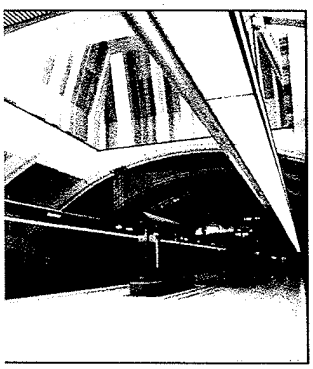

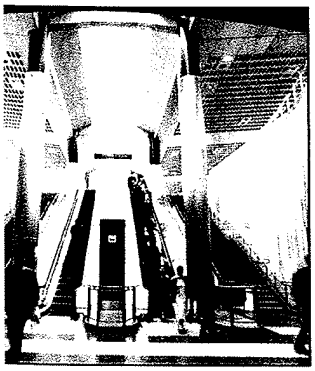

Richmond/Airport to Vancouver Rapid Transit Project

Project Definition Phase Contract T1 - Vancouver Segment

Technical Stream

REPORT

July 2002

142577

Sandwell

Hatch Mott MacDonald

Golder Associates

Richmond Airport - Vancouver Rapid Transit Project
Vancouver, BC

Vancouver Segment, Technical Stream

Volume I

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Prepared By: _____
Richard Reynolds, P. Eng., Sandwell Engineering Inc.

Prepared By: _____
Brian Garrod, P. Eng., Hatch Mott MacDonald

Prepared By: _____
Trevor Fitzell, P. Eng., Golder Associates Ltd.

REGISTERED PROFESSIONAL ENGINEER
B. L. GARROD
PROVINCE OF ONTARIO

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Richmond/Airport to Vancouver
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Vancouver Segment, Technical Stream Report

142577, August 2002

— VOLUME I —

Executive Summary

- The Vancouver Segment of the Richmond Airport – Vancouver Rapid Transit Project extends from SW Marine Drive to the downtown terminus.

- COV council has endorsed a "subway" system, accordingly a tunnelled system from downtown Vancouver to SW Marine Drive was the "base case" option.

- The reference alignment within the Vancouver Segment would follow Cambie, Davie and Granville Streets.

- To allow transit systems that do not use Skytrain technology to be used the alignment would not tie into the Skytrain Line.

- The reference alignment is expected to generate significant ridership to and from Vancouver downtown south and the business districts.

- The base case profile consists of tunnel from the downtown terminus station at Granville and Cordova Street to Cambie and 63rd Avenue with a short elevated section crossing SW Marine Drive.

- Options for shortening the tunnel at the south end of the segment using either an extended elevated section or an at-grade section were investigated.

- To investigate potential cost savings at the north end of the alignment, profile options were reviewed that would either cross under or over the existing Dunsmuir Skytrain Tunnel.

- Nine stations are recommended within the Vancouver Segment with five stations located to the south of False Creek.

- A proposed station at Cambie Street and Broadway would accommodate the proposed future extension of the Millennium Line and allow riders to transfer between the two lines.

- To the north of False Creek one station would be located on Davie Street at Pacific Boulevard and three stations would be located in downtown Vancouver on Granville Street at Nelson, Dunsmuir and Cordova streets.

- Alternate profiles were investigated along Granville Street with two stations located at Robson and Cordova streets.

- With the base case profile the station at SW Marine Drive would be an above ground station, the eight other stations would all be underground stations.

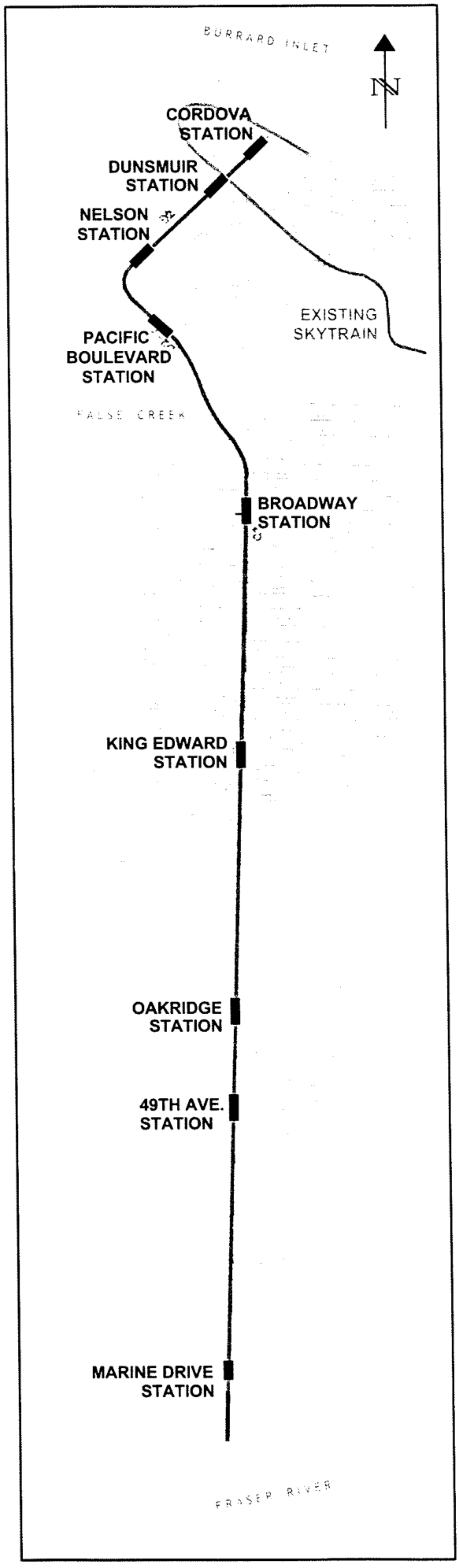
- With the extended elevated and at-grade options a proposed station at Cambie Street and 49th Avenue would also become an above ground station.

- Cut-and-cover construction of underground stations and crossover structures is envisaged to save costs.

- It is envisaged that there would be three tunnel drives for the base case alignment using six tunnel boring machines. Two drives would originate on the south side of False Creek driving north and south, and one would originate at SW Marine Drive heading north.

- Approximately 2.8 million cubic metres of excavated material will need to be disposed of. Ocean dumping of the excavated material is recommended.

- The estimated cost of the Vancouver Segment reference alignment ranges from $1,005M for the base case profile with a 5.7m diameter tunnel to $805M for a 5.0m diameter tunnel with an atgrade section at the south end and cut-and-cover tunnel at the north end.



Vancouver Segment

1 Background

A Request for Proposal was issued by RTP on March 2, 02 for the technical study to further define the project for the Vancouver Segment of the Richmond/Airport to Vancouver Rapid Transit Project (RAVP). The Sandwell, Hatch Mott McDonald and Golder Associates Team (SHMG) submitted a proposal and was selected to undertake the study which extends from SW Marine Drive to downtown Vancouver.

A kick off meeting was held on April 24, 02 at the Rapid Transit Lougheed Offices with staff from RAVP, TransLink, City of Vancouver (COV), Vancouver International Airport (YVR) and SHMG. The objectives of the assignment were agreed as:

- Identify one preferred horizontal alignment;
- Develop vertical alignment options along the preferred option;
- Locate stations and station entrances;
- Prepare a constructability report and;
- Estimate the construction costs.

Other issues and concerns that need to be addressed in the report were identified as:

- Integration with the downtown SkyTrain system;
- Connectivity with the western extension of the Millennium Line;
- COV council has endorsed a "subway" system, accordingly an underground system to SW Marine Drive would be the "base case" option. However it was recognized that an underground system extending all the way to SW Marine Drive would be a costly option and COV requested a business case to support the decision.
- YVR would like to see a Canada Place cruise ship terminal connection.

The horizontal alignment prepared under this assignment has been developed to be consistent with COV wishes and is subject to refinement and adjustment as total costs are defined and performance assessed.

The Notice to Proceed from RTP was received on May 06, 02 and COV provided compact discs for the base mapping on May 08, 2002.

2 *Layout Criteria*

The following criteria was used by SHMG to develop alignments and station layouts:

2.1. TUNNEL CRITERIA

The tunnel criteria listed below would accommodate all technologies considered likely to be adopted. Actual tunnel criteria will depend on the final accepted technology.

Tunnel Diameter	5.70 meters
Tunnel Spacing:	11.40 meters (two diameters centre to centre)
Horizontal radii:	
Minimum:	150 meters for accommodating the tunnel boring machine (TBM)
Downtown Minimum:	200 meters for 50 kph
Normal Minimum:	600 meters for 80kph
Maximum Gradient:	5%
Depth to Top of Tunnel:	
Minimum:	One tunnel diameter
Under False Creek:	Three tunnel diameters (one diameter in rock/glacial drift soils)
Under Dunsmuir Tunnel:	One metre clear with ground pre-treatment
Under Existing Buildings:	Two tunnel diameters
Under Proposed Buildings:	One tunnel diameter with ground pre-treatment

2.2. STATION CRITERIA

Maximum Station Gradient:	0.5%
Platform Length:	80 meters
Centre Platform Width:	9.5 meters
Station length	130m

2.3. ANCILLARY

Cross-passages	3m diameter at 244m maximum spacing
Emergency exits	At ±500m spacing
Ventilation/emergency exit shafts	750m spacing
Crossovers	140m long

2.4. TYPICAL STRUCTURES

Drawings numbered 6000 to 6003 are presented in Appendix A showing conceptual outlines of the following:

- Typical tunnel cross section
- Emergency exit building and ventilation shaft
- Crossover tunnels
- South Portal

The south portal concept presented would fit within the existing Cambie Street median. Behind the portal a section of cut-and-cover tunnel approximately 150 m long would extend to a depth of one tunnel diameter. The cut-and-cover section would allow a TBM launch and would widen out to give a clear spacing between the tunnels at the bored face of approximately 2.5 diameters.

3 *Alignment Options*

A meeting was held on April 29, 02 to identify the range of horizontal alignment options that the SHMG team would need to review between SW Marine Drive and Vancouver downtown waterfront. Attending the meeting were Ray Spaxman of the Spaxman Consulting Group, Lon LaClaire representing COV and Messrs Reynolds, Scholte and Fitzell representing SHMG. The task of the meeting was to find alternative routes which would meet the following objectives:

- The alignment would be primarily in tunnel within the City.
- Allow passenger connections with the existing Skytrain line in Downtown Vancouver.
- Connect the Airport with the Canada Place Cruise Ship Terminal.
- Allow stations to be located where high riderships are likely to be generated.
- Allow private bidders to use their preferred transportation system and not be confined to the Skytrain system.

The alignment options and potential station locations are presented on aerial photographs in Appendix B. For simplicity, the route between SW Marine Drive and the downtown terminus was divided into four sections designated A to D on the drawings and the alignment is described as running in a north south direction. The alignment options and station locations identified within each section were:

3.1. SECTION A

Section A extends from SW Marine Drive to 48th Ave. Only one realistic alignment following the Cambie Street ROW was identified.

The route would bridge over Marine Drive before entering into tunnel on Cambie Street. For this section two profiles were developed with the south tunnel portal located as far north as possible to minimise costs and as far south as possible to minimise the impact on adjacent communities.

The first location for a station would be at SW Marine Drive, which would serve both commercial and residential neighbourhoods.

The second location for a possible station would be at 49th Avenue to serve Langara College, a potential high-density residential development site, significant east west bus routes and the local residential neighbourhood.

3.2. SECTION B

Section B extends from 48th Ave. to 21st Ave. Two alignment options were identified within this section on Cambie and Oak Streets designated B1 and B2, respectively. They were generated by the following considerations:

- The Cambie Street alignment would serve the Oakridge Shopping Centre and cross-town bus services on 41st Avenue – which generates the continuation of the line along Cambie to 21st Avenue but cutting in a continuous northerly alignment below a portion of Little Mountain. The Cambie Street alignment would also serve City Hall and would be in walking distance of the Vancouver General Hospital (VGH) complex in the vicinity of 12th Avenue.

- The Oak Street alignment would serve the main entrance to the major hospital conglomerations on Oak Street i.e. the Children's Hospital in the vicinity of 28th Avenue, the Women's Hospital and the VGH complex, and would still serve the Oakridge Shopping Centre site,

On both alignments stations would be located at Oakridge to serve the centre, important east west bus routes and the local neighbourhood, and at King Edward Avenue where there is a minor commercial area, an important cross town bus route that serves UBC, and the local residential community.

3.3. SECTION C

Section C extends from 21st Avenue to 1st Avenue. Five alignment options were identified in this section on Yukon, Cambie, Ash, Heather and Oak Streets designated C1 to C5. The C3 alignment on Heather would tie into either of the B1 (Cambie St.) and B2 (Oak St.) alignments.

All the routes would be within walking distance of Vancouver General Hospital and City Hall, two major employment centres in Vancouver. All the routes would allow passengers to transfer to the proposed future Skytrain Millennium Line extension on either the West Broadway or West 10th Avenue alignments.

The Yukon alignment, although further from VGH, would provide an opportunity to locate a station at 2nd Avenue to serve the proposed Southeast False Creek sustainable development area and future streetcar and bus routes on 1st and 2nd Avenues. The Yukon alignment was also considered to be a very direct route to Cambie Street and Waterfront Station on the north side of False Creek.

Each of the five routes has potential connections under False Creek to the various Downtown routes.

The westerly routes would provide better access to the Hospital while the easterly ones, while still providing access to the VGH hospital complex and Broadway, would provide better access to City Hall.

3.4. SECTION D

Section D extends from 1st Ave. to the Downtown Vancouver terminus.

The objectives in developing routes in Downtown Vancouver included:

- Provide transfers to the existing Skytrain system.

- Connect to the Cruise ship facility at Canada Harbour Place.
- Avoid high rise towers to avoid foundation conflict problems.
- Pick up the best ridership locations.
- Provide service to the downtown business/office centre where the highest ridership will be generated.
- Avoid low radius curves, which slow the system and cause added operational costs.
- Achieve evenly spaced station locations and avoid providing too many stations.
- Serve Granville Street, Downtown south and the Pacific Boulevard areas.

While the major centre for anticipated highest ridership is located in the high density office core centred roughly on Hornby and Dunsmuir other centres such as St Paul's Hospital, Robson Street, the Courthouse, Yaletown, BC Stadium and General Motors Place were also considered.

Three alignments options were identified within this section on Cambie, Granville and Burrard Streets designated D1 to D3. Alignment D1 on Cambie Street would be the most easterly route and would pass through Victory Square to Waterfront Station. However, this route failed to meet many of the objectives listed above, would seem to have considerably lower ridership potential and would favour operation as a continuation of the Skytrain system out of the Waterfront Station. Alignment D1 would favour a tie-in to alignment C1 or C2 on Yukon or Cambie Streets

Alignments D2 to D3 on Granville and Burrard Streets could tie in to all C1 to C4 alignments with connections designated 1 to 4 that follow Drake, Davie, Helmcken and Smithe Streets. However, only connections that allow stations to be located at Pacific Boulevard on straight alignment sections are shown on the aerial photographs.

The aerial photograph of section D shows proposed station locations for the downtown for each of the D1 to D3 alignments. Alignment D1, which would tie in to the existing Waterfront Station, would not provide new stations at the locations listed above except for Pacific Boulevard. Alignments D2 and D3 would terminate with a new station close to Canada Place with access to the existing Waterfront Station and cruise ship terminal.

3.5. NUMBER OF OPTIONS

As noted earlier the following alignment options were identified south of False Creek:

Cambie Street

Cambie - Yukon Streets

Cambie - Ash Streets

Cambie - Heather Streets

Cambie - Oak-Heather Streets

Cambie - Oak Streets

On the north side of False Creek, five alignment options on Drake, Davie, Helmcken, Smithe and Cambie Streets were identified to tie into the False Creek alignment:. Accordingly with five alignment options on the north side of False Creek and six alignment options on the south side of False Creek there were potentially thirty alignment options crossing under False Creek.

Three streets were identified as alignment options leading to the downtown terminus: Cambie, Granville and Burrard Streets. This resulted in a potential of 90 alignment options between SW Marine Drive and the downtown terminus that would need to be reviewed. However, high rise buildings with underground structures, or Cambie Street Bridge foundations, would obstruct tunnel construction on many of the alignment options. Furthermore, a number of the alignment options either resulted in unacceptably small horizontal tunnel radii or it was not possible to locate a station close to Pacific Boulevard on a tangent.

The spreadsheet presented overleaf identifies the "obstructions" to the alignment options and identifies the "feasible" options. However, it should be noted that most alignment options identified as feasible would pass under low-rise buildings when turning between streets in downtown Vancouver.

Obstructions to Tunnelled Alignments

Section A	Section B	False Creek			Section D			"Feasible"
		Section C	to	Section D	Cambie D1	Granville D2	Burrard D3	Routes
			OK	Drake	n/a	LRB's	LRB's	2
			PBS	Davie	n/a	n/a	n/a	0
Cambie	Oak	Oak	PBS	Helmcken	n/a	n/a	n/a	0
A	B2	C5	CB	Smithe	n/a	n/a	n/a	0
			HRB's	Cambie	n/a	n/a	n/a	0
			OK	Drake	n/a	LRB's	LRB's	2
			OK	Davie	n/a	LRB's	LRB/HRB's	2
Cambie	Oak	Heather	PBS	Helmcken	n/a	n/a	n/a	0
A	B2	C4	CB	Smithe	n/a	n/a	n/a	0
			OK	Cambie	LRB's	n/a	n/a	1
			OK	Drake	n/a	LRB's	LRB's	2
			OK	Davie	n/a	LRB's	LRB/HRB's	2
Cambie	Cambie	Heather	PBS	Helmcken	n/a	n/a	n/a	0
A	B1	C4	CB	Smithe	n/a	n/a	n/a	0
			OK	Cambie	LRB's	n/a	n/a	1
			OK	Drake	n/a	LRB's	LRB's	2
			OK	Davie	n/a	LRB's	LRB/HRB's	2
Cambie	Cambie	Ash	PBS	Helmcken	n/a	n/a	n/a	0
A	B1	C3	HRB's	Smithe	n/a	n/a	n/a	0
			OK	Cambie	LRB's	n/a	n/a	1
			OK	Drake	n/a	LRB's	LRB's	2
			OK	Davie	n/a	LRB's	LRB/HRB's	2
Cambie	Cambie	Cambie	CB	Helmcken	n/a	n/a	n/a	0
A	B1	C2	CB	Smithe	n/a	n/a	n/a	0
			OK	Cambie	LRB's	n/a	n/a	1
			HRL/CB	Drake	n/a	n/a	n/a	0
			HRL/CB	Davie	n/a	n/a	n/a	0
Cambie	Cambie	Yukon	OK	Helmcken	n/a	LRB's	HRB's	1
A	B1	C1	OK	Smithe	n/a	LRB's	LRB's	2
			OK	Cambie	LRB's	n/a	n/a	1
								26

HRB's High Rise Buildings
LRB's Low Rise Buildings
PBS Not able to locate station near Pacific Boulevard on straight alignment
HRL Horizontal Radius Limitations
CB Cambie Street Bridge

3.6. SHORTLIST OF ALIGNMENTS

A meeting was held on May 30, 02 to shortlist alignment options from those previously identified as "feasible". Attending the meeting were Ray Spaxman, Lon LaClaire, Messrs J. Eastman and R. Louie representing RAVP and Messrs Reynolds, Scholte, Ekk, Fitzell and Downing representing SHMG. The evaluation criteria used to shortlist the alignments included:

- Connectivity to Skytrain Station, Sea Bus, West Coast Express, Canada Place cruise ship terminal and the proposed Convention Centre.
- Potential for locating new stations in Yaletown, Vancouver downtown south and the Vancouver business district.
- Location of a station on Granville Street to connect with the cross-town bus routes.
- Location of a station close to VGH and City Hall
- Avoidance of routes under high rise buildings with deep foundations that would result in an excessively deep tunnel and stations.
- Finding routes that cross potential construction yards where shafts could be constructed to allow TBMs to be launched.

3.6.1. Downtown Alignments

SHMG presented a number of potential downtown alignment options including two tunnel schemes tying into SkyTrain using either Cambie Street to tie into the Waterfront Station or Burrard Street to tie into the Dunsmuir tunnel. A concept for a third alignment option using Helmcken and Thurlow to tie into the existing SkyTrain was also reviewed. It was noted that tying into Dunsmuir tunnel was not a viable option since it would potentially double the number of trains using the already busy track between Burrard and Waterfront Stations. It was concluded that the only tie into SkyTrain that appeared to be feasible was the Cambie Street to Waterfront Station alignment option. An alignment that followed Cambie Street terminating near Waterfront Station that would not use Skytrain technology would also be feasible. However, it would fail to locate stations in downtown south and the business district on Burrard or Granville Streets.

The meeting was updated on progress on the Richmond Segment, where the City was favouring an at-grade system. If an at-grade system were adopted for the Richmond Segment of the project, the use of the SkyTrain cars for the Vancouver Segment would effectively be ruled out since SkyTrain cars use a linear induction motor drive system that requires a dedicated and secure right of way. In the circumstances, it was agreed to concentrate on alignments that would allow a range of technologies to be used. This effectively left two tunnel alignment options to the downtown terminus using either Granville or Burrard Streets, both terminating with a station close to Canada Place. SHMG had prepared plans showing stations at the foot of Granville and Burrard with tail lines extending north. However, SHMG were requested to review locating the terminus station closer to the

waterfront to provide better connectivity to the existing Seabus, West Coast Express, Skytrain, Canada Place cruise ship terminal and proposed Convention Centre.

Of the four alignment options identified for tying into Burrard or Granville Streets the Smithe Street option to Burrard Street is obstructed by a high rise building between Burrard and Hornby streets and the Orpheum theatre on Granville Street. Furthermore, using Smithe Street would not enable a station to be located in the downtown south area.

The new Wall Centre buildings on Burrard Street and a high rise building between Seymour and Granville Streets similarly obstruct the Helmcken Street option on to Burrard or Granville streets. Accordingly, this left Davie and Drake streets as the two preferred alignment options for tying into Burrard and Granville streets.

3.6.2. South Side of False Creek

The C1 alignment along Yukon Street had previously been identified as an alignment option to Helmcken, Smithe and Cambie streets in Vancouver. However as noted above, the Smithe and Helmcken street options were not recommended due to obstructions, and work on the Cambie Street option that would have tied in to SkyTrain was suspended. Accordingly, the C1 alignment on Yukon Street was discounted.

The meeting attendees were concerned that both the Oak and Heather Street alignments would generate considerable opposition from residents living along those alignment options who have been led to understand that the route will be along Cambie Street. The Heather Street alignments in particular would cross under a number of private residents where it ties into Oak or Cambie streets. Furthermore, with a station on Broadway, both Oak and Heather street alignments would provide good access to VGH but not to City Hall. However, a Cambie Street alignment with a station at Broadway would provide good access to City Hall, VGH and the Cancer Clinic. In addition, the Cambie Street alignment would cross under a car park owned by COV at 6th Avenue. It was noted that this car park could potentially be made available to the Contractor as a construction yard.

The alignment along Cambie-Ash could have similar advantages to the Cambie Street alignment option and as a result two alignment options south of False Creek were shortlisted:

- Cambie Street;
- Cambie Street – Ash Street.

3.7. PREFERRED ALIGNMENT OPTIONS

A meeting was held on June 13, 02 to further reduce the shortlist of alignment options. Attending the meeting were Messrs Eastman, Louie, Spaxman, Reynolds, Scholte, Ekk and Fitzell, and Wayne Pledger representing COV.

SHMG presented plans of two alignment options using:

- Cambie-Ash-Davie-Granville or Burrard
- Cambie-Drake-Granville or Burrard

It was noted that if necessary Ash Street could tie into Drake Street and Cambie Street into Davie Street.

At the termini SHMG had reviewed locating stations close to Canada Place with tunnels terminating under Waterfront Road directly beneath the Canada Place Road. However, the Burrard/Waterfront street alignment was discounted since it would have required deep tunnels under the existing Waterfront Office Tower. This would have resulted in constructability problems with a deep terminus station on Waterfront Road located immediately next to the shoreline.

The Granville/Waterfront street alignment was also discounted since locating the station on tangent would result in a terminus station location east of Canada Place, a considerable distance from the existing Waterfront Skytrain Station. This station location would also have resulted in constructability problems with a deep terminus station located immediately next to the shoreline.

It was agreed that a terminus station would need to be located at the north end of either Granville or Burrard streets with a spur line extending approximately north. "People movers' could assist passengers to transit from the terminus station to either Waterfront Station or Canada Place cruise ship terminal.

The Davie/Burrard street alignment was discounted since the tunnels would cross under the Medical Centre on Burrard Street, which has five levels of underground parking. Similarly, the Drake/Granville street alignment option was discounted since it would pass under a new high rise residential building at the corner of Drake and Granville Streets.

Immediately to the south of False Creek the Cambie Street alignment option was preferred to the Ash Street alignment option due to:

- Cambie Street has a wider right of way.
- The Ash Street alignment would need to cross under a number of buildings before tying back into the Cambie Street alignment option.
- A station on Cambie Street at Broadway would be easily accessible from VGH and City Hall.
- A station on Cambie Street at Broadway could reduce the need for passengers to cross these two busy roads.

At the end of the meeting two preferred alignment options between SW Marine Drive and the downtown terminus had emerged:

Cambie-Drake-Burrard

Cambie-Davie-Granville

It was agreed that the ridership catchment areas for the two downtown alignment options would need to be further assessed before a decision could be made on which of these alignment options would be recommended.

3.8. REFERENCE ALIGNMENT

A meeting was held on June 25, 02 to select the recommended downtown alignment option from the Davie/Granville Street and Drake/Burrard Street options. Attending the meeting were Messrs Spaxman, Pledger, Eastman, Louie, Reynolds, Scholte and Ekk.

The sketch presented overleaf shows catchments within a 400m radius for stations located on both the Drake/Burrard and Davie/Granville street routes in terms of thousands of jobs and residents. It should be noted that for stations located less than 800m apart along a route, the catchment areas overlap. Since the spacing of the downtown stations on both routes would all be under 800m, the station catchments would all overlap. The catchments were therefore used for guidance purposes only. However, the sketch indicates that the average station catchment on the two routes would be similar. With one additional station the Drake/Burrard has the higher overall catchment. However, the Granville route would be closer to the future population and job growth in Vancouver, which is towards downtown east.

Potential connections to the Cruise Ship Facility were also reviewed. Both the Burrard line and the Granville line could provide connections to the Cruise Ship Facility and proposed Convention Centre but the Granville line would provide the best opportunities to also give convenient connections to the Sea Bus, bus system, Skytrain, West Coast Express, and adjacent uses.

It was agreed that the Davie/Granville option was the preferred option due to the following:

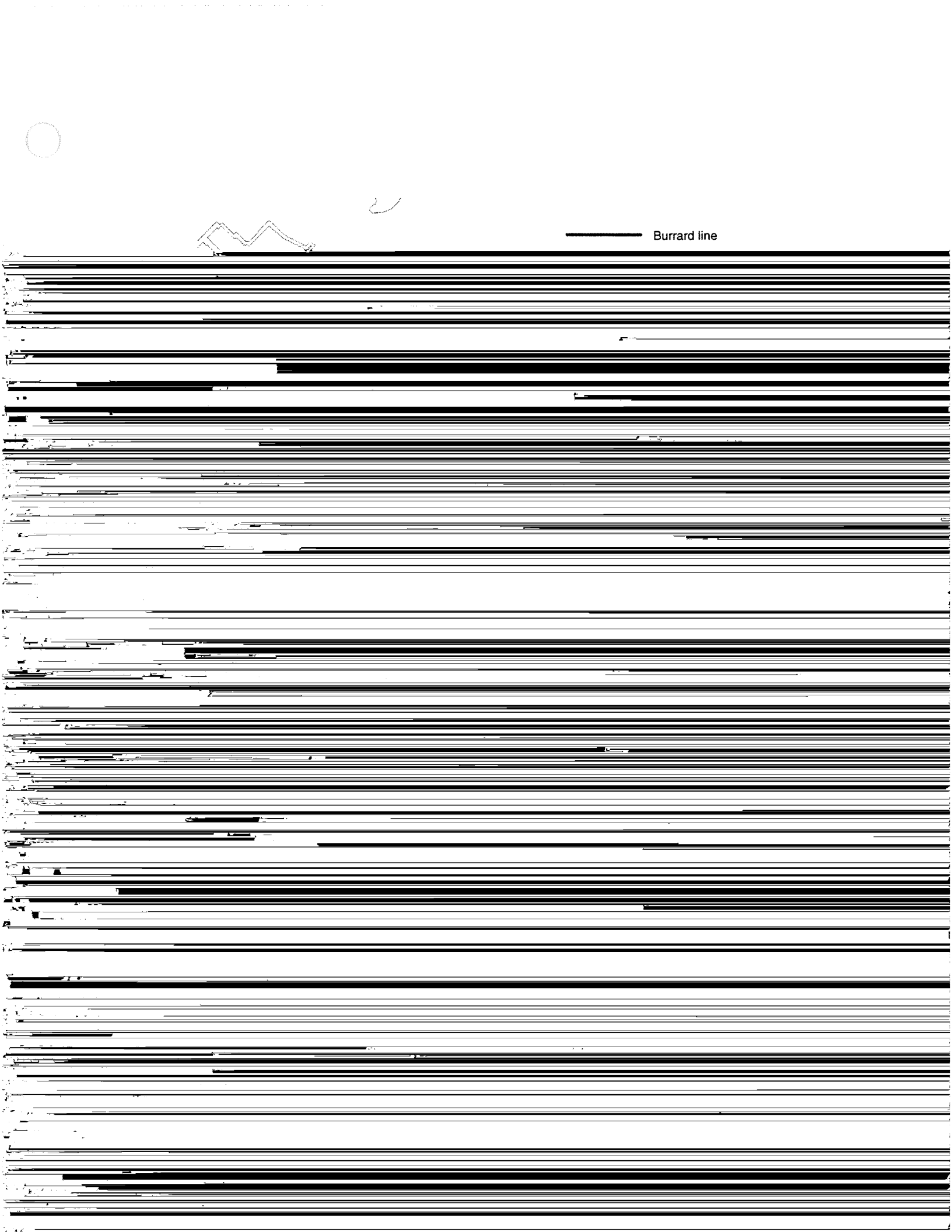
- The Granville Street terminus station would be significantly closer to the Waterfront Station than the Burrard Street terminus station and would provide good connectivity to all the transit modes that serve this major downtown transportation centre and the cruise ship terminal.

- The Davie/Granville Street option would be 400m shorter than the Drake/Burrard Street option and accordingly would have with reduced ridership times and be less expensive.

- Four stations are recommended on the Davie/Granville Street option whereas the Drake/Burrard Street option with an additional station recommended at the crossing of Granville Street would have five downtown stations and the associated additional costs.

- At the terminus the Burrard Street tunnel profile would be substantially deeper than the Granville Street terminus due to the anticipated increased depth of rock at the shoreline.

- The Granville Street alignment would provide an opportunity for the station entrances to be incorporated into the new development plans proposed for Granville Street.


Burrard line

Accordingly, within the Vancouver Segment of the RAVP the recommended alignment designated the Reference Alignment would follow the Cambie/Davie/Granville Street route with nine recommended stations at:

- Cambie St. and SW Marine Drive.
- Cambie St. and 49th Avenue.
- Cambie St. and 41st Avenue.
- Cambie St. and King Edward Ave.
- Cambie St. and Broadway.
- Davie and Pacific Boulevard
- Granville and Nelson streets.
- Granville and Dunsmuir streets.
- Granville and Cordova streets

Drawings 6100 to 6107 in Appendix B give details of the Reference Alignment.

All horizontal curves shown have a radius of 600m except the curve between Davie and Granville streets. At this location a radius of 150m was used to avoid crossing under a high rise building located on Davie Street between Seymour and Richards streets. Since the 150m radius curve is close to stations it is unlikely to be a problem in terms of restricting the vehicle speeds.

Following the meeting it was learned that COV had received a planning application for two high rise buildings at 1133 Seymour Street and foundations for one of the high rise buildings would be directly above the recommended RAVP alignment where it turns from Davie Street to Granville Street.

Accordingly, the tunnel profile has been set to give a minimum of one diameter clear between the top of the tunnel and the proposed 1133 Seymour Street building foundations. The one diameter cover assumes favourable rock conditions and careful monitoring of the tunnel and building structure.

4 Profiles

4.1. BASE CASE PROFILE

Drawings 6100 to 6107 in Appendix B give details of the profiles investigated.

As noted earlier, the base case profile is elevated for approximately 370m at the south end of the Vancouver Segment where it crosses SW Marine Drive and is then in tunnel for the rest of the route to the downtown terminus. For the SW Marine Drive crossing, a 7.0m vertical clearance was allowed between road and rail to give a minimum of 5.0m clear beneath the structure. Heading north the profile descends for approximately 200m at a 3.3% grade to the tunnel portal. The first 150m of tunnel would continue to descend at 3.3% grade and would be built using cut-and-cover construction.

After reaching a depth of one diameter to the top of the cut-and-cover tunnel, TBM tunnel construction would commence and the profile would start to climb, following the Cambie Street profile, with a 3.7% grade for 1.3km staying approximately one diameter below road level. At the proposed 49th Avenue station location, reverse vertical curves either side of 130m long 0.5% tangent would accommodate the station. After 49th Avenue, the profile would continue to climb for 0.4km following the profile of Cambie Street at a 2.3% grade to the proposed Oakridge Station. The profile would then climb for 0.8km at a 1.5% grade below Queen Elizabeth Park to a proposed ventilation shaft near station 3+500m in the Park. The profile would then descend for 0.7km at 4.8% grade to the proposed King Edward Station staying approximately one diameter below road level.

North of King Edward Station the profile would descend for 1.5km at a 4.2% grade to the proposed Broadway Station. At the Broadway Station the tunnel depth would be approximately three tunnel diameters to provide clearance below the proposed future Millennium Line extension tunnels and the existing 8th Avenue Interceptor Pipe. North of Broadway Station the profile continues to descend for 0.7km at 2.1% grade under the south side of False Creek. The alignment under False Creek was selected to give approximately one diameter of suitable ground (bedrock or glacial drift) above the tunnel. This requirement would apply across the full width of the crossing, however, the critical areas are expected to be near the shores of the Creek. Towards the north side of False Creek the profile rises for 0.5km at 1.6% grade to the proposed Pacific Boulevard Station.

North of Pacific Boulevard Station the profile climbs at 3.7% grade as it follows Davie Street north at a depth of approximately one diameter. The profile continues to climb at 3.7% as the alignment turns onto Granville Street heading towards the proposed Nelson Street Station. After Nelson Street Station the profile descends for 0.5km towards the proposed Dunsmuir Station at a 0.9% grade followed by a 1% grade to allow the profile to cross under the existing Dunsmuir Tunnel. A clearance of 1m only has been allowed at the pinch point between the RAVP and Dunsmuir profiles to limit the depths of the proposed Dunsmuir and Cordova Street Stations. It is recommended that pre-treatment of the rock beneath the existing Dunsmuir tunnel be carried out prior to the RAVP tunnelling to strengthen the soils. The profile continues to descend at a 1% grade to the Cordova Street terminus station where the grade drops to 0.5% over the length of the station and tail track.

4.2. PROFILE OPTIONS

To investigate potential cost savings a number of potential profile options were investigated and are described below. All the profiles follow the Cambie/Davie/Granville Reference Alignment. Drawings of the profile options are presented in appendix B.

4.2.1. South End #1

At the south end of the Vancouver Segment, a profile option using an extended elevated section north of SW Marine Drive was reviewed. To avoid disruption to traffic with this profile, the tunnel portal would be located south of the busy intersection at Cambie and 41st. The selection of the portal location south of 41st Avenue intersection is somewhat arbitrary but was chosen as a guide to the cost saving that could be achieved with an elevated section. With this option the proposed station at 49th Ave would be an above ground station.

4.2.2. South End #2

Similarly, at the south end of the Vancouver Segment, a profile option using an at-grade section just north of SW Marine Drive was reviewed. With this profile the tunnel portal would also be located south of the Cambie and 41st intersection. With this option the proposed station at 49th Ave would be an at-grade station.

4.2.3. North End

At the north end of the project a profile option that would cross over the existing Dunsmuir Skytrain Tunnel using a section of cut-and-cover tunnel was reviewed. This higher profile would enable the invert elevations of the proposed Dunsmuir and Cordova street stations to be raised significantly. However, at the higher elevation the close proximity of the proposed Cordova Street terminus station and the former CPR Station Building would limit the length of the tail track to approximately 60m for emergency stopping. This would require crossover tracks to be located immediately south of the Cordova Station. Depending on train headway's, locating the crossover before rather than after the terminus station could have performance implications.

4.2.4. Granville Street Alternate Profiles

Profiles were developed along Granville Street with a station located at Robson Street instead of the two stations proposed at Nelson and Dunsmuir streets. This not only results in the saving of one station but also allows the tunnel profile to be raised significantly.

With the Robson Street station arrangement, two profiles were developed which would cross under or over the Dunsmuir tunnel. The profile that crosses over the Dunsmuir tunnel would result in cut-and-cover tunnel construction for a considerable distance along Granville Street and shallow depth stations at both Robson and Cordova Streets.

4.2.5. Elevated Profiles Crossing Over False Creek

Options with an elevated crossing of False Creek were investigated. A profile that crosses under Broadway in tunnel, bridges False Creek with an elevated structure and then crosses

under Pacific Boulevard in tunnel was discounted due to excessive gradients of 8.09% to the south and 10.29% on the north side of False Creek.

A profile with a tunnel portal at station 5+646m and an elevated structure over Broadway and False Creek and tunnel under Pacific Boulevard was also discounted since it would result in an excessive gradient of 8.6% on the north side of False Creek.

A profile that would cross under False Creek and Pacific Boulevard in tunnel and then transition to an elevated structure on Davie Street was discounted since a number of cross streets would be blocked, and an excessively steep gradient would be required due to the steep slope of Davie Street.

It was concluded that if an elevated section over False Creek was to be considered it would need to commence south of West Broadway around station 5+646m and extend to the terminus at the north end of the alignment.

5 Stations

5.1. STATION LOCATIONS

Typically underground rapid transit stations have two entrances at ground level. On RAVP it is proposed that all underground stations have two ground level entrances except for the Broadway Station. Since the Broadway Station will be located at the intersection of two very busy roads, Cambie Street and Broadway, it is recommended that this station have four entrances to minimise the need for pedestrians to cross the roads.

Stations can be either constructed using cut-and-cover (open excavation) or by underground mining techniques. Since the latter is usually expensive, cut-and-cover station construction has been assumed for RAVP. With cut-and-cover construction, stations would generally be located immediately north or south of intersections to reduce construction interference to traffic and avoid utility diversions on both streets. However, the Broadway Station has been shown located on the intersection to allow incorporation of the proposed future Millennium Line extension.

Recommended station locations are as follows:

Marine Drive On Cambie Street immediately north of SW Marine Drive.

49th Avenue On Cambie Street immediately north of 49th Avenue.

Oakridge On Cambie Street immediately south of 41st Avenue.

King Edward On Cambie Street immediately south of King Edward Avenue

Broadway On Cambie Street and Broadway.

Pacific Boulevard On Davie Street immediately north of Pacific Boulevard.

Nelson Street On Granville Street immediately south of Nelson Street.

Dunsmuir Street On Granville Street immediately south of Dunsmuir Street.

Cordova Street On Granville Street immediately south of Cordova Street.

To reduce costs station entrances should preferably be located on the same side of the intersection as the station. However, station entrances can be located on the opposite side of an intersection to the station, if required.

The following table gives station chainages and the spacing between stations:

Location	Length (m)	Stationing	Distance (km) from previous station	Type
SW Marine Dr	80	0+120		Elevated
49th	130	1+895	1.78	Underground

Location	Length (m)	Stationing	Distance (km) from previous station	Type
Oakridge	130	2+555	0.66	Underground
King Edward	130	4+275	1.72	Underground
Broadway	130	5+940	1.66	Underground
Pacific Boulevard	130	7+358	1.42	Underground
Nelson	130	7+950	0.59	Underground
Dunsmuir	130	8+620	0.67	Underground
Cordova	130	8+975	0.36	Underground

5.2. STATION DRAWINGS

Conceptual station drawings are presented in appendix C for the following:

- A typical underground station with two entrances on drawings 6200 to 6203.
- Broadway Station with would accommodate a future extension of the Millennium Line. On drawings 6210 to 6212.

5.3. TERMINUS CONNECTIONS

At the proposed Dunsmuir and Cordova stations people movers could be provided to allow passengers to transfer between:

- The proposed station at Granville and Dunsmuir streets and the existing SkyTrain Granville Station.
- The proposed terminus station at Granville and Cordova streets and the SkyTrain Waterfront Station, Sea Bus, West Coast Express and the Canada Place Cruise Ship Terminal.
- The proposed terminus station at Granville and Cordova streets and the Cruise Ship Terminal

It should be noted that there appears to be a considerable opportunity to create a major pedestrian circulation space in the waterfront area which would be an especially attractive public space serving a multitude of pedestrian movements and providing a focus and integrating function in this part of town.

People mover plans and sections are shown on drawing 6300 in Appendix C.

The people movers are envisaged to be in tunnels at the approximate depth of the proposed Cordova Street station. Since these tunnels would be of small diameter they would likely be constructed using mining techniques. The alignment of the tunnel from Cordova Station to the Cruise Ship Terminal is envisaged to follow Granville Street for a short distance, turn east on to Cordova Street, right on to Howe Street and left on to Waterfront Road. The tunnel would terminate in front of the foundations to the Canada Place where elevators and/or escalators would then carry passengers to the Cruise Ship level.

5.4. CROSSOVER STRUCTURES

Four crossover structures are envisaged within the Vancouver Segment at the following locations:

- 49th Avenue
- King Edward
- Pacific Boulevard
- Cordova

Crossovers would typically be located adjacent to stations to avoid vertical curves and large grades. Excavation for the crossovers would be by cut-and-cover and would effectively be an extension of the station cut-and-cover excavation.

6 *Constructability*

No site-specific geotechnical investigation has yet been carried out for the project, so the following comments are based on the limited available subsurface information. An appropriate level of geotechnical investigation will assist in early identification of the key issues and selection of the most appropriate techniques and equipment. It will also facilitate preparation of more accurate cost estimates and minimisation of contractual risks. As discussed below, specific sections (such as shaft and station locations, and the QE Park basalt zone), may have significant impacts on tunnel design and equipment selection. Therefore, consideration should be given to planning and implementing a phased investigation program as soon as the preferred alignments have been selected and there is a firm commitment to proceed with the project.

6.1. TUNNELLING METHODOLOGY

It is envisaged that tunnelling will be carried out using TBMs. This equipment will be well suited for the diameter and length of the tunnels as proposed, and for the anticipated subsurface conditions. The following criteria were considered in assessing the suitability of TBMs for the project;

- Tunnel diameter. Ideally the tunnel is of a diameter which is common for TBMs. The RAVP tunnels are a common size for underground transit projects and suitable machines should be readily available.

- Tunnel length. TBMs require substantial preparatory work prior to commencement of a drive. The tunnel length must be sufficient to justify this advance work. For the option of tunnelling the entire alignment within the City of Vancouver, the tunnelled sections for the RAVP tunnels will be evenly divided in length, and are a suitable length for TBM operation.

- Reasonably consistent ground conditions. TBMs can be adapted for most ground conditions, however problems can be encountered when conditions are highly variable. Based on the geological conditions as currently understood from the limited information available, each of the tunnel sections for RAVP are expected to consist of reasonably similar conditions in terms of tunnelling.

Work sites. Due to the high production rates of TBMs, large work site areas must be available to handle the substantial spoil and material volumes. The work sites should be located near major transportation routes which can accept the volume of vehicle movements required for construction, and in areas where the construction impacts will be acceptable to local residents and businesses.

It is envisaged that there would be the following three tunnel drives for the base case alignment:

- A TBM launch from a section of cut-and-cover tunnel behind a portal near SW Marine Drive, and TBM removal at a shaft in Queen Elizabeth Park.

- A shaft TBM launch just south of False Creek for the southerly drive with TBM removal at the Queen Elizabeth Park shaft.

- A shaft TBM launch just south of False Creek for the northerly drive with TBM removal at Cordova.

6.1.1. Tunnelled Section 1

Marine Drive portal to QE Park – approx. 3 km. This section is expected to be driven in glacial soil deposits, which are likely to consist primarily of sands and gravels, with varying silt content. Groundwater levels are expected to be at or above tunnel level. Due to the coarse nature of the soils and potential presence of groundwater, these soils are considered to be relatively unstable in terms of tunnelling, and will require a TBM design which can provide the necessary support to the tunnel face, as described later in this report. This section will terminate in the tertiary bedrock formation at QE Park, which will be unsuitable for this TBM type.

The TBM drives will originate from the Marine Drive portal and be driven up gradient to the TBM reception shaft at QE Park. It is expected that groundwater seepage into the tunnel will be minimal, as a gasketted, sealed lining would be installed during construction.

6.1.2. Tunnelled Section 2

False Creek south worksite to QE Park. (approx. 3 km). This drive is expected to comprise primarily glacial drift soils as well as tertiary bedrock. The bedrock will be mostly weak sandstone and siltstone, but with minor volcanic intrusions. Based on experience on other projects in Vancouver, the sandstone is highly variable in terms of strength and may be expected to be locally uncemented and thus exhibiting soil-like behaviour. The glacial drift and rock will be similar in tunnelling terms, since both units have a sufficient strength to stand unsupported for reasonable lengths of time and therefore require little support from the TBM – a key aspect of TBM design. However, the potential for coarser and more permeable zones, as well as harder cobble/boulder inclusions within the glacial drift, will impact TBM selection and progress. The key concerns for TBM selection for these soils will be discussed later in this report.

The TBM drive will originate from the work site at False Creek and be driven south and up gradient to the QE Park reception shaft. It is anticipated that an interval of strong basalt may be present beneath QE Park, which may require excavation, by alternate means, as discussed in a following section.

6.1.3. Tunnelled Section 3

False Creek south worksite to Canada Place (approx. 2.9 km). This drive is expected to be in ground conditions similar to that for Section 2.

This section will be encounter two sections, which will be driven down gradient. As stated previously, seepage into the tunnel is expected to be minimal since it is expected that a sealed (gasketted) lining will be installed by the TBM during construction.

QE Park Basalt (may be present as much as 800m along the alignment). Due to the expected much higher strength of this rock type, this section may have to be excavated using drill and blast methods (or possibly by use of a roadheader). It may also be possible to adapt the Section 2 TBM for these conditions, although modifications may be too significant for practical purposes. If drill and blast (or similar) methods are used, construction access will be gained via the QE Park shaft.

6.1.4. TBM Selection

As discussed previously, the ground conditions are anticipated to potentially require the use of two different types of TBM.

Tunnelled Section 1
For Section 1, the TBM will be required to deal with the potentially unstable sands and gravels, with or without water pressure. Suitable TBMs for these types of soils are described below.

1. Earth Pressure Balance (EPB) TBM. This type of TBM provides the necessary face support and prevents water inflow by use of a sealed forward chamber (plenum) directly behind the cutterhead. Excavated soil and groundwater pass into this chamber and are slowly extracted under controlled conditions by use of a screw conveyor. Rate of extraction by the screw conveyor is used to control the pressure in the plenum chamber and therefore the pressure acting on the tunnel face. Tunnel spoil passes out of the screw conveyor into the rear of the TBM and is usually transported out of the tunnel with rail mounted spoil cars.

   The key to the EPB TBM is the seal provided by the screw conveyor, which is, in turn, dependent on the soil type, since the soil plug on the screw conveyor forms the primary barrier to water flow (and pressure loss) out of the plenum. The EPB is well suited to fine-grained soil types (or coarse soil types with a significant fines content) since these soils have a low permeability and can form the necessary seal in the screw conveyor. Soil conditioning agents have been used in unsuitable soils on other projects, however heavy use of these chemicals can create additional problems.

   EPB TBMs are relatively common in North America in soft ground tunnels. This is partly due to the presence of a leading manufacturer of EPB TBMs (Lovat) being based in Toronto.

2. Slurry TBMs. The slurry TBM also provides support to the tunnel face and is therefore suitable for unstable soil types. The slurry TBM achieves this by injecting a slurry, usually a bentonite slurry, into the cutterhead chamber. The slurry acts both to pressurise the tunnel face and acts as a transport medium for tunnel spoil. Excavated spoil is removed from the cutterhead and transported out of the tunnel in a slurry suspension. Oversize material (boulders etc) are broken down to a suitable size for slurry transport in an on-board crusher, located in the TBM cutterhead. Spoil is removed down the tunnel to the portal via the slurry transport pipes. At the portal site, the spoil is removed from the slurry in a slurry separation plant. This plant generally consists of conventional material separation equipment, such as hydrocyclones, clarifiers, centrifuges, etc. Due to the difficulty of separating fine-grained soil particles, such as silt

and clay, from bentonite slurry, this type of TBM is not well suited to soils, which contain high proportions of fine materials. In general, a slurry TBM is well suited to coarse material sizes.

Since the slurry TBM does not rely on any property of the soil (such as low permeability) to provide pressure to the face, this machine can be operated in a wide range of soil conditions, subject to the limitations of the separation plant. Slurry pressures in the plenum chamber can be difficult to maintain at constant levels, due to the rapid change in pressure in a confined space with a small injection of a liquid. Some manufacturers have overcome this by use of an "air cushion" in the plenum chamber to regulate volume surges.

Because of the complicated materials handling equipment, a slurry TBM is often more expensive to purchase and operate than an EPB TBM. Until recently, slurry TBMs have not been used in North America. Recently, two slurry TBMs were purchased for a tunnelling project in Portland. All the leading slurry TBM manufacturers are based in Europe or Japan.

Tunnelled Sections 2 and 3

For Sections 2 and 3, the selection of the TBM will be influenced by the nature of the glacial drift and sandstone/siltstone deposits. Should the glacial drift contain significant lenses of coarse soils, or the sandstone contain areas which are poorly cemented (both of which may be expected), the TBM will be required to deal effectively with these water pressures and the instability which may accompany the water inflows. Under these conditions, an EPB TBM would be the most suitable selection. This EPB would differ from that for Section 1, principally in cutterhead design. This EPB would be fitted with tools on the cutterhead which would enable the cutting of the sandstone rock (where strongly cemented) and of the boulders which may be found within the glacial drift. An appropriate level of geotechnical investigation to determine the likely variations in subsurface conditions along the alignment is a key requirement to facilitate appropriate selection of TBM, and to more accurately assess tunnelling advance rates and costs.

Tunnel linings are expected to be pre-cast segmental "one pass" linings. These linings are erected behind the TBM and form the final tunnel lining, thus not requiring a separate lining phase following completion of excavation.

6.1.5. Ancillary Underground Excavations

Cross passages between the tunnels will be required at approximately 250m spacing. These tunnels will be 3m in diameter and, where possible, will probably be constructed using hand mining methods (manual excavation equipment or lightweight mobile equipment). Where unstable ground conditions are encountered (e.g. tunnel Section 1), some form of ground treatment may be required.

Shafts will be required at the False Creek work site, at QE Park and for any required emergency egress routes. The False Creek shaft will be substantial in size, as it will be required to support four tunnel drives and will be the location for launching four TBMs. The shafts are expected to be excavated using conventional mechanical excavation equipment

and will be supported using shotcrete and anchors, or where conditions require, a tangent-piled wall or sheet piled cofferdam.

6.1.6. Work Sites

Due to the potential impact on neighbourhoods and the lack of available land, location of potential worksites requires careful consideration. Two potential major tunnel worksites are likely to be required, one at False Creek and one at Marine Drive.

The False Creek worksite is one of a very limited number of areas that is well located for construction of the downtown tunnels. The size of the site identified to the south of False Creek (in excess of 1 ha) will be suitable for siting a substantial tunnelling operation. Also, proximity to major transportation routes (2nd Ave., Cambie Street) will support the required large material movements. Should ocean dumping of spoil be carried out, the proximity to False Creek will facilitate spoil removal if a barge ramp is available. Due to the location of residential neighbourhoods near the site, measures will be required to limit noise impacts due to equipment operation on site and truck movement in and out of the site.

A major tunnelling work site will also be required at the south end of Cambie Street, near Marine Drive. There are no obvious candidate sites in this immediate area. It is anticipated that a small work area could be available in the Cambie Street corridor for establishing the portal and launching the TBM. With limited available area at the portal, it is expected that a larger site would be established nearby (possibly using an area commercial land available south of Marine Drive) in which to serve as the main materials storage area. This site will be close to good transportation routes, and feasible locations for barge loading facilities.

A smaller tunnel work site will be required at QE Park. This work site will be required for construction of a shaft to facilitate the removal of TBMs and for carrying out local excavation within the basalt. It should be feasible to locate the shaft in an area which will limit impacts on local residents and the park itself.

6.1.7. Spoil Disposal

Of the total of approximately 2.8 million m^3 of spoil to be generated in the tunnels and stations, approximately 2/3 will be produced at the False Creek site and 1/3 at the Marine Drive site. A number of options are available for disposal of spoil from tunnel operations. These are;

- Ocean disposal
- Landfill disposal
- Re-use as fill in construction.

For the significant volumes of spoil which will be generated, the potential for re-use as fill may be limited, depending on the requirements for fill in new construction in Vancouver at the time of tunnel construction. It will also be dependent on the nature of the excavated spoil, including grain size and moisture content, and the effect of potential conditioning

additives on the engineering properties. Should the southeast shoreline of False Creek be redeveloped at this time, there may be requirements for site grading materials.

Disposal of fill in local landfills may be expensive, unless the spoil can be used as cover material. Present landfills are located a considerable distance from the work sites and would involve significant truck traffic, the impacts of which would have to be assessed.

Ocean disposal is a potentially attractive alternative that should be carefully examined, since it would limit truck traffic and associated impacts on local neighbourhoods. Ocean disposal is currently being conducted in three designated disposal sites nearby in the Strait of Georgia. A thorough characterisation of the chemistry of the fill will be required in order to obtain a permit. Any contaminants within the fill, such as bentonite from the slurry tunnelling operation or soil conditioning agents, may restrict ocean disposal options.

6.1.8. Settlement and Vibration

Prediction, control and mitigation of tunnel induced settlement will be a significant factor in the implementation of the project, due to the number of major buildings within close proximity to the alignment. Modern TBMs are designed to minimise the potential for settlement to occur, through the inclusion of features such as back-grouting through the tailskin and pressure control at the tunnel face. Features such as these should be available on TBMs selected for this work. Reliance is also placed on the experience of the operating personnel, as incorrect operation of a TBM can lead to excessive ground movements.

The primary area of concern for settlement will be the downtown tunnels along Davie and Granville. These tunnels are expected to largely be driven in the glacial drift and sandstone/siltstone bedrock. As stated earlier in this report, the sandstone/siltstone may be expected to be weak, and in some areas may be uncemented. Settlement may be expected to occur in ground conditions such as this, and where glacial drift is present. The amount of settlement that occurs can be controlled through the application of good workmanship, appropriate TBM selection and a suitable monitoring program.

Settlement above tunnels tends to form a "trough" shape, with the maximum settlement magnitude immediately above the tunnel, reducing laterally from the tunnel. The deeper the tunnel, the wider is the settlement trough and the smaller the magnitude of settlement above the tunnel. This settlement profile gives rise to settlement even at points outside of the area immediately above the tunnel. Depending on the subsurface conditions and the depth of the tunnel, more severe settlement damage can occur outside of the area above the tunnel, as these are areas where differential and lateral movements and "hogging settlement" can occur. These areas are prone to tensile strains in the soil, which can cause damage to unreinforced structures, and also to tilting, or differential vertical ground movements. Due to the narrow street rights-of-way along the downtown alignment, it is expected that a number of buildings may be within the potential zone of influence of the tunnels. These settlement impacts should be given close consideration during future stages of investigation and planning for the tunnels.

Buildings at the corner of Davie and Granville, where the tunnels will be located directly beneath the buildings, will require particular consideration. It is understood that a new high rise building is planned above the alignment and that this will have five basement levels.

Construction of the tunnels following construction of this building will be difficult due to the deep foundations and potential sensitivity to movement. Consequently, efforts should be made to incorporate any needed modifications to the basement structure during building construction, or possibly to pre-build this section of tunnels to permit passage of the TBMs. The neighbouring building (Howard Johnson Hotel Annex) above the alignment has no basement structure and is low rise. There is ample precedence for carrying out tunnelling beneath similar structures on projects elsewhere. Detailed examination of the ground conditions, foundation construction and depth below foundation level will be required in order to assess settlement impacts.

Where settlement damage to a building is determined to be unavoidable or of high risk, measures to mitigate settlement damage may be required. Such measures include compensation grouting, underpinning and other forms of foundation improvement.

Investigation and settlement analysis should also be carried out for subsurface structures which may be impacted by the tunnels, including utilities and larger structures such at the Skytrain tunnel and the 8th Ave GVRD sewer tunnel. Critical parameters for crossing beneath these structures are similar to those for buildings, including soil/bedrock conditions and the structural condition of the buried structure.

With suitable investigation, design, monitoring and construction control, it is expected that tunnelling can be carried out without inducing unacceptable vibrations in nearby facilities. However, in some situations where greater vibrations cannot be avoided, mitigation or repair will be required.

6.2. STATION CONSTRUCTION

Where stations are to be constructed using cut-and-cover techniques, temporary closure of affected roads will be required. For cut and cover station construction, it is expected that excavation and support will be carried out using techniques similar to that being currently used for building construction in Vancouver. The most common technique for support of excavations in glacial drift and bedrock is shotcrete and soil nails. Where the nails cannot be accommodated within the available right-of-way and permission for encroachment into private property cannot be obtained, support using internal bracing would be required. For the coarser soils expected to the south of QE Park, alternative excavation support methods such as soldier piles with lagging or sheet piling would be required.

7 Costs

The costs of the base case profile and profile options are presented in the following table:

	Costs Of Profile Alternatives - Millions $				
South End	**Base Case**	**North End**	**South #1**	**South #2**	**Granville**
Structure	4.61	4.61	27.05	10.02	4.61
Marine Drive	7.5	7.5	7.5	4.25	7.5
Utilities,	1.68	1.68	1.32	3.29	1.68
Subtotal	**13.79**	**13.79**	**35.87**	**17.56**	**13.79**
Tunnels					
Tunnel Drive 1	120.82	120.82	69.56	71.2	120.82
Tunnel Drive 2	117.1	117.1	117.1	117.1	117.1
Tunnel Drive 3	105.9	94.74	105.9	105.9	81.02
Cut and Cover	0	12.3	0	0	53.77
Subtotal	**343.82**	**344.96**	**292.56**	**294.2**	**372.71**
South Portal	**26.42**	**26.42**	**26.42**	**26.42**	**26.42**
Stations					
49th	39.07	39.07	7.5	4.25	39.07
Oakridge	39.75	39.75	39.75	39.75	39.75
King Edward	40.66	40.66	40.66	40.66	40.66
Broadway	59.84	59.84	59.84	59.84	59.84
Pacific Blvd	41.99	41.99	41.99	41.99	41.99
Nelson	41.99	41.99	41.99	41.99	0
Robson	0	0	0	0	37.19
Dunsmuir	59.06	40.12	59.06	59.06	0
Cordova	53.55	37.99	53.55	53.55	37.99
Subtotal	**375.91**	**341.41**	**344.34**	**341.09**	**296.49**
Crossovers					
49th	16.66	16.66	4.2	0.42	16.66
King Edward	17.95	17.95	17.95	17.95	17.95
Pacific Blvd	18.1	18.1	18.1	18.1	18.1
Cordova	32.04	15.02	32.04	32.04	15.02
Subtotal	**84.75**	**67.73**	**72.29**	**68.51**	**67.73**
Shafts and EEB's					
57th EEB	2.48	2.48	0	0	2.48
QE shaft	3.02	3.02	3.02	3.02	3.02
16th EEB	2.56	2.56	2.56	2.56	2.56
TBM shaft	10.53	10.53	10.53	10.53	10.53
EEB	2.07	2.07	2.07	2.07	2.07
Subtotal	**20.66**	**20.66**	**18.18**	**18.18**	**20.66**
System- Wide	**139.56**	**137.45**	**139.56**	**139.56**	**137.45**
Grand Total	**1,004.91**	**952.42**	**925.22**	**905.52**	**935.25**

The estimate assumptions and cost spreadsheets for the Vancouver Segment are presented in Appendix D and quantities are presented in Appendix E in Volume II.

The **Base Case** profile is estimated to cost $1,004.91M and assumes the use of six TBM's.

The **North End** profile option that crosses over the existing Dunsmuir Skytrain Tunnel with cut-and-cover tunnel is estimated to cost $952.42M. The savings of $52.5M from the base case profile are due mainly to the construction of shallower stations at Dunsmuir and Cordova Streets.

The **South #1** profile option with an extended elevated section at the south end of the Segment is estimated to cost $925.22M. The $79.7M savings from the base case profile are mainly due to a shorter tunnel and less expensive station and crossover at 49th Avenue.

The **South #2** profile option with an at-grade section at the south end of the Segment is estimated to cost $905.03M. The $99.4M savings from the base case profile are mainly due to a shorter tunnel and significantly less expensive station and crossover at 49th Avenue.

The **Granville** profile in the table is the alternative profile along Granville Street with a station at Robson Street and a cut-and-cover tunnel over the Dunsmuir Tunnel. This option is estimated to cost $935.25M. The $69.7M savings from the base case are mainly due to one less station and shallower downtown stations.

The base case option with 5.0m diameter rather than the 5.7m diameter tunnels was estimated to cost $969.03M and includes a reduction in tunnel and station costs.

Profile options with cut-and-cover tunnel crossing over Dunsmuir Tunnel at the north end and with either extended elevated or at-grade sections at the south end are estimated to cost $872.7M and $853.0M respectively.

Profile options with a station at Robson Street, cut-and-cover tunnel over Dunsmuir Tunnel at the north end and with either extended elevated or at-grade sections at the south end are estimated to cost $855.31M and $835.81M respectively.

The least cost profile reviewed would have an at-grade section at the south end of the segment, 5.0m diameter tunnels, a station at Robson Street and cut and cover tunnel over Dunsmuir. This option is estimated to cost $805.33M.

The estimated costs for the profile and tunnel diameter options range from a maximum of $1,004.91M to a minimum of $805.33M

8 Schedule

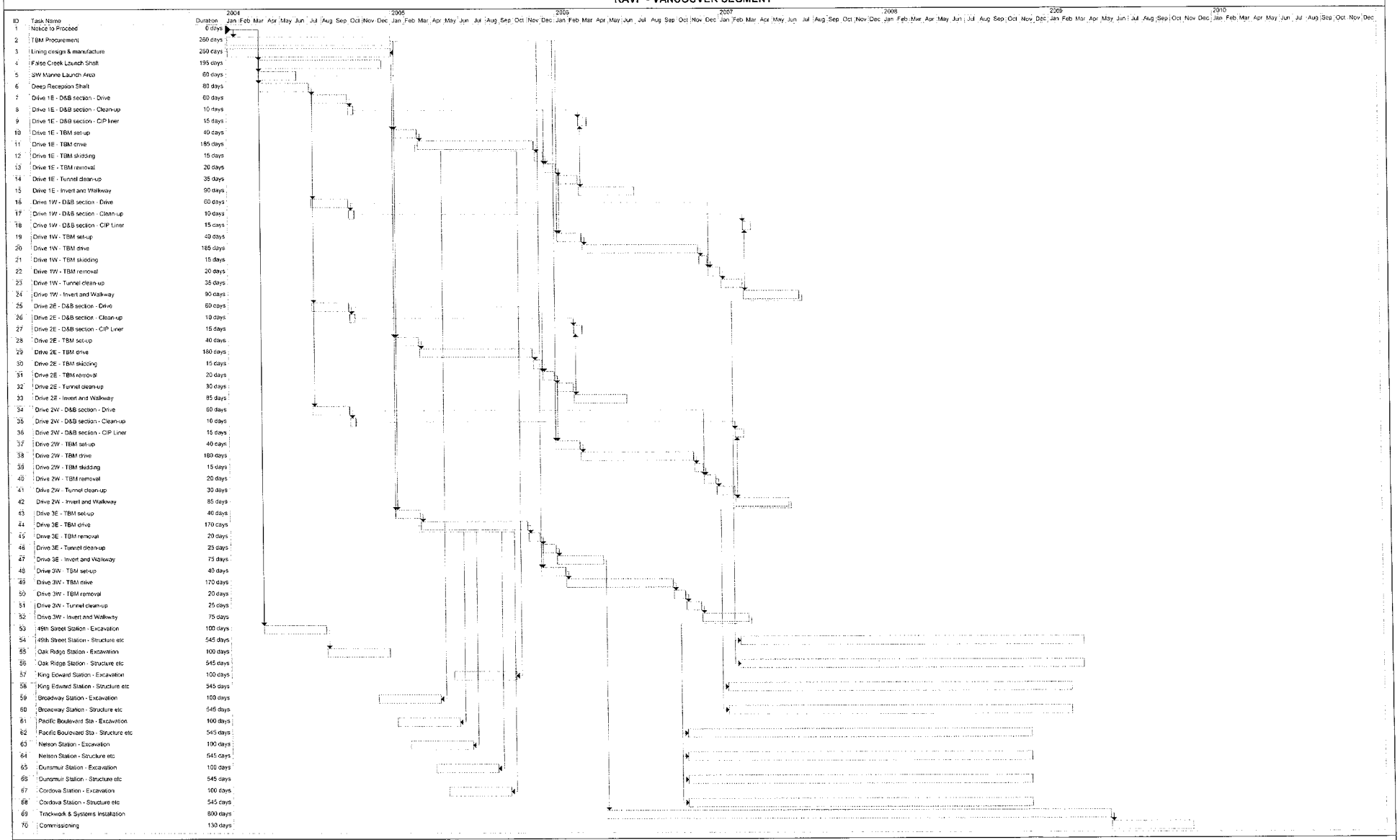
A construction schedule is presented overleaf for the base case profile using three TBM's with completion at the end of year 2010 assuming a year 2004 start.

This is followed by a construction schedule for the base case profile using six TBM's with completion at the end of year 2009 assuming a year 2004 start.

The two schedules assume station construction after the tunnel drives.

The third and fourth schedule assumes a P3 type of contracting strategy with one general contractor. The schedule is shortened with completion close to the end of year 2009 assuming a year 2004 start and simultaneous tunnel drives and station construction.

RAVP - VANCOUVER SEGMENT



ID	Task Name	Duration
1	Notice to Proceed	0 days
2	TBM Procurement	260 days
3	Lining design & manufacture	250 days
4	False Creek Launch Shaft	195 days
5	SW Marine Launch Area	60 days
6	Deep Reception Shaft	80 days
7	Drive 1E - D&B section - Drive	60 days
8	Drive 1E - D&B section - Clean-up	10 days
9	Drive 1E - D&B section - CIP liner	15 days
10	Drive 1E - TBM set-up	40 days
11	Drive 1E - TBM drive	185 days
12	Drive 1E - TBM skidding	15 days
13	Drive 1E - TBM removal	20 days
14	Drive 1E - Tunnel clean-up	35 days
15	Drive 1E - Invert and Walkway	90 days
16	Drive 1W - D&B section - Drive	60 days
17	Drive 1W - D&B section - Clean-up	10 days
18	Drive 1W - D&B section - CIP Liner	15 days
19	Drive 1W - TBM set-up	40 days
20	Drive 1W - TBM drive	185 days
21	Drive 1W - TBM skidding	15 days
22	Drive 1W - TBM removal	20 days
23	Drive 1W - Tunnel clean-up	35 days
24	Drive 1W - Invert and Walkway	90 days
25	Drive 2E - D&B section - Drive	60 days
26	Drive 2E - D&B section - Clean-up	10 days
27	Drive 2E - D&B section - CIP Liner	15 days
28	Drive 2E - TBM set-up	40 days
29	Drive 2E - TBM drive	180 days
30	Drive 2E - TBM skidding	15 days
31	Drive 2E - TBM removal	20 days
32	Drive 2E - Tunnel clean-up	30 days
33	Drive 2E - Invert and Walkway	85 days
34	Drive 2W - D&B section - Drive	60 days
35	Drive 2W - D&B section - Clean-up	10 days
36	Drive 2W - D&B section - CIP Liner	15 days
37	Drive 2W - TBM set-up	40 days
38	Drive 2W - TBM drive	180 days
39	Drive 2W - TBM skidding	15 days
40	Drive 2W - TBM removal	20 days
41	Drive 2W - Tunnel clean-up	30 days
42	Drive 2W - Invert and Walkway	85 days
43	Drive 3E - TBM set-up	40 days
44	Drive 3E - TBM drive	170 days
45	Drive 3E - TBM removal	20 days
46	Drive 3E - Tunnel clean-up	25 days
47	Drive 3E - Invert and Walkway	75 days
48	Drive 3W - TBM set-up	40 days
49	Drive 3W - TBM drive	170 days
50	Drive 3W - TBM removal	20 days
51	Drive 3W - Tunnel clean-up	25 days
52	Drive 3W - Invert and Walkway	75 days
53	49th Street Station - Excavation	100 days
54	49th Street Station - Structure etc	545 days
55	Oak Ridge Station - Excavation	100 days
56	Oak Ridge Station - Structure etc	545 days
57	King Edward Station - Excavation	100 days
58	King Edward Station - Structure etc	545 days
59	Broadway Station - Excavation	100 days
60	Broadway Station - Structure etc	545 days
61	Pacific Boulevard Sta - Excavation	100 days
62	Pacific Boulevard Sta - Structure etc	545 days
63	Nelson Station - Excavation	100 days
64	Nelson Station - Structure etc	545 days
65	Dunsmuir Station - Excavation	100 days
66	Dunsmuir Station - Structure etc	545 days
67	Cordova Station - Excavation	100 days
68	Cordova Station - Structure etc	545 days
69	Trackwork & Systems Installation	800 days
70	Commissioning	130 days

Project: 3TBMScheduePPP
Date: Aug 13 '02

Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | Group By Summary
Progress | Summary | Rolled Up Milestone | Split | Project Summary

CONCEPT SCHEDULE - BASE CASE - 3 TBM OPTION - WITH ONE CONTRACT PROCUREMENT

RAVP - VANCOUVER SEGMENT

ID	Task Name	Duration
1	Notice to Proceed	0 days
2	TBM Procurement	260 days
3	Lining design & manufacture	260 days
4	False Creek Launch Shaft	195 days
5	SW Marine Launch Area	60 days
6	Deep Reception Shaft	80 days
7	Drive 1E - D&B section - Drive	60 days
8	Drive 1E - D&B section - Clean-up	10 days
9	Drive 1E - D&B section - CIP liner	15 days
10	Drive 1E - TBM set-up	40 days
11	Drive 1E - TBM drive	185 days
12	Drive 1E - TBM skidding	15 days
13	Drive 1E - TBM removal	20 days
14	Drive 1E - Tunnel clean-up	35 days
15	Drive 1E - Invert and Walkway	90 days
16	Drive 1W - D&B section - Drive	60 days
17	Drive 1W - D&B section - Clean-up	10 days
18	Drive 1W - D&B section - CIP Liner	15 days
19	Drive 1W - TBM set-up	40 days
20	Drive 1W - TBM drive	185 days
21	Drive 1W - TBM skidding	15 days
22	Drive 1W - TBM removal	20 days
23	Drive 1W - Tunnel clean-up	35 days
24	Drive 1W - Invert and Walkway	90 days
25	Drive 2E - D&B section - Drive	60 days
26	Drive 2E - D&B section - Clean-up	10 days
27	Drive 2E - D&B section - CIP Liner	15 days
28	Drive 2E - TBM set-up	40 days
29	Drive 2E - TBM drive	180 days
30	Drive 2E - TBM skidding	15 days
31	Drive 2E - TBM removal	20 days
32	Drive 2E - Tunnel clean-up	30 days
33	Drive 2E - Invert and Walkway	85 days
34	Drive 2W - D&B section - Drive	60 days
35	Drive 2W - D&B section - Clean-up	10 days
36	Drive 2W - D&B section - CIP Liner	15 days
37	Drive 2W - TBM set-up	40 days
38	Drive 2W - TBM drive	180 days
39	Drive 2W - TBM skidding	15 days
40	Drive 2W - TBM removal	20 days
41	Drive 2W - Tunnel clean-up	30 days
42	Drive 2W - Invert and Walkway	85 days
43	Drive 3E - TBM set-up	40 days
44	Drive 3E - TBM drive	170 days
45	Drive 3E - TBM removal	20 days
46	Drive 3E - Tunnel clean-up	25 days
47	Drive 3E - Invert and Walkway	75 days
48	Drive 3W - TBM set-up	40 days
49	Drive 3W - TBM drive	170 days
50	Drive 3W - TBM removal	20 days
51	Drive 3W - Tunnel clean-up	25 days
52	Drive 3W - Invert and Walkway	75 days
53	49th Street Station - Excavation	100 days
54	49th Street Station - Structure etc	545 days
55	Oak Ridge Station - Excavation	100 days
56	Oak Ridge Station - Structure etc	545 days
57	King Edward Station - Excavation	100 days
58	King Edward Station - Structure etc	545 days
59	Broadway Station - Excavation	100 days
60	Broadway Station - Structure etc	545 days
61	Pacific Boulevard Sta - Excavation	100 days
62	Pacific Boulevard Sta - Structure etc	545 days
63	Nelson Station - Excavation	100 days
64	Nelson Station - Structure etc	545 days
65	Dunsmuir Station - Excavation	100 days
66	Dunsmuir Station - Structure etc	545 days
67	Cordova Station - Excavation	100 days
68	Cordova Station - Structure etc	545 days
69	Trackwork & Systems Installation	774 days
70	Commissioning	130 days

Project: 6TBMSchedulePPP
Date: Aug 13 '02

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary

CONCEPT SCHEDULE - BASE CASE - 6 TBM OPTION - WITH ONE CONTRACT PROCUREMENT

9 Summary

9.1. BACKGROUND

The objective of the assignment was to identify a reference alignment, constructability and construction costs for the Vancouver Segment of the Richmond/Airport to Vancouver Rapid Transit Project.

Vancouver City Council had endorsed a "subway" system and accordingly a tunnelled option from the Vancouver downtown terminus with a short elevated section crossing SW Marine Drive was designated as the base case option.

9.2. ALIGNMENT OPTIONS

Between SW Marine Drive and 48th Avenue, Cambie Street was identified as the reference alignment.

From 48th Avenue to the south of False Creek, alignment options following Yukon, Cambie, Ash, Heather and Oak Streets were reviewed.

On the north side of False Creek, alignment options following Smithe, Helmcken, Davie and Drake streets connecting to either Burrard or Granville Streets were reviewed. A Cambie Street alignment option tying into the Waterfront Skytrain Station was also reviewed

9.3. REFERENCE ALIGNMENT

9.3.1. South of False Creek

Cambie Street was identified as the reference alignment south of False Creek due to the following:

- Cambie Street was the shortest and least costly alignment option reviewed.
- A station can be located at Cambie and Broadway close to City Hall, the Cancer Clinic and Vancouver General Hospital.
- The alignment option would avoid crossing under existing buildings.
- Alignment options following other streets would all pass through residential communities and would likely generate considerable public opposition.
- Cambie Street has a wide Right of Way, which may help avoid full road closures during station construction.
- The Cambie Street alignment crosses a COV car park at 6th Avenue that potentially could be used as a Contractors yard.

9.3.2. North of False Creek

Davie Street leading to Granville Street was identified as the reference alignment option north of False Creek due to the following:

- A Cambie Street alignment option, which would tie directly into the existing Skytrain Expo line at Waterfront Station, was discounted since it would limit the new system to the use of SkyTrain cars only.

- A Cambie Street alignment which would terminate at the existing Waterfront Station and allow passengers to transfer to the existing Skytrain system was discounted since it would not service the downtown south and business districts

- Davie/Granville and Drake/Burrard alignment options were found to be the only options that avoided passing under existing downtown high rise buildings with deep underground parkades.

- A Davie/Granville Street option would be 400m shorter than the Drake/Burrard Street option and accordingly less expensive.

- Similar ridership catchment volumes per station are predicted for both the Davie/Granville Street and Drake/Burrard Street options.

- Four stations are recommended on the Davie/Granville Street option whereas the Drake/Burrard Street option with an additional station recommended at the crossing of Granville Street would have five downtown stations and the associated additional costs.

- A Granville Street terminus station located at the north end of Granville Street, would be significantly closer to the Waterfront Station (the downtown transit hub) than a Burrard Street terminus station.

- A Burrard Street tunnel profile at the terminus would be substantially deeper than a Granville Street terminus due to the proximity of the pre-existing shoreline and the resulting increased depth to rock at the proposed terminus.

9.4. VERTICAL PROFILES

The base case profile would have a short elevated section over SW Marine Drive with a tunnel portal located close to 63rd Avenue. At the north end of the tunnel the profile would cross under the existing Dunsmuir Skytrain tunnel with a terminus station at Cordova Street and a 200m long tail track for storage and crossover tracks.

Profile options for shortening the tunnel using either an elevated section or an at-grade section from SW Marine Drive to approximately 45th Avenue were reviewed.

To investigate cost savings at the north end of the alignment a profile option that would cross over the existing Dunsmuir Skytrain Tunnel using a cut-and-cover tunnel was reviewed. This higher profile would raise the invert elevations of the proposed new stations

at Dunsmuir and Cordova streets significantly. However, it would limit the length of the tail track that could be fitted between the proposed Cordova Street station and the existing Post Office Building to an emergency stop length of 60m only. Accordingly crossover tracks would need to be located south of the Cordova Street terminus station.

To investigate cost savings along the Granville Street two profile options with a station at Robson Street instead of the two stations at Nelson and Dunsmuir streets were developed. The profiles would cross over the existing Dunsmuir Skytrain Tunnel using a cut-and-cover tunnel or under Dunsmuir tunnel using bored tunnel. Both profiles would be higher than the base case profile and allow the invert elevations of the proposed new stations at Robson and Cordova streets to be raised. Of the two profiles the cut-and-cover option allows the profile to be raised significantly.

9.5. STATION AND CROSSOVER LOCATIONS

Nine stations are recommended at the following locations where high riderships are predicted:

- Cambie St. and SW Marine Drive.
- Cambie St. and 49th Avenue.
- Cambie St. and 41st Avenue.
- Cambie St. and King Edward Ave.
- Cambie St. and Broadway.
- Davie St. and Pacific Boulevard
- Granville and Nelson Streets.
- Granville and Dunsmuir Streets.
- Granville and Cordova Streets.

An option with eight stations with one station at Robson Street instead of two stations at Nelson and Dunsmuir streets was also reviewed.

Four ground level entrances are recommended for Broadway Station. All other proposed underground stations would have two ground level entrances. Broadway station would also have provision to allow passengers to transfer to and from the proposed Skytrain Millennium line extension.

The recommended method of station construction would use cut-and-cover to reduce costs and the construction schedule.

Four crossover structures are recommended at 49th Avenue, King Edward, Pacific Boulevard and Cordova. Each structure would also be constructed using cut-and-cover and each would effectively be a continuation of the adjacent station.

9.6. CONSTRUCTABILITY

It is envisaged that there would be the following three tunnel drives using six TBM's for the base case profile:

- A TBM launch from a section of cut-and-cover tunnel behind a portal near SW Marine Drive, and TBM removals at a shaft in Queen Elizabeth Park.

- A shaft TBM launch just south of False Creek for the southerly drive with TBM removals at the Queen Elizabeth Park shaft.

- A shaft TBM launch just south of False Creek for the northerly drive with TBM removals at Cordova.

Approximately 2.8 million cubic metres of bulk material will need to be disposed of.

9.7. COST ESTIMATES

The Vancouver Segment base case profile is estimated to cost $1,004.9M and assumes the use of six TBM's.

A base case option with 5.0m instead of 5.7m diameter tunnels was estimated to cost $969.0M

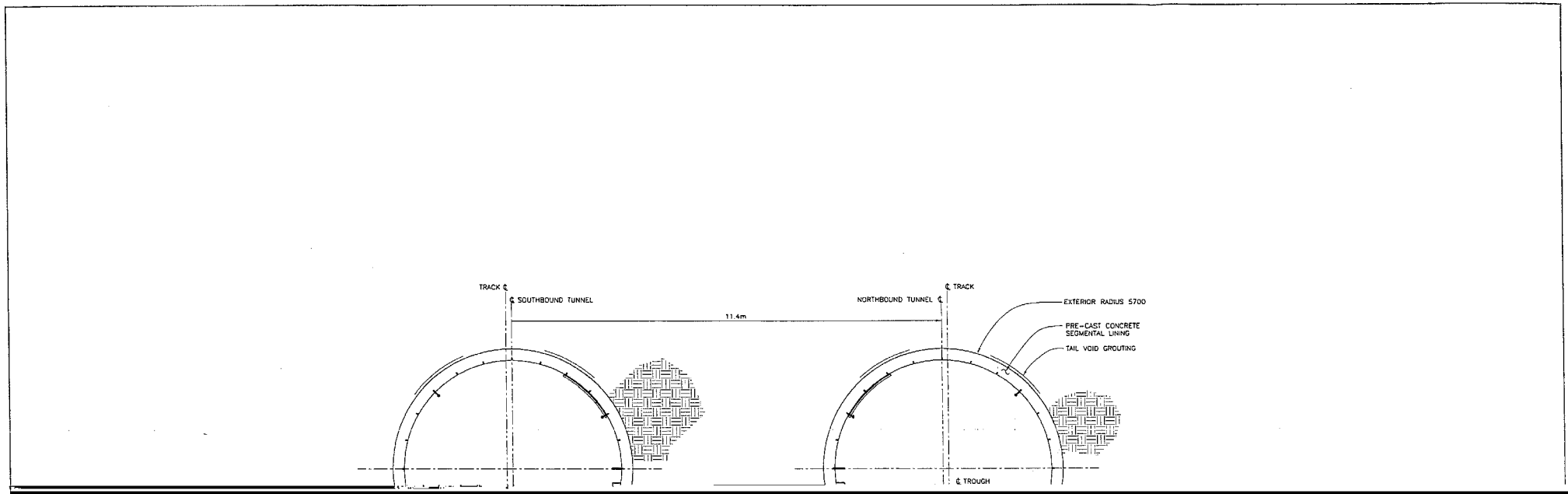
The profile option that crosses over the existing Dunsmuir Skytrain Tunnel at the north end of the Segment is estimated to cost $952.4M.

The profile option with an extended elevated section at the south end of the Segment is estimated to cost $925.2M.

The profile option with an at-grade section at the south end of the Segment is estimated to cost $905.5M.

The profile option with a station at Robson Street and cut-and-cover tunnel over Dunsmuir Tunnel is estimated to cost $935.2M

The least cost profile reviewed would have an at-grade section at the south end of the segment, 5.0m diameter tunnels, a station at Robson Street and cut and cover tunnel over Dunsmuir. This option is estimated to cost $805.33M which is $199.6M less than the base case option.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℄ SOUTHBOUND TUNNEL
11.4m
NORTHBOUND TUNNEL ℄
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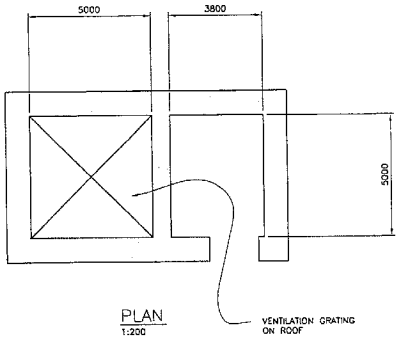
TAIL VOID GROUTING
℄ TROUGH



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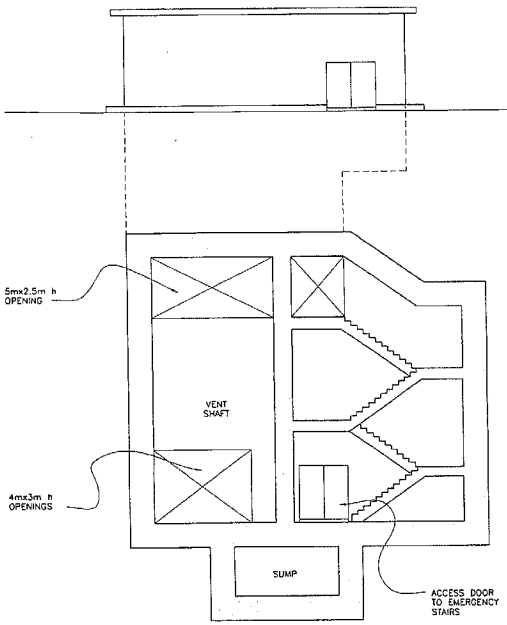

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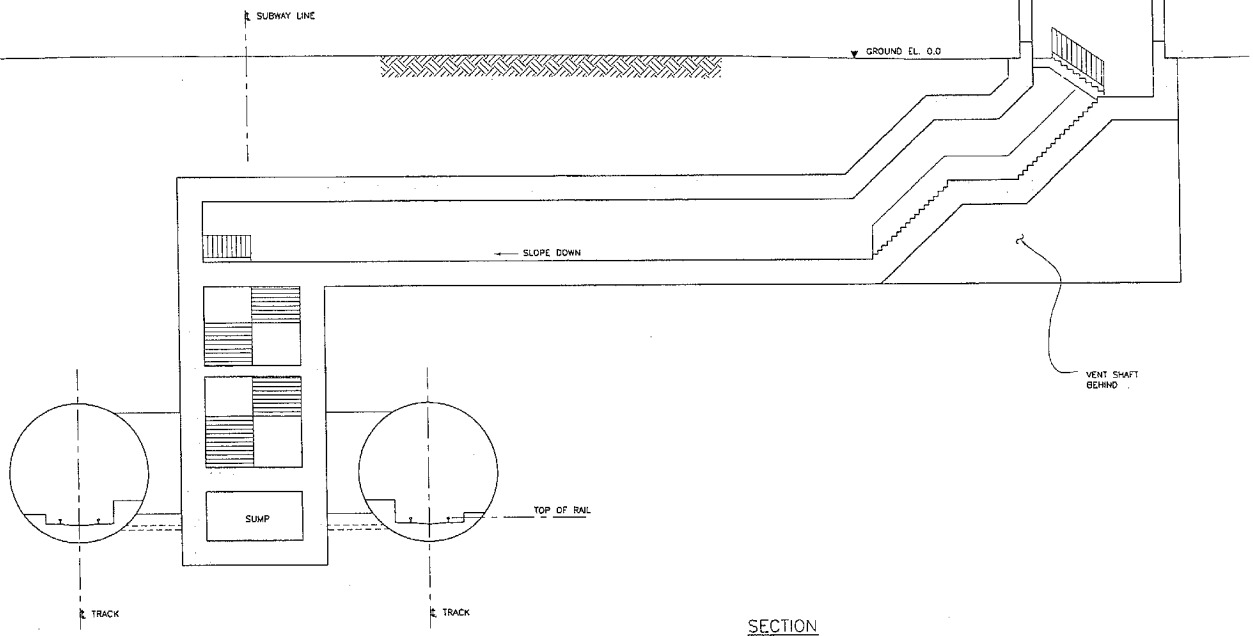

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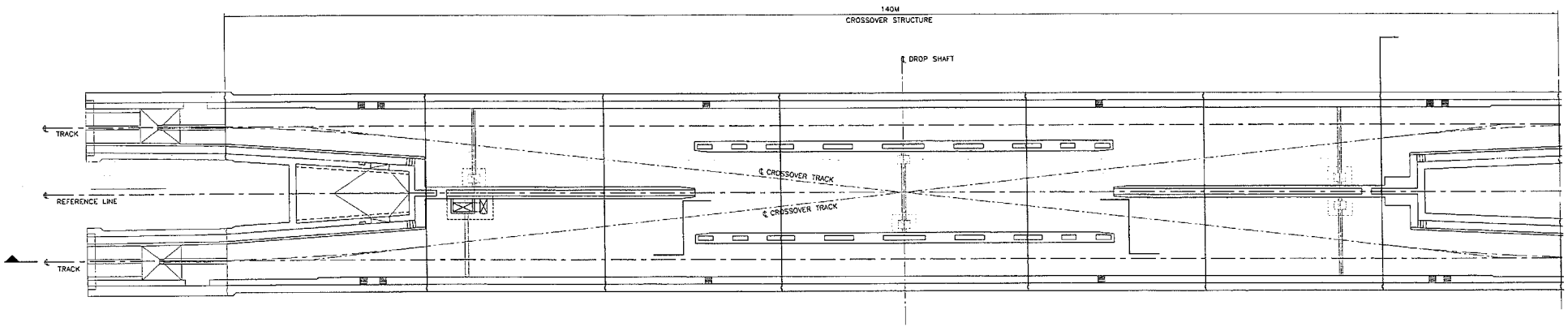

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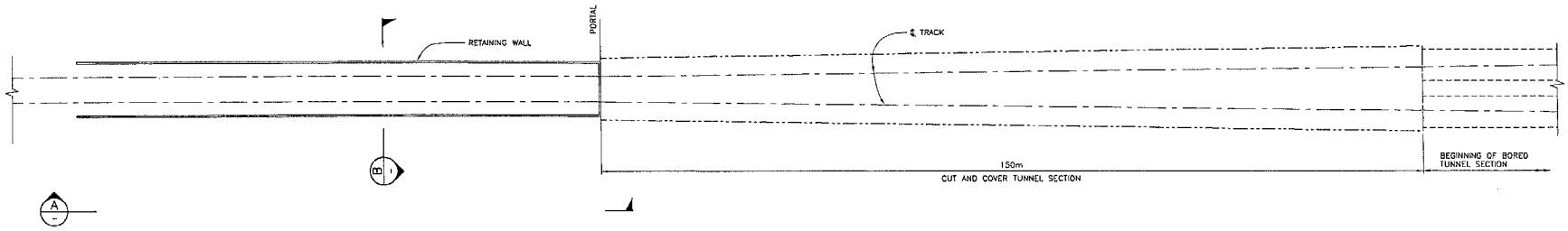

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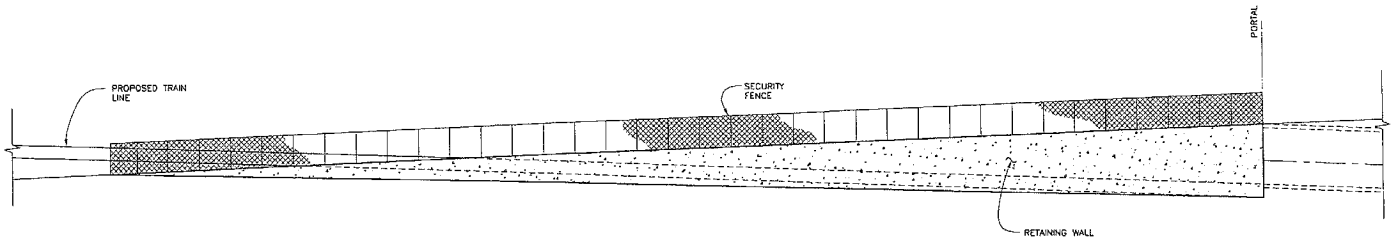

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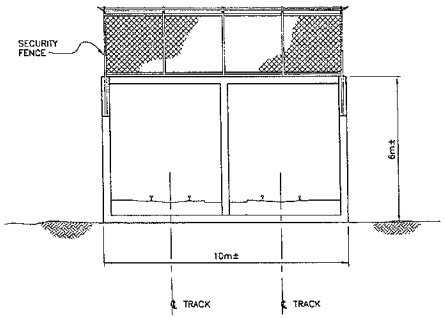

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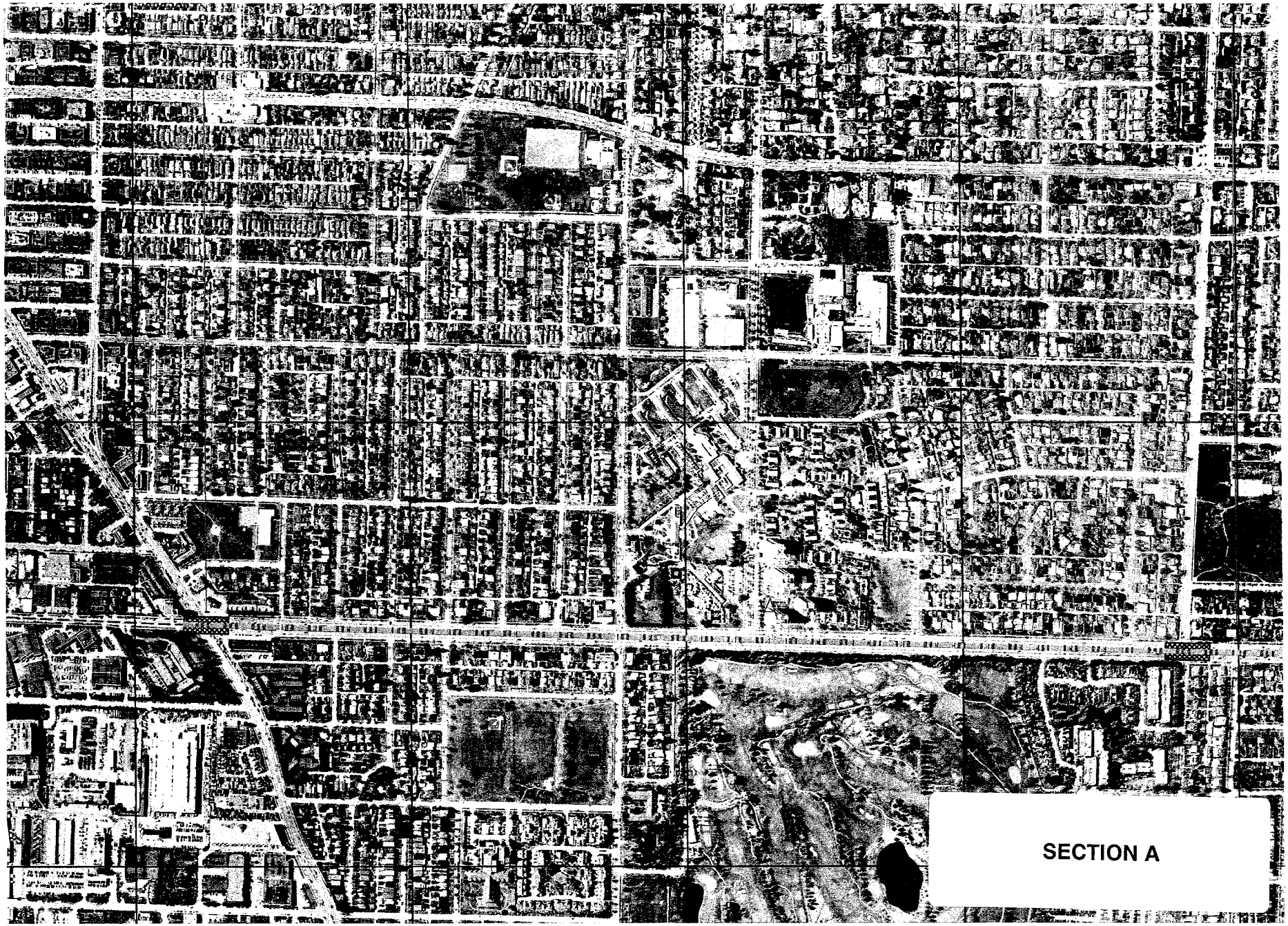
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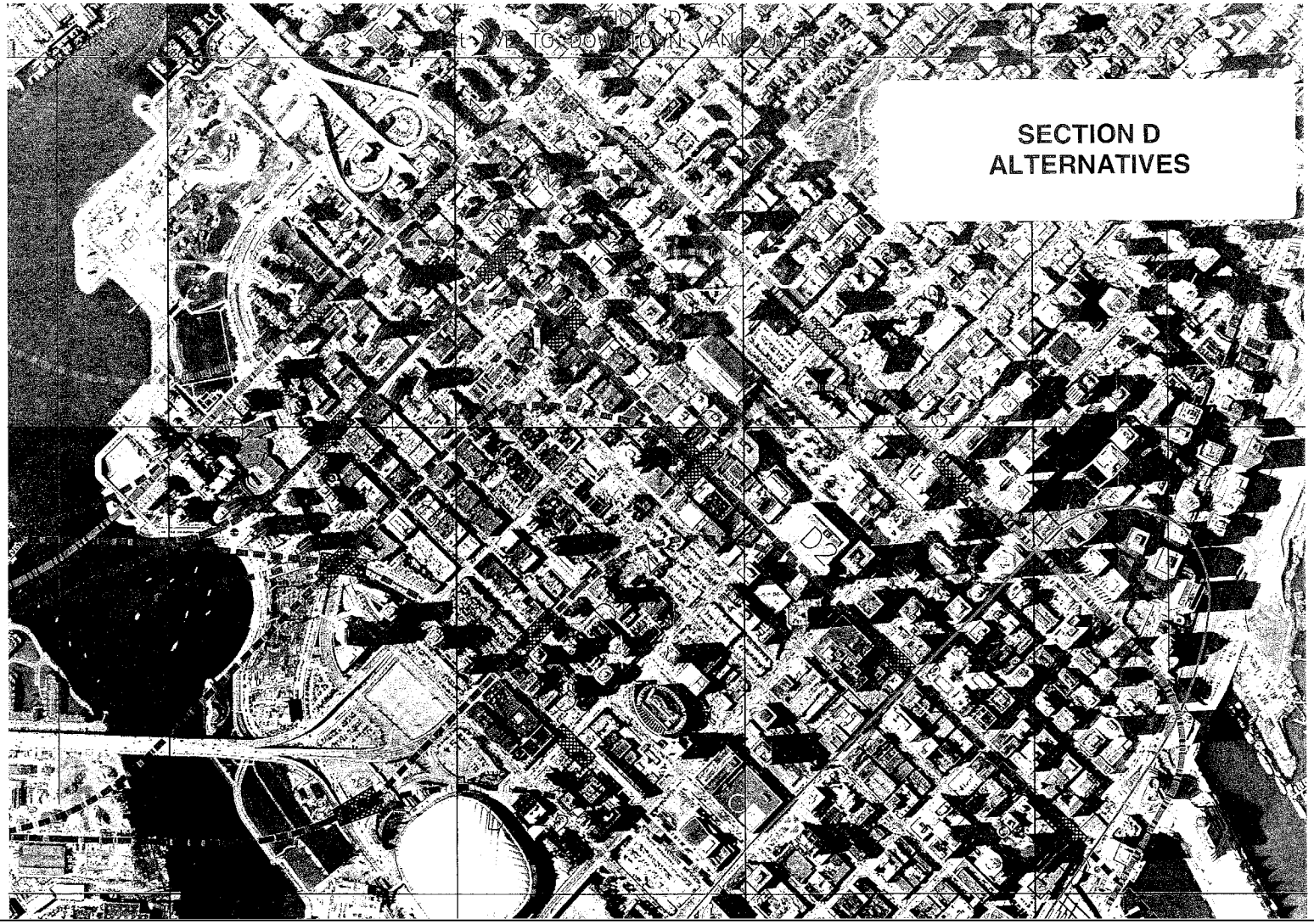
ALTERNATIVES



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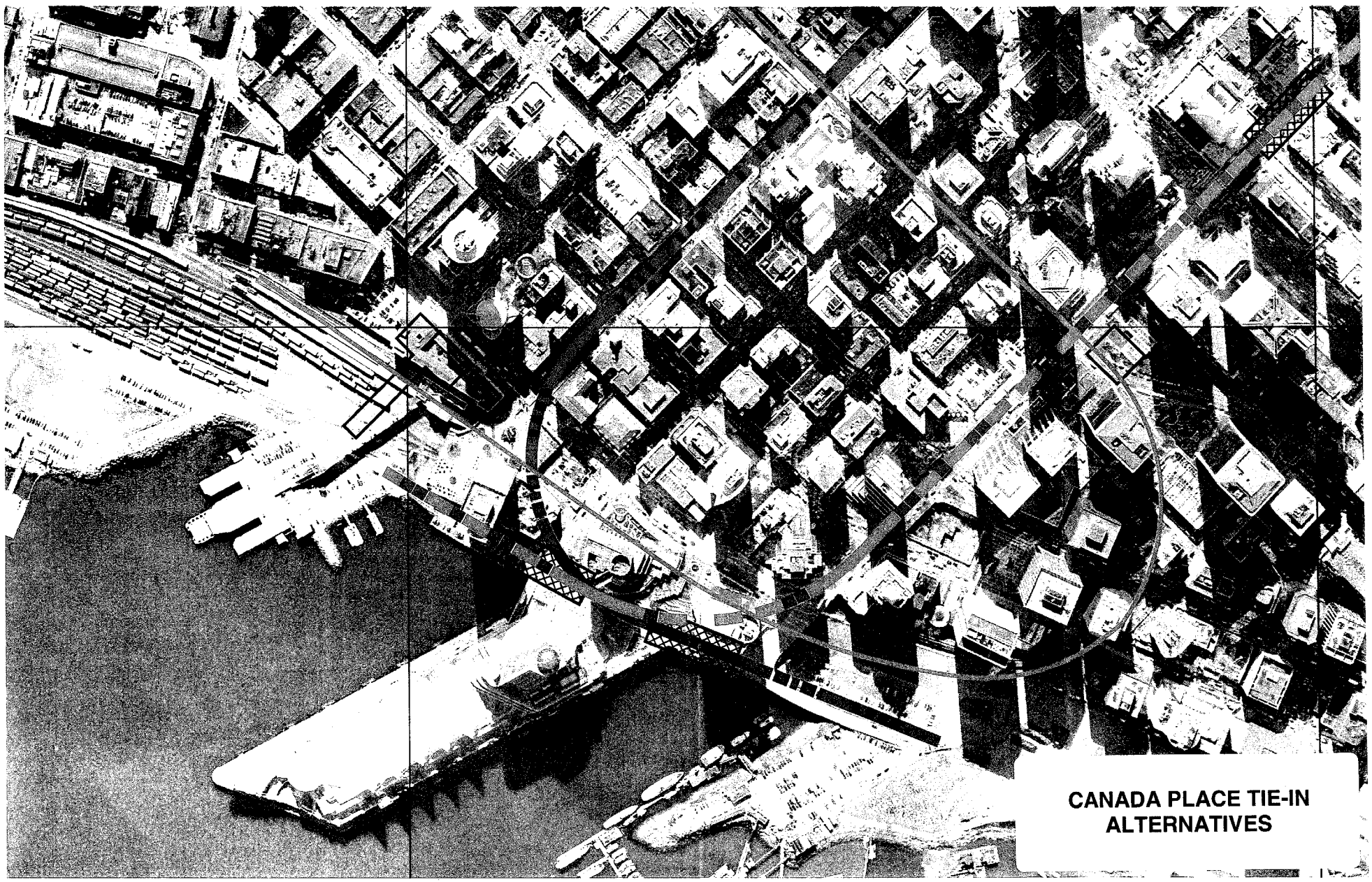

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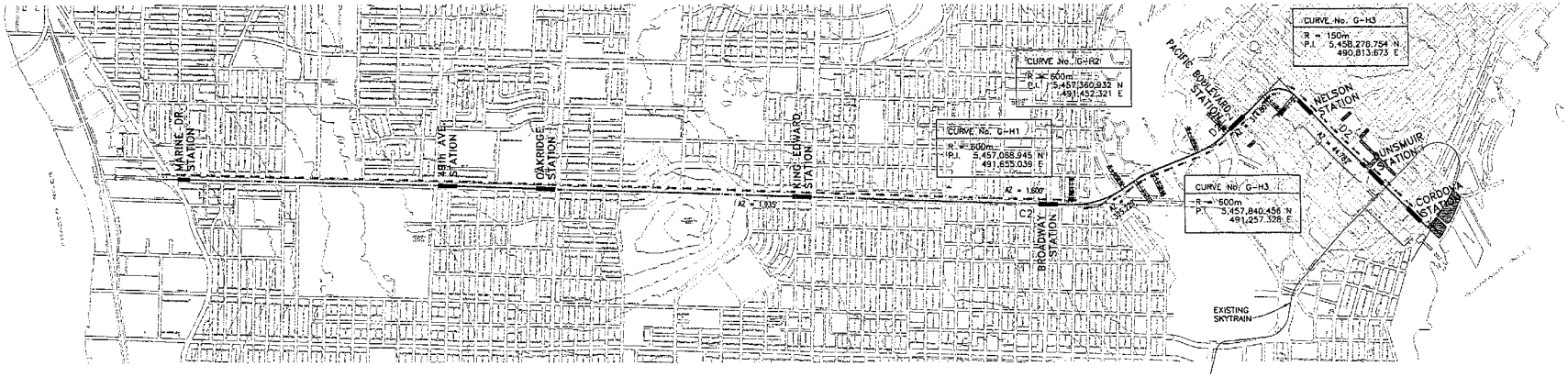

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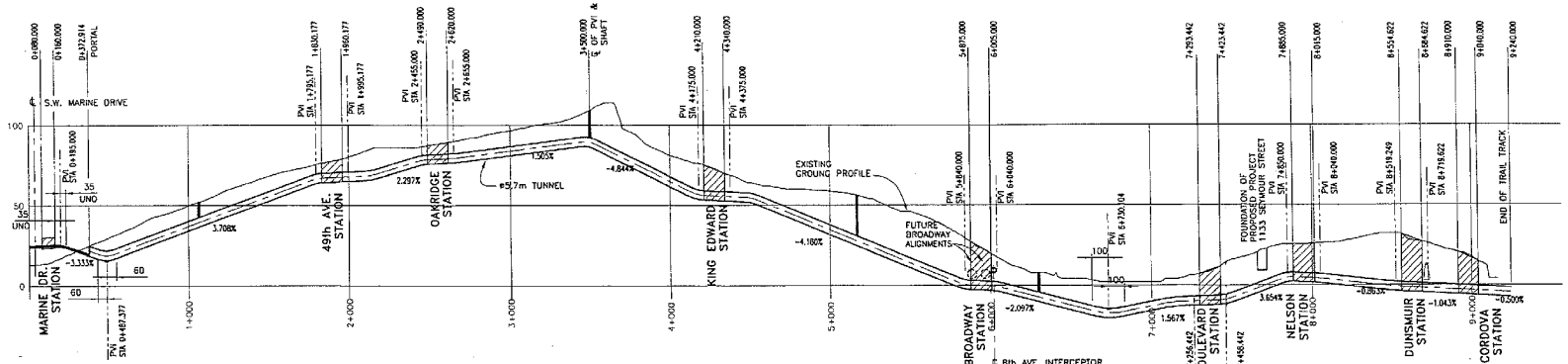

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Richmond/Airport/Vancouver Rapid Transit

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RAVP – VANCOUVER SEGMENT
GENERAL ARRANGEMENT
CAMBIE–DAVIE–GRANVILLE

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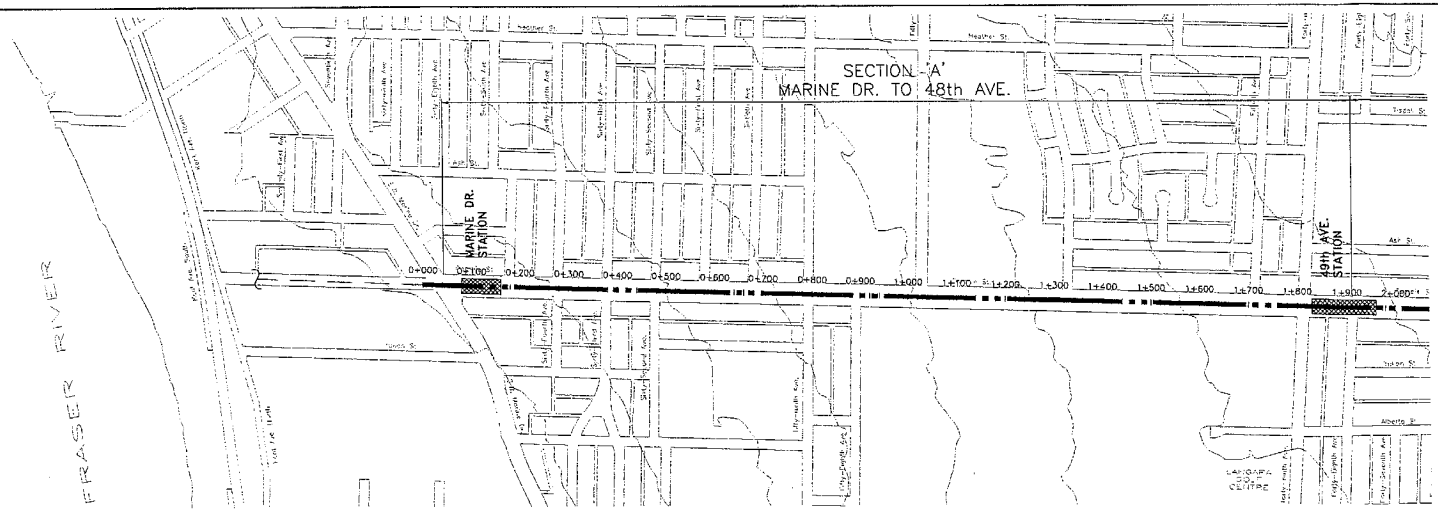

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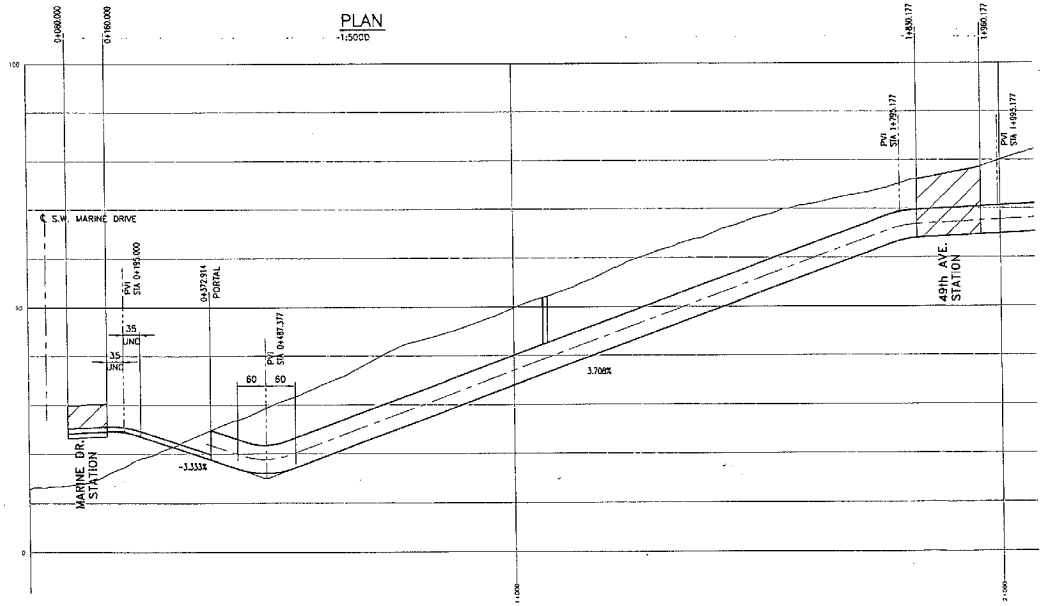

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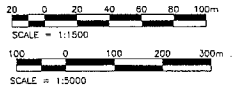

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Richmond/Airport/Vancouver Rapid Transit

PREPARED BY:
Sandwell
Hatch Mott MacDonald

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CAMBIE–DAVIE–GRANVILLE
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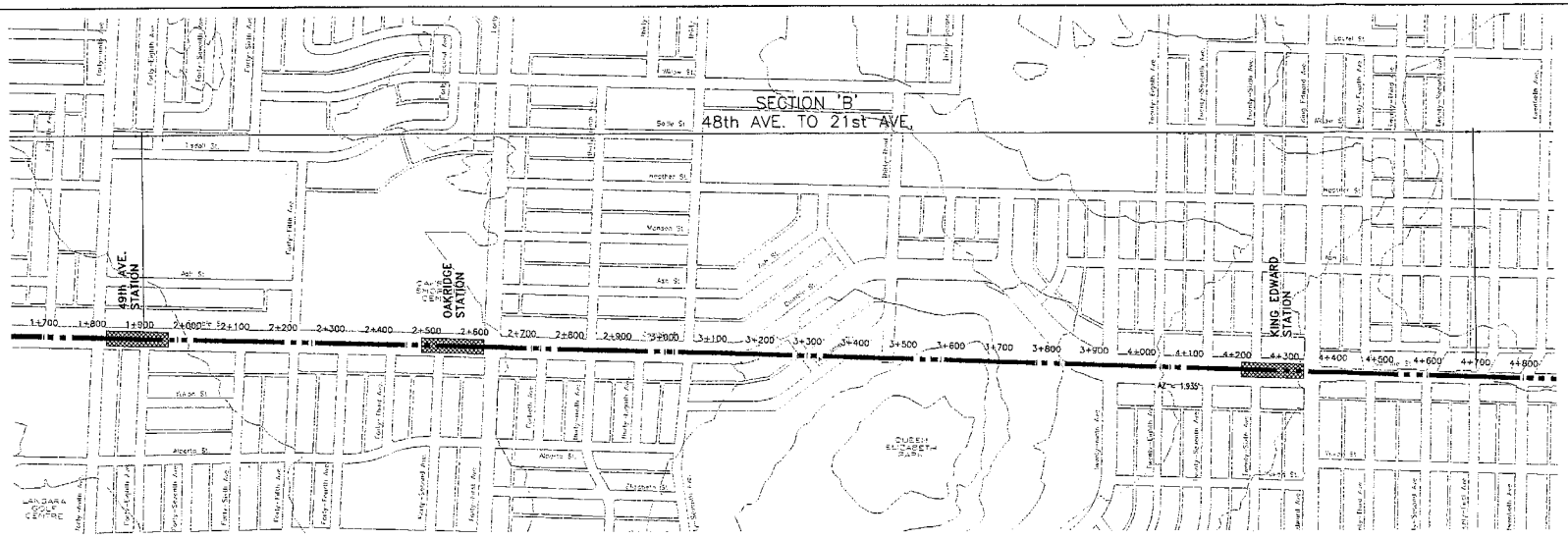

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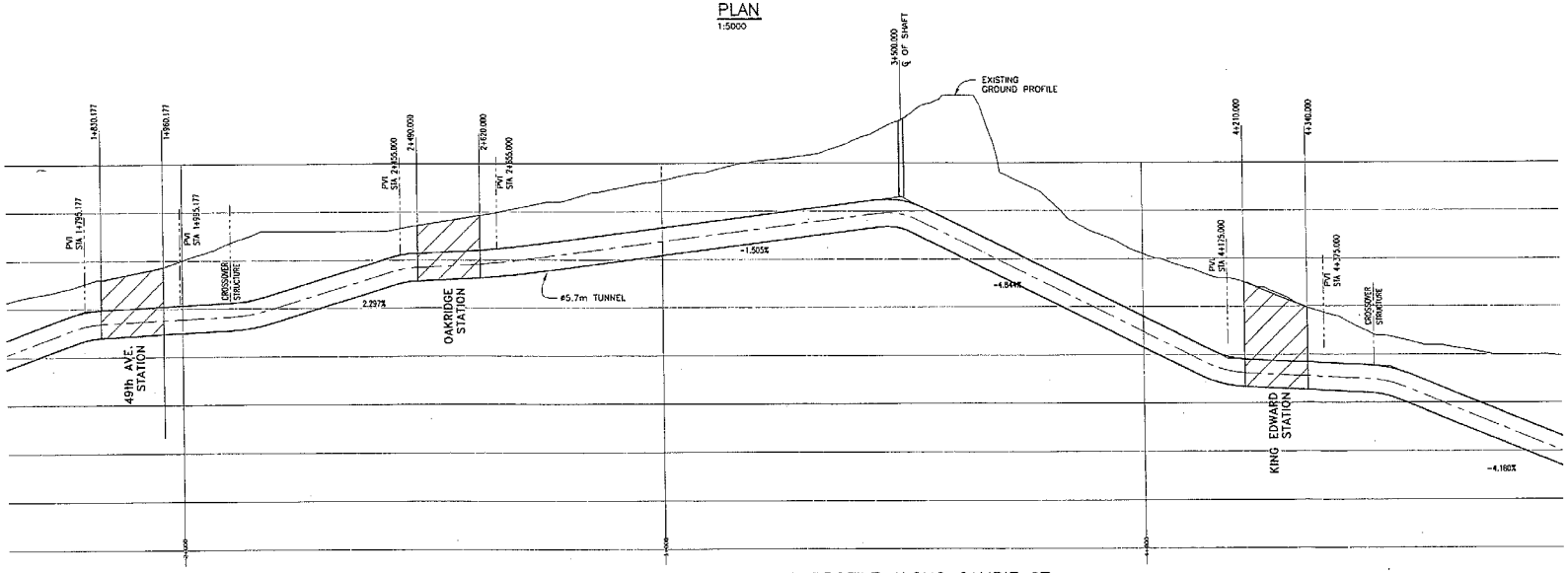
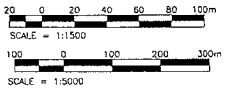


VERTICAL PROFILE ALONG CAMBIE ST.
HOR. = 1:5000
VERT. = 1:500



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DRAWN ____ DATE	No. DWG No. DESCRIPTION	DATE BY DESCRIPTION REV	
CHECKED ____ DATE			
APPROVED ____ DATE			
Rav-T6.dwg Rev. 1 2002-07-15			

Richmond/Airport/Vancouver Rapid Transit

PREPARED BY: Sandwell / Hatch Mott MacDonald

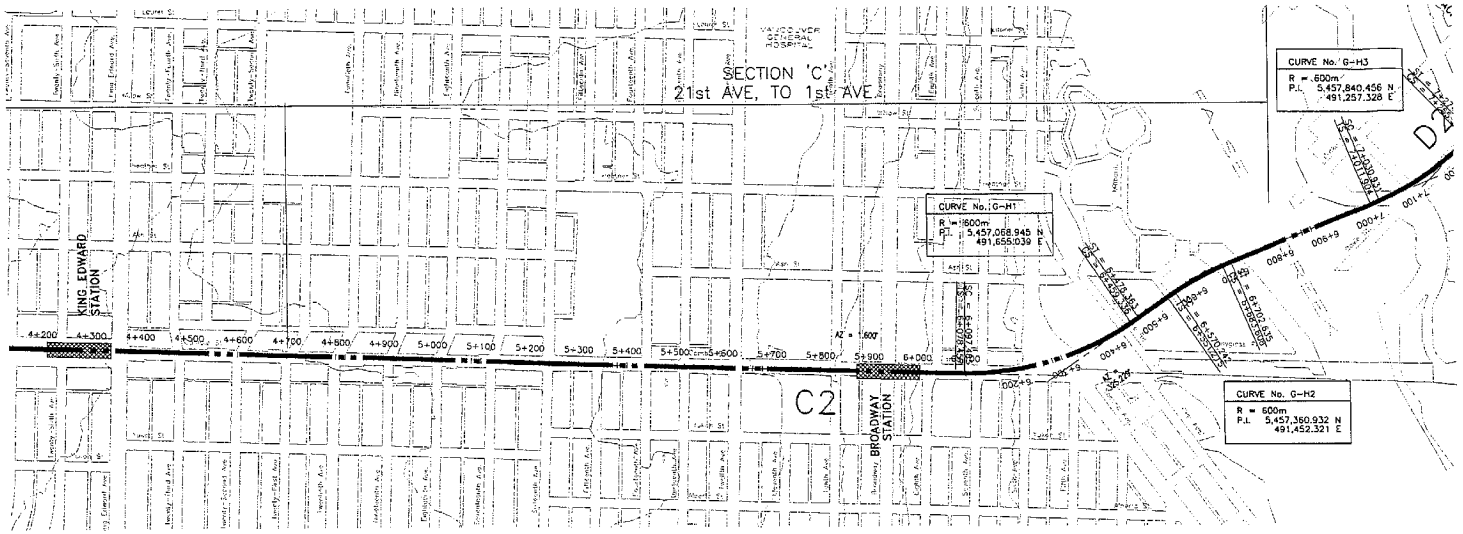
SEAL

BAR SCALE(S):

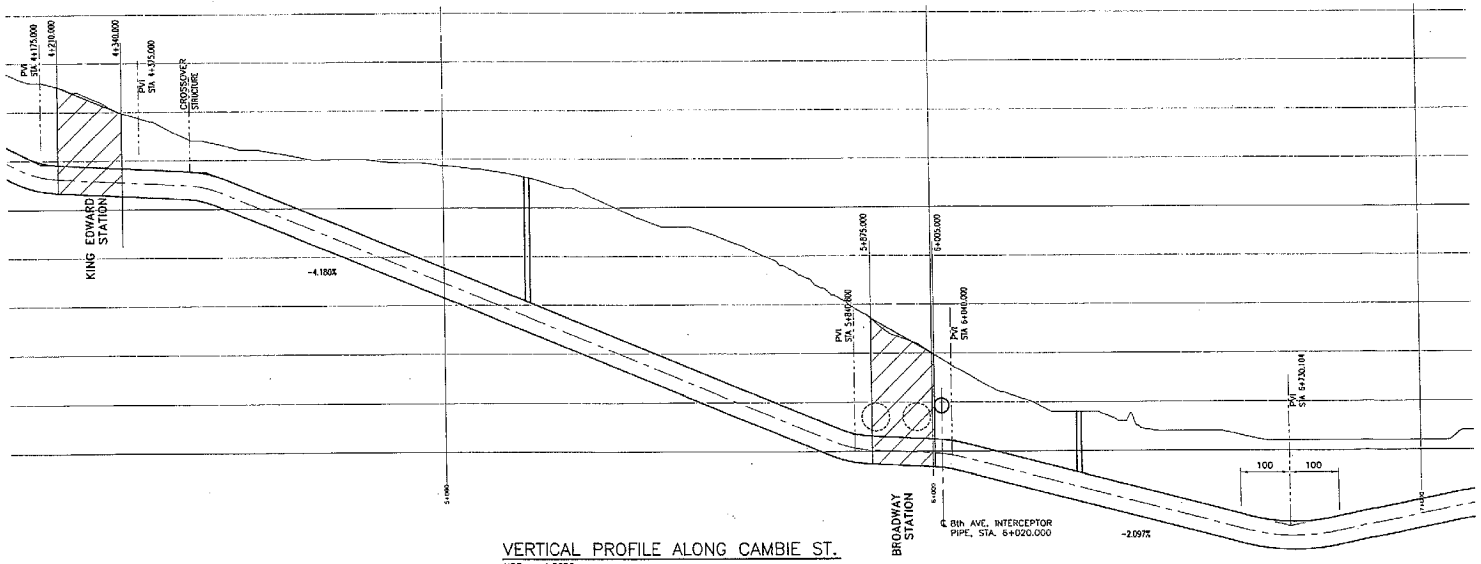
RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
SECTION 'B'

SCALE | CONTRACT T1 | DRAWING T1-6-102
DATE

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →



PLAN
1:5000



VERTICAL PROFILE ALONG CAMBIE ST.
HOR. = 1:5000
VERT. = 1:500

20 0 20 40 60 80 100m
SCALE = 1:1500

100 0 100 200 300m
SCALE = 1:5000

DESIGNED	DATE	REFERENCE DRAWING		REVISIONS				PREPARED BY:	SEAL
DRAWN	DATE	No.	DWG No. / DESCRIPTION	DATE	BY	DESCRIPTION	REV.	Sandwell / Hatch Mott MacDonald	
CHECKED	DATE								
APPROVED	DATE								

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Rev. 1 2002-07-15

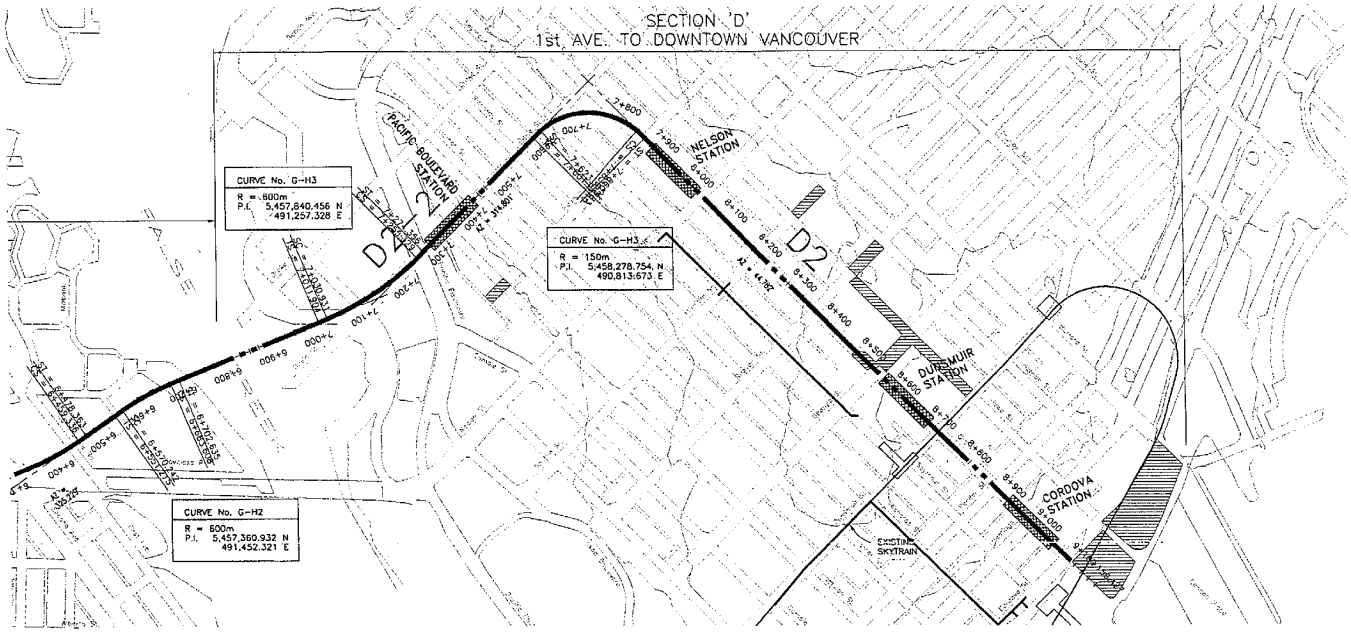
Richmond/Airport/Vancouver Rapid Transit

BAR SCALE(S):

RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
SECTION 'C'

SCALE | CONTRACT T1 | DRAWING T1-6-103
DATE

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →



PLAN
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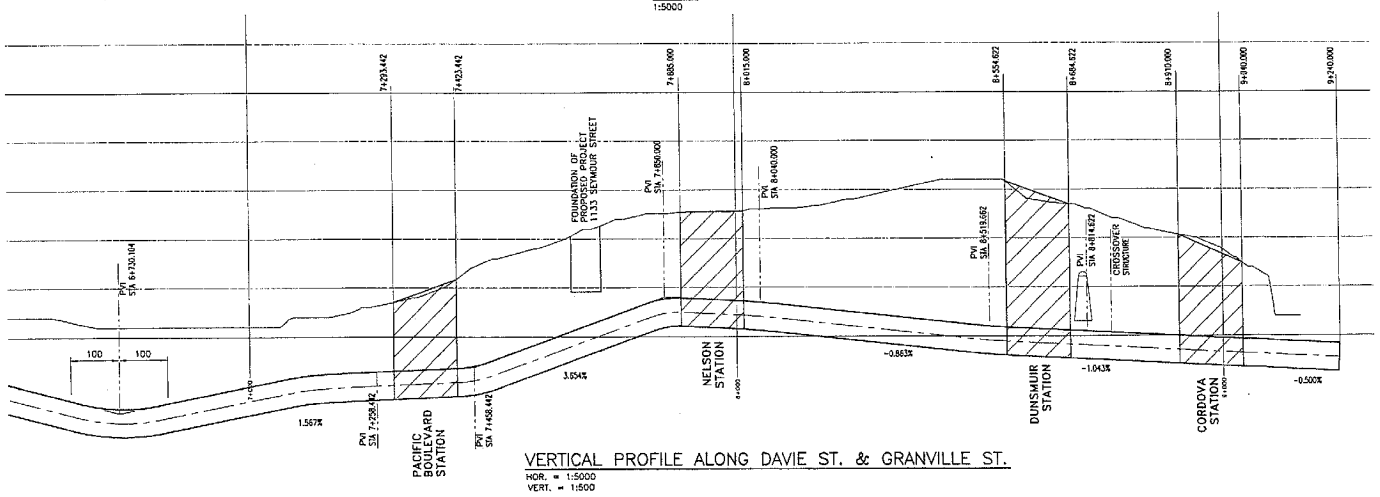


VERTICAL PROFILE ALONG DAVIE ST. & GRANVILLE ST.
HOR. = 1:5000
VERT. = 1:500

20 0 20 40 60 80 100m
SCALE = 1:1500

100 0 100 200 300m
SCALE = 1:5000

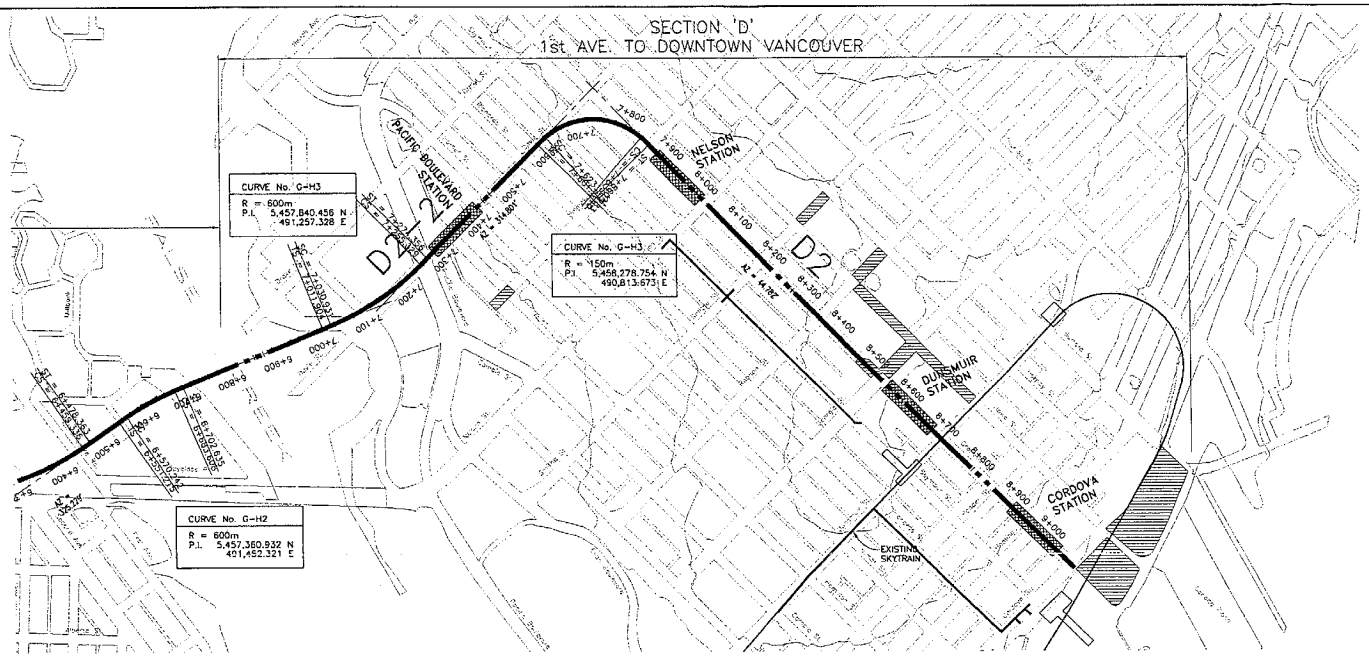
DESIGNED ____ DATE	REFERENCE DRAWING: No. / DWG. No. / DESCRIPTION	REVISIONS: DATE / BY / DESCRIPTION / REV.	PREPARED BY: Sandwell / Hatch Mott MacDonald
DRAWN ____ DATE			SEAL
CHECKED ____ DATE			BAR SCALE(S):
APPROVED ____ DATE			
RAV-T1.dwg Rev. 1 2002-07-15			Richmond/Airport/Vancouver Rapid Transit

RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
SECTION 'D'

SCALE / DATE
CONTRACT: T1
DRAWING: T1-6-104

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →

SECTION 'D'
1st AVE. TO DOWNTOWN VANCOUVER



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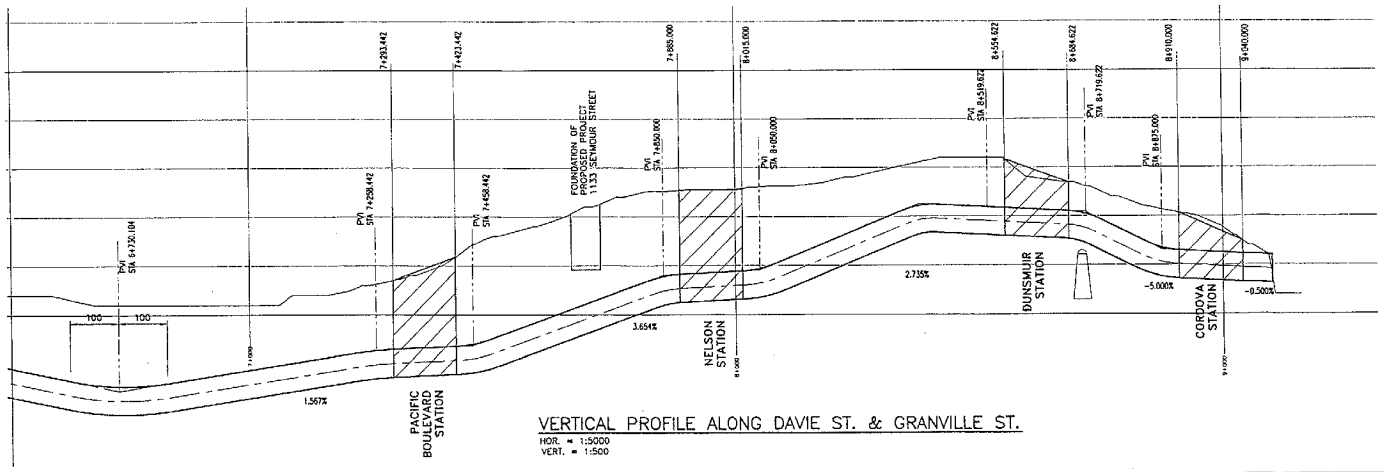


VERTICAL PROFILE ALONG DAVIE ST. & GRANVILLE ST.
HOR. = 1:5000
VERT. = 1:500

SCALE = 1:1500
SCALE = 1:5000

DESIGNED	DATE	REFERENCE DRAWING		REVISIONS				PREPARED BY:	SEAL
DRAWN	DATE	No.	DWG No. DESCRIPTION	DATE	BY	DESCRIPTION	REV	Sandwell / Hatch Mott MacDonald	
CHECKED	DATE								
APPROVED	DATE								

Richmond/Airport/Vancouver Rapid Transit

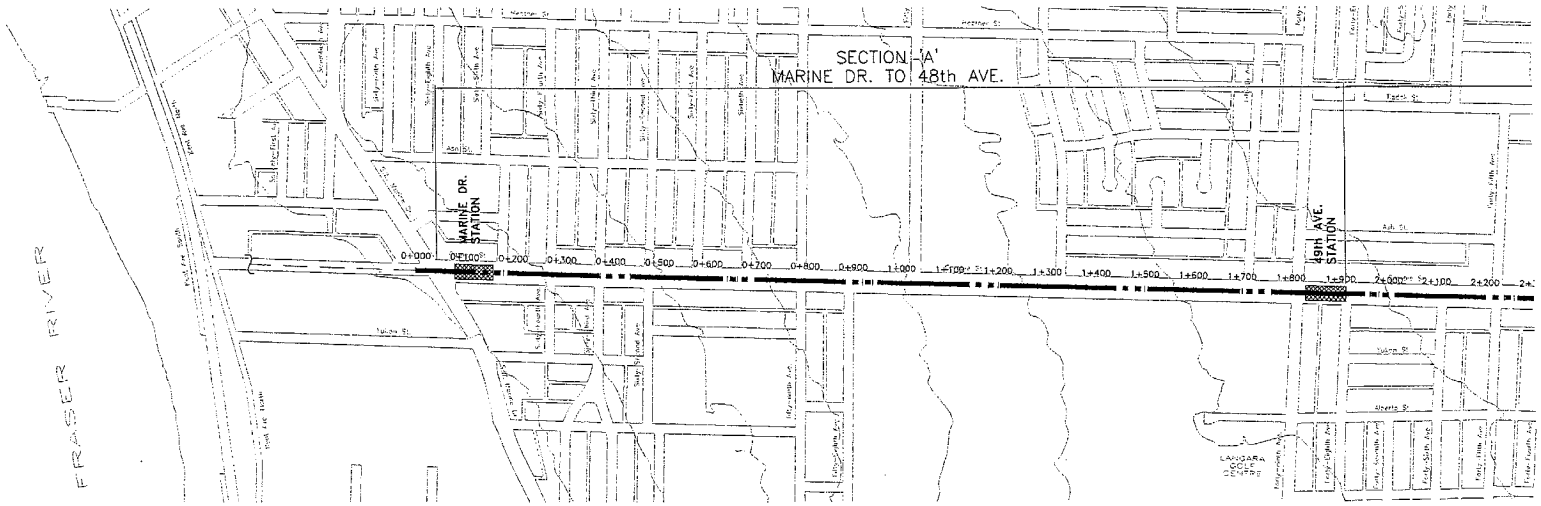
BAR SCALE(S):

RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
SECTION 'D' ABOVE DUNSMUIR OPTION

SCALE | CONTRACT T1 | DRAWING T1-6-105
DATE

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →

DWG-TB.dwg
Rev. 1 2022-07-15



PLAN
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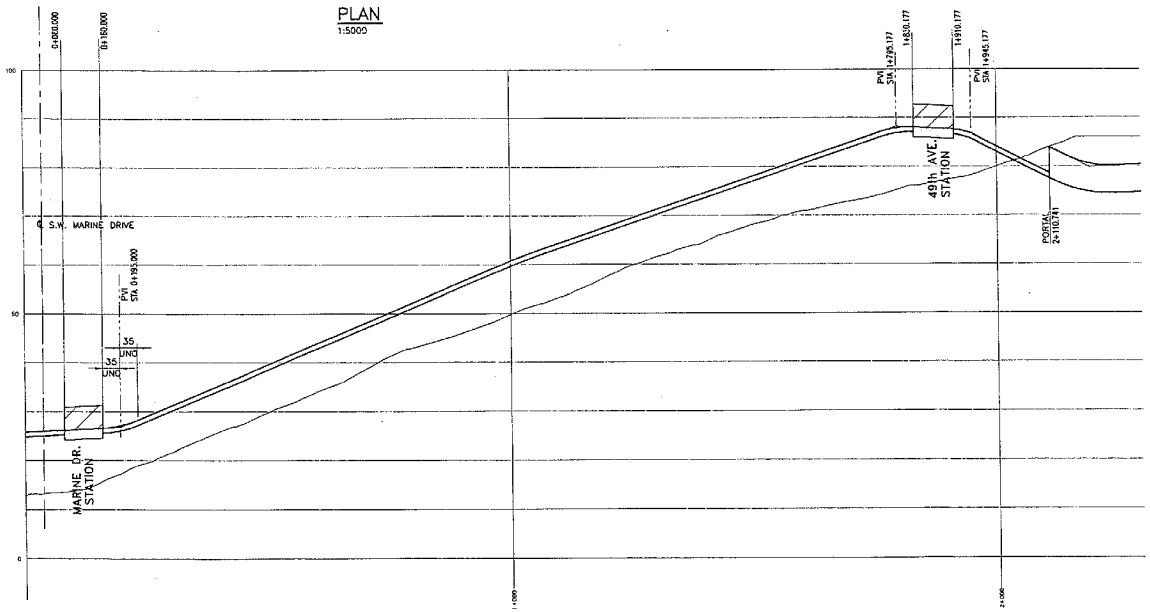

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SCALE = 1:1500

100 0 100 200 300m
SCALE = 1:5000

VERTICAL PROFILE ALONG CAMBIE ST.
HOR. = 1:5000
VERT. = 1:500

DESIGNED		DATE	
DRAWN		DATE	
CHECKED		DATE	
APPROVED		DATE	

RAV-T1.dwg
Rev. 1 2022-07-15

REFERENCE DRAWING

No	DWG No.	DESCRIPTION

REVISIONS

DATE	BY	DESCRIPTION	REV

Richmond/Airport/Vancouver Rapid Transit

PREPARED BY:
Sandwell
Hatch Mott MacDonald

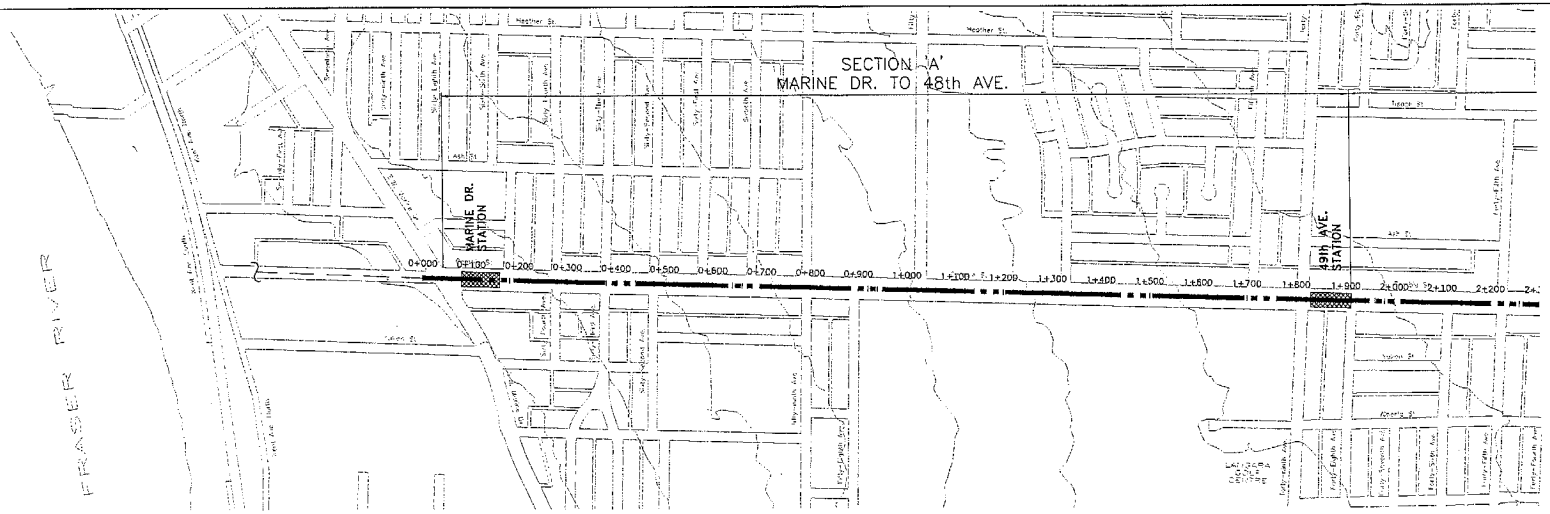
SEAL

BAR SCALE(S):

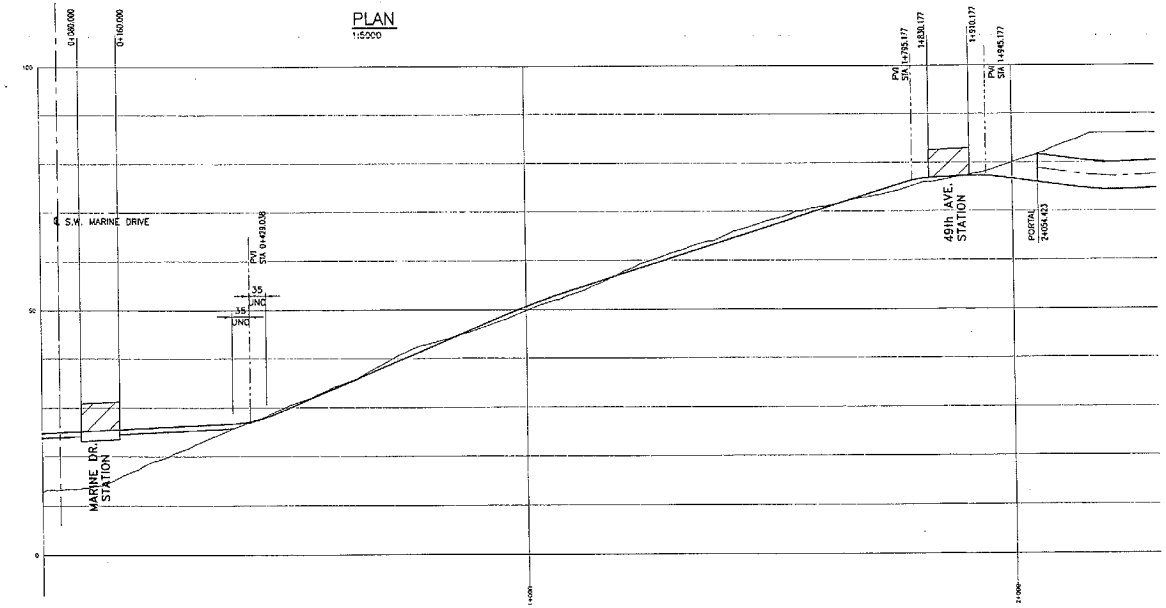
RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
SECTION 'A' (ALT–1)

SCALE	CONTRACT	DRAWING
DATE	T1	T1–6–106

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →



PLAN
1:5000



20 0 20 40 60 80 100m
SCALE = 1:1500

100 0 100 200 300m
SCALE = 1:5000

VERTICAL PROFILE ALONG CAMBIE ST.
HOR. = 1:5000
VERT. = 1:500

DESIGNED	DATE	REFERENCE DRAWING	REVISIONS
DRAWN	DATE	No. DWG No. DESCRIPTION	DATE BY DESCRIPTION REV.
CHECKED	DATE		
APPROVED	DATE		

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Rev. 1 2022-07-15

Richmond/Airport/Vancouver Rapid Transit

PREPARED BY:
Sandwell
Hatch Mott MacDonald

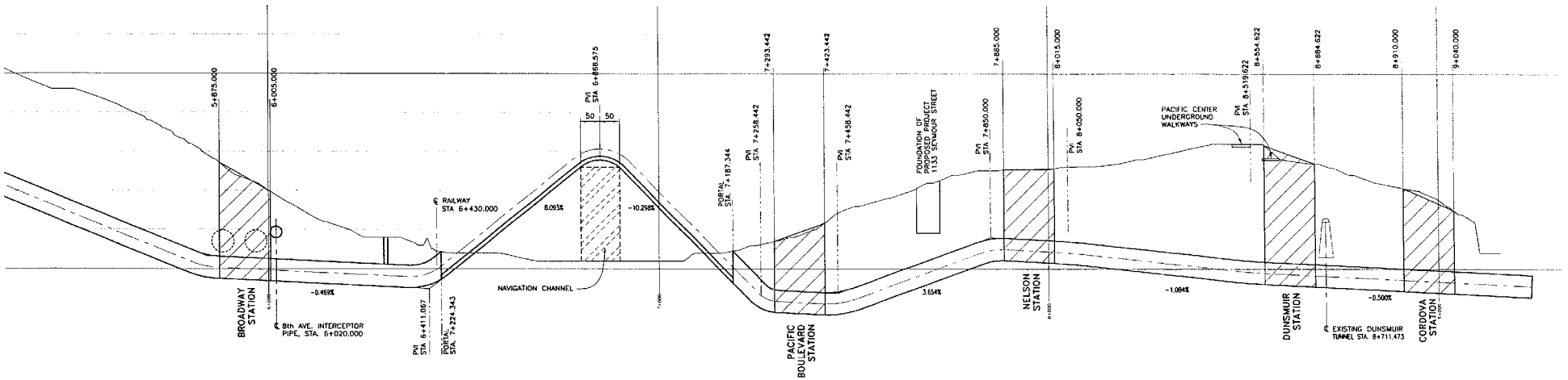
SEAL

BAR SCALE(S):

RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
SECTION 'A' (ALT-2)

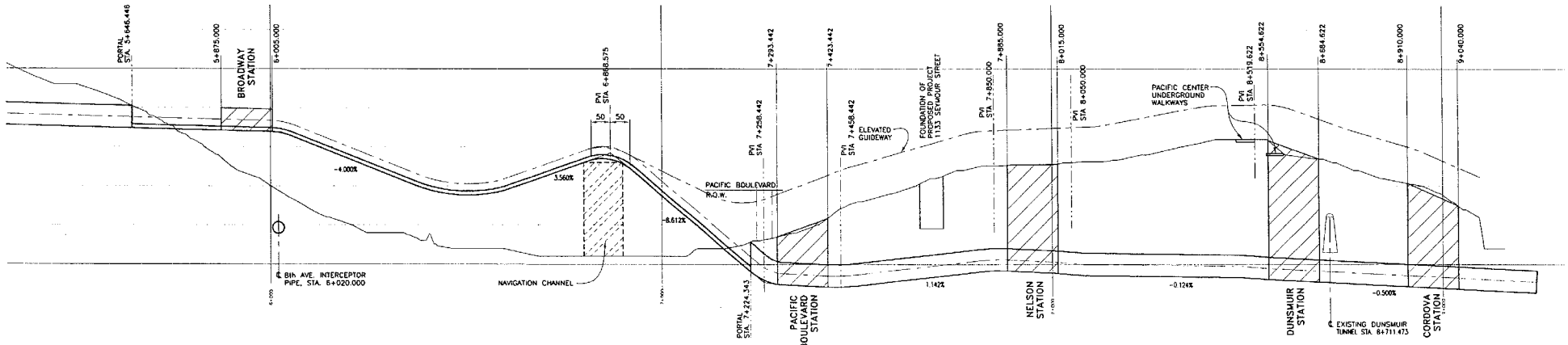
SCALE
DATE
CONTRACT T1
DRAWING T1-6-107

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →



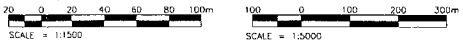
VERTICAL PROFILE OF FALSE CREEK CROSSING – OPTION 1

HOR. = 1:5000
VERT. = 1:500



VERTICAL PROFILE OF FALSE CREEK CROSSING – OPTION 2

HOR. = 1:5000
VERT. = 1:500



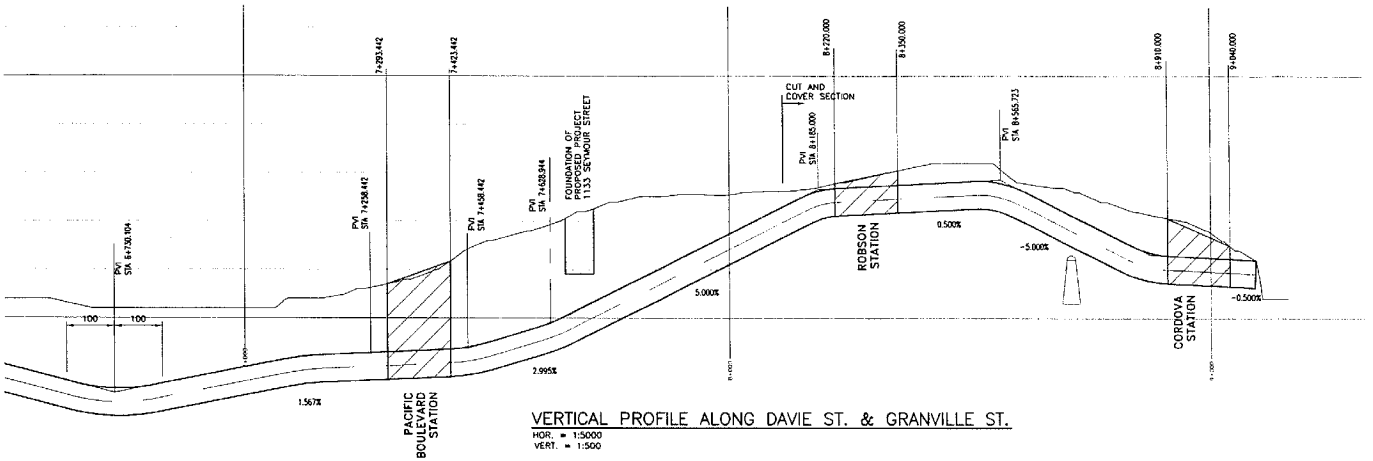
DESIGNED	DATE	REFERENCE DRAWING		REVISIONS				*Richmond/Airport/Vancouver Rapid Transit*	PREPARED BY: Sandwell / Hatch Mott MacDonald	SEAL
DRAWN	DATE	No.	DWG. No.	DESCRIPTION	DATE	BY	DESCRIPTION	REV.		
CHECKED	DATE									
APPROVED	DATE									

BAR SCALE(S):

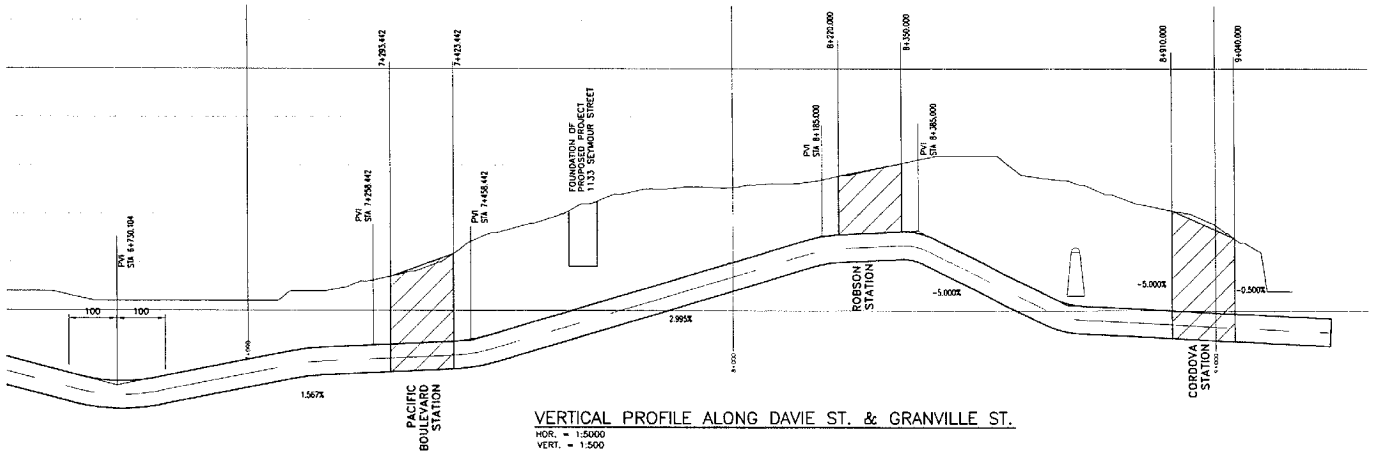
RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
FALSE CREEK CROSSING OPTIONS

SCALE | CONTRACT T1 | DRAWING T1-6-108
DATE

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →



VERTICAL PROFILE ALONG DAVIE ST. & GRANVILLE ST.
HOR. = 1:5000
VERT. = 1:500



VERTICAL PROFILE ALONG DAVIE ST. & GRANVILLE ST.
HOR. = 1:5000
VERT. = 1:500

20 0 20 40 60 80 100m
SCALE = 1:1500

100 0 100 200 300m
SCALE = 1:5000

DESIGNED	DATE	REFERENCE DRAWING	REVISIONS
DRAWN	DATE	No. DWG. No. DESCRIPTION	DATE BY DESCRIPTION REV.
CHECKED	DATE		
APPROVED	DATE		
Rev. 1 2008-07-16			

Richmond/Airport/Vancouver Rapid Transit

PREPARED BY: Sandwell / Hatch Mott MacDonald

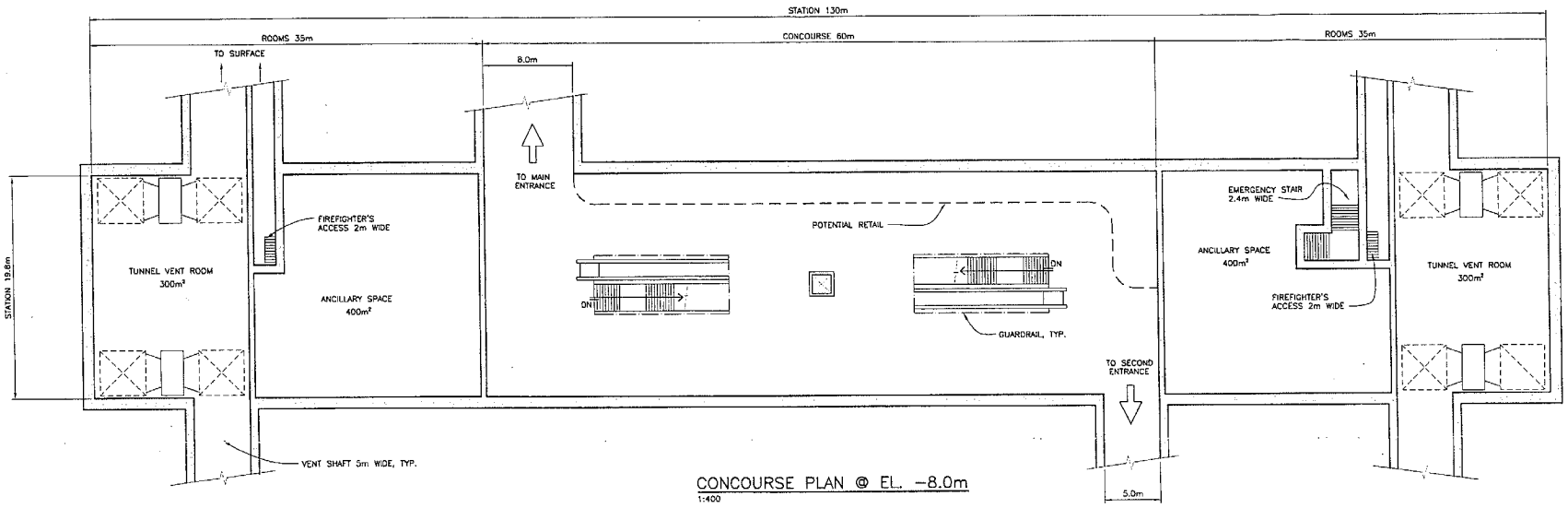
SEAL

BAR SCALE(S):

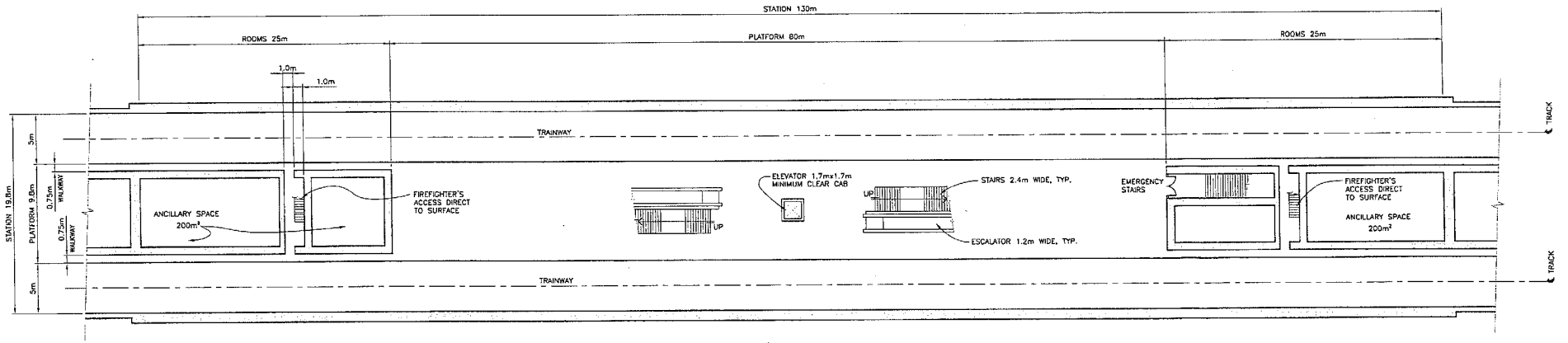
RAVP – VANCOUVER SEGMENT
CAMBIE–DAVIE–GRANVILLE
SECTION 'D' ROBSON STATION OPTION

SCALE: CONTRACT: T1 DRAWING: T1-6-109
PART:

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →



CONCOURSE PLAN @ EL. -8.0m
1:400



PLATFORM PLAN @ EL. -14.0m
1:400

DESIGNED ____ DATE	REFERENCE DRAWING	REVISIONS	PREPARED BY: Sandwell / Hatch Mott MacDonald
DRAWN ____ DATE	No. | DWG No. | DESCRIPTION	DATE | BY | DESCRIPTION | REV	SEAL
CHECKED ____ DATE			BAR SCALE(S):
APPROVED ____ DATE			

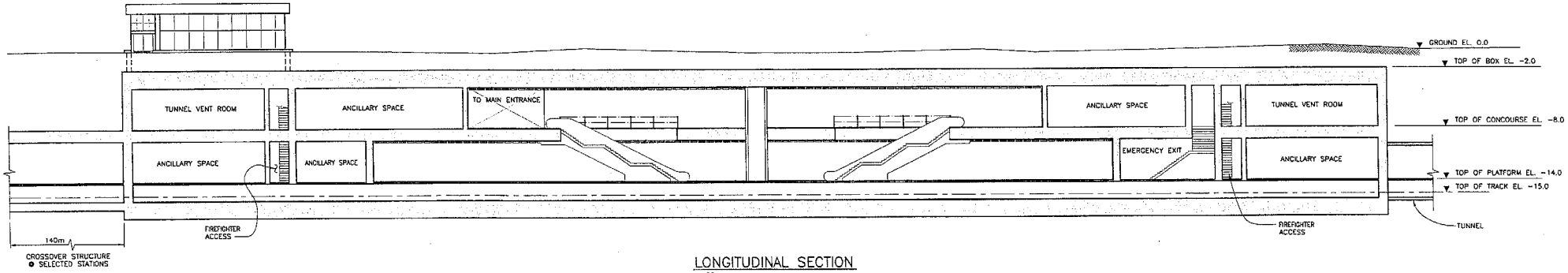
Richmond/Airport/Vancouver Rapid Transit

RAVP – VANCOUVER SEGMENT
TYPICAL UNDERGROUND STATION PLAN

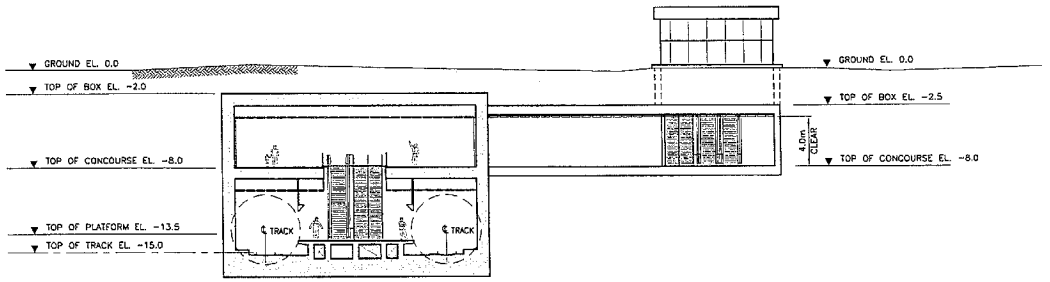
SCALE | CONTRACT T1 | DRAWING T1-6-200
DATE

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →

RAV-TB.dwg Rev. 1 2003-07-15

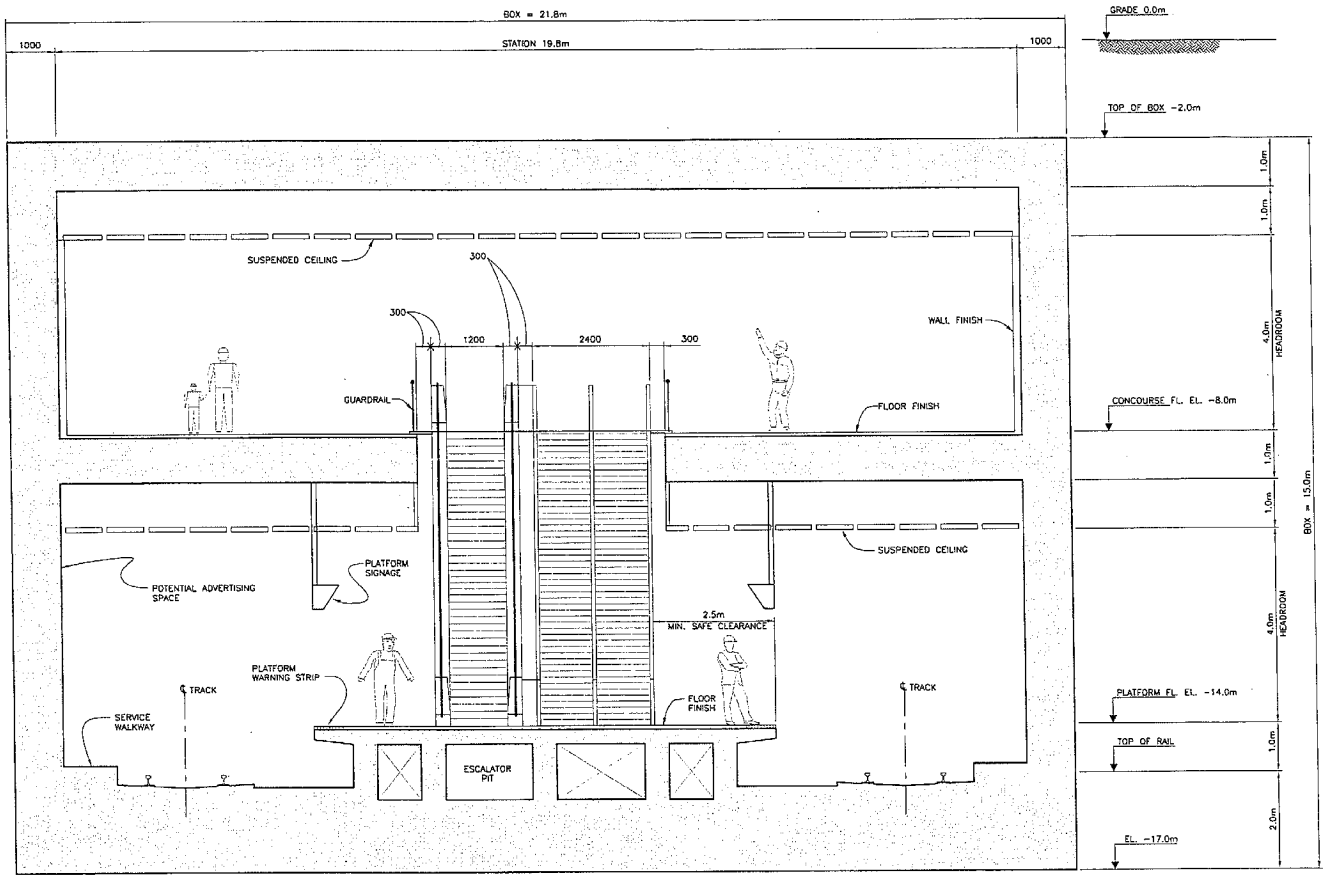


LONGITUDINAL SECTION
1:400



SECTION
1:400

DESIGNED ____ DATE	REFERENCE DRAWING		REVISIONS				*Richmond/Airport/Vancouver Rapid Transit*	PREPARED BY: Sandwell / Hatch Mott MacDonald	SEAL	BAR SCALE(S):	RAVP – VANCOUVER SEGMENT TYPICAL STATION SECTIONS
DRAWN ____ DATE	No.	DWG No. DESCRIPTION	DATE	BY	DESCRIPTION	REV					SCALE: CONTRACT: T1 DRAWING: T1-6-201
CHECKED ____ DATE											DATE:
APPROVED ____ DATE											SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO ⟶
RAV-T1.dwg Rev. 1 2002-07-15											



TYPICAL SECTION
1:100

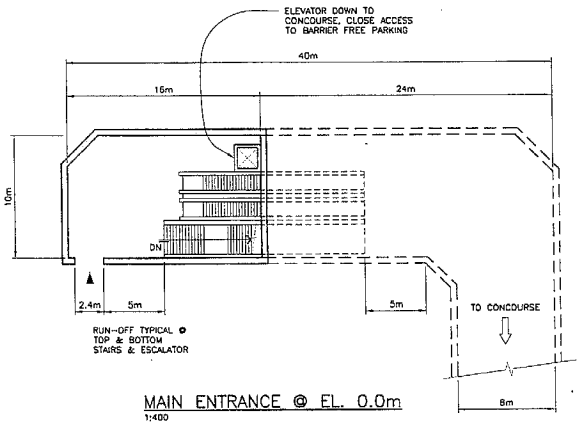
DESIGNED ____ DATE	REFERENCE DRAWING	REVISIONS	PREPARED BY: Sandwell / Hatch Mott MacDonald
DRAWN ____ DATE	No. | DWG No. | DESCRIPTION	DATE | BY | DESCRIPTION | REV	SEAL
CHECKED ____ DATE			BAR SCALE(S):
APPROVED ____ DATE			
RAV-T1.dwg Rev. 1 2022-07-15			

Richmond/Airport/Vancouver Rapid Transit

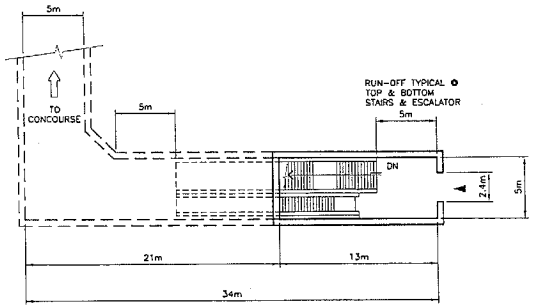
RAVP – VANCOUVER SEGMENT
TYPICAL UNDERGROUND STATION SECTION

SCALE | CONTRACT: T1 | DRAWING: T1-6-202
DATE

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →

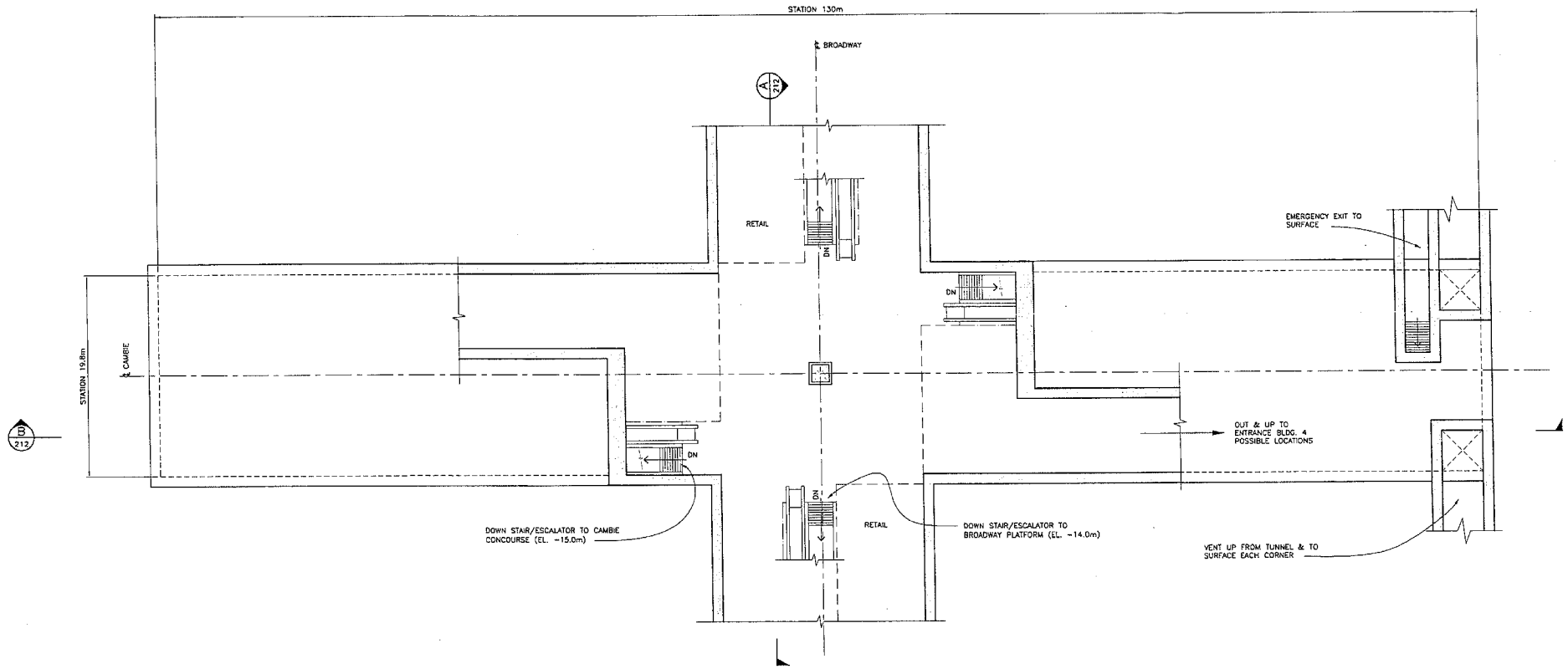


MAIN ENTRANCE @ EL. 0.0m
1:400



SECONDARY ENTRANCE @ EL. 0.0m
1:400

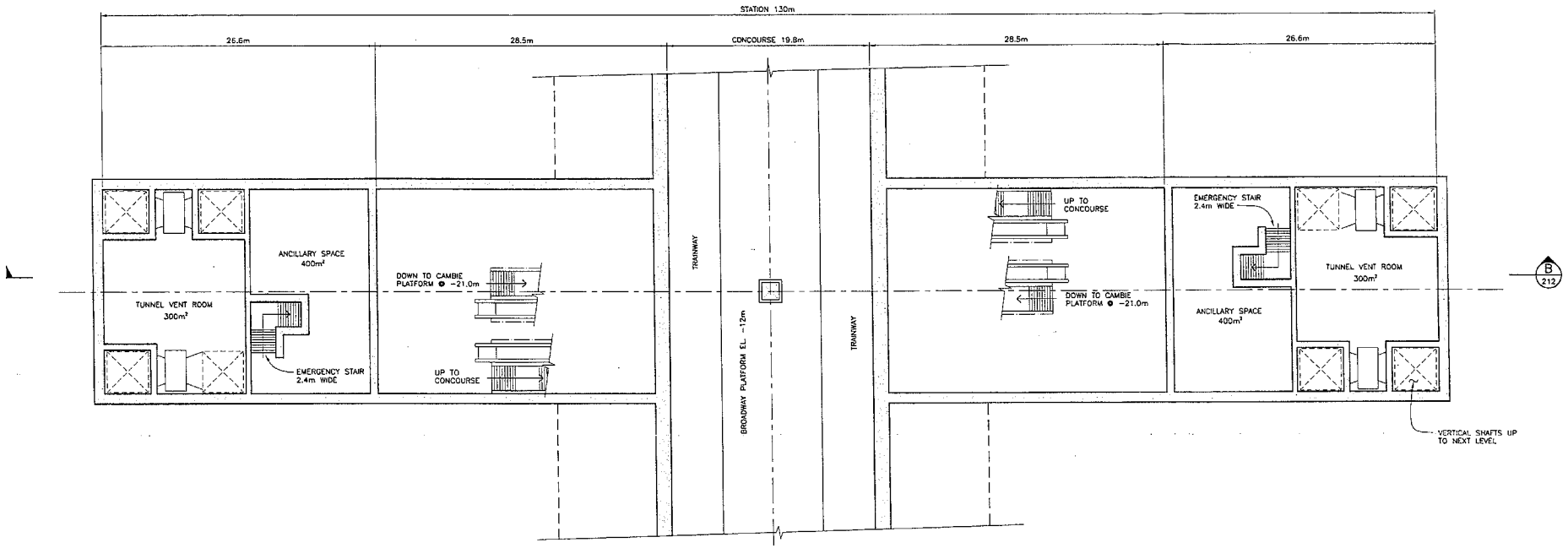
DESIGNED _____ DATE	REFERENCE DRAWING		REVISIONS				*Richmond/Airport/Vancouver Rapid Transit*	PREPARED BY: Sandwell / Hatch Mott MacDonald	SEAL	BAR SCALE(S):	RAVP -- VANCOUVER SEGMENT TYPICAL STATION ENTRANCES
DRAWN _____ DATE	No.	DWG No. DESCRIPTION	DATE	BY	DESCRIPTION	REV					SCALE: COMPACT T1 DRAWING: T1-6-203
CHECKED _____ DATE											DATE
APPROVED _____ DATE											SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO ⟶
RAV-T1.dwg Rev. 1 2002-07-15											



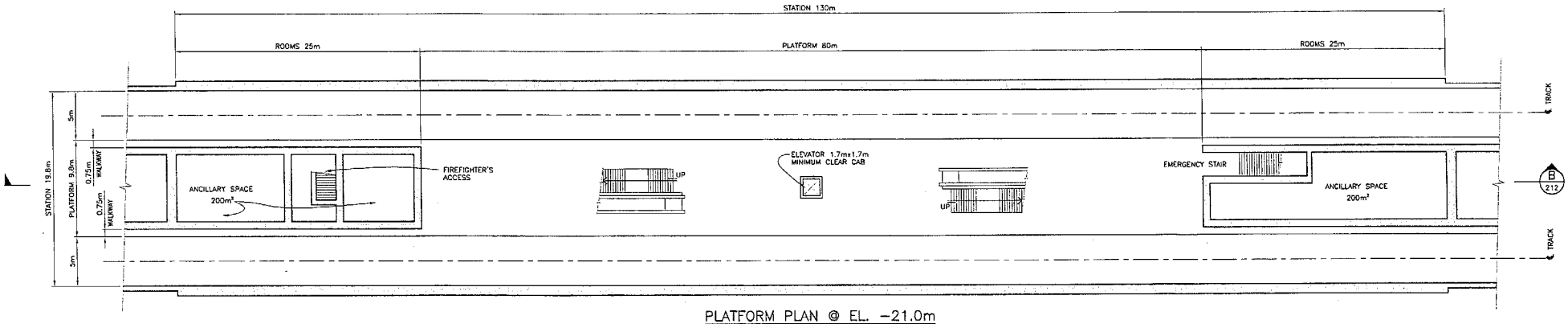
CONCOURSE PLAN @ EL. -8.0m

1:400

DESIGNED ____ DATE	REFERENCE DRAWING		REVISIONS				*Richmond/Airport/Vancouver Rapid Transit*	PREPARED BY: Sandwell / Hatch Mott MacDonald	SEAL	BAR SCALE(S):	RAVP – VANCOUVER SEGMENT BROADWAY STATION PLANS
DRAWN ____ DATE	No.	DWG No. / DESCRIPTION	DATE	BY	DESCRIPTION	REV.					SCALE / DATE: CONTRACT T1 DRAWING T1-6-210
CHECKED ____ DATE											SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →
APPROVED ____ DATE											
BRW-T0.dwg Rev. 1 2012-07-15											



2nd CONCOURSE PLAN @ EL. -15.0m
1:400



PLATFORM PLAN @ EL. -21.0m
1:400

DESIGNED	DATE	REFERENCE DRAWING			REVISIONS				Richmond/Airport/Vancouver Rapid Transit	PREPARED BY: Sandwell / Hatch Mott MacDonald
DRAWN	DATE	No.	DWG No.	DESCRIPTION	DATE	BY	DESCRIPTION	REV		
CHECKED	DATE									
APPROVED	DATE									

SEAL

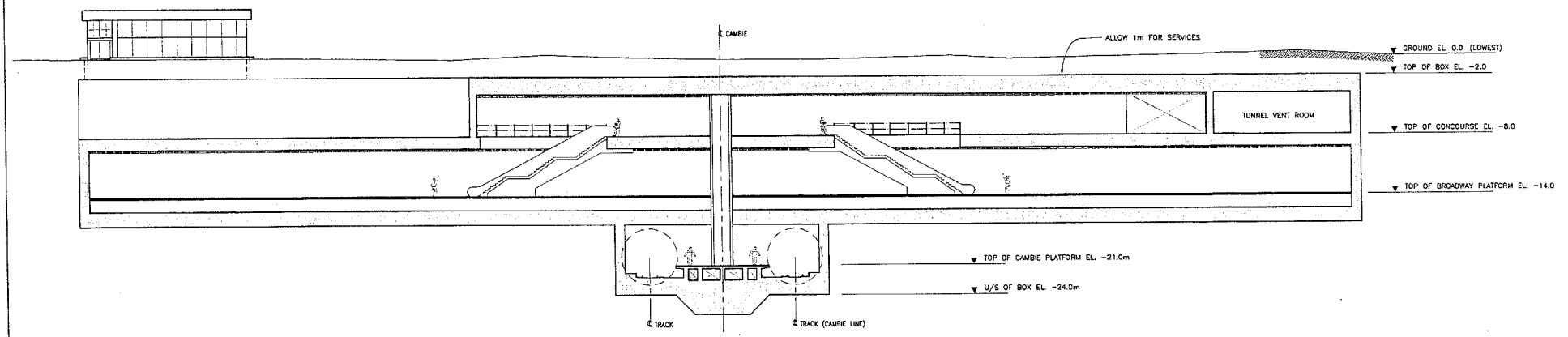
BAR SCALE(S):

RAVP – VANCOUVER SEGMENT
BROADWAY STATION
CAMBIE PLATFORM – PLANS

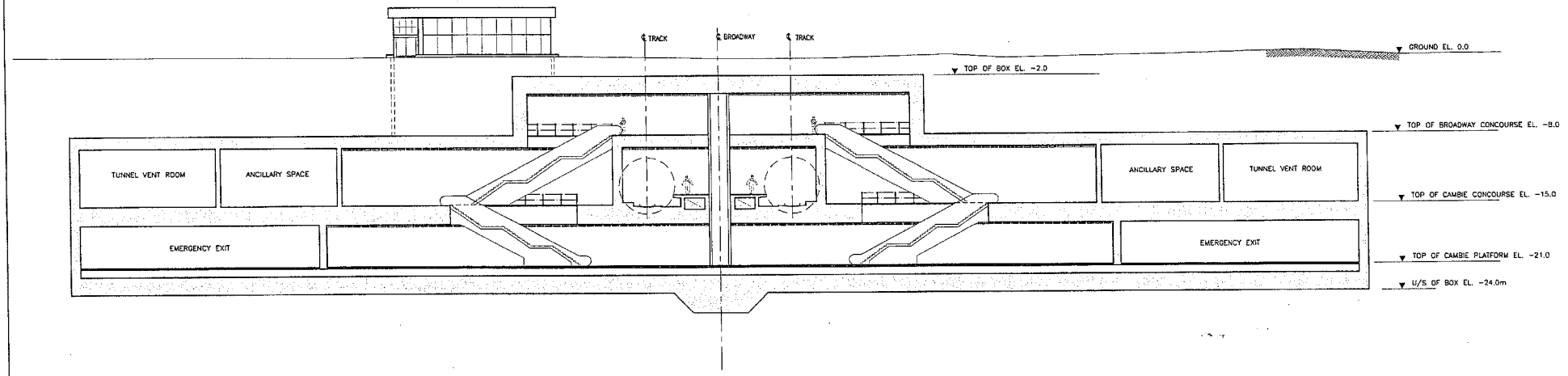
SCALE
DATE
CONTRACT T1
DRAWING T1-6-211

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →

RAV-T1.dwg
Rev. 1 2022-07-15

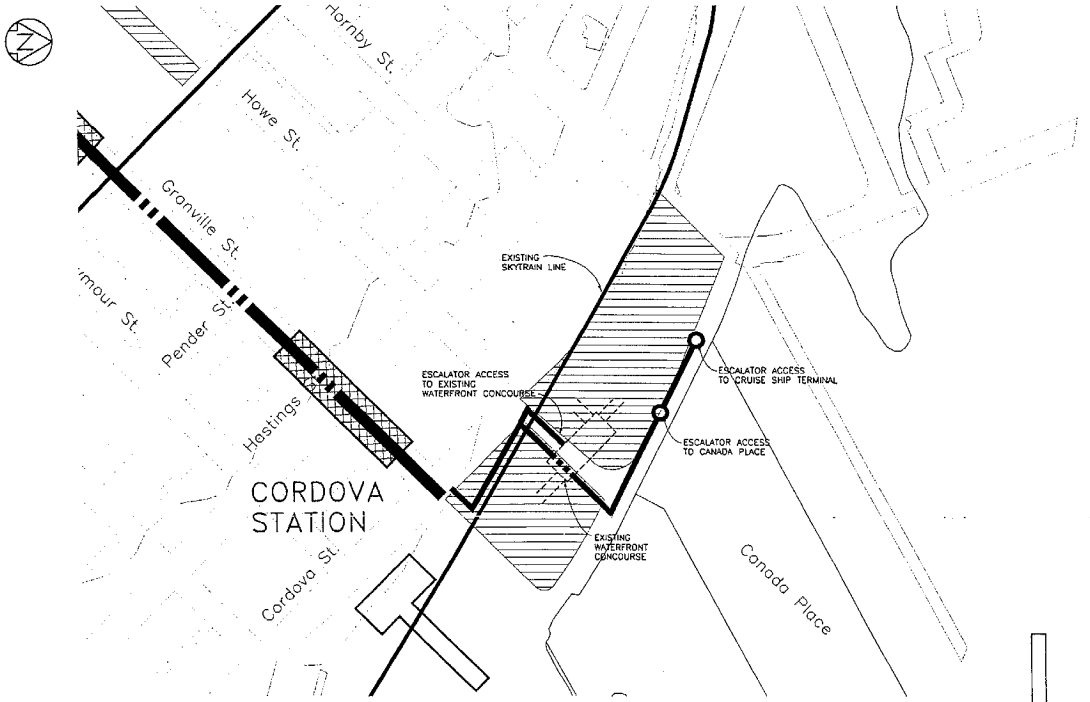


SECTION ALONG BROADWAY PLATFORM (A / 110)
1:400

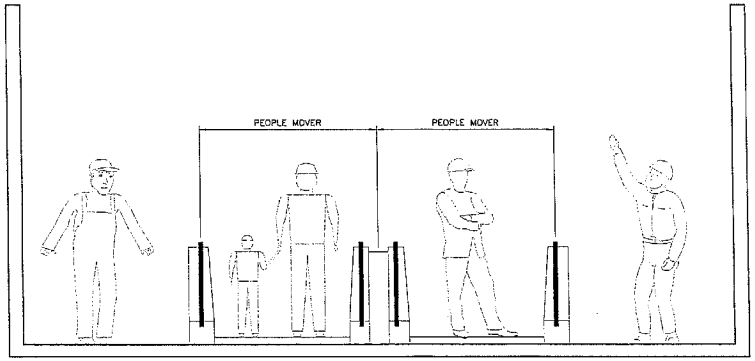


SECTION ALONG CAMBIE PLATFORM (B / 111)
1:400

DESIGNED ____ DATE	REFERENCE DRAWING		REVISIONS				*Richmond/Airport/Vancouver Rapid Transit*	PREPARED BY: Sandwell / Hatch Mott MacDonald	SEAL	BAR SCALE(S):	RAVP – VANCOUVER SEGMENT BROADWAY STATION SECTIONS
DRAWN ____ DATE	No.	DWG No. DESCRIPTION	DATE	BY	DESCRIPTION	REV					
CHECKED ____ DATE											SCALE / DATE: CONTRACT T1 / DRAWING T1-6-212
APPROVED ____ DATE											SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →
RAV-TS.dwg Rev. 1 2002-07-15											



PLAN
1:5000



TYPICAL SECTION
1:25

DESIGNED ____ DATE	REFERENCE DRAWING		REVISIONS				*Richmond/Airport/Vancouver Rapid Transit*	PREPARED BY: Sandwell / Hatch Mott MacDonald	SEAL	BAR SCALE(S):	RAVP – VANCOUVER SEGMENT PEOPLE MOVER PLAN & SECTION
DRAWN ____ DATE	No.	DRG No. DESCRIPTION	DATE	BY	DESCRIPTION	REV					SCALE ____ CONTRACT T1 DRAWING T1-6-300
CHECKED ____ DATE											DATE ____
APPROVED ____ DATE											SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO →
RAV-T1.dwg Rev. 1 2002-07-15											

Appendix D – Cost Estimates

ESTIMATE ASSUMPTIONS

Base Case

The alignment includes the following sections:

- From Ch 0+000 to Ch 0+195: elevated
- From Ch 0+195 to Ch 0+373: transition from elevated to tunnel
- From Ch 0+373 to Ch 0+520: cut and cover
- From Ch 0+520 to Ch 8+910: tunnel
- From Ch 8+910 to Ch 9+240: cut and cover

The tunnel is to be divided into three drives:

- Drive 1: TBM launch at a portal at Ch 0+520; TBM removal at shaft at Ch 3+490 to Ch 3+510
- Drive 2: TBM launch at shaft at Ch 6+330 to Ch 6+410; TBM removal at shaft at Ch 3+490 to Ch 3+510.
- Drive 3: TBM launch at shaft at Ch 6+330 to Ch 6+410; TBM removal at end of Cordova Station at Ch 8+910.

Drive 1 will be in glacial fluvial soils except for the last 200m, which will be basalt. Drive 2 will be in glacial till and tertiary bedrock except for the last 200m, which will be basalt. Drive 3 will be in glacial till and tertiary bedrock. For the sections of Drives 2 & 3 that are in basalt, drill and blast excavation has been assumed. The TBM's would be skidded through these two sections.

All drives will be driven with earth pressure balance TBM's, with Drive 1 requiring extensive use of soil conditioning agents including polymers. The other two drives will likely only require foam for soil conditioning except for the False Creek crossing where polymer will be required.

Tunnel drives will be progressed in advance of the stations. During station construction the preinstalled tunnels will be removed as part of the station excavation.

The TBM removal shaft will be excavated at 10m diameter and widened to 20 m diameter at depth, by drill and blast excavation. The vertical alignment of the trainway has been adjusted to reduce the depth of the shaft to 20 m. The TBM launch shaft will be excavated at 20 m x 80 m x 15 m depth.

- Drive 1: TBM drive length = 2770 m + 200 m of TBM skidding.
- Drive 2: TBM drive length = 2640 m + 200 m of TBM skidding.

- Drive 3: TBM drive length = 2500 m.

Emergency exit shafts are assumed; between the south portal and 49th Avenue Station; at the TBM removal shaft; between King Edward Station and Broadway Station; and between Broadway Station and Pacific Boulevard Station (within TBM launch shaft).

Crossovers have been assumed at 49th Avenue Station, King Edward Station, Pacific Boulevard Station and Cordova Station. In each case the crossovers are to be constructed as extensions, of 140 m length, to the station cut-and-cover excavations and structures. Substations have been assumed within the above noted station/crossover structures.

An allowance for a future station on a crossing line at Broadway has been included. Only that part of the future station necessary for the construction of the RAVP station has been included in this estimate.

Alternative North End

The alignment includes the following sections:

- From Ch 0+000 to Ch 0+195: elevated
- From Ch 0+195 to Ch 0+373: transition from elevated to tunnel
- From Ch 0+373 to Ch 0+520: cut and cover
- From Ch 0+520 to Ch 8+555: tunnel
- From Ch 8+555 to Ch 9+100: cut and cover

This alternative modifies Drive 3 only:

- Drive 3 - Alt: TBM launch at shaft at Ch 6+410; TBM removal at Dunsmuir Station at Ch 8+555.
- Drive 3 - Alt: TBM drive length = 2145 m.

Alternative South End – 1

The alignment includes the following sections:

- From Ch 0+000 to Ch 1+910: elevated
- From Ch 1+910 to Ch 2+111: transition from elevated to tunnel
- From Ch 2+110 to Ch 2+211: cut and cover
- From Ch 2+210 to Ch 8+910: tunnel
- From Ch 8+910 to Ch 9+240: cut and cover

This alternative modifies Drive 1 only:

- Drive 1 – Alt 1: TBM launch at a portal at Ch 2+211; TBM removal at shaft at Ch 3+490.
- Drive 1 – Alt 1: TBM drive length =1079 m + 200 m of TBM skidding.

Alternative South End - 2

- From Ch 0+000 to Ch 0+373: elevated
- From Ch 0+373 to Ch 0+473: transition from elevated to at grade
- From Ch 0+473 to Ch 1+910: at grade
- From Ch 1+910 to Ch 2+054: transition from at grade to tunnel
- From Ch 2+054 to Ch 2+160: cut and cover
- From Ch 2+160 to Ch 8+910: tunnel
- From Ch 8+910 to Ch 9+240: cut and cover

This alternative modifies Drive 1 only:

- Drive 1 – Alt 2: TBM launch at a portal at Ch 2+160; TBM removal at shaft at Ch 3+490.
- Drive 1 – Alt 2: TBM drive length =1130 m + 200 m of TBM skidding.

COSTS OF PROFILE OPTIONS

Assumptions

Anthony Steadman and Associates Inc prepared the costs of the elevated and at-grade sections using the following assumptions:

1. Stations at 49th Avenue and Marine Drive.
2. Present day costs within a cost effective construction schedule.
3. Civil works costs only.
4. The estimate excludes the following, which are assumed to be added on a project wide basis.
    - Design and engineering
    - Site investigation
    - Property costs

- Project management
- Contingencies
- IDC
- GST
- Systems

Extended Elevated Section

The estimated extended elevated guideway section cost is $44.5M and is based on the following:

- Elevated guideway, approximately 6500mm above ground on spread footings. No piling has been included. The basic guideway priced at $14,500 per metre.
- A guideway design that could accommodate both LRT or ALRT type vehicles.
- The guideway estimate includes for cable tray, walkway, utility relocations, roadworks and landscaping.
- Two elevated side platform type stations with access from at least one side of the street.
- A piled elevated guideway section is estimated to cost $48.4M

At-Grade Section

The estimated at-grade guideway section cost is $21.3M and includes the following:

- An "In Street" track bed with a basic price of $1,380 per metre for the majority of the length.
- An elevated guideway for a length of 350 metres with an enhanced rate for a short length.
- A track bed design that can only accommodate LRT type vehicles.
- The cost of isolating the rail is included, as this is required only for in street trackwork.
- The guideway estimate also includes for OHLE foundations, cable duct banks, utility relocations, roadworks, work to traffic lights, and landscaping.
- One elevated side platform station with access from at least one side of the street. One street stop station, access being by crossing the street at traffic lights.

Richmond Airport Vancouver Project

Estimate Summary

REFERENCE ALIGNMENT (5.7 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 2770 +200							
	Tunnel linings	7990231	399512	8389743	419487	8809230	1321384	10130614
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	19924733	1992473	21917206	3287581	25204787	7561436	32766223
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	304700	30470	335170	50276	385446	77089	462535
	Invert and walkway	6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
West tunnel	Total	**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7615238	380762	7996000	399800	8395800	1259370	9655170
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	19291996	1929200	21221196	3183179	24404375	7321312	31725687
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
West tunnel	Total	**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
Tunnel Drive 3:	Length 2500							
	Tunnel linings	7211400	360570	7571970	1135796	8707766	1306165	10013930
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	18655112	1865511	20520623	3078093	23598717	7079615	30678332
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	275000	27500	302500	45375	347875	69575	417450
	Invert and walkway	5750000	575000	6325000	948750	7273750	1454750	8728500

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**33873708**	**3026801**	**36900509**	**5535076**	**42435585**	**10512800**	**52948386**
West tunnel	Total		**33873708**	**3026801**	**36900509**	**5535076**	**42435585**	**10512800**	**52948386**
South Portal	Length 150								
	Civil/structural	100%	16734302	1673430	18407732	2761160	21168892	4233778	25402670
	Utilities	2%	334686	33469	368155	55223	423378	84676	508053
	Restoration	2%	334686	33469	368155	55223	423378	84676	508053
	Total		**17403674**	**1740367**	**19144041**	**2871606**	**22015648**	**4403130**	**26418777**
49th Ave Station	130								
	Road decking (50%)	2%	269170	26917	296087	44413	340500	68100	408599
	Civil/structural	100%	13458479	1345848	14804327	2220649	17024976	3404995	20429971
	Mechanical (incl vent fans)	10%	2345848	234585	2580433	387065	2967498	593500	3560997
	Electrical	10%	1345848	134585	1480433	222065	1702498	340500	2042997
	Architectural (incl esc and elev)	22%	4260865	426087	4686952	703043	5389995	1077999	6467994
	Utilities (50%)	4%	538339	53834	592173	88826	680999	136200	817199
	Street restoration (50%)	3.50%	471047	47105	518151	77723	595874	119175	715049
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25739596**	**2573960**	**28313555**	**4247033**	**32560589**	**6512118**	**39072706**
49th Ave Crossover	140								
	Road decking (50%)	2%	200444	20044	220488	33073	253561	50712	304273
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities (50%)	4%	400887	40089	440976	66146	507122	101424	608547
	Street restoration (50%)	3.5%	350776	35078	385854	57878	443732	88746	532478
	Total		**10974288**	**1097429**	**12071717**	**1810758**	**13882475**	**2776495**	**16658969**
57th Ave EEB	10								
	Road decking (50%)	2%	16008	1601	17609	2641	20250	4050	24300
	Civil/structural	100%	800408	80041	880449	132067	1012516	202503	1215019
	Architectural	5%	40020	4002	44022	6603	50626	10125	60751
	Mech/elect (incl vent fans)	20%	660082	66008	726090	108913	835003	167001	1002004
	Utilities (100%)	8%	64033	6403	70436	10565	81001	16200	97202
	Street restoration (100%)	7%	56029	5603	61631	9245	70876	14175	85051
	Total		**1636579**	**163658**	**1800237**	**270036**	**2070273**	**414055**	**2484327**
Oak Ridge Station	130								
	Road decking (50%)	2%	275099	27510	302609	45391	348000	69600	417600
	Civil/structural	100%	13754948	1375495	15130443	2269566	17400009	3480002	20880011
	Mechanical (incl vent fans)	10%	2375495	237549	2613044	391957	3005001	601000	3606001
	Electrical	10%	1375495	137549	1513044	226957	1740001	348000	2088001

	Architectural (incl esc and elev)	22%	4326089	432609	4758697	713805	5472502	1094500	6567002
	Utilities (50%)	4%	550198	55020	605218	90783	696000	139200	835200
	Street restoration (50%)	3.50%	481423	48142	529565	79435	609000	121800	730800
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26188746**	**2618875**	**28807621**	**4321143**	**33128764**	**6625753**	**39754517**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	282960	28296	311256	46688	357944	71589	429533
	Civil/structural	100%	14147988	1414799	15562787	2334418	17897205	3579441	21476646
	Mechanical (incl vent fans)	10%	2414799	241480	2656279	398442	3054720	610944	3665665
	Electrical	10%	1414799	141480	1556279	233442	1789720	357944	2147665
	Architectural (incl esc and elev)	22%	4412557	441256	4853813	728072	5581885	1116377	6698262
	Utilities (50%)	4%	565920	56592	622511	93377	715888	143178	859066
	Street restoration (50%)	3.50%	495180	49518	544698	81705	626402	125280	751683
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26784202**	**2678420**	**29462622**	**4419393**	**33882015**	**6776403**	**40658418**
King Edward Crossover	140								
	Road decking (50%)	2%	216028	21603	237630	35645	273275	54655	327930
	Civil/structural	100%	10801384	1080138	11881522	1782228	13663751	2732750	16396501
	Utilities (50%)	4%	432055	43206	475261	71289	546550	109310	655860
	Street restoration (50%)	3.5%	378048	37805	415853	62378	478231	95646	573878
	Total		**11827515**	**1182752**	**13010267**	**1951540**	**14961807**	**2992361**	**17954168**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	449802	44980	494782	74217	568999	113800	682799
	Civil/structural	100%	22490077	2249008	24739085	3710863	28449947	5689989	34139937
	Mechanical (incl vent fans)	10%	3249008	324901	3573908	536086	4109995	821999	4931994

	Electrical	10%	2249008	224901	2473908	371086	2844995	568999	3413994
	Architectural (incl esc and elev)	22%	6247817	624782	6872599	1030890	7903488	1580698	9484186
	Utilities (50%)	4%	899603	89960	989563	148435	1137998	227600	1365597
	Street restoration (50%)	3.5%	787153	78715	865868	129880	995748	199150	1194898
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**39422467**	**3942247**	**43364713**	**6504707**	**49869420**	**9973884**	**59843304**
TBM Launch Shaft	80								
	Civil/structural	100%	6454578	645458	7100036	1065005	8165041	1633008	9798049
	Utilities (50%)	4%	258183	25818	284001	42600	326602	65320	391922
	Street restoration (50%)	3.5%	225910	22591	248501	37275	285776	57155	342932
	Total		**6938671**	**693867**	**7632538**	**1144881**	**8777419**	**1755484**	**10532903**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	554333	55433	609766	91465	701231	140246	841477
	Civil/structural	100%	13858316	1385832	15244148	2286622	17530770	3506154	21036924
	Mechanical (incl vent fans)	10%	2385832	238583	2624415	393662	3018077	603615	3621692
	Electrical	10%	1385832	138583	1524415	228662	1753077	350615	2103692
	Architectural (incl esc and elev)	22%	4348830	434883	4783712	717557	5501269	1100254	6601523
	Utilities	8%	1108665	110867	1219532	182930	1402462	280492	1682954
	Street restoration	7%	970082	97008	1067090	160064	1227154	245431	1472585
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661889**	**2766189**	**30428078**	**4564212**	**34992289**	**6998458**	**41990747**
Pacific Bvld Crossover	140								
	Road decking	4%	400887	40089	440976	66146	507122	101424	608547
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities	8%	801774	80177	881952	132293	1014245	202849	1217094
	Street restoration	7%	701553	70155	771708	115756	887464	177493	1064957
	Total		**11926395**	**1192640**	**13119035**	**1967855**	**15086890**	**3017378**	**18104268**
Nelson Station	130								
	Road decking	4%	554328	55433	609761	91464	701225	140245	841470
	Civil/structural	100%	13858207	1385821	15244028	2286604	17530632	3506126	21036758
	Mechanical (incl vent fans)	10%	2385821	238582	2624403	393660	3018063	603613	3621676
	Electrical	10%	1385821	138582	1524403	228660	1753063	350613	2103676
	Architectural (incl esc and elev)	22%	4348806	434881	4783686	717553	5501239	1100248	6601487

	Utilities	8%	1108657	110866	1219522	182928	1402451	280490	1682941
	Street restoration	7%	970074	97007	1067082	160062	1227144	245429	1472573
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661713**	**2766171**	**30427885**	**4564183**	**34992067**	**6998413**	**41990481**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	544745	54474	599219	89883	689102	137820	826922
	Civil/structural	100%	21789781	2178978	23968759	3595314	27564073	5512815	33076888
	Mechanical (incl vent fans)	10%	3178978	317898	3496876	524531	4021407	804281	4825689
	Electrical	10%	2178978	217898	2396876	359531	2756407	551281	3307689
	Architectural (incl esc and elev)	22%	6093752	609375	6703127	1005469	7708596	1541719	9250315
	Utilities (65%)	5%	1089489	108949	1198438	179766	1378204	275641	1653844
	Street restoration (65%)	4.5%	980540	98054	1078594	161789	1240383	248077	1488460
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**38906263**	**3890626**	**42796889**	**6419533**	**49216422**	**9843284**	**59059707**
Cordova Station	130								
	Road decking (75%)	3%	574634	57463	632097	94815	726912	145382	872294
	Civil/structural	100%	19154459	1915446	21069905	3160486	24230391	4846078	29076469
	Mechanical (incl vent fans)	10%	2915446	291545	3206990	481049	3688039	737608	4425647
	Electrical	10%	1915446	191545	2106990	316049	2423039	484608	2907647
	Architectural (incl esc and elev)	22%	5513981	551398	6065379	909807	6975186	1395037	8370223
	Utilities (75%)	6%	1149268	114927	1264194	189629	1453823	290765	1744588
	Street restoration (75%)	5.3%	1005609	100561	1106170	165926	1272096	254419	1526515
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**35278842**	**3527884**	**38806726**	**5821009**	**44627735**	**8925547**	**53553282**
Cordova Crossover	140								
	Road decking	4%	709386	70939	780325	117049	897373	179475	1076848
	Civil/structural	100%	17734650	1773465	19508115	2926217	22434332	4486866	26921199
	Utilities	8%	1418772	141877	1560649	234097	1794747	358949	2153696
	Street restoration	7%	1241426	124143	1365568	204835	1570403	314081	1884484
	Total		**21104234**	**2110423**	**23214657**	**3482199**	**26696855**	**5339371**	**32036226**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	200	1848000	184800	2032800	304920	2337720	467544	2805264
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	4750	43890000	4389000	48279000	7241850	55520850	11104170	66625020
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			91938000	**9193800**	**101131800**	**15169770**	**116301570**	**23260314**	**139561884**
				9.62%		14.51%		21.54%	

GRAND TOTAL FOR REFERENCE ALIGNMENT (5.7)	**649656375**	**62523950**	**712180325**	**103309900**	**815490225**	**175657323**	**$ 991,147,548**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ALTERNATIVE NORTH END (5.7 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 2770 +200							
	Tunnel linings	7990231	399512	8389743	419487	8809230	1321384	10130614
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	19924733	1992473	21917206	3287581	25204787	7561436	32766223
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	304700	30470	335170	50276	385446	77089	462535
	Invert and walkway	6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
West tunnel	Total	**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7615238	380762	7996000	399800	8395800	1259370	9655170
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	19291996	1929200	21221196	3183179	24404375	7321312	31725687
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
West tunnel	Total	**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
Tunnel Drive 3:	Length 2145							
	Tunnel linings	6187381	309369	6496750	974513	7471263	1120689	8591952
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	16916216	1691622	18607838	2791176	21399013	6419704	27818717
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	235950	23595	259545	38932	298477	59695	358172
	Invert and walkway	4933500	493350	5426850	814028	6240878	1248176	7489053

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**30255243**	**2716155**	**32971398**	**4945710**	**37917108**	**9450960**	**47368068**
West tunnel	Total		**30255243**	**2716155**	**32971398**	**4945710**	**37917108**	**9450960**	**47368068**
South Portal	Length 150								
	Civil/structural	100%	16734302	1673430	18407732	2761160	21168892	4233778	25402670
	Utilities	2%	334686	33469	368155	55223	423378	84676	508053
	Restoration	2%	334686	33469	368155	55223	423378	84676	508053
	Total		**17403674**	**1740367**	**19144041**	**2871606**	**22015648**	**4403130**	**26418777**
49th Ave Station	130								
	Road decking (50%)	2%	269170	26917	296087	44413	340500	68100	408599
	Civil/structural	100%	13458479	1345848	14804327	2220649	17024976	3404995	20429971
	Mechanical (incl vent fans)	10%	2345848	234585	2580433	387065	2967498	593500	3560997
	Electrical	10%	1345848	134585	1480433	222065	1702498	340500	2042997
	Architectural (incl esc and elev)	22%	4260865	426087	4686952	703043	5389995	1077999	6467994
	Utilities (50%)	4%	538339	53834	592173	88826	680999	136200	817199
	Street restoration (50%)	3.50%	471047	47105	518151	77723	595874	119175	715049
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25739596**	**2573960**	**28313555**	**4247033**	**32560589**	**6512118**	**39072706**
49th Ave Crossover	140								
	Road decking (50%)	2%	200444	20044	220488	33073	253561	50712	304273
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities (50%)	4%	400887	40089	440976	66146	507122	101424	608547
	Street restoration (50%)	3.5%	350776	35078	385854	57878	443732	88746	532478
	Total		**10974288**	**1097429**	**12071717**	**1810758**	**13882475**	**2776495**	**16658969**
57th Ave EEB	10								
	Road decking (50%)	2%	16008	1601	17609	2641	20250	4050	24300
	Civil/structural	100%	800408	80041	880449	132067	1012516	202503	1215019
	Architectural	5%	40020	4002	44022	6603	50626	10125	60751
	Mech/elect (incl vent fans)	20%	660082	66008	726090	108913	835003	167001	1002004
	Utilities (100%)	8%	64033	6403	70436	10565	81001	16200	97202
	Street restoration (100%)	7%	56029	5603	61631	9245	70876	14175	85051
	Total		**1636579**	**163658**	**1800237**	**270036**	**2070273**	**414055**	**2484327**
Oak Ridge Station	130								
	Road decking (50%)	2%	275099	27510	302609	45391	348000	69600	417600
	Civil/structural	100%	13754948	1375495	15130443	2269566	17400009	3480002	20880011
	Mechanical (incl vent fans)	10%	2375495	237549	2613044	391957	3005001	601000	3606001
	Electrical	10%	1375495	137549	1513044	226957	1740001	348000	2088001

	Architectural (incl esc and elev)	22%	4326089	432609	4758697	713805	5472502	1094500	6567002
	Utilities (50%)	4%	550198	55020	605218	90783	696000	139200	835200
	Street restoration (50%)	3.50%	481423	48142	529565	79435	609000	121800	730800
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26188746**	**2618875**	**28807621**	**4321143**	**33128764**	**6625753**	**39754517**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	282960	28296	311256	46688	357944	71589	429533
	Civil/structural	100%	14147988	1414799	15562787	2334418	17897205	3579441	21476646
	Mechanical (incl vent fans)	10%	2414799	241480	2656279	398442	3054720	610944	3665665
	Electrical	10%	1414799	141480	1556279	233442	1789720	357944	2147665
	Architectural (incl esc and elev)	22%	4412557	441256	4853813	728072	5581885	1116377	6698262
	Utilities (50%)	4%	565920	56592	622511	93377	715888	143178	859066
	Street restoration (50%)	3.50%	495180	49518	544698	81705	626402	125280	751683
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26784202**	**2678420**	**29462622**	**4419393**	**33882015**	**6776403**	**40658418**
King Edward Crossover	140								
	Road decking (50%)	2%	216028	21603	237630	35645	273275	54655	327930
	Civil/structural	100%	10801384	1080138	11881522	1782228	13663751	2732750	16396501
	Utilities (50%)	4%	432055	43206	475261	71289	546550	109310	655860
	Street restoration (50%)	3.5%	378048	37805	415853	62378	478231	95646	573878
	Total		**11827515**	**1182752**	**13010267**	**1951540**	**14961807**	**2992361**	**17954168**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	449802	44980	494782	74217	568999	113800	682799
	Civil/structural	100%	22490077	2249008	24739085	3710863	28449947	5689989	34139937
	Mechanical (incl vent fans)	10%	3249008	324901	3573908	536086	4109995	821999	4931994

	Electrical	10%	2249008	224901	2473908	371086	2844995	568999	3413994
	Architectural (incl esc and elev)	22%	6247817	624782	6872599	1030890	7903488	1580698	9484186
	Utilities (50%)	4%	899603	89960	989563	148435	1137998	227600	1365597
	Street restoration (50%)	3.5%	787153	78715	865868	129880	995748	199150	1194898
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**39422467**	**3942247**	**43364713**	**6504707**	**49869420**	**9973884**	**59843304**
TBM Launch Shaft	80								
	Civil/structural	100%	6454578	645458	7100036	1065005	8165041	1633008	9798049
	Utilities (50%)	4%	258183	25818	284001	42600	326602	65320	391922
	Street restoration (50%)	3.5%	225910	22591	248501	37275	285776	57155	342932
	Total		**6938671**	**693867**	**7632538**	**1144881**	**8777419**	**1755484**	**10532903**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	554333	55433	609766	91465	701231	140246	841477
	Civil/structural	100%	13858316	1385832	15244148	2286622	17530770	3506154	21036924
	Mechanical (incl vent fans)	10%	2385832	238583	2624415	393662	3018077	603615	3621692
	Electrical	10%	1385832	138583	1524415	228662	1753077	350615	2103692
	Architectural (incl esc and elev)	22%	4348830	434883	4783712	717557	5501269	1100254	6601523
	Utilities	8%	1108665	110867	1219532	182930	1402462	280492	1682954
	Street restoration	7%	970082	97008	1067090	160064	1227154	245431	1472585
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661889**	**2766189**	**30428078**	**4564212**	**34992289**	**6998458**	**41990747**
Pacific Bvld Crossover	140								
	Road decking	4%	400887	40089	440976	66146	507122	101424	608547
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities	8%	801774	80177	881952	132293	1014245	202849	1217094
	Street restoration	7%	701553	70155	771708	115756	887464	177493	1064957
	Total		**11926395**	**1192640**	**13119035**	**1967855**	**15086890**	**3017378**	**18104268**
Nelson Station	130								
	Road decking	4%	554328	55433	609761	91464	701225	140245	841470
	Civil/structural	100%	13858207	1385821	15244028	2286604	17530632	3506126	21036758
	Mechanical (incl vent fans)	10%	2385821	238582	2624403	393660	3018063	603613	3621676
	Electrical	10%	1385821	138582	1524403	228660	1753063	350613	2103676
	Architectural (incl esc and elev)	22%	4348806	434881	4783686	717553	5501239	1100248	6601487

	Utilities	8%	1108657	110866	1219522	182928	1402451	280490	1682941
	Street restoration	7%	970074	97007	1067082	160062	1227144	245429	1472573
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661713**	**2766171**	**30427885**	**4564183**	**34992067**	**6998413**	**41990481**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	342160	34216	376376	56456	432833	86567	519399
	Civil/structural	100%	13686405	1368641	15055046	2258257	17313302	3462660	20775963
	Mechanical (incl vent fans)	10%	2368641	236864	2605505	390826	2996330	599266	3595596
	Electrical	10%	1368641	136864	1505505	225826	1731330	346266	2077596
	Architectural (incl esc and elev)	22%	4311009	431101	4742110	711317	5453427	1090685	6544112
	Utilities (65%)	5%	684320	68432	752752	112913	865665	173133	1038798
	Street restoration (65%)	4.5%	615888	61589	677477	101622	779099	155820	934918
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26427064**	**2642706**	**29069770**	**4360466**	**33430236**	**6686047**	**40116283**
Cut and Cover	Length 225								
	Civil/structural	100%	5177002	517700	5694702	854205	6548908	1309782	7858689
	Utilities	4%	207080	20708	227788	34168	261956	52391	314348
	Restoration	4%	207080	20708	227788	34168	261956	52391	314348
	Total		**5591162**	**559116**	**6150278**	**922542**	**7072820**	**1414564**	**8487384**
Cordova Station	130								
	Road decking (75%)	3%	377757	37776	415533	62330	477863	95573	573436
	Civil/structural	100%	12591916	1259192	13851108	2077666	15928774	3185755	19114528
	Mechanical (incl vent fans)	10%	2259192	225919	2485111	372767	2857877	571575	3429453
	Electrical	10%	1259192	125919	1385111	207767	1592877	318575	1911453
	Architectural (incl esc and elev)	22%	4070222	407022	4477244	671587	5148830	1029766	6178596
	Utilities (75%)	6%	755515	75551	831066	124660	955726	191145	1146872
	Street restoration (75%)	5.3%	661076	66108	727183	109077	836261	167252	1003513
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25024869**	**2502487**	**27527356**	**4129103**	**31656459**	**6331292**	**37987751**
Cordova Crossover	140								
	Road decking	4%	332668	33267	365935	54890	420825	84165	504990
	Civil/structural	100%	8316701	831670	9148371	1372256	10520627	2104125	12624752
	Utilities	8%	665336	66534	731870	109780	841650	168330	1009980
	Street restoration	7%	582169	58217	640386	96058	736444	147289	883733
	Total		**9896874**	**989687**	**10886562**	**1632984**	**12519546**	**2503909**	**15023455**
Cut and Cover	Length 60								
	Civil/structural	100%	2322710	232271	2554981	383247	2938228	587646	3525874
	Utilities	4%	92908	9291	102199	15330	117529	23506	141035

	Restoration		4%	92908	9291	102199	15330	117529	23506	141035
	Total			**2508527**	**250853**	**2759379**	**413907**	**3173286**	**634657**	**3807944**
System-wide Elements		9100								
	Trackwork		3000	27300000	2730000	30030000	4504500	34534500	6906900	41441400
	Contact Rail or Catenary		200	1820000	182000	2002000	300300	2302300	460460	2762760
	Tunnel Electrical/Mech		1600	14560000	1456000	16016000	2402400	18418400	3683680	22102080
	Train and Supervisory Control		4750	43225000	4322500	47547500	7132125	54679625	10935925	65615550
	Communications		400	3640000	364000	4004000	600600	4604600	920920	5525520
				90545000	**9054500**	**99599500**	**14939925**	**114539425**	**22907885**	**137447310**
					9.62%		14.48%		21.59%	
GRAND TOTAL FOR ALTERNATIVE NORTH END (5.7)				**615185602**	**59179275**	**674364877**	**97637583**	**772002460**	**166643480**	**$ 938,645,940**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ROBSON ALTERNATIVE NORTH END, DEEP (5.7 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 2770 +200							
	Tunnel linings	7990231	399512	8389743	419487	8809230	1321384	10130614
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	19924733	1992473	21917206	3287581	25204787	7561436	32766223
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	304700	30470	335170	50276	385446	77089	462535
	Invert and walkway	6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
West tunnel	Total	**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7615238	380762	7996000	399800	8395800	1259370	9655170
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	19291996	1929200	21221196	3183179	24404375	7321312	31725687
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
West tunnel	Total	**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
Tunnel Drive 3:	Length 2500							
	Tunnel linings	7211400	360570	7571970	1135796	8707766	1306165	10013930
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	18655112	1865511	20520623	3078093	23598717	7079615	30678332
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	275000	27500	302500	45375	347875	69575	417450
	Invert and walkway	5750000	575000	6325000	948750	7273750	1454750	8728500

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**33873708**	**3026801**	**36900509**	**5535076**	**42435585**	**10512800**	**52948386**
West tunnel	Total		**33873708**	**3026801**	**36900509**	**5535076**	**42435585**	**10512800**	**52948386**
South Portal	Length 150								
	Civil/structural	100%	16734302	1673430	18407732	2761160	21168892	4233778	25402670
	Utilities	2%	334686	33469	368155	55223	423378	84676	508053
	Restoration	2%	334686	33469	368155	55223	423378	84676	508053
	Total		**17403674**	**1740367**	**19144041**	**2871606**	**22015648**	**4403130**	**26418777**
49th Ave Station	130								
	Road decking (50%)	2%	269170	26917	296087	44413	340500	68100	408599
	Civil/structural	100%	13458479	1345848	14804327	2220649	17024976	3404995	20429971
	Mechanical (incl vent fans)	10%	2345848	234585	2580433	387065	2967498	593500	3560997
	Electrical	10%	1345848	134585	1480433	222065	1702498	340500	2042997
	Architectural (incl esc and elev)	22%	4260865	426087	4686952	703043	5389995	1077999	6467994
	Utilities (50%)	4%	538339	53834	592173	88826	680999	136200	817199
	Street restoration (50%)	3.50%	471047	47105	518151	77723	595874	119175	715049
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25739596**	**2573960**	**28313555**	**4247033**	**32560589**	**6512118**	**39072706**
49th Ave Crossover	140								
	Road decking (50%)	2%	200444	20044	220488	33073	253561	50712	304273
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities (50%)	4%	400887	40089	440976	66146	507122	101424	608547
	Street restoration (50%)	3.5%	350776	35078	385854	57878	443732	88746	532478
	Total		**10974288**	**1097429**	**12071717**	**1810758**	**13882475**	**2776495**	**16658969**
57th Ave EEB	10								
	Road decking (50%)	2%	16008	1601	17609	2641	20250	4050	24300
	Civil/structural	100%	800408	80041	880449	132067	1012516	202503	1215019
	Architectural	5%	40020	4002	44022	6603	50626	10125	60751
	Mech/elect (incl vent fans)	20%	660082	66008	726090	108913	835003	167001	1002004
	Utilities (100%)	8%	64033	6403	70436	10565	81001	16200	97202
	Street restoration (100%)	7%	56029	5603	61631	9245	70876	14175	85051
	Total		**1636579**	**163658**	**1800237**	**270036**	**2070273**	**414055**	**2484327**
Oak Ridge Station	130								
	Road decking (50%)	2%	275099	27510	302609	45391	348000	69600	417600
	Civil/structural	100%	13754948	1375495	15130443	2269566	17400009	3480002	20880011
	Mechanical (incl vent fans)	10%	2375495	237549	2613044	391957	3005001	601000	3606001
	Electrical	10%	1375495	137549	1513044	226957	1740001	348000	2088001

	Architectural (incl esc and elev)	22%	4326089	432609	4758697	713805	5472502	1094500	6567002
	Utilities (50%)	4%	550198	55020	605218	90783	696000	139200	835200
	Street restoration (50%)	3.50%	481423	48142	529565	79435	609000	121800	730800
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26188746**	**2618875**	**28807621**	**4321143**	**33128764**	**6625753**	**39754517**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	282960	28296	311256	46688	357944	71589	429533
	Civil/structural	100%	14147988	1414799	15562787	2334418	17897205	3579441	21476646
	Mechanical (incl vent fans)	10%	2414799	241480	2656279	398442	3054720	610944	3665665
	Electrical	10%	1414799	141480	1556279	233442	1789720	357944	2147665
	Architectural (incl esc and elev)	22%	4412557	441256	4853813	728072	5581885	1116377	6698262
	Utilities (50%)	4%	565920	56592	622511	93377	715888	143178	859066
	Street restoration (50%)	3.50%	495180	49518	544698	81705	626402	125280	751683
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26784202**	**2678420**	**29462622**	**4419393**	**33882015**	**6776403**	**40658418**
King Edward Crossover	140								
	Road decking (50%)	2%	216028	21603	237630	35645	273275	54655	327930
	Civil/structural	100%	10801384	1080138	11881522	1782228	13663751	2732750	16396501
	Utilities (50%)	4%	432055	43206	475261	71289	546550	109310	655860
	Street restoration (50%)	3.5%	378048	37805	415853	62378	478231	95646	573878
	Total		**11827515**	**1182752**	**13010267**	**1951540**	**14961807**	**2992361**	**17954168**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	449802	44980	494782	74217	568999	113800	682799
	Civil/structural	100%	22490077	2249008	24739085	3710863	28449947	5689989	34139937
	Mechanical (incl vent fans)	10%	3249008	324901	3573908	536086	4109995	821999	4931994

	Electrical	10%	2249008	224901	2473908	371086	2844995	568999	3413994
	Architectural (incl esc and elev)	22%	6247817	624782	6872599	1030890	7903488	1580698	9484186
	Utilities (50%)	4%	899603	89960	989563	148435	1137998	227600	1365597
	Street restoration (50%)	3.5%	787153	78715	865868	129880	995748	199150	1194898
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**39422467**	**3942247**	**43364713**	**6504707**	**49869420**	**9973884**	**59843304**
TBM Launch Shaft	80								
	Civil/structural	100%	6454578	645458	7100036	1065005	8165041	1633008	9798049
	Utilities (50%)	4%	258183	25818	284001	42600	326602	65320	391922
	Street restoration (50%)	3.5%	225910	22591	248501	37275	285776	57155	342932
	Total		**6938671**	**693867**	**7632538**	**1144881**	**8777419**	**1755484**	**10532903**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	554333	55433	609766	91465	701231	140246	841477
	Civil/structural	100%	13858316	1385832	15244148	2286622	17530770	3506154	21036924
	Mechanical (incl vent fans)	10%	2385832	238583	2624415	393662	3018077	603615	3621692
	Electrical	10%	1385832	138583	1524415	228662	1753077	350615	2103692
	Architectural (incl esc and elev)	22%	4348830	434883	4783712	717557	5501269	1100254	6601523
	Utilities	8%	1108665	110867	1219532	182930	1402462	280492	1682954
	Street restoration	7%	970082	97008	1067090	160064	1227154	245431	1472585
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661889**	**2766189**	**30428078**	**4564212**	**34992289**	**6998458**	**41990747**
Pacific Bvld Crossover	140								
	Road decking	4%	400887	40089	440976	66146	507122	101424	608547
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities	8%	801774	80177	881952	132293	1014245	202849	1217094
	Street restoration	7%	701553	70155	771708	115756	887464	177493	1064957
	Total		**11926395**	**1192640**	**13119035**	**1967855**	**15086890**	**3017378**	**18104268**
Robson Station	130								
	Road decking	4%	625777	62578	688355	103253	791608	158322	949929
	Civil/structural	100%	15644425	1564443	17208868	2581330	19790198	3958040	23748237
	Mechanical (incl vent fans)	10%	2564443	256444	2820887	423133	3244020	648804	3892824
	Electrical	10%	1564443	156444	1720887	258133	1979020	395804	2374824
	Architectural (incl esc and elev)	22%	4741774	474177	5215951	782393	5998343	1199669	7198012

	Utilities	8%	1251554	125155	1376709	206506	1583216	316643	1899859
	Street restoration	7%	1095110	109511	1204621	180693	1385314	277063	1662377
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**30537524**	**3053752**	**33591277**	**5038692**	**38629968**	**7725994**	**46355962**
Cordova Station	130								
	Road decking (75%)	3%	574634	57463	632097	94815	726912	145382	872294
	Civil/structural	100%	19154459	1915446	21069905	3160486	24230391	4846078	29076469
	Mechanical (incl vent fans)	10%	2915446	291545	3206990	481049	3688039	737608	4425647
	Electrical	10%	1915446	191545	2106990	316049	2423039	484608	2907647
	Architectural (incl esc and elev)	22%	5513981	551398	6065379	909807	6975186	1395037	8370223
	Utilities (75%)	6%	1149268	114927	1264194	189629	1453823	290765	1744588
	Street restoration (75%)	5.3%	1005609	100561	1106170	165926	1272096	254419	1526515
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**35278842**	**3527884**	**38806726**	**5821009**	**44627735**	**8925547**	**53553282**
Cordova Crossover	140								
	Road decking	4%	709386	70939	780325	117049	897373	179475	1076848
	Civil/structural	100%	17734650	1773465	19508115	2926217	22434332	4486866	26921199
	Utilities	8%	1418772	141877	1560649	234097	1794747	358949	2153696
	Street restoration	7%	1241426	124143	1365568	204835	1570403	314081	1884484
	Total		**21104234**	**2110423**	**23214657**	**3482199**	**26696855**	**5339371**	**32036226**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	200	1848000	184800	2032800	304920	2337720	467544	2805264
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	4750	43890000	4389000	48279000	7241850	55520850	11104170	66625020
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			91938000	**9193800**	**101131800**	**15169770**	**116301570**	**23260314**	**139561884**
				9.60%		14.48%		21.63%	
GRAND TOTAL FOR ROBSON ALT NORTH END DEEP (5.7)			**613625923**	**58920905**	**672546828**	**97364876**	**769911704**	**166541619**	**$ 936,453,323**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ROBSON ALT NORTH END, SHALLOW (5.7 m Dia)			Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length	2770 +200							
	Tunnel linings		7990231	399512	8389743	419487	8809230	1321384	10130614
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		19924733	1992473	21917206	3287581	25204787	7561436	32766223
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		304700	30470	335170	50276	385446	77089	462535
	Invert and walkway		6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
West tunnel	Total		**39529164**	**3473405**	**43002569**	**5491411**	**48493980**	**11916886**	**60410866**
Tunnel Drive 2:	Length	2640 +200							
	Tunnel linings		7615238	380762	7996000	399800	8395800	1259370	9655170
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		19291996	1929200	21221196	3183179	24404375	7321312	31725687
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		290400	29040	319440	47916	367356	73471	440827
	Invert and walkway		6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
West tunnel	Total		**38208134**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
Tunnel Drive 3:	Length	1702							
	Tunnel linings		4909521	245476	5154997	773250	5928247	889237	6817484
	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		14809468	1480947	16290415	2443562	18733977	5620193	24354170
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		187220	18722	205942	30891	236833	47367	284200
	Invert and walkway		3914600	391460	4306060	645909	4951969	990394	5942363

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**25803005**	**2334824**	**28137830**	**4220674**	**32358504**	**8149886**	**40508390**
West tunnel	Total		**25803005**	**2334824**	**28137830**	**4220674**	**32358504**	**8149886**	**40508390**
South Portal	Length 150								
	Civil/structural	100%	16734302	1673430	18407732	2761160	21168892	4233778	25402670
	Utilities	2%	334686	33469	368155	55223	423378	84676	508053
	Restoration	2%	334686	33469	368155	55223	423378	84676	508053
	Total		**17403674**	**1740367**	**19144041**	**2871606**	**22015648**	**4403130**	**26418777**
49th Ave Station	130								
	Road decking (50%)	2%	269170	26917	296087	44413	340500	68100	408599
	Civil/structural	100%	13458479	1345848	14804327	2220649	17024976	3404995	20429971
	Mechanical (incl vent fans)	10%	2345848	234585	2580433	387065	2967498	593500	3560997
	Electrical	10%	1345848	134585	1480433	222065	1702498	340500	2042997
	Architectural (incl esc and elev)	22%	4260865	426087	4686952	703043	5389995	1077999	6467994
	Utilities (50%)	4%	538339	53834	592173	88826	680999	136200	817199
	Street restoration (50%)	3.50%	471047	47105	518151	77723	595874	119175	715049
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25739596**	**2573960**	**28313555**	**4247033**	**32560589**	**6512118**	**39072706**
49th Ave Crossover	140								
	Road decking (50%)	2%	200444	20044	220488	33073	253561	50712	304273
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities (50%)	4%	400887	40089	440976	66146	507122	101424	608547
	Street restoration (50%)	3.5%	350776	35078	385854	57878	443732	88746	532478
	Total		**10974288**	**1097429**	**12071717**	**1810758**	**13882475**	**2776495**	**16658969**
57th Ave EEB	10								
	Road decking (50%)	2%	16008	1601	17609	2641	20250	4050	24300
	Civil/structural	100%	800408	80041	880449	132067	1012516	202503	1215019
	Architectural	5%	40020	4002	44022	6603	50626	10125	60751
	Mech/elect (incl vent fans)	20%	660082	66008	726090	108913	835003	167001	1002004
	Utilities (100%)	8%	64033	6403	70436	10565	81001	16200	97202
	Street restoration (100%)	7%	56029	5603	61631	9245	70876	14175	85051
	Total		**1636579**	**163658**	**1800237**	**270036**	**2070273**	**414055**	**2484327**
Oak Ridge Station	130								
	Road decking (50%)	2%	275099	27510	302609	45391	348000	69600	417600
	Civil/structural	100%	13754948	1375495	15130443	2269566	17400009	3480002	20880011
	Mechanical (incl vent fans)	10%	2375495	237549	2613044	391957	3005001	601000	3606001
	Electrical	10%	1375495	137549	1513044	226957	1740001	348000	2088001

	Architectural (incl esc and elev)	22%	4326089	432609	4758697	713805	5472502	1094500	6567002
	Utilities (50%)	4%	550198	55020	605218	90783	696000	139200	835200
	Street restoration (50%)	3.50%	481423	48142	529565	79435	609000	121800	730800
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26188746**	**2618875**	**28807621**	**4321143**	**33128764**	**6625753**	**39754517**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	282960	28296	311256	46688	357944	71589	429533
	Civil/structural	100%	14147988	1414799	15562787	2334418	17897205	3579441	21476646
	Mechanical (incl vent fans)	10%	2414799	241480	2656279	398442	3054720	610944	3665665
	Electrical	10%	1414799	141480	1556279	233442	1789720	357944	2147665
	Architectural (incl esc and elev)	22%	4412557	441256	4853813	728072	5581885	1116377	6698262
	Utilities (50%)	4%	565920	56592	622511	93377	715888	143178	859066
	Street restoration (50%)	3.50%	495180	49518	544698	81705	626402	125280	751683
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26784202**	**2678420**	**29462622**	**4419393**	**33882015**	**6776403**	**40658418**
King Edward Crossover	140								
	Road decking (50%)	2%	216028	21603	237630	35645	273275	54655	327930
	Civil/structural	100%	10801384	1080138	11881522	1782228	13663751	2732750	16396501
	Utilities (50%)	4%	432055	43206	475261	71289	546550	109310	655860
	Street restoration (50%)	3.5%	378048	37805	415853	62378	478231	95646	573878
	Total		**11827515**	**1182752**	**13010267**	**1951540**	**14961807**	**2992361**	**17954168**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	449802	44980	494782	74217	568999	113800	682799
	Civil/structural	100%	22490077	2249008	24739085	3710863	28449947	5689989	34139937
	Mechanical (incl vent fans)	10%	3249008	324901	3573908	536086	4109995	821999	4931994

	Electrical	10%	2249008	224901	2473908	371086	2844995	568999	3413994
	Architectural (incl esc and elev)	22%	6247817	624782	6872599	1030890	7903488	1580698	9484186
	Utilities (50%)	4%	899603	89960	989563	148435	1137998	227600	1365597
	Street restoration (50%)	3.5%	787153	78715	865868	129880	995748	199150	1194898
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**39422467**	**3942247**	**43364713**	**6504707**	**49869420**	**9973884**	**59843304**
TBM Launch Shaft	80								
	Civil/structural	100%	6454578	645458	7100036	1065005	8165041	1633008	9798049
	Utilities (50%)	4%	258183	25818	284001	42600	326602	65320	391922
	Street restoration (50%)	3.5%	225910	22591	248501	37275	285776	57155	342932
	Total		**6938671**	**693867**	**7632538**	**1144881**	**8777419**	**1755484**	**10532903**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	554333	55433	609766	91465	701231	140246	841477
	Civil/structural	100%	13858316	1385832	15244148	2286622	17530770	3506154	21036924
	Mechanical (incl vent fans)	10%	2385832	238583	2624415	393662	3018077	603615	3621692
	Electrical	10%	1385832	138583	1524415	228662	1753077	350615	2103692
	Architectural (incl esc and elev)	22%	4348830	434883	4783712	717557	5501269	1100254	6601523
	Utilities	8%	1108665	110867	1219532	182930	1402462	280492	1682954
	Street restoration	7%	970082	97008	1067090	160064	1227154	245431	1472585
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661889**	**2766189**	**30428078**	**4564212**	**34992289**	**6998458**	**41990747**
Pacific Bvld Crossover	140								
	Road decking	4%	400887	40089	440976	66146	507122	101424	608547
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities	8%	801774	80177	881952	132293	1014245	202849	1217094
	Street restoration	7%	701553	70155	771708	115756	887464	177493	1064957
	Total		**11926395**	**1192640**	**13119035**	**1967855**	**15086890**	**3017378**	**18104268**
Robson Station	130								
	Road decking	4%	475740	47574	523314	78497	601811	120362	722174
	Civil/structural	100%	11893506	1189351	13082857	1962428	15045285	3009057	18054342
	Mechanical (incl vent fans)	10%	2189351	218935	2408286	361243	2769529	553906	3323434
	Electrical	10%	1189351	118935	1308286	196243	1504529	300906	1805434
	Architectural (incl esc and elev)	22%	3916571	391657	4308228	646234	4954463	990893	5945355

	Utilities	8%	951480	95148	1046629	156994	1203623	240725	1444347
	Street restoration	7%	832545	83255	915800	137370	1053170	210634	1263804
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24498545**	**2449854**	**26948399**	**4042260**	**30990659**	**6198132**	**37188791**
Cut and Cover	Length 528								
	Civil/structural	100%	30478061	3047806	33525867	5028880	38554747	7710949	46265697
	Utilities	4%	1219122	121912	1341035	201155	1542190	308438	1850628
	Restoration	4%	1219122	121912	1341035	201155	1542190	308438	1850628
	Total		**32916306**	**3291631**	**36207936**	**5431190**	**41639127**	**8327825**	**49966952**
Cordova Station	130								
	Road decking (75%)	3%	377757	37776	415533	62330	477863	95573	573436
	Civil/structural	100%	12591916	1259192	13851108	2077666	15928774	3185755	19114528
	Mechanical (incl vent fans)	10%	2259192	225919	2485111	372767	2857877	571575	3429453
	Electrical	10%	1259192	125919	1385111	207767	1592877	318575	1911453
	Architectural (incl esc and elev)	22%	4070222	407022	4477244	671587	5148830	1029766	6178596
	Utilities (75%)	6%	755515	75551	831066	124660	955726	191145	1146872
	Street restoration (75%)	5.3%	661076	66108	727183	109077	836261	167252	1003513
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25024869**	**2502487**	**27527356**	**4129103**	**31656459**	**6331292**	**37987751**
Cordova Crossover	140								
	Road decking	4%	332668	33267	365935	54890	420825	84165	504990
	Civil/structural	100%	8316701	831670	9148371	1372256	10520627	2104125	12624752
	Utilities	8%	665336	66534	731870	109780	841650	168330	1009980
	Street restoration	7%	582169	58217	640386	96058	736444	147289	883733
	Total		**9896874**	**989687**	**10886562**	**1632984**	**12519546**	**2503909**	**15023455**
Cut and Cover	Length 60								
	Civil/structural	100%	2322710	232271	2554981	383247	2938228	587646	3525874
	Utilities	4%	92908	9291	102199	15330	117529	23506	141035
	Restoration	4%	92908	9291	102199	15330	117529	23506	141035
	Total		**2508527**	**250853**	**2759379**	**413907**	**3173286**	**634657**	**3807944**
System-wide Elements	9100								
	Trackwork	3000	27300000	2730000	30030000	4504500	34534500	6906900	41441400
	Contact Rail or Catenary	200	1820000	182000	2002000	300300	2302300	460460	2762760
	Tunnel Electrical/Mech	1600	14560000	1456000	16016000	2402400	18418400	3683680	22102080
	Train and Supervisory Control	4750	43225000	4322500	47547500	7132125	54679625	10935925	65615550
	Communications	400	3640000	364000	4004000	600600	4604600	920920	5525520
			90545000	**9054500**	**99599500**	**14939925**	**114539425**	**22907885**	**137447310**

		9.63%		14.47%		21.57%	
GRAND TOTAL ROBSON ALT NORTH END, SHALLOW (5.7)	**604016037**	**58190105**	**662206142**	**95813773**	**758019915**	**163468265**	**$ 921,488,180**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ALTERNATIVE SOUTH END - 1 (5.7 m Dia)			Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length	1079 +200							
	Tunnel linings		3112440	155622	3268062	163403	3431465	514720	3946185
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		11860130	1186013	13046143	1956921	15003064	4500919	19503984
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		118690	11869	130559	19584	150143	30029	180171
	Invert and walkway		2481700	248170	2729870	409481	3139351	627870	3767221
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**22511460.2**	**2015524**	**24526984**	**3232241**	**27759226**	**7018651**	**34777876**
West tunnel	Total		**22511460.2**	**2015524**	**24526984**	**3232241.4**	**27759226**	**7018651**	**34777876**
Tunnel Drive 2:	Length	2640 +200							
	Tunnel linings		7615238	380762	7996000	399800	8395800	1259370	9655170
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		19291996	1929200	21221196	3183179	24404375	7321312	31725687
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		290400	29040	319440	47916	367356	73471	440827
	Invert and walkway		6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**38208134.4**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
West tunnel	Total		**38208134.4**	**3440051.5**	**41648186**	**5447627.9**	**47095814**	**11455029**	**58550842**
Tunnel Drive 3:	Length	2500							
	Tunnel linings		7211400	360570	7571970	1135796	8707766	1306165	10013930
	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		18655112	1865511	20520623	3078093	23598717	7079615	30678332
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		275000	27500	302500	45375	347875	69575	417450
	Invert and walkway		5750000	575000	6325000	948750	7273750	1454750	8728500

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**33873708**	**3026801**	**36900509**	**5535076**	**42435585**	**10512800**	**52948386**
West tunnel	Total		**33873708**	**3026800.8**	**36900509**	**5535076.3**	**42435585**	**10512800**	**52948386**
South Portal	Length	150							
	Civil/structural	100%	16734302	1673430	18407732	2761160	21168892	4233778	25402670
	Utilities	2%	334686	33469	368155	55223	423378	84676	508053
	Restoration	2%	334686	33469	368155	55223	423378	84676	508053
	Total		**17403674**	**1740367**	**19144041**	**2871606**	**22015648**	**4403130**	**26418777**
Oak Ridge Station		130							
	Road decking (50%)	2%	275099	27510	302609	45391	348000	69600	417600
	Civil/structural	100%	13754948	1375495	15130443	2269566	17400009	3480002	20880011
	Mechanical (incl vent fans)	10%	2375495	237549	2613044	391957	3005001	601000	3606001
	Electrical	10%	1375495	137549	1513044	226957	1740001	348000	2088001
	Architectural (incl esc and elev)	22%	4326089	432609	4758697	713805	5472502	1094500	6567002
	Utilities (50%)	4%	550198	55020	605218	90783	696000	139200	835200
	Street restoration (50%)	3.50%	481423	48142	529565	79435	609000	121800	730800
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26188746**	**2618875**	**28807621**	**4321143**	**33128764**	**6625753**	**39754517**
Queen Elizabeth Park Shaft		10							
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station		130							
	Road decking (50%)	2%	282960	28296	311256	46688	357944	71589	429533
	Civil/structural	100%	14147988	1414799	15562787	2334418	17897205	3579441	21476646
	Mechanical (incl vent fans)	10%	2414799	241480	2656279	398442	3054720	610944	3665665
	Electrical	10%	1414799	141480	1556279	233442	1789720	357944	2147665
	Architectural (incl esc and elev)	22%	4412557	441256	4853813	728072	5581885	1116377	6698262
	Utilities (50%)	4%	565920	56592	622511	93377	715888	143178	859066
	Street restoration (50%)	3.50%	495180	49518	544698	81705	626402	125280	751683
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26784202**	**2678420**	**29462622**	**4419393**	**33882015**	**6776403**	**40658418**
King Edward Crossover		140							
	Road decking (50%)	2%	216028	21603	237630	35645	273275	54655	327930
	Civil/structural	100%	10801384	1080138	11881522	1782228	13663751	2732750	16396501
	Utilities (50%)	4%	432055	43206	475261	71289	546550	109310	655860

	Street restoration (50%)	3.5%	378048	37805	415853	62378	478231	95646	573878
	Total		**11827515**	**1182752**	**13010267**	**1951540**	**14961807**	**2992361**	**17954168**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	449802	44980	494782	74217	568999	113800	682799
	Civil/structural	100%	22490077	2249008	24739085	3710863	28449947	5689989	34139937
	Mechanical (incl vent fans)	10%	3249008	324901	3573908	536086	4109995	821999	4931994
	Electrical	10%	2249008	224901	2473908	371086	2844995	568999	3413994
	Architectural (incl esc and elev)	22%	6247817	624782	6872599	1030890	7903488	1580698	9484186
	Utilities (50%)	4%	899603	89960	989563	148435	1137998	227600	1365597
	Street restoration (50%)	3.5%	787153	78715	865868	129880	995748	199150	1194898
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**39422467**	**3942247**	**43364713**	**6504707**	**49869420**	**9973884**	**59843304**
TBM Launch Shaft	80								
	Civil/structural	100%	6454578	645458	7100036	1065005	8165041	1633008	9798049
	Utilities (50%)	4%	258183	25818	284001	42600	326602	65320	391922
	Street restoration (50%)	3.5%	225910	22591	248501	37275	285776	57155	342932
	Total		**6938671**	**693867**	**7632538**	**1144881**	**8777419**	**1755484**	**10532903**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	554333	55433	609766	91465	701231	140246	841477
	Civil/structural	100%	13858316	1385832	15244148	2286622	17530770	3506154	21036924
	Mechanical (incl vent fans)	10%	2385832	238583	2624415	393662	3018077	603615	3621692
	Electrical	10%	1385832	138583	1524415	228662	1753077	350615	2103692
	Architectural (incl esc and elev)	22%	4348830	434883	4783712	717557	5501269	1100254	6601523
	Utilities	8%	1108665	110867	1219532	182930	1402462	280492	1682954
	Street restoration	7%	970082	97008	1067090	160064	1227154	245431	1472585

	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661889**	**2766189**	**30428078**	**4564212**	**34992289**	**6998458**	**41990747**
Pacific Bvld Crossover	140								
	Road decking	4%	400887	40089	440976	66146	507122	101424	608547
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities	8%	801774	80177	881952	132293	1014245	202849	1217094
	Street restoration	7%	701553	70155	771708	115756	887464	177493	1064957
	Total		**11926395**	**1192640**	**13119035**	**1967855**	**15086890**	**3017378**	**18104268**
Nelson Station	130								
	Road decking	4%	554328	55433	609761	91464	701225	140245	841470
	Civil/structural	100%	13858207	1385821	15244028	2286604	17530632	3506126	21036758
	Mechanical (incl vent fans)	10%	2385821	238582	2624403	393660	3018063	603613	3621676
	Electrical	10%	1385821	138582	1524403	228660	1753063	350613	2103676
	Architectural (incl esc and elev)	22%	4348806	434881	4783686	717553	5501239	1100248	6601487
	Utilities	8%	1108657	110866	1219522	182928	1402451	280490	1682941
	Street restoration	7%	970074	97007	1067082	160062	1227144	245429	1472573
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661713**	**2766171**	**30427885**	**4564183**	**34992067**	**6998413**	**41990481**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	544745	54474	599219	89883	689102	137820	826922
	Civil/structural	100%	21789781	2178978	23968759	3595314	27564073	5512815	33076888
	Mechanical (incl vent fans)	10%	3178978	317898	3496876	524531	4021407	804281	4825689
	Electrical	10%	2178978	217898	2396876	359531	2756407	551281	3307689
	Architectural (incl esc and elev)	22%	6093752	609375	6703127	1005469	7708596	1541719	9250315
	Utilities (65%)	5%	1089489	108949	1198438	179766	1378204	275641	1653844
	Street restoration (65%)	4.5%	980540	98054	1078594	161789	1240383	248077	1488460
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**38906263**	**3890626**	**42796889**	**6419533**	**49216422**	**9843284**	**59059707**
Cordova Station	130								
	Road decking (75%)	3%	574634	57463	632097	94815	726912	145382	872294
	Civil/structural	100%	19154459	1915446	21069905	3160486	24230391	4846078	29076469
	Mechanical (incl vent fans)	10%	2915446	291545	3206990	481049	3688039	737608	4425647
	Electrical	10%	1915446	191545	2106990	316049	2423039	484608	2907647
	Architectural (incl esc and elev)	22%	5513981	551398	6065379	909807	6975186	1395037	8370223
	Utilities (75%)	6%	1149268	114927	1264194	189629	1453823	290765	1744588
	Street restoration (75%)	5.3%	1005609	100561	1106170	165926	1272096	254419	1526515
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**35278842**	**3527884**	**38806726**	**5821009**	**44627735**	**8925547**	**53553282**

Cordova Crossover	140								
	Road decking	4%	709386	70939	780325	117049	897373	179475	1076848
	Civil/structural	100%	17734650	1773465	19508115	2926217	22434332	4486866	26921199
	Utilities	8%	1418772	141877	1560649	234097	1794747	358949	2153696
	Street restoration	7%	1241426	124143	1365568	204835	1570403	314081	1884484
	Total		**21104234**	**2110423**	**23214657**	**3482199**	**26696855**	**5339371**	**32036226**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	200	1848000	184800	2032800	304920	2337720	467544	2805264
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	4750	43890000	4389000	48279000	7241850	55520850	11104170	66625020
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			91938000	**9193800**	**101131800**	**15169770**	**116301570**	**23260314**	**139561884**
				9.66%		14.61%		21.52%	
GRAND TOTAL FOR ALTERNATIVE SOUTH END - 1 (5.7)			**577270503**	**55773142**	**633043646**	**92463734**	**725507380**	**156158186**	**$ 881,665,566**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ALTERNATIVE SOUTH END - 2 (5.7 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 1130 +200							
	Tunnel linings	3259553	162978	3422530	171127	3593657	539049	4132706
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	12132276	1213228	13345504	2001826	15347329	4604199	19951528
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	124300	12430	136730	20510	157240	31448	188687
	Invert and walkway	2599000	259900	2858900	428835	3287735	657547	3945282
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**23053628.8**	**2062385**	**25116014**	**3305149**	**28421163**	**7177355**	**35598518**
West tunnel	Total	**23053628.8**	**2062385.2**	**25116014**	**3305149.1**	**28421163**	**7177355**	**35598518**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7615238	380762	7996000	399800	8395800	1259370	9655170
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	19291996	1929200	21221196	3183179	24404375	7321312	31725687
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**38208134.4**	**3440052**	**41648186**	**5447628**	**47095814**	**11455029**	**58550842**
West tunnel	Total	**38208134.4**	**3440051.5**	**41648186**	**5447627.9**	**47095814**	**11455029**	**58550842**
Tunnel Drive 3:	Length 2500							
	Tunnel linings	7211400	360570	7571970	1135796	8707766	1306165	10013930
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	18655112	1865511	20520623	3078093	23598717	7079615	30678332
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	275000	27500	302500	45375	347875	69575	417450
	Invert and walkway	5750000	575000	6325000	948750	7273750	1454750	8728500

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**33873708**	**3026801**	**36900509**	**5535076**	**42435585**	**10512800**	**52948386**
West tunnel	Total		**33873708**	**3026800.8**	**36900509**	**5535076.3**	**42435585**	**10512800**	**52948386**
South Portal	Length	150							
	Civil/structural	100%	16734302	1673430	18407732	2761160	21168892	4233778	25402670
	Utilities	2%	334686	33469	368155	55223	423378	84676	508053
	Restoration	2%	334686	33469	368155	55223	423378	84676	508053
	Total		**17403674**	**1740367**	**19144041**	**2871606**	**22015648**	**4403130**	**26418777**
Oak Ridge Station		130							
	Road decking (50%)	2%	275099	27510	302609	45391	348000	69600	417600
	Civil/structural	100%	13754948	1375495	15130443	2269566	17400009	3480002	20880011
	Mechanical (incl vent fans)	10%	2375495	237549	2613044	391957	3005001	601000	3606001
	Electrical	10%	1375495	137549	1513044	226957	1740001	348000	2088001
	Architectural (incl esc and elev)	22%	4326089	432609	4758697	713805	5472502	1094500	6567002
	Utilities (50%)	4%	550198	55020	605218	90783	696000	139200	835200
	Street restoration (50%)	3.50%	481423	48142	529565	79435	609000	121800	730800
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26188746**	**2618875**	**28807621**	**4321143**	**33128764**	**6625753**	**39754517**
Queen Elizabeth Park Shaft		10							
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station		130							
	Road decking (50%)	2%	282960	28296	311256	46688	357944	71589	429533
	Civil/structural	100%	14147988	1414799	15562787	2334418	17897205	3579441	21476646
	Mechanical (incl vent fans)	10%	2414799	241480	2656279	398442	3054720	610944	3665665
	Electrical	10%	1414799	141480	1556279	233442	1789720	357944	2147665
	Architectural (incl esc and elev)	22%	4412557	441256	4853813	728072	5581885	1116377	6698262
	Utilities (50%)	4%	565920	56592	622511	93377	715888	143178	859066
	Street restoration (50%)	3.50%	495180	49518	544698	81705	626402	125280	751683
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26784202**	**2678420**	**29462622**	**4419393**	**33882015**	**6776403**	**40658418**
King Edward Crossover		140							
	Road decking (50%)	2%	216028	21603	237630	35645	273275	54655	327930
	Civil/structural	100%	10801384	1080138	11881522	1782228	13663751	2732750	16396501
	Utilities (50%)	4%	432055	43206	475261	71289	546550	109310	655860

	Street restoration (50%)	3.5%	378048	37805	415853	62378	478231	95646	573878
	Total		**11827515**	**1182752**	**13010267**	**1951540**	**14961807**	**2992361**	**17954168**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	449802	44980	494782	74217	568999	113800	682799
	Civil/structural	100%	22490077	2249008	24739085	3710863	28449947	5689989	34139937
	Mechanical (incl vent fans)	10%	3249008	324901	3573908	536086	4109995	821999	4931994
	Electrical	10%	2249008	224901	2473908	371086	2844995	568999	3413994
	Architectural (incl esc and elev)	22%	6247817	624782	6872599	1030890	7903488	1580698	9484186
	Utilities (50%)	4%	899603	89960	989563	148435	1137998	227600	1365597
	Street restoration (50%)	3.5%	787153	78715	865868	129880	995748	199150	1194898
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**39422467**	**3942247**	**43364713**	**6504707**	**49869420**	**9973884**	**59843304**
TBM Launch Shaft	80								
	Civil/structural	100%	6454578	645458	7100036	1065005	8165041	1633008	9798049
	Utilities (50%)	4%	258183	25818	284001	42600	326602	65320	391922
	Street restoration (50%)	3.5%	225910	22591	248501	37275	285776	57155	342932
	Total		**6938671**	**693867**	**7632538**	**1144881**	**8777419**	**1755484**	**10532903**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	554333	55433	609766	91465	701231	140246	841477
	Civil/structural	100%	13858316	1385832	15244148	2286622	17530770	3506154	21036924
	Mechanical (incl vent fans)	10%	2385832	238583	2624415	393662	3018077	603615	3621692
	Electrical	10%	1385832	138583	1524415	228662	1753077	350615	2103692
	Architectural (incl esc and elev)	22%	4348830	434883	4783712	717557	5501269	1100254	6601523
	Utilities	8%	1108665	110867	1219532	182930	1402462	280492	1682954
	Street restoration	7%	970082	97008	1067090	160064	1227154	245431	1472585

	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661889**	**2766189**	**30428078**	**4564212**	**34992289**	**6998458**	**41990747**
Pacific Bvld Crossover	140								
	Road decking	4%	400887	40089	440976	66146	507122	101424	608547
	Civil/structural	100%	10022181	1002218	11024399	1653660	12678059	2535612	15213671
	Utilities	8%	801774	80177	881952	132293	1014245	202849	1217094
	Street restoration	7%	701553	70155	771708	115756	887464	177493	1064957
	Total		**11926395**	**1192640**	**13119035**	**1967855**	**15086890**	**3017378**	**18104268**
Nelson Station	130								
	Road decking	4%	554328	55433	609761	91464	701225	140245	841470
	Civil/structural	100%	13858207	1385821	15244028	2286604	17530632	3506126	21036758
	Mechanical (incl vent fans)	10%	2385821	238582	2624403	393660	3018063	603613	3621676
	Electrical	10%	1385821	138582	1524403	228660	1753063	350613	2103676
	Architectural (incl esc and elev)	22%	4348806	434881	4783686	717553	5501239	1100248	6601487
	Utilities	8%	1108657	110866	1219522	182928	1402451	280490	1682941
	Street restoration	7%	970074	97007	1067082	160062	1227144	245429	1472573
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**27661713**	**2766171**	**30427885**	**4564183**	**34992067**	**6998413**	**41990481**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	544745	54474	599219	89883	689102	137820	826922
	Civil/structural	100%	21789781	2178978	23968759	3595314	27564073	5512815	33076888
	Mechanical (incl vent fans)	10%	3178978	317898	3496876	524531	4021407	804281	4825689
	Electrical	10%	2178978	217898	2396876	359531	2756407	551281	3307689
	Architectural (incl esc and elev)	22%	6093752	609375	6703127	1005469	7708596	1541719	9250315
	Utilities (65%)	5%	1089489	108949	1198438	179766	1378204	275641	1653844
	Street restoration (65%)	4.5%	980540	98054	1078594	161789	1240383	248077	1488460
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**38906263**	**3890626**	**42796889**	**6419533**	**49216422**	**9843284**	**59059707**
Cordova Station	130								
	Road decking (75%)	3%	574634	57463	632097	94815	726912	145382	872294
	Civil/structural	100%	19154459	1915446	21069905	3160486	24230391	4846078	29076469
	Mechanical (incl vent fans)	10%	2915446	291545	3206990	481049	3688039	737608	4425647
	Electrical	10%	1915446	191545	2106990	316049	2423039	484608	2907647
	Architectural (incl esc and elev)	22%	5513981	551398	6065379	909807	6975186	1395037	8370223
	Utilities (75%)	6%	1149268	114927	1264194	189629	1453823	290765	1744588
	Street restoration (75%)	5.3%	1005609	100561	1106170	165926	1272096	254419	1526515
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**35278842**	**3527884**	**38806726**	**5821009**	**44627735**	**8925547**	**53553282**

Cordova Crossover	140								
	Road decking	4%	709386	70939	780325	117049	897373	179475	1076848
	Civil/structural	100%	17734650	1773465	19508115	2926217	22434332	4486866	26921199
	Utilities	8%	1418772	141877	1560649	234097	1794747	358949	2153696
	Street restoration	7%	1241426	124143	1365568	204835	1570403	314081	1884484
	Total		**21104234**	**2110423**	**23214657**	**3482199**	**26696855**	**5339371**	**32036226**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	200	1848000	184800	2032800	304920	2337720	467544	2805264
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	4750	43890000	4389000	48279000	7241850	55520850	11104170	66625020
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			91938000	**9193800**	**101131800**	**15169770**	**116301570**	**23260314**	**139561884**
				9.66%		14.60%		21.53%	
GRAND TOTAL FOR ALTERNATIVE SOUTH END - 2 (5.7)			**578354841**	**55866865**	**634221705**	**92609550**	**726831255**	**156475595**	**$ 883,306,850**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

REFERENCE ALIGNMENT (5.0 m Dia)			Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length	2770 +200							
	Tunnel linings		7430802	371540	7802342	390117	8192459	1228869	9421328
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		18369263	1836926	20206189	3030928	23237118	6971135	30208253
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		304700	30470	335170	50276	385446	77089	462535
	Invert and walkway		6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
West tunnel	Total		**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
Tunnel Drive 2:	Length	2640 +200							
	Tunnel linings		7082064	354103	7436167	371808	7807976	1171196	8979172
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		17707029	1770703	19477732	2921660	22399392	6719818	29119209
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		290400	29040	319440	47916	367356	73471	440827
	Invert and walkway		6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
West tunnel	Total		**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
Tunnel Drive 3:	Length	2500							
	Tunnel linings		6706500	335325	7041825	1056274	8098099	1214715	9312814
	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		17076294	1707629	18783923	2817589	21601512	6480454	28081965
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		275000	27500	302500	45375	347875	69575	417450
	Invert and walkway		5750000	575000	6325000	948750	7273750	1454750	8728500

	Architectural (incl esc and elev)	22%	4133120	413312	4546431	681965	5228396	1045679	6274075
	Utilities (50%)	4%	515113	51511	566624	84994	651617	130323	781941
	Street restoration (50%)	3.50%	450724	45072	495796	74369	570165	114033	684198
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24859891**	**2485989**	**27345880**	**4101882**	**31447762**	**6289552**	**37737315**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	265633	26563	292196	43829	336025	67205	403230
	Civil/structural	100%	13281635	1328164	14609799	2191470	16801268	3360254	20161522
	Mechanical (incl vent fans)	10%	2328164	232816	2560980	384147	2945127	589025	3534152
	Electrical	10%	1328164	132816	1460980	219147	1680127	336025	2016152
	Architectural (incl esc and elev)	22%	4221960	422196	4644156	696623	5340779	1068156	6408935
	Utilities (50%)	4%	531265	53127	584392	87659	672051	134410	806461
	Street restoration (50%)	3.50%	464857	46486	511343	76701	588044	117609	705653
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25471677**	**2547168**	**28018845**	**4202827**	**32221671**	**6444334**	**38666006**
King Edward Crossover	140								
	Road decking (50%)	2%	199294	19929	219224	32884	252107	50421	302529
	Civil/structural	100%	9964722	996472	10961194	1644179	12605373	2521075	15126448
	Utilities (50%)	4%	398589	39859	438448	65767	504215	100843	605058
	Street restoration (50%)	3.5%	348765	34877	383642	57546	441188	88238	529426
	Total		**10911371**	**1091137**	**12002508**	**1800376**	**13802884**	**2760577**	**16563461**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	426452	42645	469097	70365	539461	107892	647353
	Civil/structural	100%	21322578	2132258	23454836	3518225	26973061	5394612	32367673
	Mechanical (incl vent fans)	10%	3132258	313226	3445484	516823	3962306	792461	4754767

	Crosspassages			800000	80000	880000	132000	1012000	303600	1315600
	Total			**31789990**	**2843674**	**34633664**	**5195050**	**39828714**	**9822189**	**49650903**
West tunnel	Total			**31789990**	**2843674**	**34633664**	**5195050**	**39828714**	**9822189**	**49650903**
South Portal	Length	150								
	Civil/structural		100%	15912360	1591236	17503596	2625539	20129135	4025827	24154962
	Utilities		2%	318247	31825	350072	52511	402583	80517	483099
	Restoration		2%	318247	31825	350072	52511	402583	80517	483099
	Total			**16548854**	**1654885**	**18203740**	**2730561**	**20934301**	**4186860**	**25121161**
49th Ave Station		130								
	Road decking (50%)		2%	252515	25252	277767	41665	319432	63886	383318
	Civil/structural		100%	12625760	1262576	13888336	2083250	15971586	3194317	19165904
	Mechanical (incl vent fans)		10%	2262576	226258	2488834	373325	2862159	572432	3434590
	Electrical		10%	1262576	126258	1388834	208325	1597159	319432	1916590
	Architectural (incl esc and elev)		22%	4077667	407767	4485434	672815	5158249	1031650	6189899
	Utilities (50%)		4%	505030	50503	555533	83330	638863	127773	766636

	Electrical	10%	2132258	213226	2345484	351823	2697306	539461	3236767
	Architectural (incl esc and elev)	22%	5990967	599097	6590064	988510	7578573	1515715	9094288
	Utilities (50%)	4%	852903	85290	938193	140729	1078922	215784	1294707
	Street restoration (50%)	3.5%	746290	74629	820919	123138	944057	188811	1132869
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37653706**	**3765371**	**41419076**	**6212861**	**47631938**	**9526388**	**57158325**
TBM Launch Shaft	80								
	Civil/structural	100%	5946447	594645	6541092	981164	7522255	1504451	9026707
	Utilities (50%)	4%	237858	23786	261644	39247	300890	60178	361068
	Street restoration (50%)	3.5%	208126	20813	228938	34341	263279	52656	315935
	Total		**6392431**	**639243**	**7031674**	**1054751**	**8086425**	**1617285**	**9703710**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	586442	58644	645086	96763	741849	148370	890219
	Civil/structural	100%	14661056	1466106	16127162	2419074	18546236	3709247	22255483
	Mechanical (incl vent fans)	10%	2466106	246611	2712716	406907	3119624	623925	3743548
	Electrical	10%	1466106	146611	1612716	241907	1854624	370925	2225548
	Architectural (incl esc and elev)	22%	4525432	452543	4977976	746696	5724672	1144934	6869606
	Utilities	8%	1172884	117288	1290173	193526	1483699	296740	1780439
	Street restoration	7%	1026274	102627	1128901	169335	1298237	259647	1557884
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**28954300**	**2895430**	**31849730**	**4777460**	**36627190**	**7325438**	**43952628**
Pacific Bvld Crossover	140								
	Road decking	4%	368778	36878	405655	60848	466504	93301	559804
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities	8%	737555	73756	811311	121697	933007	186601	1119609
	Street restoration	7%	645361	64536	709897	106485	816382	163276	979658
	Total		**10971135**	**1097113**	**12068248**	**1810237**	**13878486**	**2775697**	**16654183**
Nelson Station	130								
	Road decking	4%	518987	51899	570885	85633	656518	131304	787822
	Civil/structural	100%	12974667	1297467	14272134	2140820	16412954	3282591	19695545
	Mechanical (incl vent fans)	10%	2297467	229747	2527213	379082	2906295	581259	3487554
	Electrical	10%	1297467	129747	1427213	214082	1641295	328259	1969554
	Architectural (incl esc and elev)	22%	4154427	415443	4569869	685480	5255350	1051070	6306420

	Utilities	8%	1037973	103797	1141771	171266	1313036	262607	1575644
	Street restoration	7%	908227	90823	999049	149857	1148907	229781	1378688
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26239214**	**2623921**	**28863135**	**4329470**	**33192606**	**6638521**	**39831127**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	516145	51614	567759	85164	652923	130585	783508
	Civil/structural	100%	20645789	2064579	22710368	3406555	26116923	5223385	31340308
	Mechanical (incl vent fans)	10%	3064579	306458	3371037	505656	3876692	775338	4652031
	Electrical	10%	2064579	206458	2271037	340656	2611692	522338	3134031
	Architectural (incl esc and elev)	22%	5842074	584207	6426281	963942	7390223	1478045	8868268
	Utilities (65%)	5%	1032289	103229	1135518	170328	1305846	261169	1567015
	Street restoration (65%)	4.5%	929061	92906	1021967	153295	1175262	235052	1410314
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37144515**	**3714452**	**40858967**	**6128845**	**46987812**	**9397562**	**56385374**
Cordova Station	130								
	Road decking (75%)	3%	543837	54384	598221	89733	687954	137591	825545
	Civil/structural	100%	18127899	1812790	19940689	2991103	22931792	4586358	27518151
	Mechanical (incl vent fans)	10%	2812790	281279	3094069	464110	3558179	711636	4269815
	Electrical	10%	1812790	181279	1994069	299110	2293179	458636	2751815
	Architectural (incl esc and elev)	22%	5288138	528814	5816952	872543	6689494	1337899	8027393
	Utilities (75%)	6%	1087674	108767	1196441	179466	1375908	275182	1651089
	Street restoration (75%)	5.3%	951715	95171	1046886	157033	1203919	240784	1444703
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**33674842**	**3367484**	**37042326**	**5556349**	**42598675**	**8519735**	**51118410**
Cordova Crossover	140								
	Road decking	4%	658407	65841	724248	108637	832885	166577	999462
	Civil/structural	100%	16460183	1646018	18106201	2715930	20822131	4164426	24986558
	Utilities	8%	1316815	131681	1448496	217274	1665771	333154	1998925
	Street restoration	7%	1152213	115221	1267434	190115	1457549	291510	1749059
	Total		**19587618**	**1958762**	**21546380**	**3231957**	**24778336**	**4955667**	**29734004**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	400	3696000	369600	4065600	609840	4675440	935088	5610528
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	5000	46200000	4620000	50820000	7623000	58443000	11688600	70131600
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			96096000	**9609600**	**105705600**	**15855840**	**121561440**	**24312288**	**145873728**
				9.64%		14.52%		21.47%	

GRAND TOTAL FOR REFERENCE ALIGNMENT (5.0)	**626345230**	**60352586**	**686697816**	**99716971**	**786414787**	**168829690**	**$ 955,244,477**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ALTERNATIVE NORTH END (5.0 m Dia)			Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length	2770 +200							
	Tunnel linings		7430802	371540	7802342	390117	8192459	1228869	9421328
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		18369263	1836926	20206189	3030928	23237118	6971135	30208253
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		304700	30470	335170	50276	385446	77089	462535
	Invert and walkway		6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
West tunnel	Total		**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
Tunnel Drive 2:	Length	2640 +200							
	Tunnel linings		7082064	354103	7436167	371808	7807976	1171196	8979172
East tunnel	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		17707029	1770703	19477732	2921660	22399392	6719818	29119209
	TBM skidding		600000	60000	660000	99000	759000	151800	910800
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		290400	29040	319440	47916	367356	73471	440827
	Invert and walkway		6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel		2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
West tunnel	Total		**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
Tunnel Drive 3:	Length	2145							
	Tunnel linings		5754177	287709	6041886	906283	6948169	1042225	7990394
	TBM set up		782196	78220	860416	129062	989478	197896	1187374
	TBM drive		15409308	1540931	16950239	2542536	19492775	5847832	25340607
	TBM removal		400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up		235950	23595	259545	38932	298477	59695	358172
	Invert and walkway		4933500	493350	5426850	814028	6240878	1248176	7489053

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**28315131**	**2543804**	**30858935**	**4628840**	**35487776**	**8800624**	**44288400**
West tunnel	Total		**28315131**	**2543804**	**30858935**	**4628840**	**35487776**	**8800624**	**44288400**
South Portal	Length 150								
	Civil/structural	100%	15912360	1591236	17503596	2625539	20129135	4025827	24154962
	Utilities	2%	318247	31825	350072	52511	402583	80517	483099
	Restoration	2%	318247	31825	350072	52511	402583	80517	483099
	Total		**16548854**	**1654885**	**18203740**	**2730561**	**20934301**	**4186860**	**25121161**
49th Ave Station	130								
	Road decking (50%)	2%	252515	25252	277767	41665	319432	63886	383318
	Civil/structural	100%	12625760	1262576	13888336	2083250	15971586	3194317	19165904
	Mechanical (incl vent fans)	10%	2262576	226258	2488834	373325	2862159	572432	3434590
	Electrical	10%	1262576	126258	1388834	208325	1597159	319432	1916590
	Architectural (incl esc and elev)	22%	4077667	407767	4485434	672815	5158249	1031650	6189899
	Utilities (50%)	4%	505030	50503	555533	83330	638863	127773	766636
	Street restoration (50%)	3.50%	441902	44190	486092	72914	559006	111801	670807
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24478026**	**2447803**	**26925829**	**4038874**	**30964703**	**6192941**	**37157644**
49th Ave Crossover	140								
	Road decking (50%)	2%	184389	18439	202828	30424	233252	46650	279902
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities (50%)	4%	368778	36878	405655	60848	466504	93301	559804
	Street restoration (50%)	3.5%	322680	32268	354948	53242	408191	81638	489829
	Total		**10095288**	**1009529**	**11104817**	**1665723**	**12770539**	**2554108**	**15324647**
57th Ave EEB	10								
	Road decking (50%)	2%	16008	1601	17609	2641	20250	4050	24300
	Civil/structural	100%	800408	80041	880449	132067	1012516	202503	1215019
	Architectural	5%	40020	4002	44022	6603	50626	10125	60751
	Mech/elect (incl vent fans)	20%	660082	66008	726090	108913	835003	167001	1002004
	Utilities (100%)	8%	64033	6403	70436	10565	81001	16200	97202
	Street restoration (100%)	7%	56029	5603	61631	9245	70876	14175	85051
	Total		**1636579**	**163658**	**1800237**	**270036**	**2070273**	**414055**	**2484327**
Oak Ridge Station	130								
	Road decking (50%)	2%	257556	25756	283312	42497	325809	65162	390970
	Civil/structural	100%	12877816	1287782	14165598	2124840	16290437	3258087	19548525
	Mechanical (incl vent fans)	10%	2287782	228778	2516560	377484	2894044	578809	3472852
	Electrical	10%	1287782	128778	1416560	212484	1629044	325809	1954852

	Architectural (incl esc and elev)	22%	4133120	413312	4546431	681965	5228396	1045679	6274075
	Utilities (50%)	4%	515113	51511	566624	84994	651617	130323	781941
	Street restoration (50%)	3.50%	450724	45072	495796	74369	570165	114033	684198
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24859891**	**2485989**	**27345880**	**4101882**	**31447762**	**6289552**	**37737315**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	265633	26563	292196	43829	336025	67205	403230
	Civil/structural	100%	13281635	1328164	14609799	2191470	16801268	3360254	20161522
	Mechanical (incl vent fans)	10%	2328164	232816	2560980	384147	2945127	589025	3534152
	Electrical	10%	1328164	132816	1460980	219147	1680127	336025	2016152
	Architectural (incl esc and elev)	22%	4221960	422196	4644156	696623	5340779	1068156	6408935
	Utilities (50%)	4%	531265	53127	584392	87659	672051	134410	806461
	Street restoration (50%)	3.50%	464857	46486	511343	76701	588044	117609	705653
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25471677**	**2547168**	**28018845**	**4202827**	**32221671**	**6444334**	**38666006**
King Edward Crossover	140								
	Road decking (50%)	2%	199294	19929	219224	32884	252107	50421	302529
	Civil/structural	100%	9964722	996472	10961194	1644179	12605373	2521075	15126448
	Utilities (50%)	4%	398589	39859	438448	65767	504215	100843	605058
	Street restoration (50%)	3.5%	348765	34877	383642	57546	441188	88238	529426
	Total		**10911371**	**1091137**	**12002508**	**1800376**	**13802884**	**2760577**	**16563461**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	426452	42645	469097	70365	539461	107892	647353
	Civil/structural	100%	21322578	2132258	23454836	3518225	26973061	5394612	32367673
	Mechanical (incl vent fans)	10%	3132258	313226	3445484	516823	3962306	792461	4754767

	Electrical	10%	2132258	213226	2345484	351823	2697306	539461	3236767
	Architectural (incl esc and elev)	22%	5990967	599097	6590064	988510	7578573	1515715	9094288
	Utilities (50%)	4%	852903	85290	938193	140729	1078922	215784	1294707
	Street restoration (50%)	3.5%	746290	74629	820919	123138	944057	188811	1132869
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37653706**	**3765371**	**41419076**	**6212861**	**47631938**	**9526388**	**57158325**
TBM Launch Shaft	80								
	Civil/structural	100%	5946447	594645	6541092	981164	7522255	1504451	9026707
	Utilities (50%)	4%	237858	23786	261644	39247	300890	60178	361068
	Street restoration (50%)	3.5%	208126	20813	228938	34341	263279	52656	315935
	Total		**6392431**	**639243**	**7031674**	**1054751**	**8086425**	**1617285**	**9703710**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	586442	58644	645086	96763	741849	148370	890219
	Civil/structural	100%	14661056	1466106	16127162	2419074	18546236	3709247	22255483
	Mechanical (incl vent fans)	10%	2466106	246611	2712716	406907	3119624	623925	3743548
	Electrical	10%	1466106	146611	1612716	241907	1854624	370925	2225548
	Architectural (incl esc and elev)	22%	4525432	452543	4977976	746696	5724672	1144934	6869606
	Utilities	8%	1172884	117288	1290173	193526	1483699	296740	1780439
	Street restoration	7%	1026274	102627	1128901	169335	1298237	259647	1557884
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**28954300**	**2895430**	**31849730**	**4777460**	**36627190**	**7325438**	**43952628**
Pacific Bvld Crossover	140								
	Road decking	4%	368778	36878	405655	60848	466504	93301	559804
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities	8%	737555	73756	811311	121697	933007	186601	1119609
	Street restoration	7%	645361	64536	709897	106485	816382	163276	979658
	Total		**10971135**	**1097113**	**12068248**	**1810237**	**13878486**	**2775697**	**16654183**
Nelson Station	130								
	Road decking	4%	518987	51899	570885	85633	656518	131304	787822
	Civil/structural	100%	12974667	1297467	14272134	2140820	16412954	3282591	19695545
	Mechanical (incl vent fans)	10%	2297467	229747	2527213	379082	2906295	581259	3487554
	Electrical	10%	1297467	129747	1427213	214082	1641295	328259	1969554
	Architectural (incl esc and elev)	22%	4154427	415443	4569869	685480	5255350	1051070	6306420

	Utilities	8%	1037973	103797	1141771	171266	1313036	262607	1575644
	Street restoration	7%	908227	90823	999049	149857	1148907	229781	1378688
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26239214**	**2623921**	**28863135**	**4329470**	**33192606**	**6638521**	**39831127**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	320940	32094	353034	52955	405989	81198	487187
	Civil/structural	100%	12837591	1283759	14121350	2118203	16239553	3247911	19487463
	Mechanical (incl vent fans)	10%	2283759	228376	2512135	376820	2888955	577791	3466746
	Electrical	10%	1283759	128376	1412135	211820	1623955	324791	1948746
	Architectural (incl esc and elev)	22%	4124270	412427	4536697	680505	5217202	1043440	6260642
	Utilities (65%)	5%	641880	64188	706068	105910	811978	162396	974373
	Street restoration (65%)	4.5%	577692	57769	635461	95319	730780	146156	876936
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25119890**	**2511989**	**27631879**	**4144782**	**31776661**	**6355332**	**38131993**
Cut and Cover	Length	225							
	Civil/structural	100%	4738857	473886	5212743	781911	5994654	1198931	7193585
	Utilities	4%	189554	18955	208510	31276	239786	47957	287743
	Restoration	4%	189554	18955	208510	31276	239786	47957	287743
	Total		**5117966**	**511797**	**5629762**	**844464**	**6474226**	**1294845**	**7769072**
Cordova Station	130								
	Road decking (75%)	3%	353969	35397	389366	58405	447771	89554	537326
	Civil/structural	100%	11798980	1179898	12978878	1946832	14925710	2985142	17910852
	Mechanical (incl vent fans)	10%	2179898	217990	2397888	359683	2757571	551514	3309085
	Electrical	10%	1179898	117990	1297888	194683	1492571	298514	1791085
	Architectural (incl esc and elev)	22%	3895776	389578	4285353	642803	4928156	985631	5913787
	Utilities (75%)	6%	707939	70794	778733	116810	895543	179109	1074651
	Street restoration (75%)	5.3%	619446	61945	681391	102209	783600	156720	940320
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**23785906**	**2378591**	**26164497**	**3924675**	**30089171**	**6017834**	**36107006**
Cordova Crossover	140								
	Road decking	4%	303951	30395	334346	50152	384498	76900	461397
	Civil/structural	100%	7598765	759877	8358642	1253796	9612438	1922488	11534925
	Utilities	8%	607901	60790	668691	100304	768995	153799	922794
	Street restoration	7%	531914	53191	585105	87766	672871	134574	807445
	Total		**9042530**	**904253**	**9946783**	**1492018**	**11438801**	**2287760**	**13726561**
Cut and Cover	Length	60							
	Civil/structural	100%	2127021	212702	2339723	350958	2690682	538136	3228818
	Utilities	4%	85081	8508	93589	14038	107627	21525	129153

	Restoration		4%	85081	8508	93589	14038	107627	21525	129153
	Total			**2297183**	**229718**	**2526901**	**379035**	**2905936**	**581187**	**3487123**
System-wide Elements		9100								
	Trackwork		3000	27300000	2730000	30030000	4504500	34534500	6906900	41441400
	Contact Rail or Catenary		400	3640000	364000	4004000	600600	4604600	920920	5525520
	Tunnel Electrical/Mech		1600	14560000	1456000	16016000	2402400	18418400	3683680	22102080
	Train and Supervisory Control		5000	45500000	4550000	50050000	7507500	57557500	11511500	69069000
	Communications		400	3640000	364000	4004000	600600	4604600	920920	5525520
				94640000	**9464000**	**104104000**	**15615600**	**119719600**	**23943920**	**143663520**
					9.63%		14.49%		21.51%	
GRAND TOTAL FOR ALTERNATIVE NORTH END (5.0)				**592896012**	**57102897**	**649998908**	**94212134**	**744211043**	**160082187**	**$ 904,293,230**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ROBSON ALTERNATIVE NORTH END, DEEP (5.0 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 2770 +200							
	Tunnel linings	7430802	371540	7802342	390117	8192459	1228869	9421328
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	18369263	1836926	20206189	3030928	23237118	6971135	30208253
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	304700	30470	335170	50276	385446	77089	462535
	Invert and walkway	6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
West tunnel	Total	**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7082064	354103	7436167	371808	7807976	1171196	8979172
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	17707029	1770703	19477732	2921660	22399392	6719818	29119209
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
West tunnel	Total	**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
Tunnel Drive 3:	Length 2500							
	Tunnel linings	6706500	335325	7041825	1056274	8098099	1214715	9312814
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	17122794	1712279	18835073	2825261	21660334	6498100	28158435
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	275000	27500	302500	45375	347875	69575	417450
	Invert and walkway	5750000	575000	6325000	948750	7273750	1454750	8728500

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**31836490**	**2848324**	**34684814**	**5202722**	**39887536**	**9839836**	**49727372**
West tunnel	Total		**31836490**	**2848324**	**34684814**	**5202722**	**39887536**	**9839836**	**49727372**
South Portal	Length 150								
	Civil/structural	100%	15912360	1591236	17503596	2625539	20129135	4025827	24154962
	Utilities	2%	318247	31825	350072	52511	402583	80517	483099
	Restoration	2%	318247	31825	350072	52511	402583	80517	483099
	Total		**16548854**	**1654885**	**18203740**	**2730561**	**20934301**	**4186860**	**25121161**
49th Ave Station	130								
	Road decking (50%)	2%	252515	25252	277767	41665	319432	63886	383318
	Civil/structural	100%	12625760	1262576	13888336	2083250	15971586	3194317	19165904
	Mechanical (incl vent fans)	10%	2262576	226258	2488834	373325	2862159	572432	3434590
	Electrical	10%	1262576	126258	1388834	208325	1597159	319432	1916590
	Architectural (incl esc and elev)	22%	4077667	407767	4485434	672815	5158249	1031650	6189899
	Utilities (50%)	4%	505030	50503	555533	83330	638863	127773	766636
	Street restoration (50%)	3.50%	441902	44190	486092	72914	559006	111801	670807
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24478026**	**2447803**	**26925829**	**4038874**	**30964703**	**6192941**	**37157644**
49th Ave Crossover	140								
	Road decking (50%)	2%	184389	18439	202828	30424	233252	46650	279902
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities (50%)	4%	368778	36878	405655	60848	466504	93301	559804
	Street restoration (50%)	3.5%	322680	32268	354948	53242	408191	81638	489829
	Total		**10095288**	**1009529**	**11104817**	**1665723**	**12770539**	**2554108**	**15324647**
57th Ave EEB	10								
	Road decking (50%)	2%	16008	1601	17609	2641	20250	4050	24300
	Civil/structural	100%	800408	80041	880449	132067	1012516	202503	1215019
	Architectural	5%	40020	4002	44022	6603	50626	10125	60751
	Mech/elect (incl vent fans)	20%	660082	66008	726090	108913	835003	167001	1002004
	Utilities (100%)	8%	64033	6403	70436	10565	81001	16200	97202
	Street restoration (100%)	7%	56029	5603	61631	9245	70876	14175	85051
	Total		**1636579**	**163658**	**1800237**	**270036**	**2070273**	**414055**	**2484327**
Oak Ridge Station	130								
	Road decking (50%)	2%	257556	25756	283312	42497	325809	65162	390970
	Civil/structural	100%	12877816	1287782	14165598	2124840	16290437	3258087	19548525
	Mechanical (incl vent fans)	10%	2287782	228778	2516560	377484	2894044	578809	3472852
	Electrical	10%	1287782	128778	1416560	212484	1629044	325809	1954852

	Architectural (incl esc and elev)	22%	4133120	413312	4546431	681965	5228396	1045679	6274075
	Utilities (50%)	4%	515113	51511	566624	84994	651617	130323	781941
	Street restoration (50%)	3.50%	450724	45072	495796	74369	570165	114033	684198
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24859891**	**2485989**	**27345880**	**4101882**	**31447762**	**6289552**	**37737315**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	265633	26563	292196	43829	336025	67205	403230
	Civil/structural	100%	13281635	1328164	14609799	2191470	16801268	3360254	20161522
	Mechanical (incl vent fans)	10%	2328164	232816	2560980	384147	2945127	589025	3534152
	Electrical	10%	1328164	132816	1460980	219147	1680127	336025	2016152
	Architectural (incl esc and elev)	22%	4221960	422196	4644156	696623	5340779	1068156	6408935
	Utilities (50%)	4%	531265	53127	584392	87659	672051	134410	806461
	Street restoration (50%)	3.50%	464857	46486	511343	76701	588044	117609	705653
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25471677**	**2547168**	**28018845**	**4202827**	**32221671**	**6444334**	**38666006**
King Edward Crossover	140								
	Road decking (50%)	2%	199294	19929	219224	32884	252107	50421	302529
	Civil/structural	100%	9964722	996472	10961194	1644179	12605373	2521075	15126448
	Utilities (50%)	4%	398589	39859	438448	65767	504215	100843	605058
	Street restoration (50%)	3.5%	348765	34877	383642	57546	441188	88238	529426
	Total		**10911371**	**1091137**	**12002508**	**1800376**	**13802884**	**2760577**	**16563461**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	426452	42645	469097	70365	539461	107892	647353
	Civil/structural	100%	21322578	2132258	23454836	3518225	26973061	5394612	32367673
	Mechanical (incl vent fans)	10%	3132258	313226	3445484	516823	3962306	792461	4754767

	Electrical	10%	2132258	213226	2345484	351823	2697306	539461	3236767
	Architectural (incl esc and elev)	22%	5990967	599097	6590064	988510	7578573	1515715	9094288
	Utilities (50%)	4%	852903	85290	938193	140729	1078922	215784	1294707
	Street restoration (50%)	3.5%	746290	74629	820919	123138	944057	188811	1132869
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37653706**	**3765371**	**41419076**	**6212861**	**47631938**	**9526388**	**57158325**
TBM Launch Shaft	80								
	Civil/structural	100%	5946447	594645	6541092	981164	7522255	1504451	9026707
	Utilities (50%)	4%	237858	23786	261644	39247	300890	60178	361068
	Street restoration (50%)	3.5%	208126	20813	228938	34341	263279	52656	315935
	Total		**6392431**	**639243**	**7031674**	**1054751**	**8086425**	**1617285**	**9703710**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	586442	58644	645086	96763	741849	148370	890219
	Civil/structural	100%	14661056	1466106	16127162	2419074	18546236	3709247	22255483
	Mechanical (incl vent fans)	10%	2466106	246611	2712716	406907	3119624	623925	3743548
	Electrical	10%	1466106	146611	1612716	241907	1854624	370925	2225548
	Architectural (incl esc and elev)	22%	4525432	452543	4977976	746696	5724672	1144934	6869606
	Utilities	8%	1172884	117288	1290173	193526	1483699	296740	1780439
	Street restoration	7%	1026274	102627	1128901	169335	1298237	259647	1557884
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**28954300**	**2895430**	**31849730**	**4777460**	**36627190**	**7325438**	**43952628**
Pacific Bvld Crossover	140								
	Road decking	4%	368778	36878	405655	60848	466504	93301	559804
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities	8%	737555	73756	811311	121697	933007	186601	1119609
	Street restoration	7%	645361	64536	709897	106485	816382	163276	979658
	Total		**10971135**	**1097113**	**12068248**	**1810237**	**13878486**	**2775697**	**16654183**
Robson Station	130								
	Road decking	4%	588352	58835	647187	97078	744265	148853	893118
	Civil/structural	100%	14708794	1470879	16179673	2426951	18606624	3721325	22327949
	Mechanical (incl vent fans)	10%	2470879	247088	2717967	407695	3125662	625132	3750795
	Electrical	10%	1470879	147088	1617967	242695	1860662	372132	2232795
	Architectural (incl esc and elev)	22%	4535935	453593	4989528	748429	5737957	1147591	6885549

	Utilities	8%	1176704	117670	1294374	194156	1488530	297706	1786236
	Street restoration	7%	1029616	102962	1132577	169887	1302464	260493	1562956
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**29031158**	**2903116**	**31934274**	**4790141**	**36724415**	**7344883**	**44069298**
Cordova Station	130								
	Road decking (75%)	3%	543837	54384	598221	89733	687954	137591	825545
	Civil/structural	100%	18127899	1812790	19940689	2991103	22931792	4586358	27518151
	Mechanical (incl vent fans)	10%	2812790	281279	3094069	464110	3558179	711636	4269815
	Electrical	10%	1812790	181279	1994069	299110	2293179	458636	2751815
	Architectural (incl esc and elev)	22%	5288138	528814	5816952	872543	6689494	1337899	8027393
	Utilities (75%)	6%	1087674	108767	1196441	179466	1375908	275182	1651089
	Street restoration (75%)	5.3%	951715	95171	1046886	157033	1203919	240784	1444703
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**33674842**	**3367484**	**37042326**	**5556349**	**42598675**	**8519735**	**51118410**
Cordova Crossover	140								
	Road decking	4%	658407	65841	724248	108637	832885	166577	999462
	Civil/structural	100%	16460183	1646018	18106201	2715930	20822131	4164426	24986558
	Utilities	8%	1316815	131681	1448496	217274	1665771	333154	1998925
	Street restoration	7%	1152213	115221	1267434	190115	1457549	291510	1749059
	Total		**19587618**	**1958762**	**21546380**	**3231957**	**24778336**	**4955667**	**29734004**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	400	3696000	369600	4065600	609840	4675440	935088	5610528
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	5000	46200000	4620000	50820000	7623000	58443000	11688600	70131600
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			96096000	**9609600**	**105705600**	**15855840**	**121561440**	**24312288**	**145873728**
				9.61%		14.49%		21.56%	
GRAND TOTAL ROBSON ALT NORTH END, DEEP (5.0)			**592085659**	**56926629**	**649012288**	**94064141**	**743076430**	**160173783**	**$ 903,250,213**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ROBSON ALTERNATIVE NORTH END, SHALLOW (5.0 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 2770 +200							
	Tunnel linings	7430802	371540	7802342	390117	8192459	1228869	9421328
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	18369263	1836926	20206189	3030928	23237118	6971135	30208253
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	304700	30470	335170	50276	385446	77089	462535
	Invert and walkway	6371000	637100	7008100	1051215	8059315	1611863	9671178
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
West tunnel	Total	**37414265**	**3289886**	**40704151**	**5205389**	**45909540**	**11234069**	**57143609**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7082064	354103	7436167	371808	7807976	1171196	8979172
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	17707029	1770703	19477732	2921660	22399392	6719818	29119209
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
West tunnel	Total	**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
Tunnel Drive 3:	Length 1702							
	Tunnel linings	4565785	228289	4794074	719111	5513186	826978	6340163
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	13392696	1339270	14731966	2209795	16941760	5082528	22024289
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	187220	18722	205942	30891	236833	47367	284200
	Invert and walkway	3914600	391460	4306060	645909	4951969	990394	5942363

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**24042497**	**2175960**	**26218458**	**3932769**	**30151226**	**7549962**	**37701188**
West tunnel	Total		**24042497**	**2175960**	**26218458**	**3932769**	**30151226**	**7549962**	**37701188**
South Portal	Length 150								
	Civil/structural	100%	15912360	1591236	17503596	2625539	20129135	4025827	24154962
	Utilities	2%	318247	31825	350072	52511	402583	80517	483099
	Restoration	2%	318247	31825	350072	52511	402583	80517	483099
	Total		**16548854**	**1654885**	**18203740**	**2730561**	**20934301**	**4186860**	**25121161**
49th Ave Station	130								
	Road decking (50%)	2%	252515	25252	277767	41665	319432	63886	383318
	Civil/structural	100%	12625760	1262576	13888336	2083250	15971586	3194317	19165904
	Mechanical (incl vent fans)	10%	2262576	226258	2488834	373325	2862159	572432	3434590
	Electrical	10%	1262576	126258	1388834	208325	1597159	319432	1916590
	Architectural (incl esc and elev)	22%	4077667	407767	4485434	672815	5158249	1031650	6189899
	Utilities (50%)	4%	505030	50503	555533	83330	638863	127773	766636
	Street restoration (50%)	3.50%	441902	44190	486092	72914	559006	111801	670807
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24478026**	**2447803**	**26925829**	**4038874**	**30964703**	**6192941**	**37157644**
49th Ave Crossover	140								
	Road decking (50%)	2%	184389	18439	202828	30424	233252	46650	279902
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities (50%)	4%	368778	36878	405655	60848	466504	93301	559804
	Street restoration (50%)	3.5%	322680	32268	354948	53242	408191	81638	489829
	Total		**10095288**	**1009529**	**11104817**	**1665723**	**12770539**	**2554108**	**15324647**
57th Ave EEB	10								
	Road decking (50%)	2%	16008	1601	17609	2641	20250	4050	24300
	Civil/structural	100%	800408	80041	880449	132067	1012516	202503	1215019
	Architectural	5%	40020	4002	44022	6603	50626	10125	60751
	Mech/elect (incl vent fans)	20%	660082	66008	726090	108913	835003	167001	1002004
	Utilities (100%)	8%	64033	6403	70436	10565	81001	16200	97202
	Street restoration (100%)	7%	56029	5603	61631	9245	70876	14175	85051
	Total		**1636579**	**163658**	**1800237**	**270036**	**2070273**	**414055**	**2484327**
Oak Ridge Station	130								
	Road decking (50%)	2%	257556	25756	283312	42497	325809	65162	390970
	Civil/structural	100%	12877816	1287782	14165598	2124840	16290437	3258087	19548525
	Mechanical (incl vent fans)	10%	2287782	228778	2516560	377484	2894044	578809	3472852
	Electrical	10%	1287782	128778	1416560	212484	1629044	325809	1954852

	Architectural (incl esc and elev)	22%	4133120	413312	4546431	681965	5228396	1045679	6274075
	Utilities (50%)	4%	515113	51511	566624	84994	651617	130323	781941
	Street restoration (50%)	3.50%	450724	45072	495796	74369	570165	114033	684198
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24859891**	**2485989**	**27345880**	**4101882**	**31447762**	**6289552**	**37737315**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	265633	26563	292196	43829	336025	67205	403230
	Civil/structural	100%	13281635	1328164	14609799	2191470	16801268	3360254	20161522
	Mechanical (incl vent fans)	10%	2328164	232816	2560980	384147	2945127	589025	3534152
	Electrical	10%	1328164	132816	1460980	219147	1680127	336025	2016152
	Architectural (incl esc and elev)	22%	4221960	422196	4644156	696623	5340779	1068156	6408935
	Utilities (50%)	4%	531265	53127	584392	87659	672051	134410	806461
	Street restoration (50%)	3.50%	464857	46486	511343	76701	588044	117609	705653
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25471677**	**2547168**	**28018845**	**4202827**	**32221671**	**6444334**	**38666006**
King Edward Crossover	140								
	Road decking (50%)	2%	199294	19929	219224	32884	252107	50421	302529
	Civil/structural	100%	9964722	996472	10961194	1644179	12605373	2521075	15126448
	Utilities (50%)	4%	398589	39859	438448	65767	504215	100843	605058
	Street restoration (50%)	3.5%	348765	34877	383642	57546	441188	88238	529426
	Total		**10911371**	**1091137**	**12002508**	**1800376**	**13802884**	**2760577**	**16563461**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	426452	42645	469097	70365	539461	107892	647353
	Civil/structural	100%	21322578	2132258	23454836	3518225	26973061	5394612	32367673
	Mechanical (incl vent fans)	10%	3132258	313226	3445484	516823	3962306	792461	4754767

	Electrical	10%	2132258	213226	2345484	351823	2697306	539461	3236767
	Architectural (incl esc and elev)	22%	5990967	599097	6590064	988510	7578573	1515715	9094288
	Utilities (50%)	4%	852903	85290	938193	140729	1078922	215784	1294707
	Street restoration (50%)	3.5%	746290	74629	820919	123138	944057	188811	1132869
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37653706**	**3765371**	**41419076**	**6212861**	**47631938**	**9526388**	**57158325**
TBM Launch Shaft	80								
	Civil/structural	100%	5946447	594645	6541092	981164	7522255	1504451	9026707
	Utilities (50%)	4%	237858	23786	261644	39247	300890	60178	361068
	Street restoration (50%)	3.5%	208126	20813	228938	34341	263279	52656	315935
	Total		**6392431**	**639243**	**7031674**	**1054751**	**8086425**	**1617285**	**9703710**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	586442	58644	645086	96763	741849	148370	890219
	Civil/structural	100%	14661056	1466106	16127162	2419074	18546236	3709247	22255483
	Mechanical (incl vent fans)	10%	2466106	246611	2712716	406907	3119624	623925	3743548
	Electrical	10%	1466106	146611	1612716	241907	1854624	370925	2225548
	Architectural (incl esc and elev)	22%	4525432	452543	4977976	746696	5724672	1144934	6869606
	Utilities	8%	1172884	117288	1290173	193526	1483699	296740	1780439
	Street restoration	7%	1026274	102627	1128901	169335	1298237	259647	1557884
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**28954300**	**2895430**	**31849730**	**4777460**	**36627190**	**7325438**	**43952628**
Pacific Bvld Crossover	140								
	Road decking	4%	368778	36878	405655	60848	466504	93301	559804
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities	8%	737555	73756	811311	121697	933007	186601	1119609
	Street restoration	7%	645361	64536	709897	106485	816382	163276	979658
	Total		**10971135**	**1097113**	**12068248**	**1810237**	**13878486**	**2775697**	**16654183**
Robson Station	130								
	Road decking	4%	443869	44387	488256	73238	561494	112299	673793
	Civil/structural	100%	11096727	1109673	12206400	1830960	14037360	2807472	16844832
	Mechanical (incl vent fans)	10%	2109673	210967	2320640	348096	2668736	533747	3202483
	Electrical	10%	1109673	110967	1220640	183096	1403736	280747	1684483
	Architectural (incl esc and elev)	22%	3741280	374128	4115408	617311	4732719	946544	5679263

	Utilities	8%	887738	88774	976512	146477	1122989	224598	1347587
	Street restoration	7%	776771	77677	854448	128167	982615	196523	1179138
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**23215730**	**2321573**	**25537304**	**3830596**	**29367899**	**5873580**	**35241479**
Cut and Cover	Length 528								
	Civil/structural	100%	27848030	2784803	30632833	4594925	35227758	7045552	42273310
	Utilities	4%	1113921	111392	1225313	183797	1409110	281822	1690932
	Restoration	4%	1113921	111392	1225313	183797	1409110	281822	1690932
	Total		**30075872**	**3007587**	**33083460**	**4962519**	**38045979**	**7609196**	**45655174**
Cordova Station	130								
	Road decking (75%)	3%	353969	35397	389366	58405	447771	89554	537326
	Civil/structural	100%	11798980	1179898	12978878	1946832	14925710	2985142	17910852
	Mechanical (incl vent fans)	10%	2179898	217990	2397888	359683	2757571	551514	3309085
	Electrical	10%	1179898	117990	1297888	194683	1492571	298514	1791085
	Architectural (incl esc and elev)	22%	3895776	389578	4285353	642803	4928156	985631	5913787
	Utilities (75%)	6%	707939	70794	778733	116810	895543	179109	1074651
	Street restoration (75%)	5.3%	619446	61945	681391	102209	783600	156720	940320
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**23785906**	**2378591**	**26164497**	**3924675**	**30089171**	**6017834**	**36107006**
Cordova Crossover	140								
	Road decking	4%	303951	30395	334346	50152	384498	76900	461397
	Civil/structural	100%	7598765	759877	8358642	1253796	9612438	1922488	11534925
	Utilities	8%	607901	60790	668691	100304	768995	153799	922794
	Street restoration	7%	531914	53191	585105	87766	672871	134574	807445
	Total		**9042530**	**904253**	**9946783**	**1492018**	**11438801**	**2287760**	**13726561**
Cut and Cover	Length 60								
	Civil/structural	100%	2127021	212702	2339723	350958	2690682	538136	3228818
	Utilities	4%	85081	8508	93589	14038	107627	21525	129153
	Restoration	4%	85081	8508	93589	14038	107627	21525	129153
	Total		**2297183**	**229718**	**2526901**	**379035**	**2905936**	**581187**	**3487123**
System-wide Elements	9100								
	Trackwork	3000	27300000	2730000	30030000	4504500	34534500	6906900	41441400
	Contact Rail or Catenary	400	3640000	364000	4004000	600600	4604600	920920	5525520
	Tunnel Electrical/Mech	1600	14560000	1456000	16016000	2402400	18418400	3683680	22102080
	Train and Supervisory Control	5000	45500000	4550000	50050000	7507500	57557500	11511500	69069000
	Communications	400	3640000	364000	4004000	600600	4604600	920920	5525520
			94640000	**9464000**	**104104000**	**15615600**	**119719600**	**23943920**	**143663520**

		9.64%		14.48%		21.49%	
GRAND TOTAL ROBSON ALT NORTH END,SHALLOW (5.0)	**581165277**	**56048663**	**637213940**	**92294389**	**729508329**	**156774940**	**$ 886,283,269**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ALTERNATIVE SOUTH END - 1 (5.0 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 1079 +200							
	Tunnel linings	2894525	144726	3039252	151963	3191214	478682	3669896
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	10569905	1056991	11626896	1744034	13370930	4011279	17382209
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	118690	11869	130559	19584	150143	30029	180171
	Invert and walkway	2481700	248170	2729870	409481	3139351	627870	3767221
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**21003320.4**	**1875606**	**22878926**	**3007914**	**25886840**	**6492973**	**32379813**
West tunnel	Total	**21003320.4**	**1875605.8**	**22878926**	**3007913.8**	**25886840**	**6492973**	**32379813**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7082064	354103	7436167	371808	7807976	1171196	8979172
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	17707029	1770703	19477732	2921660	22399392	6719818	29119209
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
West tunnel	Total	**36089993**	**3254896.1**	**39344889**	**5158116.6**	**44503006**	**10765360**	**55268366**
Tunnel Drive 3:	Length 2500							
	Tunnel linings	6706500	335325	7041825	1056274	8098099	1214715	9312814
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	17122794	1712279	18835073	2825261	21660334	6498100	28158435
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	275000	27500	302500	45375	347875	69575	417450
	Invert and walkway	5750000	575000	6325000	948750	7273750	1454750	8728500

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**31836490**	**2848324**	**34684814**	**5202722**	**39887536**	**9839836**	**49727372**
West tunnel	Total		**31836490**	**2848324**	**34684814**	**5202722.1**	**39887536**	**9839836**	**49727372**
South Portal	Length 150								
	Civil/structural	100%	15912360	1591236	17503596	2625539	20129135	4025827	24154962
	Utilities	2%	318247	31825	350072	52511	402583	80517	483099
	Restoration	2%	318247	31825	350072	52511	402583	80517	483099
	Total		**16548854**	**1654885**	**18203740**	**2730561**	**20934301**	**4186860**	**25121161**
Oak Ridge Station	130								
	Road decking (50%)	2%	257556	25756	283312	42497	325809	65162	390970
	Civil/structural	100%	12877816	1287782	14165598	2124840	16290437	3258087	19548525
	Mechanical (incl vent fans)	10%	2287782	228778	2516560	377484	2894044	578809	3472852
	Electrical	10%	1287782	128778	1416560	212484	1629044	325809	1954852
	Architectural (incl esc and elev)	22%	4133120	413312	4546431	681965	5228396	1045679	6274075
	Utilities (50%)	4%	515113	51511	566624	84994	651617	130323	781941
	Street restoration (50%)	3.50%	450724	45072	495796	74369	570165	114033	684198
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24859891**	**2485989**	**27345880**	**4101882**	**31447762**	**6289552**	**37737315**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	265633	26563	292196	43829	336025	67205	403230
	Civil/structural	100%	13281635	1328164	14609799	2191470	16801268	3360254	20161522
	Mechanical (incl vent fans)	10%	2328164	232816	2560980	384147	2945127	589025	3534152
	Electrical	10%	1328164	132816	1460980	219147	1680127	336025	2016152
	Architectural (incl esc and elev)	22%	4221960	422196	4644156	696623	5340779	1068156	6408935
	Utilities (50%)	4%	531265	53127	584392	87659	672051	134410	806461
	Street restoration (50%)	3.50%	464857	46486	511343	76701	588044	117609	705653
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25471677**	**2547168**	**28018845**	**4202827**	**32221671**	**6444334**	**38666006**
King Edward Crossover	140								
	Road decking (50%)	2%	199294	19929	219224	32884	252107	50421	302529
	Civil/structural	100%	9964722	996472	10961194	1644179	12605373	2521075	15126448
	Utilities (50%)	4%	398589	39859	438448	65767	504215	100843	605058

	Street restoration (50%)	3.5%	348765	34877	383642	57546	441188	88238	529426
	Total		**10911371**	**1091137**	**12002508**	**1800376**	**13802884**	**2760577**	**16563461**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	426452	42645	469097	70365	539461	107892	647353
	Civil/structural	100%	21322578	2132258	23454836	3518225	26973061	5394612	32367673
	Mechanical (incl vent fans)	10%	3132258	313226	3445484	516823	3962306	792461	4754767
	Electrical	10%	2132258	213226	2345484	351823	2697306	539461	3236767
	Architectural (incl esc and elev)	22%	5990967	599097	6590064	988510	7578573	1515715	9094288
	Utilities (50%)	4%	852903	85290	938193	140729	1078922	215784	1294707
	Street restoration (50%)	3.5%	746290	74629	820919	123138	944057	188811	1132869
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37653706**	**3765371**	**41419076**	**6212861**	**47631938**	**9526388**	**57158325**
TBM Launch Shaft	80								
	Civil/structural	100%	5946447	594645	6541092	981164	7522255	1504451	9026707
	Utilities (50%)	4%	237858	23786	261644	39247	300890	60178	361068
	Street restoration (50%)	3.5%	208126	20813	228938	34341	263279	52656	315935
	Total		**6392431**	**639243**	**7031674**	**1054751**	**8086425**	**1617285**	**9703710**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	586442	58644	645086	96763	741849	148370	890219
	Civil/structural	100%	14661056	1466106	16127162	2419074	18546236	3709247	22255483
	Mechanical (incl vent fans)	10%	2466106	246611	2712716	406907	3119624	623925	3743548
	Electrical	10%	1466106	146611	1612716	241907	1854624	370925	2225548
	Architectural (incl esc and elev)	22%	4525432	452543	4977976	746696	5724672	1144934	6869606
	Utilities	8%	1172884	117288	1290173	193526	1483699	296740	1780439
	Street restoration	7%	1026274	102627	1128901	169335	1298237	259647	1557884

	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**28954300**	**2895430**	**31849730**	**4777460**	**36627190**	**7325438**	**43952628**
Pacific Bvld Crossover	140								
	Road decking	4%	368778	36878	405655	60848	466504	93301	559804
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities	8%	737555	73756	811311	121697	933007	186601	1119609
	Street restoration	7%	645361	64536	709897	106485	816382	163276	979658
	Total		**10971135**	**1097113**	**12068248**	**1810237**	**13878486**	**2775697**	**16654183**
Nelson Station	130								
	Road decking	4%	518987	51899	570885	85633	656518	131304	787822
	Civil/structural	100%	12974667	1297467	14272134	2140820	16412954	3282591	19695545
	Mechanical (incl vent fans)	10%	2297467	229747	2527213	379082	2906295	581259	3487554
	Electrical	10%	1297467	129747	1427213	214082	1641295	328259	1969554
	Architectural (incl esc and elev)	22%	4154427	415443	4569869	685480	5255350	1051070	6306420
	Utilities	8%	1037973	103797	1141771	171266	1313036	262607	1575644
	Street restoration	7%	908227	90823	999049	149857	1148907	229781	1378688
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26239214**	**2623921**	**28863135**	**4329470**	**33192606**	**6638521**	**39831127**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	516145	51614	567759	85164	652923	130585	783508
	Civil/structural	100%	20645789	2064579	22710368	3406555	26116923	5223385	31340308
	Mechanical (incl vent fans)	10%	3064579	306458	3371037	505656	3876692	775338	4652031
	Electrical	10%	2064579	206458	2271037	340656	2611692	522338	3134031
	Architectural (incl esc and elev)	22%	5842074	584207	6426281	963942	7390223	1478045	8868268
	Utilities (65%)	5%	1032289	103229	1135518	170328	1305846	261169	1567015
	Street restoration (65%)	4.5%	929061	92906	1021967	153295	1175262	235052	1410314
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37144515**	**3714452**	**40858967**	**6128845**	**46987812**	**9397562**	**56385374**
Cordova Station	130								
	Road decking (75%)	3%	543837	54384	598221	89733	687954	137591	825545
	Civil/structural	100%	18127899	1812790	19940689	2991103	22931792	4586358	27518151
	Mechanical (incl vent fans)	10%	2812790	281279	3094069	464110	3558179	711636	4269815
	Electrical	10%	1812790	181279	1994069	299110	2293179	458636	2751815
	Architectural (incl esc and elev)	22%	5288138	528814	5816952	872543	6689494	1337899	8027393
	Utilities (75%)	6%	1087674	108767	1196441	179466	1375908	275182	1651089
	Street restoration (75%)	5.3%	951715	95171	1046886	157033	1203919	240784	1444703
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**33674842**	**3367484**	**37042326**	**5556349**	**42598675**	**8519735**	**51118410**

Cordova Crossover	140								
	Road decking	4%	658407	65841	724248	108637	832885	166577	999462
	Civil/structural	100%	16460183	1646018	18106201	2715930	20822131	4164426	24986558
	Utilities	8%	1316815	131681	1448496	217274	1665771	333154	1998925
	Street restoration	7%	1152213	115221	1267434	190115	1457549	291510	1749059
	Total		**19587618**	**1958762**	**21546380**	**3231957**	**24778336**	**4955667**	**29734004**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	400	3696000	369600	4065600	609840	4675440	935088	5610528
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	5000	46200000	4620000	50820000	7623000	58443000	11688600	70131600
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			96096000	**9609600**	**105705600**	**15855840**	**121561440**	**24312288**	**145873728**
				9.67%		14.62%		21.44%	
GRAND TOTAL FOR ALTERNATIVE SOUTH END - 1 (5.0)			**557406447**	**53912336**	**611318783**	**89362734**	**700681516**	**150221687**	**$ 850,903,204**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

Richmond Airport Vancouver Project

Estimate Summary

ALTERNATIVE SOUTH END - 2 (5.0 m Dia)		Direct Costs	Indirect Costs Varies	Subtotal	Profit Varies	Subtotal	Contingency Varies	Total Bid Costs
Tunnel Drive 1:	Length 1130 +200							
	Tunnel linings	3031338	151567	3182905	159145	3342050	501308	3843358
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	10831761	1083176	11914937	1787241	13702178	4110653	17812831
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	124300	12430	136730	20510	157240	31448	188687
	Invert and walkway	2599000	259900	2858900	428835	3287735	657547	3945282
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**21524899**	**1920923**	**23445822**	**3078583**	**26524405**	**6646069**	**33170473**
West tunnel	Total	**21524899**	**1920923**	**23445822**	**3078582.8**	**26524405**	**6646069**	**33170473**
Tunnel Drive 2:	Length 2640 +200							
	Tunnel linings	7082064	354103	7436167	371808	7807976	1171196	8979172
East tunnel	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	17707029	1770703	19477732	2921660	22399392	6719818	29119209
	TBM skidding	600000	60000	660000	99000	759000	151800	910800
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	290400	29040	319440	47916	367356	73471	440827
	Invert and walkway	6072000	607200	6679200	1001880	7681080	1152162	8833242
	D&B tunnel	2356304	235630	2591934	388790	2980725	894217	3874942
	Crosspassages	800000	80000	880000	132000	1012000	303600	1315600
	Total	**36089993**	**3254896**	**39344889**	**5158117**	**44503006**	**10765360**	**55268366**
West tunnel	Total	**36089993**	**3254896.1**	**39344889**	**5158116.6**	**44503006**	**10765360**	**55268366**
Tunnel Drive 3:	Length 2500							
	Tunnel linings	6706500	335325	7041825	1056274	8098099	1214715	9312814
	TBM set up	782196	78220	860416	129062	989478	197896	1187374
	TBM drive	17122794	1712279	18835073	2825261	21660334	6498100	28158435
	TBM removal	400000	40000	440000	66000	506000	101200	607200
	Tunnel clean up	275000	27500	302500	45375	347875	69575	417450
	Invert and walkway	5750000	575000	6325000	948750	7273750	1454750	8728500

	Crosspassages		800000	80000	880000	132000	1012000	303600	1315600
	Total		**31836490**	**2848324**	**34684814**	**5202722**	**39887536**	**9839836**	**49727372**
West tunnel	Total		**31836490**	**2848324**	**34684814**	**5202722.1**	**39887536**	**9839836**	**49727372**
South Portal	Length 150								
	Civil/structural	100%	15912360	1591236	17503596	2625539	20129135	4025827	24154962
	Utilities	2%	318247	31825	350072	52511	402583	80517	483099
	Restoration	2%	318247	31825	350072	52511	402583	80517	483099
	Total		**16548854**	**1654885**	**18203740**	**2730561**	**20934301**	**4186860**	**25121161**
Oak Ridge Station	130								
	Road decking (50%)	2%	257556	25756	283312	42497	325809	65162	390970
	Civil/structural	100%	12877816	1287782	14165598	2124840	16290437	3258087	19548525
	Mechanical (incl vent fans)	10%	2287782	228778	2516560	377484	2894044	578809	3472852
	Electrical	10%	1287782	128778	1416560	212484	1629044	325809	1954852
	Architectural (incl esc and elev)	22%	4133120	413312	4546431	681965	5228396	1045679	6274075
	Utilities (50%)	4%	515113	51511	566624	84994	651617	130323	781941
	Street restoration (50%)	3.50%	450724	45072	495796	74369	570165	114033	684198
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**24859891**	**2485989**	**27345880**	**4101882**	**31447762**	**6289552**	**37737315**
Queen Elizabeth Park Shaft	10								
	Civil/structural	100%	1189791	118979	1308770	196316	1505086	301017	1806103
	Architectural	5%	59490	5949	65439	9816	75254	15051	90305
	Mech/elect	20%	737958	73796	811754	121763	933517	186703	1120221
	Total		**1987239**	**198724**	**2185963**	**327894**	**2513857**	**502771**	**3016628**
King Edward Station	130								
	Road decking (50%)	2%	265633	26563	292196	43829	336025	67205	403230
	Civil/structural	100%	13281635	1328164	14609799	2191470	16801268	3360254	20161522
	Mechanical (incl vent fans)	10%	2328164	232816	2560980	384147	2945127	589025	3534152
	Electrical	10%	1328164	132816	1460980	219147	1680127	336025	2016152
	Architectural (incl esc and elev)	22%	4221960	422196	4644156	696623	5340779	1068156	6408935
	Utilities (50%)	4%	531265	53127	584392	87659	672051	134410	806461
	Street restoration (50%)	3.50%	464857	46486	511343	76701	588044	117609	705653
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**25471677**	**2547168**	**28018845**	**4202827**	**32221671**	**6444334**	**38666006**
King Edward Crossover	140								
	Road decking (50%)	2%	199294	19929	219224	32884	252107	50421	302529
	Civil/structural	100%	9964722	996472	10961194	1644179	12605373	2521075	15126448
	Utilities (50%)	4%	398589	39859	438448	65767	504215	100843	605058

	Street restoration (50%)	3.5%	348765	34877	383642	57546	441188	88238	529426
	Total		**10911371**	**1091137**	**12002508**	**1800376**	**13802884**	**2760577**	**16563461**
16th Ave EEB	10								
	Road decking (50%)	2%	16733	1673	18406	2761	21167	4233	25400
	Civil/structural	100%	836635	83664	920299	138045	1058343	211669	1270012
	Architectural	5%	41832	4183	46015	6902	52917	10583	63501
	Mech/elect (incl vent fans)	20%	667327	66733	734060	110109	844169	168834	1013002
	Utilities (100%)	8%	66931	6693	73624	11044	84667	16933	101601
	Street restoration (100%)	7%	58564	5856	64421	9663	74084	14817	88901
	Total		**1688022**	**168802**	**1856824**	**278524**	**2135347**	**427069**	**2562417**
Broadway Station	130								
	Road decking (50%)	2%	426452	42645	469097	70365	539461	107892	647353
	Civil/structural	100%	21322578	2132258	23454836	3518225	26973061	5394612	32367673
	Mechanical (incl vent fans)	10%	3132258	313226	3445484	516823	3962306	792461	4754767
	Electrical	10%	2132258	213226	2345484	351823	2697306	539461	3236767
	Architectural (incl esc and elev)	22%	5990967	599097	6590064	988510	7578573	1515715	9094288
	Utilities (50%)	4%	852903	85290	938193	140729	1078922	215784	1294707
	Street restoration (50%)	3.5%	746290	74629	820919	123138	944057	188811	1132869
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37653706**	**3765371**	**41419076**	**6212861**	**47631938**	**9526388**	**57158325**
TBM Launch Shaft	80								
	Civil/structural	100%	5946447	594645	6541092	981164	7522255	1504451	9026707
	Utilities (50%)	4%	237858	23786	261644	39247	300890	60178	361068
	Street restoration (50%)	3.5%	208126	20813	228938	34341	263279	52656	315935
	Total		**6392431**	**639243**	**7031674**	**1054751**	**8086425**	**1617285**	**9703710**
Launch Shaft EEB	10								
	Civil/structural	100%	692821	69282	762103	114315	876419	175284	1051702
	Architectural	5%	34641	3464	38105	5716	43821	8764	52585
	Mech/elect (incl vent fans)	20%	638564	63856	702421	105363	807784	161557	969340
	Total		**1366026**	**136603**	**1502629**	**225394**	**1728023**	**345605**	**2073628**
Pacific Blvd Station	130								
	Road decking	4%	586442	58644	645086	96763	741849	148370	890219
	Civil/structural	100%	14661056	1466106	16127162	2419074	18546236	3709247	22255483
	Mechanical (incl vent fans)	10%	2466106	246611	2712716	406907	3119624	623925	3743548
	Electrical	10%	1466106	146611	1612716	241907	1854624	370925	2225548
	Architectural (incl esc and elev)	22%	4525432	452543	4977976	746696	5724672	1144934	6869606
	Utilities	8%	1172884	117288	1290173	193526	1483699	296740	1780439
	Street restoration	7%	1026274	102627	1128901	169335	1298237	259647	1557884

	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**28954300**	**2895430**	**31849730**	**4777460**	**36627190**	**7325438**	**43952628**
Pacific Bvld Crossover	140								
	Road decking	4%	368778	36878	405655	60848	466504	93301	559804
	Civil/structural	100%	9219441	921944	10141385	1521208	11662593	2332519	13995111
	Utilities	8%	737555	73756	811311	121697	933007	186601	1119609
	Street restoration	7%	645361	64536	709897	106485	816382	163276	979658
	Total		**10971135**	**1097113**	**12068248**	**1810237**	**13878486**	**2775697**	**16654183**
Nelson Station	130								
	Road decking	4%	518987	51899	570885	85633	656518	131304	787822
	Civil/structural	100%	12974667	1297467	14272134	2140820	16412954	3282591	19695545
	Mechanical (incl vent fans)	10%	2297467	229747	2527213	379082	2906295	581259	3487554
	Electrical	10%	1297467	129747	1427213	214082	1641295	328259	1969554
	Architectural (incl esc and elev)	22%	4154427	415443	4569869	685480	5255350	1051070	6306420
	Utilities	8%	1037973	103797	1141771	171266	1313036	262607	1575644
	Street restoration	7%	908227	90823	999049	149857	1148907	229781	1378688
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**26239214**	**2623921**	**28863135**	**4329470**	**33192606**	**6638521**	**39831127**
Dunsmuir Station	130								
	Road decking (65%)	2.5%	516145	51614	567759	85164	652923	130585	783508
	Civil/structural	100%	20645789	2064579	22710368	3406555	26116923	5223385	31340308
	Mechanical (incl vent fans)	10%	3064579	306458	3371037	505656	3876692	775338	4652031
	Electrical	10%	2064579	206458	2271037	340656	2611692	522338	3134031
	Architectural (incl esc and elev)	22%	5842074	584207	6426281	963942	7390223	1478045	8868268
	Utilities (65%)	5%	1032289	103229	1135518	170328	1305846	261169	1567015
	Street restoration (65%)	4.5%	929061	92906	1021967	153295	1175262	235052	1410314
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**37144515**	**3714452**	**40858967**	**6128845**	**46987812**	**9397562**	**56385374**
Cordova Station	130								
	Road decking (75%)	3%	543837	54384	598221	89733	687954	137591	825545
	Civil/structural	100%	18127899	1812790	19940689	2991103	22931792	4586358	27518151
	Mechanical (incl vent fans)	10%	2812790	281279	3094069	464110	3558179	711636	4269815
	Electrical	10%	1812790	181279	1994069	299110	2293179	458636	2751815
	Architectural (incl esc and elev)	22%	5288138	528814	5816952	872543	6689494	1337899	8027393
	Utilities (75%)	6%	1087674	108767	1196441	179466	1375908	275182	1651089
	Street restoration (75%)	5.3%	951715	95171	1046886	157033	1203919	240784	1444703
	Substation equipment		3050000	305000	3355000	503250	3858250	771650	4629900
	Total		**33674842**	**3367484**	**37042326**	**5556349**	**42598675**	**8519735**	**51118410**

Cordova Crossover	140								
	Road decking	4%	658407	65841	724248	108637	832885	166577	999462
	Civil/structural	100%	16460183	1646018	18106201	2715930	20822131	4164426	24986558
	Utilities	8%	1316815	131681	1448496	217274	1665771	333154	1998925
	Street restoration	7%	1152213	115221	1267434	190115	1457549	291510	1749059
	Total		**19587618**	**1958762**	**21546380**	**3231957**	**24778336**	**4955667**	**29734004**
System-wide Elements	9240								
	Trackwork	3000	27720000	2772000	30492000	4573800	35065800	7013160	42078960
	Contact Rail or Catenary	400	3696000	369600	4065600	609840	4675440	935088	5610528
	Tunnel Electrical/Mech	1600	14784000	1478400	16262400	2439360	18701760	3740352	22442112
	Train and Supervisory Control	5000	46200000	4620000	50820000	7623000	58443000	11688600	70131600
	Communications	400	3696000	369600	4065600	609840	4675440	935088	5610528
			96096000	**9609600**	**105705600**	**15855840**	**121561440**	**24312288**	**145873728**
				9.67%		14.61%		21.44%	
GRAND TOTAL FOR ALTERNATIVE SOUTH END - 2 (5.0)			**558449604**	**54002970**	**612452574**	**89504072**	**701956646**	**150527879**	**$ 852,484,525**

Cost estimate does not include: floating track slab, fare collection, property, demolition, engineering, project and construction management
Costs are in 2002 dollars, before taxes, and do not include project escalation

RAVP
Station Cost Summary
Stations sized to suit 5.7m dia tunnels

Robson Station Alternative - Deep Alignment

Area	South Portal	49th St Station	Oak Ridge Station	King Edward Station	Broadway Station	Pacific Blvd Station	Robson Station	Cut and Cover	Cordova Station	North Portal	
Cut and cover section	16,734,302	0	0	0	0	0	0	0	0	0	
Platform Chamber and Concourse	0	10,376,469	10,732,732	11,076,060	15,214,035	10,732,732	11,919,301	0	15,110,241	0	
Crossover	0	10,022,181	0	10,801,384	0	10,022,181	0	0	17,734,650	0	
Tunnel Connecting Concourse to Main Entrance	0	390,784	390,784	390,784	390,784	390,784	390,784	0	390,784	0	
Main Entrance and Escalator Tunnel	0	724,970	710,990	724,970	933,971	724,970	1,108,138	0	1,108,138	0	
Tunnel Connecting Concourse to Secondary Entrance	0	353,623	353,623	353,623	353,623	353,623	353,623	0	353,623	0	
Secondary Entrance and Escalator Tunnel	0	384,043	384,043	384,043	518,033	378,540	518,033	0	518,033	0	
EEB + Vent Shaft, Tunnel, & Stairs	0	800,408	0	0	836,635	692,821	0	0	0	0	
Broadway Line Advance Works	0	0	0	0	3,026,694	0	0	0	0	0	
TBM Launch Shaft	0	0	0	0	6,454,578	0	0	0	0	0	**Grand**
Internal Walls etc (10% of 1,4,6,7, and 8)	0	1,228,589	1,182,776	1,218,507	2,052,937	1,277,667	1,354,547	0	1,673,641	0	**Total**
Total Direct Cost	**16,734,302**	**24,281,068**	**13,754,948**	**24,949,372**	**29,781,290**	**24,573,318**	**15,644,425**	**0**	**36,889,109**	**0**	186,607,833

Robson Station Alternative - Shallow Alignment

Area	South Portal	49th St Station	Oak Ridge Station	King Edward Station	Broadway Station	Pacific Blvd Station	Shallow Robson Station	Cut and Cover	Shallow Cordova Station	North Portal	
Cut and cover section	16,734,302	0	0	0	0	0	0	30,478,061	0	2,322,710	
Platform Chamber and Concourse	0	10,376,469	10,732,732	11,076,060	15,214,035	10,732,732	8,509,375	0	9,648,948	0	
Crossover	0	10,022,181	0	10,801,384	0	10,022,181	0	0	8,316,701	0	
Tunnel Connecting Concourse to Main Entrance	0	390,784	390,784	390,784	390,784	390,784	390,784	0	390,784	0	
Main Entrance and Escalator Tunnel	0	724,970	710,990	724,970	933,971	724,970	1,108,138	0	759,804	0	
Tunnel Connecting Concourse to Secondary Entrance	0	353,623	353,623	353,623	353,623	353,623	353,623	0	353,623	0	
Secondary Entrance and Escalator Tunnel	0	384,043	384,043	384,043	518,033	378,540	518,033	0	361,711	0	
EEB + Vent Shaft, Tunnel, & Stairs	0	800,408	0	0	836,635	692,821	0	0	0	0	
Broadway Line Advance Works	0	0	0	0	3,026,694	0	0	0	0	0	
TBM Launch Shaft	0	0	0	0	6,454,578	0	0	0	0	0	**Grand**
Internal Walls etc (10% of 1,4,6,7, and 8)	0	1,228,589	1,182,776	1,218,507	2,052,937	1,277,667	1,013,554	0	1,077,046	0	**Total**
Total Direct Cost	**16,734,302**	**24,281,068**	**13,754,948**	**24,949,372**	**29,781,290**	**24,573,318**	**11,893,506**	**30,478,061**	**20,908,617**	**2,322,710**	199,677,193

RAVP
Station Cost Summary
(Following costs to suit 5.0 m dia tunnels)

Robson Station Alternative - Deep Alignment

Area	South Portal	49th St Station	Oak Ridge Station	King Edward Station	Broadway Station	Pacific Blvd Station	Robson Station	Cut and Cover	Cordova Station	North Portal	
1 Cut and cover section	15,912,360	0	0	0	0	0	0	0	0	0	
2 Platform Chamber and Concourse	0	9,619,452	9,935,339	10,288,467	14,152,672	9,935,339	11,068,727	0	14,177,004	0	
3 Crossover	0	9,219,441	0	9,964,722	0	9,219,441	0	0	16,460,183	0	
4 Tunnel Connecting Concourse to Main Entrance	0	390,784	390,784	390,784	390,784	390,784	390,784	0	390,784	0	
5 Main Entrance and Escalator Tunnel	0	724,970	710,990	724,970	933,971	724,970	1,108,138	0	1,108,138	0	
6 Tunnel Connecting Concourse to Secondary Entrance	0	353,623	353,623	353,623	353,623	353,623	353,623	0	353,623	0	
7 Secondary Entrance and Escalator Tunnel	0	384,043	384,043	384,043	518,033	378,540	518,033	0	518,033	0	
8 EEB + Vent Shaft, Tunnel, & Stairs	0	800,408	0	0	836,635	692,821	0	0	0	0	
9 Broadway Line Advance Works	0	0	0	0	3,026,694	0	0	0	0	0	
10 TBM Launch Shaft	0	0	0	0	5,946,447	0	0	0	0	0	Grand
11 Internal Walls etc (10% of 1,4,6,7, and 8)	0	1,152,887	1,103,037	1,139,748	1,946,801	1,173,167	1,269,490	0	1,580,317	0	Total
Total Direct Cost	**15,912,360**	**22,645,609**	**12,877,816**	**23,246,357**	**28,105,660**	**22,868,685**	**14,708,794**	**0**	**34,588,082**	**0**	174,953,362
		12,625,759	11,887,624	**13,281,635**	**21,322,577**	**12,956,423**			18,127,899		
				13,281,635							

Robson Station Alternative - Shallow Alignment

Area	South Portal	49th St Station	Oak Ridge Station	King Edward Station	Broadway Station	Pacific Blvd Station	Shallow Robson Station	Cut and Cover	Shallow Cordova Station	North Portal
Cut and cover section	15,912,360	0	0	0	0	0	0	27,848,030	0	2,127,021
Platform Chamber and Concourse	0	9,619,452	9,935,339	10,288,467	14,152,672	9,935,339	7,785,030	0	8,928,097	0
Crossover	0	9,219,441	0	9,964,722	0	9,219,441	0	0	7,598,765	0
[illegible]	0	390,784	390,784	390,784	390,784	390,784	390,784	0	390,784	0

RAVP
Station Cost Summary
(Following costs to suit 5.0 m dia tunnels)

Reference Alignment

Area	South Portal	49th St Station	Oak Ridge Station	King Edward Station	Broadway Station	Pacific Blvd Station	Nelson Station	Dunsmuir Station	Cut and Cover	Cordova Station	North Portal	
1 Cut and cover section	15,912,360	0	0	0	0	0	0	0	0	0	0	
2 Platform Chamber and Concourse	0	9,619,452	9,935,339	10,288,467	14,152,672	9,935,339	10,009,405	16,465,995	0	14,177,004	0	
3 Crossover	0	9,219,441	0	9,964,722	0	9,219,441	0	0	0	16,460,183	0	
4 Tunnel Connecting Concourse to Main Entrance	0	390,784	390,784	390,784	390,784	390,784	390,784	390,784	0	390,784	0	
5 Main Entrance and Escalator Tunnel	0	724,970	710,990	724,970	933,971	724,970	724,970	1,108,138	0	1,108,138	0	
6 Tunnel Connecting Concourse to Secondary Entrance	0	353,623	353,623	353,623	353,623	353,623	353,623	353,623	0	353,623	0	
7 Secondary Entrance and Escalator Tunnel	0	384,043	384,043	384,043	518,033	378,540	384,043	518,033	0	518,033	0	
8 EEB + Vent Shaft, Tunnel, & Stairs	0	800,408	0	0	836,635	692,821	0	0	0	0	0	
9 Broadway Line Advance Works	0	0	0	0	3,026,694	0	0	0	0	0	0	
10 TBM Launch Shaft	0	0	0	0	5,946,447	0	0	0	0	0	0	Grand
11 Internal Walls etc (10% of 1,4,6,7, and 8)	0	1,152,887	1,103,037	1,139,748	1,946,801	1,173,167	1,111,842	1,809,217	0	1,580,317	0	Total
Total Direct Cost	15,912,360	22,645,609	12,877,816	23,246,357	28,105,660	22,868,685	12,974,667	20,645,789	0	34,588,082	0	193,865,024
		12,625,759	11,887,624	13,281,635	21,322,577	12,956,423				18,127,899		

Alternative North End

13,281,635

Area	South Portal	49th St Station	Oak Ridge Station	King Edward Station	Broadway Station	Pacific Blvd Station	Nelson Station	Shallow Dunsmuir Station	Cut and Cover	Shallow Cordova Station	North Portal	
Cut and cover section	15,912,360	0	0	0	0	0	0	0	4,738,857	0	2,127,021	
Platform Chamber and Concourse	0	9,619,452	9,935,339	10,288,467	14,152,672	9,935,339	10,009,405	9,367,633	0	8,928,097	0	
Crossover	0	9,219,441	0	9,964,722	0	9,219,441	0	0	0	7,598,765	0	
Tunnel Connecting Concourse to Main Entrance	0	390,784	390,784	390,784	390,784	390,784	390,784	390,784	0	390,784	0	
Main Entrance and Escalator Tunnel	0	724,970	710,990	724,970	933,971	724,970	724,970	1,108,138	0	759,804	0	
Tunnel Connecting Concourse to Secondary Entrance	0	353,623	353,623	353,623	353,623	353,623	353,623	353,623	0	353,623	0	
Secondary Entrance and Escalator Tunnel	0	384,043	384,043	384,043	518,033	378,540	384,043	518,033	0	361,711	0	
EEB + Vent Shaft, Tunnel, & Stairs	0	800,408	0	0	836,635	692,821	0	0	0	0	0	
Broadway Line Advance Works	0	0	0	0	3,026,694	0	0	0	0	0	0	
TBM Launch Shaft	0	0	0	0	5,946,447	0	0	0	0	0	0	Grand
Internal Walls etc (10% of 1,4,6,7, and 8)	0	1,152,887	1,103,037	1,139,748	1,946,801	1,173,167	1,111,842	1,099,380	0	1,004,961	0	Total
Total Direct Cost	15,912,360	22,645,609	12,877,816	23,246,357	28,105,660	22,868,685	12,974,667	12,837,591	4,738,857	19,397,745	2,127,021	177,732,367