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HOV access location analysis at Erin Mills Parkway and Highway 403

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HOV ACCESS LOCATION ANALYSIS AT ERIN MILLS PARKWAY AND HIGHWAY 403

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ABSTRACT

High Occupancy Vehicle (HOV) lanes are one the most commonly used methods to reduce the number of vehicles on the road network. HOV provides a faster and reliable option to single occupancy vehicles, thus inducing more people to car pool. The success of HOV lanes depends on the reduction of travel time and increased trip reliability. Therefore, in order to reduce travel time and improve trip reliability this study emphasizes on the HOV access location relative to an access ramp. In this case we have chosen the interchange at Erin Mills Parkway and Highway 403 as a subject of our study. The study was divided into 2 parts, namely the field review and simulation of different options in order to optimize the HOV access location. During the field review it was found that 75% of the vehicles are in a position to enter the HOV lane 200m upstream of the exiting access location. Also, approximately 35% of vehicles were jumping the buffer before the start of the access location. In the second part of the study a total of 6 options were explored using VISSIM micro simulation software. The results of the simulation showed that the access location 200m downstream of the Speed Change Lane with a total access length of 600m is the best option. In addition, it was found that buffer separated HOV lane operate better then HOV lane without a buffer zone. This can be attributed to the increase use of HOV lane for short trips, which increases the traffic volume on the HOV lane.

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GLOSSARY OF TERMS

HOV: This an acronym for "High Occupancy Vehicles"

GP: This is an acronym for "General Purpose" lanes

SOV: This is an acronym for "Single Occupancy Vehicles"

VISSIM: This is a computer program used for traffic simulation

1 INTRODUCTION

The increase in population of urban areas and the subsequent increase in traffic has compelled many cities to seek innovative solution to congestion on roads. The introduction of High-Occupancy Vehicles (HOV) lanes is one of the commonly used means to mitigate congestion. HOV lanes are defined as a specific lane reserved exclusively for high-occupancy vehicle with a specified minimum number of occupants (Abdulhai, 2004). In the late 1960's United States started using HOV lanes and its use has increase ever since (NCHRP Report 414, 1998).

A single HOV lane operating under favorable conditions can double the person-carrying capacity of the whole roadway. In addition, HOV lanes have been found to improve travel time saving, trip reliability, decrease in emission and improved efficiency of the entire network (NCHRP Report 414, 1998).

1.1 Problem Statement

This project addresses the problem of wait time the driver's experiences while waiting in the left most lane to merge into the HOV lane.

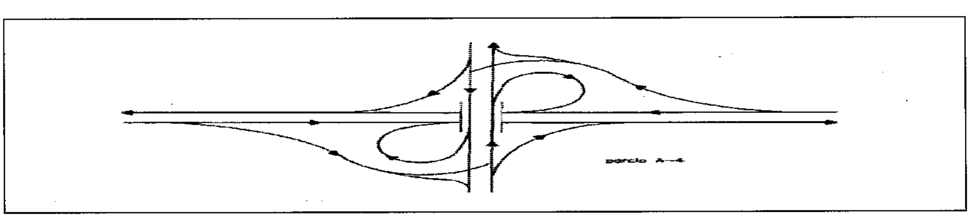
1.2 Research Motivation

Travel time saving is the main incentive for the driver to use HOV lanes. Any reduction in time will motivate more drivers to utilize HOV lanes, thus improving congestion and overall traffic operation.

1.3 Site Characteristics

The subject site of this project is the interchange at Erin Mills Parkway (EMP) and Highway 403 situated in Mississauga, Ontario, Canada. The interchange was built under MTO jurisdiction, therefore the interchange is designated as Parclo A-4 as shown in **Error! Reference source not found.**. Highway 403 is running east to west and EMP runs north and south. Highway 403 contains a single HOV lane on both sides of the highway, however the subject of this study is the east bound traffic using the HOV lane access.

Figure 1: Parclo A-4 - MTO Geometric Design Guide.



1.4 Objective and Sub-objective

The objective of this study is to study HOV access location alternatives at Erin Mills Parkway and Highway 403. The definitive aim is to reduce the travel time between the on ramp and HOV access location.

The sub-objectives of this study include the following:

- The study will provide a stepping stone for designing the access location based on the vehicles readiness to merge into the HOV lane contrary to the existing standards, which are based on weaving zone analysis, distance required by the driver to complete a lane change or a combination of both.

- The will study review removing buffer separation for HOV lane essentially providing unrestricted merging access to the drivers.

1.5 Scope

The scope of this study is limited to EMP and Highway 403 Interchange east bound traffic. In particular the traffic coming from the S-E onramp at EMP is considered as critical. Any reduction in the travel time for S-E onramp traffic to HOV lane would be the basis of success for this study.

An interchange cannot be studied in isolation because it is a part of an interconnected/dependent system of roads, upstream and downstream traffic. Thus the simulation model is setup to include the whole east bound Highway 403 traffic and crossing road interchange system.

1.6 Project Significance

The success of an HOV lane system depends on the reduction in travel time and trip reliablity. The wait time in the left most lane adjecent to HOV lane is a significant waste of time for HOV lane users. During the field review almost 35% of the vehicles jumped the buffer zone before the access location, this shows driver frustration. Hence, if the HOV access location can be optimized to reduce the wait time in the left most lane, a significant travel time saving can be achieved without substantial capital investment.

2 METHODOLOGY

The traffic analysis was divided into two parts. The first part consisted of collecting information in the field and analyzing for relevant information. The second part consists of VISSIM simulation model to analyze various scenarios.

2.1 Field/Visual Methodology

The traffic was video recorded on 3 separate occasions during the morning Peak Period. The location of the camera was on top of the Mississauga Road Bridge, which provides a ideal vantage point to analyze all the traffic activity, specifically the traffic merging from EMP S-E and N-E Ramp. The video was used to extract the following information:

i) The average speed was calculated by measuring the travel time between 2 predetermined existing features on the road. Using mapping tools the distance between the two predetermined points was calculated and multiplied by the travel time. This procedure was repeated every 5 minutes for random vehicles.

ii) The time spent by HOV's in the left most lane was determined by using a stop watch and tracking each vehicle from the S-E ramp. As previously mentioned the S-E access ramp traffic is assumed to be critical because it is closest to the HOV access location.

iii) The location at which the vehicle was in a position to enter the HOV lane but could not do so because of the buffer zone was calculated by finding the vehicle location relative to the exiting feature of the highway. The distance of the vehicle relative to the exiting feature was added to the distance between the predetermined existing feature and the access location. This calculation is in the accuracy range of 10 to 20m of the real location.

iv) The number of buffer violation by vehicles jumping the buffer zone to enter the HOV lane was observed. Although this was not a part of the scope of the project the observation is significant with respect to the HOV access location. The high number of buffer violation points toward driver frustration for not being able to enter the HOV lane earlier.

2.2 Simulation Methodology

The simulation model was setup in VISSIM modeling software. VISSIM was chosen for its user friendly dynamic assignment feature, which allows the model to simulate different types of vehicles such as HOV, Heavy Vehicles and Single Occupancy Vehicles.

Using the base mapping the network was drawn and all the links were established. Using the lane closure tool access to the HOV lane was limited to only HOV's. Furthermore the left most lane was closed to heavy vehicle traffic. The file was modified accordingly for various scenarios.

In order to use the dynamic assignment tool, separate Origin Destination (OD) matrixes were created for Single Occupancy Vehicles (SOV), High Occupancy Vehicles (HOV), and Heavy Vehicles (HV). The simulation was carried out over the peak period. The intention was to get a complete picture of the traffic behavior at various congestion and speed levels particularly peak hour and shoulder peak hour.

3 LITERATURE REVIEW

The literature review conducted emphasized on a combination of practical experience from existing HOV facilities around North America, traffic modeling conducted relevant to the subject and practical experience gathered over the years. In addition, the current standards were reviewed and the bases of these standards were analyzed.

3.1 Long Island Expressway and New York Department of Transportation (NYDOT)

The Long Island Expressway (LIE) is one of the first locations in the world where a dedicated HOV lane was implemented. The LIE has a median buffer separated HOV lane. The interchanges are spaced closely at 1.6km resulting in each access and egress location serving two interchanges. There are no acceleration or deceleration lanes provided in this corridor. The vehicles entering or exiting the expressway merge or diverge using the right through lane. The LIE uses speed change lanes to channel traffic between GP lanes and HOV lanes. This limits the use of the access and egress zone to one direction only. In most cases the distance per lane change is between 350 to 450m ranges, with no vehicle using less then 350m per lane change.

The NYDOT design manual recommends using the Highway Capacity Manual weaving analysis method to determine the location of access/egress location. There are no general guidelines included in the NYDOT design manual with regards to HOV lane design. There are some regional authorities who have developed their own guidelines for example Region 10 of NYDOT suggests that a distance of 400m per lane change is recommended for the location of access/egress location and that distance equal to or less then 270m puts pressure on the vehicles (Thornewell, 2001).

3.2 California Transportation (Caltrans) and US Department of Transportation (USDOT)

Caltrans HOV design manual was published in 1991. It is also the standard manual for USDOT. California has extensive network of buffer separated HOV lanes, which are of particular interest to this study because the understudy HOV lanes are also buffer separated. Caltrans design recommends a standard 300m per lane change for both access/ egress locations with interchange spacing of 1.6km. However, through experience designer found that 300m per lane change results in weaving zone encroaching into the access/egress location of the next interchange. The standard was thus changed to 150m per lane change.

In 2002, a Task Force comprising of Caltrans HOV district coordinators and others, reviewed the standards for HOV lanes. The task force recommended that the weaving zone be lengthened to 300m per lane change. The reason for the change was reported that through experience some drivers find it difficult to negotiate the complete weaving across all the lanes under current standards. Consequently, 300m per lane change from the 2m bull-nose is current standard for Caltrans (MRC, 2003).

Orange County Transportation Authority (OCTA) conducted a study to evaluate buffer seperated HOV lanes. OCTA and Caltrans maintains 24hour and peak hour HOV lanes. The 24hours HOV lanes are buffer seperated and the peak hour HOV lanes are contineous access without a buffer. A 4ft buffer seperation was introducted after provision of SB 699 in 1987. The reason for providing the buffer was to maintain the reliablity of service. Also, the buffer is intented to stop cars from jumping infront of higher speed HOV traffic from the slow speed GP lanes.

The study did not find any major difference in safety, operation, and improvement of level of service between buffer separated and continuous HOV lanes. The cost in case of buffer separated HOV lanes is significantly higher as it requires the widening of the pavement and additional ROW in some cases. Retaining the buffer separation might be viable if there is a possibility of HOV lanes being used for Bus Rapid Transit (BRT) (P.B Inc., 2002).

A study conducted in 2004 by the Southern Californa Government studied barrerier and buffer seperated HOV lanes. The study found that on average 36% of carpoolers in Orange County and 33.9% of carpoolers in San Bernardino were not availing HOV lanes. Both locations have buffer seperated HOV lanes . Where as San Francisco Bay Area is utilizaing continuous access HOV lanes, with a 20.2% of carpoolers observed outside the HOV lanes. This relatively large difference of utilazation was attributed to the 2+ occupancy policy and limtied access to the HOV lanes. In case of limited access the drivers are discouraged to use HOV lanes for short trips, which intern reduces unnecessary congestion of HOV lanes (SCAG, 2004).

3.3 Highway 401- Ministry of Transportation Ontario, Canada

Highway 401 HOV lanes being managed by MTO with two sided weaving (both access and egress from the same location) occurring in less than 200m per lane change. There are a few locations where the weaving is being accomplished in 140 – 150m per lane change. However MTO staff considers a shorter weaving length as undesirable operational condition (MRC, 2003).

3.4 Human Factors/Ergonomic Analysis

A study conducted by MTO and Totten Sims Hubicki (TSH) in 2003 suggested that according to human factor studies most drivers require up to 10 seconds to execute a lane change. Therefore, at a posted speed of 100km/h (27.7 meters/second) a driver requires 278m to complete a lane change maneuver. The study concluded that 300m per lane change is in conformance with the human factor principals (TSH, 2003).

Zohar and Toledo, used eastbound section of I-80 in Emeryville, California to study lane change behavior. The left most lane of the I-80 is an HOV lane and the section observed had length of 899m. The study concluded that during off peak duration a driver executes a lane change maneuver in approximately 9.7second and during peak hour the time for lane change maneuver increases to 13.3 seconds (Zohar, 1999).

The field review for this study showed that the average speed of highway 403 during the peak flow duration was approximatly 50km/h (13.8m/s). Using 13.3 seconds per lane change and an average speed of 13.8m/s the distance per lane would be 180m. Thus it would take a vehicle coming from the S-E ramp at EMP 720m to enter the HOV lanes. Subtracting 500m of the entry ramp length, a vehicle would need an added length of 220m from the end of SCL of the access ramp.

3.5 VISSIM Simulation Model (Texas)

The State of Texas has extensive network of mostly barrier seperated HOV lanes. In 2002 the Texas Transportation Institute used VISSIM computer simualtion models to study more then 2000 combination and operational options for HOV access. The weaving included 5 GP lanes for the proposed and 3 GP lanes for the existing condition. The results are valid for 10% heavy vehicles. The results of the research are as follows:

Table 1: Summary of VISSIM Model (Texas)

Level of Service	Allow upto 10 mph Mainline Speed Reduction for Managed Lane Weaving	Intermediate Ramp (between freeway entry/exit and managed lane entry/exit)	Recommended Mimimum Weaving Distance per lane (meters)
Medium (LOS C or D)	Yes	No	152
		Yes	183
	No	No	213
		Yes	228
High (LOS E or F)	Yes	No	183
		Yes	198
	No	No	274
		Yes	289

Table 1 illistrates that 300m per lane change satisfies all traffic scenarios and that 225 meets all the criateria with the exception of last most restrictive two conditions in the table.

In addition the reserachers noted that the waving methodology decribed in Highway Capcity Manual is not appropriate for complex weaving situations and modelling software CORSIM and INTEGRATION lack the functionality of real time control and dynamic assignment for various vehicle classes (MRC, 2003) (B. Khun, 2002).

3.6 MTO Field Review

In 2003 MTO staff conducted field reviews in order to study the merging behavior of vehicles from an onramp during congested conditions. The review found that over half of the entering vehicles merge into the through lane within 125m of the merge point, and few vehicles use the 500m standard entry ramp length. It was noted that HOV lane users would have clear incentive to merge earlier rather in order to shift over to the left side HOV lane.

The field review confirmed that 300m per lane change guideline would be adequate for majority of the users even under congested conditions. However MTO proposed an additional length of 125m from the end of the gore for margin of safety. Hence the 300m per lane change will be measured 125m downstream from the gore location. These standards were adopted as the MTO recommended best practice for Ontario by MTO Central Region Executive, Management and Staff in January 2003 (MRC, 2003).

3.7 Analysis of Literature Review

In the above literature review it is interesting to note that there have been no significant studies conducted using micro simulation software especially for buffer separated HOV lanes. The study conducted by MTO using INTEGRATION software had limited scope. Also an extensive study carried by Texas Transportation Institute for barrier separated HOV lanes noted that INTEGRATION does not have the functionality to take into account the verity of vehicles classes to achieve reliable results.

Buffer separated HOV lanes are a major undertaking in terms of construction costs, traffic operational measures, and ROW acquisition (if required), yet the writer could not find any study were there is an in depth analysis of buffer separated HOV's versus buffer less HOV lanes. The main argument for implementing a buffer separated HOV lanes is that it improves safety and drivers sense of security, but studies have shown these concerns to be unwarranted (Ranft, 2006).

4 ANALYSIS OF STUDY RESULTS

The study was divided into 2 parts. The first part of the study was conducted by analyzing the traffic characteristics in the field and the second part included the simulation of selected options using VISSIM software. The results of the study are as follows:

4.1 Field Review

The field data was collected on 2 separate occasions. All information was collected in the month of April 2008. The weather conditions for the reviews was clear, dry and sunny, hence there were no weather related impediments for the traffic.

The observations made during the field review are as follows:

- A vehicle coming from the S-E ramp can spend from 30 to 50 seconds in the left most lane before merging into the HOV lane. The highest time spent in the left most lane is 56 seconds, (Table 4).
- Approximately 72% of the vehicles are in a position to merge into the HOV lane 200m upstream of the existing access location (Table 2).
- The average distance at which the vehicle is in a position to enter the HOV lane is 278m upstream of the HOV access.
- As shown in Table 3 approximately 35% of the vehicles where jumping the buffer separation before reaching the access point. This is considerably higher than the 10-15% (SCAG, 2004) acceptable level.
- The vehicles jumping the buffer zone forces the HOV vehicles to reduce speed because of the speed differential between the high speed HOV and the lower speed GOP vehicles.
- The HOV's weaved through the traffic using a shorter distance to position themselves in the left most lane as compared to the GP traffic where vehicles used a longer weaving length. It is interesting to note that most HOV's using the shorter weaving length can find gaps in traffic easily without compromising safety.

Table 2: Location of vehicles relative to HOV access location

Vehicles >100 (m)	Vehicles >200 (m)	Vehicles >300 (m)	Vehicles > 400 (m)	Vehicles 100 to 200 (m)	Vehicles 200 to 300 (m)	Vehicles 300 to 400 (m)	Vehicles 400 to 500 (m)
82.46%	71.93%	36.84%	19.30%	10.53%	35.09%	17.54%	19.30%

Table 3: AM Peak Period – Summary of traffic characteristics while entering HOV

Time Period	Mainline Speed (km/h)	HOV Speed (km/h)	No. of Vehicles Entering HOV lane	No. of Vehicles v Violating HOV Buffer	% of Vehicles Violating Buffer
7:30 - 7:35	77.9	81.6	9	4	44
7:35 - 7:40	52.3	102.2	16	3	19
7:40 - 7:45	69.8	77.9	11	2	18
7:45 - 7:50	64.2	123.3	11	6	55
7:50 - 7:55	58.9	103.6	14	6	43
7:55 - 8:00	7.5	67.1	11	3	27
8:00 - 8:05	47.7	121.3	14	2	14
8:05 - 8:10	31.5	91.8	10	10	100
8:10 - 8:15	24.0	84.3	14	3	21
8:15 - 8:20	66.3	84.3	17	3	18
8:20 - 8:25	53.7	77.1	12	7	58
8:25 - 8:30	45.0	85.6	11	9	82
8:30 - 8:35	34.5	69.1	9	5	56
8:35 - 8:40	45.9	96.9	14	4	29
8:40 - 8:45	48.8	91.8	13	0	0
8:45 - 8:50	58.6	98.2	20	2	10
8:50 - 8:55	67.9	99.5	11	5	45
8:55 - 9:00	62.0	102.2	7	3	43
9:00 - 9:05	36.3	94.5	8	2	25
9:05 - 9:10	60.0	98.2	5	4	80
9:10 - 9:15	8.6	68.5	7	1	14
9:15 - 9:20	32.5	91.8	5	2	40
9:20 - 9:25	53.4	97.8	11	2	18
9:25 - 9:30	62.0	102.2	8	3	38
9:30 - 9:35	56.3	107.0	11	1	9
9:35 - 9:40	55.7	115.1	10	1	10
Average	**49.3**	**93.6**			**35%**

Table 4: Field Data Summary

Vehicle #	Time	Time for 85m		Traffic Speed		Distance to Access Location (m)	Travel time in left most lane (s)
		GP (s)	HOV (s)	GP (km/h)	HOV (km/h)		
1	8:02:00	7.00	3.88	44	79	120	10.35
2	8:03:00	7.38	3.60	41	85	80	6.30
3	8:03:00	8.30	3.66	37	84	490	32.00
4	8:03:00	7.80	3.80	39	81	490	48.63
5	8:03:00	7.66	3.75	40	82	300	31.69
6	8:03:00	7.70	4.22	40	73	380	41.57
7	8:03:00	7.77	4.10	39	75	300	32.47
8	8:04:00	6.30	4.20	49	73	300	22.95
9	8:04:00	6.00	4.60	51	67	380	48.00
10	8:05:00	7.47	4.09	41	75	380	38.09
11	8:05:00	10.97	4.53	28	68	80	10.97
12	8:00:00	10.30	4.61	30	66	0	0.00
13	8:05:00	15.25	3.93	20	78	300	45.28
14	8:06:00	18.29	4.41	17	69	240	42.35
15	8:08:00	4.94	4.00	62	77	240	16.59
16	8:08:00	5.41	3.03	57	101	490	23.40
17	8:09:00	4.90	3.70	62	83	240	13.56
18	8:11:00	6.78	3.41	45	90	80	13.22
19	8:12:00	7.16	3.90	43	78	240	40.97
20	8:00:00	6.55	3.40	47	90	0	0.00
21	8:12:00	6.50	3.19	47	96	155	13.00
22	8:13:00	5.90	3.13	52	98	120	7.69
23	8:17:00	5.35	3.37	57	91	380	22.16
24	8:17:00	6.09	3.19	50	96	380	24.16
25	8:17:00	6.10	3.18	50	96	0	0.00
26	8:17:00	5.40	3.31	57	92	490	30.39

Vehicle #	Time	Time for 85m		Traffic Speed		Distance to Access Location (m)	Travel time in left most lane (s)
		GP (s)	HOV (s)	GP (km/h)	HOV (km/h)		
27	8:19:00	11.40	3.78	27	81	155	23.97
28	8:19:00	7.91	3.78	39	81	240	15.37
29	8:19:00	11.09	4.22	28	73	155	12.37
30	8:00:00	8.54	3.98	36	77	0	0.00
30	8:22:00	7.91	3.50	39	87	490	29.33
31	8:26:00	4.97	3.50	62	87	300	16.23
32	8:26:00	6.56	3.50	47	87	240	16.79
33	8:26:00	6.56	3.44	47	89	80	5.53
34	8:28:00	5.00	2.75	61	111	155	3.50
35	8:29:00	7.16	3.00	43	102	240	19.34
36	8:30:00	5.41	3.34	57	92	80	6.15
37	8:31:00	6.15	3.20	50	96	240	16.72
38	8:35:00	5.88	3.34	52	92	300	18.55
39	8:36:00	5.10	3.50	60	87	490	29.75
40	8:38:00	5.56	3.25	55	94	490	22.94
41	8:38:00	4.47	3.59	68	85	300	15.06
42	8:39:00	5.15	3.69	59	83	300	13.65
43	8:39:00	5.15	3.22	59	95	300	19.16
44	8:42:00	11.25	3.90	27	78	490	56.94
45	8:44:00	5.50	3.34	56	92	490	21.50
46	8:46:00	5.40	4.30	57	71	380	20.85
47	8:46:00	4.41	3.84	69	80	340	16.34
48	8:47:00	4.41	3.06	69	100	340	19.23
49	8:49:00	5.97	2.94	51	104	80	5.97
50	8:51:00	4.44	2.75	69	111	240	11.81
51	8:52:00	4.41	3.53	69	87	300	15.44
52	8:54:00	4.62	3.30	66	93	490	20.71
53	9:01:00	4.03	3.10	76	99	490	19.81

Vehicle #	Time	Time for 85m		Traffic Speed		Distance to Access Location (m)	Travel time in left most lane (s)
		GP (s)	HOV (s)	GP (km/h)	HOV (km/h)		
54	9:03:00	3.54	2.97	86	103	380	17.91
55	9:04:00	7.53	5.10	41	60	240	12.21
56	9:05:00	3.35	3.00	91	102	380	18.01
Average				50.17	86.29	278.07	21.83

4.2 Simulation

Based on the objectives of the study and previous research performed 6 options were selected for the actual simulation. The options were selected such that they cover a broad range of traffic conditions.

i) **Option-1:** Do nothing; Thus maintaining the existing conditions of 400m downstream of the S-E Ramp Speed Change Lane (SCL).

ii) **Option-2:** Move the start of access location upstream to the end of SCL without changing the total length (400m) of access.

iii) **Option-3:** The access location was stretched upstream to the end of taper, while maintaining the end point at the existing location, which gives a total access length of 700m.

iv) **Option-4:** No restriction on access to HOV lane, the HOV's can enter or exit without any designated location and restriction of access location.

v) **Option-5:** The length of HOV access lane is increased to 600m and the start of access is at 200m downstream of SCL.

vi) **Option-6:** The length of HOV access lane is increased to 700m and the start is located 100m downstream of SCL.

4.2.1 Option-1: Do Nothing

In this option the existing condition is simulated to observe the current behavior of traffic. This option will serves as a bench mark for any recommended improvements to the access location at the HOV lane. The following observations were made during the simulation of existing conditions.

- The HOV lane is flowing considerably better than GOP lanes.

- Due to the bottle neck at the EMP S-E Ramp the travel time from N-E Ramp is high.

- As shown in Table 5 the travel time for HOV is notably lower than GOP lanes. This shows that HOV lane under existing condition is a better alternative for the drivers. However the vehicles coming from the on-ramps have to spend a significant amount of time in the slow GOP lanes waiting for the access location before merging into the HOV lane.

- On closer observation during simulation most vehicles are in a position to merge into HOV lane approximately 150 to 200m upstream of the existing access location.

Table 5: Option-1 Travel Times

Vehicle Type	ALL		HOV		HOV		HOV	
Name	**Mainline GP lanes**		**Mainline HOV lane**		**N-E Ramp to HOV I/E**		**S-E Ramp to HOV I/E**	
Time (s)	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**
300.0	95.8	165.1	88.6	41.0	94.3	6.7	77.9	3.7
600.0	141.7	409.5	89.5	97.6	187.3	7.0	136.4	3.2
900.0	157.6	409.0	88.7	94.8	273.5	9.3	142.5	4.7
1200.0	163.5	416.1	88.4	93.6	306.4	7.9	135.3	4.1
1500.0	166.9	388.4	87.7	88.8	307.5	9.0	137.0	6.0
1800.0	195.2	327.1	88.1	86.7	304.7	11.0	140.4	5.5
2100.0	274.4	241.3	87.8	90.0	327.2	9.0	142.0	5.6
2400.0	398.7	234.5	87.8	87.6	375.2	6.3	190.7	3.2
2700.0	526.6	234.8	87.9	81.6	508.4	5.2	271.0	2.0
3000.0	603.5	233.6	87.4	72.5	672.9	4.8	324.8	2.3
3300.0	658.7	238.9	86.6	66.2	740.8	4.3	356.9	3.6
3600.0	686.4	248.0	87.8	67.0	634.3	6.4	358.7	4.3
3900.0	683.0	247.3	87.3	67.7	699.1	7.1	333.9	4.3
4200.0	673.1	244.4	87.7	68.6	702.7	8.3	292.7	4.3
4500.0	677.8	251.2	86.9	67.0	706.9	6.2	331.0	5.8
4800.0	651.0	265.6	86.8	65.5	693.6	7.1	320.7	4.5
5100.0	619.2	262.3	87.8	66.6	653.9	7.5	331.5	5.3
5400.0	606.2	273.1	88.0	69.2	608.7	7.2	307.5	6.2
5700.0	586.1	267.1	87.3	67.6	603.9	9.4	267.1	4.8
6000.0	574.1	267.4	87.2	69.2	618.4	6.3	287.2	5.8
6300.0	570.8	278.2	86.9	70.2	613.5	6.6	271.3	3.9
6600.0	552.3	274.7	86.6	70.4	592.8	6.3	287.4	6.1
6900.0	537.2	272.4	87.7	73.5	578.8	10.8	277.8	8.0
7200.0	550.2	263.8	87.5	65.8	568.0	7.1	278.6	6.0
Average	**472.91**		**87.67**		**515.53**		**250.01**	

Figure 2: Option-1 Speed Profile Shoulder Hour

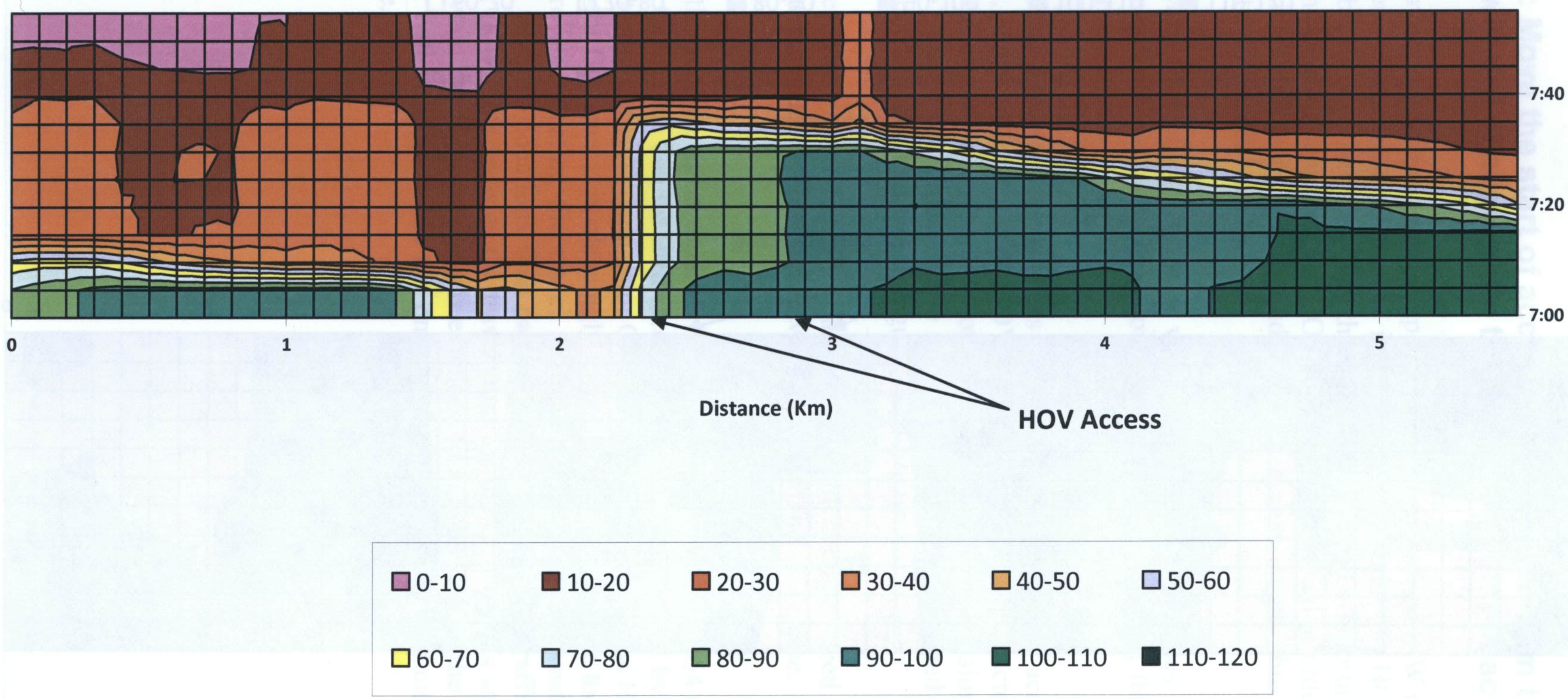
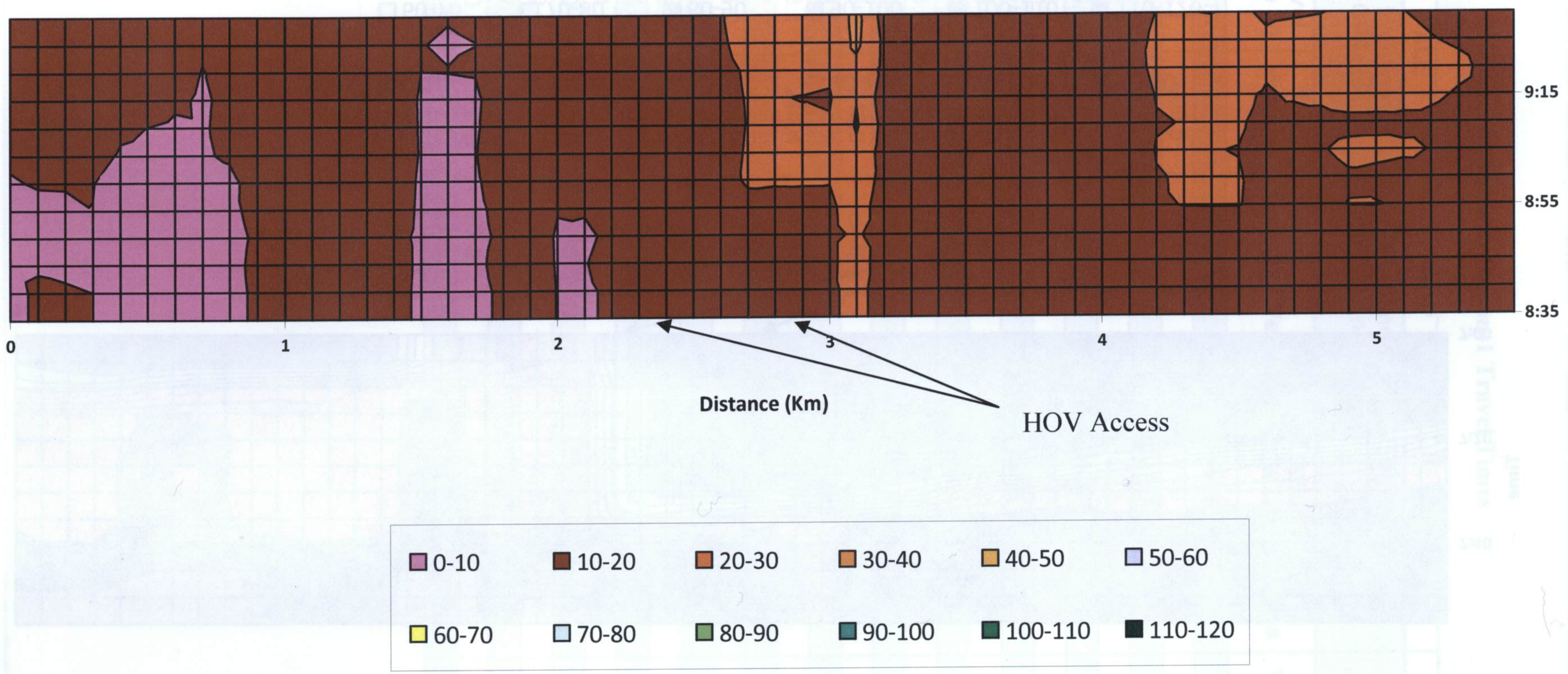


Figure 3: Option-1 Speed Profile Peak Hour



4.2.2 Option-2: Move the start of access location upstream to the end of taper without changing the total length (400m) of access.

The premise of moving the access location upstream to the end of the S-W ramp SCL is to find the location where most divers are in a position to enter the HOV lane and whether they are able to negotiate their way through the traffic and comfortably enter the HOV lane. Also, the existing length of the HOV lane was maintained in order to observe the number of vehicles that would go beyond the HOV access length, thus, finding the start and end limit of the access lengths.

- From the very start of simulation it was clear that some vehicles were having trouble to negotiate the traffic and could not avoid overshooting the end of the access location.

- As the volumes increased the vehicles overshooting the length of access location would stop, and wait for a gap in HOV traffic to enter. This impacted the traffic upstream and created a temporary bottle neck similar to a collision blocking a single lane. These temporary bottle necks over time propagated to create a permanent bottle neck as shown in Figure 2 and Figure 5.

- The vehicles which enter the HOV lane reduces the average speed of the HOV lane because the speed differential between the GOP and HOV lane.

- In Table 7 the average travel time for HOV lane has increased by 54 seconds, this increase in travel time can be attributed to the bottle neck created by lower speed vehicles entering the HOV lane from GOP lanes. In contrast to the HOV lane the travel time for GP lanes is misleadingly lower. This is because the location where the software is collecting the travel time lies significantly downstream of the access and on ramp locations thus passed the bottle neck the traffic is running almost free flow. This reduces the travel time for the GOP in this small segment of the highway, but if the analysis is extended to a larger part of the corridor, the bottle neck will back up traffic not only on the highway but also on to the EMP interchange.

Table 6: Option-2 Travel Times

Vehicle Type	ALL		HOV		HOV		HOV	
Name	**Mainline GP lanes**		**Mainline HOV lane**		**N-E Ramp to HOV I/E**		**S-E Ramp to HOV I/E**	
Time (s)	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**
300.0	106.3	107.3	103.7	26.1	100.3	5.4	79.5	2.6
600.0	206.0	285.3	129.4	95.7	205.2	6.6	178.1	2.4
900.0	283.5	307.6	126.8	85.9	345.1	4.4	150.2	2.3
1200.0	302.0	292.3	134.4	84.5	441.5	6.2	211.4	3.4
1500.0	316.1	285.6	139.1	68.2	467.4	4.7	234.3	4.2
1800.0	323.2	288.0	138.4	73.8	474.7	6.2	231.1	4.2
2100.0	340.3	253.6	145.4	69.4	488.1	7.7	221.1	5.0
2400.0	368.1	262.8	146.8	70.1	510.4	8.9	256.1	4.9
2700.0	354.6	269.6	143.7	68.8	520.5	7.4	239.9	5.2
3000.0	350.3	261.9	145.6	69.9	504.7	9.7	255.9	3.5
3300.0	346.1	270.9	143.2	75.7	502.1	10.0	252.8	3.8
3600.0	349.2	265.2	142.8	70.3	496.1	8.5	247.9	3.6
3900.0	351.5	265.1	147.2	67.5	498.7	7.8	248.8	3.7
4200.0	354.3	262.0	144.7	75.4	486.2	9.4	239.5	3.2
4500.0	353.1	267.1	148.4	70.3	485.7	6.9	227.4	4.5
4800.0	345.8	266.0	142.6	68.0	481.5	6.6	251.3	4.5
5100.0	350.5	259.7	144.7	71.3	499.9	7.0	244.4	5.6
5400.0	369.3	248.6	143.9	70.3	508.3	7.1	237.0	3.8
5700.0	389.0	246.1	144.2	74.3	500.3	7.1	252.2	5.9
6000.0	401.4	254.6	145.3	67.6	523.4	6.2	246.5	4.4
6300.0	402.2	247.3	146.1	69.0	524.8	6.1	250.1	5.0
6600.0	425.4	256.5	148.8	70.5	527.9	8.5	246.9	5.0
6900.0	425.4	255.6	148.8	68.4	519.0	7.0	264.0	5.1
7200.0	430.3	258.8	154.0	69.4	521.1	7.9	254.3	5.8
Average	**343.5**		**141.6**		**463.9**		**230.0**	

Figure 4: Option-2 Speed Profile Shoulder Hour

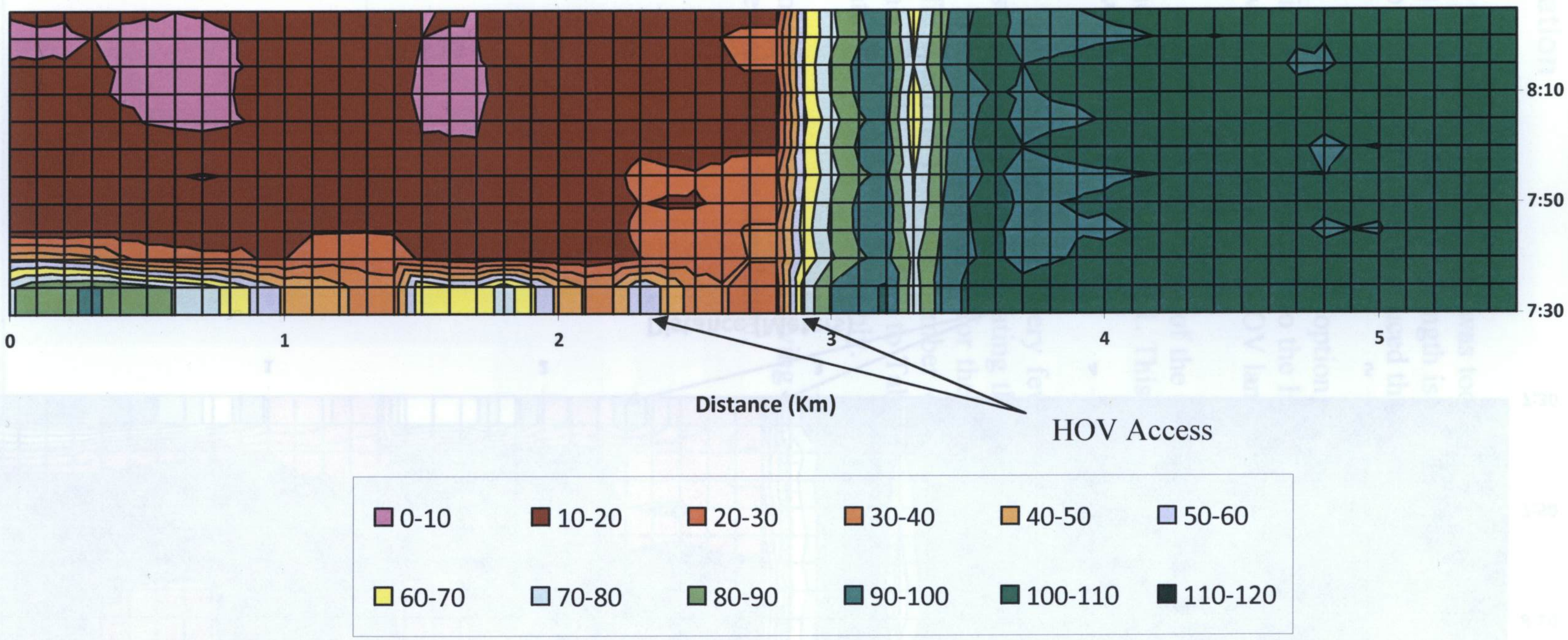
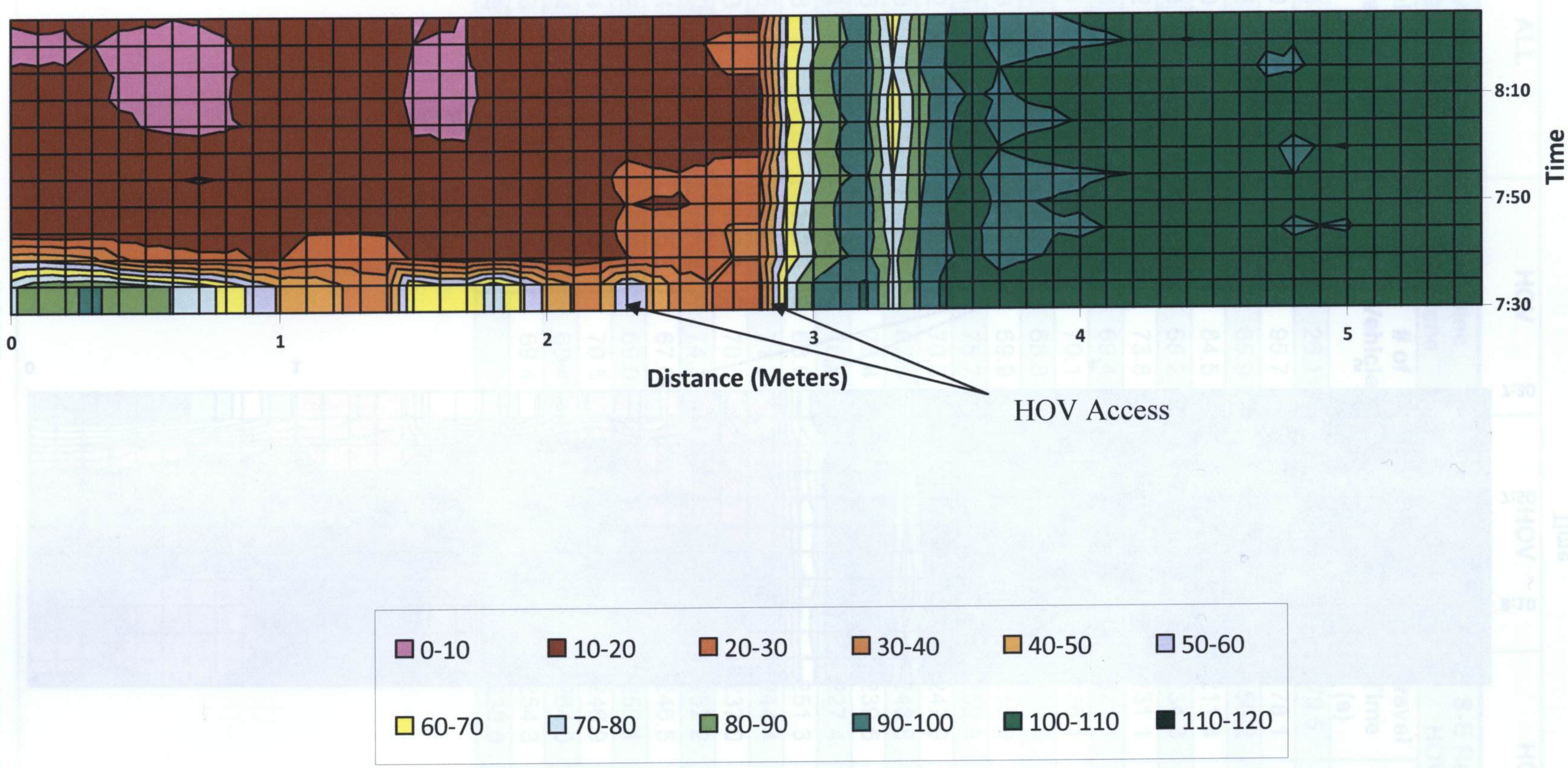


Figure 5: Option-2 Speed Profile Peak Hour



4.2.3 Option-3: the access location was stretched upstream to the end of SCL, while maintaining the end point at the existing location

In option 2 the length of the access was too short resulting in a bottle neck. Therefore to remove this bottle neck the access length is increased to 800m starting from the SCL at at S-E onramp. This modification produced the following results:

- The bottle neck produced in option 2 is resolved and the vehicles appear to have sufficient length to merge into the HOV lane. Also the effect of speed differential between the GOP lane and HOV lane has been reduced.

- The overall traffic operation of the corridor is significantly improved from option 2 and also relative to option 1. This is reflected in the improvement of travel time shown in Table 7.

- The simulation shows that very few vehicles avail the first 100m of the access. Most vehicles are still negotiating the traffic in the GOP lanes or are looking for a gap in the HOV lane traffic for the first 100m of the access. However, when the traffic speed is low, the number of vehicles availing the first 100m becomes higher. In addition according to Table 7 the travel time from N-W ramp to access location is reduced considerably.

- A minor over lap of the weaving length between on ramps of N-E and S-E is observed during the simulation.

Table 7: Option-3 Travel Time

Vehicle Type	ALL		HOV		HOV		HOV	
Name	Mainline GP lanes		Mainline HOV lane		N-E Ramp to HOV I/E		S-E Ramp to HOV I/E	
Time (s)	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles
300.0	95.7	165.6	88.4	40.9	94.5	6.9	75.6	3.5
600.0	140.0	411.8	89.4	98.1	185.8	8.1	130.7	2.6
900.0	161.9	404.3	88.3	95.3	263.0	7.9	138.3	5.8
1200.0	164.9	410.3	88.2	91.2	302.3	10.3	141.5	4.3
1500.0	162.1	411.2	87.9	89.4	285.2	10.2	141.7	4.9
1800.0	183.1	346.3	88.1	89.6	294.9	11.0	138.4	5.6
2100.0	257.4	245.9	87.2	88.2	301.2	10.8	150.2	6.2
2400.0	378.4	240.7	88.1	89.3	332.4	6.7	186.7	4.1
2700.0	487.2	240.6	87.7	82.0	504.0	4.0	239.0	1.4
3000.0	581.7	246.9	87.8	78.4	627.2	4.1	338.1	2.5
3300.0	633.0	255.0	86.8	66.1	670.7	5.2	317.4	4.2
3600.0	643.0	248.8	87.7	72.3	658.9	5.7	317.4	4.8
3900.0	649.9	246.2	87.5	70.3	642.1	8.1	300.8	4.9
4200.0	654.4	243.9	87.2	67.1	650.3	8.9	276.3	3.1
4500.0	651.6	244.1	86.7	65.2	659.6	7.0	324.8	4.1
4800.0	656.3	265.6	86.9	64.9	676.8	5.4	283.0	4.4
5100.0	627.1	259.5	87.2	71.4	657.5	5.1	300.8	7.2
5400.0	614.6	267.0	86.9	65.5	646.9	8.6	285.6	5.6
5700.0	599.7	264.4	87.4	72.1	547.7	6.9	289.7	5.3
6000.0	591.5	260.8	87.4	66.6	617.0	8.3	304.2	4.2
6300.0	587.2	272.7	86.2	70.3	610.5	6.8	278.9	4.5
6600.0	582.4	262.1	87.6	71.3	607.4	8.1	259.3	5.8
6900.0	580.3	258.0	88.0	71.6	583.3	8.6	269.8	7.1
7200.0	600.2	247.8	87.5	67.9	537.2	6.1	311.4	4.2
Average	**470.2**		**87.6**		**498.2**		**241.7**	

Figure 6: Option-3 Speed Profile Shoulder Hour

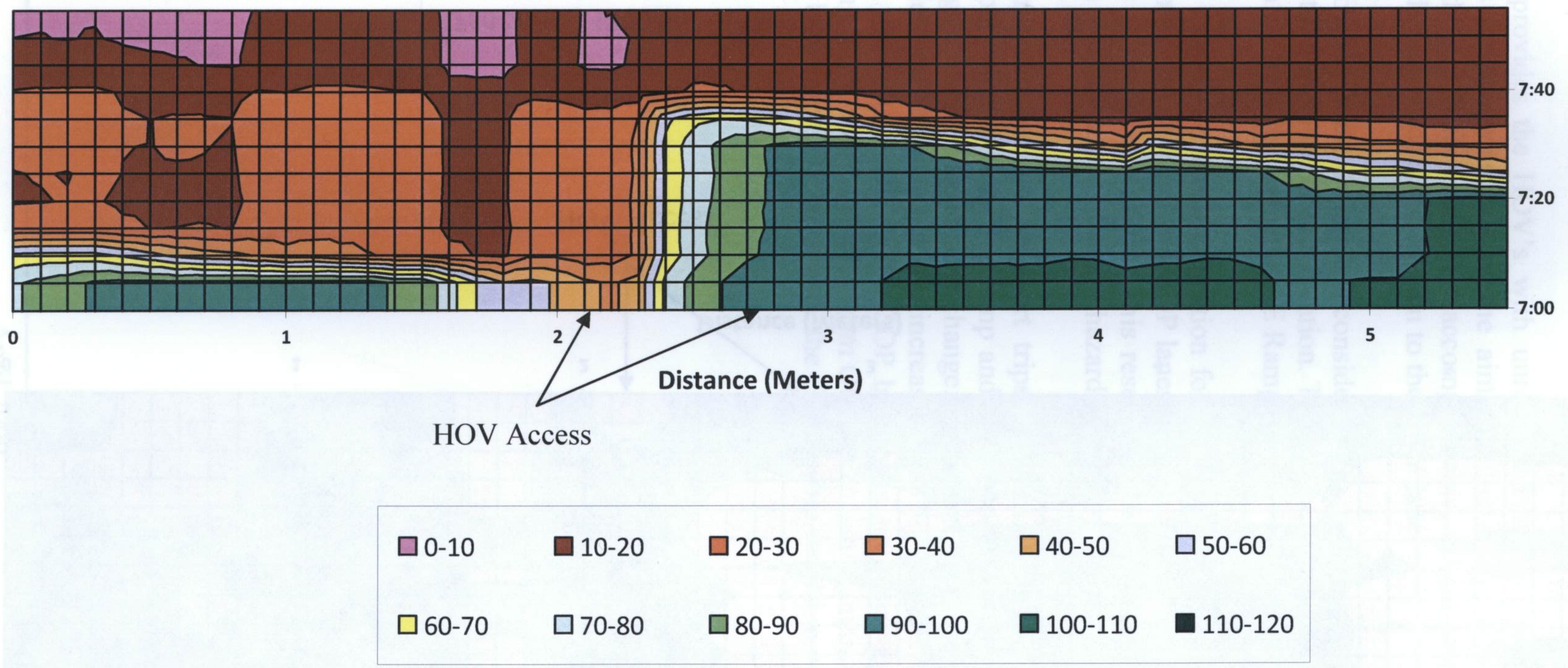
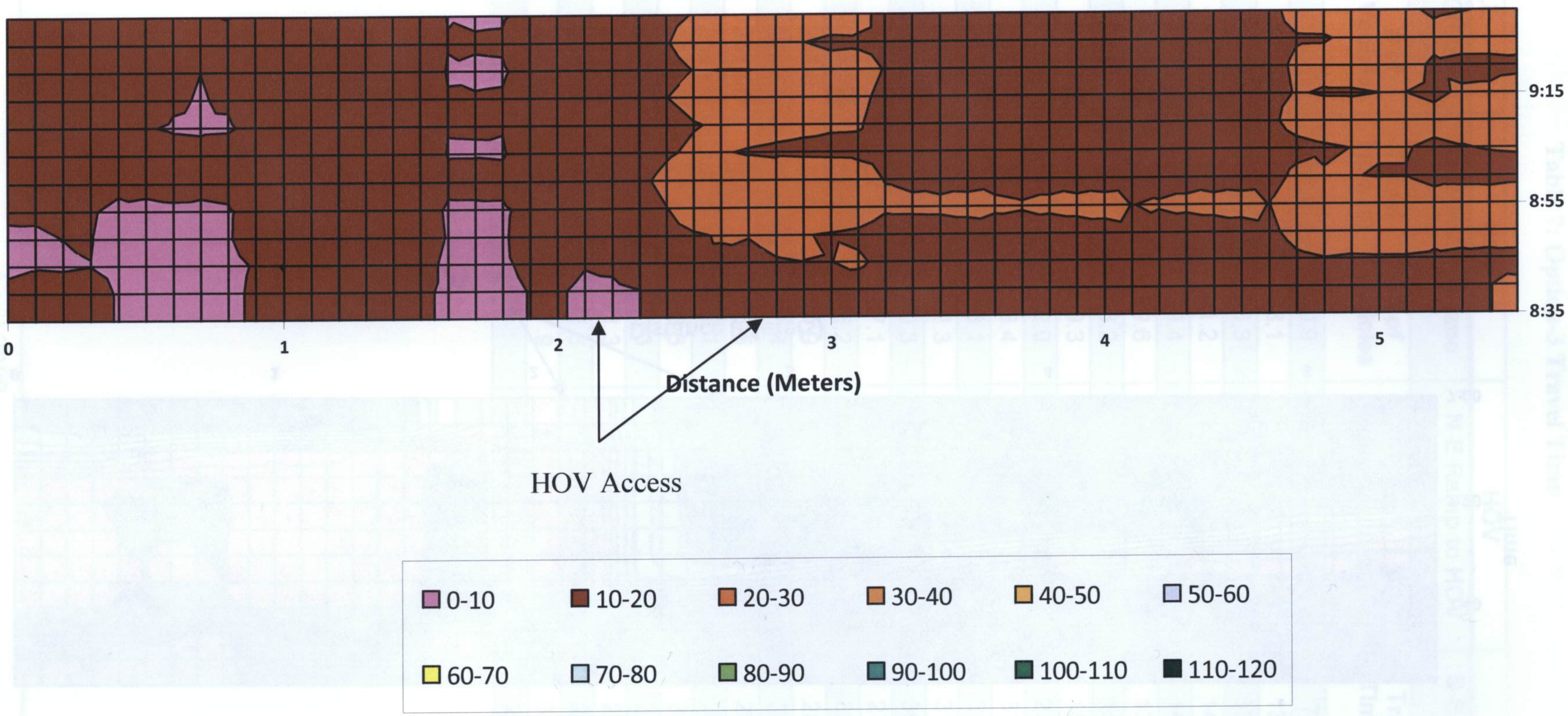


Figure 7: Option-3 Speed Profile Peak Hour



4.2.4 Option-4: No restriction of access location to HOV lane

This option provides the HOV's with unrestricted access without designated access locations. As stated earlier one of the aims of this study is to examine the HOV's operating without a buffer zone. To accomplish this, a long stretch of Hwy 403 was simulated without any access restriction to the HOV lane.

- As shown in Table 8 there is a considerable increase in the travel times because of no restriction on the access location. This is due to the increased weaving between the traffic from the N-E and S-E Ramp.

- Since there is no specific location for the GOP vehicles to enter the HOV lane, slow moving vehicles from GOP lanes jump in front of the fast moving HOV lane traffic at random locations. This results in the reduction of HOV traffic speed, which is also a potential safety hazard.

- A significant increase in short trips was observed during the simulation, for example vehicles from S-E ramp and N-E from EMP were using HOV lane and exiting at Mavis Road interchange. This not only increased the number of vehicles on HOV lane but also increased weaving in the corridor. During the peak hours when the traffic in the GOP lanes was stationary and the HOV lane was moving fairly better, vehicles from GOP lanes would jump into the HOV lane and move back into GOP lanes once the GOP traffic started moving again.

Table 8: Option-4 Travel Times

Vehicle Type	ALL		HOV		HOV		HOV	
Name	**Mainline GP lanes**		**Mainline HOV lane**		**N-E Ramp to HOV I/E**		**S-E Ramp to HOV I/E**	
Time (s)	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**	**Travel Time (s)**	**# of Vehicles**
300.0	97.4	161.1	92.3	43.4	94.8	6.7	76.5	3.9
600.0	147.4	414.6	122.2	95.4	191.4	7.4	121.8	3.7
900.0	171.0	426.4	136.0	102.0	274.0	8.5	132.7	4.9
1200.0	173.6	407.9	140.7	102.1	291.3	9.2	130.6	4.9
1500.0	211.8	327.9	143.5	100.0	277.3	9.8	130.1	5.1
1800.0	286.1	312.4	158.5	82.9	296.0	8.5	145.8	4.4
2100.0	371.8	245.8	192.7	86.7	378.0	6.2	208.8	4.3
2400.0	491.2	238.0	226.3	71.8	491.7	5.7	242.9	2.6
2700.0	577.2	253.2	280.5	77.7	543.2	4.0	351.9	4.4
3000.0	651.5	250.4	290.0	84.8	690.9	4.4	328.4	2.1
3300.0	693.3	250.4	288.1	73.8	711.8	5.6	347.0	4.9
3600.0	681.6	251.2	295.9	74.7	698.2	6.4	345.2	4.5
3900.0	680.7	250.4	290.0	82.3	687.4	6.4	325.8	4.2
4200.0	681.7	252.1	293.7	77.9	694.8	7.9	307.5	3.9
4500.0	669.4	256.5	296.3	77.3	692.5	8.2	330.3	4.7
4800.0	664.2	277.2	290.7	76.0	681.4	6.5	282.5	4.9
5100.0	622.7	285.8	267.1	84.1	639.6	6.2	312.5	5.8
5400.0	589.1	269.9	253.5	78.7	629.7	7.7	273.7	6.7
5700.0	576.5	281.4	262.4	71.5	627.4	6.8	299.5	5.0
6000.0	591.7	260.0	265.9	87.9	641.2	8.9	308.7	3.7
6300.0	596.2	275.7	252.0	74.0	615.0	5.8	307.5	4.9
6600.0	595.0	272.0	263.2	81.7	660.9	6.9	321.1	6.1
6900.0	605.3	264.9	246.6	75.5	647.7	5.4	292.3	6.5
7200.0	602.6	266.4	269.3	74.9	664.0	5.7	316.4	4.7
Average	**501.2**		**234.0**		**534.2**		**260.0**	

Figure 8: Option-4 Speed Profile Shoulder Hour

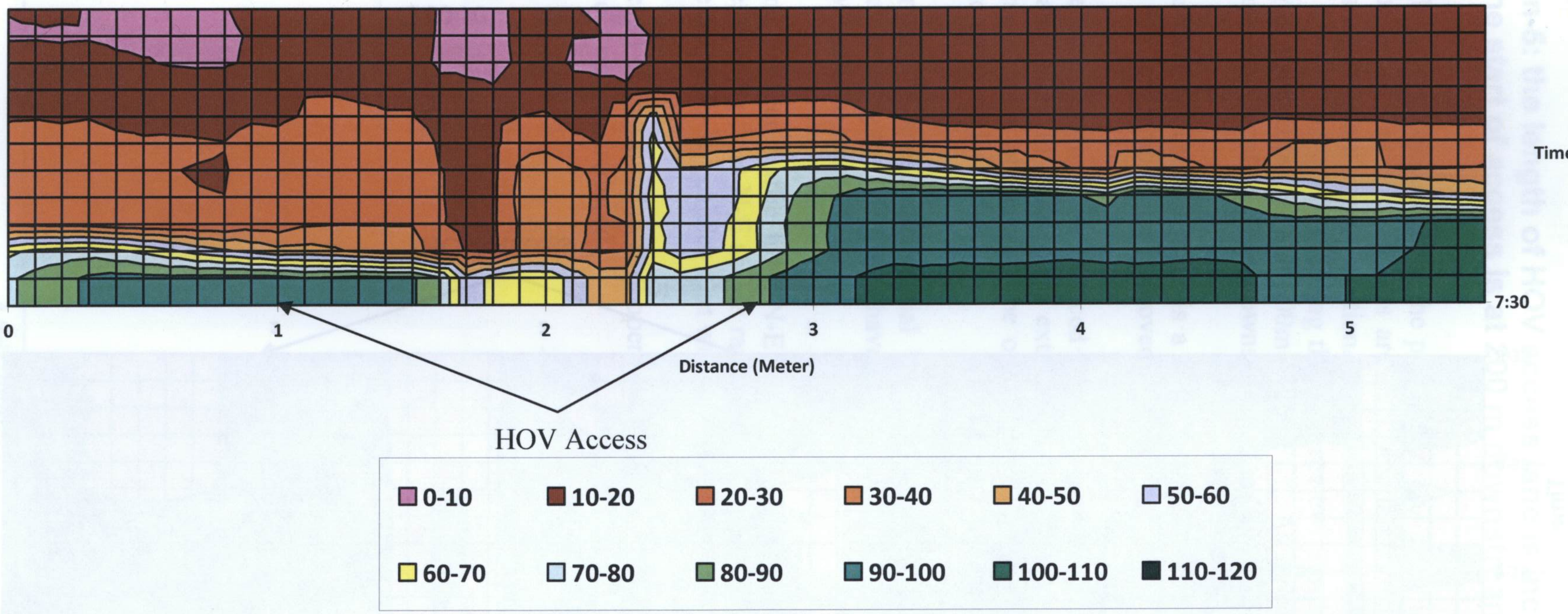
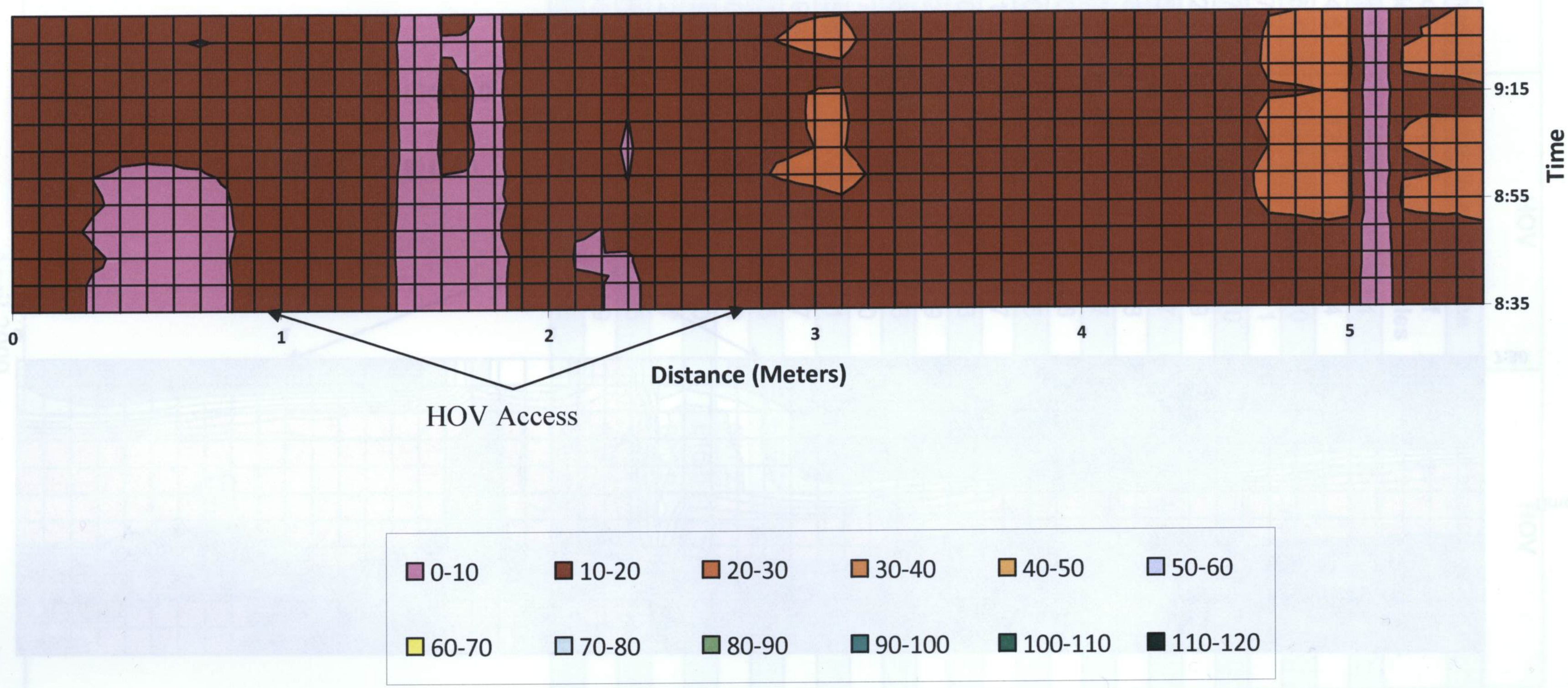


Figure 9: Option-4 Speed Profile Peak Hour



4.2.5 Option-5: the length of HOV access lane is increased to 600 m and the start of access is at 200 m downstream of SCL

During the field survey conducted for the purpose of this study and the field review by MTO it was observed that most drivers are in a position to enter the HOV lane well before the existing standard access location. This distance was observed to be 200m for approximately 75% of the vehicles during the field review. Similarly the study by MTO found that few drivers utilize the full 500m of the SCL. As a result this option explores the affects of an access location 200m downstream of the SCL lane.

- As illustrated in Table 9 there is a clear reduction in the travel time. Also the overall traffic operation has improved.

- The weaving lengths have reduced which is helping vehicles to move into the HOV lane faster. In addition the extra access length is sufficient for all vehicles. No vehicles were observed to be overshooting the access location or reducing speed to enter the HOV lane.

- The impact of speed differential between GOP and HOV lane is reduced. Vehicles entering the HOV lane have enough length to wait for an acceptable gap in HOV traffic to enter the lanes.

- Weaving between traffic from N-E and S-W access ramps is reduced because vehicles coming from N-E access ramp are in position to merge into HOV traffic well before the S-W vehicles start weaving the traffic.

- As a result of improved overall operation in the corridor the traffic backed up on the access ramps is reduced.

Table 9: Option-5 Travel Times

Vehicle Type	ALL		HOV		HOV		HOV	
Name	Mainline GP lanes		Mainline HOV lane		N-E Ramp to HOV I/E		S-E Ramp to HOV I/E	
Time (s)	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles
300.0	96.5	164.2	88.7	41.0	94.5	6.7	76.4	3.5
600.0	143.0	408.0	89.6	98.0	195.2	6.9	127.1	2.7
900.0	163.7	407.0	88.6	95.9	271.4	9.5	145.0	5.4
1200.0	165.0	414.0	88.4	91.4	294.9	7.9	147.8	4.6
1500.0	166.4	411.0	88.2	89.4	314.2	9.1	142.3	5.0
1800.0	174.1	360.9	88.3	87.8	306.1	11.6	143.1	5.4
2100.0	238.6	251.6	87.8	88.8	305.2	9.8	153.2	5.6
2400.0	362.7	240.2	88.3	93.2	340.3	8.4	153.9	4.1
2700.0	481.1	241.1	87.6	84.9	406.2	4.9	248.2	3.1
3000.0	587.6	238.1	87.9	78.6	574.1	4.9	259.9	2.7
3300.0	641.2	236.4	86.9	65.5	620.5	5.2	274.1	3.7
3600.0	687.1	239.0	87.6	71.2	623.3	6.5	287.6	4.7
3900.0	689.0	241.9	87.0	65.3	633.8	8.4	310.0	4.5
4200.0	689.5	252.0	86.9	68.3	615.9	10.1	286.0	4.3
4500.0	675.7	243.9	86.5	62.4	604.8	8.6	281.6	6.5
4800.0	655.9	256.3	87.2	65.9	592.3	5.2	285.8	4.4
5100.0	649.2	260.7	87.5	66.7	580.1	8.0	274.1	6.1
5400.0	631.4	268.6	87.1	70.6	563.0	7.8	274.3	6.2
5700.0	599.2	260.2	87.4	67.5	575.1	8.1	271.8	5.9
6000.0	599.6	270.1	87.4	65.0	569.1	8.0	233.1	4.4
6300.0	564.7	280.8	87.1	66.2	555.6	7.9	277.0	5.2
6600.0	548.4	272.3	87.3	71.2	549.3	8.4	246.2	7.4
6900.0	544.1	267.8	87.3	67.5	522.6	7.9	240.8	7.6
7200.0	553.1	259.8	88.4	71.7	520.6	8.8	242.7	5.6
Average	471.1		87.7		467.8		224.2	

Figure 10: Option-5 Speed Profile Shoulder Hour

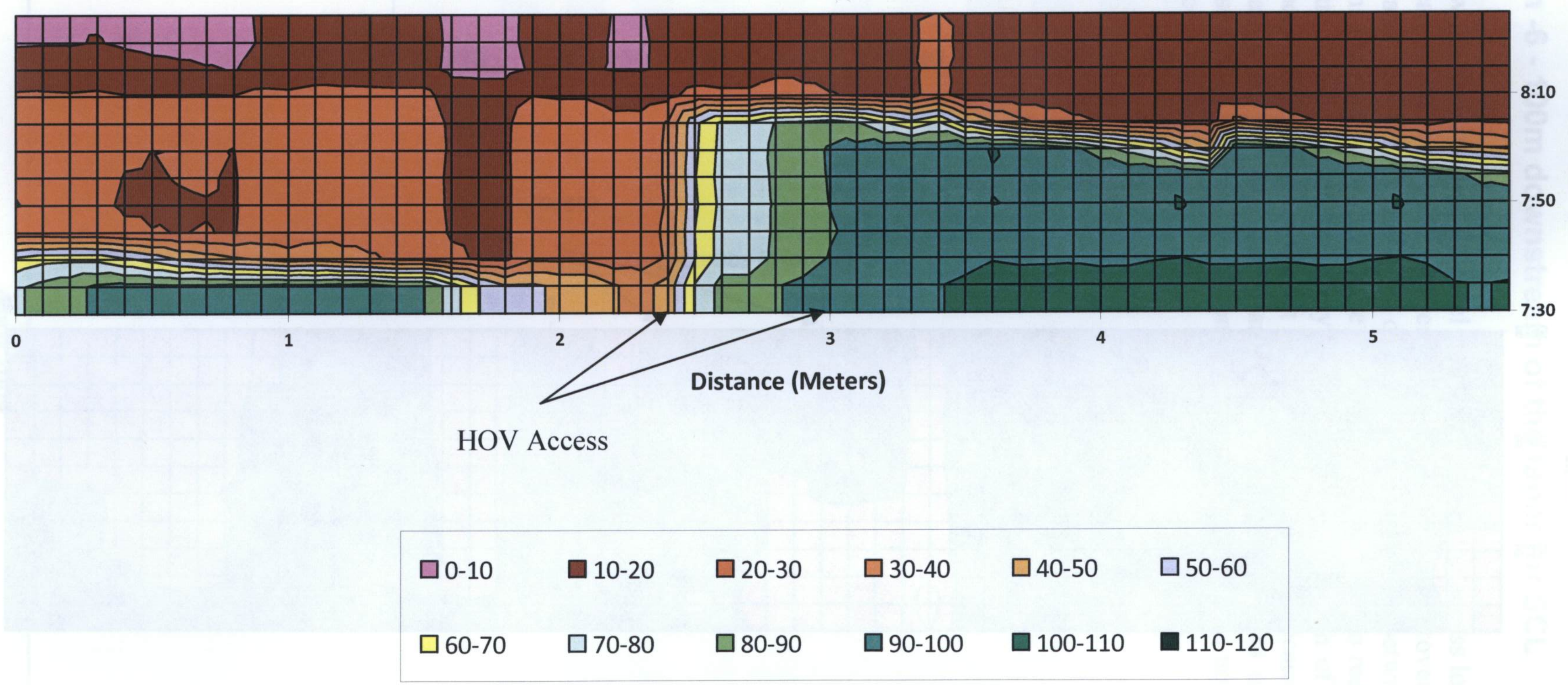
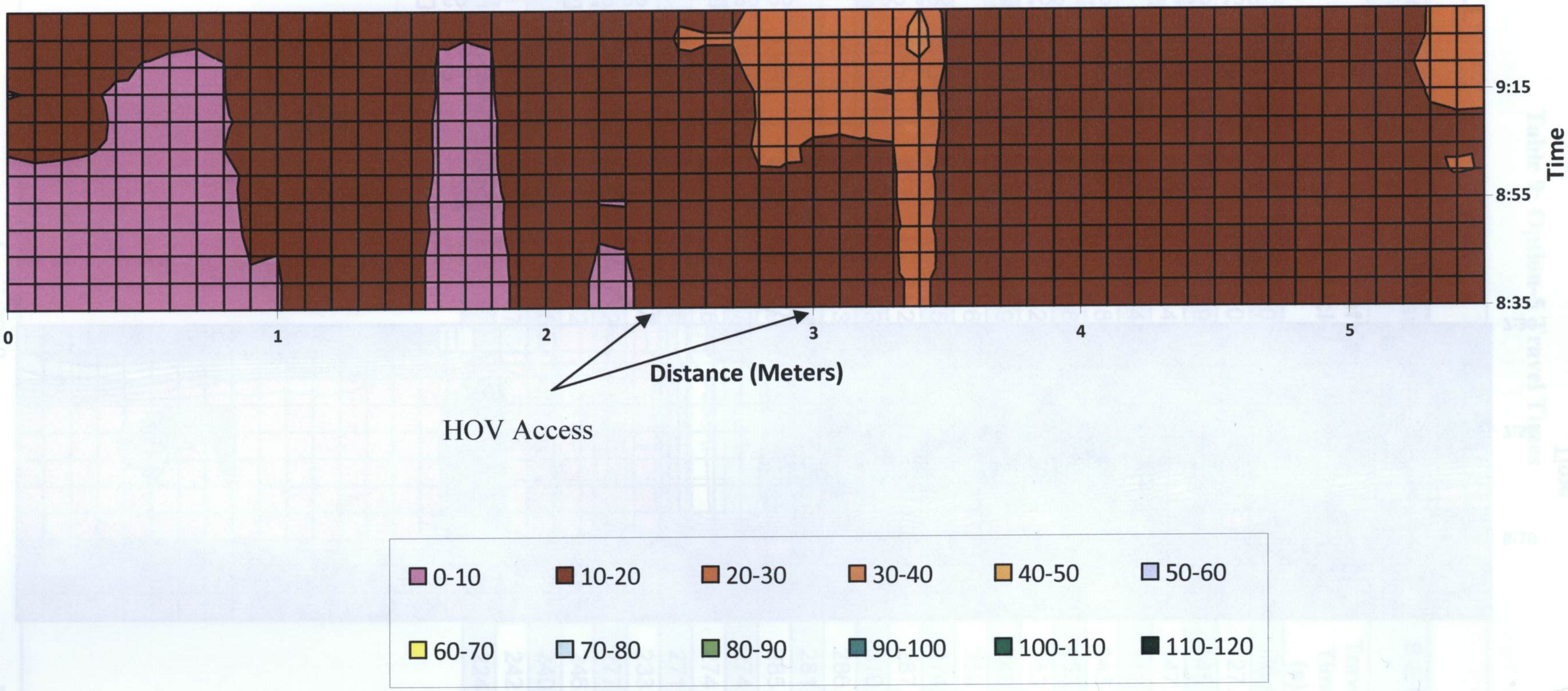


Figure 11: Option-5 Speed Profile Peak Hour



4.2.6 Option -6 - 100m downstream of the taper for SCL

Keeping in view the improvement in travel time in option-5, the access location is moved 100m downstream of the taper to test if there is further room for improvement. Table 10 , Table 11 illustrates that there is negligible difference in travel times between option 5 and 6. In simulations the results of which have not been included here (to reduce the amount of work and due to the lack of time) any further increase in length of access location towards the taper of SCL does not impact the travel time. This is because most vehicles are still negotiating the GP lane traffic and are not in a position to utilize the added length. This case is also observed in option-3 where most vehicles do not utilize the first 100m of the access length.

Table 10: Option-6 Travel Times

Vehicle Type	ALL		HOV		HOV		HOV	
Name	Mainline GP lanes		Mainline HOV lane		N-E Ramp to HOV I/E		S-E Ramp to HOV I/E	
Time (s)	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles	Travel Time (s)	# of Vehicles
300.0	96.7	164.3	88.7	41.0	95.4	6.8	75.6	3.4
600.0	142.3	406.0	89.7	98.0	187.0	8.0	141.6	3.1
900.0	164.5	404.4	88.6	95.5	280.5	8.6	145.5	5.1
1200.0	166.4	412.4	88.5	94.0	317.7	8.3	138.8	4.8
1500.0	167.7	405.2	87.6	87.8	295.4	10.8	144.3	4.6
1800.0	177.8	356.3	88.4	87.2	303.7	9.5	142.7	5.1
2100.0	245.9	249.6	87.9	88.6	318.3	11.7	144.4	6.4
2400.0	371.4	236.7	88.9	90.4	345.8	7.2	152.1	4.3
2700.0	486.9	239.8	88.2	86.6	450.5	5.7	289.3	2.5
3000.0	596.5	233.0	88.1	75.8	594.9	4.9	322.1	2.4
3300.0	658.2	241.3	87.2	61.3	581.0	4.2	301.4	4.4
3600.0	692.5	244.9	88.1	68.2	638.2	6.7	293.1	5.8
3900.0	690.9	233.1	88.1	72.3	633.8	8.1	280.3	3.8
4200.0	686.4	242.8	87.9	67.4	620.8	8.8	294.8	4.0
4500.0	674.8	243.6	87.4	63.3	608.1	9.7	296.4	5.7
4800.0	671.9	247.6	87.5	63.9	603.3	5.1	286.9	6.2
5100.0	660.3	260.8	88.0	66.7	606.3	6.2	287.8	5.8
5400.0	640.7	267.9	88.2	65.9	601.5	8.0	279.7	5.3
5700.0	607.3	271.0	87.8	63.9	559.2	8.6	270.3	6.0
6000.0	585.1	259.1	87.7	69.0	544.7	7.6	260.4	4.7
6300.0	578.2	275.0	87.5	70.7	525.4	7.8	266.9	5.9
6600.0	565.1	271.3	87.7	68.2	557.3	7.8	253.4	7.1
6900.0	562.1	263.3	87.8	70.8	527.4	8.5	253.8	6.2
7200.0	568.4	263.8	88.7	71.4	523.1	8.1	242.5	6.0
Average	**477.4**		**88.1**		**471.6**		**231.8**	

Figure 12: Option-6 Speed Profile Shoulder Hour

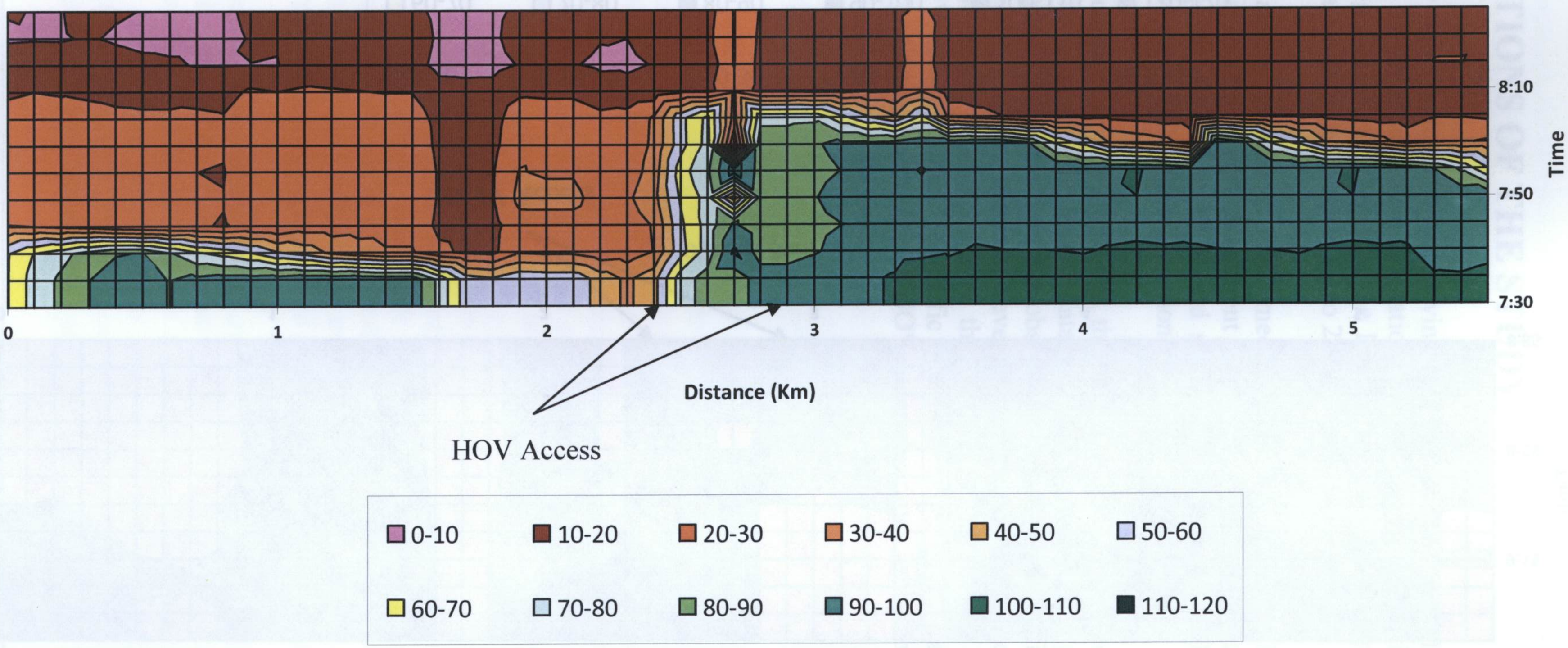
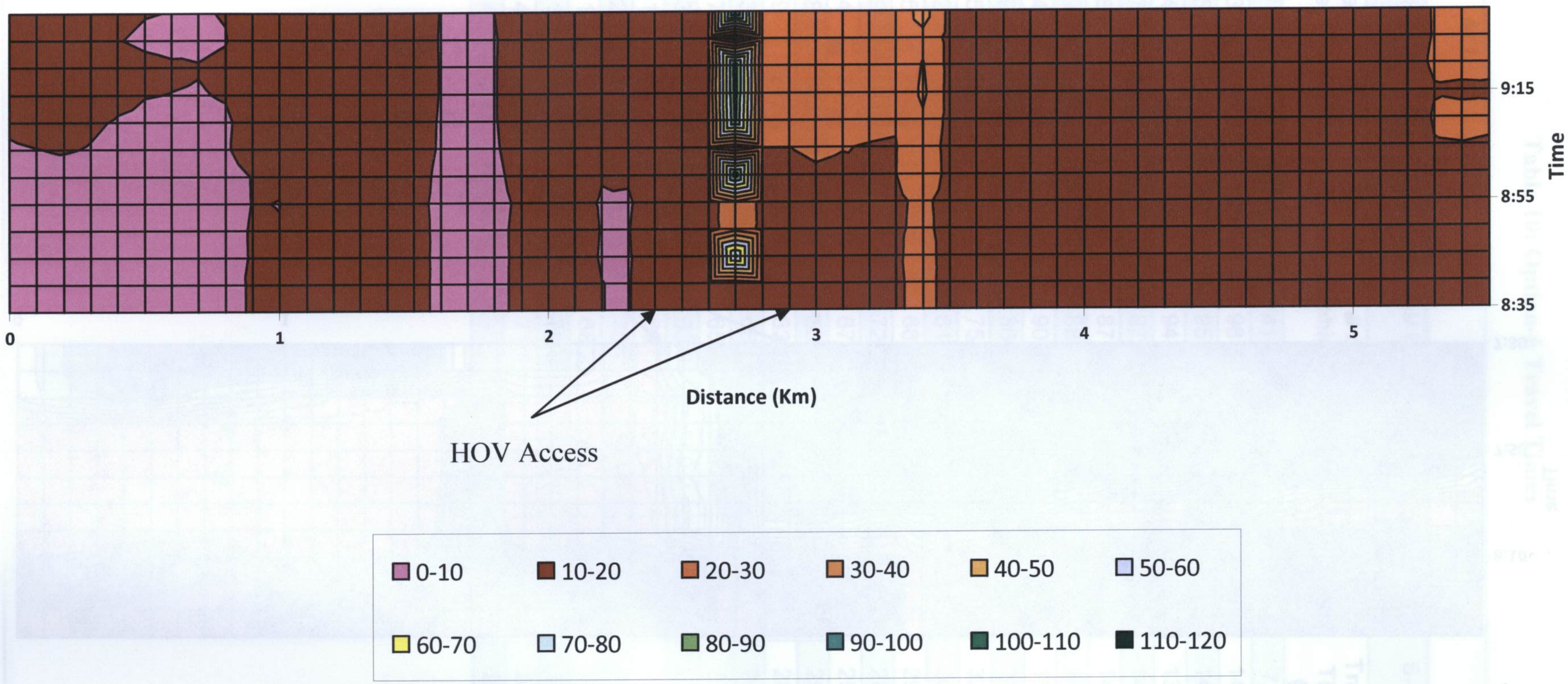


Figure 13: Option-6 Speed Profile Peak Hour



5 LIMITATIONS OF THE STUDY

The field review was conducted by observing the location of a vehicle relative to the existing features on the road. These estimations were done visually, without the use of any range finding equipment; therefore the locations of the vehicles provided in field review are accurate within the range of 10 to 20m.

The HOV lane access location at EMP meets the criteria set by MTO standards. It represents an ideal location where the current standards can be put to the test. Thus these simulation results are limited to EMP and similar HOV corridors. The result do not necessary apply to every HOV access location.

The biggest impediment in this study was the access to data. The model could not be calibrated properly because of the lack of data at certain locations. This provided a lower speed profile during simulation then the observed speed during the field review. The reduction in operating speed of traffic however would not have a significant influence on the results of the study. This is because the objective of the study was to find the influence of HOV access location on traffic operation under heavy traffic. Conversely under free flow conditions the location of HOV access becomes irrelevant.

6 SUMMARY

The HOV access location is an important part of the HOV system. The location of HOV lanes have been studied in terms of weaving length and human factors, however there are few studies which have evaluated the point at which the vehicle is ready to enter the HOV lane with respect to the HOV access location.

Most studies suggest that the HOV lane access location should be 300m per lane change from the access ramp. This number is based on the waving length calculations and human factors studies which measures the time required for a driver to change lane safely.

However, during this study the field review showed that 300m per lane is significantly higher then what most drivers utilize. Approximately 72% of the vehicles are in a position to merge into the HOV lane 200m upstream of the existing access location. On average the vehicles are ready to enter the HOV lane 278m upstream of the existing access location. In addition it was observed that 35% of the vehicles were crossing into the HOV lane before the access location, which is measurably higher than the acceptable limit of 10-15% (SCAG, 2004).

In order to confirm our observations in the field, a number of different options/scenarios of access lengths and location relative to the S-E onramp were developed. The software used to simulate the traffic operation is the micro simulation software VISSIM.

In option-1 the existing system is analyzed as a bench mark for further investigation of the system with different scenarios. During simulation the travel time for HOV and GOP lanes remains approximately unchanged from the other options however, the travel time for the traffic coming from S-E and N-W is high with a bottle neck at the S-W access location. The comparison of Travel Time between the various options is given in Table 11 and the Travel Time comparison over the length of the simulations for various type of traffic in each option is shown in Figure 14 to Figure 17.

Option-2 was used to check if the vehicles would be able to negotiate their way through the traffic and comfortably enter the HOV lane if the start of the HOV access locations is the end of SCL lanes, while maintaining the access length. The resultant simulation showed that most vehicles did not use the first 100m of the access length. Also, a bottle neck is formed in the left most lane adjacent to the HOV lane. This bottle neck was due to vehicles trying to enter the HOV lane but had already exhausted the access length.

The access length in option-2 was too short, which resulted in a bottleneck. In order to remove this discrepancy the access length was increased to 800m in option-3 but the start of the access location was maintained at the end of SCL. The resulting simulation produced significantly better results and removed the bottle neck. However, most vehicles did not use the first 100m of the access length, also the travel time for the HOV lane is increased to 141.6 seconds, which is significantly higher than other options (see

Table 11). This increase can be attributed to the increased weaving between the HOV and GP lanes.

One of the objectives of this study was to study the HOV lane without any buffer to separate the GP lanes from the HOV lane. For this purpose option-4 provide unrestricted access to the HOV lane without any designated location for access. The resultant simulation showed that the traffic operation is badly affected by unrestricted access. There was a significant increase in weaving, due the increase in short trips using the HOV lane. In addition the slow moving GP traffic could interrupt the HOV fast moving traffic at any location instead of a specific access location. This was detrimental to travel time of the HOV lane.

During the field survey almost 75% of the vehicles were in a position to enter the HOV lane 200m upstream of existing HOV access location. Therefore, for option-5 the access location was moved to 200m downstream of SCL lanes, while maintaining the existing end location. As shown in Table 11 travel time has been reduced for all types of traffic.

In option-6 the access location was moved to 100m downstream of the SCL. Option-6 did not show improvement in traffic conditions relative to option-5. Any further reduction in distance between the access location and SCL lanes does not have any positive impact on the traffic operation.

Figure 14: GP Lanes Travel Time

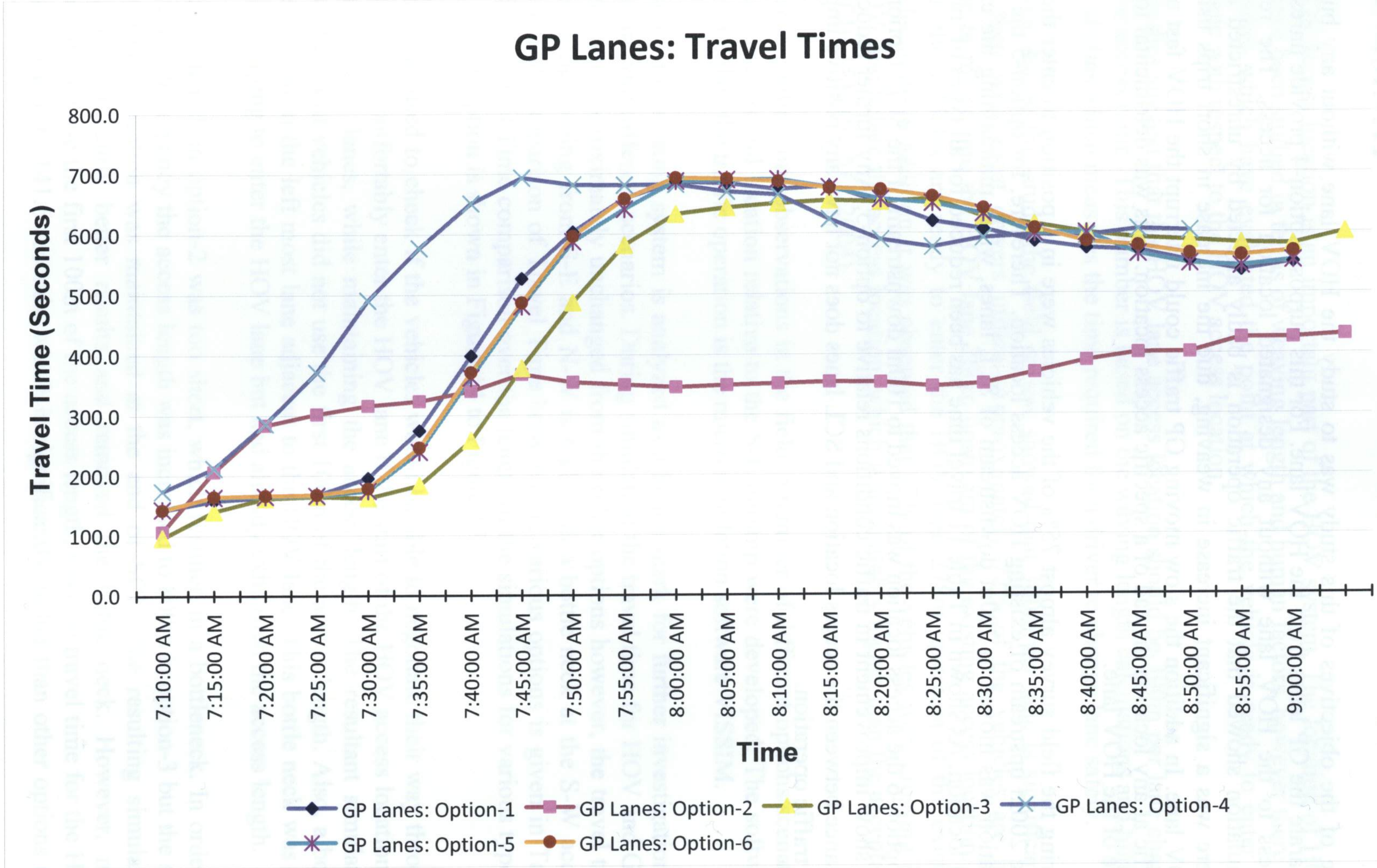


Figure 15: HOV lane Travel Time

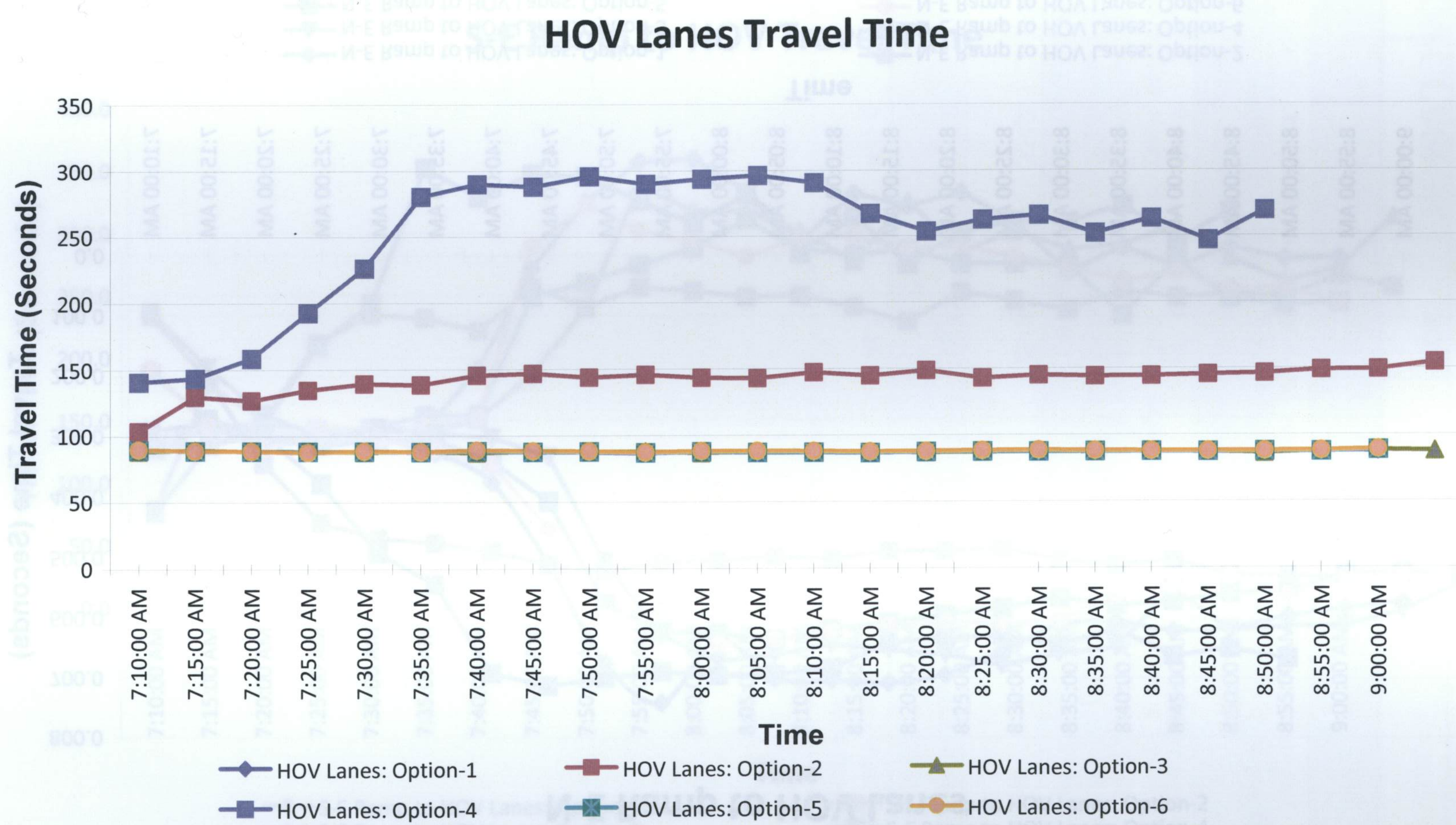


Figure 16: N-E Ramp to HOV lane Travel Time

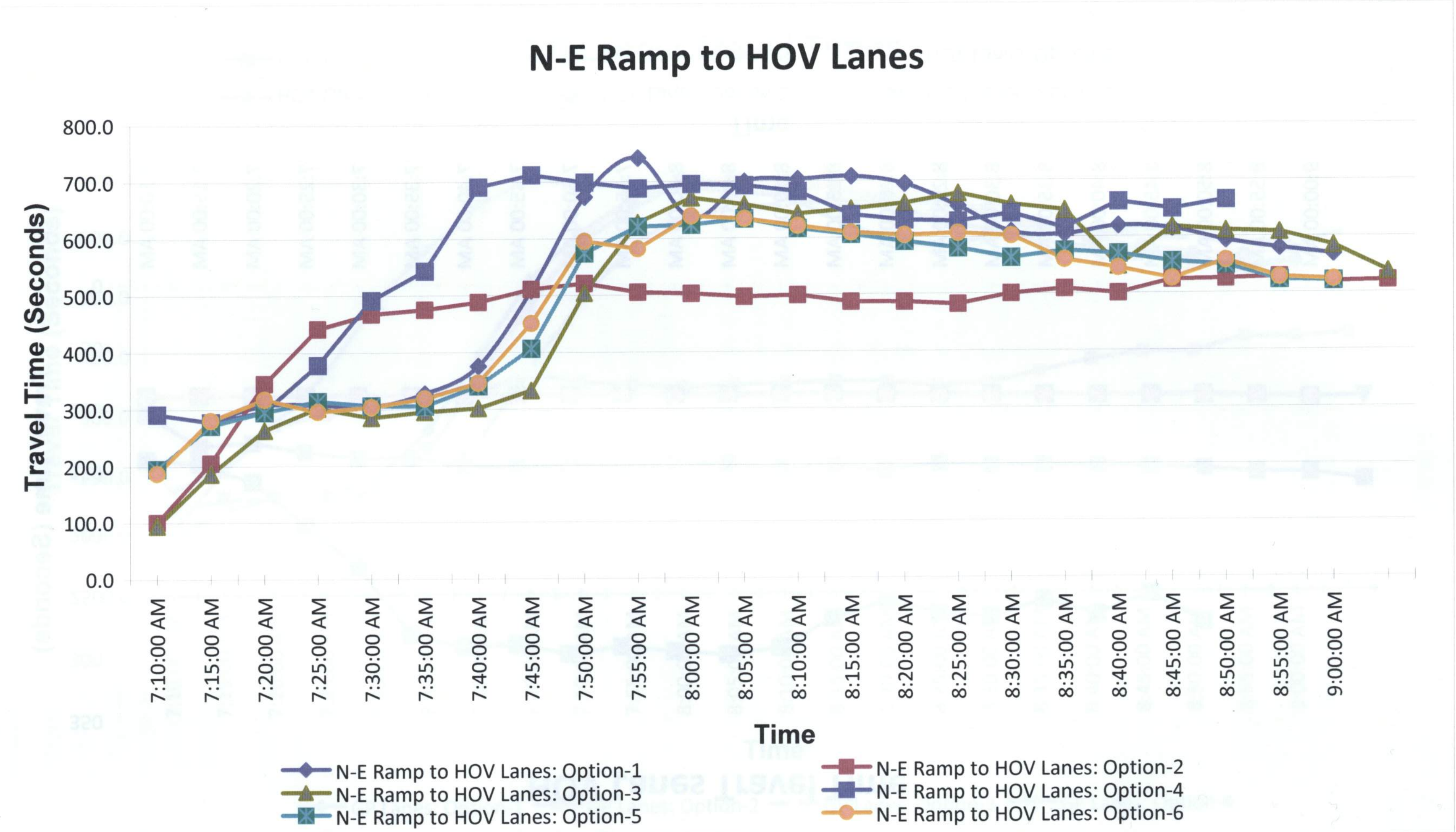


Figure 17: S-E Ramp to HOV Travel Time

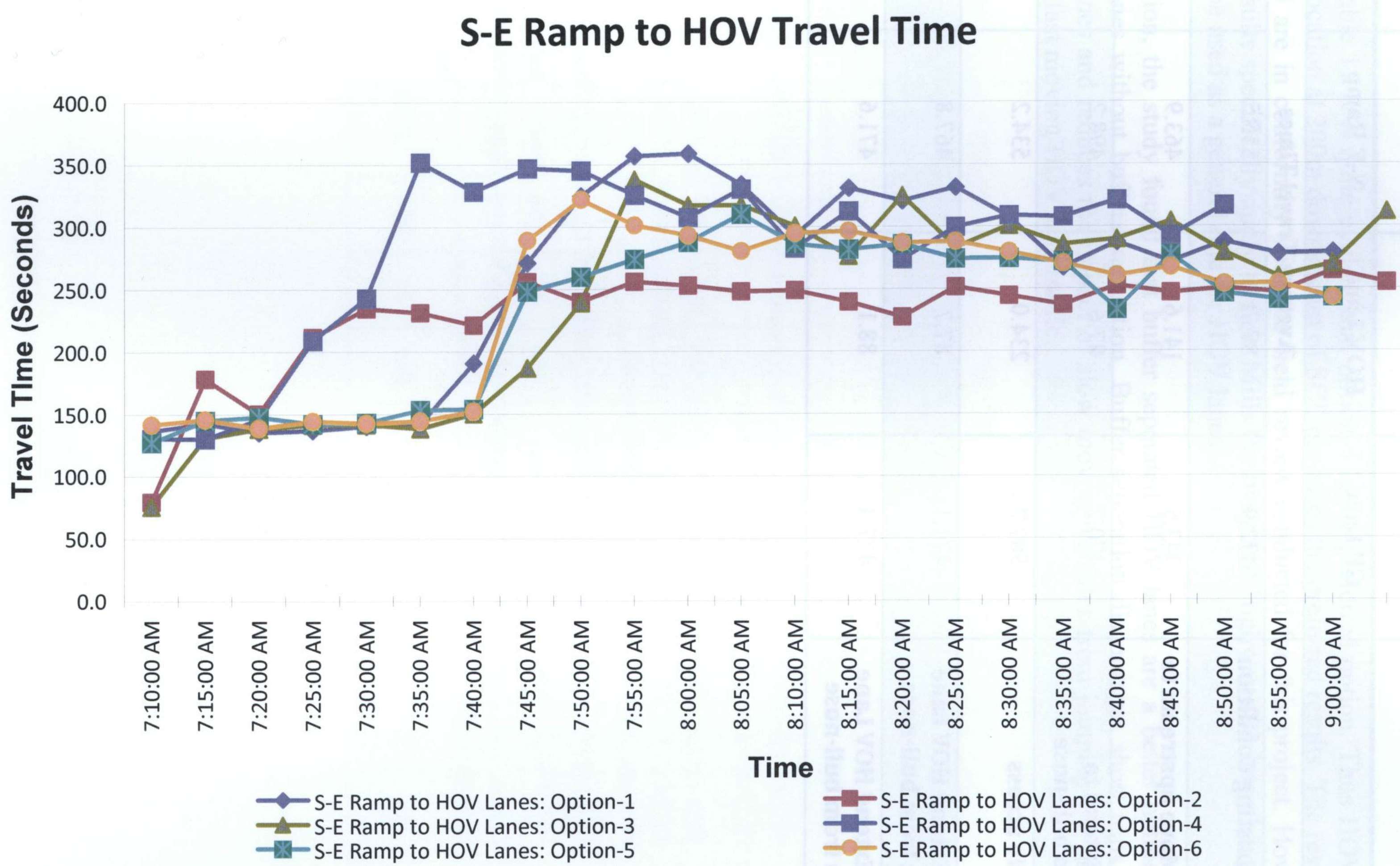


Table 11: Travel Time Summary

Vehicle Type	All	HOV	HOV	HOV
Lane Type	**GP Lane**	**HOV Lane**	**N-E Ramp**	**S-E Ramp**
	Average Travel Times			
Option-1 : Existing Condition	472.9	87.7	515.5	250.1
Option-2 : Move upstream to bull-nose	343.5	141.6	463.9	230.0
Option-3 : Extend to upstream to bull-nose	470.2	87.6	498.2	241.7
Option-4 : No access restriction	501.2	234.0	534.2	260.0
Option-5 : Extend HOV Lane up to 200m from bull-nose	471.1	87.7	467.8	224.2
Option-6 : Extend HOV Lane up to 100m from bull-nose	477.4	88.1	471.6	231.8

7 CONCLUSION

From Table 11 it is quite evident that option-5 is the preferred option. Thus HOV lane access location at 200m downstream of SCL produces the preferred results. The results in option-5 are in conformity with the field review conducted for this project. However, these results specifically apply to Erin Mills Parkway and Highway 403 interchange and cannot be used as a general rule for HOV lanes.

In addition, the study found that buffer separated HOV lanes are a better option than HOV lanes without buffers separation. Buffer separation discourages short trips using HOV lanes and reduces the impact of slow moving vehicles from jumping GP lanes in front of fast moving HOV lane traffic.

8 References

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APPENDIX A: TRAFFIC COUNTS

HIGHWAY 403 AND HIGHWAY 404 HOV PERFORMANCE MONITORING STUDY
HIGHWAY 403 POST-HOV LANE DATA SET AT 16-MONTHS

TABLE F3 - VEHICLE VOLUME/OCCUPANCY ON HIGHWAY 403 EASTBOUND

TABLE F3.1 - HIGHWAY 403 EASTBOUND AT WINSTON CHURCHILL BOULEVARD (AM PEAK PERIOD)

Count Day: Thursday
Count Date: 26-Apr-07

GP LANES										
Time Period	Autos - occupancy			Total	Total Hourly Autos		Trucks & Heavies	Buses	Total Hourly	Motor-cycles
	1	2	3+	HOV	SOV	HOV			Heavies	
6:30 - 6:45	754	43	3	46			52	3		1
6:45 - 7:00	944	48	4	52			45	4		1
7:00 - 7:15	1091	64	4	68			45	5		0
7:15 - 7:30	1017	48	4	52	3806	218	48	2	190	0
7:30 - 7:45	1000	56	4	60	4052	232	46	0	184	0
7:45 - 8:00	850	49	1	50	3958	230	68	0	207	0
8:00 - 8:15	809	45	2	47	3676	209	56	0	218	1
8:15 - 8:30	868	36	1	37	3527	194	67	0	237	0
8:30 - 8:45	871	6	1	7	3398	141	61	1	252	0
8:45 - 9:00	756	21	3	24	3304	115	76	2	260	0
9:00 - 9:15	745	21	2	23	3240	91	100	2	304	0
9:15 - 9:30	839	46	4	50	3211	104	115	1	352	0
AM Peak Period	10544	483	33	516	n/a	n/a	779	20	n/a	3
AM Peak Hour 7:00 - 8:00	3958	217	13	230	n/a	n/a	207	7	n/a	0
HOV AM Peak Hour 7:15 - 8:15	3676	198	11	209	n/a	n/a	218	2	n/a	1

HOV LANE										
Time Period	Autos - occupancy			Total	Total Hourly Autos		Trucks & Heavies	Buses	Total Hourly Heavies	Motor-cycles
	1	2	3+	HOV	SOV	HOV				
6:30 - 6:45	7	58	1	59			1	4		0
6:45 - 7:00	13	54	3	57			0	0		0
7:00 - 7:15	18	69	3	72			0	2		0
7:15 - 7:30	28	84	8	92	66	280	1	4	2	0
7:30 - 7:45	15	140	12	152	74	373	0	3	1	0
7:45 - 8:00	29	147	9	156	90	472	1	6	2	0
8:00 - 8:15	9	93	3	96	81	496	0	4	2	0
8:15 - 8:30	25	59	1	60	78	464	1	2	2	0
8:30 - 8:45	9	81	5	86	72	398	1	7	3	0
8:45 - 9:00	5	53	3	56	48	298	0	1	2	0
9:00 - 9:15	8	49	0	49	47	251	0	3	2	0
9:15 - 9:30	6	32	0	32	28	223	0	3	1	0
AM Peak Period	172	919	48	967	n/a	n/a	5	39	n/a	0
AM Peak Hour 7:00 - 8:00	90	440	32	472	n/a	n/a	2	15	n/a	0
HOV AM Peak Hour 7:15 - 8:15	81	464	32	496	n/a	n/a	2	17	n/a	0

ALL LANES										
Time Period	Autos - occupancy			Total	Total Hourly Autos		Trucks & Heavies	Buses	Total Hourly Heavies	Motor-cycles
	1	2	3+	HOV	SOV	HOV				
6:30 - 6:45	761	101	4	105			53	7		1
6:45 - 7:00	957	102	7	109			45	4		1
7:00 - 7:15	1109	133	7	140			45	7		0
7:15 - 7:30	1045	132	12	144	3872	498	49	6	192	0
7:30 - 7:45	1015	196	16	212	4126	605	46	3	185	0
7:45 - 8:00	879	196	10	206	4048	702	69	6	209	0
8:00 - 8:15	818	138	5	143	3757	705	56	4	220	1
8:15 - 8:30	893	95	2	97	3605	658	68	2	239	0
8:30 - 8:45	880	87	6	93	3470	539	62	8	255	0
8:45 - 9:00	761	74	6	80	3352	413	76	3	262	0
9:00 - 9:15	753	70	2	72	3287	342	100	5	306	0
9:15 - 9:30	845	78	4	82	3239	327	115	4	353	0
AM Peak Period	10716	1402	81	1483	n/a	n/a	784	59	n/a	3
AM Peak Hour 7:00 - 8:00	4048	657	45	702	n/a	n/a	209	22	n/a	0
HOV AM Peak Hour 7:15 - 8:15	3757	662	43	705	n/a	n/a	220	19	n/a	1

HIGHWAY 403 AND HIGHWAY 404 HOV PERFORMANCE MONITORING STUDY
HIGHWAY 403 POST-HOV LANE DATA SET AT 16-MONTHS

TABLE F3 - VEHICLE VOLUME/OCCUPANCY ON HIGHWAY 403 EASTBOUND

TABLE F3.2 - HIGHWAY 403 EASTBOUND AT CREDITVIEW ROAD (AM PEAK PERIOD) - Day 1

Count Day: Tuesday
Count Date: 17-Apr-07

GP Lanes

Time Period	Autos - occupancy			Total Autos	Total	Total Hourly Autos		Trucks & Heavies	Buses	Total Hourly	Motor-cycles
	1	2	3+		HOV	SOV	HOV			Heavies	
6:30 - 6:45	1151	53	4	1208	57			64	4		0
6:45 - 7:00	1185	45	2	1232	47			63	3		0
7:00 - 7:15	1374	38	1	1413	39			50	10		0
7:15 - 7:30	1254	27	0	1281	27	4964	170	22	5	199	0
7:30 - 7:45	1333	20	1	1354	21	5146	134	44	3	179	0
7:45 - 8:00	1173	42	13	1228	55	5134	142	45	3	161	0
8:00 - 8:15	956	40	1	997	41	4716	144	46	0	157	1
8:15 - 8:30	1090	40	2	1132	42	4552	159	70	3	205	0
8:30 - 8:45	1098	31	2	1131	33	4317	171	81	0	242	0
8:45 - 9:00	1037	39	3	1079	42	4181	158	98	1	295	0
9:00 - 9:15	1169	24	1	1194	25	4394	142	125	2	374	0
9:15 - 9:30	1016	31	1	1048	32	4320	132	125	3	429	0
AM Peak Period	13836	430	31	14297	461	n/a	n/a	833	37	n/a	1
AM Peak Hour 7:00 - 8:00	5134	127	15	5276	142	n/a	n/a	161	21	n/a	0
HOV AM Peak Hour 7:30 - 8:30	4552	142	17	4711	144	n/a	n/a	205	9	n/a	1

APPENDIX B: VISSIM OD MATRIXES

APPENDIX B: VISSIM TRAVEL TIME OUTPUT SHEETS

Please note that the following are travel time output sheets for the first run. For other 9 runs, please consult the CD attached to this project. In order to reduce paper use the data for the other runs was not included in the printed copy.

Option-1

Table of Travel
Times

File: c:\documents and settings\dmendoza\desktop\makael\highway 403-do nothing-1.inp
Comment:
Date: April 24, 2008 3:11:36 PM

No. 1005 (GP lanes): from link 23 at 383.4 m to link 28 at 6.8 mDistance 422.4 m
No. 1017 (N-E): from link 18 at 413.5 m to link 28 at 960.8 mDistance 2446.2 m
No. 1018 (S-E): from link 21 at 505.5 m to link 28 at 961.2 mDistance 1986.4 m
No. 1019 (HOV): from link 24 at 9.4 m to link 28 at 959.8 mDistance 2429.6 m
No. 1020 (HOV): from link 19 at 6.5 m to link 26 at 968.9 mDistance 2442.8 m

Trav	#Veh	Trav	#Veh	Trav	#Veh	Trav	#Veh
HOV2+		HOV2+		HOV2+		All	
1017	1017	1018	1018	1019	1019	1020	1020
N-E	N-E	S-E	S-E	HOV	HOV	HOV	HOV
90.1	5	72.7	3	86	43	96.8	162
143.3	7	148.3	4	89.6	110	141.3	431
209.8	10	187.9	3	88.5	101	148.1	429
277.8	8	136.3	4	87.4	105	161.5	387
341.5	13	169.1	3	87.2	81	178.2	387
386.7	9	224.9	4	86.7	82	222.2	313
363.7	15	185.2	11	87.4	80	289.8	265
471.4	5	281.7	5	88	88	421	213
526.9	5	367.7	4	85.5	70	526.4	224
724.1	3	465.9	4	86.4	74	647.3	223
983.5	3	465.6	1	85.6	61	708.2	202
1048.8	3	502.9	3	86.9	65	748.4	242
1401.1	1	0	0	88	63	766.6	227
0	0	607.3	4	85.2	85	764.6	257
1456.9	3	425.8	10	86.3	66	727.4	245
1427.6	1	387.7	4	87.3	67	697.9	230
1250.2	3	0	0	89.8	64	708.7	197
1298	10	905.7	5	88.3	71	838.7	250
1156.8	7	917.3	5	88.1	67	807.7	240
1265.1	4	682.6	3	85.2	61	827.9	228
1230.5	12	422	16	90.5	67	763	239
1008.5	7	454.6	10	87.9	69	763.5	220
965.4	14	458.3	12	87.7	69	734.3	218

824.8	9	415.5	8	86.8	64	783.1	240

Option-2

Table of Travel Times

File: c:\documents and settings\mkakakhel\desktop\makael kakakhel\degree project\simulation\mak - hwy 403\option-2- move hov upstream\hwy 403-move upstream-1.inp
Comment:
Date: Thursday, April 24, 2008 4:28:56 PM

No. 1017 (GP LANES): from link 19 at 14.4 m to link 26 at 951.8 mDistance 2418.0 m
No. 1018 (HOV): from link 24 at 15.1 m to link 28 at 951.9 mDistance 2418.1 m
No. 1019 (N-E): from link 18 at 412.1 m to link 28 at 953.0 mDistance 2439.4 m
No. 1020 (S-E): from link 21 at 507.1 m to link 28 at 954.2 mDistance 1977.5 m

Time	Trav	#Veh	Trav	#Veh	Trav	#Veh	Trav	#Veh
VehC	All		HOV2+		HOV2+		HOV2+	
No.:	1017	1017	1018	1018	1019	1019	1020	1020
Name	GP LANES	GP LANES	HOV	HOV	N-E	N-E	S-E	S-E
300	106.6	92	101.2	33	99.9	5	74.5	3
600	215.0	245	145.2	100	203.6	7	147.1	2
900	287.3	337	124.9	96	349.0	2	235.4	2
1200	271.7	303	131.3	75	504.8	6	351.8	3
1500	322.3	275	142.0	81	503.5	8	262.0	2
1800	354.1	258	150.8	63	631.4	8	246.8	7
2100	370.7	259	141.3	80	601.2	10	264.0	2
2400	377.8	265	156.6	62	716.8	3	246.3	9
2700	352.2	273	152.8	76	783.0	6	354.7	5
3000	405.1	164	162.2	65	817.3	12	404.8	7
3300	460.1	239	145.3	70	666.2	9	340.2	4
3600	421.4	267	162.9	63	777.9	12	338.5	3
3900	439.4	188	204.4	37	879.4	11	366.4	4
4200	516.1	188	185.4	92	791.0	7	420.0	6
4500	447.9	297	137.3	74	819.5	7	381.2	6
4800	360.4	219	152.5	49	933.7	5	292.7	8
5100	454.1	181	189.0	70	1075.5	10	388.7	4
5400	516.7	189	154.2	65	909.8	13	493.0	5
5700	507.6	234	162.1	58	853.4	8	352.5	6
6000	440.1	254	158.7	56	1063.2	6	380.1	9
6300	415.0	233	172.2	77	1085.9	11	354.4	4
6600	408.0	219	152.8	50	873.8	13	396.2	8
6900	435.0	202	168.1	79	653.2	14	355.4	5
7200	497.7	204	167.6	73	699.7	7	355.0	8

Option-3

Table of Travel Times

File: c:\documents and settings\mkakakhel\desktop\makael kakakhel\degree project\simulation\mak - hwy 403\option-3- extend to upstream\hwy 403-extended to upstream-1.inp
Comment:
Date: Thursday, April 24, 2008 5:04:37 PM

No. 1016 (GP LANES): from link 19 at 12.7 m to link 26 at 957.4 mDistance 2425.1 m
No. 1017 (HOV): from link 24 at 12.2 m to link 28 at 955.7 mDistance 2422.8 m
No. 1018 (N-E): from link 18 at 413.5 m to link 28 at 958.4 mDistance 2443.8 m
No. 1019 (S-E): from link 21 at 506.5 m to link 28 at 957.2 mDistance 1981.4 m

```
 Time; Trav;#Veh; Trav;#Veh; Trav;#Veh; Trav;#Veh;
 VehC; All;;     HOV2+;;    HOV2+;;     HOV2+;;
 No.:; 1016;1016; 1017;1017; 1018;1018; 1019;1019;
Name;GP LANES;GP LANES;HOV;HOV;N-E;N-E;S-E;S-E;
  300; 95.5; 164; 85.3; 43; 91.4;  5; 71.8;  3;
  600; 139.0; 407; 89.6; 110; 141.5;  6; 156.1;  4;
  900; 169.6; 415; 88.2; 100; 290.2;  6; 127.5;  4;
 1200; 160.5; 389; 88.6; 100; 323.5; 16; 181.7;  2;
 1500; 168.4; 397; 86.7; 89; 325.3; 10; 145.0;  6;
 1800; 215.6; 328; 86.1; 85; 374.9; 11; 179.8;  3;
 2100; 272.5; 240; 86.3; 82; 315.0; 10; 129.5; 10;
 2400; 405.5; 223; 87.9; 93; 359.3; 11; 208.2;  2;
 2700; 548.0; 206; 85.4; 77; 490.1;  6; 497.3;  5;
 3000; 665.3; 222; 86.6; 75; 627.9;  2; 316.3;  1;
 3300; 721.2; 246; 88.3; 62; 983.5;  3;  0.0;  0;
 3600; 768.6; 244; 87.1; 56; 989.3;  2; 964.9;  3;
 3900; 789.9; 244; 87.6; 71; 834.2;  1; 712.0;  2;
 4200; 781.3; 251; 85.1; 77;1130.3;  4; 487.0;  4;
 4500; 699.3; 251; 87.2; 59; 847.7;  1; 441.3;  3;
 4800; 655.3; 272; 86.4; 59;1176.4;  2; 657.2;  9;
 5100; 721.5; 245; 86.6; 58;1032.1; 10; 625.3;  8;
 5400; 722.7; 240; 92.0; 73;1026.1; 10; 522.2;  7;
 5700; 694.0; 259; 87.1; 71; 871.4; 12; 375.9; 12;
 6000; 693.8; 204; 87.6; 77; 956.9;  4; 322.8; 18;
 6300; 711.5; 226; 86.9; 68;1060.4; 15; 383.6;  2;
 6600; 709.6; 231; 86.6; 61; 834.5; 14; 467.8;  3;
 6900; 774.5; 216; 88.6; 70; 794.0; 11; 429.6;  6;
 7200; 771.2; 220; 86.8; 69; 979.2;  1; 459.7;  6;
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Option-4

Table of Travel Times

File: c:\documents and settings\mkakakhel\desktop\makael kakakhel\degree project\simulation\mak - hwy 403\option-4- no restrictive access\hwy 403- no ristricted access-1.inp
Comment:
Date: Thursday, April 24, 2008 5:38:07 PM

```
No. 1015 (N-E          ): from link   18 at  414.3 m to link   28 at  962.6 mDistance 2447.1 m
No. 1016 (S-E          ): from link   21 at  506.9 m to link   28 at  961.0 mDistance 1984.7 m
No. 1017 (HOV          ): from link   19 at   12.4 m to link   27 at    1.7 mDistance 2442.4 m
No. 1018 (GP LANES     ): from link   19 at   19.2 m to link   26 at  962.7 mDistance 2424.4 m

 Time; Trav;#Veh; Trav;#Veh; Trav;#Veh; Trav;#Veh;
 VehC; HOV2+;;   HOV2+;;   HOV2+;;   All;;
 No.:; 1015;1015; 1016;1016; 1017;1017; 1018;1018;
Name;N-E;N-E;S-E;S-E;HOV;HOV;GP LANES;GP LANES;
  300;  88.3;  5;  84.7;  3;  90.9;  42; 100.2; 145;
  600; 175.7;  7; 126.3;  4; 125.6; 108; 148.0; 425;
  900; 264.7;  4; 155.3;  5; 126.8; 104; 168.7; 419;
 1200; 323.6; 15; 138.5;  2; 142.1; 115; 168.7; 415;
 1500; 253.3; 10; 136.7;  5; 145.5;  93; 205.3; 337;
 1800; 337.7; 13; 123.1;  5; 165.8;  97; 265.9; 311;
 2100; 391.2;  4; 207.4;  6; 170.4;  79; 343.9; 304;
 2400; 517.3; 10; 282.7;  5; 212.1;  88; 432.7; 216;
 2700; 683.8;  2; 369.4;  6; 233.9;  67; 538.7; 242;
 3000; 777.2;  3; 480.2;  2; 294.2;  92; 633.1; 238;
 3300; 628.0;  1; 488.6;  2; 264.9;  63; 715.5; 263;
 3600;1186.2;  2; 452.5;  3; 336.5;  58; 710.4; 239;
 3900;1264.3;  3; 381.1;  8; 296.8;  73; 706.5; 223;
 4200;1305.6;  9; 463.6;  5; 375.9;  84; 742.6; 269;
 4500; 933.2;  6; 502.8;  4; 291.8;  88; 734.2; 237;
 4800; 905.9; 16; 392.1;  7; 359.8;  94; 717.5; 244;
 5100; 943.8;  5; 462.5;  7; 308.6;  68; 678.4; 189;
 5400; 959.4;  7; 539.5;  3; 348.1;  60; 781.4; 243;
 5700;1060.6;  5; 506.7;  5; 343.8;  69; 793.9; 244;
 6000;1169.2; 10; 483.0; 10; 362.9;  88; 818.8; 224;
 6300;1339.2;  3; 414.5; 12; 285.1;  70; 761.8; 249;
 6600; 706.9;  1;   0.0;  0; 265.6;  58; 735.7; 206;
 6900;1406.7; 11; 635.9;  5; 460.3;  67; 807.4; 172;
 7200;1314.5;  9; 644.8;  5; 429.2;  82; 859.7; 212;
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Option-5

Table of Travel Times

File: c:\documents and settings\mkakakhel\desktop\makael kakakhel\degree project\simulation\mak - hwy 403\option-5- move upstream 200m\option-5- move upstream 200m.inp
Comment:
Date: Thursday, April 24, 2008 9:22:14 AM

No. 1017 (N-E): from link 18 at 413.5 m to link 28 at 960.8 mDistance 2446.1 m
No. 1018 (S-E): from link 21 at 505.5 m to link 28 at 961.2 mDistance 1986.3 m
No. 1019 (HOV): from link 24 at 9.4 m to link 28 at 959.8 mDistance 2429.8 m
No. 1020 (HOV): from link 19 at 6.5 m to link 26 at 968.9 mDistance 2442.8 m

Time; Trav;#Veh; Trav;#Veh; Trav;#Veh; Trav;#Veh;
VehC; HOV2+;; HOV2+;; HOV2+;; All;;
No.:; 1017;1017; 1018;1018; 1019;1019; 1020;1020;
Name;N-E;N-E;S-E;S-E;HOV;HOV;HOV;HOV;
300; 91.5; 5; 72.5; 3; 85.4; 43; 97.8; 161;
600; 153.4; 8; 168.0; 3; 89.6; 110; 141.6; 435;
900; 256.7; 7; 148.4; 6; 89.1; 99; 159.5; 414;
1200; 383.0; 10; 148.1; 1; 87.4; 108; 168.5; 386;
1500; 299.1; 7; 177.0; 4; 87.1; 83; 180.8; 392;
1800; 343.2; 17; 172.1; 5; 88.0; 88; 202.3; 360;
2100; 324.8; 12; 146.7; 10; 87.1; 85; 262.4; 212;
2400; 325.6; 9; 195.9; 7; 88.3; 90; 410.1; 202;
2700; 416.6; 10; 455.8; 1; 87.3; 87; 544.2; 226;
3000; 700.9; 3; 433.1; 5; 86.8; 71; 646.5; 247;
3300; 829.3; 4; 399.0; 1; 87.5; 55; 713.3; 238;
3600;1049.7; 2; 436.5; 3; 87.0; 68; 737.4; 236;
3900; 814.2; 2; 414.2; 4; 88.4; 72; 765.1; 219;
4200; 877.8; 4; 402.5; 7; 85.7; 69; 758.7; 251;
4500; 873.7; 10; 453.2; 6; 85.7; 58; 761.3; 265;
4800; 969.1; 10; 350.3; 9; 88.4; 75; 717.6; 256;
5100; 839.4; 12; 378.4; 7; 90.4; 77; 679.7; 234;
5400; 760.3; 10; 279.9; 5; 87.5; 59; 672.9; 210;
5700; 866.0; 12; 398.4; 7; 88.8; 72; 703.0; 240;
6000; 807.1; 17; 409.8; 11; 86.4; 58; 681.0; 212;
6300; 757.0; 13; 489.6; 4; 89.6; 74; 756.1; 200;
6600; 875.1; 9; 0.0; 0; 86.7; 72; 789.9; 195;
6900; 793.5; 14; 561.7; 2; 86.6; 62; 819.5; 184;
7200; 962.7; 6; 562.2; 5; 88.8; 78; 879.8; 274;

Option-6

Table of Travel Times

File: c:\documents and settings\mkakakhel\desktop\makael kakakhel\degree project\simulation\mak - hwy 403\option-6-move upstream 100m\option -6- move upstream 100m.inp
Comment:
Date: Thursday, April 24, 2008 10:13:39 AM

No. 1017 (N-E): from link 18 at 413.5 m to link 28 at 960.8 mDistance 2446.2 m
No. 1018 (S-E): from link 21 at 505.5 m to link 28 at 961.2 mDistance 1986.3 m
No. 1019 (HOV): from link 24 at 9.4 m to link 28 at 959.8 mDistance 2429.7 m
No. 1020 (HOV): from link 19 at 6.5 m to link 26 at 968.9 mDistance 2442.8 m

Time	Trav	#Veh	Trav	#Veh	Trav	#Veh	Trav	#Veh
VehC	HOV2+		HOV2+		HOV2+		All	
No.:	1017	1017	1018	1018	1019	1019	1020	1020
Name	N-E	N-E	S-E	S-E	HOV	HOV	HOV	HOV
300	91.6	5	72.6	3	85.5	43	97.0	162
600	153.5	8	168.5	3	89.6	110	142.3	435
900	224.7	6	174.5	5	88.8	100	156.4	419
1200	357.9	8	120.8	3	87.1	107	153.2	405
1500	383.6	13	173.9	4	88.0	90	182.4	409
1800	319.3	12	154.0	4	86.5	89	183.5	311
2100	282.5	14	268.9	6	86.9	96	270.4	264
2400	315.7	7	162.7	5	88.5	90	398.6	254
2700	541.2	3	354.6	10	86.3	74	510.4	212
3000	794.1	5	356.1	2	88.3	74	633.2	274
3300	1033.6	2	312.8	3	87.4	52	639.9	270
3600	739.8	4	316.4	5	87.6	59	608.5	220
3900	968.3	3	300.3	6	87.8	79	710.9	210
4200	780.7	7	512.5	4	87.8	80	730.8	262
4500	948.4	11	683.1	3	87.5	57	700.5	296
4800	719.2	16	284.8	8	90.5	56	672.8	240
5100	633.5	16	238.6	8	90.0	68	669.5	224
5400	650.8	14	398.4	10	89.1	67	650.0	239
5700	844.0	9	331.4	8	87.2	66	672.0	234
6000	748.1	18	334.9	7	92.2	62	673.1	234
6300	757.5	13	383.8	2	88.4	63	706.8	200
6600	781.7	7	336.8	4	88.1	63	733.8	219
6900	971.7	10	518.5	5	88.2	75	725.5	191
7200	995.1	9	594.6	7	88.2	63	838.3	238