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BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

HIGHWAY 99 SQUAMISH CORRIDOR STUDY: DARRELL BAY ROAD TO DEPOT ROAD

Study Report

December 2021

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1. INTRODUCTION

The Highway 99 Squamish Corridor Study is a multi-modal corridor assessment of Highway 99 between Darrell Bay Road and Depot Road within the District of Squamish. The main objectives of the study are to assess the existing and future multi-modal performance of the corridor as well as to identify and evaluate potential opportunities to mitigate identified multi-modal performance issues.

1.1 Study Area

The study area focuses on the Highway 99 corridor between Darrell Bay Road and Depot Road as shown in ***Figure 1.1***. This segment of the highway is located within the District of Squamish, however the study is focussed on the highway corridor itself, and is not intended to encompass a wider review of the District of Squamish municipal roadway network other that at intersections where the municipal road network interfaces with the highway.

The study corridor also forms part of the traditional territories of the Squamish Nation. There are also two Squamish Nation reserves, Stawamus No. 24 and Kowtain No. 17, that are located adjacent to the highway corridor.

1.2 Report Structure

The remainder of this report is divided into seven sections:

- **Section 2**, which provides an overview of data sources that will be used to assess the mobility and safety performance of the corridor.
- **Section 3**, which summarizes findings obtained through a site visit and input from study partners.
- **Section 4**, which describes the technical performance metrics that will be used to assess the mobility and safety performance of the corridor.
- **Section 5**, which undertakes an existing and forecast future conditions assessment of mobility and safety along the corridor, and culminates in a series of identified multi-modal performance issues.
- **Section 6**, which documents the generation of options to mitigate the issues identified in Section 5.
- **Section 7**, which provides a scenario-based traffic operations assessment of the generated options.
- **Section 8**, which provides a high-level evaluation of each option, drawing on both the traffic operations improvements as well as other criteria, and a potential phasing strategy.

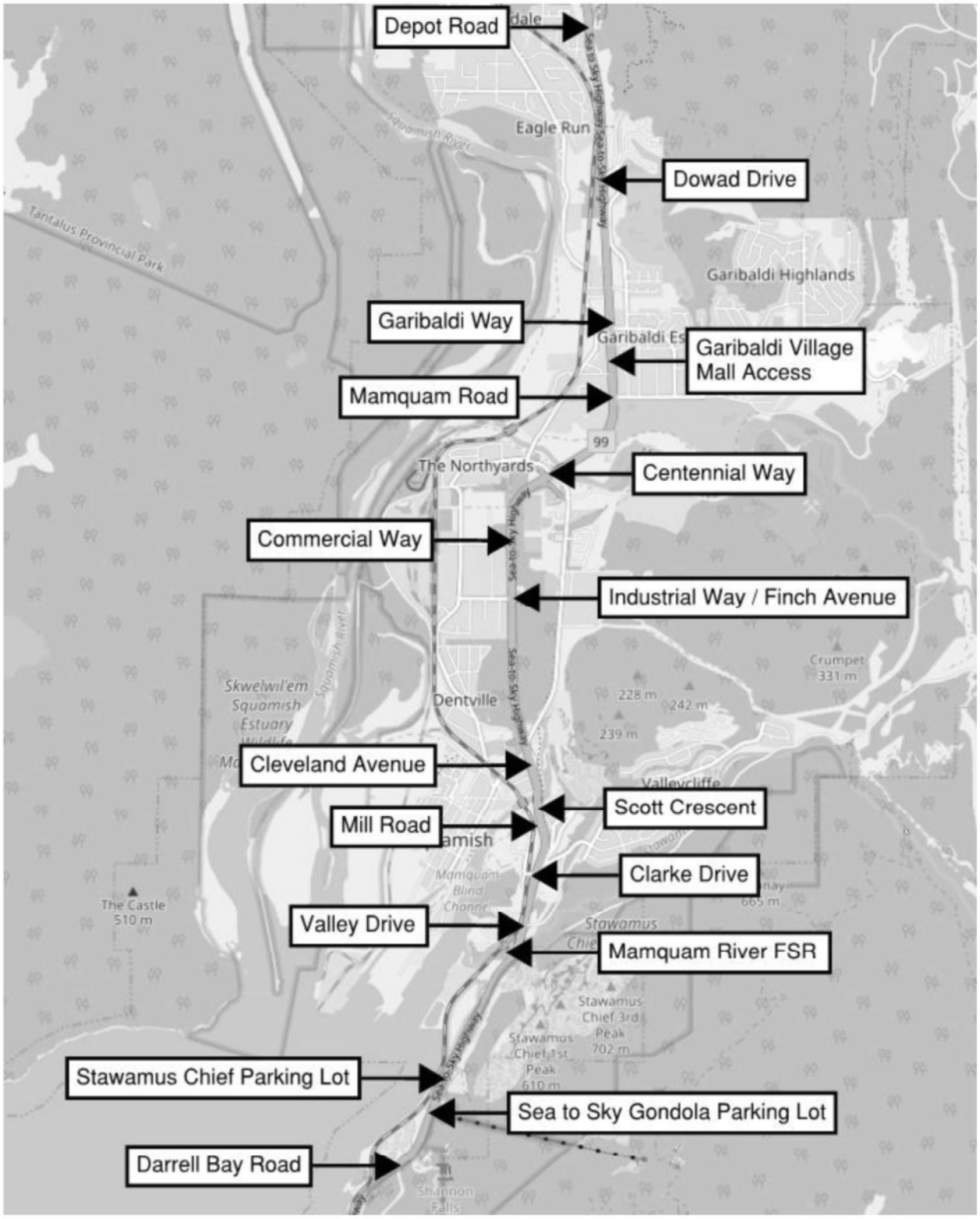

Figure 1.1: Study Area

2. STUDY CORRIDOR OVERVIEW

The purpose of this section is to provide an overview of existing data and other information related to transportation mobility and safety, as well as demographics, land use and development patterns in the Squamish area. This section does not seek to identify issues along the corridor; rather the purpose of this section is to identify current and anticipated future volumes or other trends. These findings will subsequently be used in later sections to identify issues. This section is organized as follows:

- A review of available data and other information sources
- Confirmation of the highway role and function within the Squamish area
- Generation existing conditions peak hour traffic volumes
- Forecasting of future horizon year peak hour traffic volumes

2.1 Review of Available Data and Other Information Sources

Several types of data and information were reviewed in order to provide a basis for the technical analysis of current and anticipated future conditions. The following information is reviewed herein:

- Existing Highway Infrastructure
- Highway Traffic Volumes
- Intersection Turning Movement Counts
- Commuting Patterns
- Corridor Travel Times
- Collision History
- Transit Service
- Active Transportation
- Demographic Trends
- Land Use and Development

2.1.1 Existing Highway Infrastructure

The study corridor features 14 intersections with municipal roadways, as well as three major direct accesses. These intersections and accesses are summarized in ***Table 2.1***.

Table 2.1: Accesses Along Highway 99 Study Corridor

Cross-Street Name	Intersection Configuration	Signalization
Darrell Bay Road	4 leg	Signalized
Sea to Sky Gondola	3-leg; right-in / right-out	Unsignalized
Chief Trailhead Parking	3-leg; Protected-T	Unsignalized
Mamquam River FSR	4 leg	Unsignalized
Valley Drive	4-leg	Signalized
Clarke Drive	4-leg	Signalized
Mill Road	3-leg; Protected-T	Unsignalized
Scott Crescent	3-leg; right-in / right-out	Unsignalized
Cleveland Avenue	4-leg	Signalized
Industrial Way / Finch Avenue	4-leg	Signalized
Commercial Way	4-leg	Signalized
Centennial Road Interchange	Split Diamond Interchange	Free Flow
Mamquam Road	4-leg; signal	Signalized
Garibaldi Village Mall Access	3-leg; right-in only	Unsignalized
Garibaldi Way	4-leg	Signalized
Dowad Drive	3-leg; right-in / right-out	Unsignalized
Depot Road	4-leg;	Signalized

With respect to laning and cross-section, the highway mainline primarily features two general purpose mainline lanes in each direction. Dedicated left- and right-turn lanes are provided along the length of the corridor for vehicles turning off Highway 99. In some cases acceleration lanes are provided for vehicles turning right onto Highway 99, although this treatment is inconsistent; specifically, such lanes are provided at Industrial Way / Finch Avenue (both northbound and southbound), Commercial Way (southbound only, although this is a T-intersection and therefore a northbound lane is not applicable), Mamquam Road (both northbound and southbound), Garibaldi Way (southbound only), and Depot Road (southbound only).

With respect to speeds, posted speed limits along the highway are as follows:

- 80 km/h: Southern study limit at Darrell Bay Road to Mamquam River Forest Service Road;
- 60 km/h: Mamquam River Forest Service Road to north of Clarke Drive;
- 70 km/h: North of Clark Drive to north of Garibaldi Way;
- 80 km/h: North of Garibaldi Way to northern study limit at Depot Road.

Note that as part of a proposed intersection improvement project at Cleveland Avenue, the 60 km/h posted speed zone is anticipated to be extended northwards from north of Clarke Drive to north of Cleveland Avenue.

2.1.2 Highway Traffic Volumes

The BC MoTI Cheekye permanent count station (P-15-3NS) located near Alice Lake Road just north of the study corridor is the nearest available source of data to monitor long-term trends in highway volumes. Hourly traffic volumes by direction were obtained for a five year period between October 2015 and September 2020. This data source was used to assess long-term growth trends, and travel patterns for directional travel patterns on the highway corridor on a daily and weekly basis, including how these patterns can vary seasonally, the busiest observed hours on the corridor, and vehicle classification. As this data source is located north of the main Squamish urban area, findings from this analysis will primarily reflect the longer-distance regional and inter-regional travel of the highway corridor, and will not necessarily capture the secondary role of the highway corridor with respect to facilitating local / intra-municipal travel.

LONG-TERM CORRIDOR TRAFFIC VOLUME TRENDS

Two-way annual average daily traffic (AADT) volumes on the highway at Cheekye between 2010 and 2019 are shown in ***Figure 2.1***. Over this decade-long period, AADT has grown at a compound annual growth rate of 2.8% at Cheekye, although growth rates have varied from year to year; growth rates were highest in 2015 and 2016, and subsequently flattered out, with annual growth of only 0.64% between from 2018-2019.

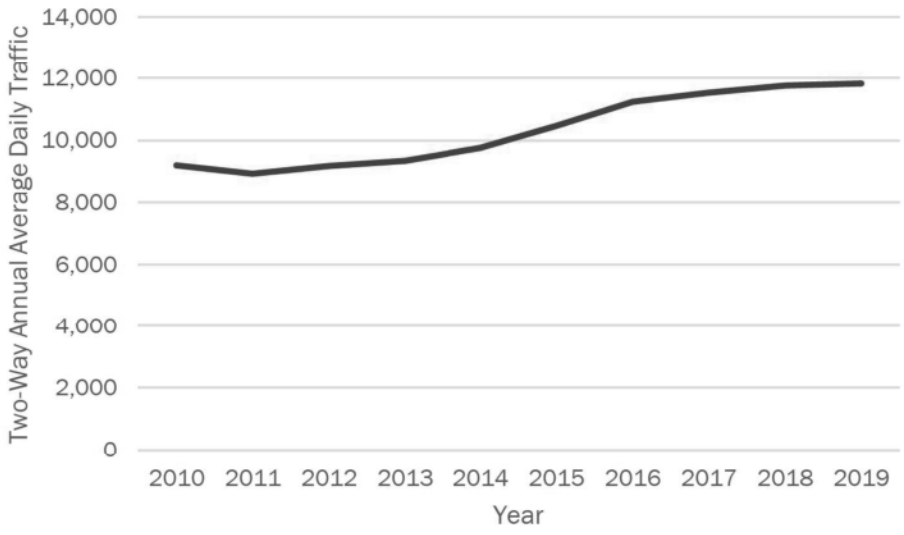

Figure 2.1: Highway 99 Long-Term Traffic Volumes Trends

Data for 2020 is not shown in the above figure as volumes are not yet available for the full year, and therefore cannot provide a like-with-like comparison against previous years. However, a review of data that is currently available suggest that in 2020 travel volumes along the corridor have declined as a result of the COVID-19 pandemic. For example, based on January-September 2020 data for the Cheekye permanent count station, AADT is 18% lower than 2019 volumes for the Monday-Thursday period and 21% lower than 2019 volumes for the Friday-Sunday period. At this point in time the likely long-term impacts of COVID-19 with respect to corridor trip volumes is not yet clear; and given the extensive tourism activity on the corridor, may not recover until restrictions are lifted on international travel and public concerns regarding the safety for long-distance travel are eased.

DAILY, WEEKLY AND SEASONALITY VOLUME DISTRIBUTION

2019 hourly traffic volumes at Cheekye count station were examined in order to identify patterns in travel on Highway 99 throughout the day, and by day of the week. Monthly average weekday traffic (MAWDT) and monthly average weekend traffic (MAWDT) are provided n ***Figure 2.2*** below. As shown, total daily traffic volumes are highest in the summertime, and lowest in the autumn, with winter and spring being in between these two extremes. Weekend volumes are higher than weekday volumes throughout the year although the differential between the two is greatest in winter and spring.

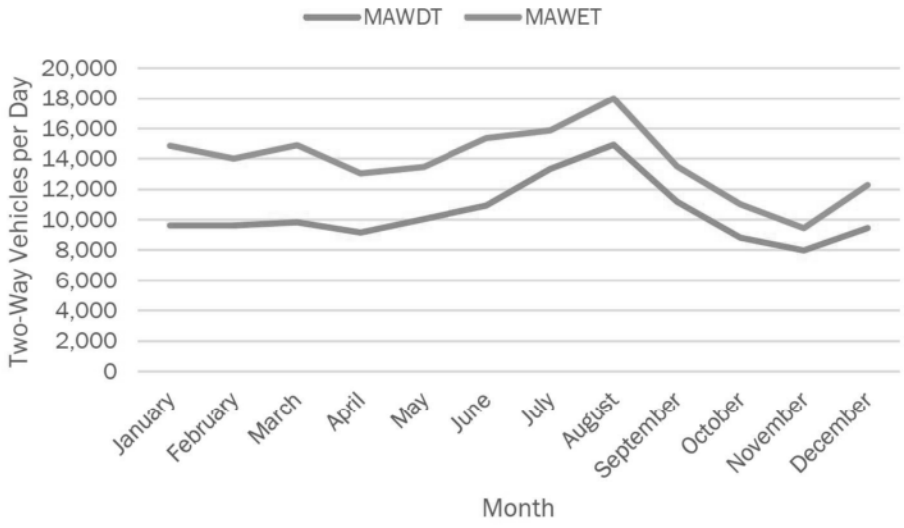

Figure 2.2: 2019 Winter Highway Daily Travel Patterns

Travel patterns on the highway vary significantly depending on the time of year and therefore all four seasons were examined separately. Hourly 2019 winter (January – March) traffic volumes split by direction and day of week are shown in ***Figure 2.3***. Northbound peaks are observed for the hour beginning at 07:00, coinciding with vehicle traveling to Whistler in time for the opening of the chairlifts at Whistler-Blackcomb ski resort. The northbound peaks are the highest on weekends, with an average of 1,120 vehicles per hour observed on Saturdays. Southbound peaks are observed at 16:00, coinciding with the daily end of chairlift operations at the ski resort. Southbound peaks are also highest on weekends, with an average of 1,170 vehicles per hour observed on Sundays. While only one daily peak is observed for most days of the week and direction, the Friday northbound traffic volumes exhibit both a morning and afternoon peak of 690 vehicles per hour. While the morning peak coincides with the opening of the ski resort, the afternoon peak is likely the result of tourists visiting Whistler for the weekend. The peak hour volumes described above for the winter season are the highest observed volumes out of all four seasons throughout 2019.

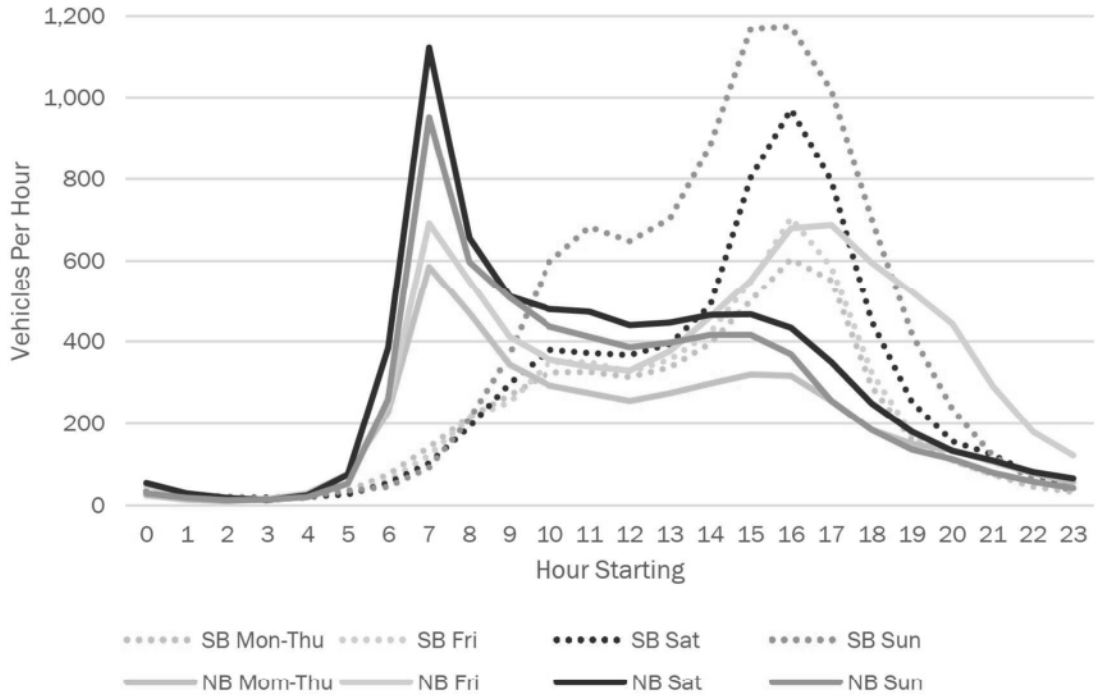

Figure 2.3: 2019 Winter Highway Daily Travel Patterns

Hourly 2019 spring (April – June) traffic volumes split by direction and day of week are shown in ***Figure 2.4***. Similar to the winter, weekend volumes are higher than weekday volumes. In comparison to the winter period, daily patterns in spring show much less extreme hourly peaks, with drivers travelling up and down the corridor in daily patterns not tied to the schedule of lift operations at Whistler ski resort; a finding that is influenced in part by the ski resort not being in operation in late May and June. In the southbound direction, similar to the winter, the southbound peak hour is at 16:00 with the highest volumes being on Sundays. However, average volumes during this time are 930 vehicles per hour in the springtime as compared to 1,170 in winter. In the northbound direction, volumes display a broader midday peak, with 670 vehicles per hour observed on Saturdays at 11:00.

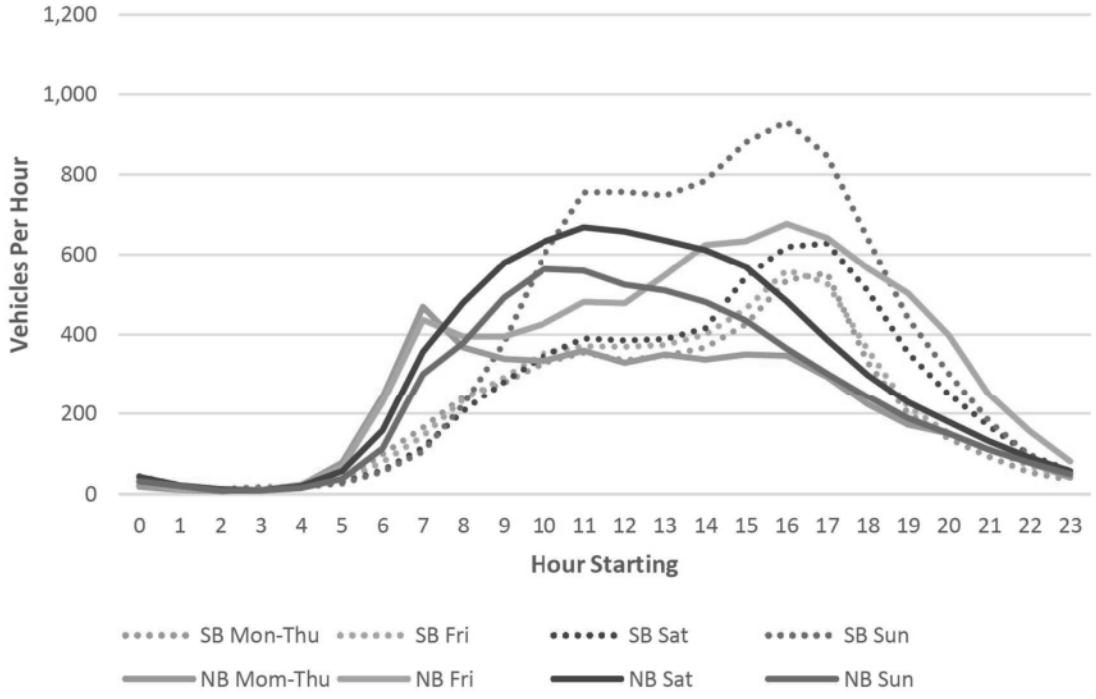

Figure 2.4: 2019 Spring Highway Daily Travel Patterns

Hourly 2019 summer (July – September) traffic volumes split by direction and day of week are shown in ***Figure 2.5***. In the summer, hourly profiles exhibit broad peaks through the midday and afternoon period. The maximum southbound hourly volume observed was 890 vehicles per hour at 17:00 on Sundays, and the maximum northbound hourly volume observed was 800 vehicles per hour at 15:00 on Fridays. Although the highest hourly volumes of the year were measured in winter, the highest daily volumes were measured in summer, peaking with a two-way volume of 16,100 on Sundays. This is due in part to volumes being more directional in the winter as compared to summer; in winter when northbound volumes are highest, southbound volumes are relatively low (and vice versa), whereas in summer when northbound volumes are highest, southbound volumes are also relatively high (and vice versa). Although the hourly peaks are significantly lower in summer than winter, the moderate volumes throughout the afternoon and evening result in higher daily totals.

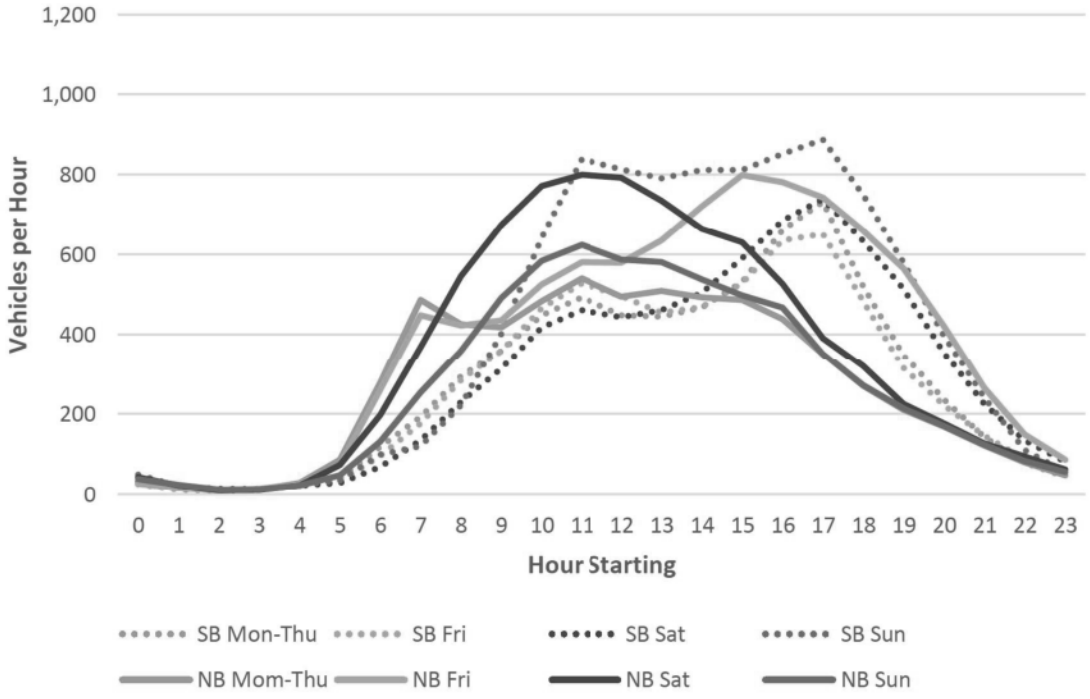

Figure 2.5: 2019 Summer Highway Daily Travel Patterns

Hourly 2019 autumn (October – December) traffic volumes split by direction and day of week are shown in ***Figure 2.6***. Fall volumes are lower than those of the other seasons. The daily distribution of volumes is similar to the summer with broad peaks in the midday to afternoon period, but lower in volume. Southbound fall volumes peak with 700 vehicles per hour at 16:00 on Sundays, and northbound fall volumes peak with 550 vehicles per hour at 12:00 on Saturdays.

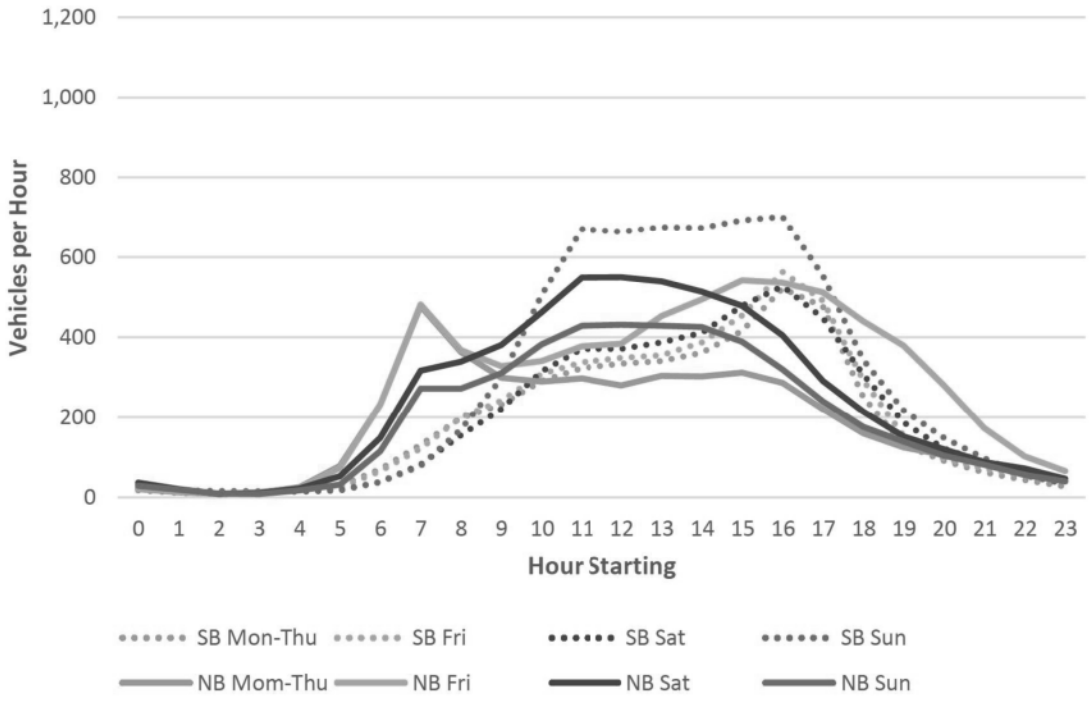

Figure 2.6: 2019 Autumn Highway Daily Travel Patterns

Key findings from the assessment of seasonality patterns include:

- The busiest individual hours on the highway are during the winter, and with appropriate lead / lag time added, correspond to day-skiers traveling using the highway in a manner that corresponds to the opening and closing of chairlift operations at Whistler-Blackcomb ski resort. Specifically, northbound volumes are highest in the hour beginning at 07:00, in advance of gondolas opening at 08:30. Southbound volumes are highest during the hour beginning at 16:00, which generally corresponds to the end of chairlift operations. Friday afternoons also exhibit a strong northbound peak, and Sunday afternoons show the greatest southbound peak, showing the impact of people staying in Whistler for the weekend.
- In comparison to the winter period, daily patterns in spring show much less extreme hourly peaks, with drivers travelling up and down the corridor in daily patterns not tied to the schedule of lift operations at the ski resort. However, chairlifts close later in the spring, which can create a more distributed arrival pattern in Whistler depending on how long individuals plan to ski for (i.e. some Metro Vancouver residents may plan to start late and finish late). Furthermore, it is noted that the ski season typically concludes over the Victoria Day weekend, whereas data for spring extends until the end of June, meaning it includes over a month of volume data for which there is no ski activity.

- Although the highest hourly volumes of the year were measured in winter, the highest daily volumes were measured in summer. Although the hourly peaks are significantly lower in summer than winter, the more evenly distributed (but still relatively high) volumes throughout the afternoon and evening result in the highest daily totals. Many summertime recreational activities (e.g. hiking and mountain biking) do not have a defined / unform "start" and "end" time like the chairlifts at the ski resort, and therefore provide travellers with increased flexibility with respect to time-of-day choice for travel.
- Fall volumes are lower than those of the other seasons. The daily volume profile is similar to the summer, with broad peaks in the midday to afternoon period, but smaller in volume.

Ultimately, the findings suggest that the presence of peak volumes (whether hourly or daily) along the corridor are driven primarily by the types of recreational activities available at different times of year.

HIGHEST VOLUME HOURS

Given the fluctuating daily, hourly and seasonal travel patterns described above, and the absence of a traditional stable weekday AM and PM peak hour, an alternate approach is required for selecting the design hour volumes that will be used as the basis for operational analysis. On rural highways, the 30th busiest hour of the year is often used as a basis for design hour volumes; this value is typically selected to avoid having once-a-year or other exceptional peak-of-the-peak occurrences excessively influence capacity analysis. Given the fluctuations in travel patterns on the Highway 99 corridor, the top 100 highest-volume hours on the highway in 2019 were identified in order to help determine appropriate design hour volumes. Given that volumes on Highway 99 can be highly directional at certain times of the day/week/year but more evenly distributed at other times, the 100 highest volumes were identified separately for both the northbound and southbound directions. A plot of the 100 highest directional hourly volumes on Highway 99 at the Cheekye permanent count station are provided in ***Figure 2.7***.

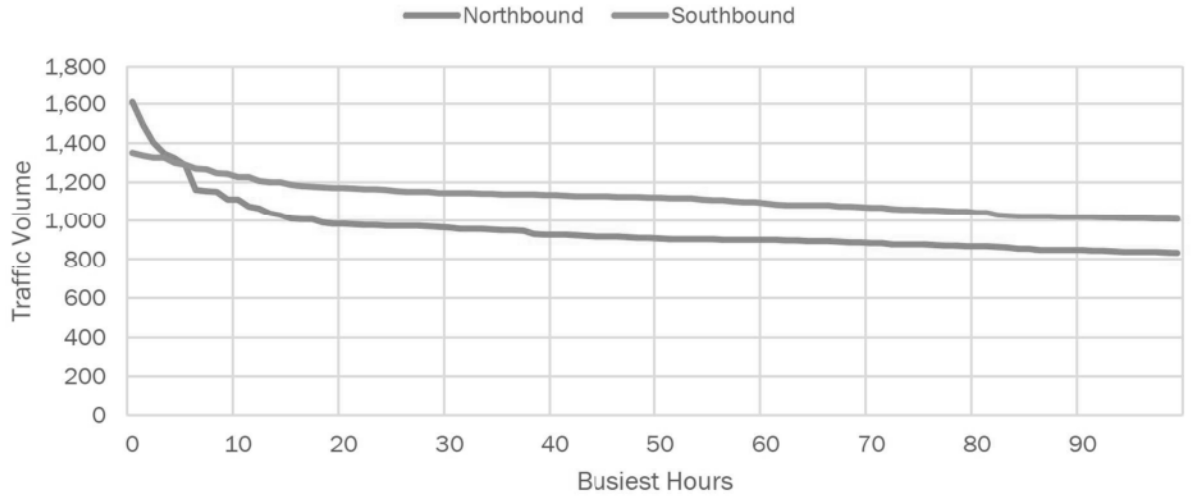

Figure 2.7: 2019 Top 100 Highest Directional Hourly Volumes on Highway 99 at Cheekye Permanent Count Station

As can be seen from the figure, the absolute busiest five hours on the highway all occur in the northbound direction; however beyond this point the southbound direction generally has busier hours than the northbound direction. To identify when during the year these volumes occur, the distribution of the busiest directional volumes on Highway 99 in 2019 by month of the year is shown in ***Table 2.2***. The table show two categories: the 100 highest volume hours as well as the 30th through 100th-highest highest hours. The intent of the second category is to exclude the absolute peak-of-the-peak volumes that correspond to relatively exceptional events.

In the northbound direction the 100 highest volume hours exhibit a bi-modal distribution, with a small peak in January / February and a larger peak in June-August. However, removing the highest hours and examining only the 30th through 100th highest-volumes hours causes the smaller peak in January-February to disappear entirely, while the June-August peak remains readily apparent. Further examination of the data shows that in the northbound direction, the ten highest volume hours of 2019 all occurred during the hour beginning at 07:00 on Saturday or Sunday mornings between early January and early March; a finding which clearly demonstrates the impact of peak season ski trips on highway volumes. However, once these peak ski days events are excluded, a clear trend emerges wherein the busiest northbound volumes are overwhelmingly occurring in the summer. This suggests that summer would be the more appropriate season for which to conduct traffic analysis along the study corridor.

The southbound direction exhibits a somewhat similar trend, but is less pronounced. Specifically, the southbound 100 highest volume hours also exhibit a bi-modal distribution, except the larger peak occurs in January-February while the smaller peak occurs in August-September. However, removing the highest hours and examining only the 30th through 100th highest-volumes hours causes the two peaks to equalize, with 21 of the busiest hours observed in both January-February as well as 21 such hours in August-September. This suggests that either summer or winter could be a reasonable period for analysis; however for consistency with the northbound direction the summer has been selected.

Table 2.2: Highest 2019 Directional Volume Hours on Highway 99 by Month

Month	Top 100 Highest Volume Hours		30th – 100th Highest Volume Hours	
	Northbound	Southbound	Northbound	Southbound
January	9	20	2	11
February	7	16	2	12
March	5	12	1	8
April	3	5	3	3
May	5	4	5	3
June	13	3	10	3
July	12	6	11	3
August	38	18	31	15
September	3	9	1	6
October	5	4	5	4
November	0	1	0	1
December	0	2	0	2

The distribution of the busiest directional volumes on Highway 99 in 2019 by day of the week is shown in ***Table 2.3***.

Table 2.3: Highest 2019 Directional Volume Hours on Highway 99 by Day of the Week

Weekday	Top 100 Highest Volume Hours		30th – 100th Highest Volume Hours	
	Northbound	Southbound	Northbound	Southbound
Monday	3	25	3	20
Tuesday	0	2	0	2
Wednesday	0	0	0	0
Thursday	0	0	0	0
Friday	21	0	19	0
Saturday	51	9	34	9
Sunday	25	64	15	40

Both the top 100 highest volumes hours and the top 30th through 100th-ranked hours (i.e. excluding the top 29 hours) show a clear trend:

- In the northbound direction, Saturdays are the busiest day of the week, followed by Friday.
- In the southbound direction, Sundays are the busiest day of the week, followed by Monday.

The distribution of the busiest directional volumes on Highway 99 in 2019 by time of day is shown in ***Table 2.4***. In the northbound direction, the top 100 highest volumes hours show a bi-modal distribution, with both the most frequent busy single hour beginning at 07:00, but a significant number of busy hours between 11:00 and 14:00. Considering only the 30th through 100th highest-volumes hours causes the 07:00 peak to diminish significant; this finding corresponds to the previous observation of many of the highest volumes occurring occurred during the hour beginning at 07:00 on Saturday or Sunday mornings between early January and early March. In the southbound direction, the late afternoon (15:00 through 18:00) is the busiest time of day, with the hour beginning at 16:00 being the busiest hour. This pattern holds for both the top 100 highest volume hours as well as the 30th through 100th highest-volumes hours.

Table 2.4: Highest 2019 Directional Volume Hours on Highway 99 by Time of Day

Hour Beginning	Top 100 Highest Volume Hours		30th – 100th Highest Volume Hours	
	Northbound	Southbound	Northbound	Southbound
1:00	0	0	0	0
2:00	0	0	0	0
3:00	0	0	0	0
4:00	0	0	0	0
5:00	0	0	0	0
6:00	0	0	0	0
7:00	22	0	6	0
8:00	0	0	0	0
9:00	3	0	3	0
10:00	9	0	6	0
11:00	15	8	11	8
12:00	12	5	11	5
13:00	13	4	13	3
14:00	9	4	7	4
15:00	9	20	7	13
16:00	5	29	4	19
17:00	2	21	2	12
18:00	1	9	1	7
19:00	0	0	0	0
20:00	0	0	0	0
21:00	0	0	0	0
22:00	0	0	0	0
23:00	0	0	0	0
0:00	0	0	0	0

Based on this above review, the following analysis periods are recommended:

- Analysis hour volumes for northbound traffic operations will be the hour beginning at 12:00 on Saturdays during summer.
- Analysis hour volumes for southbound traffic operations will be the hour beginning at 16:00 on Sundays during summer.

VEHICLE CLASSIFICATION

The Highway 99 corridor also facilitates goods movement via trucks. To provide an indication of the relative proportion of trucks on the highway corridor, an analysis of wheelbase length data collected at the Cheekye permanent count station was undertaken. Wheelbase length data is categorized into a 0-6 metres range (which would include all passenger vehicles); a 6 – 12.5 metres range (which could include most light trucks, but also other types of vehicles such as RVs and buses); and a 12.5+ metres range (which would include large trucks).

This analysis found that in 2019 at Cheekye, approximately 7.5% of vehicles had a wheelbase longer than six metres but less than 12.5 metres, and 2% had a wheelbase longer than 12.5 metres. These findings would appear to suggest a reasonable volume of light goods vehicles in the 6-12.5 metre range (although as noted, these figures are likely an overestimate), and a relatively small volume of vehicles in the 12.5+ metres range.

2.1.3 Intersection Turning Movement Count Traffic Volumes

Intersection traffic count volumes are recorded by the loop detectors at signalized intersections along the corridor. Unlike permanent count stations this data is not archived, and therefore only approximately one week of data is stored in the signal controllers. Turning movement count volumes were obtained at the following signalized intersections with Highway 99:

- Depot Road
- Garibaldi Way
- Mamquam Road
- Commercial Way
- Industrial Way / Finch Avenue
- Cleveland Avenue / Loggers Lane
- Clarke Drive
- Valley Drive
- Darrell Bay Road

Data was obtained for these intersections for the period of November 21 through November 19, 2020, with the exception of Industrial Way / Finch Avenue. Due to an equipment issue at the latter intersection, data was not being recorded in November and therefore volumes were collected for the period of January 8 through January 14, 2021.

Based on an analysis of this data, peak hours at the signalized intersections were observed in the northbound direction on Friday beginning around 16:00, and in the southbound direction on Sunday beginning around 13:30. In principle, these are the "true" peak periods on the study corridor, because unlike traffic volume data at the Cheekye permanent count station, this intersection data also reflects local trip-making within Squamish that uses Highway 99. However the turning movement count volumes were (predominantly) collected in November; as noted previously in Section 2.2.1 data recorded at the Cheekye permanent count station shows that the fall period (October – December) has the lowest inter-city volumes on the highway of any time of year. Therefore,

although Friday evening and Sunday early afternoon are the observed peaks in this week-long signalized intersection turning movement count dataset, this does not necessarily imply that these days / times would still be the peak northbound and southbound periods during other times of the year that are much busier with respect to inter-city trip volumes (e.g. summer).

Therefore, for the purpose of intersection operational analysis the summertime Saturday beginning at 12:00, and Sunday beginning at 16:00 periods will be used as design hour volumes. Accordingly, several scaling factors or other adjustments are required to convert the Saturday at 12:00 and Sunday beginning at 16:00 turning movement count volumes collected from the signal controllers in November 2020 into summertime design hour volumes appropriate for intersection operational analysis. These scaling factors include:

- Removing the short-term impacts of COVID-19 on traffic volumes by scaling volumes upwards to provide an estimate of what volumes would likely be in the absence of the pandemic. This approach implicitly assumes that over the longer-term people will return to pre-pandemic travel behaviour.
- Converting volumes from fall conditions to summer conditions.
- Volume balancing and other adjustments to account for trips on and off the corridor at locations other than signalized intersections. This includes several unsignalized public roads (namely Dowad Drive, Centennial Way, Scott Crescent, Mill Road and Valley Drive) as well as several private accesses on and off the highway (e.g. the Sea to Sky Gondola, various fast food and fueling stations, and the Garibaldi Village Mall).

Further information regarding the application of these adjustments, as well as the corresponding adjusted turning movement counts used for analysis purposes is provided in Section 2.3.

2.1.4 Commuting Patterns

Based on an analysis of 2016 Census data, commuting patterns for residents of Squamish is shown in ***Table 2.5***. As shown, of the Squamish residents with a usual place of work, 65% work within Squamish. The other 35% of Squamish residents with a usual place of work will make a longer commute on Highway 99, including 22% who travel south to Metro Vancouver, and 13% who travel north to Whistler and communities beyond.

Table 2.5: Usual Place of Work for Squamish Residents in the 2016 Census

Place of Work of Employed Squamish Residents	% of Employed Squamish Residents
Squamish	65%
Whistler, Pemberton, Lillooet	13%
Metro Vancouver	22%

The segment of the labour force with a usual place of work in Squamish is shown in ***Table 2.6***. People employed in Squamish live almost entirely within Squamish (91%), with the small remainder commuting in from the north (4%) and south (5%) on Highway 99.

Table 2.6: Place of Residence of People Working in Squamish in the 2016 Census

Place of Residence for People Employed in Squamish	% of People Employed in Squamish
Squamish	91%
Whistler, Pemberton, Lillooet	4%
Metro Vancouver	5%

Due to the lack of alternative travel options, commuting between communities along the Sea to Sky Corridor inherently requires use of Highway 99. Furthermore, due to a lack of feasible alternative routes, people commuting *within* a community may also either travel along or cross the highway as part of their commute.

Therefore, while a significant proportion of Squamish residents are using the highway to commute to either Metro Vancouver or Whistler, Pemberton and Lillooet, there are substantially fewer people commuting from these communities to a place of employment within Squamish. Given that Squamish has traditionally featured a lower cost of living than communities to the south (i.e. Metro Vancouver) and to the north (i.e. Whistler), these findings confirm that the community provides a place of residence with a lower cost of living that is still close enough to access employment opportunities in those other communities. Pemberton, although a smaller community than Squamish, can also provide lower-cost housing options for people employed in Whistler.

It is acknowledged that the COVID-19 pandemic may have had an effect on these commuting patterns, but a comparable dataset will not be available until the results of the 2021 Census are released (likely in 2022 or 2023).

2.1.5 Corridor Travel Times

Corridor travel time information was collected from online travel planning services for roughly a week-long period in November 2020. With reference to the seasonal volume trends described above in Section 2.1.1, it is noted that these volumes were collected (i) during the fall period, which is historically the lowest-volume time of year, and (ii) collected during a time when the COVID-19 pandemic is still creating an ongoing reduction in travel volumes as compared to pre-pandemic conditions. Therefore, it is anticipated that the travel times provided herein would show less of an increase during peak periods as compared to other times of year and / or in the event that trip rates return to pre-COVID-19 levels.

Average northbound travel times from Darrell Bay Road to Depot Road, disaggregated by time of day and day of the week are shown in ***Figure 2.8***. The plot shows that off-peak travel times through the study corridor are typically in the range of 10 minutes, and during the midday / afternoon period from 11:00 to 17:00 can increase to just shy of 12 minutes (a 15-20% increase in travel times). It is noted that the Friday data shows a spike in travel times for the hour beginning at 04:00; given that online travel planning services it is assumed that this spike is not due to congestion but rather is an outlier caused by either construction or some other form or temporary blockage, or the dataset being based on a very low sample size that is influenced by one or a small number of exceptionally slow-moving vehicles. As shown, travel times tend be at their maximum values during Friday afternoons and Saturday mornings.

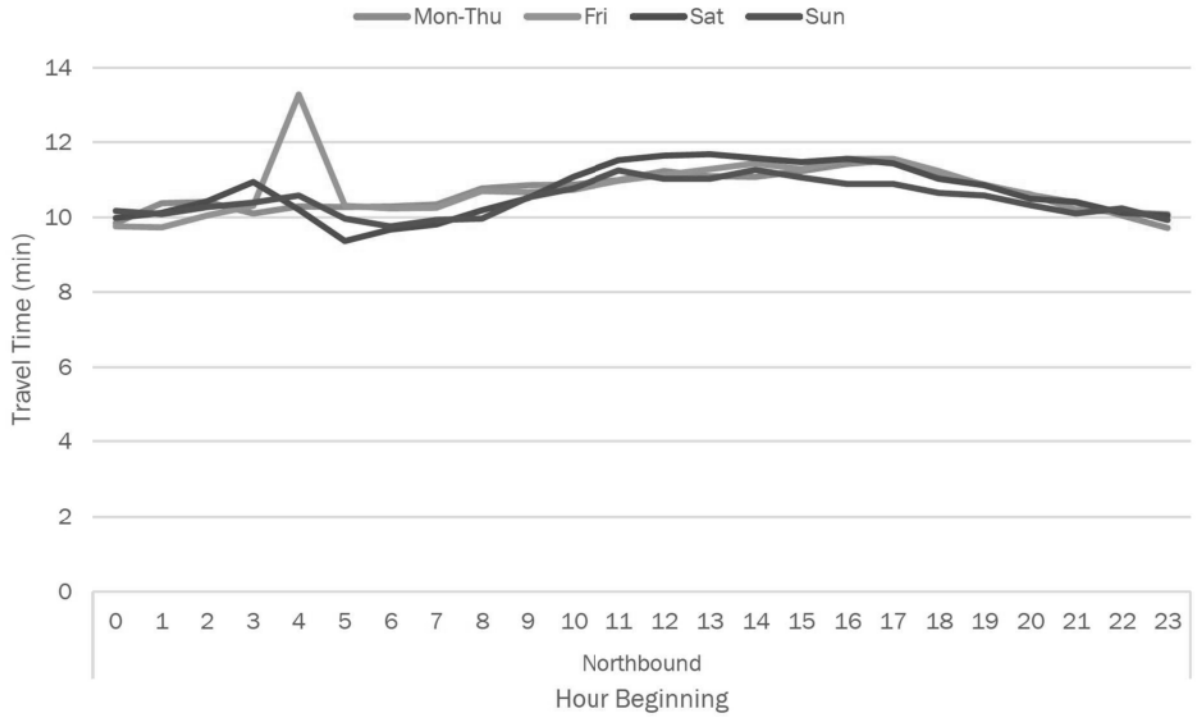

Figure 2.8: Average Northbound Travel Times from Darrell Bay Road to Depot Road

The corresponding travel times in the southbound direction from Depot Road to Darrell Bay Road are shown in ***Figure 2.9***. The plot shows that off-peak travel times through the study corridor are typically in the range of 10 minutes, and grow over the course of the afternoon, reaching just shy of 11.5 minutes (a 15% increase in travel times) around 16:00 – 17:00. The travel time analysis suggests that Sunday travel times are the lowest; a finding that is somewhat inconsistent with the analysis previously described in Section 2.1.1 which suggests that Sunday afternoons have the highest southbound volumes. However it is acknowledged that the travel time dataset was limited to one Sunday, and this finding may simply be the result of a limited sample size.

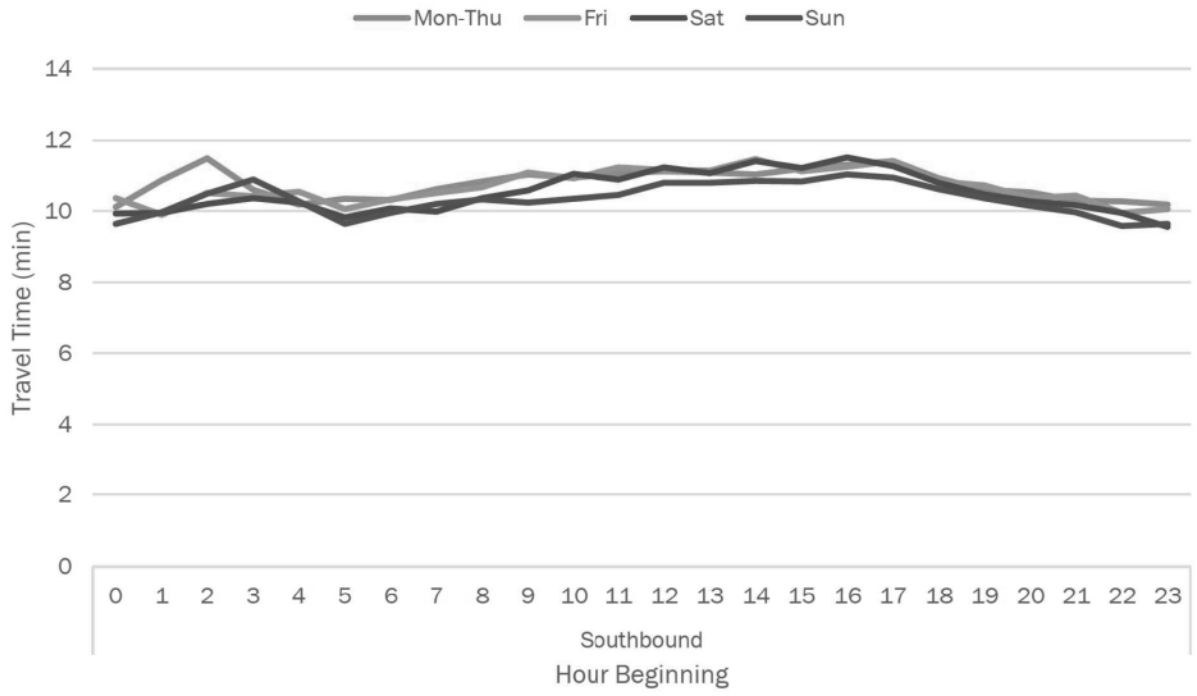

Figure 2.9: Average Southbound Travel Times from Depot Road to Darrell Bay Road

2.1.6 Collision History

Collision history was obtained from the BC MoTI Collision Information System for a five year period between 2015 and 2019, inclusive. The data available in the Collision Information System only includes collisions that were attended by police and which involved either a fatality, an injury, or damage to property in excess of $1,000. In total, 191 collision incidents are reported in the dataset.

The number of recorded collisions in each year are shown in ***Figure 2.10*** below. Some fluctuation is seen year-to-year collision counts, although no long-term trend can be inferred from this limited five-year data set.

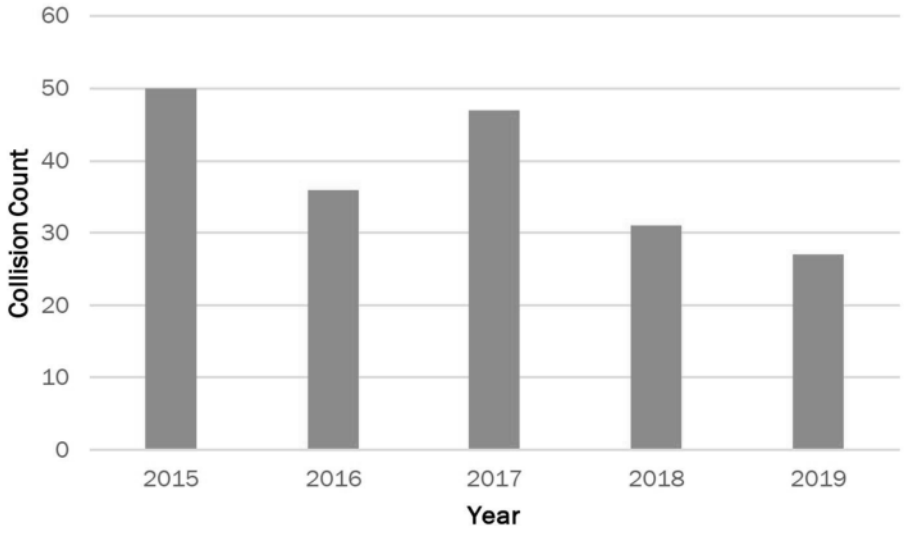

Figure 2.10: Collision History by Year

The severity level of recorded collisions are shown in ***Figure 2.11*** below. As shown, 1% of collisions (i.e. one collision) involved a fatality, 43% of collisions involved an injury, and the remaining 57% were only caused property damage. The singular fatal collision occurred at night (i.e. 2:30 AM) in February 2018 near the intersection of Highway 99 with Industrial Way / Finch Avenue when a truck struck a person walking along the side of the highway.

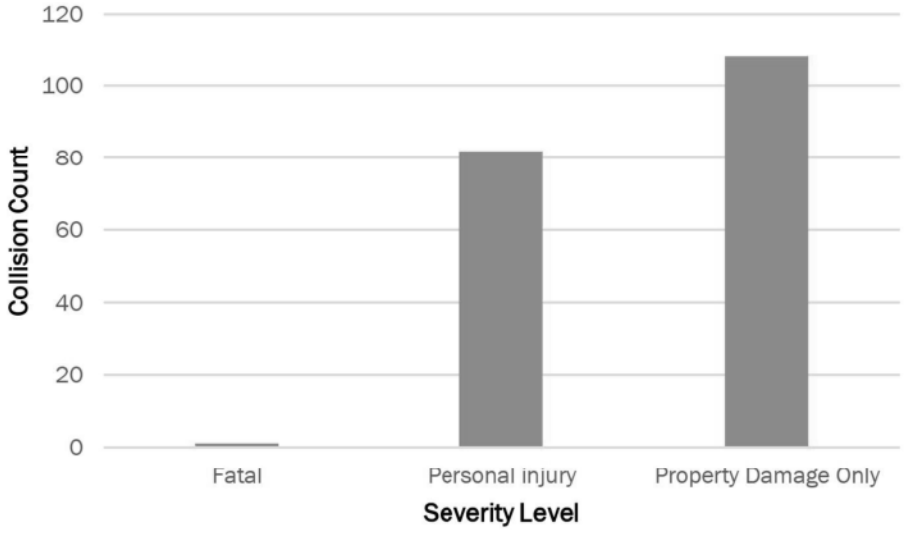

Figure 2.11: Distribution of Collision Severity Levels

The severity level of recorded collisions in are shown in ***Figure 2.12*** below. As shown, rear-end collision are overwhelmingly the most common type of collision, accounting for 41% of all collisions.

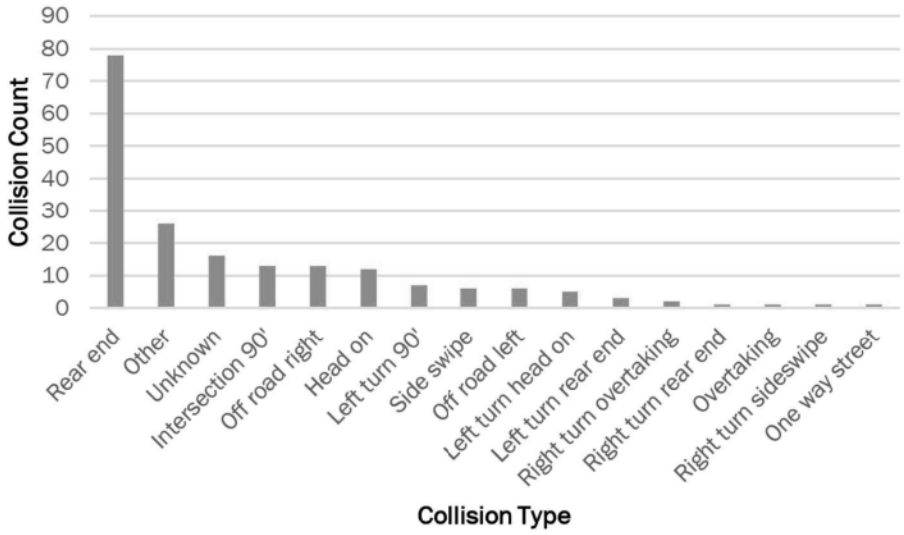

Figure 2.12: Distribution of Collision Types

A heatmap showing collision frequency along different segments of the corridor is provided in ***Figure 2.13***. As shown, collisions trends to be clustered near signalized intersections along the corridor, with the Cleveland Avenue / Loggers Lane and Mamquam Road intersections having the highest collision frequencies.

Further information regarding total collisions, collision rates and collision severities, including comparisons to provincial average rates for comparable facilities, are provided in Section 5.4.

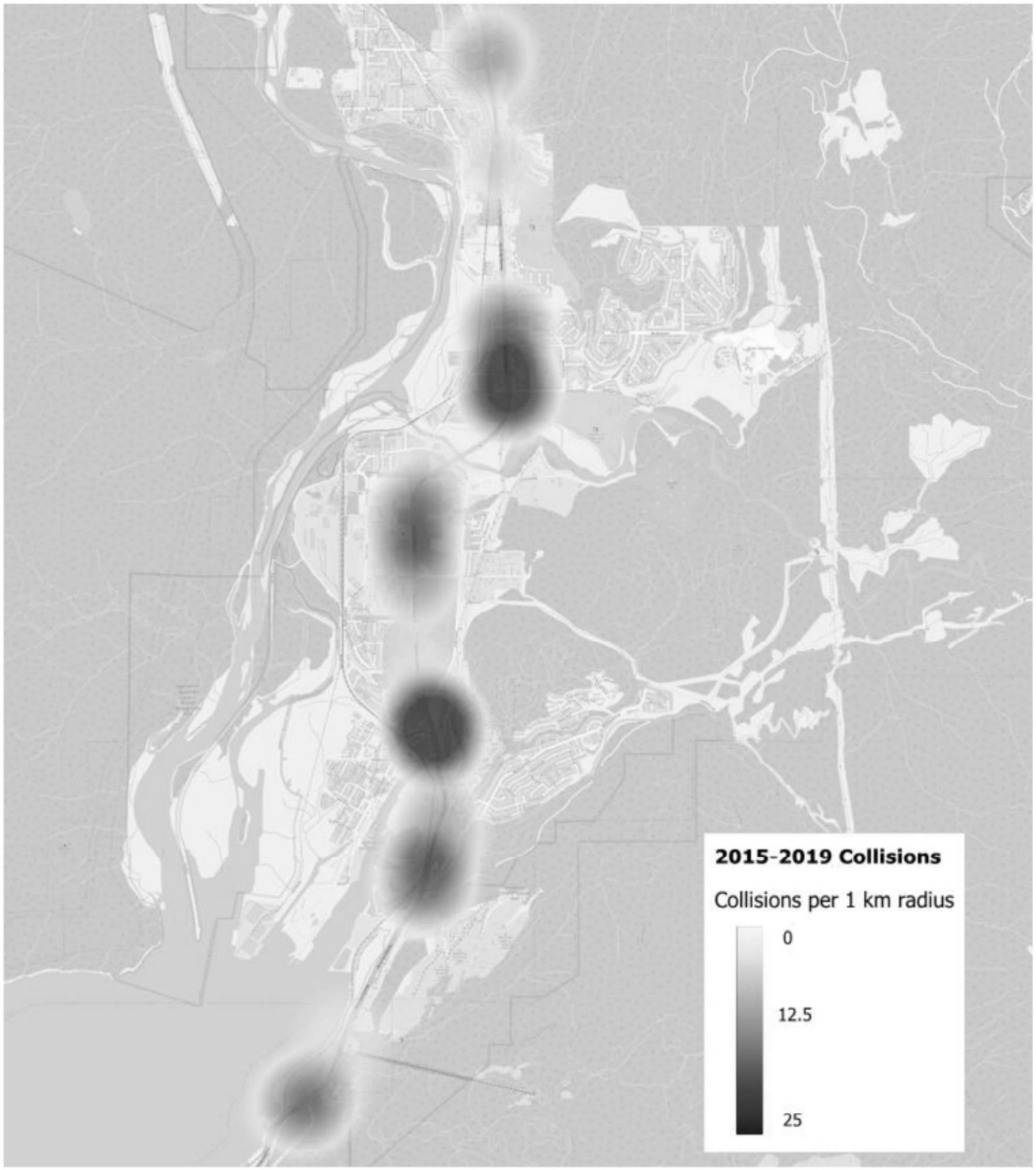

Figure 2.13: Distribution of Collision Frequency on Study Corridor

2.1.7 Transit Services

Transit within the District of Squamish is provided by the Squamish Transit System which is in turn provided by BC Transit. The route map for the Squamish Transit System is shown in ***Figure 2.14***.

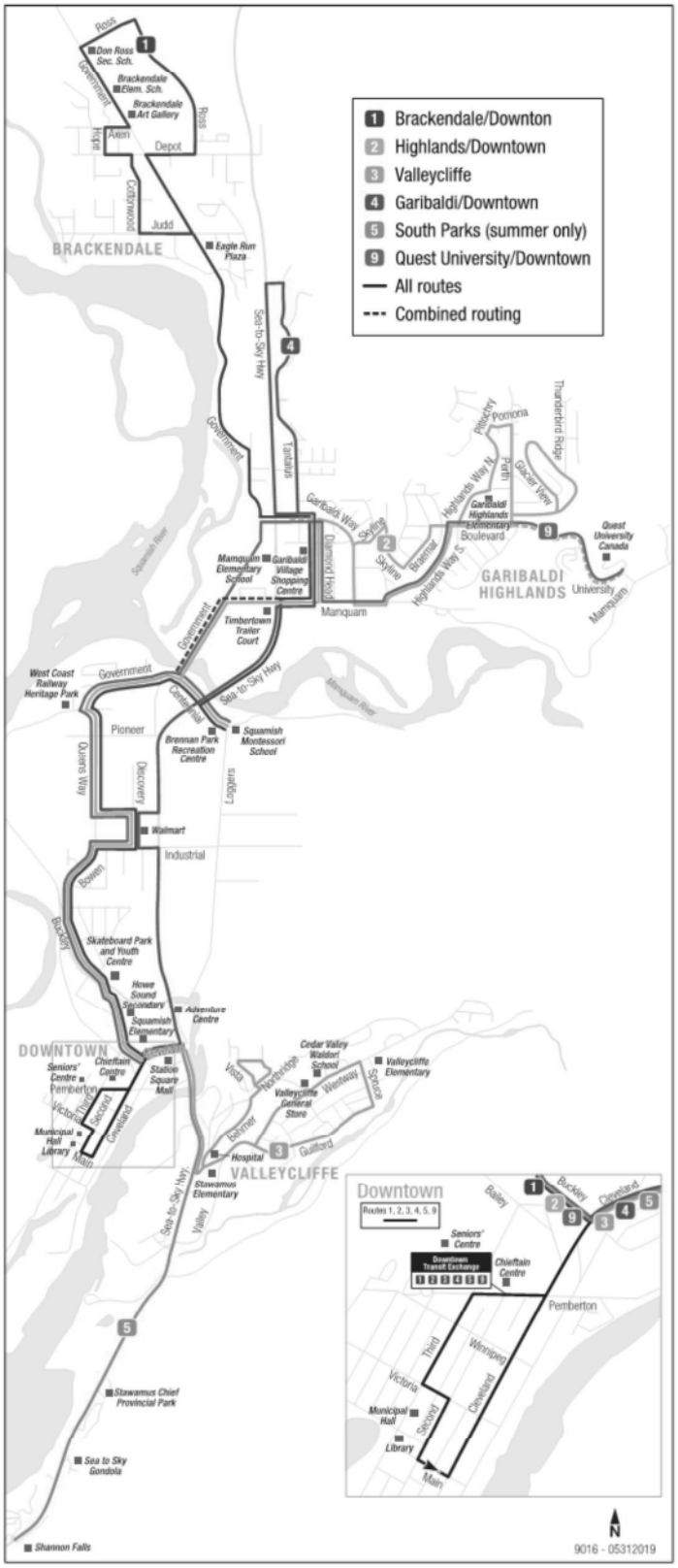

Figure 2.14: Squamish Transit System Route Map

As one of only two continuous north-south routes through Squamish, Highway 99 is heavily relied-upon by the Squamish Transit System. Of the six bus routes in the transit system, four (Routes 1 ,3, 4 and 5) travel along the highway corridor for part of their route length, and therefore these services will be affected by traffic operations on the highway. Collectively, transit service operations along much of the roughly 10 kilometres of Highway 99 between Darrell Bay Road and Dowad Drive, with the exception of two short segments of the corridor: ne segment between Industrial Way / Finch Drive and Commercial Way (where Discovery Way is used instead); and other segment between Mamquam Drive and Garibaldi Way (where Diamond Head Road is used instead). While these services operate along the highway, there are no stop facilities on the highway itself and as a result none of these routes stop along the highway.

Although other two routes in the Squamish Transit System (Routes 2 and 9) do not run along the highway corridor, they do cross the highway and therefore are still directly affected by traffic operations at intersections with the highway.

Although automobile trips make up the majority of travel within Squamish, according to the 2016 Census of Canada 3% of residents use transit for their journey to a regular place of work.

2.1.8 Active Transportation

Although automobile trips make up the majority of travel within Squamish, according to the 2016 Census of Canada, roughly 11% of residents use active modes (7% walking, and 4% cycling) for their journey to a regular place of work. Although no specific mode share data is available for other types of trips, walking and cycling are also popular modes for other forms of transportation trips, as well as recreational trips.

Currently, there are several active transportation facilities along the Highway 99 corridor:

- The Highway 99 corridor itself permits shoulder cycling along the entire length of the corridor through Squamish.
- The Corridor Trail runs north-south through most of the Squamish urban area, and for much of its route is located on the east side of the highway. Specifically, towards the south end of Squamish the trail runs immediately adjacent to the highway between the Valley Drive intersection and the Cleveland Avenue / Loggers Lane intersection. The path rejoins the highway corridor at the Centennial Way interchange, where it runs alongside the east side of the highway until Tantalus Way. The District of Squamish *Active Transportation Plan* identifies an opportunity to extend the trail south from its current southern terminus at Valley Drive to the Stawamus Chief Provincial Park; such an extension would introduce two new crossings of the highway at Valley Drive and the Mamquam River Forest Service Road.
- The Discovery Trail runs north-south along the west side of the highway in the vicinity of the Industrial Way / Finch Avenue and Commercial Way intersections. The trail crosses Industrial Way and Commercial Way at the west leg of these two roads' intersection with the highway.
- As adjacent land uses are typically set back from the highway, there are few sidewalks running along the study corridor, with the following exceptions:
    - Where watercourses create natural barriers to north-south active transportation movements (i.e. the Stawamus River near the Mamquam River FSR intersection, the Mamquam Blind Channel near the Cleveland Avenue / Loggers Lane intersection, and the Mamquam River near

the Centennial Way interchange) the highway bridges over these watercourses provide active transportation connectivity across these water courses. At the Stawamus River this consists of a sidewalk on the east side of the bridge structure, while at the Mamquam Blind Channel and Mamquam River this consists of a multi-use path connection on the east side of the bridge structure(s) and a sidewalk on the west side.

- There are short segments of sidewalk in the vicinity of the Cleveland Avenue / Loggers Lane intersection.

Active transportation users can cross the highway at all signalized intersections along the corridor. In many cases crossing opportunities are provided at all legs of the intersection, with the following exceptions:

- At Darrell Bay Road, there are no pedestrian crossings at the south and east legs of the intersection. However, there is no destination at the southeast quadrant of the intersection.
- At Clarke Drive, there are no pedestrian crossings at the south and west legs of the intersection. However, the west leg of the intersection consists of a new bridge structure over the CN railway corridor which does not include a sidewalk on the south side of the structure, and therefore there is no destination at the southwest quadrant of the intersection.
- At Commercial Way, there is no pedestrian crossing at the north leg of the intersection, although the south leg provides a crossing. However, Commercial Way is a T-intersection with no obvious destination on the east side of the highway.

In addition to the signalized intersections, there are several other opportunities for active transportation users to cross the highway corridor:

- A pedestrian bridge near the Stawamus Chief parking lot;
- A pedestrian bridge just north of the Valley Drive intersection;
- A pedestrian underpass beneath the north end of the bridge over the Mamquam Blind Channel;
- The Sea to Sky Connector Trail along Centennial Way, which passes underneath the highway just south of the Mamquam River; and,
- A pedestrian bridge structure at Diamond Road, roughly halfway between Mamquam Road and Garibaldi Way.

A map of existing cycling facilities within the District of Squamish, extracted from the municipal *Active Transportation Plan*, and which identifies many of the facilities noted above is provided in ***Figure 2.15***.

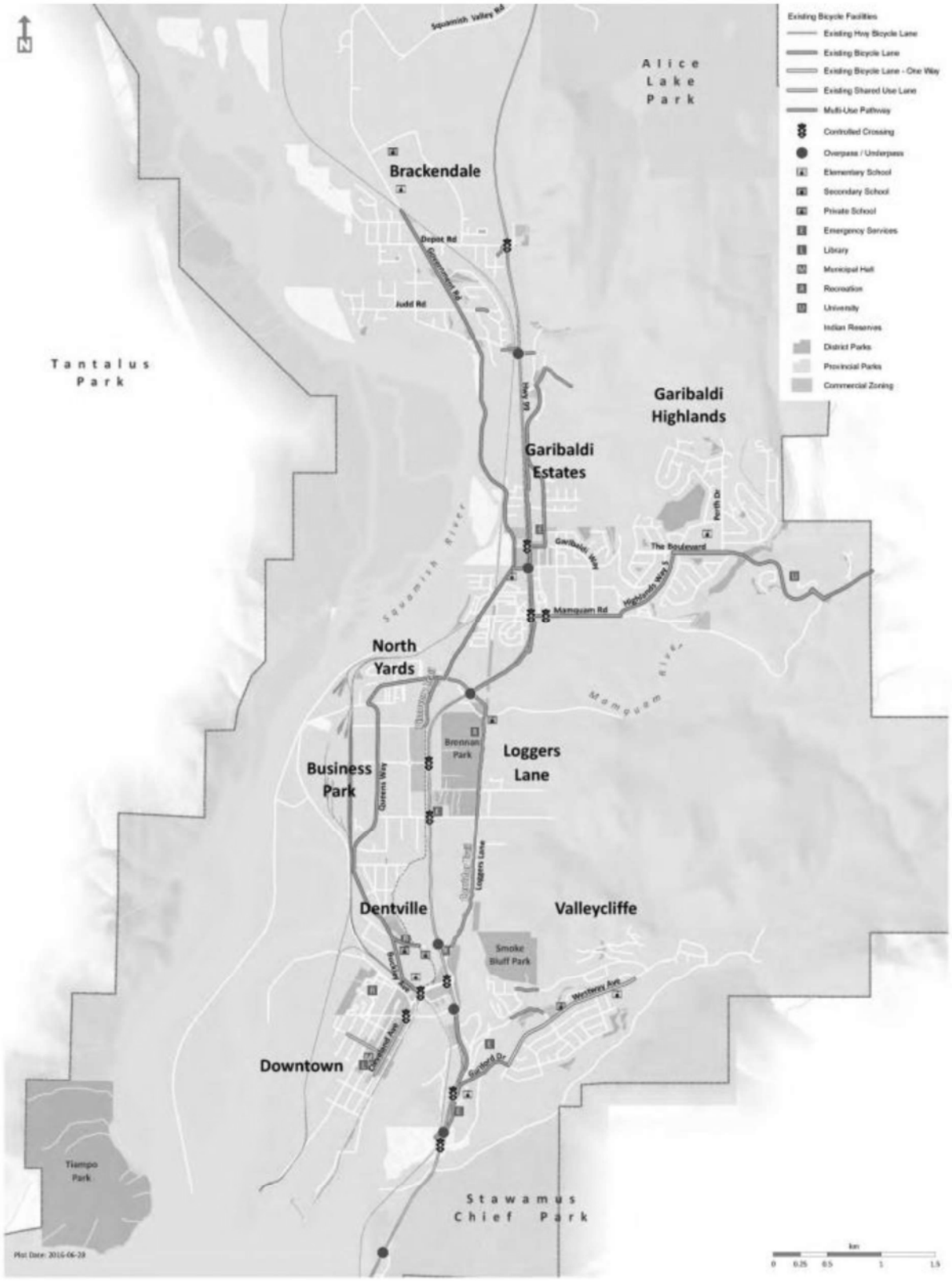

Figure 2.15: Existing Cycling Facilities in Squamish

2.1.9 Population Growth

In the 1990's and early 2000's Squamish was a relatively slow-growing community. However, beginning in the late 2000's (and roughly coinciding with the completion of the Sea to Sky Highway Improvement Project) Squamish has seen a much stronger growth in population; a trend which is anticipated to continue into the future. Historic and projected population levels in Squamish are summarized in ***Figure 2.16***. Recent historic (i.e. 2016-2019) and projected population levels are based on information from BC Stats for the Squamish Community Health Service Area (area 3351). BC Stats did not begin reporting population at the Community Health Service Area level of disaggregation until 2016, and therefore information for Squamish is unavailable prior to that year. As an alternative, population levels for the District Municipality of Squamish from the 1996, 2001, 2006, 2011 and 2016 Census of Canada datasets are used. Population levels for the four years in between each Census have been estimated via linear interpolation. As the Squamish CHSA and Squamish District Municipality share the same (or at least very similar) boundaries, the discontinuity in population level in 2016 may reflect slightly different methodologies between the two data sources.

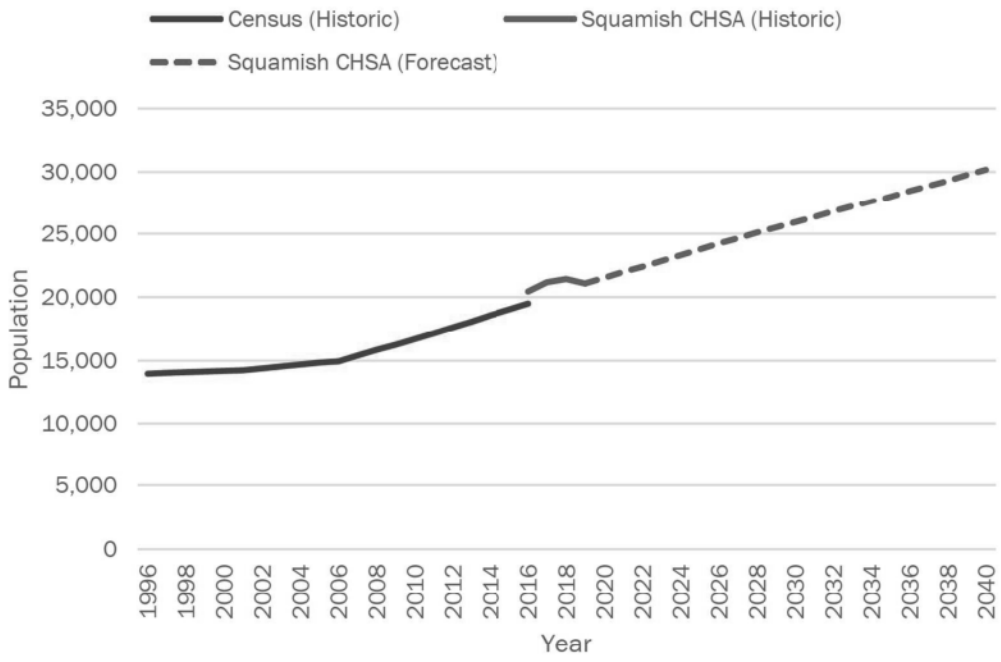

Figure 2.16: Squamish Historic and Projected Population Trends

Historic and forecast population growth rates are also provided in ***Table 2.7***. As shown, both the 20-year period between 1996 and 2016 and the 20-year period between 2020 and 2040 are anticipated to see a compound annual growth rate of 1.7%. However, it is noted that the historic trends encompass both a slower growth period between 1996 and the late 2000's, and a higher growth period between the late 2000's and 2016. Compound annual growth rates were not calculated for between 1996 and 2020 in order to avoid mixing data sources and introducing a confounding factor in the form of the population level discontinuity in 2016.

Table 2.7: Squamish Historic and Projected Population Growth Rates

Timeframe	Squamish
Historic Population Growth (Census)	
1996	13,944
2016	19,512
Historic C.A.G.R.	1.7%
Forecast Population Growth (BC Stats)	
2020	21,563
2040	30,155
Forecast C.A.G.R.	1.7%

2.1.10 Land Use and Development

Development in Squamish is guided by the municipality's Official Community Plan (OCP). The current version of the OCP was adopted in 2018, and will guide the development of the community until 2040. Key objectives of the OCP that relate to the current study include:

- The design of complete, compact and connected neighbourhoods to support walking, cycling and the use of public transit for improved health outcomes.
- Growing local employment to reduce or eliminate commuting.
- Improving, along with partners, regional multi-modal transportation options and undertake long-range transportation planning within the Sea to Sky Corridor and beyond to address cumulative growth impacts and manage congestion within the corridor.

Notably, the OCP recommends work with BC MoTI to review any future proposed capacity improvements and / or widening of Highway 99. The OCP does not support the expansion of Highway 99 beyond four lanes within the municipal boundaries, but does identify the need to work with BC MoTI to address highway crossing issues and optimize signalized intersections for safe east / west connectivity across Highway 99.

Given that the OCP extends until 2040, this year is also used for the study future conditions analysis horizon year.

2.2 Existing Conditions Analysis Hour Volumes

As described above in Section 2.2.1, the following peak hour periods are to be assessed for this study:

- Summertime Saturdays from 12:00-13:00 (the northbound peak hour); and,
- Summertime Sundays from 16:00-17:00 (the southbound peak hour).

The loop detector turning movement counts collected in Fall 2020 (described previously in Section 2.2.2) were the starting point for developing analysis hour volumes; however several adjustment factors are required.

The first adjustment relates to seasonal volume fluctuations. Historic data from the Cheekye permanent count station was used to factor these fall volumes to summer volumes; the corresponding seasonality adjustment factors are summarized in ***Table 2.8***.

Table 2.8: Fall-to-Summer Seasonality Adjustment Factors

Fall to Summer Conversion Factor	Saturday (12:00-13:00)	Sunday (16:00-17:00)
2016-2019 Average Hourly Summer Volumes	4,889	5,236
2016-2019 Average Hourly Fall Volumes	3,542	4,026
Seasonality Adjustment Factor	1.38	1.30

The second adjustment relates to filtering out the impacts of COVID-19 in order to estimate what volumes would have been observed in summer 2020 had the COVID-19 not occurred. Historic data from the Cheekye permanent count station was used to compare differences in volumes between 2019 and 2020 against average year-over-year growth rates between 2016-2019. The resultant adjustment factors are shown in ***Table 2.9***.

Table 2.9: Filtering of COVID-19 Effects Adjustment Factors

Historic Growth	Saturday (12:00-13:00)	Sunday (16:00-17:00)
2016-2019 Average Growth	1.0%	0.2%
2019-2020 Change	-3.4%	1.3%
Adjustment Factor for "Would Be" Volumes Without COVID	1.04	0.99

As shown, data from the Cheekye permanent count station suggests that volumes in summer 2020 were relatively similar to what they would likely otherwise have been had the pandemic not occurred. It is noted that the summer 2020 period for which volume data is being assessed corresponds to a period between the first wave (spring 2020) and the second wave (fall 2020), and therefore was more likely to see somewhat smaller changes to travel volumes that the spring or fall.

With these two factors applied, the fall 2020 volumes were converted to estimate summer 2020 under a scenario in which the COVID-19 pandemic had not occurred.

Turning movement count data is only available at the nine signalized intersections along the corridor. However, in addition to these intersections there are several other unsignalized intersections and major accesses along the corridor:

- Sea to Sky Gondola Parking Lot
- Stawamus Chief Parking Lot
- Mamquam River Forest Service Road
- Mill Road
- Scott Crescent

- Centennial Way
- Dowad Drive

Two primary techniques were applied to estimate volumes at these unsignalized intersections and accesses for which no data is available:

- Where an access services a relatively small catchment area, trip generation rates from the Institute of Transportation Engineers *Trip Generation Manual, 10th Edition* were applied to estimate trips in and out to any land uses in the catchment area. Reflecting the analysis period, these trip rates were Saturday and Sunday peak hour trip rates rather than the more typical weekday AM and PM peak hour trip rates.
- In some cases, engineering judgement was applied to estimate volumes, with a focus on ensuring balanced volumes between upstream and downstream intersections (i.e. no vehicles "appearing" or "disappearing" from the highway on segments where there are not entries or exits).
- Adjustments were also made to the Industrial Way / Finch Avenue turning movement count. As noted previously, volumes at this intersection were recorded in January (generally a higher volume time of year in Squamish) rather than November (generally a lower volume time of year in Squamish).

The resultant volumes for the summer 2020 analysis hours are provided in ***Table 2.10***.

Table 2.10: Existing (Summer 2020) Intersection Turning Movement Count Volumes

Intersection	Control	Analysis Period	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Darrell Bay Road	4 leg: signalized	Saturday 12:00	3	832	32	866	19	683	4	706	23	6	4	33	23	6	49	78	1,683
		Sunday 16:00	4	480	8	491	4	797	6	807	13	3	6	22	12	4	12	27	1,347
Sea to Sky Gondola Parking	3-leg: RIRO	Saturday 12:00	-	874	30	904	-	784	-	784	-	-	-	-	-	-	30	30	1,718
		Sunday 16:00	-	484	20	504	-	834	-	834	-	-	-	-	-	-	40	40	1,378
Stawamus Chief Parking	3-leg: Protected-T	Saturday 12:00	-	884	20	904	20	774	-	794	-	-	-	-	10	-	50	60	1,758
		Sunday 16:00	-	509	15	524	5	829	-	834	-	-	-	-	5	-	30	35	1,393
Mamquam River FSR	4 leg: TWSC	Saturday 12:00	3	929	3	935	5	788	5	798	4	-	4	8	2	-	2	4	1,746
		Sunday 16:00	3	539	3	545	5	828	5	838	4	-	4	8	2	-	2	4	1,395
Valley Drive	4-leg: signal	Saturday 12:00	3	879	53	935	40	758	12	810	16	12	1	29	39	3	58	99	1,874
		Sunday 16:00	5	478	62	545	22	810	13	845	9	6	-	15	28	-	35	63	1,468
Clarke Drive	4-leg: signal	Saturday 12:00	16	896	29	941	425	713	19	1,157	22	7	19	47	59	1	414	474	2,620
		Sunday 16:00	9	501	14	525	306	834	23	1,164	28	3	5	36	37	6	226	270	1,994
Mill Road	3-leg: Protected-T	Saturday 12:00	10	1,322	-	1,332	-	1,143	10	1,153	29	-	14	43	-	-	-	-	2,528
		Sunday 16:00	19	737	-	756	-	1,154	9	1,162	10	-	10	20	-	-	-	-	1,938
Scott Crescent	3-leg: RIRO	Saturday 12:00	-	1,348	2	1,350	-	1,153	-	1,153	-	-	-	-	-	-	5	5	2,508
		Sunday 16:00	-	745	2	747	-	1,162	-	1,162	-	-	-	-	-	-	5	5	1,914
Cleveland Avenue	4-leg: signal	Saturday 12:00	455	843	55	1,353	20	721	617	1,358	657	98	395	1,150	37	88	9	134	3,995
		Sunday 16:00	261	462	27	750	15	833	390	1,238	359	55	300	714	30	39	8	76	2,777
Industrial Way / Finch Avenue	4-leg: signal	Saturday 12:00	244	1,248	16	1,509	18	1,140	201	1,359	242	45	201	488	16	52	16	84	3,440
		Sunday 16:00	108	707	14	829	11	997	81	1,089	81	13	230	324	12	24	14	50	2,292
Commercial Way	4-leg: signal	Saturday 12:00	65	1,441	-	1,506	-	1,232	369	1,601	297	-	127	424	-	-	-	-	3,531
		Sunday 16:00	55	753	-	809	-	1,005	190	1,196	190	-	84	274	-	-	-	-	2,278
Centennial Way Interchange	Split Diamond Interchange	Saturday 12:00	-	1,718	20	1,738	-	1,550	40	1,590	-	-	52	52	-	-	49	49	3,428
		Sunday 16:00	-	904	40	944	-	1,125	80	1,205	-	-	71	71	-	-	82	82	2,302
Mamquam Road	4-leg: signal	Saturday 12:00	66	1,124	577	1,767	81	886	36	1,003	58	124	48	229	656	169	135	960	3,959
		Sunday 16:00	53	559	374	986	58	759	41	858	33	69	41	144	405	138	96	639	2,627
Garibaldi Village Mall Access	RI only	Saturday 12:00	0	1098	219	1,317	0	1022	0	1,022	0	0	0	-	0	0	0	-	2,339
		Sunday 16:00	0	588	102	689	0	856	0	856	0	0	0	-	0	0	0	-	1,545
Garibaldi Way	4-leg: signal	Saturday 12:00	199	690	209	1,098	148	545	82	775	49	244	239	532	238	232	205	675	3,080
		Sunday 16:00	127	293	167	588	163	532	66	761	33	172	163	369	161	172	108	441	2,159
Dowad Drive	3-leg: RIRO	Saturday 12:00	-	914	30	944	-	775	-	775	-	-	-	-	-	-	27	27	1,747
		Sunday 16:00	-	408	26	435	-	783	-	783	-	-	-	-	-	-	20	20	1,238
Depot Road	4-leg: signal	Saturday 12:00	172	757	13	941	3	631	43	677	33	3	144	180	-	19	-	19	1,817
		Sunday 16:00	103	318	8	428	-	671	33	705	10	1	112	123	-	8	-	8	1,264

Finally, as will be described further in Section 5.4, road safety analysis requires the application of annual average daily traffic (AADT) volumes rather than peak hour volumes. Therefore, the Cheekye permanent count station was used to develop an adjustment factor to convert the sum of the summer Saturday 12:00-13:00 and summer Sunday 16:00-17:00 volumes to AADT. The conversion factor is summarized in ***Table 2.11***.

Table 2.11: Summer Saturday and Sunday Analysis Hour to AADT Adjustment Factor

(SumSat12+SumSun16) to AADT	Traffic Volume
Saturday 12:00	1,222
Sunday 16:00	1,309
AADT	11,576
Adjustment Factor	4.57

2.3 Future Horizon Year Analysis Hour Volumes

As described previously in Section 2.2.9, a 2040 horizon year is proposed for future conditions analysis. Over the next 20 years, volumes on Highway 99 may increase from two different sources:

- Additional trips generated by additional development within the District of Squamish (referred to herein as "Squamish-generated trips"). These trips will primarily consist of intra-Squamish trips, but will also include trips between Squamish and other communities (e.g. Metro Vancouver or Whistler).
- Additional growth in through trips (e.g. people travelling through Squamish on their way from Metro Vancouver to Whistler).

To forecast Squamish-generated trips, the District of Squamish Development Showcase map[1] was reviewed. The full list of development are provided in ***Appendix A***. For each development on the map the following key characteristics were recorded:

- Development type (residential, commercial, mixed use etc.);
- The size and scale (e.g. number of units and by type, square footage of commercial and industrial developments);
- Development area / neighbourhood;
- the likely intersection that any trips generated by this development would use to access Highway 99; and,
- current status (ranging from a sub-area plan in the OCP, to under construction).

For each of these developments, trip generation rates from the Institute of Transportation Engineers *Trip Generation Manual, 10th Edition* were applied to estimate trips in and out to any land uses in the catchment area. Reflecting the analysis period, these trip rates were Saturday and Sunday peak hour trip rates, although in some cases the absence of weekend trip rates required the use of weekday rates.

[1] https://maps.squamish.ca/mobile/?viewer=dsapps

Several adjustment factors were subsequently applied to these trip generation rates in order to estimate the proportion of generated trips that would end up interacting with Highway 99:

- Trips that are likely to never leave the site (i.e. internal trip capture). This consideration applies to major mixed use developments where results have access to retail and (in some cases) employment opportunities on-site.
- Trips that leave the development site, but remain on the local road network (or use sustainable transportation modes) and do not result in a vehicle trip that interacts with Highway 99.
- Trips that will cross Highway 99.
- Trips that will travel along Highway 99.

It total, the developments listed on the District of Squamish Development Showcase map include 7,983 additional residential dwelling units. As a "sanity check", growth projections from BC Stats were reviewed to consider whether all development is likely to proceed (i.e. some developments may be competing for the same new residents, and some developments may include a longer-term build-out that will extend beyond 20 years). Although BC Stats provides population growth forecasts at the Community Health Service Area level, it does not provide dwelling unit growth forecasts. However, both population and dwelling growth unit forecasts are available for Local Health Areas. Therefore, data for the Howe Sound Local Health Area was used to calculate an average new dwelling unit occupancy rate, which was then used to convert the forecast Squamish Community Health Service Area population growth to an estimated dwelling unit growth. The resultant conversion is shown in ***Table 2.12***.

Table 2.12: Calculation of Estimated Squamish Dwelling Unit Growth (2020 – 2040)

Category	Value
Howe Sound Local Health Area	
Forecast Population Growth (2020-2040)	16,694
Forecast Dwelling Unit Growth (2020-2040)	7,192
Calculated Average New Dwelling Unit Occupancy	2.32
Squamish Community Health Service Area	
Forecast Population Growth (2020-2040)	8,592
Calculated Dwelling Unit Growth (2020-2040)	3,702

Based on these projections, it is estimated that the District of Squamish will require 3,702 additional units of development to accommodate population growth between 2020 and 2040, which is 46% of the total number of dwelling units included in the Development Showcase map. Therefore, it was assumed that all developments that have either received a development permit, are in pre-construction or under construction would proceed, while the remainder of developments would have their development levels pro-rated, such that the total number of units assumed to be constructed and occupied by 2040 sums to approximately 3,700[2]. A comparison of the

[2] Based on the individual development assumptions, the analysis ultimately assumes 3,732 units would be implemented.

population increase forecasted by BC Stats versus the implied population increase if all 7,983 units in the Development Showcase map were built out by 2040 is provided in ***Figure 2.17***.

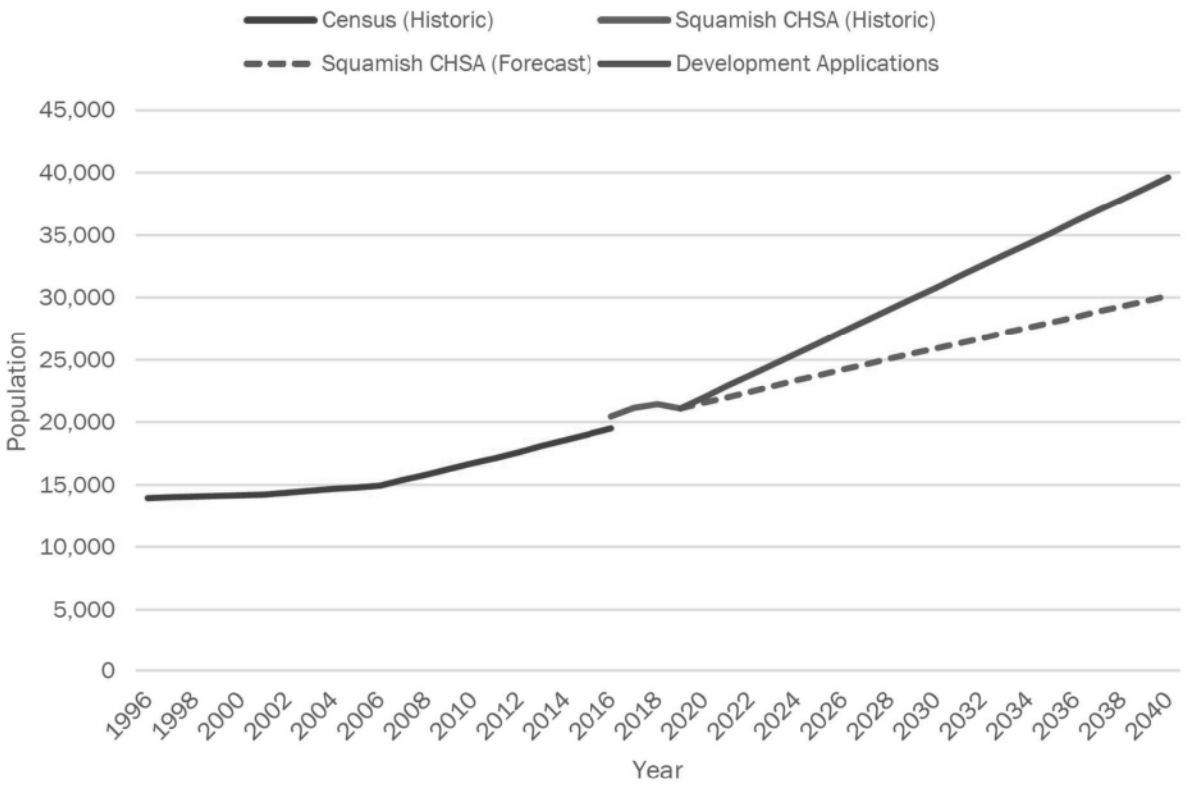

Figure 2.16: Squamish Historic and Projected Population Trends

BC stats does not provide forecasts for commercial or industrial development. Based on the assumption that much of this development will be "local-serving", it was similarly assumed that only 46% of this development would be implemented by 2040. The process for allocating which developments would be constructed and occupied by 2040 is the same as residential developments. Residential and commercial / industrial trips do not equally balance for either of the two peak hours (i.e. there is more / less total trip production than trip attraction); in these cases excess volumes were assumed to be travelling to / from Metro Vancouver (75%) Whistler (25%).

For through trips, based on recent (2016-2019) data from the Cheekye permanent count station suggests a growth rate of 0.2% for both the summer Saturday 12:00-13:00 and summer Sunday 16:00-17:00 periods. This low growth rate likely reflects upstream capacity constrains (i.e. the single-lane sections of Highway 99 travelling south from Whistler or north from Metro Vancouver). This growth rate of 0.2% was assumed to carry forward from 2020 to 2040, although it is noted that this assumption is sensitive to other improvement projects along the corridor (e.g. if the highway corridor were to be fully four-laned from Metro Vancouver to Squamish, then this growth rate would likely increase as upstream capacity constraints are eliminated).

The resultant summer 2040 analysis hour volumes are shown in ***Table 2.13***.

Table 2.13: Future (Summer 2040) Intersection Turning Movement Count Volumes

Intersection	Control	Analysis Period	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Darrell Bay Road	4 leg: signalized	Saturday 12:00	3	1,201	32	1,235	19	829	4	852	23	6	4	33	23	6	49	78	2,198
		Sunday 16:00	4	496	8	508	4	791	6	801	13	3	6	22	12	4	12	27	1,358
Sea to Sky Gondola Parking	3-leg: RIRO	Saturday 12:00	-	1,243	30	1,273	-	930	-	930	-	-	-	-	-	-	30	30	2,233
		Sunday 16:00	-	501	20	521	-	828	-	828	-	-	-	-	-	-	40	40	1,389
Stawamus Chief Parking	3-leg: Protected-T	Saturday 12:00	-	1,253	20	1,273	20	920	-	940	-	-	-	-	10	-	50	60	2,273
		Sunday 16:00	-	526	15	541	5	823	-	828	-	-	-	-	5	-	30	35	1,404
Mamquam River FSR	4 leg: TWSC	Saturday 12:00	3	1,298	3	1,304	5	934	5	944	4	-	4	8	2	-	2	4	2,260
		Sunday 16:00	3	556	3	562	5	822	5	832	4	-	4	8	2	-	2	4	1,406
Valley Drive	4-leg: signal	Saturday 12:00	3	1,248	53	1,304	40	904	12	956	16	12	1	29	39	3	58	99	2,388
		Sunday 16:00	5	495	62	562	22	804	13	838	9	6	-	15	28	-	35	63	1,479
Clarke Drive	4-leg: signal	Saturday 12:00	36	1,246	29	1,310	431	847	163	1,441	155	7	31	192	59	1	419	479	3,422
		Sunday 16:00	24	503	14	541	311	828	223	1,362	204	3	5	212	37	6	231	275	2,391
Mill Road	3-leg: Protected-T	Saturday 12:00	10	1,809	-	1,819	-	1,427	10	1,437	29	-	14	43	-	-	-	-	3,298
		Sunday 16:00	19	919	-	939	-	1,352	9	1,361	10	-	10	20	-	-	-	-	2,320
Scott Crescent	3-leg: RIRO	Saturday 12:00	-	1,801	36	1,837	-	1,437	-	1,437	-	-	-	-	-	-	39	39	3,313
		Sunday 16:00	-	890	39	929	-	1,361	-	1,361	-	-	-	-	-	-	29	29	2,319
Cleveland Avenue	4-leg: signal	Saturday 12:00	700	1,085	55	1,840	20	804	978	1,802	936	188	595	1,719	37	88	9	134	5,496
		Sunday 16:00	614	278	27	919	15	782	863	1,660	780	184	550	1,514	30	39	8	76	4,169
Industrial Way / Finch Avenue	4-leg: signal	Saturday 12:00	244	1,658	127	2,030	48	1,500	201	1,749	242	45	201	488	101	122	49	272	4,539
		Sunday 16:00	108	811	148	1,067	27	1,302	81	1,411	81	13	230	324	128	102	33	263	3,065
Commercial Way	4-leg: signal	Saturday 12:00	77	1,872	-	1,949	-	1,612	369	1,981	300	-	137	437	-	-	-	-	4,367
		Sunday 16:00	73	858	-	932	-	1,322	190	1,512	200	-	89	289	-	-	-	-	2,733
Centennial Way Interchange	Split Diamond Interchange	Saturday 12:00	-	2,116	56	2,172	2	1,900	40	1,942	-	-	81	81	-	-	53	53	4,248
		Sunday 16:00	-	978	81	1,059	2	1,412	80	1,494	-	-	100	100	-	-	87	87	2,740
Mamquam Road	4-leg: signal	Saturday 12:00	66	1,452	651	2,169	85	1,172	36	1,293	58	124	48	229	723	169	135	1,027	4,718
		Sunday 16:00	53	568	444	1,065	58	985	41	1,084	33	69	41	144	468	138	96	702	2,995
Garibaldi Village Mall Access	RI only	Saturday 12:00	0	1426	219	1,645	0	1311	0	1,311	0	0	0	-	0	0	0	-	2,957
		Sunday 16:00	-	596	102	698	-	1,083	-	1,083	-	-	-	-	-	-	-	-	1,781
Garibaldi Way	4-leg: signal	Saturday 12:00	202	993	231	1,426	148	790	82	1,021	49	244	242	535	279	232	205	716	3,698
		Sunday 16:00	130	279	187	596	164	718	66	948	33	172	165	371	200	172	108	480	2,395
Dowad Drive	3-leg: RIRO	Saturday 12:00	-	1,192	55	1,247	-	1,021	-	1,021	-	-	-	-	-	-	27	27	2,295
		Sunday 16:00	-	370	50	420	-	970	-	970	-	-	-	-	-	-	20	20	1,410
Depot Road	4-leg: signal	Saturday 12:00	361	846	13	1,219	3	703	53	759	33	3	318	354	-	19	-	19	2,351
		Sunday 16:00	289	93	8	390	-	695	43	738	10	1	275	286	-	8	-	8	1,422

3. INPUT FROM SITE REVIEW AND STUDY PARTNERS

In addition to a review of previous reports and a technical analysis of multi-modal mobility and safety, potential issues were also identified through a site visit with local BC MoTI staff and engagement with study stakeholders. A summary of this feedback is provided in ***Table 3.1***, and includes both broader corridor-level or network / regional level considerations, as well as issues at specific locations along the corridor (organized in a south-to-north sequences).

Table 3.1: Summary of Issues and Challenges Identified Through Site Review and Engagement

Location	Feedback Type	Description
Network Wide	Network Connectivity	There is a challenge with through-traffic rat-running on local streets during congested conditions on the highway.
Corridor–Wide	Traffic Operations, Road Safety	Acceleration lanes on the highway are provided inconsistently, resulting in a variety of yield and accelerate / merge configurations. Design consistency could improve efficiency and safety of operations.
	Active Transportation, Road Safety	Multi-use trail crossings of the at highway offramps / right turn lanes can feel unsafe. Potential improvement opportunities could involve improved lighting, markings and / or signage to ensure people driving are more aware of people walking and cycling.
	Transit	There is a desire for an inter-city transit service on Highway 99, which could include stops along the highway corridor itself (e.g. at Garibaldi Village Mall).
Darrel Bay Road	Traffic Operations	Overflow parking for the Sea to Sky Gondola is provided here. Although a shuttle is provided, many people will choose to walk to the base of the Gondola via the Shannon Falls trail network. These people will cross Highway 99 at the Darrell Bay Road signalized intersection and therefore when there the overflow parking lot is in use the pedestrian signal is constantly triggered at the Darrell Bay Road intersection, which can in turn reduce green time for north-south movements on the highway.
		s.13
	Traffic Operations, Land Use	
	Traffic Operations, Road Safety	Lots of U-Turns and other illegal movements relating to Sea to Sky Gondola access have been observed at this intersection.
Between Darrell Bay Road and Sea to Sky Gondola	Traffic Operations	Consider whether there is a potential opportunity for a mini-interchange or underpass (similar to Centennial Way)

Location	Feedback Type	Description
Sea to Sky Gondola	Traffic Operations	The facility operator has requested to extend the northbound right turn deceleration lane into their parking lot. However, queues for the parking lot generally don't back up onto the highway.
		The facility operator has requested a signal at their parking lot.
Stawamus Chief Parking Lot	Traffic Operations	Since the Stawamus Chief parking lot access provides a Protected-T intersection that enables access to southbound movements on the highway, the roundabout within the parking lot is a common turn-around route for Sea to Sky Gondola visitors who whish to travel south (e.g. back to Metro Vancouver).
Mamquam River Forest Service Road (FSR)	Traffic Operations, Road Safety	The west leg of the Mamquam River FSR is a private road that leads to a log sort owned as fee-simple land by Squamish Nation. MacMillan Bloedel has a permit to run unlicensed logging trucks cross the highway between the Mamquam River FSR logging areas to the east and the log sort to the west. This can be a challenging connection due to both traffic volumes on the highway as well as sightlines. With respect to the latter challenge, in the southbound direction on the highway, the vertical crest at the bridge over the Stawamus River creates challenges with respect to sightlines between southbound vehicles on the highway and vehicles queued at the west leg of the Mamquam River FSR intersection who are intending to make a through-movement or a turn onto the highway. Many of these vehicles at the west leg of the intersection are trucks who are departing the nearby log sort. To mitigate the sightline issue, at the west leg of the Mamquam River FSR intersection there are loops to detect a truck waiting to cross or turn onto the highway. When the loops detect a truck, a warning flasher just downstream of the Valley Drive intersection is activated. However, the trucks do not always stop on the loops (and therefore do not active the loops).
		Due to this intersection being with a private road, it is not built to the same standard as other intersection. For example, there are only painted right turn channelization islands rather than raised concrete islands.
	Traffic Operations, Land Use	There is a private property parcel located on the west side of the intersection between the highway and the log sort. This site could potentially redevelop in the future.
		The east leg of this intersection is a common turn-around route for Sea to Sky Gondola visitors who whish to travel south (e.g. back to Metro Vancouver). s.13 Visitors departing this facility could have challenges accessing the southbound direction on the highway during busy periods (e.g. Sunday afternoons) due to a lack of gaps in the highway traffic stream. An idea was developed to force this traffic to make a northbound right (although MacMillan Bloedel logging trucks would still need to pass straight through the intersection). A protected-T intersection has also been considered, but would similarly create challenges with respect to through-movements by logging tracks. There is also an alternate route out of the area via Westway Avenue. On the east side of the intersection (i.e. not at the intersection with the highway itself), there is also an idea to provide a roundabout to help facilitate the turn-

Location	Feedback Type	Description
		around movements for Sea to Sky Gondola visitors looking to travel south (e.g. back to Metro Vancouver).
Valley Drive / Chief Billy Drive	Traffic Operations	The east leg of this intersection is a common turn-around route for Sea to Sky Gondola visitors who whish to travel south (e.g. back to Metro Vancouver).
		The railway corridor is immediately adjacent to the intersection, and train movements through this at-grade rail crossing can create vehicle stacking issues at this intersection. Currently this is not a major challenge as train volumes are relatively low, but could become more of a concern if there were to be additional railway activity along the corridor in the future.
	Transit	Transit vehicles leave the highway to service Totem Hall; turnaround operations on Chief Billy Drive can be a challenge.
Clarke Drive	Traffic Operations, Land Use	Intersection was recently converted to a four-leg intersection with a new bridge over the railway corridor. The at-grade rail crossing at Mill Road was closed in conjunction.
		s.13
		The Squamish General Hospital and Fire Hall 1 are both accessed via the east side of Clarke Drive, and therefore emergency access is important in this location.
		There is lots of growth potential for further development in the Valleycliffe / Northridge area that would access the highway via Clark Drive.
Mill Road	Traffic Operations, Land Use	s.13
Scott Crescent	Active Transportation	This section of the Corridor Trail has a pinch point near the Scott Crescent intersection. Trail widening is desired, but would require bluff scaling.
	Traffic Operations, Land Use	s.13
Cleveland Avenue	Traffic Operations	No observed issues with double northbound left turn capacity; storage capacity is adequate in terms of managing queues.
	Traffic Operations, Road Safety	The current eastbound right turn movement is a yield condition rather than providing an acceleration lane. This intersection has the highest collision frequency on the Sea to Sky Highway corridor. A project is underway to provide an acceleration lane here, which will require the northern boundary of the 60km/h posted speed limit section to be extended to roughly the Squamish Adventure Centre.

Location	Feedback Type	Description
	Active Transportation, Traffic Operations, Road Safety	The current signal timing provides very little green time for westbound through-movements from Loggers Lane unless the pedestrian signal is activated. The pedestrian crossing time is also relatively short.
Industrial Way / Finch Avenue	Traffic Operations	Operations are pretty good right now; no major concerns.
	Active Transportation	The Discovery Trail on the west side of the highway has a natural desire line to cross Industrial Way just west of the intersection with Highway 99. Upgrades currently being implemented to enable this trail to cross at west leg of intersection.
Commercial Way	Traffic Operations	Operations are pretty good right now; no major concerns.
	Active Transportation	The Discovery Trail on the west side of the highway has a natural desire line to cross Commercial Way just west of the intersection with Highway 99. Upgrades similar to those at Industrial Way / Finch Avenue intersection (see below) planned for implementation, which will enable this trail to cross at west leg of intersection.
West side of Highway 99 between Commercial Way and Pioneer Street	Network Connectivity	Potential opportunity to upgrade the Old 99 Hwy connection and provide another route through this area.
	Land Use	s.13
Centennial Way	Traffic Operations	Some road users who are accessing the highway at this interchange do not take advantage of the available acceleration lanes / onramps and instead wait for a gap in the traffic stream (i.e. treat the intersection as a yield configuration).
		In general, local BC MoTI staff felt this interchange works well and provided a potential precedent approach to address traffic operations at other locations along the corridor.
Mamquam Road	Traffic Operations	Similar to Garibaldi Way, there is currently limited storage for westbound left turn movements. There is interest in converting the existing westbound through lane to a shared westbound left / through lane to increase westbound left turn capacity.
		The Mamquam Road / Glenalder Place signalized intersection is located only 135 metres east of the highway. At times, eastbound left turn queues at that intersection can spill back beyond the available storage length, which blocks eastbound through traffic on Mamquam Road, which can in turn cause queue spillbacks that can affect operations at the Highway 99 / Mamquam Road intersection.
	Traffic Operations, Active Transportation	Active transportation improvements are planned along Mamquam Road in 2021.
Northbound right-turn into Garibaldi Village Mall	Traffic Operations, Active Transportation	No concerns have been noted with respect to the northbound right-in into the Garibaldi Village Mall in terms of traffic operations or conflicts with active transportation users.
Garibaldi Way	Traffic Operations	There is currently limited storage for westbound left turn movements. There is interest in converting the existing westbound through lane to a shared westbound left / through lane to increase westbound left turn capacity.

Location	Feedback Type	Description
		Improved coordination with the Garibaldi Way / Tantalus Road intersection could also improve operations.
	Traffic Operations, Road Safety	A westbound right turn acceleration lane is missing for northbound travel on the highway. Provision of an acceleration lane would require additional right-of-way. There was an attempt several years ago to negotiate with the developer of the adjacent condominium building, but this did not prove successful. As the building is now occupied, negotiations would need to be undertaken with the strata council instead. In addition to being a traffic operations consideration at this location in particular, the lack of acceleration lanes also results in an inconsistent design treatment along the length of the corridor.
	Active Transportation, Road Safety	There are painted bicycle lanes on Garibaldi Way on either side of the intersection. At the intersection, the painted bicycle lanes direct people cycling to the pedestrian crosswalks of the channelized right turn lanes. Some cyclists make "cross like a pedestrian" manoeuvres while others may weave across the right turn lane and wait in the shoulder area on the island. Improvements to the treatment are currently being investigated. It was also noted that the existing pedestrian refuge islands are often too small to accommodate bicycles, particularly multiple bicycles or larger wheelbase bicycles (e.g. cargo bikes or bicycles pulling a trailer). Although it is anticipated that any new infrastructure would be built to a higher standard, at this point in time there are no plans to retrofit existing facilities. Note that this consideration was raised in the context of the Garibaldi Way intersection, but could also apply to other intersections along the corridor.
Dowad Drive	Traffic Operations, Network Connectivity	A right-in / right-out was recently build at Dowad Drive, which is what BC MoTI agreed to at the time that nearby development proceeded. Notwithstanding this agreement, it is anticipated that there will be strong interest from the municipality and / or developers to provide a full-movement intersection of Highway 99 and Dowad Drive in the future. However, local BC MoTI staff are concerned about impacts to corridor operations and travel times, and are interested in opportunities to improve connectivity without introducing a signal.
East side of Highway 99 between Dowad Drive and Depot Road	Network Connectivity	There have been discussions in the past about extending Tantalus Road further north through the "Cheema Lands" to connect to Depot Road. At the moment such a connection seems unlikely.
Depot Road	Traffic Operations	There is a long stretch of single-lane southbound highway leading into Squamish, although the cross-section widens out to two southbound lanes prior to Depot Road. The southbound direction at Depot Road also has dedicated southbound left turn and right turn lanes. However, this is the first signal in the southbound direction since the Chekamus Lake Road / Alpha Lake Road intersection in Whistler, and high vehicle volumes can cause extended queuing in the southbound direction. On busy days, queues can extend back towards Alice Lake Road.

4. TECHNICAL ASSESSMENT CRITERIA

In order to assess the performance of the highway, several assessment criteria were identified and grouped into the following four categories:

- Intersection-Level Operations
- Corridor-Level Operations
- Sustainable Transportation Modes
- Road Safety

A brief description of each assessment criteria is provided below in terms of the general methodology and data inputs.

4.1 Intersection-Level Operations

The performance of arterial roadway segments is often controlled by the capacity of major junctions along the length of the segment rather than the number of lanes on the highway corridor. Where the intersections are signalized, the volume and distribution of through and turning traffic, as well as safety and operational requirements can necessitate special signal phases, resulting in increased delays and reduced throughput.

Intersection operational analysis for the Highway 99 corridor through Squamish was undertaken using the intersection capacity modelling software Synchro version 10.0. The software uses key inputs such as peak hour intersection turning movements, traffic composition, lane geometry, and traffic signal timing parameters to estimate key outputs such as the average delay per vehicle per movement, the associated LOS, volume-to-capacity ratios, and the 50th and 95th percentile queue lengths.

Three metrics were developed to use outputs from Synchro to assess intersection operations along the corridor:

- Intersection Level of Service
- Volume-to-Capacity Ratio
- Queue Lengths

Each of these metrics are described in further detail below.

4.1.1 Level of Service

Control delay, measured in seconds per vehicle, has traditionally been translated into Level of Service letter-grade scoring ranging from A to F, which represents the quality of service experienced by the driver. These ratings are described below in ***Table 4.1*** for signalized intersections and unsignalized intersections:

Table 4.1: Intersection Level of Service

LOS	Control Delay (seconds/vehicle)	
	Signalized Intersection	Unsignalized Intersection
A	≤10	≤10
B	>10 and ≤20	>10 and ≤15
C	>20 and ≤35	>15 and ≤25
D	>35 and ≤55	>25 and ≤35
E	>55 and ≤80	>35 and ≤50
F	>80	>50

Control delays can be calculated at three levels of disaggregation: for each movement at an intersection, for each approach to the intersection, and for the overall intersection. This analysis will report on each level of disaggregation but will focus on individual intersection movements.

However, it is further noted that because the Level of Service ranking is measured on a per-vehicle basis, the letter-grade scoring does not differentiate between movements with high volumes of vehicles versus those with low volumes of vehicles.

Therefore, for the purpose of identifying key intersection movements along the study corridor where significant volumes of people are being affected by significant delays, critical thresholds have been developed to simultaneously consider both the highway movements specifically (i.e. northbound / southbound left-turn, through and right-turn movements) as well as the intersection as a whole. The resultant critical threshold metric is summarized in ***Table 4.2*** below.

Table 4.2: Level of Service Critical Threshold

Metric	Critical Threshold
Level of Service (Highway Movements)	Level of Service E
Level of Service (Other Movements, Overall Intersection)	Level of Service F

4.1.2 Volume to Capacity Ratio

Another quantitative measure of performance is the volume to capacity (v/c) ratio. Lower v/c ratios indicate low traffic density with extensive freedom to maneuver in the traffic stream. It also implies surplus green time is available on every signal cycle. Higher v/c ratios indicate high traffic density, restrictive movement, and limited or no surplus capacity. Some individual signal cycles may "fail" by not processing all of the waiting vehicles on the end of a red phase on the subsequent green phase. When v/c ratios fall between 0.90 and 1.00, there is little capacity available to accommodate day-to-day traffic fluctuations, and variations due to traffic composition, weather and construction, or unplanned incidents. Volume in excess of capacity implies that queues will continue to build until the approach flow rate falls below the processing capacity.

Similar to the Level of Service metric, critical thresholds have been developed to simultaneously consider both the volume to capacity ratio for each movement as well the number of vehicles on these movements. The resultant critical threshold metric is summarized in ***Table 4.3*** below.

Table 4.3: Volume-to-Capacity Ratio Critical Threshold

General Congestion Level	Threshold
V/C (Highway Movements)	0.85
V/C (Other Movements)	0.95

4.1.3 Queue Lengths

Queue lengths are calculated to represent the 50th and 95th percentile threshold (i.e. 50 or 95 out of 100 queue length observations would be at or below this length, respectively). Queue lengths are considered detrimental to the system when they spill into upstream intersections or block through-moving lanes, thereby limiting throughput for through movements. Additionally, due to the Highway 99 corridor through Squamish being a higher speed corridor with posted speed limits ranging from 60 km/h to 80 km/h, a certain proportion of the turning lanes act as a deceleration section, which allow for turning vehicles to decelerate without impacting through moving traffic. The applicable deceleration distances are approximately 40 metres for left turn lanes and 50 metres for right turn lanes. The resultant critical threshold metric is summarized in ***Table 4.4*** below.

Table 4.4: Queue Length Critical Threshold Summary

Metric	Critical Threshold
50th Percentile Queue Length	Exceeds designated storage capacity
95th Percentile Queue Length	Exceeds storage capacity and deceleration portion of turning lane

Note that in instances where two intersections are spaced closely together, the 50th Percentile Queue Length metric is also intended to capture queues of through-moving vehicles at a downstream intersection spilling back into the upstream intersection.

4.2 Corridor-Level Operations

Notwithstanding that, as noted above, traffic operations are controlled by the capacity of major junctions rather than the corridor itself, the corridor-focussed nature of this study necessitates an overall assessment of the corridor as a whole, including the highway's key role to provide through-movements, as well as to assess the overall operations. This approach ensures that each intersection is not considered solely in isolation, but also in the context of overall corridor mobility. Corridor-level metrics are available to capture the potential cumulative traffic operations implications for a range of complementary options along the highway corridor. Two metrics were developed to use outputs from Synchro to assess overall operations along the corridor:

- Highway Corridor Travel Time Index
- Vehicle Hours Travelled

Both of these metrics are described in further detail below.

4.2.1 Highway Corridor Travel Time Index

One of the key roles of the Highway 99 corridor through Squamish is to provide an intercity transportation function not only for Squamish residents to access destinations to the north (e.g. to Whistler or Pemberton) and the south (e.g. Metro Vancouver), but also for residents to travel between those other communities, for which trips will use the highway to travel through Squamish. However, from the perspective of a through-trip (e.g. someone driving from Vancouver to Whistler), the magnitude of delay experienced at any single intersection is less relevant than the cumulative travel time required to pass through the Squamish area as a whole. Therefore, a corridor travel time index (TTI) is proposed as a measure of the overall level of congestion and delay on the highway corridor. The TTI provides a measure of how much additional time is required to traverse a roadway segment during congested peak periods relative to the time required to traverse the same roadway segment during a comparison period – typically an off-peak period to represent uncongested conditions, calculated as follows:

$$TTI = \frac{Analysis\ period\ travel\ time}{Uncongested\ condition\ travel\ time}$$

Unlike the Level of Service metric, there is not any industry-standard thresholds for the TTI. For the purposes of this assignment, it is proposed that travel time indices of 1.05, 1.15, 1.25 and 1.60 be used as threshold values to assess congestion, as summarized in ***Table 4.5***.

Table 4.5: Highway Corridor Travel Time Index Threshold Summary

General Congestion Level	Threshold
Uncongested	TTI < 1.05 (Uncongested)
Slightly Congested	1.05 < TTI < 1.15
Congested	1.15 ≤ TTI < 1.25
Heavily Congested	1.25 ≤ TTI < 1.60
Extremely Congested	TTI ≥ 1.60

For the purposes of this analysis, TTI's corresponding to the "Heavily Congested" and "Extremely Congested" levels will be identified as exceeding the critical threshold.

In addition to providing a basis for assessment during the problem definition phase, the travel time metric can also be used to assess cumulative impacts for a range of complementary options along the highway corridor.

4.2.2 Network Vehicle Hours Travelled

The network travel time represents the total time travelled during the peak hour in the model and is presented in terms of vehicle hours travelled (VHT). There are no specific performance thresholds associated with this metric, it is primarily intended for context and relative comparison, and can also be used to assess cumulative

impacts for a range of complementary options along the highway corridor. Unlike the highway corridor travel time index, the network vehicle hours travelled metric also implicitly considers operations on side streets.

4.3 Sustainable Transportation Modes

The previous metrics are primarily focussed on motorized traffic operations, and by extension, assess impacts to people and goods moving by passenger vehicle or truck. Therefore, two metrics related to sustainable transportation modes are proposed:

- Transit Provisions
- Active Transportation Provisions
- Bicycle Intersection Conflicts

These metrics are described in further detail below.

4.3.1 Transit Provisions

A qualitative assessment will be undertaken for the accommodation of high-quality transit services and facilities along the study corridor. This assessment will focus primarily on the highway corridor itself, although consideration will also subsequently be given to provisions on intersecting streets at select intersections that are identified for mitigation option development. The assessment will consider such qualitative and quantitative metrics as bus stop coverage area, bus stop accessibility and corridor travel time.

There are no specific performance thresholds associated with this qualitative metric, it is primarily intended for context and relative comparison.

4.3.2 Active Transportation Provisions

A qualitative assessment will be undertaken for the availability of active transportation facilities. This assessment will focus primarily on the study corridor itself, including consideration for cross-corridor movement at intersections. The assessment will consider such qualitative and quantitative metrics as the existence or lack of active transportation infrastructure, distance between highway crossing opportunities, and potential active transportation desire paths.

There are no specific performance thresholds associated with this qualitative metric, it is primarily intended for context and relative comparison.

4.3.3 Bicycle Intersection Conflicts

The Highway 99 corridor through Squamish features several segments with multi-use paths running parallel to the highway, and based on a review of the District of Squamish Active Transportation Plan, it is anticipated that additional multi-use path facilities running parallel to the highway corridor may be implemented in the future.

In general, these multi-use paths are set back from the highway and do not interface with highway traffic. However, at intersections people walking and cycling on these multi-use paths will have conflict points with vehicles making right-turns or left-turns on or off the highway. This interface can create challenges with respect to both user comfort and safety. A similar consideration also applies for paths on municipal streets that intersect the highway.

In order to provide a quantitative basis to assess areas with greater potential conflict, threshold right-turning and left-turning vehicle volumes were identified in ***Table 4.6***. This table is adapted from Table G-32 and Table G-33 of the *BC Active Transportation Design Guide*. The tables in the design guide were originally developed to provide guidance with respect to when intersection movements for protected bicycle lane facilities should be temporally-separated from conflicting intersection movements for vehicles. It is acknowledged that the context in which these threshold volumes were developed envisioned protected cycling facilities (rather than multi-use paths) and did not assume the presence of channelized right turn lanes with refuge islands (as is the case on most intersections along the Highway 99 corridor in Squamish).

However, notwithstanding these differences, it is proposed that these threshold volumes be applied to right-turn and left turn movements across any multi-use paths that interface with the corridor. For the purposes of this assessment, meeting the threshold value does necessarily indicate that temporal-separation is required (since channelization means that right turn conflicts are not signalized in the first place); rather meeting the threshold value implies that a range of potential opportunities could be explored to mitigate potential conflicts.

Table 4.6: Bicycle Intersection Conflicts Critical Threshold Summary

Protected Cycling Facility Configuration	Two-Way Motor Vehicle Turn			One-Way Motor Vehicle Road
	Right Turn	Left Turn Across One Lane	Left Turn Across Two Lanes	Right or Left Turn
Vehicles Turning from High Speed Streets (>50 km/h)				
Uni-Directional	100	100	0	100
Bi-Directional	50	50	0	0
Vehicles Turning from Low Speed Streets (50 km/h and below)				
Uni-Directional	250	150	50	250
Bi-Directional	150	100	0	150

4.4 Road Safety

Road safety performance is proposed to be measured using three quantitative metrics, each of which will be applied at the highway segment level and at the intersection level. The resultant metrics will be Level 1 and Level 2 collision prone segments and collision prone locations along the study corridor. To undertake this analysis, the study highway corridor will be segmented at the locations of signalized intersections. Data from the Collision Information System for the study corridor from 2015-2019 will be used to calculate the following three proposed inputs:

- Collision Frequency
- Collision Rate
- Collision Severity Index

Identifying a segment or location as collision-prone will be subject to a combination of thresholds for all three inputs. To be designated as a Collision Prone Segment or Collision Prone Location, a location along the study corridor must:

- Have a minimum annual collision frequency of two collisions per year; and,
- Must exceed at least one of the two following thresholds:
    - A Collision Rate in excess of the Provincial Critical Collision Rate for similar facility types; or,
    - A Collision Severity Ratio in excess of the provincial average for similar facility types.

The individual inputs are described in further detail below.

4.4.1 Collision Frequency

Collision frequency is a measure of the average number of collisions in a location each year of the observation period. Subject to at least one of the Collision Rate and / or Collision Severity thresholds being met, then a Collision Prone Location is defined as follows:

- A Level One Collision Prone Location will have an annual average collision frequency ≥ 3 collisions per year (i.e. 15 or more collisions over the course of the five year analysis period).
- A Level Two Collision Prone Location will have an annual average collision frequency ≥ 2 and < 3 collisions per year (i.e. between 10 and 14 collisions over the course of the five year analysis period).

Due to the greater collision frequency, a Level One Collision Prone Location is generally considered "worse" from a safety perspective than a Level Two Collision Prone Location.

4.4.2 Collision Rate

The collision rate is the number of collisions per million-vehicle-kilometres for highway segments and collisions per million-entering-vehicles for the intersections. The observed collision rate for each segment and signalized intersection will be compared to the average collision rates for highways with the same classification around the province. The study corridor is classified as a rural divided 4-lane arterial (RAD4).

To account for randomness in the observation of collision, a segment or intersection will be identified as exceeding the rate threshold if it exceeds the Critical Collision Rate (CR), based on the provincial average collision rate. This method ensures that a location is more collision-prone than the provincial average at a given confidence interval, and 95% will be used for the current study. The Critical Collision Rate is calculated as follows:

$$CR = CR_{ave} + k\sqrt{\frac{CR_{ave}}{m} + \frac{1}{2m}}$$

Where,

CR_{ave} = Average Provincial Collision Rate, specific for RAD4 facilities;
k is a constant (1.64 for 95% confidence); and
m = Million Vehicle Kilometres for segments and Million Entering Vehicles for intersections.

4.4.3 Collision Severity Index

The Collision Severity Index (CSI) incorporates collision severity into the identification of collision-prone locations, reflecting the increased negative impacts of injury and fatal collisions compared to property damage-only collisions.

The collision severity ratio is calculated as follows:

$$CSI = \frac{PDO + 10 \times I + 100 \times F}{PDO + I + F}$$

Where,

PDO = Number of property damage-only collisions;
I = Number of injury collisions; and
F = Number of fatal collisions.

The CSI of each highway segment and signalized intersection in the study area will be compared to the provincial average for RAD4 facilities.

4.5 Summary of Metrics

The performance metrics used for each evaluation tool are summarized in this section. The key performance metrics, methodology used to obtain them, and range of values adopted can be found in ***Table 4.7*** below, forming the evaluation framework.

Table 4.7: Summary of Performance Metrics

Metric Type	Metric	Critical Threshold
Intersection-Level Operations	Level of Service	LOS E (Highway Movements) LOS F (Overall Intersection)
	V/C	≥0.85 (Highway Movements) ≥0.95 (Overall Intersection)
	50th Percentile Queue Length	Exceeds designated storage capacity
	95th Percentile Queue Length	Exceeds storage capacity and deceleration portion of turning lane
Corridor-Level Operations	Highway Corridor Travel Time Index	Moderate: 1.25 ≤ TTI < 1.60 Severe: TTI ≥ 1.60
	Network Vehicle Hours Travelled	n/a
Sustainable Transportation Modes	Transit Services and Facilities	Qualitative
	Active Transportation Provisions	Qualitative
	Bicycle Intersection Conflicts	Turning movement vehicle volume threshold values range from 0 vph to 250 vph depending on turn type, roadway cross section, roadway posted speed and cycling facility type.
Road Safety	Collision Prone Segments	Level 1 or Level 2.
	Collision Prone Locations	Level 1 or Level 2.

5. TECHNICAL PERFORMANCE ASSESSMENT

This section documents the technical assessment of highway performance, as grouped into the following four categories:

- Intersection-Level Operations
- Corridor-Level Operations
- Sustainable Transportation Modes
- Road Safety

5.1 Intersection-Level Operations

Analysis outputs of the following three intersection-level metrics are documented herein:

- Intersection Level of Service
- Volume-to-Capacity Ratio
- Queue Lengths

Note that unsignalized intersections that only featured right-in / right-out movements were not assessed. This consideration applies to the Sea to Sky Gondola Parking, Centennial Way Interchange, the Garibaldi Village Mall access, and Dowad Drive.

5.1.1 Level of Service

Intersection LOS results for existing (2020) and future (2040) base runs are for the summer Saturday AM and Sunday PM peak hours are shown in ***Table 5.1*** and ***Table 5.2***, respectively. Movements exceeding the thresholds noted in Section 4.1.1 are highlighted in red. As shown, the following movements were observed to have deficiencies:

- Stawamus Chief Parking:
    - Westbound left (2040 only).
- Mamquam River Forest Service Road:
    - Eastbound left and westbound left (2040 only).
- Clarke Drive:
    - Southbound left (2020 and 2040).
    - Northbound left (2040 only).
- Mill Road:
    - Eastbound movements (2020 and 2040).

- Cleveland Avenue:
  - Northbound left (2020 and 2040).
  - southbound right, eastbound left (2040 only).
- Industrial Way / Finch Avenue:
  - Southbound through, northbound left (2020 and 2040).
  - Northbound through, southbound left, overall intersection (2040 only).
- Mamquam Road:
  - Westbound left, northbound left, southbound left (2020 and 2040).
  - Northbound through, overall intersection (2040 only).
- Garibaldi Way:
  - Northbound left, southbound left (2020 and 2040).
- Depot Road:
  - Northbound left (2040 only).

Table 5.1: Summer Saturday 12:00 Peak Hour Level of Service Analysis

Intersection	Control	Year	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Darrell Bay Road	4 leg; signalized	2020	B	A	A	A	B	A	A	A	A	B	A	B	A	B	A	A	A
		2040	C	A	A	A	C	A	A	A	A	C	A	C	A	C	A	B	A
Sea to Sky Gondola Parking	3-leg; RIRO	2020																	
		2040																	
Stawamus Chief Parking	3-leg; Protected-T	2020					B			A					D			C	A
		2040					B			A					F			C	A
Mamquam River FSR	4 leg; TWSC	2020	A			A	B			A	E		B	D	E		B	D	A
		2040	B			A	B			A	F		B	E	F		B	F	A
Valley Drive	4-leg; signal	2020	D	A	A	A	D	A	A	A	A	D	A	D	D	D	A	B	A
		2040	D	A	A	A	D	A	A	A	A	D	A	D	D	D	A	B	A
Clarke Drive	4-leg; signal	2020	D	C	A	C	F	B	A	D	C	C	A	B	C	C	C	C	D
		2040	D	C	A	C	F	B	A	F	C	C	A	C	C	C	C	C	E
Mill Road	3-leg; Protected-T	2020	B			A					F			F					A
		2040	B			A					F			F					A
Scott Crescent	3-leg; RIRO	2020															C	C	A
		2040															C	C	A
Cleveland Avenue	4-leg; signal	2020	D	B	A	C	D	C	A	C	D	C	A	C	D	D	A	D	C
		2040	F	C	A	D	D	C	F	E	F	C	C	F	D	D	A	D	E
Industrial Way / Finch Avenue	4-leg; signal	2020	D	B	A	C	D	E	A	E	D	B	A	C	D	D	A	D	D
		2040	D	E	A	E	D	F	A	F	D	B	A	C	D	D	A	D	F
Commercial Way	4-leg; signal	2020	D	A	A	A	A	B	A	B	C	A	A	C					B
		2040	D	B	A	B	A	C	A	C	C	A	A	C					B
Centennial Way Interchange	Split Diamond Interchange	2020																	
		2040																	
Mamquam Road	4-leg; signal	2020	D	D	A	C	D	C	A	C	D	D	A	D	F	B	A	F	E
		2040	D	F	B	F	D	D	A	D	D	D	A	D	F	B	A	F	F
Garibaldi Village Mall Access	RI only	2020																	
		2040																	
Garibaldi Way	4-leg; signal	2020	D	C	A	C	D	C	A	C	C	D	A	C	D	C	A	C	C
		2040	D	D	A	C	D	C	A	C	C	D	A	C	D	C	A	C	C
Dowad Drive	3-leg; RIRO	2020																	
		2040																	
Depot Road	4-leg; signal	2020	C	A	A	A	C	B	A	B	C	A	A	B	A	C	A	C	B
		2040	F	A	A	D	C	B	A	B	C	A	A	B	A	C	A	C	C

Table 5.2: Summer Sunday 16:00 Peak Hour Level of Service Analysis

Intersection	Control	Year	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Darrell Bay Road	4 leg; signalized	2020	B	A	A	A	B	A	A	A	A	B	A	B	A	B	A	A	A
		2040	B	A	A	0.19	B	A	A	0.3	A	B	A	0.04	A	B	A	0.04	
Sea to Sky Gondola Parking	3-leg; RIRO	2020																	
		2040																	
Stawamus Chief Parking	3-leg; Protected-T	2020					A			A					C		B	B	A
		2040					A			A					C		B	B	A
Mamquam River FSR	4 leg; TWSC	2020	A			A	A			A	D		B	C	D		B	C	A
		2040	A			A	A			A	D		B	C	D		B	C	A
Valley Drive	4-leg; signal	2020	D	A	A	A	D	A	A	A	A	D	A	D	D	A	A	C	A
		2040	D	A	A	A	D	A	A	A	A	D	A	D	D	A	A	C	A
Clarke Drive	4-leg; signal	2020	D	B	A	B	D	A	A	B	D	D	A	D	D	D	B	C	B
		2040	E	C	A	C	E	B	A	C	E	C	A	D	D	C	A	B	C
Mill Road	3-leg; Protected-T	2020	B			A					E			E					A
		2040	B			A					F			F					A
Scott Crescent	3-leg; RIRO	2020															B	B	A
		2040															B	B	A
Cleveland Avenue	4-leg; signal	2020	E	B	A	C	D	C	A	B	D	D	A	C	D	E	A	D	C
		2040	F	C	A	F	D	C	C	C	E	D	D	E	D	E	A	D	E
Industrial Way / Finch Avenue	4-leg; signal	2020	E	A	A	B	D	B	A	B	D	B	A	C	D	E	A	D	B
		2040	E	B	A	B	E	C	A	C	D	C	A	C	E	D	A	D	C
Commercial Way	4-leg; signal	2020	C	A	A	A	A	B	A	B	C	A	A	B					A
		2040	C	A	A	A	A	B	A	B	C	A	A	C					B
Centennial Way Interchange	Split Diamond Interchange	2020																	
		2040																	
Mamquam Road	4-leg; signal	2020	E	C	A	B	E	C	A	C	D	D	A	D	D	C	A	C	C
		2040	E	C	A	B	E	C	A	C	D	D	A	D	E	C	A	D	C
Garibaldi Village Mall Access	RI only	2020																	
		2040																	
Garibaldi Way	4-leg; signal	2020	E	C	A	C	E	C	A	C	D	E	A	C	C	C	A	C	C
		2040	E	C	A	C	E	C	A	C	D	E	A	C	D	C	A	C	C
Dowad Drive	3-leg; RIRO	2020																	
		2040																	
Depot Road	4-leg; signal	2020	C	A	A	A	A	B	A	B	C	A	A	A	A	C	A	C	A
		2040	D	A	A	D	A	B	A	B	C	A	A	A	A	C	A	C	B

5.1.2 Volume to Capacity Ratio

Intersection volume-to-capacity ratio results for existing (2020) and future (2040) base runs are for the summer Saturday AM and Sunday PM peak hours in ***Table 5.3*** and ***Table 5.4***, respectively. Movements exceeding the thresholds noted in Section 4.1.2 are highlighted in red. As shown, the following movements were observed to have deficiencies:

- Clarke Drive:
  - Southbound left (2020 and 2040).
- Mill Road:
  - Eastbound movements (2040 only).
- Cleveland Avenue:
  - Northbound left (2020 and 2040).
  - southbound right, eastbound left (2040 only).
- Industrial Way / Finch Avenue:
  - Southbound through, northbound left (2020 and 2040).
  - Northbound through, southbound left (2040 only).
- Commercial Way:
  - Southbound through (2040 only).
- Mamquam Road:
  - Northbound through, westbound left (2020 and 2040).
  - Southbound through (2040 only).
- Garibaldi Way:
  - Northbound through (2040 only).
- Depot Road:
  - Northbound left (2040 only).

Table 5.3: Saturday 12:00 Peak Hour Volume-to-Capacity Ratio Analysis

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	2020	0.01	0.36	0.03	0.06	0.29	0.00	0.00	0.09	0.01	0.00	0.09	0.11
		2040	0.01	0.54	0.03	0.07	0.35	0.00	0.00	0.12	0.01	0.00	0.12	0.14
Sea to Sky Gondola Parking	3-leg; RIRO	2020												
		2040												
Stawamus Chief Parking	3-leg; Protected-T	2020				0.02						0.04		0.06
		2040				0.02						0.09		0.08
Mamquam River FSR	4 leg; TWSC	2020	0.00			0.01				0.04	0.01		0.02	0.00
		2040	0.01			0.01				0.08	0.01		0.06	0.01
Valley Drive	4-leg; signal	2020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2040	0.03	0.50	0.05	0.25	0.33	0.01	0.00	0.17	0.00	0.27	0.01	0.22
Clarke Drive	4-leg; signal	2020	0.15	0.67	0.05	1.12	0.35	0.02	0.07	0.02	0.01	0.19	0.00	0.82
		2040	0.25	0.83	0.04	1.60	0.45	0.18	0.46	0.02	0.02	0.18	0.00	0.83
Mill Road	3-leg; Protected-T	2020	0.02							0.62				
		2040	0.03							1.61				
Scott Crescent	3-leg; RIRO	2020												0.02
		2040												0.18
Cleveland Avenue	4-leg; signal	2020	0.85	0.51	0.07	0.14	0.63	0.71	0.83	0.23	0.60	0.24	0.54	0.03
		2040	1.12	0.64	0.07	0.15	0.75	1.16	1.21	0.45	0.87	0.24	0.54	0.03
Industrial Way / Finch Avenue	4-leg; signal	2020	0.56	0.64	0.02	0.13	1.01	0.32	0.49	0.62	0.00	0.09	0.29	0.01
		2040	0.58	1.08	0.17	0.29	1.57	0.36	0.49	0.62	0.00	0.44	0.51	0.03
Commercial Way	4-leg; signal	2020	0.31	0.63	0.00	0.00	0.68	0.39	0.47	0.00	0.09			
		2040	0.38	0.80	0.00	0.00	0.86	0.39	0.49	0.00	0.09			
Centennial Way Interchange	Split Diamond Interchange	2020												
		2040												
Mamquam Road	4-leg; signal	2020	0.36	0.90	0.67	0.41	0.70	0.06	0.38	0.53	0.03	1.34	0.24	0.09
		2040	0.36	1.17	0.79	0.42	0.92	0.06	0.38	0.53	0.03	1.47	0.24	0.09
Garibaldi Village Mall Access	RI only	2020												
		2040												
Garibaldi Way	4-leg; signal	2020	0.69	0.61	0.32	0.58	0.51	0.14	0.22	0.67	0.16	0.74	0.36	0.31
		2040	0.69	0.85	0.35	0.58	0.73	0.14	0.22	0.67	0.16	0.90	0.36	0.31
Dowad Drive	3-leg; RIRO	2020												
		2040												
Depot Road	4-leg; signal	2020	0.51	0.35	0.01	0.01	0.47	0.07	0.15	0.40	0.00	0.00	0.07	0.00
		2040	1.10	0.39	0.01	0.01	0.50	0.08	0.15	0.62	0.00	0.00	0.06	0.00

Table 5.4: Sunday 16:00 Peak Hour Volume-to-Capacity Ratio Analysis

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	2020	0.01	0.18	0.01	0.01	0.30	0.01	0.00	0.04	0.01	0.00	0.04	0.03
		2040	0.01	0.19	0.01	0.01	0.30	0.01	0.00	0.04	0.01	0.00	0.04	0.03
Sea to Sky Gondola Parking	3-leg; RIRO	2020												
		2040												
Stawamus Chief Parking	3-leg; Protected-T	2020				0.01						0.02		0.03
		2040				0.01						0.02		0.03
Mamquam River FSR	4 leg; TWSC	2020	0.00			0.01				0.03	0.01		0.01	0.00
		2040	0.00			0.01				0.03	0.01		0.01	0.00
Valley Drive	4-leg; signal	2020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2040	0.05	0.19	0.05	0.18	0.29	0.01	0.00	0.12	0.00	0.24	0.00	0.07
Clarke Drive	4-leg; signal	2020	0.09	0.27	0.02	0.77	0.31	0.02	0.22	0.02	0.00	0.29	0.04	0.65
		2040	0.21	0.33	0.02	0.79	0.37	0.18	0.69	0.01	0.00	0.15	0.02	0.49
Mill Road	3-leg; Protected-T	2020	0.04							0.16				
		2040	0.05							0.25				
Scott Crescent	3-leg; RIRO	2020												0.01
		2040												0.06
Cleveland Avenue	4-leg; signal	2020	0.64	0.24	0.03	0.08	0.53	0.43	0.58	0.16	0.57	0.22	0.27	0.03
		2040	1.26	0.17	0.03	0.07	0.59	0.91	0.99	0.43	0.92	0.23	0.28	0.03
Industrial Way / Finch Avenue	4-leg; signal	2020	0.52	0.30	0.01	0.10	0.50	0.08	0.26	0.69	0.00	0.10	0.18	0.01
		2040	0.54	0.41	0.16	0.21	0.77	0.10	0.25	0.71	0.00	0.58	0.44	0.02
Centennial Way Interchange	4-leg; signal	2020	0.22	0.35	0.00	0.00	0.57	0.22	0.29	0.00	0.06			
		2040	0.34	0.36	0.00	0.00	0.70	0.21	0.38	0.00	0.06			
Centennial Road Interchange	Split Diamond Interchange	2020												
		2040												
Mamquam Road	4-leg; signal	2020	0.36	0.37	0.42	0.38	0.49	0.06	0.28	0.38	0.03	0.81	0.22	0.06
		2040	0.36	0.36	0.48	0.38	0.63	0.05	0.28	0.38	0.03	0.97	0.23	0.06
Garibaldi Village Mall Access	RI only	2020												
		2040												
Garibaldi Way	4-leg; signal	2020	0.60	0.21	0.23	0.66	0.37	0.09	0.19	0.62	0.11	0.49	0.30	0.20
		2040	0.61	0.20	0.26	0.69	0.50	0.09	0.19	0.62	0.11	0.58	0.30	0.19
Dowad Drive	3-leg; RIRO	2020												
		2040												
Depot Road	4-leg; signal	2020	0.31	0.13	0.01	0.00	0.37	0.04	0.04	0.32	0.00	0.00	0.03	0.00
		2040	0.86	0.04	0.01	0.00	0.50	0.06	0.05	0.58	0.00	0.00	0.03	0.00

5.1.3 Queue Lengths

The 50th percentile queue lengths for the existing (2020) and future (2040) base runs during the summer Saturday AM and Sunday PM peak hours are shown in ***Table 5.5*** and ***Table 5.6***. The corresponding 95th percentile queue lengths are shown in ***Table 5.7*** and ***Table 5.8***. Storage lengths are also provided in these tables, and queues exceeding those storage lengths (or storage and deceleration length in the case of 95th percentile queues) are marked in red. Mamquam River Forest Service Road, Mill Road, Scott Crescent and Dowad Drive are excluded from the 50th percentile queue tables, as this value is not reported for unsignalized intersections. Note that the 95th percentile queue spillbacks are measured relative to the storage plus deceleration distance, and therefore consistent with Section 4.1.3 an additional 40 metres of storage has been provided for left turn lanes and an addition 50 metres of storage for right turn lanes.

As shown, the following movements were observed to have deficiencies:

- Clarke Drive:
  - 50th percentile queues: westbound right, (2020 and 2040); eastbound left (2040 only).
  - 95th percentile queues: southbound left (2020 and 2040); westbound right (2040 only).
- Cleveland Avenue:
  - 50th percentile queues: eastbound right (2040 only).
  - 95th percentile queues: southbound right, eastbound right (2040 only).
- Mamquam Road:
  - 50th percentile queues: Westbound left (2020 and 2040).
  - 95th percentile queues: Westbound left (2020 and 2040).
- Garibaldi Way:
  - 50th percentile queues: Westbound left (2020 and 2040).
  - 95th percentile queues: Westbound left (2040 only).

Table 5.5: Saturday 12:00 Peak Hour 50th Percentile Queuing Analysis

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		2020	0.2	15.3	0	0.9	11.8	0	0	1.3	0	0	1.3	0
		2040	0.2	26	0	1.3	15.2	0	0	1.9	0	0	1.9	0
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		2020												
		2040												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		2020												
		2040												
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		2020												
		2040												
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		2020	0.6	37.8	0	7.9	15	0	0	5.4	0	7.6	0.5	0
		2040	0.6	63.5	0	7.9	19	0	0	5.4	0	7.6	0.5	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		2020	3.7	74.4	0	0	28.2	0	3.4	1.1	0	9.3	0.1	39.6
		2040	6.8	110.5	0	0	55.1	0	25.5	1.1	0	9	0.1	46.9
Mill Road	3-leg; Protected-T	Storage Length	1050					-	0		-			
		2020												
		2040												
Scott Crescent	3-leg; RIRO	Storage Length												0
		2020												
		2040												
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		2020	45.8	52	0	3.8	64.6	10.2	64.6	15.8	0	6.9	17.1	0
		2040	0	74.3	0	3.8	74.5	0	0	31.9	31.1	6.9	17.1	0
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		2020	44.3	75.6	0	3.6	0	1.6	24	9.9	0	3	10.3	0
		2040	44.3	0	0	9.4	0	1.7	24	9.9	0	19.6	23.9	0

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		2020	9.6	51.4	0	0	71.2	3.7	21.8	0	0			
		2040	13.3	94.1	0	0	123.3	10.2	25.7	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		2020												
		2040												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		2020	12.5	0	11.7	15.3	82.5	0	10.6	23.2	0	0	21.7	0
		2040	12.5	0	41.7	16	0	0	10.6	23.2	0	0	21.7	0
Garibaldi Village Mall Access	RI only	Storage Length												
		2020												
		2040												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		2020	37.6	59.8	0	28.1	47	0	8.1	45.2	0	34.7	33.3	2.2
		2040	38.3	97.5	0	28.1	75	0	8.1	45.2	0	41.8	33.3	2.2
Dowad Drive	3-leg; RIRO	Storage Length												
		2020												
		2040												
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		2020	16.6	13.1	0	0.3	25.2	0	3.2	0.3	0	0	1.8	0
		2040	0	15.2	0	0.3	29.1	0	3.4	1	0	0	1.9	0

Table 5.6: Sunday 16:00 Peak Hour 50th Percentile Queuing Analysis

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		2020	0.2	0	0	0.2	0	0	0	0.6	0	0	0.6	0
		2040	0.2	0	0	0.2	0	0	0	0.6	0	0	0.6	0
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		2020												
		2040												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		2020												
		2040												
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		2020												
		2040												
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		2020	1.1	16.7	0	5.3	15.7	0	0	3.7	0	6.6	0	0
		2040	1.1	17.4	0	5.3	15.5	0	0	3.7	0	6.6	0	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		2020	2.2	32.3	0	71.5	16.8	0	6.5	0.7	0	8.8	1.5	0
		2040	5.8	43.5	0	72.4	52.3	0	47.8	0.6	0	7.5	1.3	0
Mill Road	3-leg; Protected-T	Storage Length	1050						0					
		2020												
		2040												
Scott Crescent	3-leg; RIRO	Storage Length												0
		2020												
		2040												
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		2020	32.2	26.3	0	3.6	81.8	0	41.9	11.5	0	7.2	9.2	0
		2040	0	14.3	0	3.6	72.1	66	0	41.9	0	7.3	9.3	0

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		2020	26.4	26.7	0	2.7	75.6	0	10.3	3.1	0	3	5.9	0
		2040	26.4	58.7	0	6.6	133.7	0	10.3	7.5	0	31.5	24.6	0
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		2020	6.3	16.4	0	0	46.5	0	10.7	0	0			
		2040	10.3	19.9	0	0	74	2.5	14.2	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		2020												
		2040												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		2020	12.9	54.1	0	14	78.8	0	7.8	16.6	0	77.9	21.8	0
		2040	12.9	49.6	0	14	101.3	0	7.8	16.6	0	104.9	24	0
Garibaldi Village Mall Access	RI only	Storage Length												
		2020												
		2040												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		2020	30.8	24.6	0	39.5	46.7	0	7.4	41.2	0	30.1	32.2	1.6
		2040	31.5	24.1	0	39.7	70.1	0	7.4	41.2	0	37.3	31.3	1.5
Dowad Drive	3-leg; RIRO	Storage Length												
		2020												
		2040												
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		2020	9.4	4.3	0	0	25.1	0	0.9	0.1	0	0	0.8	0
		2040	30.3	1.2	0	0	27.6	0	1	0.1	0	0	0.8	0

Table 5.7: Saturday 12:00 Peak Hour 95th Percentile Queuing Analysis

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		2020	2.4	49.7	0.2	7.2	36.3	0	0	9.3	0	0	9.3	4
		2040	2.8	80.4	0	8.9	44.5	0	0	11.7	0	0	11.7	4.2
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		2020												
		2040												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		2020				0						0.1		0.2
		2040				0.1						0.3		0.3
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		2020	0			0				0.1	0		0.1	0
		2040	0			0				0.2	0		0.2	0
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		2020	3.4	59.6	0	17.7	41.2	0	0	13.5	0	17.2	3.1	0
		2040	3.4	98.2	0	17.7	51.6	0	0	13.5	0	17.2	3.1	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		2020	10.5	87.1	0	207.2	67.3	0	8.5	4.1	0	17.5	1.2	68.1
		2040	16.1	139.1	0	209.9	86	11.4	40.2	4.1	0	17.5	1.2	77.4
Mill Road	3-leg; Protected-T	Storage Length	1050						0					
		2020	0.1							2.7				
		2040	0.1							5.4				
Scott Crescent	3-leg; RIRO	Storage Length												0
		2020												0
		2040												0.6
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		2020	70.4	88.3	0	11	84.6	48.3	92.5	29.6	23.4	16.8	32.8	0
		2040	127.5	123.8	0	11	96.5	229.4	155.7	52.5	98.9	16.8	32.8	0

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		2020	69.8	178.1	0	10.5	210.5	19.3	33.6	31.6	0	9.1	21.5	0
		2040	82.3	305	11.1	20.2	294.6	19.3	33.6	31.6	0	34.1	39.6	0
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		2020	22.2	86	0	0	118.3	19.7	35	0	0			
		2040	27.5	145.8	0	0	208.5	30.6	39.6	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		2020												
		2040												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		2020	24.6	179.7	51.7	28.5	120.2	0	23.1	41.2	0	210.9	36.3	0
		2040	24.6	255	118.7	29.4	186.2	0	23.1	41.2	0	241.8	36.3	0
Garibaldi Village Mall Access	RI only	Storage Length												
		2020												
		2040												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		2020	59.5	90.9	17	45.1	69.3	3.5	17.5	67.6	0	56	49.5	15.4
		2040	60.4	165.6	17.8	45.1	118.5	3.5	17.5	67.6	0	77.8	49.5	15.4
Dowad Drive	3-leg; RIRO	Storage Length												
		2020												
		2040												
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		2020	40.5	42.7	0	2.5	40.6	1.6	10.7	13.8	0	0	7.3	0
		2040	128.1	54.8	0	2.9	50.2	2.8	11.6	21.5	0	0	7.9	0

Table 5.8: Sunday 16:00 Peak Hour 95th Percentile Queuing Analysis

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		2020	2.5	24.2	0	2.5	42.1	0	0	5.7	0	0	5.7	0
		2040	2.5	25.1	0	2.5	41.7	0	0	5.7	0	0	5.7	0
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		2020												
		2040												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		2020				0						0.1		0.1
		2040				0						0.1		0.1
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		2020	0			0				0.1	0		0	0
		2040	0			0				0.1	0		0	0
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		2020	5.2	26.8	3.7	13.5	43	0	0	10.6	0	15.9	0	0
		2040	5.2	27.7	3.7	13.5	42.6	0	0	10.6	0	15.9	0	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		2020	7.8	54.6	0	96.1	51.8	0	15.2	3.4	0	18.8	5.7	22.7
		2040	14.5	64.4	0	113	82.8	11.7	68.4	2.8	0	15.4	4.7	18.5
Mill Road	3-leg; Protected-T	Storage Length	1050						0					
		2020	0.1							0.6				
		2040												
Scott Crescent	3-leg; RIRO	Storage Length												0
		2020												0
		2040												0.2
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		2020	46.7	69.3	0	7.8	100.8	17.4	56.7	22.8	23.4	17.3	20.6	0
		2040	146.8	46.8	0	6.6	89.9	153.8	164.7	65.8	148.6	17.3	20.6	0

Intersection	Control	Year	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		2020	43.4	67.3	0	8.9	126.7	0	16.9	27.2	0	9.2	14.8	0
		2040	44.7	102.4	12.3	15.7	233.8	0	16.7	31.9	0	49.8	40.5	0
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		2020	18.4	26.4	0	0	73.4	9	23.1	0	0			
		2040	22.8	31.6	0	0	116.9	12.9	24.5	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		2020												
		2040												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		2020	25.3	68.2	18.5	27	96.3	0	17.7	30.4	0	136.1	38.8	0
		2040	25.3	64.2	18.1	27	124.2	0	17.7	30.4	0	203.1	41.6	0
Garibaldi Village Mall Access	RI only	Storage Length												
		2020												
		2040												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		2020	48.9	42.8	16.2	59.2	75.2	3.2	16.2	61.2	0	42.4	44.7	12.5
		2040	50	37	15.4	62.2	99.4	3.1	16.2	61.2	0	55	47.3	13.2
Dowad Drive	3-leg; RIRO	Storage Length												
		2020												
		2040												
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		2020	25.9	9.1	0	0	42.2	0.3	5	12.3	0	0	4.5	0
		2040	97.9	4.1	0	0	49.5	1.5	5.1	18.4	0	0	4.5	0

5.2 Corridor-Level Operations

Analysis outputs of the following two corridor-level metrics are documented herein:

- Highway Corridor Travel Time Index
- Network Vehicle Hours Travelled

5.2.1 Highway Corridor Travel Time Index

Travel times for each movement along the corridor, as well as an off-peak travel time, were assessed using SimTraffic. The travel time values, and the corresponding travel time indices are shown in ***Table 5.9***. Note that the off-peak travel times, which were generated with SimTraffic, correlate relatively well with the travel times summarize previously in ***Figure 2.8*** and ***Figure 2.9***.

Table 5.9: Travel Time Index

Year	Period	Metric	Northbound	Southbound
2020 / 2040	Off-Peak	Travel Time (min)	10.3	10.3
2020	Saturday 12:00	Travel Time (min)	14.4	14.3
		TTI	1.40	1.38
	Sunday 16:00	Travel Time (min)	12.7	12.7
		TTI	1.24	1.23
2040	Saturday 12:00	Travel Time (min)	21.7	25.3
		TTI	2.12	2.45
	Sunday 16:00	Travel Time (min)	16.1	13.8
		TTI	1.57	1.34

As shown, the current Saturday analysis hour peak hour is heavily congested (travel time index between 1.25 and 1.60), while the Sunday peak hour is just barely below this threshold. By 2040, it is anticipated that the Saturday analysis hour will be extremely congested (travel time index greater than 1.60), while the Sunday analysis hour will also become heavily congested.

Currently, the travel time indices in each direction are relatively similar for a given analysis period. However, as the highway becomes increasingly congested in the future, this will diverge, with marked differences in travel time between the two directions.

5.2.2 Network Vehicle Hours Travelled

Overall network vehicle hours travelled was extracted from SimTraffic, and is summarized in ***Table 5.10***.

Table 5.10: Network Vehicles Hours Travelled

Year	Period	Vehicle Hours Travelled
2020	Saturday 12:00	763.6
	Sunday 16:00	432.3
2040	Saturday 12:00	1566.3
	Sunday 16:00	661.7

As shown, a significant increase in network hours travelled is anticipated, although this is due to both (i) additional vehicles on the network resulting in addition vehicles to accrue travel time, and (ii) increasing congestion causing all trips to take longer than they otherwise would. Overall the Saturday analysis hour is significantly busier than the Sunday analysis hour, reflecting both the additional volumes and additional congestion during this period.

5.3 Sustainable Transportation Modes

Supporting a shift towards more sustainable transportation modes is a key provincial priority. Sustainable transportation modes were assessed via the following metrics:

- Transit Provisions
- Active Transportation Provisions
- Bicycle Intersection Conflicts

These metrics provide a multi-pronged approach to identify the active transportation challenges along a highway corridor. Each metric is discussed below.

5.3.1 Transit Provisions

(

As described above in Section 2.2.6, BC Transit currently operates four transit routes (Routes 1, 3, 4 and 5) that make use of the Highway 99 corridor; however none of these services stop along the corridor and therefore no transit-specific infrastructure is provided along the corridor.

Based on feedback from the stakeholder engagement process, there is an interest in planning for a potential stop for an intercity transit service along Highway 99 in the vicinity of the Garibaldi Village Mall (i.e. near either Mamquam Road or Garibaldi Way).

With respect to the efficiency and reliability of transit service, buses will also be affected by congested operations at intersections. The following movements with deficient operations (as measured by Level of Service) impact transit operations:

- Clarke Drive
    - Southbound left (2020 and 2040).

- Cleveland Avenue
    - Northbound left (2020 and 2040).
    - Southbound right, eastbound left (2040 only).
- Industrial Way / Finch Avenue
    - Northbound left (2020 and 2040).
- Mamquam Road
    - Westbound left (2020 and 2040).
- Garibaldi Way
    - Southbound left (2020 and 2040).

5.3.2 Active Transportation Provisions

A qualitative assessment was undertaken with respect to the availability of active transportation facilities.

A key challenge is the usage of shoulders for active transportation; the *B.C. Supplement to TAC Geometric Design Guide* recommends against bicycle and pedestrian accessible shoulders for design speeds greater than 70 km/h (which is the case for at least part of the corridor). If cycling facilities are necessary, the guide specifies that shoulders should be maintained to a minimum design width of 2.5m for highways with design speeds greater than 80 km/h and SADT greater than 10,000 (noting that a posted speed of 70 km/h will typically correspond to a design speed of 80 km/h.). In contrast, Highway 99 through Squamish generally has paved shoulders that are 2.0 metres wide, which do not meet the applicable design guideline.

Roughly parallel to the study corridor, the Corridor Trail is a paved multi-use trail for walking and cycling that currently runs from Valley Drive in the south to Tantalus Way (between Garibaldi Way and Dowad Drive) in the north. Although generally off-street, this trail does interface with Highway 99 at several intersections along the corridor, and as summarized in ***Table 3.1***, these intersection configurations can create challenges for trail users. Furthermore, the trail does not currently extend all the way to the south or north of the study area, although the District of Squamish *Active Transportation Plan* identifies the need for a southern extension.

At several intersections, specific issues were noted:

- Darrell Bay Road
    - Missing southwest quadrant sidewalk;
    - Missing northwest quadrant sidewalk;
    - Missing northeast quadrant sidewalk;
    - Missing north and east crosswalks, although value may be limited due to lack of sidewalk connections on east leg of the intersection.
- Mamquam River Forest Service Road
    - District of Squamish *Active Transportation Plan* includes a multi-use pathway running along the east side of the highway through this intersection. Currently the east leg of the intersection is not configured for active transportation users to cross (i.e. lack of formal channelized right turn islands and crosswalks / crossrides);

  - Assume no east-west crossing required here given the limited destinations on the west side; southbound cyclists needing to use.

- Valley Drive
  - At the northeast quadrant of the intersection, multi-use path does not extend all the way to the crosswalk, pedestrians / cyclists must use road shoulder;
  - District of Squamish *Active Transportation Plan* includes a multi-use pathway running along the east side of the highway through this intersection; this may require introduction of separate crosswalk / crossride.

- Clarke Drive
  - Missing south and west crosswalks, however no connecting sidewalk facility on bridge across railway corridor;
  - Unclear routing choices / multiple options available for southbound trail users; some people walking and cycling may choose to use the east crosswalk at the intersection.

- Scott Road
  - Pinch point in multi-use path just south of right-in/right-out.

- Mamquam Blind Channel Bridge
  - Limited multi-use path width on bridge structure across Mamquam Blind Channel.

- Cleveland Avenue
  - Limited walking time for pedestrians crossing east-west across Highway 99.

- Industrial Way / Finch Drive
  - Poor connections for Discovery Trail to cross Industrial Way; improvements already planned to provide connections to west crosswalk of Highway 99 intersection;
  - Missing sidewalk connection / curb letdown at northeast quadrant of intersection;
  - Missing sidewalk connection / curb letdown at southeast quadrant of intersection, although no sidewalk connection provided on south side of Finch Avenue.

- Commercial Way:
  - Poor connections for Discovery Trail to cross Commercial Way, improvements already planned to provide connections to west crosswalk of Highway 99 intersection;
  - Missing north crosswalk, although no destinations on east side of intersections.

- Mamquam River Bridge
  - Limited multi-use path width on bridge structure across Mamquam River.

- Mamquam Road
  - Conflicts between turning vehicles and Corridor Trail users.

- Garibaldi Way
  - Conflicts between turning vehicles and Corridor Trail users;
  - Challenging design for east-west cyclists.

- Depot Road

- Missing sidewalks.

5.3.2 Bicycle Intersection Conflicts

Based on the existing and potential future multi-use path network (as documented in the District of Squamish *Active Transportation Plan*), several instances of turning movement conflicts were identified at intersections along the study corridor. Applying the turning movement conflict threshold values summarized previously in ***Table 3.6***, the vehicle threshold volumes were identified at several intersections along the corridor, as summarized in ***Table 5.11***. For movements where vehicle volumes exceed these thresholds, the *BC Active Transportation Design Guide* recommends consideration be given to providing separate cycling and turning signal phases.

Table 5.11: Turning Movement Conflict Threshold Volumes

Intersection	NBL	NBR	SBL	SBR	EBL	EBR	WBL	WBR	Comments
Mamquam River FSR		50							Multi-use pathway does not currently pass through intersection but is planned for implementation on the east side of the highway (per District of Squamish *Active Transportation Plan*).
Valley Drive		50							Multi-use pathway does not currently pass through intersection but is planned for implementation on the east side of the highway (per District of Squamish *Active Transportation Plan*).
Clarke Drive							100		
Scott Crescent		50							Scott Crescent does not currently have deceleration lane; NBR turns are from shared through / right lane.
Industrial Way	0			50					
Commercial Way	0			50					
Mamquam Road		50							
Garibaldi Way		50							
Dowad Drive		50							

Existing (summer 2020) turning movement volumes provided previously in ***Table 2.10*** were compared against the threshold volumes, and the resulting temporary separation warranted are summarized below in ***Table 5.12***. Similarly, future (summer 2040) peak hour volumes provided previously in ***Table 2.13*** were compared against the threshold volumes, and the resulting temporary separation warranted are summarized below in ***Table 5.13***.

Table 5.12: Cycling Conflict Temporal Separation Warrant (Summer 2020 Volumes)

Intersection	Time	NBL	NBR	SBL	SBR	EBL	EBR	WBL	WBR
Mamquam River FSR	Saturday AM		No						
	Sunday PM		No						
Valley Drive	Saturday AM		No						
	Sunday PM		Yes						
Clarke Drive	Saturday AM							No	
	Sunday PM							No	
Scott Crescent	Saturday AM		No						
	Sunday PM		No						
Industrial Way	Saturday AM	Yes			Yes				
	Sunday PM	Yes			Yes				
Commercial Way	Saturday AM	Yes			Yes				
	Sunday PM	Yes			Yes				
Mamquam Road	Saturday AM		Yes						
	Sunday PM		Yes						
Garibaldi Way	Saturday AM		Yes						
	Sunday PM		Yes						
Dowad Drive	Saturday AM		No						
	Sunday PM		No						

Table 5.13: Cycling Conflict Temporal Separation Warrant (Summer 2040 Volumes)

Intersection	Time	NBL	NBR	SBL	SBR	EBL	EBR	WBL	WBR
Mamquam River FSR	Saturday AM		No						
	Sunday PM		No						
Valley Drive	Saturday AM		No						
	Sunday PM		Yes						
Clarke Drive	Saturday AM							No	
	Sunday PM							No	
Scott Crescent	Saturday AM		No						
	Sunday PM		No						
Industrial Way	Saturday AM	Yes			Yes				
	Sunday PM	Yes			Yes				
Commercial Way	Saturday AM	Yes			Yes				
	Sunday PM	Yes			Yes				
Mamquam Road	Saturday AM		Yes						
	Sunday PM		Yes						
Garibaldi Way	Saturday AM		Yes						
	Sunday PM		Yes						
Dowad Drive	Saturday AM		No						
	Sunday PM		No						

As shown, signal phasing strategies that temporally separate conflicting vehicle turning and cycling movements are currently warranted at the following locations:

- Valley Drive:
  - Northbound Right-Turn (*note: conflict does not yet exist but will be introduced once multi-use pathway is extended southwards per District of Squamish Active Transportation Plan*).
- Industrial Way / Finch Avenue:
  - Northbound Left Turn (*note: signal phase separation already provided*).
  - Southbound Right Turn.
- Commercial Way:
  - Northbound Left Turn (*note: signal phase separation already provided*).
  - Southbound Right Turn.
- Mamquam Road:
  - Northbound Right Turn.
- Garibaldi Way:
  - Northbound Right Turn.

It is not anticipated that any additional signal phase separations will begin to be warranted in the future.

5.4 Road Safety

The collision prone segment and collision prone location analysis below follows the methodology described previously in Section 3.4. The segments and locations were assessed based on collision frequency, collision rate, and collision severity index (CSI) for the five-year period from 2015 to 2019. Collision rates consider both collision frequency and exposure in terms of traffic volume and distance. Collision severity index, on the other hand, assesses severity using a weighted approach, with greater weights placed on fatalities and personal injury collisions compared to property damage only collisions. The critical collision rates and threshold CSI used for comparison represented collisions that occurred between November 1, 2011, to October 31, 2016, the latest available set of calculated provincial rates. The critical collision rates and threshold CSI depend on the highway service class and traffic volume of the segment.

Unlike traffic operations, road safety analysis is typically based on daily or annual volumes, rather than peak hour volumes. Therefore, using data from the Cheekye permanent count station, a scaling factor was developed to convert the sum of the existing summer Saturday AM and Sunday PM peak hour volumes (as shown in ***Table 2.10***) to annual average daily traffic volumes. The sum of the two peak hour volumes was multiplied by 5.68 to convert to annual average daily traffic volumes.

The existing traffic volumes are intended to represent summer 2020 conditions with the impacts of COVID-19 filtered out. In contrast, the collision history data is for the time period from 2015-2019. To provide a consistent comparison between collision history and traffic volumes, it is necessary to estimate annual average daily traffic volumes for 2015 through 2019. Therefore, using data from the Cheekye permanent count station, a compound annual growth rate in annual average daily traffic volumes of 3.1% was calculated for the years 2015 through 2019. Using this rate, the summer 2020 annual average daily traffic volume were "backcast" to annual average daily traffic volumes for each year between 2015 and 2019.

5.4.1 Collision Prone Segments

As the characteristics of the Highway 99 corridor vary between Darrell Bay Road and Depot Road, the corridor was divided into six distinct segments to allow for a closer assessment of safety performance as shown in ***Table 5.14*** from south to north.

Table 5.14: Highway Segments for Safety Assessment

From	To	LKI Segment	From KM	To KM	Length (KM)
Darrell Bay Road	Valley Drive	2929	24.7	27.52	2.82
Valley Drive	Cleveland Avenue	2929	27.52	29.1	1.58
Cleveland Avenue	Commercial Way	2945	0	2.07	2.07
Commercial Way	Mamquam Road	2945	2.07	3.87	1.8
Mamquam Road	Garibaldi Way	2945	3.87	4.52	0.65
Garibaldi Way	Depot Road	2945	4.52	7.3	2.78

The service class and traffic volume of each segment of the study corridor is provided in ***Table 5.15***. Segment volumes were calculated for each intersection-to-intersection pair using intersection approach and departure volumes, and where segments extend through more than one intersection, taking an average of these segment volumes weighted in proportion to the distance between each intersection-to-intersection pair. The resultant segment-based road safety performance results are summarized in ***Table 5.16*** below.

Table 5.15: Highway Segments for Service Class and Traffic Volume Range

From	To	Segment Length	Highway Class	Highway Segment Annual Average Daily Traffic Volume (2015-2019)	Annual Average Daily Traffic Volume Range
Darrell Bay Road	Valley Drive	2.82	Rural arterial divided, ≥ 4 lanes	16,187	15,001-20,000
Valley Drive	Cleveland Avenue	1.58	Rural arterial divided, ≥ 4 lanes	15,313	15,001-20,000
Cleveland Avenue	Commercial Way	2.07	Rural arterial divided, ≥ 4 lanes	16,753	15,001-20,000
Commercial Way	Mamquam Road	1.8	Rural arterial divided, ≥ 4 lanes	20,297	20,001+
Mamquam Road	Garibaldi Way	0.65	Rural arterial divided, ≥ 4 lanes	22,883	20,001+
Garibaldi Way	Depot Road	2.78	Rural arterial divided, ≥ 4 lanes	15,422	15,001-20,000

Table 5.16 Identification of Potential Collision Prone Segments

From	To	Total Segment Collisions	Segment Collision Frequency	Level One: Collision Frequency ≥ 3 / year?	Level Two: Collision Frequency ≥ 2 / year?	Segment Collision Rate	Critical Collision Rate	Segment Collision Rate > Critical Collision Rate?	Segment CSI	Provincial Average CSI	Segment CSI > Provincial Average CSI?	Collision Prone Segment?
Darrell Bay Road	Valley Drive	38	7.6	Yes	n/a	0.55	0.31	Yes	5.38	6.53	No	Level One
Valley Drive	Cleveland Avenue	34	6.8	Yes	n/a	0.48	0.36	Yes	4.55	6.53	No	Level One
Cleveland Avenue	Commercial Way	49	9.8	Yes	n/a	0.70	0.39	Yes	3.91	6.53	No	Level One
Commercial Way	Mamquam Road	35	7	Yes	n/a	0.64	0.54	Yes	7.80	5.74	Yes	Level One
Mamquam Road	Garibaldi Way	16	3.2	Yes	n/a	0.47	0.54	No	5.11	5.74	No	No
Garibaldi Way	Depot Road	19	3.8	Yes	n/a	0.87	0.48	Yes	5.50	6.53	No	Level One

Based on the criteria noted above, all by one segment of the corridor is collision prone compared to other similar roadways in the province. Note that all five collision prone segments exceeded the collision rate threshold, but only one of the six segments (between Cleveland Avenue and Commercial Way) exceeded the collision severity threshold. The segments of the corridor that are collision prone are shown in ***Figure 5.1*** below.

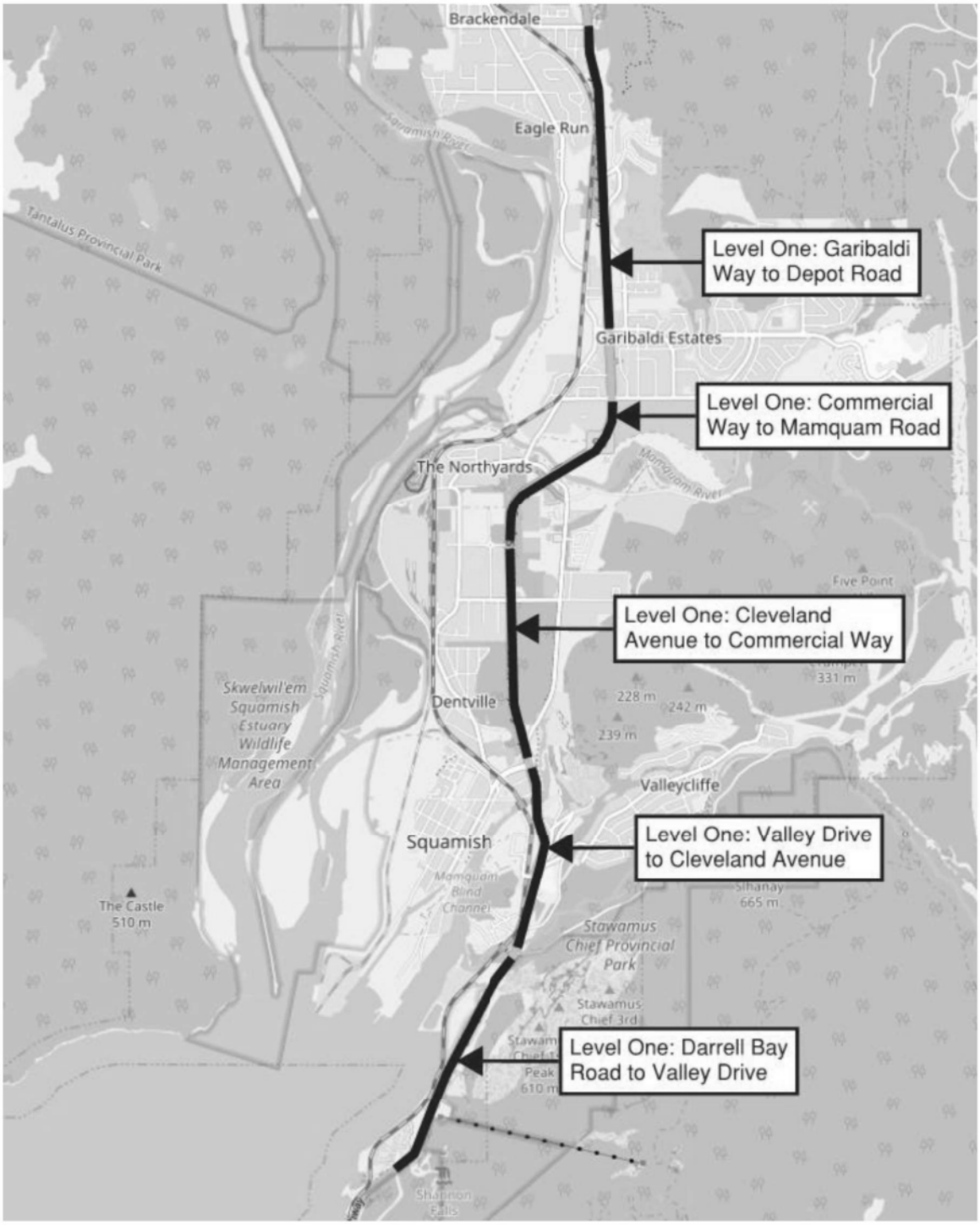

Figure 5.1: Identified Level One and Level Two Collision-Prone Segments

5.4.2 Collision Prone Locations

Collision prone locations were assessed separately for each intersection along the corridor. These intersections, as well as their location along the corridor and intersection control type, are summarized in ***Table 5.17*** from south to north. The corresponding service class and traffic volume range is summarized in ***Table 5.18***. The resultant segment-based road safety performance results are summarized in ***Table 5.19*** below.

Table 5.17: Highway Intersection Locations for Safety Assessment

Intersection	LKI Segment	KM	Highway Class	Intersection Control
Darrell Bay Road	2929	24.9	Rural arterial divided, ≥ 4 lanes	Signalized
Mamquam River FSR	2929	27.3	Rural arterial divided, ≥ 4 lanes	Unsignalized
Valley Drive	2929	27.5	Rural arterial divided, ≥ 4 lanes	Signalized
Clarke Drive	2929	28	Rural arterial divided, ≥ 4 lanes	Signalized
Mill Road	2929	28.5	Rural arterial divided, ≥ 4 lanes	Unsignalized
Scott Crescent	2929	28.7	Rural arterial divided, ≥ 4 lanes	Unsignalized
Cleveland Avenue	2929,2945	29-0.3	Rural arterial divided, ≥ 4 lanes	Signalized
Industrial Way / Finch Avenue	2945	1.6	Rural arterial divided, ≥ 4 lanes	Signalized
Commercial Way	2945	2.1	Rural arterial divided, ≥ 4 lanes	Signalized
Mamquam Road	2945	3.9	Rural arterial divided, ≥ 4 lanes	Signalized
Garibaldi Way	2945	4.5	Rural arterial divided, ≥ 4 lanes	Signalized
Dowad Drive	2945	6	Rural arterial divided, ≥ 4 lanes	Unsignalized
Depot Road	2945	7.3	Rural arterial divided, ≥ 4 lanes	Signalized

Table 5.18: Highway Locations for Service Class and Traffic Volume Range

From	Highway class	Intersection Entries Annual Average Daily Traffic Volume (2015-2019)	Annual Average Daily Traffic Volume Range
Darrell Bay Road	Rural arterial divided, ≥ 4 lanes	12,580	10,001-15,000
Mamquam River FSR	Rural arterial divided, ≥ 4 lanes	13,038	10,001-15,000
Valley Drive	Rural arterial divided, ≥ 4 lanes	13,871	10,001-15,000
Clarke Drive	Rural arterial divided, ≥ 4 lanes	19,150	15,001-20,000
Mill Road	Rural arterial divided, ≥ 4 lanes	18,536	15,001-20,000
Scott Crescent	Rural arterial divided, ≥ 4 lanes	18,355	15,001-20,000
Cleveland Avenue	Rural arterial divided, ≥ 4 lanes	28,109	20,001+
Industrial Way / Finch Avenue	Rural arterial divided, ≥ 4 lanes	23,793	20,001+
Commercial Way	Rural arterial divided, ≥ 4 lanes	24,112	20,001+
Mamquam Road	Rural arterial divided, ≥ 4 lanes	27,335	20,001+
Garibaldi Way	Rural arterial divided, ≥ 4 lanes	21,744	20,001+
Dowad Drive	Rural arterial divided, ≥ 4 lanes	12,386	10,001-15,000
Depot Road	Rural arterial divided, ≥ 4 lanes	12,789	10,001-15,000

Table 5.19: Identification of Potential Collision Prone Segments

Intersection	Total Intersection Collisions	Intersection Collision Frequency	Level One: Collision Frequency ≥ 3 / year?	Level Two: Collision Frequency ≥ 2 / year?	Intersection Collision Rate	Critical Collision Rate	Segment Collision Rate > Critical Collision Rate?	Intersection CSI	Provincial Average CSI	Segment CSI > Provincial Average CSI?	Collision Prone Location?
Darrell Bay Road	11	2.20	No	Yes	0.48	0.60	No	4.27	7.55	No	No
Mamquam River FSR	1	0.20	No	No	0.04	0.58	No	1.00	3.52	No	No
Valley Drive	12	2.40	No	Yes	0.47	0.59	No	7.00	7.55	No	No
Clarke Drive	10	2.00	No	Yes	0.29	0.55	No	5.50	5.26	Yes	Level Two
Mill Road	0	0.00	No	No	0.00	0.23	No	n/a	3.25	n/a	n/a
Scott Crescent	3	0.60	No	No	0.09	0.23	No	1.00	3.25	No	No
Cleveland Avenue	38	7.60	Yes	n/a	0.74	0.47	Yes	5.97	5.91	Yes	Level One
Industrial Way / Finch Avenue	12	2.40	No	Yes	0.28	0.48	No	5.50	5.91	No	No
Commercial Way	13	2.60	No	Yes	0.30	0.48	No	3.77	5.91	No	No
Mamquam Road	25	5.00	Yes	n/a	0.50	0.47	Yes	5.32	5.91	No	Level One
Garibaldi Way	14	2.80	No	Yes	0.35	0.49	No	6.14	5.91	Yes	Level Two
Dowad Drive	1	0.20	No	No	0.04	0.59	No	1.00	3.52	No	No
Depot Road	9	1.80	No	No	0.39	0.60	No	4.00	7.55	No	No

Based on the criteria noted above, the following four locations, shown in ***Figure 5.2,*** were collision-prone compared to other similar intersections in the province:

- Level One:
  - Cleveland Avenue (exceeds both collision rate and collision severity thresholds); and,
  - Mamquam Road (exceeds both collision rate threshold).
- Level Two:
  - Clarke Drive (exceeds both collision severity threshold); and,
  - Garibaldi Way (exceeds collision severity threshold).

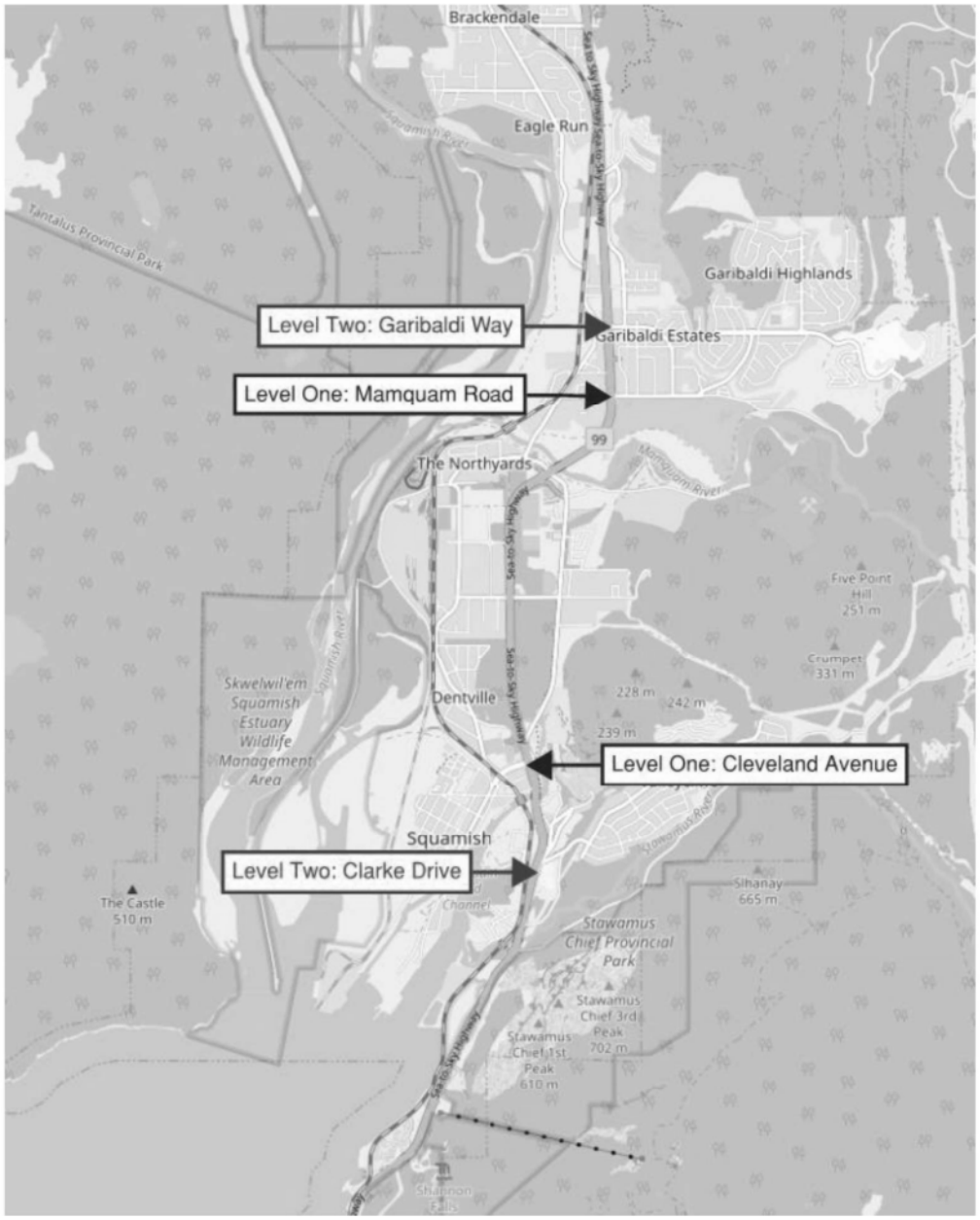

Figure 5.2: Identified Level One and Level Two Collision-Prone Locations

5.5 Issues Identification Summary

At a network-wide level, two major mobility and road safety issues were noted:

- Increased travel times for through-movements that exceed desirable thresholds during the Saturday analysis hour and are anticipated to significantly increase in both the northbound and southbound directions on both Saturdays and Sundays in the future.
- Collision prone locations (whole of the corridor, except between Mamquam Road and Garibaldi Way).

Intersection-level issues are summarized in ***Table 5.20***.

Table 5.20: Summary of Identified Issues

Location	Issue Type	Existing Conditions (2020)	Future Conditions (2040)
Darrell Bay Road	Active Transportation	• Missing sidewalks.	
Stawamus Chief Parking	Traffic Operations	-	• **Level of Service:** Westbound left.
Mamquam River Forest Service Road	Traffic Operations	-	• **Level of Service:** Eastbound left; Westbound left.
	Active Transportation	• Will require an active transportation crossing on east leg of intersection in the future (per District of Squamish *Active Transportation Plan*).	
Valley Drive	Active Transportation	• Missing sidewalk / multi-use path on northeast quadrant. • Will require an active transportation crossing on east leg of intersection in the future (per District of Squamish *Active Transportation Plan*). Signal separation of active transportation users and northbound right turning vehicles is warranted.	
Clarke Drive	Traffic Operations	• **Level of Service:** Southbound left (also affects transit operations). • **V/C Ratio:** Southbound left. • **50th percentile queues:** Westbound right. • **95th percentile queues:** Southbound left.	• **Level of Service:** Southbound left (also affects transit operations); Northbound left. • **V/C Ratio:** Southbound left. • **50th percentile queues:** Westbound right; Eastbound left. • **95th percentile queues:** Southbound left; Westbound right.
	Road Safety	• Collision prone location (Level 2).	
Mill Road	Traffic Operations	• **Level of Service:** Eastbound movements.	• **Level of Service:** Eastbound movements. • **V/C Ratio:** Eastbound movements.
Scott Crescent	Network Connectivity	• Lack of full movement access in and out of the area.	
	Active Transportation	• Pinch point in multi-use path just south of right-in / right-out.	

Location	Issue Type	Existing Conditions (2020)	Future Conditions (2040)
Mamquam Blind Channel Bridge	Active Transportation	• Limited multi-use path width on bridge structure across Mamquam Blind Channel.	
Cleveland Avenue	Traffic Operations	• **Level of Service:** Northbound left (also affects transit operations). • **V/C Ratio:** Northbound left.	• **Level of Service:** Northbound left; Southbound right; Eastbound left. All movements also affect transit operations. • **V/C Ratio:** Northbound left; Southbound right; Eastbound left. • **50th percentile queues:** Eastbound right. • **95th percentile queues:** Southbound right; Eastbound right.
	Active Transportation	• Limited walking time for pedestrians crossing east-west across Highway 99;	
	Road Safety	• Collision prone location (Level 1).	
Industrial Way / Finch Drive	Traffic Operations	• **Level of Service:** Southbound through; Northbound left (also affects transit operations). • **V/C Ratio:** Southbound through; Northbound left.	• **Level of Service:** Southbound through; Northbound left (also affects transit operations); Northbound through; Southbound left; Overall intersection. • **V/C Ratio:** Southbound through; Northbound left; Northbound through; Southbound left.
	Active Transportation	• Missing sidewalks / curb letdowns.	
Commercial Way	Traffic Operations	-	• **V/C Ratio:** Southbound through.
Mamquam River Bridge	Active Transportation	• Limited multi-use path width on bridge structure across Mamquam River.	
Mamquam Road	Traffic Operations	• **Level of Service:** Westbound left (also affects transit operations); Northbound left; Southbound left. • **V/C Ratio:** Northbound through; Westbound left. • **50th percentile queues:** Westbound left. • **95th percentile queues:** Westbound left.	• **Level of Service:** Westbound left (also affects transit operations); Northbound left; Southbound left; Northbound through; Overall intersection. • **V/C Ratio:** Northbound through; Westbound left; Southbound through. • **50th percentile queues:** Westbound left. • **95th percentile queues:** Westbound left.
	Transit	• Potential future requirement for on-corridor bus stop (in the vicinity of Mamquam Road / Garibaldi Way).	

Location	Issue Type	Existing Conditions (2020)	Future Conditions (2040)
	Active Transportation	• Conflicts between turning vehicles and Corridor Trail users.	
	Road Safety	• Collision prone location (Level 1).	
Garibaldi Way	Traffic Operations	• **Level of Service:** Northbound left; Southbound left (also affects transit operations). • **50th percentile queues:** Westbound left.	• **Level of Service:** Northbound left; Southbound left (also affects transit operations). • **V/C Ratio:** Northbound through. • **50th percentile queues:** Westbound left. • **95th percentile queues:** Westbound left.
	Transit	• Potential future requirement for on-corridor bus stop (in the vicinity of Mamquam Road / Garibaldi Way).	
	Active Transportation	• Conflicts between turning vehicles and Corridor Trail users. • Conflicts between right-turning vehicles and east-west cycling; understood that separate design investigation is already underway.	
	Road Safety	• Collision prone location (Level 2).	
Dowad Drive	Network Connectivity	• Pressure to introduce new signal here will create future traffic operations challenges.	
Depot Road	Traffic Operations	-	• **Level of Service:** Northbound left. • **V/C Ratio:** Northbound left.
	Active Transportation	• Missing sidewalks.	

6. OPTION GENERATION

In response to the above-noted issues, mitigation measures have been developed to address each issue. In generating mitigation options, the previously documented Role and Function of Highway 99 through the District of Squamish was considered. Most critically, mitigation measures have been developed in a manner that avoids introducing additional signalized intersections along the corridor. However, the corridor is not planned for conversion to a freeway, and therefore the focus of the assignment is on improving intersections rather than implementing interchanges. Other key considerations include limiting public access density and intersection spacing, and supportive transit and active transportation movements parallel to or across the highway corridor.

Below, each of the previously noted issues is reviewed in further detail, and the corresponding potential mitigation measures have described and (if applicable) shown in a sketch.

6.1 Darrell Bay Road

The issues identified at the intersection of Highway 99 and the Darrell Bay Road, as well as potential mitigation measures, are summarized in ***Table 6.1*** below.

Table 6.1: Darrell Bay Road Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Active Transportation: Missing sidewalks / landings at all intersection quadrants.	Add sidewalks / landings to the northeast, northwest and southwest quadrants of the intersection to provide a landing area so that people don't have to walk in vehicle lanes or on gravel shoulders. The southeast quadrant does not require a sidewalk / landing because there are no crosswalks to access this quadrant (i.e. no crosswalks for the south and east legs of the intersections). Such crosswalks do not service a desire line that is not equally well served by the existing crosswalks on the north and west legs of the intersection, and therefore are not recommended.

The potential mitigation options are shown schematically in ***Figure 6.1***.

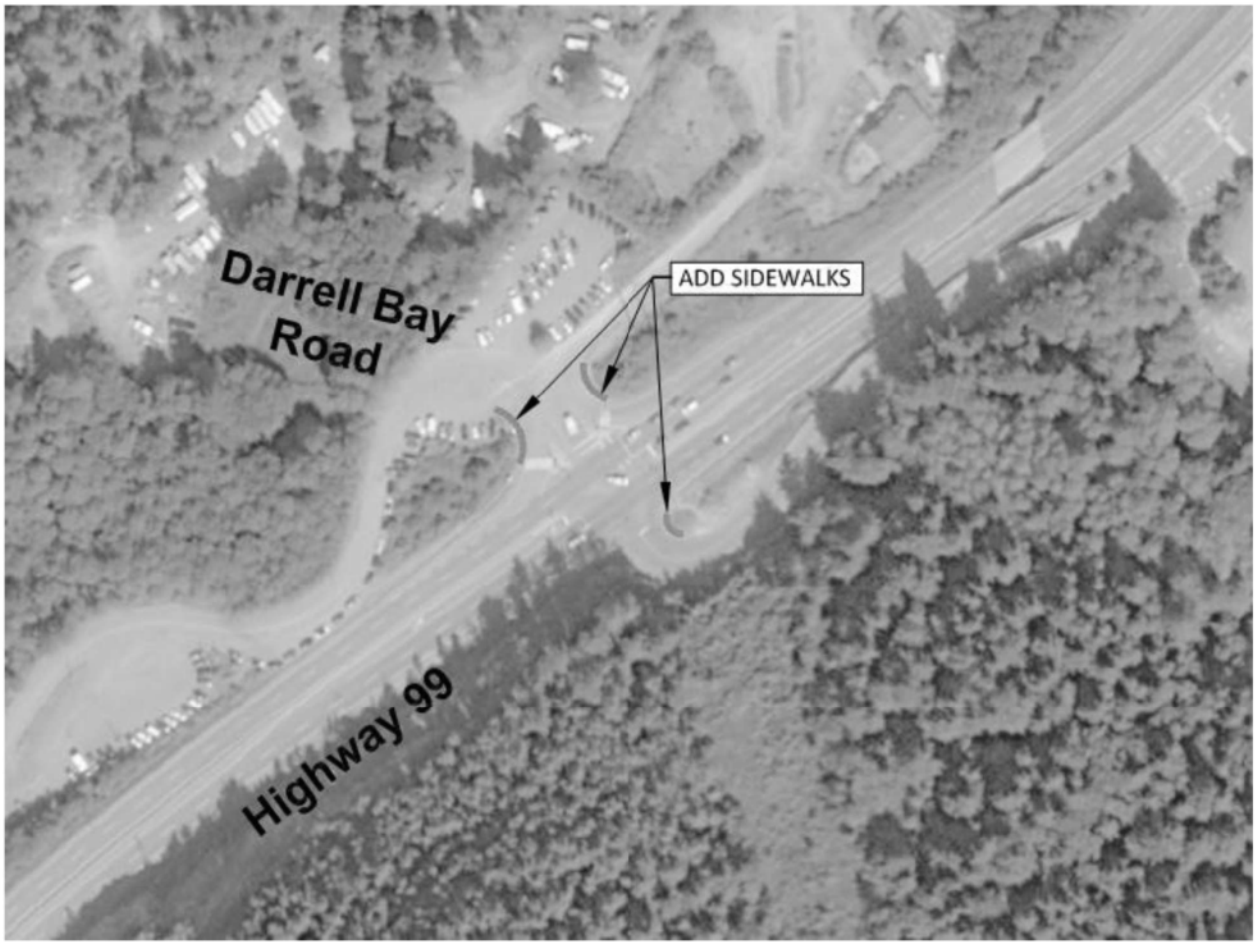

Figure 6.1: Schematic of Potential Mitigation Options at Darrell Bay Road

6.2 Stawamus Chief Parking Lot

The issues identified at the intersection of Highway 99 and the Stawamus Chief Parking Lot, as well as potential mitigation measures, are summarized in ***Table 6.2*** below.

Table 6.2: Stawamus Chief Parking Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Westbound left (2040 only).	During summer days when the westbound left movement out of the parking lot is busiest, the Darrell Bay Road intersection will also see frequent pedestrian actuations, and therefore the Darrell Bay Road signal can help create some gaps in the northbound Highway 99 traffic stream in order to allow westbound left turn movements to occur.

Issue	Potential Mitigation Option
	However, if delays for the westbound left turn movement get too severe, then outbound drivers from the Stawamus Chief Parking Lot destined to Metro Vancouver may end up giving up and making a westbound right-turn movement in order to travel north and then turn around at either the Mamquam River Forest Service Road or Valley Drive. In this case, it is recommended that opportunities for a more formalized jughandle turnaround route be examined at the cross-street of nearby intersections that are already signalized. Note that a jughandle turnaround would still involve a detour of 3+ kilometres of additional travel, and therefore is not anticipated to be the preferred choice but rather to act as a "relief valve" during the busiest days where there is extensive delays and queuing.

6.3 Mamquam River Forest Service Road

The issues identified at the intersection of Highway 99 and Mamquam River Forest Service Road, as well as potential mitigation measures, are summarized in ***Table 6.3*** below.

Table 6.3: Mamquam River Forest Service Road Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Eastbound left/through (2040 only). Westbound left/through (2040 only).	It is likely not possible to coordinate Valley Drive and Darrell Bay signals such that this intersection will have a gap in both the northbound and southbound Highway 99 traffic streams simultaneously. Given the relatively low volumes, in the absence of implementing a traffic signal or a grade-separation, WBL / EBL vehicles may have to go to the nearest signalized intersection and turnaround (Valley Drive for WBL desire lines, and Darrell Bay Road for EBL desire lines). WBT / EBT vehicles may have to wait for a gap. If a jughandle were to be provided north of the Mamquam River Forest Service Road intersection (as described above in Table 6.2), then that facility could also be used by WBL vehicles at this intersection.
Active Transportation: The District of Squamish *Active Transportation Plan* includes a multi-use pathway (an extension of the Corridor Trail) running along the east side of the highway through this intersection. Currently the east leg of the intersection is not configured for active transportation users to cross (i.e. lack of formal channelized right turn islands and crosswalks/crossrides).	Provide a crosswalk / crossride on the east leg of the intersection in order to enable continuous connectivity for the future Corridor Trail extension. In conjunction with this improvement, provide concrete channelized right turn islands for the NBR and WBR movements in order to provide a more comfortable waiting / refuge area for people walking and cycling across this intersection. Provide a high-angle "smart channelization" for the NBR in order to improve sightlines and manage speeds for right-turning vehicles that have movements conflicting with

Issue	Potential Mitigation Option
	multi-use path users[3]. A smart channelization is not suggested for the WBR movement due to the lack of room for a subsequent acceleration lane. This mitigation measure should be timed to be implemented in conjunction with an extension of the Corridor Trail multi-use path.

The potential mitigation options are shown schematically in ***Figure 6.2***.

Figure 6.2: Schematic of Potential Mitigation Options at Mamquam River Forest Service Road

It is acknowledged that WBR / EBR acceleration lanes are not provided at this intersection, however volumes for these movements are low. Providing a reasonable WBR acceleration lane would not be possible without widening the highway bridge structure over the Stawamus River and providing a EBR acceleration lane would likely run into challenges with the swept path of turning vehicles unless the west leg of the intersection was also realigned.

[3] Refer to *BC Active Transportation Design Guide* Figure G-100 for further information on smart channelization.

6.4 Valley Drive

The issues identified at the intersection of Highway 99 and Valley Drive, as well as potential mitigation measures, are summarized in ***Table 6.4*** below.

Table 6.4: Valley Drive Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Active Transportation: At the northeast quadrant of the intersection, the Corridor Trail multi-use path does not extend all the way to the crosswalk, pedestrians / cyclists must use road shoulder.	Extend multi-use path to properly connect to the intersection without requiring use of the shoulder (may require shifting of electrical box).
Active Transportation: The District of Squamish *Active Transportation Plan* includes a multi-use pathway (an extension of the Corridor Trail) running along the east side of the highway through this intersection. Currently the east leg of the intersection is not configured for active transportation users to cross (i.e. lack of formal channelized right turn islands and crosswalks / crossrides). Based on the *BC Active Transportation Design Guide*, signal separation of active transportation users and northbound right turning vehicles warrants consideration.	Provide a crosswalk / crossride on the east leg of the intersection in order to enable continuous connectivity for the future Corridor Trail extension. In conjunction with this improvement, reconfigure the concrete channelized right turn island for the NBR movement in order to improve sightlines and manage speeds for right-turning vehicles that have movements conflicting with multi-use path users. Smart channelization will reduce vehicle speeds and increase yielding to pedestrians and cyclists. As a result, many of the intended benefits of temporal-separation are achieved, without the accompanying significant increase in vehicle delays. Smart channelization is not suggested for the WBR movement due to the lack of room for a subsequent acceleration lane. A smart channelization is not suggested for the WBR movement due to the lack of room for a subsequent acceleration lane. This mitigation measure should be timed to be implemented in conjunction with an extension of the Corridor Trail multi-use path.

The potential mitigation options are shown schematically in ***Figure 6.3***.

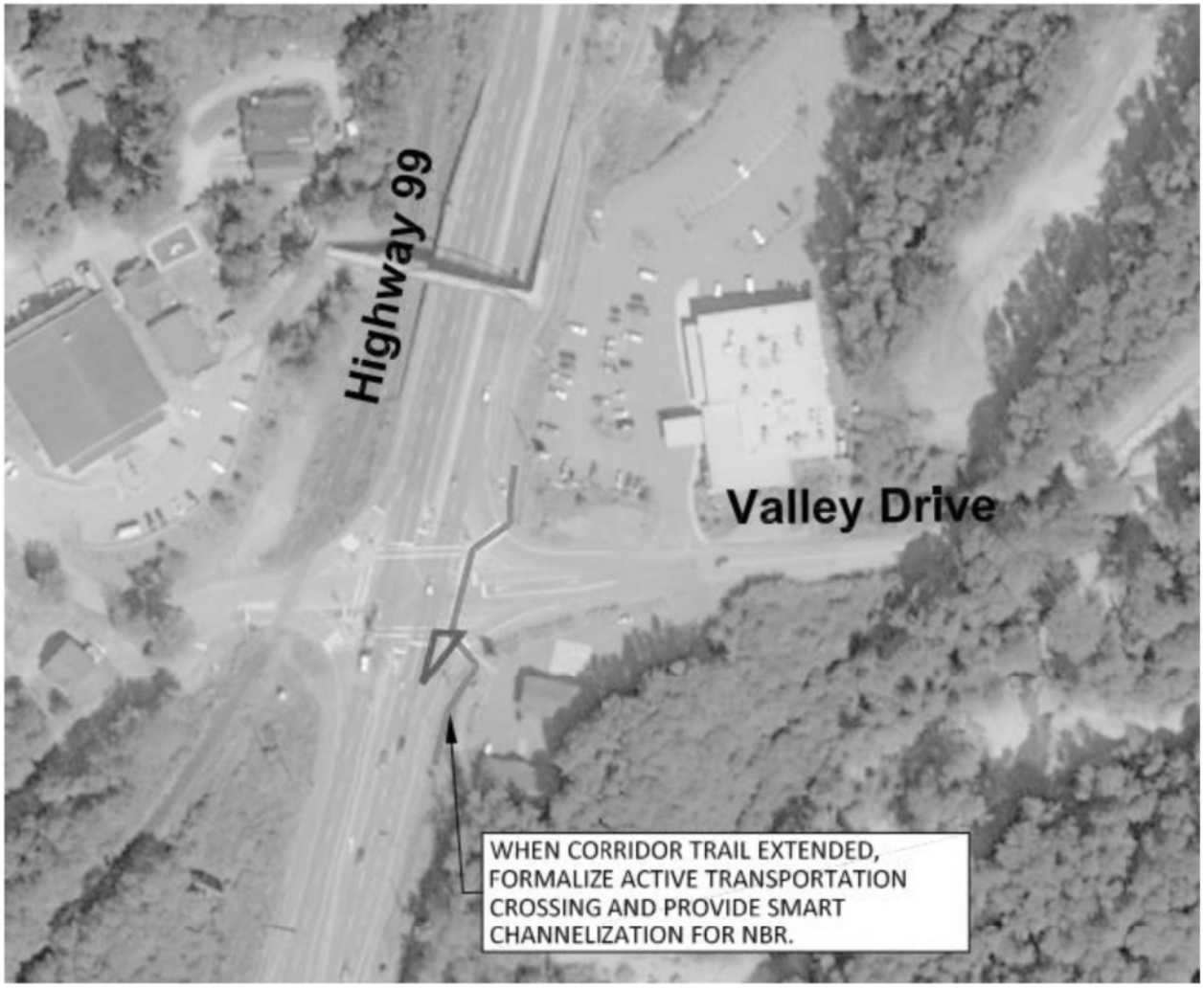

Figure 6.3: Schematic of Potential Mitigation Options at Valley Drive

6.5 Clarke Drive

The issues identified at the intersection of Highway 99 and Clarke Drive, as well as potential mitigation measures, are summarized in ***Table 6.5*** below.

Table 6.5: Clarke Drive Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Southbound left (2020 and 2040). Northbound left (2040 only).	This intersection was recently expanded to a four-leg intersection through the introduction of a new west leg consisting of an overpass across the BC Rail corridor. The Waterfront Landing development will be required to build a new vehicular bridge over Mamquam Blind Channel that will connect to downtown Squamish via Pemberton Avenue. This new connection will provide a new route in and out of the Waterfront Landing that will reduce the need for SBR and EBL movements. Furthermore, the new connection will enable people travelling to / from the Valleycliffe or Northridge neighbourhoods to make EBT / WBT movements at the Clarke Drive intersection (which generally operate adequately) through the intersection instead of relying on SBL / WBR movements. With the shift in trip routing through the intersection in place, the signal would be re-timed in order to optimize operations for the new vehicle movement patterns.
V/C Ratio: Southbound left (2020 and 2040).	
50th percentile queues: Westbound right, (2020 and 2040). Eastbound left (2040 only).	
95th percentile queues: Southbound left (2020 and 2040). Westbound right (2040 only).	
Transit: Poor Level of Service for the southbound left movement affects transit operations.	The changes described above (specifically, enabling some SBL traffic travelling from downtown Squamish to the Valleycliffe or Northridge neighbourhoods to instead make a EBT movement) are anticipated to also reduce delays for transit. If automatic vehicle location (AVL) devices were to be installed on Squamish Transit System buses in the future, then opportunities to add green extensions for the SBL movement (or red truncations for other movements) could be investigated. Currently, Route 3 buses making this movement operate at roughly 30 minute headways during much of the weekday (although increasing to 60-120 minutes at times), and 60 minute headways on Saturdays and Sundays.

Issue	Potential Mitigation Option
Road Safety: Intersection is a Collision Prone Location (Level 2). Further analysis shows 10 collision records over a 5-year period, consisting of 5 injury collisions and 5 PDO collisions. This intersection was identified as a Collision Prone Location due to a higher than provincial average Collision Severity Index; the collision rate at this intersection is well below the critical collision rate. Of the 9 collisions with sufficient data, 7 of the 9 collisions were related to collisions between NBT and SBL movements. The most likely culprit is that SBL vehicles are making permissive turns where there is an insufficient gap in the NBT traffic stream. The vertical crest of Highway 99 at this intersection may contribute to SBL vehicles not being able to adequately judge gaps in the NBT traffic stream. An alternative explanation is that NBT vehicles are consistently running red lights (i.e. during the SBL protected phase), however this is seen as a less likely cause. Note that the collision history reflects intersection conditions prior to the recent reconfiguration to add a fourth (west) leg to the intersection.	As part of the recent reconfiguration of the intersection to add a fourth (west) leg, the SBL movement was converted from permissive + protected to protected-only. This is anticipated to mitigate the primary collision pattern that was observed at this intersection. Note that the NBL movement (which did not exist prior to the recent introduction of the west leg) also features protected-only movements. In the event that NBT / SBL collisions continue in the future even with the protected-only SBL phase, then it is anticipated that NBT movements running red lights may be the culprit. In this case, consider introducing high friction pavement to assist with quick deceleration.

The potential mitigation options are shown schematically in ***Figure 6.4***.

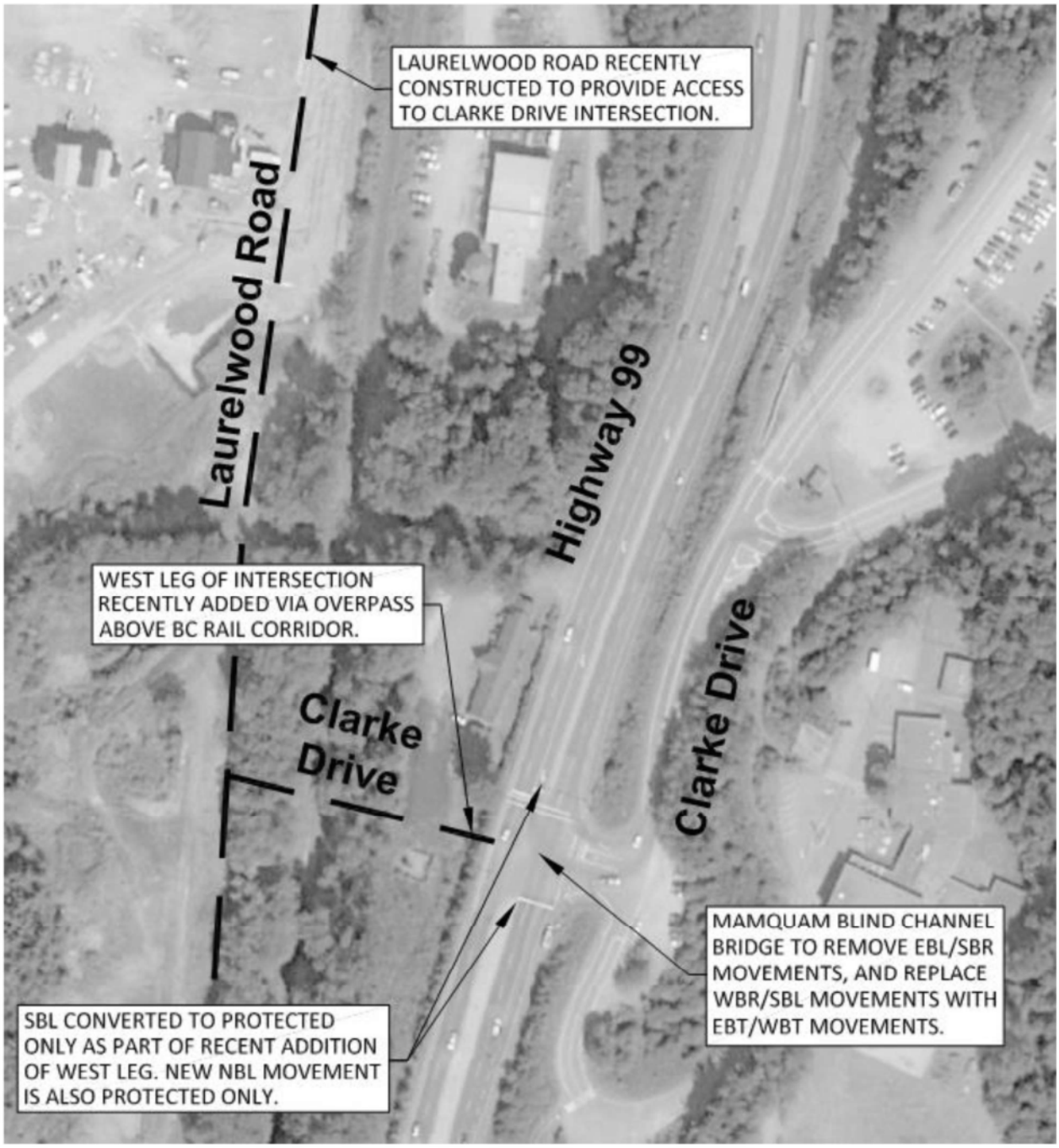

Figure 6.4: Schematic of Potential Mitigation Options at Clarke Drive

6.6 Mill Road

The issues identified at the intersection of Highway 99 and Mill Road, as well as potential mitigation measures, are summarized in ***Table 6.6*** below.

Table 6.6: Mill Road Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Eastbound movements (2020 and 2040).	This three-leg intersection already has a Protected-T intersection allowing for full movements to / from the third (west) leg of the intersection. Currently this intersection only services a gas station and restaurant on the north side of Mill Road, although there is development potential on the south side of Mill Road. Mill Road formerly had an at-grade crossing of the BC Rail corridor; however this was recently closed in conjunction with the opening of the new west leg of the Clarke Drive intersection, which provides an overpass above the railway corridor. Given the new development occurring in the vicinity of the former Mill Road at-grade crossing (i.e. the Waterfront Landing development already underway to the west side of the BC Rail corridor, potential for redevelopment on the east side of the BC Rail corridor), a re-opened Mill Road crossing will likely have greater traffic volumes than the previous crossing, and more potential for queue spillbacks from the crossing onto the nearby Highway 99 Protected-T during train occupancy events. As such, re-opening the crossing could trigger additional operational issues at the Highway 99 Protected-T, and is therefore not recommended to be re-opened for vehicles. However, it is noted that an at-grade crossing at Mill Road that provides connectivity only for pedestrians and cyclists may provide an opportunity to encourage use of sustainable transportation modes to access this new development while avoiding the challenges associated with a (vehicular) at-grade crossing so close to the Highway 99 Protected-T intersection. It is therefore recommended that other agencies (i.e. the road authority and rail authority) consider the potential for an active transportation-only crossing in the event that redevelopment were to occur on the east side of the BC Rail corridor.
V/C Ratio: Eastbound movements (2040 only).	

The potential mitigation options are shown schematically in ***Figure 6.5***.

Figure 6.5: Schematic of Potential Mitigation Options at Mill Road

The Mill Road crossing was formerly a private crossing and is not under BC MoTI jurisdiction. As such, the option has been identified for consideration by applicable road (and rail) authorities but will not be pursued further as part of this study. It is noted that if providing a full vehicular crossing is found to be infeasible, opportunities to provide an active transportation-only crossing could be investigated.

6.7 Scott Crescent

The issues identified at the intersection of Highway 99 and Scott Crescent, as well as potential mitigation measures, are summarized in ***Table 6.7*** below.

Table 6.7: Scott Crescent Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Traffic Operations / Access: Lack of full movement access at this three-leg intersection (i.e. SBL and WBL are not possible). While the lack of full movements will not directly create a traffic operations challenge at Scott Crescent in and out of the area, it will require both existing users and residents of new developments in the area to undertake a more circuitous route in and out of the area.	The addition of a Protected-T intersection at Scott Crescent would provide full movements to and from Scott Crescent. However, a Protected-T intersection at the current intersection location is not possible without needing to widen the highway bridge over the Mamquam River to provide a deceleration and storage lane for SBL movements. An alternative approach was investigated wherein the Scott Crescent intersection would be realigned southwards in order to enable the SBL deceleration lane to only begin developing on the south side of the Mamquam River (and thus avoiding any need to widen the bridge). However, the Scott Crescent intersection would need to be relocated approximately 115 metres south of the current location and would therefore generate property impacts to residences along Harbour View Place and would along require bluff scaling. This new Protected-T intersection would also conflict with the existing Protected-T intersection at Mill Road and would require the existing Mill Road Protected-T intersection to be converted to a right-in / right-out instead. Given these challenges, this option was found to be infeasible, and was not pursued further. For downtown Squamish to Scott Crescent, the proposed new Mamquam River Bridge would provide an alterative “right-in” access.
Active Transportation: Pinch point in Corridor Trail multi-use path just south of Scott Crescent right-in / right-out.	Widen multi-use path by undertaking bluff scaling.

The potential mitigation options are shown schematically in ***Figure 6.6***.

Figure 6.6: Schematic of Potential Mitigation Options at Scott Crescent

6.8 Mamquam Blind Channel Bridge

The issues identified at the Highway 99 bridge over the Mamquam Blind Channel, as well as potential mitigation measures, are summarized in ***Table 6.8*** below.

Table 6.8: Mamquam Blind Channel Bridge Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Active Transportation: Limited multi-use path width on bridge structure across Mamquam Blind Channel.	Widening the bridge structure is a high-cost initiative as a standalone improvement. However, if a major bridge rehabilitation project is required in the future, then use this opportunity to also expand the bridge cross-section to provide a wider multi-use path that meets current best practices for all ages and abilities facilities.

The potential mitigation options are shown schematically in ***Figure 6.7***.

Figure 6.7: Schematic of Potential Mitigation Options at Mamquam Blind Channel Bridge

6.9 Cleveland Avenue

The issues identified at the intersection of Highway 99 and Cleveland Avenue, as well as potential mitigation measures, are summarized in ***Table 6.9*** below.

Table 6.9: Cleveland Avenue Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Northbound left (2020 and 2040). Southbound right (2040 only). Eastbound left (2040 only).	The intersection is already relatively built-out, and adjacent development and the alignment of the east leg (Loggers Lane) constrain the ability to widen further. Therefore, network-level improvements are likely required in order to redirect demands elsewhere. An opportunity was identified to provide a SBR "bypass" / slip lane that runs behind the gas station and fast food restaurant, in order to minimize intersections between people travelling in / out of these retail establishments and people making a SBR from Highway 99 onto Cleveland Avenue. As part of this mitigation option, the existing SBR lane would be closed. An eastbound right turn acceleration lane is already under development, which will assist with traffic flows and may help reduce queue lengths.
V/C Ratio: Northbound left (2020 and 2040). Southbound right (2040 only). Eastbound left (2040 only).	
50th percentile queues: Eastbound right (2040 only).	
95th percentile queues: Southbound right (2040 only). Eastbound right (2040 only).	
Transit: Poor Level of Service for all of the above-noted movements (NBL, SBR, EBL) affects transit operations.	Limited opportunity for changes beyond those described above (i.e. EBR acceleration lane will benefit Routes 3 and 5, potential SBR "bypass" would benefit Routes 4 and 5). If automatic vehicle location (AVL) devices were to be installed on Squamish Transit System buses in the future, then opportunities to add green extensions for the NBL movement (or red truncations for other movements) could be investigated. Currently, Route 3 buses making this movement operate at roughly 30 minute headways during much of the weekday (although increasing to 60-120 minutes at times), and 60 minute headways on Saturdays and Sundays. Similarly, Route 4 buses making an EBL movement operate at roughly 30 minute headways during weekday peak hours, but do not operate off-peak or on weekends.

Issue	Potential Mitigation Option
Active Transportation: Limited walking time for pedestrians crossing east-west across Highway 99.	No specific evidence of collisions involving pedestrians or cyclists at this intersection that would be attributable to short walk time was identified. An increase in walk time across the highway would result in an increase in vehicle delay on Highway 99. Given the moderate pedestrian volumes and lack of historical safety issues for pedestrians crossing the highway at Cleveland Avenue, increasing the walking time is not warranted at this time, There is the potential to install signage on the Valley Trail to encourage pedestrians / cyclists seeking to access downtown area to use the existing underpass beneath the highway near Pemberton Avenue / Mamquam Blind Channel Bridge.
Road Safety: Collision prone location (Level 1). Further analysis shows 38 collision records over a 5-year period, consisting of 21 injury collisions and 17 PDO collisions. This intersection was identified as a Collision Prone Location due to the collision rate at this intersection being significantly higher than the critical collision rate, as well as a slightly higher than provincial average Collision Severity Index. Nine of 38 collisions were related to eastbound right turning movements; a known location for rear-end collisions due to the lack of an acceleration lane. Seven of 38 collisions were related to southbound rear-end collisions. Seven of 38 collisions were related to northbound rear-end collisions. The remaining collisions included an assortment of through movement / left turn collisions, fixed object collisions etc., without any specific patterns emerging.	An eastbound right turn acceleration lane is already under development, which will assist with traffic flows and is expected to reduce collisions associated with the eastbound right movement. With respect to northbound and southbound rear-end collisions, insufficient information is available regarding where specifically these collisions are occurring. However, it is speculated that if queues for northbound or southbound through movements are extremely long, then vehicles may need to stop much sooner than drivers anticipate (i.e. not at the stop bar, but 100+ metres upstream). In these instances, the advance warning flashers do not provide a useful function, as drivers may need to begin decelerating before they see the advance warning flasher signboard. Therefore, flashing "congestion ahead" signs placed further upstream could be activated during periods with extended queuing[4]. Additionally, high friction pavement could also be provided to assist drivers needing to make sudden decelerations.

[4] A precedent example of such a sign is located on Highway 17 in the southbound direction upstream of the Beacon Avenue intersection in Sidney, BC. This sign, which provides four flashers and "Congestion Ahead – Slow Down When Flashing" text, is intended to alert drivers to extended queues generated by sudden platoons of southbound vehicles associated with ferry unloading at the nearby BC Ferries Swartz Bay terminal.

The potential mitigation options are shown schematically in ***Figure 6.8***.

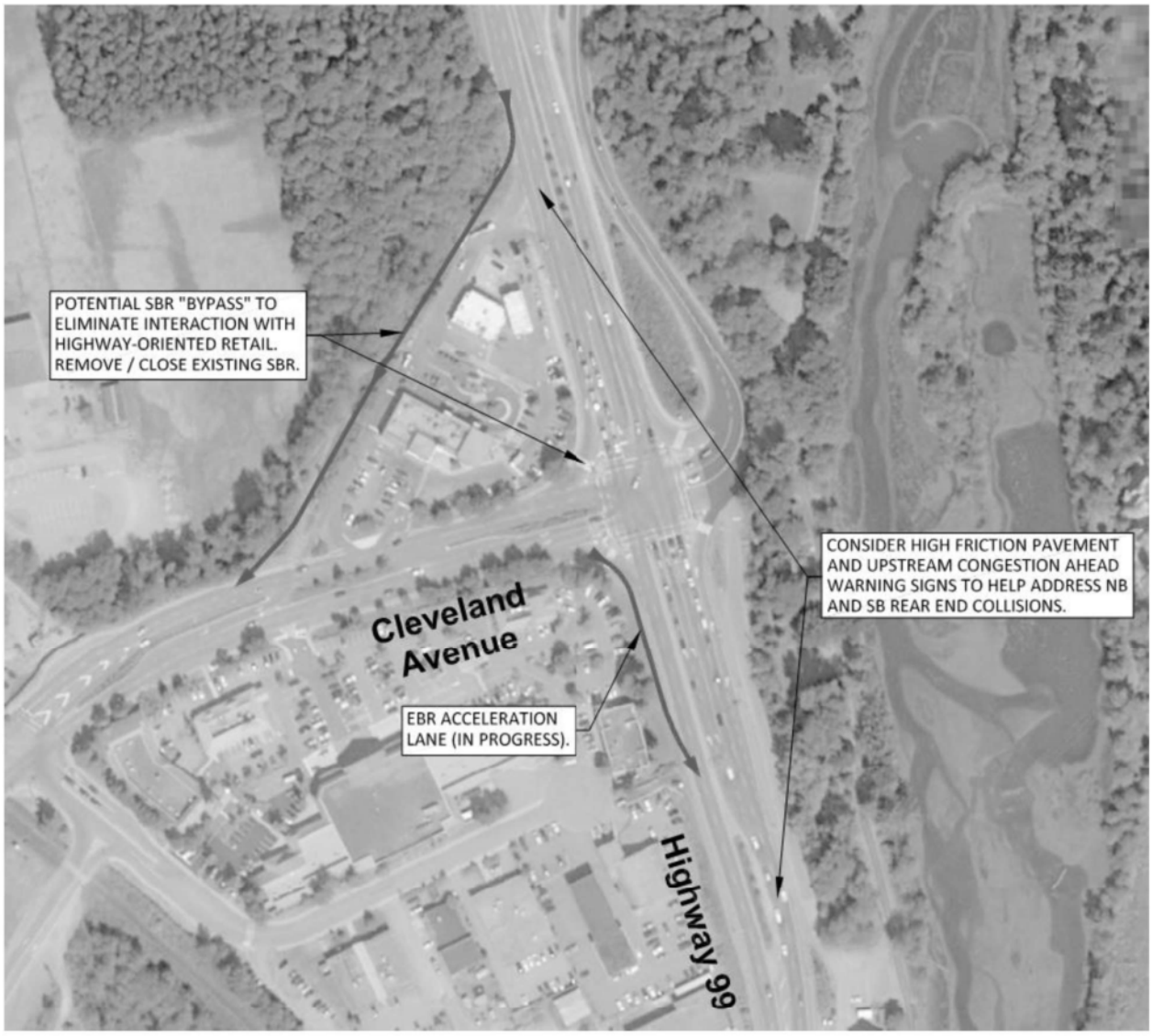

Figure 6.8: Schematic of Potential Mitigation Options at Cleveland Avenue

6.10 Industrial Way / Finch Avenue

The issues identified at the intersection of Highway 99 and the Industrial Way / Finch Avenue, as well as potential mitigation measures, are summarized in ***Table 6.10*** below.

Table 6.10: Industrial Way / Finch Drive Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Southbound through (2020 and 2040). Northbound left (2020 and 2040). Northbound through (2040 only). Southbound left (2040 only). Overall intersection (2040 only).	Convert the single NBL and SBL lanes to dual NBL and SBL lanes in order to double capacity of these movements. NBL and SBL movements are already protected-only, so there is no permissive LT capacity that is "lost" when converting to dual turn lanes. This will require downstream adjustments to Industrial Way westbound and widening of Finch Drive eastbound. There is limited ability to directly address through-movements further (without six-laning), however, signal timings can be adjusted as required to optimize operations for the overall intersection (i.e. redirect some NBL / SBL signal time to NBT / SBT movements).
V/C Ratio: Southbound through (2020 and 2040). Northbound left (2020 and 2040). Northbound through (2040 only). Southbound left (2040 only).	
Transit: Poor Level of Service for the northbound left movement affects transit operations.	The above-noted laning improvements to the intersection should help reduce delays for northbound left-turning buses. If automatic vehicle location (AVL) devices were to be installed on Squamish Transit System buses in the future, then opportunities to add green extensions for the NBL movement (or red truncations for other movements) could be investigated. Currently, Route 4 buses making this movement operate at roughly 30 minute headways during weekday peak hours, but do not operate off-peak or on weekends.
Active Transportation: Missing sidewalk connections / curb letdowns at the northeast and southeast quadrants of the intersection.	Provide sidewalk / curb letdown on northeast quadrant of the intersection, and tie-in to existing sidewalk fronting RCMP Building. Provide sidewalk / landing on southeast quadrant of the intersection to tie into Dark Roast Connector trail.
Active Transportation: Poor connections for Discovery Trail to cross Industrial Way. Based on the *BC Active Transportation Design Guide*, signal separation of active transportation users and southbound right turning vehicles warrants consideration.	An improved Discovery Trail connection is already being added. Provide smart channelization for SBR and EBR in response to further improvements to Discovery Trail (e.g. widening, paving, lighting) to facilitate increased walking and cycling volumes. Smart channelization will reduce vehicle speeds and increase yielding to pedestrians and cyclists. As a result, many of the benefits of signal separation are achieved, without the accompanying significant increase in vehicle delays.

The potential mitigation options are shown schematically in ***Figure 6.9***.

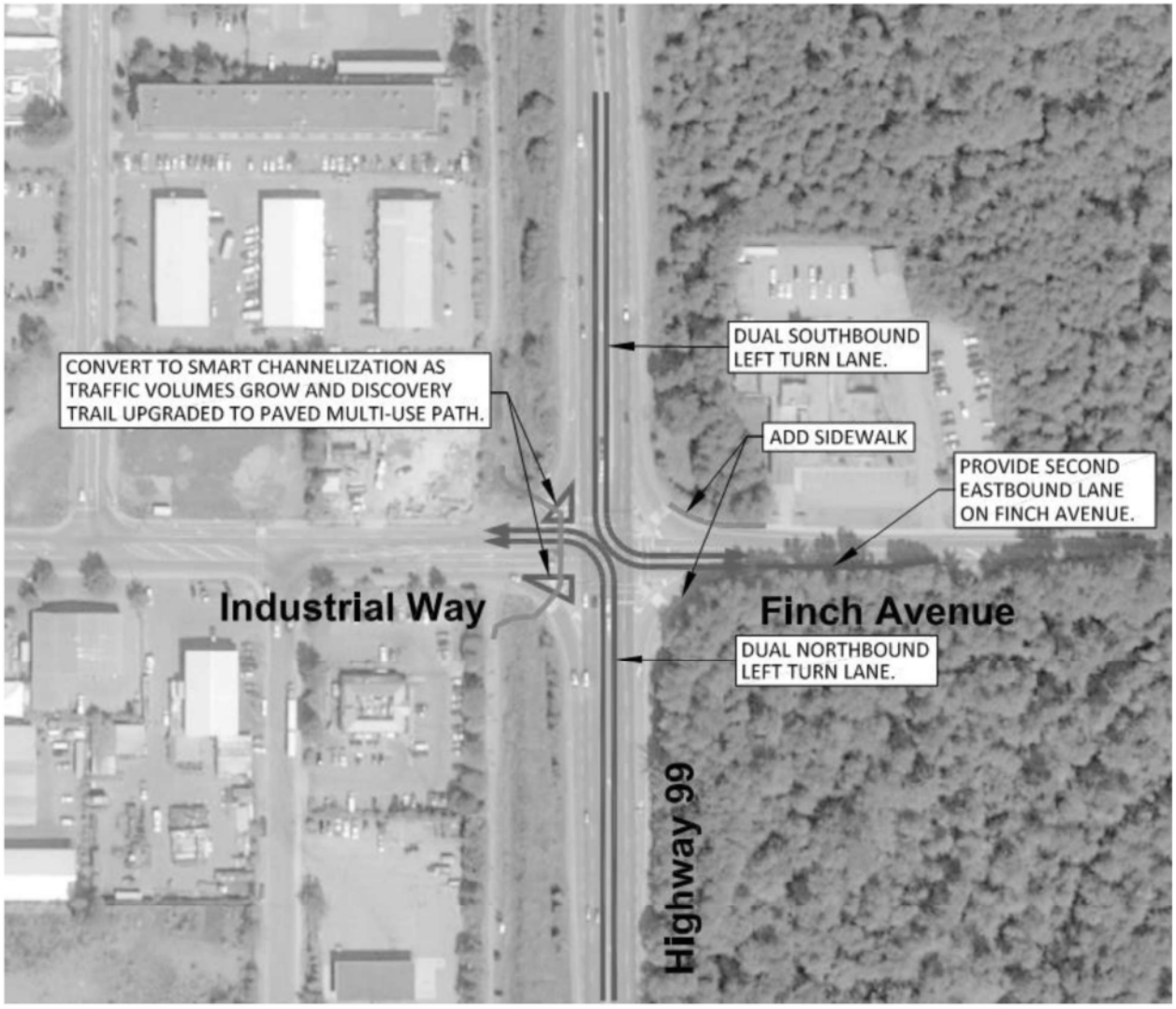

Figure 6.9: Schematic of Potential Mitigation Options at Industrial Way / Finch Avenue

6.11 Commercial Way

The issues identified at the intersection of Highway 99 and Commercial Way, as well as potential mitigation measures, are summarized in ***Table 6.11*** below.

Table 6.11: Commercial Way Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
V/C Ratio: Southbound through (2040 only).	Notwithstanding that the volume to capacity ratio is an issue (0.86, just above the threshold of 0.85), the Level of Service for this movement is reasonable (no worse than LOS C in the 2040 Saturday peak hour). On this basis, no potential mitigation options have been developed. However, in the event that southbound left turning volumes were to grow at a greater rate than forecast, then providing a dual lane NBL could be investigated; this improvement would reduce the amount of green time required for NBL movements, which could in turn enable this time to be reassigned to SBT movements, thereby addressing this movement. Commercial Way already has two downstream westbound receiving lanes, and therefore is not anticipated to require further widening.
Active Transportation: Poor connections for Discovery Trail to cross Industrial Way. Based on the *BC Active Transportation Design Guide*, signal separation of active transportation users and southbound right turning vehicles warrants consideration. Missing north crosswalk.	Improved Discovery Trail connection already being added. Provide smart channelization for SBR and EBR in response to further improvements to Discovery Trail (e.g. widening, paving, lighting) to facilitate increased walking and cycling volumes. Smart channelization will reduce vehicle speeds and increase yielding to pedestrians and cyclists. As a result, many of the benefits of signal separation are achieved, without the accompanying significant increase in vehicle delays. No destinations on east side of intersection; no need to provide north crosswalk.

The potential mitigation options are shown schematically in ***Figure 6.10***.

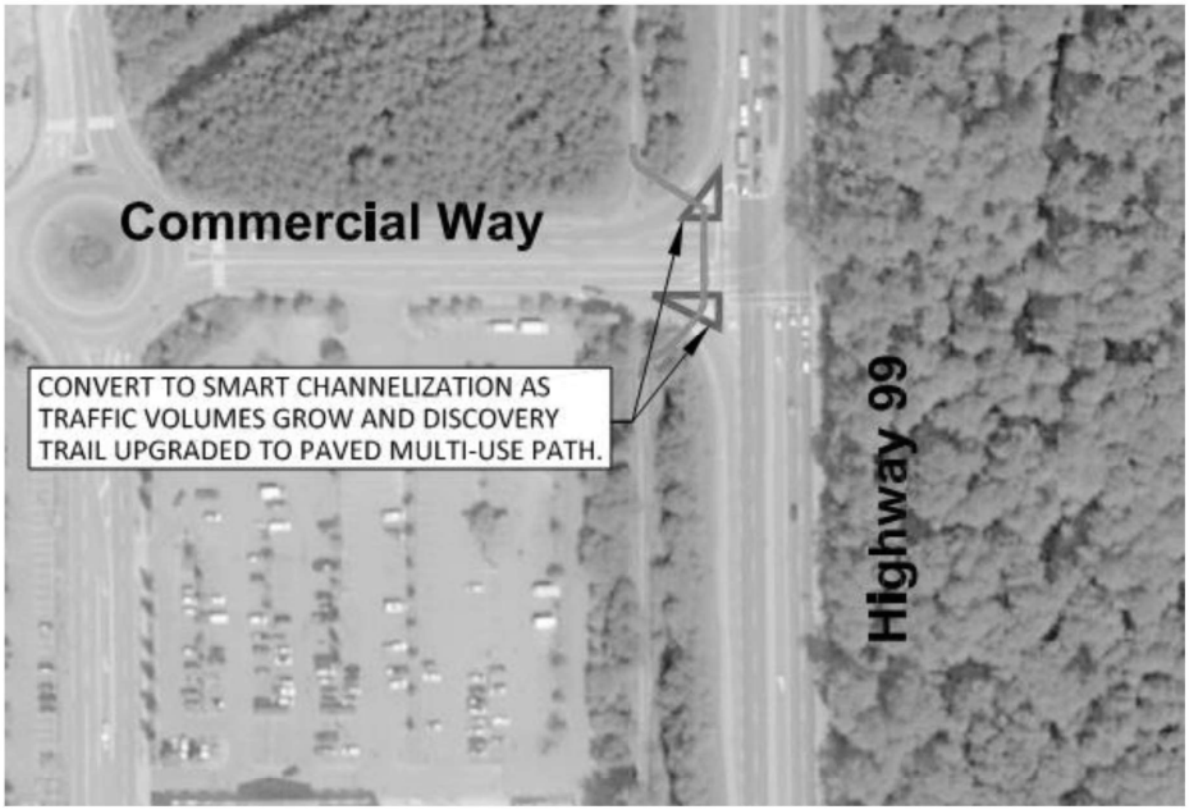

Figure 6.10: Schematic of Potential Mitigation Options at Commercial Way

6.12 Mamquam River Bridge

The issues identified at the Highway 99 bridge over the Mamquam River, as well as potential mitigation measures, are summarized in ***Table 6.12*** below.

Table 6.12: Mamquam River Bridge Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Active Transportation: Limited multi-use path width on bridge structure across Mamquam River.	Widening the bridge structure is a high-cost initiative as a standalone improvement. However, if a major bridge rehabilitation project is required in the future, then use this opportunity to also expand the bridge cross-section to provide a wider multi-use path that meets current best practices for all ages and abilities facilities.

The potential mitigation options are shown schematically in ***Figure 6.11***.

Figure 6.11: Schematic of Potential Mitigation Options at Mamquam River Bridge

6.13 Mamquam Road

The issues identified at the intersection of Highway 99 and Mamquam Road, as well as potential mitigation measures, are summarized in ***Table 6.13*** below.

Table 6.13: Mamquam Road Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Westbound left (2020 and 2040). Northbound left (2020 and 2040). Southbound left (2020 and 2040). Northbound through, (2040 only). Overall intersection (2040 only).	Convert the single WBL permissive + protected lane to dual WBL protected only lane in order to increase capacity of this movement. Depending on the number of vehicles able to make a WBL permissive movement (which is a function of EBT volumes), the net impact of this option may be limited. Highway 99 southbound of the intersection already provides two receiving lanes, and therefore does not require widening. With increased WBL capacity, signal timings could be adjusted to also provide increased capacity for other movements. Converting the WBT to a WBTL lane and implementing split phasing was tested, however this was found to exacerbate rather than improve operational issues.
V/C Ratio: Northbound through (2020 and 2040). Westbound left (2020 and 2040). Southbound through (2040 only).	
50th percentile queues: Westbound left (2020 and 2040).	
95th percentile queues: Westbound left (2020 and 2040).	
Transit: Poor Level of Service for the westbound left movement affects transit operations.	The changes described above (specifically, the dual WBL movement) are anticipated to also reduce delays for transit. If automatic vehicle location (AVL) devices were to be installed on Squamish Transit System buses in the future, then opportunities to add green extensions for the WBL movement (or red truncations for other movements) could be investigated. Currently, Route 4 buses making this movement operate at roughly 30 minute headways during weekday peak hours, but do not operate off-peak or on weekends. Route 1 buses also make this movement, and operate at roughly 60 minute headways throughout the weekdays, Saturdays and Sundays.
Transit: Potential future requirement for on-corridor bus stop (in the vicinity of Mamquam Road / Garibaldi Way).	Further coordination is required with BC Transit to identify a preferred location for an on-corridor bus stop but it is anticipated that space for bus bay pullouts and stop facilities is available just south of Mamquam Road (although conflicts with accelerating / decelerating traffic would need to be managed).
Active Transportation: Conflicts between turning vehicles and Corridor Trail users. Based on the *BC Active Transportation Design Guide*, signal separation of active transportation users and northbound right turning vehicles warrants consideration.	Provide smart channelization for NBR and WBR and signalization of NBR. . Smart channelization will reduce vehicle speeds and increase yielding to pedestrians and cyclists. As a result, many of the benefits of signal separation are achieved, without the accompanying significant increase in vehicle delays.

Issue	Potential Mitigation Option
Road Safety: Collision prone location (Level 1). Further analysis shows 25 collision records over a 5-year period, consisting of 12 injury collisions and 13 PDO collisions. This intersection was identified as a Collision Prone Location due to the collision rate at this intersection being significantly higher than the critical collision rate. The Collision Severity Index at this intersection is below the provincial average. Two of 25 collisions related to vehicles making northbound right turns rear-ending another vehicle making a northbound right turn; another one of 25 collisions related to a vehicle going east colliding with another vehicle merging east (i.e. most likely a NBR). Three of 25 collisions related to EBT (2) or WBL (1) vehicles colliding with SBT vehicles. Six of 25 collisions were related to northbound rear-end collisions. Two of 25 collisions were related to southbound rear-end collisions.	Conversion of the NBR movement to a smart channelization should encourage vehicles to expect to not take the channelized right turn at speed, and to come to a stop (or almost a stop). The smart channelization should also improve NBR visibility of EBT movements. With respect to northbound and (to a lesser extent) southbound rear-end collisions, insufficient information is available regarding where specifically these collisions are occurring. However, it is speculated that if queues for northbound or southbound through movements are extremely long, then vehicles may need to stop much sooner than drivers anticipate (i.e. not at the stop bar, but 100+ metres up stream). In these instances, the advance warning flashers do not provide a useful function, as drivers may need to begin decelerating before they see the advance warning flasher signboard. Therefore, flashing "congestion ahead" signs placed further upstream could be activated during periods with extended queuing. Additionally, high friction pavement could also be provided to assist drivers needing to make sudden decelerations.

The potential mitigation options are shown schematically in ***Figure 6.12***.

Figure 6.12: Schematic of Potential Mitigation Options at Mamquam Road

6.14 Garibaldi Way

The issues identified at the intersection of Highway 99 and Garibaldi Way, as well as potential mitigation measures, are summarized in ***Table 6.14*** below.

Table 6.14: Garibaldi Way Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Northbound left (2020 and 2040). Southbound left (2020 and 2040). **V/C Ratio:** Northbound through (2040 only). **50th percentile queues:** Westbound left (2020 and 2040). **95th percentile queues:** Westbound left (2040 only).	Convert the single WBL permissive + protected lane to dual WBL protected only lane in order to increase capacity of this movement. Depending on the number of vehicles able to make a WBL permissive movement (which is a function of EBT volumes), the net impact of this option maybe limited. Highway 99 southbound of the intersection already provides two receiving lanes, and therefore does not require widening. With increased WBL capacity, signal timings could be adjusted to also provide increased capacity for other movements. Converting the WBT to a WBTL lane and implementing split phasing was tested, however this was found to exacerbate rather than improve operational issues. Providing a Protected-T intersection at Dowad Drive (as described below in section 6.14) will redirect some volume away from the WBL movement and can help improve operations.
Transit: Poor Level of Service for the southbound left movement affects transit operations.	The changes described above (specifically, the re-optimization of signal green time) is anticipated to also reduce delays for transit. If automatic vehicle location (AVL) devices were to be installed on Squamish Transit System buses in the future, then opportunities to add green extensions for the NBL movement (or red truncations for other movements) could be investigated. Currently, Route 4 buses making this movement operate at roughly 30 minute headways during weekday peak hours, but do not operate off-peak or on weekends.
Transit: Potential future requirement for on-corridor bus stop (in the vicinity of Mamquam Road / Garibaldi Way);	Further coordination is required with BC Transit to identify a preferred location for an on-corridor bus stop. Space for bus bays is more limited at Garibaldi Way as compared to Mamquam Road.
Active Transportation: Conflicts between turning vehicles and Corridor Trail users. Based on the *BC Active Transportation Design Guide*, signal separation of active transportation users and northbound right turning vehicles warrants consideration.	Consider smart channelization for NBR and WBR and signalization of NBR.. Smart channelization will reduce vehicle speeds and increase yielding to pedestrians and cyclists. As a result, many of the benefits of signal separation are achieved, without the accompanying significant increase in vehicle delays.

Issue	Potential Mitigation Option
Active Transportation: Conflicts between WBR vehicles and east-west cycling; understood that separate design investigation is already underway	Await findings of separate design investigation for east-west cycling facilities along Garibaldi Way.
Road Safety: Collision prone location (Level 2). Further analysis shows 14 collision records over a 5-year period, consisting of 8 injury collisions and 6 PDO collisions. This intersection was identified as a Collision Prone Location due to a higher than provincial average Collision Severity Index; the collision rate at this intersection is below the critical collision rate. Only one of the 14 recorded collisions relates to the WBR movement, suggesting that the lack of an acceleration lane for this movement is not a major road safety issue. Two collisions related to conflicts between east-west moving vehicles (i.e. EBT / WBL collision and an EBL / WBT collision). Two of the 14 collisions related to northbound vehicles colliding with a fixed object. Three of 14 collisions were related to southbound rear-end collisions. Two of 14 collisions were related to northbound rear-end collisions.	The collision history does not suggest no that the lack of a WBR acceleration lane is currently a safety challenge. However, conversion of the WBR to a smart channelization would slow vehicle speeds (in order to improve safety for trail users) but would also lead to greater speed differentials between vehicles turning onto the highway and vehicles already on the highway. Therefore, an acceleration lane is proposed to pre-emptively address this potential emerging safety issue. Conversion of the single WBL permissive + protected lane to dual WBL protected only lane (as described above) will help mitigate EBT / WBL collision risk. The EBL movement could similarly be converted to protected-only to help mitigate EBL / WBT collision risk. There are no specific / obvious hazards that contribute to NBT single vehicle collisions with fixed objects. With respect to northbound and southbound rear-end collisions, insufficient information is available regarding where specifically these collisions are occurring. However, it is speculated that if queues for northbound or southbound through movements are extremely long, then vehicles may need to stop much sooner than drivers anticipate (i.e. not at the stop bar, but 100+ metres up stream). In these instances, the advance warning flashers do not provide a useful function, as drivers may need to begin decelerating before they see the advance warning flasher signboard. Therefore, flashing "congestion ahead" signs placed further upstream could be activated during periods with extended queuing. Additionally, high friction pavement could also be provided to assist drivers needing to make sudden decelerations.

The potential mitigation options are shown schematically in ***Figure 6.13***.

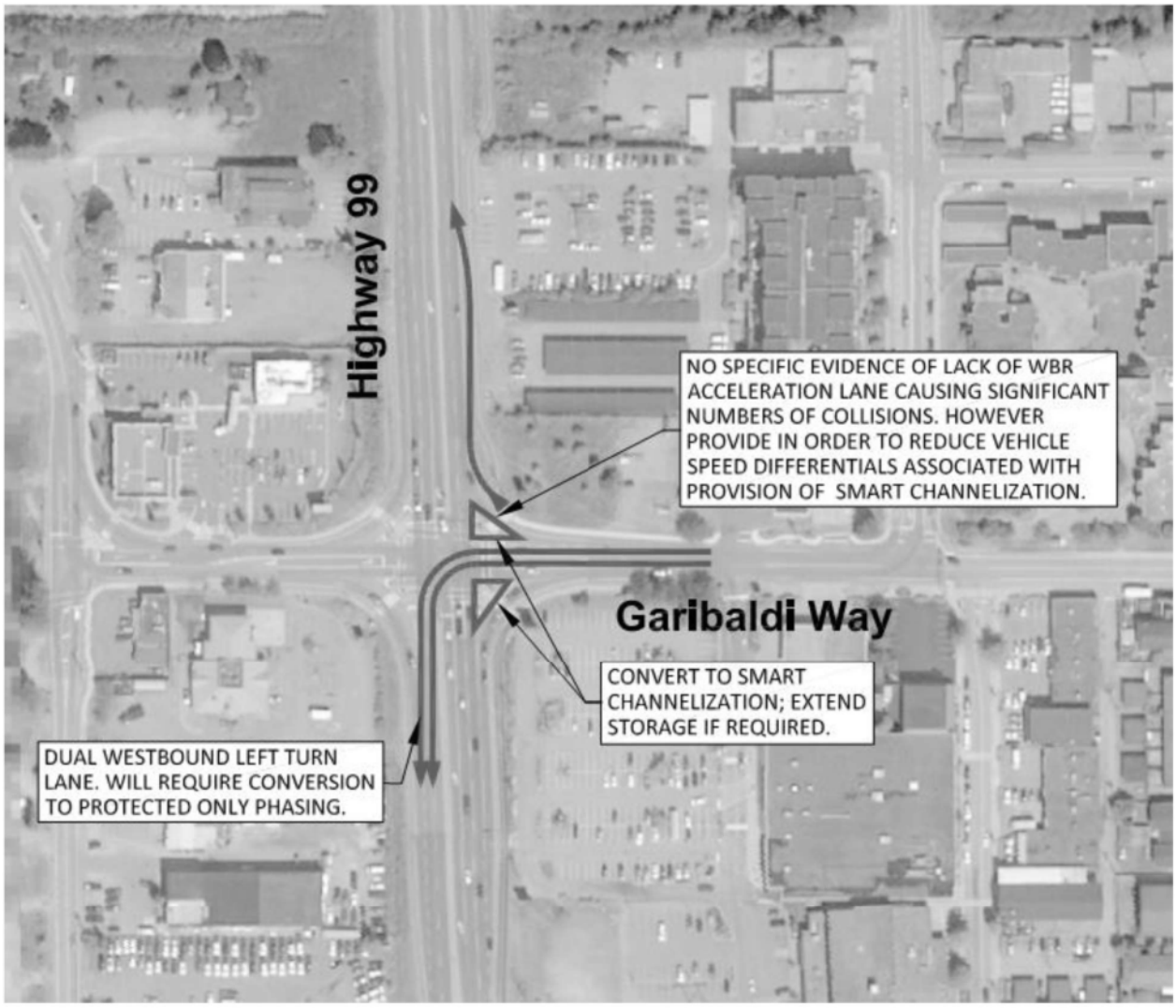

Figure 6.13: Schematic of Potential Mitigation Options at Garibaldi Way

6.15 Dowad Drive

The issues identified at the intersection of Highway 99 and Dowad Drive, as well as potential mitigation measures, are summarized in ***Table 6.15*** below.

Table 6.15: Dowad Drive Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Traffic Operations / Access: No direct issues, but pressure to introduce new signal here could create future traffic operations challenges.	Convert to a Protected-T intersection to provide more direct access to new development areas while also reducing the extent of growth in WBL volumes at Garibaldi Way. The Protected-T intersection would also provide a SBL movement, and attract some SBL volumes away from the Garibaldi Way intersection.

The potential mitigation options are shown schematically in ***Figure 6.14***.

Figure 6.14: Schematic of Potential Mitigation Options at Dowad Drive

Over the longer-term, if a Protected-T intersection at Dowad Drive does not provide sufficient capacity for access onto and off of Highway 99, alternatives involving grade-separated connections could be considered. Potential approaches could include a flyover for the westbound left turn movement (as shown in ***Figure 6.15***) or a partial diamond interchange (as shown in ***Figure 6.16***). It is noted that the westbound left-turn flyover would eliminate the Southbound Left Turn movement that would be provided as part of the Protected-T intersection. The elimination of this movement would result in traffic making this movement being redirected back towards the Southbound Left Turn movement at Garibaldi Way (which is where this , which currently operates at LOS E in both the existing (2020) and anticipated future (2040) condition.

More generally, compared to a Protected-T intersection, both grade-separations represent more complex options with the potential to trigger the need for additional geotechnical, archaeological and environmental investigations.

Figure 6.15: Potential Long-Term Opportunity at Dowad Drive (Flyover for WBL)

Figure 6.16: Potential Long-Term Opportunity at Dowad Drive (Partial Diamond)

6.16 Depot Road

The issues identified at the intersection of Highway 99 and Depot Road, as well as potential mitigation measures, are summarized in ***Table 6.16*** below.

Table 6.16: Depot Road Issues and Potential Mitigation Options

Issue	Potential Mitigation Option
Level of Service: Northbound left (2040 only).	Convert the single NBL lane to dual NBL lane in order to double capacity of this movement. The NBL movement is already protected-only, so there is no permissive LT capacity that is "lost" when converting to dual turn lanes. This will require downstream widening of Depot Road westbound.
V/C Ratio: Northbound left (2040 only).	
Active Transportation: Missing sidewalks / landings at intersection quadrants.	Add sidewalks / landings to the northeast and southeast quadrants of the intersection to provide a landing area so that people don't have to walk in vehicle lanes or on gravel shoulders.

The potential mitigation options are shown schematically in ***Figure 6.17***.

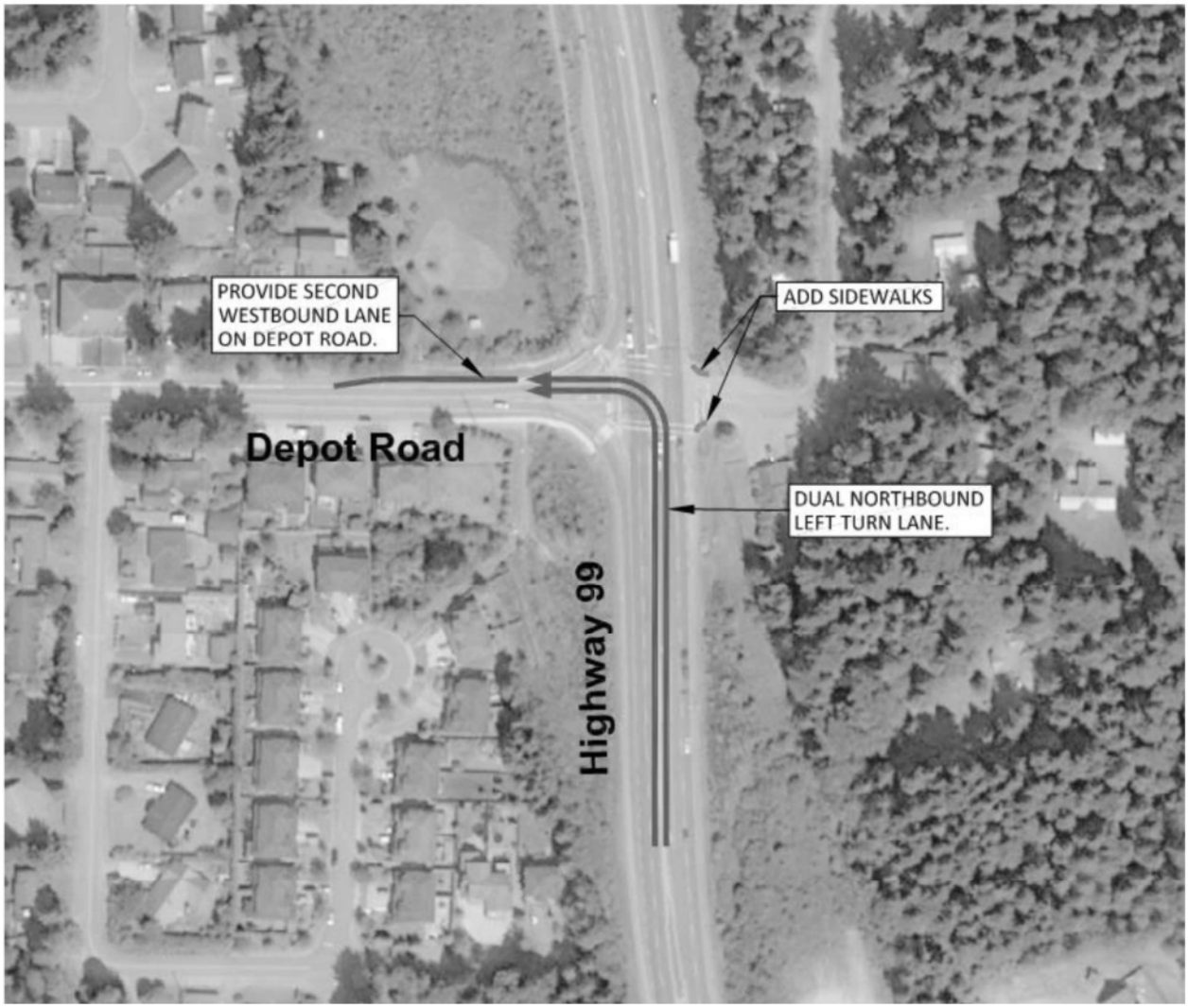

Figure 6.17: Schematic of Potential Mitigation Options at Depot Road

6.17 Corridor and Network-Level Considerations

At a network-wide level, increased travel times for through-movements already exceed desirable thresholds during the Saturday analysis hour and are anticipated to significantly increase in both the northbound and southbound directions on both Saturdays and Sundays in the future.

The forecasting methodology assumed a very limited growth rate in through-movements along the highway (due to upstream bottlenecks on the Sea to Sky Corridor that metre the number of vehicles that can reach Squamish in an hour), and therefore most of the increase in congestion on Highway 99 is attributable to further growth and development in Squamish that in turn makes use of the highway[5].

While some opportunities exist to improve operations on Highway 99 (as described above in the preceding sections) there is also a need to implement improvements to limit the growth in local trips using the highway. These improvements could consist of improvements to active transportation facilities or transit services (thereby eliminating a vehicle trip altogether), or parallel network improvements (trips are still occurring by vehicle, but not interacting with the highway).

[5] Note that the forecasting methodology did not assume that all new trips will travel on the highway. For each development, an estimate was developed of internal trip capture (e.g. for mixed use developments, where trips don't need to leave the immediate site), trips that would use alternate route, trips that would cross (but not travel along) Highway 99, and finally, trips that would travel along Highway 99.

7. TRAFFIC OPERATIONS ANALYSIS OF OPTIONS

An assessment of mitigation options was conducted using a scenario-based approach. Four scenarios were developed to improve upon the 2040 future base condition, which each scenario "building on" the preceding scenario:

- **Scenario 1** focusses on signal optimization in order to update signal timings to reflect new travel patterns in the area.
- **Scenario 2** incorporates signal optimization, but also incorporates a new bridge over the Mamquam Blind Channel as part of the Waterfront Landing development to connect to Pemberton Avenue in downtown Squamish. This new bridge is anticipated to shift traffic volumes at the Clarke Drive, Mill Road, Scott Crescent and Cleveland Avenue intersections.
- **Scenario 3** incorporates signal optimization, a new bridge over the Mamquam Blind Channel, as well as all the other traffic-operations relatives improvements described above in Section 3.
- **Scenario 4** incorporates signal optimization, a new bridge over the Mamquam Blind Channel, traffic operations improvements noted in Section 3, and a 10% reduction in the growth in volumes entering Highway 99 within Squamish. This 10% reduction is intended to act as a proxy for the effects of improved active transportation, transit and parallel municipal road network elements.

Note that as this initial assessment is focussed on quantifiable traffic operations outcomes. Other potential mitigation options noted in Section 3 such as improvements to active transportation facilities are not explicitly captured.

Relative to the 2040 future base case, the specific elements included in each of the four scenarios are summarized in ***Table 7.1***.

Table 7.1: Initial Assessment Scenario Definition

Location	Scenario 1	Scenario 2	Scenario 3	Scenario 4
General Approach	• Signal Optimizations Only	• Scenario 1 + • New Mamquam River Bridge at Waterfront Landing connecting Pemberton Avenue to Clarke Drive.	• Scenario 1 + • Scenario 2 + • Improvements at other intersections (as described in Section 3).	• Scenario 1 + • Scenario 2 + • Scenario 3 + • Reducing in volume growth to reflect alternative network improvements.
Darrell Bay Road	• n/a	• n/a	• n/a	• n/a
Chief Parking Lot	• n/a	• n/a	• n/a	• n/a
Mamquam River Forest Service Road	• n/a	• n/a	• n/a	• n/a

Location	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Valley Drive	• Optimized signal timings.	• Optimized signal timings.	• Optimized signal timings.	• Optimized signal timings.
Clarke Drive	• Optimized signal timings.	• Optimized signal timings. • Some volumes rerouted via New Mamquam River Bridge.	• Optimized signal timings. • Some volumes rerouted via New Mamquam River Bridge.	• Optimized signal timings. • Some volumes rerouted via New Mamquam River Bridge.
Mill Street	• n/a	• Some volumes rerouted via New Mamquam River Bridge.	• Some volumes rerouted via New Mamquam River Bridge.	• Some volumes rerouted via New Mamquam River Bridge.
Scott Crescent	• n/a	• Some volumes rerouted via New Mamquam River Bridge.	• Some volumes rerouted via New Mamquam River Bridge.	• Some volumes rerouted via New Mamquam River Bridge.
Cleveland Avenue	• Optimized signal timings.	• Optimized signal timings. • Some volumes rerouted via New Mamquam River Bridge. • EBR acceleration lane.	• Optimized signal timings. • Some volumes rerouted via New Mamquam River Bridge. • EBR acceleration lane.	• Optimized signal timings. • Some volumes rerouted via New Mamquam River Bridge. • EBR acceleration lane.
Industrial Way / Finch Avenue	• Optimized signal timings.	• Optimized signal timings.	• Optimized signal timings • Dual SBL and NBL lanes.	• Optimized signal timings. • Dual SBL and NBL lanes.
Commercial Way	• n/a	• n/a	• n/a	• n/a
Centennial Way	• n/a	• n/a	• n/a	• n/a
Mamquam Road	• Optimized signal timings.	• Optimized signal timings.	• Optimized signal timings. • Dual WBL turn lane.	• Optimized signal timings. • Dual WBL turn lane.
Garibaldi Way	• Optimized signal timings.	• Optimized signal timings.	• Optimized signal timings. • Dual WBL turn lane. • Some volume shifted to Dowad Drive (due to implementation of Protected-T).	• Optimized signal timings • Some volume shifted to Dowad Drive (due to implementation of Protected-T).

Location	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Dowad Drive	• n/a	• n/a	• New Protected-T intersection.	• New Protected-T intersection.
Depot Road	• Optimized signal timings.	• Optimized signal timings.	• Optimized signal timings. • Dual NBL turn lane.	• Optimized signal timings. • Dual NBL turn lane.
Network Wide	• n/a	• n/a	• n/a	• On and off turning movements between the southern approach of Depot Road to the northern approach of Cleveland Ave reduced by 10%.

Intersection-level options and corridor-level operations are summarized in Section7.1 and Section 7.2, below.

7.1 Intersection-Level Operations

Analysis outputs of the following three intersection-level metrics are documented herein:

- Intersection Level of Service
- Volume-to-Capacity Ratio
- Queue Lengths

Similar to the issues identification phase, unsignalized intersections that only featured right-in / right-out movements were not assessed. This consideration applies to the Sea to Sky Gondola Parking, Centennial Way Interchange, the Garibaldi Village Mall access, and Dowad Drive.

7.1.1 Level of Service

Intersection Level of Service for the summer Saturday AM and Sunday PM peak hours are shown in ***Table 7.2*** and ***Table 7.3***, respectively.

Signal Optimization only	Signal Optimization and changes to either volumes or laning

Table 7.2: 2040 Summer Saturday 12:00 - 13:00 Peak Hour Level of Service

Intersection	Control	Scenario	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Darrell Bay Road	4 leg; signalized	Scenario 1	C	A	A	A	C	A	A	A	A	C	A	C	A	C	A	B	A
		Scenario 2	C	A	A	A	C	A	A	A	A	C	A	C	A	C	A	B	A
		Scenario 3	C	A	A	A	C	A	A	A	A	C	A	C	A	C	A	B	A
		Scenario 4	C	A	A	A	C	A	A	A	A	C	A	C	A	C	A	B	A
Sea to Sky Gondola Parking	3-leg; RIRO	Scenario 1																	
		Scenario 2																	
		Scenario 3																	
		Scenario 4																	
Stawamus Chief Parking	3-leg; Protected-T	Scenario 1					B			A					F		C	C	A
		Scenario 2					B			A					F		C	C	A
		Scenario 3					B			A					F		C	C	A
		Scenario 4					B			A					F		C	C	A
Mamquam River FSR	4 leg; TWSC	Scenario 1	B			A	B			A	F		B	E	F		B	F	A
		Scenario 2	B			A	B			A	F		B	E	F		B	F	A
		Scenario 3	B			A	B			A	F		B	E	F		B	F	A
		Scenario 4	B			A	B			A	F		B	E	F		B	F	A
Valley Drive	4-leg; signal	Scenario 1	D	A	A	A	D	A	A	A	A	D	A	D	D	D	A	B	A
		Scenario 2	D	A	A	A	D	A	A	A	A	D	A	D	D	D	A	B	A
		Scenario 3	D	A	A	A	D	A	A	A	A	D	A	D	D	D	A	B	A
		Scenario 4	D	A	A	A	D	A	A	A	A	D	A	D	D	D	A	B	A
Clarke Drive	4-leg; signal	Scenario 1	D	D	A	C	F	B	A	C	D	C	A	C	C	C	B	B	C
		Scenario 2	D	C	A	C	D	B	A	C	C	D	A	C	D	D	C	C	C
		Scenario 3	D	C	A	C	D	B	A	C	C	D	A	C	D	D	C	C	C
		Scenario 4	D	C	A	C	D	B	A	C	C	D	A	C	D	D	C	C	C
Mill Road	3-leg; Protected-T	Scenario 1	B			A						F		F					A
		Scenario 2	B			A						F		F					A
		Scenario 3	B			A						F		F					A
		Scenario 4	B			A						F		F					A
Scott Crescent	3-leg; RIRO	Scenario 1															C	C	A
		Scenario 2															C	C	A
		Scenario 3															C	C	A
		Scenario 4															C	C	A
Cleveland Avenue	4-leg; signal	Scenario 1	E	C	A	C	C	B	F	F	F	C	C	F	D	D	A	D	E
		Scenario 2	E	C	A	C	C	A	D	C	F	C	A	F	D	D	A	D	D
		Scenario 3	E	C	A	C	C	A	D	C	F	C	A	F	D	D	A	D	D
		Scenario 4	E	C	A	C	C	B	C	B	F	C	A	E	D	D	A	D	C
Industrial Way / Finch Avenue	4-leg; signal	Scenario 1	E	E	A	E	D	F	A	F	D	B	A	C	D	D	A	D	E
		Scenario 2	E	E	A	E	D	F	A	F	D	B	A	C	D	D	A	D	E
		Scenario 3	D	E	A	D	D	F	A	E	D	B	A	C	D	D	A	D	E
		Scenario 4	D	C	A	C	D	E	A	D	D	B	A	C	D	D	A	D	D

Intersection	Control	Scenario	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Commercial Way	4-leg; signal	Scenario 1	D	B	A	B	A	C	A	B	C	A	A	A	A	A	A	A	B
		Scenario 2	D	B	A	B	A	C	A	B	C	A	A	A	A	A	A	A	B
		Scenario 3	D	B	A	B	A	C	A	B	C	A	A	A	A	A	A	A	B
		Scenario 4	D	B	A	B	A	B	A	B	C	A	A	A	A	A	A	A	B
Centennial Way Interchange	Split Diamond Interchange	Scenario 1																	
		Scenario 2																	
		Scenario 3																	
		Scenario 4																	
Mamquam Road	4-leg; signal	Scenario 1	D	F	B	F	D	D	A	D	D	D	A	D	F	B	A	F	F
		Scenario 2	D	F	B	F	D	D	A	D	D	D	A	D	F	B	A	F	F
		Scenario 3	D	E	B	D	D	C	A	C	E	E	A	D	E	C	A	E	D
		Scenario 4	D	D	B	D	D	C	A	C	E	E	A	D	E	C	A	D	D
Garibaldi Village Mall Access	RI Only	Scenario 1																	
		Scenario 2																	
		Scenario 3																	
		Scenario 4																	
Garibaldi Way	4-leg; signal	Scenario 1	D	D	A	C	D	C	A	C	C	D	A	C	D	C	A	C	C
		Scenario 2	D	D	A	C	D	C	A	C	C	D	A	C	D	C	A	C	C
		Scenario 3	D	C	A	C	D	C	A	C	C	D	A	C	D	C	A	C	C
		Scenario 4	D	C	A	C	D	C	A	C	C	D	A	C	D	C	A	C	C
Dowad Drive	3-leg; RIRO / Protected T	Scenario 1																	
		Scenario 2																	
		Scenario 3													E		B	D	A
		Scenario 4													D		B	D	A
Depot Road	4-leg; signal	Scenario 1	D	A	A	B	C	B	A	B	C	B	A	B	A	C	A	C	B
		Scenario 2	D	A	A	B	C	B	A	B	C	B	A	B	A	C	A	C	B
		Scenario 3	C	A	A	B	C	B	A	B	C	A	A	B	A	C	A	C	B
		Scenario 4	C	A	A	B	C	B	A	B	C	A	A	B	A	C	A	C	B

Signal Optimization only	Signal Optimization and changes to either volumes or laning

Table 7.3: 2040 Summer Sunday 16:00 Peak Hour Level of Service

Intersection	Control	Scenario	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Darrell Bay Road	4 leg; signalized	Scenario 1	B	A	A	A	B	A	A	A	A	B	A	B	A	B	A	A	A
		Scenario 2	B	A	A	A	B	A	A	A	A	B	A	B	A	B	A	A	A
		Scenario 3	B	A	A	A	B	A	A	A	A	B	A	B	A	B	A	A	A
		Scenario 4	B	A	A	A	B	A	A	A	A	B	A	B	A	B	A	A	A
Sea to Sky Gondola Parking	3-leg; RIRO	Scenario 1																	
		Scenario 2																	
		Scenario 3																	
		Scenario 4																	
Stawamus Chief Parking	3-leg; Protected-T	Scenario 1					A			A					C		B	B	A
		Scenario 2					A			A					C		B	B	A
		Scenario 3					A			A					C		B	B	A
		Scenario 4					A			A					C		B	B	A
Mamquam River FSR	4 leg; TWSC	Scenario 1	A			A	A			A	D		B	C	D		B	C	A
		Scenario 2	A			A	A			A	D		B	C	D		B	C	A
		Scenario 3	A			A	A			A	D		B	C	D		B	C	A
		Scenario 4	A			A	A			A	D		B	C	D		B	C	A
Valley Drive	4-leg; signal	Scenario 1	D	A	A	A	D	A	A	A	A	D	A	D	D	A	A	C	A
		Scenario 2	D	A	A	A	D	A	A	A	A	D	A	D	D	A	A	C	A
		Scenario 3	D	A	A	A	D	A	A	A	A	D	A	D	D	A	A	C	A
		Scenario 4	D	A	A	A	D	A	A	A	A	D	A	D	D	A	A	C	A
Clarke Drive	4-leg; signal	Scenario 1	D	C	A	C	D	B	A	B	D	C	A	D	C	C	A	B	C
		Scenario 2	E	B	A	C	D	B	A	C	E	D	A	D	D	D	B	C	C
		Scenario 3	E	B	A	C	D	B	A	C	E	D	A	D	D	D	B	C	C
		Scenario 4	E	B	A	C	D	B	A	C	E	D	A	D	D	D	B	C	C
Mill Road	3-leg; Protected-T	Scenario 1	B			A						F		F					A
		Scenario 2	B			A						D		D					A
		Scenario 3	B			A						D		D					A
		Scenario 4	B			A						D		D					A
Scott Crescent	3-leg; RIRO	Scenario 1															B	B	A
		Scenario 2															B	B	A
		Scenario 3															B	B	A
		Scenario 4															B	B	A
Cleveland Avenue	4-leg; signal	Scenario 1	E	B	A	D	D	C	D	C	F	D	D	F	D	D	A	D	E
		Scenario 2	D	B	A	C	D	C	C	C	F	D	A	E	D	D	A	D	D
		Scenario 3	D	B	A	C	D	C	C	C	F	D	A	E	D	D	A	D	D
		Scenario 4	D	B	A	C	D	C	B	C	E	D	A	D	D	D	A	D	C
Industrial Way / Finch Avenue	4-leg; signal	Scenario 1	D	B	A	B	D	C	A	C	D	B	A	C	D	D	A	D	C
		Scenario 2	D	B	A	B	D	C	A	C	D	B	A	C	D	D	A	D	C
		Scenario 3	D	B	A	B	D	C	A	C	D	B	A	C	D	D	A	D	C
		Scenario 4	D	B	A	B	D	C	A	C	D	B	A	C	D	D	A	D	C

Intersection	Control	Scenario	Northbound				Southbound				Eastbound				Westbound				Overall Intersection
			NBL	NBT	NBR	App.	SBL	SBT	SBR	App.	EBL	EBT	EBR	App.	WBL	WBT	WBR	App.	
Commercial Way	4-leg; signal	Scenario 1	C	A	A	A	A	B	A	B	C	A	A	A	A	A	A	A	B
		Scenario 2	C	A	A	A	A	B	A	B	C	A	A	A	A	A	A	A	B
		Scenario 3	C	A	A	A	A	B	A	B	C	A	A	A	A	A	A	A	B
		Scenario 4	C	A	A	A	A	B	A	B	C	A	A	A	A	A	A	A	B
Centennial Way Interchange	Split Diamond Interchange	Scenario 1																	
		Scenario 2																	
		Scenario 3																	
		Scenario 4																	
Mamquam Road	4-leg; signal	Scenario 1	D	C	A	B	D	C	A	C	D	D	A	D	E	C	A	D	C
		Scenario 2	D	C	A	B	D	C	A	C	D	D	A	D	E	C	A	D	C
		Scenario 3	D	B	A	B	D	C	A	C	D	D	A	D	C	C	A	C	C
		Scenario 4	D	B	A	B	D	C	A	C	D	D	A	D	C	C	A	C	C
Garibaldi Village Mall Access	RI Only	Scenario 1																	
		Scenario 2																	
		Scenario 3																	
		Scenario 4																	
Garibaldi Way	4-leg; signal	Scenario 1	D	C	A	C	D	C	A	C	D	D	A	C	D	C	A	C	C
		Scenario 2	D	C	A	C	D	C	A	C	D	D	A	C	D	C	A	C	C
		Scenario 3	D	C	A	C	D	C	A	C	D	D	A	C	D	C	A	C	C
		Scenario 4	D	C	A	C	D	C	A	C	D	D	A	C	D	C	A	C	C
Dowad Drive	3-leg; RIRO / Protected T	Scenario 1																	
		Scenario 2																	
		Scenario 3													B		A	B	A
		Scenario 4													B		A	B	A
Depot Road	4-leg; signal	Scenario 1	D	A	A	D	A	B	A	B	C	A	A	A	A	C	A	C	B
		Scenario 2	D	A	A	D	A	B	A	B	C	A	A	A	A	C	A	C	B
		Scenario 3	C	A	A	B	A	B	A	B	C	A	A	A	A	C	A	C	B
		Scenario 4	C	A	A	B	A	B	A	B	C	A	A	A	A	C	A	C	B

As shown, each scenario tends to incrementally improve performance relative to the previous scenario. The number of movements not meeting the Level of Service critical threshold for each of the scenarios are summarized in ***Table 7.4***.

Table 7.4: Number of Movements Not Meeting Level of Service Critical Thresholds

Scenario	Saturday (12:00 – 13:00)	Sunday (16:00 – 17:00)
2040 Base	31	18
2040 Scenario 1	22	5
2040 Scenario 2	19	2
2040 Scenario 3	13	2
2040 Scenario 4	9	1

By Scenario 3, there is only one instance of an overall intersection not meeting the target performance threshold (Industrial Way / Finch Avenue during the Saturday midday peak hour). However, even by Scenarios 3 and 4, there are still several instances of individual movements not meeting performance thresholds. In some cases, this is because no specific mitigation measures have been developed to directly address these issues (e.g. Westbound Left Turn at Stawamus Chief Parking Lot), while in other cases mitigation options are the intersection are proposed, but do not deliver the magnitude of improvement required to ensure all movements meet performance thresholds (e.g. Eastbound Left Turn at Cleveland Avenue).

7.1.2 Volume to Capacity Ratio

Intersection volume to capacity ratios for the summer Saturday AM and Sunday PM peak hours are shown in ***Table 7.5*** and ***Table 7.6***, respectively.

Signal Optimization only	Signal Optimization and changes to either volumes or laning

Table 7.5: 2040 Summer Saturday 12:00 Peak Hour Volume-to-Capacity Ratio Analysis

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Scenario 1	0.01	0.54	0.03	0.07	0.35	0.00	0.00	0.12	0.01	0.00	0.12	0.14
		Scenario 2	0.01	0.54	0.03	0.07	0.35	0.00	0.00	0.12	0.01	0.00	0.12	0.14
		Scenario 3	0.01	0.54	0.03	0.07	0.35	0.00	0.00	0.12	0.01	0.00	0.12	0.14
		Scenario 4	0.01	0.54	0.03	0.07	0.35	0.00	0.00	0.12	0.01	0.00	0.12	0.14
Sea to Sky Gondola Parking	3-leg; RIRO	Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Stawamus Chief Parking	3-leg; Protected-T	Scenario 1				0.02						0.09		0.08
		Scenario 2				0.02						0.09		0.08
		Scenario 3				0.02						0.09		0.08
		Scenario 4				0.02						0.09		0.08
Mamquam River FSR	4 leg; TWSC	Scenario 1	0.01			0.01				0.08	0.01		0.06	0.01
		Scenario 2	0.01			0.01				0.08	0.01		0.06	0.01
		Scenario 3	0.01			0.01				0.08	0.01		0.06	0.01
		Scenario 4	0.01			0.01				0.08	0.01		0.06	0.01
Valley Drive	4-leg; signal	Scenario 1	0.03	0.50	0.05	0.25	0.33	0.01	0.00	0.17	0.00	0.27	0.01	0.22
		Scenario 2	0.03	0.50	0.05	0.25	0.33	0.01	0.00	0.17	0.00	0.27	0.01	0.22
		Scenario 3	0.03	0.50	0.05	0.25	0.33	0.01	0.00	0.17	0.00	0.27	0.01	0.22
		Scenario 4	0.03	0.50	0.05	0.25	0.33	0.01	0.00	0.17	0.00	0.27	0.01	0.22
Clarke Drive	4-leg; signal	Scenario 1	0.24	0.91	0.04	1.03	0.41	0.17	0.60	0.02	0.02	0.23	0.00	0.76
		Scenario 2	0.57	0.78	0.04	0.80	0.44	0.07	0.26	0.34	0.05	0.30	0.42	0.71
		Scenario 3	0.57	0.78	0.04	0.80	0.44	0.07	0.26	0.34	0.05	0.30	0.42	0.71
		Scenario 4	0.57	0.78	0.04	0.80	0.44	0.07	0.26	0.34	0.05	0.30	0.42	0.71
Mill Road	3-leg; Protected-T	Scenario 1	0.03						1.61					
		Scenario 2	0.02						0.77					
		Scenario 3	0.02						0.77					
		Scenario 4	0.02						0.77					
Scott Crescent	3-leg; RIRO	Scenario 1												0.18
		Scenario 2												0.13
		Scenario 3												0.13
		Scenario 4												0.13
Cleveland Avenue	4-leg; signal	Scenario 1	0.95	0.64	0.07	0.15	0.84	1.27	1.21	0.45	0.87	0.24	0.54	0.03
		Scenario 2	0.82	0.64	0.07	0.15	0.64	1.06	1.21	0.45	0.23	0.24	0.54	0.03
		Scenario 3	0.82	0.64	0.07	0.15	0.64	1.06	1.21	0.45	0.23	0.24	0.54	0.03
		Scenario 4	0.82	0.64	0.07	0.14	0.64	0.95	1.09	0.45	0.23	0.24	0.54	0.03

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Industrial Way / Finch Avenue	4-leg; signal	Scenario 1	0.92	1.07	0.17	0.31	1.21	0.31	0.50	0.63	0.00	0.44	0.50	0.03
		Scenario 2	0.92	1.07	0.17	0.31	1.21	0.31	0.50	0.63	0.00	0.44	0.50	0.03
		Scenario 3	0.59	1.04	0.16	0.19	1.11	0.29	0.50	0.63	0.00	0.44	0.50	0.03
		Scenario 4	0.56	0.95	0.14	0.17	1.03	0.26	0.47	0.61	0.00	0.39	0.50	0.03
Commercial Way	4-leg; signal	Scenario 1	0.38	0.80	0.00	0.00	0.86	0.39	0.49	0.00	0.09			
		Scenario 2	0.38	0.80	0.00	0.00	0.86	0.39	0.49	0.00	0.09			
		Scenario 3	0.38	0.80	0.00	0.00	0.86	0.39	0.49	0.00	0.09			
		Scenario 4	0.34	0.77	0.00	0.00	0.81	0.35	0.45	0.00	0.08			
Centennial Way Interchange	Split Diamond Interchange	Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam Road	4-leg; signal	Scenario 1	0.36	1.17	0.79	0.42	0.92	0.06	0.38	0.53	0.03	1.47	0.24	0.09
		Scenario 2	0.36	1.17	0.79	0.42	0.92	0.06	0.38	0.53	0.03	1.47	0.24	0.09
		Scenario 3	0.36	1.06	0.74	0.42	0.84	0.05	0.54	0.74	0.03	1.02	0.27	0.09
		Scenario 4	0.43	1.00	0.67	0.40	0.83	0.05	0.49	0.74	0.03	0.92	0.27	0.08
Garibaldi Village Mall Access	RI only	Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Garibaldi Way	4-leg; signal	Scenario 1	0.69	0.85	0.35	0.58	0.73	0.14	0.22	0.67	0.16	0.90	0.36	0.31
		Scenario 2	0.69	0.85	0.35	0.58	0.73	0.14	0.22	0.67	0.16	0.90	0.36	0.31
		Scenario 3	0.72	0.81	0.33	0.53	0.76	0.14	0.23	0.68	0.16	0.62	0.36	0.31
		Scenario 4	0.65	0.78	0.30	0.49	0.73	0.13	0.20	0.67	0.15	0.57	0.37	0.29
Dowad Drive	3-leg; RIRO / Protected T	Scenario 1												
		Scenario 2												
		Scenario 3										0.31		0.07
		Scenario 4										0.26		0.06
Depot Road	4-leg; signal	Scenario 1	0.86	0.37	0.01	0.02	0.53	0.08	0.16	0.65	0.00	0.00	0.07	0.00
		Scenario 2	0.86	0.37	0.01	0.02	0.53	0.08	0.16	0.65	0.00	0.00	0.07	0.00
		Scenario 3	0.51	0.38	0.01	0.01	0.51	0.08	0.15	0.63	0.00	0.00	0.07	0.00
		Scenario 4	0.48	0.38	0.01	0.01	0.51	0.08	0.15	0.59	0.00	0.00	0.07	0.00

Signal Optimization only	Signal Optimization and changes to either volumes or laning

Table 7.6: 2040 Summer Sunday 16:00 Peak Hour Volume-to-Capacity Ratio Analysis

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Scenario 1	0.01	0.19	0.01	0.01	0.30	0.01	0.00	0.04	0.01	0.00	0.04	0.03
		Scenario 2	0.01	0.19	0.01	0.01	0.30	0.01	0.00	0.04	0.01	0.00	0.04	0.03
		Scenario 3	0.01	0.19	0.01	0.01	0.30	0.01	0.00	0.04	0.01	0.00	0.04	0.03
		Scenario 4	0.01	0.19	0.01	0.01	0.30	0.01	0.00	0.04	0.01	0.00	0.04	0.03
Sea to Sky Gondola Parking	3-leg; RIRO	Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Stawamus Chief Parking	3-leg; Protected-T	Scenario 1				0.01						0.02		0.03
		Scenario 2				0.01						0.02		0.03
		Scenario 3				0.01						0.02		0.03
		Scenario 4				0.01						0.02		0.03
Mamquam River FSR	4 leg; TWSC	Scenario 1	0.00			0.01				0.03	0.01		0.01	0.00
		Scenario 2	0.00			0.01				0.03	0.01		0.01	0.00
		Scenario 3	0.00			0.01				0.03	0.01		0.01	0.00
		Scenario 4	0.00			0.01				0.03	0.01		0.01	0.00
Valley Drive	4-leg; signal	Scenario 1	0.05	0.19	0.05	0.17	0.29	0.01	0.00	0.11	0.00	0.22	0.00	0.07
		Scenario 2	0.05	0.19	0.05	0.17	0.29	0.01	0.00	0.11	0.00	0.22	0.00	0.07
		Scenario 3	0.05	0.19	0.05	0.17	0.29	0.01	0.00	0.11	0.00	0.22	0.00	0.07
		Scenario 4	0.05	0.19	0.05	0.17	0.29	0.01	0.00	0.11	0.00	0.22	0.00	0.07
Clarke Drive	4-leg; signal	Scenario 1	0.20	0.35	0.02	0.79	0.39	0.22	0.73	0.01	0.00	0.13	0.02	0.46
		Scenario 2	0.60	0.22	0.02	0.71	0.37	0.08	0.54	0.36	0.04	0.25	0.26	0.51
		Scenario 3	0.60	0.22	0.02	0.71	0.37	0.08	0.54	0.36	0.04	0.25	0.26	0.51
		Scenario 4	0.60	0.22	0.02	0.71	0.37	0.08	0.54	0.36	0.04	0.25	0.26	0.51
Mill Road	3-leg; Protected-T	Scenario 1	0.05							0.25				
		Scenario 2	0.04							0.14				
		Scenario 3	0.04							0.14				
		Scenario 4	0.04							0.14				
Scott Crescent	3-leg; RIRO	Scenario 1												0.05
		Scenario 2												0.05
		Scenario 3												0.05
		Scenario 4												0.05
Cleveland Avenue	4-leg; signal	Scenario 1	0.94	0.16	0.03	0.07	0.64	0.97	1.15	0.50	0.94	0.21	0.26	0.03
		Scenario 2	0.68	0.16	0.03	0.07	0.60	0.93	1.06	0.46	0.19	0.21	0.26	0.03
		Scenario 3	0.68	0.16	0.03	0.07	0.60	0.93	1.06	0.46	0.19	0.21	0.26	0.03
		Scenario 4	0.68	0.17	0.03	0.07	0.62	0.85	0.90	0.43	0.19	0.21	0.26	0.02

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Industrial Way / Finch Avenue	4-leg; signal	Scenario 1	0.50	0.43	0.16	0.20	0.82	0.10	0.24	0.67	0.00	0.56	0.43	0.02
		Scenario 2	0.50	0.43	0.16	0.20	0.82	0.10	0.25	0.68	0.00	0.56	0.43	0.02
		Scenario 3	0.34	0.42	0.16	0.11	0.77	0.10	0.25	0.68	0.00	0.56	0.43	0.02
		Scenario 4	0.31	0.39	0.14	0.10	0.72	0.08	0.23	0.65	0.00	0.53	0.45	0.02
Commercial Way	4-leg; signal	Scenario 1	0.34	0.36	0.00	0.00	0.70	0.21	0.38	0.00	0.06			
		Scenario 2	0.34	0.36	0.00	0.00	0.70	0.21	0.38	0.00	0.06			
		Scenario 3	0.34	0.36	0.00	0.00	0.70	0.21	0.38	0.00	0.06			
		Scenario 4	0.32	0.33	0.00	0.00	0.66	0.19	0.35	0.00	0.05			
Centennial Way Interchange	Split Diamond Interchange	Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam Road	4-leg; signal	Scenario 1	0.34	0.37	0.48	0.35	0.65	0.06	0.27	0.37	0.03	0.97	0.23	0.06
		Scenario 2	0.34	0.37	0.48	0.35	0.65	0.06	0.27	0.37	0.03	0.97	0.23	0.06
		Scenario 3	0.34	0.33	0.45	0.35	0.57	0.05	0.27	0.37	0.03	0.63	0.27	0.06
		Scenario 4	0.31	0.31	0.41	0.33	0.55	0.04	0.25	0.37	0.02	0.58	0.28	0.06
Garibaldi Village Mall Access	RI only	Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Garibaldi Way	4-leg; signal	Scenario 1	0.58	0.21	0.26	0.65	0.52	0.10	0.18	0.60	0.11	0.60	0.30	0.19
		Scenario 2	0.58	0.21	0.26	0.65	0.52	0.10	0.18	0.60	0.11	0.60	0.30	0.19
		Scenario 3	0.59	0.20	0.25	0.63	0.52	0.09	0.18	0.60	0.11	0.46	0.32	0.20
		Scenario 4	0.56	0.18	0.23	0.60	0.51	0.08	0.17	0.60	0.10	0.42	0.32	0.19
Dowad Drive	3-leg; RIRO / Protected T	Scenario 1												
		Scenario 2												
		Scenario 3										0.08		0.03
		Scenario 4										0.07		0.02
Depot Road	4-leg; signal	Scenario 1	0.86	0.04	0.01	0.00	0.50	0.06	0.05	0.58	0.00	0.00	0.03	0.00
		Scenario 2	0.86	0.04	0.01	0.00	0.50	0.06	0.05	0.58	0.00	0.00	0.03	0.00
		Scenario 3	0.47	0.04	0.01	0.00	0.50	0.06	0.05	0.57	0.00	0.00	0.03	0.00
		Scenario 4	0.43	0.05	0.01	0.00	0.49	0.06	0.05	0.54	0.00	0.00	0.03	0.00

As shown, each scenario tends to incrementally improve performance relative to the previous scenario. The number of movements not meeting the volume-to-capacity ratio critical threshold for each of the scenarios are summarized in ***Table 7.7***.

Table 7.7: Number of Movements Not Meeting Volume-to-Capacity Ratio Critical Thresholds

Scenario	Saturday (12:00 – 13:00)	Sunday (16:00 – 17:00)
2040 Base	13	5
2040 Scenario 1	15	5
2040 Scenario 2	11	4
2040 Scenario 3	7	2
2040 Scenario 4	5	1

7.1.3 Queue Lengths

50th percentile queue lengths for the summer Saturday AM and Sunday PM peak hours are shown in ***Table 7.8*** and ***Table 7.9***, respectively. Similarly, 95th percentile queue lengths for the summer Saturday AM and Sunday PM peak hours are shown in ***Table 7.10*** and ***Table 7.11***, respectively.

Signal Optimization only	Signal Optimization and changes to either volumes or laning

Table 7.8: 50th 2040 Summer Saturday 12:00 Peak Hour 50th Percentile Queuing Analysis

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		Scenario 1	0.2	26	0	1.3	15.2	0	0	1.9	0	0	1.9	0
		Scenario 2	0.2	26	0	1.3	15.2	0	0	1.9	0	0	1.9	0
		Scenario 3	0.2	26	0	1.3	15.2	0	0	1.9	0	0	1.9	0
		Scenario 4	0.2	26	0	1.3	15.2	0	0	1.9	0	0	1.9	0
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		Scenario 1	0.6	63.5	0	7.9	19	0	0	5.4	0	7.6	0.5	0
		Scenario 2	0.6	63.5	0	7.9	19	0	0	5.4	0	7.6	0.5	0
		Scenario 3	0.6	63.5	0	7.9	19	0	0	5.4	0	7.6	0.5	0
		Scenario 4	0.6	63.5	0	7.9	19	0	0	5.4	0	7.6	0.5	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		Scenario 1	6.4	111.6	0	0	43.5	0	26.7	1.1	0	9.4	0.2	15.9
		Scenario 2	25.7	96.8	0	62.6	45.7	0	7.9	19.1	0	10.4	23.7	20
		Scenario 3	25.7	96.8	0	62.6	45.7	0	7.9	19.1	0	10.4	23.7	20
		Scenario 4	25.7	96.8	0	62.6	45.7	0	7.9	19.1	0	10.4	23.7	20
Mill Road	3-leg; Protected-T	Storage Length	1050					-	0		-			
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Scott Crescent	3-leg; RIRO	Storage Length												0
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		Scenario 1	72.2	74.3	0	3	49.3	0	0	31.9	31.1	6.9	17.1	0
		Scenario 2	36.5	74.3	0	3.4	35	0	0	31.9	0	6.9	17.1	0
		Scenario 3	36.5	74.3	0	3.4	35	0	0	31.9	0	6.9	17.1	0
		Scenario 4	36.5	74.3	0	3.1	37.7	161.9	0	31.9	0	6.9	17.1	0
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		Scenario 1	51	0	2.4	9	0	5.8	22.9	9.7	0	18.7	22.8	0
		Scenario 2	51	0	2.4	9	0	5.8	22.9	9.7	0	18.7	22.8	0
		Scenario 3	25	0	2.2	4.6	0	5.8	22.9	9.7	0	18.7	22.8	0
		Scenario 4	21.9	0	1.7	4.2	0	4.3	20.7	9.7	0	16.7	22.8	0
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		Scenario 1	13.3	94.1	0	0	123.3	10.2	25.7	0	0			
		Scenario 2	13.3	94.1	0	0	123.3	10.2	25.7	0	0			
		Scenario 3	13.3	94.1	0	0	123.3	10.2	25.7	0	0			
		Scenario 4	10.5	81.1	0	0	106.9	7.8	20.3	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		Scenario 1	12.5	0	41.7	16	0	0	10.6	23.2	0	0	21.7	0
		Scenario 2	12.5	0	41.7	16	0	0	10.6	23.2	0	0	21.7	0
		Scenario 3	12.5	0	29.2	16	113	0	11.3	24.7	0	0	23.8	0
		Scenario 4	16.9	0	19.9	14.6	109.7	0	10.2	24.7	0	66.4	23.8	0
Garibaldi Village Mall Access	RI only	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		Scenario 1	38.3	97.5	0	28.1	75	0	8.1	45.2	0	41.8	33.3	2.2
		Scenario 2	38.3	97.5	0	28.1	75	0	8.1	45.2	0	41.8	33.3	2.2
		Scenario 3	37.3	93.3	0	21.4	80	0	8	44.1	0	23	32.3	2.2
		Scenario 4	34.5	90.7	0	19.8	76.3	0	7.4	45.2	0	21.1	33.3	2
Dowad Drive	3-leg; RIRO	Storage Length			1000									
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		Scenario 1	44	15.3	0	0.4	34.5	0	3.8	1.2	0	0	2.2	0
		Scenario 2	44	15.3	0	0.4	34.5	0	3.8	1.2	0	0	2.2	0
		Scenario 3	20	15.3	0	0.3	31.5	0	3.6	1.1	0	0	2.1	0
		Scenario 4	17.1	15.2	0	0.3	30	0	3.4	0.3	0	0	2	0

Signal Optimization only | **Signal Optimization and changes to either volumes or laning**

Table 7.9: 50th 2040 Summer Sunday 16:00 Peak Hour 50th Percentile Queuing Analysis

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		Scenario 1	0.2	0	0	0.2	0	0	0	0.6	0	0	0.6	0
		Scenario 2	0.2	0	0	0.2	0	0	0	0.6	0	0	0.6	0
		Scenario 3	0.2	0	0	0.2	0	0	0	0.6	0	0	0.6	0
		Scenario 4	0.2	0	0	0.2	0	0	0	0.6	0	0	0.6	0
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		Scenario 1	1	8.4	0	4.8	15.3	0	0	3.4	0	6	0	0
		Scenario 2	1	8.4	0	4.8	15.3	0	0	3.4	0	6	0	0
		Scenario 3	1	8.4	0	4.8	15.3	0	0	3.4	0	6	0	0
		Scenario 4	1	8.4	0	4.8	15.3	0	0	3.4	0	6	0	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		Scenario 1	5.2	40.6	0	65.6	49.9	0	43.2	0.5	0	6.8	1.2	0
		Scenario 2	29.8	24.8	0	54.3	44.8	0	21.2	19.1	0	8.4	13.9	0
		Scenario 3	29.8	24.8	0	54.3	44.8	0	21.2	19.1	0	8.4	13.9	0
		Scenario 4	29.8	24.8	0	54.3	44.8	0	21.2	19.1	0	8.4	13.9	0
Mill Road	3-leg; Protected-T	Storage Length	1050						0					
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Scott Crescent	3-leg; RIRO	Storage Length												0
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		Scenario 1	0	14.3	0	3.2	78	93.6	0	37.3	51.2	6.6	8.4	0
		Scenario 2	38.2	14.3	0	3.2	75.6	78.8	0	37.3	0	6.6	8.4	0
		Scenario 3	38.2	14.3	0	3.2	75.6	78.8	0	37.3	0	6.6	8.4	0
		Scenario 4	38.2	14.3	0	3	75.6	43.9	0	37.3	0	6.6	8.4	0
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		Scenario 1	23.7	57	0	5.9	128.6	0	9.2	2.8	0	28.2	22.1	0
		Scenario 2	23.9	57.1	0	6	129	0	9.3	2.9	0	28.5	22.3	0
		Scenario 3	12.3	56	0	3	120.5	0	9.3	2.9	0	28.5	22.3	0
		Scenario 4	11	49.7	0	2.7	109.3	0	8.4	2.9	0	25.7	22.5	0
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		Scenario 1	10.3	19.9	0	0	74	2.5	14.2	0	0			
		Scenario 2	10.3	19.9	0	0	74	2.5	14.2	0	0			
		Scenario 3	10.3	19.9	0	0	74	2.5	14.2	0	0			
		Scenario 4	9.3	17.3	0	0	66.8	1.7	12.6	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		Scenario 1	11.7	45.2	0	12.7	92.3	0	7.1	15	0	0	22.4	0
		Scenario 2	11.7	45.2	0	12.7	92.3	0	7.1	15	0	0	22.4	0
		Scenario 3	11.7	43.6	0	12.7	89.1	0	7.1	15	0	43.5	23.1	0
		Scenario 4	10.5	38.8	0	11.5	83	0	6.5	15	0	39.3	23.6	0
Garibaldi Village Mall Access	RI only	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		Scenario 1	28.5	23	0	36	67	0	6.6	37.2	0	33.2	27.9	0.4
		Scenario 2	28.5	23	0	36	67	0	6.6	37.2	0	33.2	27.9	0.4
		Scenario 3	28.6	21.1	0	33.1	66.6	0	6.6	37.2	0	17.7	29.8	0.2
		Scenario 4	25.7	19.8	0	29.9	65	0	6.1	37.2	0	15.9	30.1	0
Dowad Drive	3-leg; RIRO	Storage Length			1000									
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		Scenario 1	30.3	1.2	0	0	27.6	0	1	0.1	0	0	0.8	0
		Scenario 2	30.3	1.2	0	0	27.6	0	1	0.1	0	0	0.8	0
		Scenario 3	14.1	1.2	0	0	27.6	0	1	0.1	0	0	0.8	0
		Scenario 4	12.5	1.3	0	0	26.9	0	1	0.1	0	0	0.8	0

Signal Optimization only | **Signal Optimization and changes to either volumes or laning**

Table 7.10:95th 2040 Summer Saturday 12:00 Peak Hour 95th Percentile Queuing Analysis

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		Scenario 1	2.8	80.4	0	8.9	44.5	0	0	11.7	0	0	11.7	4.2
		Scenario 2	2.8	80.4	0	8.9	44.5	0	0	11.7	0	0	11.7	4.2
		Scenario 3	2.8	80.4	0	8.9	44.5	0	0	11.7	0	0	11.7	4.2
		Scenario 4	2.8	80.4	0	8.9	44.5	0	0	11.7	0	0	11.7	4.2
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		Scenario 1				0.1						0.3		0.3
		Scenario 2				0.1						0.3		0.3
		Scenario 3				0.1						0.3		0.3
		Scenario 4				0.1						0.3		0.3
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		Scenario 1	0			0				0.2	0		0.2	0
		Scenario 2	0			0				0.2	0		0.2	0
		Scenario 3	0			0				0.2	0		0.2	0
		Scenario 4	0			0				0.2	0		0.2	0
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		Scenario 1	3.4	98.2	0	17.7	51.6	0	0	13.5	0	17.2	3.1	0
		Scenario 2	3.4	98.2	0	17.7	51.6	0	0	13.5	0	17.2	3.1	0
		Scenario 3	3.4	98.2	0	17.7	51.6	0	0	13.5	0	17.2	3.1	0
		Scenario 4	3.4	98.2	0	17.7	51.6	0	0	13.5	0	17.2	3.1	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		Scenario 1	15.4	154.7	0	171.5	74.1	10	42.2	4.2	0	18.2	1.3	45.4
		Scenario 2	42	122.5	0	145.9	85.3	0	15.8	29.9	0	19.4	35.7	42
		Scenario 3	42	122.5	0	145.9	85.3	0	15.8	29.9	0	19.4	35.7	42
		Scenario 4	42	122.5	0	145.9	85.3	0	15.8	29.9	0	19.4	35.7	42
Mill Road	3-leg; Protected-T	Storage Length	1050						0					
		Scenario 1	0.1							5.4				
		Scenario 2	0.1							3.4				
		Scenario 3	0.1							3.4				
		Scenario 4	0.1							3.4				
Scott Crescent	3-leg; RIRO	Storage Length												0
		Scenario 1												0.6
		Scenario 2												0.5
		Scenario 3												0.5
		Scenario 4												0.5

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		Scenario 1	109.8	123.8	0	3	39.8	163.3	155.7	52.5	98.9	16.8	32.8	0
		Scenario 2	58.5	123.8	0	3.6	29.8	160.6	155.7	52.5	0	16.8	32.8	0
		Scenario 3	58.5	123.8	0	3.9	34.2	181	155.7	52.5	0	16.8	32.8	0
		Scenario 4	58.5	123.8	0	3.8	37.7	166.5	134.5	52.5	0	16.8	32.8	0
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		Scenario 1	92.4	225.1	4.8	20.7	234.4	20.4	33.6	32.5	0	32.9	38.6	0
		Scenario 2	90.2	213.9	4.8	20.7	234.4	20.4	33.6	32.5	0	32.9	38.6	0
		Scenario 3	31.7	213.9	3.4	10.3	234.4	20.4	33.6	32.5	0	32.9	38.6	0
		Scenario 4	27.7	219.9	3	9.4	218.8	18	30.6	31.4	0	30.2	38.6	0
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		Scenario 1	27.5	145.8	0	0	208.5	30.6	39.6	0	0			
		Scenario 2	27.5	145.8	0	0	208.5	30.6	39.6	0	0			
		Scenario 3	27.5	145.8	0	0	208.5	30.6	39.6	0	0			
		Scenario 4	25.1	125.2	0	0	165.4	24.5	35.9	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		Scenario 1	24.6	255	118.7	29.4	186.2	0	23.1	41.2	0	241.8	36.3	0
		Scenario 2	24.6	255	118.7	29.4	186.2	0	23.1	41.2	0	241.8	36.3	0
		Scenario 3	24.6	236	84.6	29.4	167.1	0	27.4	52.7	0	115.3	39.9	0
		Scenario 4	30.5	219.2	65.4	27.3	164.5	0	23.3	52.7	0	98.5	39.9	0
Garibaldi Village Mall Access	RI only	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		Scenario 1	60.4	165.6	17.8	45.1	118.5	3.5	17.5	67.6	0	77.8	49.5	15.4
		Scenario 2	60.4	165.6	17.8	45.1	118.5	3.5	17.5	67.6	0	77.8	49.5	15.4
		Scenario 3	60.8	141.6	16	37.7	117	3	17.6	68	0	35.2	49.8	15.7
		Scenario 4	54.7	148.7	16	34.5	123.4	1.7	16.3	67.6	0	32.9	49.5	14.6
Dowad Drive	3-leg; RIRO	Storage Length			1000									
		Scenario 1												
		Scenario 2												
		Scenario 3										1.2		0.2
		Scenario 4										1		0.2
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		Scenario 1	121.1	53.8	0	3	56.6	0	12.5	23.3	0	0	8.5	0
		Scenario 2	121.1	53.8	0	3	56.6	0	12.5	23.3	0	0	8.5	0
		Scenario 3	42.2	53.8	0	3	56.6	0	12.5	23.3	0	0	8.5	0
		Scenario 4	37.9	53.1	0	2.9	55.8	0	12.4	20.3	0	0	8.4	0

Signal Optimization only | **Signal Optimization and changes to either volumes or laning**

Table 7.11: 95th 2040 Summer Sunday 16:00 Peak Hour 95th Percentile Queuing Analysis

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Darrell Bay Road	4 leg; signalized	Storage Length	90	0	20	130	0	35	0	0	15	0	0	10
		Scenario 1	2.5	25.1	0	2.5	41.7	0	0	5.7	0	0	5.7	0
		Scenario 2	2.5	25.1	0	2.5	41.7	0	0	5.7	0	0	5.7	0
		Scenario 3	2.5	25.1	0	2.5	41.7	0	0	5.7	0	0	5.7	0
		Scenario 4	2.5	25.1	0	2.5	41.7	0	0	5.7	0	0	5.7	0
Sea to Sky Gondola Parking	3-leg; RIRO	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Stawamus Chief Parking	3-leg; Protected-T	Storage Length			300	1150						0		200
		Scenario 1				0						0.1		0.1
		Scenario 2				0						0.1		0.1
		Scenario 3				0						0.1		0.1
		Scenario 4				0						0.1		0.1
Mamquam River FSR	4 leg; TWSC	Storage Length	850		400	700		1000			250			350
		Scenario 1	0			0				0.1	0		0	0
		Scenario 2	0			0				0.1	0		0	0
		Scenario 3	0			0				0.1	0		0	0
		Scenario 4	0			0				0.1	0		0	0
Valley Drive	4-leg; signal	Storage Length	65	0	65	130	0	100	0	0	10	0	0	55
		Scenario 1	4.7	27.6	3.4	12.6	42.5	0	0	9.8	0	14.8	0	0
		Scenario 2	4.7	27.6	3.4	12.6	42.5	0	0	9.8	0	14.8	0	0
		Scenario 3	4.7	27.6	3.4	12.6	42.5	0	0	9.8	0	14.8	0	0
		Scenario 4	4.7	27.6	3.4	12.6	42.5	0	0	9.8	0	14.8	0	0
Clarke Drive	4-leg; signal	Storage Length	105	0	75	120	0	90	30	0	15	25	0	25
		Scenario 1	13.7	60.7	0	95.6	75.3	11	65.5	2.6	0	14.8	4.5	18.3
		Scenario 2	47.7	43.3	0	76.2	73.7	6.9	36.4	32.7	0	18	25.6	18.9
		Scenario 3	47.7	43.3	0	76.2	73.7	6.9	36.4	32.7	0	18	25.6	18.9
		Scenario 4	47.7	43.3	0	76.2	73.7	6.9	36.4	32.7	0	18	25.6	18.9
Mill Road	3-leg; Protected-T	Storage Length	1050											
		Scenario 1	0.1							0.9				
		Scenario 2	0.1							0.5				
		Scenario 3	0.1							0.5				
		Scenario 4	0.1							0.5				
Scott Crescent	3-leg; RIRO	Storage Length												0
		Scenario 1												0.2
		Scenario 2												0.2
		Scenario 3												0.2
		Scenario 4												0.2

Intersection	Control	Scenario	Northbound			Southbound			Eastbound			Westbound		
			NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Cleveland Avenue	4-leg; signal	Storage Length	110	0	80	60	0	170	0	0	15	30	0	10
		Scenario 1	113.1	42.8	0	6.8	99.1	191.1	145.7	59.8	121.4	16.1	19.2	0
		Scenario 2	53	42.8	0	6.8	97.5	180.8	145.7	59.8	0	16.1	19.2	0
		Scenario 3	53	42.8	0	6.8	97.5	180.8	145.7	59.8	0	16.1	19.2	0
		Scenario 4	53	42.8	0	6.5	97.5	137.3	125.3	59.8	0	16.1	19.2	0
Industrial Way / Finch Avenue	4-leg; signal	Storage Length	130	0	80	115	0	75	0	0	0	35	0	20
		Scenario 1	39.7	98.1	12.2	14.7	236.7	0	15.4	25.4	0	45.4	37	0
		Scenario 2	39.9	98.5	12.3	14.7	237.1	0	15.6	25.4	0	45.7	37.4	0
		Scenario 3	20.6	95.3	11.9	7.5	215.6	0	15.6	25.4	0	45.7	37.4	0
		Scenario 4	19	84.7	10.9	7.1	194.1	0	14.4	24.7	0	42.2	37.9	0
Commercial Way	4-leg; signal	Storage Length	185	0	0	0	0	82	0	0	0			
		Scenario 1	22.8	31.6	0	0	116.9	12.9	24.5	0	0			
		Scenario 2	22.8	31.6	0	0	116.9	12.9	24.5	0	0			
		Scenario 3	22.8	31.6	0	0	116.9	12.9	24.5	0	0			
		Scenario 4	21.1	27.6	0	0	105.2	11.1	22.3	0	0			
Centennial Way Interchange	Split Diamond Interchange	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Mamquam Road	4-leg; signal	Storage Length	110	0	75	130	0	80	35	0	35	35	0	0
		Scenario 1	23.6	62.8	18.6	24.9	121.6	0	16.9	28.5	0	183	37.7	0
		Scenario 2	23.6	62.8	18.6	24.9	121.6	0	16.9	28.5	0	183	37.7	0
		Scenario 3	23.6	62.8	18.6	24.9	121.6	0	16.9	28.5	0	56.8	37.7	0
		Scenario 4	21.7	57.8	17.7	23.1	116.7	0	15.6	28.5	0	50.9	37.7	0
Garibaldi Village Mall Access	RI only	Storage Length												
		Scenario 1												
		Scenario 2												
		Scenario 3												
		Scenario 4												
Garibaldi Way	4-leg; signal	Storage Length	110	0	80	150	0	80	35	0	0	30	0	20
		Scenario 1	45.8	34.1	14.7	55.8	89.5	1.8	15.1	56	0	55.5	46.5	12.2
		Scenario 2	45.8	34.1	14.7	55.8	89.5	1.8	15.1	56	0	55.5	46.5	12.2
		Scenario 3	46.2	34	14.7	52.4	96.1	1.8	15.1	56	0	29.1	46	11.8
		Scenario 4	42.6	32.9	14	48.4	95.5	0.3	14	56	0	26.3	45.4	11
Dowad Drive	3-leg; RIRO	Storage Length			1000									
		Scenario 1												
		Scenario 2												
		Scenario 3										0.3		0.1
		Scenario 4										0.2		0.1
Depot Road	4-leg; signal	Storage Length	140	0	50	125	0	130	20	0	10	0	0	0
		Scenario 1	97.9	4.1	0	0	49.5	1.5	5.1	18.4	0	0	4.5	0
		Scenario 2	97.9	4.1	0	0	49.5	1.5	5.1	18.4	0	0	4.5	0
		Scenario 3	33.6	4.1	0	0	49.5	1.5	5.1	18.4	0	0	4.5	0
		Scenario 4	30.3	4.4	0	0	48.4	1.5	5.1	17.6	0	0	4.5	0

7.2 Corridor-Level Operations

Analysis outputs of the following two corridor-level metrics are documented herein:

- Highway Corridor Travel Time Index
- Network Vehicle Hours Travelled

Travel times for each movement along the corridor, as well as an off-peak travel time, were assessed using SimTraffic. The travel time values, and the corresponding travel time indices are shown in ***Table 7.12*** for both the future base (F.B.) and the four previously described scenarios.

Table 7.12: 2040 Travel Time Index for Each Scenario

Year	Period	Metric	Northbound					Southbound				
			F.B.	1	2	3	4	F.B.	1	2	3	4
2020 / 2040	Off-Peak	Travel Time (min)	10.3					10.3				
2040	Saturday 12:00	Travel Time (min)	21.7	18.8	21.3	16.7	16.6	25.3	19.2	18.8	19.0	17.3
		TTI	2.12	1.83	2.08	1.63	1.62	2.45	1.86	1.82	1.84	1.68
	Sunday 16:00	Travel Time (min)	16.1	12.4	12.5	12.5	12.8	13.8	13.6	13.8	13.7	13.7
		TTI	1.57	1.21	1.22	1.22	1.25	1.34	1.32	1.34	1.33	1.32

These travel times are also shown visually in ***Figure 7.1*** (for the Saturday midday peak hour) and ***Figure 7.2*** (for the Sunday midday peak hour). As shown, each scenario generally progressively improves the travel time savings, although in most cases the travel time index will still be above desirable thresholds.

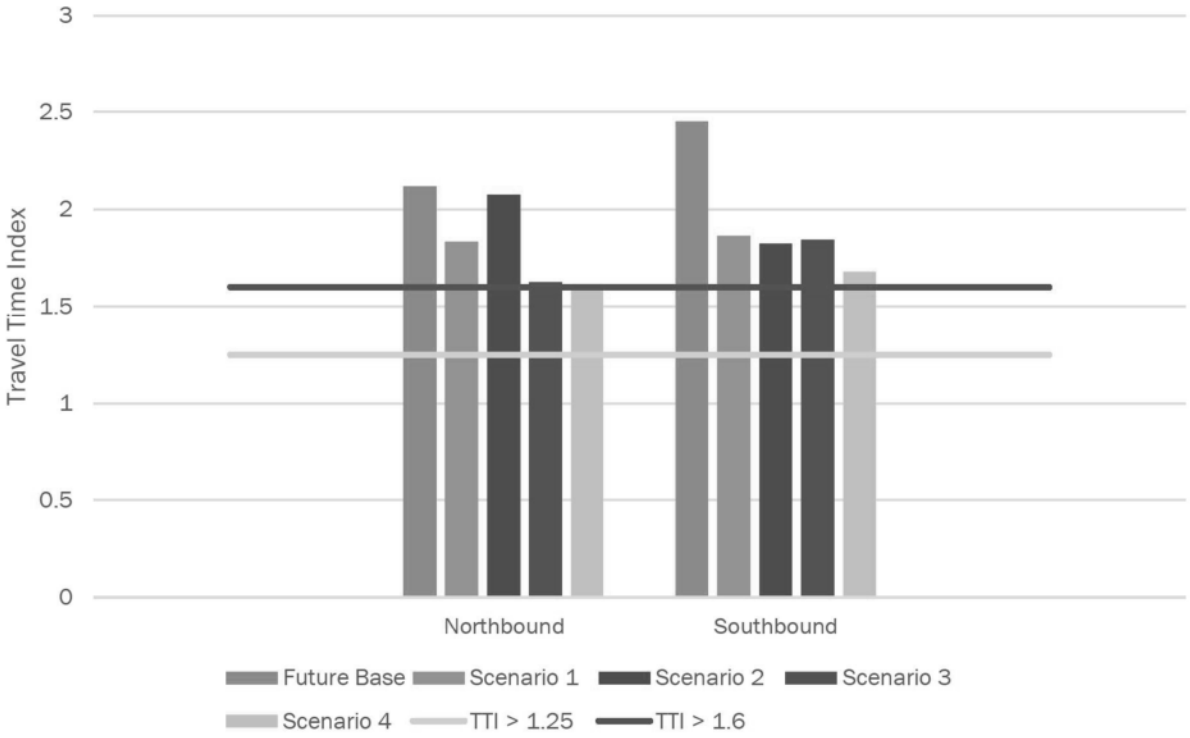

Figure 7.1: 2040 Saturday Midday Travel Time Indices

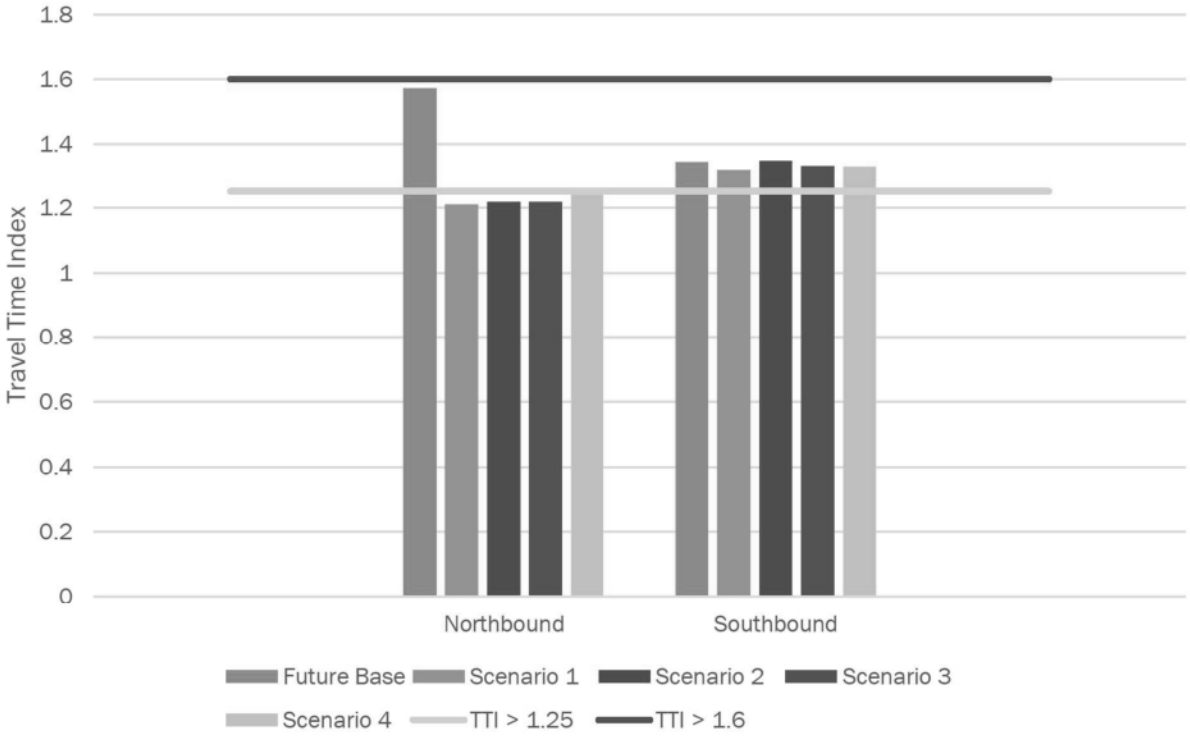

Figure 7.2: 2040 Sunday PM Travel Time Indices

Overall 2040 network vehicle hours travelled was extracted from SimTraffic and is summarized in ***Table 7.13***. As shown, each scenario (generally) progressively reduced network vehicle hours travelled (particularly on the Saturday); however it is acknowledged that some of the reduction in Scenario 4 is simply due to less vehicles on the network in the first place, rather than solely being attributable to an improvement in operations for vehicles that remain on the network. These changes to network vehicle hours travelled are also shown visually in ***Figure 7.3***.

Table 7.13: 2040 Network Vehicles Hours Travelled

Year	Period	Vehicle Hours Travelled				
		Future Base	Scenario 1	Scenario 2	Scenario 3	Scenario 4
2040	Saturday 12:00	1,566	1,471	1,400	1,191	1,002
	Sunday 16:00	662	692	530	521	510

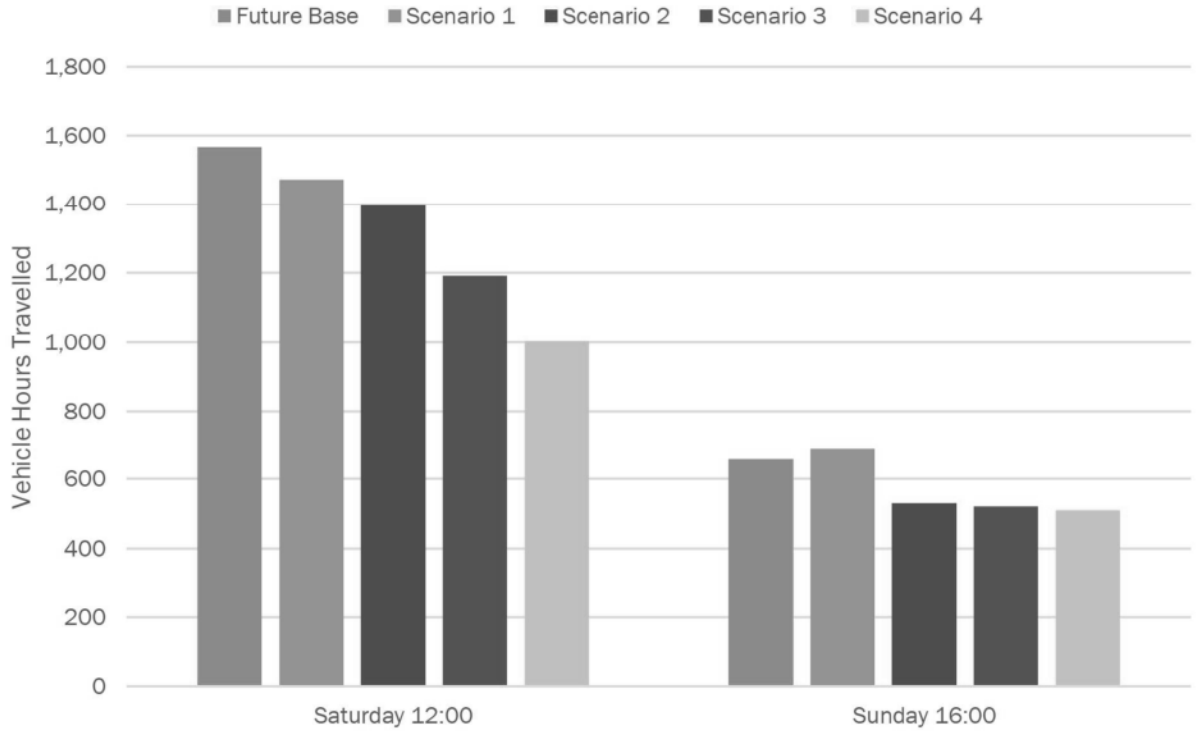

Figure 7.3: 2040 Network Vehicle Hours Travelled

8. HIGH-LEVEL ASSESSMENT OF OPTIONS AND POTENTIAL PHASING

This section provides a high-level assessment of options, outlines a potential phasing strategy, and finally highlights several considerations for any next steps.

8.1 Assessment of Options

In order to assess the relative merits of each option relative to a base case, and recognizing the smaller scale of the options being considered as well as the existing highway environment at each option location, a high-level multiple account evaluation framework was developed that included the following criteria:

- Traffic operations
- Road safety
- Transit
- Active transportation
- Socio-community impacts
- Environmental impacts
- Capital costs

Where applicable, traffic operations benefits have been quantified using outputs from the Synchro models, by comparing Scenario 3 (which as described above in Section 7, assumes all potential mitigation options are in place) against a Scenario 2 "base case" (which includes signal timing optimization and the Mamquam Blind Channel crossing, but none of the other improvements developed through this study). Values for travel time savings and consumer surplus were then monetized using outputs from the BC Ministry of Transportation and Infrastructure *Default Values for Cost Benefit Analysis* (2018), which were adjusted to 2020 values based on

the Statistics Canada Consumer Price Index. The resultant values of time were $19.23/person-hour for personal travel, $38.77/hour for light goods vehicles, and $47.31/hour for heavy goods vehicles.

Road safety benefits were also reviewed, and potential collision modification factors were identified. However, given that in some cases further confirmation of the specifics of the collision patterns is necessary to confirm appropriate ness of the modification factors, road safety metrics have not been monetized.

Transit and active transportation assessments primarily focussed on the degree to which the option addresses previously-identified issues or meetings prevailing design best-practices.

Socio-community impacts included considerations such as property impacts / acquisition, noise impacts and traffic exposure, and archaeological potential. The latter consideration was assessed using information from the District of Squamish Web Map system.

Environmental impacts focussed on potential terrestrial and aquatic impacts. These impacts were primarily developed through a review of potential footprint impacts of options and supplemented with output from the District of Squamish Environmentally Sensitive Areas Web Map.

The design and construction cost of each option was assessed using a high-level single line sketch, typical unit costs, and the methods of Highway Cost Estimating Using the Elemental Parametric Method. Given the highly conceptual nature of the project scope and lack of engineering detail, contingencies were provided to all estimates, and costs are presented as a potential range. Furthermore, only capital costs were considered at this stage, although it was acknowledged that a full benefit cost analysis would also need to capture escalation costs, property costs, maintenance and rehabilitation costs (including foregone expenses for infrastructure nearing the end of its service life that is being replaced as part of an option), as well as salvage value.

Where quantification is not possible, potential impacts were evaluated qualitatively. To evaluate qualitative scoring consistently, a five-level rating system was applied as shown in ***Table 8.1***.

Table 8.1: Qualitative Scoring Format

Score	Meaning
○	Significantly Worse
◔	Somewhat Worse
◑	Similar to Base Case (i.e. Scenario 2)
◕	Somewhat Better
●	Significantly Better

The resultant evaluation is provided in ***Table 8.2***.

Table 8.2: High-Level Assessment of Potential Improvement Options

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
Darrell Bay Road	Add sidewalks at northeast, northwest and southwest quadrants.	◑ No major effects anticipated under normal operations.	◕ On busy summer days, may slightly reduce instances of pedestrians queuing in the eastbound and westbound vehicle lanes while waiting to cross the intersection and the resultant vehicle / pedestrian conflicts, particularly at the northwest quadrant where SBR vehicles have a more limited sightlines of pedestrians.	◑ Route 5 uses this intersection but is not anticipated to be significantly affected.	◕ Safer and more comfortable pedestrian crossing experience by providing a more formalized walking area. Paved rather than gravel surfaces are likely to be a benefit for users with mobility challenges (e.g. in wheelchairs).	◑ No significant effects anticipated. In the District of Squamish WebMap, the Darrell Bay Road intersection has an Archaeological Overview Assessment (AOA) potential of Moderate. However, works are anticipated to be limited to areas that were previously disturbed.	◑ Minor shrub clearing likely required at northwest and southwest quadrants, however, no major effects anticipated. In the District of Squamish Environmentally Sensitive Areas Web Map, the Darrell Bay intersection has an Environmental Sensitivity Rating (ESR) of Low, and is located in an already disturbed ecosystem.	$40K - $70K	
Mamquam River Forest Service Road	Crosswalk / crossride on east leg of the intersection. NBR and WBR smart channelization.	◑ May slightly slow speeds for NBR movements and increase queueing, but no impact to overall intersection operations or capacity is anticipated. However, volumes are anticipated to be very limited (e.g. less than 10 vehicles / hour in the peak hours.)	◕ Improved crossing safety for would-be Corridor Trail users by formalizing channelized turn islands and providing a marked crossing. Converting the NBR movement (where vehicles are approaching from the highway and acclimatized to higher driving speeds) to a smart channelization that encourages slower turning speeds and improves sightlines.	◑ Route 5 uses this intersection but is not anticipated to be affected as this route does not use the NBR lane.	◕ Crossing configuration is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide*.	◑ No effects anticipated. In the District of Squamish WebMap, the northeast quadrant of the Mamquam River Forest Service Road intersection has an AOA potential of High. However, works are anticipated to be limited to areas that were previously disturbed.	◑ No effects anticipated. In the District of Squamish Environmentally Sensitive Areas Web Map, the Mamquam River FSR intersection has an ESR of Low, and is located in an already disturbed ecosystem.	$450K - $675K	Improvements only recommended when Corridor Trail Multi-Use Path is extended through this intersection.
Valley Drive	Crosswalk / crossride on east leg of the intersection. NBR and WBR smart channelization.	◑ May slightly slow speeds for NBR movements and increase queueing, but no impact to overall intersection operations or capacity is anticipated. However, volumes are anticipated to be relatively limited (e.g. 55 – 65 vehicles / hour in the peak hours.)	◕ Improved crossing safety for would-be Corridor Trail users by providing a marked crossing. Converting the NBR movement (where vehicles are approaching from the highway and acclimatized to higher driving speeds) to a smart channelization that encourages slower turning speeds and improves sightlines.	◑ Route 5 uses this intersection but is not anticipated to be affected as this route does not use the NBR lane.	◕ Crossing configuration for Corridor Trail is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide*.	◑ No effects anticipated. In the District of Squamish WebMap, the northeast quadrant of the Mamquam River Forest Service Road intersection has an AOA potential of Moderate, and the southeast quadrant has an AOA potential of High. However, works are anticipated to be limited to areas that were previously disturbed.	◑ No effects anticipated. In the District of Squamish Environmentally Sensitive Areas Web Map, the Valley Drive intersection has an ESR of Low, and is located in an already disturbed ecosystem.	$1M - $1.5M	Intersection crossing improvements only recommended when Corridor Trail Multi-Use Path is extended through this intersection.

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
Valley Drive	U-turn jughandle for use by vehicles at Stawamus Chief Parking Lot and Mamquam River FSR.	Option would provide a "relief valve" for WBL vehicles at the Stawamus Chief Parking Lot or Mamquam River Forest Service Road on exceptionally busy days, and would help limit the extent of delays. However, this jughandle is not anticipated to be heavily used on less busy days when there are sufficient gaps in the NBT traffic stream and lower WBL demand.	Jughandle would reduce the risk of drivers making WBL at either the Stawamus Chief Parking Lot or Mamquam River Forest Service Road from getting impatient and making a risky turn (i.e. low gap acceptance)	Route 5 uses this intersection but is not anticipated to be affected as this route does not use the NBR lane.	No effects anticipated.	As depicted in Section 6, the jughandle could potentially interface with the Squamish Valley Gas Bar, owned by Squamish Nation. Engagement would be required with Squamish Nation with respect to both business impacts and broader property impacts. In the District of Squamish WebMap, this section of Valley Drive has an AOA potential of High, and works would not necessarily be limited to a previously-disturbed area.	The option would require tree clearance. Additionally, although the jughandle was located with the intention to avoid direct impacts to the Stawamus River, further surveys would be required to confirm potential aquatic impacts both in the permanent condition as well as during construction. Depending on where specifically the jughandle was located, in the District of Squamish Environmentally Sensitive Areas Web Map, the facility could be placed in an area with an ESR of High (comprising a mixture riparian-river, riparian-midbench and riparian low-bench areas) or in an area with an ESR of Low (comprising a mixture of young forest-broadleaf and already disturbed area).	$3.1M - $4.7M	As described in Table 3.1, during busy days the pedestrian signal at the Darrell Bay Road intersection is constantly triggered, which can reduce green time for the NBT movement at this intersection. This can have the effect of increasing gap availability to facilitate WBL movements at the Stawamus Chief Parking Lot and Mamquam River Forest Service Road. As the traffic operations analysis does not fully capture this upstream metering effect, it is recommended that this issue be monitored during peak summer days to confirm the issue is severe in practice.
Clarke Drive	Mamquam Blind Channel Bridge.	Travel time savings associated with the Mamquam Blind Channel are not monetized because the bridge is assumed to already been in place in the base case (Scenario 2). However, it is acknowledged that relative to Scenario 1, Scenario 2 (which incorporates the Mamquam Blind Channel Bridge) improves overall operations at the Cleveland Avenue intersection LOS from LOS E to D by	Clarke Drive was identified as a Level 2 Collision Prone Location, however this collision history pre-dates the current intersection configuration (which implemented measures to mitigate the primary collision types). The Mamquam Blind Channel Bridge will likely change traffic patterns through the intersection further, but the road safety impacts are not clear.	For Route 3, Scenario 2 (which incorporates the Mamquam Blind Channel Bridge) improves summer Saturday Level of Service from F to D. If AVL is installed on buses, transit signal priority measures consisting of green extension and / or red truncation could further improve bus speeds and reliability.	Bridge crossing provides an opportunity for improved active transportation connectivity between downtown Squamish and Waterfront Landing, Northridge, and Valleycliffe neighbourhoods.	Would result in some traffic between Highway 99 and downtown Squamish to travel through the Waterfront Landing development. Would provide an alternative route to / from Squamish General Hospital and Squamish Fire Hall 1 in the event that there was an incident / closure on Highway 99 between Cleveland Avenue and Clarke Drive.	Option would require a new crossing of the Mamquam Blind Channel and will likely have DFO and Transport Canada permitting requirements. In the District of Squamish Environmentally Sensitive Areas Web Map, the crossing would pass through several areas, including an area with an ESR of High (comprising a mixture of freshwater-pond and wetland-swamp), an ESR of High (comprising a mixture of riparian-	n/a Not provincial infrastructure.	As described previously in Section 6.5, the primary collision pattern at this intersection related to SBL movements – these movements have already been converted to Protected-Only.

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
		diverting traffic to Clarke Drive. At a corridor / network level, compared to Scenario 1, Scenario 2 provides a 16% reduction in vehicle hours traveled is anticipated on a summer Saturday, and a 3% reduction is anticipated on a summer Sunday.				In the District of Squamish WebMap, the Mamquam Blind Channel crossing area is not noted as having an AOA potential of either Moderate or High.	midbench and wetland-swamp) an ESR of High (comprising of Ocean), and an ESR of Low (comprising already disturbed areas). Depending on the structural configuration, some of these areas could be spanned over-top of rather than directly impacted with a permanent footprint.		
Mill Road	Re-opening of at-grade rail crossing.	Not assessed – not provincial infrastructure or jurisdiction.							
Scott Crescent	Multi-Use Path Widening.	◑ No effects anticipated.	◑ No effects anticipated.	◑ No effects anticipated.	◕ Would provide a wider multi-use path cross-section that is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide* and would be more suitable to support increased use of walking and cycling for local trips.	◑ Likely minor noise impacts during construction, otherwise no effects anticipated. In the District of Squamish WebMap, the Mill Road crossing area is not noted as having an AOA potential of either Moderate or High.	◑ No effects anticipated. In the District of Squamish Environmentally Sensitive Areas Web Map, the Scott Crescent bluff area has an ESR of Low, and is located in an already disturbed ecosystem.	$230K - $350K	
Mamquam Blind Channel Bridge	Widen multi-use path across the river.	◑ No effects anticipated.	◑ No effects anticipated.	◑ No effects anticipated.	◕ Would provide a wider multi-use path cross-section that is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide* and would be more suitable to support increased use of walking and cycling for local trips.	◑ No effects anticipated. In the District of Squamish WebMap, the routing was not noted as having an AOA potential of either Moderate or High.	◔ Option would require a widened crossing of the Mamquam River. In the District of Squamish Environmentally Sensitive Areas Web Map, the crossing would pass through several areas, including an area with an ESR of High (comprising ocean), and ESR of Low (comprising already disturbed areas).	$10.3M - $15.4M	
Cleveland Avenue	EBR Acceleration Lane. SBR "Bypass". "Congestion ahead" automated warning flashers and high friction	◕ No significant change in overall operations performance assessed using Synchro; however in practice anticipate higher throughput for both	◕ Acceleration lane should reduce rear-end collisions at EBR movement. This movement accounted for ~25% of observed	◕ Comparing Scenario 3 to Scenario 2, there is no change in LOS on key movements with transit service (Routes 3,4, and 5, which collectively make	◑ Option would replace the existing SBR channelization crossing with a new crossing. However, no net effects anticipated	◕ SBR bypass would be placed close to Squamish Elementary School, but would not directly interface with the school. However, this would create a new	○ Would require 5-6 metre wide corridor of tree-clearing for a distance of approximately 200 metres.	$5.0M - $7.5M	It is noted that the EBR acceleration lane improvement was already identified by the Ministry and is already in the design phase.

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
	pavement for northbound and southbound directions.	movements due to increased capacity of SBR movements as well as reduced complexity / friction for SBR traffic with developments at NE quadrant of intersection.	collisions at the intersection. Scenario 2 improves overall operations at the intersection, which may help reduce NBT and SBR rear-end collisions. The SBR "bypass" is intended to simplify operations in the future as demand for this movement increases, although there is currently no observed collision pattern for this movement. Literature review suggests that installing changeable "Queue Ahead" warning signs can reduce crash severity (roughly a 16% reduction in injury collisions is anticipated, although this is offset by a 16% increase in property damage only collisions)[6].	NBL, SBR, and EBR movements). However, many of these movements benefit from the Mamquam Blind Channel bridge (included in Scenario 2), which diverts traffic away from the Cleveland Avenue intersection. If AVL is installed on buses, transit signal priority measures consisting of green extension and / or red truncation could improve bus speeds and reliability.		potential interface with vehicle traffic for students from both the elementary school and the nearby Howe Sound Secondary School on their walk to / from the schools. SBR bypass may disrupt user experience on Discovery Trail in the vicinity of the bypass. In the District of Squamish WebMap, the SBR bypass routing was not noted as having an AOA potential of either Moderate or High. The EBR has an AOA potential of Moderate, however works are anticipated to be limited to areas that were previously disturbed.	In the District of Squamish Environmentally Sensitive Areas Web Map, the EBR would pass through an area with an ESR of Low, and is located in an already disturbed ecosystem. In the District of Squamish Environmentally Sensitive Areas Web Map, the SBR would pass through an area with an ESR of Medium (comprising a mixture of young forest-broadhead, riparian-highbench and already disturbed areas).		
Industrial Way / Finch Avenue	Dual NBL. Dual SBL and additional eastbound receiving lane. Add sidewalks at northeast and southeast quadrants. SBR and EBR smart channelization.	◕ Number of LOS-deficient movements decreases from 5 in Scenario 2 (without option) to 3 in Scenario 3 (with option) during summer Saturday. By 2040, anticipate an annualized travel time savings in the range of $780K.	◕ No significant effects anticipated with respect to left-turn operations; left turn movements are already protected-only. Improved crossing safety for Discovery Trail users by providing a smart channelization which encourages slower turning speeds and improves sightlines	◕ For Route 4, Scenario 3 (which incorporates the dual NBL) improves summer Saturday Level of Service from E to D. If AVL is installed on buses, transit signal priority measures consisting of green extension and / or red truncation could further improve bus speeds and reliability.	● Additional sidewalks will eliminate existing gaps in pedestrian connectivity in a high-speed and high-volume environment. Discovery Trail crossing configuration is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide*.	◑ No effects anticipated. In the District of Squamish WebMap, the Mill Road crossing area is not noted as having an AOA potential of either Moderate or High.	○ Adding NBL and SBL will likely require a 3-4 metre wide corridor of tree-clearing for a distance of 150 metres. Adding a second eastbound receiving lane will likely require a 3-4 metre wide corridor of tree-clearing for a distance of 85 metres. In the District of Squamish Environmentally Sensitive Areas Web Map, the Industrial Way / Finch Avenue intersection has an ESR of Low, and is located	$6.3M - $9.5M	SBR and EBR smart channelization contingent on improvements to Discovery Trail to transform the facility to a wider paved facility that would see greater volumes of people walking and cycling.

[6] http://www.cmfclearinghouse.org/study_detail.cfm?stid=14

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
							in an already disturbed ecosystem. However, the Discovery Trail has an ESR of Medium (comprising a mixture of already disturbed and riparian-river areas). The additional eastbound receiving lane would impact an area with an ESR of High (comprising a mixture of Wetland-swamp and Riparian-river areas).		
Commercial Way	SBR and EBR smart channelization.	◑ No effects anticipated.	◕ Improved crossing safety for Discovery Trail users by providing a smart channelization which encourages slower turning speeds and improves sightlines.	◑ No effects anticipated.	◕ Discovery Trail crossing configuration is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide*.	◑ No effects anticipated. In the District of Squamish WebMap, the Mill Road crossing area is not noted as having an AOA potential of either Moderate or High.	◑ Minimal effects anticipated. In the District of Squamish Environmentally Sensitive Areas Web Map, the Commercial Way intersection has an ESR of Low, and is located in an already disturbed ecosystem. However, the Discovery Trail south of Commercial Way (which may be impacted by the smart channelization) has an ESR of Medium (comprising a mixture of already disturbed and riparian-river areas).	$1.1M - $1.7M	SBR and EBR smart channelization contingent on improvements to Discovery Trail to transform the facility to a wider paved facility that would see greater volumes of people walking and cycling.
Mamquam River Bridge	Widen multi-use path across the river.	◑ No effects anticipated.	◑ No effects anticipated.	◑ No effects anticipated.	◕ Would provide a wider multi-use path cross-section that is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide* and would be more suitable to support increased use of walking and cycling for local trips.	◑ No effects anticipated. In the District of Squamish WebMap, some areas along the river an AOA potential of High.	◔ Option would require a widened crossing of the Mamquam River. In the District of Squamish Environmentally Sensitive Areas Web Map, the crossing would pass through several areas, including an area with an ESR of High (comprising a mixture of freshwater-pond and wetland-swamp), and ESR of High (comprising riparian-river a riparian-	$8.5M - $12.7M	

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
							lowbench areas), and an ESR of Low (comprising already disturbed areas).		
Mamquam Road	Dual WBL. NBR smart channelization. WBR smart channelization. "Congestion ahead" automated warning flashers and high friction pavement for northbound and southbound directions.	◕ Option will improve WBL on a summer Saturday from LOS F to LOS E, and on a summer Sunday from LOS E to LOS C. On a summer Saturday, overall intersection operations improve from LOS F to LOS D, while remaining unchanged at LOS C on a summer Sunday. By 2040, anticipate an annualized travel time savings in the range of $2.1M.	◕ Mamquam Road was identified as a Level 1 Collision Prone Location. The dual WBL requires protected-only phasing which reduces collision risk as compared to permissive + protected phasing, and this movement was noted as having a significant collision history. Literature review suggests that converting permitted-protected to protected-only phasing on a major approach can reduce angled collisions for these movements by 97%[7]. Literature suggests that improving pavement friction will reduce rear end collisions (particularly on wet roads), but the level of improvement is contingent on the specific pavement mix. No collision modification factors were able to be located specifically for pavement treatments to improve deceleration at intersection approaches. Several NBR-related collisions were noted; smart channelization may help manage speeds and improve sightlines.	● Routes 1 and 4 will both benefit from significantly reduced delays for WBL movements. If AVL is installed on buses, transit signal priority measures consisting of green extension and / or red truncation could further improve bus speeds and reliability.	◕ Crossing configuration for Corridor Trail is more consistent with all ages and abilities recommendations provided in *BC Active Transportation Design Guide*.	◔ Provision of a second WBL lane will require road widening on Mamquam Road and will create either property and potentially business impacts to the north side of the road, and / or impacts to the golf course on the south side of the road. In the District of Squamish WebMap, the Mill Road crossing area is not noted as having an AOA potential of either Moderate or High.	◔ No significant impacts if road widening is located to the north side of Mamquam Road. Tree and vegetation clearing (likely a 3-4 metre wide corridor for a distance of 100 metres) would be required if the roadway were to be widened to the south. In the District of Squamish Environmentally Sensitive Areas Web Map, the Mamquam Road intersection has an ESR of Low, and is located in an already disturbed ecosystem.	$7.1M - $10.6M	
Garibaldi Way	Dual WBL NBR smart channelization.	◕ Option will reduce WBL delays on a summer Saturday (from 55 seconds to 38 seconds), although	◕ Garibaldi Way was identified as a Level 2 Collision Prone Location. The dual WBL requires	◑ Route 4 featured a SBL movement at this intersection, but is not anticipated to be	◕ Crossing configuration for Corridor Trail is more consistent with all ages and abilities recommendations	◔ Provision of a second WBL lane will require road widening on Garibaldi Way and will likely create	◔ Minor tree-clearing required on either north or south boulevard.	$6.9M - $10.3M	

[7] http://www.cmfclearinghouse.org/study_detail.cfm?stid=10

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
	WBR smart channelization (plus acceleration lane). "Congestion ahead" automated warning flashers and high friction pavement for northbound and southbound directions.	no change to LOS D. No change to overall intersection operations anticipated. By 2040, anticipate an annualized travel time savings in the range of $50K.	protected-only phasing which reduces collision risk as compared to permissive-protected phasing. However, only two of 14 recorded collisions involved this movement. Literature review suggests that converting permitted-protected to protected-only phasing on a major approach can reduce angled collisions for these movements by 97%[8]. A WBR acceleration lane could improve safety, although no collision outcomes were noted. No literature was able to be located providing collision modification factors specifically for the provision of right-turn acceleration lanes at signalized intersections. Literature review suggests that installing changeable "Queue Ahead" warning signs can reduce crash severity (roughly a 16% reduction in injury collisions is anticipated, although this is offset by a 16% increase in property damage only collisions)[9]. Literature suggests that improving pavement friction will reduce rear-end collisions (particularly on wet roads), but the level of improvement is contingent on the specific pavement mix. No collision modification factors were able to be located	significantly impacted by this option. If AVL is installed on buses, transit signal priority measures consisting of green extension and / or red truncation could further improve bus speeds and reliability.	provided in *BC Active Transportation Design Guide*.	property and potentially business impacts to adjacent properties. In the District of Squamish WebMap, the Mill Road crossing area is not noted as having an AOA potential of either Moderate or High.	If road widening to accommodate a dual WBL impacts a gas station (Petro-Canada on the north side and Chevron on the south side), then there may be an increased risk of contaminated sites clean up costs. In the District of Squamish Environmentally Sensitive Areas Web Map, the Garibaldi Way intersection has an ESR of Low, and is located in an already disturbed ecosystem.		

[8] http://www.cmfclearinghouse.org/study_detail.cfm?stid=10
[9] http://www.cmfclearinghouse.org/study_detail.cfm?stid=14

Location	Option	Traffic Operations	Road Safety	Transit	Active Transportation	Socio-Community	Environment	Capital Cost Range	Other Comments
			specifically for pavement treatments to improve deceleration at intersection approaches.						
Dowad Dive	Protected-T Intersection.	◑ Option will introduce new movements at Dowad Drive that do not currently exist (WBL and SBL). Traffic operations analysis suggests that the WBL movement could operates relatively poorly (LOS E).	◑ Option will redirect some traffic away from Garibaldi Way signalized intersection, which is a Level 2 Collision Prone Location. However, the Protected-T will introduce new conflicting movements at Dowad Drive, and could create collisions between NBT vehicles and either WBL or SBL vehicles.	◑ No effects anticipated.	◑ No effects anticipated.	◕ Option will provide improved access to the highway from new development areas, and reduce traffic volumes on adjacent municipal streets (e.g. Tantalus Road). In the District of Squamish WebMap, the Mill Road crossing area is not noted as having an AOA potential of either Moderate or High.	◑ Very minor effects anticipated; highway median has already been pre-emptively widened in this area. Some additional widening would be required for the acceleration lane and medians, which could require additional shrub and tree clearing on the west side of the highway. In the District of Squamish Environmentally Sensitive Areas Web Map, the intersection would pass through several areas, including an area with an ESR of Medium (comprising a young forest broadleaf area) and an ESR of Low (comprising already disturbed areas).	$7.2M - $10.8M	As described above in Section 6, over the long term a grade-separation could also be considered to improve WBL operations while avoiding introducing a new traffic signal on Highway 99.
Depot Road	Dual NBL and additional westbound receiving lane. Add sidewalks at northeast and southeast quadrants.	◕ Scenario 1 (re-timing signals) significantly improves NBL LOS on a Summer Saturday (from LOS F to LOS D). Providing a dual NBL further improves this movement to LOS C. By 2040, anticipate an annualized travel time savings in the range of $160K.	◑ No significant effects anticipated; left turn movements are already protected-only.	◑ No effects anticipated.	◕ Additional sidewalks will provide a safe pedestrian waiting area in a high-speed and high-volume environment.	◔ Would require removal of informal gravel parking area on north side of Depot Road west of intersection. In the District of Squamish WebMap, some areas east of Highway 99 south of the intersection have an AOA potential of Moderate.	◑ No significant effects anticipated; widening for additional westbound receiving lane would e predominantly accommodated in informal gravel parking area. In the District of Squamish Environmentally Sensitive Areas Web Map, the intersection would pass through an area with an ESR of Low (comprising a mixture of already disturbed areas and a limited area of wetland-swamp).	$6.4M - $9.6M	

8.2 Potential Phasing

A phasing strategy has been developed based on the following categorizations:

- Nearer-Term Improvements, primarily consisting of smaller-scale improvements, or improvements to address existing issues.
- Longer-Term Improvements, primarily consisting of improvements to address issues that will emerge or be more severe in the future.
- Improvements Contingent on Specific Initiatives or Developments.

The organization of the mitigation options into the three categories is provided below.

Nearer-Term Improvements (primarily smaller-scale improvements, or improvements to address existing issues):

- Darrell Bay Road: Adding missing sidewalks. This is a relatively minor issue that is likely to only be a concern during the summertime when there are many pedestrians crossing Darrell Bay Road. However, the scope of the improvement is also small and simple to implement.
- Cleveland Avenue: Eastbound Right Turn Acceleration Lane. Analysis of historic collision data shows that this movement is the single most frequent collision type on the entire Highway 99 corridor through Squamish. Provision of an acceleration lane is intended to address rear-end collisions at this location and increase EBR capacity.
- Industrial Way / Finch Avenue: Adding missing sidewalks. This improvement will provide a continuous east-west pedestrian network along Industrial Way / Finch Avenue in the vicinity of Highway 99. The scope of the improvement is also small and simple to implement.
- Mamquam Road: Dual WBL; NBR and WBR smart channelization; congestion ahead signage and high fiction pavement. The WBL movement is already a significant operational challenge and anticipated to be exacerbated in the future. Mamquam Road is also one of the top two collision prone locations along the corridor and providing protected phasing for eastbound and westbound left turn movements may help address some collision patterns. It is suggested that this location also be used as an opportunity to pilot higher friction pavement and congestion ahead warning signage – if this treatment proves effective then it can also be deployed as Cleveland Avenue and Garibaldi Way.
- Scott Crescent: Bluff scaling for Corridor Trail multi-use path widening. This small-scale improvement will provide a cross-section for the Corridor Trail that is more consistent with the *BC Active Transportation Design Guide.* It is acknowledged that this option is currently primarily characterized as a convenience issue– a wider path is "nice to have" when volumes are low, but can be expected to become more of a constraint and (active transportation) operations issue in the future as walking and cycling volumes increase.

Longer-Term Improvements (primarily improvements to address issues that will emerge or be more severe in the future)

- Cleveland Avenue: Southbound Right Turn "Bypass", pavement and "queue ahead" warning flasher treatments. SBR movements at this intersection are anticipated to grow as downtown Squamish continues to redevelop and densify. This option is intended to reduce conflicts with adjacent businesses

as these volumes increase. However, further investigation of potential environmental and community impacts is also required. The decision to proceed with pavement and "queue ahead" warning flasher treatments should be based on the experience at Mamquam Road.

- Industrial Way / Finch Avenue: Dual NBL; dual SBL and additional eastbound receiving lane, Discovery Trail interface improvements. As volumes on the highway corridor increase, dual left turn lanes will become necessary to maintain operations for through-movements. Furthermore, upgrades to the intersection will also allow for geometric improvements to the SBR and EBR channelized right turns (i.e. conversion to smart channelization) in order to reflect the evolving role of this trail towards a multi-use path.
- Dowad Drive: Protected-T intersection. Improvement will be required as additional development occurs in the Garibaldi Highlands.
- Garibaldi Way: Dual WBL; NBR and WBR smart channelization; congestion ahead signage and high fiction pavement. Needs at this intersection are similar to Mamquam Road, but less critical and more contingent on development. Furthermore, the introduction of a Protected-T intersection at Dowad Drive could also defer the need for this improvement if sufficient WBL volumes divert to the new Protected-T intersection. The decision to proceed with pavement and "queue ahead" warning flasher treatments should be based on the experience at Mamquam Road.
- Depot Road: Dual NBL and additional westbound receiving lane, and sidewalks. This improvement will only be required over the longer-term as additional development occurs in Brackendale.

Improvements Contingent on Specific Initiatives or Developments

- Clarke Drive: Mamquam Blind Channel Bridge. The timing of this option is contingent on the buildout of the Waterfront Landing development.
- Mamquam River FSR: Corridor Trail Crossing Improvements and Smart Channelization. These improvements do not need to be implemented until the point in time that the District of Squamish implements a southern extension of the Corridor Trail (per the municipal active transportation plan).
- Valley Drive: Corridor Trail Crossing Improvements and Smart Channelization. These improvements do not need to be implemented until the point in time that the District of Squamish implements a southern extension of the Corridor Trail (per the municipal active transportation plan).
- Mamquam Blind Channel: Multi-Use Path Widening. This is a high cost improvement, and should be integrated with any other planned rehabilitation / capital maintenance works required on the bridge structure. The existing path is narrow but separated from vehicular traffic, and therefore this improvement is primarily an operations / convenience consideration rather than a safety consideration, at least until such a time that active transportation volumes begin to create frequent conflicts for users to pass one another.
- Mamquam River Bridge: Multi-Use Path Widening. This is a high cost improvement, and should be integrated with any other planned rehabilitation / capital maintenance works required on the bridge structure. The existing path is narrow but separated from vehicular traffic, and therefore this improvement is primarily an operations / convenience consideration rather than a safety consideration, at least until such a time that active transportation volumes begin to create frequent conflicts for users to pass one another.

8.3 Other Considerations for Next Steps

In addition to the overall phasing strategy noted above, several additional considerations have also been identified for incorporation into future planning and design activities on Highway 99 in the Squamish area:

- This study used BC Stats projections for population growth, which forecasts population growing from approximately, 21,800 in 2020 to approximately 30,200 by 2040. The District of Squamish has separately developed a population growth forecast, which anticipates that a population of 30,200 would be reached by 2032 instead of 2040. In effect, this more aggressive growth rate would result results in the traffic operations conditions assessed in the 2040 scenario being reached 8 years sooner. If, in the coming years the population does increase at the faster rate forecasted the District of Squamish, then the timeline for improvements along the corridor may need to be advanced.
- Facilitating a shift towards increased use of active transportation is a key element of reducing the demand for use of the Highway 99 corridor for local trips. A key component of facilitating this shift is ensuring that active transportation facilities are suitable for people of all ages and abilities, including in locations where such facilities interface with vehicular traffic on Highway 99. In this study, high-angle smart channelization was selected as the means identified to improve safety and sense of comfort for trail users (both the Corridor Trail and Discovery Trail) and vehicles travelling to / from Highway 99. However, it is acknowledged that there are a number of other design enhancements or approaches (such as rectangular rapid-flashing beacons, conventional right-turn lanes, signalization and temporal separation of turning movements etc.) that could also provide a similar improvement for active transportation users, although these options also have their own limitations and trade-offs. However, it is recommend that further exploration of these alternatives be investigated as part of the design process for any future improvements.
- Discussions are ongoing regarding the opportunity to provide an intercity bus service along the Sea to Sky Corridor. While the study noted that there may be a need for a stop at either Mamquam Road or Garibaldi Way, there is also the possibility that stops could be considered at other locations along the corridor. It is recommended that BC MoTI continue to work with partners such as the District of Squamish and other corridor municipalities, First Nations and BC Transit to confirm a potential service plan and stop requirements for such a service. Based on the identified stop locations, further work would be required to assess the need for modifications to the highway to accommodate on-corridor transit stops.
- There is a need for ongoing engagement with the local road authority to ensure that the timing of any potential improvements are coordinated in order to avoid re-work and construction-related disruption, and ideally, to leverage partnerships in order to deliver mutually beneficial improvements.

APPENDIX A

District of Squamish Development Assumptions

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Withheld pursuant to/removed as

s.13 ; s.16