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TRANSPORTATION SOLUTIONS LIMITED



4063 Upper Middle Road Transportation Impact Study

Paradigm Transportation Solutions Limited

December 2016

Project Summary

Project Number
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December 2016

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4063 Upper Middle Rd. Developments
c/o
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4063 Upper Middle Road Transportation Impact Study

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Signatures and Seals



Signature

Engineer's Seal

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Executive Summary

Content

Paradigm Transportation Solutions Limited (Paradigm) has been retained to conduct this Transportation Impact Study for a multi-family residential development located at 4063 Upper Middle Road in Burlington, Ontario.

This Transportation Impact Study (TIS) includes an analysis of existing traffic conditions, a description of the proposed development, traffic forecasts for a horizon of five years from full build-out (2022 – 1 year assumed for construction and to reach full occupancy), and recommendations to improve future traffic conditions. The scope of the project was developed in consultation with the City of Burlington via email in November 2016.

Development Concept

The proposed multi-family residential development is located on the north side of Upper Middle Road, east of Walker's Line, in the City of Burlington and encompasses a 0.55-hectare parcel of land. The proposed development has been planned to accommodate a total of 32 residential condominium apartment units in a single, 5-storey mid-rise building.

Parking is to be provided through a combination of surface and underground parking lots with 19 stalls being provided at-grade and the remaining 39 stalls provided within an underground parking garage.

Access to the development is proposed by two driveways into the site. The east driveway is proposed to facilitate all moves, and the west driveway will restrict left turns out of the site. It is anticipated that the east driveway will retain its current location (existing residential driveway) and align with the proposed Park City Condo site driveway which is located on the south side of Upper Middle Road.

Conclusions

Based on the investigations carried out, it is concluded that:

- under 2016 existing conditions:
  - at the intersection of Upper Middle Road and Walker's Line:
    - the eastbound left movement operates at LOS F (v/c = 0.89) during the PM peak hour;
    - the westbound left movement operates at LOS F (v/c = 1.10) during the AM peak hour; and
    - the northbound left movement operates at LOS E (v/c = 0.90) during the PM peak hour.

- at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
  - the northbound left movement operates at LOS E (v/c = 0.52 and 0.59) during the AM and PM peak hour; and
  - the southbound left movement operates at LOS E (v/c = 0.55) during the AM peak hour.

- the development is forecast to generate 20 and 34 net new trips during the AM and PM peak hours, respectively;
- under 2022 background conditions:
  - at the intersection of Upper Middle Road and Walker's Line:
    - the eastbound left movement operates at LOS F (v/c = 1.00) during the PM peak hour;
    - the westbound left movement operates at LOS F (v/c = 1.29) during the AM peak hour and LOS E (v/c = 0.94) during the PM peak hour;
    - the westbound through movement operates at LOS E (v/c = 0.90) during the PM peak hour;
    - the northbound left movement operates at LOS F (v/c = 1.14) during the PM peak hour;
    - the southbound left movement operates at LOS E (v/c = 0.87) during the PM peak hour; and
    - the southbound through movement operates at LOS E (v/c = 0.89) during the PM peak hour.
  - at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
    - the northbound left movement operates at LOS E (v/c = 0.57 and 0.63) during the AM and PM peak hour; and
    - the southbound left movement operates at LOS E (v/c = 0.58) during the AM peak hour.
- under 2022 total conditions:
  - at the intersection of Upper Middle Road and Walker's Line:
    - the eastbound left movement operates at LOS F (v/c = 1.00) during the PM peak hour;
    - the westbound left movement operates at LOS F (v/c = 1.31) during the AM peak hour and LOS E (v/c = 0.95) during the PM peak hour;
    - the westbound through movement operates at LOS E (v/c = 0.91) during the PM peak hour;
    - the northbound left movement operates at LOS F (v/c = 1.14) during the PM peak hour;

  - the southbound left movement operates at LOS E (v/c = 0.88) during the PM peak hour; and
  - the southbound through movement operates at LOS E (v/c = 0.89) during the PM peak hour.
- at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
  - the northbound left movement operates at LOS E (v/c = 0.57 and 0.63) during the AM and PM peak hour; and
  - the southbound left movement operates at LOS E (v/c = 0.58) during the AM peak hour.
  - at the intersection of Upper Middle Road and East Driveway / Park City Driveway:
  - the southbound left-through-right movements operate at LOS E (v/c = 0.07) during the PM peak hour.

- signalized intersections within the study area will operate with reduced delays if signal timing plans are optimized;
- no traffic signals are warranted under 2022 total traffic conditions;
- utilizing the existing middle lane along Upper Middle Road, the left-turn storage provided is forecast to be sufficient to meet the queueing demands of traffic turning into the site;
- under background and total conditions, at the intersection of Upper Middle Road and Walker's Line both a westbound and northbound dual-left turn lane are warranted and would help reduce traffic delays;
- under background and total conditions, at the intersection of Upper Middle Road and William O'Connell Boulevard / Itabashi Way the eastbound right turn traffic volumes are in excess of 100 vehicles during the PM peak hour;
- at the development's driveways there are no anticipated safety concerns with regards to sight distance; and
- when considering a scenario with only one development driveway, the driveway was forecast to operate within acceptable levels, with no problem movements.

Recommendations

Based on the findings of this study, it is recommended that:

- signal timing plans for signalized intersections be optimized in order to reduce delays;
- the centre lane along Upper Middle Road be painted to designate that it is a left turn lane into the subject site; and



- the City of Burlington and Halton Region consider implementing westbound and northbound dual left-turn lanes at the intersection of Upper Middle Road and Walker's Line.

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1 Introduction

1.1 Overview

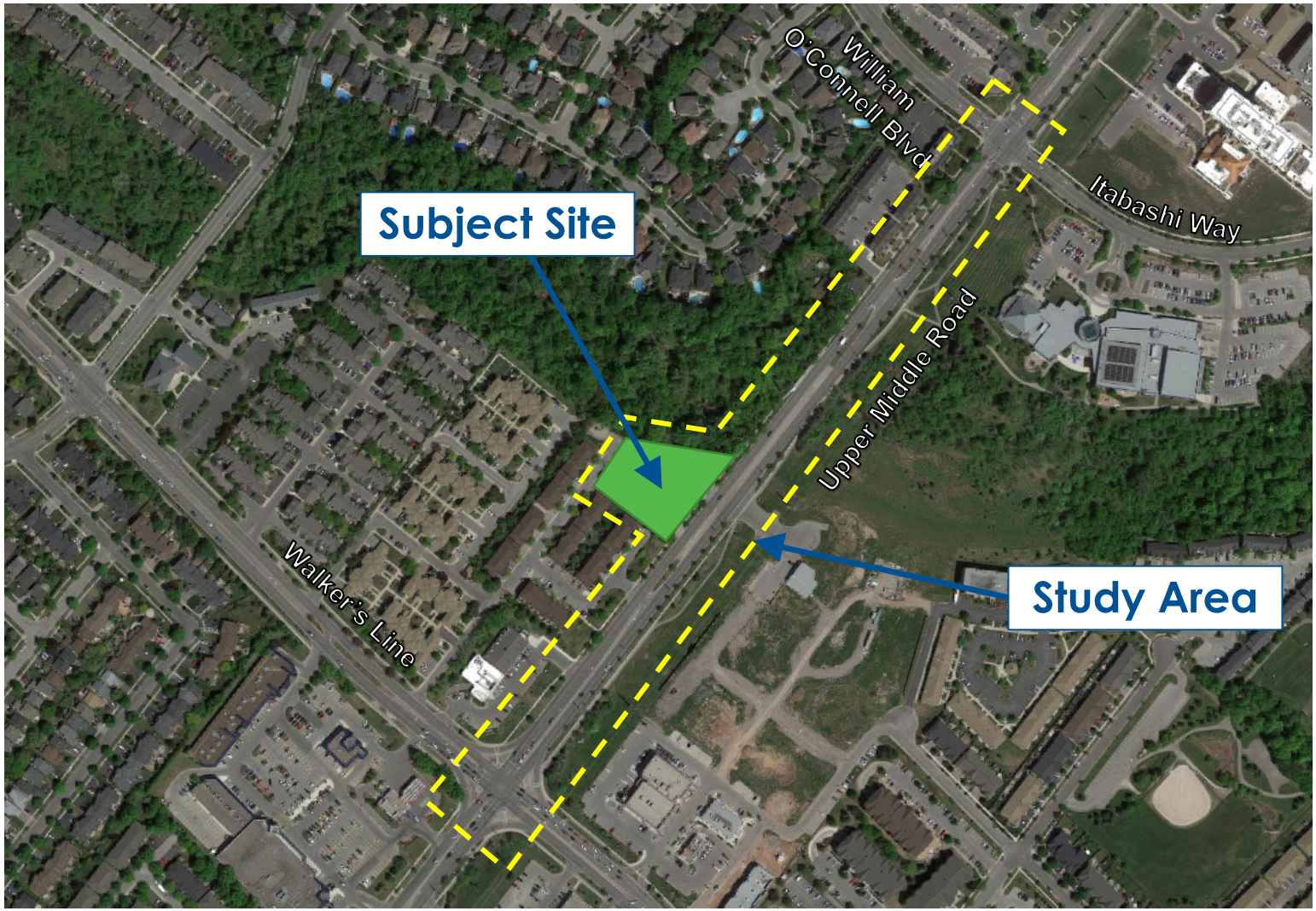
Paradigm Transportation Solutions Limited (Paradigm) has been retained to conduct this Transportation Impact Study for a multi-family residential development located at 4063 Upper Middle Road in Burlington, Ontario. **Figure 1.1** details the location of the subject development.

The scope of the study includes a determination and assessment of the current traffic and conditions in the vicinity of the existing site, the additional traffic that will be generated by the proposed development, analyses of the impact that this traffic may have on the adjacent street system and recommendations with regard to any necessary remedial measures required to mitigate the site generated traffic in a satisfactory manner. More specifically, the purpose of this report is to address the anticipated traffic impact of the proposed development by determining the forecast impact of traffic generated by the upgraded site on the adjacent street network at the intersections of:

- Upper Middle Road and Walker's Line (traffic signal control);
- Upper Middle Road and Itabashi Way / William O'Connell Boulevard (traffic signal control); and
- Upper Middle Road and development driveway (minor-street stop control).

This Transportation Impact Study (TIS) includes an analysis of existing traffic conditions, a description of the proposed development, traffic forecasts for a horizon of five years from full build-out (2022 – 1 year assumed for construction and to reach full occupancy), and recommendations to improve future traffic conditions. The scope of the project was developed in consultation with the City of Burlington via email in November 2016.

Paradigm analyzed the AM and PM peak hours for this study.



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Study Area and Subject Development Location

4063 Upper Middle Road, Burlington, TIS
162390

Figure 1.1

2 Existing Conditions

This section documents current traffic conditions, operational deficiencies, and constraints experienced by the public travelling at the intersections within the study area. The operational deficiencies and constraints identified at this stage will be fundamental to the process of defining the required remedial measures.

2.1 Road Network

The existing road network consists of a grid of major east-west and north-south arterial roadways, and a network of collector and local roads serving the existing residential subdivisions south of Upper Middle Road. Details of the existing roadway network, including lane configurations and traffic control at key intersections, are described below and illustrated in Figure 2.1.

Upper Middle Road (Regional Road 38) is a major east-west arterial road under the jurisdiction of Halton Region which connects Brant Street in the west to Burloak Drive (Regional Road 21) in the east. East of Walker's Line along the development frontage, Upper Middle Road consists of a divided, five-lane urban cross-section providing two lanes of capacity per direction with back-to-back left-turn lanes. Auxiliary turn lanes are provided at its intersections with Walker's Line and Itabashi Way. Upper Middle Road has a posted maximum speed limit of 60 km/h and stopping is prohibited on both sides of the roadway.

Walker's Line is a major north-south arterial roadway under the jurisdiction of the City of Burlington which connects the QEW in the south to Dundas Street (Regional Road 5) in the north. South of Upper Middle Road, Walker's Line consists of a five-lane urban cross-section providing two lanes of apacity
per direction, with a centre two-way left-turn lane. Auxiliary turn lanes are provided at its intersection with Upper Middle Road. Walker's Line has a posted maximum speed limit of 60 km/h and stopping is prohibited on both sides of the roadway.

Itabashi Way is an east-west minor collector roadway under the jurisdiction of the City of Burlington which provides direct access to the Tansley Woods Community Centre. The roadway consists of a two lane urban cross-section, providing one lane of capacity per direction, with auxiliary left-turn lanes provided at its intersection with Upper Middle Road. Itabashi Way has a posted maximum speed limit of 40 km/h and parking is permitted on both sides of the roadway.

William O'Connell Boulevard is a north-south residential collector roadway under the jurisdiction of the City of Burlington which provides access to the Millrose Mews commercial plaza. The roadway consists of a two-lane urban cross-section, providing one lane of capacity per direction, with an auxiliary

left-turn lane provided at its intersection with Upper Middle Road. William O'Connell Boulevard has an assumed maximum speed limit of 50 km/h and parking is prohibited on the east side of the roadway between Upper Middle Road and Millcroft Park Drive.

2.2 Existing Traffic Volumes

Weekday AM and PM peak hour turning movement counts were collected by Paradigm in November 2016. The existing AM and PM peak hour traffic volumes are shown in **Figure 2.2a** and **Figure 2.2b,** respectively.

The two-way peak hour traffic volumes on Upper Middle Road near the site range from approximately 1,615 vehicles in the AM peak hour to 2,070 vehicles during the PM peak hour, both of which are well within the maximum accepted capacity for a four-lane major arterial street (3,600).

2.3 Transit Service

Transit service within the vicinity of the site is provided by Burlington Transit. Upper Middle Road is serviced by Route #12 – Upper Middle which originates at the Burlington GO Station and includes a stop at the Tansley Woods Community Centre, terminating at the First Pro Shopping Centre located at the intersection of Dundas Street and Appleby Line. The westbound route mirrors the eastbound travel route and originates at the First Pro Shopping Centre. Weekday service is provided every 30 minutes during the AM and PM peak periods, with 60-minute headway during the midday and evening periods. Weekend service is provided every 60 minutes on Saturdays and Sundays.

Walker's Line is serviced by Route #15 – Walker's which originates at the Appleby GO Station and includes a stop at the Dundas & 407 GO Carpool lot, and terminates at the First Pro Shopping Centre located at the intersection of Dundas Street and Appleby Line. The southbound route mirrors the northbound travel route and originates at the First Pro Shopping Centre. Weekday service is provided every 30 minutes during the AM and PM peak periods, with 60-minute headway during the midday and evening periods. Weekend

2.4 Pedestrian and Cycling Facilities

Halton Region has several designated cycling routes (as identified on the Halton Region Cycling Map) within the study area. Within the study limits, the north side of Upper Middle Road is designated as a shared cycling facility (shared travel and cycling curb lane) and includes provision of concrete sidewalk adjacent to the roadway. The south side of Upper Middle Road is designated as a multi-use facility and includes provision of a concrete sidewalk and an off-road multi-use trail. It is noted that cycling is permitted on most sidewalks within the City of Burlington.

2.5 Travel Demand Management Initiatives

Halton Region and its area municipalities, including the City of Burlington, are actively developing and implementing trip reduction measures under the Smart Commute Halton initiative through the encouragement of active and sustainable transportation. The initiative is led by Halton Region, in partnership with Metrolinx, and offers a range of services and tools which have been designed to make commuting easier. Commuter options (as listed on the Smart Commute Halton website) include the promotion of carpooling, transit, active transportation and other measures.

2.6 Traffic Operations

Intersection level of service (LOS) is a recognized method of quantifying the average delay experienced by drivers at intersections. It is based on the delay experienced by individual vehicles executing the various movements. The delay is related to the number of vehicles desiring to make a particular movement, compared to the estimated capacity for that movement. The capacity is based on a number of criteria related to the opposing traffic flows and intersection geometry.

The highest possible rating is LOS A, under which the average total delay is equal or less than 10.0 seconds per vehicle. When the average delay exceeds 80 seconds for signalized intersections, 50 seconds for unsignalized intersections or when the volume to capacity ratio is greater than 1.0, the movement is classed as LOS F and remedial measures are usually implemented, if they are feasible. LOS E is usually used as a guideline for the determination of road improvement needs on through lanes, while LOS F may be acceptable for left-turn movements at peak times, depending on delays.

The operations of intersections in the study area were evaluated with the existing turning movement volumes using Synchro 9. The current signal timings for the signalized intersections were provided by Halton Region.

The intersection analysis considered two separate measures of performance:

- the volume to capacity ratio for each intersection; and
- the LOS for each turning movement. LOS is based on the average control delay per vehicle.

The existing intersection operations are summarized in **Table 2.1** indicating the existing levels of service (LOS), volume to capacity ratios (V/C) and 95th percentile queues experienced within the study area, for the AM and PM peak hours. Detailed Synchro reports are provided in **Appendix A**.

The following is noted regarding the 2016 existing operations:

- at the intersection of Upper Middle Road and Walker's Line:

- the eastbound left movement operates at LOS F (v/c = 0.89) during the PM peak hour;
- the westbound left movement operates at LOS F (v/c = 1.10) during the AM peak hour; and
- the northbound left movement operates at LOS E (v/c = 0.90) during the PM peak hour.

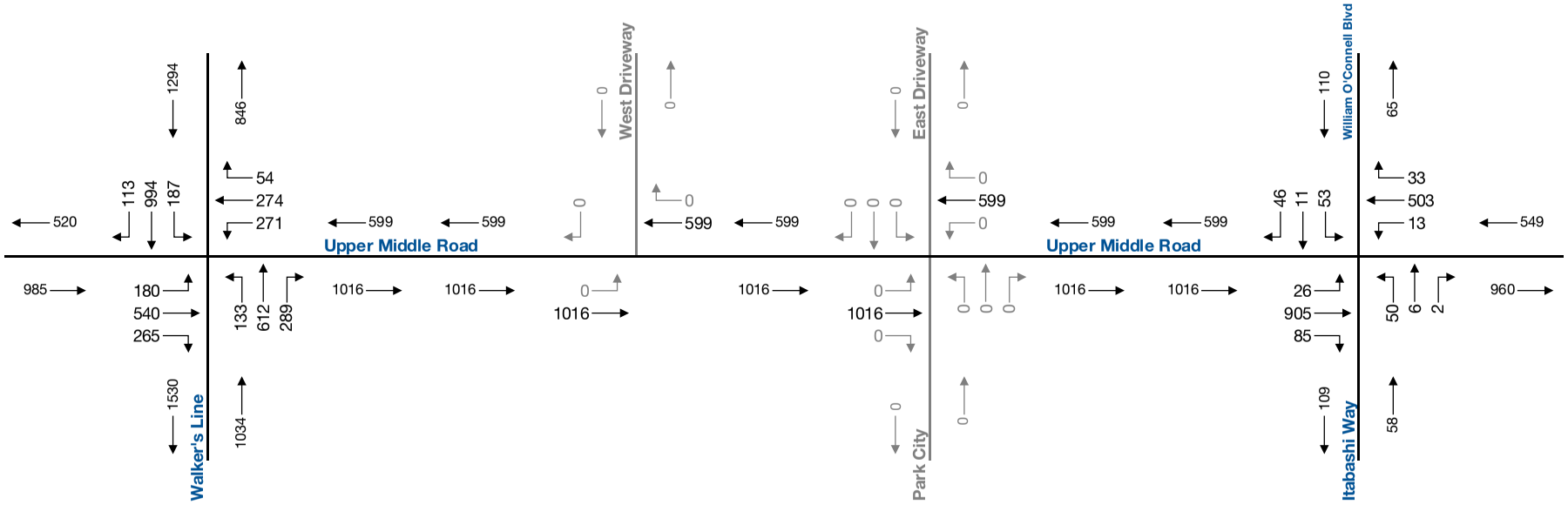
- at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
  - the northbound left movement operates at LOS E (v/c = 0.52 and 0.59) during the AM and PM peak hour; and
  - the southbound left movement operates at LOS E (v/c = 0.55) during the AM peak hour.



TABLE 2.1: 2016 PEAK HOUR TRAFFIC OPERATIONS

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				
				LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	OVERALL
AM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	D	D	D	**D**	F	C	B	**E**	C	C	C	**C**	B	C	C	**C**	**D**
			Delay	35	49	41	**44**	130	33	11	**75**	23	26	24	**25**	17	31	21	**28**	**38**
			V/C	0.54	0.77	0.44		1.10	0.35	0.04		0.58	0.45	0.30		0.49	0.71	0.10		
			Queue	49	87	51		109	30	1		31	85	43		42	152	16		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	A	A	**A**	E	D	D	**E**	E	D	D	**E**	**B**
			Delay	4	8	8	**8**	3	5	5	**5**	58	52	52	**57**	59	52	52	**56**	**12**
			V/C	0.04	0.40	0.40		0.04	0.23	0.23		0.52	0.05	0.05		0.55	0.13	0.13		
			Queue	3	96	96		2	35	35		26	7	7		27	16	16		
PM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	F	D	D	**E**	D	D	D	**D**	E	D	C	**D**	D	D	D	**D**	**D**
			Delay	87	51	47	**57**	50	54	38	**51**	56	38	29	**40**	43	50	37	**47**	**47**
			V/C	0.89	0.48	0.18		0.84	0.86	0.19		0.90	0.80	0.45		0.70	0.77	0.18		
			Queue	56	60	26		104	146	30		169	204	88		52	141	29		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	A	A	**A**	E	D	D	**D**	D	D	D	**D**	**B**
			Delay	6	7	7	**7**	4	10	10	**10**	57	49	49	**53**	50	48	48	**49**	**13**
			V/C	0.18	0.34	0.34		0.09	0.55	0.55		0.59	0.13	0.13		0.23	0.09	0.09		
			Queue	6	56	56		7	115	115		37	17	17		18	14	14		

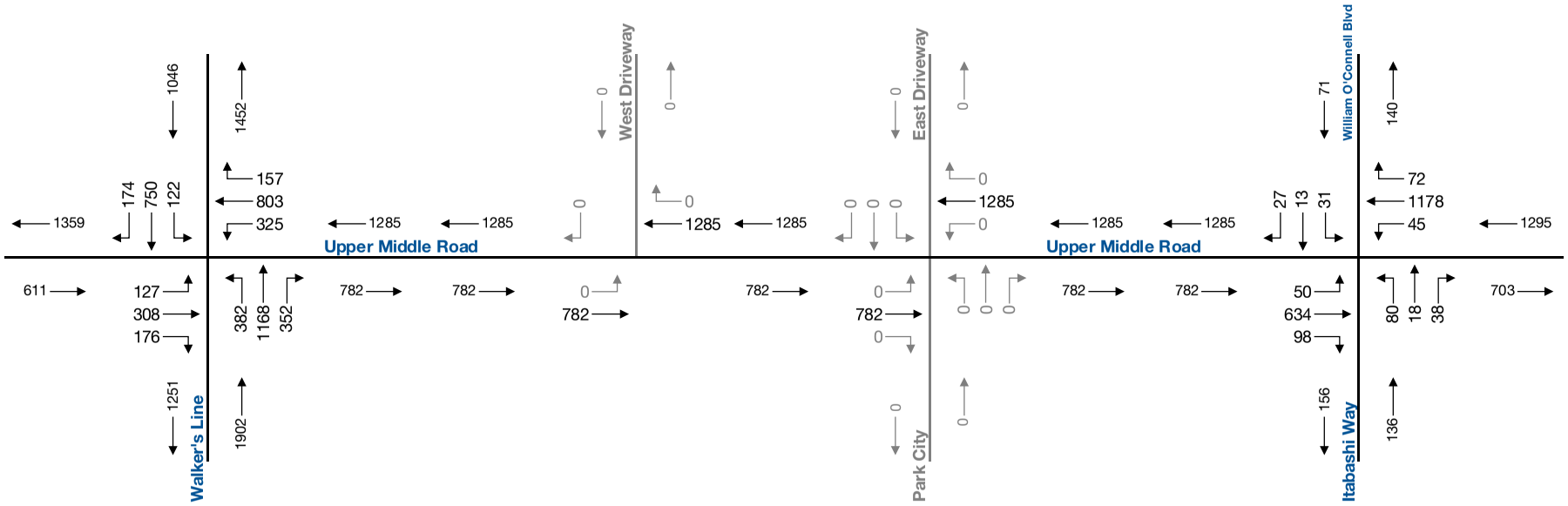
MOE - Measure of Effectiveness LOS - Level of Service Delay - Average Delay per Vehicle in Seconds V/C - Volume to Capacity Ratio Queue - 95th Percentile Queue Length



2016 Existing AM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

Figure 2.1a



2016 Existing PM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

Figure 2.1b

3 Development Concept

3.1 Development Description

The proposed multi-family residential development is located on the north side of Upper Middle Road, east of Walker's Line, in the City of Burlington and encompasses a 0.55-hectare parcel of land. The proposed development has been planned to accommodate a total of 32 residential condominium apartment units in a single, 5-storey mid-rise building. **Figure 3.1** displays the proposed site plan.

Parking is to be provided through a combination of surface and underground parking lots with 19 stalls being provided at-grade and the remaining 39 stalls provided within an underground parking garage.

Access to the development is proposed by two driveways into the site. The east driveway is proposed to facilitate all moves, and the west driveway will restrict left turns out of the site. It is anticipated that the east driveway will retain its current location (existing residential driveway) and align with the proposed Park City Condo site driveway which is located on the south side of Upper Middle Road.

3.2 Development Trip Generation

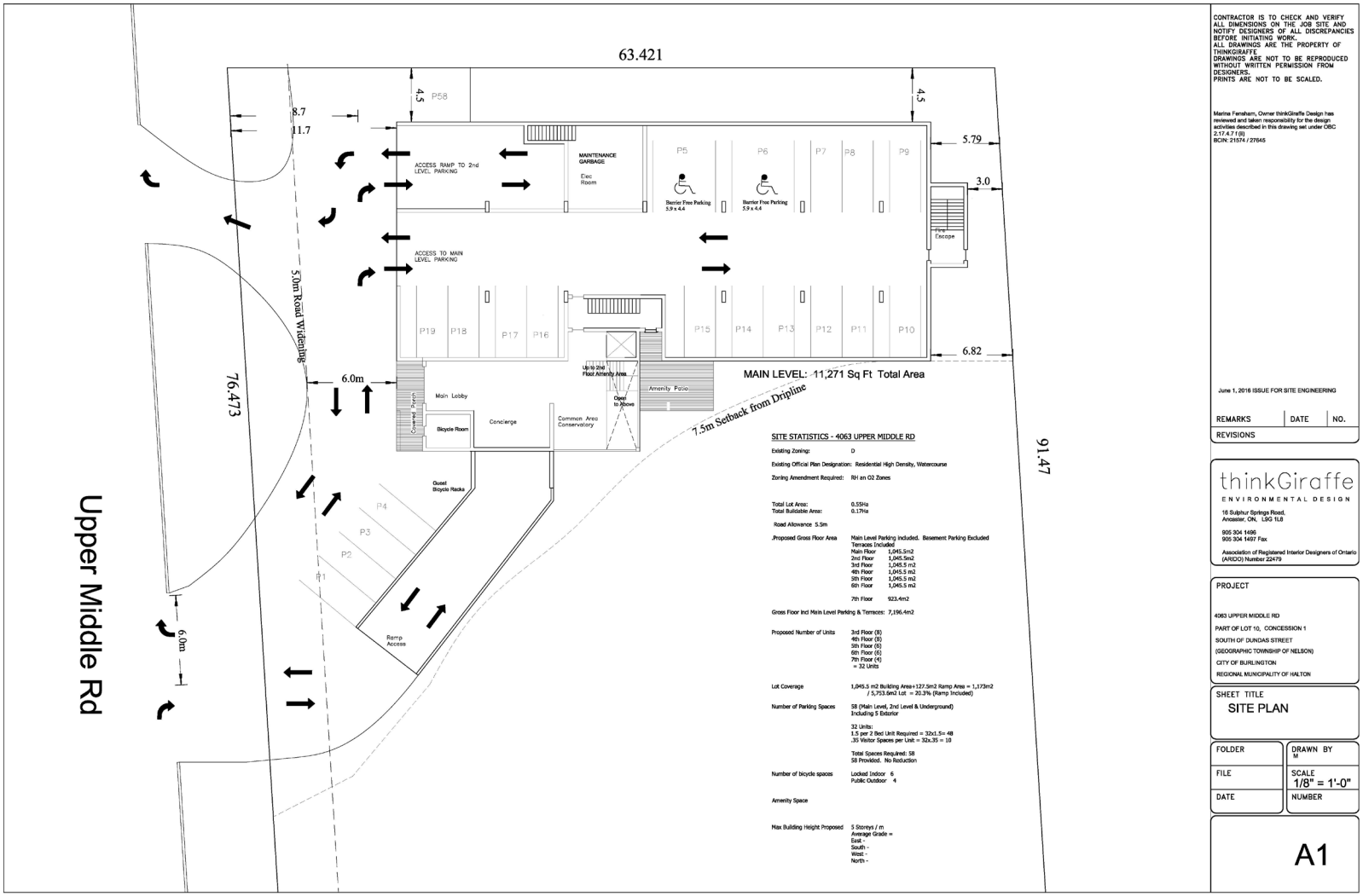
For the purposes of forecasting traffic demand that is likely be generated by the proposed development, Paradigm utilized the Institute of Transportation Engineer's Trip Generation[1] Land Use Code (ITE LUC) 220 (Apartment). Utilizing the fitted curve equation ITE code and the number of units, Paradigm determined approximate volume of traffic to be generated by the subject site. **Table 3.1** summarizes the trip generation based upon the ITE LUC 220.

TABLE 3.1: DEVELOPMENT TRIP GENERATION

Land Use	Units	AM Peak Hour					PM Peak Hour				
		R^2	Rate	Total	In	Out	R^2	Rate	Total	In	Out
220: Apartment (Fitted Curve)	32	0.82	0.62	20	6	14	0.80	1.07	34	21	13
New Trips				**20**	**6**	**14**			**34**	**21**	**13**

Paradigm determined that the site would generate an estimated 64 net new AM peak hour trips and 23 net new PM peak hour trips. Given the small number of trips estimated, Paradigm did not assume any trip reductions (transit/active modes), as to not under represent the site's traffic and to maintain a more conservative approach.

[1] Trip Generation Ninth Edition, Institute of Transportation Engineers, Washington D.C., 2012



Proposed Site Plan

4063 Upper Middle Road, Burlington, TIS
162390

Figure 3.1

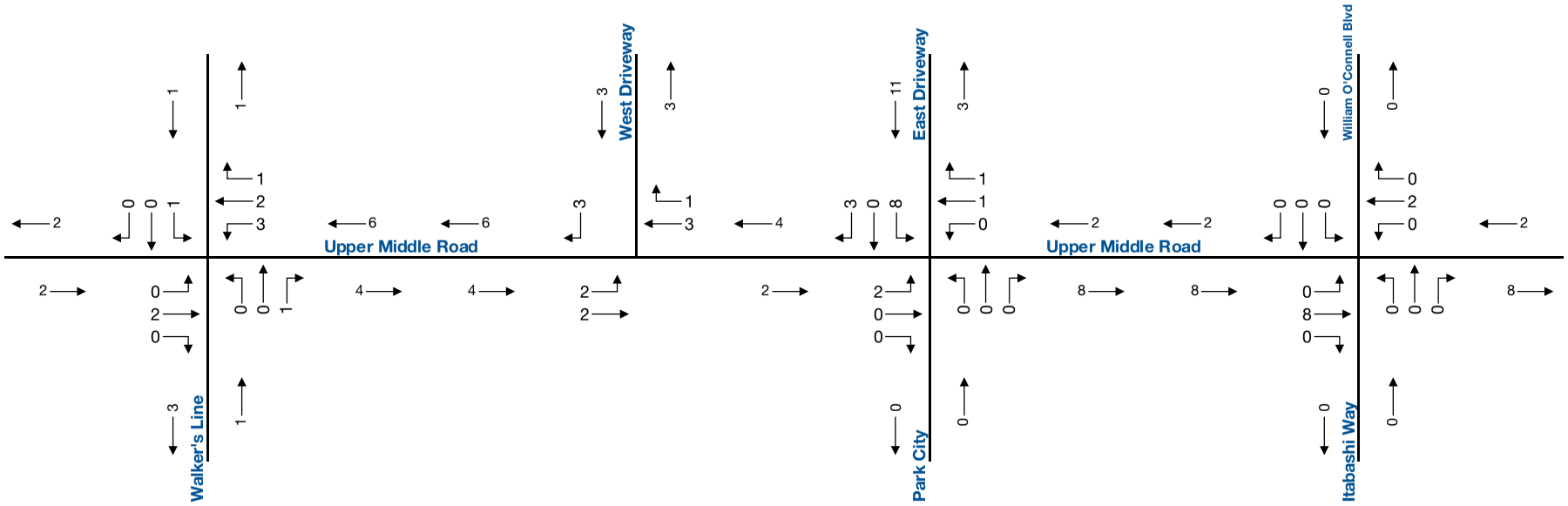
3.3 Development Trip Distribution and Assignment

The estimated direction of approach has been based on a review of existing travel patterns and distribution of trips entering and exiting the study area. Given the commuter nature of area traffic, the prevailing orientation is to/from the east via Upper Middle Road and south via Walker's Line (presumably to access the QEW and Highway 407 at Appleby Line). The resulting trip distribution is summarized in **Table 3.2**.

TABLE 3.2: TRIP DISTRIBUTION

Origin/Destination	AM Peak Hour		PM Peak Hour	
	Inbound	Outbound	Inbound	Outbound
To/From North via Walker's Line	12%	4%	7%	9%
To/From North via William O'Connell Boulevard	3%	3%	2%	3%
To/From South via Walker's Line	15%	20%	14%	15%
To/From South via Itabashi Way	5%	2%	6%	7%
To/From East via Upper Middle Road	35%	54%	57%	25%
To/From West via Upper Middle Road	30%	17%	14%	41%
Total	**100%**	**100%**	**100%**	**100%**

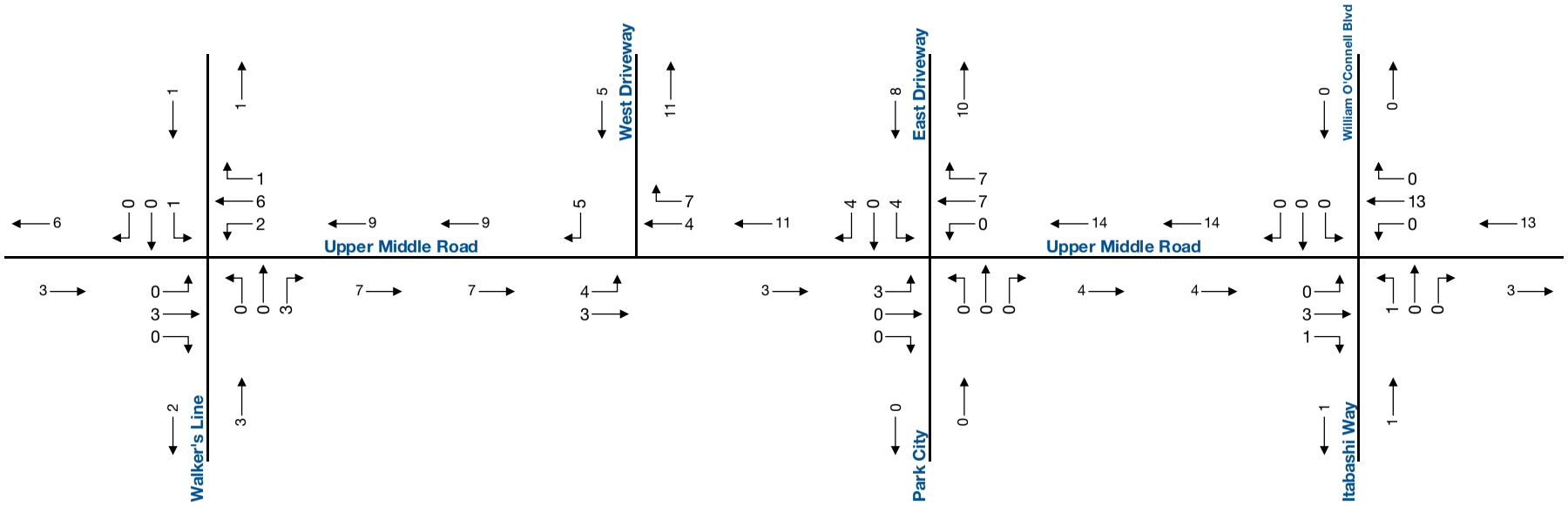
Site-generated trips were assigned to the adjacent road network based on logical routings which have considered the location of the site driveway, overall connectivity, prevailing traffic conditions and local knowledge of the surrounding area. **Figures 3.2a** and **Figure 3.2b** display the resulting AM and PM site traffic assignments.



Site Generated AM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

Figure 3.2a



Site Generated PM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

Figure 3.2b

4 Evaluation of Future Traffic Conditions

The assessment of future traffic conditions contained in this section includes estimates of future background and total traffic and analysis for the 2022 horizons. The future traffic volumes in the vicinity of the development will likely consist of increased non-site traffic volumes (background traffic), traffic generated by other developments, and the traffic forecast to be generated by the proposed development.

4.1 2022 Background Horizon

4.1.1 2022 Background Traffic Growth

The non-site traffic increase represents generalized traffic growth in the City of Hamilton. A growth rate of 2% per year was used for traffic on roads within the study area, as confirmed by Halton Region.

4.1.2 Other Area Developments

With regard to other area developments, it is recognized that the parcel of land located at 4030 Upper Middle Road (directly south of the site) is planned for future development of 374-unit multi-family residential condominium apartment units as well as a proposed 120-unit expansion to the existing Heritage Place Retirement Community. Application for the development of the Park City Condominium has been submitted to City and Regional review agencies, however approvals are pending. It is also noted that the final phase of the Village of Walker's Mews commercial development has not yet been constructed.

Given that the construction and occupancy of the above-noted developments is anticipated to occur within the 5-year planning horizon, traffic contributions associated with the respective developments have been included as part of the future background traffic forecast.

Consultation with the City of Burlington Planning and Building department confirmed that there are no further developments within the study area (planned or approved) that need to be examined as part of this study.

4.1.3 2022 Background Traffic Operations

Based on the forecast 2022 background traffic volumes (general growth plus other developments; shown in **Figure 4.1a** and **Figure 4.1b**), operational analyses have been conducted using Synchro 9 to determine the peak hour conditions for the intersections within the study area. No changes to the existing signal timings were made in this analysis. **Table 4.1** summarizes the 2022 background traffic operations.

Appendix B contains the detailed Synchro 9 reports for the 2022 background traffic conditions.



The following is noted regarding the 2022 background operations:

- at the intersection of Upper Middle Road and Walker's Line:
  - the eastbound left movement operates at LOS F (v/c = 1.00) during the PM peak hour;
  - the westbound left movement operates at LOS F (v/c = 1.29) during the AM peak hour and LOS E (v/c = 0.94) during the PM peak hour;
  - the westbound through movement operates at LOS E (v/c = 0.90) during the PM peak hour;
  - the northbound left movement operates at LOS F (v/c = 1.14) during the PM peak hour;
  - the southbound left movement operates at LOS E (v/c = 0.87) during the PM peak hour; and
  - the southbound through movement operates at LOS E (v/c = 0.89) during the PM peak hour.
- at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
  - the northbound left movement operates at LOS E (v/c = 0.57 and 0.63) during the AM and PM peak hour; and
  - the southbound left movement operates at LOS E (v/c = 0.58) during the AM peak hour.

TABLE 4.1: 2022 BACKGROUND OPERATIONS SUMMARY

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				
				LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	OVERALL
AM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	D	D	D	**D**	F	C	B	**F**	D	C	C	**C**	C	D	C	**D**	**D**
			Delay	36	48	41	**44**	202	31	13	**107**	41	29	27	**30**	23	39	23	**35**	**47**
			V/C	0.61	0.79	0.53		1.29	0.37	0.05		0.76	0.54	0.37		0.64	0.85	0.13		
			Queue	54	98	65		139	33	2		69	97	55		49	184	20		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	A	A	**A**	E	D	D	**E**	E	D	D	**E**	**B**
			Delay	5	10	10	**10**	4	5	5	**5**	60	51	51	**59**	60	52	52	**56**	**13**
			V/C	0.06	0.47	0.47		0.05	0.26	0.26		0.57	0.06	0.06		0.58	0.13	0.13		
			Queue	4	116	116		2	41	41		29	7	7		30	17	17		
	3 - Upper Middle Road and Park City Driveway	One-Way Stop Control	LOS		A	A	**A**	A	A		**A**	C		C	**C**					
			Delay		0	0	**0**	0	0		**0**	16		16	**16**					**0**
			V/C		0.49	0.25		0.01	0.29			0.09		0.09						
			Queue		0	0		0	0			2		2						
PM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	F	D	D	**E**	E	E	D	**E**	F	D	C	**E**	E	E	D	**E**	**E**
			Delay	118	49	46	**62**	66	57	37	**57**	132	51	33	**64**	71	59	39	**57**	**60**
			V/C	1.00	0.50	0.25		0.94	0.90	0.24		1.14	0.94	0.55		0.87	0.89	0.24		
			Queue	72	68	35		146	171	37		219	260	107		72	172	37		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	B	B	**B**	E	D	D	**D**	D	D	D	**D**	**B**
			Delay	8	8	8	**8**	5	12	12	**11**	58	48	48	**54**	49	47	47	**48**	**14**
			V/C	0.27	0.39	0.39		0.12	0.64	0.64		0.63	0.14	0.14		0.24	0.10	0.10		
			Queue	7	69	69		7	156	156		41	18	18		19	15	15		
	3 - Upper Middle Road and Park City Driveway	One-Way Stop Control	LOS		A	A	**A**	A	A		**A**	C		C	**C**					
			Delay		0	0	**0**	1	0		**1**	20		20	**20**					**0**
			V/C		0.38	0.19		0.05	0.62			0.07		0.07						
			Queue		0	0		1	0			2		2						

MOE - Measure of Effectiveness LOS - Level of Service Delay - Average Delay per Vehicle in Seconds V/C - Volume to Capacity Ratio Queue - 95th Percentile Queue Length

4.2 2022 Total Traffic Operations

The total trips expected in 2022, which is the addition of the development traffic to the background traffic is shown in **Figure 4.2a** and **Figure 4.2b**. Based on the forecasted 2022 total traffic volumes, operations analyses have been conducted using Synchro 9 to determine the peak hour conditions for the intersections within the study area. No changes to the existing signal timings were made in this analysis.

Table 4.2 summarizes the 2022 background traffic operations. **Appendix C** contains the detailed Synchro 9 reports for the 2022 total traffic conditions.

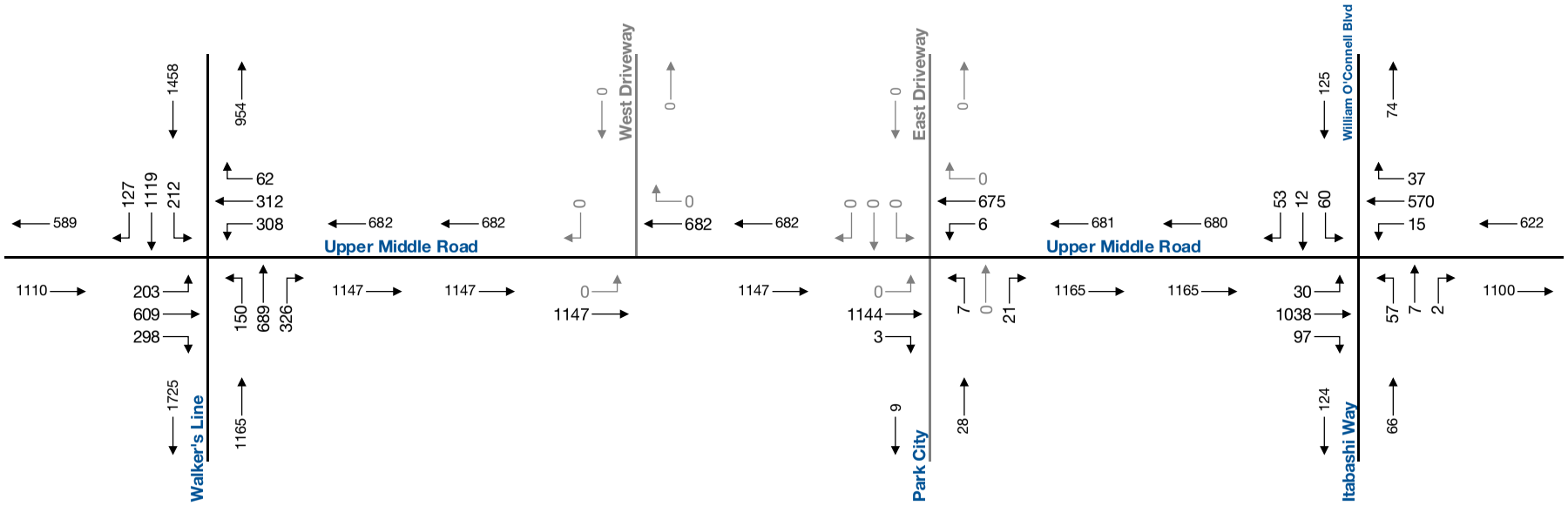
The following is noted regarding the 2022 total operations:

- at the intersection of Upper Middle Road and Walker's Line:
  - the eastbound left movement operates at LOS F (v/c = 1.00) during the PM peak hour;
  - the westbound left movement operates at LOS F (v/c = 1.31) during the AM peak hour and LOS E (v/c = 0.95) during the PM peak hour;
  - the westbound through movement operates at LOS E (v/c = 0.91) during the PM peak hour;
  - the northbound left movement operates at LOS F (v/c = 1.14) during the PM peak hour;
  - the southbound left movement operates at LOS E (v/c = 0.88) during the PM peak hour; and
  - the southbound through movement operates at LOS E (v/c = 0.89) during the PM peak hour.
- at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
  - the northbound left movement operates at LOS E (v/c = 0.57 and 0.63) during the AM and PM peak hour; and
  - the southbound left movement operates at LOS E (v/c = 0.58) during the AM peak hour.
- at the intersection of Upper Middle Road and East Driveway / Park City Driveway:
  - the southbound left-through-right movements operate at LOS E (v/c = 0.07) during the PM peak hour.

TABLE 4.2: 2022 TOTAL TRAFFIC OPERATIONS

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				
				LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	OVERALL
AM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	D	D	D	**D**	F	C	B	**F**	D	C	C	**C**	C	D	C	**D**	**D**
			Delay	36	48	41	**44**	206	31	13	**109**	41	29	27	**30**	23	39	23	**35**	**47**
			V/C	0.61	0.80	0.53		1.31	0.37	0.05		0.76	0.54	0.37		0.65	0.85	0.13		
			Queue	54	98	65		142	34	2		69	97	55		50	184	20		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	A	A	**A**	E	D	D	**E**	E	D	D	**E**	**B**
			Delay	5	10	10	**10**	4	5	5	**5**	60	51	51	**59**	60	52	52	**56**	**13**
			V/C	0.06	0.47	0.47		0.05	0.26	0.26		0.57	0.06	0.06		0.58	0.13	0.13		
			Queue	4	117	117		2	41	41		29	7	7		30	17	17		
	3 - Upper Middle Road and East Driveway / Park City Driveway	Two-Way Stop Control	LOS	A	A	A	**A**	A	A	A	**A**	C	C	C	**C**	C	C	C	**C**	
			Delay	0	0	0	**0**	0	0	0	**0**	18	18	18	**18**	23	23	23	**23**	**1**
			V/C	0.00	0.37	0.37		0.01	0.22	0.22		0.10	0.10	0.10		0.06	0.06	0.06		
			Queue	0	0	0		0	0	0		3	3	3		1	1	1		
	4 - Upper Middle Road and West Driveway	One-Way Stop Control	LOS	A	A		**A**		A	A	**A**							B	**B**	
			Delay	0	0		**0**		0	0	**0**							11	**11**	**0**
			V/C	0.00	0.49				0.29	0.15								0.00		
			Queue	0	0				0	0								0		
PM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	F	D	D	**E**	E	E	D	**E**	F	D	C	**E**	E	E	D	**E**	**E**
			Delay	118	49	46	**62**	67	57	36	**57**	134	51	33	**64**	72	59	39	**57**	**61**
			V/C	1.00	0.50	0.25		0.95	0.91	0.24		1.14	0.94	0.55		0.88	0.89	0.24		
			Queue	72	68	35		148	173	38		219	260	107		74	172	37		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	B	B	**B**	E	D	D	**D**	D	D	D	**D**	**B**
			Delay	8	8	8	**8**	5	12	12	**12**	58	48	48	**54**	49	47	47	**48**	**14**
			V/C	0.27	0.39	0.39		0.12	0.65	0.65		0.63	0.14	0.14		0.24	0.10	0.10		
			Queue	7	69	69		7	158	158		41	18	18		19	15	15		
	3 - Upper Middle Road and East Driveway / Park City Driveway	Two-Way Stop Control	LOS	A	A	A	**A**	A	A	A	**A**	D	D	D	**D**	E	E	E	**E**	
			Delay	0	0	0	**0**	1	0	0	**1**	25	25	25	**25**	36	36	36	**36**	**1**
			V/C	0.01	0.29	0.29		0.05	0.47	0.47		0.09	0.09	0.09		0.07	0.07	0.07		
			Queue	0	0	0		1	0	0		3	3	3		2	2	2		
	4 - Upper Middle Road and West Driveway	One-Way Stop Control	LOS	A	A		**A**		A	A	**A**							A	**A**	
			Delay	0	0		**0**		0	0	**0**							10	**10**	**0**
			V/C	0.01	0.38				0.62	0.32								0.01		
			Queue	0	0				0	0								0		

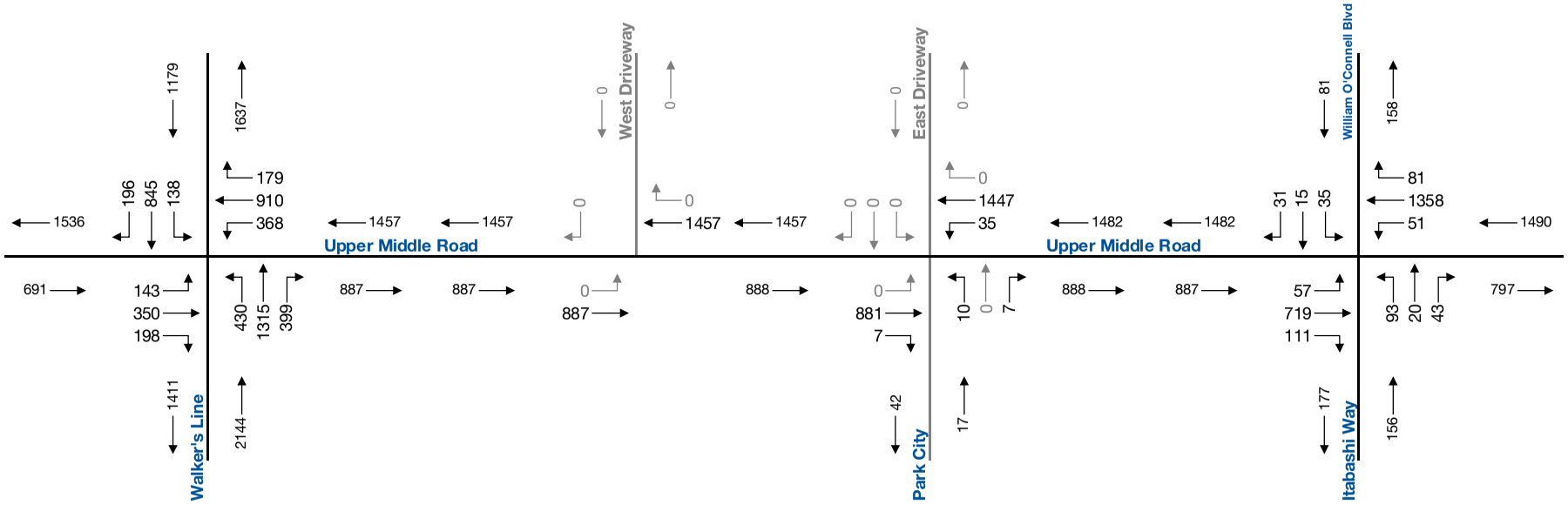
MOE - Measure of Effectiveness LOS - Level of Service Delay - Average Delay per Vehicle in Seconds V/C - Volume to Capacity Ratio Queue - 95th Percentile Queue Length



2022 Background AM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

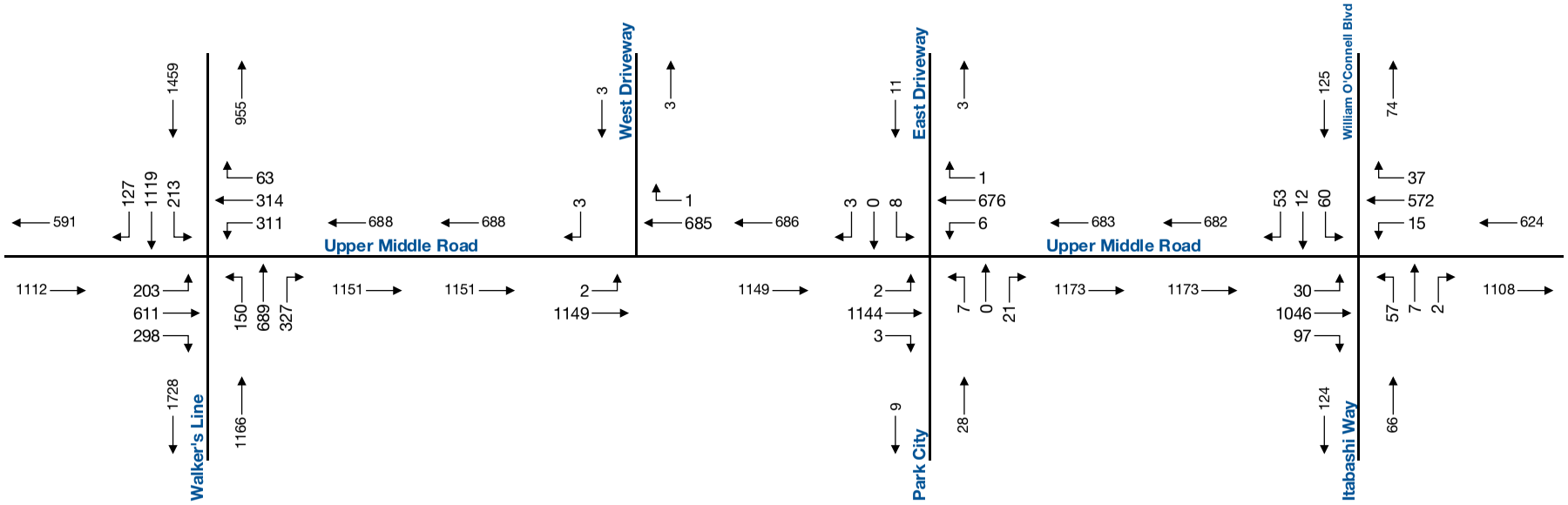
Figure 4.1a



2022 Background PM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

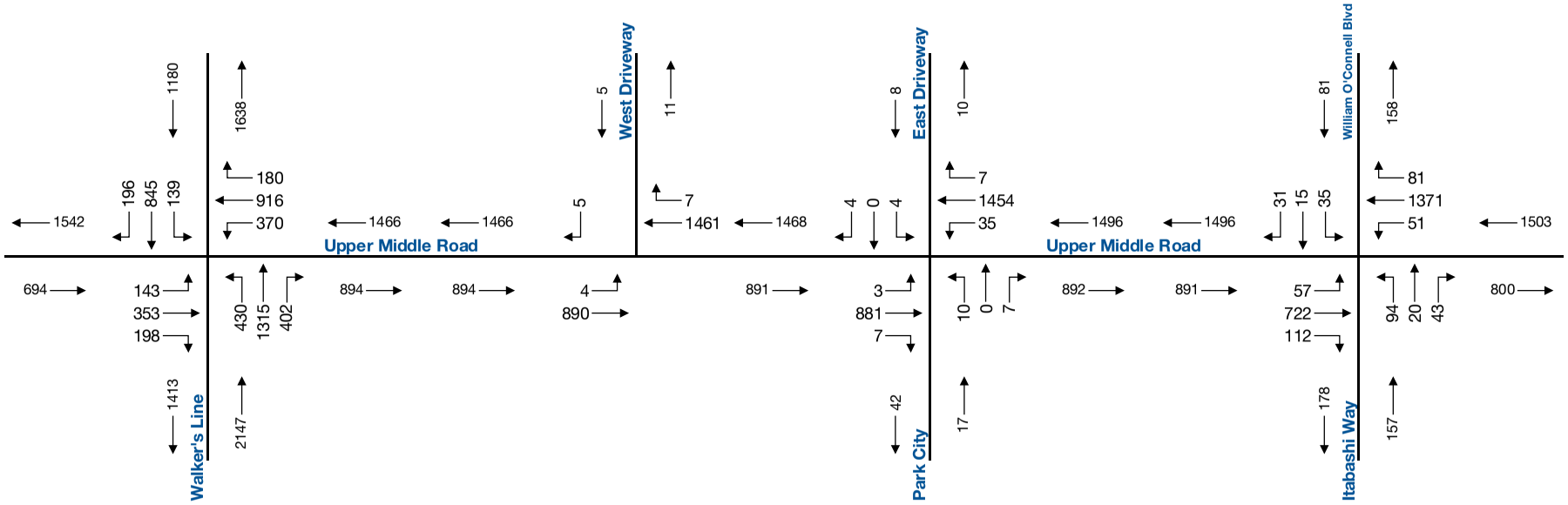
Figure 4.1b



2022 Total AM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

Figure 4.2a



2022 Total PM Peak Hour Traffic Volumes

4063 Upper Middle Road, Burlington, TIS
162390

Figure 4.2b

5 Remedial Measures

5.1 Signals

5.1.1 Signal Timing Plan Optimization

As traffic grows over time, often the previous signal timing plans for intersections become obsolete as particular turning movements require more signal green time. Utilizing Synchro 9, Paradigm optimized signal timing plans to determine the potential improved operations. **Table 5.1** summarizes the signalized intersection's operations with an optimized signal timing plan. **Appendix D** contains the detailed Synchro 9 reports.

Comparing the total traffic operations pre and post optimization, the following is noted:

- at the intersection of Upper Middle Road and Walker's Line:
  - the overall intersection delay during the AM peak hour was reduced from 47 seconds to 39 seconds; and
  - the overall intersection delay during the PM peak hour was reduced from 61 seconds to 55 seconds.
- at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
  - the overall intersection delay during the AM peak hour was reduced from 13 seconds to 11 seconds; and
  - the overall intersection delay during the PM peak hour was increased from 14 seconds to 15 seconds, and reduced delays such that no turning movements were LOS E or worse.

5.1.2 New Signal Implementation

As a result of site-generated traffic, the potential need for traffic signals at the intersection of Upper Middle Road and East Driveway / Park City Driveway has been examined. Paradigm assessed the need for a traffic signal using the methodologies contained in the Ontario Traffic Manual (OTM), Book 12 – Traffic Signals.

Traffic signals have both advantages and disadvantages. While traffic signals can provide efficient movement of traffic and reduce the frequency of certain types of collisions, they also require substantially more operational maintenance, cost more than a stop-controlled intersection, and can result in an increased occurrence of rear-end collisions. Therefore, the decision to install a traffic signal should be based on sound engineering judgment and a determination of operational need. OTM Book 12 has seven justifications that can assist in determining the need for traffic signals. Due to the uncertainty of future volume projections, an increased justification threshold is used in the warrant analysis when examining future need for signals.



Justification 1 and Justification 2 are used and are required to both be satisfied 120% in order to consider the installation of traffic signals.

Justification 1 – Minimum Vehicle Volumes is intended for applications where the principal reason to consider the installation of a traffic signal is the cumulative delay produced by a large volume of intersecting traffic at an unsignalized intersection. Justification 1A reflects the lowest total traffic on all approaches and Justification 1B reflects the lowest volume on the minor road for which the average delay is similar for both signalized and unsignalized conditions. Therefore, this justification is intended to address the minimum volume conditions in which signalization can be used to minimize total average vehicle delay at the intersection.

Justification 2 – Delay to Cross Traffic is intended for applications where the traffic volume on the main road is so heavy that traffic on the minor road suffers excessive delay or hazard in entering or crossing the main road.

Based on the warrant analysis, the intersection of Upper Middle Road and the proposed East Driveway / Park City Driveway does not meet the criteria necessary to warrant the installation of traffic signals under forecasted future total traffic volumes. The completed analysis is provided in **Figure 5.1**.

TABLE 5.1: SIGNALIZED INTERSECTION'S OPERATIONS WITH OPTIMIZED TIMING PLANS

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				OVERALL
				LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	
AM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	C	E	D	**D**	F	C	C	**E**	D	C	C	**C**	C	D	B	**C**	**D**
			Delay	25	59	36	**47**	91	32	29	**58**	46	28	24	**29**	21	37	18	**33**	**39**
			V/C	0.55	0.96	0.60		1.05	0.47	0.05		0.83	0.64	0.35		0.68	0.91	0.10		
			Queue	45	99	60		103	43	1		47	80	37		37	151	12		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	A	A	**A**	C	C	C	**C**	C	C	C	**C**	**B**
			Delay	5	10	10	**10**	6	8	8	**8**	24	22	22	**24**	24	22	22	**23**	**11**
			V/C	0.07	0.64	0.64		0.08	0.36	0.36		0.40	0.04	0.04		0.40	0.10	0.10		
			Queue	3	95	95		2	37	37		15	4	4		16	11	11		
PM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	E	D	D	**D**	E	E	C	**E**	F	D	C	**D**	D	E	C	**D**	**E**
			Delay	67	48	38	**49**	55	74	28	**64**	96	47	25	**53**	54	59	29	**53**	**55**
			V/C	0.85	0.76	0.15		0.94	1.03	0.18		1.08	0.98	0.53		0.83	0.97	0.15		
			Queue	46	60	22		115	156	23		152	200	73		46	140	18		
	2 - Upper Middle Road and William O'Connell Blvd / Itabashi Way	Signal	LOS	A	A	A	**A**	A	B	B	**B**	D	C	C	**C**	C	C	C	**C**	**B**
			Delay	8	10	10	**10**	5	16	16	**15**	41	25	25	**34**	26	25	25	**25**	**15**
			V/C	0.25	0.50	0.50		0.14	0.82	0.82		0.71	0.15	0.15		0.27	0.11	0.11		
			Queue	5	52	52		4	138	138		29	12	12		12	10	10		

MOE - Measure of Effectiveness LOS - Level of Service Delay - Average Delay per Vehicle in Seconds V/C - Volume to Capacity Ratio Queue - 95th Percentile Queue Length

Signal Justification Calculation for Forecasted Volumes
(OTM Book 12 - Justification 7)

Horizon Year: 2022 (Total Traffic)
Region/City/Township: Halton Region

Major Street: Upper Middle Road
Minor Street: East Driveway / Park City Driveway
North/South?: N

Number of Approach Lanes: 2 or more
Tee Intersection? N
Flow Conditions: Free

PM Forecast Only? N

Warrant Results		
150% Satisfied	No	Justification for new intersections with forecast traffic
120% Satisfied	No	Justification for existing intersections with forecast traffic

	Major Street						Minor Street						
	Upper Middle Road						East Driveway / Park City Driveway						
	Eastbound			Westbound			Northbound			Southbound			Peds
Time Period	Left	Through	Right	Left	Through	Right	Left	Through	Right	Left	Through	Right	Crossing
AM Peak Hour	2	1144	3	6	676	1	7	0	21	8	0	3	10
PM Peak Hour	3	881	7	35	1454	7	10	0	7	4	0	4	10
Average Hourly Volume	1	506	3	10	533	2	4	0	7	3	0	2	5

Warrant	AHV
1A - All	1071
1B - Minor	16
2A - Major	1055
2B - Cross	12

Warrant 1 - Minimum Vehicular Volume

	Approach Lanes	1		2 or more		Average Hourly Volume
1A	Flow Conditions	Free	Restricted	Free	Restricted	
				X		
	All Approaches	480	720	600	900	1071
					% Fulfilled	178.5%

	Approach Lanes	1		2 or more		Average Hourly Volume
1B	Flow Conditions	Free	Restricted	Free	Restricted	
				X		
	Minor Street Approaches	120	170	120	170	16
					% Fulfilled	13.3%

Warrant 2 - Delay To Cross Traffic

	Approach Lanes	1		2 or more		Average Hourly Volume
2A	Flow Conditions	Free	Restricted	Free	Restricted	
				X		
	Major Street Approaches	480	720	600	900	1055
					% Fulfilled	175.8%

	Approach Lanes	1		2 or more		Average Hourly Volume
2B	Flow Conditions	Free	Restricted	Free	Restricted	
				X		
	Traffic Crossing Major Street	50	75	50	75	12
					% Fulfilled	24.5%

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Upper Middle Road and East Driveway / Park City Driveway Traffic Signal Warrant Analysis

5.2 Auxiliary Turn Lanes

5.2.1 Development Driveways

At the intersection of the East Driveway and West Driveway with Upper Middle Road, there exists an unmarked centre turning lane with approximately 30 metres storage (from the east driveway). With the construction of the site, this lane should be marked and utilized as a left-turn lane into the site. Additionally, it is expected that the Park City development utilize the 45 metres of storage available for an westbound left turn lane.

The current five-lane cross-section of Upper Middle Road provides for an eastbound left-turn lane at the site driveway with approximately 30 metres of left-turn storage. Queuing analyses of total traffic conditions has confirmed that the existing 30 metres of storage can satisfactorily accommodate the forecasted left-turn demand at the proposed site driveway.

However, it is noted that there is an existing median opening located at the proposed location of the west driveway. At this location there is approximately 5 metres of storage. Queuing analyses of total traffic conditions has confirmed that the existing 5 metres of storage can satisfactorily accommodate the forecasted left-turn demand at the proposed site driveway.

Table 5.2 summarizes the operations with the developments utilizing the fifth lane as left-turn lanes into their respective sites. **Appendix E** contains the detailed Synchro 9 reports.

5.2.2 Dual Left-Turn Lanes

The City of Burlington will typically consider implementation of a dual left-turn lane when volumes are in excess of 350 vehicles in a given peak hour. At the intersection of Upper Middle Road and Walker's Line, the westbound left and northbound left movements, both have turning volumes over the 350 vehicle threshold. As such, implementation of dual-left turn lanes should be considered.

The provision of a dual left-turn lane has both advantages and disadvantages. While the delay associated with the left-turns will be reduced, there is an increased delay for the other movements at the intersection, as dual left-turn lanes require their own protected signal phase. Paradigm looked at the potential benefits of implementing both a westbound and northbound dual left-turn lane at the intersection of Upper Middle Road and Walker's Line. Signal timing plans were also optimized for the new road geometry.

Comparing the total traffic operations pre and post optimization, the following is noted:

- at the intersection of Upper Middle Road and Walker's Line:



- the overall intersection delay during the AM peak hour was reduced from 47 seconds to 36 seconds; and
- the overall intersection delay during the PM peak hour was reduced from 61 seconds to 48 seconds.

Overall the implementation of the dual-left turn lanes provides an overall net-benefit for the intersection's operations, and therefore should be considered for implementation. It is noted that the poor operations at the intersection are a direct result of existing traffic, compounded by the background traffic growth, and that the subject development is not a factor in the poor operations. **Appendix F** contains the detailed Synchro 9 reports.

5.2.3 Right-Turn Lanes

A designated right-turn lane is typically considered for implementation when right-turn traffic volumes are in excess of 100 vehicles in a peak hour. The only location within the study area that meets this volume criteria without already having a designated right-turn lane is the eastbound right at the intersection of Upper Middle Road and William O'Connell Road / Itabashi Way. Additionally, the volume is only just over 100 vehicles during the PM peak hour (112 vehicles). Due to the current acceptable operations and the traffic volumes being slightly over the volume threshold, Paradigm does not recommend an eastbound right-turn at this location.

It is noted that the development is not responsible for the right-turn lane, as it's potential requirement is present under background conditions.



TABLE 5.2: DEVELOPMENT DRIVEWAY OPERATIONS WITH LEFT TURN LANES

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																OVERALL
				Eastbound				Westbound				Northbound				Southbound				
				LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	
AM Peak Hour	3 - Upper Middle Road and East Driveway / Park City Driveway	Two-Way Stop Control	LOS	A	A	A	**A**	B	A	A	**A**	C	C	C	**C**	C	C	C	**C**	**1**
			Delay	9	0	0	**0**	11	0	0	**0**	18	18	18	**18**	23	23	23	**23**	
			V/C	0.00	0.49	0.25		0.01	0.29	0.14		0.10	0.10	0.10		0.06	0.06	0.06		
			Queue	0	0	0		0	0	0		3	3	3		1	1	1		
	4 - Upper Middle Road and West Driveway	One-Way Stop Control	LOS	A	A		**A**		A	A	**A**							B	**B**	**0**
			Delay	9	0		**0**		0	0	**0**							11	**11**	
			V/C	0.00	0.37				0.29	0.15								0.00		
			Queue	0	0				0	0								0		
PM Peak Hour	3 - Upper Middle Road and East Driveway / Park City Driveway	Two-Way Stop Control	LOS	B	A	A	**A**	A	A	A	**A**	D	D	D	**D**	E	E	E	**E**	**1**
			Delay	13	0	0	**0**	10	0	0	**0**	25	25	25	**25**	37	37	37	**37**	
			V/C	0.01	0.38	0.19		0.05	0.62	0.31		0.10	0.10	0.10		0.07	0.07	0.07		
			Queue	0	0	0		1	0	0		3	3	3		2	2	2		
	4 - Upper Middle Road and West Driveway	One-Way Stop Control	LOS	B	A		**A**		A	A	**A**							A	**A**	**0**
			Delay	13	0		**0**		0	0	**0**							10	**10**	
			V/C	0.01	0.28				0.62	0.32								0.01		
			Queue	0	0				0	0								0		

MOE - Measure of Effectiveness LOS - Level of Service Delay - Average Delay per Vehicle in Seconds V/C - Volume to Capacity Ratio Queue - 95th Percentile Queue Length

TABLE 5.3: UPPER MIDDLE AND WALKER'S OPERATIONS WITH DUAL LEFT TURN LANES

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																OVERALL
				Eastbound				Westbound				Northbound				Southbound				
				LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	
AM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	C	E	C	**D**	E	C	C	**D**	D	C	C	**C**	B	D	B	**C**	**D**
			Delay	23	55	32	**43**	78	32	28	**52**	42	24	20	**25**	19	35	16	**31**	**36**
			V/C	0.58	0.96	0.61		0.98	0.58	0.05		0.65	0.62	0.30		0.67	0.92	0.09		
			Queue	42	90	60		55	41	0		26	70	26		33	138	10		
PM Peak Hour	1 - Upper Middle Road and Walker's Line	Signal	LOS	E	D	C	**D**	E	E	C	**E**	D	D	C	**D**	D	D	C	**D**	**D**
			Delay	64	38	34	**42**	55	74	28	**64**	54	47	25	**45**	51	40	25	**39**	**48**
			V/C	0.85	0.56	0.14		0.84	1.03	0.18		0.86	0.98	0.53		0.83	0.84	0.15		
			Queue	48	53	20		65	156	23		74	200	73		48	119	17		

MOE - Measure of Effectiveness LOS - Level of Service Delay - Average Delay per Vehicle in Seconds V/C - Volume to Capacity Ratio Queue - 95th Percentile Queue Length

5.3 Development Site Access

5.3.1 Driveway Sight Distance

Sight distance requirements for minor street stop-controlled intersections, as contained in the TAC Geometric Design Guide for Canadian Roads[2], recommends that driveway intersections with private roadways should have sight distance equal to, or greater than, the minimum stopping sight distance (SSD) for the chosen design speed. Achieving the minimum stopping sight distance allows alert, competent drivers to come to a quick stop under ordinary circumstances.

The available sight distances at the proposed site driveway were reviewed in the field and considered to be satisfactory as the minimum stopping sight distance (SSD) for an 80 km/h design speed has been achieved. It is noted that based on a 70 km/h design speed, both minimum stopping sight and minimum decision sight distance are achieved. **Table 5.4** summarizes the findings of the sight distance analysis.

TABLE 5.4: SIGHT DISTANCE MEASUREMENTS

Intersection	Posted Speed	Design Speed	Available Visibility				Required Sight Distance [1]		Remarks
			To / From East		To / From West				
			Turning	Approaching	Turning	Approaching	Min SSD	Min DSD	
Upper Middle Road at East Driveway	60 km/h	80 km/h	210 m	165 m	> 250 m	> 250 m	135 m	235 m	Satisfies Minimum SSD for 80 km/h design speed
Upper Middle Road at West Driveway	60 km/h	80 km/h	250 m	205 m	> 250 m	> 250 m	135 m	235 m	Satisfies Minimum SSD for 80 km/h design speed

[1] Required Sight Distance given in terms of minimum stopping sight distance (SSD) and minimum decision sight distance (DSD) for an 80 km/h Design Speed

5.3.2 Intersection Spacing

The spacing of the proposed site driveway was reviewed in conjunction with the minimum intersection spacing requirements of Halton Region. As specified in the Halton Region Access Management Policy for Regional Roads[3], the minimum spacing between a signalized intersection and Private Entrance / Site Driveway should satisfy a minimum spacing of 230 metres in order to ensure that vehicles queued at the upstream/downstream traffic signal will not block the use of the site driveway.

The proposed all-turns site driveway to Upper Middle Road satisfies minimum spacing requirements as it is located approximately 250 metres east of Walker's Line and 320 metres west of William O'Connell Boulevard / Itabashi Way.

[2] Geometric Design Guide for Canadian Roads, Transportation Association of Canada, September 1999.

[3] Access Management Plan for RR25 - Regional Roads 5 & 25 Corridor Strategy Study, Synectics, November 1999.

5.3.3 One Driveway Scenario

Paradigm assessed a scenario where the development only provides one access to the subject site from Upper Middle Road. The analysis showed, that should only one driveway be provided for the site, the intersection of Upper Middle Road and East Driveway / Park City Driveway will operate within acceptable levels, with no problem movements. **Table 5.5** displays the operations, and **Appendix G** contains the detailed Synchro 9 reports.

5.4 Transportation Demand Management Initiatives

The proposed condominium development is located adjacent to two key transit corridors which provide links to various mobility hubs within the City of Burlington. The sites location to the Upper Middle and Walker's Line transit corridors provides for direct transit service to both the Appleby GO station as well as the Highway 407 GO Carpool lot, making public transit an attractive alternative for commuters. Given the strategic location of the proposed development, it is recommended that the applicant consider implementing select Transportation Demand Management (TDM) initiatives that will encourage efficient use of the existing transportation system by promoting alternate travel modes such as walking, cycling and public transit, thereby reducing reliance on the private automobile. The following TDM initiatives are recommended for further consideration:

- **Pedestrian Friendly Development**: Encourage a pedestrian friendly environment through the provision of safe, direct, level and obstacle-free pedestrian facilities that integrate with the existing sidewalk network along Upper Middle Road;
- **Secure and Convenient Bicycle Parking:** Promote cycling by providing bicycle parking that is safe, sure and stored away from inclement weather. Ideally, bicycle parking should be located within a well lit, secured shelter in the underground parking garage. It is recommended that the facility be access-controlled in order to maintain a high level of security;
- **Site and Bus Stop Integration:** Burlington Transit bus stops are located at the intersection of Upper Middle Road and Walker's Line. An additional stop should be considered on Upper Middle Road at

or near the proposed site driveway in order to provide transit access to the proposed development. Strong pedestrian connections should be made in order to encourage transit use and make it convenient for residents to get to and from bus stops. Burlington Transit should also consider providing additional amenities at nearby bus stops including accessible landing pads and shelters to further encourage transit use;

Embracing some or all of the above noted TDM initiatives will encourage the use of alternative modes and reduce demand for single occupant vehicles. Experience in other jurisdictions has shown that TDM initiatives can reduce

the single occupant vehicle demand by as much as 30 percent, thereby helping to reduce vehicle demands associated with the site.



TABLE 5.5: ONE DEVELOPMENT ACCESS OPERATIONS

Analysis Period	Intersection	Control Type	MOE	Direction / Movement / Approach																
				Eastbound				Westbound				Northbound				Southbound				OVERALL
				LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	LEFT	THROUGH	RIGHT	APPROACH	
AM Peak Hour	3 - Upper Middle Road and East Driveway / Park City Driveway	Two-Way Stop Control	LOS	A	A	A	**A**	B	A	A	**A**	C	C	C	**C**	C	C	C	**C**	**1**
			Delay	9	0	0	**0**	11	0	0	**0**	19	19	19	**19**	20	20	20	**20**	
			V/C	0.00	0.49	0.25		0.01	0.29	0.15		0.10	0.10	0.10		0.06	0.06	0.06		
			Queue	0	0	0		0	0	0		3	3	3		2	2	2		
PM Peak Hour	3 - Upper Middle Road and East Driveway / Park City Driveway	Two-Way Stop Control	LOS	B	A	A	**A**	A	A	A	**A**	D	D	D	**D**	D	D	D	**D**	**1**
			Delay	13	0	0	**0**	10	0	0	**0**	26	26	26	**26**	26	26	26	**26**	
			V/C	0.02	0.38	0.19		0.05	0.62	0.32		0.10	0.10	0.10		0.08	0.08	0.08		
			Queue	0	0	0		1	0	0		3	3	3		2	2	2		

MOE - Measure of Effectiveness LOS - Level of Service Delay - Average Delay per Vehicle in Seconds V/C - Volume to Capacity Ratio Queue - 95th Percentile Queue Length

6 Conclusions and Recommendations

6.1 Conclusions

Based on the investigations carried out, it is concluded that:

- under 2016 existing conditions:
  - at the intersection of Upper Middle Road and Walker's Line:
    - the eastbound left movement operates at LOS F (v/c = 0.89) during the PM peak hour;
    - the westbound left movement operates at LOS F (v/c = 1.10) during the AM peak hour; and
    - the northbound left movement operates at LOS E (v/c = 0.90) during the PM peak hour.
  - at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
    - the northbound left movement operates at LOS E (v/c = 0.52 and 0.59) during the AM and PM peak hour; and
    - the southbound left movement operates at LOS E (v/c = 0.55) during the AM peak hour.
- the development is forecast to generate 20 and 34 net new trips during the AM and PM peak hours, respectively;
- under 2022 background conditions:
  - at the intersection of Upper Middle Road and Walker's Line:
    - the eastbound left movement operates at LOS F (v/c = 1.00) during the PM peak hour;
    - the westbound left movement operates at LOS F (v/c = 1.29) during the AM peak hour and LOS E (v/c = 0.94) during the PM peak hour;
    - the westbound through movement operates at LOS E (v/c = 0.90) during the PM peak hour;
    - the northbound left movement operates at LOS F (v/c = 1.14) during the PM peak hour;
    - the southbound left movement operates at LOS E (v/c = 0.87) during the PM peak hour; and
    - the southbound through movement operates at LOS E (v/c = 0.89) during the PM peak hour.
  - at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
    - the northbound left movement operates at LOS E (v/c = 0.57 and 0.63) during the AM and PM peak hour; and

        - the southbound left movement operates at LOS E (v/c = 0.58) during the AM peak hour.
- under 2022 total conditions:
    - at the intersection of Upper Middle Road and Walker's Line:
        - the eastbound left movement operates at LOS F (v/c = 1.00) during the PM peak hour;
        - the westbound left movement operates at LOS F (v/c = 1.31) during the AM peak hour and LOS E (v/c = 0.95) during the PM peak hour;
        - the westbound through movement operates at LOS E (v/c = 0.91) during the PM peak hour;
        - the northbound left movement operates at LOS F (v/c = 1.14) during the PM peak hour;
        - the southbound left movement operates at LOS E (v/c = 0.88) during the PM peak hour; and
        - the southbound through movement operates at LOS E (v/c = 0.89) during the PM peak hour.
    - at the intersection of Upper Middle Road and William O'Connell Boulevard/Itabashi Way:
        - the northbound left movement operates at LOS E (v/c = 0.57 and 0.63) during the AM and PM peak hour; and
        - the southbound left movement operates at LOS E (v/c = 0.58) during the AM peak hour.
        - at the intersection of Upper Middle Road and East Driveway / Park City Driveway:
        - the southbound left-through-right movements operate at LOS E (v/c = 0.07) during the PM peak hour.
- signalized intersections within the study area will operate with reduced delays if signal timing plans are optimized;
- no traffic signals are warranted under 2022 total traffic conditions;
- utilizing the existing middle lane along Upper Middle Road, the left-turn storage provided is forecast to be sufficient to meet the queueing demands of traffic turning into the site;
- under background and total conditions, at the intersection of Upper Middle Road and Walker's Line both a westbound and northbound dual-left turn lane are warranted and would help reduce traffic delays;
- under background and total conditions, at the intersection of Upper Middle Road and William O'Connell Boulevard / Itabashi Way the eastbound right turn traffic volumes are in excess of 100 vehicles during the PM peak hour;

- at the development's driveways there are no anticipated safety concerns with regards to sight distance; and
- when considering a scenario with only one development driveway, the driveway was forecast to operate within acceptable levels, with no problem movements.

6.2 Recommendations

Based on the findings of this study, it is recommended that:

- signal timing plans for signalized intersections be optimized in order to reduce delays;
- the centre lane along Upper Middle Road be painted to designate that it is a left turn lane into the subject site; and
- the City of Burlington and Halton Region consider implementing westbound and northbound dual left-turn lanes at the intersection of Upper Middle Road and Walker's Line.



Appendix A

2016 Existing Traffic Operations Reports

Queues
1: Walker's Line & Upper Middle Road

2016 Existing AM
4063 Upper Middle Road



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	196	587	288	295	298	59	145	665	314	203	1080	123
v/c Ratio	0.52	0.77	0.60	1.08	0.35	0.13	0.57	0.45	0.41	0.48	0.71	0.17
Control Delay	32.6	50.6	20.9	113.7	32.8	1.0	23.7	27.1	10.8	18.3	32.5	7.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.6	50.6	20.9	113.7	32.8	1.0	23.7	27.1	10.8	18.3	32.5	7.4
Queue Length 50th (m)	34.2	72.4	24.6	~59.4	23.8	0.0	16.3	62.2	16.8	23.6	115.2	3.3
Queue Length 95th (m)	49.0	87.1	50.9	#108.5	30.6	1.1	31.3	84.8	43.2	42.0	151.5	16.4
Internal Link Dist (m)		126.1			576.9			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	377	983	572	273	1060	528	254	1462	773	423	1517	713
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.52	0.60	0.50	1.08	0.28	0.11	0.57	0.45	0.41	0.48	0.71	0.17

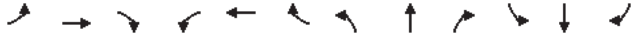
Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
1: Walker's Line & Upper Middle Road

2016 Existing AM
4063 Upper Middle Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	180	540	265	271	274	54	133	612	289	187	994	113
Future Volume (vph)	180	540	265	271	274	54	133	612	289	187	994	113
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1735	3471	1583	1787	3438	1489	1736	3471	1555	1786	3539	1530
Flt Permitted	0.57	1.00	1.00	0.19	1.00	1.00	0.14	1.00	1.00	0.31	1.00	1.00
Satd. Flow (perm)	1041	3471	1583	360	3438	1489	247	3471	1555	580	3539	1530
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	196	587	288	295	298	59	145	665	314	203	1080	123
RTOR Reduction (vph)	0	0	135	0	0	44	0	0	119	0	0	57
Lane Group Flow (vph)	196	587	153	295	298	15	145	665	195	203	1080	66
Confl. Peds. (#/hr)	1					1	2		4	4		2
Heavy Vehicles (%)	4%	4%	2%	1%	5%	7%	4%	4%	2%	1%	2%	4%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	35.5	26.5	26.5	41.5	29.5	29.5	60.6	50.6	50.6	62.4	51.5	51.5
Effective Green, g (s)	35.5	26.5	26.5	41.5	29.5	29.5	60.6	50.6	50.6	62.4	51.5	51.5
Actuated g/C Ratio	0.30	0.22	0.22	0.35	0.25	0.25	0.51	0.42	0.42	0.52	0.43	0.43
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	360	766	349	267	845	366	248	1463	655	411	1518	656
v/s Ratio Prot	0.04	0.17		c0.11	0.09		c0.05	0.19		0.04	c0.31	
v/s Ratio Perm	0.12		0.10	c0.27		0.01	0.25		0.13	0.21		0.04
v/c Ratio	0.54	0.77	0.44	1.10	0.35	0.04	0.58	0.45	0.30	0.49	0.71	0.10
Uniform Delay, d1	33.6	43.8	40.3	34.1	37.4	34.5	19.7	24.8	23.0	16.4	28.1	20.4
Progression Factor	1.00	1.00	1.00	1.28	0.87	0.32	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.7	4.6	0.9	85.8	0.3	0.0	3.5	1.0	1.2	0.9	2.9	0.3
Delay (s)	35.3	48.5	41.2	129.5	32.6	11.0	23.2	25.8	24.1	17.3	31.0	20.7
Level of Service	D	D	D	F	C	B	C	C	C	B	C	C
Approach Delay (s)		44.1			74.5			25.0			28.1	
Approach LOS		D			E			C			C	

Intersection Summary

HCM 2000 Control Delay	38.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.0
Intersection Capacity Utilization	81.5%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	28	1076	14	583	54	9	58	62
v/c Ratio	0.04	0.38	0.03	0.22	0.45	0.05	0.46	0.32
Control Delay	3.7	8.6	2.7	5.3	62.7	43.5	63.1	22.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	3.7	8.6	2.7	5.3	62.7	43.5	63.1	22.3
Queue Length 50th (m)	0.9	45.6	0.5	22.9	13.0	1.6	13.9	2.8
Queue Length 95th (m)	m3.2	96.1	2.0	34.5	25.9	6.7	27.4	16.1
Internal Link Dist (m)		576.9		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	682	2805	443	2688	336	454	348	446
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.38	0.03	0.22	0.16	0.02	0.17	0.14

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	26	905	85	13	503	33	50	6	2	53	11	46
Future Volume (vph)	26	905	85	13	503	33	50	6	2	53	11	46
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.99		1.00	0.99		1.00	0.97		1.00	0.88	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1670	3505		1671	3436		1783	1812		1763	1634	
Flt Permitted	0.42	1.00		0.25	1.00		0.72	1.00		0.75	1.00	
Satd. Flow (perm)	746	3505		436	3436		1345	1812		1395	1634	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	28	984	92	14	547	36	54	7	2	58	12	50
RTOR Reduction (vph)	0	3	0	0	2	0	0	2	0	0	46	0
Lane Group Flow (vph)	28	1073	0	14	581	0	54	7	0	58	16	0
Confl. Peds. (#/hr)	1		3	3		1	2		3	3		2
Heavy Vehicles (%)	8%	1%	6%	8%	4%	3%	1%	1%	1%	2%	1%	1%
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	95.2	91.0		92.4	89.6		9.2	9.2		9.2	9.2	
Effective Green, g (s)	95.2	91.0		92.4	89.6		9.2	9.2		9.2	9.2	
Actuated g/C Ratio	0.79	0.76		0.77	0.75		0.08	0.08		0.08	0.08	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	624	2657		364	2565		103	138		106	125	
v/s Ratio Prot	c0.00	c0.31		0.00	0.17			0.00			0.01	
v/s Ratio Perm	0.03			0.03			0.04			c0.04		
v/c Ratio	0.04	0.40		0.04	0.23		0.52	0.05		0.55	0.13	
Uniform Delay, d1	2.6	5.1		3.4	4.6		53.3	51.4		53.4	51.7	
Progression Factor	1.46	1.56		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.4		0.0	0.2		4.7	0.2		5.7	0.5	
Delay (s)	3.9	8.3		3.4	4.8		58.0	51.5		59.1	52.1	
Level of Service	A	A		A	A		E	D		E	D	
Approach Delay (s)		8.2			4.8			57.1			55.5	
Approach LOS		A			A			E			E	

Intersection Summary				
HCM 2000 Control Delay	11.8	HCM 2000 Level of Service	B	
HCM 2000 Volume to Capacity ratio	0.41			
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	17.0	
Intersection Capacity Utilization	49.3%	ICU Level of Service	A	
Analysis Period (min)	15			

c Critical Lane Group

Queues
1: Walker's Line & Upper Middle Road

2016 Existing PM
4063 Upper Middle Road

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	138	335	191	353	873	171	415	1270	383	133	815	189
v/c Ratio	0.87	0.48	0.44	0.82	0.86	0.32	0.89	0.80	0.50	0.69	0.77	0.33
Control Delay	75.5	52.0	11.8	49.7	56.1	14.2	55.5	39.0	21.7	44.0	50.8	11.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	75.5	52.0	11.8	49.7	56.1	14.2	55.5	39.0	21.7	44.0	50.8	11.6
Queue Length 50th (m)	26.3	45.8	4.5	77.3	125.8	11.6	91.5	172.8	55.7	18.2	115.4	8.7
Queue Length 95th (m)	#55.9	59.7	25.7	#104.3	146.0	30.0	#168.9	204.2	87.5	#51.9	141.4	29.2
Internal Link Dist (m)		126.1			576.9			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	159	816	483	430	1148	585	465	1588	763	193	1055	572
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.87	0.41	0.40	0.82	0.76	0.29	0.89	0.80	0.50	0.69	0.77	0.33

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
1: Walker's Line & Upper Middle Road

2016 Existing PM
4063 Upper Middle Road

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	127	308	176	325	803	157	382	1168	352	122	750	174
Future Volume (vph)	127	308	176	325	803	157	382	1168	352	122	750	174
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3574	1536	1785	3574	1574	1787	3574	1567	1787	3505	1559
Flt Permitted	0.15	1.00	1.00	0.37	1.00	1.00	0.13	1.00	1.00	0.12	1.00	1.00
Satd. Flow (perm)	277	3574	1536	694	3574	1574	245	3574	1567	217	3505	1559
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	138	335	191	353	873	171	415	1270	383	133	815	189
RTOR Reduction (vph)	0	0	139	0	0	84	0	0	67	0	0	103
Lane Group Flow (vph)	138	335	52	353	873	87	415	1270	316	133	815	86
Confl. Peds. (#/hr)	2		5	5		2	2		5	5		2
Heavy Vehicles (%)	1%	1%	3%	1%	1%	1%	1%	1%	1%	1%	3%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	35.2	27.2	27.2	52.0	40.0	40.0	76.0	62.2	62.2	51.9	42.1	42.1
Effective Green, g (s)	35.2	27.2	27.2	52.0	40.0	40.0	76.0	62.2	62.2	51.9	42.1	42.1
Actuated g/C Ratio	0.25	0.19	0.19	0.37	0.29	0.29	0.54	0.44	0.44	0.37	0.30	0.30
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	155	694	298	419	1021	449	462	1587	696	190	1054	468
v/s Ratio Prot	0.05	0.09		c0.12	c0.24		c0.19	0.36		0.05	0.23	
v/s Ratio Perm	0.17		0.03	0.19		0.06	c0.30		0.20	0.21		0.05
v/c Ratio	0.89	0.48	0.18	0.84	0.86	0.19	0.90	0.80	0.45	0.70	0.77	0.18
Uniform Delay, d1	45.0	50.1	47.1	35.5	47.3	37.8	36.5	33.5	27.1	32.0	44.6	36.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	42.0	0.5	0.3	14.2	7.1	0.2	19.8	4.3	2.1	10.7	5.5	0.9
Delay (s)	86.9	50.7	47.3	49.7	54.4	38.0	56.3	37.9	29.2	42.8	50.1	37.1
Level of Service	F	D	D	D	D	D	E	D	C	D	D	D
Approach Delay (s)		57.2			51.2			40.0			47.1	
Approach LOS		E			D			D			D	

Intersection Summary

HCM 2000 Control Delay	46.7	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	20.0
Intersection Capacity Utilization	87.9%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	54	796	49	1358	87	61	34	43
v/c Ratio	0.17	0.34	0.09	0.54	0.58	0.28	0.23	0.21
Control Delay	4.4	7.8	3.5	10.2	65.7	23.8	50.7	24.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	4.4	7.8	3.5	10.2	65.7	23.8	50.7	24.6
Queue Length 50th (m)	2.2	36.7	2.0	79.4	20.9	4.6	7.8	3.2
Queue Length 95th (m)	6.1	55.5	5.6	114.7	36.8	17.1	17.5	13.9
Internal Link Dist (m)		576.9		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	330	2364	562	2507	340	449	336	439
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.16	0.34	0.09	0.54	0.26	0.14	0.10	0.10

Intersection Summary



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	50	634	98	45	1178	72	80	18	38	31	13	27
Future Volume (vph)	50	634	98	45	1178	72	80	18	38	31	13	27
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.99	1.00		1.00	1.00	
Frt	1.00	0.98		1.00	0.99		1.00	0.90		1.00	0.90	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1787	3327		1787	3538		1776	1676		1785	1670	
Flt Permitted	0.16	1.00		0.33	1.00		0.73	1.00		0.72	1.00	
Satd. Flow (perm)	298	3327		623	3538		1363	1676		1348	1670	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	54	689	107	49	1280	78	87	20	41	34	14	29
RTOR Reduction (vph)	0	7	0	0	2	0	0	37	0	0	26	0
Lane Group Flow (vph)	54	789	0	49	1356	0	87	24	0	34	17	0
Confl. Peds. (#/hr)	2					2	5		1	1		5
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		0										
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	90.0	84.3		89.8	84.2		13.1	13.1		13.1	13.1	
Effective Green, g (s)	90.0	84.3		89.8	84.2		13.1	13.1		13.1	13.1	
Actuated g/C Ratio	0.75	0.70		0.75	0.70		0.11	0.11		0.11	0.11	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	294	2337		520	2482		148	182		147	182	
v/s Ratio Prot	c0.01	0.24		0.00	c0.38			0.01			0.01	
v/s Ratio Perm	0.13			0.07			c0.06			0.03		
v/c Ratio	0.18	0.34		0.09	0.55		0.59	0.13		0.23	0.09	
Uniform Delay, d1	5.4	7.0		4.0	8.7		50.9	48.3		48.8	48.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.3	0.4		0.1	0.9		5.9	0.3		0.8	0.2	
Delay (s)	5.7	7.4		4.1	9.5		56.7	48.7		49.7	48.3	
Level of Service	A	A		A	A		E	D		D	D	
Approach Delay (s)		7.2			9.3			53.4			48.9	
Approach LOS		A			A			D			D	

Intersection Summary				
HCM 2000 Control Delay	12.5	HCM 2000 Level of Service	B	
HCM 2000 Volume to Capacity ratio	0.53			
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	17.0	
Intersection Capacity Utilization	63.9%	ICU Level of Service	B	
Analysis Period (min)	15			
c Critical Lane Group				

Appendix B

2022 Background Traffic Operations Reports

Queues
1: Walker's Line & Upper Middle Road

2022 Background AM
4063 Upper Middle Road



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	221	662	324	335	339	67	163	749	354	230	1216	138
v/c Ratio	0.58	0.79	0.65	1.27	0.37	0.14	0.75	0.54	0.47	0.63	0.85	0.20
Control Delay	33.3	50.1	25.9	180.4	31.6	1.4	46.6	29.9	13.6	25.0	40.0	8.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.3	50.1	25.9	180.4	31.6	1.4	46.6	29.9	13.6	25.0	40.0	8.9
Queue Length 50th (m)	37.4	80.6	36.0	~84.2	26.2	0.0	23.2	77.1	26.1	29.2	147.4	5.9
Queue Length 95th (m)	54.1	98.0	65.0	#139.2	33.6	1.7	#68.5	97.4	54.9	#49.2	#183.7	19.7
Internal Link Dist (m)		126.1			248.7			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	380	983	563	264	1060	528	217	1395	746	367	1431	678
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.58	0.67	0.58	1.27	0.32	0.13	0.75	0.54	0.47	0.63	0.85	0.20

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
1: Walker's Line & Upper Middle Road

2022 Background AM
4063 Upper Middle Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	203	609	298	308	312	62	150	689	326	212	1119	127
Future Volume (vph)	203	609	298	308	312	62	150	689	326	212	1119	127
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1735	3471	1583	1787	3438	1489	1736	3471	1553	1786	3539	1530
Flt Permitted	0.53	1.00	1.00	0.16	1.00	1.00	0.08	1.00	1.00	0.26	1.00	1.00
Satd. Flow (perm)	976	3471	1583	306	3438	1489	151	3471	1553	486	3539	1530
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	221	662	324	335	339	67	163	749	354	230	1216	138
RTOR Reduction (vph)	0	0	122	0	0	49	0	0	122	0	0	60
Lane Group Flow (vph)	221	662	202	335	339	18	163	749	232	230	1216	79
Confl. Peds. (#/hr)	1					1	2		5	5		2
Heavy Vehicles (%)	4%	4%	2%	1%	5%	7%	4%	4%	2%	1%	2%	4%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	37.8	28.8	28.8	43.8	31.8	31.8	58.9	48.3	48.3	59.5	48.6	48.6
Effective Green, g (s)	37.8	28.8	28.8	43.8	31.8	31.8	58.9	48.3	48.3	59.5	48.6	48.6
Actuated g/C Ratio	0.31	0.24	0.24	0.36	0.27	0.27	0.49	0.40	0.40	0.50	0.41	0.41
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	364	833	379	259	911	394	214	1397	625	359	1433	619
v/s Ratio Prot	0.05	0.19		c0.13	0.10		c0.07	0.22		0.06	c0.34	
v/s Ratio Perm	0.15		0.13	c0.34		0.01	0.31		0.15	0.26		0.05
v/c Ratio	0.61	0.79	0.53	1.29	0.37	0.05	0.76	0.54	0.37	0.64	0.85	0.13
Uniform Delay, d1	32.7	42.8	39.8	31.9	36.0	32.8	26.0	27.3	25.2	18.8	32.4	22.4
Progression Factor	1.00	1.00	1.00	1.39	0.86	0.38	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.9	5.3	1.4	157.4	0.3	0.0	14.7	1.5	1.7	3.9	6.4	0.4
Delay (s)	35.5	48.1	41.2	201.8	31.3	12.6	40.7	28.8	26.9	22.7	38.8	22.8
Level of Service	D	D	D	F	C	B	D	C	C	C	D	C
Approach Delay (s)		43.9			106.7			29.8			35.1	
Approach LOS		D			F			C			D	

Intersection Summary					
HCM 2000 Control Delay	47.0	HCM 2000 Level of Service		D	
HCM 2000 Volume to Capacity ratio	1.05				
Actuated Cycle Length (s)	120.0	Sum of lost time (s)		20.0	
Intersection Capacity Utilization	89.8%	ICU Level of Service		E	
Analysis Period (min)	15				

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	33	1233	16	660	62	10	65	71
v/c Ratio	0.05	0.44	0.04	0.25	0.49	0.06	0.49	0.34
Control Delay	4.4	10.1	2.9	5.7	63.9	42.4	63.5	21.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	4.4	10.1	2.9	5.7	63.9	42.4	63.5	21.0
Queue Length 50th (m)	1.5	60.7	0.6	27.3	14.9	1.9	15.6	3.0
Queue Length 95th (m)	m3.8	115.9	2.3	41.0	28.7	7.1	29.7	16.9
Internal Link Dist (m)		304.2		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	631	2788	381	2672	333	456	348	451
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.44	0.04	0.25	0.19	0.02	0.19	0.16

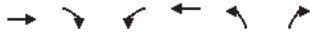
Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	1038	97	15	570	37	57	7	2	60	12	53
Future Volume (vph)	30	1038	97	15	570	37	57	7	2	60	12	53
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.99		1.00	0.99		1.00	0.97		1.00	0.88	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1671	3505		1671	3437		1783	1819		1763	1631	
Flt Permitted	0.39	1.00		0.20	1.00		0.71	1.00		0.75	1.00	
Satd. Flow (perm)	683	3505		358	3437		1334	1819		1394	1631	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	1128	105	16	620	40	62	8	2	65	13	58
RTOR Reduction (vph)	0	3	0	0	2	0	0	2	0	0	53	0
Lane Group Flow (vph)	33	1230	0	16	658	0	62	8	0	65	18	0
Confl. Peds. (#/hr)	1		3	3		1	2		3	3		2
Heavy Vehicles (%)	8%	1%	6%	8%	4%	3%	1%	1%	1%	2%	1%	1%
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	94.6	90.4		91.8	89.0		9.8	9.8		9.8	9.8	
Effective Green, g (s)	94.6	90.4		91.8	89.0		9.8	9.8		9.8	9.8	
Actuated g/C Ratio	0.79	0.75		0.76	0.74		0.08	0.08		0.08	0.08	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	573	2640		304	2549		108	148		113	133	
v/s Ratio Prot	c0.00	c0.35		0.00	0.19			0.00			0.01	
v/s Ratio Perm	0.04			0.04			0.05			c0.05		
v/c Ratio	0.06	0.47		0.05	0.26		0.57	0.06		0.58	0.13	
Uniform Delay, d1	2.8	5.6		3.7	5.0		53.1	50.8		53.1	51.2	
Progression Factor	1.61	1.63		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.5		0.1	0.2		7.2	0.2		6.9	0.5	
Delay (s)	4.5	9.6		3.8	5.2		60.3	51.0		60.0	51.6	
Level of Service	A	A		A	A		E	D		E	D	
Approach Delay (s)		9.5			5.2			59.0			55.6	
Approach LOS		A			A			E			E	

Intersection Summary				
HCM 2000 Control Delay	12.7	HCM 2000 Level of Service	B	
HCM 2000 Volume to Capacity ratio	0.47			
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	17.0	
Intersection Capacity Utilization	53.8%	ICU Level of Service	A	
Analysis Period (min)	15			

c Critical Lane Group



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (veh/h)	1144	3	6	675	7	21
Future Volume (Veh/h)	1144	3	6	675	7	21
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1243	3	7	734	8	23
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)	273			328		
pX, platoon unblocked			0.83		0.84	0.83
vC, conflicting volume			1246		1626	623
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			877		1217	122
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		94	97
cM capacity (veh/h)			633		144	748

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1
Volume Total	829	417	252	489	31
Volume Left	0	0	7	0	8
Volume Right	0	3	0	0	23
cSH	1700	1700	633	1700	359
Volume to Capacity	0.49	0.25	0.01	0.29	0.09
Queue Length 95th (m)	0.0	0.0	0.3	0.0	2.3
Control Delay (s)	0.0	0.0	0.4	0.0	16.0
Lane LOS			A		C
Approach Delay (s)	0.0		0.1		16.0
Approach LOS					C

Intersection Summary			
Average Delay	0.3		
Intersection Capacity Utilization	41.7%	ICU Level of Service	A
Analysis Period (min)	15		



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	155	380	215	400	989	195	467	1429	434	150	918	213
v/c Ratio	0.97	0.50	0.47	0.92	0.90	0.35	1.13	0.94	0.59	0.86	0.89	0.38
Control Delay	98.7	50.5	14.9	61.1	58.4	16.3	123.5	50.9	25.4	71.7	59.6	14.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	98.7	50.5	14.9	61.1	58.4	16.3	123.5	50.9	25.4	71.7	59.6	14.7
Queue Length 50th (m)	28.3	50.7	10.5	85.9	142.3	16.3	~148.4	208.8	69.7	26.3	135.3	14.0
Queue Length 95th (m)	#72.1	67.6	34.7	#145.9	171.1	37.3	#218.9	#260.0	106.5	#72.3	#172.1	37.1
Internal Link Dist (m)		126.1			247.9			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	159	816	481	434	1148	585	413	1525	737	174	1026	561
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.97	0.47	0.45	0.92	0.86	0.33	1.13	0.94	0.59	0.86	0.89	0.38

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	143	350	198	368	910	179	430	1315	399	138	845	196
Future Volume (vph)	143	350	198	368	910	179	430	1315	399	138	845	196
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3574	1533	1785	3574	1574	1787	3574	1564	1787	3505	1559
Flt Permitted	0.13	1.00	1.00	0.34	1.00	1.00	0.09	1.00	1.00	0.10	1.00	1.00
Satd. Flow (perm)	251	3574	1533	647	3574	1574	167	3574	1564	184	3505	1559
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	155	380	215	400	989	195	467	1429	434	150	918	213
RTOR Reduction (vph)	0	0	134	0	0	81	0	0	70	0	0	105
Lane Group Flow (vph)	155	380	81	400	989	114	467	1429	364	150	918	108
Confl. Peds. (#/hr)	2		6	6		2	2		6	6		2
Heavy Vehicles (%)	1%	1%	3%	1%	1%	1%	1%	1%	1%	1%	3%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	38.0	30.0	30.0	55.0	43.0	43.0	73.0	59.7	59.7	50.3	41.0	41.0
Effective Green, g (s)	38.0	30.0	30.0	55.0	43.0	43.0	73.0	59.7	59.7	50.3	41.0	41.0
Actuated g/C Ratio	0.27	0.21	0.21	0.39	0.31	0.31	0.52	0.43	0.43	0.36	0.29	0.29
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	155	765	328	424	1097	483	411	1524	666	172	1026	456
v/s Ratio Prot	0.06	0.11		c0.14	0.28		c0.23	0.40		0.06	0.26	
v/s Ratio Perm	0.21		0.05	c0.23		0.07	c0.36		0.23	0.26		0.07
v/c Ratio	1.00	0.50	0.25	0.94	0.90	0.24	1.14	0.94	0.55	0.87	0.89	0.24
Uniform Delay, d1	45.9	48.4	45.6	36.0	46.5	36.2	44.7	38.4	30.0	36.0	47.4	37.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	72.3	0.5	0.4	29.6	10.3	0.3	87.0	12.3	3.2	35.1	11.9	1.2
Delay (s)	118.2	48.9	46.0	65.6	56.7	36.5	131.7	50.7	33.2	71.1	59.3	38.8
Level of Service	F	D	D	E	E	D	F	D	C	E	E	D
Approach Delay (s)		62.4			56.5			63.7			57.3	
Approach LOS		E			E			E			E	

Intersection Summary				
HCM 2000 Control Delay	60.2	HCM 2000 Level of Service	E	
HCM 2000 Volume to Capacity ratio	1.10			
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	20.0	
Intersection Capacity Utilization	96.9%	ICU Level of Service	F	
Analysis Period (min)	15			

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	62	903	55	1564	101	69	38	50
v/c Ratio	0.24	0.39	0.11	0.63	0.63	0.29	0.24	0.22
Control Delay	5.8	8.9	4.1	12.6	66.4	22.1	49.4	23.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	5.8	8.9	4.1	12.6	66.4	22.1	49.4	23.0
Queue Length 50th (m)	2.8	45.5	2.5	105.2	24.2	5.0	8.7	3.6
Queue Length 95th (m)	7.3	69.1	6.7	155.6	41.2	18.1	18.9	15.0
Internal Link Dist (m)		305.0		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	268	2330	499	2472	338	453	334	442
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.23	0.39	0.11	0.63	0.30	0.15	0.11	0.11

Intersection Summary



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	57	719	111	51	1358	81	93	20	43	35	15	31
Future Volume (vph)	57	719	111	51	1358	81	93	20	43	35	15	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.99	1.00		1.00	1.00	
Frt	1.00	0.98		1.00	0.99		1.00	0.90		1.00	0.90	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1787	3327		1787	3539		1774	1674		1785	1667	
Flt Permitted	0.11	1.00		0.29	1.00		0.72	1.00		0.71	1.00	
Satd. Flow (perm)	212	3327		542	3539		1353	1674		1338	1667	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	62	782	121	55	1476	88	101	22	47	38	16	34
RTOR Reduction (vph)	0	7	0	0	2	0	0	41	0	0	30	0
Lane Group Flow (vph)	62	896	0	55	1562	0	101	28	0	38	20	0
Confl. Peds. (#/hr)	2					2	6		1	1		6
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		0										
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	88.8	83.0		88.6	82.9		14.3	14.3		14.3	14.3	
Effective Green, g (s)	88.8	83.0		88.6	82.9		14.3	14.3		14.3	14.3	
Actuated g/C Ratio	0.74	0.69		0.74	0.69		0.12	0.12		0.12	0.12	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	233	2301		459	2444		161	199		159	198	
v/s Ratio Prot	c0.01	0.27		0.01	c0.44			0.02			0.01	
v/s Ratio Perm	0.18			0.08			c0.07			0.03		
v/c Ratio	0.27	0.39		0.12	0.64		0.63	0.14		0.24	0.10	
Uniform Delay, d1	7.6	7.8		4.5	10.3		50.3	47.3		47.9	47.1	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.6	0.5		0.1	1.3		7.4	0.3		0.8	0.2	
Delay (s)	8.2	8.3		4.6	11.6		57.7	47.7		48.7	47.3	
Level of Service	A	A		A	B		E	D		D	D	
Approach Delay (s)		8.3			11.3			53.6			47.9	
Approach LOS		A			B			D			D	

Intersection Summary				
HCM 2000 Control Delay	14.0	HCM 2000 Level of Service	B	
HCM 2000 Volume to Capacity ratio	0.62			
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	17.0	
Intersection Capacity Utilization	70.4%	ICU Level of Service	C	
Analysis Period (min)	15			
c Critical Lane Group				



Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (veh/h)	881	7	35	1447	10	7
Future Volume (Veh/h)	881	7	35	1447	10	7
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	958	8	38	1573	11	8
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)	272			329		
pX, platoon unblocked			0.91		0.78	0.91
vC, conflicting volume			966		1824	483
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			774		1001	245
tC, single (s)			4.1		6.8	6.9
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			95		94	99
cM capacity (veh/h)			765		178	690

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1
Volume Total	639	327	562	1049	19
Volume Left	0	0	38	0	11
Volume Right	0	8	0	0	8
cSH	1700	1700	765	1700	259
Volume to Capacity	0.38	0.19	0.05	0.62	0.07
Queue Length 95th (m)	0.0	0.0	1.3	0.0	1.9
Control Delay (s)	0.0	0.0	1.3	0.0	20.0
Lane LOS			A		C
Approach Delay (s)	0.0		0.5		20.0
Approach LOS					C

Intersection Summary					
Average Delay	0.4				
Intersection Capacity Utilization	75.1%	ICU Level of Service			D
Analysis Period (min)	15				

Appendix C

2022 Total Traffic Operations Reports

Queues
1: Walker's Line & Upper Middle Road

2022 Total AM
4063 Upper Middle Road

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	221	664	324	338	341	68	163	749	355	232	1216	138
v/c Ratio	0.58	0.80	0.65	1.28	0.37	0.14	0.75	0.54	0.48	0.63	0.85	0.20
Control Delay	33.3	50.1	26.0	184.6	31.6	1.5	46.9	29.9	13.7	25.4	40.1	8.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.3	50.1	26.0	184.6	31.6	1.5	46.9	29.9	13.7	25.4	40.1	8.9
Queue Length 50th (m)	37.4	80.9	36.2	~85.6	26.4	0.0	23.2	77.1	26.2	29.5	147.4	5.9
Queue Length 95th (m)	54.1	98.2	65.3	#141.7	33.6	1.7	#68.5	97.4	55.2	#50.4	#183.7	19.7
Internal Link Dist (m)		126.1			208.1			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	380	983	562	264	1060	528	217	1392	745	366	1430	678
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.58	0.68	0.58	1.28	0.32	0.13	0.75	0.54	0.48	0.63	0.85	0.20

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
1: Walker's Line & Upper Middle Road

2022 Total AM
4063 Upper Middle Road

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	203	611	298	311	314	63	150	689	327	213	1119	127
Future Volume (vph)	203	611	298	311	314	63	150	689	327	213	1119	127
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1735	3471	1583	1787	3438	1489	1736	3471	1553	1786	3539	1530
Flt Permitted	0.53	1.00	1.00	0.16	1.00	1.00	0.08	1.00	1.00	0.26	1.00	1.00
Satd. Flow (perm)	972	3471	1583	305	3438	1489	152	3471	1553	483	3539	1530
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	221	664	324	338	341	68	163	749	355	232	1216	138
RTOR Reduction (vph)	0	0	121	0	0	50	0	0	123	0	0	60
Lane Group Flow (vph)	221	664	203	338	341	18	163	749	232	232	1216	78
Confl. Peds. (#/hr)	1					1	2		5	5		2
Heavy Vehicles (%)	4%	4%	2%	1%	5%	7%	4%	4%	2%	1%	2%	4%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	37.9	28.9	28.9	43.9	31.9	31.9	58.7	48.1	48.1	59.5	48.5	48.5
Effective Green, g (s)	37.9	28.9	28.9	43.9	31.9	31.9	58.7	48.1	48.1	59.5	48.5	48.5
Actuated g/C Ratio	0.32	0.24	0.24	0.37	0.27	0.27	0.49	0.40	0.40	0.50	0.40	0.40
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	364	835	381	259	913	395	214	1391	622	358	1430	618
v/s Ratio Prot	0.05	0.19		c0.13	0.10		c0.07	0.22		0.06	c0.34	
v/s Ratio Perm	0.15		0.13	c0.35		0.01	0.31		0.15	0.26		0.05
v/c Ratio	0.61	0.80	0.53	1.31	0.37	0.05	0.76	0.54	0.37	0.65	0.85	0.13
Uniform Delay, d1	32.6	42.8	39.7	31.8	35.9	32.7	26.0	27.5	25.3	18.9	32.5	22.5
Progression Factor	1.00	1.00	1.00	1.39	0.86	0.40	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.9	5.3	1.4	162.1	0.3	0.0	14.7	1.5	1.7	4.0	6.5	0.4
Delay (s)	35.5	48.0	41.1	206.2	31.2	13.3	40.7	29.0	27.0	22.9	39.0	22.9
Level of Service	D	D	D	F	C	B	D	C	C	C	D	C
Approach Delay (s)		43.9			108.8			29.9			35.2	
Approach LOS		D			F			C			D	

Intersection Summary

HCM 2000 Control Delay	47.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	1.06		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	20.0
Intersection Capacity Utilization	90.0%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	33	1242	16	662	62	10	65	71
v/c Ratio	0.05	0.45	0.04	0.25	0.49	0.06	0.49	0.34
Control Delay	4.4	10.1	2.9	5.7	63.9	42.4	63.5	21.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	4.4	10.1	2.9	5.7	63.9	42.4	63.5	21.0
Queue Length 50th (m)	1.5	61.0	0.6	27.4	14.9	1.9	15.6	3.0
Queue Length 95th (m)	m3.7	116.7	2.3	41.1	28.7	7.1	29.7	16.9
Internal Link Dist (m)		304.2		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	631	2789	379	2672	333	456	348	451
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.45	0.04	0.25	0.19	0.02	0.19	0.16

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	1046	97	15	572	37	57	7	2	60	12	53
Future Volume (vph)	30	1046	97	15	572	37	57	7	2	60	12	53
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.99		1.00	0.99		1.00	0.97		1.00	0.88	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1671	3506		1671	3437		1783	1819		1763	1631	
Flt Permitted	0.39	1.00		0.20	1.00		0.71	1.00		0.75	1.00	
Satd. Flow (perm)	682	3506		354	3437		1334	1819		1394	1631	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	1137	105	16	622	40	62	8	2	65	13	58
RTOR Reduction (vph)	0	3	0	0	2	0	0	2	0	0	53	0
Lane Group Flow (vph)	33	1239	0	16	660	0	62	8	0	65	18	0
Confl. Peds. (#/hr)	1		3	3		1	2		3	3		2
Heavy Vehicles (%)	8%	1%	6%	8%	4%	3%	1%	1%	1%	2%	1%	1%
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	94.6	90.4		91.8	89.0		9.8	9.8		9.8	9.8	
Effective Green, g (s)	94.6	90.4		91.8	89.0		9.8	9.8		9.8	9.8	
Actuated g/C Ratio	0.79	0.75		0.76	0.74		0.08	0.08		0.08	0.08	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	572	2641		301	2549		108	148		113	133	
v/s Ratio Prot	c0.00	c0.35		0.00	0.19			0.00			0.01	
v/s Ratio Perm	0.04			0.04			0.05			c0.05		
v/c Ratio	0.06	0.47		0.05	0.26		0.57	0.06		0.58	0.13	
Uniform Delay, d1	2.8	5.6		3.7	5.0		53.1	50.8		53.1	51.2	
Progression Factor	1.60	1.62		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.0	0.5		0.1	0.2		7.2	0.2		6.9	0.5	
Delay (s)	4.5	9.6		3.8	5.2		60.3	51.0		60.0	51.6	
Level of Service	A	A		A	A		E	D		E	D	
Approach Delay (s)		9.5			5.2			59.0			55.6	
Approach LOS		A			A			E			E	

Intersection Summary				
HCM 2000 Control Delay	12.7	HCM 2000 Level of Service	B	
HCM 2000 Volume to Capacity ratio	0.47			
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	17.0	
Intersection Capacity Utilization	54.0%	ICU Level of Service	A	
Analysis Period (min)	15			

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	2	1144	3	6	676	1	7	0	21	8	0	3
Future Volume (Veh/h)	2	1144	3	6	676	1	7	0	21	8	0	3
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	2	1243	3	7	735	1	8	0	23	9	0	3
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		273			328							
pX, platoon unblocked	0.97			0.83			0.84	0.84	0.83	0.84	0.84	0.97
vC, conflicting volume	736			1246			1633	1998	623	1398	2000	368
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	672			876			1223	1659	121	944	1660	293
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			99			93	100	97	95	100	100
cM capacity (veh/h)	896			638			113	81	752	176	81	687

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	624	624	374	368	31	12
Volume Left	2	0	7	0	8	9
Volume Right	0	3	0	1	23	3
cSH	896	1700	638	1700	305	216
Volume to Capacity	0.00	0.37	0.01	0.22	0.10	0.06
Queue Length 95th (m)	0.1	0.0	0.3	0.0	2.7	1.4
Control Delay (s)	0.1	0.0	0.3	0.0	18.1	22.6
Lane LOS	A		A		C	C
Approach Delay (s)	0.0		0.2		18.1	22.6
Approach LOS					C	C

Intersection Summary				
Average Delay	0.5			
Intersection Capacity Utilization	43.1%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (veh/h)	2	1149	685	1	0	3
Future Volume (Veh/h)	2	1149	685	1	0	3
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	2	1249	745	1	0	3
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)		232	369			
pX, platoon unblocked	0.98				0.83	0.98
vC, conflicting volume	746				1374	373
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	704				951	324
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				100	100
cM capacity (veh/h)	880				218	662

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	SB 1
Volume Total	418	833	497	249	3
Volume Left	2	0	0	0	0
Volume Right	0	0	0	1	3
cSH	880	1700	1700	1700	662
Volume to Capacity	0.00	0.49	0.29	0.15	0.00
Queue Length 95th (m)	0.1	0.0	0.0	0.0	0.1
Control Delay (s)	0.1	0.0	0.0	0.0	10.5
Lane LOS	A				B
Approach Delay (s)	0.0		0.0		10.5
Approach LOS					B

Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	36.5%	ICU Level of Service	A
Analysis Period (min)	15		

Queues
1: Walker's Line & Upper Middle Road

2022 Total PM
4063 Upper Middle Road



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	155	384	215	402	996	196	467	1429	437	151	918	213
v/c Ratio	0.97	0.50	0.47	0.93	0.91	0.35	1.13	0.94	0.59	0.86	0.89	0.38
Control Delay	98.7	50.5	15.1	62.5	58.7	16.4	124.9	51.3	25.5	72.6	59.6	14.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	98.7	50.5	15.1	62.5	58.7	16.4	124.9	51.3	25.5	72.6	59.6	14.7
Queue Length 50th (m)	28.3	51.3	10.8	86.5	143.8	16.5	~148.4	208.8	70.4	26.6	135.3	14.0
Queue Length 95th (m)	#72.1	68.1	35.0	#148.1	172.5	37.9	#218.9	#260.0	107.4	#73.6	#172.1	37.1
Internal Link Dist (m)		126.1			208.1			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	159	816	480	432	1148	585	412	1522	736	175	1026	561
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.97	0.47	0.45	0.93	0.87	0.34	1.13	0.94	0.59	0.86	0.89	0.38

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
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95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
1: Walker's Line & Upper Middle Road

2022 Total PM
4063 Upper Middle Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	143	353	198	370	916	180	430	1315	402	139	845	196
Future Volume (vph)	143	353	198	370	916	180	430	1315	402	139	845	196
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98	1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3574	1533	1785	3574	1574	1787	3574	1564	1787	3505	1559
Flt Permitted	0.13	1.00	1.00	0.34	1.00	1.00	0.09	1.00	1.00	0.10	1.00	1.00
Satd. Flow (perm)	250	3574	1533	641	3574	1574	167	3574	1564	184	3505	1559
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	155	384	215	402	996	196	467	1429	437	151	918	213
RTOR Reduction (vph)	0	0	133	0	0	81	0	0	71	0	0	105
Lane Group Flow (vph)	155	384	82	402	996	115	467	1429	366	151	918	108
Confl. Peds. (#/hr)	2		6	6		2	2		6	6		2
Heavy Vehicles (%)	1%	1%	3%	1%	1%	1%	1%	1%	1%	1%	3%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	38.1	30.1	30.1	55.1	43.1	43.1	72.9	59.6	59.6	50.3	41.0	41.0
Effective Green, g (s)	38.1	30.1	30.1	55.1	43.1	43.1	72.9	59.6	59.6	50.3	41.0	41.0
Actuated g/C Ratio	0.27	0.22	0.22	0.39	0.31	0.31	0.52	0.43	0.43	0.36	0.29	0.29
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	155	768	329	423	1100	484	409	1521	665	172	1026	456
v/s Ratio Prot	0.06	0.11		c0.14	0.28		c0.23	0.40		0.06	0.26	
v/s Ratio Perm	0.21		0.05	c0.23		0.07	c0.37		0.23	0.26		0.07
v/c Ratio	1.00	0.50	0.25	0.95	0.91	0.24	1.14	0.94	0.55	0.88	0.89	0.24
Uniform Delay, d1	45.9	48.3	45.6	36.1	46.5	36.2	44.7	38.5	30.2	36.0	47.4	37.6
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	72.3	0.5	0.4	31.2	10.5	0.3	89.2	12.6	3.3	36.0	11.9	1.2
Delay (s)	118.2	48.8	46.0	67.4	57.0	36.4	133.8	51.0	33.4	72.0	59.3	38.8
Level of Service	F	D	D	E	E	D	F	D	C	E	E	D
Approach Delay (s)		62.3			57.1			64.3			57.4	
Approach LOS		E			E			E			E	

Intersection Summary

HCM 2000 Control Delay	60.7	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.11		
Actuated Cycle Length (s)	140.0	Sum of lost time (s)	20.0
Intersection Capacity Utilization	97.1%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Queues
2022 Total PM
2: Itabashi Way/William O'Connell Boulevard & Upper Middle Road
4063 Upper Middle Road



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	62	907	55	1578	102	69	38	50
v/c Ratio	0.25	0.39	0.11	0.64	0.63	0.29	0.24	0.22
Control Delay	5.9	8.9	4.1	12.7	66.6	22.1	49.3	23.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	5.9	8.9	4.1	12.7	66.6	22.1	49.3	23.0
Queue Length 50th (m)	2.8	45.9	2.5	107.3	24.4	5.0	8.7	3.6
Queue Length 95th (m)	7.3	69.4	6.7	158.0	41.4	18.1	18.9	15.0
Internal Link Dist (m)		304.2		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	264	2329	497	2470	338	453	334	442
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.23	0.39	0.11	0.64	0.30	0.15	0.11	0.11

Intersection Summary

HCM Signalized Intersection Capacity Analysis
2022 Total PM
2: Itabashi Way/William O'Connell Boulevard & Upper Middle Road
4063 Upper Middle Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	57	722	112	51	1371	81	94	20	43	35	15	31
Future Volume (vph)	57	722	112	51	1371	81	94	20	43	35	15	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.99	1.00		1.00	1.00	
Frt	1.00	0.98		1.00	0.99		1.00	0.90		1.00	0.90	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1787	3327		1787	3539		1774	1674		1785	1667	
Flt Permitted	0.11	1.00		0.29	1.00		0.72	1.00		0.71	1.00	
Satd. Flow (perm)	207	3327		539	3539		1353	1674		1338	1667	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	62	785	122	55	1490	88	102	22	47	38	16	34
RTOR Reduction (vph)	0	7	0	0	2	0	0	41	0	0	30	0
Lane Group Flow (vph)	62	900	0	55	1576	0	102	28	0	38	20	0
Confl. Peds. (#/hr)	2					2	6		1	1		6
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		0										
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	88.7	82.9		88.5	82.8		14.4	14.4		14.4	14.4	
Effective Green, g (s)	88.7	82.9		88.5	82.8		14.4	14.4		14.4	14.4	
Actuated g/C Ratio	0.74	0.69		0.74	0.69		0.12	0.12		0.12	0.12	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	229	2298		456	2441		162	200		160	200	
v/s Ratio Prot	c0.01	0.27		0.01	c0.45			0.02			0.01	
v/s Ratio Perm	0.19			0.08			c0.08			0.03		
v/c Ratio	0.27	0.39		0.12	0.65		0.63	0.14		0.24	0.10	
Uniform Delay, d1	7.8	7.9		4.5	10.4		50.3	47.2		47.8	47.0	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.6	0.5		0.1	1.3		7.4	0.3		0.8	0.2	
Delay (s)	8.4	8.4		4.6	11.7		57.7	47.6		48.6	47.3	
Level of Service	A	A		A	B		E	D		D	D	
Approach Delay (s)		8.4			11.5			53.6			47.8	
Approach LOS		A			B			D			D	

Intersection Summary				
HCM 2000 Control Delay	14.1	HCM 2000 Level of Service	B	
HCM 2000 Volume to Capacity ratio	0.62			
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	17.0	
Intersection Capacity Utilization	70.5%	ICU Level of Service	C	
Analysis Period (min)	15			
c Critical Lane Group				



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	3	881	7	35	1454	7	10	0	7	4	0	4
Future Volume (Veh/h)	3	881	7	35	1454	7	10	0	7	4	0	4
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	3	958	8	38	1580	8	11	0	8	4	0	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		273			328							
pX, platoon unblocked	0.73			0.91			0.78	0.78	0.91	0.78	0.78	0.73
vC, conflicting volume	1588			966			1838	2632	483	2153	2632	794
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1075			772			1001	2023	243	1406	2023	0
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			95			93	100	99	95	100	99
cM capacity (veh/h)	477			772			147	43	694	73	43	798

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total	482	487	828	798	19	8
Volume Left	3	0	38	0	11	4
Volume Right	0	8	0	8	8	4
cSH	477	1700	772	1700	220	135
Volume to Capacity	0.01	0.29	0.05	0.47	0.09	0.06
Queue Length 95th (m)	0.2	0.0	1.2	0.0	2.2	1.5
Control Delay (s)	0.2	0.0	1.3	0.0	22.9	33.4
Lane LOS	A		A		C	D
Approach Delay (s)	0.1		0.7		22.9	33.4
Approach LOS					C	D

Intersection Summary				
Average Delay	0.7			
Intersection Capacity Utilization	75.5%	ICU Level of Service	D	
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (veh/h)	4	890	1461	7	0	5
Future Volume (Veh/h)	4	890	1461	7	0	5
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	4	967	1588	8	0	5
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)		232	369			
pX, platoon unblocked	0.74				0.78	0.74
vC, conflicting volume	1596				2084	798
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1102				1321	24
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	99				100	99
cM capacity (veh/h)	470				117	777

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	SB 1
Volume Total	326	645	1059	537	5
Volume Left	4	0	0	0	0
Volume Right	0	0	0	8	5
cSH	470	1700	1700	1700	777
Volume to Capacity	0.01	0.38	0.62	0.32	0.01
Queue Length 95th (m)	0.2	0.0	0.0	0.0	0.2
Control Delay (s)	0.3	0.0	0.0	0.0	9.7
Lane LOS	A				A
Approach Delay (s)	0.1		0.0		9.7
Approach LOS					A

Intersection Summary				
Average Delay	0.1			
Intersection Capacity Utilization	50.6%	ICU Level of Service	A	
Analysis Period (min)	15			

Appendix D

2022 Total Traffic with Signals Optimized Operations Reports

Queues
2022 Total AM Remedial - Signals Optimized
1: Walker's Line & Upper Middle Road
4063 Upper Middle Road

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	221	664	324	338	341	68	163	749	355	232	1216	138
v/c Ratio	0.52	0.96	0.72	1.02	0.48	0.16	0.81	0.64	0.51	0.66	0.91	0.21
Control Delay	23.8	62.0	26.1	80.6	34.2	1.0	46.1	28.4	9.8	22.4	38.2	4.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.8	62.0	26.1	80.6	34.2	1.0	46.1	28.4	9.8	22.4	38.2	4.7
Queue Length 50th (m)	27.0	63.4	26.0	~48.8	29.2	0.0	15.2	60.4	12.6	22.5	108.4	0.6
Queue Length 95th (m)	44.8	#99.0	#59.8	#102.9	43.0	0.9	#46.6	80.3	37.1	37.0	#151.4	12.0
Internal Link Dist (m)		126.1			208.1			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	439	694	451	330	716	415	202	1170	695	356	1336	661
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.50	0.96	0.72	1.02	0.48	0.16	0.81	0.64	0.51	0.65	0.91	0.21

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
2022 Total AM Remedial - Signals Optimized
1: Walker's Line & Upper Middle Road
4063 Upper Middle Road

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	203	611	298	311	314	63	150	689	327	213	1119	127
Future Volume (vph)	203	611	298	311	314	63	150	689	327	213	1119	127
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1735	3471	1583	1787	3438	1490	1736	3471	1556	1787	3539	1531
Flt Permitted	0.51	1.00	1.00	0.21	1.00	1.00	0.13	1.00	1.00	0.21	1.00	1.00
Satd. Flow (perm)	938	3471	1583	400	3438	1490	241	3471	1556	397	3539	1531
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	221	664	324	338	341	68	163	749	355	232	1216	138
RTOR Reduction (vph)	0	0	134	0	0	54	0	0	170	0	0	83
Lane Group Flow (vph)	221	664	190	338	341	14	163	749	185	232	1216	55
Confl. Peds. (#/hr)	1					1	2		5	5		2
Heavy Vehicles (%)	4%	4%	2%	1%	5%	7%	4%	4%	2%	1%	2%	4%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	29.2	18.0	18.0	30.8	18.8	18.8	36.3	30.3	30.3	43.7	34.0	34.0
Effective Green, g (s)	29.2	18.0	18.0	30.8	18.8	18.8	36.3	30.3	30.3	43.7	34.0	34.0
Actuated g/C Ratio	0.32	0.20	0.20	0.34	0.21	0.21	0.40	0.34	0.34	0.49	0.38	0.38
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	403	694	316	321	718	311	196	1168	523	342	1336	578
v/s Ratio Prot	0.07	0.19		c0.14	0.10		0.06	0.22		c0.07	c0.34	
v/s Ratio Perm	0.11		0.12	c0.22		0.01	0.28		0.12	0.26		0.04
v/c Ratio	0.55	0.96	0.60	1.05	0.47	0.05	0.83	0.64	0.35	0.68	0.91	0.10
Uniform Delay, d1	23.5	35.6	32.7	25.7	31.3	28.4	20.8	25.3	22.5	15.4	26.6	18.1
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.5	23.8	3.1	64.8	0.5	0.1	24.9	2.7	1.9	5.3	10.8	0.3
Delay (s)	25.1	59.4	35.8	90.5	31.8	28.5	45.7	28.0	24.3	20.7	37.3	18.4
Level of Service	C	E	D	F	C	C	D	C	C	C	D	B
Approach Delay (s)		46.8			58.1			29.2			33.3	
Approach LOS		D			E			C			C	

Intersection Summary

HCM 2000 Control Delay	39.4	HCM 2000 Level of Service		D	
HCM 2000 Volume to Capacity ratio	0.98				
Actuated Cycle Length (s)	90.0	Sum of lost time (s)		20.0	
Intersection Capacity Utilization	90.0%	ICU Level of Service		E	
Analysis Period (min)	15				

c Critical Lane Group

Queues 2022 Total AM Remedial - Signals Optimized

2: Itabashi Way/William O'Connell Boulevard & Upper Middle Road 4063 Upper Middle Road



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	33	1242	16	662	62	10	65	71
v/c Ratio	0.06	0.54	0.04	0.31	0.32	0.04	0.32	0.25
Control Delay	3.7	9.6	3.7	8.3	26.1	19.0	25.9	11.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	3.7	9.6	3.7	8.3	26.1	19.0	25.9	11.3
Queue Length 50th (m)	1.0	33.1	0.5	13.9	5.9	0.8	6.2	1.2
Queue Length 95th (m)	3.0	#95.0	1.9	36.6	15.4	4.2	15.9	10.5
Internal Link Dist (m)		304.2		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	589	2302	379	2118	194	266	203	286
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.54	0.04	0.31	0.32	0.04	0.32	0.25

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis 2022 Total AM Remedial - Signals Optimized

2: Itabashi Way/William O'Connell Boulevard & Upper Middle Road 4063 Upper Middle Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	30	1046	97	15	572	37	57	7	2	60	12	53
Future Volume (vph)	30	1046	97	15	572	37	57	7	2	60	12	53
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.99		1.00	0.99		1.00	0.97		1.00	0.88	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1671	3507		1671	3437		1785	1820		1767	1633	
Flt Permitted	0.38	1.00		0.17	1.00		0.71	1.00		0.75	1.00	
Satd. Flow (perm)	664	3507		303	3437		1336	1820		1397	1633	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	33	1137	105	16	622	40	62	8	2	65	13	58
RTOR Reduction (vph)	0	10	0	0	7	0	0	2	0	0	51	0
Lane Group Flow (vph)	33	1232	0	16	655	0	62	8	0	65	20	0
Confl. Peds. (#/hr)	1		3	3		1	2		3	3		2
Heavy Vehicles (%)	8%	1%	6%	8%	4%	3%	1%	1%	1%	2%	1%	1%
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	33.0	30.2		30.2	28.8		6.4	6.4		6.4	6.4	
Effective Green, g (s)	33.0	30.2		30.2	28.8		6.4	6.4		6.4	6.4	
Actuated g/C Ratio	0.60	0.55		0.55	0.52		0.12	0.12		0.12	0.12	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	449	1925		201	1799		155	211		162	190	
v/s Ratio Prot	c0.00	c0.35		0.00	0.19			0.00			0.01	
v/s Ratio Perm	0.04			0.04			0.05			c0.05		
v/c Ratio	0.07	0.64		0.08	0.36		0.40	0.04		0.40	0.10	
Uniform Delay, d1	4.5	8.6		6.1	7.7		22.5	21.6		22.5	21.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.1	1.6		0.2	0.6		1.7	0.1		1.6	0.2	
Delay (s)	4.6	10.3		6.2	8.3		24.2	21.6		24.2	22.0	
Level of Service	A	B		A	A		C	C		C	C	
Approach Delay (s)		10.1			8.2			23.9			23.0	
Approach LOS		B			A			C			C	

Intersection Summary

HCM 2000 Control Delay	10.8	HCM 2000 Level of Service	B		
HCM 2000 Volume to Capacity ratio	0.58				
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	17.0		
Intersection Capacity Utilization	54.0%	ICU Level of Service	A		
Analysis Period (min)	15				

c Critical Lane Group

Queues
1: Walker's Line & Upper Middle Road

2022 Total PM Remedial
4063 Upper Middle Road

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	155	384	215	402	996	196	467	1429	437	151	918	213
v/c Ratio	0.81	0.76	0.54	0.92	1.03	0.36	1.07	0.98	0.59	0.81	0.97	0.37
Control Delay	56.2	52.5	11.4	53.0	74.6	9.1	90.3	48.2	17.3	50.7	59.9	6.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	56.2	52.5	11.4	53.0	74.6	9.1	90.3	48.2	17.3	50.7	59.9	6.6
Queue Length 50th (m)	20.7	40.2	0.6	63.5	~115.3	4.9	~88.4	147.6	40.9	15.1	97.5	0.9
Queue Length 95th (m)	#46.4	#60.4	21.7	#115.2	#155.8	22.5	#151.6	#199.8	73.1	#45.6	#139.7	18.3
Internal Link Dist (m)		126.1			208.1			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	192	502	398	439	964	545	437	1465	742	187	946	572
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.81	0.76	0.54	0.92	1.03	0.36	1.07	0.98	0.59	0.81	0.97	0.37

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
1: Walker's Line & Upper Middle Road

2022 Total PM Remedial
4063 Upper Middle Road

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	143	353	198	370	916	180	430	1315	402	139	845	196
Future Volume (vph)	143	353	198	370	916	180	430	1315	402	139	845	196
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3574	1538	1786	3574	1576	1787	3574	1569	1787	3505	1561
Flt Permitted	0.28	1.00	1.00	0.27	1.00	1.00	0.13	1.00	1.00	0.15	1.00	1.00
Satd. Flow (perm)	534	3574	1538	503	3574	1576	243	3574	1569	279	3505	1561
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	155	384	215	402	996	196	467	1429	437	151	918	213
RTOR Reduction (vph)	0	0	182	0	0	120	0	0	99	0	0	151
Lane Group Flow (vph)	155	384	33	402	996	76	467	1429	338	151	918	62
Confl. Peds. (#/hr)	2		6	6		2	2		6	6		2
Heavy Vehicles (%)	1%	1%	3%	1%	1%	1%	1%	1%	1%	1%	3%	2%
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Actuated Green, G (s)	20.1	14.1	14.1	37.0	27.0	27.0	51.0	41.0	41.0	33.0	27.0	27.0
Effective Green, g (s)	20.1	14.1	14.1	37.0	27.0	27.0	51.0	41.0	41.0	33.0	27.0	27.0
Actuated g/C Ratio	0.20	0.14	0.14	0.37	0.27	0.27	0.51	0.41	0.41	0.33	0.27	0.27
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	182	503	216	428	964	425	432	1465	643	182	946	421
v/s Ratio Prot	0.05	0.11		c0.18	c0.28		c0.22	0.40		0.05	0.26	
v/s Ratio Perm	0.12		0.02	0.17		0.05	c0.33		0.22	0.22		0.04
v/c Ratio	0.85	0.76	0.15	0.94	1.03	0.18	1.08	0.98	0.53	0.83	0.97	0.15
Uniform Delay, d1	37.3	41.3	37.7	26.3	36.5	28.0	29.2	29.0	22.2	27.8	36.1	27.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	29.8	6.8	0.3	28.3	37.9	0.2	66.8	18.3	3.1	25.7	22.9	0.7
Delay (s)	67.2	48.1	38.0	54.6	74.4	28.2	96.0	47.3	25.2	53.5	59.0	28.5
Level of Service	E	D	D	D	E	C	F	D	C	D	E	C
Approach Delay (s)		49.2			63.7			52.9			53.3	
Approach LOS		D			E			D			D	

Intersection Summary				
HCM 2000 Control Delay	55.4	HCM 2000 Level of Service	E	
HCM 2000 Volume to Capacity ratio	1.11			
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	20.0	
Intersection Capacity Utilization	97.1%	ICU Level of Service	F	
Analysis Period (min)	15			

c Critical Lane Group



Lane Group	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	62	907	55	1578	102	69	38	50
v/c Ratio	0.18	0.44	0.11	0.73	0.57	0.26	0.21	0.20
Control Delay	4.6	9.8	3.7	16.0	38.9	14.4	26.5	14.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	4.6	9.8	3.7	16.0	38.9	14.4	26.5	14.5
Queue Length 50th (m)	1.9	35.9	1.7	85.7	11.3	2.3	4.0	1.7
Queue Length 95th (m)	4.6	52.0	4.2	#137.6	#29.3	12.2	11.7	10.0
Internal Link Dist (m)		304.2		76.1		86.2		72.2
Turn Bay Length (m)	55.0		50.0		40.0		40.0	
Base Capacity (vph)	341	2045	507	2165	180	264	178	252
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.18	0.44	0.11	0.73	0.57	0.26	0.21	0.20

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	57	722	112	51	1371	81	94	20	43	35	15	31
Future Volume (vph)	57	722	112	51	1371	81	94	20	43	35	15	31
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	0.99		1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.98		1.00	0.99		1.00	0.90		1.00	0.90	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1787	3327		1787	3540		1781	1674		1786	1671	
Flt Permitted	0.12	1.00		0.28	1.00		0.72	1.00		0.71	1.00	
Satd. Flow (perm)	232	3327		519	3540		1358	1674		1339	1671	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	62	785	122	55	1490	88	102	22	47	38	16	34
RTOR Reduction (vph)	0	18	0	0	6	0	0	42	0	0	30	0
Lane Group Flow (vph)	62	889	0	55	1572	0	102	27	0	38	20	0
Confl. Peds. (#/hr)	2					2	6		1	1		6
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)		0										
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			8			4	
Permitted Phases	2			6			8			4		
Actuated Green, G (s)	36.6	32.4		36.6	32.4		6.4	6.4		6.4	6.4	
Effective Green, g (s)	36.6	32.4		36.6	32.4		6.4	6.4		6.4	6.4	
Actuated g/C Ratio	0.61	0.54		0.61	0.54		0.11	0.11		0.11	0.11	
Clearance Time (s)	4.0	6.0		4.0	6.0		7.0	7.0		7.0	7.0	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	250	1796		405	1911		144	178		142	178	
v/s Ratio Prot	c0.02	0.27		0.01	c0.44			0.02			0.01	
v/s Ratio Perm	0.13			0.07			c0.08			0.03		
v/c Ratio	0.25	0.50		0.14	0.82		0.71	0.15		0.27	0.11	
Uniform Delay, d1	7.7	8.7		4.9	11.4		25.9	24.3		24.6	24.2	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.5	1.0		0.2	4.2		14.7	0.4		1.0	0.3	
Delay (s)	8.2	9.6		5.0	15.6		40.6	24.7		25.7	24.5	
Level of Service	A	A		A	B		D	C		C	C	
Approach Delay (s)		9.6			15.2			34.2			25.0	
Approach LOS		A			B			C			C	

Intersection Summary

HCM 2000 Control Delay	14.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.75		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	70.5%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Appendix E

2022 Total Traffic with Driveway Left-Turn Lanes Operations Reports



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	2	1144	3	6	676	1	7	0	21	8	0	3
Future Volume (Veh/h)	2	1144	3	6	676	1	7	0	21	8	0	3
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	2	1243	3	7	735	1	8	0	23	9	0	3
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		273			328							
pX, platoon unblocked	0.97			0.83			0.84	0.84	0.83	0.84	0.84	0.97
vC, conflicting volume	736			1246			1633	1998	623	1398	2000	368
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	675			876			1230	1665	122	950	1667	297
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			99			93	100	97	95	100	100
cM capacity (veh/h)	895			638			112	80	751	174	80	684

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	2	829	417	7	490	246	31	12
Volume Left	2	0	0	7	0	0	8	9
Volume Right	0	0	3	0	0	1	23	3
cSH	895	1700	1700	638	1700	1700	303	214
Volume to Capacity	0.00	0.49	0.25	0.01	0.29	0.14	0.10	0.06
Queue Length 95th (m)	0.1	0.0	0.0	0.3	0.0	0.0	2.7	1.4
Control Delay (s)	9.0	0.0	0.0	10.7	0.0	0.0	18.2	22.8
Lane LOS	A			B			C	C
Approach Delay (s)	0.0			0.1			18.2	22.8
Approach LOS							C	C

Intersection Summary				
Average Delay	0.5			
Intersection Capacity Utilization	41.7%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (veh/h)	2	1149	685	1	0	3
Future Volume (Veh/h)	2	1149	685	1	0	3
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	2	1249	745	1	0	3
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)		232	369			
pX, platoon unblocked	0.98				0.83	0.98
vC, conflicting volume	746				1374	373
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	704				951	324
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				100	100
cM capacity (veh/h)	880				218	662

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	SB 1
Volume Total	2	624	624	497	249	3
Volume Left	2	0	0	0	0	0
Volume Right	0	0	0	0	1	3
cSH	880	1700	1700	1700	1700	662
Volume to Capacity	0.00	0.37	0.37	0.29	0.15	0.00
Queue Length 95th (m)	0.1	0.0	0.0	0.0	0.0	0.1
Control Delay (s)	9.1	0.0	0.0	0.0	0.0	10.5
Lane LOS	A					B
Approach Delay (s)	0.0			0.0		10.5
Approach LOS						B

Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	35.1%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	3	881	7	35	1454	7	10	0	7	4	0	4
Future Volume (Veh/h)	3	881	7	35	1454	7	10	0	7	4	0	4
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	3	958	8	38	1580	8	11	0	8	4	0	4
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		273			328							
pX, platoon unblocked	0.74			0.92			0.78	0.78	0.92	0.78	0.78	0.74
vC, conflicting volume	1588			966			1838	2632	483	2153	2632	794
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1090			800			1067	2089	277	1472	2089	17
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			95			92	100	99	94	100	99
cM capacity (veh/h)	474			763			132	39	669	66	39	785

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	3	639	327	38	1053	535	19	8
Volume Left	3	0	0	38	0	0	11	4
Volume Right	0	0	8	0	0	8	8	4
cSH	474	1700	1700	763	1700	1700	199	121
Volume to Capacity	0.01	0.38	0.19	0.05	0.62	0.31	0.10	0.07
Queue Length 95th (m)	0.2	0.0	0.0	1.3	0.0	0.0	2.5	1.7
Control Delay (s)	12.6	0.0	0.0	10.0	0.0	0.0	25.0	36.8
Lane LOS	B			A			D	E
Approach Delay (s)	0.0			0.2			25.0	36.8
Approach LOS							D	E

Intersection Summary				
Average Delay	0.5			
Intersection Capacity Utilization	50.4%	ICU Level of Service	A	
Analysis Period (min)	15			



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (veh/h)	4	890	1461	7	0	5
Future Volume (Veh/h)	4	890	1461	7	0	5
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	4	967	1588	8	0	5
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)		232	369			
pX, platoon unblocked	0.74				0.78	0.74
vC, conflicting volume	1596				2084	798
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1102				1369	24
tC, single (s)	4.1				6.8	6.9
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	99				100	99
cM capacity (veh/h)	470				108	777

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	SB 1
Volume Total	4	484	484	1059	537	5
Volume Left	4	0	0	0	0	0
Volume Right	0	0	0	0	8	5
cSH	470	1700	1700	1700	1700	777
Volume to Capacity	0.01	0.28	0.28	0.62	0.32	0.01
Queue Length 95th (m)	0.2	0.0	0.0	0.0	0.0	0.2
Control Delay (s)	12.7	0.0	0.0	0.0	0.0	9.7
Lane LOS	B					A
Approach Delay (s)	0.1			0.0		9.7
Approach LOS						A

Intersection Summary			
Average Delay	0.0		
Intersection Capacity Utilization	50.6%	ICU Level of Service	A
Analysis Period (min)	15		

Appendix F

2022 Total Traffic with Dual Left-Turn Lanes Operations Reports

Queues
2022 Total AM Remedial - Dual Left-Turn

1: Walker's Line & Upper Middle Road
4063 Upper Middle Road

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	221	664	324	338	341	68	163	749	355	232	1216	138
v/c Ratio	0.56	0.96	0.72	0.98	0.58	0.18	0.65	0.62	0.48	0.65	0.92	0.21
Control Delay	24.0	58.5	24.9	81.5	35.5	1.0	49.0	24.2	6.7	20.4	36.3	3.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.0	58.5	24.9	81.5	35.5	1.0	49.0	24.2	6.7	20.4	36.3	3.5
Queue Length 50th (m)	24.7	55.7	22.9	28.3	27.0	0.0	13.3	51.4	6.3	19.0	95.3	0.0
Queue Length 95th (m)	42.4	#90.0	#59.8	#54.6	40.8	0.0	#25.7	70.0	26.3	#32.6	#138.3	9.5
Internal Link Dist (m)		126.1			208.1			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	410	694	449	346	583	377	252	1216	738	357	1327	667
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.54	0.96	0.72	0.98	0.58	0.18	0.65	0.62	0.48	0.65	0.92	0.21

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
2022 Total AM Remedial - Dual Left-Turn

1: Walker's Line & Upper Middle Road
4063 Upper Middle Road

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	203	611	298	311	314	63	150	689	327	213	1119	127
Future Volume (vph)	203	611	298	311	314	63	150	689	327	213	1119	127
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1735	3471	1583	3467	3438	1490	3367	3471	1557	1787	3539	1531
Flt Permitted	0.42	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.24	1.00	1.00
Satd. Flow (perm)	764	3471	1583	3467	3438	1490	3367	3471	1557	447	3539	1531
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	221	664	324	338	341	68	163	749	355	232	1216	138
RTOR Reduction (vph)	0	0	133	0	0	56	0	0	192	0	0	86
Lane Group Flow (vph)	221	664	191	338	341	12	163	749	163	232	1216	52
Confl. Peds. (#/hr)	1					1	2		5	5		2
Heavy Vehicles (%)	4%	4%	2%	1%	5%	7%	4%	4%	2%	1%	2%	4%
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Prot	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4			8			2	6		6
Actuated Green, G (s)	26.4	16.0	16.0	8.0	13.6	13.6	6.0	28.0	28.0	38.0	30.0	30.0
Effective Green, g (s)	26.4	16.0	16.0	8.0	13.6	13.6	6.0	28.0	28.0	38.0	30.0	30.0
Actuated g/C Ratio	0.33	0.20	0.20	0.10	0.17	0.17	0.08	0.35	0.35	0.48	0.38	0.38
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	378	694	316	346	584	253	252	1214	544	346	1327	574
v/s Ratio Prot	c0.08	c0.19		c0.10	0.10		0.05	0.22		c0.07	c0.34	
v/s Ratio Perm	0.12		0.12			0.01			0.10	0.25		0.03
v/c Ratio	0.58	0.96	0.61	0.98	0.58	0.05	0.65	0.62	0.30	0.67	0.92	0.09
Uniform Delay, d1	20.7	31.7	29.1	35.9	30.6	27.8	36.0	21.6	18.9	13.7	23.8	16.2
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	2.3	23.8	3.3	41.7	1.5	0.1	5.6	2.4	1.4	5.0	11.4	0.3
Delay (s)	23.0	55.4	32.4	77.7	32.1	27.8	41.6	23.9	20.3	18.8	35.2	16.5
Level of Service	C	E	C	E	C	C	D	C	C	B	D	B
Approach Delay (s)		43.3			52.3			25.2			31.2	
Approach LOS		D			D			C			C	

Intersection Summary				
HCM 2000 Control Delay	35.9	HCM 2000 Level of Service	D	
HCM 2000 Volume to Capacity ratio	0.94			
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	20.0	
Intersection Capacity Utilization	78.4%	ICU Level of Service	D	
Analysis Period (min)	15			

c Critical Lane Group

Queues
1: Walker's Line & Upper Middle Road

2022 Total PM Remedial - Dual Left-Turn
4063 Upper Middle Road

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Group Flow (vph)	155	384	215	402	996	196	467	1429	437	151	918	213
v/c Ratio	0.82	0.56	0.46	0.84	1.03	0.36	0.86	0.98	0.59	0.81	0.84	0.34
Control Delay	57.1	40.2	8.4	59.0	74.6	9.1	57.8	48.2	17.3	50.2	40.3	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	57.1	40.2	8.4	59.0	74.6	9.1	57.8	48.2	17.3	50.2	40.3	5.7
Queue Length 50th (m)	20.7	37.7	0.0	41.6	~115.3	4.9	48.2	147.6	40.9	15.1	91.6	0.9
Queue Length 95th (m)	#47.8	53.2	19.6	#65.4	#155.8	22.5	#73.6	#199.8	73.1	#47.6	#118.7	17.2
Internal Link Dist (m)		126.1			208.1			155.6			135.5	
Turn Bay Length (m)	90.0		30.0	95.0		30.0	95.0		30.0	65.0		30.0
Base Capacity (vph)	190	687	469	485	964	545	554	1465	742	187	1097	630
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.82	0.56	0.46	0.83	1.03	0.36	0.84	0.98	0.59	0.81	0.84	0.34

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
1: Walker's Line & Upper Middle Road

2022 Total PM Remedial - Dual Left-Turn
4063 Upper Middle Road

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	143	353	198	370	916	180	430	1315	402	139	845	196
Future Volume (vph)	143	353	198	370	916	180	430	1315	402	139	845	196
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Lane Util. Factor	1.00	0.95	1.00	0.97	0.95	1.00	0.97	0.95	1.00	1.00	0.95	1.00
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.99
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1787	3574	1538	3467	3574	1576	3467	3574	1569	1787	3505	1561
Flt Permitted	0.21	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.13	1.00	1.00
Satd. Flow (perm)	392	3574	1538	3467	3574	1576	3467	3574	1569	240	3505	1561
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	155	384	215	402	996	196	467	1429	437	151	918	213
RTOR Reduction (vph)	0	0	174	0	0	120	0	0	99	0	0	142
Lane Group Flow (vph)	155	384	41	402	996	76	467	1429	338	151	918	71
Confl. Peds. (#/hr)	2		6	6		2	2		6	6		2
Heavy Vehicles (%)	1%	1%	3%	1%	1%	1%	1%	1%	1%	1%	3%	2%
Turn Type	pm+pt	NA	Perm	Prot	NA	Perm	Prot	NA	Perm	pm+pt	NA	Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4			8			2	6		6
Actuated Green, G (s)	25.2	19.2	19.2	13.8	27.0	27.0	15.7	41.0	41.0	37.3	31.3	31.3
Effective Green, g (s)	25.2	19.2	19.2	13.8	27.0	27.0	15.7	41.0	41.0	37.3	31.3	31.3
Actuated g/C Ratio	0.25	0.19	0.19	0.14	0.27	0.27	0.16	0.41	0.41	0.37	0.31	0.31
Clearance Time (s)	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0	4.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	182	686	295	478	964	425	544	1465	643	182	1097	488
v/s Ratio Prot	0.05	0.11		c0.12	c0.28		c0.13	c0.40		0.05	0.26	
v/s Ratio Perm	0.16		0.03			0.05			0.22	0.26		0.05
v/c Ratio	0.85	0.56	0.14	0.84	1.03	0.18	0.86	0.98	0.53	0.83	0.84	0.15
Uniform Delay, d1	33.8	36.6	33.5	42.0	36.5	28.0	41.1	29.0	22.2	25.4	32.0	24.7
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	29.8	1.0	0.2	12.6	37.9	0.2	12.7	18.3	3.1	25.7	7.6	0.6
Delay (s)	63.6	37.6	33.8	54.6	74.4	28.2	53.8	47.3	25.2	51.1	39.6	25.3
Level of Service	E	D	C	D	E	C	D	D	C	D	D	C
Approach Delay (s)		41.8			63.7			44.5			38.6	
Approach LOS		D			E			D			D	

Intersection Summary				
HCM 2000 Control Delay	48.0	HCM 2000 Level of Service	D	
HCM 2000 Volume to Capacity ratio	1.01			
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	20.0	
Intersection Capacity Utilization	94.0%	ICU Level of Service	F	
Analysis Period (min)	15			

c Critical Lane Group

Appendix G

2022 Total Traffic with One Development Driveway Operations Reports



HCM Unsignalized Intersection Capacity Analysis
3: Park City/East Driveway & Upper Middle Road

2022 Total AM - One Access
4063 Upper Middle Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	4	1144	3	6	675	2	7	0	21	8	0	6
Future Volume (Veh/h)	4	1144	3	6	675	2	7	0	21	8	0	6
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	4	1243	3	7	734	2	8	0	23	9	0	7
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		273			328							
pX, platoon unblocked	0.97			0.83			0.84	0.84	0.83	0.84	0.84	0.97
vC, conflicting volume	736			1246			1640	2002	623	1402	2003	368
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	675			876			1239	1670	122	954	1671	297
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			99			93	100	97	95	100	99
cM capacity (veh/h)	895			638			109	79	751	173	79	684

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	4	829	417	7	489	247	31	16
Volume Left	4	0	0	7	0	0	8	9
Volume Right	0	0	3	0	0	2	23	7
cSH	895	1700	1700	638	1700	1700	298	257
Volume to Capacity	0.00	0.49	0.25	0.01	0.29	0.15	0.10	0.06
Queue Length 95th (m)	0.1	0.0	0.0	0.3	0.0	0.0	2.8	1.6
Control Delay (s)	9.0	0.0	0.0	10.7	0.0	0.0	18.5	20.0
Lane LOS	A			B			C	C
Approach Delay (s)	0.0			0.1			18.5	20.0
Approach LOS							C	C

Intersection Summary					
Average Delay	0.5				
Intersection Capacity Utilization	41.7%	ICU Level of Service		A	
Analysis Period (min)	15				

HCM Unsignalized Intersection Capacity Analysis
3: Park City & Upper Middle Road

2022 Total PM - One Access
4063 Upper Middle Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	7	881	7	35	1447	14	10	0	7	4	0	9
Future Volume (Veh/h)	7	881	7	35	1447	14	10	0	7	4	0	9
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	8	958	8	38	1573	15	11	0	8	4	0	10
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)		273			328							
pX, platoon unblocked	0.74			0.92			0.78	0.78	0.92	0.78	0.78	0.74
vC, conflicting volume	1588			966			1850	2642	483	2160	2638	794
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	1090			800			1084	2102	277	1481	2098	17
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	98			95			91	100	99	94	100	99
cM capacity (veh/h)	474			763			126	38	668	64	38	785

Direction, Lane #	EB 1	EB 2	EB 3	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	8	639	327	38	1049	539	19	14
Volume Left	8	0	0	38	0	0	11	4
Volume Right	0	0	8	0	0	15	8	10
cSH	474	1700	1700	763	1700	1700	191	186
Volume to Capacity	0.02	0.38	0.19	0.05	0.62	0.32	0.10	0.08
Queue Length 95th (m)	0.4	0.0	0.0	1.3	0.0	0.0	2.6	1.9
Control Delay (s)	12.7	0.0	0.0	10.0	0.0	0.0	25.9	25.9
Lane LOS	B			A			D	D
Approach Delay (s)	0.1			0.2			25.9	25.9
Approach LOS							D	D

Intersection Summary					
Average Delay	0.5				
Intersection Capacity Utilization	50.4%	ICU Level of Service		A	
Analysis Period (min)	15				