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Before and After Performance Study

BC Ministry of Transportation and Infrastructure

Highway 1 Before and After Study FINAL Rev.0
Lynn Valley Road to Ironworkers Memorial Bridge

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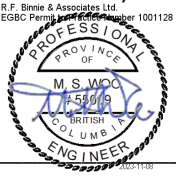

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1 INTRODUCTION

R.F. Binnie & Associates Ltd. (Binnie) has been retained by the Ministry of Transportation and Infrastructure (MOTI) to perform a review of the operational performance changes on Highway 1 between the south end of Iron Workers Memorial Bridge (IWMB) and the Lynn Valley Road Interchange, for both before and after the Highway 1 - Lower Lynn Improvements Project (the Project). The following are the components of the Project:

- Mountain Highway Interchange, completed spring 2019
- Keith Road / Seymour Parkway Interchange, completed fall 2021
- Main Street / Dollarton Highway Interchange, completed fall 2021
- Lynn Creek Connectivity Improvement Project, completed fall 2021

1.1 Study Objectives

The purpose of this report is to compare the traffic operational performance of Highway 1 before and after the improvements were made as part of the Project. Traffic performance data, specifically operating speed and segment travel times, were provided by Downtown.AI, a local company that specializes in the use of Big Data to analyze human movements. Supplementary data were obtained from MOTI's permanent induction loop counter on the south end of the IWMB and Wavetronix microwave radar data collectors within the Project corridor. This study does not include performance and impacts of the surrounding municipal road network connecting to Highway 1. The sub-sections below describe the study objectives and study scope:

- Review data provided from Downtown.AI, Wavetronix collectors, induction loop traffic counters.
- Obtain and compare the average and 85th percentile operating speeds on Highway 1 segments noted in the AM peak, PM peak, and off-peak periods for 2018 (before) and for 2022 (after completion of the Project).
- Obtain and compare the median travel times for the origin-destination pairs listed below for the AM peak and PM peak periods, in both 2018 and 2022.
- Determine how the seasonal changes in traffic patterns impact the operational performance along the study corridor for 2018 and 2022.
- Determine the changes in AM and PM peak periods for 2018 and 2022 utilizing data with intervals of 15-minute increments.
- Estimate Greenhouse gas emission (GHG) reductions by reviewing how improved traffic speeds translate to lower emission on a per car basis.
- Perform a high-level before and after cost benefit analysis for the Project to quantify social benefits.

2 PROJECT BACKGROUND

2.1 Project Location

Highway 1 connects the City of Vancouver, and other municipalities to the east to the North Shore and is a vital, regional transportation corridor that is used by more than 120,000 daily vehicle trips, both for commuting and leisure. The Project area encompasses Highway 1 from the north end of the Iron Workers Memorial Bridge to the north end of the Mountain Highway Interchange. The Project area is also the main corridor that provides access to the Horseshoe Bay Ferry Terminal and Highway 99 to the north. **Figure 2-1** illustrates a high-level view of the location of the project area and the surrounding road network.

2.2 Project Overview: Highway Network Improvements – 2018 to 2022

The original Highway 1 – Lower Lynn Interchanges were designed and built more than 50 years ago and have experienced increasing congestion and safety problems due to limitations in capacity and function. Some major issues that were identified were the corridor's capacity to handle increasing traffic volumes, short weaving/merging lengths between closely spaced interchanges, and limited connectivity across Highway 1. The Project was intended to improve the mobility and reliability of the corridor by reducing congestion and increasing average operating speeds during peak periods. Another Project objective is to improve safety by reducing the frequency and severity of accidents. The Project phases and the operational changes relevant to this study is presented below.

2.2.1 Phase 1 – Mountain Highway Interchange

Completed spring of 2019, this phase of the Project delivered a new interchange design. This included a new southbound on and off-ramp, northbound on-ramp, and five-lane Mountain Highway underpass as part of the upgrades. The new interchange was developed with the goals of improving connectivity across the Highway as well as alleviating congestion at the Mount Seymour Parkway and Main Street/Dollarton Highway Interchanges. **Figure 2-2** illustrates the changes to the interchange configuration at this location.

2.2.2 Phase 2 – Keith Road / Mount Seymour Parkway Interchange

Completed fall of 2021, this phase of construction included an overpass and the reconfiguration of the existing on and off-ramps. Northbound off ramps were configured to improve access to Keith Road and Mount Seymour Parkway, as well as Mountain Highway through a new collector-distributor road. Reconfiguration of the Lillooet Road, Mount Seymour Parkway, and Keith Road intersection, as well as improved facilities for other modes of transportation were also included in this phase. **Figure 2-3** illustrates the changes to the interchange configuration at this location.

2.2.3 Phase 3 – Main Street / Dollarton Highway Interchange

Completed fall of 2021, Phase 3 involved a redesign of the traffic operations on the Main Street on-ramp and Highway 1 southbound on-ramp. The Dollarton westbound on-ramp and Phibbs Exchange Transit Access on-ramp are now routed through the new Highway 1 Main Street overpass. All three southbound

ramps are now connected to Highway 1 through an Adaptive Traffic Signal which meters the on-ramp traffic onto the IWMB. Buses are prioritized at this on-ramp with the addition of a bus queue jumper lane at the Adaptive Traffic Signal. Merging issues are no longer as significant of a concern for southbound traffic at this interchange with the retention of the add lane at the north end of the IWMB. **Figure 2-4** illustrates the changes to the interchange configuration at this location.

2.2.4 Phase 4 – Lynn Creek Connectivity Improvement Project

Completed fall of 2021, this phase of the Project completes the addition of the new southbound on-ramp from Mountain Highway and northbound on-ramp from Mount Seymour Parkway. Both on-ramps are provided by the construction of two bridges on both sides of the existing Lynn Creek Bridge. The northbound side features as a distributor-collector that separates on-ramp and off-ramp merging activities from the Highway 1 mainline at the new north Lynn Creek Bridge.

Figure 2-1: Project Area Overview

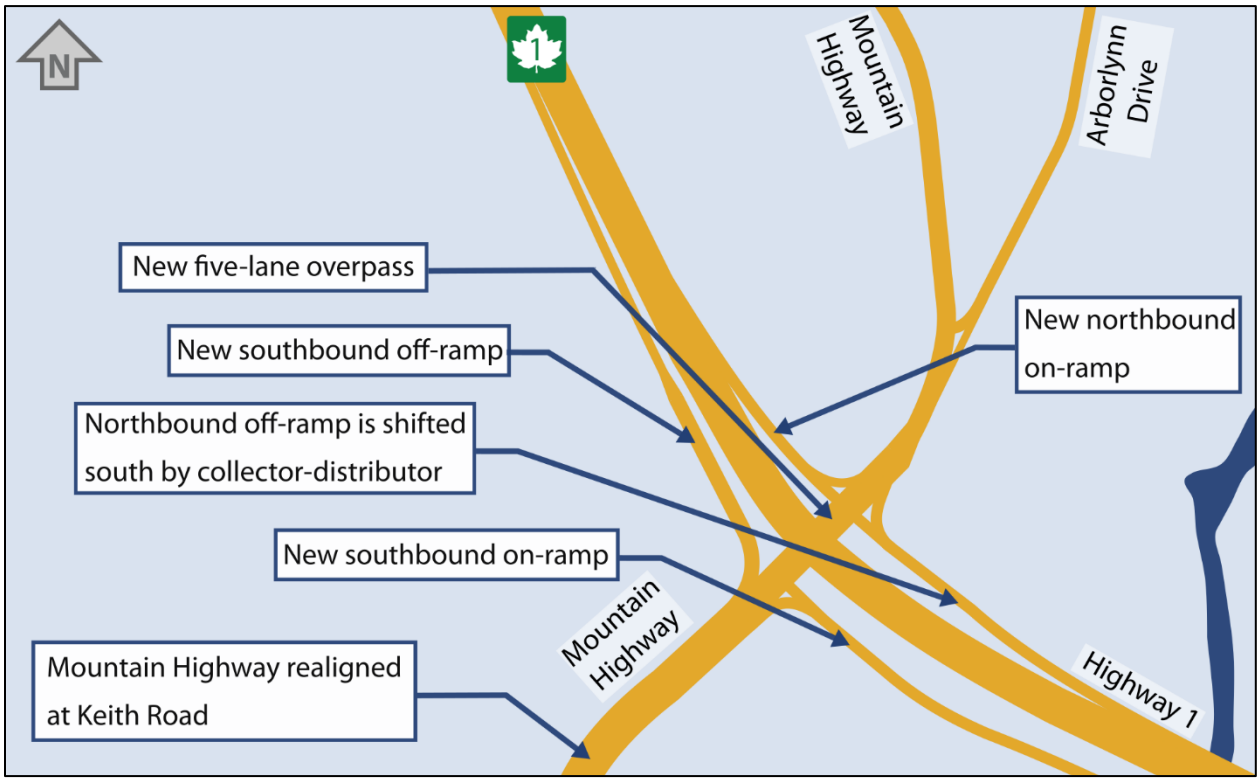

Figure 2-2: High-Level Summary of Configuration Changes to Mountain Highway Interchange

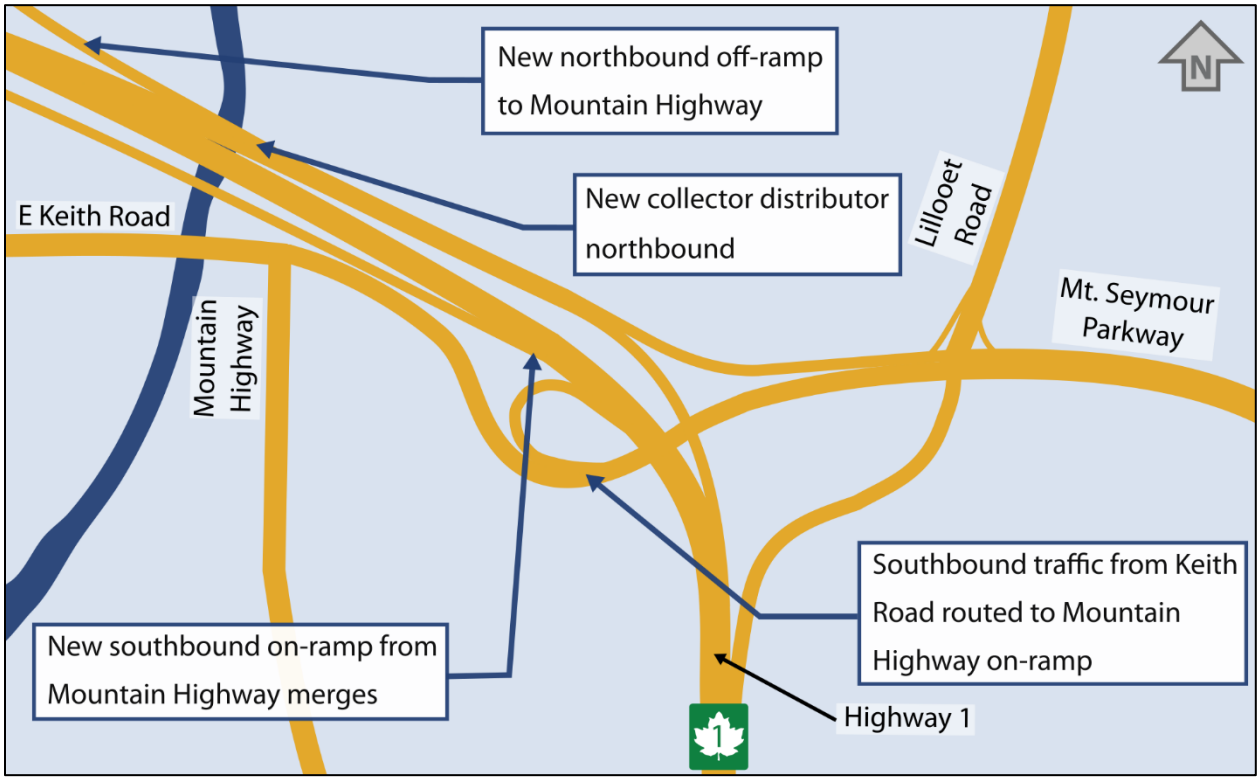

Figure 2-3: High-Level Summary of Configuration Changes to Mount Seymour Parkway Interchange

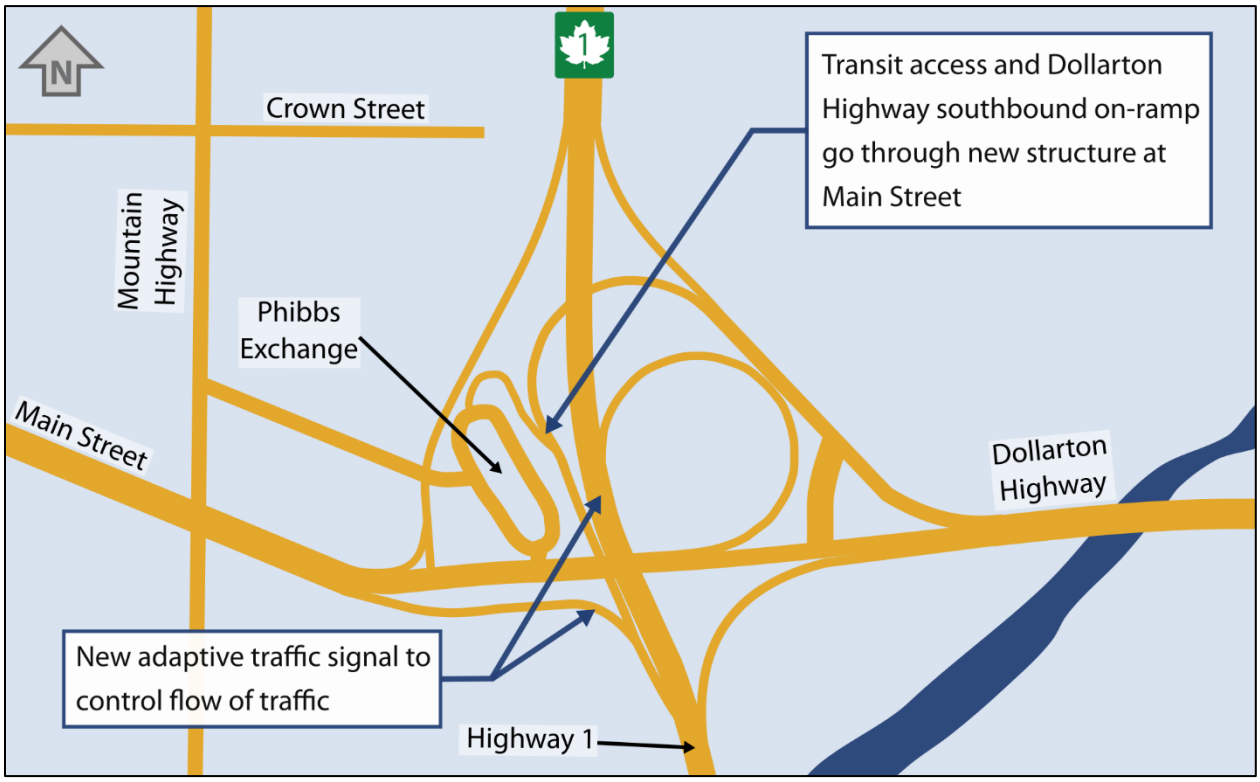

Figure 2-4: High-Level Summary of Configuration Changes to Main Street/Dollarton Highway Interchange

3 DATA SUMMARY

3.1 Operating Speed and Travel Time Data

3.1.1 Downtown.AI Provided Traffic Data

Downtown.AI was engaged to obtain and process mobile device location data to allow a comparison of travel times and speeds for Highway 1 segments before and after construction of the Project. A summary of the data collection methodology from Downtown.AI can be found in **Appendix A.**

Limitations of Data Collected, and Potential Sources of Error

Downtown.AI confirmed that no data has been discarded during the data processing operation to ensure sample sizes remain robust. Using vehicle telemetry, Downtown.AI confirms that location data is accurate to the range of 5-10 metres. Assignment of individual data points to Highway segments are also based on previous travel and location data, therefore it is determined that misclassification should not be considered a significant source of error. Sampling bias may also be a potential source of error as the data is dependent on the portion of the population who are contributing to the data production. This may lead to the unlikely possibility that a portion of the population is underrepresented within the data provided by Downtown.AI.

COVID-19 Pandemic and Response

A caveat to consider for the comparison of traffic operations in 2018 and 2022 is the effects of the pandemic on the 2022 data. Most of the provincial COVID-19 restrictions were still in place from January – February 16th 2022, which limited the size of gatherings, and parties at restaurants, among other restrictions. Some restrictions remained in place for March and April of 2022 as well, albeit with likely less impact to traffic and travel patterns. These restrictions may have contributed to reduced traffic volumes during this period which could have skewed the results of traffic operations. The expected magnitude of the effects of restrictions on traffic operations will be discussed when reviewing the month-to-month data for seasonality.

3.1.2 Wavetronix Data Provided by MOTI

Data was provided by MOTI from its Wavetronix microwave radar vehicle detectors within the Project corridor, and was grouped in bin sizes of 15 minutes, categorized by lane, from August 2022 to February 2023. Wavetronix data collectors are typically mounted on poles to track vehicle data per lane with the use of radar technology. For the purposes of this study, Wavetronix collector data from the three following locations illustrated in **Figure 3-1** were chosen to be reviewed due to their alignment with the chosen Highway study segments.

Figure 3-1: Locations of Wavetronix Data Collectors

Space-Mean Speed vs. Time-Mean Speed

When comparing traffic data from different sources and collection methods, it is necessary to distinguish the differences in the types of vehicle speed data. The U.S. Department of Transportation, Federal Highway Administration's (FWHA) *Travel Time Data Collection Handbook* defines time-mean speed as the average speed of all vehicles for a specified period of time at a specific point, and space-mean speed as the average speed of vehicles over a segment of roadway. The speed data provided by Downtown.AI is a space-mean speed measure because it is measured over a Highway segment, while the Wavetronix data is a measure of time-mean speed as it is measured at a given point. FHWA defines the relationship between time-mean speed and space-mean speed as follows:

$$\nabla_{TMS} \approx \nabla_{SMS} + \frac{S^2{}_{SMS}}{\nabla_{SMS}}$$

Where:

$$\nabla_{TMS} = sample\ time\ mean\ speed;$$

$$\nabla_{SMS} = sample\ space\ mean\ speed;$$

$$S^2{}_{SMS} = sample\ variance\ of\ the\ space\ mean\ speed.$$

Time-mean speed will always report a higher average speed when compared to space-mean speed unless there is zero variance in sample space-mean speed. Therefore, it is expected to see a moderate (one to five percent as stated by FWHA for U.S. roadways) discrepancy in the observed average speed as reported from Wavetronix in comparison to Downtown.AI's dataset based off of them being different measures of speed.

Discrepancies may also be caused by other factors that would result in drivers changing speeds, as well as weaving segments, vertical and horizontal curves, and other Highway elements. Figure 3-2 and Figure 3-3, shows a comparison of the mean speeds collected from MOTI's Wavetronix collector, and Downtown.AI's NBD3 and SBD2 Highway segment sample data for the same time periods.

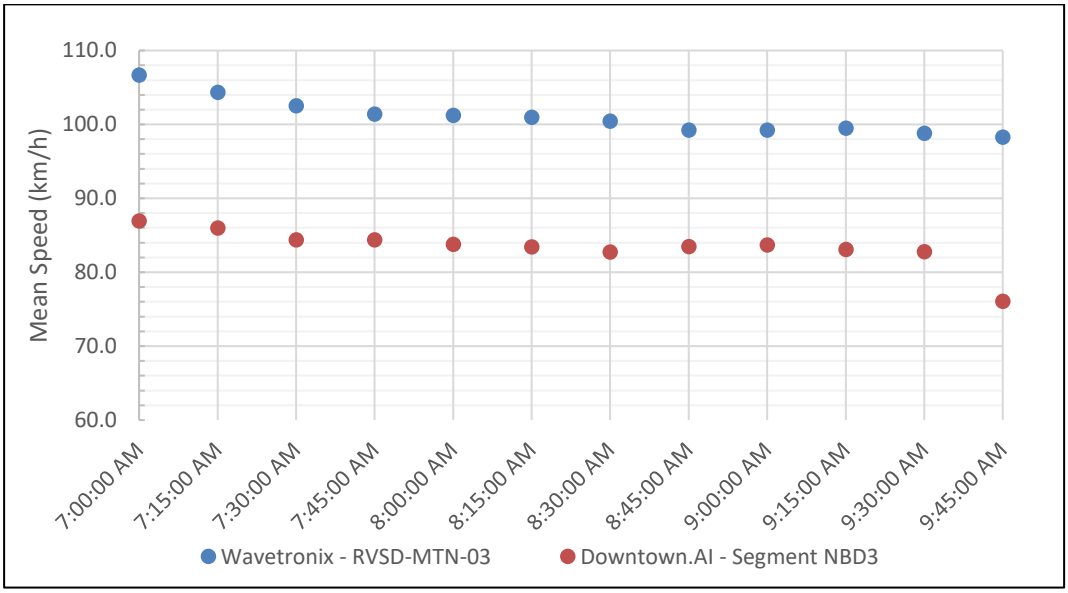

Figure 3-2: Mean Northbound Speeds on Highway 1 Mainline During AM Peak Periods – August 2022

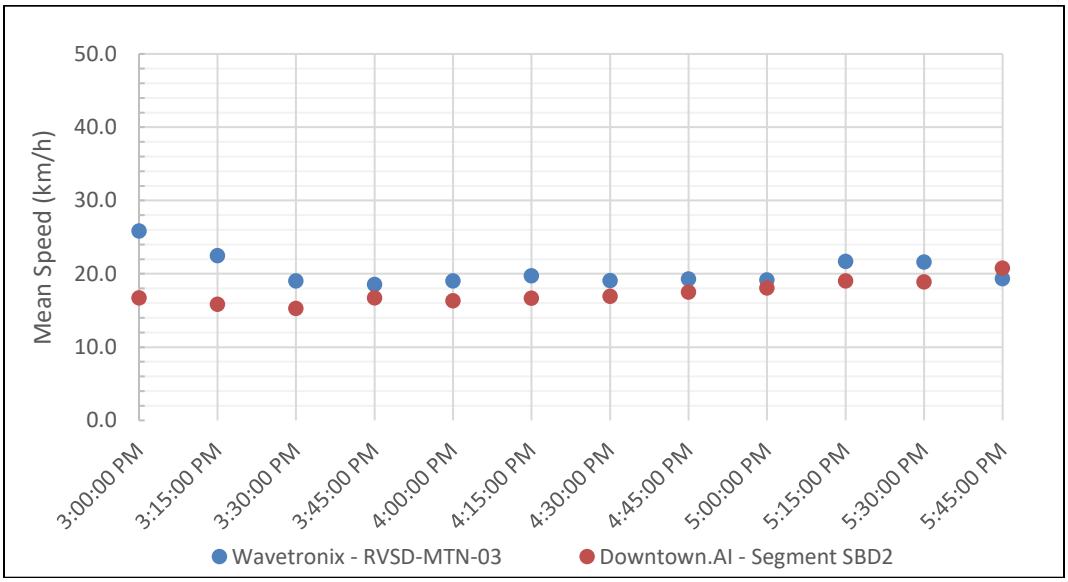

Figure 3-3: Mean Southbound Speeds on Highway 1 Mainline During PM Peak Periods – August 2022

Figure 3-2 shows Highway conditions with speeds near free-flow conditions for a section of the Highway with an 80 km/h speed limit. Part of the discrepancy between the two datasets may be attributed to the differences in time-mean speed and space-mean speed. However, another potential factor is the specific location of the Wavetronix collector. Prior to a steep incline, drivers may speed up to gain momentum prior. The location of ITS-MTN-03 is located at the base of the northbound incline known as "The Cut" where drivers may accelerate before travelling up the hill.

Figure 3-3 shows Highway conditions with relatively heavy congestion with low speeds. Given the traffic congestion which is likely to be affecting drivers along the whole SBD2 Highway segment, Downtown.AI speeds are consistently close to the speeds recorded by Wavetronix collectors. See **Figure 3-4** below for the division of the Highway study corridor into segments in order to process the Downtown.AI traffic data.

3.2 Traffic Volume Data Sourced from MOTI Traffic Data Program

Traffic volume data was sourced from MOTI's permanent traffic counter located at the south end of the IWMB to be able to compare 2018 volumes to 2022 volumes. Although traffic volume data was also sourced from Wavetronix collectors, these collectors were not in place during 2018 and the first half of 2022. This prevents the analysis of traffic volumes before and after the construction of the Project with the Wavetronix data.

With the intention of being consistent with the speed review and travel time analysis, available volumes were aggregated by year for 2018 and 2022 with a bin size of one hour. Traffic volumes from weekends and provincial statutory holidays were removed from the data set. **Table 3-1** summarizes and compares the 2018 and 2022 mean volumes for the peak and off-peak periods to give additional context to the data presented in the following sections of this study. Note that the yearly aggregations start from Mar 14th instead of the first day of the year because this is the only data available for 2022. Some observations from the average volume data are as follows:

- It is important to note that the data from MOTI's permanent traffic counter at the south end of the IWMB is not within the project area but is within one of the Highway segments for the scope of this study (SBD4 and NBD1). Traffic accessing the three subsequent interchanges to the north are not entirely captured by this volume data.
- During the period of 6:00 AM to 7:00 AM, the data shows that there is a decrease of 36% in average southbound traffic volumes in 2022 compared to 2018. This could possibly be attributed to shifting commuting patterns and an increase of commuters working from home since the COVID-19 pandemic, which resulted in a general decrease of commuters from the population who work typical 9:00 AM to 5:00 PM office jobs.
- During the periods of 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM, in both the southbound and northbound directions, a total traffic volume decrease of about 4-15% is observed. This could also possibly be attributed to the increase of commuters working from home since the COVID-19 pandemic.

- During the mid-day and early PM peak periods, 1:00 PM to 2:00 PM and 3:00 PM to 4:00 PM, a minor increase in traffic volumes of about 2-6% is observed for the southbound direction. This increase may possibly be attributed to those who work in the service sector who do not have a typical 9:00 AM to 5:00 PM work schedule and are also not able to work from home. This portion of the population may also be generally assumed to be increasing correspondingly with regional population growth.

Table 3-1: Average Weekday Volume Summary from South End of IWMB (March 14 – December 31)

	Hour of the Day	Southbound Volumes			Northbound Volumes		
		2018	2022	% Difference	2018	2022	% Difference
AM Peak	6-7AM	4190	2701	-36%	3075	3846	25%
AM Peak	7-8AM	4620	3977	-14%	4877	4403	-10%
AM Peak	8-9AM	4343	4160	-4%	4722	4292	-9%
Mid Day	1-2PM	3797	3935	4%	3962	3682	-7%
PM Peak	3-4PM	4529	4597	2%	4794	4296	-10%
PM Peak	4-5PM	4962	4587	-8%	4810	4548	-5%
PM Peak	5-6PM	4882	4410	-10%	4601	4414	-4%

3.3 Highway 1 Segments & Origin-Destination Travel Time Pairs

To undertake the speed review and travel time analysis, the project area was broken into segments and origin-destination pairs for the southbound and northbound direction. **Figure 3-4** illustrates the Highway 1 segments and origin-destination pairs listed below:

District of North Vancouver to City of Vancouver in the Southbound Direction

- SBD1 – Highway 1 from East of Lynn Valley Road Interchange to Mountain Highway Interchange
- SBD2 – Highway 1 from Mountain Highway Interchange to Mount Seymour Parkway Interchange
- SBD3 – Highway 1 from Mount Seymour Parkway Interchange to Main Street / Dollarton Highway Interchange
- SBD4 – Highway 1 from Main Street / Dollarton Highway to the South end of the Ironworkers Memorial Bridge (IWMB)

City of Vancouver to District of North Vancouver in the Northbound Direction

- NBD1 – Highway 1 from the South end of the IWMB to Highway 1 at Main Street / Dollarton Highway Interchange
- NBD2 – Highway 1 from Main Street / Dollarton Highway to Mount Seymour Parkway Interchange

- NBD3 – Highway 1 from Mount Seymour Parkway Interchange to Mountain Highway Interchange
- NBD4 – Highway 1 from Mountain Highway Interchange to East of Lynn Valley Road Interchange

Figure 3-4: Highway 1 Segments and Origin-Destination Pairs

4 TRAFFIC SPEED REVIEW

The average operating speeds on the Highway 1 segments for peak periods and off-peak periods were compared between the 2018 data to the 2022 data. The 85th percentile speeds for each segment were also compared. Mean speed provides a representation of the operational performance of a typical vehicle along each Highway segment over the year, before and after the Project. The 85th percentile speed is an indicator of the speed at which 85 percent of drivers, during that hour, would be travelling below. Periods selected for this study are 6:00 AM to 9:00 AM for AM peak, 3:00 PM to 6:00 PM for PM peak, and 1:00 PM to 2:00 PM for mid-day free-flow conditions.

The traffic speed review data set was aggregated in hour-long bins for each of the study years to maximize sample size and minimize the effects of outlier events such as car accidents or extreme weather. The 85th percentile speed comparison also removes bias created by outlier events. The data set omits weekends and provincial statutory holidays to examine the operational performance of each segment under a typical weekday commute times.

The following sections analyze and compare the 2018 and 2022 speeds by segment. Percent difference is provided to quantify the change in observed speeds. The formula used for percent difference calculation is as follows:

$$\%\ Difference = \frac{(2022\ Speed - 2018\ Speed)}{2018\ Speed}$$

Where:

$$2018\ Speed = Mean\ or\ 85th\ Percentile\ Speed\ Aggregated\ for\ 2018\ for\ the\ Specified\ Hour$$

$$2022\ Speed = Mean\ or\ 85th\ Percentile\ Speed\ Aggregated\ for\ 2022\ for\ the\ Specified\ Hour$$

The 24-hour period comparison of 2018 vs. 2022 mean and 85th percentile speeds for all eight segments in graph form are provided in **Appendix B**.

4.1 Southbound Direction

4.1.1 SBD1: Highway 1 from East of Lynn Valley Road Interchange to Mountain Highway Interchange

Table 4-1 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between the Lynn Valley Road Interchange to the Mountain Highway Interchange. During the AM peak, the mean and 85th percentile speed is observed to increase marginally from 6:00 AM to 7:00 AM. The mean speed from 7:00 AM to 9:00 AM increases significantly by ~30 km/h while the 85th percentile speed is observed to increase moderately by 8-9 km/h. Between 1:00 PM and 2:00 PM, where speeds are generally consistent and volumes are typically lower than the peak periods, the percent difference is observed to be relatively consistent for both mean and 85th percentile speeds. During the PM peak period, mean speed is observed to change minimally by ±3 km/h. The 85th percentile speed during the same period is observed to increase for all hours by 5-11 km/h.

The observation of significant improvement in mean speed and moderate improvement of 85th percentile speed from 7:00 AM to 9:00 AM indicates that the best commuting days have improved slightly from 2018 to 2022 and overall speeds have improved dramatically. The observations from the PM peak period suggests that overall there are minimal changes in travel speed along this segment, however the best commuting days have increased moderately in speed for 2022. These moderate improvements to operating speed can possibly be attributed to the addition of the Mountain Highway Interchange off ramp. Southbound traffic headed to a destination in North Vancouver would have had to utilize the off ramp at Keith Road or Main Street Interchanges in 2018. However, in 2022, these commuters now have the option to utilize the Mountain Highway off ramp which may alleviate some congestion in this Highway segment. It is important to note that in portions of 2018, construction speed limits may have been in effect already, which may have influenced the data collected for this segment of the Highway.

Table 4-1: Highway 1 Speed Data from Lynn Valley Road Interchange to Mountain Highway Interchange

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
SBD1	AM Peak	06:00-07:00	92.3	93.6	1%	106.0	108.2	2%
		07:00-08:00	52.8	82.5	56%	92.4	100.6	9%
		08:00-09:00	37.8	70.1	85%	86.8	95.3	10%
	Mid Day	13:00-14:00	63.6	61.6	-3%	89.1	93.3	5%
	PM Peak	15:00-16:00	23.1	22.1	-4%	63.2	70.5	12%
		16:00-17:00	22.4	24.1	8%	71.8	82.6	15%
		17:00-18:00	30.2	32.8	9%	85.4	90.0	5%

4.1.2 SBD2: Highway 1 from Mountain Highway Interchange to Mount Seymour Parkway Interchange

Table 4-2 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between Mountain Highway Interchange and Mount Seymour Parkway Interchange. During the AM peak, from 6:00 AM to 7:00 AM, there is an approximately 2-3 km/h increase for both mean and 85th percentile speed. From 7:00 AM to 8:00 AM, mean speed increases significantly by about 40 km/h. The 85th percentile speed for the same hour is observed to increase moderately by about 10 km/h. From 8:00 AM to 9:00 AM the mean speed increases by 30 km/h and the 85th percentile speed is observed to increase by 12 km/h. Between 1:00 PM to 2:00 PM, mean speed decreases by 13 km/h and 85th percentile speed increases by 6 km/h. During the PM peak, from 3:00 PM to 4:00 PM, mean speed decreases by 2 km/h and 85th percentile speed decreases by 11 km/h. However, the mean speed from 4:00 PM to 6:00 PM, changes minimally by ± 2 km/h. During the same period, the 85th percentile speed increases significantly from 4:00 PM to 5:00 PM by 23 km/h and increases moderately from 5:00 PM to 6:00 PM by 7 km/h.

Similarly to SBD1, from 7:00 AM to 9:00 AM, speeds for the best commuting days have increased moderately, but the overall speeds have increased remarkably from 7:00 AM to 9:00 AM. Some of the

additional congestion during the PM peak hour of 3:00 PM to 4:00 PM can be attributed to the addition of the southbound on ramp from the new Mountain Highway Interchange. However, the significant increase from 4:00 PM to 5:00 PM for 85th percentile speeds suggests that the Highway, with the addition of this new on-ramp, can still operate relatively efficiently given reasonable traffic volumes.

Table 4-2: Highway 1 Speed Data from Mountain Highway Interchange to Mount Seymour Parkway Interchange

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
SBD2	AM Peak	06:00-07:00	91.6	94.2	3%	104.3	107.6	3%
		07:00-08:00	38.1	78.6	106%	90.5	100.7	11%
		08:00-09:00	30.6	61.0	99%	84.8	96.6	14%
	Mid Day	13:00-14:00	67.6	55.1	-18%	89.8	95.9	7%
		15:00-16:00	20.6	18.5	-10%	51.0	39.7	-22%
	PM Peak	16:00-17:00	20.8	20.7	-1%	48.5	71.1	47%
		17:00-18:00	26.5	27.9	5%	83.3	90.7	9%

4.1.3 SBD3: Highway 1 from Mount Seymour Parkway Interchange to Main Street / Dollarton Highway

Table 4-3 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between Mount Seymour Parkway Interchange and Main Street/Dollarton Highway. During the AM peak, from 6:00 AM to 7:00 AM, there is negligible change in mean speed and a minimal decrease in 85th percentile speed by 3 km/h. From 7:00 AM to 8:00 AM, the mean speed increases significantly by 31 km/h. The 85th percentile speed for the same hour increases moderately by 6 km/h. From 8:00 AM to 9:00 AM the mean speed increases by 28 km/h, and the 85th percentile speed increases by 5 km/h. From 1:00 PM to 2:00 PM, the mean speed decreases by 6 km/h and the 85th percentile speed decreases by 4 km/h. During the PM peak, the mean speed is observed to increase significantly by about 11-13 km/h from 3:00 PM to 6:00 PM. The 85th percentile speed from 3:00 PM to 4:00 PM and 4:00 PM to 5:00 PM increases by 17 km/h and 19 km/h respectively. From 5:00 PM to 6:00 PM, there is negligible change in 85th percentile speed.

The significant improvement of mean speed for both AM and PM peak periods indicates that overall operating speeds for this segment are due to the removal of the merge on ramp from Dollarton Highway and the corresponding metering of the add lane on ramp reducing queueing upstream. This segment has historically been known to be a major choke point along this corridor and often resulted in queueing and congestion spanning into this Highway segment. Due to the significant improvements in operating speeds observed during both AM and PM peak periods, it is speculated that the reduction of speed during the mid-day period is due to increased southbound traffic volumes in 2022 as observed by the Ministry's permanent counter data at the south end of the IWMB.

Table 4-3: Highway 1 Speed Data from Mount Seymour Parkway Interchange to Main Street/Dollarton Highway

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
SBD3	AM Peak	06:00-07:00	81.9	81.9	0%	96.8	94.2	-3%
		07:00-08:00	34.5	66.0	91%	78.9	85.3	8%
		08:00-09:00	29.9	57.6	93%	75.8	80.8	7%
	Mid Day	13:00-14:00	59.3	53.2	-10%	86.4	81.6	-6%
	PM Peak	15:00-16:00	22.2	33.4	50%	35.9	52.8	47%
		16:00-17:00	23.3	35.4	51%	38.0	57.1	51%
		17:00-18:00	27.7	40.8	47%	73.5	73.6	0%

4.1.4 SBD4: Highway 1 from Main Street / Dollarton Highway to South end of IWMB

Table 4-4 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between Main Street/Dollarton Highway and the south end of the IWMB. During the AM peak, there is minimal improvement in both mean and 85th percentile speed from 6:00 AM to 7:00 AM. From 7:00 AM to 9:00 AM, there is an increase of 7-9 km/h for both the mean speeds and 85th percentile speeds. During the mid-day period of 1:00 PM to 2:00 PM, mean and 85th percentile speeds decrease minimally by 2-4 km/hr. During the PM peak, from 3:00 PM to 5:00 PM, mean speeds are constant while the 85th percentile speeds increase by 2 km/h. From 5:00 PM to 6:00 PM, mean speed increases by 1 km/h and 85th percentile speed increases by about 3 km/h.

This segment of the Highway is observed to have moderate improvements to mean and 85th percentile speed for the hours between 7:00 AM to 9:00 AM. This can likely be attributed to the adaptive signal system of the new Main Street Overpass on ramp. The metering of this on ramp onto the north approach of the IWMB improves congestion on the main span of the bridge by forcing traffic joining the Highway to wait for an actuated signal. Even though this on ramp is routed through to an added lane on the bridge, congestion may still be an issue when weaving occurs on the bridge itself. Immediately south of the IWMB, the added lane becomes an exit only lane to McGill Street and Hastings Street. Minimal mean speed and 85th percentile speed difference observed for other mid-day and peak periods is expected as the interchange improvements are not expected to improve traffic operations greatly downstream of the project area.

Table 4-4: Highway 1 Speed Data from Main Street / Dollarton Highway to South end of IWMB

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
SBD4	AM Peak	06:00-07:00	76.6	77.2	1%	91.4	92.3	1%
		07:00-08:00	54.3	62.2	14%	71.7	80.5	12%
		08:00-09:00	50.9	58.1	14%	66.7	75.6	13%
	Mid Day	13:00-14:00	58.1	53.8	-7%	75.4	73.5	-3%
		15:00-16:00	45.5	45.7	0%	57.8	59.5	3%
	PM Peak	16:00-17:00	45.8	45.8	0%	58.6	61.2	5%
		17:00-18:00	48.1	49.1	2%	64.5	67.6	5%

4.2 Northbound Direction

4.2.1 NBD1: Highway 1 from South end of the IWMB to Main Street / Dollarton Highway

Table 4-5 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between the south end of the IWMB to Main Street/Dollarton Highway. During the AM peak, from 6:00 AM to 7:00 AM, mean and 85th percentile speed increase minimally by 2-3 km/h. From 7:00 AM to 9:00 AM, mean speed increases by about 9 km/h and 85th percentile speed increases by 5-7 km/h. From 1:00 PM to 2:00 PM, the mean speed increases by about 6 km/h and the 85th percentile speed stays relatively the same. During the PM peak period, from 3:00 PM to 4:00 PM, the mean speed increases by 9 km/h and the 85th percentile speed increases marginally by 3 km/h. From 4:00 PM to 5:00 PM, the mean speed increases significantly by 11 km/h and the 85th percentile speed increases by 7 km/h. During the 5:00 PM to 6:00 PM hour, mean speeds increase dramatically by 16 km/h and the 85th percentile speed increases by 12 km/h.

The fact that there are moderate to substantial mean speed improvements across multiple periods of the day, despite no changes to the configuration of the off ramp at the north end of this segment, points to the cause being upstream effects of interchange improvements. Lower volumes may also play a meaningful role as the Ministry's permanent traffic counter on the south end of the IWMB shows a general decrease in all study period hours, excluding 6:00 AM to 7:00 AM. Due to the fact that mean speeds have increased by a greater percentage than 85th percentile speed, it can be inferred that the best commuting days have improved, but the worst commuting days have improved even more so. This will be explored further in the subsequent sections where 95th percentile travel time comparison will analyze the days with the worst congestion for 2018 and 2022.

Table 4-5: Highway 1 Speed Data from South end of IWMB to Main Street/Dollarton Highway

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
NBD1	AM Peak	06:00-07:00	69.3	72.2	4%	86.3	88.4	2%
		07:00-08:00	52.8	63.3	20%	71.9	77.3	8%
		08:00-09:00	41.8	60.6	45%	67.7	74.6	10%
	Mid Day	13:00-14:00	64.8	71.3	10%	85.7	86.3	1%
	PM Peak	15:00-16:00	60.9	69.6	14%	81.2	83.7	3%
		16:00-17:00	54.7	66.4	21%	74.4	80.7	9%
		17:00-18:00	48.4	64.3	33%	67.7	79.5	17%

4.2.2 *NBD2: Highway 1 from Main Street / Dollarton Highway to Mount Seymour Parkway Interchange*

Table 4-6 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between Main Street/Dollarton Highway to Mount Seymour Parkway Interchange. During the AM peak period, from 6:00 AM to 7:00 AM, the mean speed increases moderately by 9 km/h with an increase of 85th percentile speed by 8 km/h. From 7:00 AM to 8:00 AM, mean speed increases dramatically by 29 km/h and 85th percentile speed increases by 16 km/h. 8:00 AM to 9:00 AM shows a similar dramatic increase of mean operating speed of 37 km/h and 85th percentile speed increase of 23 km/h. During the mid-day hour of 1:00 PM to 2:00 PM, mean speed and 85th increased considerably by 21 km/h and 85th percentile speed increases by 11 km/h. During the PM peak period, both 3:00 PM to 4:00 PM and 4:00 PM to 5:00 PM mean speeds increase considerably by 28-31 km/h. Likewise, the 85th percentile speed for both hours increase moderately by 16-19 km/h. From the hour of 5:00 PM to 6:00 PM, the mean speed increases dramatically by 33 km/h and 85th percentile speed increases by 22 km/h.

This segment of the Highway, along with segment NBD3, shows some of the greatest and most consistent increases in mean and 85th percentile speeds. These percent differences can be directly attributed to the improvements of the Mount Seymour Parkway Interchange and the collector-distributor roadway as part of the Lynn Creek Connectivity Improvement. By having the off ramp for the Mountain Highway Interchange at the Mount Seymour Parkway Interchange, additional capacity on the main lanes of the Highway in this segment is available to relieve traffic congestion. Apart from the hour of 6:00 AM to 7:00 AM, the mean speed of peak periods from 2022 is greater than the corresponding 85th percentile speed in 2018. This suggests that the average commuting day in 2022 performs better than the best commuting days in 2018 for this time period.

Table 4-6: Highway 1 Speed Data from Main Street/Dollarton Highway to Mount Seymour Parkway Interchange

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
NBD2	AM Peak	06:00-07:00	82.4	91.1	11%	95.2	102.9	8%
		07:00-08:00	54.5	84.4	55%	80.1	95.8	20%
		08:00-09:00	42.9	80.1	87%	71.1	94.1	32%
	Mid Day	13:00-14:00	64.9	85.7	32%	88.2	99.1	12%
	PM Peak	15:00-16:00	58.8	87.3	49%	84.0	99.5	19%
		16:00-17:00	54.2	84.8	57%	80.3	99.1	23%
		17:00-18:00	50.6	84.3	67%	76.6	99.4	30%

4.2.3 NBD3: Highway 1 from Mount Seymour Parkway Interchange to Mountain Highway Interchange

Table 4-7 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between Mount Seymour Parkway Interchange to Mountain Highway Interchange. During the AM Peak period, from 6:00 AM to 7:00 AM, mean speed increases moderately by 8 km/h with an increase of 6 km/h for 85th percentile speed. From the hours of 7:00 AM to 8:00 AM and 8:00 AM to 9:00 AM, the mean speed increases considerably by 29 and 40 km/h respectively. The 85th percentile speed increases by 14-22 km/h for the same period. During the mid-day hour of 1:00 PM to 2:00 PM, mean speed increases by 21 km/h, and the 85th percentile speed increases by 10 km/h. For the PM peak hour, the mean speed for all three hours increases considerably by 29-36 km/h. The 85th percentile speed also increases moderately by 15-23 km/h.

The speed data from this segment of the Highway shares many similarities with the adjacent upstream, northbound segment. There are consistent and significant increases in mean speed that, in 2022, exceeds the corresponding 2018 85th percentile speed, a part from the hour between 6:00 AM to 7:00 AM and 1:00 PM to 2:00 PM. In the ramp configuration prior to the Project, a short merge taper off of Mount Seymour Parkway onto the Highway created tight weaving conditions within this segment. However, the configuration after the completion of the Project shifts the on ramp further downstream at the Mountain Highway Interchange via the new collector distributor. The new on ramp no longer requires drivers to merge with Highway mainline traffic immediately as there is now an add lane for both the on ramp from Mount Seymour Parkway and from Mountain Highway.

Table 4-7: Highway 1 Speed Data from Mount Seymour Parkway Interchange to Mountain Highway Interchange

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
NBD3	AM Peak	06:00-07:00	82.1	89.9	10%	94.5	101.2	7%
		07:00-08:00	53.8	83.3	55%	79.9	94.1	18%
		08:00-09:00	40.3	79.7	98%	70.7	92.5	31%
	Mid Day	13:00-14:00	63.9	84.9	33%	88.0	97.6	11%
		15:00-16:00	56.8	86.4	52%	83.4	97.9	17%
	PM Peak	16:00-17:00	51.5	83.9	63%	79.2	97.3	23%
		17:00-18:00	47.1	83.3	77%	75.1	97.5	30%

4.2.4 NBD4: Highway 1 from Mountain Highway Interchange to East of Lynn Valley Road Interchange

Table 4-8 summarizes the speed data collected by Downtown.AI for the Highway 1 segment between Mountain Highway Interchange and Lynn Valley Road Interchange. For the AM peak period, from 6:00 AM to 8:00 AM, the mean speed increases by 3-7 km/h, while the 85th percentile speed increases by 3-6 km/h. From 8:00 AM to 9:00 AM, mean speed decreases which is against the trend for segments of the Highway along the northbound direction. Mean speed is observed to decrease by 3 km/h while 85th percentile speed increases by 3 km/h. From 1:00 PM to 2:00 PM, mean speed increases by 4 km/h, while 85th percentile speed increases minimally by 3 km/h. For the PM peak period, there are only minor changes for both mean and 85th percentile speeds. From 3:00 PM to 4:00 PM, mean and 85th percentile speeds increase by about 3 km/h. From 4:00 PM to 6:00 PM, mean speeds for both hours change by less than 1 km/h and 85th percentile speeds increase by about 2 km/h.

It can be generalized that this northbound segment sees minimal to minor improvements to mean speed in all study periods apart from the hour between 8:00 AM to 9:00 AM which is observed to decrease slightly. The operational changes in this segment of the Highway includes the addition of the on ramp onto an extended merge lane from Mountain Highway and an additional lane that starts from the Mount Seymour Parkway on ramp under the Mountain Highway overpass. In 2018, there is also a climbing or truck lane that allows heavy vehicles to make the ascent up "the Cut" without hindering faster traffic behind. The added lanes in the 2022 configuration operate much in the same way to allow slower traffic going up the steep grade to do so in its assigned lane. Both 2018 and 2022 have the same location for where the three lanes northbound merge into two lanes. Similarly to Highway segment SBD1, it is important to note that in portions of 2018, construction speed limits may have been in effect which may have influenced the data collected for this segment of the Highway.

Table 4-8: Highway 1 Speed Data from Mountain Highway Interchange to East of Lynn Valley Road Interchange

		Hour of the Day	Mean Speed (km/h)			85th Percentile Speed (km/h)		
			2018	2022	% Difference	2018	2022	% Difference
NBD4	AM Peak	06:00-07:00	79.6	83.3	5%	95.7	98.6	3%
		07:00-08:00	63.9	71.4	12%	81.3	87.2	7%
		08:00-09:00	61.2	57.5	-6%	79.5	82.6	4%
	Mid Day	13:00-14:00	73.7	77.8	6%	90.6	93.9	4%
		15:00-16:00	76.1	78.6	3%	91.4	94.5	3%
	PM Peak	16:00-17:00	77.2	77.4	0%	91.6	94.2	3%
		17:00-18:00	78.6	78.2	0%	91.6	94.2	3%

5 ORIGIN-DESTINATION PAIR TRAVEL TIME

Median travel times on Highway 1 origin-destination (OD) pairs for peak periods and off-peak periods were compared between the 2018 data to the 2022 data. Median, similarly to average travel speed, is a representation of how long a typical commuter would take to get from the origin point to the destination point. The key difference of median travel time from average travel speed as a descriptor of traffic operations is the influence of outlier events on the reported data. It is unclear whether or not travel time along the study area is similar to a normal or skewed distribution, therefore median travel time can be considered more robust in the sense that it is less likely to be skewed by special occurrences such as: vehicular accidents, extreme weather, or construction.

The formula used for percent difference calculation is as follows:

$$\%\ Difference = \frac{(2022\ TT - 2018\ TT)}{2018\ TT}$$

Where:

$$2018\ TT = Median\ Travel\ Time\ Aggregated\ for\ 2018\ for\ the\ Hour$$

$$2022\ TT = Median\ Travel\ Time\ Aggregated\ for\ 2022\ for\ the\ Hour$$

Similar to the travel speed review, OD pair travel time comparison will be examined with the same peak and off-peak periods of 6:00 AM to 9:00 AM, 1:00 PM to 2:00 PM, and 3:00 PM to 6:00 PM.

In addition to OD travel time comparison from 2018 to 2022, this section will also review the effects of seasonality on travel time along the corridor as well as the measures of travel time reliability across the whole study corridor. Comparison of corridor travel times for both 2018 and 2022 on a month-to-month basis can provide a clearer picture of seasonality trends between the two study years. Corridor travel time reliability is difficult to quantify precisely, but important to explore as this is a significant factor for how commuters plan out their trip. If travel time reliability is low, as in the operational performance of the corridor is highly variable, commuters will require additional buffer time to consistently arrive to their destination on time. Several travel time reliability measures will be utilized to try and determine if this has improved from 2018 to 2022.

5.1 Corridor Analysis

5.1.1 Corridor Seasonality Trends

Typical trends in local tourism may impact local traffic volumes, contributing to the seasonal changes along the study corridor. Peak tourism season in Vancouver has typically been in the summer months of June to August with highest volumes in July and August. The last two weeks of March and December may also be considered peak season as it corresponds to school closures of winter and spring break. Shoulder season, where tourism volumes are at about mid-levels, is late spring in the months of April and May, as well as the fall months of September and October. Off-peak tourist season is typically November to mid-December, and January to mid-March.

Figure 5-1 and **Figure 5-2** compares the corridor travel times as a sum of all four segments in the same direction during the peak direction and peak hour between 2018 and 2022 by month. It is evident that travel times in the southbound direction during the PM peak hour is most affected by seasonal changes. This sensitivity to seasonality aligns with speed data showing that traffic in the northbound direction during peak periods is closer to free-flow speeds in comparison to southbound traffic. The northbound direction during the AM peak hour is less affected by seasonal changes. Notably in 2022, there is minimal seasonal variation to travel times. This observation may be attributed to the improvements of the interchange configurations in the northbound direction being able to handle the increase of seasonal traffic in the summer months as compared to in 2018 where travel times see an increase from season to season.

The southbound corridor median travel time experiences the biggest year-to-year variation in January. This is likely to be due to provincial health protocols restricting gatherings and other in-person events in response to the COVID-19 pandemic. Once many of the more prohibitive restrictions were lifted on Feb. 16th 2022, trends in travel time duration in 2022 have mostly followed what's been observed for 2018. The peak in travel time duration by month is observed to be in the months of July and August. Corridor travel times for all months in the southbound PM direction have improved except for the month of December which has a slight increase in travel time in 2022 compared to 2018. A potential cause of this discrepancy is significant snowfall seen in December 2022, whereas December 2018 had no snowfall. Environment Canada reported snowfall exceeding 10 cm on two separate days in December 2022.

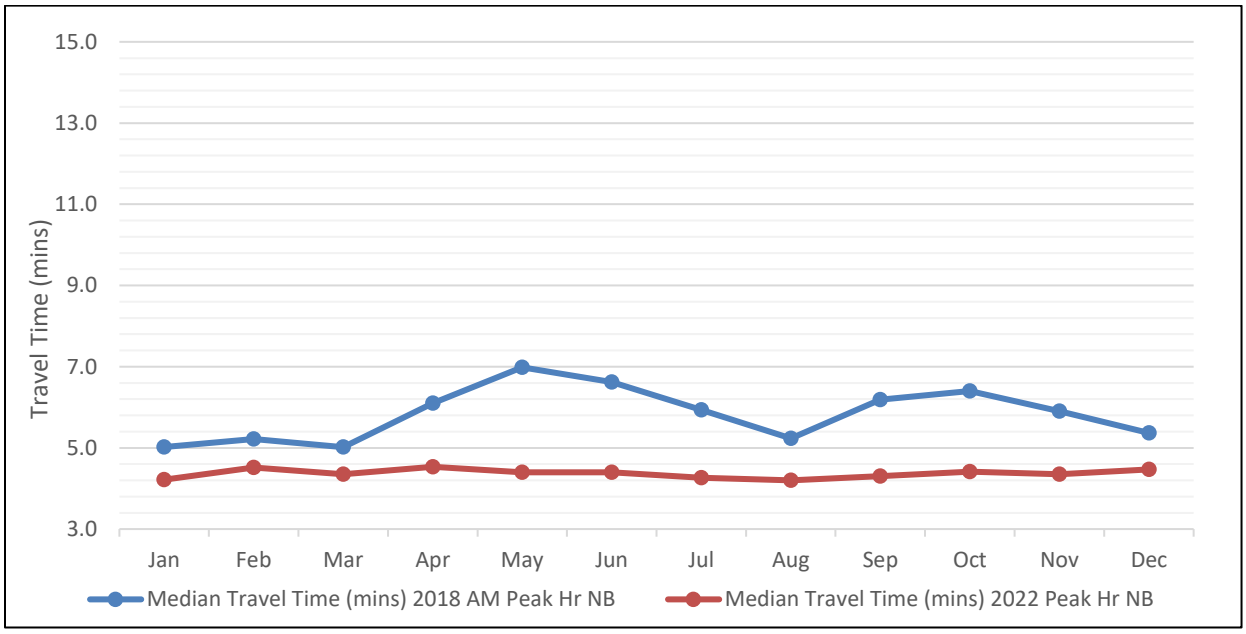

Figure 5-1: 2018 vs 2022 Northbound Corridor Median Travel Time - Weekday AM Peak Hour (08:00 - 09:00)

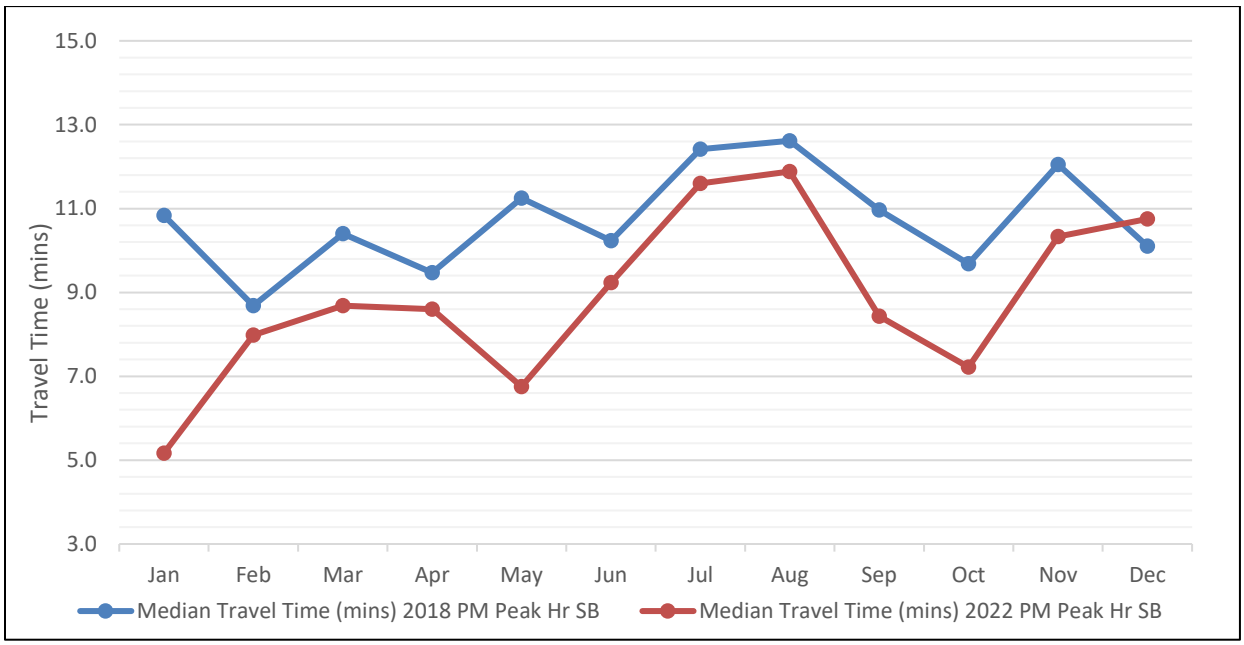

Figure 5-2: 2018 vs 2022 Southbound Corridor Median Travel Time - Weekday PM Peak Hour (16:00 - 17:00)

5.1.2 Corridor Peak Period and Direction Graphs in 15 Minute Intervals

An analysis of corridor travel times were compared for 2018 and 2022 utilizing time intervals of 15 minutes. The peak periods and peak directions were chosen to be 7:00 AM to 10:00 AM in the northbound direction and 3:00 PM to 6:00 PM in the southbound direction. The month of September was chosen as it was considered a typical commuting month with enough time elapsed since the COVID-19 provincial restrictions to see traffic volumes mostly recovered to pre-pandemic levels. **Figure 5-3** and **Figure 5-4** compares the 2018 and 2022 corridor travel times for each 15 minute bin.

The northbound direction, in 2022, during the AM peak period is consistent with all other analyses done, with near free-flow conditions after the Project was completed. There are very minor increases in corridor travel times from 7:00 AM to 8:45 AM, but the range in travel times is only about 0.5 minutes during this period. This is a significant improvement from 2018 which is observed to have a pronounced peak in travel times with a plateau from 7:45 AM to 8:45 AM.

The PM peak southbound direction in 2022 is observed to have a greater spike in corridor travel times in comparison with the northbound direction during the AM peak. Several observations show improvements in travel time peak durations and magnitudes in 2022. The worst PM southbound travel time in 2018 occurs during the time period of 3:30 PM to 3:45 PM which has a corridor travel time of 12 minutes. The worst PM southbound travel time in 2022 occurs during the time period of 3:45 PM to 4:00 PM which has a corridor travel time of 10.2 minutes which is an improvement of 15%. The recovery of travel times in 2022 is observed to occur faster in comparison with 2018. By 4:30 PM, traffic in 2022 experiences steeper drops in corridor travel times while 2018 is observed to have minor fluctuations until 6:00 PM.

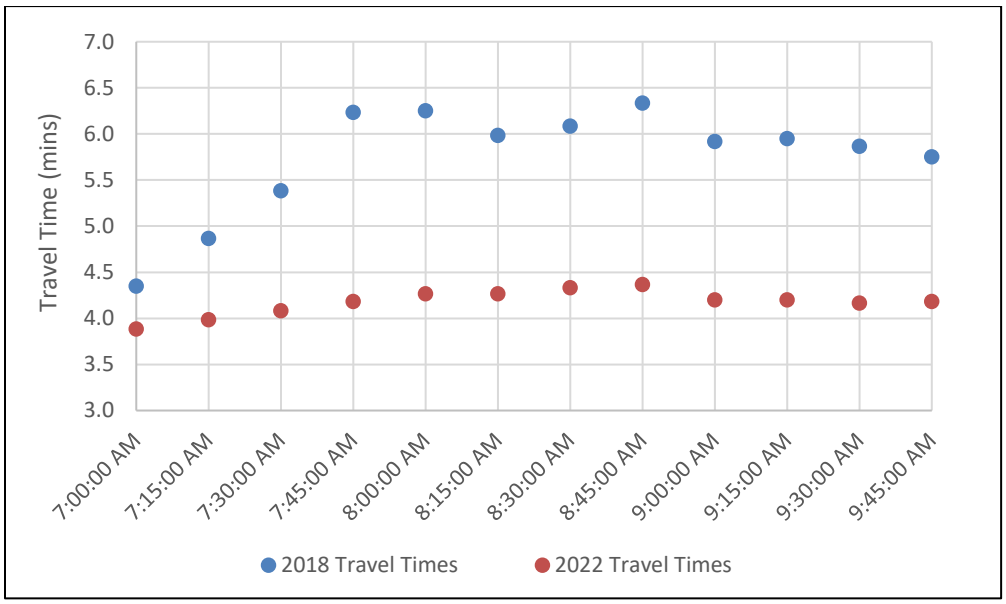

Figure 5-3: Weekday AM Peak Median Travel Times in the Northbound Direction for September

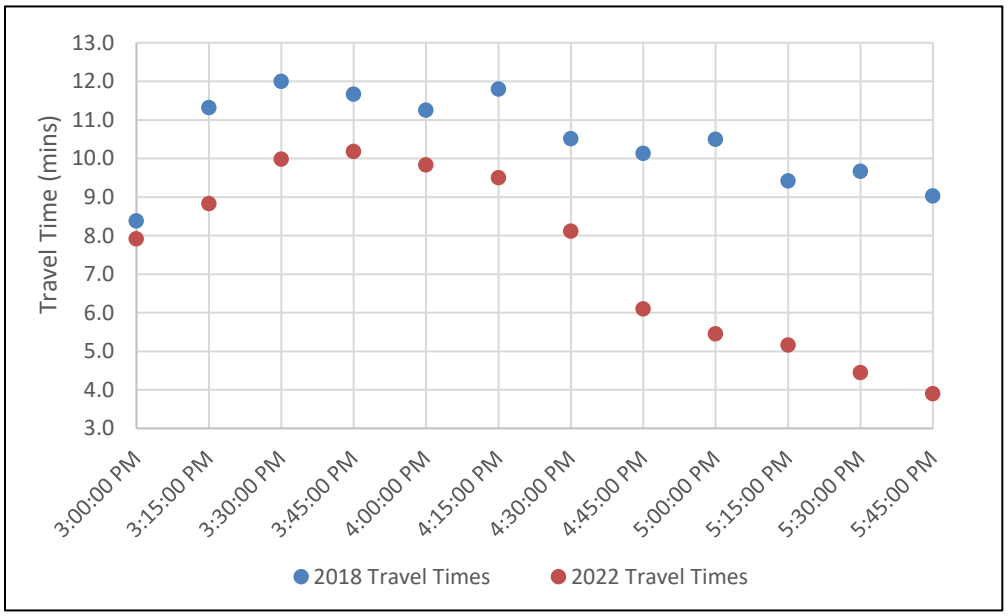

Figure 5-4: Weekday PM Peak Median Travel Times in the Southbound Direction for September

5.2 Travel Time Comparison - Southbound Direction

5.2.1 SBD1: Highway 1 from East of Lynn Valley Road Interchange to Mountain Highway Interchange

Table 5-1 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the Lynn Valley Road Interchange to the Mountain Highway Interchange. During the AM peak, median travel time has decreased significantly and is observed to decrease by 25% during the time period of 8:00 AM to 9:00 AM. During the off-peak hour of 1:00 PM to 2:00 PM, median travel time shows a minor decrease of 7% in 2022. During the PM peak, median travel times are observed to

decrease moderately at about 2% from 3:00 PM to 4:00 PM and then decrease substantially at 18% and 43% respectively from 4:00 PM to 6:00 PM.

Table 5-1: 2018 and 2022 Travel Time Comparison for SBD1 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
SBD1	AM Peak	06:00-07:00	1.12	1.10	-1%
		07:00-08:00	1.37	1.20	-12%
		08:00-09:00	1.70	1.28	-25%
	Mid Day	13:00-14:00	1.43	1.33	-7%
	PM Peak	15:00-16:00	4.35	4.28	-2%
		16:00-17:00	4.63	3.78	-18%
		17:00-18:00	2.80	1.58	-43%

5.2.2 SBD2: Highway 1 from Mountain Highway Interchange to Mount Seymour Parkway Interchange

Table 5-2 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the Mountain Highway Interchange to the Mount Seymour Parkway Interchange. During the AM peak period, from 6:00 AM to 7:00 AM, median travel times have remained relatively consistent. Significant travel time improvements of 17% and 49% per hour are observed from 7:00 AM to 9:00 AM. During the mid-day period, median travel time has stayed relatively consistent. PM peak period travel times have generally stayed consistent or increased moderately apart from the hour between 5:00 PM to 6:00 PM, where there is a 26% decrease observed in median travel time.

Table 5-2: 2018 and 2022 Travel Time Comparison for SBD2 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
SBD2	AM Peak	06:00-07:00	0.63	0.60	-5%
		07:00-08:00	0.80	0.67	-17%
		08:00-09:00	1.38	0.70	-49%
	Mid Day	13:00-14:00	0.75	0.72	-4%
	PM Peak	15:00-16:00	2.60	2.83	9%
		16:00-17:00	2.62	2.62	0%
		17:00-18:00	2.02	1.50	-26%

5.2.3 SBD3: Highway 1 from Mount Seymour Parkway Interchange to Main Street / Dollarton Highway Interchange

Table 5-3 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the Mount Seymour Parkway Interchange to the Main Street/Dollarton Highway Interchange. During the AM peak period, from 6:00 AM to 7:00 AM, there was only a minor difference in

median travel time. The second and third hour of the AM peak period has seen meaningful decreases in median travel time of 38% and 52% respectively. The mid-day hour of 1:00 PM to 2:00 PM has shown a moderate increase in median travel time of 11 %. During the three PM peak period hours, it is observed that median travel time decreases considerably, by over 30%.

Table 5-3: 2018 and 2022 Travel Time Comparison for SBD3 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
SBD3	AM Peak	06:00-07:00	0.50	0.53	7%
		07:00-08:00	0.97	0.60	-38%
		08:00-09:00	1.37	0.65	-52%
	Mid Day	13:00-14:00	0.58	0.65	11%
	PM Peak	15:00-16:00	1.77	1.12	-37%
		16:00-17:00	1.68	1.07	-37%
		17:00-18:00	1.45	0.93	-36%

5.2.4 SBD4: Highway 1 from Main Street / Dollarton Highway Interchange to South end of IWMB

Table 5-4 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the Main Street/Dollarton Highway interchange to the south end of the IWMB. During the AM peak period, from 6:00 AM to 7:00 AM, there is no change in median travel times. From 7:00 AM to 9:00 AM, there is a consistent moderate decrease of 14-15% in median travel time. During the mid-day hour of 1:00 PM to 2:00 PM, there is a minor increase of 5% in median travel time. During the PM peak period, there is a consistent minor decrease of travel times of two to four percent.

Table 5-4: 2018 and 2022 Travel Time Comparison for SBD4 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
SBD4	AM Peak	06:00-07:00	1.00	1.00	0%
		07:00-08:00	1.40	1.18	-15%
		08:00-09:00	1.50	1.28	-14%
	Mid Day	13:00-14:00	1.30	1.37	5%
	PM Peak	15:00-16:00	1.67	1.63	-2%
		16:00-17:00	1.65	1.60	-3%
		17:00-18:00	1.58	1.52	-4%

5.3 Travel Time Comparison - Northbound Direction

5.3.1 NBD1: Highway 1 from South end of the IWMB to Main Street/Dollarton Highway Interchange

Table 5-5 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the south end of the IWMB to the Main Street/Dollarton Highway Interchange.

During the AM peak period, median travel times have improved with the most significant decrease in the hour between 8:00 AM to 9:00 AM. This hour also sees the worst travel times but has improved by 21%. During the mid-day study hour, median travel times have stayed the same. During the PM peak period, travel times have also improved with the largest difference being observed for the hour of 5:00 PM to 6:00 PM where there is a 19% improvement.

Table 5-5: 2018 and 2022 Travel Time Comparison for NBD1 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
NBD1	AM Peak	06:00-07:00	1.22	1.18	-3%
		07:00-08:00	1.48	1.35	-9%
		08:00-09:00	1.77	1.40	-21%
	Mid Day	13:00-14:00	1.20	1.20	0%
	PM Peak	15:00-16:00	1.28	1.23	-4%
		16:00-17:00	1.43	1.28	-10%
		17:00-18:00	1.63	1.32	-19%

5.3.2 NBD2: Highway 1 from Main Street/Dollarton Highway Interchange to Mount Seymour Parkway Interchange

Table 5-6 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the Main Street/Dollarton Highway Interchange and Mount Seymour Parkway Interchange. This segment of the Highway shows improvement in all study hours for median travel times. The largest observed differences were from 7:00 AM to 9:00 AM, and 4:00 PM to 6:00 PM. These periods had the longest travel times in 2018, but in 2022, median travel times have started to stay at a steady state for all study periods.

Table 5-6: 2018 and 2022 Travel Time Comparison for NBD2 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
NBD2	AM Peak	06:00-07:00	0.70	0.63	-10%
		07:00-08:00	0.90	0.68	-24%
	Mid Day	08:00-09:00	1.23	0.70	-43%
		13:00-14:00	0.78	0.67	-15%
	PM Peak	15:00-16:00	0.85	0.65	-24%
		16:00-17:00	0.97	0.65	-33%
		17:00-18:00	1.10	0.65	-41%

5.3.3 NBD3: Highway 1 from Mount Seymour Parkway Interchange to Mountain Highway Interchange

Table 5-7 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the Mount Seymour Parkway Interchange and the Mountain Highway Interchange. Analogous to OD pair NBD2, this Highway segment is also observed to have improvements to median travel time across all study periods. The study hour with the most significant improvement is the hour from 8:00 AM to 9:00 AM. This hour was observed to have the longest median travel time in 2018 for this segment. In 2022, all study periods are presumably operating at free-flow conditions.

Table 5-7: 2018 and 2022 Travel Time Comparison for NBD3 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
NBD3	AM Peak	06:00-07:00	0.72	0.63	-12%
		07:00-08:00	0.90	0.68	-24%
	Mid Day	08:00-09:00	1.33	0.70	-48%
		13:00-14:00	0.80	0.67	-17%
	PM Peak	15:00-16:00	0.87	0.67	-23%
		16:00-17:00	1.02	0.67	-34%
		17:00-18:00	1.18	0.67	-44%

5.3.4 NBD4: Highway 1 from Mountain Highway Interchange to East of Lynn Valley Road Interchange

Table 5-8 summarizes the median travel time data collected by Downtown.AI for the Highway 1 segment between the Mountain Highway Interchange and East of Lynn Valley Road Interchange. This Highway segment also sees improvements in median travel times for all study hours. Most of the decrease in median travel time is marginal, with the largest decrease observed from 7:00 AM to 8:00 AM.

Table 5-8: 2018 and 2022 Travel Time Comparison for NBD4 OD Pair

		Hour of the Day	Median Travel Time (mins)		
			2018	2022	% Difference
NBD4	AM Peak	06:00-07:00	1.27	1.23	-3%
		07:00-08:00	1.55	1.42	-9%
		08:00-09:00	1.58	1.57	-1%
	Mid Day	13:00-14:00	1.35	1.30	-4%
	PM Peak	15:00-16:00	1.32	1.30	-1%
		16:00-17:00	1.32	1.30	-1%
		17:00-18:00	1.32	1.30	-1%

6 GREENHOUSE GAS EMISSIONS ESTIMATE

The transportation sector has been identified as a generator of Greenhouse gases (GHG), which have been linked to climate change. The burning of fossil fuels for internal combustion engines that still power a significant portion of vehicles on BC highways is a major source of carbon dioxide being released into the atmosphere. The City of Vancouver's 2011 Emissions Inventory shows that approximately 34% of Vancouver's community based GHG emissions come from transportation. Since GHG emissions is known to be a function of speed, reducing congestion along the Lower Lynn Interchanges of Highway 1 may reduce the total output of GHGs from this corridor.

Japan's Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) has developed a graph (**Figure 6-1**) comparing speed with its associated emission factor. Similar to fuel consumption, the graph shows that vehicles travelling at higher speeds will generally reduce their GHG emissions. More specifically, vehicles travelling at a speed within the range of about 60-80 km/h achieve an optimal point of producing the least amount of GHG emissions per kilometre travelled. Therefore, based on this relationship, a high-level estimate of total GHG emissions can be determined with the associated improvements in operating speed.

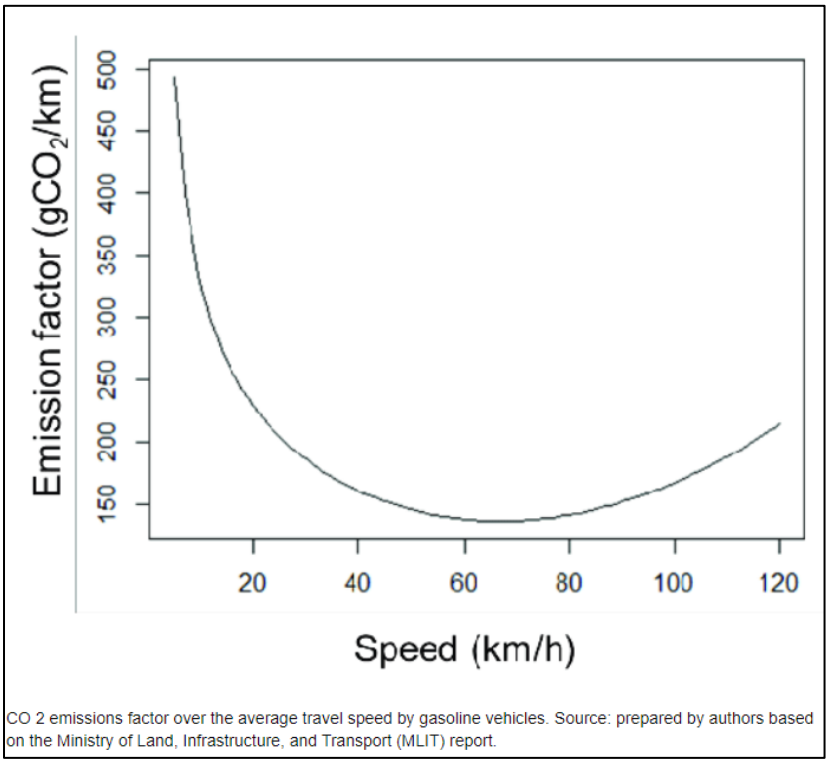

Figure 6-1: Emissions vs. Speed Curve (Japan's Ministry of Land, Infrastructure, Transport, and Tourism, 2020)

This estimate of total GHG emissions reduced assumes that all vehicles analyzed are travelling at the mean operating speed along the whole corridor. The weighted, mean corridor operating speeds for the peak direction in the AM and PM peak hour was determined by averaging the segment mean speeds

and weighing them by segment length. **Table 6-1** shows the AM and PM peak hour corridor operating speeds of 2018 and 2022 by peak direction.

Table 6-1: Corridor Speeds – AM & PM Peak Hours by Peak Direction

Weighted Mean Corridor Speed (km/h)			
	2018	2022	Net
Northbound	45.3	69.1	23.8
Southbound	34.0	37.5	3.5

Using the mean corridor operating speeds, during the peak hour and peak direction, the emissions factor can be determined using MLIT's graph to approximate carbon dioxide emissions by vehicle per kilometre travelled. This analysis assumes that all vehicles along the corridor have the same emissions output. It does not account for the percentage of electric or heavy vehicles which may produce more or less carbon dioxide than indicated by the graph. Multiplying the northbound and southbound emissions factor by the respective corridor lengths results in an approximate change of emissions on a per car basis. **Table 6-2** shows the average emissions per car (gCO_2) from 2018 to 2022, during the peak hour for each direction, for the northbound and southbound directions of the Highway 1 mainline within the Project corridor. From a high-level, the AM peak hour and direction sees approximately 10% in reduced emissions on a per car basis. The PM peak hour and direction sees approximately 5% in reduced emissions on a per car basis.

Table 6-2: Corridor Emissions On a Per Car Basis (By Peak Hour and Peak Direction)

	Emission Factor From Graph: (gCO2/km)			Corridor Length (km)	Emissions per Car (gCO2)		
	2018	2022	Net		2018	2022	Net
Northbound (8-9AM)	153	136	17	5.2	802	713	89
Southbound (5-6 PM)	175	166	9	4.8	840	797	47

The per car rates of emissions are extrapolated using the volumes collected at the south end of the IWMB through the MOTI permanent counter (**Section 3.2**) and then by the number of working days per year. **Table** 6-3 shows the peak hour volumes by direction, and the emissions per year in metric tonnes ($mtCO_2$) using the assumption of 248 working days per year. For additional detailed emissions modelling, microsimulation models may be developed to provide more comprehensive estimates for changes in emissions. On a per year basis, the northbound direction during the AM peak hour is approximated to have a net decrease of 180 $mtCO_2$ while the southbound direction during the PM peak hour is approximated to have a net decrease of 146 $mtCO_2$.

Table 6-3: Corridor Emissions per Year (By Peak Hour and Peak Direction)

	Volumes (P-15-2EW)		Emissions per Year in Tonnes (mtCO2)		
	2018	2022	2018	2022	Net
Northbound (8-9AM)	4,722	4,292	939	759	-180.4
Southbound (5-6 PM)	4,882	4,410	1,017	871	-145.6

7 BENEFIT COST ANALYSIS

A limited benefit cost analysis was conducted to assess the benefits provided by the project to commuters, in dollars. An estimate was done by quantifying the time savings and the reduction in collisions for the Lower Lynn Interchange corridor after the completion of the Project. As a limited benefit cost analysis, the following social benefits are not within the scope of analysis and not accounted for: transit reliability, active transportation improvements, travel time improvements on the surrounding network, and highway accessibility changes.

7.1 Time Savings

To determine justifiable estimates for the benefit cost analysis, MOTI's "Default Values for Benefit Cost Analysis in British Colombia" (2018) was used. From the reference, it was determined that distance-based costs are not applicable for this specific analysis since the Highway 1 mainline remains the same length after the Project. However, time-based costs are applicable and can be broken down between automobiles and trucks. The value of time for non-commercial vehicle occupants is assumed to be 50% of the hourly wage rate as estimated using Greater Vancouver's median household income. The value of time for truck drivers are calculated by using the average wage for truck drivers with a 25% added buffer to account for benefits and other payroll related expenses. Other truck time related costs account for depreciation, permits and licenses, cargo, and administration costs.

Using the parameters above, a rough calculation of the benefit cost of the Project to peak period commuters can be estimated. The costs of various types of collisions were omitted from this cost benefit analysis as there is insufficient collision data for conditions after the Project to calculate a representative average rate. **Table 7-1**, below, summarizes the values used and the associated assumptions applied for this analysis.

Table 7-1: Automobile and Truck Costs by the Hour

Vehicle Type	Value of Time ($/hour)	
Automobile	*50% of GV Household Annual Income* [1]	$ 24.09
Trucks	*125% of Average Truck Driver's Wage* [2]	$ 33.75
	Other Time Related Costs (2018)	$ 14.65
	Other Time Related Costs (2022) [3]	$ 16.66
Composite [4]	**95% Automobile, 5% Truck Traffic**	**$ 25.41**

[1] *Median total income data for all households in Greater Vancouver is from 2021 Canadian Census ($90,000), and then divided by 2080 full time hours per year, adjusted for inflation to convert to 2022 dollars.*

[2] *BC median truck driver wage ($27.00/hour) referenced from Labour Force Survey (2022) where wages and salaries are a part of the data collected.*

[3] *Time related costs were originally pulled from MOTI's "Benefit Cost Default Values" from 2018. This was converted to 2022 dollars using CPI data.*

[4]Composite of volumes from permanent loop counter was assumed to consist of 95% automobile traffic, and 5% commercial truck traffic.

Median corridor travel times are presented in **Appendix D**. Using volume data from MOTI's permanent traffic counter located on the south end of the IWMB, total travel time savings for all traffic can be estimated. **Table 7-2** and **Table 7-3**, summarizes the southbound and northbound travel time savings, in hours, during the AM and PM peak periods on weekdays.

Table 7-2: Corridor Travel Time Savings in Hours - Southbound Direction

Southbound Direction	Hour of the Day (Weekdays)		Median Travel Time (Minutes)		Travel Time Difference (Hours)	Median Volumes*	Total Travel Time Saved (Hours)
			2018	2022		2022	
	AM Peak	06:00-07:00	3.25	3.23	0.0003	2776	0.8
		07:00-08:00	4.53	3.65	0.0147	4110	60.5
		08:00-09:00	5.95	3.92	0.0339	4277	144.9
	PM Peak	15:00-16:00	10.38	9.87	0.0086	4721	40.6
		16:00-17:00	10.58	9.07	0.0253	4712	119.1
		17:00-18:00	7.85	5.53	0.0386	4530	174.9

Table 7-3: Corridor Travel Time Savings in Hours - Northbound Direction

Northbound Direction	Hour of the Day (Weekdays)		Median Travel Time (Minutes)		Travel Time Difference (Hours)	Median Volumes*	Total Travel Time Saved (Hours)
			2018	2022		2022	
	AM Peak	06:00-07:00	3.90	3.68	0.0036	3975	14.4
		07:00-08:00	4.83	4.13	0.0117	4567	53.3
		08:00-09:00	5.92	4.37	0.0258	4414	114.0
	PM Peak	15:00-16:00	4.32	3.85	0.0078	4331	33.7
		16:00-17:00	4.73	3.90	0.0139	4667	64.8
		17:00-18:00	5.23	3.93	0.0217	4529	98.1

Total time savings for all traffic can be converted to 2022 dollars. **Table 7-4** summarizes the travel time savings in 2022 dollars during the peak periods on a daily basis. In the southbound and northbound direction, the estimated daily average savings for AM and PM peak periods is $14,000 and $10,000 respectively.

Table 7-4: Travel Time Saved Converted to 2022 Dollar Values

	Hour of the Day	Southbound Direction				Northbound Direction			
		Travel Time Saved (Hours)	Travel Time Saved ($2022)	By Peak Period	Daily Average	Travel Time Saved (Hours)	Travel Time Saved ($2022)	By Peak Period	Daily Average
AM Peak	06:00-07:00	0.8	$ 19.59	$ 5,238.85	$ 14,000	14.4	$ 364.68	$ 4,614.88	$ 10,000
AM Peak	07:00-08:00	60.5	$ 1,537.28			53.3	$ 1,353.53		
AM Peak	08:00-09:00	144.9	$ 3,681.99			114.0	$ 2,896.68		
PM Peak	15:00-16:00	40.6	$ 1,032.72	$ 8,502.20		33.7	$ 855.82	$ 4,995.21	
PM Peak	16:00-17:00	119.1	$ 3,025.76			64.8	$ 1,646.63		
PM Peak	17:00-18:00	174.9	$ 4,443.72			98.1	$ 2,492.77		

The daily average travel time savings, in both directions, are then multiplied by the number of working weekdays in a year to determine the annual travel time saved. The estimated, annual travel time savings in 2022 dollars, during the AM and PM peak periods is **$5,950,000.** This estimate does not account for time savings during off-peak periods, weekends, or holidays. This corridor has historically experienced heavy congestion, even during off-peak periods and weekends. These time savings, due to the Project increasing the capacity of the corridor, during off-peak periods and weekends does not translate to a social benefit that can be quantified by wages and commercial costs. However, these time savings will still provide value to travelers of the corridor and the region with the improved transportation of goods. **Table 7-5** summarizes the annual travel time savings in 2022 dollars.

Table 7-5: Annual Travel Time Saved in 2022 Dollars

Highway 1 - Lower Lynn Interchanges Corridor	Daily Travel Time Saved ($2022) during AM & PM Peak	Annual Travel Time Saved during AM & PM Peak[5]	Annual Travel Time Saved during AM & PM Peak[5]
Southbound Direction	$ 14,000.00	$ 3,472,000.00	$ 5,950,000.00
Northbound Direction	$ 10,000.00	$ 2,480,000.00	

[5]*Annual savings calculated under the assumption of 248 workdays in a year.*

7.2 Reduction in Rate of Collisions

As reported in Binnie's accompanying memorandum to this study, titled "Highway 1 Before and After Study – Safety Review", collision data for the northbound and southbound segments were provided by MOTI from 2017 to October 2022. Typically, multiple years of collision data are required for before and after safety studies. Therefore, this benefit cost analysis simply compares the two years where data is available, and may not be representative of the long-term collision rates and collision reduction benefits of the Project corridor.

In order to compare a similar timeframe before and after the Project, the January to October time period was compared in 2018 and 2022 as November and December 2022 data were not available at the time

of writing this report. Collision types were then broken down into property damage only (PDO), injury collisions, and fatal collisions. These totals are presented in **Table 7-6**. **Table 7-7** shows the reported collision rates for 2018 and 2022 from January to October. Additional details on collision rates can be found in **Section 4** of the accompanying safety review memorandum.

Table 7-6: Reported Collisions for 2018 and 2022 – January to October

Year (Jan-Oct)	Northbound				Southbound			
	Property Only	Injury Collisions	Fatal Collisions	Total Collisions	Property Only	Injury Collisions	Fatal Collisions	Total Collisions
2018	10	12	0	22	19	11	0	30
2022	4	2	0	6	9	5	0	14

Table 7-7: Reported Collision Rates for 2018 and 2022 – January to October

Year (Jan-Oct)	Northbound				Southbound			
	Property Only	Injury Collisions	Fatal Collisions	Total Collisions	Property Only	Injury Collisions	Fatal Collisions	Total Collisions
2018	11	14	0	25	21	12	0	34
2022	5	2	0	7	10	6	0	16
Units: Collisions per 100 million vehicle - kilometres of travel (VKT)								

MOTI's "Default Values for Benefit Cost Analysis in British Colombia" (2018) lists 2018 collision cost estimates for fatal, injury, and property damage only collisions. **Table 7-8** shows the collision types and their associated costs, from the reference document, in 2022 dollars.

Table 7-8: Collision Costs (2022 Dollars) by Type

Collision Type	2022 Cost[6]
Fatal	$9,236,396
Injury	$345,641
PDO	$15,439

[6] *2022 Costs Converted from 2018 Costs using Canadian CPI data.*

These costs are then applied to the previously calculated collision rates to determine the rate of costs due to collisions per 100 million vehicle – kilometres of travel (VKT). As shown in **Table 7-9**, the total aggregated costs due to collisions in 2022 are lower on a VKT basis. This reduction in costs may be a benefit as a result of the Project, however, additional years of collision data would be required for further confirmation.

Table 7-9: Average Collision Costs per VKT in 2022 Dollars

Year (Jan-Oct)	Fatal Collision Costs	Injury Collsion Costs	Property Damage Only Costs	Total Costs (2022 Dollars)
2018	$0	$8,987,000	$494,000	$9,481,000
2022	$0	$2,765,000	$232,000	$2,997,000
Units: Collision Costs per 100 million vehicle - kilometres of travel (VKT)				

8 REPORT SUMMARY

As a historically vital corridor for connecting people, services, and goods across the Burrard Inlet, one of the major goals of the Lower Lynn Improvements Project was to reduce congestion and improve travel times along Highway 1 and the Lower Lynn Interchanges. Another major goal of the Project was to address safety issues, such as merging and weaving from closely spaced interchanges, by reducing the frequency and severity of incidents. Through this before and after study, travel times and operating speeds were reviewed for Highway 1 along the Project corridor, between Lynn Valley Road and the South end of the Ironworkers Memorial Bridge.

8.1 Ironworkers Memorial Bridge Traffic Volumes

Travel times and operating speeds are heavily dependent on traffic volumes. By framing the changes in operational performance of the study corridor within the context of annual traffic volumes, more insight on the effects of interchange configuration changes may be extracted from the data. This is especially true for traffic volume changes between the study years of 2022 and 2018. Generally, there has been a decrease in traffic volumes during both the AM and PM peak hours from 2018 to 2022. However, during the adjacent hours to the peak hour, there has been both increases and decreases in traffic volumes indicating that commuting patterns may have changed from 2018 to 2022 (**Table 3-1**).

8.2 Speed Review of Highway 1 Segments

Operating speeds were found to improve throughout the corridor northbound during peak and off-peak periods. There were also considerable improvements observed in the southbound direction for select segments during select time periods.

Northbound, the improvements in operating speeds are most evident in the segment between the Main Street/Dollarton Highway Interchange and the Mountain Highway Interchange. This segment also corresponds with the largest configuration changes with the Lynn Creek Connectivity Improvements. Southbound operating speeds were observed to improve significantly during the AM peak period of 7:00 AM to 9:00 AM, however did not see great improvement during the PM peak period.

8.3 Travel Time Comparison

Similarly, travel times were found to improve significantly northbound, while moderately or not at all southbound. The southbound direction in the Highway segments from Lynn Valley Road to Main Street/Dollarton Highway was observed to have considerable median travel time improvements during the AM peak period (off-peak direction). The northbound direction in the Highway segments between the south end of the IWMB to the Mountain Highway interchange was observed to have considerable median travel time improvements during the AM and PM peak periods.

8.4 Travel Time Seasonality Trends

With travel time data aggregated monthly, seasonal patterns in the Highway's operational performance were compared from 2018 to 2022. Northbound AM peak periods in 2022 show minor seasonal variations when compared to 2018, suggesting that this direction may be operating at higher speeds

and lower delays, aligning with the speed and travel time reviews. Southbound PM peak periods in 2022 generally follows the seasonal trends observed in 2018, however corridor travel times have decreased for most months (**Figure 5-1** & **Figure 5-2**).

8.5 Peak Period Shoulder Analysis

The 15-minute interval analysis for corridor travel times revealed how delays appear to subside faster in 2022 in comparison to 2018. The 2022 northbound AM peak direction was observed to have a lower increase in corridor travel times when compared to 2018 (**Figure 5-3**). While the 2022 southbound direction was observed during the PM Peak period to have an increase in corridor travel times, this increase was not as pronounced when compared with the same period in 2018. The total duration of the travel time increases in 2022 were also reduced when compared to 2018 (**Figure 5-4**).

8.6 GHG Emissions Estimate

To analyze the approximate magnitude of GHG emissions before and after the Project, AM and PM peak hours and peak directions were compared from 2018 to 2022. From a high level, due to the overall improvement of operating speeds, there is a 5-10% reduction in overall GHG emissions for both AM and PM peak hours on a per-vehicle basis. On a per year basis, the northbound direction during the AM peak hour is approximated to have a net decrease of 180 $mtCO_2$ while the southbound direction during the PM peak hour is approximated to have a net decrease of 146 $mtCO_2$. This approximation does not account for induced demand effects or vehicle fleet composition changes. Microsimulation modelling will be required to provide a more detailed and accurate estimate of actual GHG emissions reductions.

8.7 Cost Benefit Analysis

With the purpose of quantifying the time savings during peak period commuting, and the reduction in collision costs as a result of the Project, a cost benefit analysis was undertaken. From a high level, it is estimated that the corridor will benefit by $24,000 per weekday during the AM and PM peak periods, and $5,950,000 annually based on travel time savings. Collision data from 2018 and 2022 shows a reduction from $9,481,000 per VKT in 2018 to $2,997,000 per VKT in 2022. Additional collision data for after the completion of the Project will be required to provide a more definitive conclusion.

8.8 Overall Performance

Overall performance of the Project corridor related to speed and travel time has improved as a cause of the Project, with improvements in traffic flow during peak times, and reduced travel times for commuters.

APPENDIX A

PROJECT METHODOLOGY FROM DOWNTOWN.AI

Downtown.AI

Methodology for the Lower Lynn Improvements Traffic Review

Comparison of trip times prior to and after the upgrades to Highway 1 between Ironworkers Bridge and Lynn Valley Road, 2018-2022

1. Study Goals

To enable the analysis of the effects of the Lower Lynn Improvements project on traffic performance in the area, Downtown.AI was engaged to conduct a survey of our mobility datasets to allow comparison of trip times and speeds between two time periods:

1. Before construction began
2. After completion of construction; new overpasses, on-ramps, lane improvements and routing, etc.

Trip times were analyzed on an hourly aggregation for one full year before and after, with a more detailed 15 minute timeframe included for peak periods AM/PM.

2. Criteria

As we were able to obtain samples for an entire year before and after construction, considerations around seasonality and weather events were largely ameliorated; in addition, since road safety/incident reduction was a significant goal of the project it was thought best to obtain a sample from the entire study period(s) without excluding days where traffic was impacted by road incidents. This way the incident reduction benefit is captured in the KPI improvements from the post-construction period.

We also ensured that the study period did not include active construction on either end, and separated the aggregations into weekday and weekend/statutory holiday groups – the latter are particularly important in order to capture ferry related traffic. To allow readers to account for changes in baseline traffic volumes, counts at the TRADAS station on the south end of the Ironworkers Bridge were obtained for the before/after periods.

3. Methodology

Bearing the above criteria in mind, two yearlong timeframes were selected; one prior to construction, and one after:

1. January 1 2018 – December 31 2018 (Pre-construction)
2. January 1 2022 – December 31 2022 (Post-Construction)

Weekends and statutory holidays were aggregated separately in the "Weekend" group; this allows for analysis of to what extent weekday/weekend traffic patterns differ, including seasonal variation.

With regard to traffic volumes, our calibration with Ministry sensor data (Second Narrows P-15-2EW) indicates that general traffic on Highway 1 in this area has undergone some interesting changes, whether related to the post-COVID increase in work-from-home resulting in a reduction in commute behaviour or changes to public transit uptake.

	Mean daily weekday traffic	Mean daily weekend traffic
2018	130155	107753
2022	124134	109969

So while weekday mean counts appear to have declined by 5%, weekend traffic has increased by 2% -- the latter result seems more in line with Lower Mainland population trends, so although the extent to which this is related to a structural shift in commute patterns is an open question, it should be taken into account during analysis.

Note that this pattern holds to an even greater extent if we look only at peak traffic; taking 7-8AM and 4-5PM as the morning/afternoon peaks, we get the following:

	Mean weekday peak traffic (2h)	Mean weekend peak traffic (2h)
2018	18922	11815
2022	17352	12718

This is an 8% drop in weekday peak vehicles, accompanied by an 8% *increase* for the weekend periods.

4. Trip Routing, Sample Size, and Accuracy

- Since many of the goals of the project related to improved local traffic patterns and connectivity with the municipal road network by improving interchange layout/accessibility, it was neither possible nor desirable to hold exact routes the same for the before/after comparison. Particularly around the Mountain Highway interchange, the normal path for a number of the O-D pairs was significantly altered. Therefore the benefit of the upgrades on such routes is likely to be reflected in reduced travel times, even if average speeds are somewhat less.

- Before/after route lengths are as follows:

Route	Before	After
NB/SB1	1.8 km	1.8 km
NB/SB2	1.0 km	1.0 km
NB/SB3	0.7 km	0.7 km
NB/SB4	1.3 km	1.3 km
MHMSP1E	2.4 km	2.1 km
MHMSP2E	1.4 km	1.4 km
MHMSP3W	3.8 km	1.4 km
MHMSP4	2.8 km	0.9 km
MSDH1	1.0 km	1.0 km
MSDH2	1.5 km	1.2 km
MHMSP1W	2.0 km	2.0 km
MHMSP2W	1.6 km	1.6 km
MHMSP3E	0.8 km	0.8 km

- It makes sense to compare trip times for these routes even though they differ before and after, because one of the goals of the construction was to open up shorter route for local traffic.

- In general, our data is obtained as a sample of users of mobility apps and in-car navigation; reported average speeds and trip times are estimated to represent actual conditions with a margin of error no larger than ±3%.

- However, as we are working with a sample of total traffic, on route aggregations where total traffic is relatively low some statistical metrics can become problematic – for example, if we have a sample of 50 vehicles, while the median travel time/speed is still an accurate representation of motorist behaviour, the 95th percentile represents only 2-3 individuals, and therefore will be likely to reflect significant individual variation in the form of noisy results.

- It was noted that 85th percentile trip time values in these cases had much less noise between sample periods, while still accurately reflecting the "worst case scenario" for a given period; so while the 95th percentile aggregations should be approached with caution, the 85th percentile results will have statistical errors less than ±5% in all cases.

- This effect is particularly pronounced as the time aggregation gets smaller – in cases where the sample size was less than 50 motorists observed, the 95th percentile data was held out for this reason. Due to improved device penetration this was less of a problem with the 2022 data, but for the 15 minute aggregation, periods around the shoulders of the peaks (7-7:30 AM, 3-3:30PM), on weekends, or covering lower traffic routes should be considered less reliable. It's difficult to compute an exact error margin for this as it's determined by individual behaviour; something like two standard deviations of the traffic speed would be a conservative (ie. underconfident) estimate. In this dataset, that's about ±20% on the affected periods and routes – which are shoulder times potentially for all routes, and weekends in particular on MSDH2. (a low traffic route for 2018)

- The 2022 data is more robust in general, so we can maintain the ±5% confidence level even for the 95th percentile data, with the possible exception of weekend periods on MHMSP3 & 4, which were somewhat low volume. (Note that this is again a conservative MOE, applying mostly to periods not in the heart of the peak; at such times we are sampling thousands of vehicles every 15 minutes, so even the 95th percentile is reflective of the behaviour of a few hundred motorists – as such during the true peak hours the MOE would be more in line with the normal ±3%.)

Additional data related questions may be addressed to Jordie Fulton, our CTO – feel free to email jordie@downtown.ai for further information.

APPENDIX B

2018 & 2022 SPEED GRAPHS

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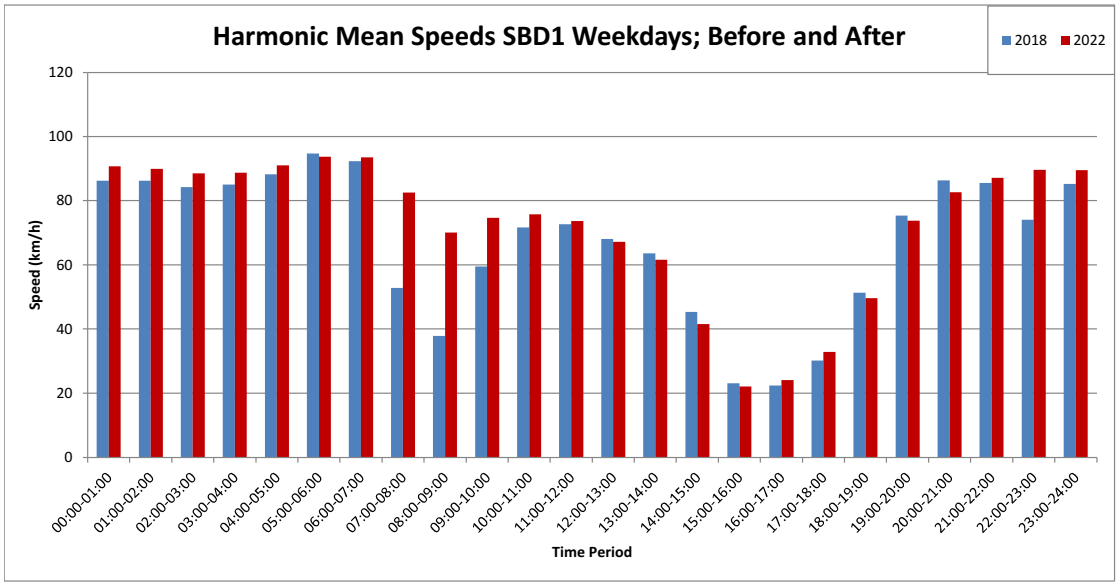
Harmonic Mean Speeds SBD1 Weekdays; Before and After
2018
2022
Speed (km/h)
0
20
40
60
80
100
120
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
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21:00-22:00
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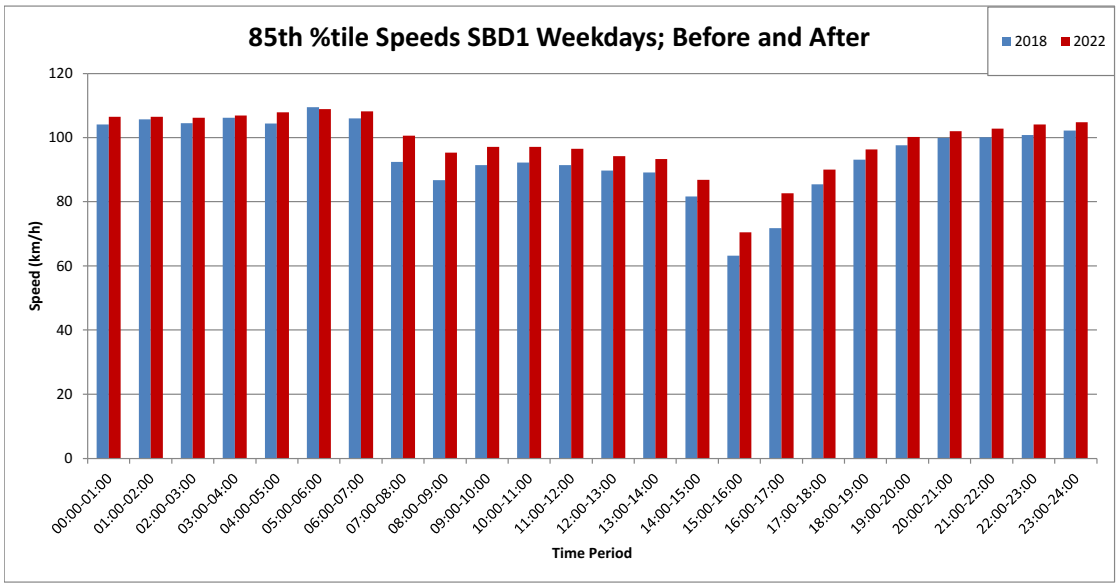
23:00-24:00
Time Period


85th %tile Speeds SBD1 Weekdays; Before and After
2018
2022
Speed (km/h)
0
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60
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120
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
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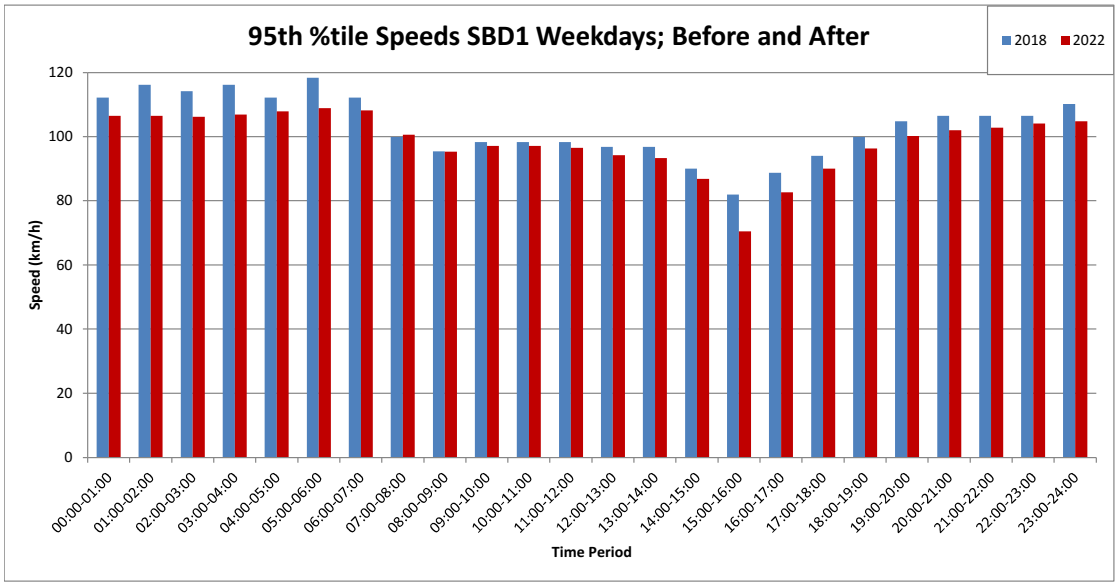
22:00-23:00
23:00-24:00
Time Period


95th %tile Speeds SBD1 Weekdays; Before and After
2018
2022
Speed (km/h)
0
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40
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80
100
120
00:00-01:00
01:00-02:00
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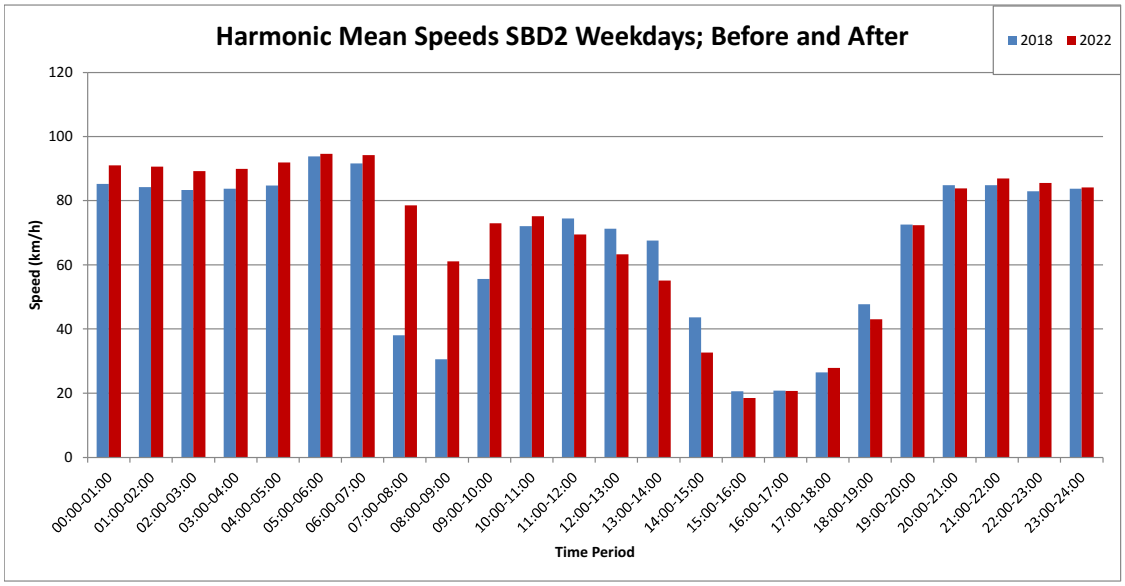
Time Period


Harmonic Mean Speeds SBD2 Weekdays; Before and After
2018
2022
Speed (km/h)
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100
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60
40
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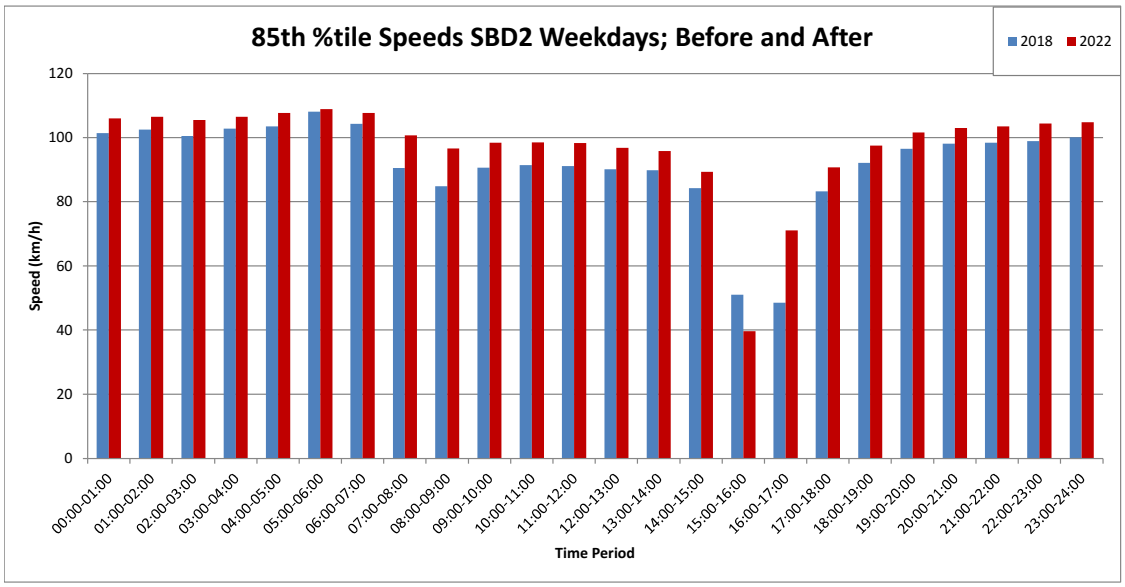
Time Period


85th %tile Speeds SBD2 Weekdays; Before and After
2018
2022
Speed (km/h)
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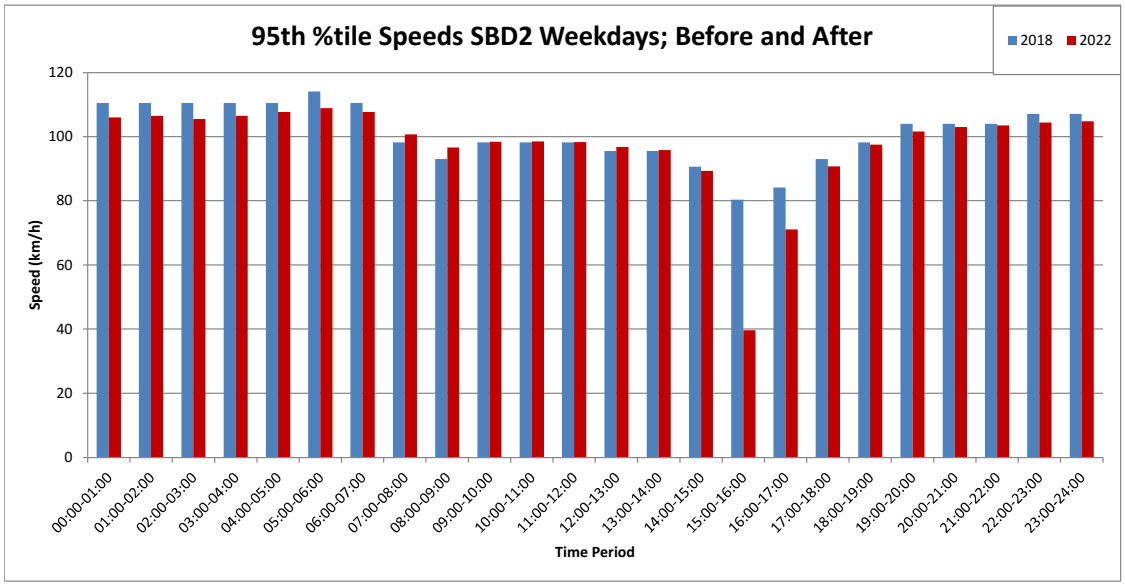
Time Period


95th %tile Speeds SBD2 Weekdays; Before and After
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2022
Speed (km/h)
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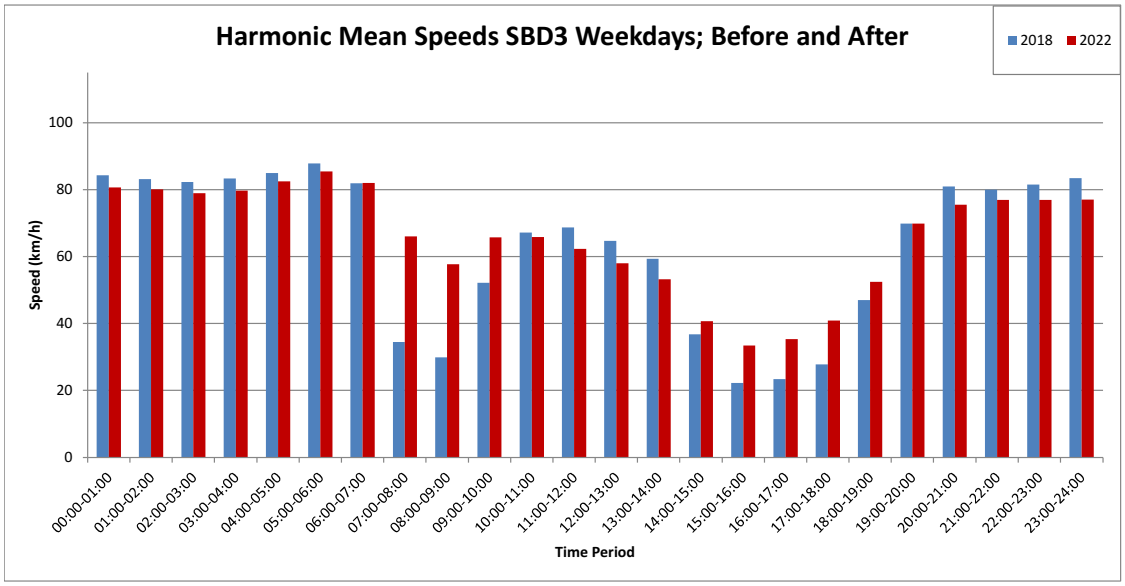
Time Period


Harmonic Mean Speeds SBD3 Weekdays; Before and After
2018
2022
Speed (km/h)
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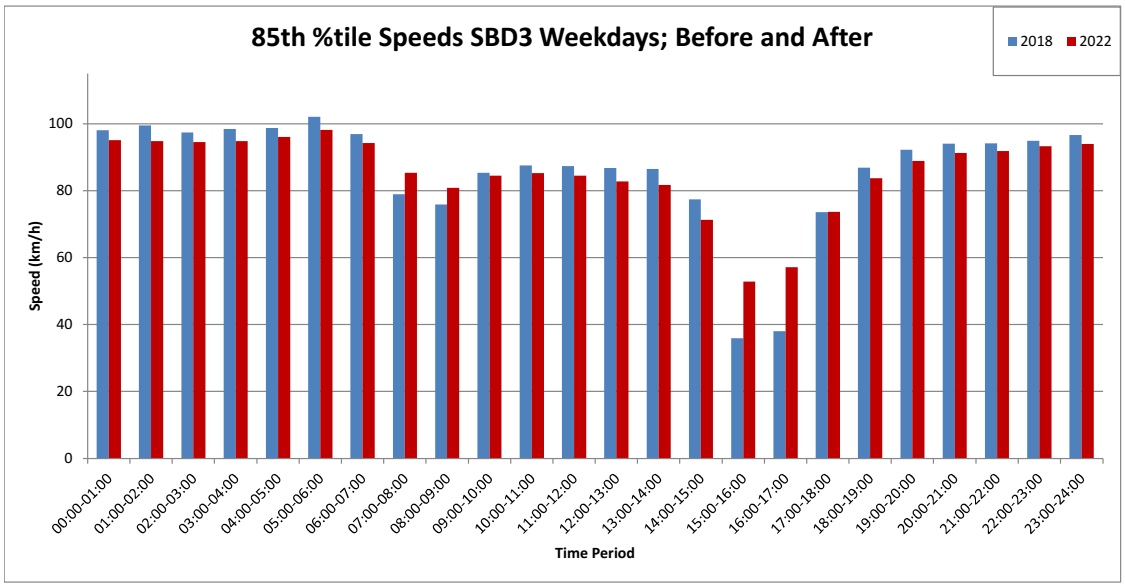
Time Period


85th %tile Speeds SBD3 Weekdays; Before and After
2018
2022
Speed (km/h)
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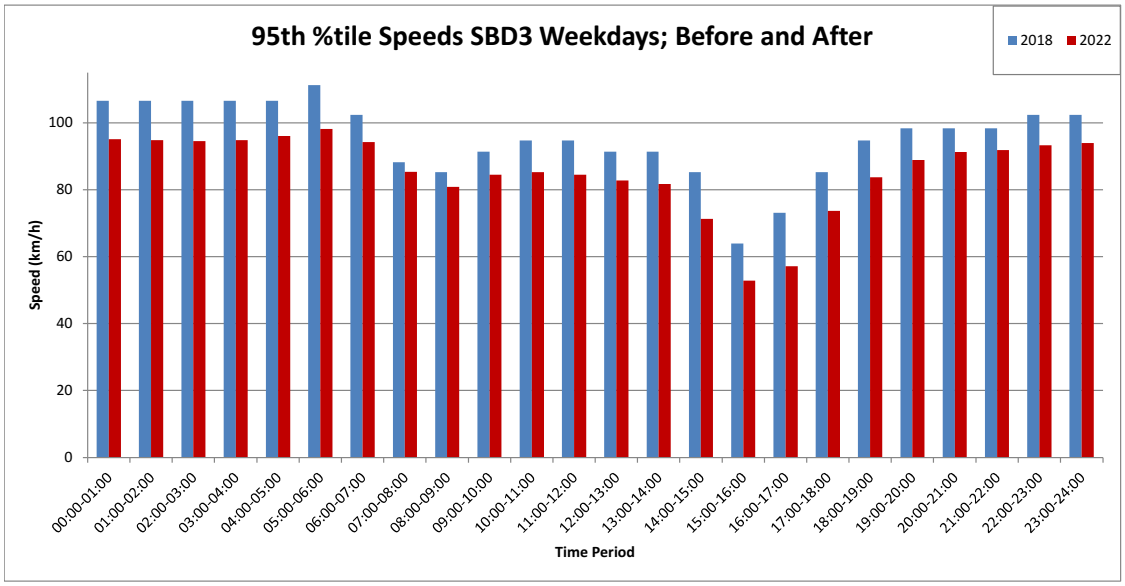
Time Period


95th %tile Speeds SBD3 Weekdays; Before and After
2018
2022
Speed (km/h)
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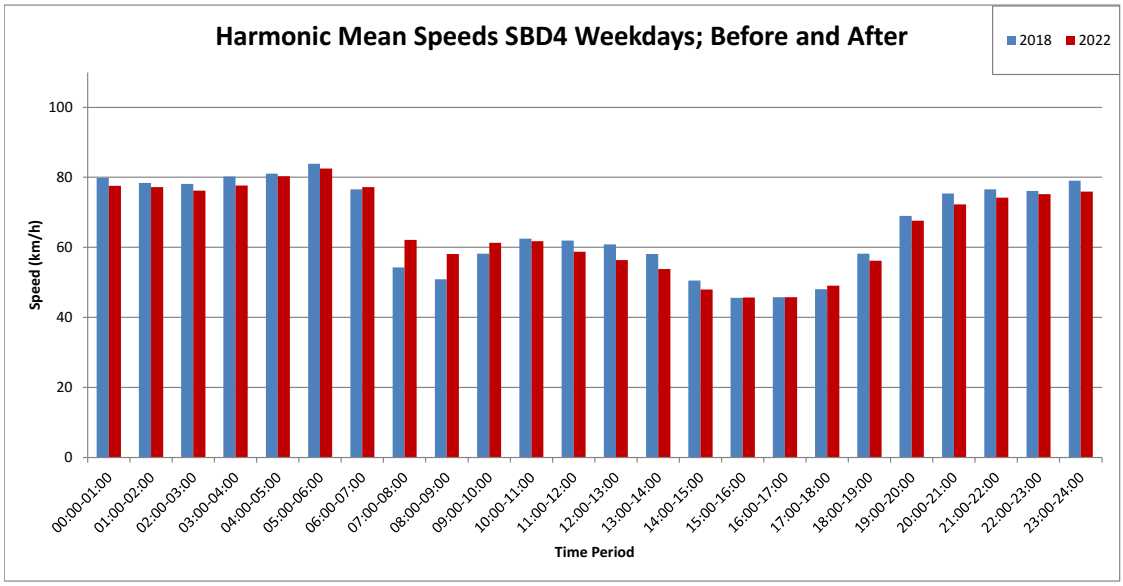
Time Period


Harmonic Mean Speeds SBD4 Weekdays; Before and After
2018
2022
Speed (km/h)
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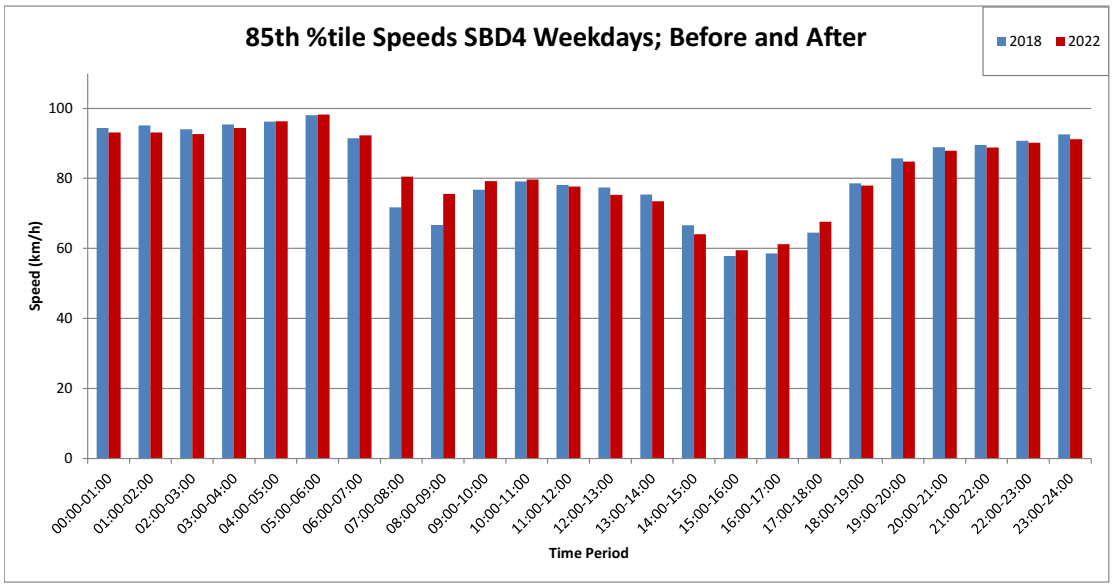
Time Period


85th %tile Speeds SBD4 Weekdays; Before and After
2018
2022
Speed (km/h)
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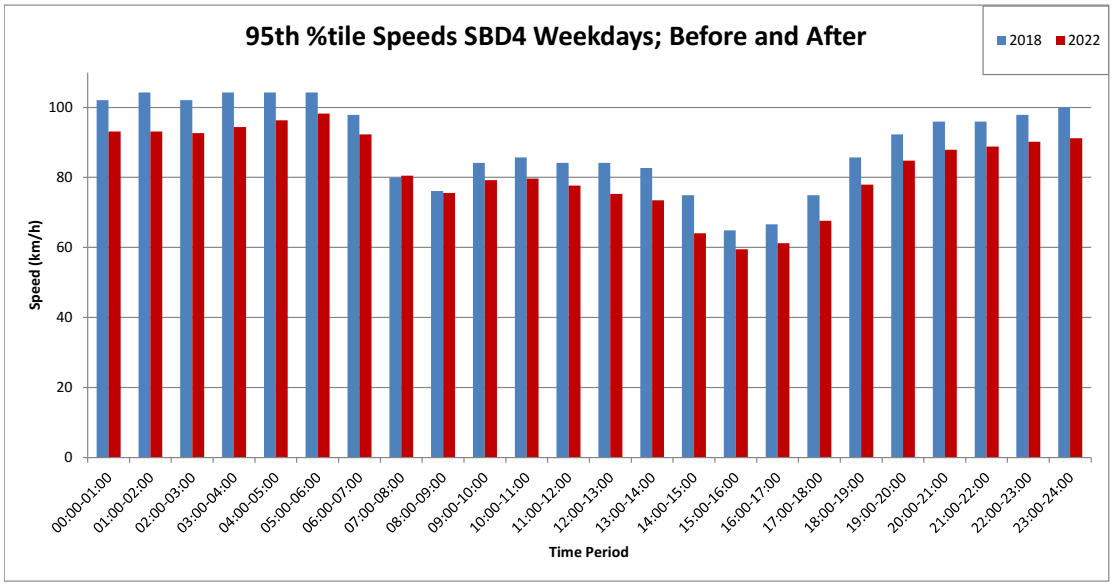
Time Period


95th %tile Speeds SBD4 Weekdays; Before and After
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2022
Speed (km/h)
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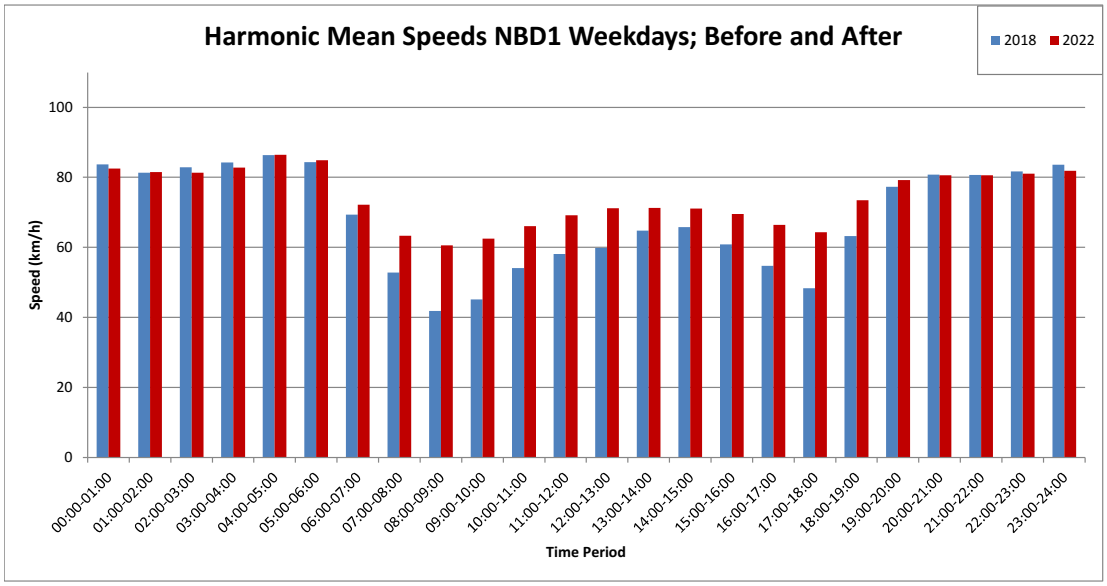
Time Period


Harmonic Mean Speeds NBD1 Weekdays; Before and After
2018
2022
Speed (km/h)
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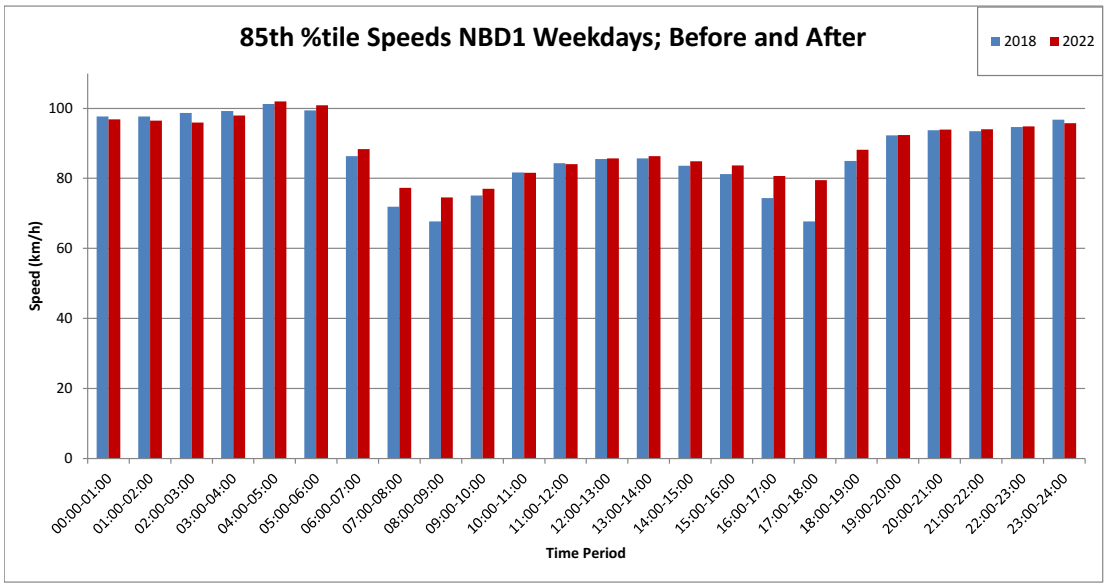
Time Period


85th %tile Speeds NBD1 Weekdays; Before and After
2018
2022
Speed (km/h)
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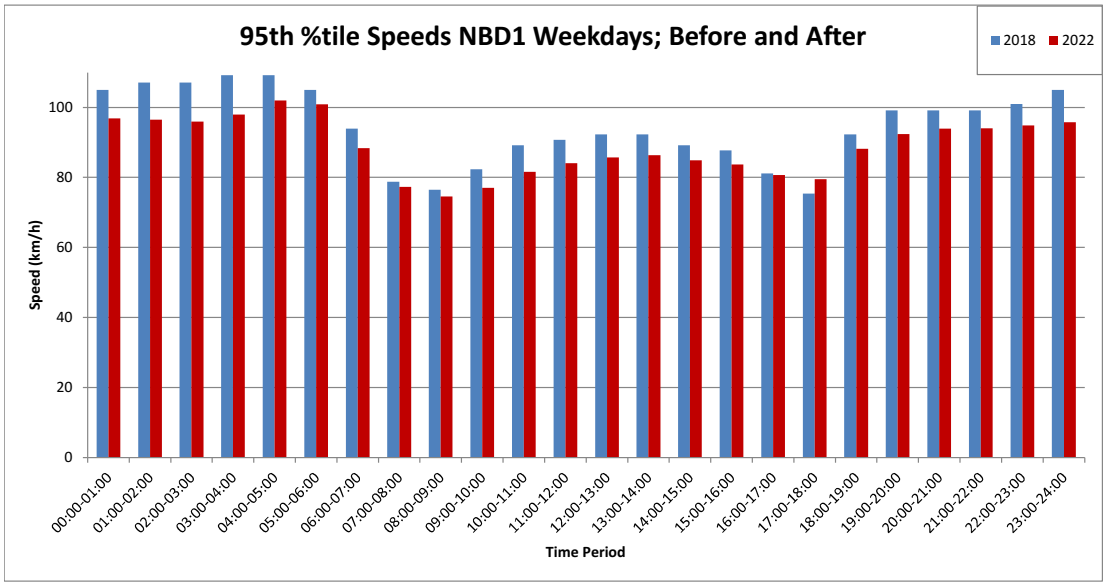
Time Period


95th %tile Speeds NBD1 Weekdays; Before and After
2018
2022
Speed (km/h)
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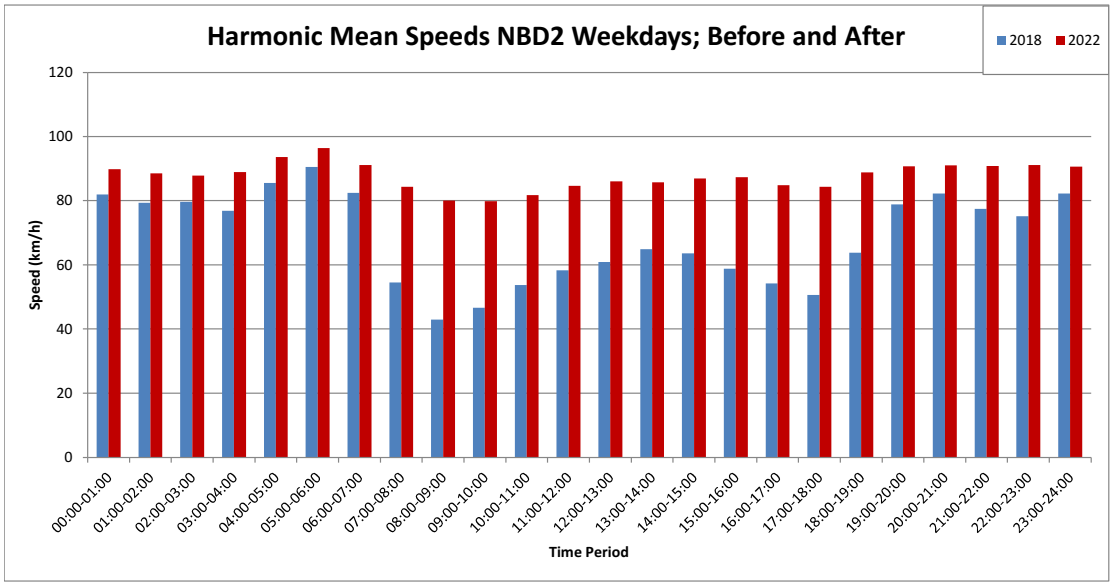
Time Period


Harmonic Mean Speeds NBD2 Weekdays; Before and After
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2022
Speed (km/h)
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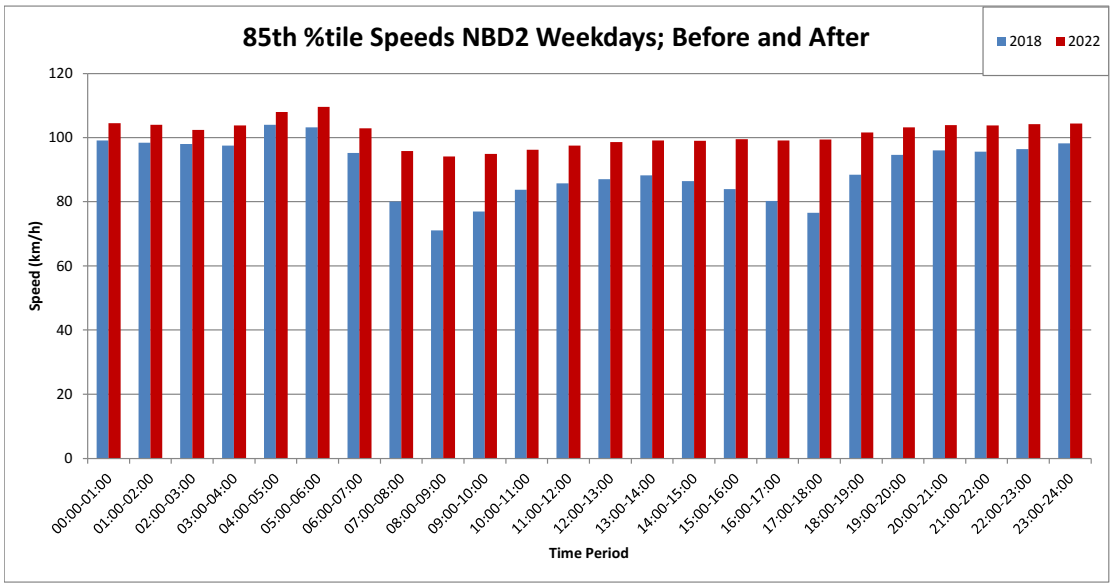
Time Period


85th %tile Speeds NBD2 Weekdays; Before and After
2018
2022
Speed (km/h)
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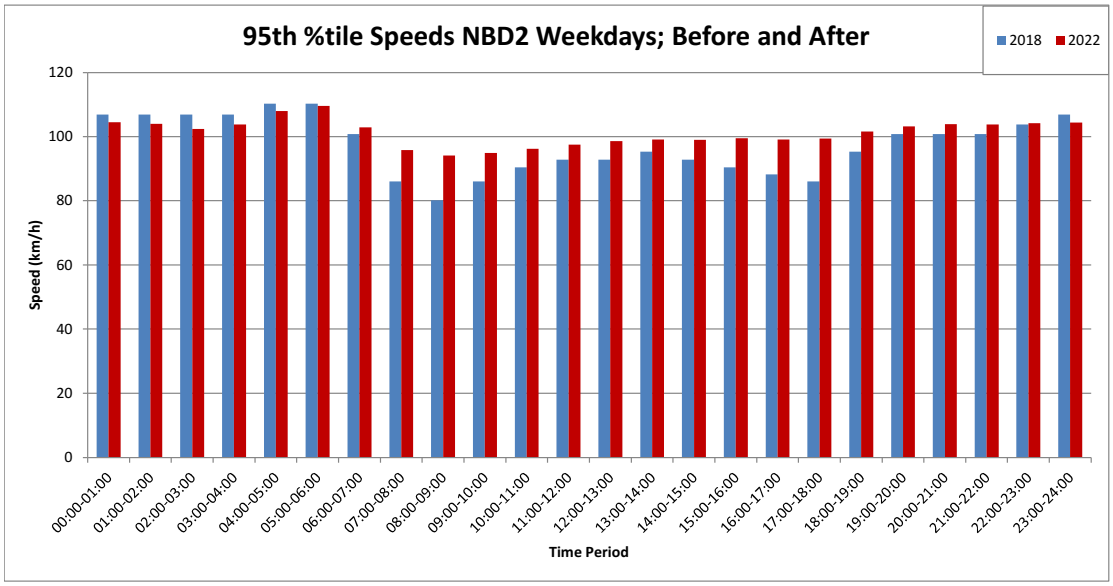
Time Period


95th %tile Speeds NBD2 Weekdays; Before and After
2018
2022
Speed (km/h)
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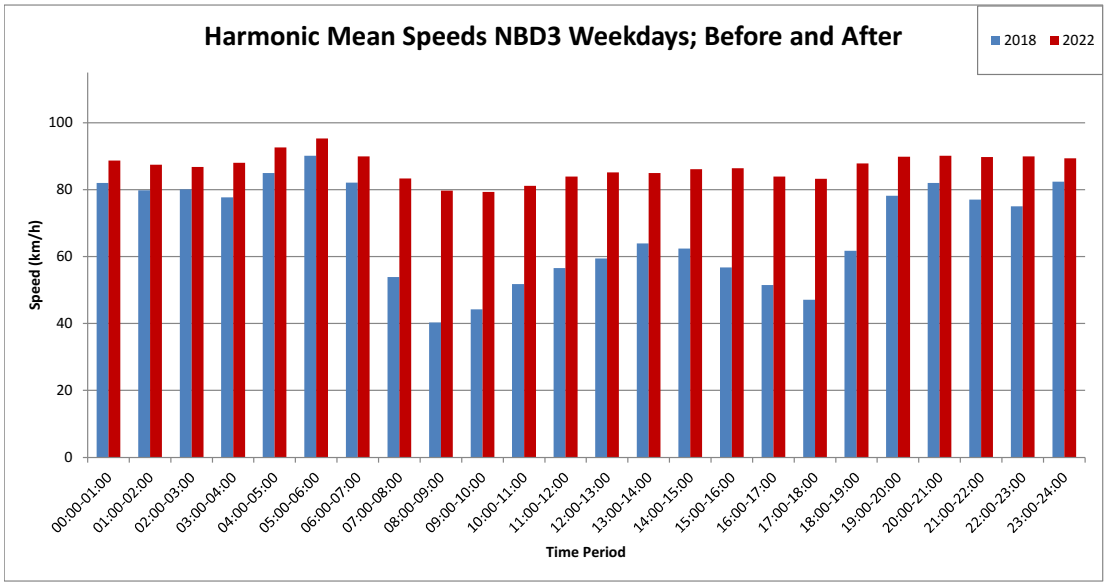
Time Period


Harmonic Mean Speeds NBD3 Weekdays; Before and After
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2022
Speed (km/h)
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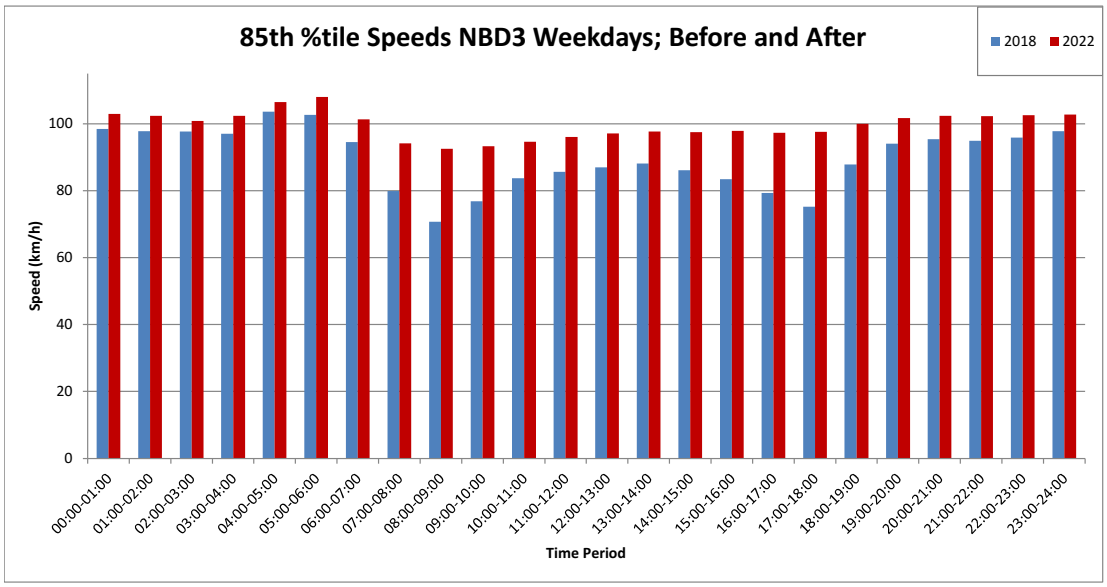
Time Period


85th %tile Speeds NBD3 Weekdays; Before and After
2018
2022
Speed (km/h)
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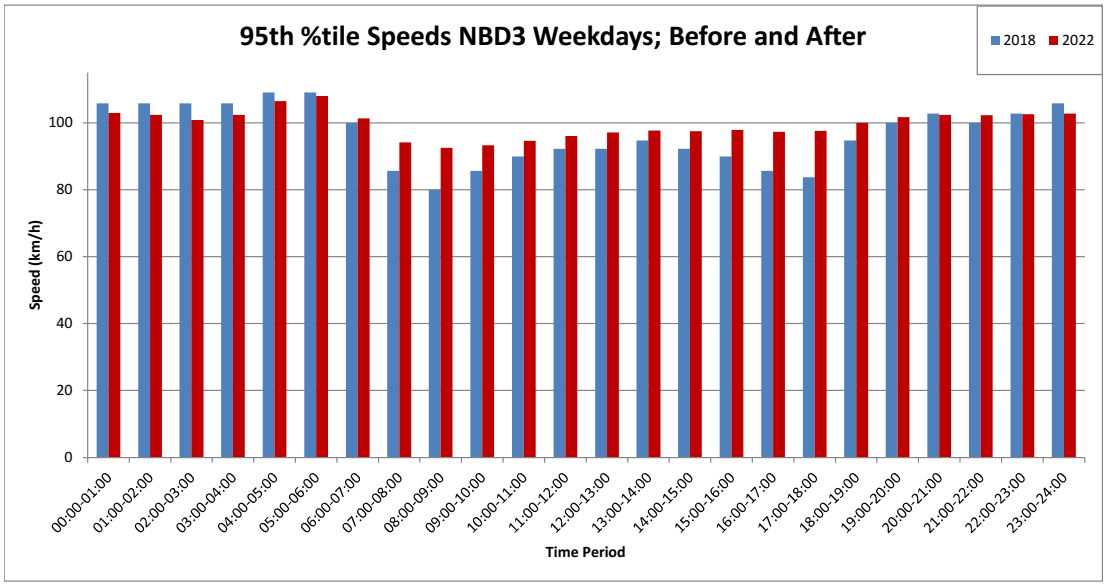
Time Period


95th %tile Speeds NBD3 Weekdays; Before and After
2018
2022
Speed (km/h)
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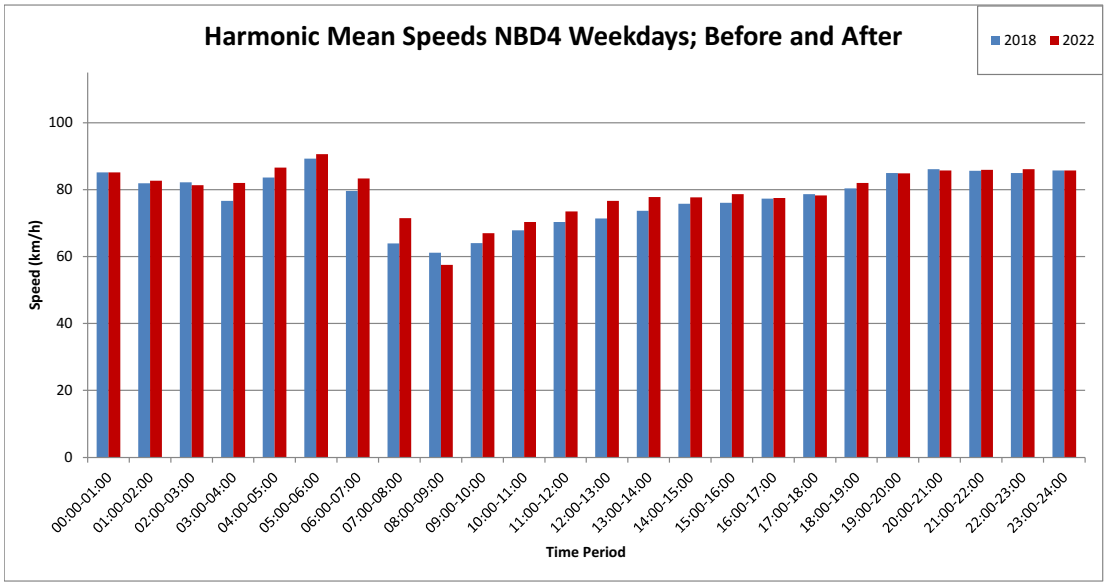
Time Period


Harmonic Mean Speeds NBD4 Weekdays; Before and After
2018
2022
Speed (km/h)
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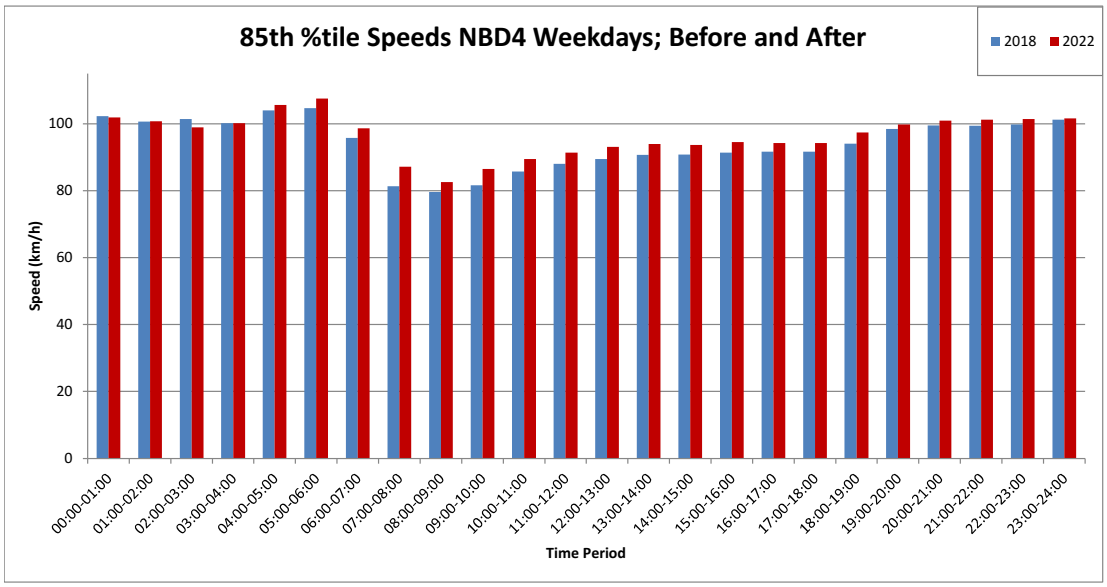
Time Period


85th %tile Speeds NBD4 Weekdays; Before and After
2018
2022
Speed (km/h)
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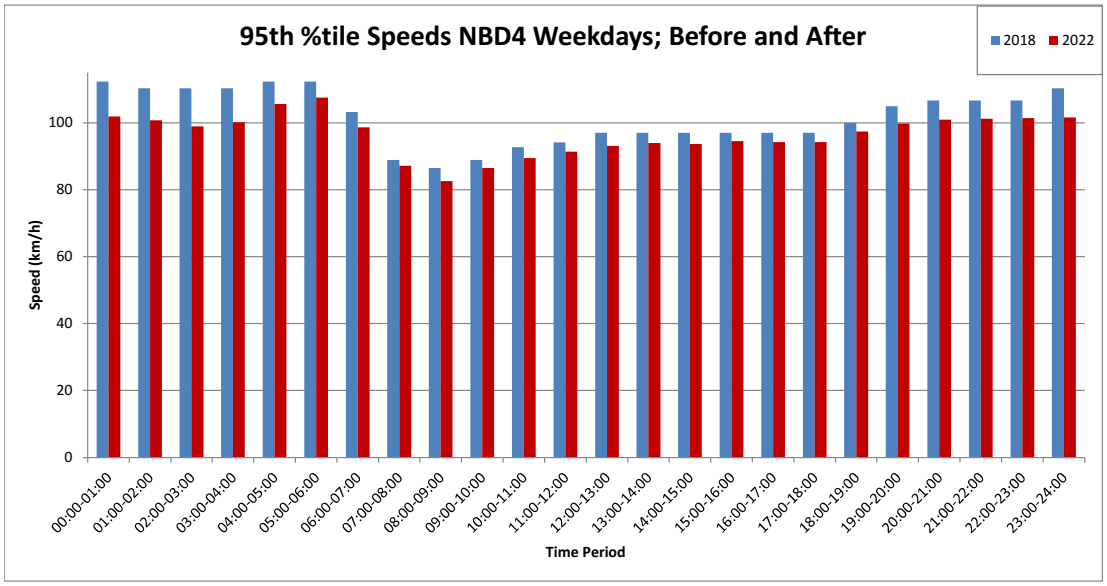
80
100
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Speeds NBD4 Weekdays; Before and After
2018
2022
Speed (km/h)
0
20
40
60
80
100
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
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13:00-14:00
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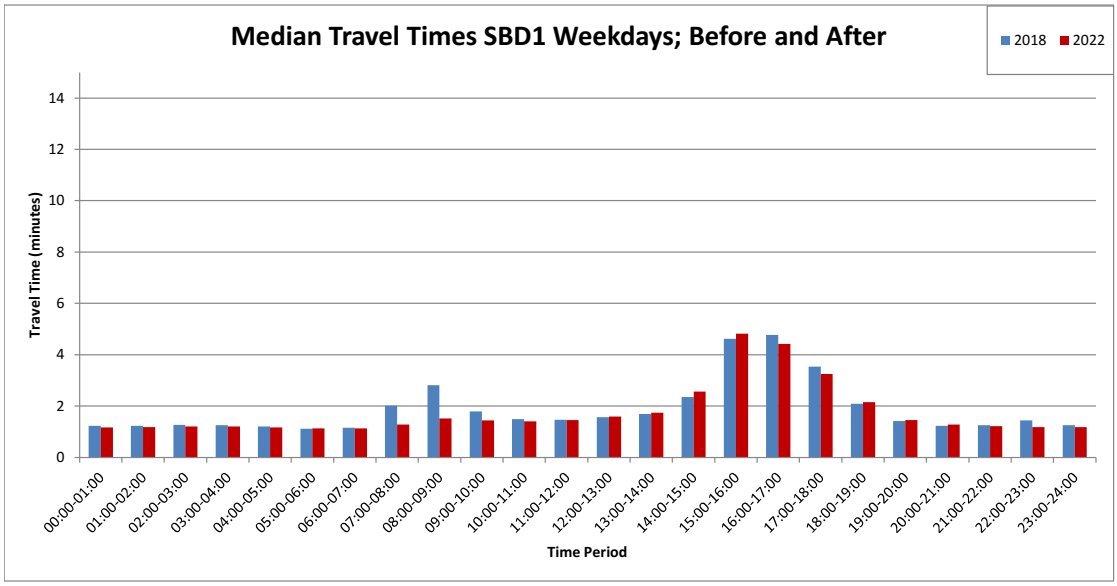
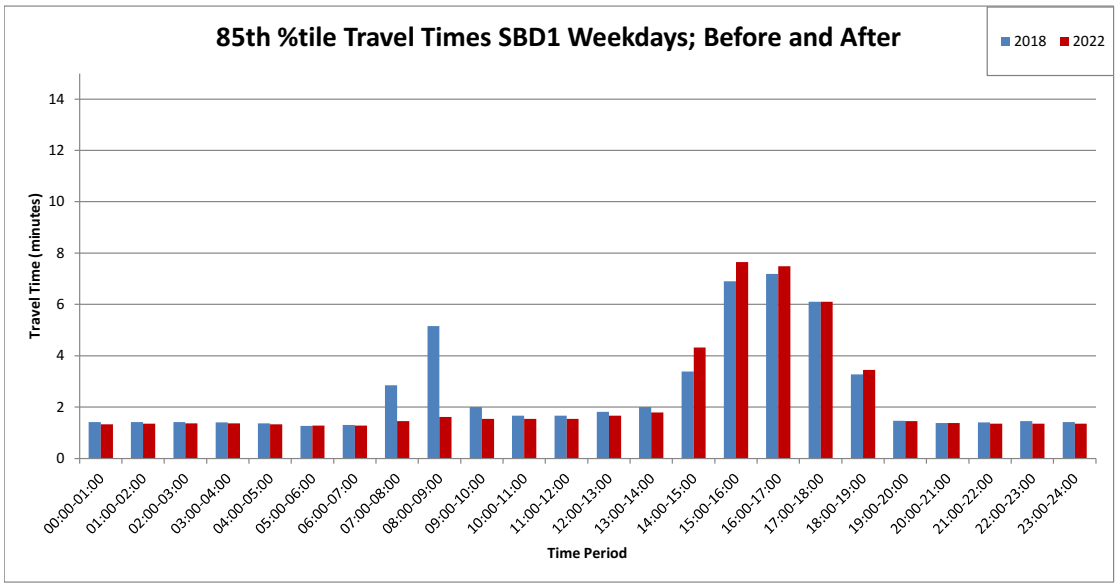
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period

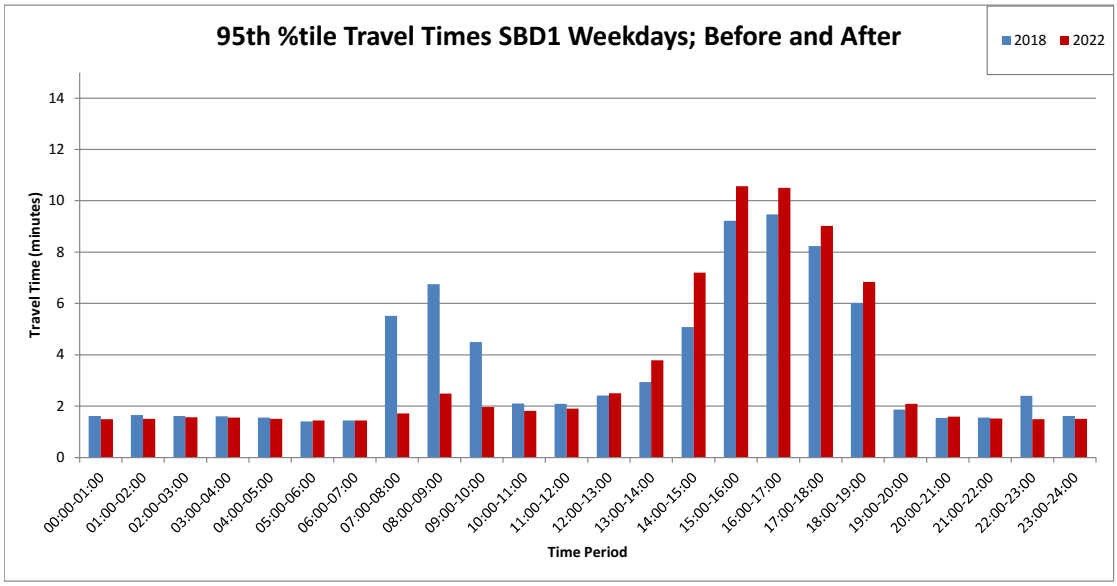
APPENDIX C

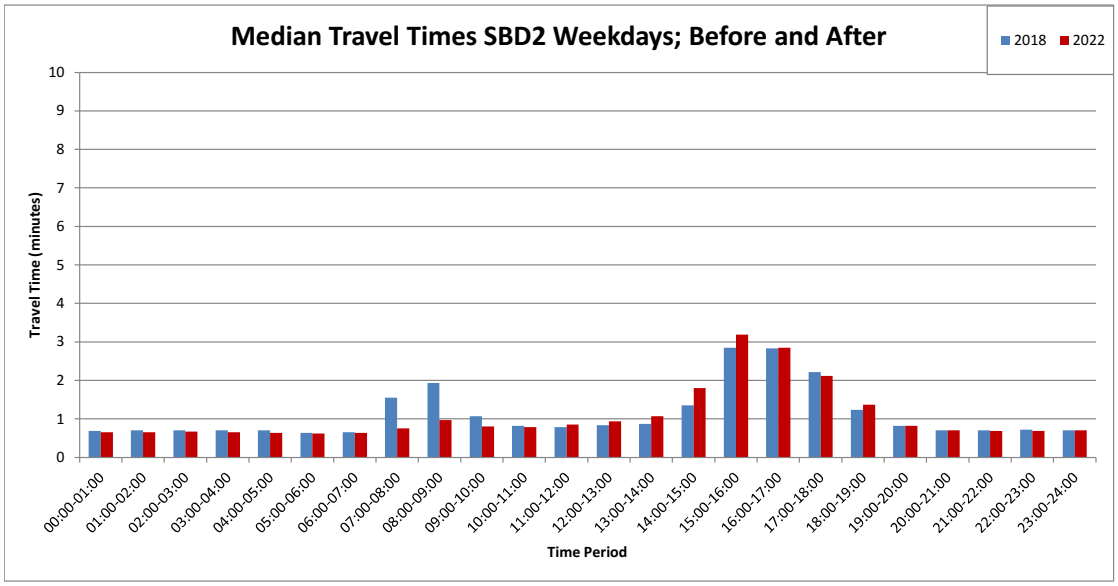
2018 & 2022 TRAVEL TIME GRAPHS

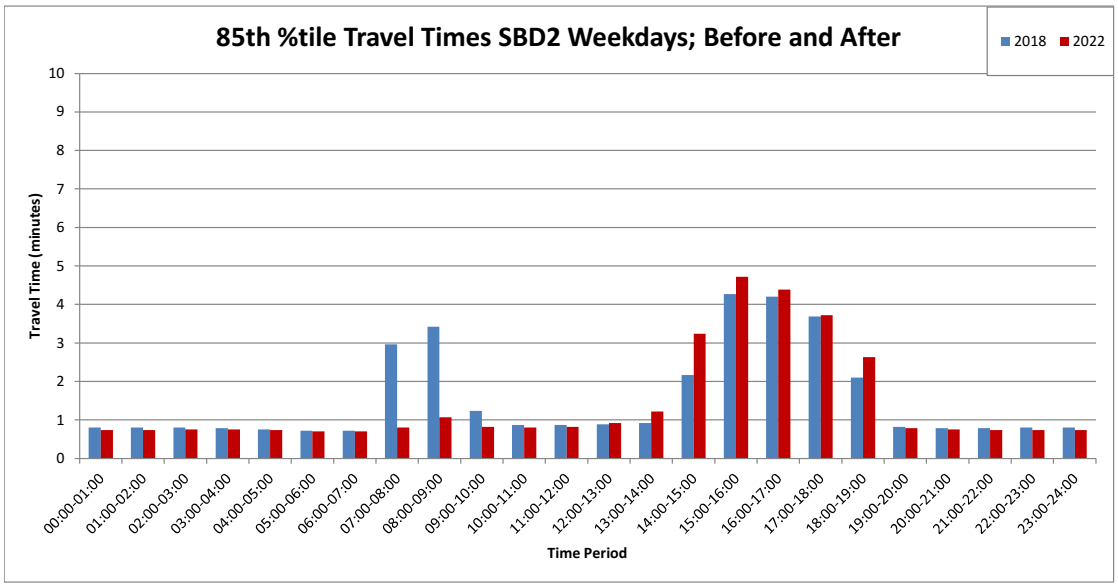
BINNIE


Median Travel Times SBD1 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
2
4
6
8
10
12
14
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


85th %tile Travel Times SBD1 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
2
4
6
8
10
12
14
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Travel Times SBD1 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
2
4
6
8
10
12
14
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


Median Travel Times SBD2 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
1
2
3
4
5
6
7
8
9
10
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


85th %tile Travel Times SBD2 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
1
2
3
4
5
6
7
8
9
10
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
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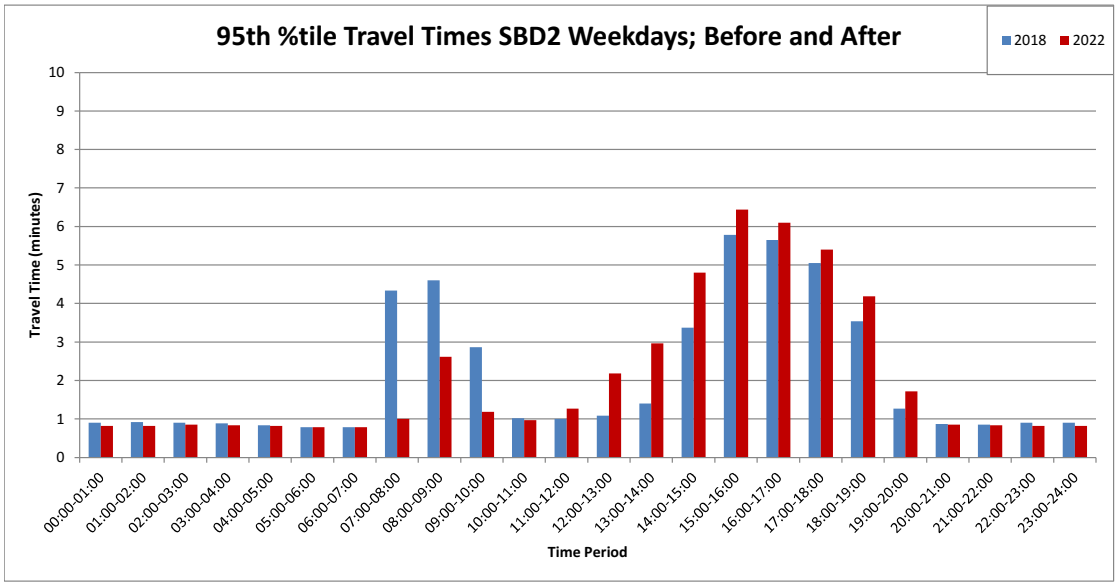
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Travel Times SBD2 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
1
2
3
4
5
6
7
8
9
10
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
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12:00-13:00
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14:00-15:00
15:00-16:00
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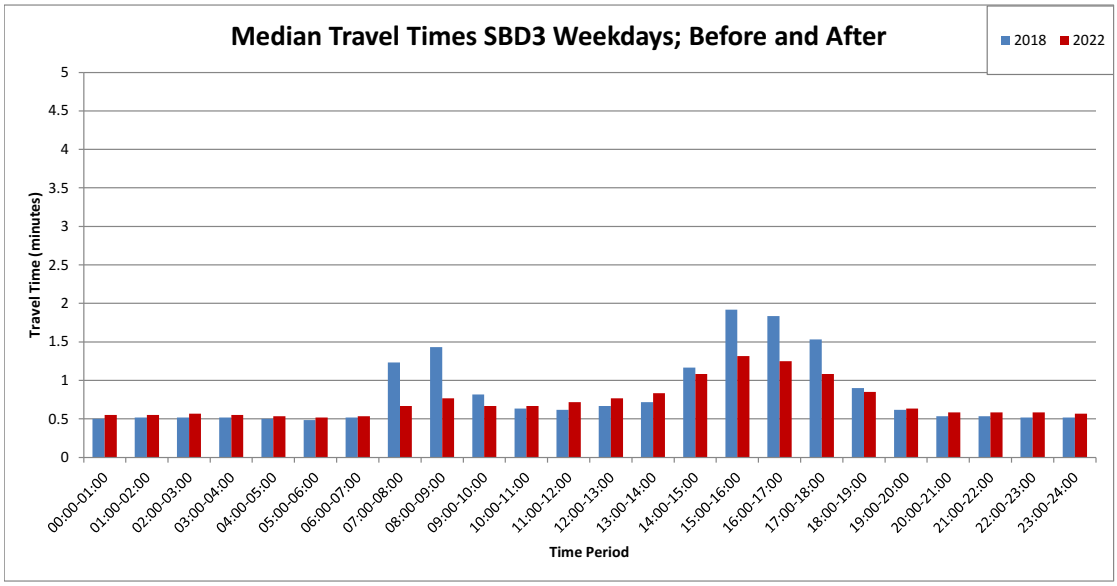
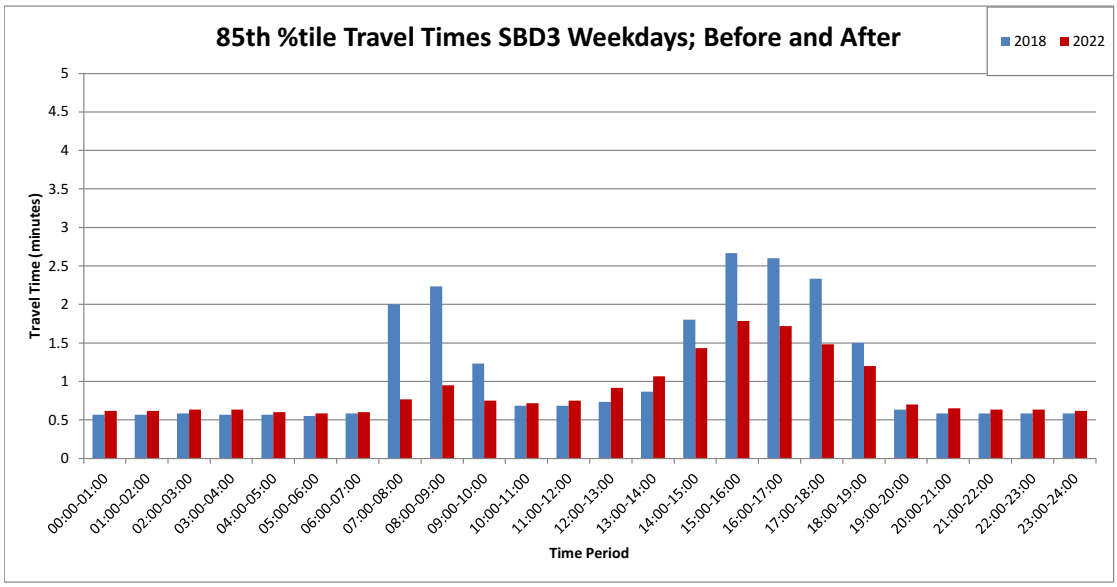
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


Median Travel Times SBD3 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


85th %tile Travel Times SBD3 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
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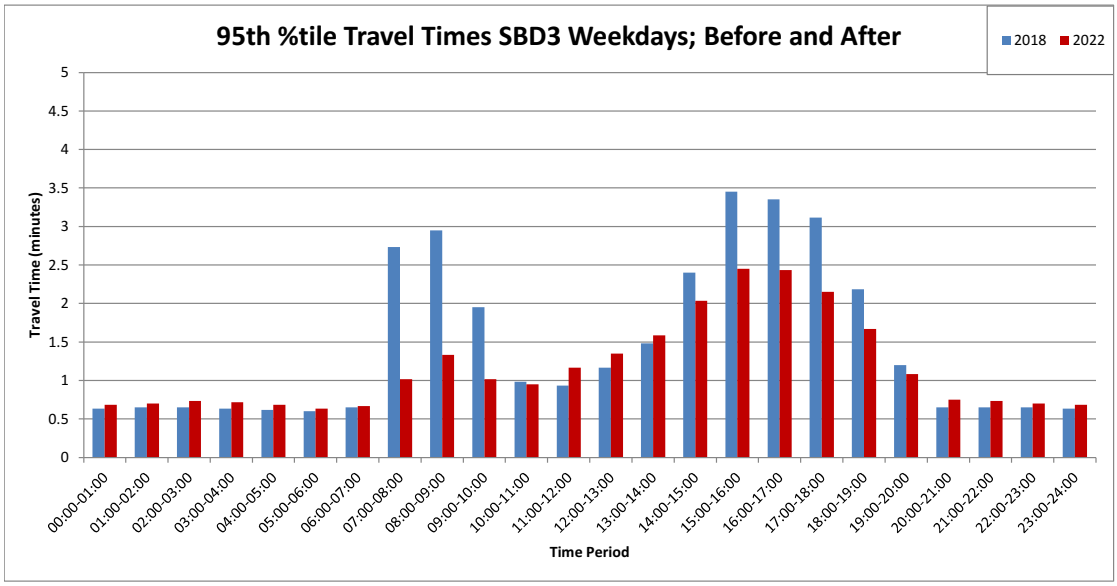
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Travel Times SBD3 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
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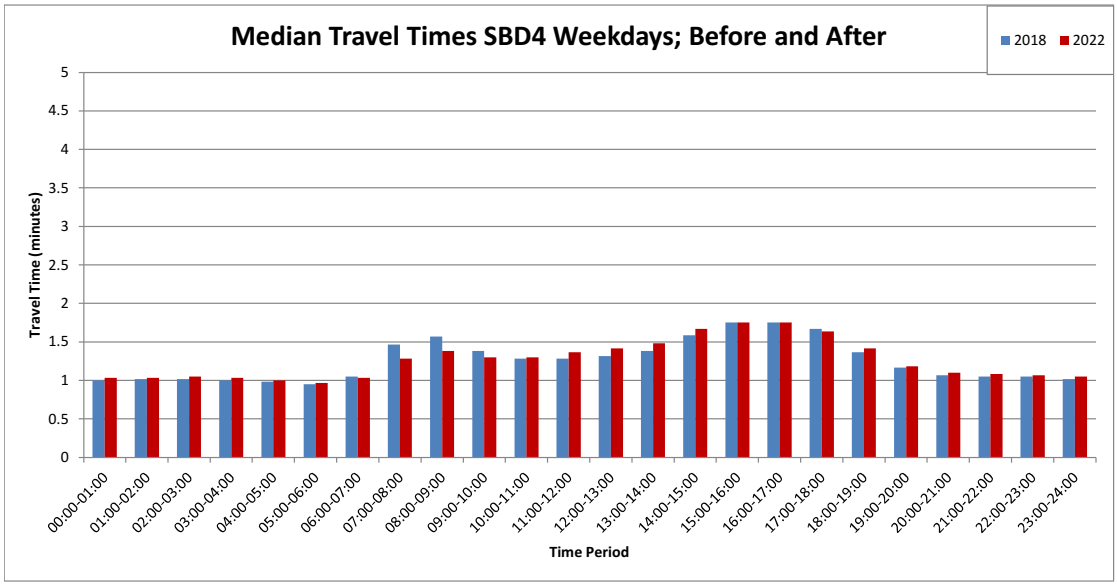
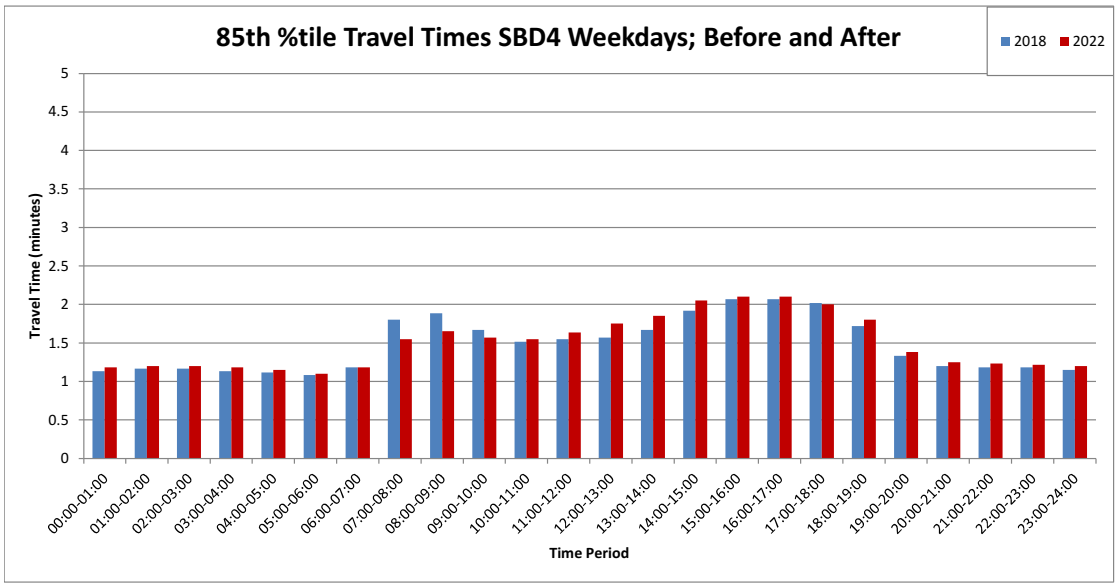
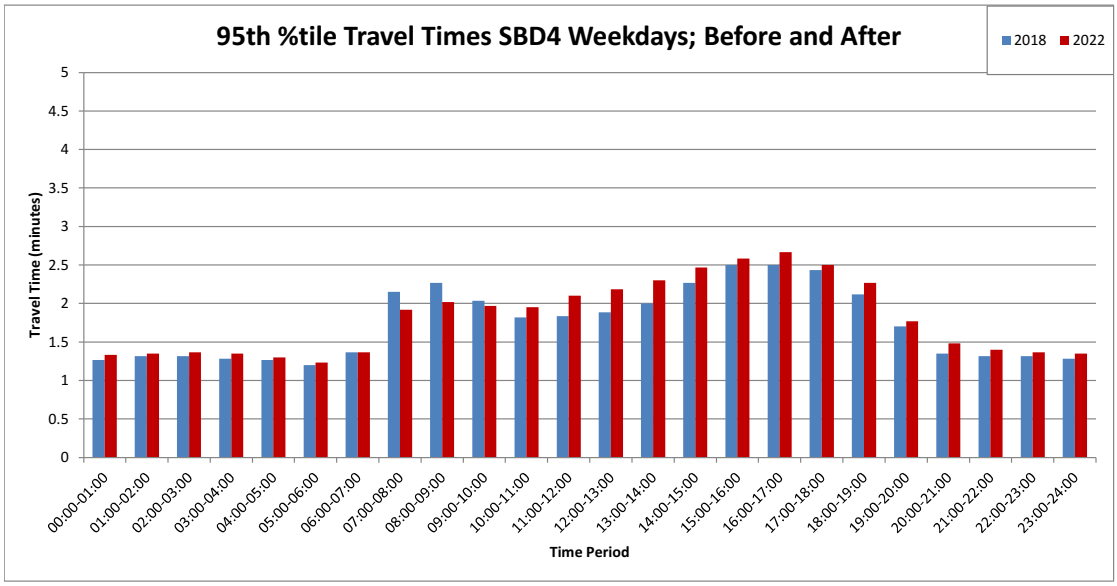
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


Median Travel Times SBD4 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


85th %tile Travel Times SBD4 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Travel Times SBD4 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
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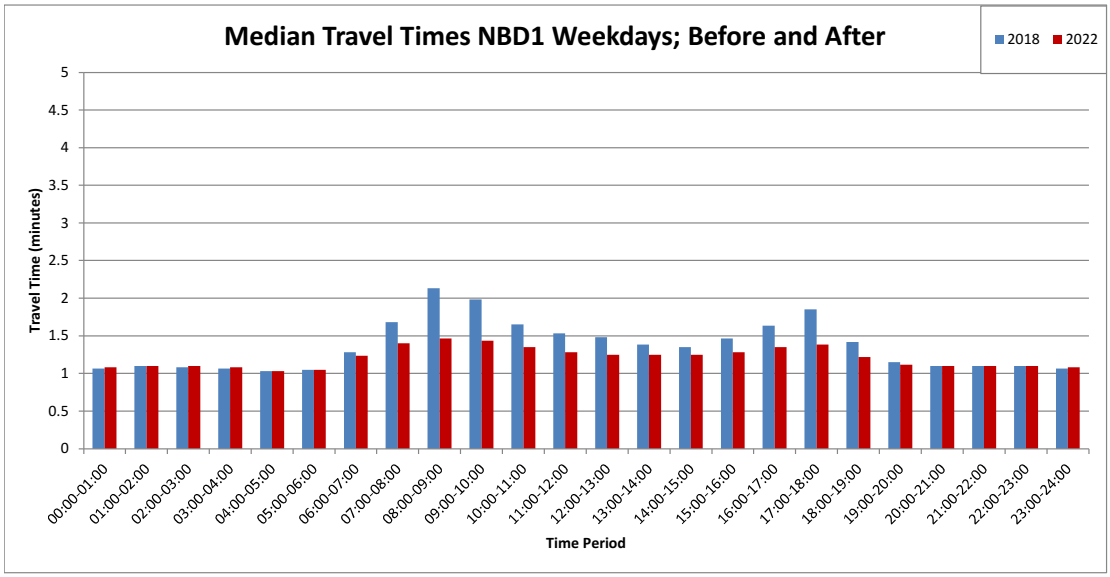
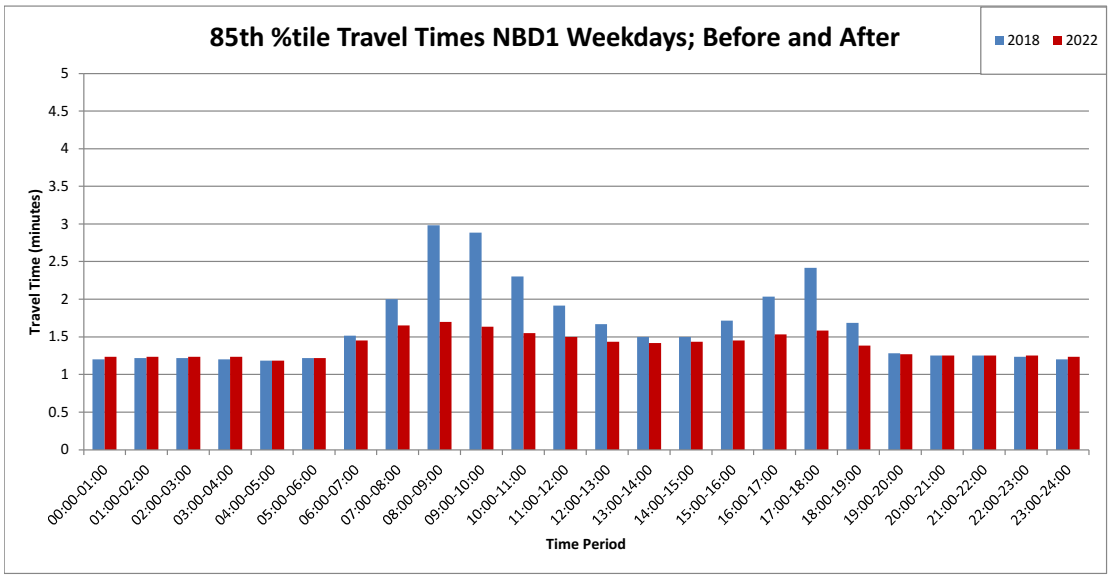
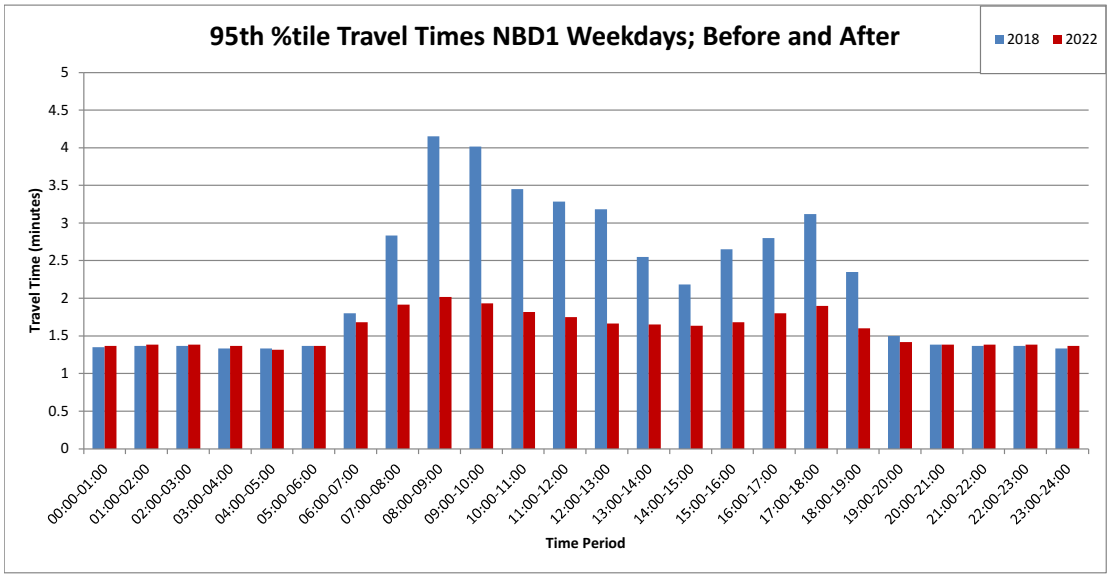
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


Median Travel Times NBD1 Weekdays; Before and After
2018
2022
Travel Time (minutes)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


85th %tile Travel Times NBD1 Weekdays; Before and After
2018
2022
Travel Time (minutes)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Travel Times NBD1 Weekdays; Before and After
2018
2022
Travel Time (minutes)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
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12:00-13:00
13:00-14:00
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15:00-16:00
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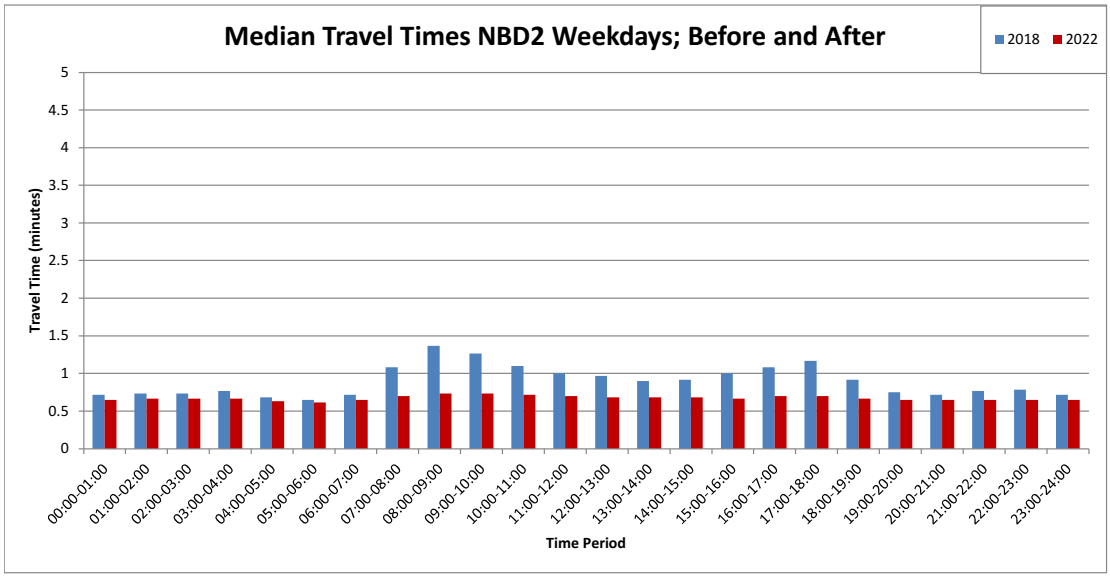
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


Median Travel Times NBD2 Weekdays; Before and After
2018
2022
Travel Time (minutes)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
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09:00-10:00
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15:00-16:00
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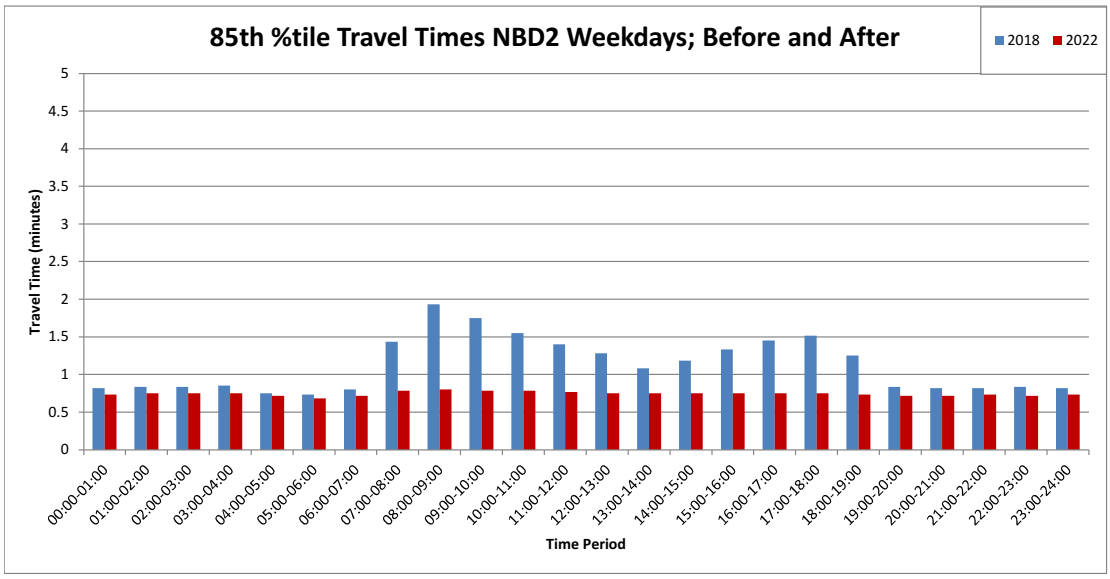
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


85th %tile Travel Times NBD2 Weekdays; Before and After
2018
2022
Travel Time (minutes)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
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09:00-10:00
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15:00-16:00
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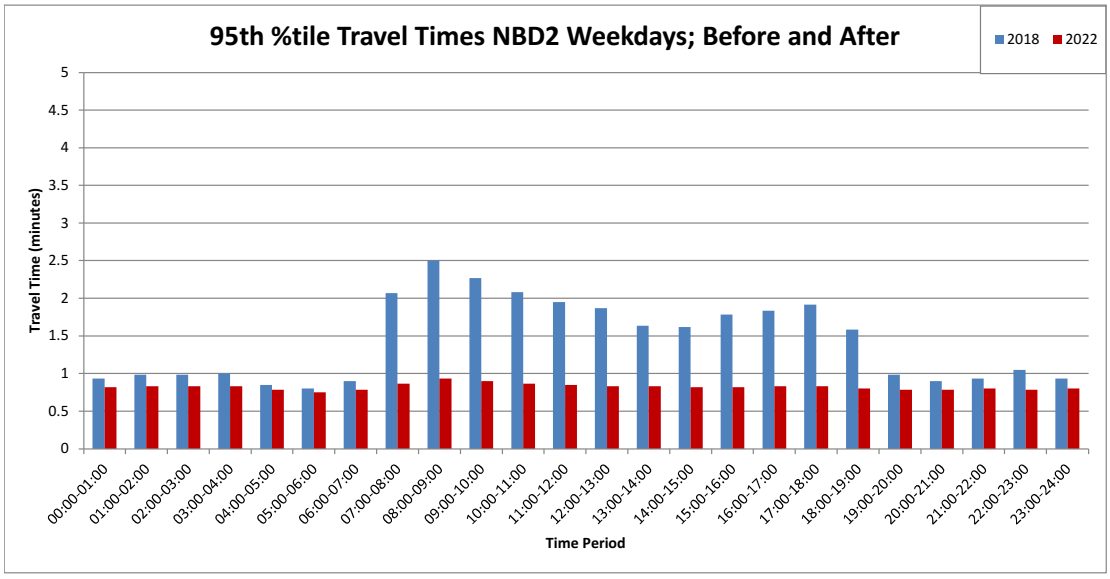
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Travel Times NBD2 Weekdays; Before and After
2018
2022
Travel Time (minutes)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
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13:00-14:00
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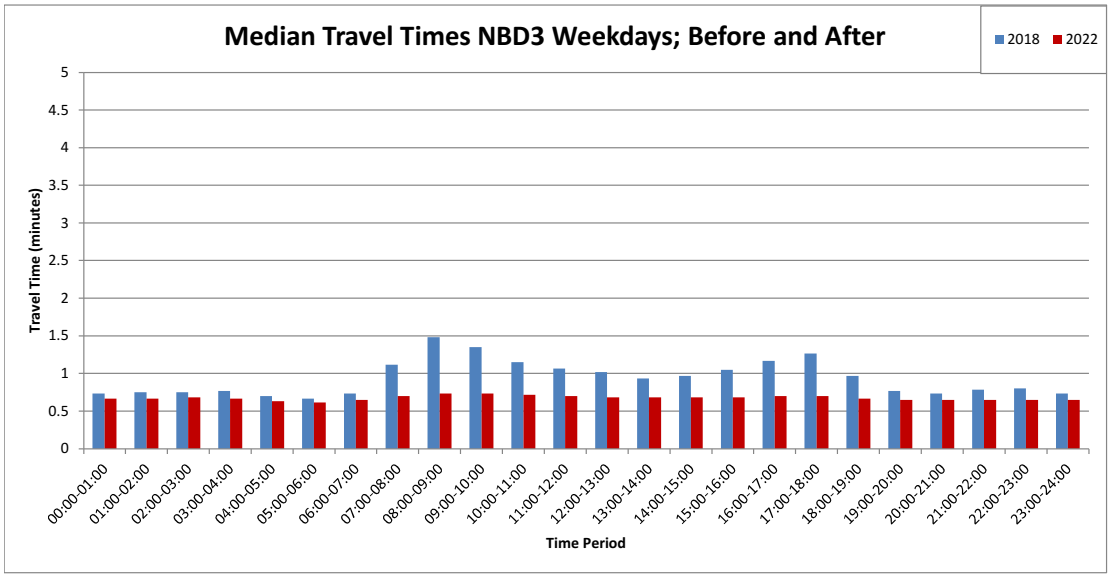
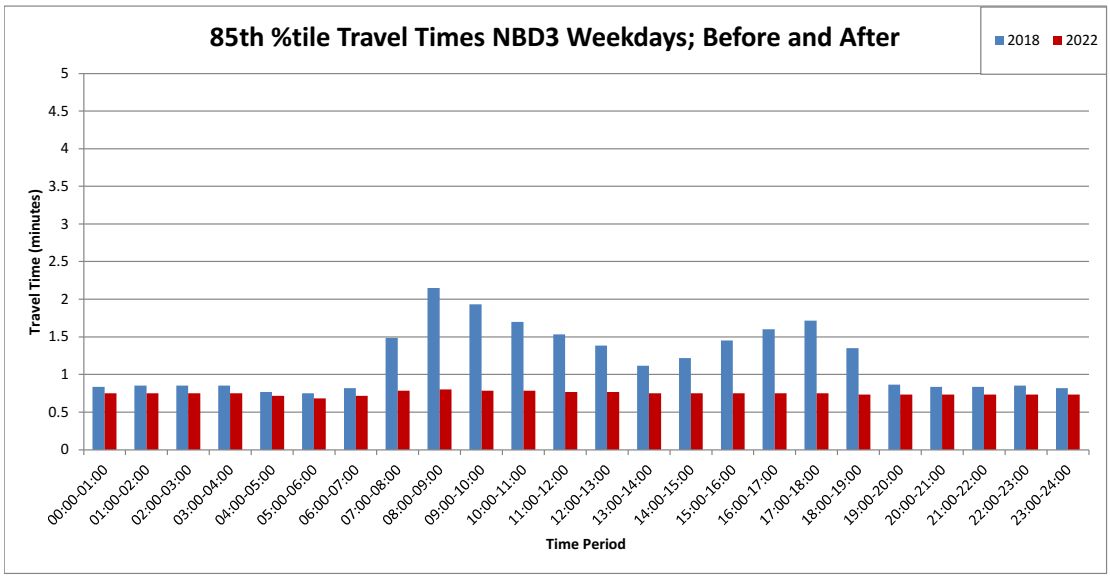
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


Median Travel Times NBD3 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


85th %tile Travel Times NBD3 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
09:00-10:00
10:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
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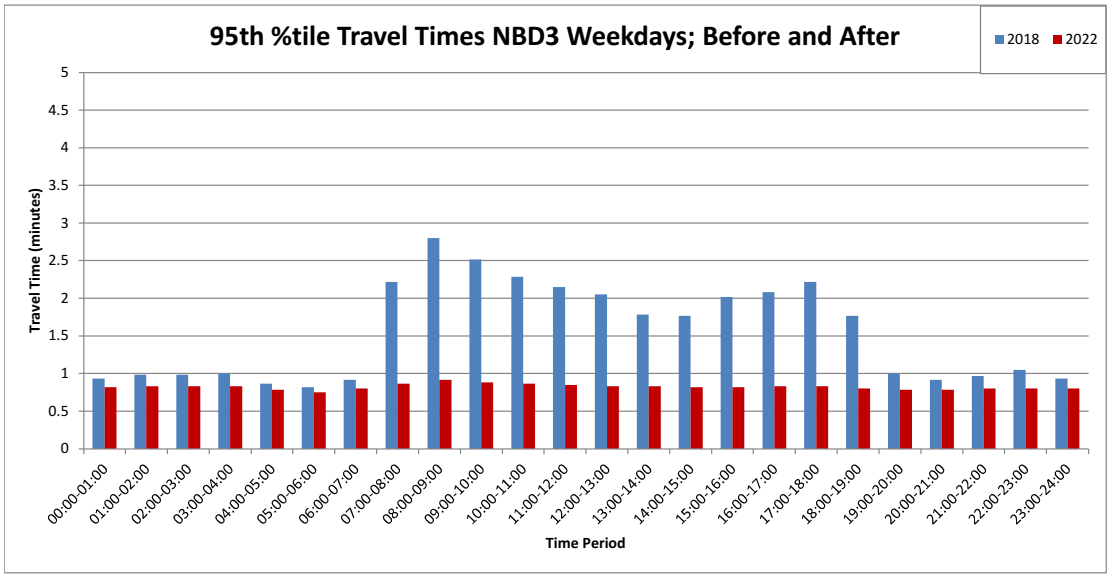
21:00-22:00
22:00-23:00
23:00-24:00
Time Period


95th %tile Travel Times NBD3 Weekdays; Before and After
2018
2022
Travel Time (minutes)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
00:00-01:00
01:00-02:00
02:00-03:00
03:00-04:00
04:00-05:00
05:00-06:00
06:00-07:00
07:00-08:00
08:00-09:00
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12:00-13:00
13:00-14:00
14:00-15:00
15:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
19:00-20:00
20:00-21:00
21:00-22:00
22:00-23:00
23:00-24:00
Time Period

APPENDIX D

95TH PERCENTILE TRAVEL TIMES BY OD PAIRS TRAVEL AND TIME RELIABILITY

D.1 95TH PERCENTILE - ORIGIN-DESTINATION PAIR TRAVEL TIME

The 95th percentile travel times on Highway 1 origin-destination (OD) pairs for peak periods and off-peak periods were compared between the 2018 data to the 2022 data. The 95th percentile travel times for each OD pair are used to compare between 2018 and 2022 to better gauge the percent difference in travel times on days where congestion is at its worst. To provide additional context, the 95th percentile is the equivalent to the slowest day of commuting for a typical month.

The formula used for percent difference calculation is as follows:

$$\%\ Difference = \frac{(2022\ TT - 2018\ TT)}{2018\ TT}$$

Where:

$$2018\ TT = 95th\ Percentile\ Travel\ Time\ Aggregated\ for\ 2018\ for\ the\ Hour$$

$$2022\ TT = 95th\ Percentile\ Travel\ Time\ Aggregated\ for\ 2022\ for\ the\ Hour$$

Similar to the travel speed review, OD pair travel time comparison will be examined with the same peak and off-peak periods of 6:00 AM to 9:00 AM, 1:00 PM to 2:00 PM, and 3:00 PM to 6:00 PM.

D.1.1 95th Percentile Travel Time Comparison - Southbound Direction:

SBD1: Highway 1 from East of Lynn Valley Road Interchange to Mountain Highway Interchange:
Table D-0-1 summarizes the 95th percentile travel time data collected by Downtown.AI for the Highway 1 segment between the Lynn Valley Road Interchange to the Mountain Highway Interchange. During the AM peak, 95th percentile travel times have decreased significantly, which has been consistent for this Highway segment during this time period. During the off-peak hour of 1:00 PM to 2:00 PM, 95th percentile travel time increased significantly by 29%. During the PM peak, 95th percentile travel times during all hours of the PM peak have increased moderately by 10-15%.

Table D-0-1: 2018/2022 95th Percentile Travel Time (SBD1 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
SBD1	AM Peak	06:00-07:00	1.43	1.43	0%
		07:00-08:00	5.52	1.72	-69%
		08:00-09:00	6.75	2.48	-63%
	Mid Day	13:00-14:00	2.93	3.78	29%
	PM Peak	15:00-16:00	9.22	10.57	15%
		16:00-17:00	9.47	10.50	11%
		17:00-18:00	8.23	9.02	10%

SBD2: Highway 1 from Mountain Highway Interchange to Mount Seymour Parkway Interchange

Table D-0-2 summarizes the 95th percentile travel time data collected by Downtown.AI for the Highway 1 segment between the Mountain Highway Interchange to the Mount Seymour Parkway Interchange. During the AM peak period, from 6:00 AM to 7:00 AM, 95th percentile travel times have remained relatively unchanged. Significant improvements are observed from 7:00 AM to 9:00 AM for 95th percentile travel times. During the mid-day period, 95th percentile travel time has increased quite significantly. PM peak period 95th percentile travel times have increased slightly by 7% to 11%.

Table D-0-2: 2018/2022 95th Percentile Travel Time (SBD2 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
SBD2	AM Peak	06:00-07:00	0.78	0.78	0%
		07:00-08:00	4.33	1.00	-77%
		08:00-09:00	4.60	2.62	-43%
	Mid Day	13:00-14:00	1.40	2.97	112%
	PM Peak	15:00-16:00	5.78	6.43	11%
		16:00-17:00	5.65	6.10	8%
		17:00-18:00	5.05	5.40	7%

SBD3: Highway 1 from Mount Seymour Parkway Interchange to Main Street / Dollarton Highway Interchange

Table D-0-3 summarizes the 95th percentile travel time data collected by Downtown.AI for the Highway 1 segment between the Mount Seymour Parkway Interchange to the Main Street/Dollarton Highway Interchange. During the AM peak period, from 6:00 AM to 7:00 AM, there are minor changes to the 95th percentile travel time. The second and third hour of the AM peak period has seen meaningful decreases in 95th percentile travel time. The mid-day hour of 1:00 PM to 2:00 PM has shown a minor increase in the 95th percentile travel time. During the PM peak period, there is a consistent ~30% decrease in 95th percentile travel times.

Table D-0-3: 2018/2022 95th Percentile Travel Time (SBD3 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
SBD3	AM Peak	06:00-07:00	0.65	0.67	3%
		07:00-08:00	2.73	1.02	-63%
		08:00-09:00	2.95	1.33	-55%
	Mid Day	13:00-14:00	1.48	1.58	7%
	PM Peak	15:00-16:00	3.45	2.45	-29%
		16:00-17:00	3.35	2.43	-27%
		17:00-18:00	3.12	2.15	-31%

SBD4: Highway 1 from Main Street / Dollarton Highway Interchange to South end of IWMB

Table D-0-4 summarizes the 95th percentile travel time data collected by Downtown.AI for the Highway 1 segment between the Main Street/Dollarton Highway interchange to the south end of the IWMB. During the AM peak period, from 6:00 AM to 7:00 AM, there is no change in the 95th percentile travel time. From 7:00 AM to 9:00 AM, there is a consistent moderate decrease of 11% in 95th percentile travel times. During the mid-day hour of 1:00 PM to 2:00 PM, there is a moderate increase of 15% in the 95th percentile travel time. During the PM peak period, there is a slight increase in 95th percentile travel times.

Table D-0-4: 2018/2022 95th Percentile Travel Time (SBD4 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
SBD4	AM Peak	06:00-07:00	1.37	1.37	0%
		07:00-08:00	2.15	1.92	-11%
		08:00-09:00	2.27	2.02	-11%
	Mid Day	13:00-14:00	2.00	2.30	15%
	PM Peak	15:00-16:00	2.50	2.58	3%
		16:00-17:00	2.50	2.67	7%
		17:00-18:00	2.43	2.50	3%

D.1.2 95th Percentile Travel Time Comparison - Northbound Direction

NBD1: Highway 1 from South end of the IWMB to Main Street/Dollarton Highway Interchange

Table D-0-5 summarizes the 95th percentile travel time data collected by Downtown.AI for the Highway 1 segment between the south end of the IWMB to the Main Street/Dollarton Highway Interchange. During the AM peak period, travel times have improved with the most significant decrease in the hour between 8:00 AM to 9:00 AM, when travel times are the worst. During the mid-day study hour, 95th percentile travel times have decreased substantially by 35%. During the PM peak period, travel times

have also improved substantially during all three study hours with a decrease in travel time of 36% to 39%.

Table D-0-5: 2018/2022 95th Percentile Travel Time (NBD1 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
NBD1	AM Peak	06:00-07:00	1.80	1.68	-6%
		07:00-08:00	2.83	1.92	-32%
		08:00-09:00	4.15	2.02	-51%
	Mid Day	13:00-14:00	2.55	1.65	-35%
	PM Peak	15:00-16:00	2.65	1.68	-36%
		16:00-17:00	2.80	1.80	-36%
		17:00-18:00	3.12	1.90	-39%

NBD2: Highway 1 from Main Street/Dollarton Highway Interchange to Mount Seymour Parkway Interchange

Table D-0-6 summarizes the 95th percentile travel time data collected by Downtown.AI for the Highway 1 segment between the Main Street/Dollarton Highway Interchange and Mount Seymour Parkway Interchange. This segment of the Highway shows improvement in all study hours for 95th percentile travel times. The largest observed differences were from 7:00 AM to 9:00 AM, and 4:00 PM to 6:00 PM. These periods had the longest travel times in 2018, but in 2022, 95th percentile travel times have started to stay at a steady state for all study periods.

Table D-0-6: 2018/2022 95th Percentile Travel Time (NBD2 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
NBD2	AM Peak	06:00-07:00	0.90	0.78	-13%
		07:00-08:00	2.07	0.87	-58%
		08:00-09:00	2.50	0.93	-63%
	Mid Day	13:00-14:00	1.63	0.83	-49%
	PM Peak	15:00-16:00	1.78	0.82	-54%
		16:00-17:00	1.83	0.83	-55%
		17:00-18:00	1.92	0.83	-57%

NBD3: Highway 1 from Mount Seymour Parkway Interchange to Mountain Highway Interchange

Table D-0-7 summarizes the travel time data collected by Downtown.AI for the Highway 1 segment between the Mount Seymour Parkway Interchange and the Mountain Highway Interchange. Analogous to OD pair NBD2, this Highway segment is also observed to have improvements to 95th percentile travel times across all study periods. The study hour with the most significant improvement is the hour from

8:00 AM to 9:00 AM. This hour was observed to have the longest 95th percentile travel time in 2018. In 2022, this hour is still the slowest study time period, however only marginally so.

Table D-0-7: 2018/2022 95th Percentile Travel Time (NBD3 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
NBD3	AM Peak	06:00-07:00	0.92	0.80	-13%
		07:00-08:00	2.22	0.87	-61%
		08:00-09:00	2.80	0.92	-67%
	Mid Day	13:00-14:00	1.78	0.83	-53%
	PM Peak	15:00-16:00	2.02	0.82	-60%
		16:00-17:00	2.08	0.83	-60%
		17:00-18:00	2.22	0.83	-62%

NBD4: Highway 1 from Mountain Highway Interchange to East of Lynn Valley Road Interchange

Table D-0-8 summarizes the travel time data collected by Downtown.AI for the Highway 1 segment between the Mountain Highway Interchange and East of Lynn Valley Road Interchange. This Highway segment also sees improvements in 95th percentile travel times for all study periods except for the hour of 8:00 AM to 9:00 AM. All other periods show minor, but consistent improvements in travel time.

Table D-0-8: 2018/2022 95th Percentile Travel Time (NBD4 OD Pair)

		Hour of the Day	95th Percentile Travel Time (mins)		
			2018	2022	% Difference
NBD4	AM Peak	06:00-07:00	1.82	1.70	-6%
		07:00-08:00	2.40	2.10	-13%
		08:00-09:00	2.55	3.60	41%
	Mid Day	13:00-14:00	2.03	1.85	-9%
	PM Peak	15:00-16:00	1.85	1.78	-4%
		16:00-17:00	1.80	1.78	-1%
		17:00-18:00	1.77	1.73	-2%

D.2 CORRIDOR RELIABILITY ANALYSIS

To determine the travel time reliability of the project area corridor, a formal definition is required. FWHA defines travel time reliability as "the consistency or dependability in travel times, as measured from day-to-day and/or across different times of the day". To determine the magnitude of change in reliability between 2022 from 2018, two FWHA metrics were used to compare the two years.

Planning Time

Planning time is a metric that quantifies the total travel time for the corridor including buffer time. In this case the 95th percentile travel time is reported to ensure that the trip will arrive early or on time 95% of the time.

Planning Time Index

Planning time index is a comparison of the total travel time that should be planned with adequate buffer time, when compared to the free-flow travel time, and is reported as a ratio. The greater the ratio, the more time a traveler needs to budget in comparison to periods of light traffic. Both these metrics capture expected and unexpected delay. Unexpected delay is influential to a traveler's schedule with larger consequences and cause travelers the greatest amount of frustration. For the purposes of defining a period where free-flow speeds are observed along the study corridor, free-flow travel time is specified to be between 1:00 PM to 2:00 PM.

Table D-9 and **Table D-10** present a direct comparison of both study years of the study corridor using median travel time, planning time, and the planning time index, which are broken down into times of the day, for the northbound and southbound directions.

Table D-9: Weekday, Peak Period, Corridor Travel Time Reliability – Southbound Direction

Southbound Direction	Hour of the Day		Median Travel Time (Minutes)		Planning Time (Minutes)		Planning Time Index (Ratio)	
			2018	2022	2018	2022	2018	2022
	AM Peak	06:00-07:00	3.25	3.23	4.23	4.25	1.04	1.05
		07:00-08:00	4.53	3.65	14.73	5.65	3.62	1.39
		08:00-09:00	5.95	3.92	16.57	8.45	4.07	2.08
	PM Peak	15:00-16:00	10.38	9.87	20.95	22.03	5.15	5.42
		16:00-17:00	10.58	9.07	20.97	21.70	5.16	5.34
		17:00-18:00	7.85	5.53	18.83	19.07	4.63	4.69

Table D-10: Weekday, Peak Period, Corridor Travel Time Reliability – Northbound Direction

Northbound Direction	Hour of the Day		Median Travel Time (Minutes)		Planning Time (Minutes)		Planning Time Index (Ratio)	
			2018	2022	2018	2022	2018	2022
	AM Peak	06:00-07:00	3.90	3.68	5.43	4.97	1.31	1.30
		07:00-08:00	4.83	4.13	9.95	5.75	2.41	1.50
		08:00-09:00	5.92	4.37	13.60	7.47	3.29	1.95
	PM Peak	15:00-16:00	4.32	3.85	9.10	5.10	2.20	1.33
		16:00-17:00	4.73	3.90	9.52	5.25	2.30	1.37
		17:00-18:00	5.23	3.93	10.37	5.30	2.51	1.38

Southbound Direction

The planning time, or 95th percentile travel time, has improved significantly in the AM peak period from 7:00 AM to 9:00 AM. The PM peak period shows minor increases in planning time which shows that congestion on the worst days is still considerable in this direction during this period. The median travel time for the study corridor in the southbound direction for 2018 and 2022 were both observed to be 4m 4s from 1:00 PM to 2:00 PM, which is assumed to represent periods of light traffic or free-flow conditions. Travel time reliability is at its worst for the AM peak period in 2018 from 8:00 AM to 9:00 AM, where we see a planning time index of greater than four. This means that four times the free-flow travel time must be budgeted to reliably reach the travellers destination on time. For the same hour in 2022, planning time index is about equal to two. Which means the time a traveller would budget for the commute through this corridor can be halved. During the PM peak period, travel time reliability is at its worst for the PM peak period in 2018 from 4:00 PM to 5:00 PM with an associated planning time index of 5.16. In 2022, during the same hour, the planning time index is marginally worse at 5.34.

Northbound Direction

The planning time (95th percentile travel time) for all hours during the AM and PM peak periods. The median travel time for the study corridor in the northbound direction for 2018 and 2022 was observed to be four minutes and eight seconds and three minutes and 50 seconds during free-flow conditions. In 2018, travel time reliability is at its worst during the hour of 8:00 AM to 9:00 AM with a planning time index of 3.29. The same hour in 2022 sees a planning time index of 1.95, which guarantees on-time arrival with expected and unexpected delays to the 95th percentile by budgeting less than double the free-flow travel time. During the PM peak period, in 2018, travel time reliability is at its worst from 5:00 PM to 6:00 PM with a planning time index of 2.51. This improves considerably to 1.38 in 2022.

Travel Time Reliability Summary

Travel time reliability analysis reviewed the Highway's ability to maintain a robust expected travel time for commuters by limiting unexpected delays. Travel time reliability was found to improve significantly when travelling northbound, however, it was found to change less so for the southbound direction, indicating that the majority of the travel time reliability improvements from the Project resulted in

savings for the northbound direction. Notably, the reliability metrics were observed to improve in the southbound direction during the AM peak periods (**Table D-9** and **Table D-10**).