.4.1 Roles of Senior Management

S.17(1)(e)
S.21

S.17(1)(e)
S.21

4.5 KEY EXTERNAL INTERFACES

S.17(1)(e)
S.21

Figure 4.3: Key Interfaces

S.17 (1)(e)
S.21

4.6 OPERATIONS ORGANIZATION

S.17 (1)(e)
S.21

Figure 4.4: Operations Organization

S.17(1)(e)
S.21

4.6.1 Service Delivery Team

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Figure 4.5: Control Room

S.15(1)(L)
S.17(1)(e)
S.21

S.17(1)(e)
S.21

Controllers

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Duty Manager (DM)

S.17(1)(e)
S.21

Service Operators

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Operations Supervisors

S.17(1)(e)
S.21

Designated Policing Unit Officers (DPUs)

S.17(1)(e)
S.21

Customer Services Assistants (CSAs)

S.17(1)(e)
S.21

4.6.2 Other Operations Staff

Operations Manager

S.17(1)(e)
S.21

External Security Advisor

S.17(1)(E)
S.21

Customer Service Manager

S.17(1)(e)
S.21

4.7 ENGINEERING ORGANIZATION

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Figure 4.6: Engineering Organization

S.17(1)(e)
S.21

4.8 TECHNICAL ENGINEERING TEAM

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Head of Technical Engineering

S.17(1)(e)
S.21

S.17(1)(e)
S.21

4.9 MAINTENANCE ENGINEERING TEAM

S.17(1)(e)
S.21

Infrastructure Team

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Guideway Team

S.17(1)(e)
S.21

Signal and Telecommunications Team

S.17(1)(e)
S.21

Structures Team

S.17(1)(e)
S.21

Building Services Team

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Third Rail Team

S17(1)(e)
S.21

First Line Response Team

S.17(1)(e)
S.21

Infrastructure Manager

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Rolling Stock and Procurement Team

S.17(1)(e)
S.21

The Rolling Stock Manager (RSM)

S.17(1)(e)
S.21

The Rolling Stock Engineer (RSE)

S.17(1)(e)
S.21

The Rolling Stock Supervisors (RSS)

S.17(1)(e)
S.21

Rolling Stock Technicians (RSTs)

S.17(1)(e)
S.21

Procurement Manager

S.17(1)(e)
S.21

Stores Person

S.17(1)(e)
S.21

4.10 SAFETY, QUALITY AND ENVIRONMENTAL ORGANIZATION

S.17(1)(e)
S.21

Figure 4.7: Safety, Quality and Environmental Organization

S.17(1)(e)
S.21

Environment

S.17(1)(e)
S.21

Quality Assurance

S.17(1)(e)
S.21

Document Control

S.17(1)(e)
S.21

Safety Plan

S.17(1)(e)
S.21

Safety Monitoring

S.17(1)(e)
S.21

4.11 COMMERCIAL ORGANIZATION

Figure 4.8: Commercial Organization

S.17(1)(e)
S.21

Accounts Manager and Staff

IT Manager & Staff

S.17(1)(e)
S.21

4.12 HUMAN RESOURCES ORGANIZATION

S.17(1)(e)
S.21

Figure 4.9: Human Resources Organization

Training Manager

S.17(1)(e)
S.21

4.13 ANTICIPATED ORGANIZATIONAL CHANGES

S.17(1)(e)
S.21

Figure 4.10: O&M Steady State Organization

s.17(1)(e)
s.21

4.14 KEY PERSONNEL QUALIFICATIONS

The qualifications for the key personnel of OPCO are listed in the table below.

POSITION	QUALIFICATIONS

S.17(1)(e)
S.21

1.0 MOBILIZATION PLAN

1.1 INTRODUCTION

S.17(1)(e)
S.21

2.0 PHILOSOPHY

S.17(1)(e)
S.21

3.0 KEY ELEMENTS

S.17(1)(e)
S21

4.0 MANAGEMENT OF THE MOBILIZATION PROCESS

S 17(1)(e)
S.21

S.17(1)(e)
S.21

5.0 PROVISION OF INFRASTRUCTURE AND EQUIPMENT

S 17(1)(e)
S.21

S.17(1)(e)
S.21

5.1 SPECIFICATION OF FACILITIES, VEHICLES AND SYSTEMS

S.17(1)(e)
S.21

5.2 BUILDING AND ACQUISITION OF FACILITIES, VEHICLES AND SYSTEMS

S.17(1)(e)
S.21

5.3 DESIGN REVIEWS

S.17(1)(e)
S.21

5.4 SITE VISITS

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.5 ESTABLISHING THE OMC

S.17(1)(e)
S.21

5.6 TESTING AND COMMISSIONING

S.17(1)(e)
S.21

5.7 TRIAL OPERATIONS

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.7.1 Description of the Trial Operations Plan

S.17(1)(e)
S.21

5.7.2 Development of the Trial Operations Plan

S.17(1)(e)
S.21

S.17(1)(e)
S.21

6.0 RECRUITMENT PLAN

S.17(1)(e)
S.21

6.1 RECRUITMENT OF MANAGEMENT STAFF

S.17(1)(e)
S.21

S. 17(1)(e)
S. 21

6.2 RECRUITMENT OF OTHER EMPLOYEES

S. 17(1)(e)
S. 21

7.0 OPERATIONS PREPAREDNESS

S. 17(1)(e)
S. 21

5.0 OPERATIONS PLANS

5.1 INTRODUCTION

This section of our proposal contains the outline for the Operations Plans designed to provide the levels of service tabulated in the Service Plans contained in Schedule 4 of the Concession Agreement.

S.17(1)(e)
S.21

5.1.1 Background

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.1.2 *Legislation and Statutory Requirements*

S.17(1)(e)
S.21

5.1.3 *Interfaces with Existing Vancouver Transit Systems*

S.17(1)(e)
S.21

5.1.4 *Other Interfaces*

S.17(1)(e)
S.21

5.2 OPERATIONS PHILOSOPHY

S.17(1)(e)
S.21

5.3 SAFETY PROGRAMS

S.17(1)(e)
S.21

S. 17 (1)(e)
S.21

5.3.1 *Safety Plan*

S. 17(1)(e)
S. 21

5.4 SERVICE PROVISION

S. 17(1)(e)
S. 21

5.5 CONTROL ROOM OPERATIONS

5.5.1 *Introduction*

S. 17 (1)(e)
S. 21

S.17(1)(e)
S.21

5.5.2 Control Room Layout, Communications and Protocols

S.17(1)(e)
S.21

Figure 5.1: Basic Layout of the Control Room

S.15(1)(L)
S.17(1)(e)
S.21

Table 5.1: Control Room Responsibility Matrix

Location	Identity, Key Interface & Provision	Key Responsibilities

S.17 (1)(e) S.21

S.17
(1)(c)
S.21

s.17
(1)(e)
s.21

5.6 CUSTOMER SERVICES AND PASSENGER INFORMATION PROVISION

s.17
(1)(e)
s.21

s.17(1)(e)
s.21

5.6.1 Telephone Information Service

s.17(1)(e)
s.21

5.6.2 Internet Information Service

s.17(1)(e)
s.21

5.6.3 Information at Stations

s.17(1)(e)
s.21

5.6.4 Public Address System (PA)

S. 17(1)(e)
S. 21

5.6.5 Fixed Information and Signage

S. 17(1)(e)
S. 21

5.6.6 Information on Vehicles

S. 17(1)(e)
S. 21

S.17(1)(e)
S.21

5.6.7 *Accessibility*

S.17(1)(e)
S.21

5.6.8 *Safety and Security Information*

S.17(1)(e)
S.21

5.6.9 *Property – Lost and Found*

S.17(1)(e)
S.21

5.7 REVENUE PROTECTION

Revenue protect

- Operatio
- Service C

Effective Reven
revenue leakage
deterrent and a
environment in
Standards withi

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.7.1 Selection and Recruitment

S.17(1)(e)
S.21

5.7.2 Training

S.17(1)(e)
S.21

5.7.3 Supervision – Operations Supervisors

S.17(1)(e)
S.21

5.7.4 Deployment and Methodology

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.7.5 Dedicated Policing Unit Officers (DPUs)

S.17(1)(e)
S.21

5.8 MOBILE RESPONSE TO OPERATIONAL INCIDENTS

5.8.1 Incident Management and Resource Allocation

S.17(1)(e)
S.21

5.8.2 Dedicated Internal Response at the Scene

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.8.4 Training

S.17(1)(e)
S.21

5.9 SECURITY MANAGEMENT

S.17(1)(e)
S.21

5.9.1 Staffing

S.17(1)(e)
S.21

5.9.2 Security Advisor

S.17(1)(e)
S.21

5.9.3 *Designated Policing Unit Officers (DPUs)*

S.17(1)(e)
S.21

5.9.4 *Relationships with External Agencies*

S.17(1)(e)
S.21

5.9.5 *Secure Vehicles*

S.17(1)(e)
S.21

5.9.6 *Control Room – Around-the-Clock Coverage*

S.17(1)(e)
S.21

5.9.7 *Communications*

S.17(1)(e)
S.21

5.9.8 *CCTV*

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.9.9 Station and Car Park Lighting and Security Features

S.17(1)(e)
S.21

5.9.10 Reporting, Monitoring and Actions

S.17(1)(e)
S.21

5.9.11 Review Process

S.17(1)(e)
S.21

5.10 CLEANING

The following will be key to achieving customer satisfaction with the Canada Line travel experience:

- The overall presentation of the Canada Line system
- The provision of a high-quality environment for the travelling public
- The comfort of a controlled environment

We firmly believe that the quality of cleaning on the system is a customer-service issue and not a routine maintenance task. To ensure quality standards and targets specified under the Concession Agreement are achieved, the service provider will be directly monitored and such contracts managed under the direction of the Customer Services Manager.

The contract will be written by one of our experienced Contract Managers, with careful consideration given to our service performance targets and our objective of delivering a neat and attractive system to passengers at all times. As part of this contract, OPCO will produce a Cleaning Plan, specifying the frequency and levels of cleaning required to achieve this objective. We will review the Cleaning Plan regularly and modify it if the required level of cleanliness is not being achieved.

S.17(1)(e)
S.21

This Cleaning Plan will reflect the standards set out in Schedule 4 of the Concession Agreement and the aspirations of OPCO to provide a high standard of cleaning to support the overall desired image of the Canada Line.

Sufficient resources will be procured under the cleaning contract to deliver the specified requirements, including:

- Ongoing cleaning during revenue service
- Planned daily cleaning of public areas
- Periodic heavy cleaning
- Specific service entry cleaning of vehicle interiors

With a fully automated system, external cleaning with be undertaken as part of the schedule and processes for making a vehicle ready for service (e.g. a hand-back of a vehicle from maintenance).

5.10.1 Performance Levels

S.17(1)(e)
S.21

5.10.2 Approach and Staffing

S.17(1)(e)
S.21

s.17(1)(e)
s.21

5.11 PROVISION OF RESOURCES TO DEVELOP SOLUTIONS TO OPERATIONAL AND MAINTENANCE PROBLEMS

s.17(1)(e)
s.21

S.17(1)(e)
S.21

5.12 ABNORMAL OPERATIONS

5.12.1 Anticipated Abnormal Requirements

S.17(1)(e)
S.21

5.12.2 Working with Special Event Organizers

S.17(1)(e)
S.21

5.12.3 Additional Resources

S.17(1)(e)
S.21

5.12.4 Security Arrangements

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.12.5 Regular Events – Specific Plans

S.17(1)(e)
S.21

5.12.6 Management and Control

S.17(1)(e)
S.21

5.13 FAILURE MANAGEMENT

S.17(1)(e)
S.21

5.13.1 Major Incidents

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.13.2 Service Disruptions and Failures

S.17(1)(e)
S.21

Figure 5.2: Service Disruption Response Diagram

S.17(1)(e)
S.21

5.13.3 Steps for Response to Service Disruption

S.17(1)(e)
S.21

S.17(1)(e)
S.21

S.17(1)(e)
S.21

eplacement Bus Services

S.17(1)(e)
S.21

S.17(1)(e)
S.21

ERFORMANCE STANDARDS

S.17(1)(e)
S.21

S 17(1)(e)
S.21

S.17(1)(e)
S.21

5.14.1 Overview

S.17(1)(e)
S.21

5.14.2 Expected Levels of Performance

S.17(1)(e)
S.21

5.14.3 Methods of Measurement

S.17(1)(e)
S.21

5.15 PROVINCIAL EMERGENCY PLAN

S.17(1)(e)
S.21

5.16 HEALTH AND SAFETY PROCEDURES

S.17(1)(e)
S.21

S.17(1)(e)
S.21

5.17 OPERATIONS RISK MANAGEMENT

S.17(1)(e)
S.21

6.0 THE MAINTENANCE PLAN

S.17(1)(e)
S.21

6.1 GENERAL MAINTENANCE

S.17(1)(E)
S.21

S.17(1)(e)
S.21

6.1.1 The One and Five Year Maintenance Plans

S.17(1)(e)
S.21

6.1.2 Management of Disruption

Aims

S.17(1)(e)
S.21

Key Elements

S.17(1)(e)
(d)

S.21

S.17(1)(e)
(d)

S.21

6.1.3 Monitoring Performance, Analysis of Failures and Reporting of Trends

Aims

S.17(1)(e)
17(1)(d)
S.21

Key Elements

S.17(1)(e)
17(1)(d)
S.21

6.1.4 Solutions to Maintenance Problems

Aims

S.17(1)(e)
17(1)(d)
S.21

Key Elements

S.17(1)(e)
17(1)(d)
S.21

S.17(1)(e)
17(1)(d)
S.21

6.1.5 Feedback Of Corrective Actions into Engineering Procedures

Aims

S.17(1)(e)
17(1)(d)
S.21

S.17(1)(e)
17(1)(d)
S.21

S.17(1)(e)
S.17(1)(d)
S.21

6.1.6 Management of Process Control Risks

Aims

S.17(1)(e)
S.17(1)(d)
S.21

Key Elements

S.17(1)(e)
17(1)(d)
S.21

s.17(1)(e)
s.17(1)(d)
s.21

6.1.7 Vandalism Management

Aims

s.17(1)(e)
s.17(1)(d)
s.21

Key Elements

s.17(1)(d)
s.17(1)(e)
s.21

S.17(1)(e)
S.17(1)(d)
S.21

6.1.8 Maintenance Performance

Aims

S.17(1)(e)
S.17(1)(d)
S.21

Key Elements

S.17(1)(e)
S.17(1)(d)
S.21

S.17(1)(d)
S.17(1)(e)
S.21

6.1.9 Procedures for Technical Documentation Control

Aims

S.17(1)(d)
S.17(1)(e)
S.21

Key Elements

S.17(1)(d)
S.17(1)(e)
S.21

Document Input -

Document Review -

S.17(1)(d)
S.17(1)(e)
S.21

Document Issue –

S.17(1)(d)
17(1)(e)
S.21

Routine Review –

Withdrawal –

6.1.10 Training

Aims

S.17(1)(d)
17(1)(e)
S.21

Key Elements

S.17(1)(d)
17(1)(e)
S.21

S.17(1)(d)
17(1)(e)
S.21

6.1.11 External Resources

Aims

S.17(1)(d)
17(1)(e)
S.21

Key Elements

S.17(1)(d)
17(1)(e)
S.21

S.17(1)(d)
17(1)(e)
S.21

6.2 VEHICLE MAINTENANCE PLAN

S 17(1)(d)
17(1)(e)
S.21

6.2.1 *Maintenance Philosophy*

Aims

S.17(1)(d)
17(1)(e)
S.21

Key Elements

S.17(1)(d)
17(1)(e)
S.21

s.17(1)(d)
17(1)(e)
s.21

6.2.2 *Rolling Stock Maintenance Staff Structure*

Aims

S.17(1)(e)
17(1)(d)
S.21

Key Elements

S.17(1)(d)
17(1)(e)
S.21

6.2.3 *Job Descriptions*

S.17(1)(d)
17(1)(e)
S.21

6.2.4 Vehicle Maintenance Procedures

Aims

S.17(1)(d)
17(1)(e)
S.21

Key Elements

S.17(1)(d)
17(1)(e)
S.21

Figure 6.1: Example of a Rolling Stock Maintenance Procedure

S.17(1)(d)
17(1)(e)
S.21

Figure 6.2: Example of a Maintenance Checklist and Procedure

S.17
(1)(d)
17(1)(e)
S.21

6.3 INFRASTRUCTURE MAINTENANCE PLAN

S.17(1)(d)
17(1)(e)
S.21

6.3.1 Maintenance Philosophy

Aims

Key Elements

S. 17(1)(d)
17(1)(e)
S.21

6.3.2 Infrastructure Maintenance Staff Structure

Aims

s.17(1)(d)
17(1)(e)
S.21

Key Elements

S.17(1)(d)
17(1)(e)
S.21

Infrastructure Manager

S.17(1)(d)
17(1)(e)
S.21

6.3.2.1 Signalling and Telecommunications Team

Signalling and Telecommunications Supervisors

S.17(1)(d)
17(1)(e)
S.21

S.17(1)(d)
17(1)(e)
S.21

S&T Technicians

First Line Response

S.17(1)(d)
17(1)(e)
S.21

6.3.2.2 Guideway Team

Guideway Supervisors

S.17(1)(d)
17(1)(e)
S.21

6.3.2.3 Building Services Team

Building Services Supervisor

S.17(1)(d)
17(1)(e)
S.21

Electrical Supervisor

Electrical Technicians

Building Works Technicians

S.17(1)(d)
17(1)(e)
S.21

6.3.3 Preventative Maintenance

Aims

Key Elements

S.17(1)(d)
17(1)(e)
S.21

s.17(1)(d)
17(1)(e)
s.21

6.3.4 Asset Management

Aims

s.17(1)(d)
17(1)(e)
s.21

s.17(1)(d)
17(1)(e)
s.21

6.4 UPGRADES AND REFURBISHMENT PLAN

s.17(1)(d)
17(1)(e)
s.21

S.17(1)(e)
S.17(1)(d)
S.21

6.4.1 Stations and Buildings

S.17(1)(d)
S.17(1)(e)
S.21

6.4.2 Guideway

S.17(1)(d)
S.17(1)(e)
S.21

6.4.3 Systems

S.17(1)(d)
S.17(1)(e)
S.21

6.4.4 Signalling

S.17(1)(d)
S.17(1)(e)
S.21

6.4.5 Light Metro Vehicles

S.17(1)(e)
S.17(1)(d)
S.21

6.4.6 Structures

S.17(1)(d)
S.17(1)(e)
S.21

6.4.7 Workshop Equipment

S.17(1)(d)
S.17(1)(e)
S.21

6.4.8 Renewal and Upgrade

S.17(1)(d)
S.17(1)(e)
S.21

6.4.9 Refurbishment Program

S.17(1)(d)
S.17(1)(e)
S.21

Table 6.1: Asset Replacement/Refurbishment Program for O&M

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Control Room and Systems	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Wheel Re-profiling Lathe																															
Overhead Crane																															
Vehicle Body Lifting Jacks																															
Exterior Washplant																															
Rail Grinder																															
Fork Lift Truck X 2																															
Ride Quality, Noise and Vibration Equipment																															
Access Platforms (Elevated Guideway) X 2																															
Tunnel Cleaning Machine																															
SPV																															
Flat Bed Truck																															
Office Refit (progressive complete refit at OMC)																															
Compressor																															
Standby Generator																															
Wheel/Tyre Press																															
Portable Generators x 2																															

S. 17(1)(d)
17(1)(e)
S. 21

Table 6.2: Asset Replacement/Refurbishment Program for O&M

S.17(1)(d)
S.17(1)(e)
S.21

7.0 PERFORMANCE STANDARDS

7.1 INTRODUCTION

s. 17(1)(e)
17(1)(d)
s.21

7.2 APPROACH

s.17(1)(e)
17(1)(d)
s.21

7.3 STANDARDS TO BE MET

s.17(1)(e)
17(1)(d)
s.21

7.4 EXPECTED LEVELS OF PERFORMANCE

s.17(1)(e)
17(1)(d)
s. 21

S.17(1)(e)
17(1)(d)
S.21

7.5 METHODS OF MEASUREMENT

S.17(1)(e)
17(1)(d)
S.21

Table 7.1: Measurement of Performance

s. 17(1)(e)
s. 17(1)(d)
s. 21

S.17(1)(d)
S.17(1)(e)
S.21

S.17(1)(d)
S.17(1)(e)
S.21

S.17(1)(d)
S.17(1)(e)
S.21

s.17(1)(d)
s.17(1)(e)
s.21

S. 17(1)(d)
17(1)(e)
S.21

9.0 METHOD OF COUNTING PASSENGERS

S.17(1)(e)
S.21

S.17(1)(e)
S.21

Revenue Protection

S.17(1)(e)
S.21

Ridership

S.17(1)(e)
S.21

FIRST NATIONS CONSULTATION PLAN

S.16(1)(a)(iii)
S.17(1)(e)

S.16(1)(a)(iii)
S.17(1)(e)

855-A

COMMUNICATIONS PROTOCOL

1. GENERAL PRINCIPLES

The Concessionaire and RAVCO agree that the following general principles will guide implementation of this protocol:

a) Recognition of the significant public profile and importance of the Project in the region;

b) The Concessionaire's responsibility to Design, Construct, Operate and Maintain the System, which includes an obligation to engage and inform the public as these responsibilities are carried out;

c) RAVCO's responsibility to oversee the Concessionaire's progress and achievements against the obligations set out in the Concession Agreement;

d) Mutual respect for the respective roles of each Party;

e) Full cooperation and coordination between the Concessionaire and RAVCO to provide for consistency, efficiency and success;

f) Public and stakeholder input regarding the Design, Construction and Operation and Maintenance of the System will be recorded and considered, along with financial, technical and schedule implications, by the Concessionaire. Further, the Concessionaire will work with RAVCO to report to the public and stakeholders regarding the manner in which public and stakeholder input will be/has been considered.

2. CONCESSIONAIRE RESPONSIBILITIES

Recognizing the significant public, stakeholder and media interest in the Project, as well as the impact that large scale construction in a busy corridor will have on residents, businesses, commuters and others, the Concessionaire is committed to cooperating with its project partners and to engaging the public through communications, consultation, liaison and notification activities as the Project is built.

During the Construction Period, the emphasis of communications, consultation and community liaison and notification activities will be on involving and informing project stakeholders, particularly those directly affected by construction, about construction activities.

During the Operating Period, the emphasis of communications will be on reporting, customer service, participating in the preparation and delivery of critical incident communications and cooperating on general communications activities.

2.1 Communications & Media Relations

In preparation for and during the Construction Period, the Concessionaire will:

2.1.1 Develop, update, resource and implement, as agreed between the Concessionaire and RAVCO, communications and media plans, to keep the public, stakeholders and media informed about project construction activities.

2.1.2 Identify dedicated communications and media personnel and coordinate, as agreed between the Concessionaire and RAVCO, responses to media requests;

2.1.3 Identify a spokesperson for project construction activities, schedule, notification and related issues.

2.1.4 Develop and produce collateral material, including:

a) Print, web-based, and other elements describing and providing information about the project, to support communications and media plans;

b) Review collateral materials with RAVCO and, where necessary as agreed between the Concessionaire and RAVCO, seek approval on such collateral materials;

2.1.5 Participate in issues identification and management, including responding to issues that arise within agreed timeframes;

2.1.6 Participate in regular conference calls and/or meetings with RAVCO, the Cities and YVR;

2.1.7 Monitor daily and report on communications and media activities in monthly Progress Reports as agreed between the Concessionaire and RAVCO

2.2 *Community and Business Liaison and Notification*

In preparation for and during the Construction Period, the Concessionaire will:

2.2.1 Develop, update, resource and implement, as agreed to between the Concessionaire and RAVCO a community and business liaison and Construction Period notification program, including a traffic management consultation program, which addresses the objectives of:

a) Regular communication and outreach to residents, businesses, commuters and others along the route to inform them of construction activities with particular attention to communicating the scope, schedule and status of the Construction program;

b) Gathering and considering input from external stakeholders;

c) Establishing processes, between the Community Liaison & Construction Management teams, to:

I. Respond to construction-related inquiries and complaints;

II. Address and respond to inquires related to construction impacts;

III. Work towards developing communications materials that provide a level of predictability in accordance with the Approved Construction Schedule as defined in the Concession Agreement; and

IV. Collaborate to implement solutions to issues or problems that arise during construction while respecting schedule and budget;

d) Providing timely notice of construction activities as agreed by the Concessionaire, RAVCO and the Cities/YVR;

e) Participating in community events and meetings as agreed by the Concessionaire, RAVCO and the Cities/YVR;

2.2.2 Make available resources for community and business liaison and notification activities consistent with agreed plans including:

a) Identification of three community liaison officers to be responsible for community and business liaison and related activities prior to and during the Construction Period;

b) Identification of technical resources to facilitate the timely provision of Construction Period information to the community liaison and communications team and to stakeholders;

c) Responding to public inquiries and complaints within agreed timeframes;

d) Coordinating community liaison and construction notification activities with RAVCO;

2.2.3 Develop and produce collateral material to support community and business liaison and construction notification activities, including:

a) Print, web-based, visual, outdoor signage, public notice advertising, and other elements as appropriate to describe and provide information about the Design and Construction of the Project;

b) Review collateral materials with RAVCO and, where necessary as agreed between the Concessionaire and RAVCO, seek approval on such collateral materials;

2.2.4 Participate in issues identification and management, including responding to issues that arise within agreed timeframes;

2.2.5 Monitor and report on community liaison and construction notification activities monthly as agreed between the Concessionaire and RAVCO;

2.2.6 Establish a project office where members of the public can access information about construction activities;

2.2.7 Establish and maintain a public information telephone line with recorded information on public consultation and construction activities, with voicemail capability to record comments;

2.2.8 Maintain records of all material public inquiries, complaints and communications and provide copies or summary reports to RAVCO as agreed between RAVCO and the Concessionaire.

2.3 Public and Stakeholder Consultation

The Concessionaire will:

2.3.1 Support the Preliminary Design Phase of consultation by providing:

a) Input and participation from technical and design personnel to support preparation, program and reporting requirements;

b) Development and production of collateral materials to support the Preliminary Design Phase as agreed to by the Concessionaire and RAVCO;

2.3.2 Lead the development and implementation of a Detailed Design Phase Consultation Program, including:

a) Development of plans, including description of those aspects of design upon which the Concessionaire seeks input from participants, as agreed between the Concessionaire and RAVCO;

b) Providing technical, design, and consultation personnel to plan, coordinate, facilitate/conduct and report on the consultation program;

c) Providing public notice and logistical coordination to support community participation in consultation events;

d) Development and production of collateral materials consistent with plans as agreed between the Concessionaire and RAVCO.

2.3.3 It is understood that the Design Advisory Process runs in conjunction with the Detailed Design phase consultation. Responsibility for content of submission, presentations, and meetings associated with the Design Advisory Process is the sole responsibility of the Concessionaire.

2.3.4 On behalf of and working with the Traffic Management Committee, lead the development and implementation of a traffic management consultation program, including:

a) Development of a process to identify the scope of consultation

b) Providing public notice and logistical coordination to support community participation

2.4 Data Collection and Reporting

In preparation for and during the Construction Period, the Concessionaire will be responsible for:

2.4.1 Participation in regular conference calls and/or meetings as agreed by the Concessionaire with RAVCO and Cities and YVR to inform, report on activities and issues;

2.4.2 Public reporting on activities and progress against plans on a quarterly basis and annual basis as agreed between the Concessionaire and RAVCO;

2.4.3 Reporting to RAVCO on critical incidents/issues as necessary;

2.4.4 Ongoing data collection, including maintenance of records and submission of summary reports as agreed between the Concessionaire and RAVCO.

3. RAVCO RESPONSIBILITIES

In preparation for and during the Construction Period, RAVCO will:

3.1 Promote understanding of the Project;

3.2 Function as lead spokesperson(s) on broad project issues, including those not related to specific construction and operating issues;

3.3 Lead development and delivery of the Preliminary Design Phase Consultation with support from the Concessionaire as defined in Section 2.3 above;

3.4 Lead and coordinate liaison with and reporting to (quarterly and annual) Funding and Participating Agencies, with support from the Concessionaire as described in the approved protocols, plans and work programs developed further to Section 4 of this Protocol;

3.5 Review and provide input on the Concessionaire plans and public communications materials, including media releases and approve such materials as agreed to between the Concessionaire and RAVCO;

3.6 Communicate promptly with the Concessionaire on important Project issues;

3.7 Provide the Concessionaire with advice and support for specific communications, consultation and community liaison activities as agreed and documented in the approved protocols, plans and work programs developed further to Section 4 of this Protocol;

3.8 Monitor the Concessionaire's progress against plans and provide feedback on performance.

4. FURTHER WORK

The Parties acknowledge that further work between the Concessionaire and RAVCO is required to implement the roles and responsibilities as currently assigned. During the course of this work, or in light of practical experience, the Concessionaire and RAVCO may mutually agree to amend this Protocol. The Parties have developed:

4.1 Protocol agreements outlining the further roles and responsibilities of their respective communications, consultation, community liaison and construction notification teams;

4.2 Protocol agreements, including public notice protocols, and outlined processes to support the terms of this document;

4.3 Outline plans that will assist the development of detailed communications, consultation, and community liaison and construction notification programs;

4.4 Outline plans that define shared responsibilities, including: development and maintenance of a project website, management of public inquiries and contacts, and certain community and business liaison activities.

The following protocol agreements are referenced above and attached here as Appendices 1 – 10:

Appendix 1 – Outline of Roles & Responsibilities

Appendix 2 – Construction Notification Program

Appendix 3 – Community & Business Liaison Program

Appendix 4 – Traffic Management Consultation & Communications Program

Appendix 5 – Managing Construction Period Disruptions

Appendix 6 – Public Enquiries & Contact Management

Appendix 7 – Issues Management

Appendix 8 – Project Website

Appendix 9 – Community Project Office

Appendix 10 – Media Relations

5. COMMUNICATIONS PLAN

The Concessionaire will, no later than 20 days after the Closing Date, complete the Communications Plan for the Construction Period in accordance with the principles and requirements set out in this Communications Protocol (including the Appendices hereto) and will submit such Communications Plan to RAVCO for review and comment. RAVCO will review such plan and may (but will not be obliged to) provide comments to the Concessionaire proposing changes that RAVCO, acting reasonably, considers necessary to finalize the plan consistent with the requirements described in the Communications Protocol. The Concessionaire will amend the plan to include any such comments. If RAVCO does not respond within 10 days, the Communications Plan will be deemed to be approved.

Appendix 1: Outline of Roles & Responsibilities

Joint Agency Communications/Significant Milestones (as defined in Project Funding Agreements)

Category	Description	RAVCO	Concessionaire	Funding Agencies	Cities / YVR / GVTA	Timeframes	Notes	Budget
Joint Agency / marquee announcements and communications	Described in Schedule A to Federal Framework Agreement	Overall responsibility for the development and implementation of plans & products;	Input, review and participate in planning with provision of graphics as agreed	Agencies approve scenarios, products and participate	Agencies approve scenarios, products and participate	Planning: 30+ days; Product approvals: 20-30 days	Products must be bilingual	RAVCO responsibility
Joint Agency / marquee signage	Described in Section 3.5 of Schedule A to Framework Agreement	Overall responsibility for the development and production of templates	Input, review and comment on signage (The Concessionaire is not responsible for non-construction signage)	Agencies approve template		August – September 2005	Marquee signage must be bilingual	The Concessionaire to be responsible for no more than 5 signs under Section 3.5 of Schedule A to Framework Agreement

Project Communications/Consultation – Construction Period

Category	Description	RAVCO	Concessionaire	Funding Agencies	Cities / YVR (& GVTA on transit access / issues)	Timeframes	Notes	Budget
Project Communications Plan	Outline of general comm. priorities, products & implementation, including Project branding protocols & templates	Overall responsibility for the development and implementation of plan and priorities	Input, review and comment on plan as required	Receive copy	Receive copy	August 2005 Update frequency: 6 months		RAVCO responsibility
Project construction calendar / schedule	Upcoming construction activity / related communications / notification schedule	Review	Responsible	Receive copy	Permitting Agencies provide requirements / input per Access and Concession Agreements	Updated & distributed as required		Concessionaire responsibility
Construction Period Community Liaison Program	Outline of community liaison priorities, tools, programs & implementation	Input, review and comment on plan	Overall responsibility for the development and implementation of plan	Receive copy	Review, provide input; approve as required for permits per Access and Concession Agreements	July 2005 and updated thereafter as required at least annually beginning in 2006	Consult with community, business associations; If the Concessionaire chooses not to participate in Business Liaison Committees then the Concessionaire has the responsibility to establish separate process	The Concessionaire responsibility with the exception of already established Business Liaison Committees which is RAVCO's responsibility
Preliminary design consultation program	Consultation plan, products, meetings, logistics	Overall responsibility for the development and implementation of plan	Input, review and comment on plan	N/A	Review, provide input, participate	May – June 2005		RAVCO responsibility

Project Communications/Consultation – Construction Period								
Category	Description	RAVCO	Concessionaire	Funding Agencies	Cities / YVR (& GVTA on transit access / issues)	Timeframes	Notes	Budget
Detailed design consultation program	Consultation plan, products, meetings, logistics	Input, review and comment on plan	Overall responsibility for the development and implementation of plan	N/A	Review, provide input, participate	Beginning Fall 2005		Concessionaire responsibility
Traffic Consultation Program	Public/Stakeholder consultation process, materials, responses and reporting out	Input, review, comment	Responsible	Receive Copy	Outline permitting agency requirements; Participate to address their areas of responsibility	Beginning August 2005	In conjunction with Traffic Management Committee	Concessionaire responsibility
Construction & traffic notification program	Outline of construction & traffic notification programs & schedule	Input, review, comment	Overall responsibility for the development and implementation of plans	Receive copy	Outline permitting agency requirements; Participate to address areas of their responsibility	August/September 2005 Update frequency as necessary – quarterly		Concessionaire responsibility
General communications & liaison products	Media Releases, Advisories	Develop & approve (within timelines to be developed in the Communications Plan)	Develop & approve (within timelines to be developed in the Communications Plan)	Receive advance (min. 2 days) copies	Receive advance (min. 2 days)copies	2 days advance notice & copies to Agencies	Note: exceptions for breaking/urgent issues. This does not apply to routine construction and traffic updates – see following section for Construction & traffic management	Joint RAVCO and the Concessionaire – according to topic area/area of responsibility
	Information Bulletins	Develop & approve (within timelines to be developed in the Communications Plan) ; Provide templates or brand identity standards	Develop & approve (within timelines to be developed in the Communications Plan)	Receive advance (min. 2 days) copies	Receive advance (min. 2 days)copies	2 days advance notice & copies to Agencies	Note: exceptions for breaking/urgent issues. This does not apply to routine construction and traffic updates – see section for Construction & traffic management	Joint RAVCO and the Concessionaire – according to topic area/area of responsibility
	Fact Sheets	Develop & approve ; Provide templates or brand identity standards	Develop & approve	Receive advance (min. 2 days)copies	Receive advance (min. 2 days)copies	As necessary	Note: exceptions for breaking/urgent issues. This does not apply to routine construction and traffic updates– see section for Construction & traffic management	Joint RAVCO and the Concessionaire – according to topic area/area of responsibility

863

Project Communications/Consultation – Construction Period								
Category	Description	RAVCO	Concessionaire	Funding Agencies	Cities / YVR (& GVTA on transit access / issues)	Timeframes	Notes	Budget
	Postcards / e-newsletters	Develop & approve (within timelines to be developed in the Communications Plan)	Provide input	Receive advance (min. 2 days) copies	Receive advance (min. 2 days) copies	TBD	Note: exceptions for breaking/urgent issues. This does not apply to routine construction and traffic updates– see section for Construction & traffic management	RAVCO responsibility
	Briefing Notes	Develop & : Provide templates or brand identity standards approve	Develop & approve	Receive copies	Receive advance (min. 2 days) copies	As necessary	Note: exceptions for breaking/urgent issues. This does not apply to routine construction and traffic updates– see section for Construction & traffic management	Joint RAVCO and the Concessionaire – according to topic area/area of responsibility
	Public notices, advertising	Approve templates for Project branding & agency logo requirements	Develop & implement according to notification program and permit requirements	Receive advance (min. 2 days) copies	Receive advance (min. 2 days) copies	TBD	Note: exceptions for breaking/urgent issues. This does not apply to routine construction and traffic updates– see section for Construction & traffic management	Joint RAVCO and the Concessionaire – according to topic area/area of responsibility
Construction & traffic management tools	Public/Media notices, ads, advisories, bulletins & other tools to implement the construction & traffic notification program	Approve templates, receive notice; Provide templates or brand identity standards	Overall responsibility for development and implementation	Receive advance (min. 2 days) copies	As required under the Access Agreements or Permits	Fall 2005	Exceptions for safety or emergency communications	Concessionaire responsibility
	Construction and traffic Signage	Review templates, receive notice	Overall responsibility for development and implementation consistent with the Concession Agreement	N/A	As required under the Access Agreements or Permits	Develop template August 2005 (subject to receiving brand identity standards from RAVCO)	In Conjunction with Traffic Management Committee	Concessionaire responsibility
	Public safety announcements	Receive copies	Generate & distribute as necessary; Inform RAVCO, Cities & YVR	Receive copies	Receive copies	As necessary	No approvals required	Concessionaire responsibility
Critical incident communications plans	Outline process & protocols in case of emergencies, incidents	Review and provide input as necessary	Overall responsibility for development and implementation	Receive copies	Coordinate as necessary	TBD	In conjunction with Construction Management and Environmental Management Plans	Concessionaire responsibility

Note: Reference to "days" is defined as regular working business days

Appendix 2: **RAV PROJECT PROTOCOL – Construction Notification Program**

Subject:	**Construction Notification Program**
Background:	The Concessionaire is responsible for Construction Period notification. Throughout the Construction Period, the Concessionaire's communications effort will be guided by the Approved Project Schedule in order to provide advance notice to the public, residents, businesses and stakeholders about impacts or traffic disruptions. It should be noted that with a Project of this magnitude and complexity, the Approved Project Schedule will be subject to change. Communications tactics will therefore be flexible and adaptable in order to ensure that advance notification is provided to all stakeholders about construction and traffic impacts. The Approved Project Schedule, for communications purposes, will be prepared for each calendar year—broken down by month—along with a timeline outlining notification tactics.
Protocols:	The Concessionaire is developing a construction notification program designed to provide advance notice to the public, businesses and stakeholders about construction impacts and traffic disruptions. Notification tools will be flexible and adaptable in order to ensure that advance notification is provided to all stakeholders about construction impacts and traffic disruptions. Based on the Approved Project Schedule, the Concessionaire will prepare for communications purposes, a notification plan for each calendar year—broken down by month—along with a timeline outlining notification tactics. To establish this document, the Concessionaire will work with RAVCO, the Cities, YVR and other Relevant Authorities to determine appropriate notice periods and notification tactics for specific activities. This notification plan will also consider input provided by corridor residents & stakeholders, through various consultation activities. Based on the Approved Project Schedule, both an annual and a six month schedule (noting that changes will occur), along with a regular one-month "look ahead" schedule will be made available for those corridor businesses and stakeholders with advance planning requirements. The following processes will be put in place to ensure ongoing, joint review by RAVCO and the Concessionaire of the Concessionaire's construction notification program: 1. Bi-weekly RAV project technical & construction team meetings 2. Weekly RAVCO / Concessionaire issues calls
RAVCO Lead:	Vice President, Corporate Affairs Senior Vice President, Engineering
Concessionaire Lead:	Vice President, Public Affairs Technical Director

Appendix 3: **RAV PROJECT PROTOCOL – Community & Business Liaison Program – Construction Period**

Subject:	**Community & Business Liaison Program – Construction Period**
Background:	Significant expansion of the regional rapid transit network involves major construction activities in busy urban corridors. This construction will inconvenience corridor residents, adjacent businesses and commuters. Temporary traffic diversions or limitations will be required to allow construction to take place, and construction sites will generate noise and dust. The Concessionaire and RAVCO are committed to establishing and coordinating community and business liaison programs. The objectives of these programs are to provide for ongoing communication with residents, businesses and commuters, for dissemination of Project information, to respond to inquiries, monitor construction activities, and to address specific issues that arise during the Construction Period.
Protocols:	The Concessionaire will develop a community and business liaison program designed to provide information and seek input and feedback from residents, businesses and other stakeholders about construction impacts and traffic disruptions. The Concessionaire's Community and Business Liaison Programs will include such activities as: • Community Liaison Officer participation in community events & meetings; • Contact programs to identify issues of concern to individual businesses, residents and other stakeholders; • Community presence through the Project office; • School outreach program; • Small group & neighbourhood meetings to discuss the Project; and • Construction tours for selected stakeholders. The Concessionaire will also liaise with businesses to inform and notify them about construction impacts. In addition, the Concessionaire will attend RAVCO's Business Liaison Committee meetings regularly to provide technical and schedule updates on construction and receive feedback. The Concessionaire will develop a process by which it will assess and act on issues and problems arising from construction related activities. See Appendix 5 for description of this process. In addition, RAVCO is developing and funding the following Business Liaison Program Initiatives: 1. Retention of a Director of Community Relations, responsible for developing and implementing RAVCO's community & business liaison activities and working with the Concessionaire to facilitate and coordinate joint activities; 2. Establishment of Business Liaison & Communication Committees to: a. Provide information and advice to RAVCO and the Concessionaire to be used for the development of a business liaison & notification programs to manage

	construction-related disruptions where possible and achieve predictability in the schedule for businesses adjacent to construction, while respecting Project constraints associated with safety, affordability, and schedule; b. Provide a conduit for businesses adjacent to construction to raise concerns and provide advice on strategies to address issues; and c. Provide a forum for RAVCO and the Concessionaire to present information and discuss approaches for addressing business concerns regarding construction-related disruptions; and to provide recommendations and feedback to RAVCO and the Concessionaire regarding business liaison & notification; 3. Funding a full-time Project Director to provide direct support for the Business Liaison Committees; 4. Funding Market research to guide customer attraction strategies during the Construction Period; 5. Funding a Retail Consultant to develop tools and templates to assist small and independent businesses to manage through the construction period; and 6. Pursuant to the terms of the Environmental Assessment Certificate: a. Investigate opportunities to mitigate impacts of lost parking opportunities for retail businesses; b. Initiate communication programs to inform the public of access to businesses and promote continued business patronization; and c. Allocate $200,000 per year for four years, beginning in 2005 for such communication programs for the Downtown and Cambie Street segments of the Project where cut and cover technology will be employed.
RAVCO Communications Lead:	Vice President, Corporate Affairs
Concessionaire Communications Lead:	Vice President, Public Affairs

Appendix 4: RAV PROJECT PROTOCOL – Traffic Management Consultation & Communications Program

Subject:	Traffic Management Consultation and Communication Program
Background:	The Concessionaire's Traffic Management Plan calls for the Traffic Management Committee to consider public input on traffic management strategies and to implement public information or notification programs to advise the public of traffic disruptions during the Construction Period.
Protocols:	On behalf of and in conjunction with the work of the Traffic Management Committee, the Concessionaire Community Liaison and consultation team will undertake these two activities related to traffic management: first to consult with key stakeholders (such as emergency responders and large corridor destinations) and the public on traffic impacts and incorporate feedback, where possible, into the Traffic Management Plan; and second to develop a traffic notification program to advise the public about Traffic Management plans. The Concessionaire's traffic management consultation will: • Take place far enough in advance of pre-construction/construction activities requiring traffic disruption to allow for adequate consultation and advance notification; • Identify those aspects of the traffic management program on which input can be considered; • Provide for stakeholder and public review of draft plans, gathering of input and reporting out on decisions/rationale; • The Concessionaire will collaborate with the Cities, YVR, RAVCO and TransLink as appropriate to develop these consultation and notification programs.
RAVCO Communications Lead:	Vice President, Corporate Affairs
Concessionaire Communications Lead:	Vice President, Public Affairs

Appendix 5: RAV PROJECT PROTOCOL – Managing Construction Period Disruptions

Subject:	**Managing Construction Period Disruptions**
Background:	In the RAV corridor, the guideway, stations and associated infrastructure will be built as per the Approved Project Schedule. This construction will inconvenience corridor residents, adjacent businesses and commuters. Temporary traffic diversions or limitations will be required to allow construction to take place, and construction sites will generate noise, dust and other construction-related impacts. The Concessionaire is committed to managing construction-related disruptions and working towards predictability in the schedule where possible. Determining whether or how construction activities can be managed to address concerns or problems arising from construction-related disruptions will be a priority for the Concessionaire. As part of its Communications Plan, the Concessionaire will describe the process it will implement to assess and act on corridor resident, stakeholder, and adjacent business concerns over construction-related impacts. Concerns about construction will be brought to the attention of the Concessionaire through a variety of communications vehicles, including: • Construction Phone Line • Emails/letters • Open houses/public meetings • CLOs • RAVCO's business liaison committees and the Concessionaire's business liaison program • Onsite construction managers
Protocols:	Within 30 days of Financial Close, the Concessionaire will form a Joint Technical & Communications Committee, which will review problems/issues arising from construction activities and implement strategies to address such problems. The composition of the Committee will be determined by agreement between the Concessionaire and RAVCO, and will include senior technical and community relations representatives from RAVCO and the Concessionaire. The Committee will invite participation from the Cities, YVR, representatives of utility or emergency service providers or others as the Concessionaire or RAVCO may consider appropriate to address specific issues. The Committee will be chaired by the Concessionaire's Project Director or his designate. The Committee will meet as required to address issues, but no less frequently than every two weeks for the first year and once per month thereafter through December 2009.

869

	Issues that will be reviewed by the Committee include but are not limited to: 1. Issues/problems or anticipated issues/problems related to the management of construction and traffic disruptions as identified by Project team members, corridor residents, adjacent businesses or stakeholders along the route; 2. Requests for changes to the Schedule or construction program proposed by the Concessionaire/contractors; and 3. Any other construction related issues that the Concessionaire or RAVCO consider appropriate for determination by this committee. The Committee will receive information on construction-related issues and impacts; review and evaluate issues to determine the mitigation strategies that can be implemented to address the issues while respecting schedule and budget; and communicate with those concerned regarding the resolution of the issues. Noting that issues brought to this Committee may have technical, schedule, financial and/or community/public impacts; and noting that during active construction, decisions may be needed quickly; the Concessionaire and RAVCO will agree on the process by which issues will be brought to the Committee and decisions made. This process will be organized to allow for the consideration of technical and community/public impacts at every stage.
RAVCO Lead:	Senior Vice President Engineering, (or designate) Vice President Corporate Affairs, (or designate)
Concessionaire Lead:	Project Director Vice President Public Affairs

870

Appendix 6: RAV PROJECT PROTOCOL – Public Enquiries & Contact Management – Construction Period

Subject:	Public Enquiries & Contact Management – Construction Period
Background:	RAVCO and the Concessionaire will implement a contact management program in order to: • Record enquiries, comments and complaints; • Develop and manage responses to enquiries, comments and complaints; • Support data collection and reporting requirements; • Support communication, liaison and notification activities; • Record Communication, Consultation and Liaison activities; • Assist the Project team in managing issues; The contact management program will be in place prior to the start of active construction, will be web-based, and be implemented as part of a joint Project website.
Protocols:	All members of both RAVCO's and the Concessionaire's teams will participate in the program by recording/tracking contacts and entering any follow-up action required into a common database. The program and instructions to users will accommodate all sources of public enquiries, including: • Project telephone line; • Telephone calls to office(s); • Email/mail; • Construction site "drop-ins"; • Community Liaison and Consultation meetings; Responses to enquiries will be routed to either RAVCO or the Concessionaire for response, according to the subject of the enquiry and pursuant to the roles and responsibilities defined in the Concession Agreement. The costs of designing and maintaining the Contact Management Program are addressed as part of the Project Website Protocol (Appendix 8). Both RAVCO and the Concessionaire will appoint a lead contact with responsibility to • Track & report out on enquiries and follow-up actions required; and • Coordinate responses to public enquiries. The responsibilities of contractors with respect to enquiries and contact management will be addressed in sub-contracts by the EPC and described in the Communications Plan. Prior to the establishment of the web-based contact management system, all public enquiries or comments related to the RAV Project are collected by the RAV Project office. Public enquiries routed directly to the Concessionaire will be copied to the RAV Project Communications team and responses coordinated with RAVCO except for routine construction and traffic related issues.

871

	During the pre-Construction Period, responses to general public enquiries are issued within 14 days. If a response cannot be issued within this timeframe, an interim response is issued. During the Construction Period, enquiries related to construction activities, traffic management and schedule will be more urgent and require quicker response. A construction information telephone line will be established as of August 1, 2005. The telephone line will be set up as a general information line, including the option to reach a live operator (as of September 1, 2005), and as deemed necessary, over the Construction Period. The Concessionaire will also provide a pager number for a Community Liaison Officer (who will be available 24/7). Further discussion on the project telephone line will be included in the Communications Plan. RAVCO and the Concessionaire will strive to respond to calls/enquiries as follows:

Type of call/message	Targeted Response Time
Calls identified as related to safety or emergencies	Immediate
Urgent calls related to active construction or traffic disruptions/impacts	As soon as possible within 4 business hours
Other calls/messages related to construction activities	As soon as possible within 1 to 2 business days
General messages/feedback/ correspondence	Within 14 days

	RAVCO will coordinate with Funding Agencies as necessary in order to respond to enquiries or ensure that the appropriate organization responds to enquiries. Responses to enquiries forwarded by the Agencies or Cities are copied to the forwarding Agency/City. Records of all enquiries & responses are maintained by both RAVCO and the Concessionaire, and these records, along with a summary report, are reviewed by RAVCO and the Concessionaire each month.
RAVCO Communications Lead:	Vice President, Corporate Affairs
Concessionaire Communications Lead:	Vice President, Public Affairs

Appendix 7: RAV PROJECT PROTOCOL – Issues Management

Subject:	Issues Management
Background	Both RAVCO and the Concessionaire are responsible for managing issues as they relate to their respective responsibilities or joint activities. In particular, the Concessionaire is responsible for identifying potential issues related to construction of the Line that could have a public or stakeholder impact and managing them in a proactive manner.
Protocols:	The issues management process will consist of identifying and prioritizing issues, followed by the development and implementation of a response/resolution, and communicating the result. The identification of issues during the Construction Period will be assessed by the following: • Geographic segments (i.e., where) • Construction schedule/milestone (i.e., when) • Construction activity (i.e., how and why) • Construction impact on residents, businesses, and commuters (i.e., what). Once issues are identified, they will be catalogued and addressed in a standard format. In most cases, issues will be managed by informing affected stakeholders "early and often" about all construction and traffic management-related impacts, through vehicles such as: • Advertising (radio and print) • Business Liaison Program • Community outreach (Community Liaison Officers) • Mailings (to both residents and businesses along the Project route) • Media relations (e.g., media advisories) • Online communications (email and web updates) • Technology • Project telephone line • Public meetings/personal contact • Signage In the case of certain issues that arise from construction and traffic impacts, these will be managed through the process outlined in Appendix 5. The following processes are in place to ensure ongoing coordination and joint review of issues & responses: 1. Bi-weekly RAV project technical & construction team meetings 2. Weekly RAVCO / Concessionaire issues call 3. Joint Communications Committee meetings
RAVCO Communications Lead:	Vice President, Corporate Affairs
Concessionaire Communications Lead:	Vice President, Public Affairs

873

Appendix 8: **RAV PROJECT PROTOCOL – Project Website – Construction Period**

Subject:	**Project Website - Construction Period**
Background:	RAVCO and the Concessionaire have agreed to jointly maintain one Project website during the Construction Period in order to: • Provide a "one-window" approach for the public to access Project information online; • Provide a user-friendly, up-to-date tool for people to learn more about the construction of the System, particularly to access detailed information about construction and traffic management activities that affect them; • Provide access to additional Project information, background and reports online to meet Project commitments with respect to information and access; and • Establish an online subscriber update and contact management system to support notification activities and tracking of community liaison activities, public enquiries and complaints.
Protocols:	Generally: 1. RAVCO and the Concessionaire will work together to launch the joint Project website for the Construction Period meeting the objectives outlined above. This website may be launched in phases, the first phase of which must be launched by a mutually agreed date in September 2005. 2. RAVCO and the Concessionaire will each assign a lead contact responsible for managing the website and securing necessary and timely approvals for the site launch as well as ongoing updates & maintenance. 3. RAVCO will maintain the existing Project website prior to the launch of the new site in September 2005; the Concessionaire is responsible for providing content relating to pre-construction and construction activities and/or notification to RAVCO during this period. 4. RAVCO owns the web address www.canadaline.ca and will register the site address for the duration of the Construction Period. 5. The costs of launching, maintaining and updating the Construction Period website will be shared by RAVCO and the Concessionaire within respective budget parameters, and will be allocated according to areas of responsibility as outlined in the Concession Agreement Communications Protocol and summarized below. Responsibility for content generation, approvals and costs (both initial and ongoing costs for design, programming and maintenance) will be allocated within respective budget parameters as follows: 1. RAVCO is responsible for general Project information and will retain responsibility for areas of the website developed for general/introductory and Project archival material (eg: overviews, governance, reports, description of pre-construction activities, etc). 2. The Concessionaire is responsible for Construction Period program, schedule, liaison, notification, and consultation, and will retain responsibility for the areas of the website developed to describe such activities. 3. Both RAVCO and the Concessionaire retain responsibilities for community liaison and media relations, therefore responsibility for these areas of the website will be shared.

874

	4. RAVCO is responsible for Project branding and will retain responsibility for design of home and inside page templates. 5. RAVCO and the Concessionaire will share equally the initial programming and ongoing maintenance costs of an online database and contact management system to meet Project liaison and notification objectives. 6. RAVCO and the Concessionaire will share equally the costs of registering the site with key search engines.
RAVCO Communications Lead:	Vice President, Corporate Affairs
Concessionaire Communications Lead:	Vice President, Public Affairs

Appendix 9: **RAV PROJECT PROTOCOL – Community Project Office – Construction Period**

Subject:	**Community Project Office - Construction Period**
Background:	RAVCO has explored various possible arrangements for community offices in Vancouver and Richmond during the Construction Period. In Richmond, the City's RAV project team is interested in providing limited space to community and business liaison program staff from RAVCO and the Concessionaire in order to facilitate coordination. It is anticipated that basic space (desk, phone, internet connections) will be made available for community liaison officers. In Vancouver, it will not be possible for community and business liaison program staff from RAVCO and the Concessionaire to co-locate with City's project team. Therefore RAVCO will establish a community office as a base for community and business liaison program staff.
Protocols:	RAVCO will make space available for use by the Concessionaire's project team at the following locations: a) office space within the City of Richmond's RAV project office located at or near Richmond City Hall; and b) office space located in the vicinity of Cambie and 16th Street in the City of Vancouver. In furtherance of the Concessionaire's obligation to establish a project office where members of the public can access information about construction activities, the Concessionaire's Community Liaison Officers will establish a presence in these offices. Noting the need for Community Liaison Officers to be mobile at times, the Concessionaire will also jointly fund a receptionist (costs to be shared equally with RAVCO) for the office at Cambie and 16th Street in the City of Vancouver for a period of time to be determined in the Communications Plan.
RAVCO Communications Lead:	Vice President, Corporate Affairs
Concessionaire Communications Lead:	Vice President, Public Affairs

876

Appendix 10: RAV PROJECT PROTOCOL – Media Relations – Construction Period

Subject:	**Media Relations - Construction Period**
Background:	Both RAVCO and the Concessionaire retain responsibilities for media relations during the Construction Period. To meet RAVCO's & the Concessionaire's goal of communicating early and often about construction-related impacts, media relations will be crucial. Media activities will include: providing a spokesperson and responding to media inquiries, writing and distributing news materials, organizing media briefings, preparing key messages, preparing presentations to editorial boards, arranging small group interviews with select media, and developing and maintaining relationships with relevant reporters and editors. The Concessionaire and RAVCO will coordinate these activities. During the Construction Period of the Project, the following key information tools, combined with regular Project briefings and responses to specific requests, will be used to communicate the status of Project activities to media:
Spokespersons	The primary spokespersons for the overall Project, including issues related to Project rationale, marketing, and funding during the Construction Periods are the RAVCO CEO and RAVCO Senior VP Engineering, or on specific issues, their designate. The Concessionaire's VP-Public Affairs will be the Concessionaire's primary spokesperson, and will assume the role of primary spokesperson for media inquiries relating to specific Project construction issues, including construction management, traffic management and schedule.

Tool	Purpose	Primary Audience
News Releases	Communicate news, marquee events, milestones & announcements	Media
Media Advisories	Announce public events, displays, etc.	Media
Information Bulletins	Communicate Project news and developments	Media, Public
Public Notices	Advise the public of regular program activity	Media, Public (particularly corridor residents & businesses)
Fact Sheets	Provide factual/descriptive information on topics of interest/concern	Media, Public (particularly corridor residents & businesses)

	Wherever possible, media inquiries will be coordinated between RAVCO and the Concessionaire with information shared in advance.
Coordination	Agencies involved in the Project will forward relevant media calls to RAVCO or the Concessionaire for either direct or coordinated response as agreed.
Enquiries	Media inquiries related to RAVCO's responsibilities are forwarded to the attention of RAVCO Director of Communications for routing/response. Media inquiries related to detailed design, construction and related impacts (e.g., traffic management) and Approved Project Schedule are forwarded to the attention of the Concessionaire's Vice President Public Affairs, or designate for routing/response:
Media Monitoring	Media monitoring and cost-sharing between RAVCO and the Concessionaire will be further discussed in the Communications Plan.
RAVCO Communications Lead:	Vice President, Corporate Affairs
Concessionaire Communications Lead:	Vice President, Public Affairs

7.0 LABOUR RELATIONS

7.1 CONSTRUCTION PERIOD

7.1.1 Labour Relations and Safety

7.1.1.1 Objectives

It is our strong commitment:

- To provide all of our employees with safe working conditions that are alcohol and drug free
- Work in an environment free from discrimination and harassment, including sexual harassment
- Maximize employment of local residents with special emphasis on providing opportunities for members of First Nations
- Train and develop our workforce, and provide a work environment that encourages individuality and personal growth, and promotes teamwork and employee commitment to attaining good workmanship so that specified standards of quality are maintained at all times
- Strict compliance with labour agreements
- Comply with federal, provincial, WCB, and local laws and regulations

7.1.1.2 Labour Relations

S.17(1)(e)

7.1.1.3 Equal Employment Opportunity

S.17(1)(e)

7.1.2 *Training, Apprenticing and Safety Programs*

7.1.2.1 Safety and Accident Prevention

SNC-Lavalin, Serco and its team of Designated Subcontractors have all developed comprehensive corporate safety programs that will be used as the basis for a Project Specific Safety Plan, which will govern our operations on the RAV Project.

SNC-Lavalin's General and Construction Safety Policy below will be the basis for the Project Specific Safety Plan. A proactive accident prevention approach will be used, through the application of the following procedures:

1. Establishment of a safety committee with designated safety officers answerable only to the Project Director
2. Regular site meetings with site personnel at which safety issue feedback will be encouraged
3. Regular site inspections
4. Compulsory safety orientation and training
5. Site safety and maintenance procedures
6. Procedure review with site personnel
7. Site visitor control
8. Regular follow-up

7.1.2.2 Subcontractor Employee Safety Adherence Overview

Subcontractors will be responsible for assigning employees with the knowledge and expertise to perform required job functions in a safe and professional manner. Subcontractors will use only those individuals who are fully trained and licensed to perform their assignments. Mandatory attendance will be required at any project orientations and meetings that pertain to operations and safety. Subcontractors will be required to provide the company with pre-qualification documents regarding their safety program and experience rating and with suitable Safe Job Procedures for tasks they are performing.

Subcontractor employees, vendor employees and agents will also be subject to the same safety and disciplinary action program as our employees. The process can culminate in requiring that a subcontractor or vendor employee be removed from the site if corrective action is not successful.

The Project Manager will establish the level and frequency of attendance by subcontract and vendor employees at dedicated safety meetings. Attendance requirements will be commensurate with the degree to which personnel are exposed to hazards inherent to ongoing construction or station system.

It will be contractually established and clearly communicated that while on our work sites, subcontractor and vendor employees are under the authority of, and must be responsive to, the general directions and specific instructions of the company's Project Manager or his designate with respect to all matters, but in particular, safety.

7.1.2.3 SNC-Lavalin's General Policy on Occupational Health and Safety

1. As an engineering-construction and manufacturing company operating worldwide, the SNC-Lavalin Group and its subsidiaries make occupational health and safety a primary objective in all of their activities both in Canada and abroad.
2. The Board of Directors established the Occupational Health and Safety Committee and mandated it to monitor the general Policy on Occupational Health and Safety. Each business unit, operating division or wholly owned subsidiary is responsible for enforcing the laws and regulations under this general policy, along with the operating guidelines issuing therefrom, which are applicable to all employees without exception.
3. Measures implemented by the company include, among other things:
   3.1. Training employees so that they can help integrate the occupational health and safety standards into SNC-Lavalin activities
   3.2. Developing construction, operating and working methods to ensure that occupational health and safety objectives are part of SNC-Lavalin project quality criteria
   3.3. Producing an annual report on SNC-Lavalin's progress in attaining its occupational health and safety commitments and objectives
4. SNC-Lavalin, with regard to all the establishments where it is assigned a mandate or responsibility in occupational health and safety matters, has an objective of zero (0) accidents in the workplace and the elimination at source of any risk or danger.
5. All units, divisions and subsidiaries are responsible for reporting any fatal or serious accident resulting in lost time or property damage and to present their reports on such matters to the company's Occupational Health and Safety Committee.
6. SNC-Lavalin has identified measurable objectives which are specific and adapted to each type of operation in which it is involved which will be subject to periodic review.
7. SNC-Lavalin favours a return-to-work policy to assist those who have been involved in a workplace accident at any of its worksites or facilities.
8. The Director, Occupational Health and Safety, is responsible for verifying official directives regarding occupational health and safety and to assure that all offices, plants and worksites comply with laws, regulations and operating policies. Status reports are submitted to the company's Occupational Health and Safety Committee.

* This general policy is supplemented by another organizational health and safety policy specific to construction work sites – please see below.

7.1.2.4 Specific Policy Regarding Occupational Health and Safety on Construction Sites

This is a specific policy statement issued from the SNC-Lavalin Group regarding occupational health and safety on worksites where our firm acts as prime contractor (turnkey contracts), as the representative of the prime contractor, as the owner's agent with a mandate for occupational health and safety or as a contractor.

1. This specific policy constitutes the minimum requirement in such matters as it applies to all our construction sites. If applicable, it will become the object of a specific prevention program.

2. The safety of workers and other participants on SNC-Lavalin Group construction sites is a priority objective and takes precedence over any other activity or consideration.

   On all its construction sites, the SNC-Lavalin Group aims at eliminating the very causes of dangers to workers' health, safety and physical integrity.

3. Safety on construction sites is everyone's business: SNC-Lavalin Group, contractors, sub-contractors, the Project Manager, the construction manager, worksite supervisory personnel, security agents, the workers themselves and the organizations representing them.

4. On each worksite where we have a mandate regarding occupational health and safety, the SNC-Lavalin Group agrees to:

   a) Identify risks relating to construction work

   b) Identify the means for eliminating such risks

   c) Identify the person in charge of management regarding occupational health and safety matters

   The SNC-Lavalin Group will see to it that on each worksite the indications of frequency and seriousness be compiled on a monthly basis.

   These indications are to be compiled according to the local methods and usages and in the absence of such usage, then in the following way:

   Frequency: $\frac{\text{Number of lost time accidents} \times 200{,}000}{\text{Total number of hours worked}}$

   Seriousness: $\frac{\text{Number of lost days} \times 200{,}000}{\text{Total number of hours worked}}$

5. With regard to occupational health and safety matters on worksites where we have a mandate, the SNC-Lavalin Group agrees to minimum standards of procedures and activities related to follow-up and reporting:

   a) A written report on the nature of worksite risks and the identification of means for eliminating them, plus the identification of the manager in charge

   b) A quarterly report on the frequency and seriousness indications from the worksite

c) A report relating to every serious or mortal accident including the circumstances surrounding the accident, causes as identified and recommendations for avoiding a repetition of such an accident

6. The Project Manager and construction manager are directly liable for the performance of their projects where safety is concerned. Performance regarding safety on a given project will be used in the annual evaluation of Project Managers and Construction Managers.

7. The company agrees to provide itself with means and instruments enabling it to apply this policy on worksites; such means may include, among other things, contractual provisions or other means such as inspections, audits, safety committee, etc.

8. The decision to carry out an audit, and the decision regarding its location, shall be made by the Health and Safety Officer and by the members of the Health and Safety Committee. The project's director shall be notified of the audit approximately three (3) weeks before it is carried out.

9. The SNC-Lavalin Group ensures that the organization of work on worksites and the methods and techniques in use are safe and do not prejudice the health of anyone.

   In particular, the company ensures the proper upkeep of the worksite and the providing of adequate sanitary facilities.

10. The SNC-Lavalin Group ensures that the emission of a contaminant or other hazardous substance on the construction site does not prejudice the health or safety of anyone working on such site.

11. The SNC-Lavalin Group ensures that worksite personnel has received adequate training and information regarding:

    a) Risks arising from work;

    b) Means for avoiding a risk;

    c) Onsite first aid services.

12. Each contractor or sub-contractor whose indication of frequency or indication of seriousness is deemed to be unacceptable, may be required by the SNC-Lavalin Group to submit a recovery plan aimed at eliminating the life or health threatening risks for anyone on its worksite. It must then apply this recovery plan to the worksite.

7.1.3 Training

7.1.3.1 Construction Period

SNC-Lavalin has a history of specific and meaningful participation in professional training through Canadian Universities. The combined work forces of SNC-Lavalin, Serco and the Designated Subcontractors will include people under training as apprentices and as professionals, including minorities, women, and persons with disabilities.

It is expected that proposed construction in the Lower Mainland over the coming years will place major demands on the construction workforce. We therefore anticipate that the RAV Project will provide abundant opportunities for apprentices and others new to the construction industry. In this regard, SNC-Lavalin/Serco and the Designated Subcontractors will participate in development and employee training programs on the RAV Project.

All new employees and apprentices will receive appropriate training and will be assigned to experienced, qualified supervisors, enabling them to develop and perfect their skills over the course of the project.

It is expected that the Project will be constructed utilizing established construction techniques, however, in instances where new equipment, means or methods can demonstrate efficiencies, all affected personnel will be provided the appropriate training to ensure effective implementation of the process.

7.2 OPERATING PERIOD

s.17(1)(e)

7.2.1 Recruitment Plan

s.17(1)(e)

Recruitment of Management Staff

s.17(1)(e)

Recruitment of Other O&M Staff

s.17(1)(e)

S.17(1)(e)

7.2.2 Labour Relations and Safety

S.17(1)(e)

Safety

S.17(1)(e)

S.17(1)(e)

7.2.3 Training and Apprenticeship Programs

S.17(1)(e)

7.2.4 Relationship to GVTA Staff

S.17(1)(e)