BRITISH COLUMBIA MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

George Massey Crossing Technical Services

TRAFFIC AND GEOMETRICS TECHNICAL REPORT DRAFT

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APPENDICES

1. Introduction

COWI, with support from subconsultants Stantec, GNEC, McElhanney and others (the COWI-Stantec Team, or "CST"), were retained by the Ministry of Transportation and Infrastructure (“MoTI”) to provide “Technical Services for George Massey Crossing Project” ("Project"). The technical services referred to included, inter alia, transportation planning, traffic engineering and highway design for the purposes of providing technical support to the MoTI regarding future options for the George Massey Crossing ("GMC").

The purpose of this report compiled by Stantec and GNEC is to document the preliminary work of the traffic engineering and highway design teams and present the associated findings that supported the development of preliminary conceptual level geometric design for the proposed GMC. At the commencement of the assignment in July 2019, there were a number of GMC “technologies” under consideration by the MoTI including:

- Deep Bored Tunnel (“DBT”)
- Immersed Tube Tunnel (“ITT”) and
- Long Span Bridge (“Bridge”).

As the Project evolved, it became apparent that there were notable traffic, geometric and other technical issues related to the DBT option and attention thus focused more closely on the ITT and Bridge options. As a result, this report focuses primarily on the ITT and Bridge options.

The following directives from the MoTI were followed with regard to the geometric design for the GMC:

- The proposed GMC shall comprise of three general purpose (GP) traffic lanes and one transit (bus) only lane in each direction. The transit lanes could either be in the existing tunnel or on the proposed GMC DBT, ITT or Bridge.
- The proposed GMC shall connect to the existing Highway 99 and adjacent interchanges at Highway 17A and Steveston Highway.
- The interim works that were being considered in and around the existing tunnel in 2019 (by others) to support transit and mobility shall be included in or integrated with the GMC design where feasible.

The GMC traffic engineering and highway design work has been an iterative process whereby preliminary traffic forecasts and analysis have been utilized to develop initial design concepts, followed by a revisit of the future traffic forecasts to reflect the concept design. Further refinements have been made to the design with a revisiting of the traffic forecasts where necessary. Individual studies and investigations have also been undertaken and these have been documented in separate memos where applicable as cross-referenced in this report. Due to the fast-track nature of the Project, time constraints did not allow for all analysis to be updated as new traffic forecast or design revisions became available. Where relevant, this report may supersede the findings from previous analysis, memos and reports.

It is expected that as the design concepts evolve in future, further and more detailed traffic forecasting and analysis at each stage of design should be undertaken. It is noted that the traffic engineering analysis that has been undertaken to date has focused on individual components of the proposed designs (e.g. ramps or intersections) and the analysis of the overall “system” including the GMC and adjacent interchanges has not been performed.

Note that for the purposes of this report, Highway 99 is assumed to run north/south and Highway 17A and Steveston Highway are assumed to run east/west. Abbreviations such as NB = northbound, SB = southbound, EB = eastbound and WB = westbound have also been used throughout this report to indicate traffic directions. Furthermore, intersection turning movements are abbreviated as NBL = northbound left, SBR = southbound right, EBT = eastbound through, etc.

2. Existing Conditions

This section of the report documents the existing conditions at the George Massey Tunnel, on Highway 99 and at the adjacent interchanges at Highway 17A and Steveston Highway in terms of geometrics and traffic.

2.1. Highway Laning and Interchange Configuration

A single-line schematic drawing showing the existing laning on Highway 99, from north of Steveston Highway to south of Highway 17A is provided in ***Appendix A***. Lane designations (GP, HOV, Bus) are colour coded as shown in the drawing legend. Detailed laning schematics of existing Steveston Highway Interchange and Highway 17A Interchange are also provided (***Appendices B*** and ***C***), with ramp merge and diverge distances notated.

General descriptions of the existing laning on Highway 99 Mainline and at the Steveston Highway Interchange and Highway 17A Interchange are as follows:

2.1.1 Existing Highway 99 Mainline – Steveston Highway to Highway 17A

- The existing tunnel is approximately 600 m long and contains four lanes, located in two separate 'tubes'. During most hours of operation, the tunnel has two NB lanes, and two SB lanes. The four-lane highway cross section at the existing tunnel extends south to the bridge at Deas Slough.
- During weekday peak periods, a counterflow lane operation is used.
    - During the weekday morning peak period (approximately 0600 to 0900 hours), there are three NB lanes and one SB lane.
    - During the weekday afternoon peak periods (approximately 1500 - 1800 hours), there are three SB lanes and one NB lane.
- Between Highway 17A and Deas Slough there are a total of six lanes (two Highway 99 mainline lanes and four ramp/HOV/CD road lanes) which, during off peak periods, merge into the two NB lanes at the Deas Slough bridge and the existing tunnel. The most easterly of these is an HOV lane, which enters the Highway 99 mainline lanes immediately south of the Deas Slough bridge. During weekday morning peak periods, access to the NB counterflow lane is achieved from a left-side added lane, located beside the mainline lanes. During weekday afternoon peak periods, the six approach lanes must merge into a single NB lane at the Deas Slough bridge.
- North of the existing tunnel, and in off-peak periods, the two NB lanes continue through to Steveston Highway and beyond. In weekday morning peak periods, the three NB lanes also extend to Steveston Highway and beyond. In weekday afternoon peak periods, the single NB lane transitions to two NB lanes just south of Steveston Highway.
- On Highway 99 at Steveston Highway there are: two SB lanes in off-peak periods; one SB lane in weekday morning peak periods; and, three SB lanes in weekday

afternoon peak periods. There is also one interchange ramp entrance and one bus queue-jumper lane entrance between Steveston Highway and the Rice Mill Road overpass.
- South of the existing tunnel, and in off-peak periods, the two SB lanes continue to Highway 17A and beyond. In weekday afternoon peak periods, the three SB lanes also extend to Highway 17A and beyond. In weekday morning peak periods, the single SB lane transitions to two SB lanes just north of Highway 17A.

2.1.2 Existing Steveston Highway Interchange

- The Highway 99/Steveston Highway interchange provides for all traffic movements and includes an EB to NB single lane loop ramp in the southeast quadrant.
- Steveston Highway consists of: four lanes west of Highway 99 (plus auxiliary lanes); two lanes at the highway overpass; and two lanes east of Highway 99.
- There are two signalized intersections on Steveston Highway, one at each ramp terminal.
- Buses on Highway 99 NB exit the mainline with GP traffic as they approach the interchange. They stop on the south side of Steveston Highway, before continuing through the east signalized intersection and onto the Highway 99 entrance ramp. This ramp joins the mainline as a lane-away and then transitions to a bus shoulder lane configuration.
- Buses on Highway 99 SB approaching the interchange use the Highway 99 SB HOV lane. Just north of the interchange, this HOV lane designation ends. Buses exit the mainline in the GP ramp, then immediately exit left into a bus-only ramp. This ramp passes under the Steveston Highway bridge west approach span and provides access to a bus stop located just south of the bridge. Another bus-only ramp from Steveston Highway also provides access to this bus stop. Immediately south of the bus stop, buses cross the southbound entrance ramp through a signalized intersection. Buses then continue south - separate from the mainline - and through a vehicle inspection/ weigh scale station, before entering the mainline lanes just north of the Rice Mill Road overpass.

2.1.3 Existing Highway 17A Interchange

- The Highway 99/Highway 17A interchange provides for all traffic movements and includes single lane loop ramps in the southeast (EB to NB) and northwest (WB to SB) quadrants.
- Highway 17A consists of; five lanes west of Highway 99; four lanes east of Highway 99; and two, two-lane bridges over Highway 99. On the bridges, there are three EB lanes and one WB lane.
- There are two signalized intersections on Highway 17A, one at each ramp terminal.
- Northbound HOV traffic in the Highway 99 corridor north of Highway 17 is located on the Collector/Distributor (CD) road that runs between the Highway 17 and Highway 17A interchanges. The HOV lane designation ends approximately 600 m south of Highway 17A and HOV traffic exits the CD road using the GP ramp. Approaching the east signalized intersection on Highway 17A from the ramp, HOV traffic is located in a short designated HOV lane. HOV traffic continues straight through the intersection onto a designated HOV lane on the entrance ramp. The HOV lane ends approximately 900 m further north, immediately south of the Deas Slough bridge.
- There is also an HOV lane on Highway 17A, west of Highway 99. It is located in the Highway 17A eastbound median lane and begins at Ladner Trunk Road. The HOV lane designation ends at the west signalized intersection, then starts again

approaching the east signalized intersection. Here HOV traffic has a designated left turn lane where they can directly access the HOV lane on the ramp and queue jump north to the Deas Slough bridge.

2.2. Traffic Patterns

Highway 99 is a major corridor serving international, provincial and regional travel. In addition to serving these markets, the existing tunnel serves commuter traffic from Delta/South Surrey into Richmond and Vancouver, and vice versa. ***Figures 1*** and ***2*** below show the percentage of existing traffic accessing and egressing Highway 99 that use the existing tunnel in the northbound and southbound directions respectively in the AM and PM peak periods. These charts were developed using processed data from TomTom from September/October 2018. The TomTom statistics are calculated from anonymized GPS data collected via navigation devices, in-dash systems and smartphones

In the AM peak northbound direction (***Figure 1***), most of the traffic through the existing tunnel is coming from South Surrey/White Rock and North Delta and then going into west and central Richmond with 34% continuing into Vancouver. In the PM peak southbound direction (***Figure 2***), most of the traffic through the existing tunnel is coming from west and central Richmond and going to Ladner/Tsawwassen, North Delta and South Surrey/White Rock.

Figure 1 - Existing Tunnel Observed Northbound Traffic Pattern – AM Peak/PM Peak

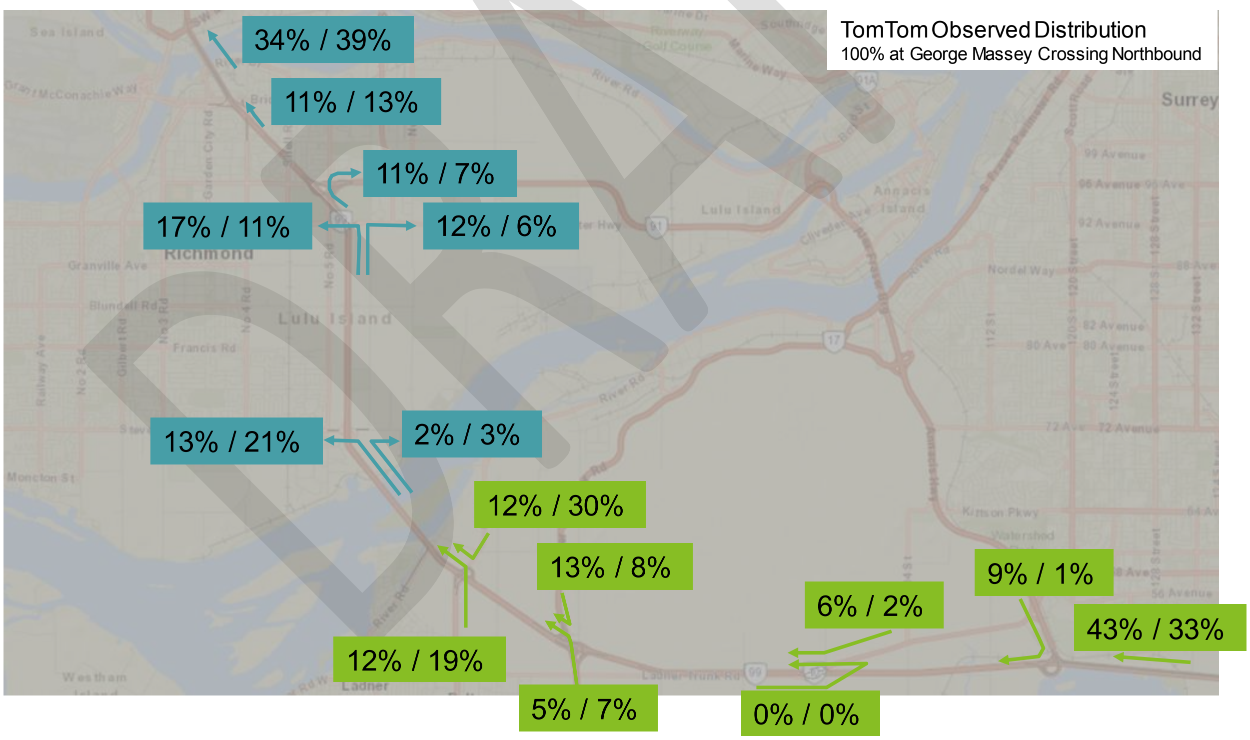
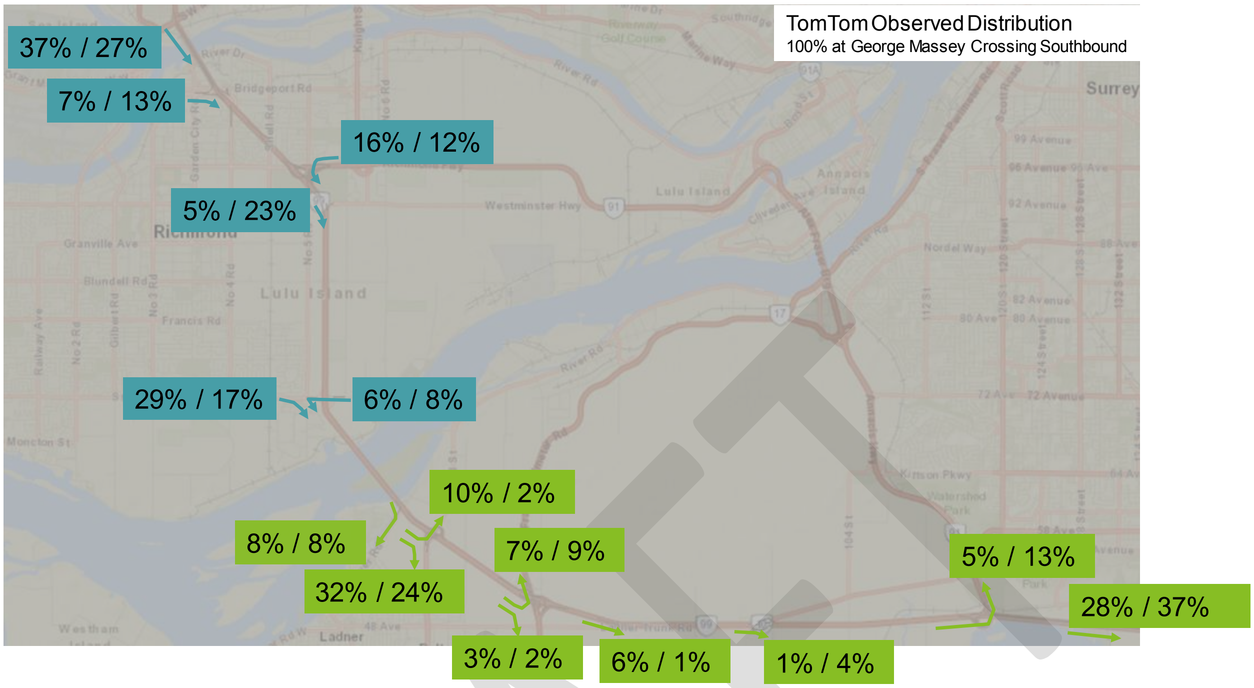


Figure 2 - Existing Tunnel Observed Southbound Traffic Pattern – AM Peak/PM Peak



2.3. Daily Trends

As mentioned earlier, the existing tunnel currently is operated with a counter-flow lane in the weekday peak direction which generally operates from 6:00-9:00 am in the northbound direction and from 3:00-6:00 pm in the southbound direction. Hourly traffic volumes at the existing tunnel are typical of a regional commuter facility with a well-defined AM peak in the northbound direction and a PM peak in the southbound direction (see ***Figure 3*** and ***4***). The data that was used to generate these figures was from weekday October/November 2017 MoTI Permanent Count data. As can be seen from the figures, there are significant variations in the traffic flows through the tunnel especially during peak periods.

It is also noted that the AM NB peak hour at the existing tunnel is at around 6:00 with average throughput volumes of approximately 5000 veh/hour. During the Regional Transportation Model ("RTM" – see later) peak hour between 7:30 and 8:30, the average NB volumes at the existing tunnel are tapering off. Similarly, the PM SB peak hour at the existing tunnel is at around 15:00 with average throughput volumes of approximately 4900 veh/hour. During the RTM regional peak hour between 16:30 and 17:30, the average SB volumes at the existing tunnel are tapering off. The single lane available in the off-peak direction processes approximately 1,350 veh/hr in the SB direction during the AM peak period and approximately 1,500 veh/hr in the NB direction during the PM peak period. It is stressed that the volumes presented in ***Figures 3*** and ***4*** are throughput volumes (i.e. the volumes processed through the tunnel) and not necessarily the demands (i.e. the amount of traffic that desires to travel through the tunnel). In the lead up to and during the RTM peak periods, volumes exceed demands, and this is reflected in the recurring daily queues that occur in both directions – see later.

Figure 3 - Existing Tunnel Hourly Northbound Traffic Volumes

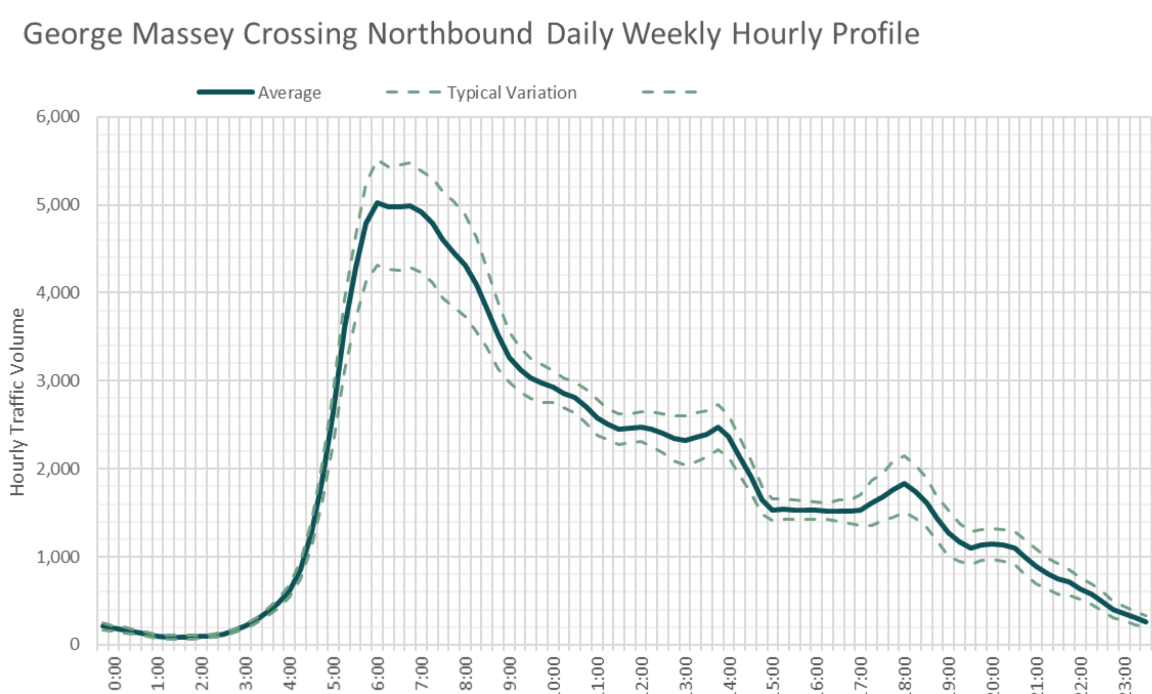
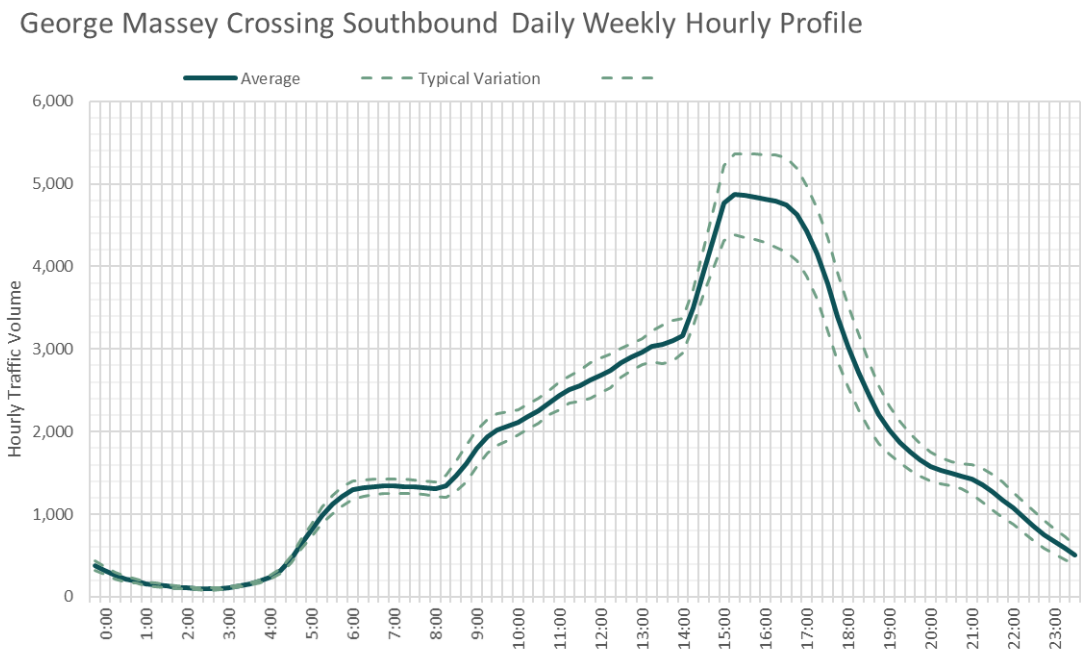


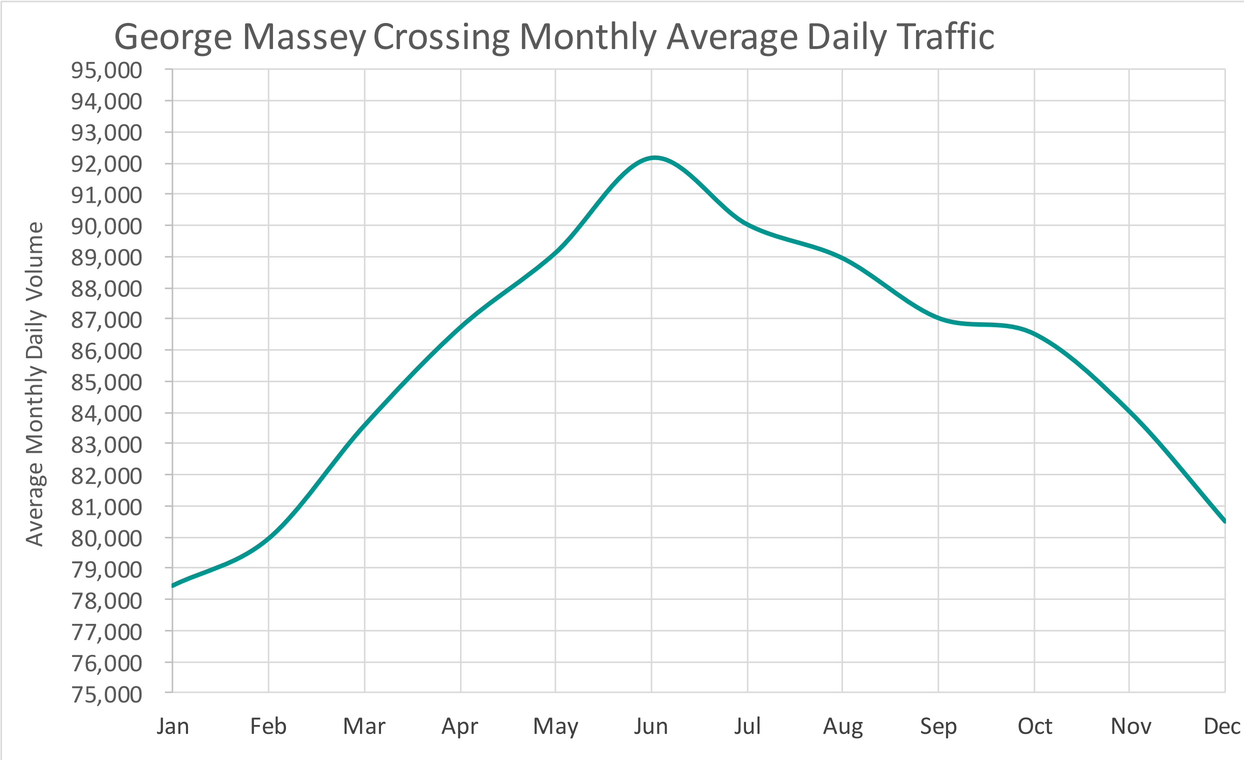
Figure 4 - Existing Tunnel Hourly Southbound Traffic Volumes



2.4. Seasonal Trends

Traffic volumes through the existing tunnel vary significantly based on the time of year. ***Figure 5*** below shows that average daily traffic volumes can vary from a low of 78,500 veh/day in January to a high of 92,000 veh/day in June during the peak summer months. This speaks to the high proportion of tourist activity based on Highway 99's connection to the Canada/US border. On an annual average basis, the existing tunnel carries approximately 85,000 veh/day which is close to the monthly October/November volumes in the fall or the March/April volumes in the spring.

__Figure 5 - Existing Tunnel Seasonal Variation in Daily Traffic Volume__



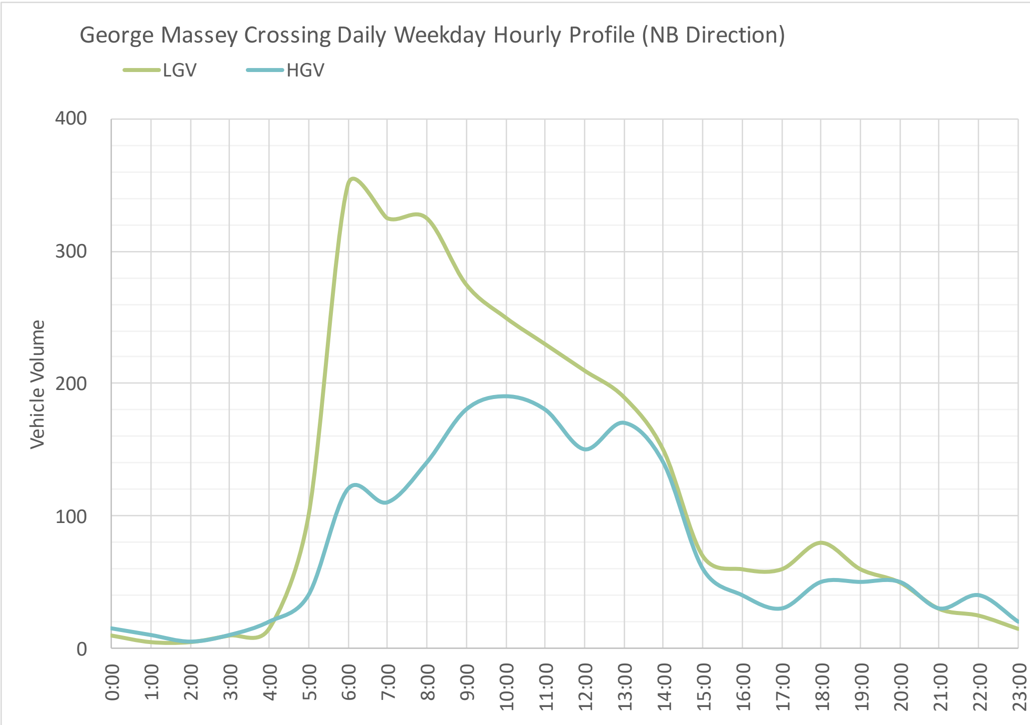
Source: BC MoTI Permanent Traffic Counter, 2017

2.5. Vehicle Classifications

Traffic volumes at the existing tunnel consist primarily of automobiles at 90% in the northbound direction and 87% in the southbound direction. Light trucks account for 6% and 7% of traffic volumes in the north and southbound directions respectively. Heavy trucks including buses account for 4% and 6% of vehicle volumes in the north and southbound directions respectively.

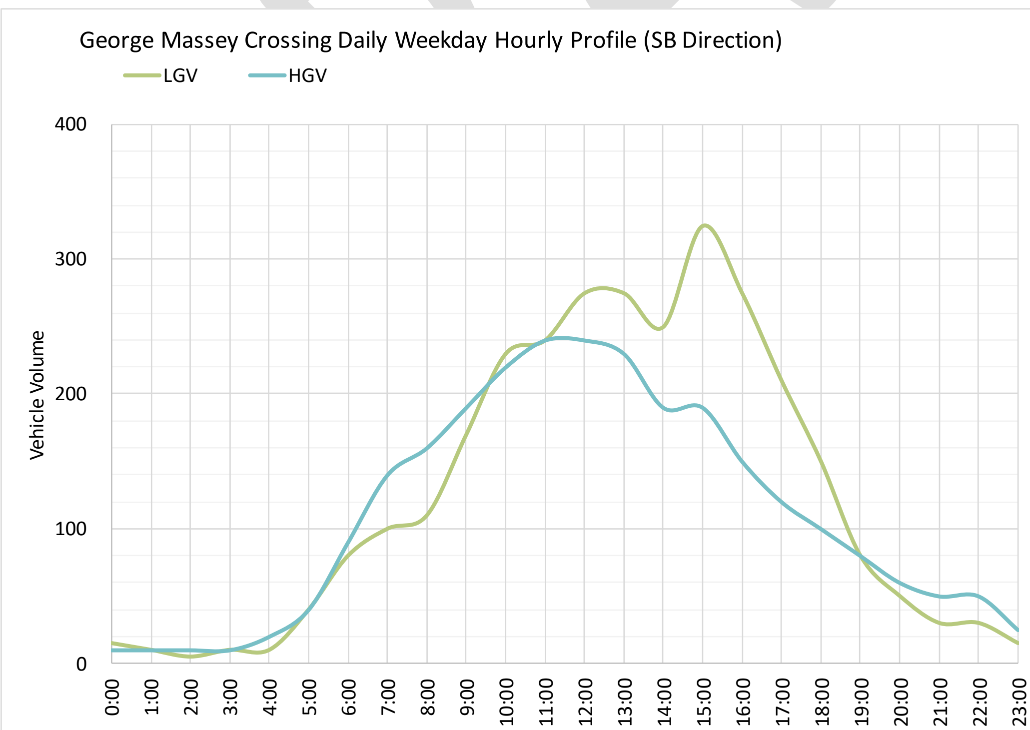
Light goods vehicles (LGVs) and heavy goods vehicles (HGVs) (including buses) display unique time of day patterns as shown in ***Figures 6*** and ***7*** below. Light trucks tend to peak similarly to automobile traffic, however heavy trucks tend to peak during the midday when vehicle delays and queues crossing the existing tunnel are lower. The heavy truck profile is also a function of freight logistics whereby trucks make deliveries within specific time windows to meet their customer requirements.

Figure 6 - Existing Tunnel Light and Heavy Truck Hourly Profile (Northbound)



Source BC MoTI Permanent Counter, Oct/Nov 2017

Figure 7 - Existing Tunnel Light and Heavy Truck Hourly Profile (Southbound)



Source BC MoTI Permanent Counter, Oct/Nov 2017

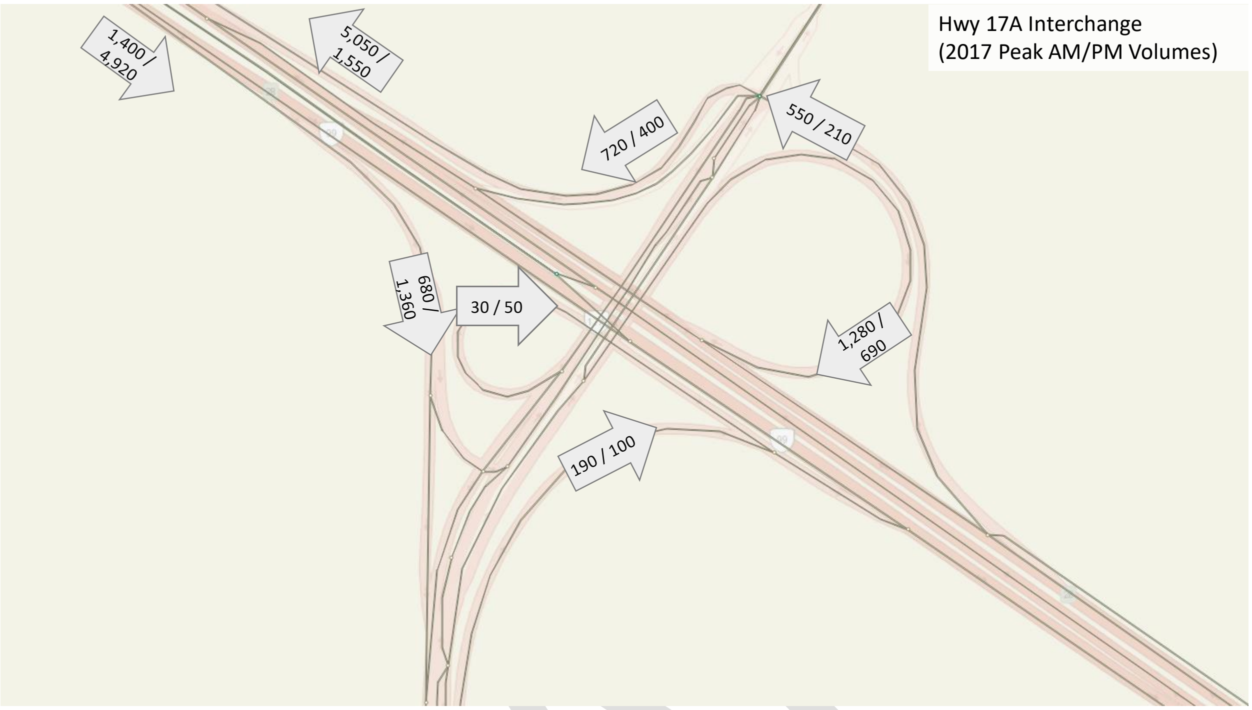
2.6. Peak Period Traffic Volumes

Existing AM and PM peak hour traffic volumes at the Steveston Highway and Highway 17A interchanges are presented in ***Figures 8*** and ***9***. Note that these ramp volumes have been developed from the Regional Transportation Model (RTM) factored to permanent traffic counts along Highway 99 since observed count data on all ramps was either dated, incomplete or not available (see ***Appendix D***)

Figure 8 - Existing AM/PM Peak Hour Ramp Volumes at Steveston Highway Interchange (veh/hr)

Source: Regional Transportation Model Phase 3 adjusted with MoTI permanent count data from Oct/Nov 2017.

Figure 9 - Existing AM/PM Peak Hour Ramp Volumes at Highway 17A Interchange (veh/hr)



Source: Regional Transportation Model Phase 3 adjusted with MoTI permanent count data from Oct/Nov 2017.

2.7. Transit Services and Ridership

The existing tunnel carries a significant volume of transit services and ridership as shown in ***Table 1*** below. During the morning and afternoon peak periods, the existing tunnel carries almost 30 buses per hour which is equivalent to a bus every two minutes based on the current schedule. In terms of ridership, there is a total of 770 transit riders travelling northbound in the AM peak hour resulting in a transit mode share of 11% assuming an average vehicle occupancy of 1.2. A transit mode share in the southbound PM peak of 12% is estimated with 790 riders and the same vehicle occupancy assumptions. For a highway-based facility, this is a fairly high level of transit ridership speaking to the importance of transit in this part of the Highway 99 corridor.

Table 1 - Existing Tunnel Transit Services and Ridership

Route	Description	Dir	AM Peak Buses/Hr	PM Peak Buses/Hr	AM Peak Freq (min)	PM Peak Freq (min)	Max Load AM	Max Load PM	AM Peak Ridership	PM Peak Ridership
311	Bridgeport Stn	NB	4		15		39	39	156	0
311	Scottsdale Exch	SB		3		20	39	39	0	117
351	Bridgeport Stn	NB	7	6	8	10	28	28	196	168
351	Crescent Beach	SB	4	5	15	12	28	28	112	140
352	Bridgeport Stn	NB		3		20	32	32	0	96
352	Ocean Park	SB					32	32	0	0
354	Bridgeport Stn	NB	3		20		48	48	144	0
354	White Rock South	SB		4		15	48	48	0	192
601	Bridgeport Stn	NB	5	4	12	15	24	24	120	96
601	South Delta/Boundary Bay	SB	4	4	15	15	24	24	96	96
602	Bridgeport Stn	NB	2		30		25	25	50	0
602	Tsawwassen Heights	SB		1		60	25	25	0	25
603	Bridgeport Stn	NB	3		20		11	11	33	0
603	Beach Grove	SB		2		30	11	11	0	22
604	Bridgeport Stn	NB	3		20		11	11	33	0
604	English Bluff	SB		2		30	11	11	0	22
620	Bridgeport Stn	NB	1	4	60	15	36	36	36	144
620	Tsawwassen Ferry	SB	2	5	30	12	36	36	72	180
	AM Peak NB Total		28						768	
	PM Peak SB Total			26						794

Source: TransLink Ridership Dashboard 2018.

As mentioned previously, there are existing NB bus or HOV lanes approaching the existing tunnel from south of the Highway 17 interchange, and SB from north of Steveston Highway interchange. There are, however, currently no bus or HOV lanes at the existing tunnel itself and buses have to merge with GP traffic in advance in order to cross the existing tunnel.

2.8. Geometric Observations

Based on review of available information the following geometric observations have been noted regarding the existing geometrics:

- The existing tunnel does not meet current design guidelines for lane width, shoulder width or vertical clearance.
- The existing Highway 99 and ramps at Steveston Highway and Highway 17A appear to be based on a design speed of 90 km/h on Highway 99, whereas the proposed criteria for the new GMC project is 100 km/h on Highway 99.
- The width available under the existing overpasses carrying Steveston Highway and Highway 17A over Highway 99 will limit the widening that can be achieved on Highway 99 if the existing overpasses are to remain.
- The short, successive merges NB between Highway 17A and the existing tunnel are undesirable for operations, particularly given the proposed increase in design speed on Highway 99.

2.9. Operational Observations

Currently, the following traffic operational issues are observed in the weekday AM peak period in the immediate vicinity of the existing tunnel:

- NB queueing on the Highway 99 mainline, at the end of the Collector/Distributor ("CD") road between Highway 17 and Highway 17A, and at the merge of the Highway 17A loop ramp to Highway 99 NB;
- SB queueing on the Highway 99 mainline and Steveston Highway entrance ramp to Highway 99 SB; and
- NB queueing on the Steveston Highway NB exit ramp due to the limited capacity at the ramp terminal intersection with only one NB left turn lane.

Currently, the following operational issues are observed in the weekday PM peak period in the immediate vicinity of the existing tunnel:

- NB queueing on the Highway 99 mainline, the CD road between Highway 17 and Highway 17A, and the Highway 17A loop ramp to Highway 99 NB; and
- SB queueing on the Highway 99 mainline and Steveston Highway entrance ramp to Highway 99 SB.

Outside of the weekday AM and PM peak periods, the existing tunnel currently operates reasonably well with the two lanes in each direction, although occasional queueing is observed. It is also noted that there is currently limited spare capacity at the existing tunnel, and any slight impediment or disruption to traffic flows due to accidents, incidents, weather, etc. can very quickly result in long queues and delays.

Existing average operating speeds on Highway 99 and the connecting roads, ramps etc. in the AM and PM peak hours are illustrated in ***Figures 10*** and ***11*** respectively below. The information contained therein was derived from TomTom data from fall 2018 and provides an indication of existing queueing/congestion.

Estimates of existing queue lengths that can be used for comparative purposes are provided and discussed later in Section 3 of this report.

Figure 10 - Current AM Peak Average Operating Speeds

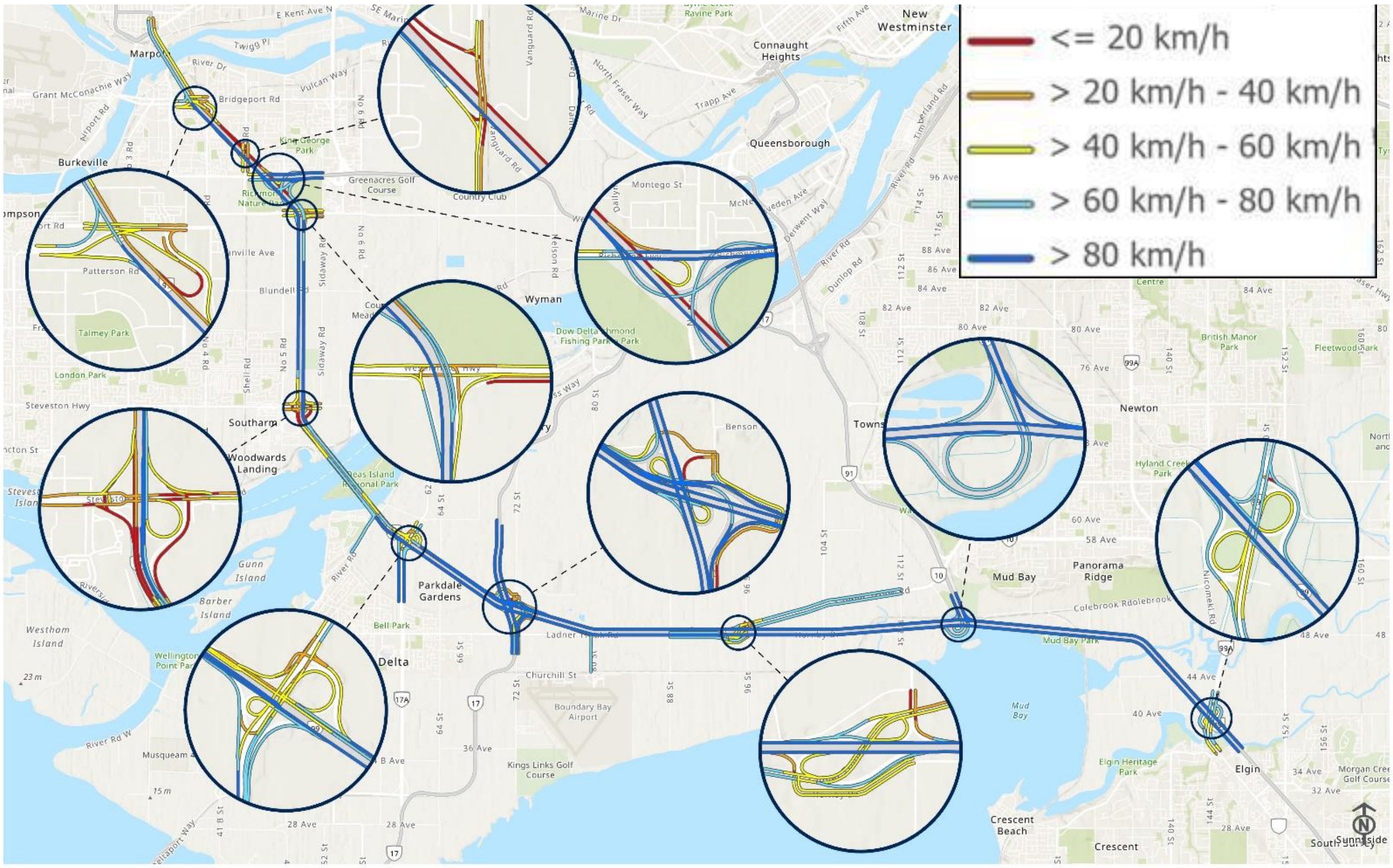
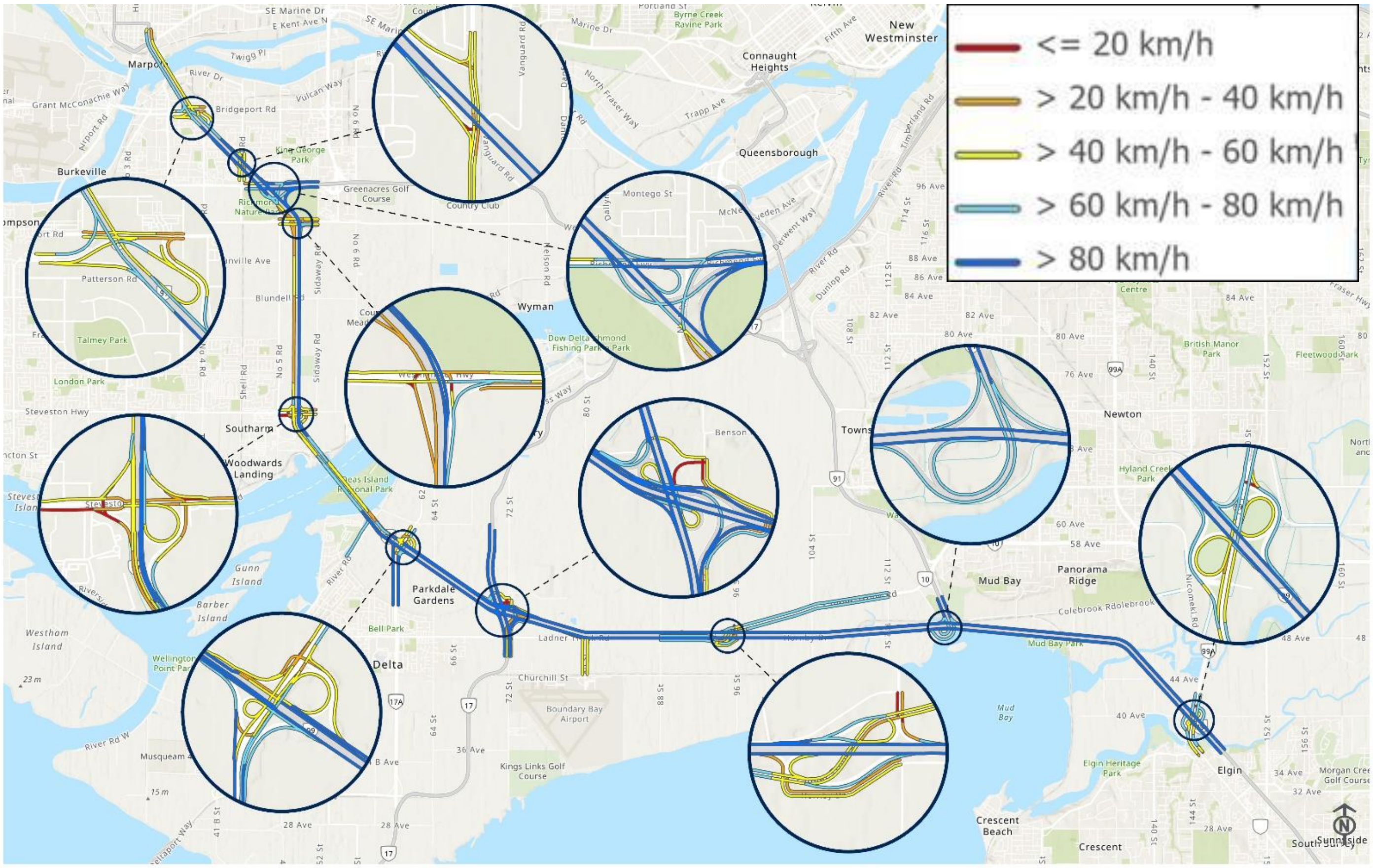


Figure 11 - Current PM Peak Average Operating Speed



2.10. Existing Tunnel Lane Capacities

At present, the existing tunnel is operating at or over capacity in both directions in both the weekday AM and PM peak periods as evident by existing queues. ***Table 2*** presents the observed maximum 2017 AM and PM average hourly traffic volumes from ***Figures 3*** and ***4,*** and the estimated capacity per lane at the existing tunnel.

Table 2 - Existing Tunnel 2017 Maximum Volumes and Lane Capacities

Time Period	Direction	2017 Volumes veh/hr	# of Lanes	Volume/Lane/ hr
AM Peak Hour	NB	5100	3	1700
	SB	1350	1	1350
PM Peak Hour	NB	1500	1	1500
	SB	4900	3	1630

As discussed previously, the actual peak volume times at the existing tunnel, occur earlier than the peak hours defined in the regional RTM. ***Table 3*** presents the observed average traffic volumes from ***Figures 3*** and ***4*** during the RTM peak hours (7:30-8:30 and 16:30-17:30) and the estimated capacity per lane at the existing tunnel during those times.

Table 3 - Existing Tunnel 2017 RTM Peak Period Volumes and Lane Capacities

Time Period	Direction	2017 Volumes veh/hr	# of Lanes	Volume/Lane/hr
AM Peak Hour	NB	4800	3	1600
	SB	1350	1	1350
PM Peak Hour	NB	1500	1	1500
	SB	4800	3	1600

For the lanes operating at capacity, the existing capacity per lane at the existing tunnel is approximately 1350 to 1700 veh/lane/hr as evident in the above tables. These values are relatively low and are below the theoretical capacity of a traffic lane (approximately 1800 veh/hr). This is attributed to the constrained geometry, counterflow operations and other interferences (e.g. merges, diverges, etc.) present at the existing crossing.

In order to obtain an understanding of the possible future improved GMC capacities, the existing volumes (September 2018 from MoTI website) at the Ironworkers Memorial 2^{nd} Narrows Crossing were reviewed. This crossing has three GP lanes in each direction similar to what is being proposed at GMC and is also operating at or near capacity in both directions in both the weekday AM and PM peak periods. ***Table 4*** summarizes the observed weekday AM/PM peak hour volumes at 2^{nd} Narrows and the calculated volume/lane/hr.

Table 4 - Ironworkers Memorial 2^{nd} Narrows 2018 Volumes and Lane Capacities

Time Period	Direction	2018 Volumes veh/hr	# of Lanes	Volume/Lane/hr
AM Peak Hour	NB	4797	3	1599
	SB	5077	3	1692
PM Peak Hour	NB	5067	3	1689
	SB	4843	3	1614

As is evident from ***Table 4***, the maximum lane capacity at Ironworkers Memorial 2^{nd} Narrows is approximately 1700 veh/hr/lane. It is however noted that at Ironworkers Memorial 2^{nd} Narrows there are also no shoulders, and this could explain why the capacities at Ironworkers Memorial 2^{nd} Narrows are also less than the theoretical capacity of a lane (1800 veh/hr).

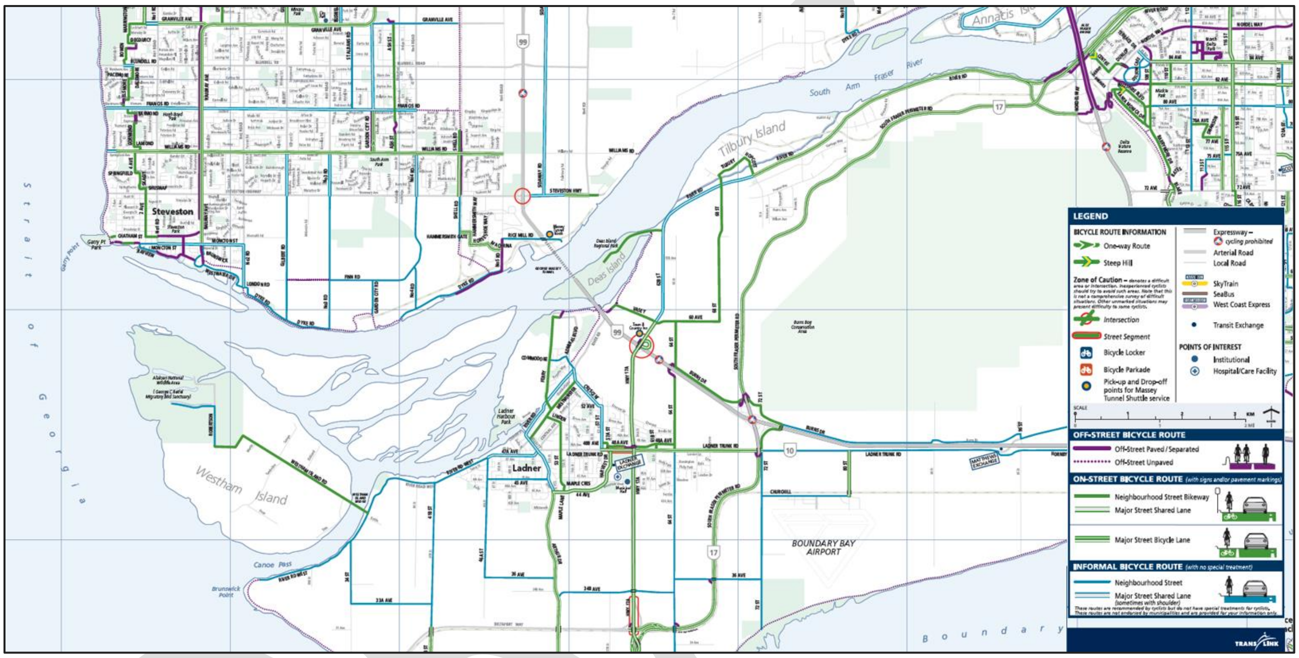
Based on ***Table 2*** and ***3*** estimates, it is considered reasonable to assume that the lane capacity of a new GMC (tunnel or bridge) lane will be in the order of 1700-1800 veh/lane/hr given that design standards are expected to be higher than existing at the existing tunnel and the Ironworkers Memorial 2^{nd} Narrows Bridge. This lane capacity value has been assumed for the purposes of this report, and for the work of the CST, however it needs to be verified using micro-simulation modelling, which at the time of writing this report was not included in CST's scope of work.

2.11. Bicycle Usage and Network

2.11.1. Existing Network for Bicycle Users

The existing bicycle network from TransLink is shown in ***Figure 12***.

Figure 12 - Existing Pedestrian and Bicycle Network



Some intersections that provide access to the George Massey Tunnel to the north (Hwy 99 and Steveston Hwy) and south (Hwy 99 and Hwy 17A) are noted as a ‘Zone of Caution’ which is defined as a ‘difficult area or intersection, inexperienced cyclists should try to avoid’

Notable gaps in the network from a connectivity perspective (i.e. not considering local site constraints that may exist and need to be addressed) on the north access are a link between Rice Mill Rd adjacent to Hwy 99 to Steveston Hwy, circuitous connections within the industrial area to the west of the access point, and a missing connection along Steveston Hwy. The south access has visible gaps in the network on the off-street unpaved bicycle routes along the South Arm Fraser River and a more direct connection to Burns Drive from the access.

It should be noted that while there are many routes identified within the bicycle network, the suitability of these facilities to meet the common design user of ‘casual rider’, as adopted by many local agencies and nationally through TAC, requires review. In particular, the suitability of streets based on motor vehicle volume and speed will likely suggest that legacy infrastructure, such as shared lanes and bicycle lanes, should be changed to facilities that provide more separation for bicycle users.

2.11.2. Future Network for Bicycle Users

The George Massey Tunnel area is addressed in two Translink documents on cycling: Southwest Area Transport Plan (April 2018) and Cycling for Everyone (June 2011) as well as being included in TransLink's Major Bike Network. These documents articulate a potential network in both Delta and Richmond. The planned bicycle network surrounding the tunnel from the most recent document is shown in ***Figure 13***.

Figure 13 - Proposed Future Bicycle Network (Southwest Area Transport Plan, TransLink, April 2018)

Notable considerations from this plan is the identification of a desire line on the south side of GMC that travels adjacent to the South Arm Fraser, to Ladner, then south in close proximity to Arthur Drive. An additional connection noted is on the Hwy 99 alignment (with consideration of the 17A Hwy interchange area) to Burns Drive, which would then coincide with a route that follows the Ladner Trunk Road alignment.

To the north, a connection to Steveston Highway via Highway 99 and then along Steveston Highway to Moncton Road (near the Steveston Harbour) is very clearly identified. Routes that travel north-south that intersect with Steveston Hwy are noted, as well as a desire line that runs adjacent to Sidaway Rd.

3. Traffic Modelling

An advance copy version of the Regional Transportation Model Phase 3 (RTM3) was used as the basis for developing traffic forecasts for GMC. A base year of 2017 has been developed with available land use and traffic count information. Horizon years of 2035 and 2050 have been developed based on land use forecasts developed by Metro Vancouver as part of their Regional Growth Strategy.

Modelling and traffic forecasting were initially based on information available in July 2019, and as new transportation information became available, the models were updated. Notably, in mid August 2019, new RTM population and employment data became available from TransLink and this was incorporated in the Project modelling on the understanding that a full release of RTM version 3.3 would occur in fall 2019.

Throughout the Project, traffic information has been provided to MoTI based on the RTM updates available at the time. The RTM modelling and forecasts included in this report supersede those provided previously.

The RTM modelling has been documented in more detail in the separate McElhanney technical memo titled "*GMC Forecasts*" in ***Appendix D.*** Since all RTM modelling to date has been based on an advance copy of the model inputs and time sensitive laning design assumptions, further modelling should be undertaken when the next version of RTM version 3.3 is released in fall 2019 and/or as the GMC designs evolve in the future, to confirm the designs and findings presented in this report.

3.1. Base Network Assumptions

The modelling of existing 2017 conditions is referred to as the Business as Usual (BAU) condition and is based on the existing road and infrastructure as at 2017 and includes the existing configurations at the existing tunnel.

The following road network improvements were assumed to be completed for the future 2035 and 2050 horizons:

- 216th Interchange on Highway 1;
- Highway 1 Lower Lynn Interchanges Phase 1,2,3,4;
- Highway 1 Widening 216th to 264th
- Alex Fraser Bridge Counterflow Lane;
- Highway 17/91 Improvement Project (Sunbury Interchange concept based on publicly available information); and
- Pattullo Bridge Replacement Project (preferred option from 2018 business case).

The following transit improvements were assumed to have been implemented for the 2035 and 2050 horizons:

- Broadway Subway to Arbutus;
- Surrey Langley Skytrain to Fleetwood;

- RapidBus Services from Phase 1,2,3;
- Mayor's Vision 10-year plan service updates;
- SkyTrain Fleet capacity updates and service increases;
- New Canada Line Station – Capstan Way; and
- SeaBus service increases.

3.2. GMC Scenarios

The six shortlisted options that CST investigated consider three "6 lane" options and three "8 lane" options. For the 6 lane options, the new crossing carries six GP lanes while two transit only lanes are carried through the existing tunnel. For the 8 lane options, the new crossing carries the 6 GP lanes as well as the two transit only lanes. As a result, all options investigated from a GMC traffic capacity perspective are essentially the same and although 6 and 8 lane GMC modelling was undertaken with almost identical results, only the results of the 8 lane options are presented here.

The traffic forecasting at GMC discussed in this report considered the following timelines and scenarios:

- 2017 Business as Usual (BAU which assumes the existing configuration of the existing tunnel);
- 2035 BAU;
- 2050 BAU
- 2035 with 8 lane GMC (6 GP lanes and 2 transit only lanes); and
- 2050 with 8 lane GMC (6 GP lanes and 2 transit only lanes).

Although three technologies for GMC are considered (DBT, ITT and Bridge), the traffic modelling to date did not specifically differentiate between the technologies. It is noted that due to the similarities between the ITT and Bridge laning configurations, the macro-modeling for both options would be similar. The modelling for the DBT options was not specifically undertaken as the connections to the adjacent Highway 99 interchanges had not been resolved at the time.

It is noted that as part of the GMC option, River Road was assumed to cross Highway 99 as a new two-way two-lane road to be delivered by others.

3.3. Model Results

Table 5 presents the observed 2017 traffic count volumes at the existing tunnel (from ***Table 3***) and the 2017 BAU demands from the RTM in the AM and PM peak hours. The following are noted:

- To ensure consistency and for comparative purposes, all volumes and demands presented in this section are for the RTM peak hours (7:30-8:30 and 16:30-17:30) and not necessarily the peak hours at the crossing
- The demands represent the volumes that desire to travel across the facility and not necessarily the volume that can physically travel across the facility.

Table 5 - Existing Tunnel 2017 Observed Volumes vs 2017 Model BAU Demands (veh/hr)

Time Period	Direction	2017 Existing Tunnel Count Volume	2017 Existing Tunnel BAU Demand	Difference 2017 BAU vs 2017 Count	% Difference
AM Peak Hour	NB	4800	4880	80	2%
	SB	1350	2010	660	49%
PM Peak Hour	NB	1500	2470	970	65%
	SB	4800	5410	610	13%

From ***Table 5***, it is evident that there are notable differences between the 2017 observed counts and the RTM demands at the following locations where the throughput (count) volumes are constrained by capacity:

- SB in AM peak hour – hence observed SB queuing with existing single SB lane;
- NB in PM peak hour - hence observed NB queuing with existing single SB lane; and
- SB in PM peak hour – hence observed SB queuing even with three existing SB lanes.

Table 6 shows the 2017, 2035 and 2050 BAU demands from the RTM at the existing tunnel in the AM and PM peak hours. As evident, there is a moderate increase in demand between 2017 and 2035/2050 assuming BAU, notwithstanding changes in population and employment growth. This is attributed in part to the new reversible lane system at Alex Fraser Bridge and the resultant rerouting of traffic from the existing tunnel to Alex Fraser with its increased peak direction capacity.

Table 6 - Existing Tunnel 2017/2035/2050 BAU Demands and Growth (veh/hr)

Time Period	Direction	2017 Existing Tunnel BAU Demand	2035 Existing Tunnel BAU Demand	2017-2035 BAU Model Growth	2017-2035 BAU % Model Growth	2050 Existing Tunnel BAU Demand	2017-2050 BAU Model Growth	2017-2050 BAU % Model Growth
AM Peak Hour	NB	4880	5290	410	8%	5540	660	14%
	SB	2010	2240	230	11%	2290	280	14%
PM Peak Hour	NB	2470	2680	210	9%	2770	300	12%
	SB	5410	5710	300	6%	6030	620	11%

Table 6 shows the 2017/2035/2050 existing tunnel BAU and 2035/2050 GMC 8 lane demands in the AM and PM peak periods. As expected, the increase in capacity at GMC results in significant increases in demands at GMC in the non-peak direction (SB in AM and NB in PM) where the number of available traffic lanes increases from the existing one to four (3 GP) lanes. There are also lesser increases in demands at GMC in the peak direction (NB in AM and SB in PM) attributed to improved lane capacity. Note that the assumed directional capacity of the 8 lane GMC is estimated at between 5100 and 5400 veh/hr assuming three GP lanes, and where demand exceeds capacity (highlighted in red), queues are to be expected.

Table 7 - 2017/2035/2050 BAU vs 2035/2050 GMC 8 Lane Demands (veh/hr)

Time Period	Direction	2017 Existing Tunnel BAU Demand	2035 Existing Tunnel BAU Demand	2035 GMC 8 Lane Demand	2035 GMC 8 Lane Growth (vs 2017 BAU)	2035 GMC 8 Lane % Growth (vs 2017 BAU)	2050 Existing Tunnel BAU Demand	2050 GMC 8 Lane Demand	2050 GMC 8 Lane Growth (vs 2017 BAU)	2050 GMC 8 Lane % Model Growth (vs 2017 BAU)
AM Peak Hour	NB	4880	5290	5300	420	9%	5540	5570	690	14%
	SB	2010	2240	3280	1270	63%	2290	3460	1450	72%
PM Peak Hour	NB	2470	2680	3820	1350	55%	2770	4050	1580	64%
	SB	5410	5710	5960	550	10%	6030	6300	890	16%

Tables 5 to 7 above show the demands at the existing tunnel/GMC as produced by RTM. However, in many cases the demand exceeds the available capacity in 2017, 2035 and in 2050 with the existing tunnel BAU as well as the 8 lane GMC option. In these cases, the excess demand will be reflected as queues.

3.4. Highway 99 Interchange Volumes

The forecast 2035/2050 AM and PM peak hour demand volumes on Highway 99 and at the interchanges assuming an 8 lane ITT or Bridge GMC are provided in ***Appendices G to J***. These show the total volumes, 2+HOV volumes, Heavy Truck volumes and bus volumes from the RTM. Note that similar figures for the 6 lane GMC forecasts have not been prepared at this time, but generally, it is expected that the 6 lane forecasts will be similar to the 8 lane forecasts as the number of GP lanes is the same in both options.

When reviewing the appended figures, it is important to note that the values shown are forecast demands, and not necessarily the actual throughput volumes which may be constrained by capacity. Furthermore, the volumes in the figures were extracted from the RTM which is a regional model used to forecast regional travel patterns and it is not intended to forecast traffic volumes at the individual minor link level. As such, anomalies between observed and forecast traffic volumes may be expected, and these become more apparent as one “drills down” to specific links or turning movements. In order to obtain a better estimate of volumes, capacity, queues, etc., the use of an operational traffic model using a micro-simulation tool such as VISSIM would be required, however, this work is currently not included in CST's scope of work. The demands in ***Appendices G to J*** are, however, what was available at the time and these have been used in the later traffic analysis documented in section 4 of this report.

4. Highway Design Considerations

This section documents the considerations that went into the development of the conceptual design of the highway alignments, geometrics and laning for the GMC options.

4.1. Roadway Design Criteria

The design criteria adopted for the conceptual design of Highway 99 was based on the criteria previously used for the George Massey Tunnel Replacement project.

The key highway design criteria used for Highway 99 are as follows:

Highway Classification: Rural Freeway Divided (RFD)

Design Speed: 100 km/h

Lane Width: 3.7 m

Maximum Grade: 5.0%

Max. Superelevation: 6.0%

Min. Vertical Clearance: 5.0 m

The design criteria adopted for the conceptual design of the connecting roads was based on an assessment of the existing conditions taken from LiDAR survey.

Proposed Design Criteria Sheets for Highway 99, Steveston Highway and River Road are included in ***Appendix K*** of this report, and additional detail on the design criteria for pedestrian and bicycle accommodation is provided below.

Two key project objectives communicated by the Ministry which influenced the highway design are:

- Crossing alignment to tie to existing Highway 99 as quickly as possible to minimize impacts; impacts to the existing bridge structures at Steveston Highway Interchange and at Highway 17A Interchange are to be avoided.
- Potential interim improvements to twin the existing bridge on Steveston Highway are to be incorporated into the conceptual highway design.

4.1.1 Design Criteria For Pedestrian and Bicycle Accommodation

Design criteria for pedestrian and bicycle accommodation were gathered from the 2019 BC Active Transportation Design Guide (BCATDG) and from the 2017 Transportation Association of Canada (TAC) Geometric Design Guide (GDG). Key criteria related to the development of options is summarized in ***Table 8***

Table 8 - Pedestrian and Bicycle Cross Section Design Criteria

	BC Active Transportation Design Guide	2017 TAC GDG**	Recommended
Shared Pathway Width* (m)	3.0 – 4.0	3.0 – 6.0	3.0 - 4.0
Shy Distance Width to obstructions 100mm – 750mm high (m)	0.6	0.2	0.2 – 0.6

Shy Distance Width to obstructions greater than 750mm high (m)	0.6	0.5	0.6
Two-Way Bicycle Path*	3.0 – 4.0	3.0 – 3.6	3.0 – 4.0
One-Way Bicycle Path*	2.0 – 3.0	1.8 – 2.5	1.8 – 3.0
Buffer Width	0.5 – 1.0	0.3 – 0.6***	0.3 – 1.0
Pedestrian Only Path*	2.4 – 3.0	1.8 – 3.0	1.8 – 3.0

**Path width ranges identified are influenced based on the anticipated use of the facility, documented further in Table 11.*

***The range provided is the recommended lower limit to the recommended upper limit.*

****The recommended buffer width and delineator treatment is subject to consideration of adjacent use as per TAC Table 5.7.1, Delineator Based on Type and Speed of Adjacent Lane.*

The recommended design criteria are provided as a range to allow for maximization of cross section element widths in locations where space allows, and a minimum in locations where the upper range is not achievable.

As noted above, the requirement for different pathway widths and levels of separation is informed by the anticipated pathway usage. These requirements are summarized in ***Table 9***, which is based on the BCATDG and the 2017 TAC GDG.

Table 9 - Pathway Width Functionality Limits

Pathway Width	Upper Limit of Pathway Width Functionality (Users Per Day)
3.0m Multi-Use Pathway	1,000 (more than 20% pedestrians) 1,500 (less than 20% pedestrians)
3.5 m Multi-Use Pathway	1,200 (more than 20% pedestrians) 1,750 (less than 20% pedestrians)
4.0m Multi-Use Pathway	1,400 (more than 20% pedestrians) 2,000 (less than 20% pedestrians)

It should be noted that once pathway use exceeds 1,400 users per day (with more than 20% pedestrians) or 2,000 users per day (with less than 20% pedestrians), separated pathway treatments would be justified.

Further, it is noted in the BCATDG that communities such as the City of Vancouver suggest that if there are 1,500 combined users on a facility that is between 3.0 and 4.0 metres in width, and if space is available, separation of people walking and cycling is recommended.

Since there is not an existing pathway in place at this location, the following guideline was drawn from the BCATDG:

> *In locations where no pathway is currently in place, existing and future land use should be considered as well as ridership numbers on existing facilities within a similar context to obtain an understanding of projected volumes. (BCATDG, E17)*

4.2. Base Mapping

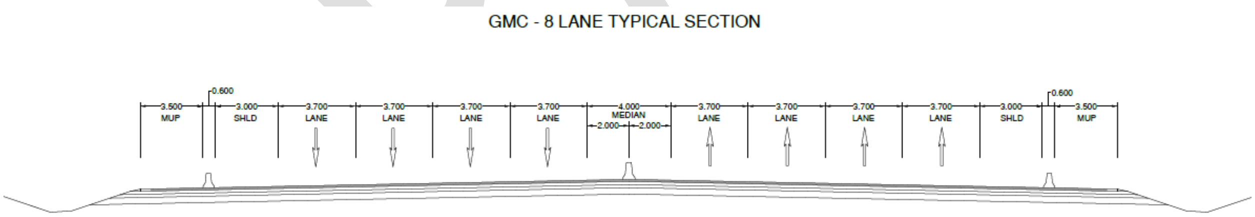
AutoCAD base mapping was prepared for the conceptual designs, compiled from 2016 LiDAR survey data acquired for the project, supplemented by 2014 aerial photography provided by the Ministry.

4.3. Typical Section Development

Relevant design standards and other recent, similar bridge and tunnel projects were investigated. A draft memo titled "Road Shoulder Standards and Minimums" was prepared on August 2, 2019, which outlined desirable minimum and rationalized minimum shoulder widths for roadways in tunnels and on bridges based on the investigation. Ultimately, the Ministry determined the shoulder widths to be used on the project, partially driven by first responders input on minimum acceptable shoulder widths in tunnels and on bridges.

The conceptual typical sections for the crossing itself, incorporating the above noted shoulder widths, are shown on the General Arrangement drawings for the bridge, immersed tube tunnel and bored tunnel options. A conceptual typical section for Highway 99 beyond the limits of the bridge or tunnel was prepared based on the draft project design criteria sheet (see ***Appendix K***) and BC MoTI highway design guidelines. Of note, due to the radii of curves required to tie the new crossing back to the existing Highway 99 alignment it was determined that a 4.0 m wide Modified Median is required on the curves in accordance with BC Supplement to TAC Figure 630.A. For conceptual design purposes the Modified Median has been applied to the highway cross-section for the length of the project. During future phases of design, consideration may be given to transitioning from a narrow 2.6 m median on tangent sections of the highway to the Modified Median in curves only. The 8-lane Highway 99 Typical Section with Modified Median is shown below in ***Figure 14***.

Figure 14 - GMC - 8 Lane Typical Section



4.4. Horizontal and Vertical Alignment Development

Plan/profile drawings of the design concepts for the bridge, immersed tube tunnel and bored tunnel options, including an alternate bridge option with a clear span over Deas Slough, are provided in ***Appendices L, M, N*** and ***O****.*

4.4.1 Deep Bored Tunnel

Due to the depth of the bore, the bored tunnel horizontal alignment was not influenced by the existing tunnel location. The conceptual horizontal alignment was determined by the location where the tunnel daylights and the ability to tie to Highway 99 with least impacts. The depth of the bored tunnel option was based on geotechnical assessment of the minimum acceptable depth measured in tunnel diameters (D) from the bottom of the river to the top of the tunnel.

Horizontal and vertical alignments which were developed and assessed for the bored tunnel included:

- Twin bores straddling existing tunnel - 1D depth
- Twin bores straddling existing tunnel - 2D depth
- Twin bores crossing under existing tunnel – 2D depth
- Twin bores crossing under existing tunnel – 3D depth
- Twin bores crossing under existing tunnel – 2.5D depth

The final concept for the horizontal and vertical alignment of the bored tunnel is twin bored tunnels from north-east of the Steveston Interchange to south-west of the Highway 17A Interchange, at a depth of 2.5 D below the bottom of the assumed navigational channel elevation. The horizontal alignment was selected to avoid having the new tunnels cross under the existing tunnel to minimize the risk of damaging the existing tunnel during construction.

4.4.2 Immersed Tube Tunnel

The conceptual horizontal alignment of the immersed tube tunnel (ITT) option was determined in conjunction with geotechnical assessment of the minimum acceptable separation between the existing and new tunnels and structural assessment of maximum tube width. Horizontal alignments which were developed and assessed for the immersed tube tunnel included:

- Twin immersed tubes straddling the existing tunnel
- Twin immersed tubes downstream of existing tunnel – 25 m offset from existing
- Single immersed tube upstream of existing a curved alignment – 25 m offset
- Single immersed tube upstream of existing on a straight alignment – 37 m offset
- Single immersed tube upstream of existing on a straight alignment – 55 m offset
- Single immersed tube upstream of existing on a straight alignment – 42 m offset

The final concept for the horizontal alignment for the immersed tube tunnel is located east (upstream) of the existing tunnel and has been set based on geotechnical recommendations that a minimum 42 m separation be provided between the existing and new tunnels, which will allow the new tunnel to be constructed without requiring an underwater separation wall between them.

The vertical alignment of the immersed tube tunnel was set based on a minimum elevation of -17 metres GSL at the top of the tunnel within the assumed shipping channel. This allows for 2m of rock cover on top of the ITT below the assumed navigational clearance elevation of -15 metres GSL. The ITT profile was also influenced by a requirement to raise the elevation outside the tunnel up to a future assumed dike elevation of approximately 4.4 m. If the provincial dike authority requires a higher dike elevation it can be accommodated with minor profile adjustments. The final concept for the vertical alignment has a maximum grade of 5% and a minimum K value of 60 at the sag. At the northern project limit this alignment ties back to existing Highway 99 several hundred meters south of Steveston Highway, thereby maintaining the existing vertical clearance on Highway 99 under the overpass. It is noted that the conceptual profile is heavily influenced by the assumed navigational clearance envelope shown on the ITT Concept drawings.

The horizontal and vertical alignments of the immersed tube tunnel concept match to existing Highway 99 several hundred meters north of the Highway 17A interchange but highway reconstruction is proposed to extend to Highway 17A in order to reconfigure the laning to properly develop the 8-lane cross-section on the new crossing.

4.4.3 Long Span Bridge

The conceptual horizontal alignment for the long span bridge option is located east (upstream) of the existing tunnel and has been set to allow existing Highway 99 to remain in operation for the duration of single-stage bridge construction.

The conceptual vertical alignment has a maximum grade of 5% and a minimum K value of 80 at the crest. At the northern project limit this alignment ties back to the existing Highway 99 immediately south of existing Steveston Highway, maintaining the existing vertical clearance on Highway 99 under the bridge. It is noted that the conceptual profile and resulting ability to tie back to existing Highway 99 without impacting the existing bridge on Steveston Highway is heavily influenced by the assumed navigational clearance envelope shown on the Bridge Concept drawings.

The horizontal and vertical alignments of the long span bridge concept match to existing Highway 99 several hundred meters north of the Highway 17A interchange but highway reconstruction is proposed to extend to Highway 17A in order to reconfigure the laning to properly develop the 8-lane cross-section on the new crossing.

4.5. Geometrics and Laning Development

Initial geometrics and laning for the various crossing options and connecting roads were developed based on the attached draft project Design Criteria, the TAC Geometric Design Guide (interchanges) and the BC Supplement to TAC (highways). Initial ramp concepts were developed by applying the high end of the TAC design domain values for lengths, tapers etc. where physically possible. Initial laning concepts were based on matching existing lanes and ramp configurations at the “project limits” of Steveston Highway and Highway 17A. This meant matching ambient conditions which may not meet the standards required for the increased Highway 99 design speed. As the concept was further developed these “substandard” aspects were redesigned to match TAC design standards for 100 km/h design speed. As traffic data became available, the initial geometrics and laning designs were further refined based on assessments of the traffic data. The traffic analysis for the ramps and tie-ins has been based on traffic forecasts and further design refinement may be expected if more detailed traffic analysis is undertaken. However, future refinements are not expected to substantially change the overall footprint of the project within the crossing limits from what is shown on the conceptual plan/profile drawings provided in ***Appendices L, M, N and O***.

Laning and operations consideration specific to the different 8-Lane crossing options are summarized below.

4.5.1 Bridge and ITT – North Side Considerations

This section of the report documents the laning and operations considerations at the north end of GMC where it returns to grade and includes the Steveston Highway interchange connections. Laning and operations for the long span bridge option and immersed tube tunnel option are essentially the same and therefore have been combined in the sub-sections below.

4.5.1.1 Proposed Laning Arrangement

Single-line schematic drawings showing the initial overall laning schematic and the concept for laning on Highway 99 and at the Steveston Highway Interchange are provided in ***Appendices E and P***, respectively.

Based on geometric review during the conceptual design, it appears that, with the elimination of the existing counterflow lane, the available horizontal clearance under the existing Steveston Highway bridge will accommodate 6 through lanes on Highway 99 (3 lanes in each direction) plus the existing EB to NB entrance ramp and the existing SB bus-only lane. Therefore, from a geometric perspective, it appears that the proposed laning shown on the plan/profile drawings can be achieved without replacing the existing two-lane Steveston Highway bridge, although shoulder widths may need to be locally narrowed under the existing bridge. Cross-sections showing the current and proposed lane and shoulder widths under the existing Steveston Highway bridge, derived from as-built drawings of the structure, are provided in ***Appendix S***. As noted in Section 4.1, the Ministry is giving consideration to future twinning of the existing bridge at Steveston Highway and a conceptual design of the twinning, provided by others, has been included on the plan/profile drawings.

In order to tie the 8-lane cross-section of the new crossing to the 6-lane cross-section under the Steveston Highway overpass the outside bus-only lanes on the bridge crossing are added/dropped at the Steveston Highway Interchange as shown on the Bridge and ITT plan/profile drawing and schematics. At the NB exit ramp to Steveston Highway, the existing three-lane ramp is changed to two GP lanes plus a bus-only lane. The existing two-lane exit has been changed to a single exit lane, which then develops into two GP lanes, due to highway operations/safety concerns related to the 2-lane exit. In the SB direction, the existing bus stop immediately south of the Steveston Highway overpass is maintained and the queue-jumper lane is replaced by an additional lane which carries through to the dedicated bus lane on the Crossing. The GP traffic from the Steveston Highway entrance ramp briefly shares the outside lane on Highway 99 with buses before merging with the 3rd SB GP lane on the new crossing and the outside lane becomes bus-only.

It is assumed that the current bus and HOV lane designations on Highway 99 are maintained north of Steveston Highway Interchange. In the NB direction the GP traffic from the entrance ramp will merge into the three existing GP lanes and the bus traffic from the entrance ramp will continue into the existing shoulder bus lane. In the SB direction the third (outside) lane is designated as Bus/HOV but the designation ends before the Steveston Highway interchange SB exit ramp to allow exiting GP traffic to cross into the outside lane and exit, and to allow through GP traffic to merge into one of the two GP lanes crossing under the Steveston Highway overpass. It is proposed to end the HOV designation at the current end location but revise the pavement markings from the SB exit to the Steveston Highway overpass to continue the existing outside lane to become the third SB lane crossing under Steveston Highway.

Note that new pavement construction associated with the crossing is expected to extend from Steveston Highway Interchange to Highway 17A interchange, however barrier relocation and revisions to pavement markings to eliminate the counterflow lane and tie into the existing laning will be required north of Steveston Highway. Asphalt milling and overlay may also be required in the areas of barrier and pavement marking relocation. The proposed limits of new construction and proposed limits of barrier and pavement marking relocation are shown on the plan/profile drawings in ***Appendices L, M, and N***.

4.5.1.2 Highway 99 Mainline Operations

Forecast 2035/2050 AM and PM peak hour traffic demands on the Highway 99 mainline under the Steveston Highway overpass are summarized in ***Table 10*** below***.*** Based on the proposed GMC ITT and Bridge designs as of October 30, 2019, there are three mainline GP lanes in each direction under the Steveston Highway overpass with an assumed directional capacity of 5100-5400 veh/hr. At this stage of design, traffic analysis can conclude that the three lane capacity in each direction under the Steveston Highway overpass can accommodate future demands in both 2035 and 2050 assuming balanced lane utilization.

Table 10 - 2035/2050 Highway 99 Mainline Demands at Steveston Highway Overpass (veh/hr)

Peak Period	Direction	2035	2050	Estimated Capacity
AM	NB	3920	4120	5100-5400
	SB	2400	2560	5100-5400
PM	NB	2620	2770	5100-5400
	SB	4700	5000	5100-5400

4.5.1.3 Ramp Operations

Table 11 summarises the 2035/2050 AM and PM peak hour traffic demands on the Steveston Highway interchange ramps. It also includes an indication of the proposed laning configuration associated with the ITT and Bridge conceptual options as at October 30, 2019.

Table 11 - 2035/2050 Ramp Demands (veh/hr)

Interchange	Direction	Ramp	2035 AM Demand	2035 PM Demand	2050 AM Demand	2050 PM Demand	# of Lanes
Steveston	NB	Exit ramp	1380	1200	1450	1280	2 GP + 1 BUS
Steveston	WB to NB	Entrance ramp	150	120	150	120	1 GP
Steveston	EB to NB	Loop entrance ramp	460	570	450	580	1 GP
Steveston	SB	Exit ramp	640	470	640	430	2 GP
Steveston	SB	Entrance ramp	880	1260	900	1290	1 GP + 1 BUS

Reviewing the forecast demands and the proposed laning on the Steveston Highway Interchange ramps, and assuming that a free flow ramp lane has a capacity of approximately 1600 veh/hr to account for alignment, deceleration, acceleration, etc., it is evident that the ramps as currently designed are expected to operate within capacity. Note that this assessment refers specifically to the linear capacity on the ramps themselves and does not consider merges, diverges, intersections, etc. that occur at the start and ends of the ramps.

An operational analysis of the ramp merges and diverges on Highway 99 was undertaken using the Highway Capacity Software (HCS) to inform the layout of the ramps in the design. This was based on the 2035/2050 AM and PM peak hour forecasts (***Appendices G*** to ***J***) with assumed lane utilization by mode and the design concepts as at October 30, 2019. The analysis to date focused on the critical peak directions NB in AM peak period and SB in PM peak period. This work is documented in a separate Stantec memo titled "*George Massey Crossing: Traffic Review, Highway 99 Ramp Analysis Immersed Tube Tunnel 8-lane Concept*" in ***Appendix Q*** with a summary of the findings presented in ***Table 12*** below. For the purposes of this project, Level of Service (LOS) A to D is considered acceptable, whereas LOS E to F is indicative of undesirable operations.

Table 12 - Steveston Highway Ramp Operations 2035/2050

Interchange	Movement	2035 LOS	2035 Remarks	2050 LOS	2050 Remarks
Steveston		**AM Peak Period**			
	NB Exit Ramp	D		D	
	NB Entrance Ramp	D		D	
		PM Peak Period			
	SB Exit Ramp	D		D	
	SB Entrance Ramp	D		F	Merging traffic and freeway traffic exceeds capacity

The Steveston Highway Interchange entrance and exit ramp connections at Highway 99 are expected to operate at an acceptable level of service in 2035 in both peak periods The SB entrance ramp is expected to operate poorly in the 2050 PM peak period and with the proposed merge lane configurations, queuing is to be expected.

4.5.1.4 Ramp Terminal Intersection Operations

The two signalised ramp terminal intersections at the Steveston Highway interchange were analyzed using the Synchro program. This analysis assumed:

- The two interchange signalized intersections operate in isolation (i.e. downstream congesting, weaving, etc. was not considered, for example, between the interchange and the Steveston Highway/No. 5 Road intersection);
- 2050 AM and PM peak hour all vehicle volumes from ***Appendices I*** to ***J***;
- Uncoordinated traffic signal operations;
- Existing traffic signal phasing;
- Proposed laning configuration as per the ITT/Bridge conceptual design drawings as at October 30, 2019 (see ***Appendices L and N***); and
- Preliminary traffic signal timing optimization.

Intersection performance data was extracted from Synchro and is presented in ***Table 13*** below in terms of Level of Service (LOS) and volume/capacity (v/c) ratio. LOS is an indication of vehicular delays due to the intersection controls ranging from A (low delays) to F (lengthy delays). The v/c ratio indicates the level of congestion and if the ratio approaches or exceeds 1.0, excess queues are to be expected.

Table 13 - Steveston Hwy Interchange Ramp Terminal Intersection Performance (2050)

				Turning Movements											
	Intersection	**Int. LOS**		**EBL**	**EBT**	**EBR**	**WBL**	**WBT**	**WBR**	**NBL**	**NBT**	**NBR**	**SBL**	**SBT**	**SBR**
2050 AM	Hwy 99 SB Ramp Terminal	**B**	***Traffic Vol (vph)***	**0**	**860**	**850**	**20**	**1300**	**0**	**0**	**0**	**0**	**40**	**0**	**600**
			v/c ratio	-	0.55	0.74	0.05	0.75	-	-	-	-	-	0.09	0.75
			LOS	-	B	A	A	B	-	-	-	-	-	B	C
	Hwy 99 NB Ramp Terminal	**B**	***Traffic Vol (vph)***	**0**	**460**	**0**	**0**	**100**	**50**	**1220**	**100**	**130**	**0**	**0**	**0**
			v/c ratio	-	0.52	-	-	0.17	-	0.74	0.26	-	-	-	-
			LOS	-	B	-	-	B	-	B	A	-	-	-	-
2050 PM	Hwy 99 SB Ramp Terminal	**B**	***Traffic Vol (vph)***	**0**	**690**	**1100**	**100**	**1310**	**0**	**0**	**0**	**0**	**30**	**0**	**400**
			v/c ratio	-	0.40	0.93	0.20	0.60	-	-	-	-	-	0.10	0.69
			LOS	-	B	B	A	A	-	-	-	-	-	C	C
	Hwy 99 NB Ramp Terminal	**B**	***Traffic Vol (vph)***	**0**	**140**	**0**	**0**	**220**	**80**	**1180**	**50**	**50**	**0**	**0**	**0**
			v/c ratio	-	0.18	-	-	0.36	-	0.71	0.12	-	-	-	-
			LOS	-	B	-	-	B	-	B	A	-	-	-	-

From ***Table 13*** it is evident that traffic operations at the two ramp terminal intersections at Steveston Highway will be acceptable in 2050. In 2035, the operations should be better given the lower demand volumes. It is however noted that this intersection analysis does not take into account downstream queuing on the SB entrance ramp or westbound on Steveston Highway towards No 5 Road.

4.5.2 Bridge and ITT – South Side Considerations

This section of this report documents the laning and operations considerations at the south end of GMC where it returns to grade and includes the Highway 17A interchange connections. Laning and operations for the long span bridge option and immersed tube tunnel option are essentially the same and therefore have been combined in the sub-sections below.

4.5.2.1 Proposed Laning Arrangement

Single-line schematic drawings showing the initial concept for laning on Highway 99 and at the Highway 17A Interchange are provided in ***Appendices E*** and ***R***, respectively.

Based on geometric review during the conceptual design it appears that, with elimination of the counterflow lane, the available horizontal clearance under the existing Highway 17A bridges will accommodate the proposed laning shown on the plan/profile drawings Therefore, from a geometric perspective, the proposed laning can be achieved without replacing the existing Highway 17A bridges, although shoulder widths may need to be locally narrowed under the existing bridges. Cross-sections showing the current and proposed lane and shoulder widths under the existing Highway 17A bridges, derived from as-built drawings of the structures, are provided in ***Appendix S***.

In the NB direction the new lanes under Highway 17A will match the existing lanes on Highway 99 which consist of two mainline lanes and two Collector-Distributor (C-D) lanes. The EB to NB loop ramp from Highway 17A and C-D lanes merge together and join Highway 99 as an add lane approaching the crossing. Northbound bus and HOV traffic traveling on the existing bus/HOV lane will continue to leave Highway 99 at the NB exit ramp to Highway 17A, cross Highway 17A at the signalized intersection, and re-enter Highway 99 via the NB entrance ramp. It is noted that MoTI is considering interim improvements at Highway 17A interchange to widen the NB exit ramp to provide separate bus and HOV lanes through the intersection on Highway 17A. The laning concept incorporates the proposed widening of the NB exit ramp but, instead of merging the bus and HOV traffic on the NB entrance ramp, maintains the dedicated bus lane down the NB entrance ramps and along Highway 99 to match the dedicated bus lane on the 8-lane Bridge or ITT concept for the George Massey Crossing. HOV and GP traffic on the NB entrance ramp merge together and then ultimately merge into the outside NB GP lane on Highway 99.

In the SB direction the new lanes will match into the existing mainline lanes on Highway 99 between Highway 17 and Highway 17A. The three SB GP lanes from the new crossing will continue under the existing Highway 17A bridges and match into the existing mainline lanes on Highway 99 between Highway 17 and Highway 17A. [Note that the median lane (the counterflow lane today) merges into the middle lane before Highway 17.] Buses will travel in the dedicated outside bus lane from the new crossing and will briefly leave Highway 99 at the SB exit ramp to avoid having to merge with the three GP lanes crossing under the Highway 17A bridges. A new dedicated bus slip ramp off the SB exit ramp will allow buses to cross under the bridges on the WB to SB entrance ramp, before eventually merging with the existing SB GP lanes on Highway 99 between Highway 17A and Highway 17.

Note that new pavement construction associated with the crossing is expected to extend from the Steveston Highway interchange to the Highway 17A interchange, however barrier relocation and revisions to pavement markings to eliminate the counterflow lane and tie into the existing laning will be required south of Highway 17A. Asphalt milling and overlay may also be required in the areas of barrier and pavement marking relocation. The proposed limits of new construction and proposed limits of barrier and pavement marking relocation are shown on the plan/profile drawings in ***Appendices L, M and N***.

For both the Bridge and ITT concepts, a potential crossing has been added to connect River Road across Highway 99 (to be undertaken by others); the crossing goes under Highway 99 for the Bridge option and over Highway 99 for the ITT option. The existing SB exit ramp to River Road has been shifted south and reconfigured to provide turning movements to both EB and WB River Road. A roundabout is proposed at the intersection of the SB exit ramp and River Road to accommodate the anticipated increase in traffic using River Road once the crossing is in place.

4.5.2.2 Highway 99 Mainline Operations

Forecast 2035/2050 AM and PM peak hour demands on the Highway 99 mainline underneath the Highway 17A overpass are summarized in ***Table 16*** below. Based on the proposed GMC ITT and Bridge designs as at October 30, 2019, there are:

- two NB mainline GP lanes under the Highway 17A overpass with an assumed directional capacity of 3400 to 3600 veh/hr.
- two auxiliary NB lanes under the Highway 17A overpass (CD road plus the Highway 17A loop ramp) with an assumed directional capacity of 3400 to 3600 veh/hr.
- three SB mainline GP lanes under the Highway 17A overpass with an assumed directional capacity of 5100 to 5400 veh/hr.

Table 14 - 2035/2050 Highway 99 Mainline/CD Road Demands at Highway 17A Overpass (veh/hr)

Peak Period	Direction	2035 Demand	2050 Demand	Estimated Capacity
AM	NB Mainline	3350	3560	3400-3600
	NB CD/Highway 17A Loop Ramp	780	770	3400-3600
	SB Mainline	1540	1590	5100-5400
PM	NB Mainline	2150	2290	3400-3600
	NB CD/Highway 17A Loop Ramp	530	530	3400-3600
	SB Mainline	3530	3810	5100-5400

From ***Table 14***, it can be concluded that the Highway 99 capacities in each direction under the Highway 17A overpass should be able to accommodate future demands in 2035/2050 based on the current design. It is however noted that the forecast NB mainline demands under the Highway 17A overpass in the AM peak periods will be approaching capacity. In addition, there will be downstream NB congestion in the AM peak period due to the capacity constraint at GMC itself as reported earlier.

4.5.2.3 Ramp Operations

Table 15 summarises the 2035/2050 AM and PM peak hour demands at the SB River Road exit and on the Highway 17A interchange ramps. It also includes an indication of the proposed laning configuration associated with the ITT and Bridge conceptual options as at October 30, 2019.

Table 15 - 2035/2050 Ramp Demands(veh/hr)

Interchange	Direction	Ramp	2035 AM Demand	2035 PM Demand	2050 AM Demand	2050 PM Demand	# of Lanes
River Road	SB	Exit Ramp	580	680	630	700	1 GP
Highway 17A	NB	Exit ramp	780	370	840	400	1 GP + 1 BUS
Highway 17 A	NB	WB to NB GP entrance ramp	270	500	290	560	1 GP
Highway 17A	NB	HOV entrance ramp	800	600	860	640	1 HOV
Highway 17A	NB	Bus entrance ramp	100	50	100	50	1 BUS
Highway 17A	EB to NB	Loop entrance ramp	590	410	590	400	1 GP
Highway 17A	SB	Exit ramp	1150	1690	1220	1730	2 GP

Highway 17A	EB to SB	Entrance ramp	190	90	220	100	1 GP
Highway 17A	WB to SB	Loop entrance ramp	80	80	90	100	1 GP

Reviewing the forecast demands and the proposed laning on the River Road and Highway 17A ramps, and assuming that a free flow ramp lane has a capacity of approximately 1600 veh/hr as before, it is evident that the ramps as currently designed are expected to operate within capacity. Note that this assessment refers specifically to the linear capacity on the ramps themselves and does not consider merges, diverges, intersections, etc. that occur at the start and ends of the ramps.

An operational analysis (using HCS) of the ramp merges and diverges on Highway 99 was undertaken using the 2035/2050 AM and PM peak hour forecasts (***Appendices G*** to ***J***) with assumed lane utilization by mode and the design concepts as at October 30, 2019. The analysis to date focused on the critical peak directions NB in AM peak period and SB in PM peak period. This work is documented in a separate Stantec memo titled "*George Massey Crossing: Traffic Review, Highway 99 Ramp Analysis Immersed Tube Tunnel 8-lane Concept*" included in ***Appendix Q*** with a summary of the findings presented in ***Table 16*** below.

Table 16 - River Road Ramp and Highway 17A Ramp Operations

Interchange	Movement	2035 LOS	2035 Remarks	2050 LOS	2050 Remarks
		AM Peak Period			
Highway 17A	NB Exit Ramp	B		B	
	NB Entrance Ramp (i.e. last merge of the NB auxiliary lanes, before the merged lane joins the Hwy as an add lane)	D		D	
		PM Peak Period			
River Road	SB Exit Ramp	D		F	Capacity on Highway 99 approaching ramp exceeded
Highway 17A	SB Exit Ramp	C		C	
	SB Entrance Ramp	C		C	

As can be seen, the River Road and Highway 17A exit and entrance ramps as designed are expected to operate acceptably in 2035 with LOS D or better). The SB River Road exit ramp from Highway 99 is however expected to operate at LOS F in the 2050 PM peak period due to the capacity issues on Highway 99 approaching the ramp.

4.5.2.4 Ramp Terminal Intersection Operations

The two signalised ramp terminal intersections at the Highway 17A interchange were analyzed using the Synchro program. This analysis assumed:

- The two interchange signalized intersections operate in isolation (i.e. downstream congesting was not considered);
- 2050 AM and PM peak hour all vehicle volumes from ***Appendices I*** to ***J***;
- All HOVs would use the designated HOV facilities, and there would be no violators or electric vehicles in the HOV lanes;
- Uncoordinated traffic signal operations;
- Existing traffic signal phasing;
- Proposed laning configuration as per the ITT/Bridge conceptual design drawings as at October 30, 2019 (see ***Appendices L and N***); and
- Preliminary traffic signal timing optimization.

The Synchro output is summarized in ***Table 17***.

Table 17 - Highway 17A Interchange Ramp Terminal Intersection Performance (2050)

				Turning Movements											
	Intersection	**Int. LOS**		**EBL**	**EBT**	**EBR**	**WBL**	**WBT**	**WBR**	**NBL**	**NBT**	**NBR**	**SBL**	**SBT**	**SBR**
2050 AM	Hwy 99 NB Ramp Terminal	**B**	***Traffic Vol (vph)***	**290**	**590**	**0**	**0**	**140**	**330**	**120**	**630**	**100**	**0**	**0**	**0**
			v/c ratio	0.47	0.34	-	-	0.36	0.73	0.26	0.68	0.20	-	-	-
			LOS	B	A	-	-	C	C	B	C	A	-	-	-
	Hwy 99 SB Ramp Terminal	**B**	***Traffic Vol (vph)***	**0**	**260**	**0**	**0**	**160**	**0**	**0**	**0**	**0**	**370**	**0**	**0**
			v/c ratio	-	0.46	-	-	0.28	-	-	-	-	0.58	-	-
			LOS	-	B	-	-	B	-	-	-	-	B	-	-
2050 PM	Hwy 99 NB Ramp Terminal	**B**	***Traffic Vol (vph)***	**420**	**290**	**0**	**0**	**290**	**640**	**180**	**180**	**40**	**0**	**0**	**0**
			v/c ratio	0.67	0.14	-	-	0.47	0.90	0.56	0.28	0.11	-	-	-
			LOS	B	A	-	-	B	C	C	C	A	-	-	-
	Hwy 99 SB Ramp Terminal	**B**	***Traffic Vol (vph)***	**0**	**400**	**0**	**0**	**370**	**0**	**0**	**0**	**0**	**150**	**0**	**0**
			v/c ratio	-	0.57	-	-	0.53	-	-	-	-	0.33	-	-
			LOS	-	B	-	-	B	-	-	-	-	B	-	-

From ***Table 17*** It is evident that traffic operations at the two ramp terminal intersections at the Highway 17A interchange will be acceptable in 2050. In 2035, the operations should be better given the lower demand volumes. It is however noted that this intersection analysis does not take into account any downstream queuing that may occur.

4.5.3 Deep Bored Tunnel Considerations

The depth of the bored tunnel required for geotechnical considerations, combined with the 5% maximum grade requirement, results in the tunnel daylighting well north of the existing Steveston Highway Interchange and well south of the existing Highway 17A Interchange. Elimination of the connections to Highway 99 at Steveston Highway and Highway 17A (i.e. provide crossings over the tunnel without connecting ramps) is expected to severely impact the overall highway network operations in the area. Therefore, the conceptual design for the bored tunnel option provides long ramps which loop Highway 99 traffic back to Steveston Highway and Highway 17A as shown on the Bored Tunnel plan/profile drawing found in ***Appendix O***. It is noted that the bored tunnel option eliminates any direct connection from Highway 99 to River Road, however River Road may be connected in the east-west direction to cross over the tunnel at-grade.

The shape of the bore (a circle) results in the need to stack the traffic in each bore (2 lanes on a top deck and 2 lanes on a bottom deck). This presents geometric and operational challenges, both to unstack the traffic at each end, as well as the need to get traffic into the correct lanes to allow them to enter and exit at Steveston Highway and Highway 17A. The stacking and unstacking can be accomplished in the length of the tunnel portals, however getting the traffic in and out of the correct lanes is more challenging. The locations of the long ramps which loop Highway 99 traffic back to Steveston Highway and Highway 17A shown on the Bored Tunnel plan/profile drawing found in ***Appendix O*** provide sufficient distance for the lane stacking/unstacking but provides insufficient weave distance between the portals and the entrance/exit ramps at Steveston Highway and Highway 17A. Therefore, significant queueing is expected in the single lane that serves the Highway 17A entrance ramp to Steveston Highway Interchange exit ramp traffic and vice versa, as discussed in section 3.3. The only solution that our team was able to identify involved moving the entrances/exits from Steveston Highway and Highway 17A an additional 1km from the locations shown to allow the traffic to weave into the correct lanes, however this solution is not considered practical.

4.6. Other Design Considerations

4.6.1. Estimated Property Impacts

A review of the approximate property impact of each of the options presented in plan/profile drawings found in ***Appendices L, M, N and O*** was undertaken. Quantities were estimated based on a proposed Highway Right-of-Way offset 10 m from the proposed lane edges and are summarized below in ***Table 18***. The quantities below do not include construction below the ground surface or within the river.

Table 18 - Notional Property Impact Estimates

	8-Lane Bridge	***8-Lane ITT***	***8-Lane Bore***
South Side Impact	*5 ha*	*2 ha*	*49 ha*
North Side Impact	*3 ha*	*1 ha*	*21 ha*
Total Impact	***8 ha***	***3 ha***	***70 ha***

It is noted that based on a desktop review of land uses, all the above property impacts appear to be in ALR land.

4.6.2. Transit

In the future, bus service has been assumed to be as per existing in terms of general routing and bus stop locations. For the 6 lane GMC options, buses were assumed to use the existing tunnel, whereas, with the 8 lane GMC, buses were assumed to use the new ITT/Bridge or DBT in dedicated bus lanes. The travel time impacts of buses using the existing tunnel or the new GMC were assessed and documented in a separate Stantec memo titled "*George Massey Crossing – Bus Travel Time Estimation*". This assessment showed that assigning buses to the existing tunnel resulted in longer travel times in the order of two to four 4 minutes, compared to running the buses on/in the new GMC.

The accommodation of buses in the conceptual highway designs has been described in more detail in previous sections of this report.

4.6.3. Bicycle Connectivity

Based on review of the Southwest Area Transport Plan, the following items are offered for consideration as the Project moves into its next stages.

North connectivity and access points:

- Connectivity may be considered through to Shell Road from the GMC pathway access point.
- Connectivity may be considered from the GMC pathway access point to Sidaway Road.
- Suitable all ages and abilities bicycle connectivity may be considered on Steveston Highway with adequate protection for crossings at bridge structures, ramps, and signalized intersections.
- Utilization of the BCATDG may be considered at all intersections where bicycles are accommodated, with high consideration for truck volumes and speed differentials in this area.

South connectivity and access points:

- Enhanced bicycle accommodation through the paving of pathways may be considered along the south side of the South Arm of the Fraser River
- Extended pathway connections may be considered along the South Arm of the Fraser River to River Road and Ferry Road.
- Connectivity along Highway 99 to Burns Drive may be considered.
- Connectivity adjacent to Highway 17A may be considered.
- Interim connections may be considered to Burns Drive via River Road, 60 Avenue, and 64 Street.
- Utilization of the BCATDG may be considered at all intersections where bicycles are accommodated, with high consideration for truck volumes and speed differentials in this area.

4.6.4. Truck Assessment

The MoTI requested that the feasibility of providing a designated truck lane on the new GMC be assessed. ***Table 19*** below shows the 2050 AM and PM peak hour demands in the peak direction by vehicle class from McElhanney's "*GMC Traffic Forecast" memo* (***Appendix D***). Assuming an 8 lane GMC with one bus lane, one truck lane, and two GP lanes per direction, the capacities and excess volumes of the respective lanes are then presented. The assumed capacities are 1800 veh/hr capacity for a GP lane, and then 1000 trucks/hr for a truck lane and 1000 buses/hr for a bus lane based on engineering judgement.

Table 19 - 2050 Demands and Capacities by Class – 8 Lane GMC – 2GP, 1 Bus, 1 Truck Lane

	# Lanes	Capacity (veh/hr)	AM NB Peak Hour Volume (veh/hr)	AM NB Peak Hour Excess Volume (veh/hr)	PM SB Peak Hour Volume (veh/hr)	PM Peak Hour Excess Volume (veh/hr)
Transit	1	1000	100	-	90	-
Trucks	1	1000	470	-	310	-
GP Traffic	2	3600	4990	1390	5900	2300
Total	4	5600	5570		6300	

From ***Table 19***, it is evident that the provision of separately designated truck and transit lanes will have a significant impact on GP capacity and hence queues on GMC. In addition to the obvious capacity/queueing issues at GMC itself if a dedicated truck lane were to be provided, there would also be additional operational/safety issues introduced at the merge/diverge areas on Highway 99 at the Steveston Highway and Highway 17A ramps, as GP traffic would have to weave across the truck lane as well as the bus lane when entering/exiting the highway.

As an alternative, an 8 lane GMC with one combination bus/truck lane and three GP lanes per direction was considered. Whilst this option may partially alleviate the GP congestion on GMC, it was not considered feasible as the mix of trucks and buses in a dedicated reserved lane is not desirable and does not promote transit usage. In addition, there would be operational/safety issues introduced at the merge/diverge areas at the Steveston Highway and Highway 17A ramps on Highway 99, as GP traffic would have to weave across the combination truck/bus lane when entering/exiting the highway.

As a result of the preliminary assessment presented above, truck lanes have not been included in the conceptual designs to date.

5. Summary

The planned eight-lane GMC, including a dedicated bus-only lane in each direction, would support improved mobility for sustainable modes, goods movement as well as vehicular travel through:

- Dedicated bus-only lanes, which would support the existing services in peak directions with increasing service levels and capacity through the introduction of double-decker buses over the next few years. Dedicated lanes would connect with bus-on-shoulder facilities both north and south of the existing crossing and would ultimately support increased ridership to/from South of Fraser communities;

- Dedicated pedestrian and cycling facilities between Richmond and Delta connecting into TransLink's Major Bike Network that serves urban centres across Metro Vancouver;

- Additional capacity serving off-peak directional travel as well as midday and weekend traffic, including commercial vehicles supporting regional, provincial and national trade corridors. The additional capacity for off-peak periods would be particularly important for summer periods when daily traffic is highest; and,

- Improved safety due to higher design standards and less congestion.

The combination of removing buses from general traffic lanes, increased transit service, and moderate improvements in general purpose capacity due to wider travel lanes and improved safety would help improve travel time speed and reliability and reduce congestion. Continued improvement in transit service levels between South of Fraser and Richmond / Bridgeport Station also would be needed to further reduce congestion during these times, as is the case in other parts of the region, to provide attractive alternatives, manage demands and support regional and provincial goals for sustainable modes and climate action.

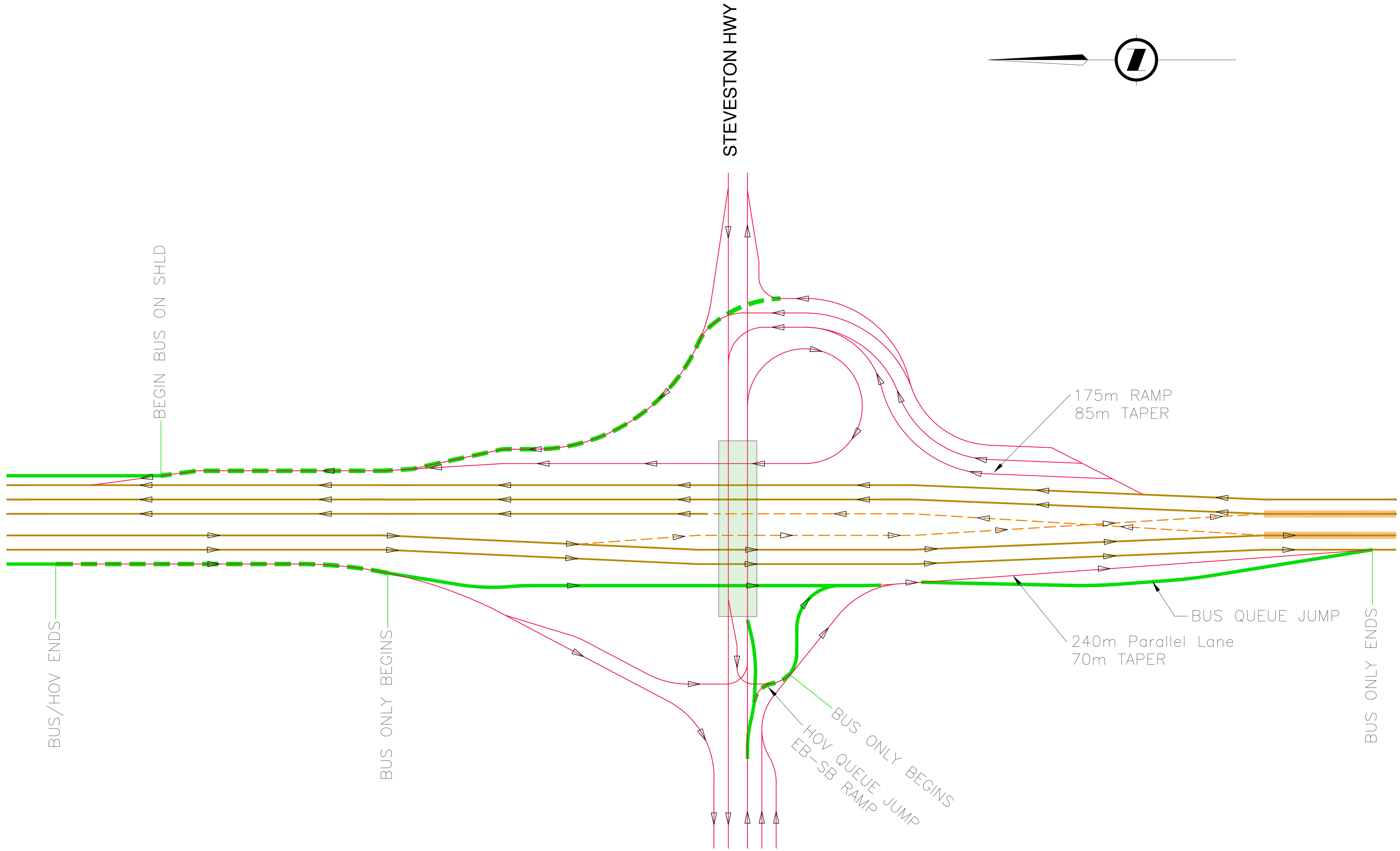
Additionally, improved utilization for the bus-only lanes could be considered through alternative lane designations (HOV/transit, auxiliary lanes) to avoid or minimize peak period queues in future. In this regard, technical strategies could be considered at subsequent stages of planning and design, to address some of the growth in vehicle queues while maintaining priorities for transit on the new crossing.

APPENDIX A - EXISTING OVERALL LANING SCHEMATIC

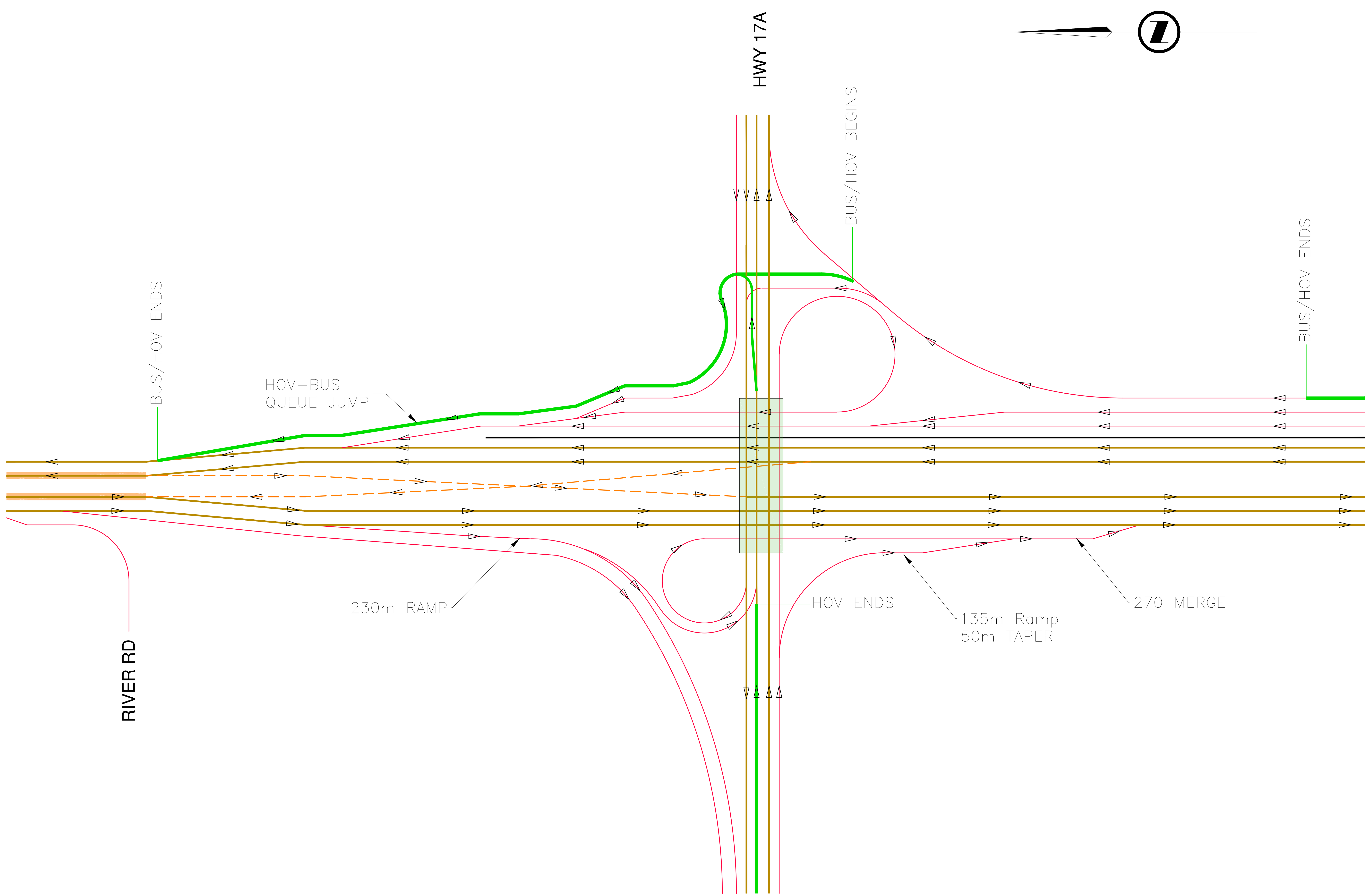
HWY 99

EXISTING LANE CONFIGURATION

APPENDIX B. EXISTING STEVESTON HIGHWAY INTERCHANGE LANING SCHEMATIC



APPENDIX C. EXISTING HIGHWAY 17A INTERCHANGE LANING SCHEMATIC



APPENDIX D. TRAFFIC FORECASTS

Our File: 2121-00610-00

H. S. CLEMENT #28190 PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA

Basse Clement Nov. 8, 2019

TECHNICAL MEMO

To	**From**
Darryl Matson, PEng, PE, COWI Ross McLaren, PEng, GNEC	Basse Clement, PEng, MASc Harvey Harrison
Re	**Date**
GMC Traffic Forecasts (Revised Draft)	November 8, 2019

The purpose of this technical memorandum is to document and confirm the key assumptions incorporated into the George Massey Crossing (GMC) modelling work as well as model outcomes. The travel demand modelling work presented here is based on application of the Regional Transportation Model Phase 3 available from TransLink and was performed in support of the Technical Services for the George Massey Crossing Project. The first section describes the key assumptions within the RTM3 model including road and transit networks, land use, model structure and pricing. A backcheck of the growth rates for traffic volumes crossing the South Fraser river was conducted through development of an independent regression model. Following this, the RTM3 model underwent an extensive validation of traffic volumes, travel times and origin-destination patterns to ensure that it reasonably represents observed conditions. Through this validation exercise, several minor adjustments were made to the model ahead of developing a set of traffic forecasts for the 2035 and 2050 horizons for the GMC. These form the latest traffic forecasts as well as the detailed ramp volumes and turn volumes that were used to assess the performance of the corridor in the future.

Regional Transportation Model Assumptions

The current version of the Regional Transportation Model (RTM) is version 3.2 which was released in August 2018. An updated RTM 3.3 is expected in the Fall of 2019 incorporating updates developed in support of recent forecasting and regional project evaluation. An advance version of the RTM containing changes expected to be present in RTM 3.3 was made available in early August 2019 for use by the GMC project; the official RTM 3.3 release will be used when available for the final traffic forecasts.

Some of the major updates in version 3.3 include:

- Updated land use inputs from Metro Vancouver for 2017, 2035 and 2050;
- New rapid transit assumptions for future Surrey rapid transit projects;
- Highway interchange and widening projects refined based on current funded commitments;

- Additional econometric and benefits calculation tools developed from recent project business cases.

The following sections describe the data made available for the GMC modelling based on discussions with TransLink.

HORIZON YEARS / LAND USE / TRAVEL DATA

The current 2017, 2035 and 2050 model horizon years in the RTM 3.2 will remain the same in the RTM 3.3 as this represents the current planning horizons being used in the region.

Metro Vancouver has produced updated population and employment forecasts for the regional model incorporating all available information from the 2016 census including final population undercount adjustments, employment category information from the journey to work survey and other municipal control totals. This update supersedes the interim update incorporated in RTM 3.2 which included proxy information from the 2011 Census where data was not yet available from the 2016 Census. The updates to land use were implemented at the 1,741 traffic zone level of detail as shown in *Figure 1*. *Figure 2*, *Figure 3* and *Figure 4* then show the land use growth between 2017 and 2035 for households, population and employment with *Figure 5*, *Figure 6* and *Figure 7* showing growth between 2035 and 2050.

Figure 1: 1,741 Traffic Zone System in RTM3

ROAD NETWORK ASSUMPTIONS

The RTM 3.3 generally represents the roadway network as it existed in fall 2017 after the removal of the tolls on the Port Mann and Golden Ears bridges. Future horizon years for the base case contain no updated assumptions for the GMC and adjacent interchanges which remain in their present configuration with AM and PM peak counterflow operation and bus shoulder lanes north and south of GMC. The base and future scenarios contain no road tolling assumptions consistent with present regional policy.

TRANSIT NETWORK ASSUMPTIONS

Updates are included for the Broadway Subway to Arbutus and the Surrey-Langley Skytrain project to Fleetwood. In addition, planned capacity upgrades to the Expo Line, Canada Line and SeaBus services are included based on currently committed funding and fleet expansion plans. The 3-zone fare structure has been maintained as there is not enough clarity in the distance-based fare option being considered.

MODEL ASSIGNMENT PROCEDURE

The model convergence criteria have been updated based on recent experience in calculating benefits on the auto network between different roadway alternatives and volumes assigned in the congested transit assignment. The auto assignment criteria are now solely based on the relative gap measure and will no longer complete at a maximum number of iterations. This has a limited impact on model runtime while reducing background variation in the benefits comparison due to networks of different levels of convergence. The congested transit assignment has also had the number of iterations increased to reduce variation in the final assigned transit volumes.

BENEFITS EVALUATION

The conventional benefits previously calculated using the consumer surplus method has been updated to a logsum formulation which is more consistent with the 24-hour model formulation. The previous consumer surplus 'rule-of-a-half' calculations are still available but recent business cases have been presented using benefits derived from the logsum approach. Additional analysis tools to estimate reliability benefits are now available for both auto and transit services in addition to safety (collision), GHG (vehicle-kilometres travelled (VKT) based approach) and economic agglomeration. These accounts can be included in a multiple account evaluation as required using the predefined calculations in the RTM or through custom approaches as desired.

Figure 2: Household Growth 2017-2035

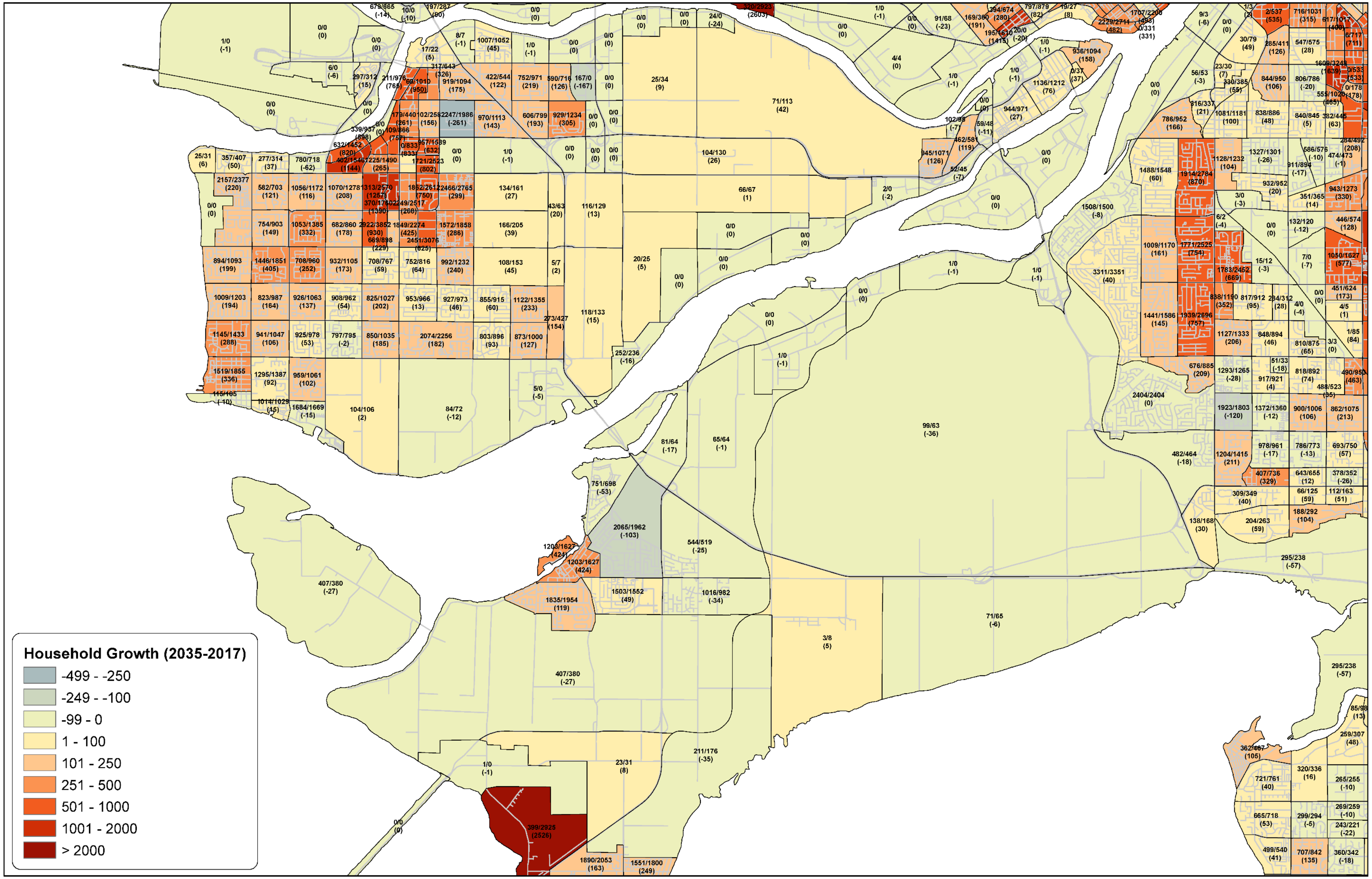


Figure 3: Population Growth 2017-2035

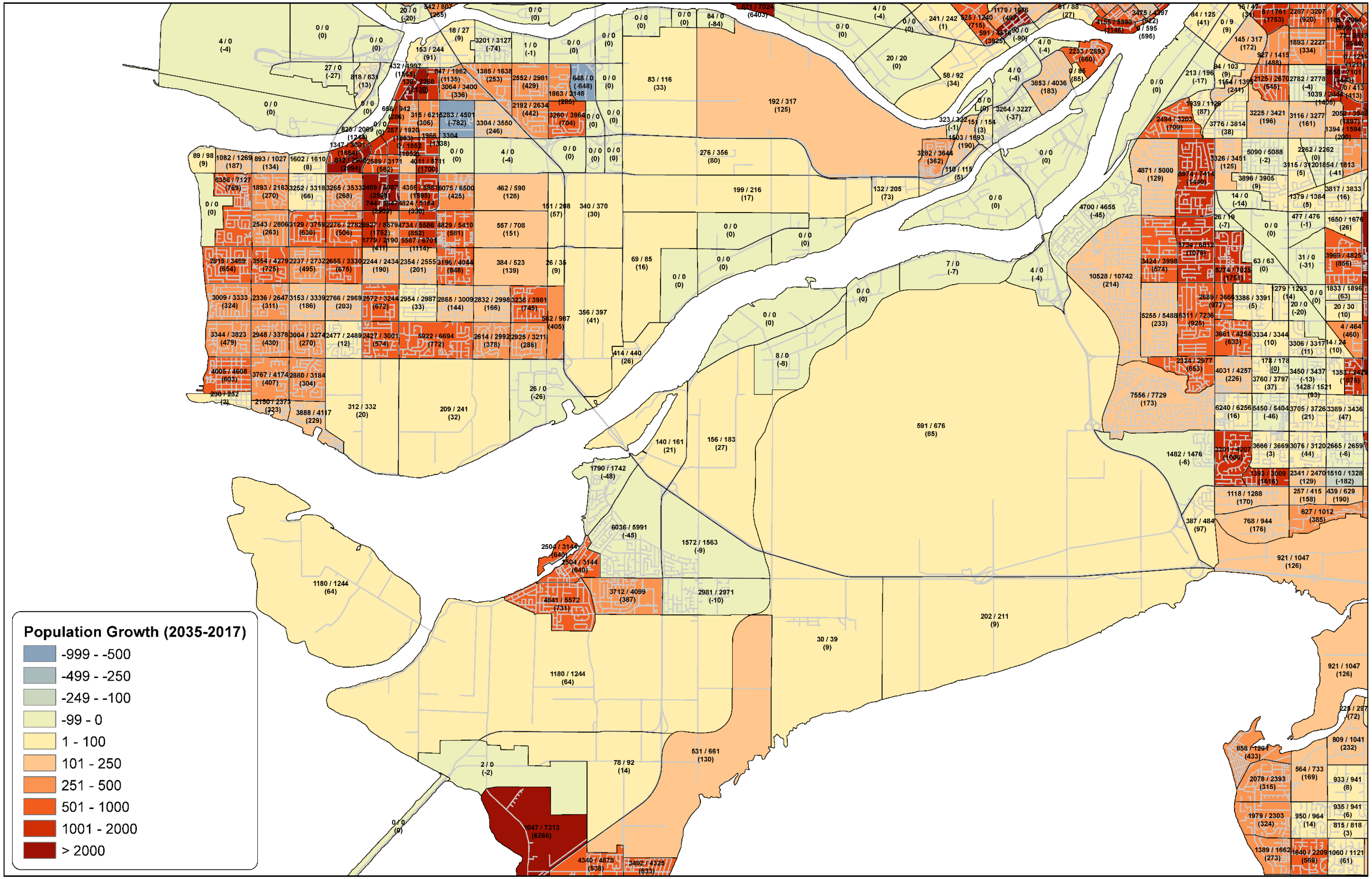


Figure 4: Employment Growth 2017-2035

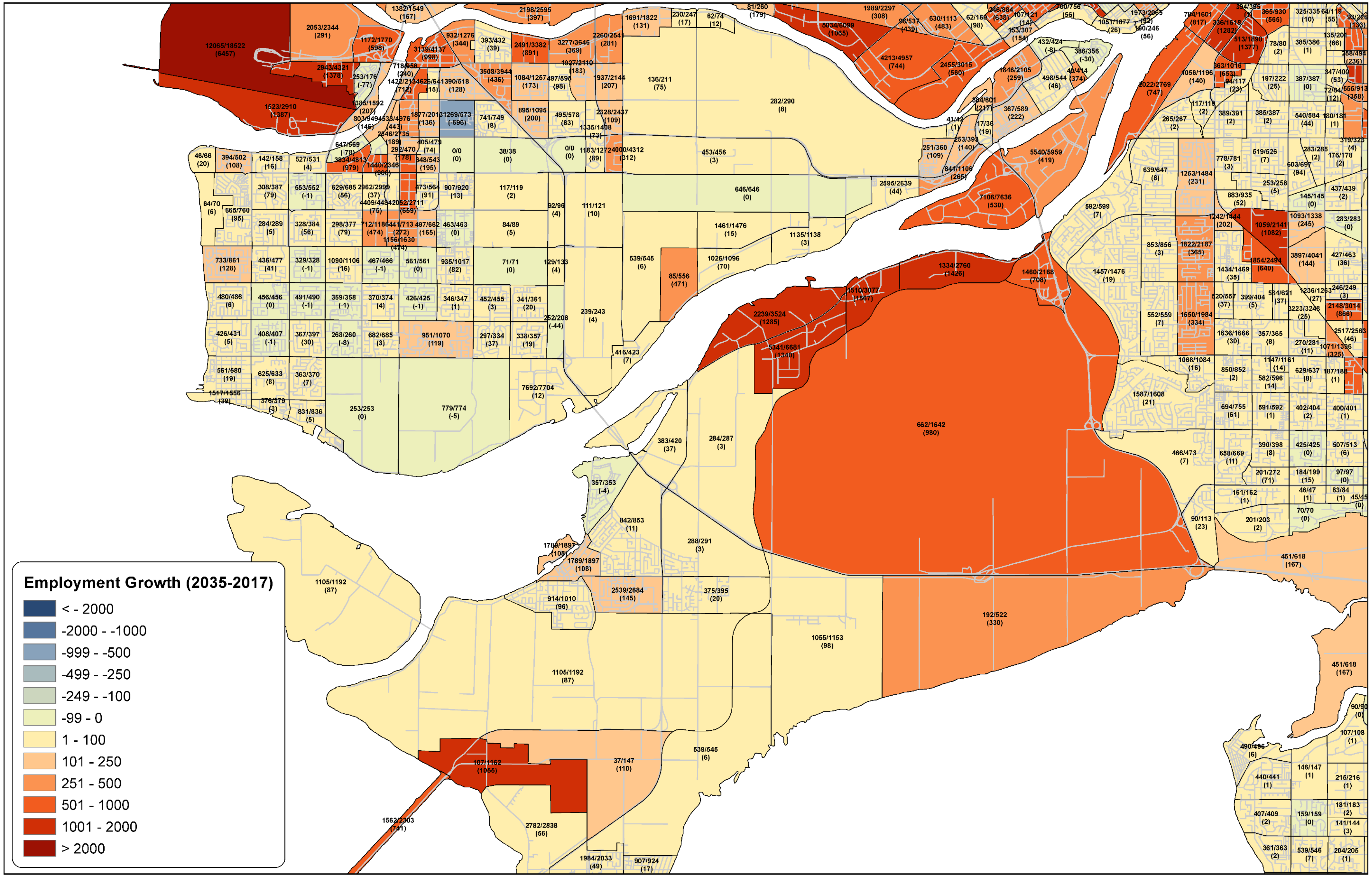


Figure 5: Household Growth 2035-2050

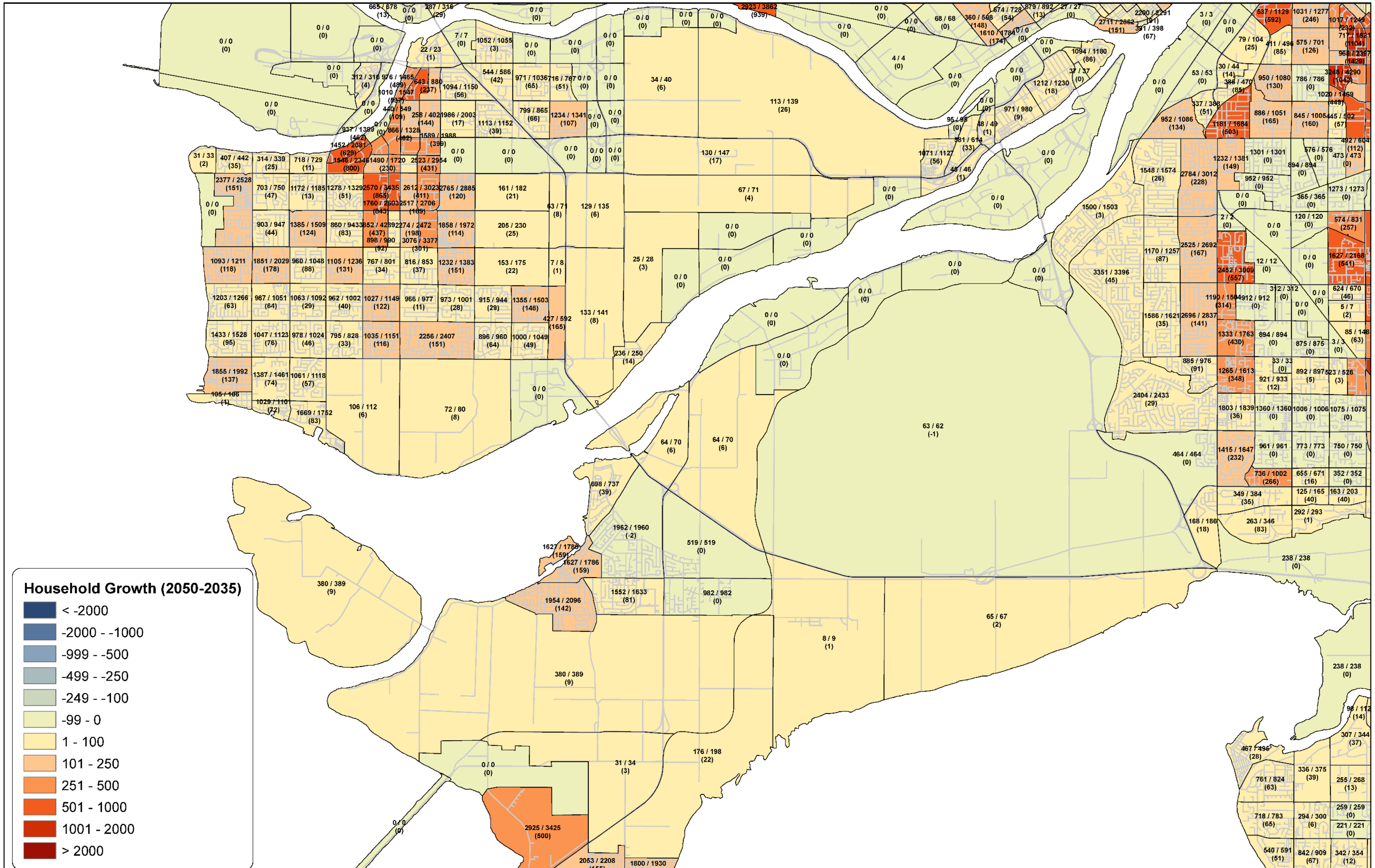


Figure 6: Population Growth 2035-2050

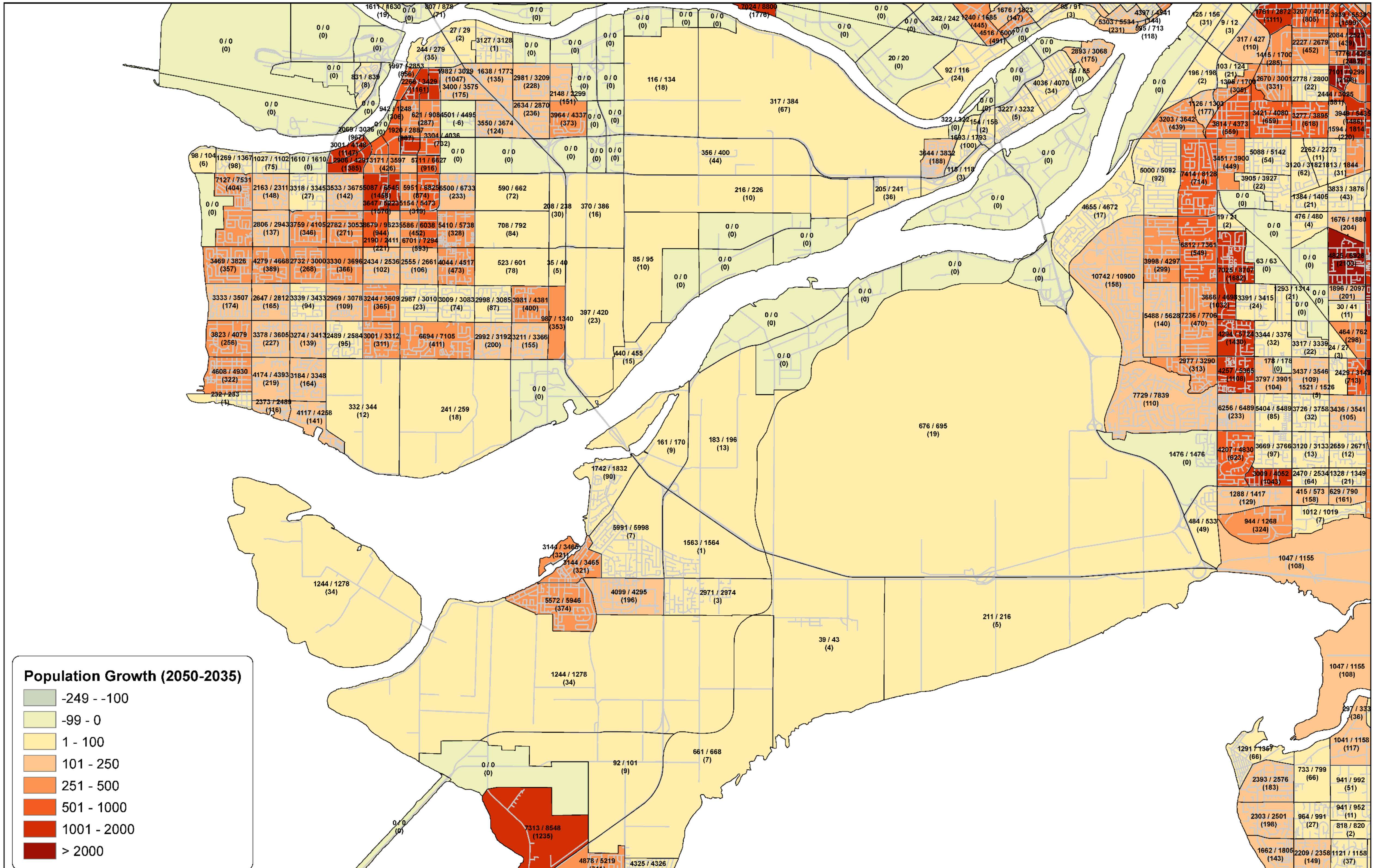
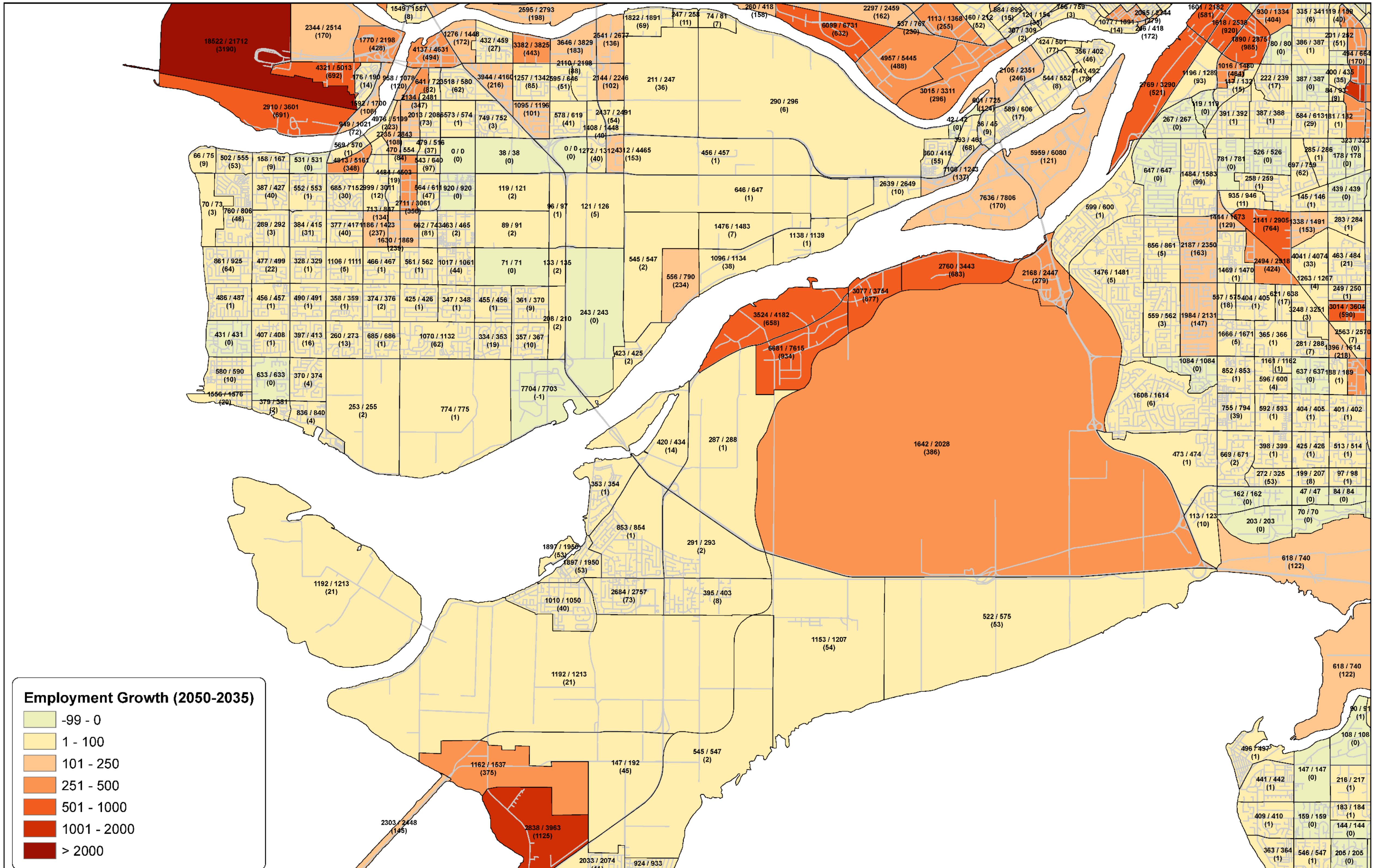


Figure 7: Employment Growth 2035-2050



ASSUMPTIONS SUMMARY

The assumptions inherited from the RTM 3.3 which will have the largest impacts to the GMC modelling will generally be in the land use forecasts as the source of trip productions and attractions. Growth assumptions for the major truck special generators, BC Ferries growth and network improvements to Sunbury interchange will have lower impacts in attracting or diverting traffic to the improved crossing.

UNMODELLED FUTURE PROJECTS

There are regionally significant projects and policies that are currently being considered that are not included in the RTM3 model due to uncertainty in the final funding or implementation plan. While these may be evaluated as sensitivity cases in the regional model they have not been included for evaluation in this project. Example sensitivity scenarios could include:

- Rail to UBC Skytrain extension (currently assume extension to Arbutus only);
- SFU Gondola (alignment and funding commitment unclear);
- South of Fraser Rapid Transit (Skytrain extension beyond Fleetwood; rapid transit on King George Blvd / 104th Ave);
- Mobility Pricing (Bridge tolls, distance-based pricing, congestion pricing);
- Alternative land use scenarios;
- Distance-based transit fare policy;
- Connected and autonomous vehicle impacts;
- Transportation network companies (TNCs); and
- Vehicle fleet electrification.

The detailed project assumptions within RTM3 from the base model are provided in *Table 1*.

Table 1: GMC Study – Consolidated Modelling and Network Assumptions

ITEM	ASSUMPTION
Regional Model and Version	TransLink's Regional Transportation Model Phase 3.3
Horizon Years	2017, 2035, 2050
Land Use	Metro Vancouver updated 2016/2017, 2035 and 2050 forecasts based on Census 2016, BC Stats and Regional Growth Strategy controls
Road Networks	2017: • 72nd Ave Interchange w/ Hwy 91 Complete • Municipal network updates (Burrard bridge reconfiguration, Cambie SB bike lane)
	2035 & 2050: • 216th Interchange on Hwy 1 • Hwy 1 Lower Lynn Interchanges Phase 1,2,3,4 • Hwy 1 Widening 216th to 264th • Alex Fraser Bridge Counterflow Lane • Hwy 17/91 Improvement Project (Sunbury Interchange concept based on publicly available information) • Pattullo Bridge Replacement Project (preferred option from 2018 business case)
Transit Network	2017: • Updated Transit Coding, particularly connectivity to transit exchanges • Evergreen Extension to Millennium Line

<table>
<tr><th>ITEM</th><th>ASSUMPTION</th></tr>
<tr><td></td><td>2035 & 2050:
Broadway Subway to Arbutus
Surrey Langley Skytrain to Fleetwood
RapidBus Services from Phase 1,2,3
Mayor’s Vision 10-year plan service updates
SkyTrain Fleet capacity updates and service increases
New Canada Line Station – Capstan Way
SeaBus service increases</td></tr>
<tr><td>Model Structure</td><td>Updates to model convergence criteria in auto assignment, congested transit assignment and overall cycling convergence.
Transit Vehicle capacity updates for consistent measure of transit congestion.
Evaluation of different transit service types (RapidBus, BRT, LRT)
Updated volume delay function formulation.</td></tr>
<tr><td>Truck Model / External Growth</td><td>No updates from previous RTM 3.2 assumptions.
Deltaport Terminal 2 medium case growth forecast for future years and GDP based growth assumptions from cross border and interregional truck market.
YVR growth maintained as previously assumed.
BC Ferries and Cross-Border traffic assumptions kept as-is.
Review current developments on Tsawwassen First Nations and Amazon fulfillment center for inclusion.</td></tr>
<tr><td rowspan="2">Pricing</td><td>2017
Port Mann and Golden Ears Bridges Tolls Removed
Zone-based Transit Fare on SeaBus, SkyTrain, West Coast Express
Flat Fare for other Bus services</td></tr>
<tr><td>2035 & 2050
No mobility pricing assumptions made (no road or bridge tolls)
No escalation in real fuel price
Transit Fare Structure maintained per 2017 (distance-based fares not implemented)</td></tr>
<tr><td>Time Slices</td><td>Trip Generation, Distribution and Mode split continues as 24-hour with peak hour time slices assigned to the network for:
AM Peak Hour (07:30 - 08:30)
MD Peak Hour (12:00 - 13:00)
PM Peak Hour (16:30 - 17:30)</td></tr>
<tr><td rowspan="3">Benefits Evaluation</td><td>Newly developed tooling allows updated benefits accounts to be analyzed:</td></tr>
<tr><td>Conventional Benefits:
Transit Travel Savings
Auto Travel Savings
Truck Travel Savings
Incremental Fare/Tolling Revenue</td></tr>
<tr><td>Wider User Benefits
Economic Agglomeration
Auto Travel Reliability
Transit Travel Reliability
Safety (collision reduction)
GHG (vkt-based)</td></tr>
</table>

Regional Transportation Model Findings

This section provides a summary of key model outcomes and findings to date. The modelling work first focused on validation of the Regional Transportation Model including traffic volumes, travel times and origin destination patterns. This resulted in a set of adjustments to the model to account for study area specific travel patterns. A backcheck of the modelled traffic growth rates across the Fraser River south arm was conducted to ensure the growth component of the model was reasonable. Following the adjustments to the model, a set of traffic forecasts were developed to inform the development of future options.

HIGH-LEVEL VALIDATION OF RTM3 MODEL

Before developing the model forecasts, the RTM3 model underwent a high-level validation of key metrics. The following data sources were used to validate the model:

- Updated land use assumptions received from TransLink for the 2035 and 2050 horizons;
- Travel time validation based on Google Maps API travel times;
- Batched in the 2017 Screenline Survey counts and additional MoTI permanent count stations along Highway 99, 91 and 17; and
- TomTom[1] origin-destination data for ramp on and off activity within Highway 99 corridor.

Details of the model validation, including comparisons of modelled versus observed conditions for each of these metrics is provided in *Appendix A* and *Appendix B*.

The validation of the model showed that there were some minor deficiencies that needed to be addressed. Most of the adjustments to the model were related to the network which incorporated work in progress for the 72nd Ave interchange, roadway network fixes around Pattullo Bridge as well as municipal roadway fixes across Coquitlam, Surrey, North Vancouver, Delta and Richmond. Further model network adjustments included merge functions on Highway 91 and Highway 17 to account for the choice market between Highway 99 and Highway 91. These all resulted in a more accurate representation of traffic volumes and patterns within the study area. *Figure 8* to *Figure 11* show the validated traffic volumes assigned to the base model network. To further illustrate trip distribution patterns, *Figure 12* and *Figure 13* show the select-link assignments in the north and southbound directions for traffic using GMC. The percentage distribution shows the links that are feeding into the crossing and then how that traffic disperses onto the network.

[1] *TomTom data is based on GPS probe data collected anonymously from personal navigation devices installed in vehicles as well as navigation applications on Smartphones.*

Figure 8: 2017 AM Peak Base Traffic Volume Assignment Plot (Richmond)

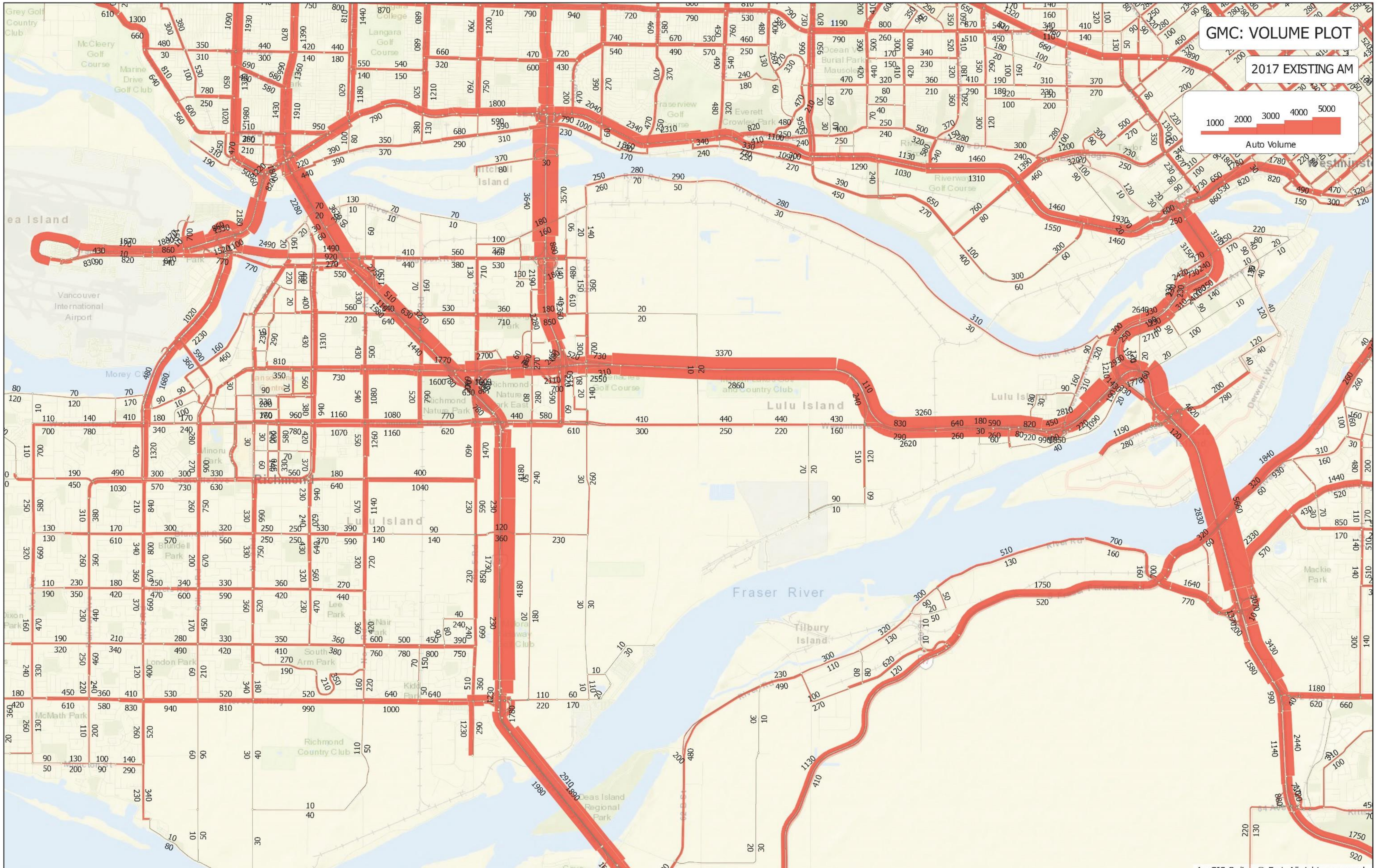


Figure 9: 2017 AM Peak Base Traffic Volume Assignment Plot (Delta)

Figure 10: 2017 PM Peak Base Traffic Volume Assignment Plot (Richmond)

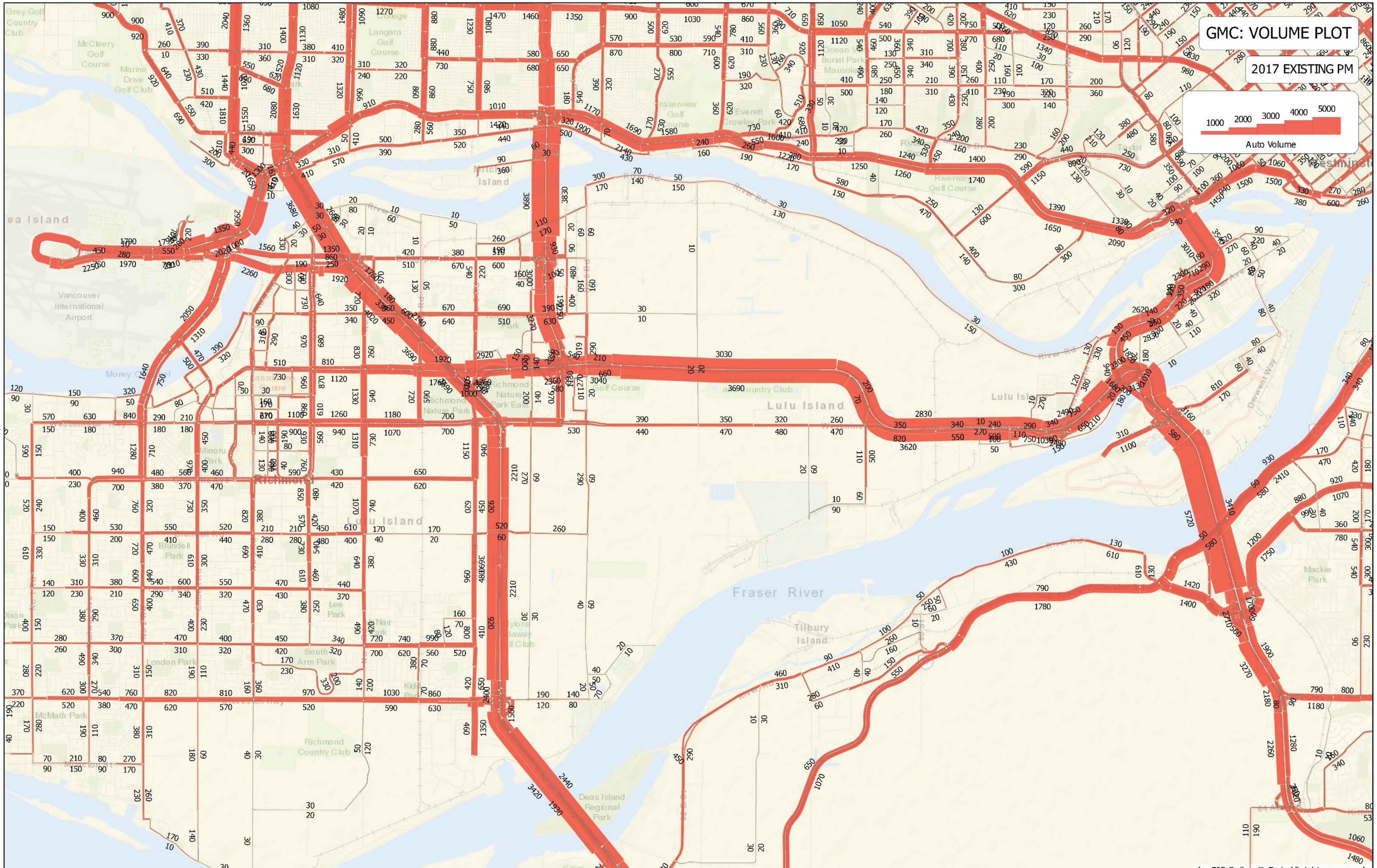


Figure 12: 2017 AM Trip Distribution Patterns

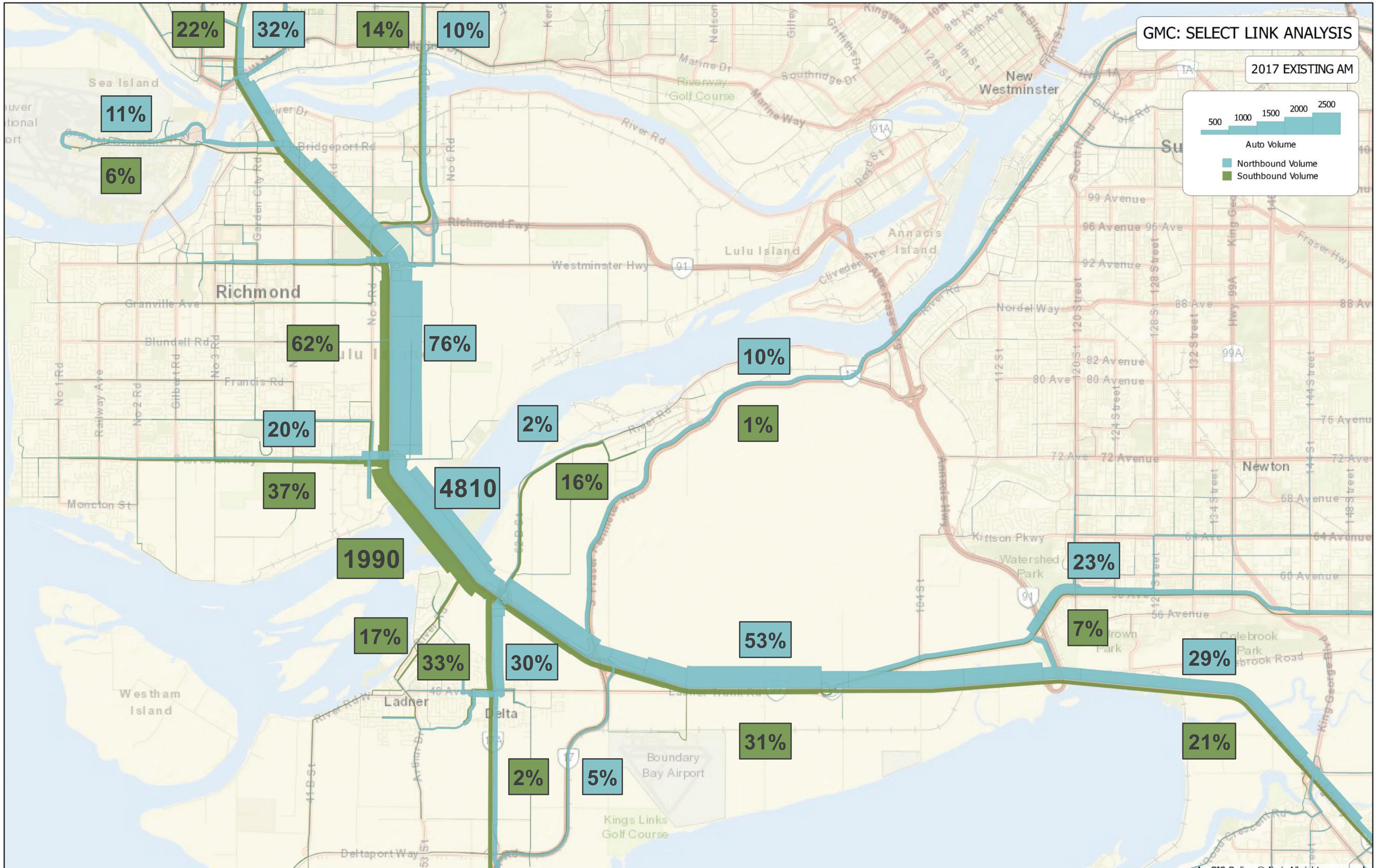
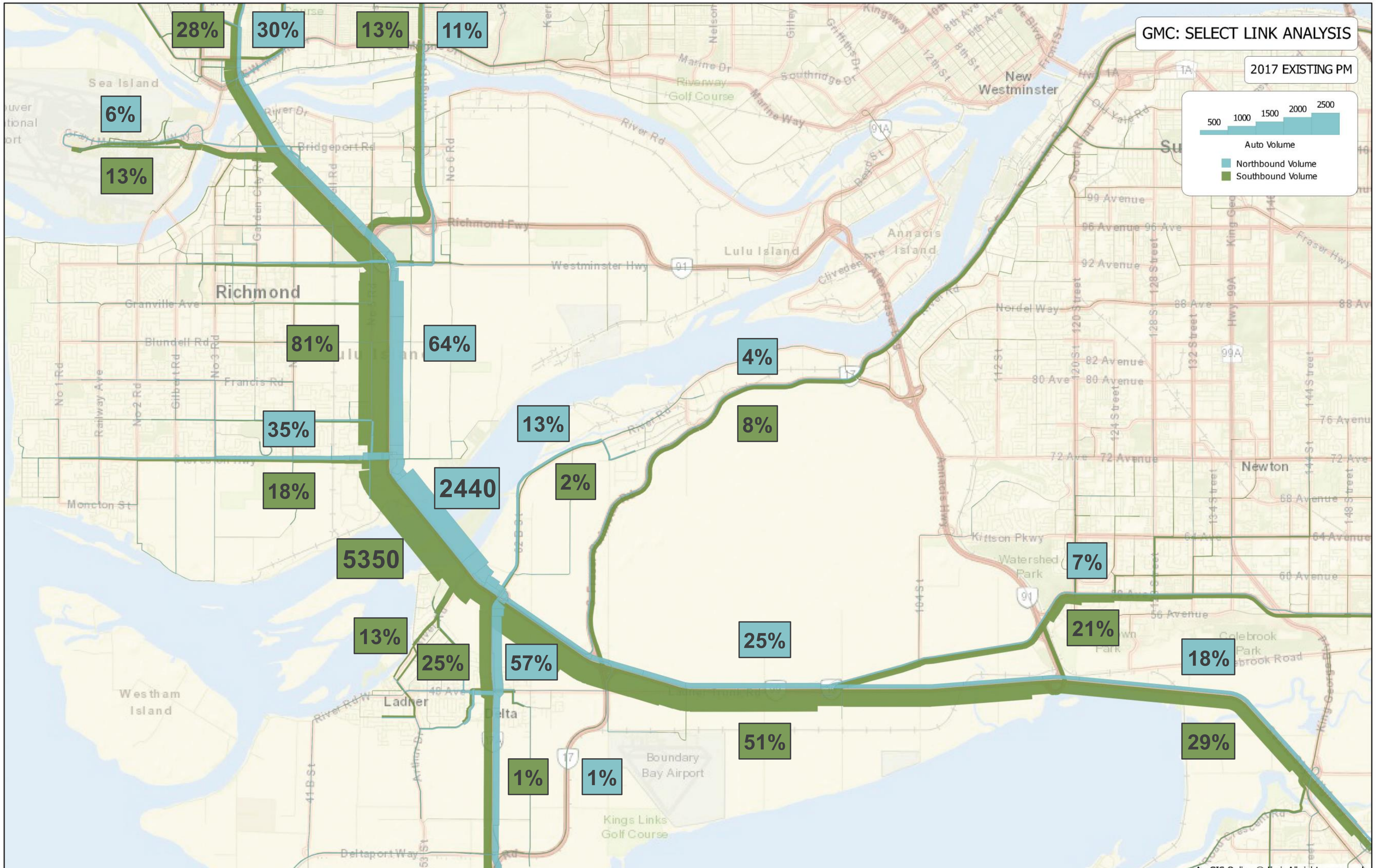


Figure 13: 2017 PM Trip Distribution Patterns



TRAFFIC FORECASTS

With further model validation activities undertaken, including updating of key network elements as discussed in the previous section, the traffic forecasts were developed. The traffic forecasts are fundamentally driven by growth in land use. The land use growth assumptions from 2017 to 2050 by municipality are illustrated in *Figure 14* for population, *Figure 15* for households and *Figure 16* for employment. These options were developed for an updated 8-Lane crossing of the Fraser River with six general purpose lanes and two bus-only lanes. The general laning configuration of the Highway 99 corridor assumed at the time is illustrated in *Figure 17A*, *17B* and *17C*. It is, however, acknowledged that there have been minor design revisions in the vicinity of the interchanges since that time, and the RTM modelling should therefore be rerun to reflect these design changes as they evolve. In the meantime, until such time that the modelling "catches up with the design", the GMC forecasts presented in this report are considered to be suitable for the planning level work currently underway. For the six lane alternative modelled in 2050, a similar configuration was developed, however, the bus lanes were rerouted to utilize the existing GMC tunnel rather than running them on the Highway 99 mainline. This scenario was run only in the long-term horizon as a sensitivity test to illustrate the impact of this alternate highway configuration.

Other future base network updates included coding for the following projects:

- Highway 91/17 Sunbury Interchange
- Pattullo Bridge Replacement to four general purpose lanes
- Alex Fraser Bridge Counter Flow System
- Surrey-Langley SkyTrain Project to Fleetwood
- Millennium Line Broadway Extension to Arbutus
- 216th Interchange and Highway 1 widening to 264th St
- Highway 1 Lower Lynn Improvements
- Transit capacity improvements on SkyTrain (Expo and Canada Line)
- SeaBus capacity improvements

Table 3 provides the 2035 traffic forecasts with an 8 lane GMC for each of the South of Fraser crossings for the AM and PM periods as well as by direction while *Table 4* provides the same information for the 2050 horizon with a 6 and 8 lane GMC. Detailed lane and turning movement volumes for the 2035 and 2050 traffic forecasts along the Highway 99 corridor were extracted from the RTM and have been provided in the separate *Traffic and Geometric Technical Report* in *Appendices H* to *K*. From 2017 to 2035 the GMC sees background growth of approximately 8% during the combined AM and PM peak hours. Growth during the peak periods is constrained with the current configuration of the crossing. With an 8-lane crossing, traffic grows by approximately 15% from the base year, much of this coming from Alex Fraser Bridge in the off-peak direction. From 2017 to 2050, GMC traffic volumes grow by 13% during the combined AM and PM peak hours. This grows to 17% with an 8-lane crossing, again much of the additional traffic coming from Alex Fraser Bridge in the off peak direction.

In order to better understand the effect of future growth on the network, a series of network plots were produced to show AM and PM peak volumes in detail on both the Richmond and Delta side of the Fraser River. *Figure 18* to *Figure 37* show the network volume plots for the following scenarios:

- 2035 AM and PM peak for the BAU
- 2035 AM and PM peak for the 8 lane option
- 2050 AM and PM peak for the BAU
- 2050 AM and PM peak for the 6 lane option
- 2050 AM and PM peak for the 8 lane option

To further understand the impacts of change to the network, a set of network difference plots were developed. *Figure 38* to *Figure 41* show the net incremental traffic volumes by link for the following comparator scenarios:

- 2050 AM and PM peak for the 6 lane scenario versus BAU
- 2050 AM and PM peak for the 8 lane scenario versus BAU

In order to provide further confidence in the traffic forecasts, a backcheck of the historical and forecast traffic growth rates across the Fraser River south arm was conducted. *Appendix C* provides the detailed methodology and outcomes of this work which looked at the collective traffic volumes across the Fraser River from George Massey Crossing to Golden Ears Bridge. The RTM3-based forecasts are driven largely by growth in households and employment, and an independent backcheck based on economic development, fuel prices and number of lanes is helpful to gauge the level of growth in traffic volumes across the Fraser River. The following summarizes the annual growth rate outputs from this analysis showing that the RTM3 growth rates (highlighted in green) match very closely to the regression model forecasts (highlighted in yellow):

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

Figure 14: Population Growth from 2017 to 2050 by Municipality

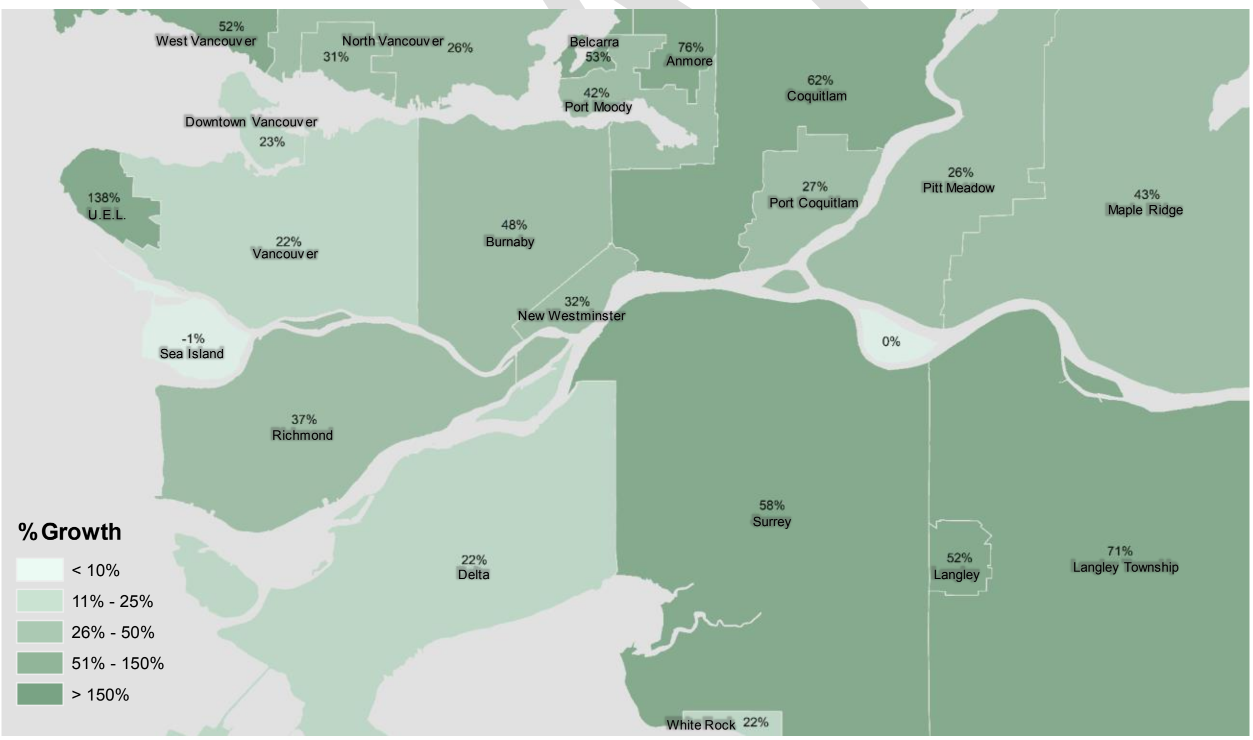


Figure 15: Household Growth from 2017 to 2050 by Municipality

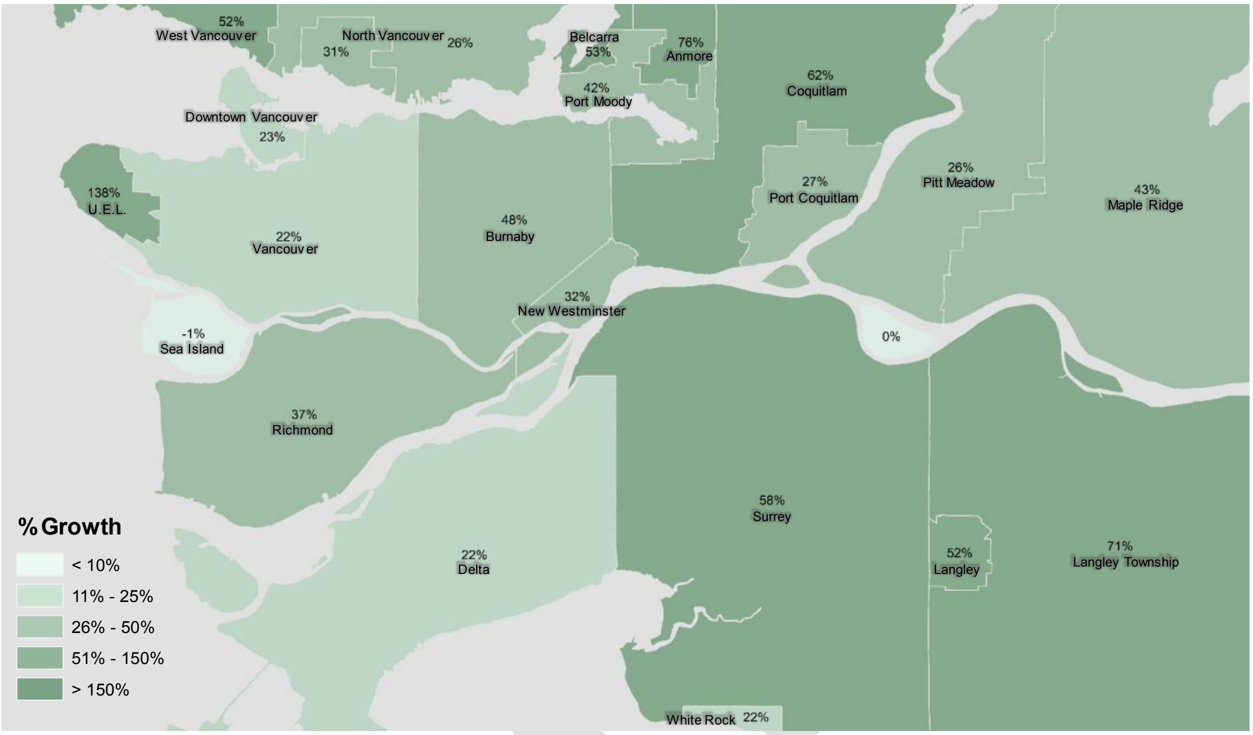
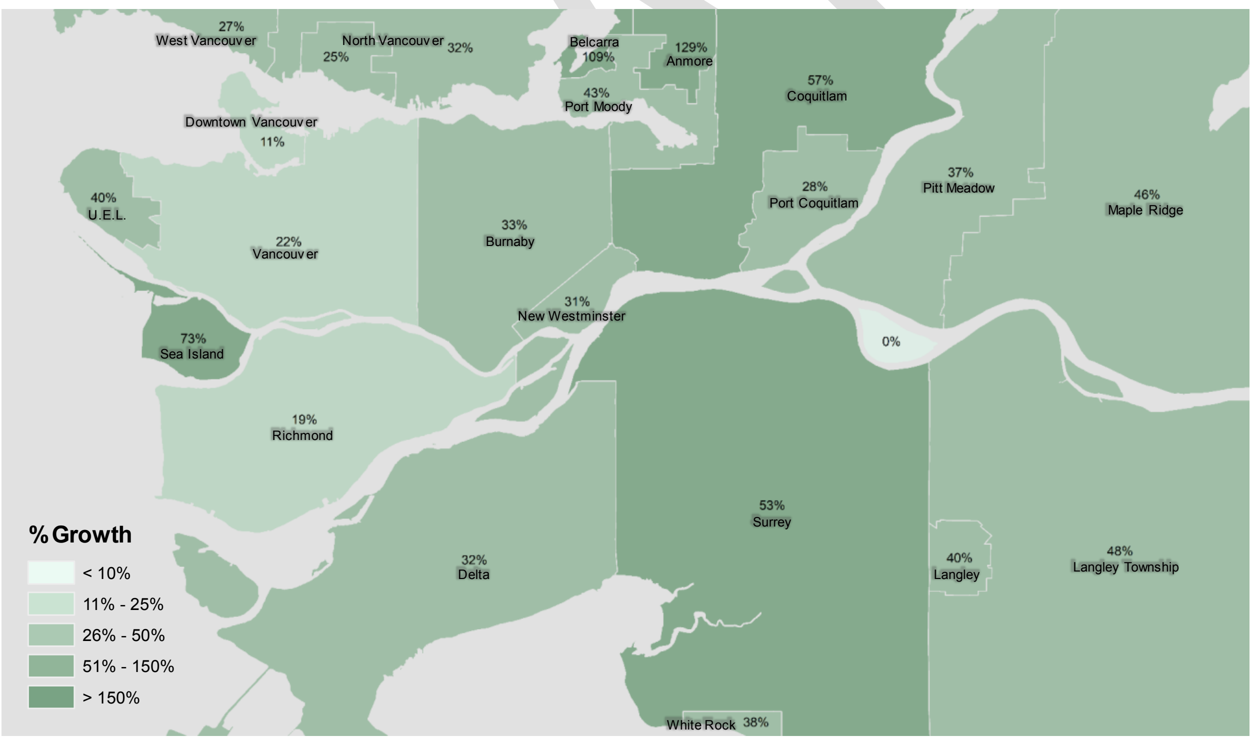


Figure 16: Employment Growth from 2017 to 2050 by Municipality



The modelling conducted to date is suitable for the purpose of forecasting traffic volumes and patterns within the scope of the Technical Services for the George Massey Crossing Project. These forecasts are considered planning level and are appropriate to determine the differences between the six and eight lane alternatives. Further model validation work will be required before the traffic forecasts are suitable for developing refined design alternatives and a project business case.

Figure 17A: Laning Assumptions for Highway 99 Corridor – 8-Lane Crossing

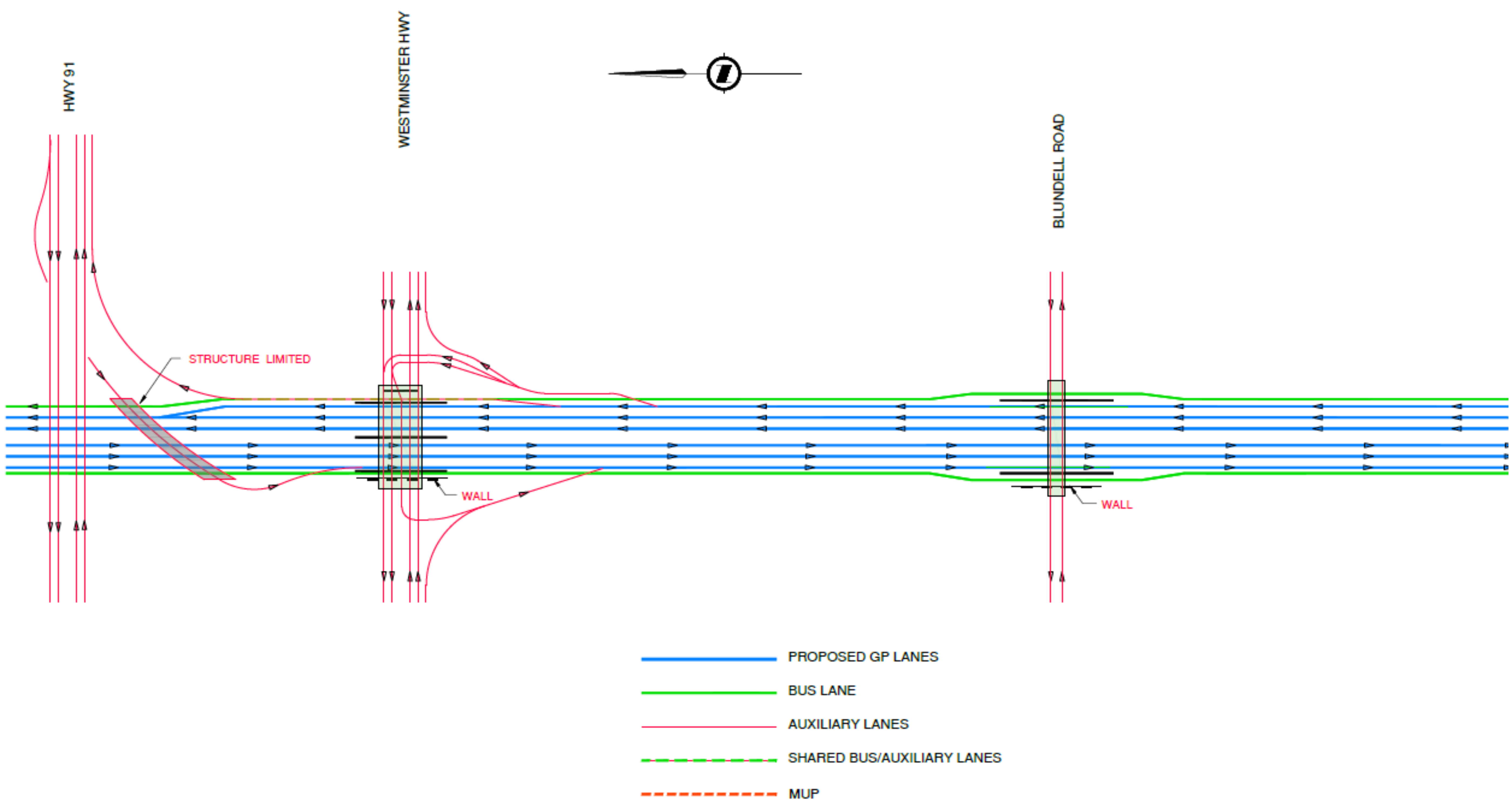


Figure 17B: Laning Assumptions for Highway 99 Corridor – 8-Lane Crossing

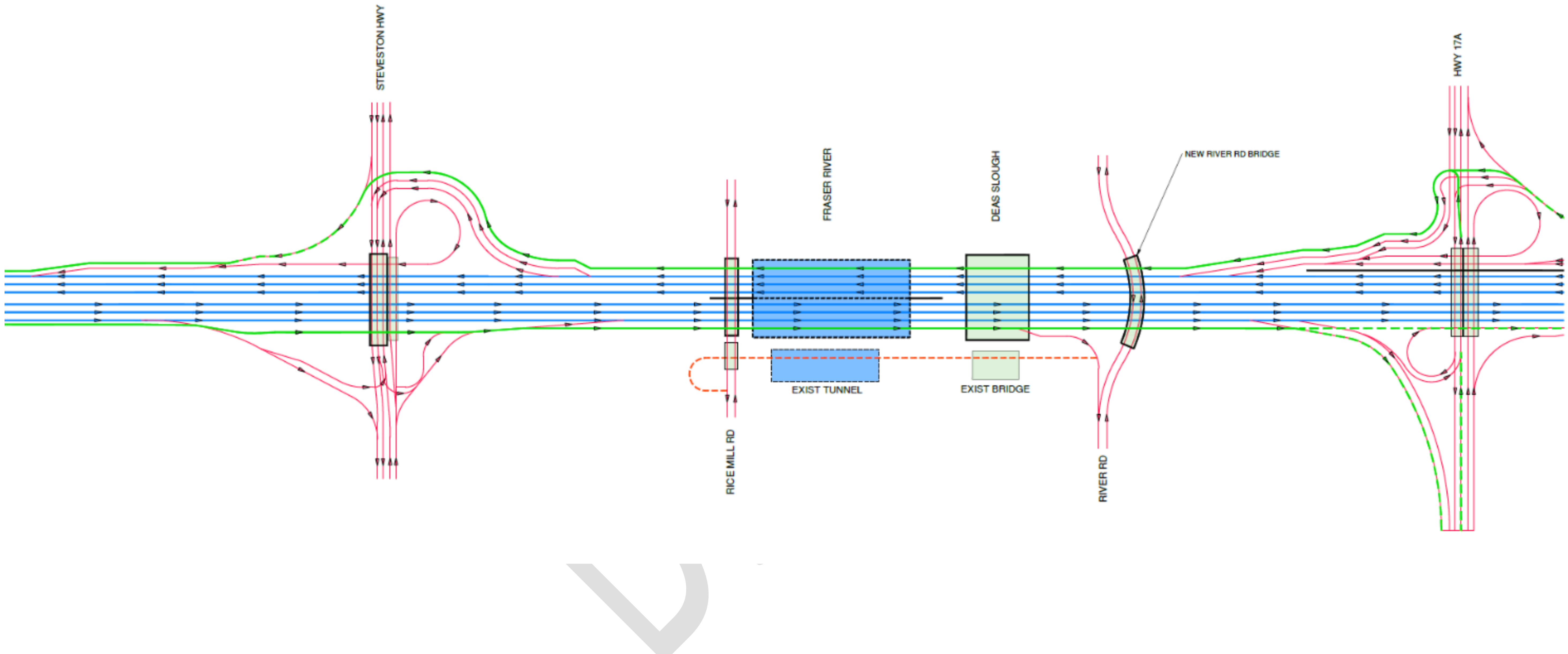


Figure 17C: Laning Assumptions for Highway 99 Corridor – 8-Lane Crossing

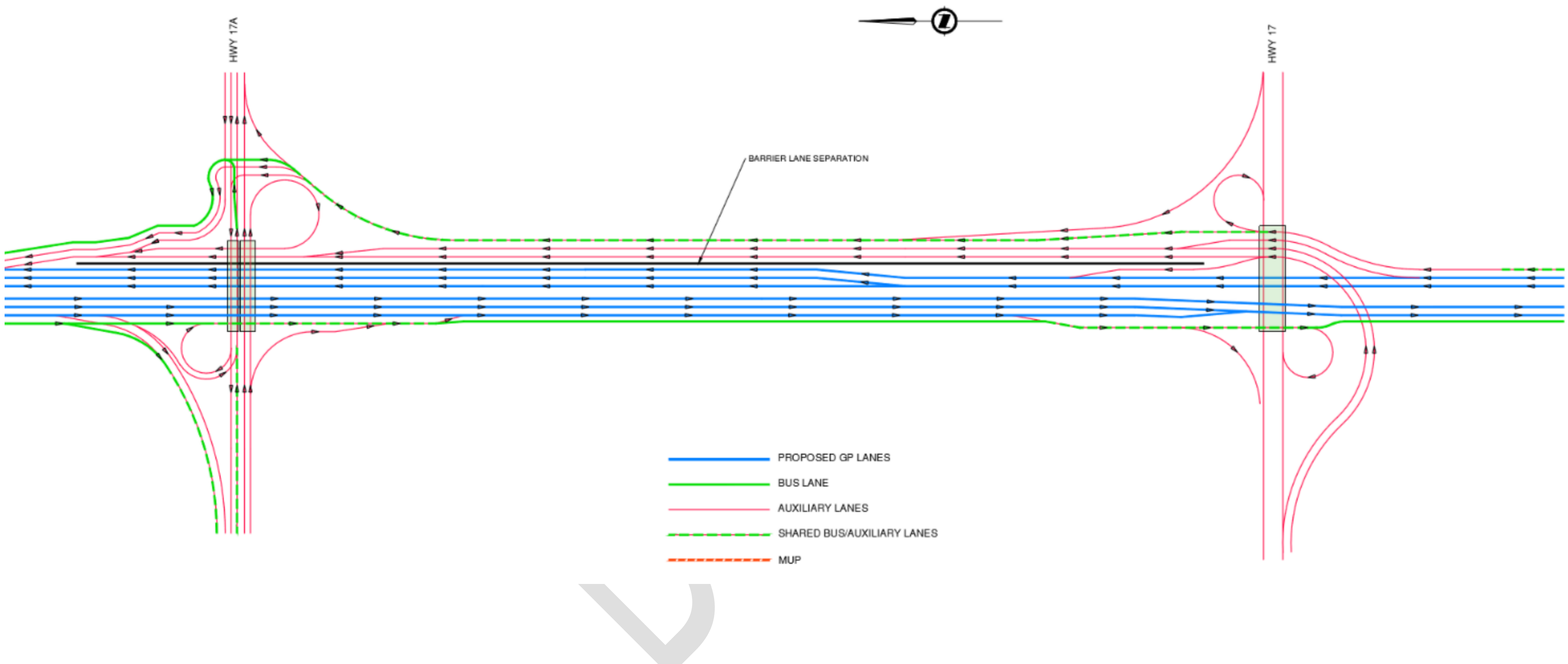


Table 2: 2035 Traffic Forecasts for South of Fraser Crossings

AM	NB	2017 BASE						2035 BAU						2035 8-Lane					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	3,790	4,840	2,580	5,680	1,810	18,700	4,030	5,240	3,440	6,520	2,250	21,480	3,950	5,300	3,450	6,530	2,260	21,490
	HOV	670	470	310	1,200	230	2,880	720	570	450	1,530	280	3,550	800	510	450	1,530	280	3,570
	TRUCK	350	350	170	520	220	1,610	440	460	250	620	270	2,040	450	470	250	620	270	2,060
	TRANSIT	70	30	-	30	10	140	100	40	-	20	10	170	100	40	-	20	10	170
	TOTAL	4,880	5,690	3,060	7,420	2,260	23,310	5,290	6,290	4,130	8,680	2,800	27,190	5,300	6,310	4,140	8,700	2,810	27,260
TRANSIT	PASSENGERS	810	330	-	470	30	1,640	860	300	-	330	60	1,550	1,110	290	-	330	60	1,790

AM	SB	2017 BASE						2035 BAU						2035 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	1,530	2,040	2,010	4,010	2,810	12,400	1,670	2,250	2,620	4,470	3,100	14,110	2,360	1,920	2,520	4,390	3,100	14,290
	HOV	220	340	260	570	490	1,880	240	390	330	680	550	2,190	430	280	320	650	560	2,240
	TRUCK	230	460	130	540	230	1,590	310	570	200	650	280	2,010	470	460	180	630	280	2,020
	TRANSIT	20	20	-	20	10	70	30	30	-	20	10	90	30	30	-	20	10	90
	TOTAL	2,010	2,850	2,410	5,120	3,530	15,920	2,240	3,230	3,150	5,810	3,940	18,370	3,280	2,690	3,020	5,690	3,940	18,620
TRANSIT	PASSENGERS	100	80	-	70	20	270	140	100	-	120	40	400	230	100	-	120	40	490

AM	TOTAL	2017 BASE						2035 BAU						2035 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	5,320	6,880	4,590	9,690	4,620	31,100	5,700	7,490	6,060	10,990	5,350	35,590	6,310	7,220	5,970	10,920	5,360	35,780
	HOV	890	810	570	1,770	720	4,760	960	960	780	2,210	830	5,740	1,230	790	770	2,180	840	5,810
	TRUCK	580	810	300	1,060	450	3,200	750	1,030	450	1,270	550	4,050	920	930	430	1,250	550	4,080
	TRANSIT	90	50	-	50	20	210	130	70	-	40	20	260	130	70	-	40	20	260
	TOTAL	6,890	8,540	5,470	12,540	5,790	39,230	7,530	9,520	7,280	14,490	6,740	45,560	8,580	9,000	7,160	14,390	6,750	45,880
TRANSIT	PASSENGERS	910	410	-	540	50	1,910	1,000	400	-	450	100	1,950	1,340	390	-	450	100	2,280

PM	NB	2017 BASE						2035 BAU						2035 8-Lane					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	1,820	2,570	2,070	4,590	3,210	14,270	1,930	3,080	2,690	5,290	3,520	16,500	2,630	2,660	2,630	5,250	3,520	16,700
	HOV	470	590	370	940	620	2,980	510	730	490	1,160	670	3,560	870	460	480	1,130	670	3,600
	TRUCK	150	250	90	320	120	930	200	330	130	390	150	1,210	270	280	130	390	150	1,230
	TRANSIT	30	20	-	20	10	80	50	30	-	20	10	90	50	30	-	20	10	90
	TOTAL	2,470	3,430	2,530	5,860	3,960	18,250	2,680	4,170	3,310	6,860	4,350	21,360	3,820	3,430	3,240	6,780	4,350	21,620
TRANSIT	PASSENGERS	110	90	-	90	30	320	150	110	-	120	50	440	230	120	-	120	50	530

PM	SB	2017 BASE						2035 BAU						2035 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	4,180	4,990	2,890	6,430	2,420	20,910	4,340	5,880	3,530	7,300	3,070	24,120	4,610	5,730	3,510	7,300	3,070	24,220
	HOV	950	520	450	1,470	390	3,780	1,010	660	680	1,780	480	4,620	970	720	690	1,780	480	4,650
	TRUCK	210	210	80	350	140	1,000	260	300	130	410	180	1,270	290	290	130	410	180	1,280
	TRANSIT	60	20	-	20	10	110	90	30	-	20	10	140	90	30	-	20	10	140
	TOTAL	5,410	5,740	3,420	8,280	2,950	25,800	5,710	6,870	4,330	9,510	3,730	30,150	5,960	6,780	4,330	9,500	3,730	30,300
TRANSIT	PASSENGERS	730	250	-	390	40	1,390	750	300	-	370	70	1,480	1,120	270	-	370	70	1,820

PM	TOTAL	2017 BASE						2035 BAU						2035 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	6,000	7,560	4,960	11,020	5,630	35,180	6,270	8,960	6,220	12,590	6,590	40,620	7,240	8,390	6,140	12,550	6,590	40,920
	HOV	1,420	1,110	820	2,410	1,010	6,760	1,520	1,390	1,170	2,940	1,150	8,180	1,840	1,180	1,170	2,910	1,150	8,250
	TRUCK	360	460	170	670	260	1,930	460	630	260	800	330	2,480	560	570	260	800	330	2,510
	TRANSIT	90	40	-	40	20	190	140	60	-	40	20	230	140	60	-	40	20	230
	TOTAL	7,880	9,170	5,950	14,140	6,910	44,050	8,390	11,040	7,640	16,370	8,080	51,510	9,780	10,210	7,570	16,280	8,080	51,920
TRANSIT	PASSENGERS	840	340	-	480	70	1,710	900	410	-	490	120	1,920	1,350	390	-	490	120	2,350

AM + PM	TOTAL	2017 BASE						2035 BAU						2035 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	11,320	14,440	9,550	20,710	10,250	66,280	11,970	16,450	12,280	23,580	11,940	76,210	13,550	15,610	12,110	23,470	11,950	76,700
	HOV	2,310	1,920	1,390	4,180	1,730	11,520	2,480	2,350	1,950	5,150	1,980	13,920	3,070	1,970	1,940	5,090	1,990	14,060
	TRUCK	940	1,270	470	1,730	710	5,130	1,210	1,660	710	2,070	880	6,530	1,480	1,500	690	2,050	880	6,590
	TRANSIT	180	90	-	90	40	400	270	130	-	80	40	490	270	130	-	80	40	490
	TOTAL	14,770	17,710	11,420	26,680	12,700	83,280	15,920	20,560	14,920	30,860	14,820	97,070	18,360	19,210	14,730	30,670	14,830	97,800
TRANSIT	PASSENGERS	1,750	750	-	1,020	120	3,620	1,900	810	-	940	220	3,870	2,690	780	-	940	220	4,630

Table 2A: 2035 Growth and Change in Volume due to Widening George Massey Crossing

AM	NB	GROWTH: 2017 TO 2035	GROWTH: 2017 TO 2035 (%)	CHANGE: 2035 BAU TO 8-LANE	CHANGE: 2035 BAU TO 8-LANE (%)
CLASSIFICATION					
VEHICLES	SOV	240	6%	(80)	-2%
	HOV	50	7%	80	11%
	TRUCK	90	26%	10	2%
	TRANSIT	30	43%	0	0%
	TOTAL	410	8%	10	0%
TRANSIT	PASSENGERS	50	6%	250	29%

AM	SB	GROWTH: 2017 TO 2035	GROWTH: 2017 TO 2035 (%)	CHANGE: 2035 BAU TO 8-LANE	CHANGE: 2035 BAU TO 8-LANE (%)
CLASSIFICATION					
VEHICLES	SOV	140	9%	690	41%
	HOV	20	9%	190	79%
	TRUCK	80	35%	160	52%
	TRANSIT	10	50%	0	0%
	TOTAL	230	11%	1,040	46%
TRANSIT	PASSENGERS	40	40%	90	64%

AM	TOTAL	GROWTH: 2017 TO 2035	GROWTH: 2017 TO 2035 (%)	CHANGE: 2035 BAU TO 8-LANE	CHANGE: 2035 BAU TO 8-LANE (%)
CLASSIFICATION					
VEHICLES	SOV	380	7%	610	11%
	HOV	70	8%	270	28%
	TRUCK	170	29%	170	23%
	TRANSIT	40	44%	0	0%
	TOTAL	640	9%	1,050	14%
TRANSIT	PASSENGERS	90	10%	340	34%

PM	NB	GROWTH: 2017 TO 2035	GROWTH: 2017 TO 2035 (%)	CHANGE: 2035 BAU TO 8-LANE	CHANGE: 2035 BAU TO 8-LANE (%)
CLASSIFICATION					
VEHICLES	SOV	110	6%	700	36%
	HOV	40	9%	360	71%
	TRUCK	50	33%	70	35%
	TRANSIT	20	67%	0	0%
	TOTAL	210	9%	1,140	43%
TRANSIT	PASSENGERS	40	36%	80	53%

PM	SB	GROWTH: 2017 TO 2035	GROWTH: 2017 TO 2035 (%)	CHANGE: 2035 BAU TO 8-LANE	CHANGE: 2035 BAU TO 8-LANE (%)
CLASSIFICATION					
VEHICLES	SOV	160	4%	270	6%
	HOV	60	6%	(40)	-4%
	TRUCK	50	24%	30	12%
	TRANSIT	30	50%	0	0%
	TOTAL	300	6%	250	4%
TRANSIT	PASSENGERS	20	3%	370	49%

PM	TOTAL	GROWTH: 2017 TO 2035	GROWTH: 2017 TO 2035 (%)	CHANGE: 2035 BAU TO 8-LANE	CHANGE: 2035 BAU TO 8-LANE (%)
CLASSIFICATION					
VEHICLES	SOV	270	4%	970	15%
	HOV	100	7%	320	21%
	TRUCK	100	28%	100	22%
	TRANSIT	50	56%	0	0%
	TOTAL	510	6%	1,390	17%
TRANSIT	PASSENGERS	60	7%	450	50%

AM + PM	TOTAL	GROWTH: 2017 TO 2035	GROWTH: 2017 TO 2035 (%)	CHANGE: 2035 BAU TO 8-LANE	CHANGE: 2035 BAU TO 8-LANE (%)
CLASSIFICATION					
VEHICLES	SOV	650	6%	1,580	13%
	HOV	170	7%	590	24%
	TRUCK	270	29%	270	22%
	TRANSIT	90	50%	0	0%
	TOTAL	1,150	8%	2,440	15%
TRANSIT	PASSENGERS	150	9%	790	42%

Table 3: 2050 Traffic Forecasts for South of Fraser Crossings

AM	NB	2017 BASE						2050 BAU						2050 6-Lane						2050 8-Lane					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	3,790	4,840	2,580	5,680	1,810	18,700	4,230	5,570	3,730	7,000	2,480	23,010	4,150	5,640	3,740	7,020	2,490	23,040	4,140	5,630	3,740	7,010	2,490	23,010
	HOV	670	470	310	1,200	230	2,880	750	600	470	1,770	310	3,900	860	530	460	1,770	310	3,930	850	530	460	1,760	310	3,910
	TRUCK	350	350	170	520	220	1,610	460	490	260	660	290	2,160	470	510	260	670	290	2,200	470	510	260	660	290	2,190
	TRANSIT	70	30	-	30	10	140	100	40	-	20	10	170	100	40	-	20	10	170	100	40	-	20	10	170
	TOTAL	4,880	5,690	3,060	7,420	2,260	23,310	5,540	6,700	4,460	9,450	3,080	29,230	5,590	6,710	4,470	9,460	3,090	29,320	5,570	6,710	4,460	9,450	3,090	29,280
TRANSIT	PASSENGERS	810	330	-	470	30	1,640	780	280	-	330	60	1,450	960	270	-	330	60	1,620	1,090	270	-	330	60	1,750

AM	SB	2017 BASE						2050 BAU						2050 6-LANE						2050 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	1,530	2,040	2,010	4,010	2,810	12,400	1,710	2,310	2,750	4,770	3,360	14,900	2,450	1,990	2,640	4,660	3,350	15,090	2,450	2,000	2,650	4,660	3,350	15,110
	HOV	220	340	260	570	490	1,880	220	430	350	730	630	2,360	470	260	330	710	630	2,400	470	260	330	710	630	2,400
	TRUCK	230	460	130	540	230	1,590	320	600	200	710	310	2,140	500	480	190	690	310	2,170	500	480	190	690	310	2,170
	TRANSIT	20	20	-	20	10	70	30	30	-	20	10	90	30	30	-	20	10	90	30	30	-	20	10	90
	TOTAL	2,010	2,850	2,410	5,120	3,530	15,920	2,290	3,370	3,310	6,230	4,310	19,510	3,450	2,770	3,160	6,070	4,300	19,750	3,460	2,770	3,170	6,070	4,300	19,770
TRANSIT	PASSENGERS	100	80	-	70	20	270	140	100	-	130	40	410	210	100	-	130	40	480	240	100	-	130	40	510

AM	TOTAL	2017 BASE						2050 BAU						2050 6-LANE						2050 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	5,320	6,880	4,590	9,690	4,620	31,100	5,940	7,880	6,480	11,770	5,840	37,910	6,600	7,630	6,380	11,680	5,840	38,130	6,590	7,630	6,390	11,670	5,840	38,120
	HOV	890	810	570	1,770	720	4,760	970	1,030	820	2,500	940	6,260	1,330	790	790	2,480	940	6,330	1,320	790	790	2,470	940	6,310
	TRUCK	580	810	300	1,060	450	3,200	780	1,090	460	1,370	600	4,300	970	990	450	1,360	600	4,370	970	990	450	1,350	600	4,360
	TRANSIT	90	50	-	50	20	210	130	70	-	40	20	260	130	70	-	40	20	260	130	70	-	40	20	260
	TOTAL	6,890	8,540	5,470	12,540	5,790	39,230	7,830	10,070	7,770	15,680	7,390	48,740	9,040	9,480	7,630	15,530	7,390	49,070	9,030	9,480	7,630	15,520	7,390	49,050
TRANSIT	PASSENGERS	910	410	-	540	50	1,910	920	380	-	460	100	1,860	1,170	370	-	460	100	2,100	1,330	370	-	460	100	2,260

PM	NB	2017 BASE						2050 BAU						2050 6-Lane						2050 8-Lane					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	1,820	2,570	2,070	4,590	3,210	14,260	1,990	3,270	2,920	5,680	3,810	17,670	2,790	2,800	2,860	5,630	3,800	17,880	2,790	2,800	2,860	5,630	3,800	17,880
	HOV	470	590	370	940	620	2,990	530	770	520	1,290	740	3,850	930	480	510	1,250	750	3,920	930	480	510	1,250	750	3,920
	TRUCK	150	250	90	320	120	930	210	360	140	430	170	1,310	290	310	140	420	170	1,330	290	310	140	420	170	1,330
	TRANSIT	30	20	-	20	10	80	50	30	-	20	10	110	50	30	-	20	10	110	50	30	-	20	10	110
	TOTAL	2,470	3,430	2,530	5,860	3,960	18,250	2,770	4,420	3,580	7,410	4,720	22,900	4,050	3,610	3,510	7,310	4,720	23,200	4,050	3,610	3,510	7,310	4,720	23,200
TRANSIT	PASSENGERS	110	90	-	90	30	320	150	110	-	140	50	450	210	120	-	140	50	520	250	120	-	140	50	560

PM	SB	2017 BASE						2050 BAU						2050 6-LANE						2050 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	4,180	4,990	2,890	6,430	2,420	20,910	4,560	6,280	3,770	7,840	3,370	25,820	4,900	6,100	3,760	7,830	3,370	25,960	4,880	6,090	3,760	7,830	3,370	25,930
	HOV	950	520	450	1,470	390	3,780	1,100	680	740	2,020	520	5,060	1,020	780	750	2,030	530	5,110	1,020	780	750	2,030	530	5,110
	TRUCK	210	210	80	350	140	990	280	320	140	440	190	1,370	310	310	140	440	190	1,390	310	310	140	440	190	1,390
	TRANSIT	60	20	-	20	10	110	90	30	-	20	10	150	90	30	-	20	10	150	90	30	-	20	10	150
	TOTAL	5,410	5,740	3,420	8,280	2,950	25,800	6,030	7,300	4,650	10,320	4,090	32,390	6,310	7,220	4,640	10,320	4,090	32,580	6,300	7,210	4,640	10,310	4,090	32,550
TRANSIT	PASSENGERS	730	250	-	390	40	1,410	700	290	-	380	80	1,450	970	260	-	380	80	1,690	1,110	260	-	380	80	1,830

PM	TOTAL	2017 BASE						2050 BAU						2050 6-LANE						2050 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	6,000	7,560	4,960	11,020	5,630	35,170	6,550	9,550	6,690	13,520	7,180	43,490	7,690	8,900	6,620	13,460	7,170	43,840	7,670	8,890	6,620	13,460	7,170	43,810
	HOV	1,420	1,110	820	2,410	1,010	6,770	1,630	1,450	1,260	3,310	1,260	8,910	1,950	1,260	1,260	3,280	1,280	9,030	1,950	1,260	1,260	3,280	1,280	9,030
	TRUCK	360	460	170	670	260	1,920	490	680	280	870	360	2,680	600	620	280	860	360	2,720	600	620	280	860	360	2,720
	TRANSIT	90	40	-	40	20	190	140	60	-	40	20	260	140	60	-	40	20	260	140	60	-	40	20	260
	TOTAL	7,880	9,170	5,950	14,140	6,910	44,050	8,800	11,720	8,230	17,730	8,810	55,290	10,360	10,830	8,150	17,630	8,810	55,780	10,350	10,820	8,150	17,620	8,810	55,750
TRANSIT	PASSENGERS	840	340	-	480	70	1,730	850	400	-	520	130	1,900	1,180	380	-	520	130	2,210	1,360	380	-	520	130	2,390

AM + PM	TOTAL	2017 BASE						2050 BAU						2050 6-LANE						2050 8-LANE					
CLASSIFICATION		GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL	GMC	AFB	PAT	PMB	GEB	TOTAL
VEHICLES	SOV	11,320	14,440	9,550	20,710	10,250	66,270	12,490	17,430	13,170	25,290	13,020	81,400	14,290	16,530	13,000	25,140	13,010	81,970	14,260	16,520	13,010	25,130	13,010	81,930
	HOV	2,310	1,920	1,390	4,180	1,730	11,530	2,600	2,480	2,080	5,810	2,200	15,170	3,280	2,050	2,050	5,760	2,220	15,360	3,270	2,050	2,050	5,750	2,220	15,340
	TRUCK	940	1,270	470	1,730	710	5,120	1,270	1,770	740	2,240	960	6,980	1,570	1,610	730	2,220	960	7,090	1,570	1,610	730	2,210	960	7,080
	TRANSIT	180	90	-	90	40	400	270	130	-	80	40	520	270	130	-	80	40	520	270	130	-	80	40	520
	TOTAL	14,770	17,710	11,420	26,680	12,700	83,280	16,630	21,790	16,000	33,410	16,200	104,030	19,400	20,310	15,780	33,160	16,200	104,850	19,380	20,300	15,780	33,140	16,200	104,800
TRANSIT	PASSENGERS	1,750	750	-	1,020	120	3,640	1,770	780	-	980	230	3,760	2,350	750	-	980	230	4,310	2,690	750	-	980	230	4,650

Table 3A: 2050 Growth and Change in Volume due to Widening George Massey Crossing

AM	NB	GROWTH: 2017 TO 2050	GROWTH: 2017 TO 2050 (%)	CHANGE: BAU TO 6-LANE	CHANGE: BAU TO 6-LANE (%)	CHANGE: BAU TO 8-LANE	CHANGE: BAU TO 8-LANE (%)	CHANGE: 6-LANE TO 8-LANE	CHANGE: 6-LANE TO 8-LANE (%)
CLASSIFICATION									
VEHICLES	SOV	440	12%	-80	-2%	-90	-2%	-10	0%
	HOV	80	12%	110	15%	100	13%	-10	-1%
	TRUCK	110	31%	10	2%	10	2%	0	0%
	TRANSIT	30	43%	0	0%	0	0%	0	0%
	TOTAL	660	14%	50	1%	30	1%	-20	0%
TRANSIT	PASSENGERS	-30	-4%	180	23%	310	40%	130	14%

AM	SB	GROWTH: 2017 TO 2050	GROWTH: 2017 TO 2050 (%)	CHANGE: BAU TO 6-LANE	CHANGE: BAU TO 6-LANE (%)	CHANGE: BAU TO 8-LANE	CHANGE: BAU TO 8-LANE (%)	CHANGE: 6-LANE TO 8-LANE	CHANGE: 6-LANE TO 8-LANE (%)
CLASSIFICATION									
VEHICLES	SOV	180	12%	740	43%	740	43%	0	0%
	HOV	0	0%	250	114%	250	114%	0	0%
	TRUCK	90	39%	180	56%	180	56%	0	0%
	TRANSIT	10	50%	0	0%	0	0%	0	0%
	TOTAL	280	14%	1,160	51%	1,170	51%	10	0%
TRANSIT	PASSENGERS	40	40%	70	50%	100	71%	30	14%

AM	TOTAL	GROWTH: 2017 TO 2050	GROWTH: 2017 TO 2050 (%)	CHANGE: BAU TO 6-LANE	CHANGE: BAU TO 6-LANE (%)	CHANGE: BAU TO 8-LANE	CHANGE: BAU TO 8-LANE (%)	CHANGE: 6-LANE TO 8-LANE	CHANGE: 6-LANE TO 8-LANE (%)
CLASSIFICATION									
VEHICLES	SOV	620	12%	660	11%	650	11%	(10)	0%
	HOV	80	9%	360	37%	350	36%	(10)	-1%
	TRUCK	200	34%	190	24%	190	24%	0	0%
	TRANSIT	40	44%	0	0%	0	0%	0	0%
	TOTAL	940	14%	1,210	15%	1,200	15%	(10)	0%
TRANSIT	PASSENGERS	10	1%	250	27%	410	45%	160	14%

PM	NB	GROWTH: 2017 TO 2050	GROWTH: 2017 TO 2050 (%)	CHANGE: BAU TO 6-LANE	CHANGE: BAU TO 6-LANE (%)	CHANGE: BAU TO 8-LANE	CHANGE: BAU TO 8-LANE (%)	CHANGE: 6-LANE TO 8-LANE	CHANGE: 6-LANE TO 8-LANE (%)
CLASSIFICATION									
VEHICLES	SOV	170	9%	800	40%	800	40%	0	0%
	HOV	60	13%	400	75%	400	75%	0	0%
	TRUCK	60	40%	80	38%	80	38%	0	0%
	TRANSIT	20	67%	0	0%	0	0%	0	0%
	TOTAL	300	12%	1,280	46%	1,280	46%	0	0%
TRANSIT	PASSENGERS	40	36%	60	40%	100	67%	40	19%

PM	SB	GROWTH: 2017 TO 2050	GROWTH: 2017 TO 2050 (%)	CHANGE: BAU TO 6-LANE	CHANGE: BAU TO 6-LANE (%)	CHANGE: BAU TO 8-LANE	CHANGE: BAU TO 8-LANE (%)	CHANGE: 6-LANE TO 8-LANE	CHANGE: 6-LANE TO 8-LANE (%)
CLASSIFICATION									
VEHICLES	SOV	380	9%	340	7%	320	7%	(20)	0%
	HOV	150	16%	(80)	-7%	(80)	-7%	0	0%
	TRUCK	70	33%	30	11%	30	11%	0	0%
	TRANSIT	30	50%	0	0%	0	0%	0	0%
	TOTAL	620	11%	280	5%	270	4%	(10)	0%
TRANSIT	PASSENGERS	(30)	-4%	270	39%	410	59%	140	14%

PM	TOTAL	GROWTH: 2017 TO 2050	GROWTH: 2017 TO 2050 (%)	CHANGE: BAU TO 6-LANE	CHANGE: BAU TO 6-LANE (%)	CHANGE: BAU TO 8-LANE	CHANGE: BAU TO 8-LANE (%)	CHANGE: 6-LANE TO 8-LANE	CHANGE: 6-LANE TO 8-LANE (%)
CLASSIFICATION									
VEHICLES	SOV	550	9%	1140	17%	1120	17%	-20	0%
	HOV	210	15%	320	20%	320	20%	0	0%
	TRUCK	130	36%	110	22%	110	22%	0	0%
	TRANSIT	50	56%	0	0%	0	0%	0	0%
	TOTAL	920	12%	1560	18%	1550	18%	-10	0%
TRANSIT	PASSENGERS	10	1%	330	39%	510	60%	180	15%

AM + PM	TOTAL	GROWTH: 2017 TO 2050	GROWTH: 2017 TO 2050 (%)	CHANGE: BAU TO 6-LANE	CHANGE: BAU TO 6-LANE (%)	CHANGE: BAU TO 8-LANE	CHANGE: BAU TO 8-LANE (%)	CHANGE: 6-LANE TO 8-LANE	CHANGE: 6-LANE TO 8-LANE (%)
CLASSIFICATION									
VEHICLES	SOV	1170	10%	1800	14%	1770	14%	-30	0%
	HOV	290	13%	680	26%	670	26%	-10	0%
	TRUCK	330	35%	300	24%	300	24%	0	0%
	TRANSIT	90	50%	0	0%	0	0%	0	0%
	TOTAL	1860	13%	2770	17%	2750	17%	-20	0%
TRANSIT	PASSENGERS	20	1%	580	33%	920	52%	340	14%

Figure 18: 2035 AM Peak BAU Traffic Volume Assignment Plot (Richmond)

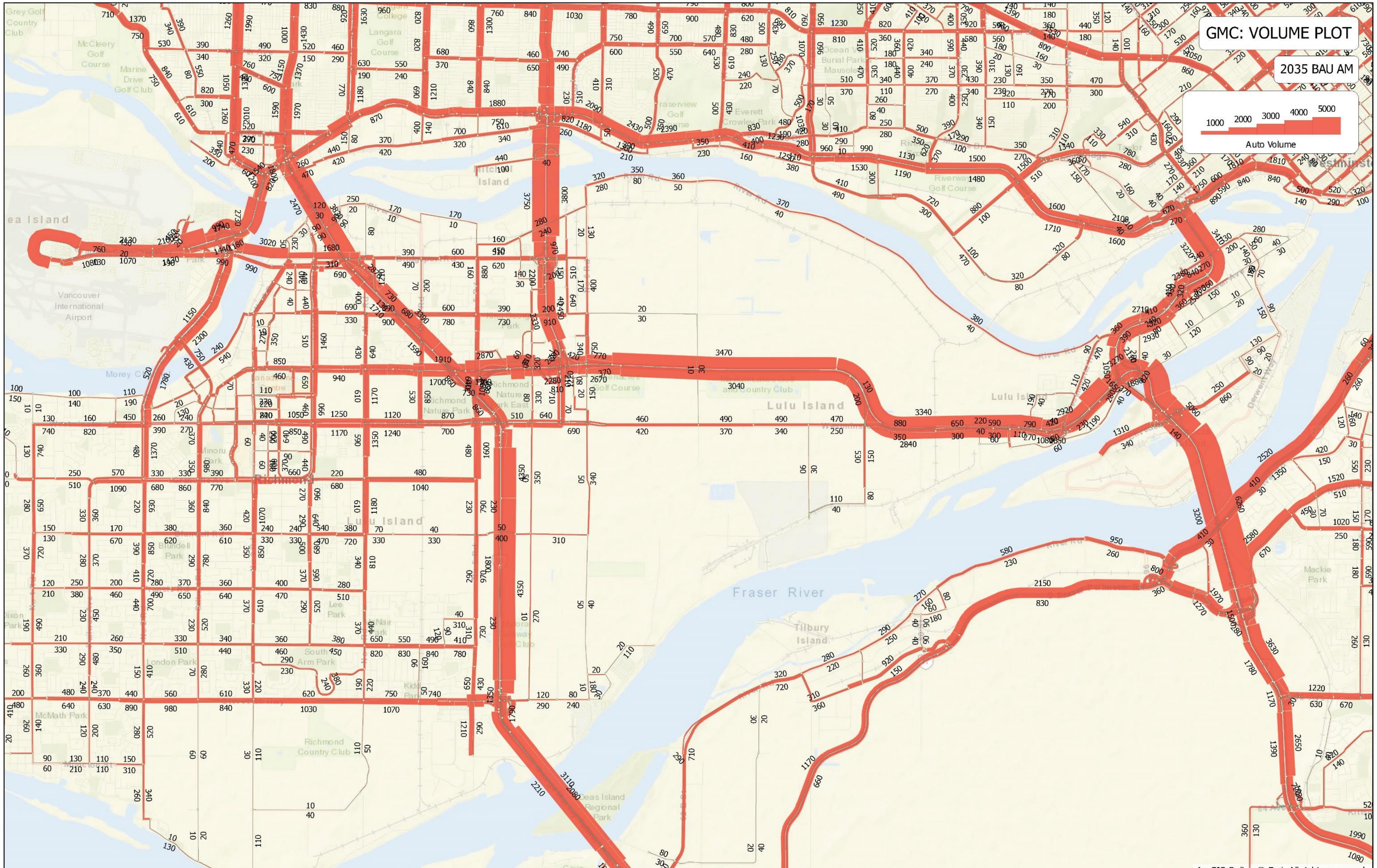


Figure 19: 2035 AM Peak BAU Traffic Volume Assignment Plot (Delta)

Figure 20: 2035 PM Peak BAU Traffic Volume Assignment Plot (Richmond)

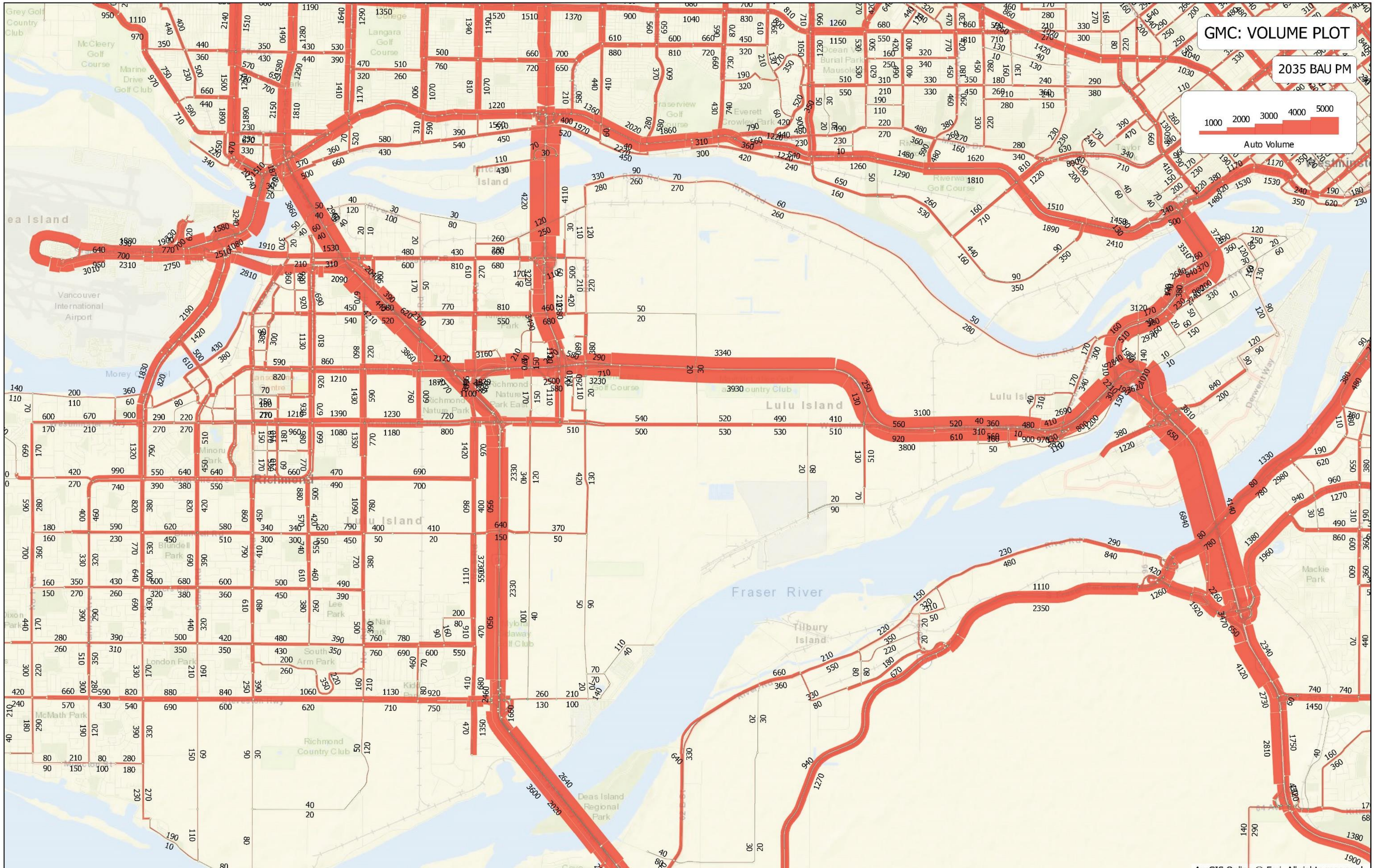


Figure 21: 2035 PM Peak BAU Traffic Volume Assignment Plot (Delta)

Figure 22: 2035 AM 8-Lane Peak Traffic Volume Assignment Plot (Richmond)

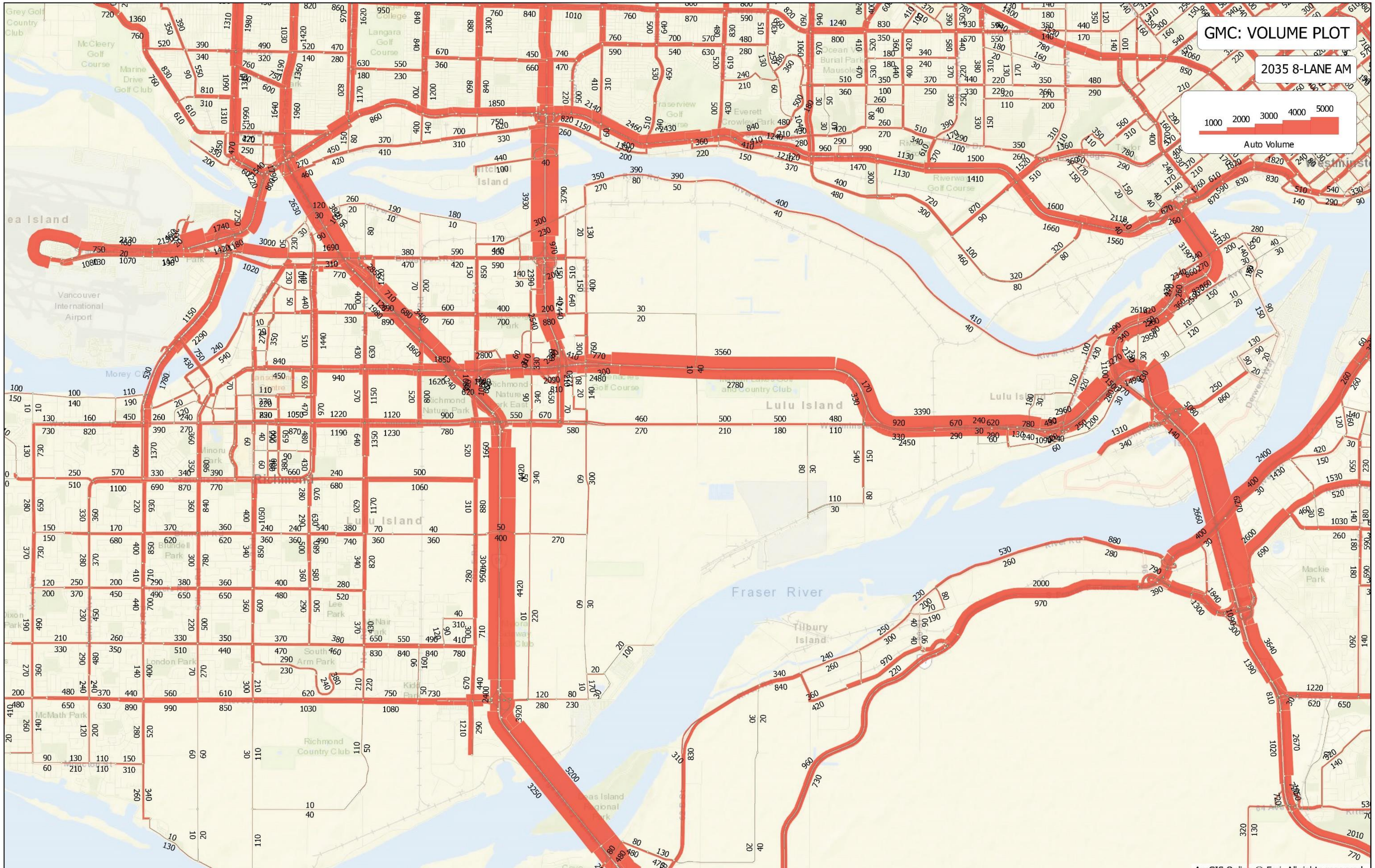


Figure 23: 2035 AM 8-Lane Peak Traffic Volume Assignment Plot (Delta)

Figure 24: 2035 PM 8-Lane Peak Traffic Volume Assignment Plot (Richmond)

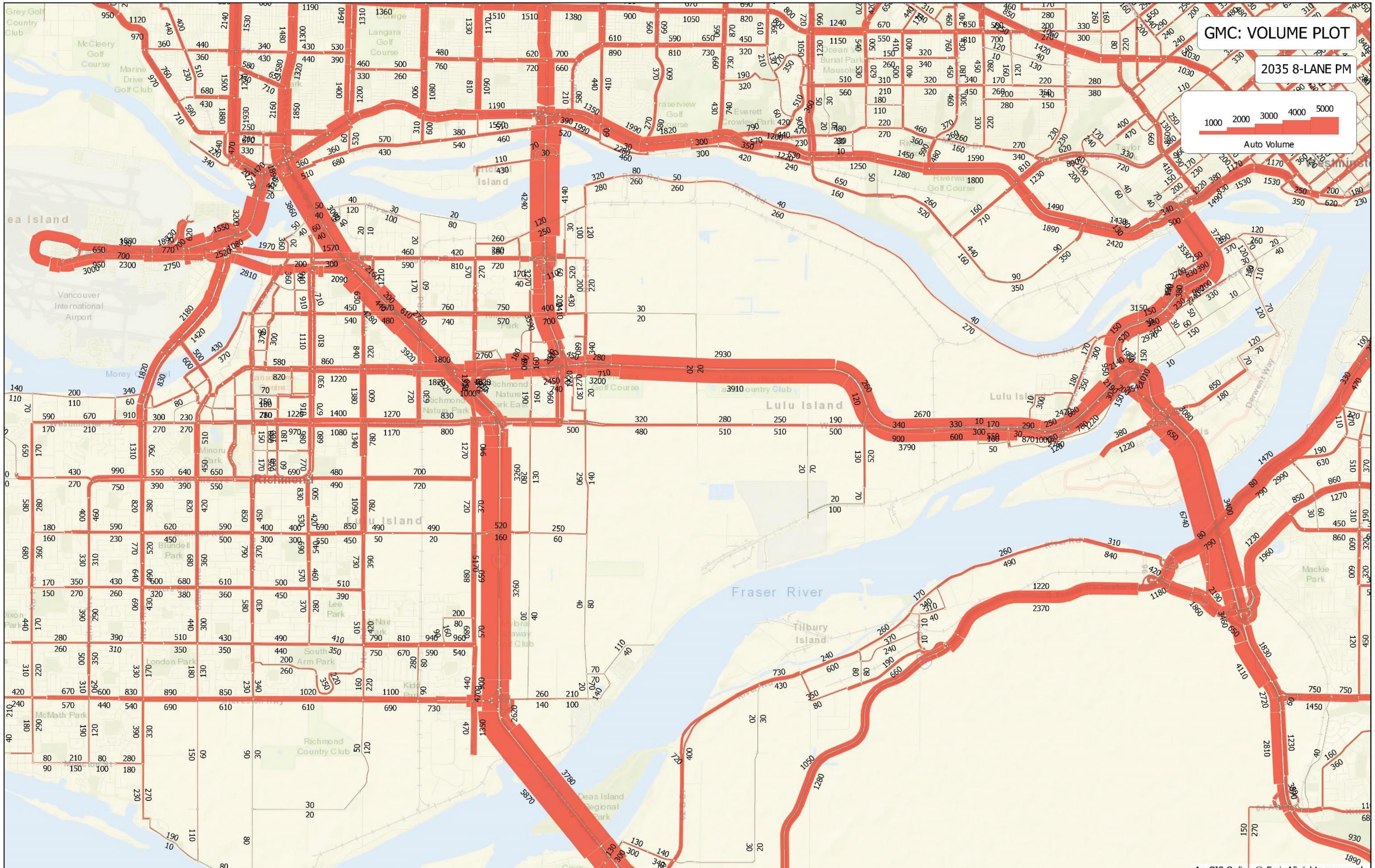


Figure 25: 2035 PM 8-Lane Peak Traffic Volume Assignment Plot (Delta)

Figure 26: 2050 AM Peak BAU Traffic Volume Assignment Plot (Richmond)

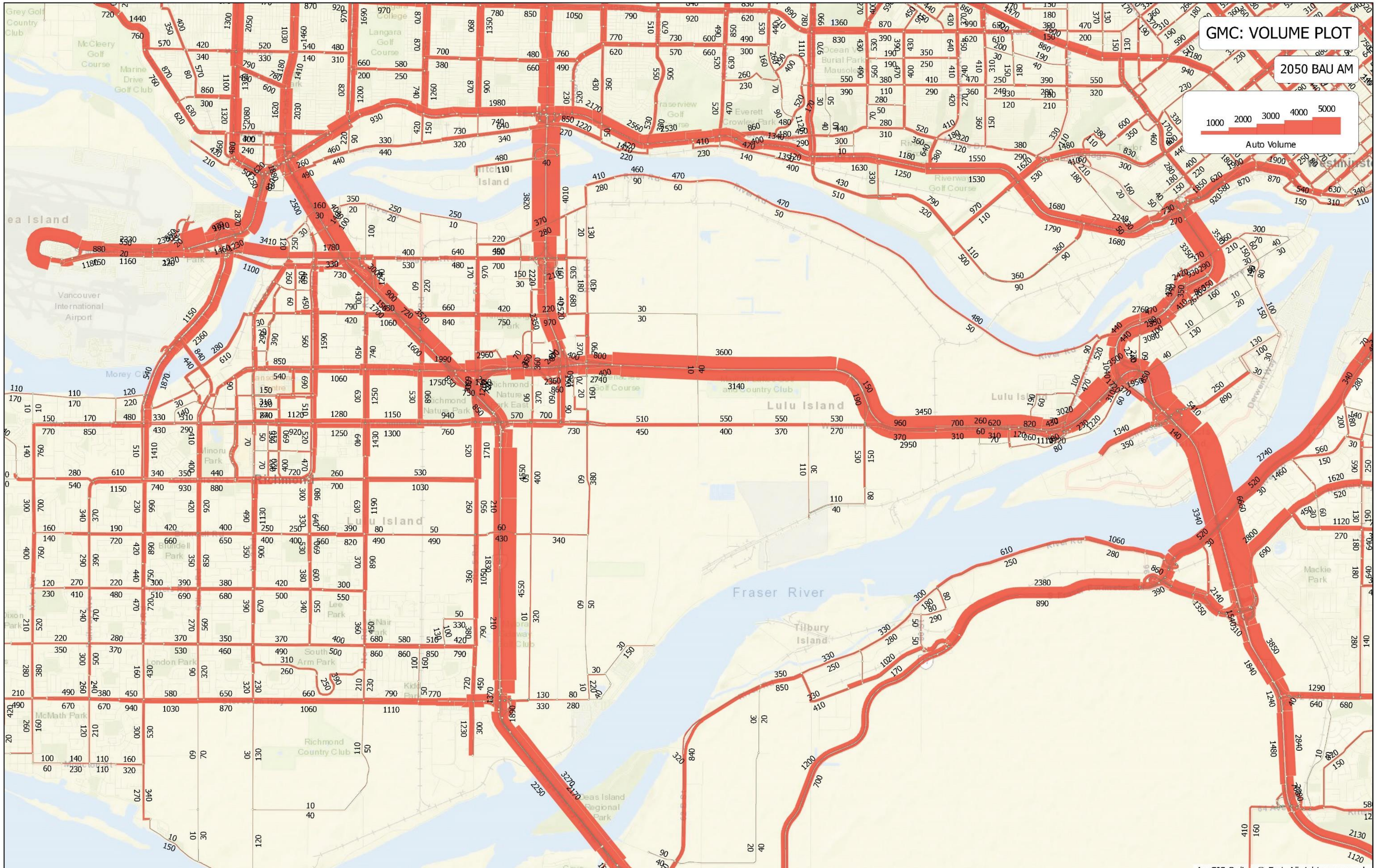


Figure 27: 2050 AM Peak BAU Traffic Volume Assignment Plot (Delta)

Figure 28: 2050 PM Peak BAU Traffic Volume Assignment Plot (Richmond)

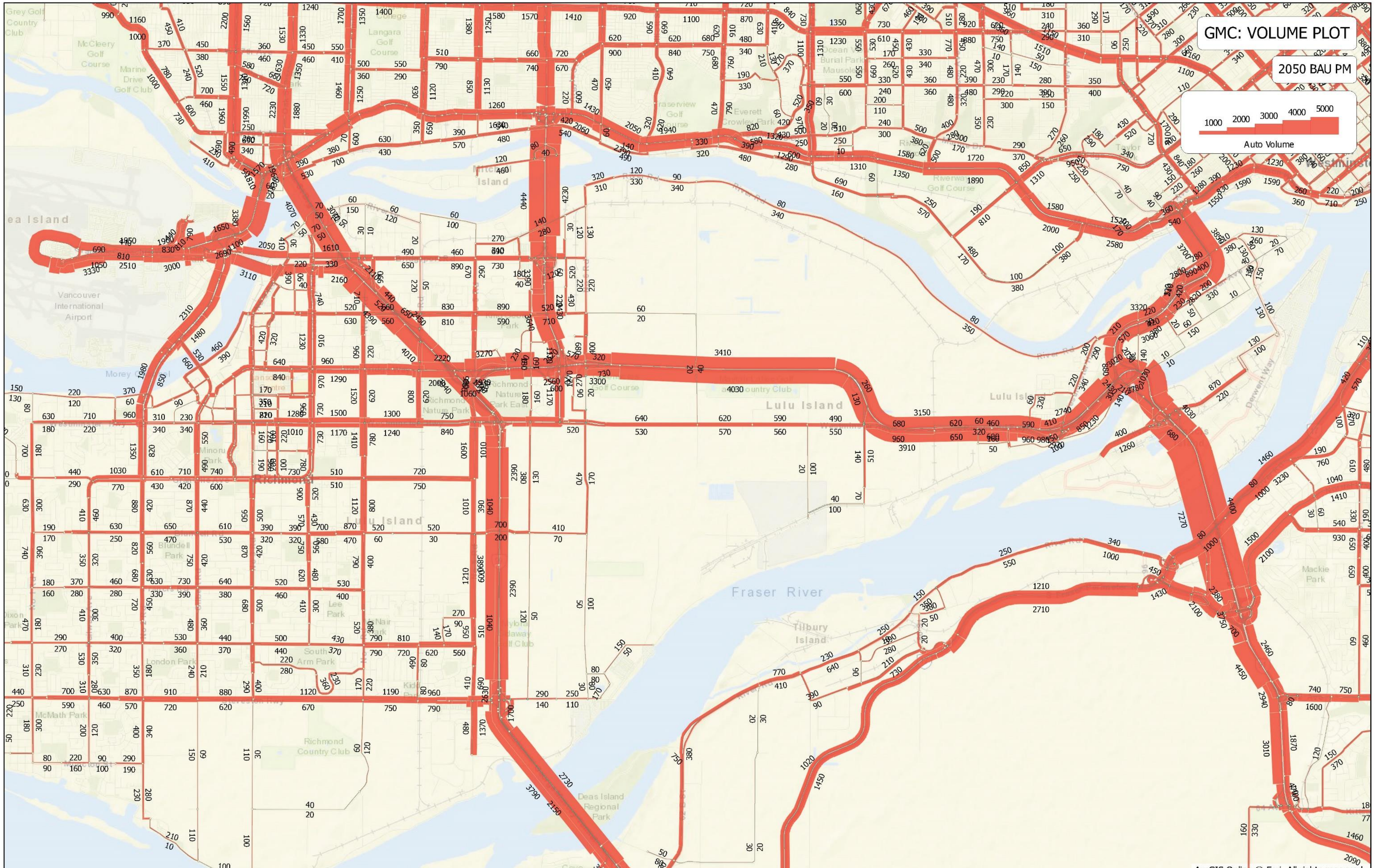


Figure 29: 2050 PM Peak BAU Traffic Volume Assignment Plot (Delta)

Figure 30: 2050 AM 6-Lane Peak Traffic Volume Assignment Plot (Richmond)

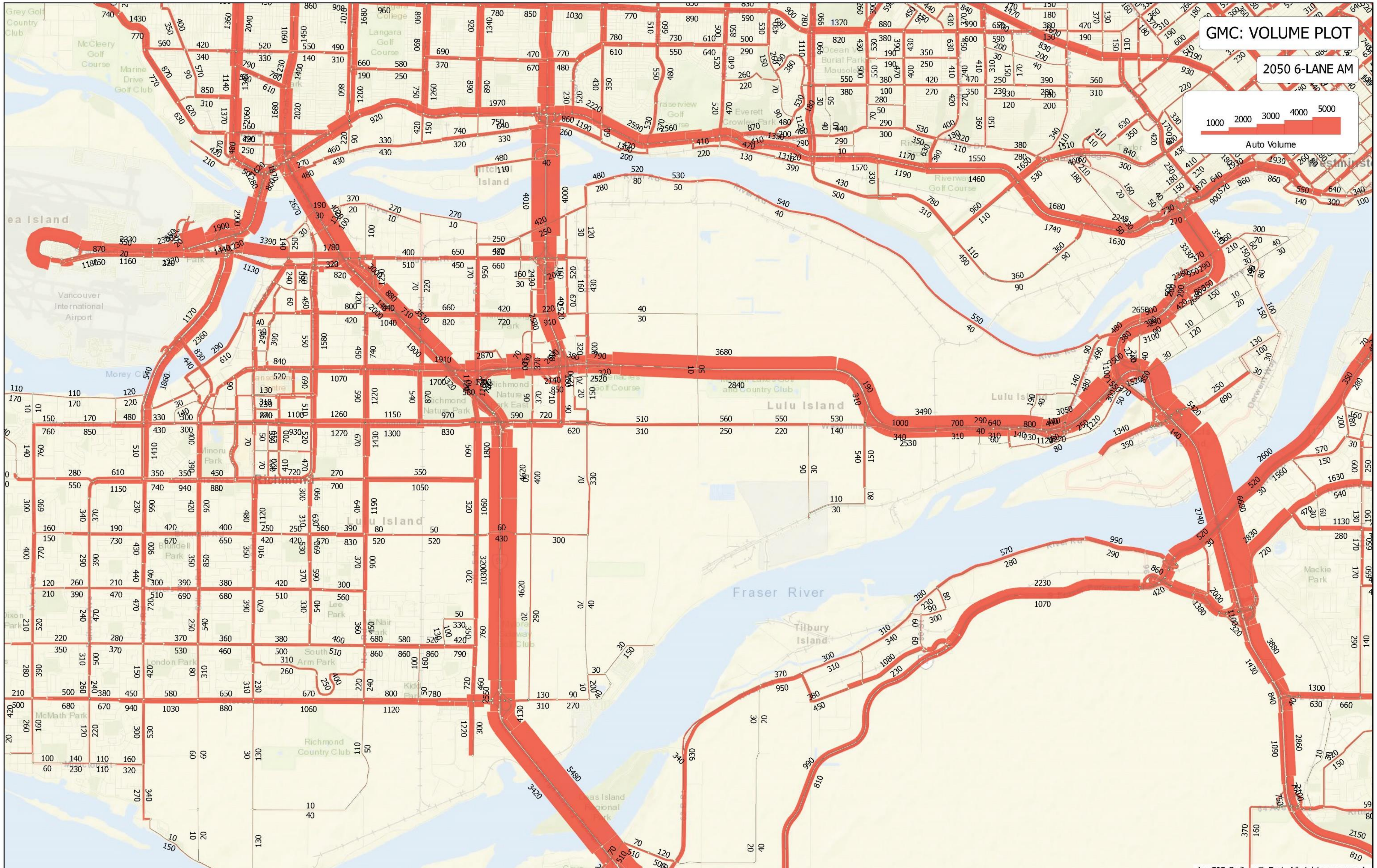


Figure 31: 2050 AM 6-Lane Peak Traffic Volume Assignment Plot (Delta)

Figure 32: 2050 PM 6-Lane Peak Traffic Volume Assignment Plot (Richmond)

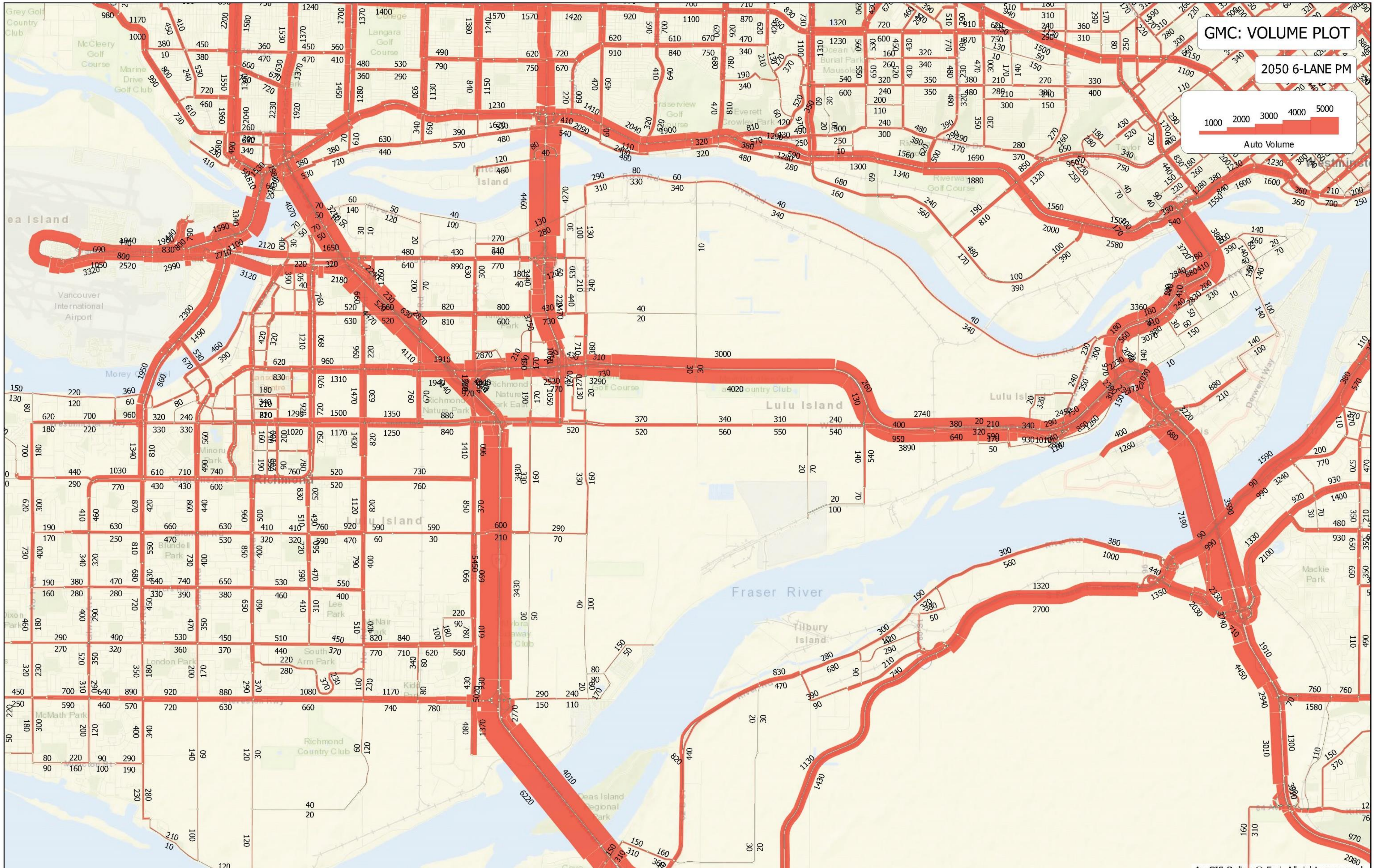


Figure 33: 2050 PM 6-Lane Peak Traffic Volume Assignment Plot (Delta)

Figure 34: 2050 AM 8-Lane Peak Traffic Volume Assignment Plot (Richmond)

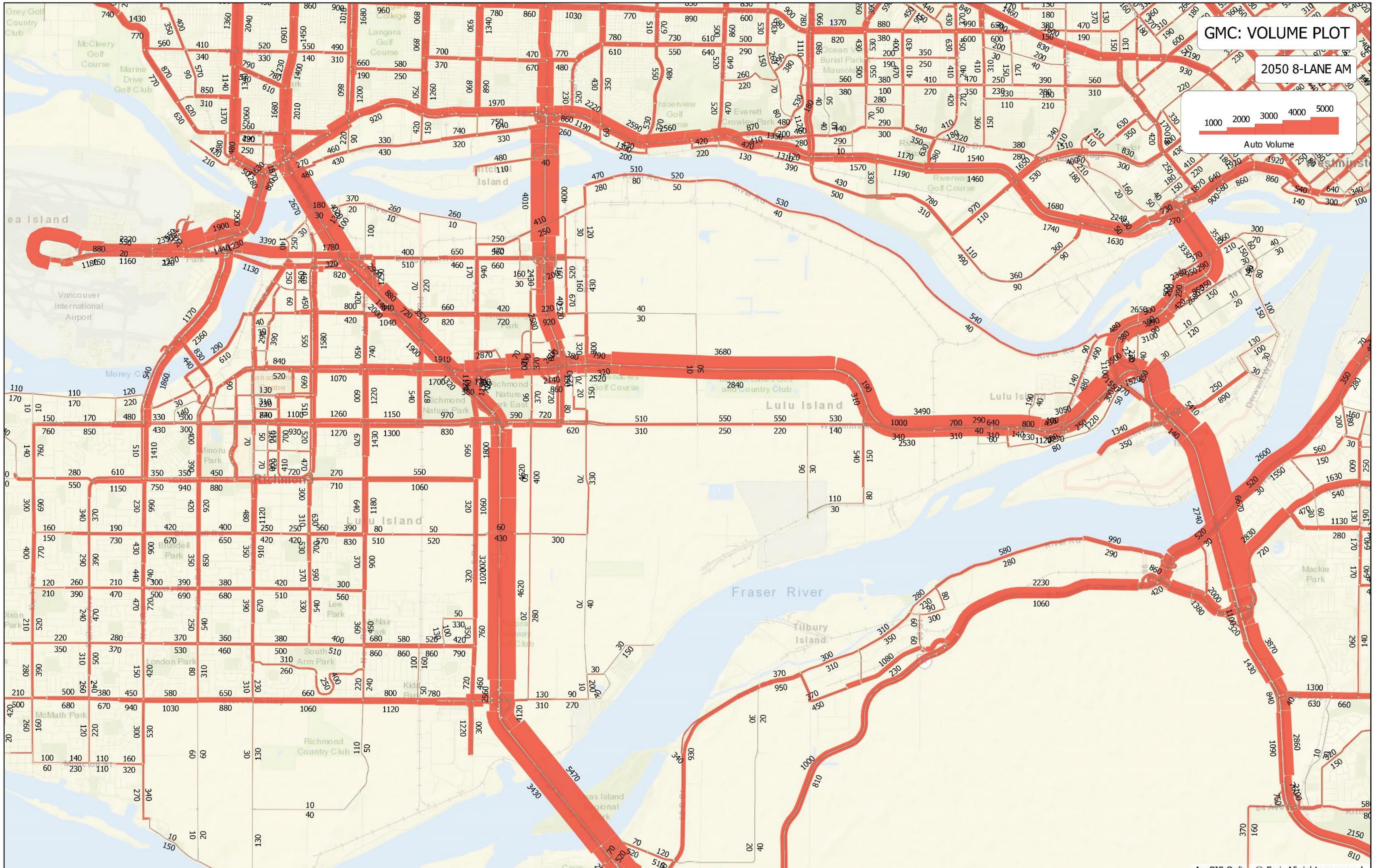


Figure 35: 2050 AM 8-Lane Peak Traffic Volume Assignment Plot (Delta)

Figure 36: 2050 PM 8-Lane Peak Traffic Volume Assignment Plot (Richmond)

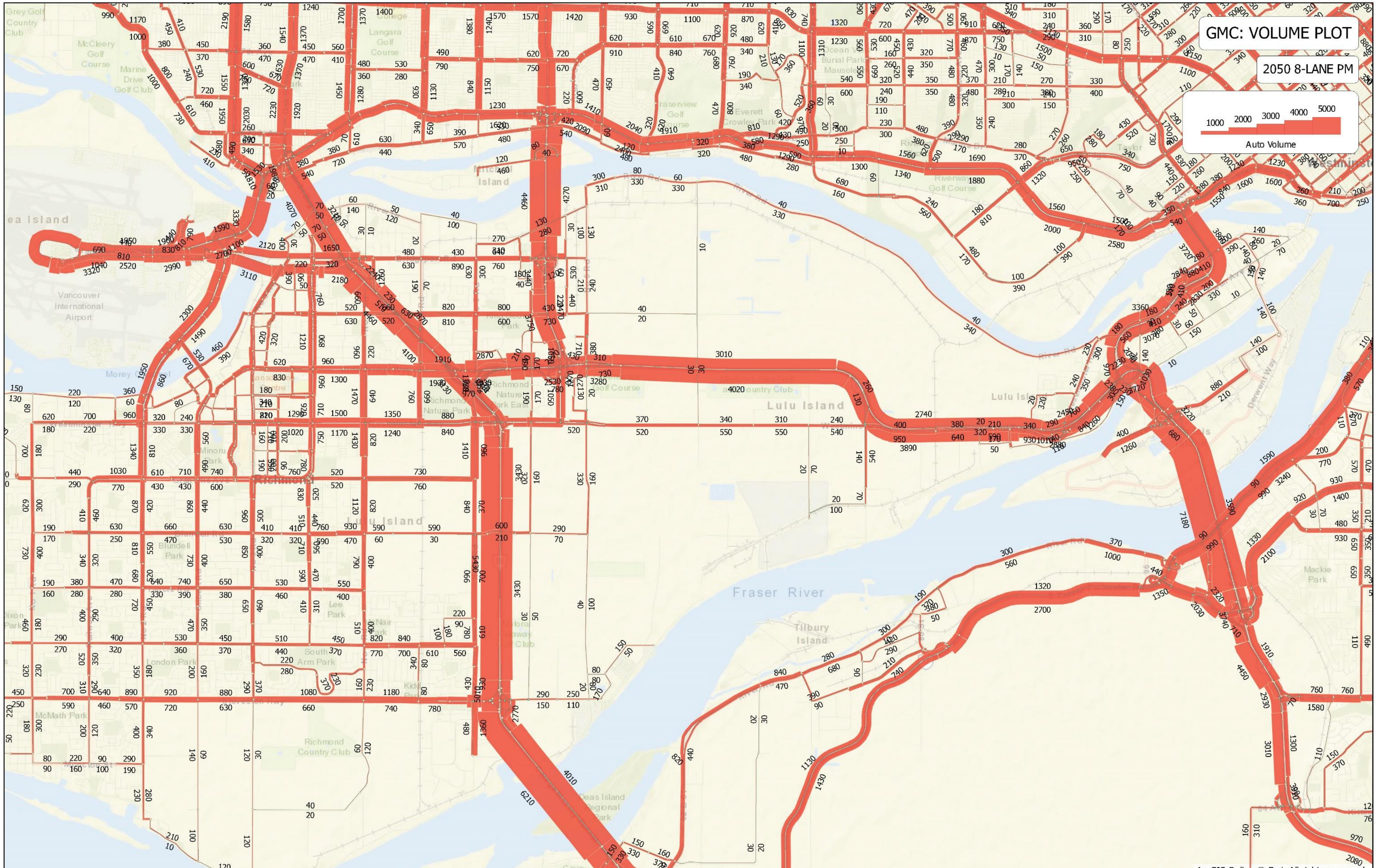


Figure 37: 2050 PM 8-Lane Peak Traffic Volume Assignment Plot (Delta)

Figure 11: 2017 PM Peak Base Traffic Volume Assignment Plot (Delta)