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Figure 38: 2050 AM Volume Difference Plot – 6-Lane vs BAU

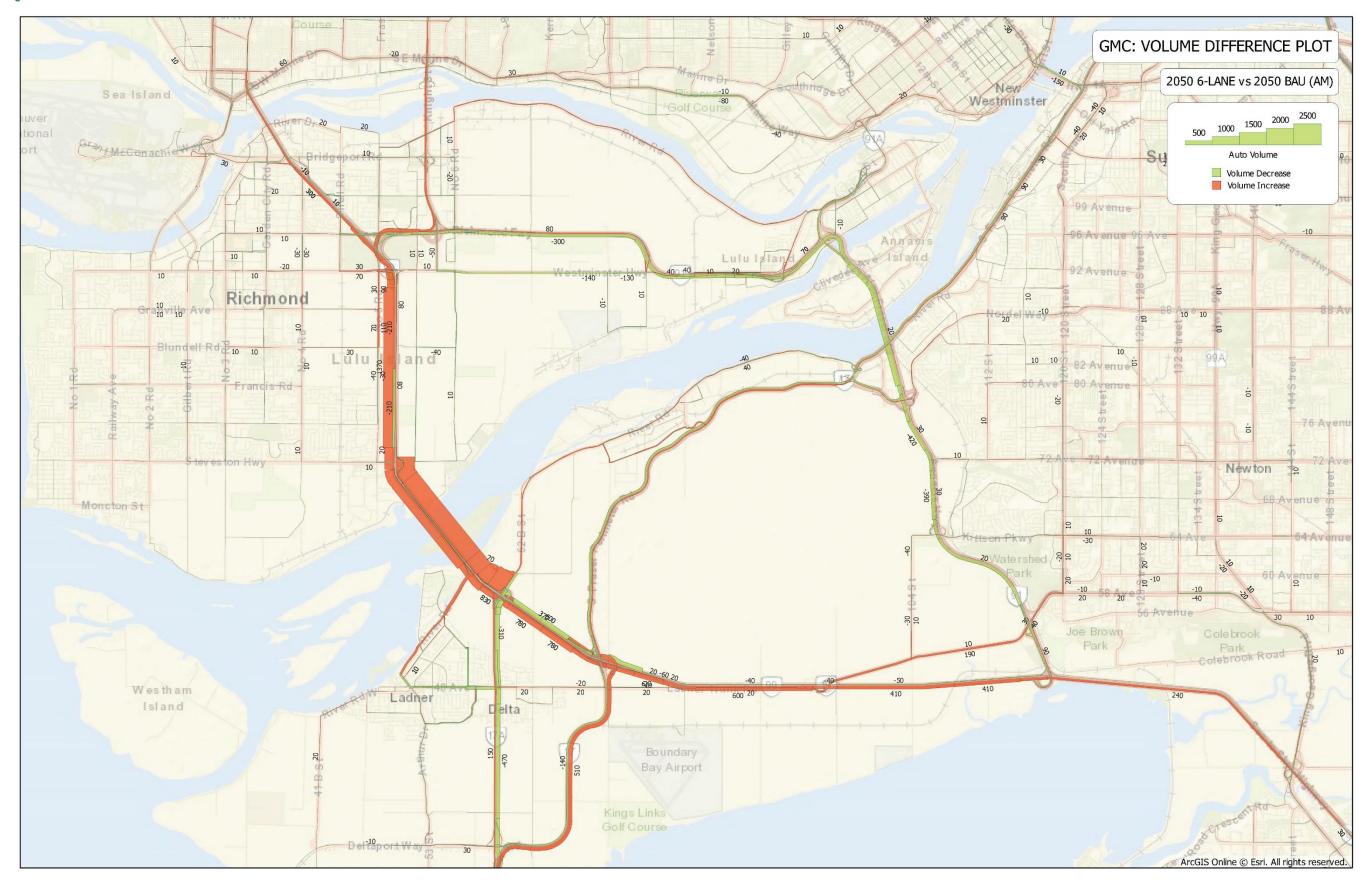


Figure 39: 2050 PM Volume Difference Plot – 6-Lane vs BAU



Figure 40: 2050 AM Volume Difference Plot – 8-Lane vs BAU



Figure 41: 2050 PM Volume Difference Plot – 8-Lane vs BAU



Figure 42: 2050 AM BAU Trip Distribution Patterns

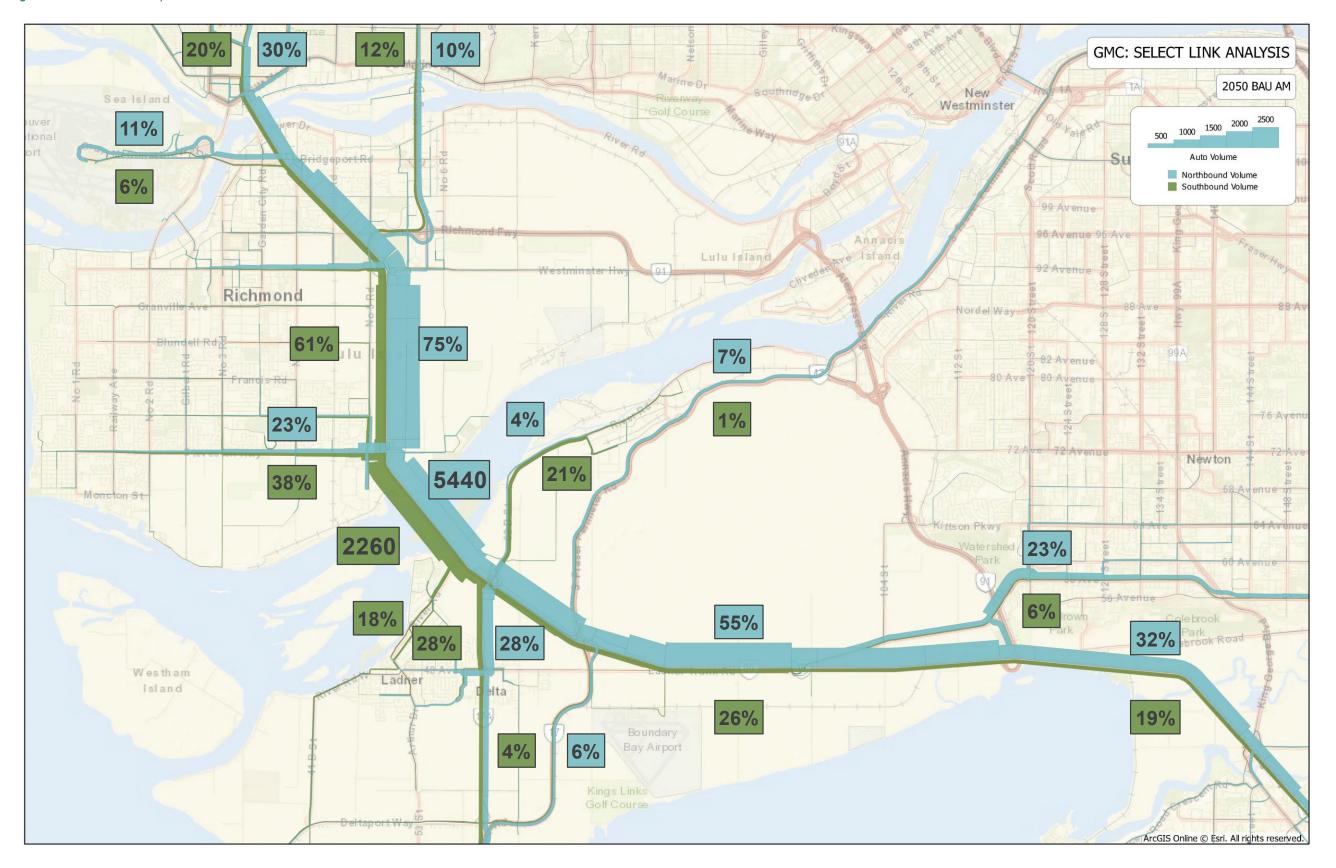


Figure 43: 2050 PM BAU Trip Distribution Patterns

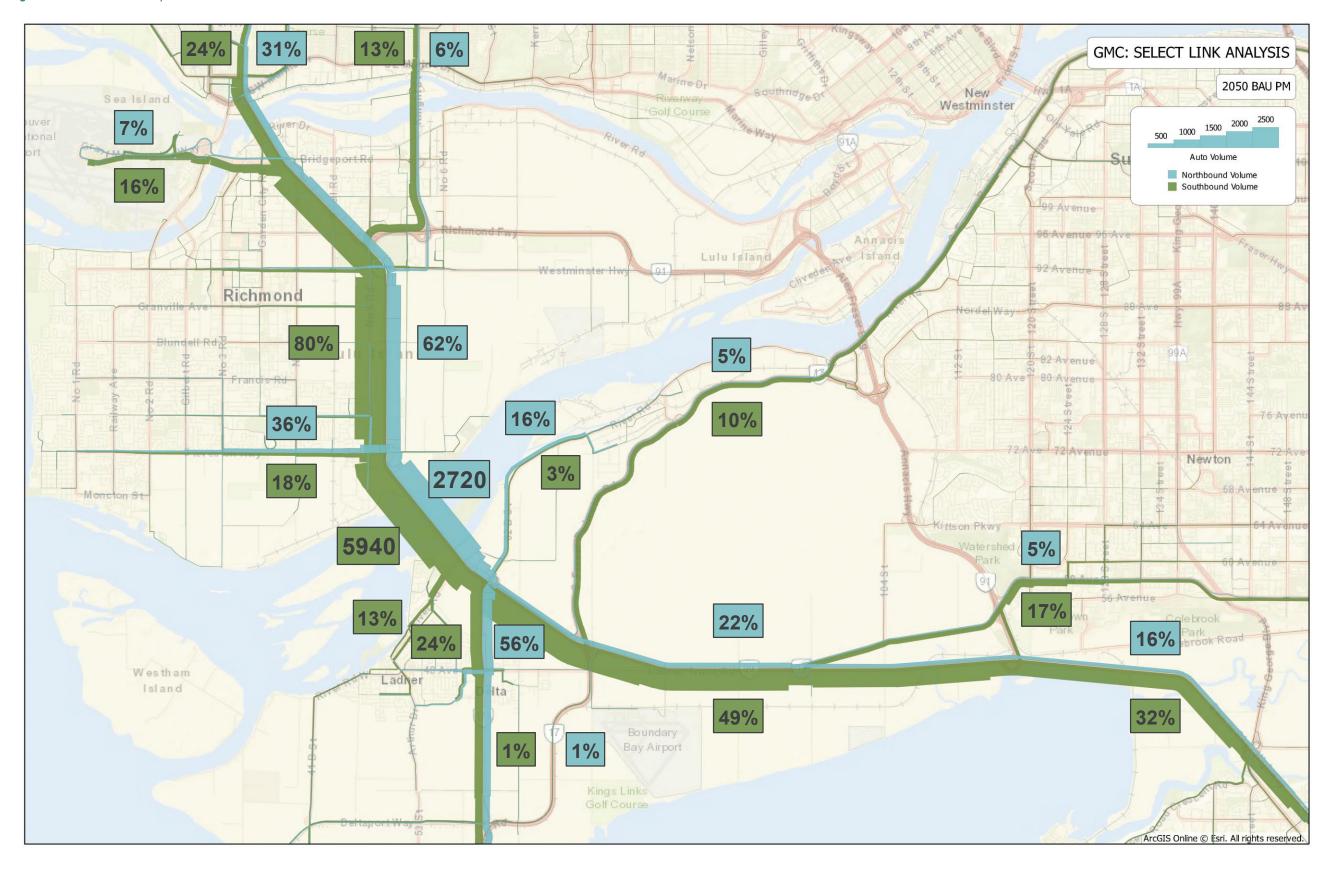


Figure 44: 2050 AM 8-Lane Trip Distribution Patterns

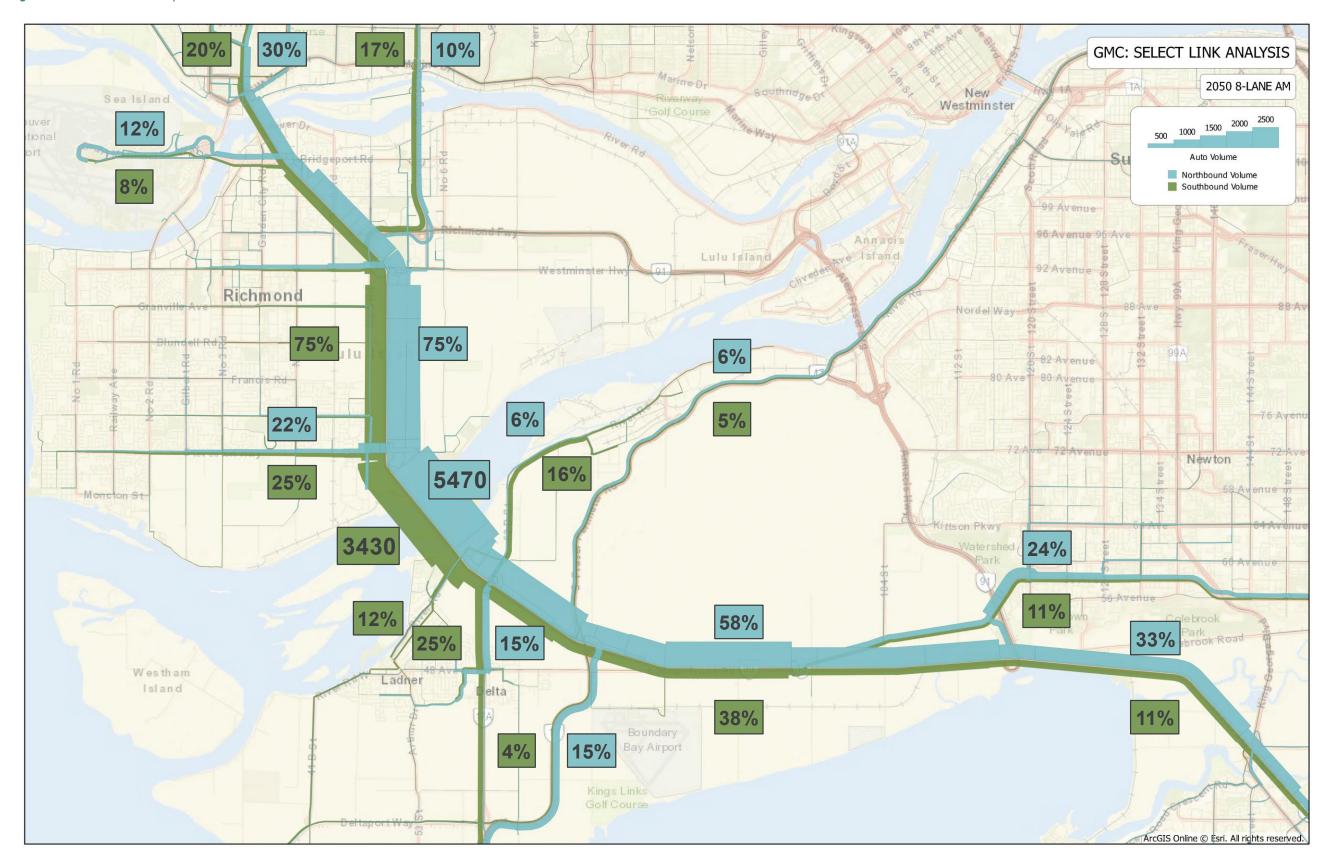
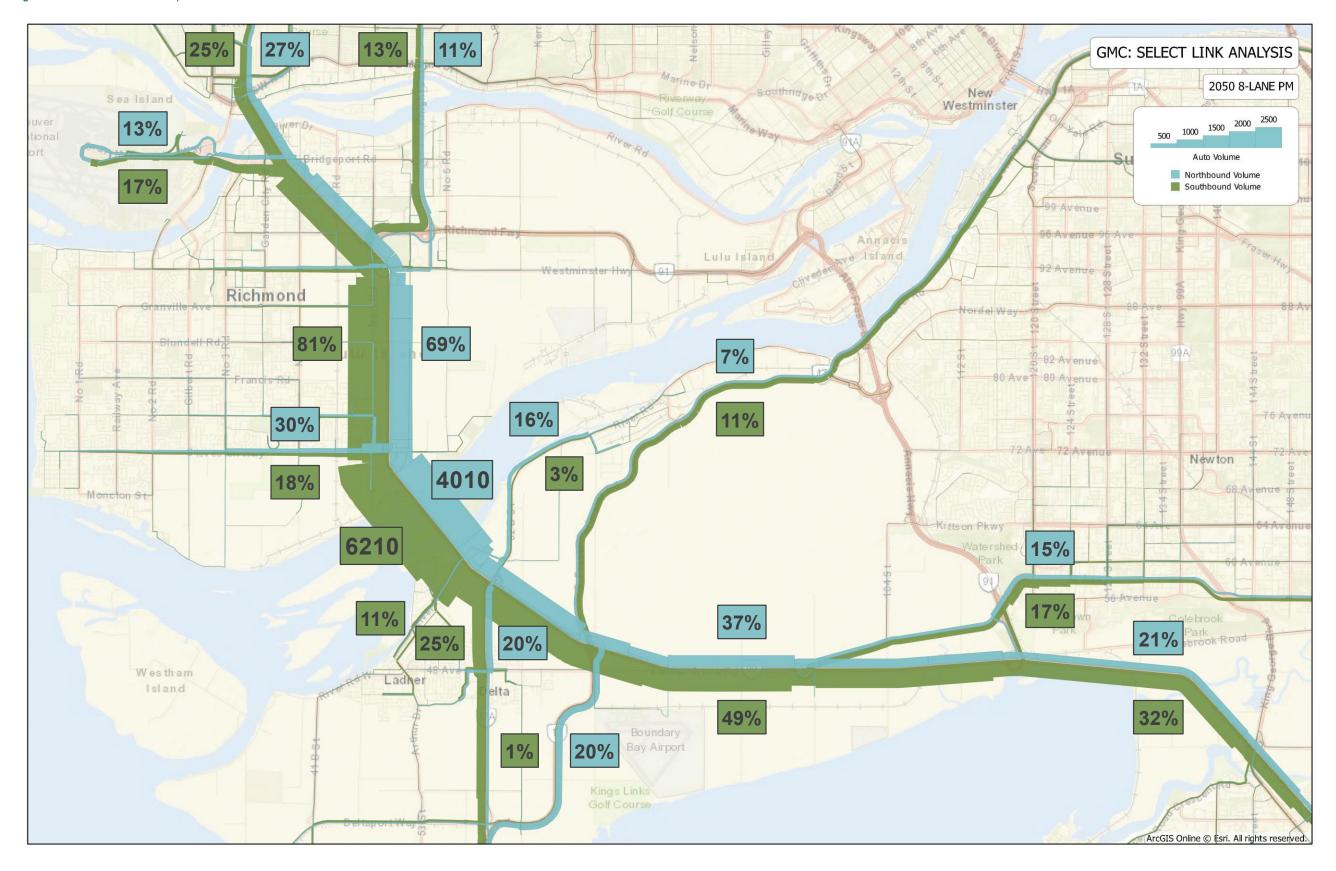


Figure 45: 2050 PM 8-Lane Trip Distribution Patterns



Appendix A – Model Validation

The comparison of modelled to observed travel metrics as part of the model validation process is provided in the following set of figures. A comparison of directional trip distribution patterns of the TomTom observed versus the RTM3 is shown in *Figures A1* through *A4*. Note that the percentages are reported as a percentage of the GMC directional crossing volume. Generally, the model provides a good fit for traffic entering and existing the Highway 99 corridor in the study area. There appears to be a slight deficiency in the representation of long distance trips from the South Surrey/White Rock area to Vancouver. This could be a deficiency in the trip distribution component of the model, or potential underrepresentation of long distance trips coming from and going to the Canada/US border.

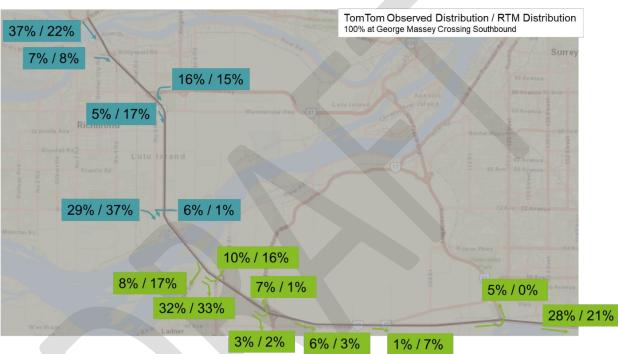


Figure A1: 2017 AM Peak Southbound Trip Distribution Validation

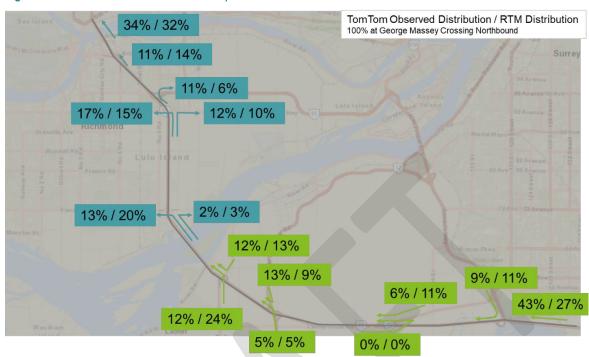
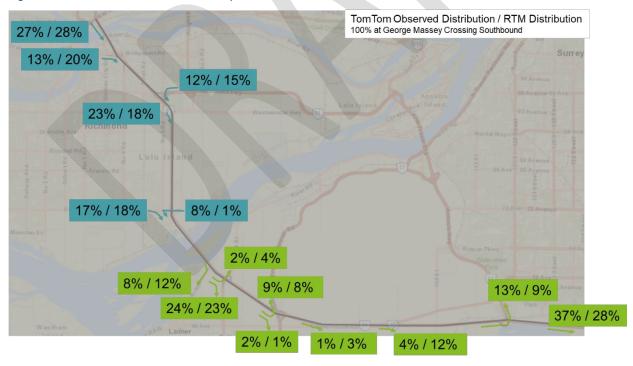


Figure A2: 2017 AM Peak Northbound Trip Distribution Validation





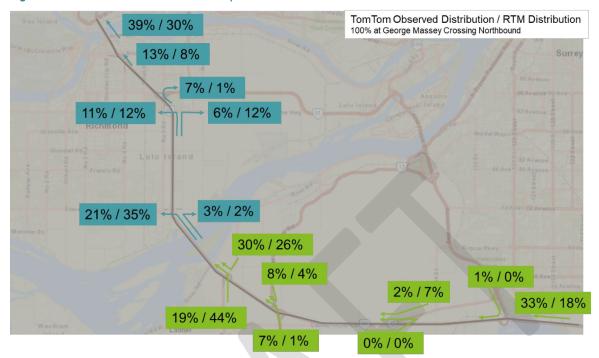


Figure A4: 2017 PM Peak Northbound Trip Distribution Validation

Permanent count data was available from the Ministry of Transportation and Infrastructure to check volumes for key links in the network. *Figure A5* below shows the observed traffic volumes by link south of the Fraser River. Note that these volumes, particularly for GMC, are peak throughput volumes during the AM peak period. Note that the peak volumes generally occur at 7:00 am and the RTM3 model represents traffic volumes from 7:30-8:30 am. These are useful reference numbers, however, to determine peak directional throughput at GMC.



Figure A5: 2017 PM Peak Northbound Trip Distribution Validation

Traffic volume validation is summarized in *Table A1* and *Figure A6* through *A8* which shows a reasonable goodness of fit (R²>0.9) compared to observed volumes at several traffic count locations for the AM peak, midday and PM peak conditions. The GEH statistic provides a comparable validation metric that accounts for the volume of traffic. For example, a deviation of 10 vehicles on a total count of 100 is significant, while for a count of 1,000 is not significant. A GEH value of less than 10 shows that a modelled link volume is acceptable when compared to a traffic count. The metric in *Table A1* is the percentage of traffic count stations that fall within a GEH of less than 10.

Table A1: Model Volume Validation GEH Statistics

GEH Calculation	AM Peak		lation AM Peak Midday		PM Peak	
Total Points	59		59		59	
GEH < 10.0	78%	46	71%	42	73%	43

Figure A6: AM Peak Hour Traffic Volume Validation

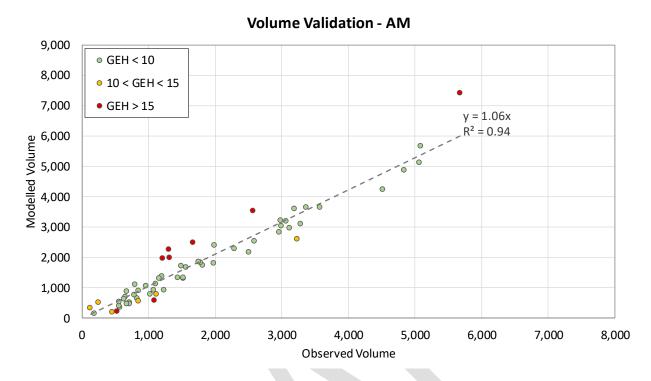
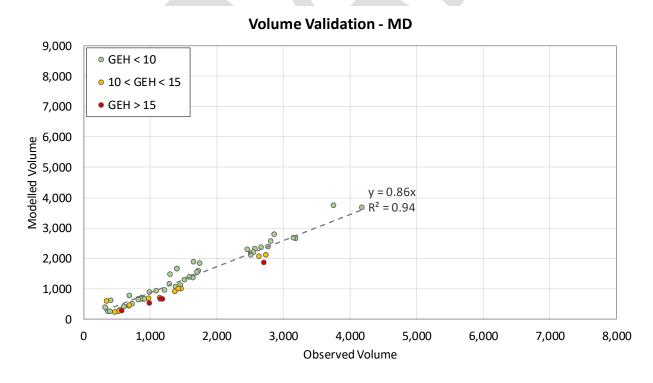


Figure A7: Midday Traffic Volume Validation



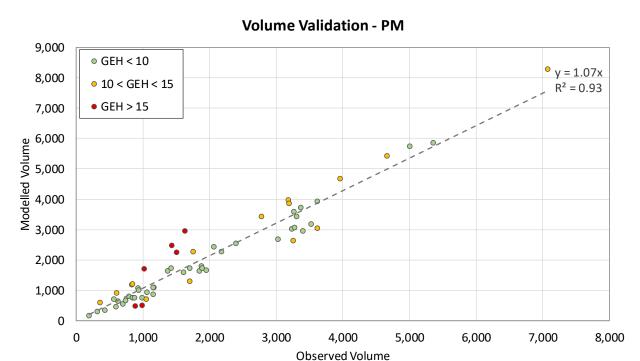


Figure A8: PM Peak Hour Traffic Volume Validation

Figures A9 through A14 show the travel time validation of the RTM3 model for the Highway 99 north and southbound directions during AM peak, midday and PM peak periods. All of these illustrate a good level of model fit to observed travel times with the model falling within the Google Maps API optimistic and pessimistic travel times. Detailed corridor travel time plots for the other major corridors reviewed as part of this study are included in Appendix B.



Figure A9: AM Peak Northbound Highway 99 Travel Time Validation

AM Travel Time Validation - Hwy 99 - Northbound

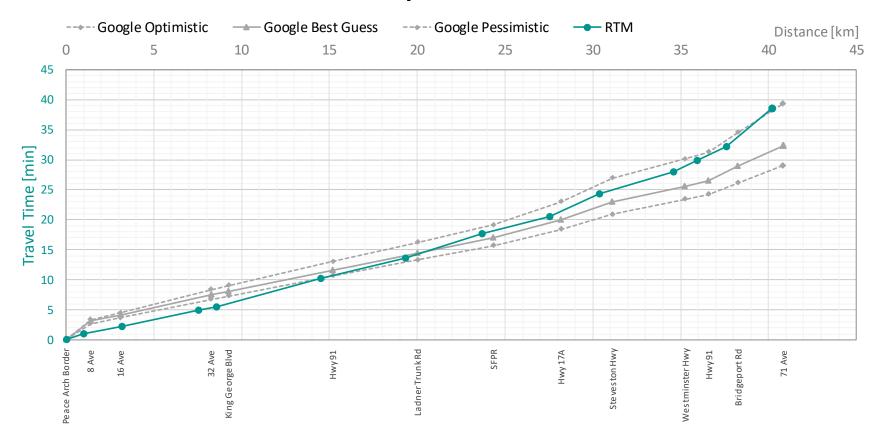




Figure A10: Midday Northbound Highway 99 Travel Time Validation

MD Travel Time Validation - Hwy 99 - Northbound

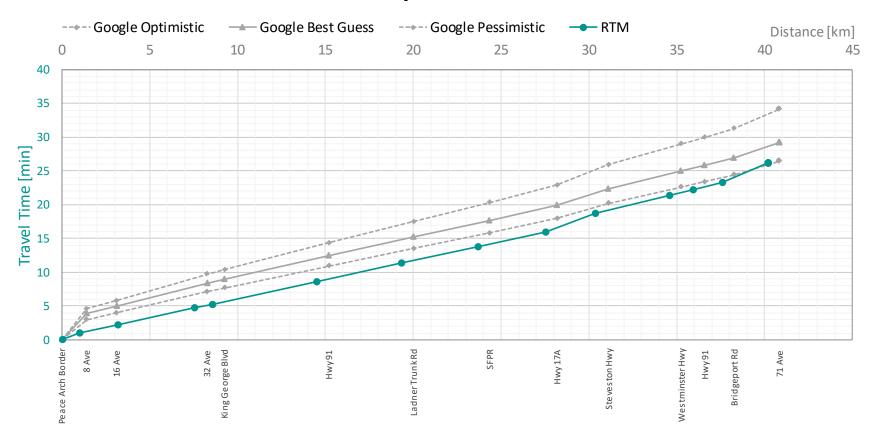




Figure A11: PM Peak Northbound Highway 99 Travel Time Validation

PM Travel Time Validation - Hwy 99 - Northbound

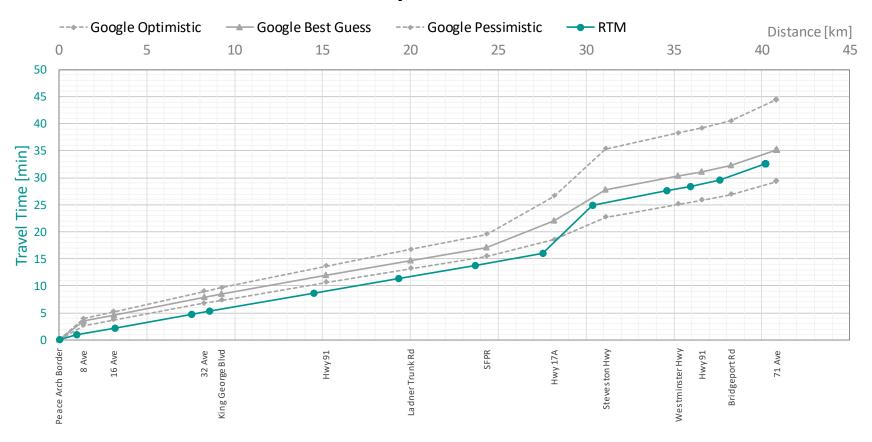




Figure A12: AM Peak Southbound Highway 99 Travel Time Validation

AM Travel Time Validation - Hwy 99 - Southbound

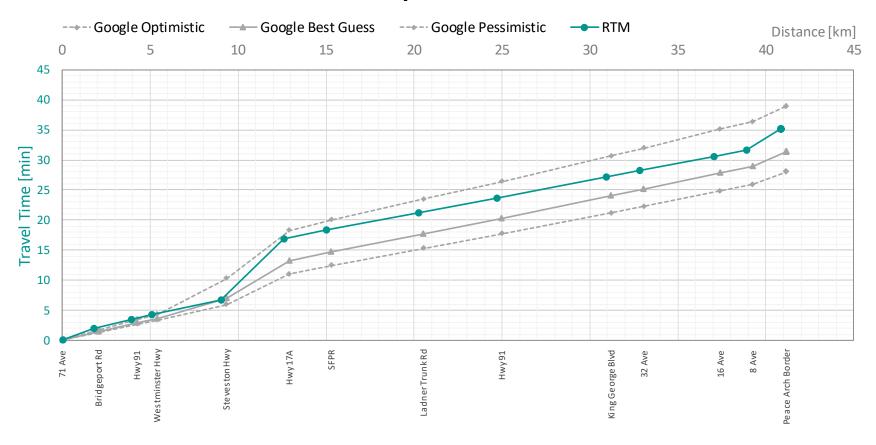




Figure A13: Midday Southbound Highway 99 Travel Time Validation

MD Travel Time Validation - Hwy 99 - Southbound

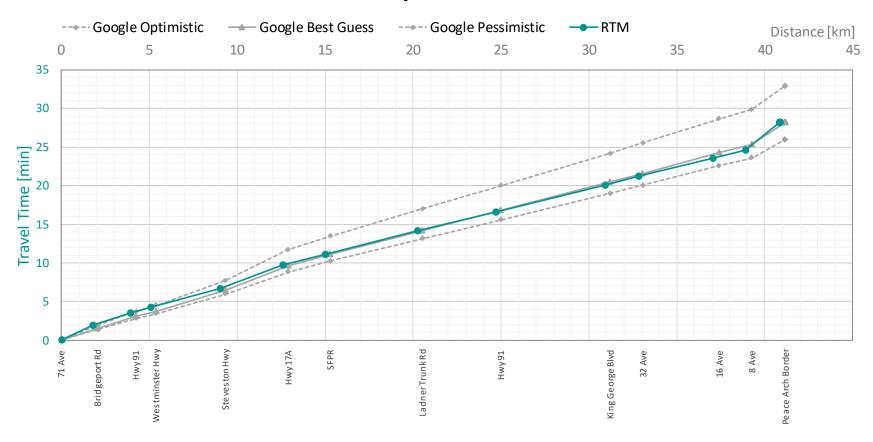
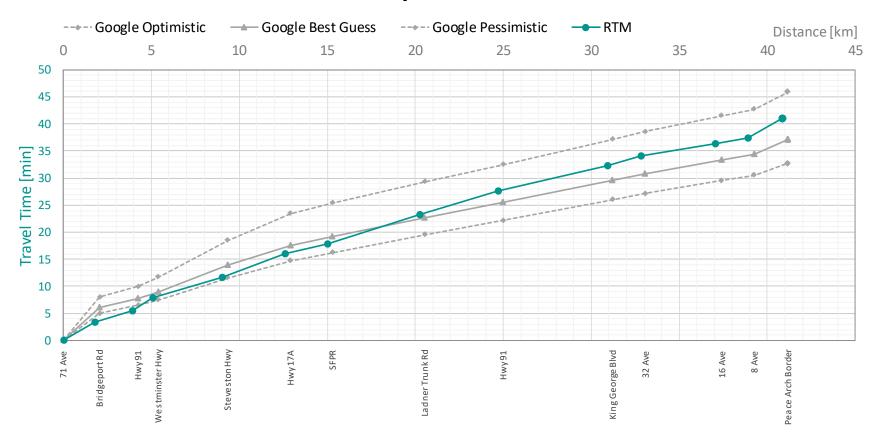




Figure A14: PM Peak Southbound Highway 99 Travel Time Validation

PM Travel Time Validation - Hwy 99 - Southbound





Appendix B – Additional Travel Time Validation Plots

Figure B1: AM Peak Northbound Knight Street Travel Time Validation

AM Travel Time Validation - Knight St - Northbound

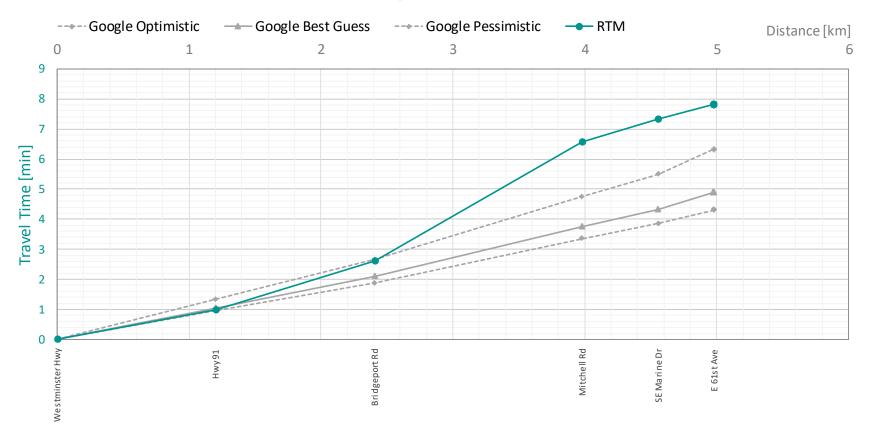


Figure B2: Midday Northbound Knight Street Travel Time Validation

MD Travel Time Validation - Knight St - Northbound

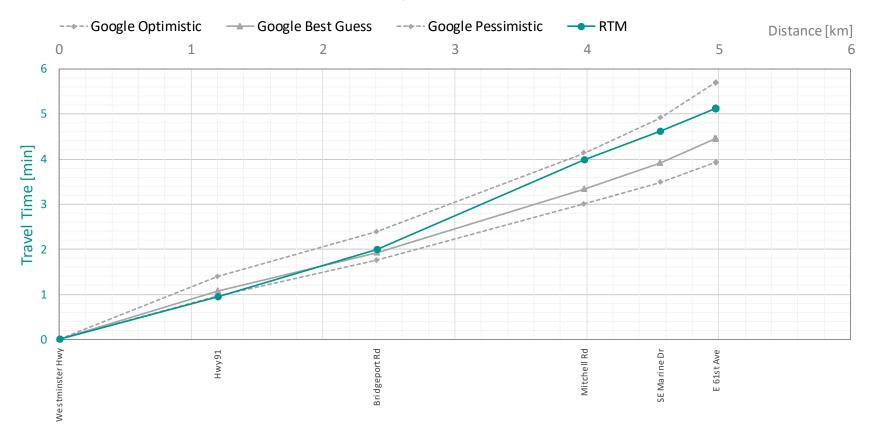




Figure B3: PM Peak Northbound Knight Street Travel Time Validation

PM Travel Time Validation - Knight St - Northbound

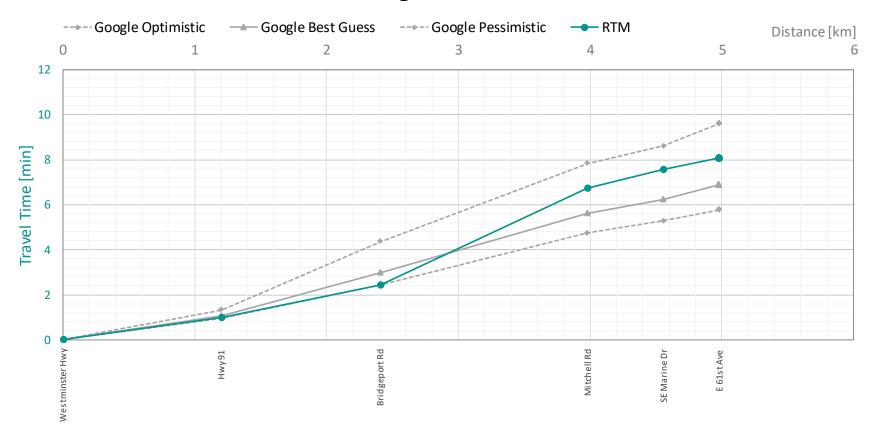




Figure B4: AM Peak Southbound Knight Street Travel Time Validation

AM Travel Time Validation - Knight St - Southbound

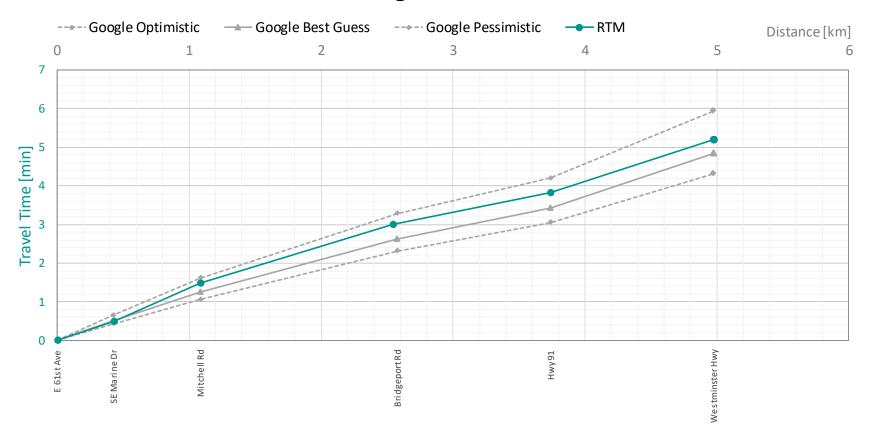




Figure B5: Midday Southbound Knight Street Travel Time Validation

MD Travel Time Validation - Knight St - Southbound

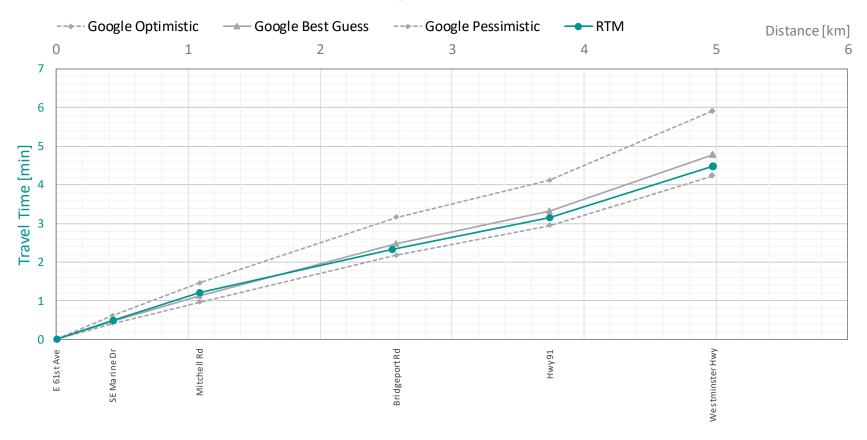




Figure B6: PM Peak Southbound Knight Street Travel Time Validation

PM Travel Time Validation - Knight St - Southbound

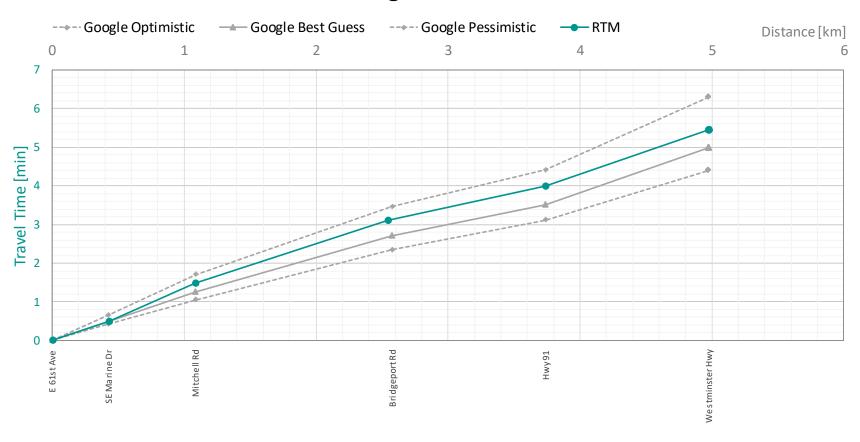




Figure B7: AM Peak Northbound Highway 17A Travel Time Validation

AM Travel Time Validation - Hwy 17A - Northbound

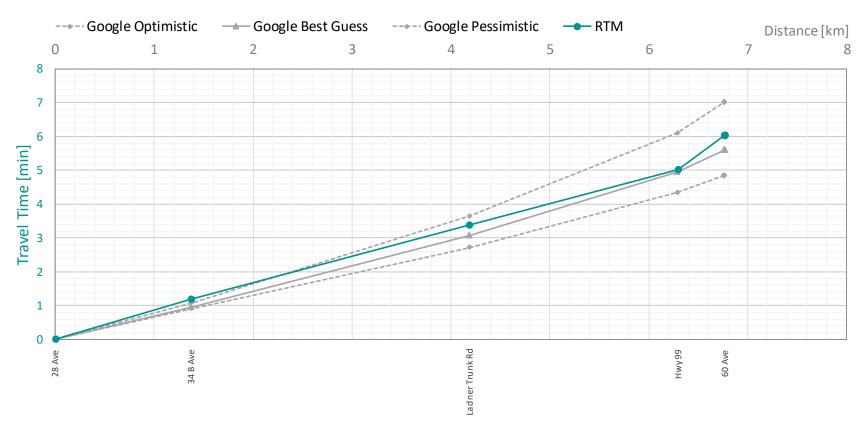




Figure B8: Midday Northbound Highway 17A Travel Time Validation

MD Travel Time Validation - Hwy 17A - Northbound

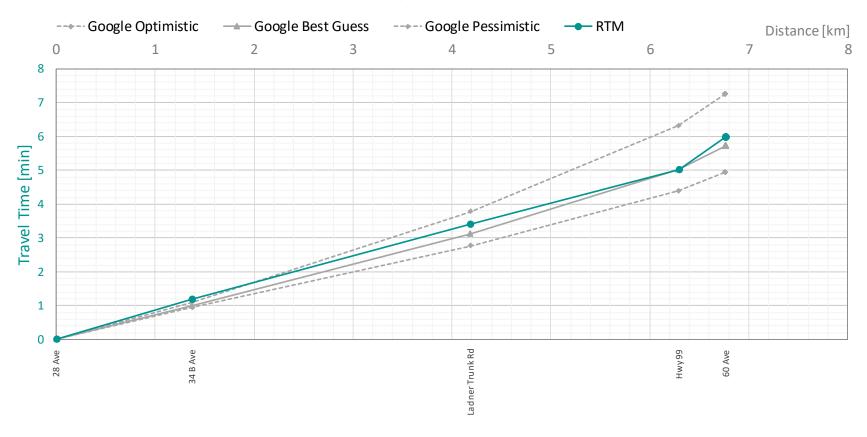




Figure B9: PM Peak Northbound Highway 17A Travel Time Validation

PM Travel Time Validation - Hwy 17A - Northbound

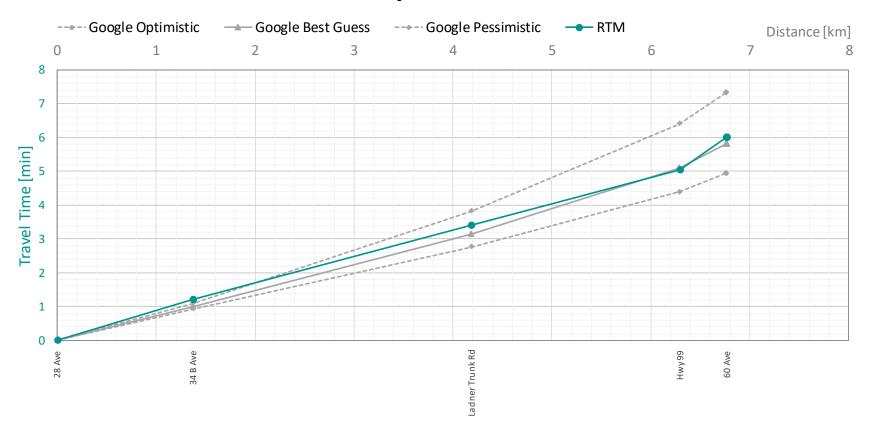




Figure B10: AM Peak Southbound Highway 17A Travel Time Validation

AM Travel Time Validation - Hwy 17A - Southbound

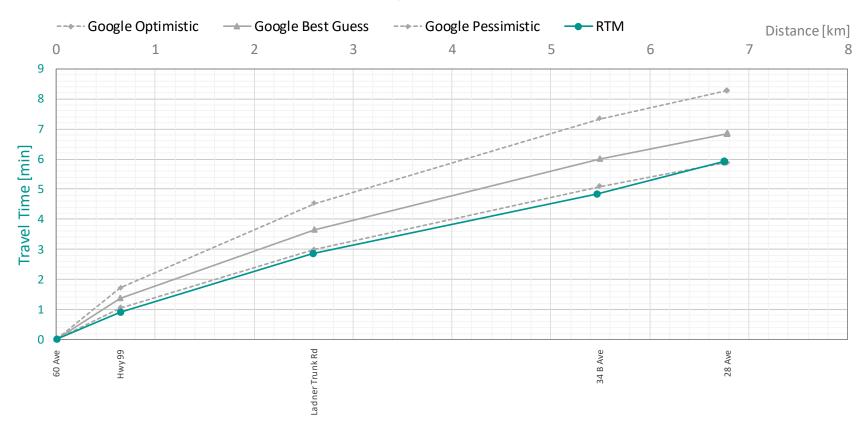




Figure B11: Midday Southbound Highway 17A Travel Time Validation

MD Travel Time Validation - Hwy 17A - Southbound

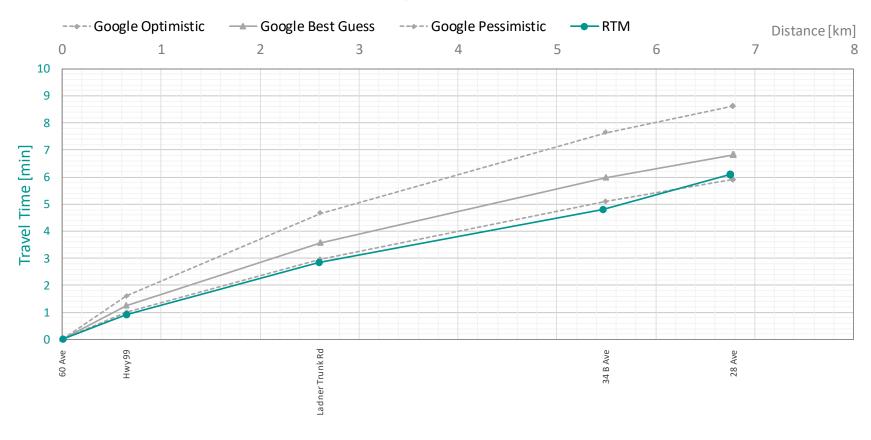




Figure B12: PM Peak Southbound Highway 17A Travel Time Validation

PM Travel Time Validation - Hwy 17A - Southbound

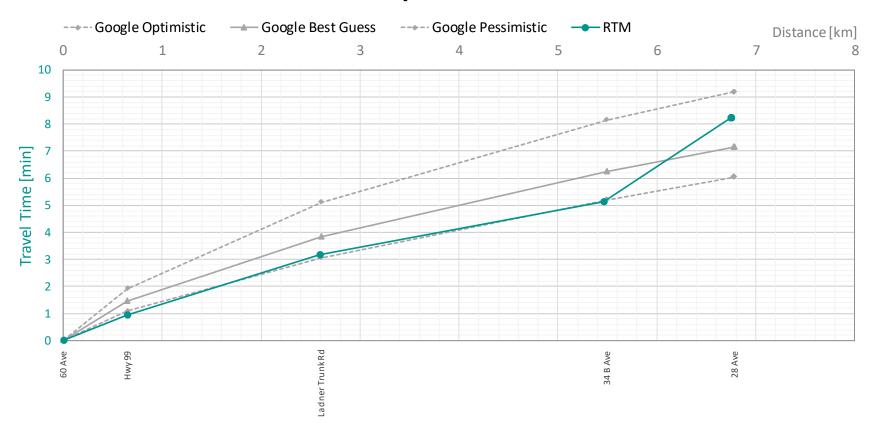




Figure B13: AM Peak Northbound South Fraser Perimeter Road Travel Time Validation

AM Travel Time Validation - SFPR - Northbound

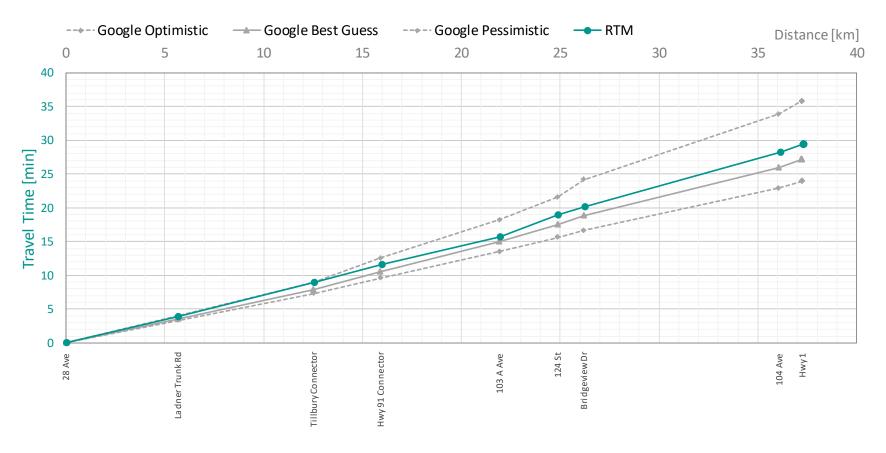




Figure B14: Midday Northbound South Fraser Perimeter Road Travel Time Validation

MD Travel Time Validation - SFPR - Northbound

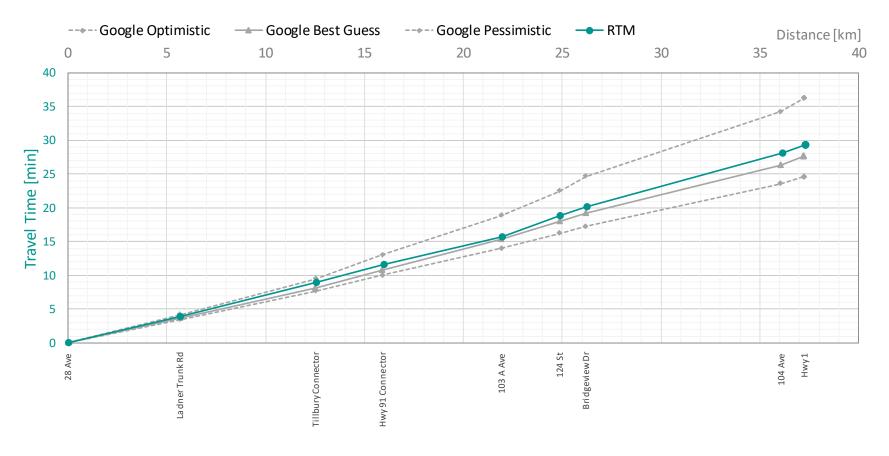




Figure B15: PM Peak Northbound South Fraser Perimeter Road Travel Time Validatio

PM Travel Time Validation - SFPR - Northbound

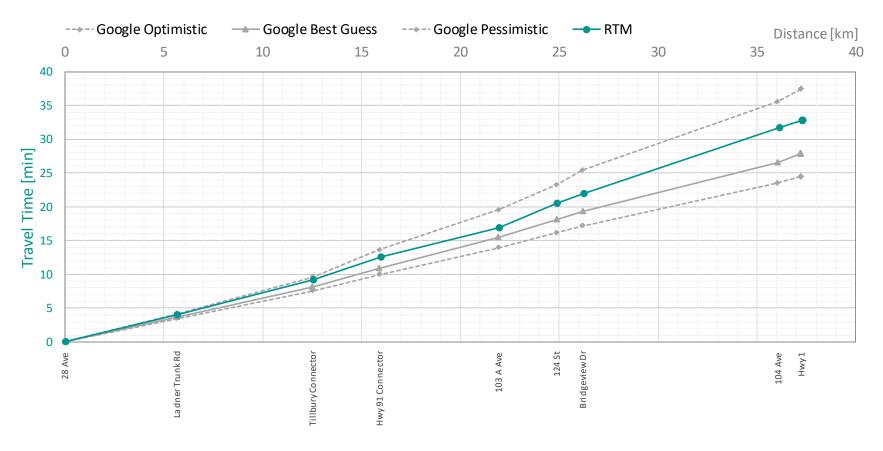




Figure B16: AM Peak Southbound South Fraser Perimeter Road Travel Time Validation

AM Travel Time Validation - SFPR - Southbound

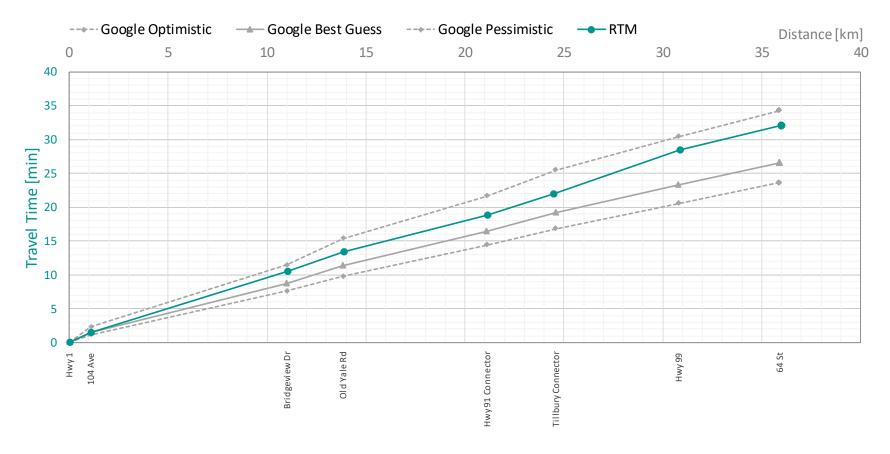




Figure B17: Midday Southbound South Fraser Perimeter Road Travel Time Validation

MD Travel Time Validation - SFPR - Southbound

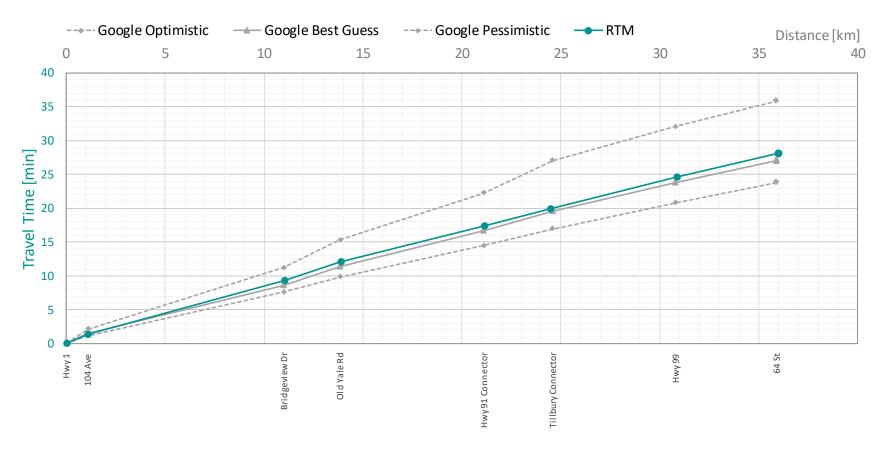




Figure B18: PM Peak Southbound South Fraser Perimeter Road Travel Time Validation

PM Travel Time Validation - SFPR - Southbound

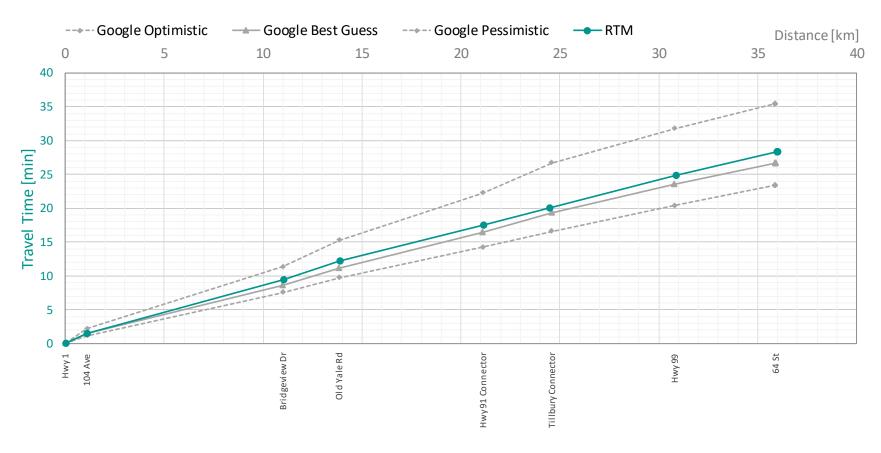




Figure B19: AM Peak Northbound Highway 91 Travel Time Validation

AM Travel Time Validation - Hwy 91 - Northbound

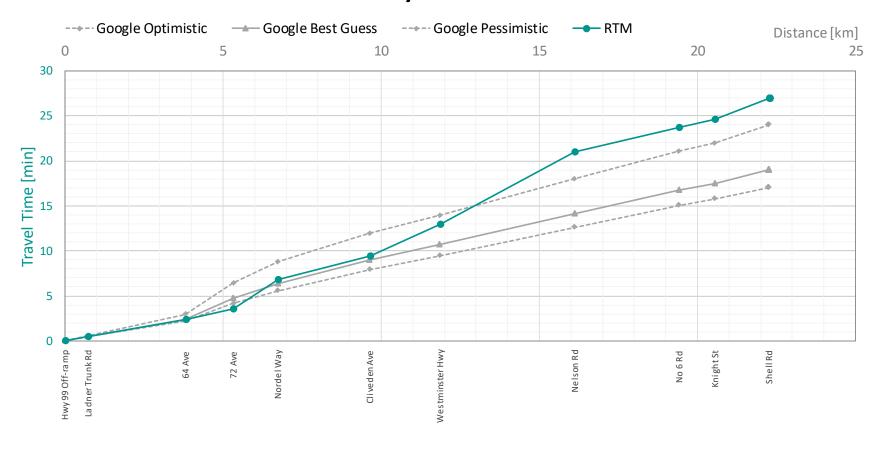




Figure B20: Midday Northbound Highway 91 Travel Time Validation

MD Travel Time Validation - Hwy 91 - Northbound

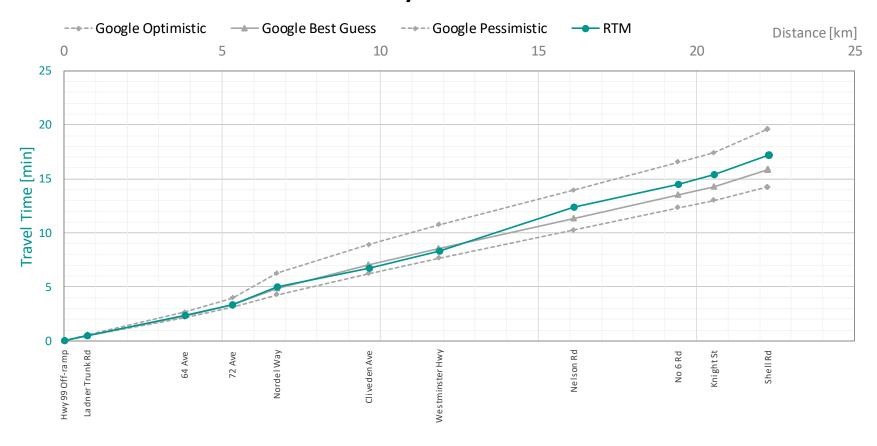




Figure B21: PM Peak Northbound Highway 91 Travel Time Validation

PM Travel Time Validation - Hwy 91 - Northbound

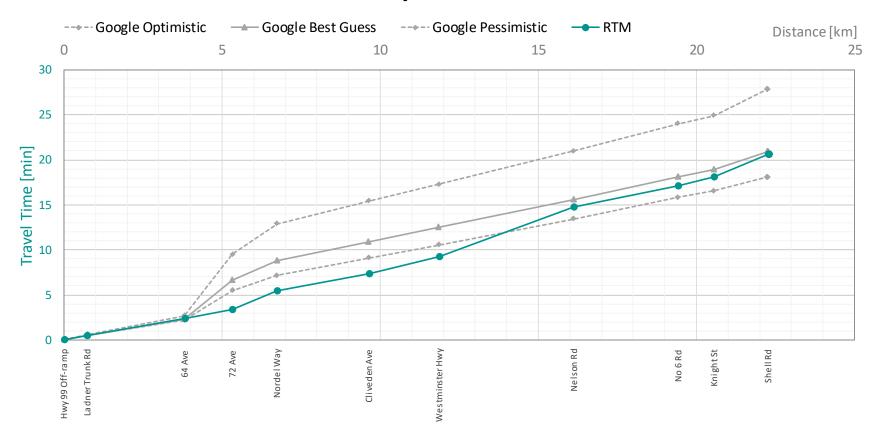




Figure B22: AM Peak Southbound Highway 91 Travel Time Validation

AM Travel Time Validation - Hwy 91 - Southbound

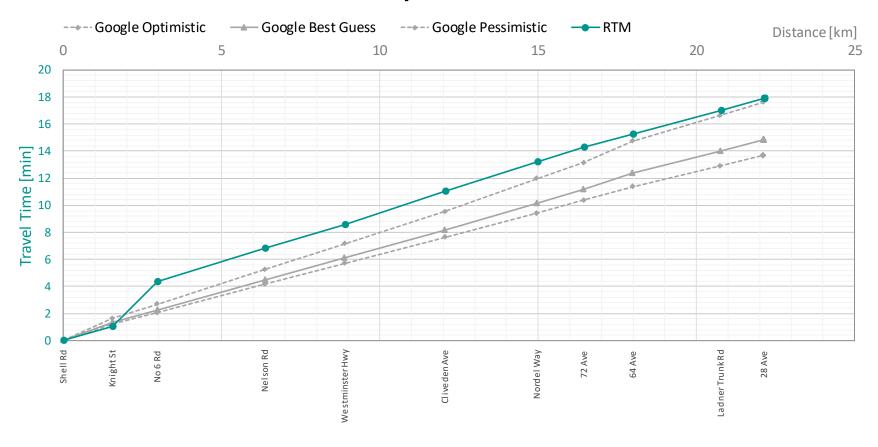




Figure B23: Midday Southbound Highway 91 Travel Time Validation

MD Travel Time Validation - Hwy 91 - Southbound

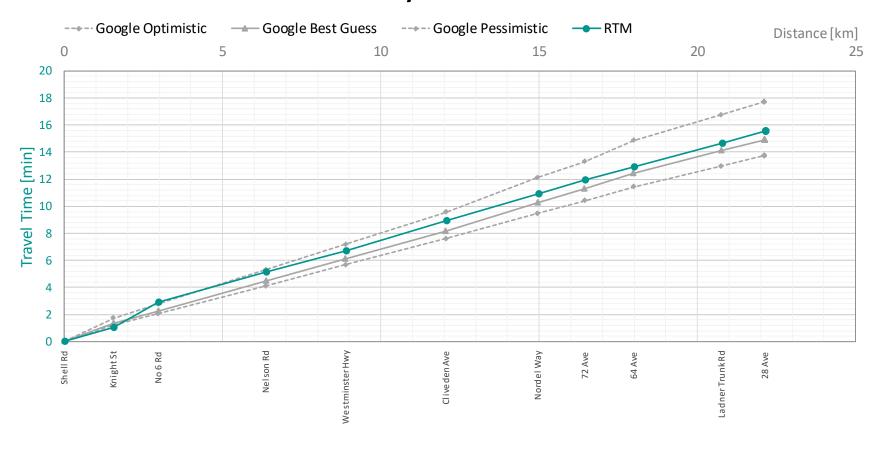




Figure B24: PM Peak Southbound Highway 91 Travel Time Validation

PM Travel Time Validation - Hwy 91 - Southbound

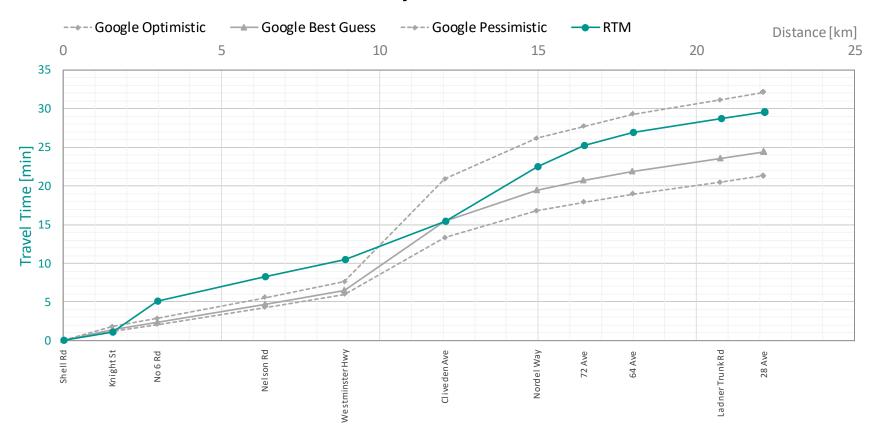




Figure B25: AM Peak Northbound Highway 99 Travel Time Validation

AM Travel Time Validation - Hwy 99 - Northbound

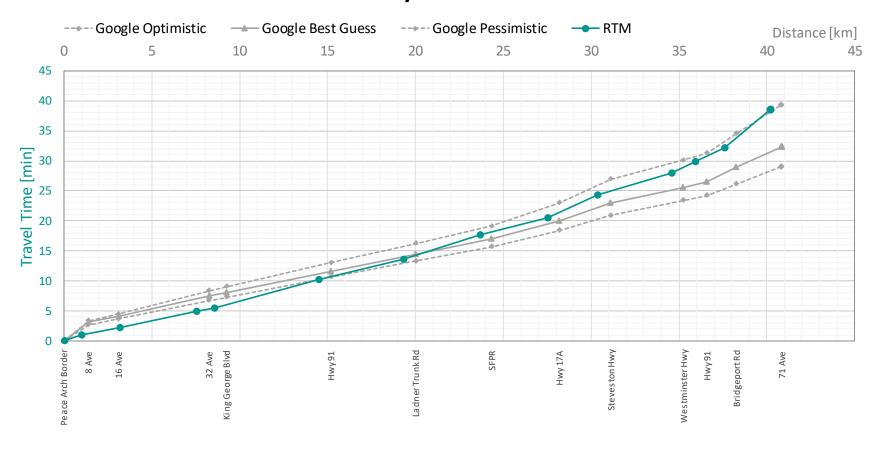




Figure B26: Midday Northbound Highway 99 Travel Time Validation

MD Travel Time Validation - Hwy 99 - Northbound

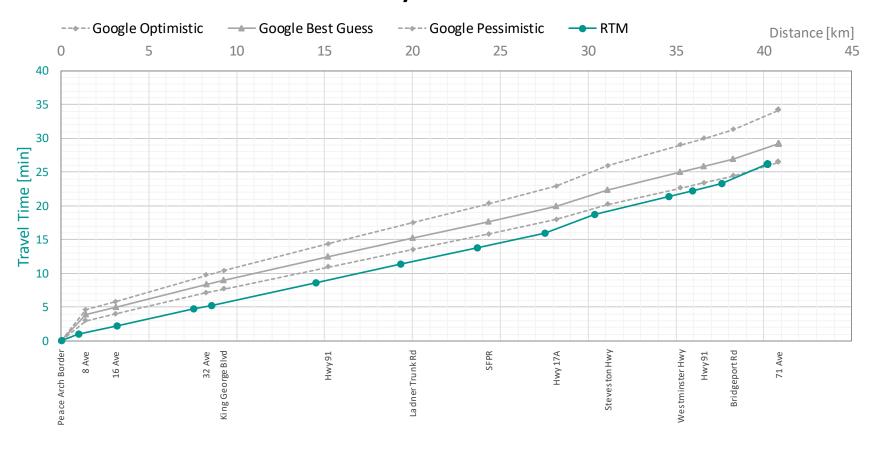




Figure B27: PM Peak Northbound Highway 99 Travel Time Validation

PM Travel Time Validation - Hwy 99 - Northbound

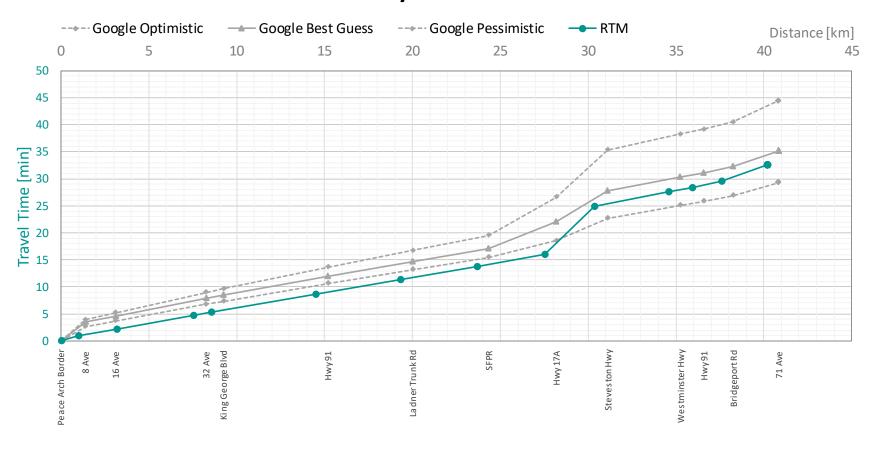




Figure B28: AM Peak Southbound Highway 99 Travel Time Validation

AM Travel Time Validation - Hwy 99 - Southbound

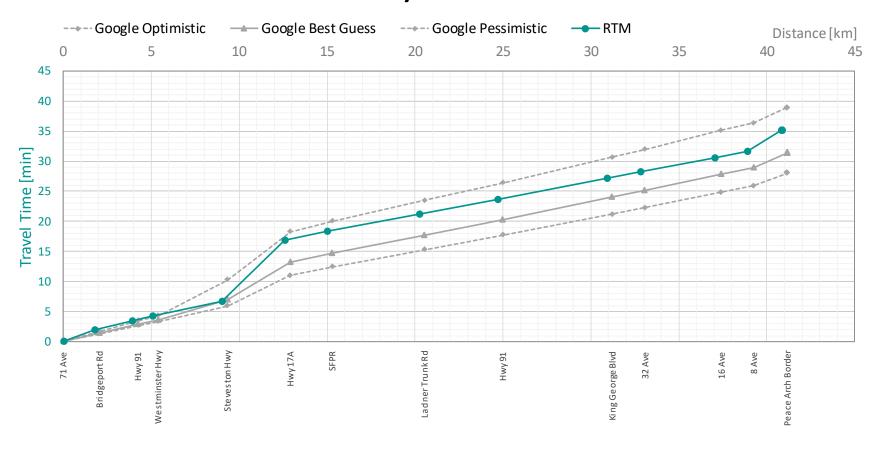




Figure B29: Midday Southbound Highway 99 Travel Time Validation

MD Travel Time Validation - Hwy 99 - Southbound

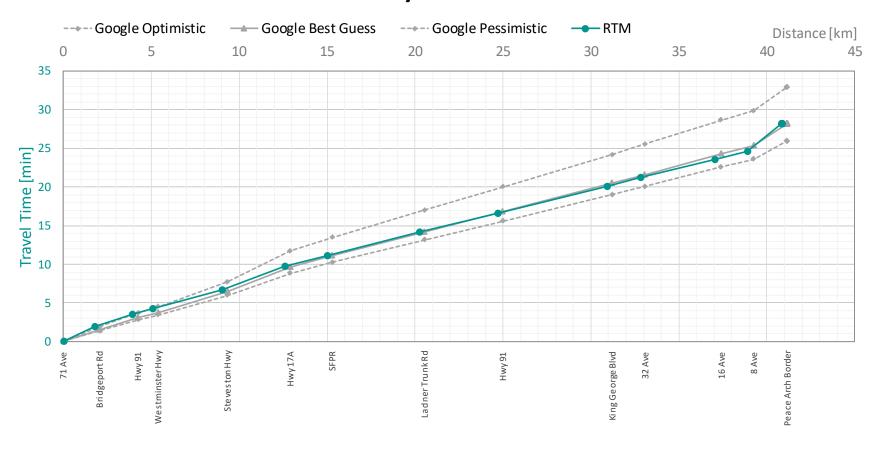




Figure B30: PM Peak Southbound Highway 99 Travel Time Validation

PM Travel Time Validation - Hwy 99 - Southbound

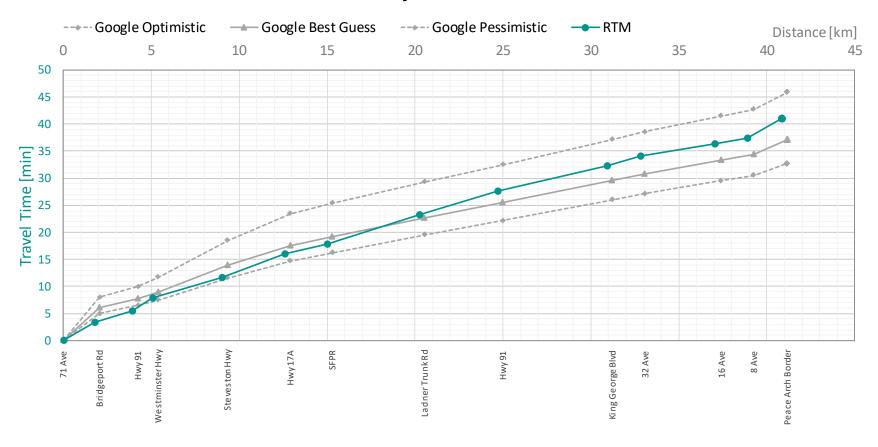




Figure B31: AM Peak Northbound No 5 Road Travel Time Validation

AM Travel Time Validation - No 5 Rd - Northbound

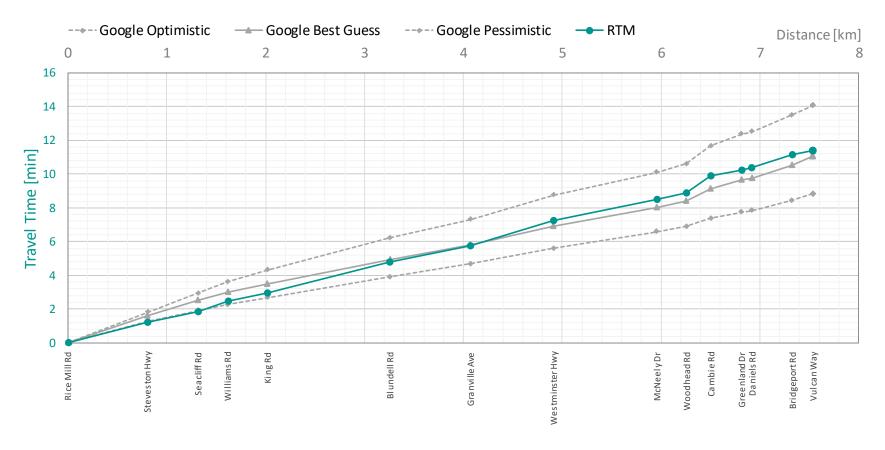




Figure B32: Midday Northbound No 5 Road Travel Time Validation

MD Travel Time Validation - No 5 Rd - Northbound

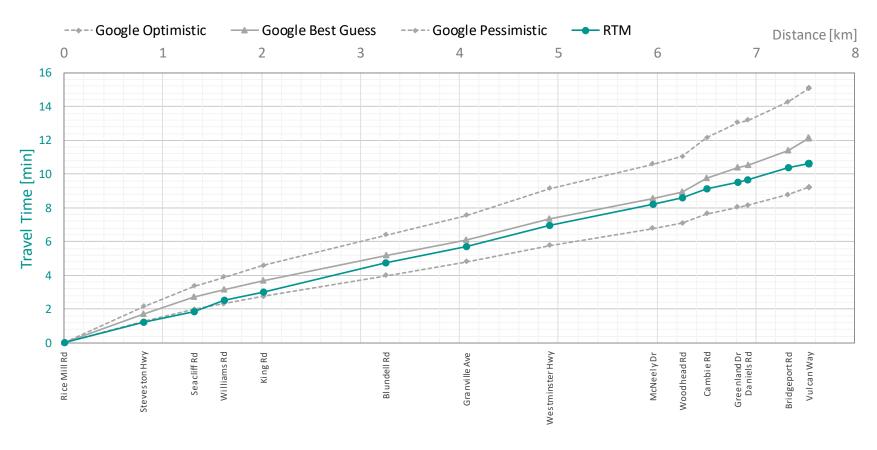




Figure B33: PM Peak Northbound No 5 Road Travel Time Validation

PM Travel Time Validation - No 5 Rd - Northbound

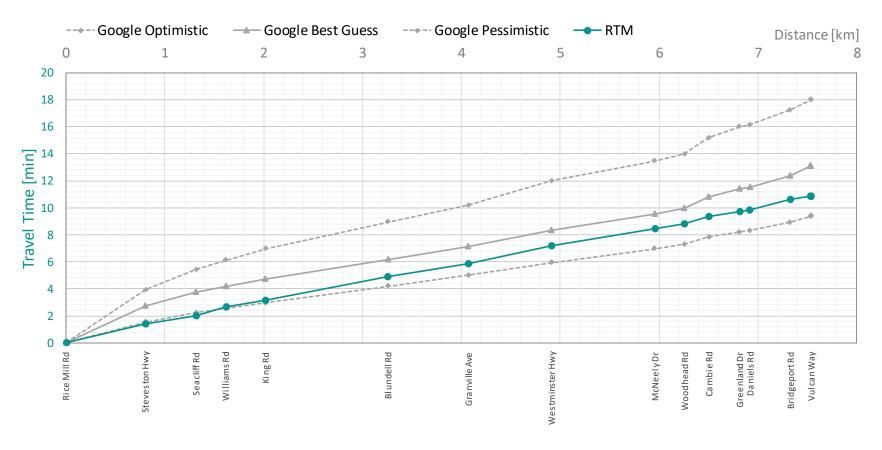




Figure B34: AM Peak Southbound No 5 Road Travel Time Validation

AM Travel Time Validation - No 5 Rd - Southbound

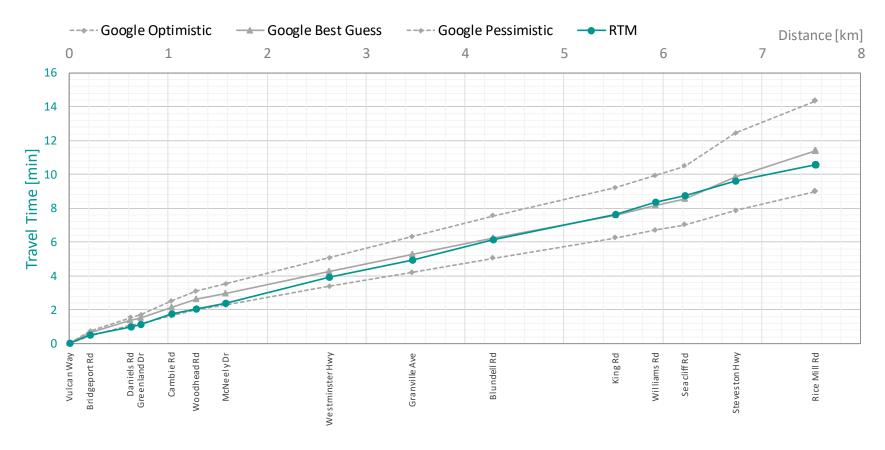




Figure B35: Midday Southbound No 5 Road Travel Time Validation

MD Travel Time Validation - No 5 Rd - Southbound

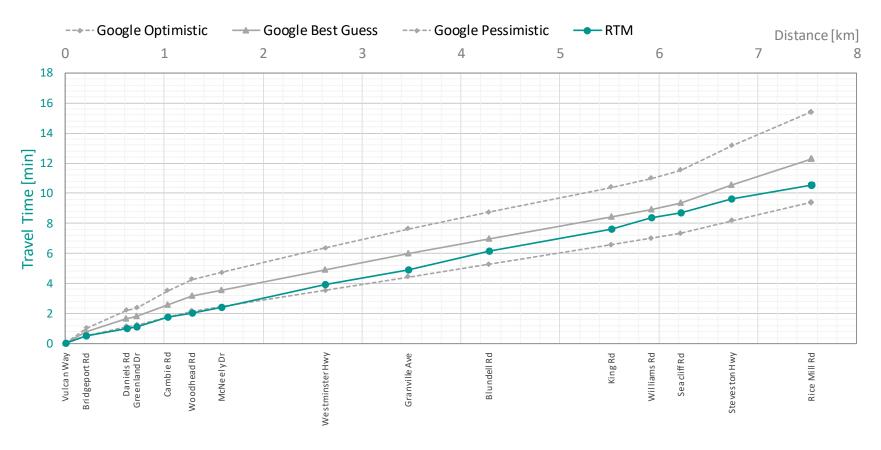




Figure B36: PM Peak Southbound No 5 Road Travel Time Validation

PM Travel Time Validation - No 5 Rd - Southbound

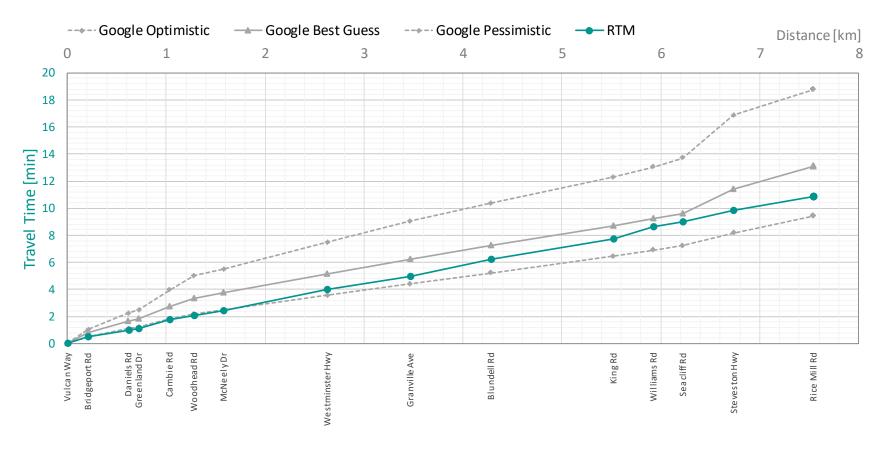




Figure B37: AM Peak Eastbound Steveston Highway Travel Time Validation

AM Travel Time Validation - Steveston Hwy - Eastbound

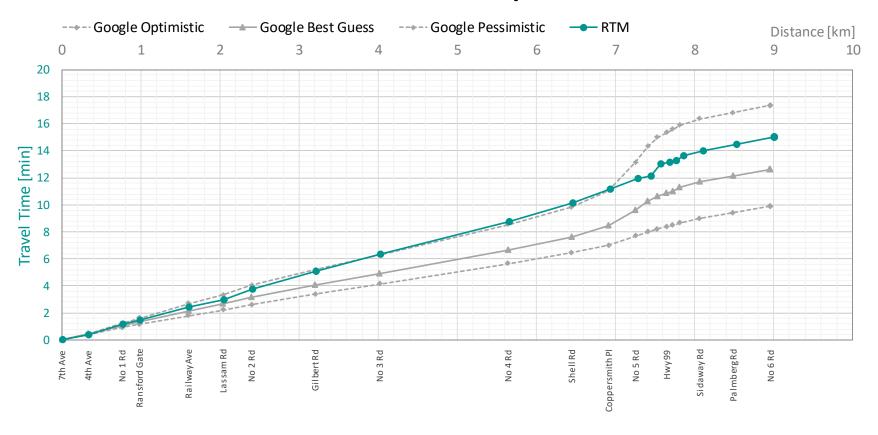




Figure B38: Midday Eastbound Steveston Highway Travel Time Validation

MD Travel Time Validation - Steveston Hwy - Eastbound

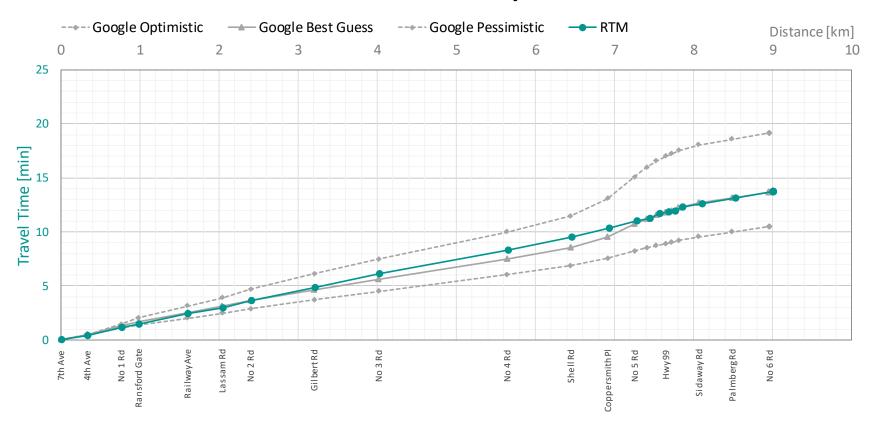




Figure B39: PM Peak Eastbound Steveston Highway Travel Time Validation

PM Travel Time Validation - Steveston Hwy - Eastbound

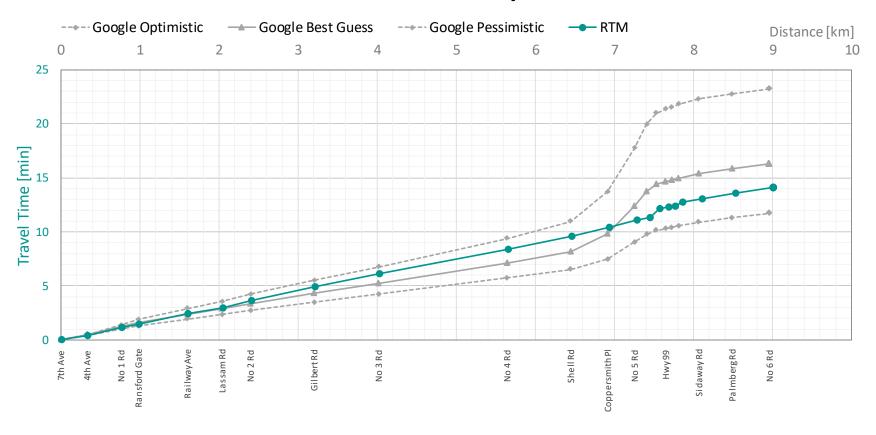




Figure B40: AM Peak Westbound Steveston Highway Travel Time Validation

AM Travel Time Validation - Steveston Hwy - Westbound

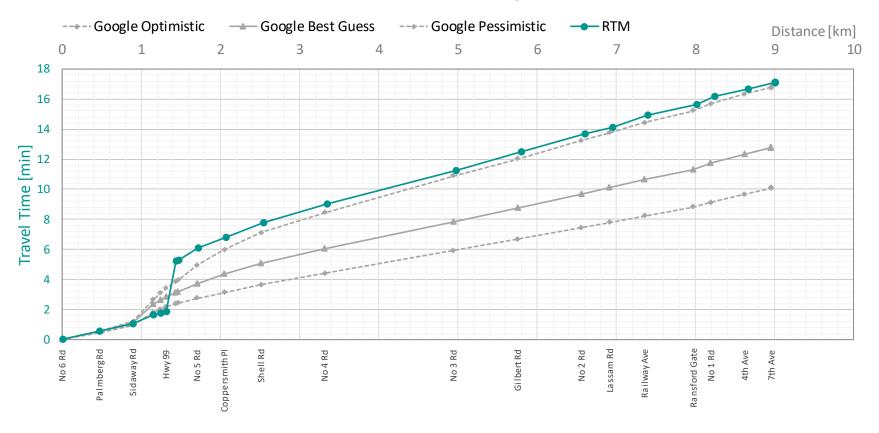




Figure B41: Midday Westbound Steveston Highway Travel Time Validation

MD Travel Time Validation - Steveston Hwy - Westbound

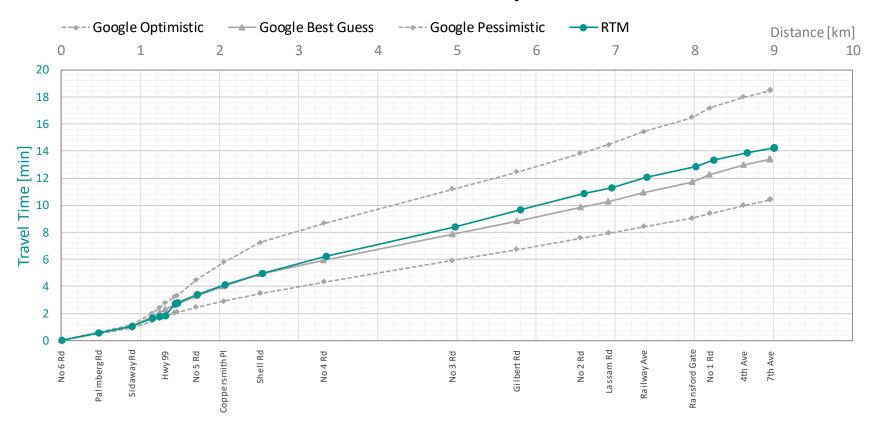




Figure B42: PM Peak Westbound Steveston Highway Travel Time Validation

PM Travel Time Validation - Steveston Hwy - Westbound

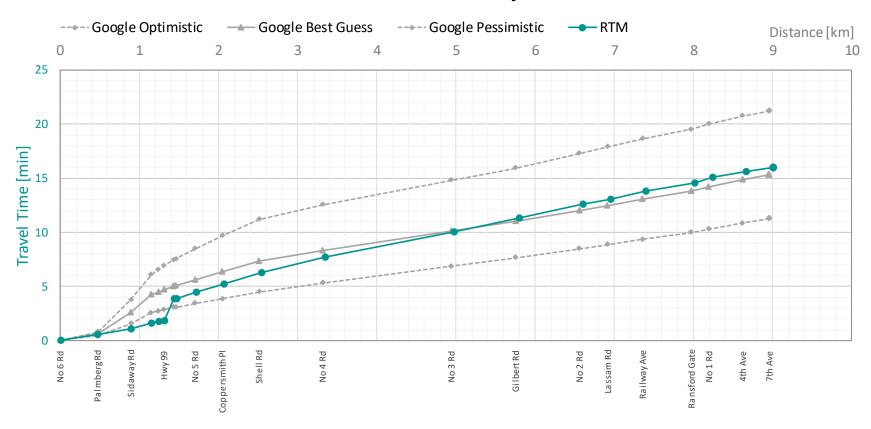




Figure B43: AM Peak Northbound River Road Travel Time Validation

AM Travel Time Validation - River Rd - Northbound

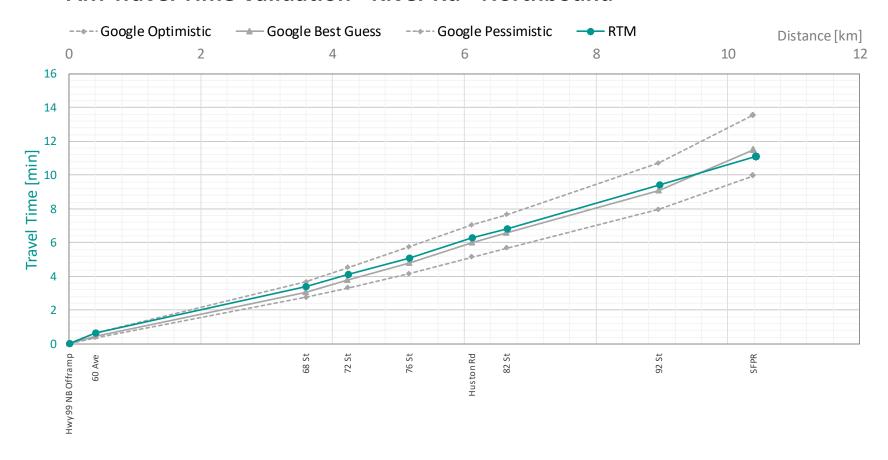




Figure B44: Midday Northbound River Road Travel Time Validation

MD Travel Time Validation - River Rd - Northbound

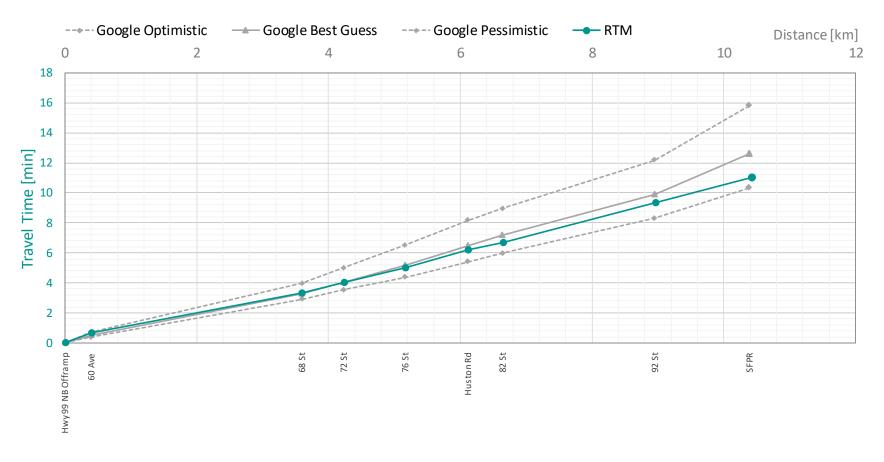




Figure B45: PM Peak Northbound River Road Travel Time Validation

PM Travel Time Validation - River Rd - Northbound

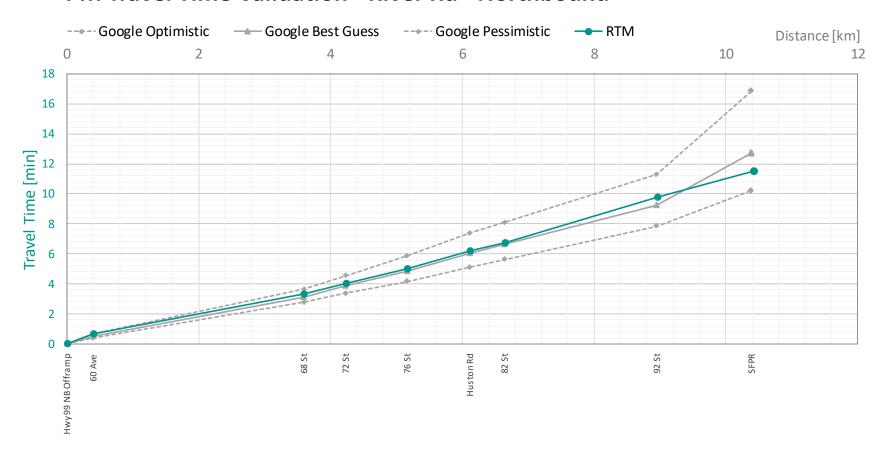




Figure B46: AM Peak Southbound River Road Travel Time Validation

AM Travel Time Validation - River Rd - Southbound

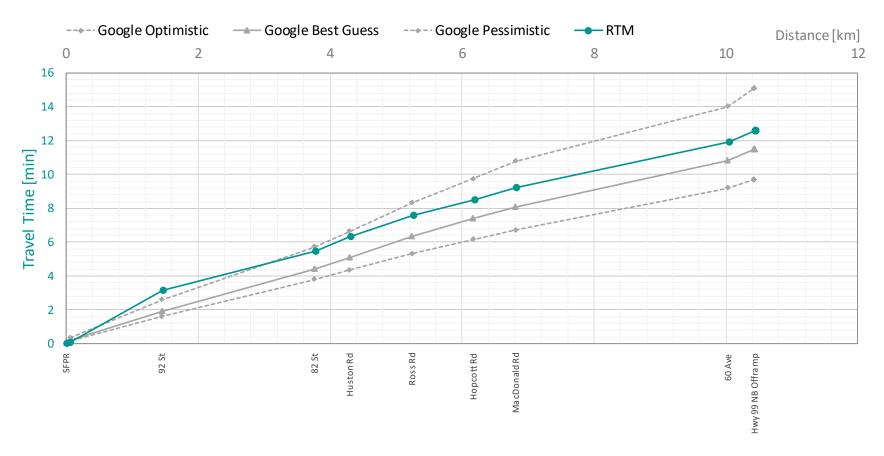




Figure B47: Midday Southbound River Road Travel Time Validation

MD Travel Time Validation - River Rd - Southbound

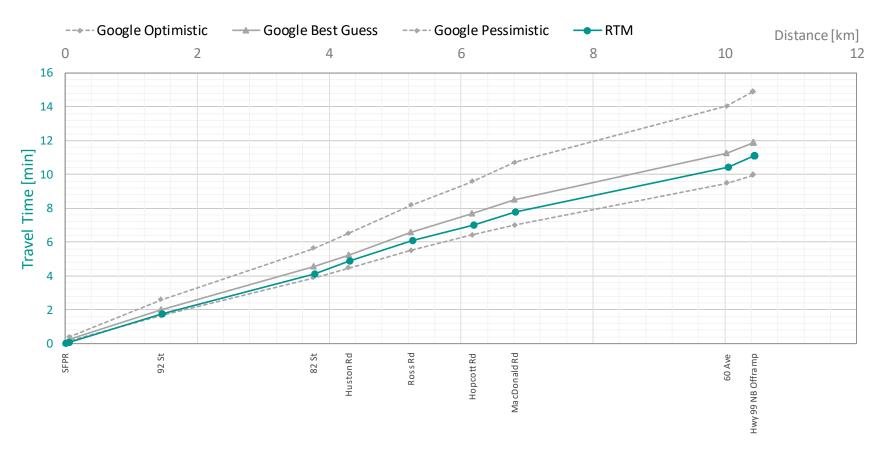




Figure B48: PM Peak Southbound River Road Travel Time Validation

PM Travel Time Validation - River Rd - Southbound

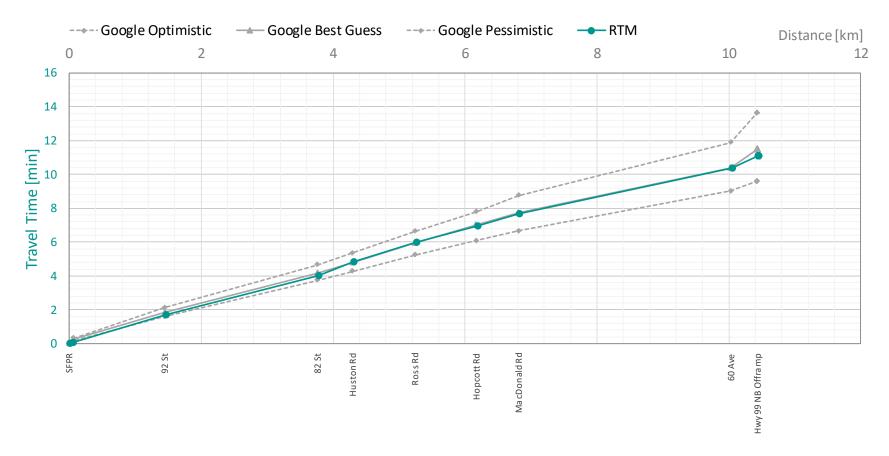




Figure B49: AM Peak Eastbound Westminster Highway Travel Time Validation

AM Travel Time Validation - Westminster Hwy - Eastbound

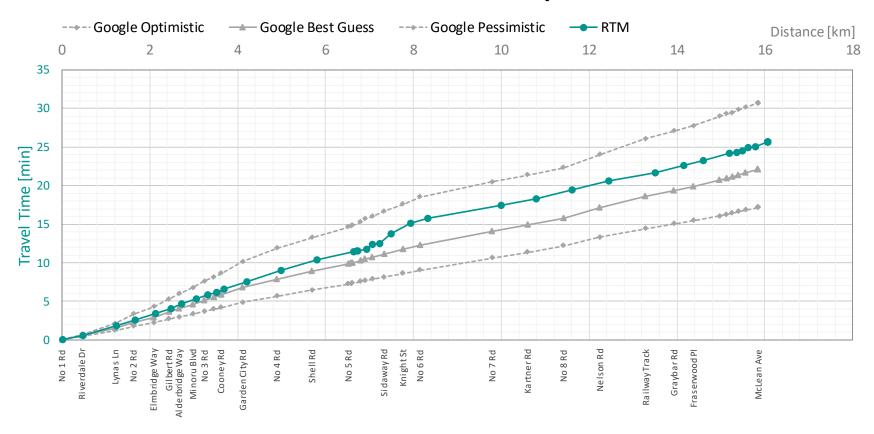




Figure B50: Midday Eastbound Westminster Highway Travel Time Validation

MD Travel Time Validation - Westminster Hwy - Eastbound

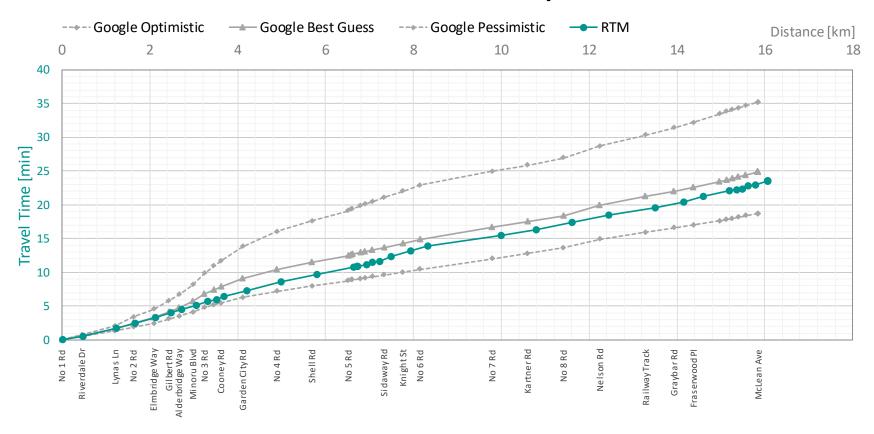




Figure B51: PM Peak Eastbound Westminster Highway Travel Time Validation

PM Travel Time Validation - Westminster Hwy - Eastbound

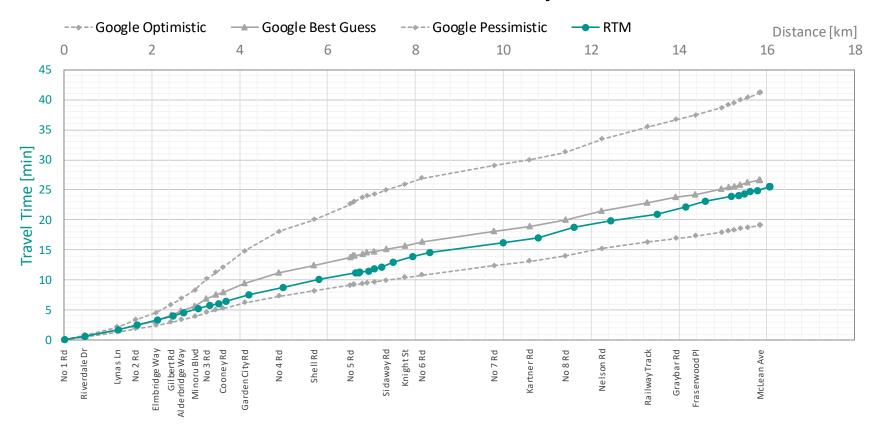




Figure B52: AM Peak Westbound Westminster Highway Travel Time Validation

AM Travel Time Validation - Westminster Hwy - Westbound

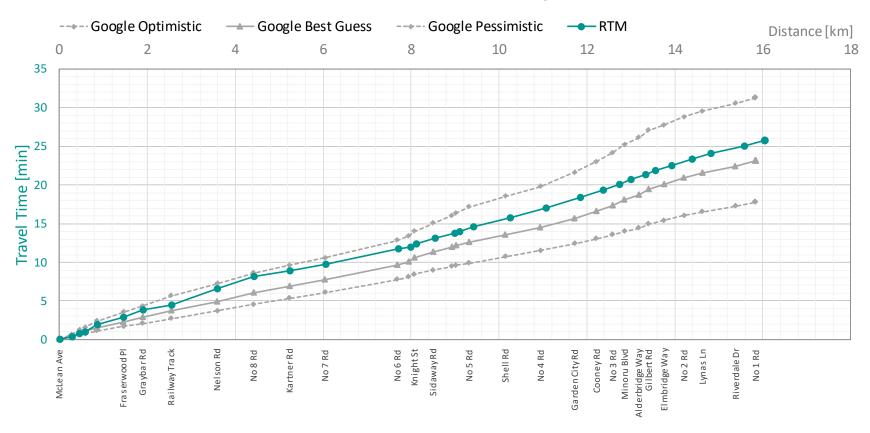




Figure B53: Midday Westbound Westminster Highway Travel Time Validation

MD Travel Time Validation - Westminster Hwy - Westbound

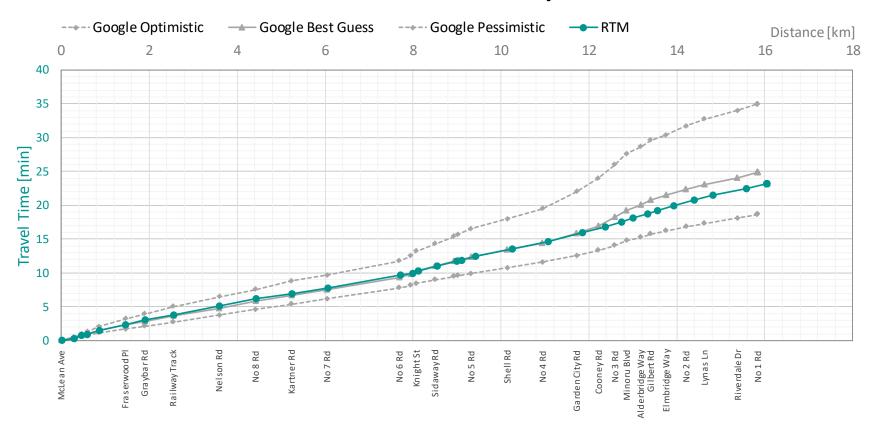




Figure B54: PM Peak Westbound Westminster Highway Travel Time Validation

PM Travel Time Validation - Westminster Hwy - Westbound

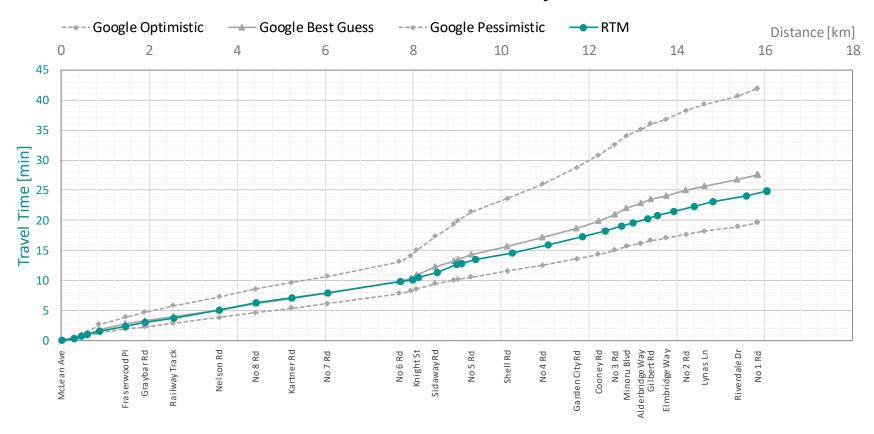




Figure B55: AM Peak Eastbound Highway 10 Travel Time Validation

AM Travel Time Validation - Hwy 10 - Eastbound

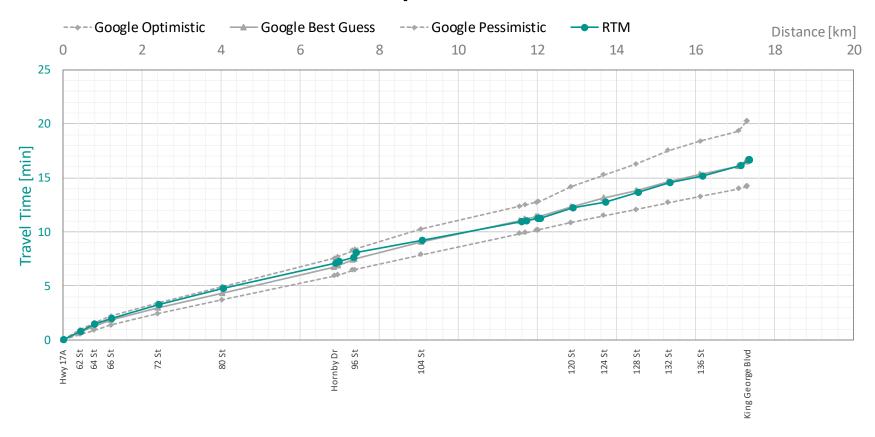




Figure B56: Midday Eastbound Highway 10 Travel Time Validation

MD Travel Time Validation - Hwy 10 - Eastbound

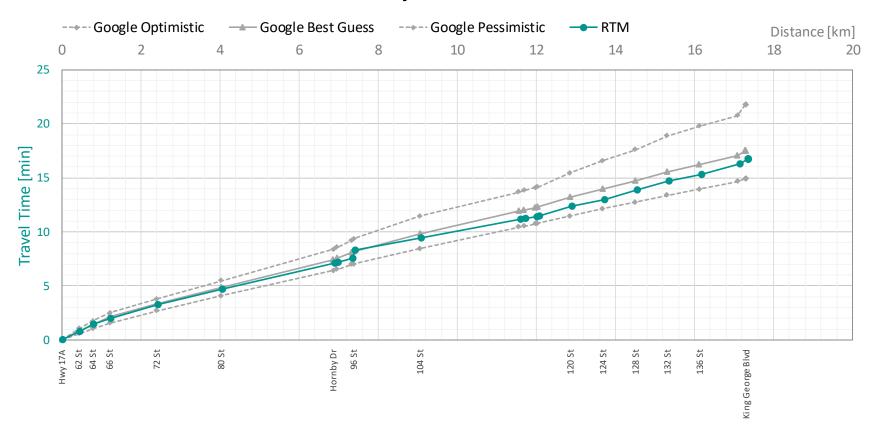




Figure B57: PM Peak Eastbound Highway 10 Travel Time Validation

PM Travel Time Validation - Hwy 10 - Eastbound

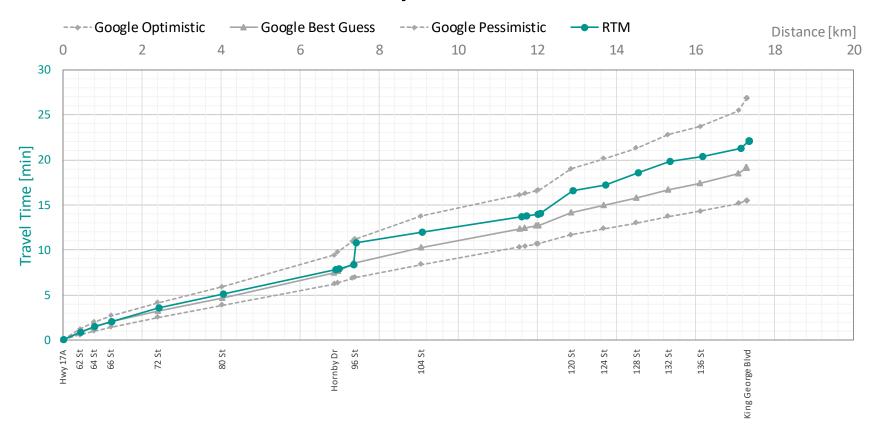




Figure B58: AM Peak Westbound Highway 10 Travel Time Validation

AM Travel Time Validation - Hwy 10 - Westbound

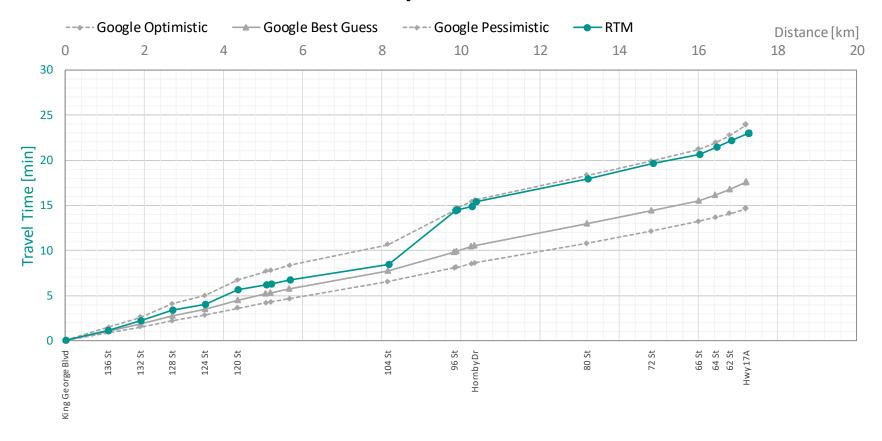




Figure B59: Midday Westbound Highway 10 Travel Time Validation

MD Travel Time Validation - Hwy 10 - Westbound

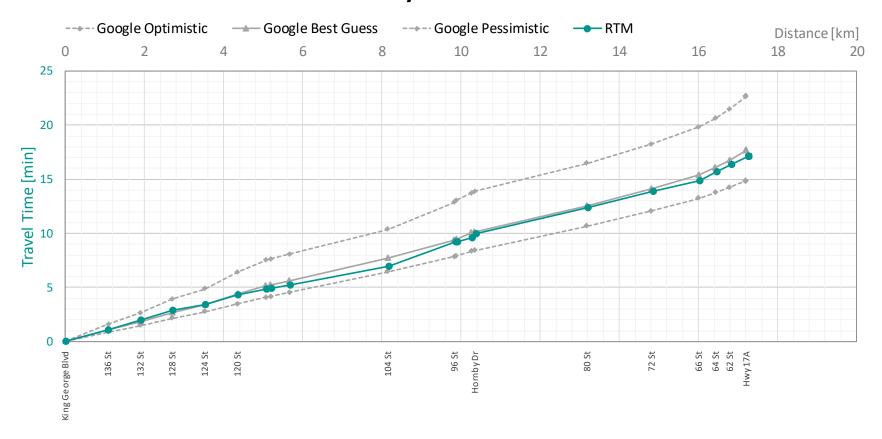
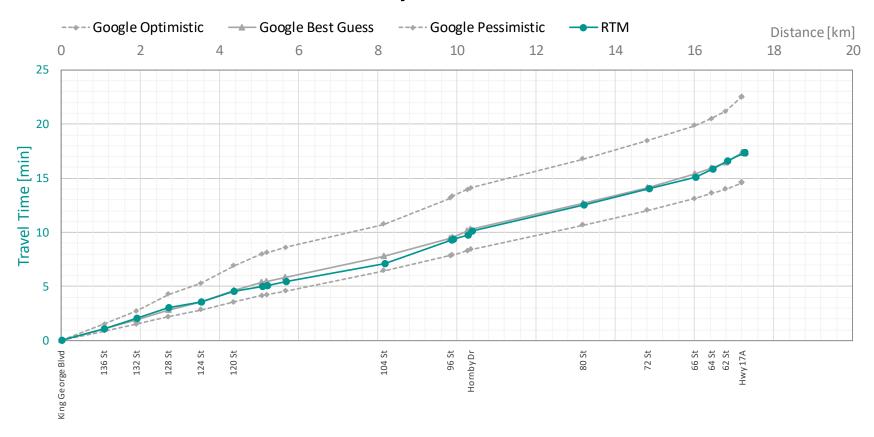




Figure B60: PM Peak Westbound Highway 10 Travel Time Validation

PM Travel Time Validation - Hwy 10 - Westbound





Corridor Travel Time [min]

Figure B61: Corridor Travel Times for AM Peak Period





Figure B62: Corridor Travel Times for Midday Period



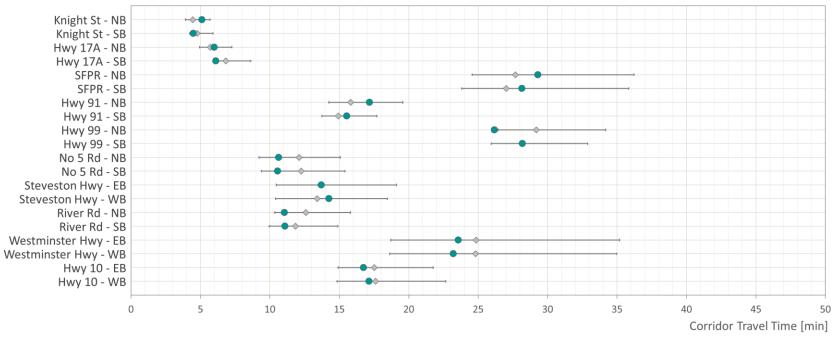
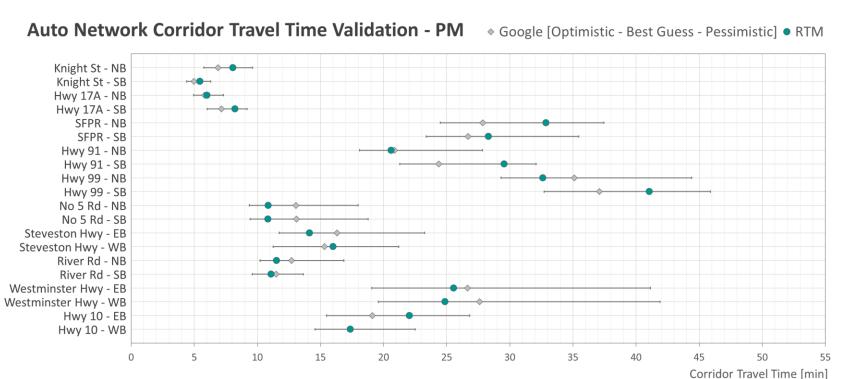




Figure B63: Corridor Travel Times for PM Peak Period





Appendix C – BACKCHECK OF FRASER RIVER CROSSING GROWTH RATES

In order to provide further confidence in the traffic growth rates coming from the RTM3 (ver 3.2) model, particularly for traffic volumes across the South Arm of the Fraser River, a backcheck of historical traffic growth rates and any correlation to explanatory variables was conducted. *Figure C1* below provides a summary of historical Average Annual Daily Traffic for all of the South of Fraser crossings which provides a basis for regression analysis. The dashed grey line provides the indexed (1986=100 on vertical axis on right) growth in all crossings. *Table C1* then provides a summary of annual growth rates from 1990 to 2018. A noticeable uptick in growth rates was observed between 2010 and 2018, which has been separated out for each crossing.

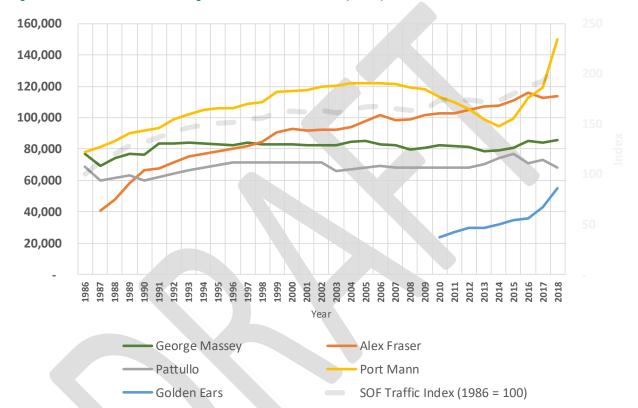


Figure C1: South of Fraser Crossing Historical Traffic Volumes (AADT)

Table C1: South of Fraser Crossing Traffic Growth Rates

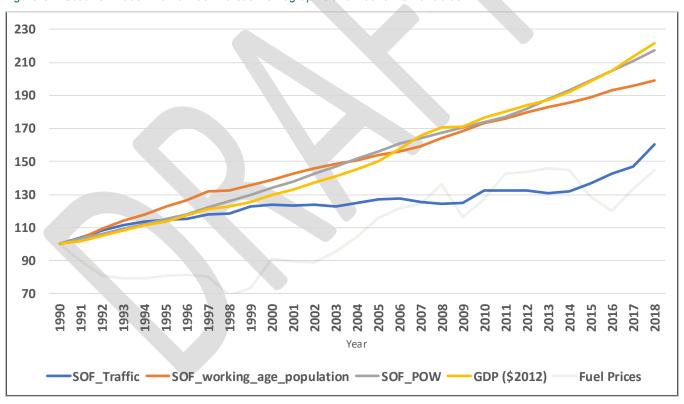
Crossing	Annual Growth Rate (1990 – 2018)	Annual Growth Rate (2010 – 2018)
George Massey	0.4%	0.5%
Alex Fraser	1.9%	1.3%
Pattullo	0.5%	0.0%
Port Mann	1.8%	3.6%
Golden Ears	-	11.0%
South of Fraser	1.70%	2.4%

The next step considered indexing all of the South of Fraser crossing traffic to other variables to develop a multivariate regression model. This tool is used to determine the individual impact of different variables on traffic growth on the South of Fraser crossings. The variables chosen for analysis include the following and indexed in *Figures C2* and *C3*:

- South of Fraser region employment [SOF POW]
- South of Fraser region working age population (Ages 20 64) [SOF_working_age_population]
- Number of lanes across the Fraser
- Fuel Price [Fuel Prices]
- Tolls
- BC Gross Domestic Product [GDP (\$2012)]

Note that other variables such as fuel, congestion, tolls and number of lanes contribute significantly to growth in traffic.

Figure C2: South of Fraser Traffic Index versus Demographic and Economic Variables



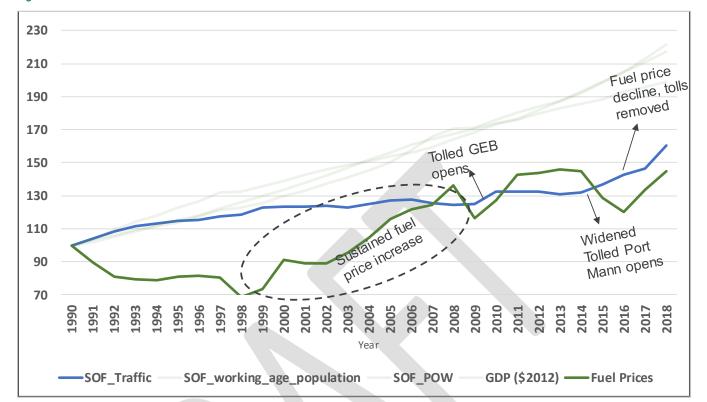


Figure C3: South of Fraser Traffic Index versus Fuel Prices

A log-log model was developed which implies that the model parameters can be interpreted as elasticities. *Table C2* provides a summary of the regression model outputs including explanatory variables and coefficients or elasticities which produced an R² value of 0.98 to observed traffic growth trends. For example, a 1% increase in the fuel + tolls variable [Fuel_Tolls] results in a -0.21% decrease in South of Fraser crossing traffic. *Figure C4* provides a summary of the regression model showing the tight correlation to observed traffic volumes between 1986 and 2018. This model then provides a forecast to 2050 similar to the RTM3 model. Annual growth beyond 2018 is at approximately 1% annually. Note that this model provides a steady state forecast and the intervening years will be much noisier given uncertainty in the explanatory variables.

Table C2: Multivariate Regression Model Coefficients

Parameters	Description	Coefficients	t-Stat
Intercept		0.16	0.31
Lanes_per_ELF	Number of crossing lanes per 100,000 people of age 20 - 64 in SOF	0.34	8.27
SOF_(ELF+POW)	SOF jobs + population aged 20 - 64	0.94	26.09
Fuel_Tolls	Cents/Litre + average toll per crossing trip	-0.21	-11.87

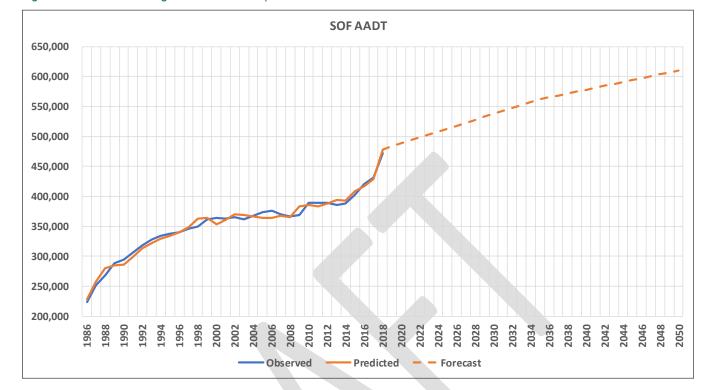
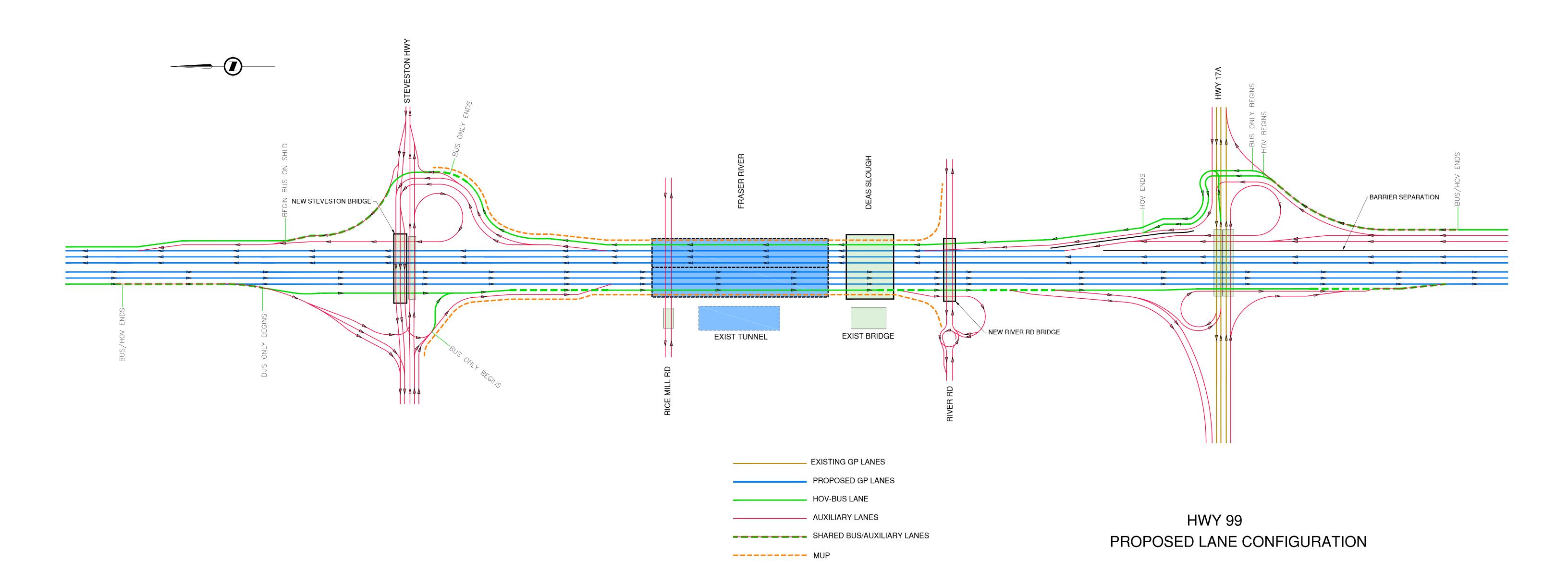


Figure C4: Multivariate Regression Model Outputs and Forecast

The regression model proved to be a useful tool to backcheck the traffic forecasts developed from the RTM3 model. The following summarizes the annual growth rate outputs from this analysis:

- Historical Growth
 - o 1986-2018: 1.7% 2010-2018: 2.4%
- Regression Model
 - o 2017-2035: 1.5% 2035-2050: 0.5%
 - No toll corrected (0.9%)
- RTM (AM and PM Peak Only)
 - o 2017-2035: 0.9% 2035-2050: 0.5%

Note that the regression model outputs were adjusted for tolls which were removed in 2017. When this correction is applied then the regression model and RTM3 model produce a 0.95% average annual growth rate between 2017 and 2035 and an average annual growth rate of 0.5% between 2035 and 2050. The high traffic growth rate between 1986 and 2018 is driven largely by the number of lanes added. In 1986 there were a total of 12 lanes of general-purpose traffic lanes for the South of Fraser crossing in Metro Vancouver. This grew to 29 lanes in 2017 with HOV lanes accounted as half of a general-purpose lane due to lower utilization compared to a general purpose lane. The current plan is to increase this to 32 lanes which includes an additional counterflow lane on the Alex Fraser Bridge and two additional general purpose lanes added to the George Massey Crossing.



APPENDIX F. 6 LANE CAPACITY ANALYSIS

GNEC Technical Memorandum

GNEC Contact: Ross McLaren, P.Eng. Project Name: George Massey Crossing

Traffic Engineering Lead GNEC Project #: 19BC-0090

Document #: 19BC-0090-mem001

Date: November 8, 2019

To: Darryl Matson, P.Eng.

COWI

RE: George Massey Crossing - Interim 6 Lane Option Traffic Capacity Assessment - DRAFT

1.0 Objective

The objective of this memorandum is to document the interim, high-level assessment of the traffic capacity of proposed 6 lane George Massey Crossing (GMC) options that has been undertaken under the COWI led "Technical Services for George Massey Crossing Project". This memo is based on interim information available as at November 4, 2019 and relies on interim traffic forecast information contained in McElhanney's draft memo dated November 1, 2019 and titled "GMC Traffic Forecasts".

2.0 Methodology and Execution

Interim traffic demands and capacities at the 6 lane GMC were estimated from the Regional Transportation Model (RTM) for the 2050 AM and PM peak hours. The excess traffic demands in each peak hour in each direction were then converted to queue lengths by multiplying the excess demand by an average "vehicle length plus gap" between leading and following vehicles. It was then assumed that the resultant queue length measured in lane-km would then generally be distributed between the highway mainline lanes, ramps, other auxiliary lanes and cross streets depending on their respective configurations and capacities.

3.0 Technical Information

Interim 2050 traffic demand forecasts were produced by McElhanney from the Regional Transportation Model (RTM) for the proposed 6 lane GMC option. The forecasts assumed that the 6 lane GMC would consist of six general purpose (GP) lanes and there was no consideration of crossing type (i.e. Immersed Tube Tunnel (ITT), Bridge or Deep Bored Tunnel (DBT)). For the 6 lane GMC option, buses were assumed to use the existing George Massey Tunnel.

Table 1 shows the forecast 2050 "all vehicle" demand volumes (veh/hr) on the 6 lane GMC in the AM/PM peak hours as well as an estimate of the GMC capacity assuming a capacity of 1800 veh/hr/lane and three northbound (NB) and three southbound (SB) lanes. The demand volume that is greater than the available capacity is the calculated excess volume which was then converted to a static queue length by multiplying by 8.4m which is based on an average automobile length (5.6m) plus an average gap of ½ a vehicle length (2.8m) between leading and following vehicles. This is considered a reasonable estimate for this level of analysis noting that the gaps will vary depending on level of congestion, operating speed, weather, etc. and there will be trucks in the traffic streams.

Table 1 – Estimated Interim 2050 Demands and Capacities 6 Lane GMC

Peak Hour	Direction	Demand (veh/hr)	Capacity (veh/hr)	Queue (lane-km)
AM	NB	5590	5400	1.6
	SB	3450	5400	-
PM	NB	4050	5400	-
	SB	6310	5400	7.6



The red text in *Table 1* shows where the volume demands exceed capacity. It is evident that with a 6 lane GMC, 2050 demands are expected to exceed capacity NB in the AM peak hour with an estimated queue of 1.6 lane-km. In the SB direction, the PM peak hour queue is estimated at 7.6 lane-km. The queue lengths would then generally be distributed between the highway mainline lanes, ramps, other auxiliary lanes and cross streets depending on their respective configurations and capacities.

With the proposed 6 lane ITT and Bridge options, the three lanes per direction are not physically separated from each other, so traffic can distribute/queue between the three lanes to a degree – although this is obviously influenced by volumes entering/exiting at Steveston interchange and Highway 17A interchange so lane utilization on GMC will not be equal.

With the 6 lane DBT option, however, there are three lanes per tube, with two lanes on top and one lane below (buses are in the existing tunnel) based on the design concepts available at the time (known as Option (c)). As evident on the attached preliminary laning designs produced by Stantec, the lower single SB lane in the tube accommodates some of the through traffic as well as the volumes that enter from Steveston and exit at Hwy 17A. Note that the SB off ramp to River Road is closed with the DBT option and the River Road ramp traffic has to reassign to the Hwy 17A SB off ramp. In the NB direction, the lower single NB lane in the tube accommodates some of the through traffic from Hwy 17 via the CD road, as well as the volumes that enter from Hwy 17A and exit at Steveston. In both directions, the inter-interchange volumes are confined to the lower single lanes in the tubes.

To illustrate the resultant traffic patterns in the 2050 PM peak hour for the 6 lane DBT, the attached schematic was prepared showing the SB volumes between Steveston and Hwy 17A off ramp. All SB traffic from Steveston (1920 veh/hr) plus the traffic that wants to exit at Hwy 17A (2510 veh/hr) is forced into the lower single lane. It was then assumed that all through traffic on Hwy 99 SB from north of Steveston to south of Hwy 17A will use the upper two lanes, as the lower lane serving the interchange ramps will be way over capacity. As is evident, the lane utilization on GMC is not balanced, with the lower lane being way over capacity and the two upper lanes being under capacity. The SB queue in the lower lane is estimated to be 15.8 lane-km ((3680 – 1800) *8.4/1000) distributed between the Steveston ramps (and into Richmond) and along Hwy 99 SB before Steveston. This analysis has been based on the 6 lane DBT configuration. Similar (or worse since volumes will likely be higher) results are to be expected with the 8 lane DBT option (f) with the upper cell carrying the one GP lane serving the interchanges and one bus lane. Note there will be only be one lane serving the interchanges (i.e. similar to the 6 lane DBT).

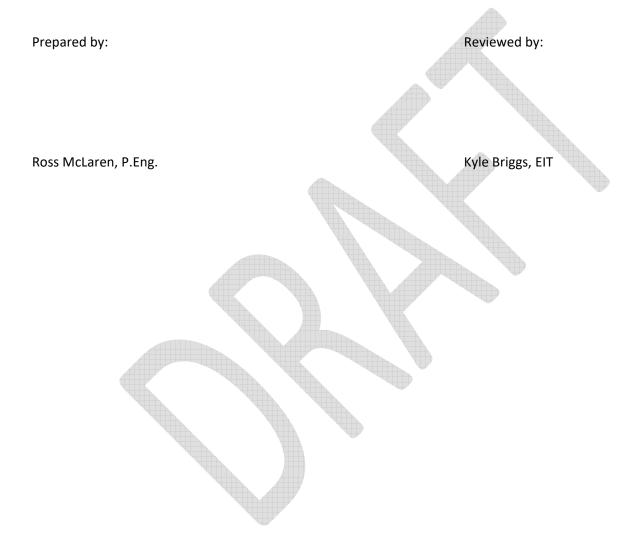
An alternative 6 lane GMC was also assessed assuming that the single lower lane in the DBT tube is for through traffic only, and the upper two lanes are for through traffic as well as the ramp traffic. This assumed that there would be equal utilization of the 3 lanes on GMC as through traffic can use either the upper or lower cells. This assessment of 2050 PM southbound traffic demands (attached) shows better results at mid-GMC however, the ability of the 1920 veh/hr to merge onto Hwy 99 SB from Steveston is unlikely. The equal utilization of the two upper lanes is also highly unlikely with most of the traffic using the right-hand lane to exit at Hwy 17A. Even with the assumed balanced 2140 veh/lane at mid-GMC, there will be queues in all lanes averaging 2.9 lane-km ((2140 - 1800) *8.4/1000). Note that the feasibility of this alternative 6 lane option from a geometric design perspective was not assessed in detail.

A similar analysis of the 6 lane DBT has not been undertaken for the NB direction in the AM peak period, but similar results demonstrating over-capacity are to be expected. It is noted that the NB direction is obviously more complex as there will be the requirement to merge the CD lanes from Hwy 17, the Hwy 17A loop ramp and the NB bus lanes before entering the tube.

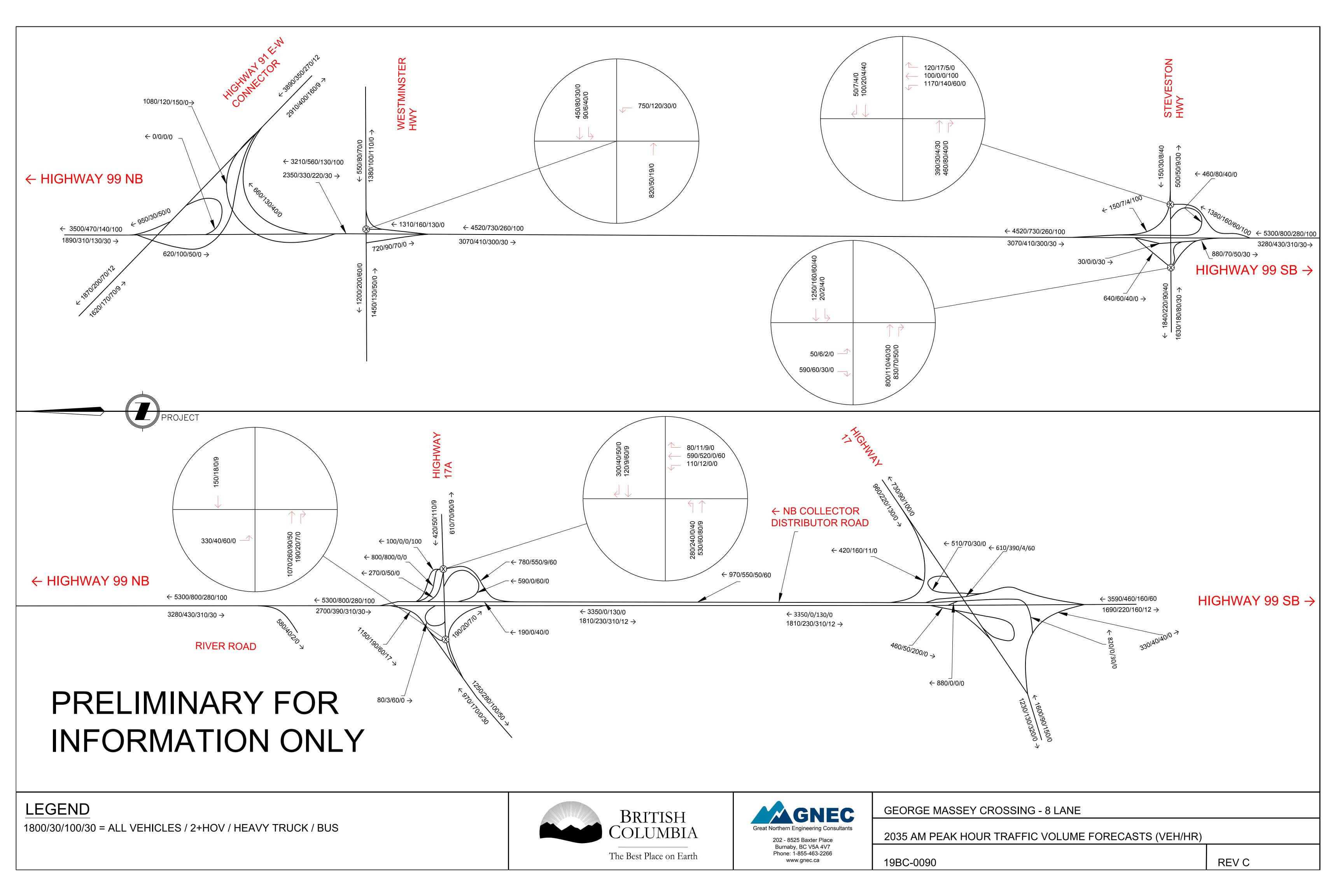


4.0 Conclusions

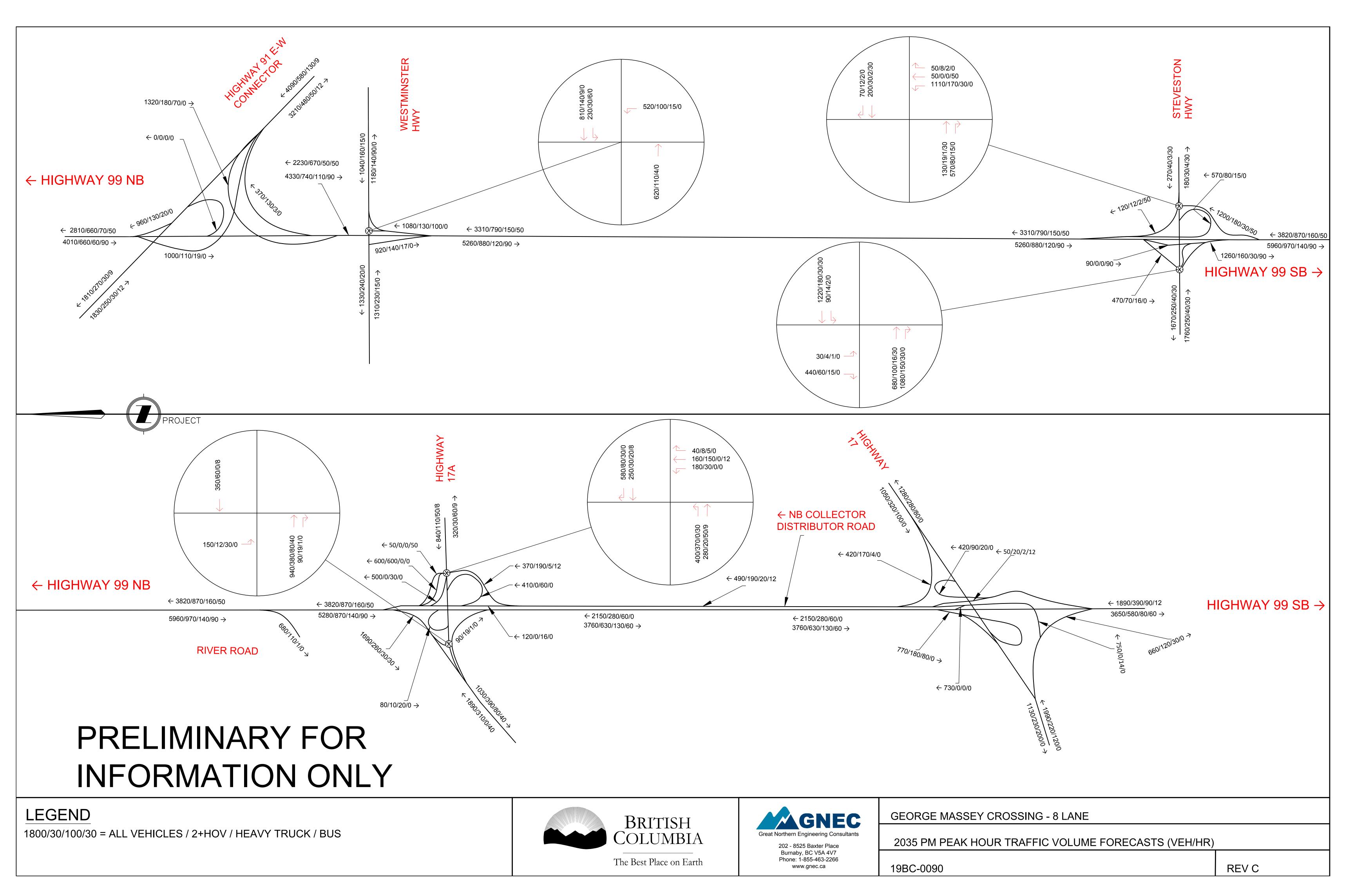
As evident from the above interim analysis, there are concerns not only with the peak direction traffic capacity of all 6 lane GMC options, but also with the Hwy 99 lanes on GMC that serve the Steveston and Hwy 17A interchanges under both the 6 and 8 lane DBT options.



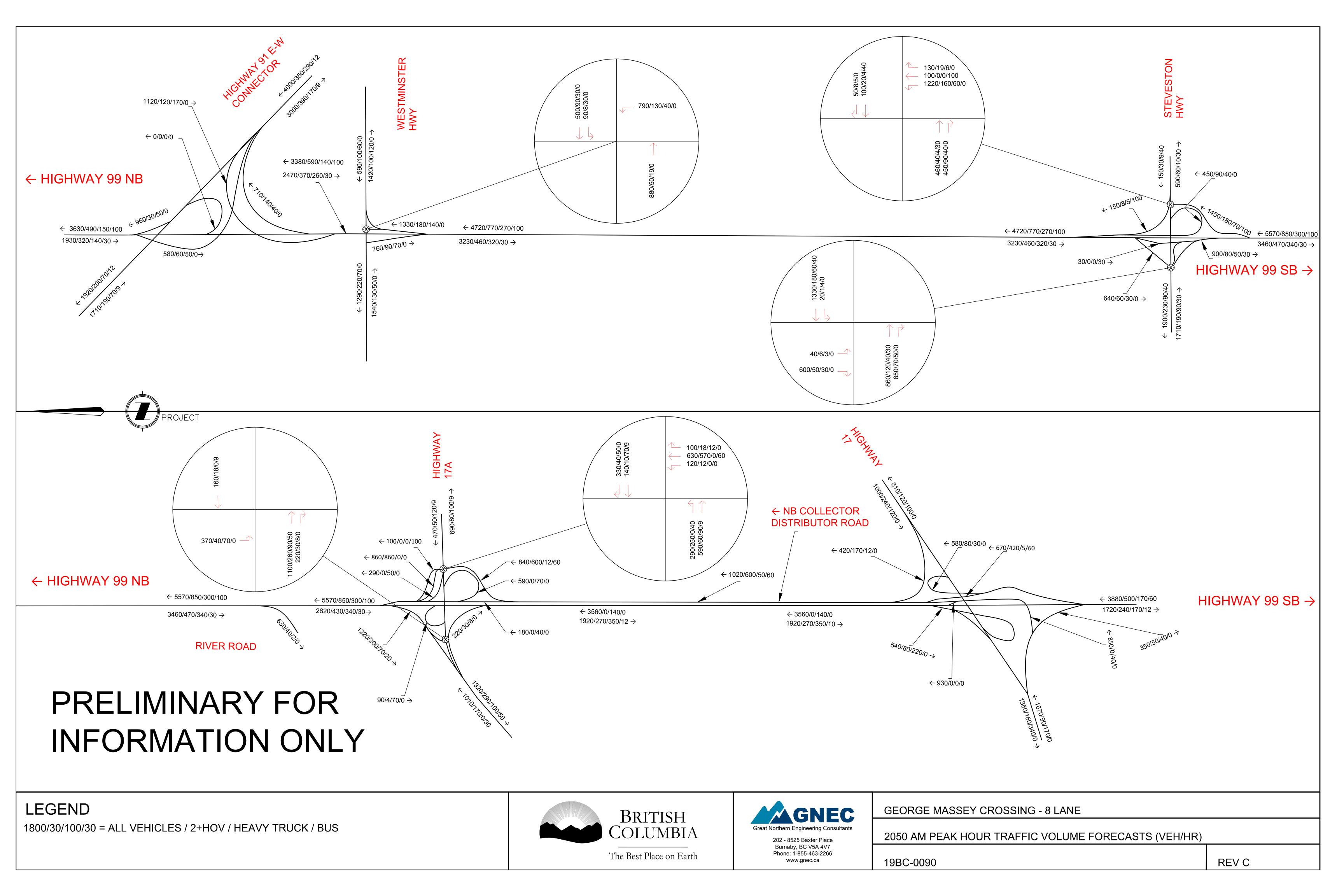
APPENDIX G. 2035 AM INTERCHANGE VOLUMES



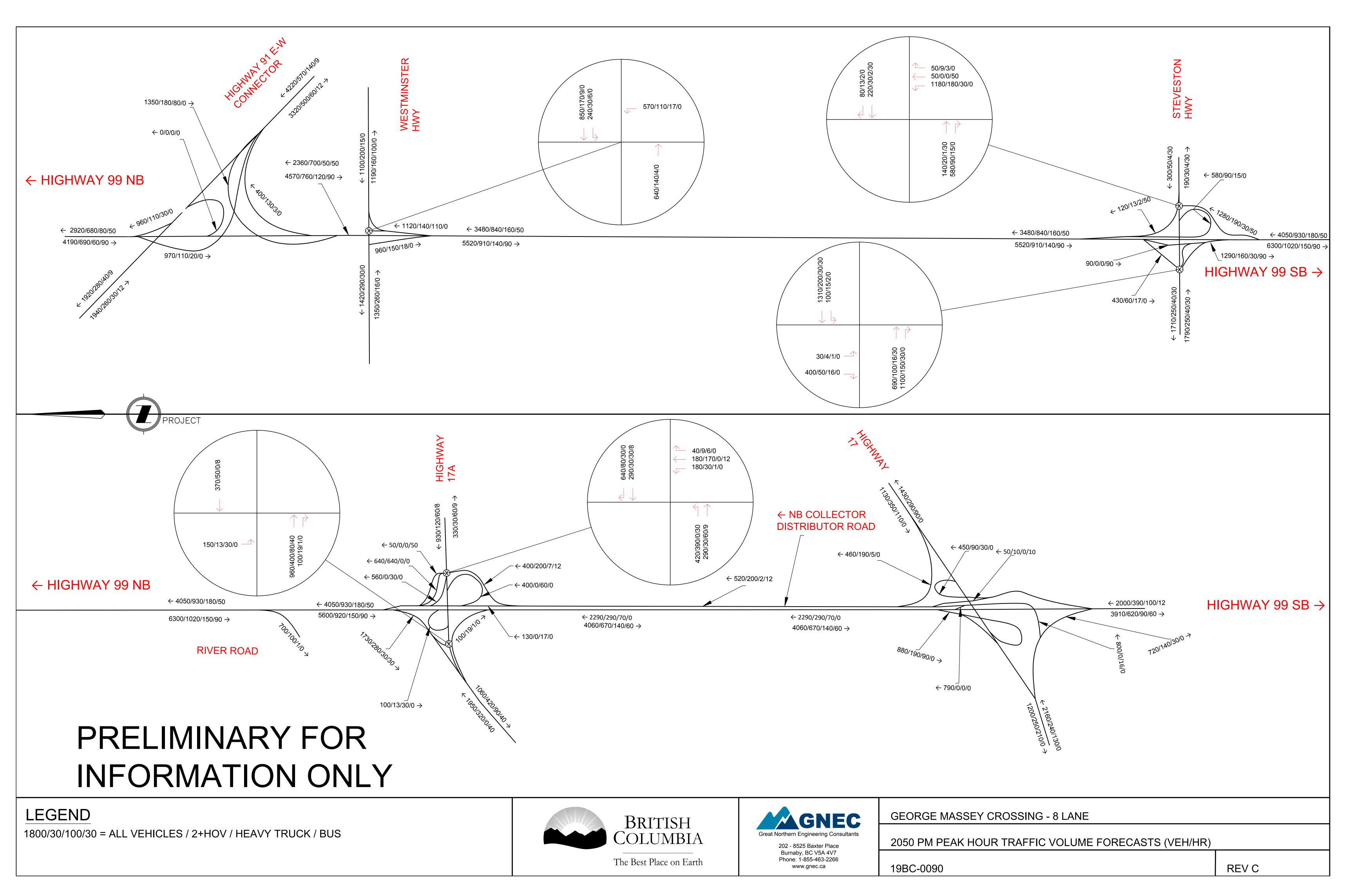
APPENDIX H. 2035 PM INTERCHANGE VOLUMES



APPENDIX I. 2050 AM INTERCHANGE VOLUMES



APPENDIX J. 2050 PM INTERCHANGE VOLUMES



APPENDIX K. GEOMETRIC DESIGN CRITERIA

Project Design Criteria

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 – Long Span Bridge Crossing

Location: Hwy 99, between Sta. 204+30 (Steveston Hwy) and Sta. 240+00 (Hwy 17A)

Length: Approximately 3.5 km

all Projects involving highway geometrics	ACCEPTED BY:	
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	Senior Highway Design Engineer	Date
minor exceptions to standards	ACCEPTED BY:	
ambient standards or context sensitive guidleines		
	Senior Engineering Manager, Highway Design Services	Date
	ACCEPTED BY:	
Major ProjectsPartnership Projects		
highway corridor standards		Date
	Director, Highway Design and Survey Engineering	
		I
major exceptions to standards	ACCEPTED BY:	
Standards		
	Chief Engineer	 Date
standards are proposed proposed, the Senior End Partnership Projects, and	otance at the Senior Highway Design Engineer level. Where for a project, or where Ambient Standards or Context Sensiti gineering Manager, Highway Design Services must accept. If for corridor-wide standards, the Director, Highway Design a re are major exceptions to prevailing standards, the Chief En	ve Guidelines are For Major Projects or and Survey Engineering

2) The following page(s) set out more detailed design criteria for this project.

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 – Long Span Bridge Crossing

Location: Hwy 99, between Sta. 204+30 (Steveston Hwy) and Sta. 240+00 (Hwy 17A)

Length: Approximately 3.5 km

Design Element ^(a)	Present Conditions	Adjacent Project Conditions	MoTI/TAC Guidelines Criteria	Proposed Project Criteria	Achieved Project Criteria	Comments/Notes (c)
Functional Classification (b)	Primary		Primary	Primary	Primary	
Design Classification (b)	RAD		RFD	RFD	RFD	
Posted Speed	80 km/h	km/h	-	90 km/h	90 km/h	
Design Speed	90 km/h	km/h	100 km/h	100 km/h	100 km/h	
Basic # of Lanes	4		8	8	8	
Minimum Horizontal Radius	340 m	m	440 m	440 m	600 m	
Min. "K" factor Sag V.C.	na		45 / 25	45 / 25	26.4	
Min. "K" factor Crest V.C.	na		52	80	80	
Max. Grade	na	%	5 %	5 %	5 %	
Max. Superelevation	na	%	6 %	6 %	5.3 %	
Minimum S.S.D.	na	m	185 m	185 m	230 m	
Lane Width	3.6 m	m	3.7 m	3.7 m	3.7 m	
Shoulder Width Outside	2.5 m	m	3.0 m	3.0 m	3.0 m	
Shoulder Width Inside	na	m	1.0 m	1.7 / 2.0 m	1.7 / 2.0 m	
Clear Zone - Offset Width Recovery Slope (X:1)	m :1	m :1	m 4:1	m 4:1	m 4:1	
Median Width	m	m	4 m / 2.6 m	4 m	4 m	
Catchment Width in Rock Cuts	m	m	m	m	m	
Current Traffic Volume: SADT						
Design SADT / Design Hourly Vol.						
Level of Service (to year 20xx)						
Design Vehicle			ELS B-Train	ELS B-Train	ELS B-Train	
_						

<u>Notes</u>: a) The list of Design Elements will not necessarily be the same for all projects; therefore, items may be deleted or added as appropriate.

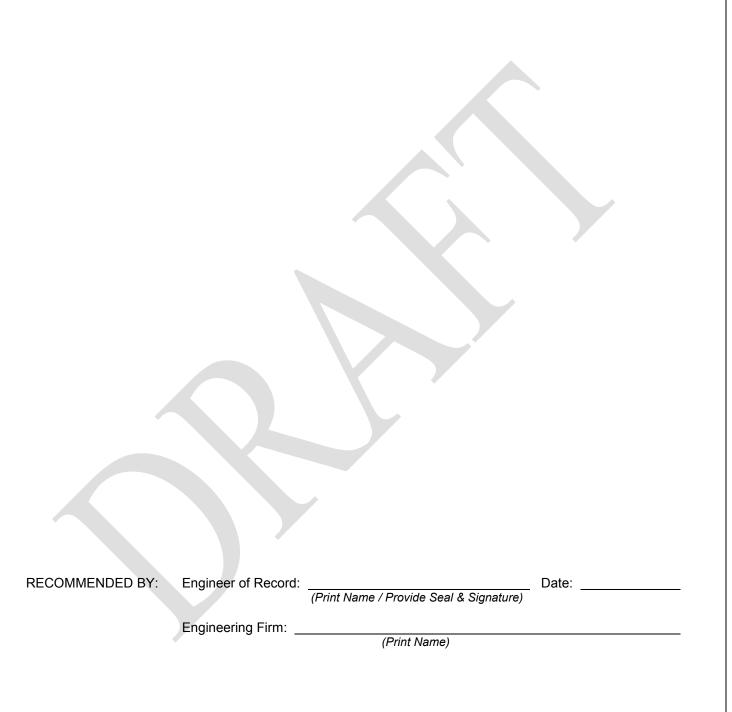
- b) For clarification regarding Functional and Design Classifications, refer to Section 100.11.1.3 of the *BC Supplement to TAC*.
- c) Explanatory Notes / Discussion: On the following pages, provide a brief scope statement, purpose of project and what is being achieved. Enter comments for clarification where appropriate and provide justification and evidence of engineering judgment used for items where deviations are noted in the design parameters listed above or any other deviations from TAC or BC Supplement to TAC which are not noted in the table above.

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 – Long Span Bridge Crossing

Location: Hwy 99, between Sta. 204+30 (Steveston Hwy) and Sta. 240+00 (Hwy 17A)

Length: Approximately 3.5 km



Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 - Immersed Tunnel Crossing

Location: Hwy 99, between Sta. 104+30 (Steveston Hwy) and Sta. 140+00 (Hwy 17A)

Length: Approximately 3.5 km

all Projects involving highway geometrics	ACCEPTED BY:	
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	Senior Highway Design Engineer	Date
minor exceptions to standards	ACCEPTED BY:	
ambient standards or context sensitive guidleines		
guidienies	Senior Engineering Manager, Highway Design Services	Date
Major Projects	ACCEPTED BY:	
Partnership Projects		
 highway corridor standards 		Date
	Director, Highway Design and Survey Engineering	
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major exceptions to standards	ACCEPTED BY:	
standards		
	Chief Engineer	 Date
standards are proposed proposed, the Senior En Partnership Projects, an	ptance at the Senior Highway Design Engineer level. Where for a project, or where Ambient Standards or Context Sensiting in the Standards of Context Sensiting in the Standards, Highway Design Services must accepted for corridor-wide standards, the Director, Highway Design are are major exceptions to prevailing standards, the Chief Engre	ve Guidelines are For Major Projects or and Survey Engineering

2) The following page(s) set out more detailed design criteria for this project.

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 - Immersed Tunnel Crossing

Location: Hwy 99, between Sta. 104+30 (Steveston Hwy) and Sta. 140+00 (Hwy 17A)

Length: Approximately 3.5 km

Design Element ^(a)	Present Conditions	Adjacent Project Conditions	MoTI/TAC Guidelines Criteria	Proposed Project Criteria	Achieved Project Criteria	Comments/Notes (c)
Functional Classification (b)	Primary		Primary	Primary	Primary	
Design Classification (b)	RAD		RFD	RFD	RFD	
Posted Speed	80 km/h	km/h	-	90 km/h	90 km/h	
Design Speed	90 km/h	km/h	100 km/h	100 km/h	100 km/h	
Basic # of Lanes	4		8	8	8	
Minimum Horizontal Radius	340 m	m	440 m	440 m	440 m	
Min. "K" factor Sag V.C.	na		45 / 25	45 / 25	60	
Min. "K" factor Crest V.C.	na		52	52	52	Deas Slough Brg
Max. Grade	na	%	5 %	5 %	5 %	
Max. Superelevation	na	%	6 %	6 %	6 %	
Minimum S.S.D.	na	m	185 m	185 m	185 / 450 m	450m DSD in ITT
Lane Width	3.6 m	m	3.7 m	3.7 m	3.7 m	
Shoulder Width Outside	2.5 m	m	3.0 m	3.0 m	3.0 m	
Shoulder Width Inside	na	m	1.0 m	1.7 / 2.0 m	1.7 / 2.0 m	
Clear Zone - Offset Width	m	m	m	m	m	
Recovery Slope (X:1)	:1	:1	4:1	4:1	4:1	
Median Width	m	m	4 m / 2.6 m	4 m	4 m	
Catchment Width in Rock Cuts	m	m	m	m	m	
Current Traffic Volume: SADT						
Design SADT / Design Hourly Vol.						
Level of Service (to year 20xx)	Y					
Design Vehicle			ELS B-Train	ELS B-Train	ELS B-Train	

<u>Notes</u>: a) The list of Design Elements will not necessarily be the same for all projects; therefore, items may be deleted or added as appropriate.

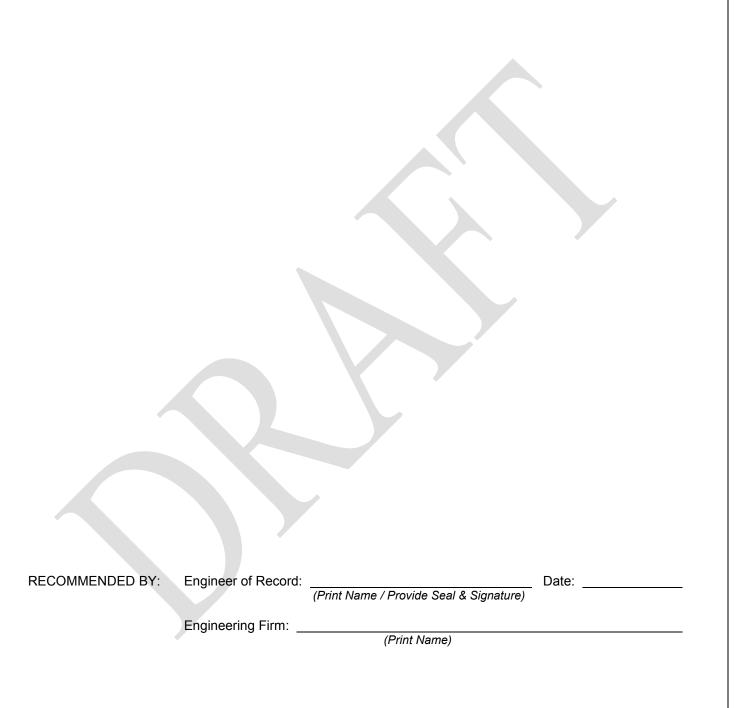
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- c) Explanatory Notes / Discussion: On the following pages, provide a brief scope statement, purpose of project and what is being achieved. Enter comments for clarification where appropriate and provide justification and evidence of engineering judgment used for items where deviations are noted in the design parameters listed above or any other deviations from TAC or BC Supplement to TAC which are not noted in the table above.

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 - Immersed Tunnel Crossing

Location: Hwy 99, between Sta. 104+30 (Steveston Hwy) and Sta. 140+00 (Hwy 17A)

Length: Approximately 3.5 km



Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 - Bored Tunnel Crossing

Location: Hwy 99, between Sta. 102+00 (Steveston Hwy) and Sta. 162+00 (Hwy 17A)

Length: Approximately 6.0 km

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		Senior Highway Design Engineer	 Date
	minor exceptions to	ACCEPTED BY:	
	standards ambient standards or		
	context sensitive guidleines		
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•	Major Projects	ACCEPTED BY:	
•	Partnership Projects		
	highway corridor standards		
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		Chief Engineer	Date
<u>Notes</u> :	standards are propose proposed, the Senior E Partnership Projects, a	ceptance at the Senior Highway Design Engineer level. Where d for a project, or where Ambient Standards or Context Sensitive Engineering Manager, Highway Design Services must accept. and for corridor-wide standards, the Director, Highway Design an ere are major exceptions to prevailing standards, the Chief Engineering Standards.	ve Guidelines are For Major Projects or ınd Survey Engineering
	2) The following page(s):	set out more detailed design criteria for this project.	

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing

Type of work: Highway 99 - Bored Tunnel Crossing

Location: Hwy 99, between Sta. 102+00 (Steveston Hwy) and Sta. 162+00 (Hwy 17A)

Length: Approximately 6.0 km

Design Element (a)	Present Conditions	Adjacent Project Conditions	MoTI/TAC Guidelines Criteria	Proposed Project Criteria	Achieved Project Criteria	Comments/Notes (c)
Functional Classification (b)	Primary		Primary	Primary	Primary	
Design Classification (b)	RAD		RFD	RFD	RFD	
Posted Speed	80 km/h	km/h	-	90 km/h	90 km/h	
Design Speed	90 km/h	km/h	100 km/h	100 km/h	100 km/h	
Basic # of Lanes	4		8	8	8	
Minimum Horizontal Radius	340 m	m	440 m	440 m	850 m	
Min. "K" factor Sag V.C.	na		45 / 25	45 / 25	60	
Min. "K" factor Crest V.C.	na		52	52	61	
Max. Grade	na	%	5 %	5 %	5 %	
Max. Superelevation	na	%	6 %	6 %	4.6 %	
Minimum S.S.D.	na	m	185 m	185 m	200 / 450 m	450m DSD in Tunnel
Lane Width	3.6 m	m	3.7 m	3.7 m	3.7 m	
Shoulder Width Outside	2.5 m	m	3.0 m	3.0 m	3.0 m	
Shoulder Width Inside	na	m	1.0 m	1.7 / 2.0 m	1.7 / 2.0 m	
Clear Zone - Offset Width	m	m	m	m	m	
Recovery Slope (X:1)	:1	:1	4:1	4:1	4:1	
Median Width	m	m	4 m / 2.6 m	4 m	4 m	
Catchment Width in Rock Cuts	m	m	m	m	m	
Current Traffic Volume: SADT						
Design SADT / Design Hourly Vol.						
Level of Service (to year 20xx)						
Design Vehicle			ELS B-Train	ELS B-Train	ELS B-Train	
		-				

<u>Notes</u>: a) The list of Design Elements will not necessarily be the same for all projects; therefore, items may be deleted or added as appropriate.

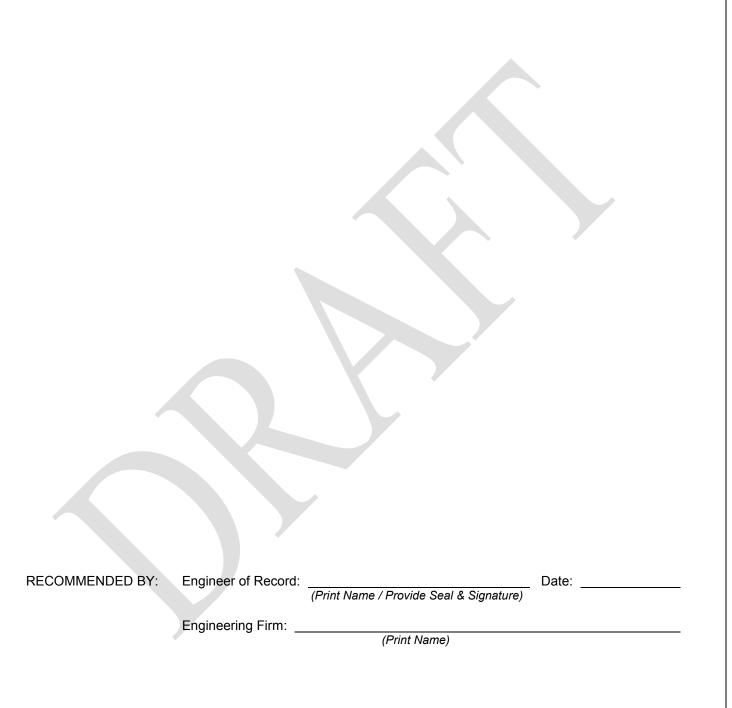
- b) For clarification regarding Functional and Design Classifications, refer to Section 100.11.1.3 of the *BC Supplement to TAC*.
- c) Explanatory Notes / Discussion: On the following pages, provide a brief scope statement, purpose of project and what is being achieved. Enter comments for clarification where appropriate and provide justification and evidence of engineering judgment used for items where deviations are noted in the design parameters listed above or any other deviations from TAC or BC Supplement to TAC which are not noted in the table above.

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: Highway 99 - Bored Tunnel Crossing

Location: Hwy 99, between Sta. 102+00 (Steveston Hwy) and Sta. 162+00 (Hwy 17A)

Length: Approximately 6.0 km



Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 - George Massey Crossing

Type of work: Steveston Hwy New Structure

Hwy 99, between Sta. 200+00 and Sta. 205+00 Location:

Length: Approximately 0.5 km

all Projects involving highway geometrics	ACCEPTED BY:	
	Senior Highway Design Engineer	Date
minor exceptions to standards	ACCEPTED BY:	
ambient standards or context sensitive guidleines		
	Senior Engineering Manager, Highway Design Services	Date
Major Projects	ACCEPTED BY:	
Partnership Projects	_	
highway corridor standards		Date
	Director, Highway Design and Survey Engineering	
major exceptions to	ACCEPTED BY:	
standards		
	Chief Engineer	Date
tes: 1) All projects require accep	otance at the Senior Highway Design Engineer level. Where r	minor exceptions to

- Partnership Projects, and for corridor-wide standards, the Director, Highway Design and Survey Engineering must accept. Where there are major exceptions to prevailing standards, the Chief Engineer's acceptance will be required.
- 2) The following page(s) set out more detailed design criteria for this project.

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing

Type of work: Steveston Hwy New Structure

Location: Hwy 99, between Sta. 200+00 and Sta. 205+00

Length: Approximately 0.5 km

Design Element ^(a)	Present Conditions	Adjacent Project Conditions	MoTI/TAC Guidelines Criteria	Proposed Project Criteria	Achieved Project Criteria	Comments/Notes (c)
Functional Classification (b)						
Design Classification (b)	UAU		UAU	UAU	UAU	
Posted Speed	50 km/h	km/h	-	50 km/h	50 km/h	
Design Speed	50 km/h	km/h	50 km/h	50 km/h	50 km/h	
Basic # of Lanes	2		4	4	4	
Minimum Horizontal Radius	340 m	m	90 m	250 m	250 m	
Min. "K" factor Sag V.C.	14		13 / 6	13 / 6	9	
Min. "K" factor Crest V.C.	8.5		7	9	9	
Max. Grade	5.8 %	%	6 %	5.5 %	5.5 %	
Max. Superelevation	na	%	6 %	4.1 %	4.1 %	
Minimum S.S.D.	40	m	40 m	50 m	50 m	
Lane Width	3.6 m	m	3.7 m	3.7 m	3.7 m	
Shoulder Width Outside	na	m		0.5 m	0.5 m	
Shoulder Width Inside	na	m	m	0.5 m	0.5 m	
Clear Zone - Offset Width Recovery Slope (X:1)	m :1	m :1	m :1	m :1	m :1	
Median Width	m	m	m	m	m	
Catchment Width in Rock Cuts	m	m	m	m	m	
Current Traffic Volume: SADT						
Design SADT / Design Hourly Vol.						
Level of Service (to year 20xx)						
Design Vehicle			WB-20	WB-20	WB-20	

<u>Notes</u>: a) The list of Design Elements will not necessarily be the same for all projects; therefore, items may be deleted or added as appropriate.

- b) For clarification regarding Functional and Design Classifications, refer to Section 100.11.1.3 of the *BC Supplement to TAC*.
- c) Explanatory Notes / Discussion: On the following pages, provide a brief scope statement, purpose of project and what is being achieved. Enter comments for clarification where appropriate and provide justification and evidence of engineering judgment used for items where deviations are noted in the design parameters listed above or any other deviations from TAC or BC Supplement to TAC which are not noted in the table above.

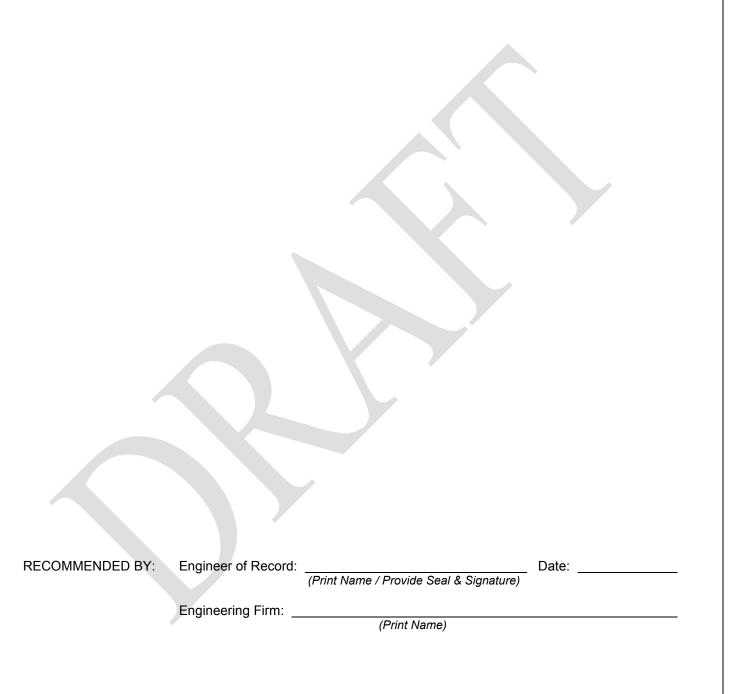
Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing

Type of work: Steveston Hwy New Structure

Location: Hwy 99, between Sta. 200+00 and Sta. 205+00

Length: Approximately 0.5 km



Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing

Type of work: River Road Connector over Hwy 99

Location: Hwy 99, between Sta. 300+00 and Sta. 306+50

Length: Approximately 0.65 km

all Projects involving highway geometrics	ACCEPTED BY:	
	Senior Highway Design Engineer	Date
		1
minor exceptions to standards	ACCEPTED BY:	
ambient standards or context sensitive guidleines		
	Senior Engineering Manager, Highway Design Services	Date
Major Projects	ACCEPTED BY:	
Partnership Projects		
highway corridor standards		Date
	Director, Highway Design and Survey Engineering	
		1
major exceptions to standards	ACCEPTED BY:	
Standards		
	Chief Engineer	 Date
standards are proposed f proposed, the Senior Eng Partnership Projects, and	tance at the Senior Highway Design Engineer level. Where or a project, or where Ambient Standards or Context Sensitivineering Manager, Highway Design Services must accept. For corridor-wide standards, the Director, Highway Design are major exceptions to prevailing standards, the Chief Engrey of the Senior Standards of the Senior Standards.	ve Guidelines are For Major Projects or and Survey Engineering
2) The following page(s) set	out more detailed design criteria for this project.	

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing

Type of work: River Road Connector over Hwy 99

Location: Hwy 99, between Sta. 300+00 and Sta. 306+50

Length: Approximately 0.65 km

Design Element ^(a)	Present Conditions	Adjacent Project Conditions	MoTI/TAC Guidelines Criteria	Proposed Project Criteria	Achieved Project Criteria	Comments/Notes (c)
Functional Classification (b)						
Design Classification (b)	RCU		RCU	RCU	RCU	
Posted Speed	60 km/h	km/h	-	60 km/h	60 km/h	
Design Speed	60 km/h	km/h	60 km/h	60 km/h	60 km/h	
Basic # of Lanes	2		2	2	2	
Minimum Horizontal Radius	m	m	130 m	250 m	250 m	
Min. "K" factor Sag V.C.			18 / 9	18 / 9	9.2	
Min. "K" factor Crest V.C.			11	11	11.1	
Max. Grade	%	%	6 / 10 %	7 %	7 %	
Max. Superelevation	na	%	6 %	4.8 %	4.8 %	
Minimum S.S.D.		m	85 m	85 m	85 m	
Lane Width	m	m	3.6 m	3.6 m	3.6 m	
Shoulder Width Outside	na	m	1.5 m	2.0 m	2.0 m	
Shoulder Width Inside	na	m	m	m	m	
Clear Zone - Offset Width	m	m	m	m	m	
Recovery Slope (X:1)	:1	:1	4:1	:1	:1	
Median Width	m	m	m	m	m	
Catchment Width in Rock Cuts	m	m	m	m	m	
Current Traffic Volume: SADT						
Design SADT / Design Hourly Vol.						
Level of Service (to year 20xx)	Y					
Design Vehicle			WB-20	WB-20	WB-20	

<u>Notes</u>: a) The list of Design Elements will not necessarily be the same for all projects; therefore, items may be deleted or added as appropriate.

- b) For clarification regarding Functional and Design Classifications, refer to Section 100.11.1.3 of the *BC Supplement to TAC*.
- c) Explanatory Notes / Discussion: On the following pages, provide a brief scope statement, purpose of project and what is being achieved. Enter comments for clarification where appropriate and provide justification and evidence of engineering judgment used for items where deviations are noted in the design parameters listed above or any other deviations from TAC or BC Supplement to TAC which are not noted in the table above.

Highway Engineering Ministry of Transportation and Infrastructure

Project: No.15CS1036 – George Massey Crossing
Type of work: River Road Connector over Hwy 99

Location: Hwy 99, between Sta. 300+00 and Sta. 306+50

Length: Approximately 0.65 km

