A Technical Memo
For:

GEORGE MASSEY TUNNEL REPLACEMENT PROJECT

ANALYSIS OF OD SURVEY DATA

DRAFT

Submitted By:

Delcan
TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

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1. Background

The Ministry of Transportation and Infrastructure (the Ministry) uses Bluetooth readers along Highways 91 and 99 in Richmond, Delta and Surrey in order to estimate real-time travel speeds in the two corridors and to provide this information to the travelling public through their Automated Traveller Information System (ATIS).

The GMT project commissioned a Bluetooth Survey to supplement this data with the objective of understanding origin-destination (OD) patterns along the two highway corridors. **Figure 1.1** illustrates the locations of the Ministry and survey Bluetooth readers. Note that the Ministry stations marked in grey were out of service during the time of the survey.

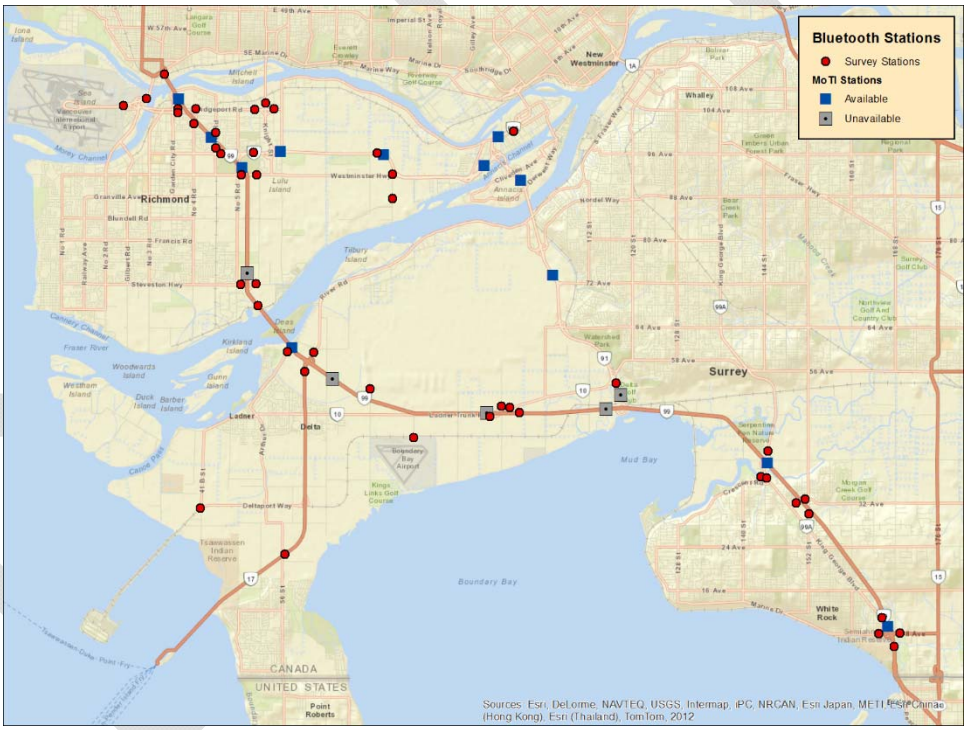

Figure 1.1 - Map of Bluetooth Reader Locations

2. Bluetooth Data Collection and Processing

Bluetooth OD Survey

Key characteristics of the Bluetooth survey were as follows:

- The survey was conducted from October 21 through November 6 2013;
- Bluetooth readers were installed at 45 locations to capture Media Access Control (MAC) addresses, unique identifiers linked to devices that use Bluetooth communications;
- Almost 8 million Bluetooth "hits" were captured – yielding 2.3 million events, once duplicate hits at specific stations were removed;
- About 125,000 events were excluded since they were stationary devices;
- A substantial proportion of events occurred at only one station (541,000 or about 25%). These primarily represent cross traffic or traffic that did not use the Highway 99 corridor. These events are not included in the OD analysis.
- The remaining 1.76 million events were converted to 590,000 trips from/to specific station pairs over the period Oct. 22 to Nov. 5 (in order to focus on full days of data).

Initial analysis of trip records indicated that readings at survey locations along the Highway 99 mainline were potentially incomplete relative to the Ministry data; therefore, the survey dataset was integrated with the Ministry data prior to undertaking a detailed analysis of trip patterns.

Ministry ATIS Bluetooth Data

Key characteristics of the Ministry Bluetooth data were as follows:

- Data was extracted for October 23 through November 6 2013;
- About 6 million Bluetooth "hits" yielding 1.5 million events were captured, once duplicate hits at specific stations were removed; and
- Bluetooth readers were installed at 17 locations, although data were not usable from five stations due to temporary relocations and service disruptions.

Analysis of Combined Datasets

The two datasets were integrated in order to improve the coverage of the Highway 91 corridor. Error checks were performed to identify trips with possible errors including:

- Loop trips with common start and end points (possible with a short stop along the loop);
- Trips that appear to use both crossings;
- Trips with a very low sample size, which limits the potential for consistency checks; and,
- Trips that were significantly longer in time than the norm for a given O/D pair.

The key characteristics of the combined dataset are as follows:

- About 3.47 million events;
- About 107,000 valid unique MACID addresses;
- About 675,000 valid trip records available for analysis; and,
- About 230,000 crossing trips (both George Massey and Alex Fraser).

The Bluetooth sites were grouped geographically into 18 subareas to assist in the analysis of origin-destination patterns. The sub-areas are mapped in **Figure 2.1**.

Figure 2.1 - Map of Sub-Area Locations

The combined set of Bluetooth stations were identified as either entry/exit stations to the Highway 99 / Highway 91 system or mainline stations. Trip records which have a mainline station as either a start or end point cannot be allocated with certainty to a particular sub-area. Nevertheless, these trip record still provide useful information on O/D patterns. The allocation of stations by type is illustrated in **Figure 2.2**.

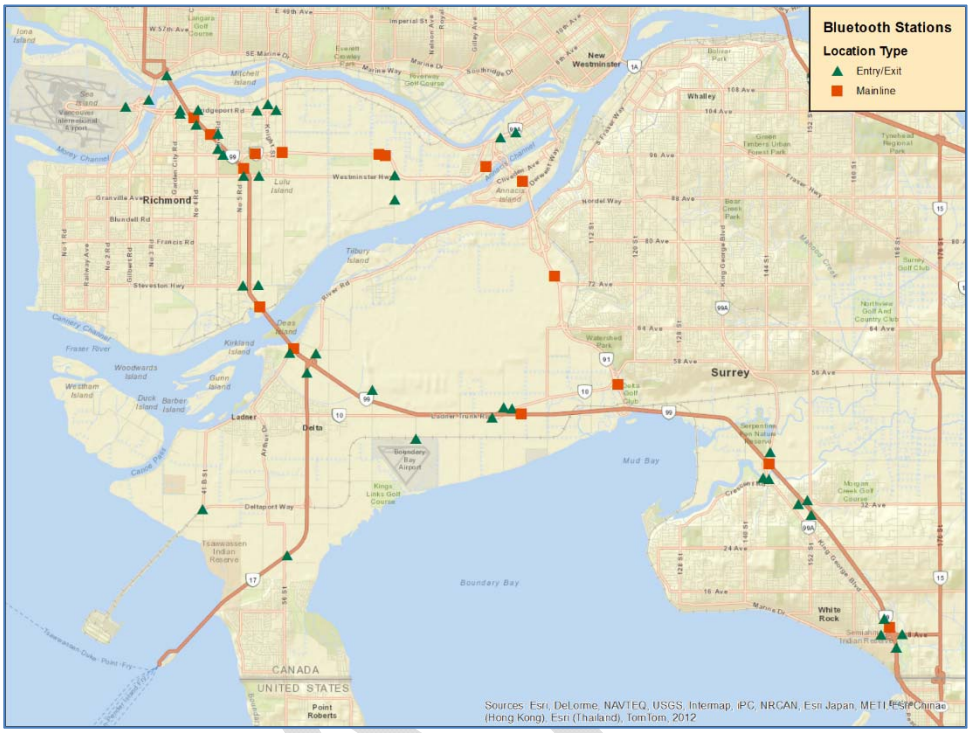

Figure 2.2 - Map of Station Location Types

3 GMT Trip Patterns - North Side of the Fraser River

The estimated distribution of northbound trip destinations and southbound trip origins for trips that were recorded travelling through the GMT during weekdays is tabulated in **Figure 3.1**.

It should be noted that given the nature of the Bluetooth data these distributions are estimates of the travel patterns and can vary somewhat from actual distributions. For example, the percentage of vehicles exiting northbound at Steveston Highway relative to the northbound GMT volumes based on traffic counts in the field is slightly higher than the estimated percentage from the Bluetooth data (24% versus 22% over the day). Actual distributions can also vary day-to-day and by season.

The largest differences between the northbound and southbound directions occur in the Vancouver and Steveston sub-areas. As a result of these differences, the proportion of Richmond related traffic through the GMT varies from 58% in the northbound direction to 64% in the southbound direction.

Sub Area	Northbound Trip Destinations	Southbound Trip Origins
Vancouver	40%	34%
YVR	7%	7%
Richmond West of Hwy 99	16%	16%
Richmond East of Hwy 99	11%	10%
Richmond Fraser	2%	2%
Steveston	22%	29%
Burnaby/New Westminster	2%	2%

Figure 3.1 – Distribution of GMT Trip North Side Destinations and Origins on Weekdays

Differences in the distribution of weekday trip destinations on the north side of the GMT by time of day are illustrated in **Figures 3.2** and **3.3**. The first figure shows that northbound GMT traffic is slightly more oriented towards Richmond during off-peak times. This is not surprising since trip distances tend to be longer during peak periods due to the prevalence of commute trips. Commute trips are longer on average than trips for other purposes (shopping, social/recreational).

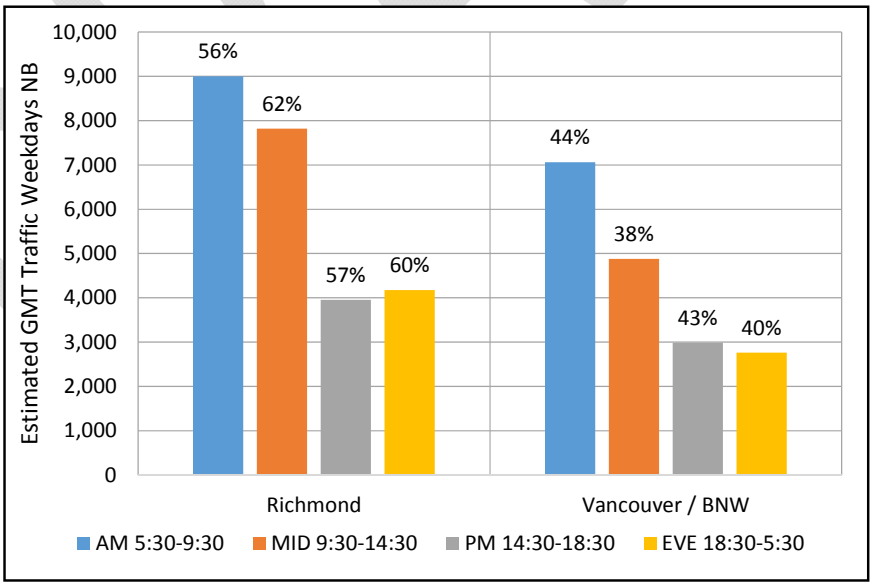

Figure 3.2 – Time-of-Day Distribution of NB GMT Trip Destinations

The detailed distributions of trips destined to different areas of Richmond by time-of-day are presented in **Figure 3.3**. The percentages given in the chart are relative to all northbound GMT trips during each respective time period.

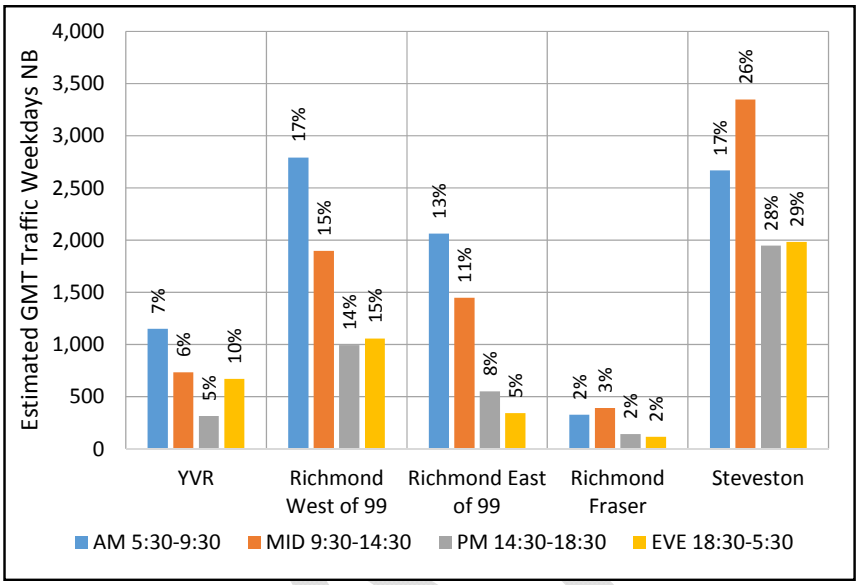

Figure 3.3 – Time-of-Day Distribution for Richmond Destinations

The distribution of destinations for northbound GMT trips on weekends is tabulated in **Figure 3.4**. Relative to weekdays more Richmond trips are destined for Steveston. This is consistent with the land use activities of that area. About 40% of the trips have destinations in Vancouver.

Sub Area	Weekdays	Saturdays	Sundays
Vancouver	40%	39%	40%
YVR	7%	6%	8%
Richmond West of Hwy 99	16%	16%	15%
Richmond East of Hwy 99	11%	7%	6%
Richmond Fraser	2%	1%	1%
Steveston	22%	29%	28%
Burnaby/New Westminster	2%	2%	2%

Figure 3.4 – Distribution of NB GMT Trip North Side Destinations on Weekends

Comparable charts and tables for southbound GMT trip origins are presented in **Figures 3.5** through **3.7**. In the case of southbound trips through the GMT, about 65% of the trips originate in Richmond throughout most of the day. The differences in the southbound versus northbound distributions may relate to differences in routings, including potential routings of Vancouver originating trips through Richmond (potentially for shopping or other trip purposes).

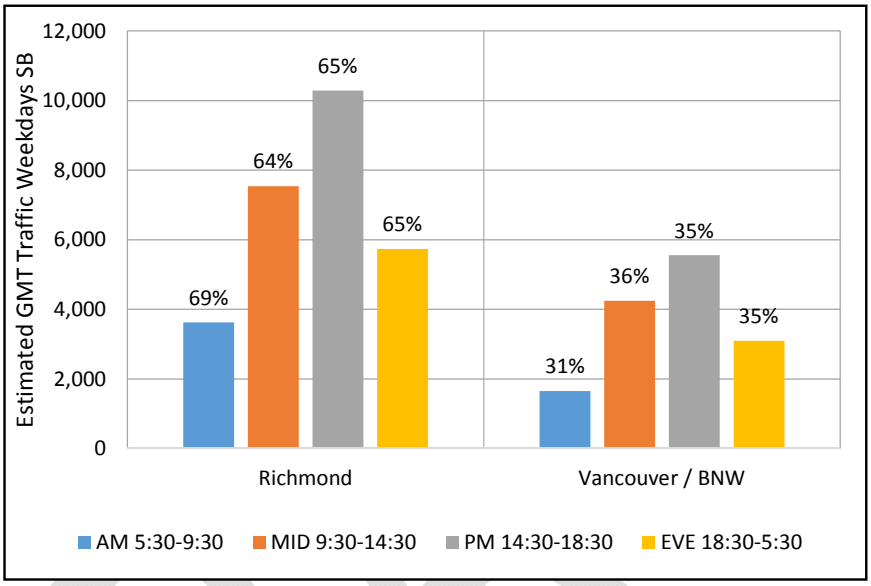

Figure 3.5 – Time-of-Day Distribution of SB GMT Trip Origins

The detailed distributions of trips originating from different areas of Richmond by time-of-day are presented in **Figure 3.6**. The percentages given in the chart are relative to all southbound GMT trips during each respective time period.

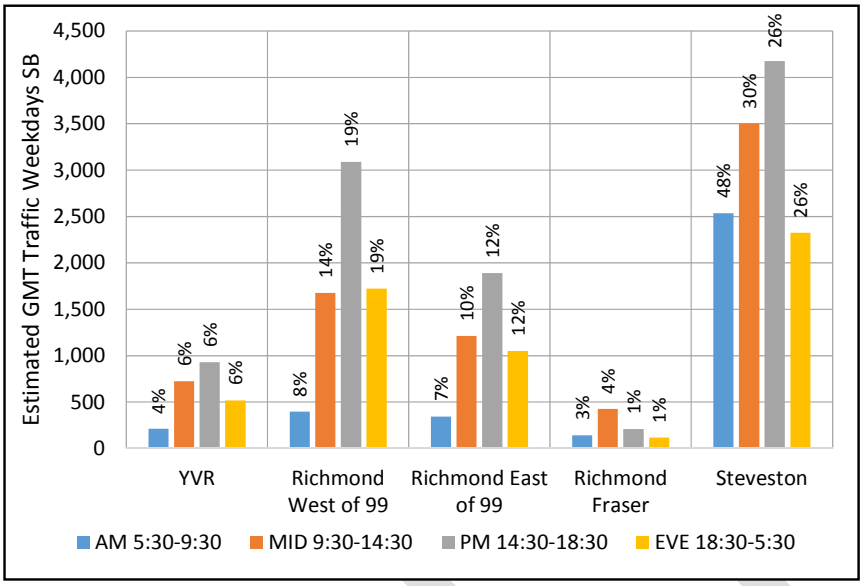

Figure 3.6 – Time-of-Day Distribution for Richmond Origins

The estimated percentage of trips originating from Steveston during the AM peak period (48%) is somewhat higher than expected based on count data (43%). This relates to the small sample size during that period and the use of daily correction factors for Steveston origins and destinations. Nevertheless, the Steveston Interchange accounts for a substantial portion (about 30% on a weekday) of the southbound trips through the tunnel.

The distribution of origins for southbound GMT trips on weekends is tabulated in **Figure 3.7**. The distributions are generally consistent with the destinations for northbound GMT trips on weekends with fewer trips originating in the industrial areas of Richmond.

Sub Area	Weekdays	Saturdays	Sundays
Vancouver	34%	36%	37%
YVR	7%	7%	8%
Richmond West of Hwy 99	16%	16%	17%
Richmond East of Hwy 99	10%	7%	5%
Richmond Fraser	2%	1%	0%
Steveston	29%	31%	31%
Burnaby/New Westminster	2%	2%	2%

Figure 3.7 – Distribution of SB GMT Trip North Side Origins on Weekends

4 GMT Trip Patterns - South Side of the Fraser River

The estimated distribution of northbound trip origins and southbound trip destinations for trips that were recorded travelling through the GMT during weekdays is tabulated in **Figure 4.1**.

The distribution patterns on the south side of the GMT are similar for both northbound and southbound trips.

Sub Area	Northbound Trip Origins	Southbound Trip Destinations
Ladner	18%	17%
Industrial Delta	9%	8%
DeltaPort	2%	2%
Tsawwassen	21%	21%
Rural Delta	8%	5%
North Delta	7%	10%
South Surrey	27%	27%
White Rock	8%	10%

Figure 4.1 – Distribution of GMT Trip South Side Origins and Destinations on Weekdays

Differences in the distribution of weekday trip origins on the south side of the GMT by time of day are illustrated in **Figures 4.2** through **4.4**. The first figure shows that northbound GMT trips originate more heavily from Ladner/Tsawwassen (including locations served by River Road and Highway 17 such as Deltaport and Tilbury) during the mid-day and pm peak periods. The mid-day pattern is not surprising since northbound trip distances through the GMT would tend to be longer during AM peak period due to the prevalence of commute trips. During the PM peak period, trips from south Surrey / White Rock have the option of using the Alex Fraser Bridge to avoid the congestion related to the counter-flow operations in the GMT.

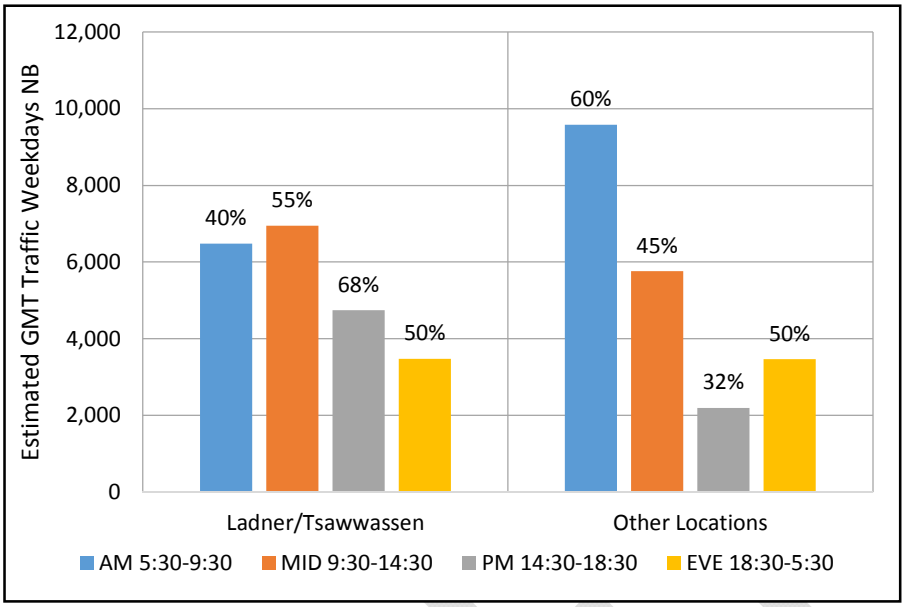

Figure 4.2 – Time-of-Day Distribution of NB GMT Trip Origins

The detailed distributions of weekday trips originating from different areas south of the GMT by time-of-day are presented in **Figure 4.3** and **Figure 4.4**. The percentages given in the chart are relative to all northbound GMT trips during each respective time periods.

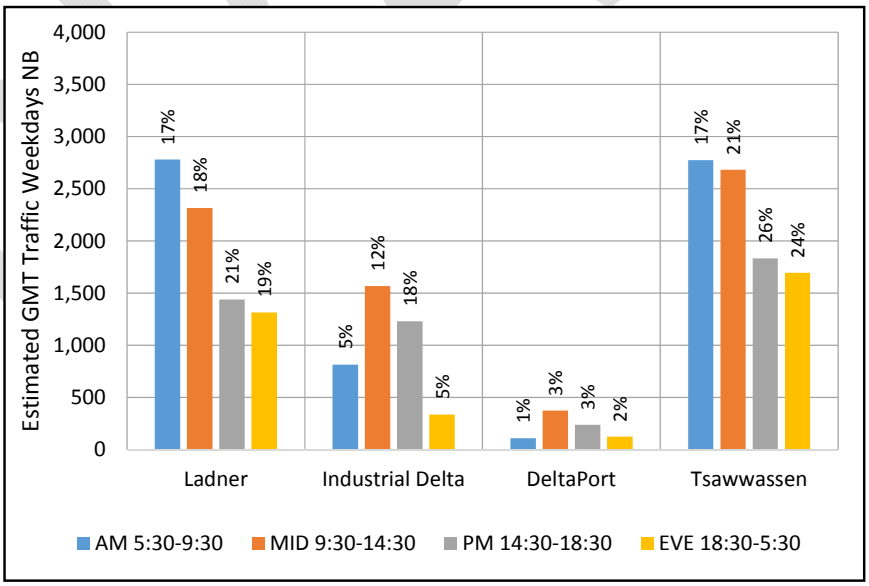

Figure 4.3 – Time-of-Day Distribution for Ladner / Tsawwassen Origins

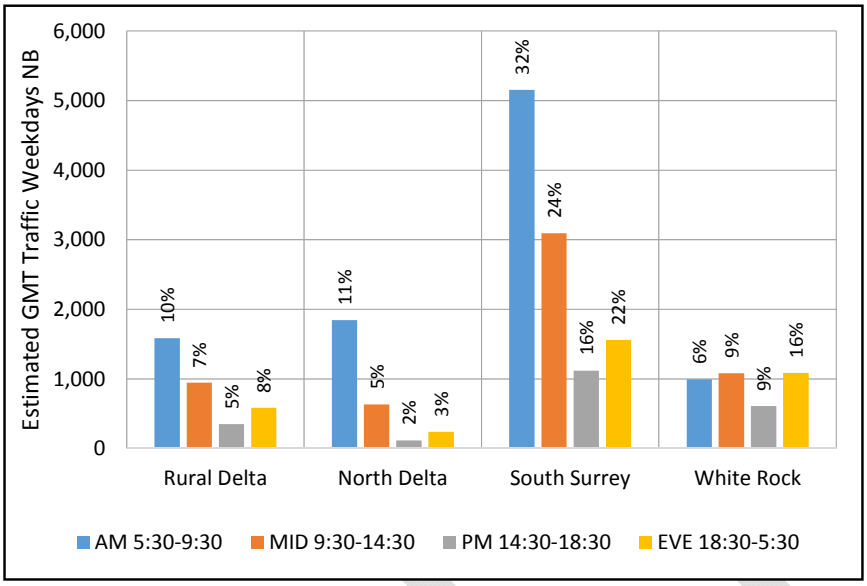

Figure 4.4 – Time-of-Day Distribution for Other Origins

The distribution of origins for northbound GMT trips on weekends is tabulated in **Figure 4.5**. The weekend pattern has fewer origins in industrial areas and more from the White Rock area (which includes the US border). Saturday and Sunday patterns are similar.

Sub Area	Weekdays	Saturdays	Sundays
Ladner	18%	20%	21%
Industrial Delta	9%	4%	3%
DeltaPort	2%	1%	0%
Tsawwassen	21%	25%	26%
Rural Delta	8%	8%	8%
North Delta	7%	4%	3%
South Surrey	27%	24%	24%
White Rock	8%	14%	15%

Figure 4.5 – Distribution of NB GMT Trip South Side Origins on Weekends

Comparable charts and tables for southbound GMT trip destinations are presented in **Figures 4.6** through **4.9**. In the case of southbound trips through the GMT, about 48% of the trips are destined to Ladner / Tsawwassen on a weekday. This is similar to the pattern of origins (47% from Ladner / Tsawwassen).

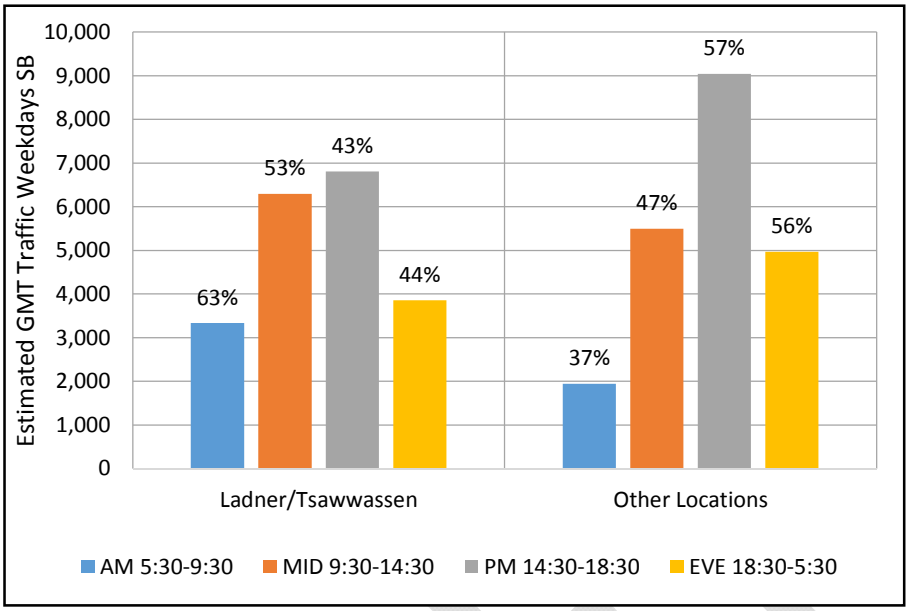

Figure 4.6 – Time-of-Day Distribution of SB GMT Trip Destinations

The high estimated percent of trips destined to Ladner / Tsawwassen during the AM peak period is consistent with traffic counts taken in the fall of 2013.

The detailed distributions of weekday trips destined to different areas south of the GMT by time-of-day are presented in **Figure 4.7** and **4.8**. The percentages given in the chart are relative to all southbound GMT trips during each respective time periods.

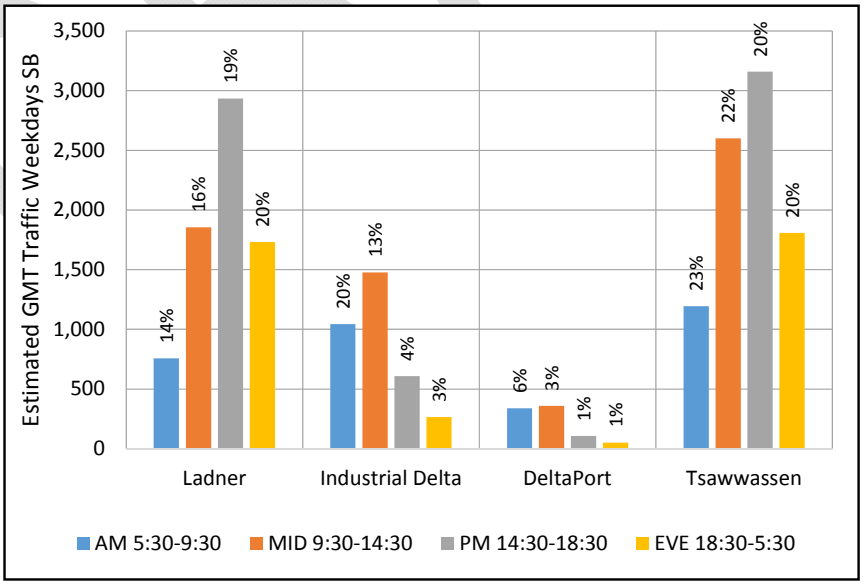

Figure 4.7 – Time-of-Day Distribution for Ladner / Tsawwassen Destinations

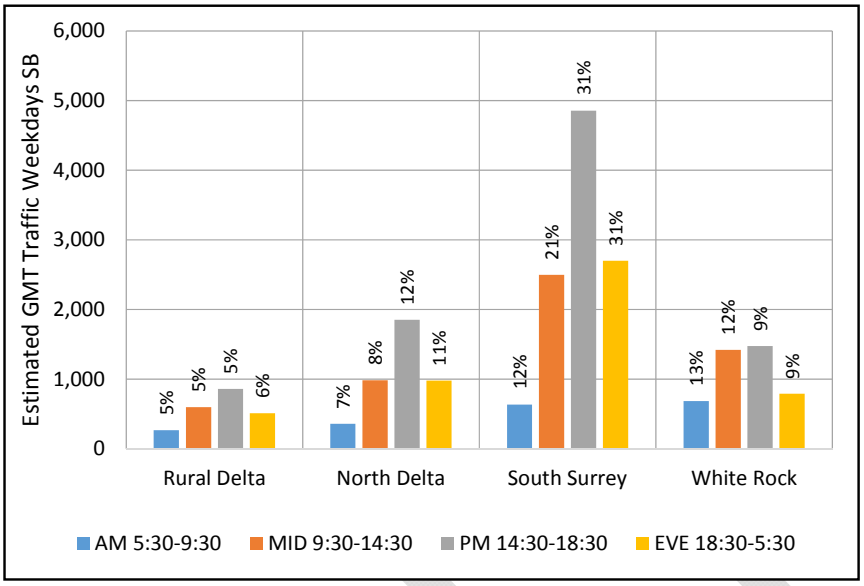

Figure 4.8 – Time-of-Day Distribution for Other Destinations

The distributions of destinations for southbound GMT trips on weekends are tabulated in **Figure 4.9**. The distributions are generally consistent with the origins for northbound GMT trips on weekends. The weekend pattern for southbound trips has fewer destinations in industrial areas and more to the White Rock area (which includes the US border).

Sub Area	Weekdays	Saturdays	Sundays
Ladner	17%	18%	17%
Industrial Delta	8%	4%	3%
DeltaPort	2%	1%	0%
Tsawwassen	21%	24%	25%
Rural Delta	5%	6%	6%
North Delta	10%	9%	9%
South Surrey	27%	23%	24%
White Rock	10%	15%	16%

Figure 4.9 – Distribution of SB GMT Trip South Side Destinations on Weekends