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Project # 5829

Memorandum

To: Denise Marshall – County of Northumberland
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From: Elizabeth Szymanski – HDR|iTRANS
Tony Reitmeier – HDR|iTRANS
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Date: March 23, 2012
Re: **County Road No. 2 Port Hope to Cobourg, Ontario**
Analysis of Traffic Conditions to 2031

1. BACKGROUND

Northumberland County is considering the widening of County Road 2 between the Municipality of Port Hope and the Town of Cobourg. The study limits along County Road 2 are from Hamilton Road in the Municipality of Port Hope to Burnham Street / William Street in the Town of Cobourg. The study area is highlighted in **Exhibit 1-1**. County Road 2 is an arterial road that spans across the Municipality of Port Hope, the Township of Hamilton and the Town of Cobourg.

Currently the road has a two-lane rural cross-section between from just west of Hamilton Road in Port Hope to Wilkins Gate in Cobourg and a four-lane, primarily urban, cross-section east of Wilkins Gate. The section under study is approximately 6 kilometres long. The posted speed limit is 50 to 60 km/h in the urban sections of the Municipality Port Hope and the Town of Cobourg and 80 km/h in the rural section in the Township of Hamilton.

There are five existing signalized intersections in the study area:

- Hamilton Road,
- New Amherst Boulevard / Lovshin Road,
- Rogers Road,
- Strathy Road and
- Burnham Street / William Street.

Exhibit 1-1: Study Area

2. PREVIOUS STUDIES

HDR has reviewed two traffic impact studies in the vicinity of the study area. The studies are ***Town of Cobourg Transportation Study*** by TSH, September 2002 and ***New Amherst Residential Development Traffic Impact Study*** by TSH, February 2003. The Transportation Study reviewed the operational and strategic transportation needs in the Town of Cobourg. This assessment also considered the results of the traffic impact study for the New Amherst Subdivision development, located south of County Road 2 and west of Rogers Road in Cobourg.

3. EXISTING CONDITIONS

3.1 Level of Service

Level of service (LOS) is a term used to qualitatively describe the operating conditions of a roadway based on factors such as speed, travel time, manoeuvrability, delay, and safety. The LOS of a facility is designated with a letter, A to F, with A representing the best operating conditions and F the worst.

Table 3-1 show the levels of service for arterials as per the *Highway Capacity Manual* (HCM, 1994).

Table 3-1: Level of Service Criteria for Arterials[a] based on Volume:Capacity Ratios

Level of Service	Description	V/C[b]
A	Free-flow conditions with unimpeded manoeuvrability. Stopped delay at signalized intersections is minimal.	0.00 to 0.60
B	Reasonably unimpeded operations with slightly restricted manoeuvrability. Stopped delays are not bothersome.	0.61 to 0.70
C	Stable operations with somewhat more restrictions in making mid-block lane changes than LOS B. Motorists will experience appreciable tension while driving.	0.71 to 0.80
D	Approaching unstable operations where small increases in volume produce substantial increases in delay and decreases in speed.	0.81 to 0.90
E	Operations with significant intersection approach delays and low average speeds.	0.91 to 1.00
F	Operations with extremely low speeds caused by intersection congestion, high delay, and adverse signal progression.	Greater Than 1.00

Notes:
a. For arterials that are multilane divided or undivided with some parking, a signalized intersection density of four to eight per mile, and moderate roadside development.
b. Volume-to-capacity ratio

The level of service criteria will be applied to the volume-capacity ratios for County Road 2.

3.2 Volume-to-Capacity Ratios

Traffic volumes are typically higher during the summer months in the study area; therefore, summer volumes were used in the forecast to be conservative. Data obtained from 2008 shows a summer average daily traffic (SADT) of 12,200 vehicles per day.

A weekday 24-hour count from Wednesday May 26, 2010 was used to create an hourly traffic profile of the 2008 SADT volumes. This generated a maximum hourly one-way traffic volume of 528 vehicles per hour per lane (vphpl).

The *Highway Capacity Manual* (HCM, 2010) defines the capacity of a two-lane roadway under base conditions (i.e., in the absence of restrictive geometric, traffic or environmental factors) as being 1,700 vphpl. HCM notes that capacity conditions are rarely observed, except in relatively short segments. To account for the number of slow moving farming equipment and trucks that travel along the study corridor, a conservative estimate for the roadway capacity was used. The maximum flow was assumed to be 900 vphpl, that is, a 47% reduction from the maximum base capacity specified by HCM.

Using the conservative SADT values and the adjusted maximum flow, the existing maximum volume to capacity ratio is 0.59, or a LOS A. This means that County Road 2 is operating below the threshold of a typical acceptable volume to capacity ratio threshold (0.85 can be used as a threshold). The hourly volume distribution and volume to capacity ratios is provided in **Table 3-2**.

Table 3-2: Existing Link Volumes on County Road 2 based on SADT

Hour	Volume (vehicles)		Capacity (vehicles)	Volume to Capacity		Level of Service	
	Eastbound	Westbound		Eastbound	Westbound	Eastbound	Westbound
0	0	18	900	0.00	0.02	A	A
1	10	15	900	0.01	0.02	A	A
2	4	4	900	0.00	0.00	A	A
3	6	5	900	0.01	0.01	A	A
4	9	7	900	0.01	0.01	A	A
5	39	29	900	0.04	0.03	A	A
6	140	109	900	0.16	0.12	A	A
7	243	241	900	0.27	0.27	A	A
8	336	332	900	0.37	0.37	A	A
9	374	312	900	0.42	0.35	A	A
10	402	429	900	0.45	0.48	A	A
11	453	442	900	0.50	0.49	A	A
12	515	505	900	0.57	0.56	A	A
13	500	511	900	0.56	0.57	A	A
14	464	**528**	900	0.52	**0.59**	**A**	**A**
15	502	**528**	900	0.56	**0.59**	**A**	**A**
16	494	494	900	0.55	0.55	A	A
17	436	490	900	0.48	0.54	A	A
18	357	332	900	0.40	0.37	A	A
19	259	284	900	0.29	0.32	A	A
20	185	261	900	0.21	0.29	A	A
21	129	176	900	0.14	0.20	A	A
22	94	99	900	0.10	0.11	A	A
23	32	66	900	0.04	0.07	A	A

4. GROWTH ASSUMPTIONS

4.1 Existing Studies

The growth used in the *Town of Cobourg Transportation Study* (2002) varied from 1.5% to 3% per annum depending on the link and horizon year. The links on County Road 2 varied from 2% to 3%. The *New Amherst Residential Development Traffic Impact Study* (2003) reports the growth rate varying from 1.5% to 3% per annum. A 1.5% growth was used between 2001 and 2006, and a growth rate of 3% was used between 2006 and 2011. The average rate was 2.25%.

4.2 Traffic Growth

A growth rate was developed based on historical average annual daily traffic (AADT) data at a location on County Road 2 that is 0.7 kilometres west of Theatre Road. A regression analysis of AADT data from 2003, 2008 and 2010 resulted in a growth rate of 1.8% per annum. The AADT regression analysis is shown in **Exhibit 4-1**.

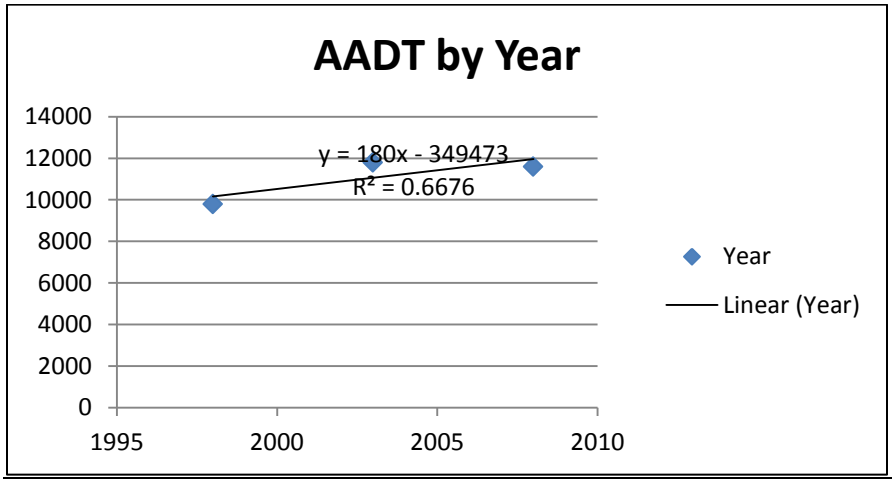


Exhibit 4-1: Growth Regression Analysis.

4.3 Population Growth

A regression analysis of the population growth was also undertaken. Using the combined population forecast for the County of Northumberland and its member Municipalities' *Growth Management Strategy* (2008), the growth rate along County Road 2 from 2001 to 2031 was less than 1%.

4.4 Assumed Growth Rate

Our analysis could not match or recreate the growth rate reported in either the *Town of Cobourg Transportation Study* (2002) or the *New Amherst Residential Development Traffic Impact Study* (2003).

To be conservative, the traffic growth rate was used in the forecasts instead of the population growth rate because it had the higher growth rate. This assumes that if the traffic continues to grow at a rate observed over the last 10 years, the average annual growth rate will reach 1.8%. The 1.8% per annum growth rate was considered a better estimate because it was modelled based on existing travel demand on County Road 2 instead of using aggregated population forecasts over the entire County.

5. FUTURE CONDITIONS

The level of service analysis was completed using the more conservative summer traffic conditions (by using SADT) and the annual traffic conditions (by using AADT). These traffic volumes were forecast to the 2031 horizon year assuming a maximum capacity of 900 vphpl and a 1.8% annual growth rate to reflect observed traffic growth. The future conditions were analysed using the same methodology for the Level of Service (LOS) analysis of existing conditions.

The Highway Capacity Manual and AASHTO Geometric Design of Highways and Streets the following levels of service:
A= Free flow
B=Reasonably free flow
C=Stable flow
D=Approaching unstable flow
E=Unstable flow
F=Forced or breakdown flow

The 2031 forecasts show a LOS C and D in the worst case scenarios for 2 to 4 hours of peak period traffic.

LOS C describes at or near free-flow operations in which most experienced drivers are comfortable. Roads remain safely below but efficiently close to capacity, and posted speed is maintained. Minor incidents may still have no effect but localized service will have noticeable effects and traffic delays will form behind the incident. This is the targeted LOS for some urban and most rural highways.

LOS D describes decreasing free-flow levels. Speeds will slightly decrease as the traffic volumes slightly increase. Freedom to maneuver within the traffic stream is much more limited and driver comfort levels decrease. LOS D is comparable to the level of service of a busy shopping corridor in the middle of a weekday, or a functional urban highway during commuting hours. It is a common goal for urban streets during peak hours, as attaining LOS C would require a prohibitive cost and societal impact in bypass roads and lane additions.

5.1 2031 SADT Forecasts

The volume to capacity ratio for Country Road 2 exceeds 0.80 has a LOS D for the 2031 SADT using the 1.8% per annum growth rate as shown in **Table 5-1**. County Road 2 will begin to experience congestion in the afternoon peak period from 12:00 to 4:00PM with the volume to capacity ratios reaching up to 0.88, or a LOS D.

Table 5-1: Assessment with 1.8% Growth Rate, 2031 SADT

Hour	Volume (vehicles)		Capacity (vehicles)	Volume to Capacity		Level of Service	
	Eastbound	Westbound		Eastbound	Westbound	Eastbound	Westbound
0	0	27	900	0	0.03	A	A
1	15	23	900	0.02	0.03	A	A
2	6	6	900	0.01	0.01	A	A
3	9	8	900	0.01	0.01	A	A
4	14	11	900	0.02	0.01	A	A
5	59	44	900	0.07	0.05	A	A
6	211	164	900	0.23	0.18	A	A
7	366	363	900	0.41	0.4	A	A
8	506	500	900	0.56	0.56	A	A
9	564	470	900	0.63	0.52	B	A
10	606	647	900	0.67	0.72	B	C
11	683	666	900	0.76	0.74	C	C
12	776	761	900	**0.86**	**0.85**	**D**	**D**
13	754	770	900	0.84	**0.86**	D	**D**
14	699	796	900	0.78	**0.88**	C	**D**
15	757	796	900	0.84	**0.88**	D	**D**
16	745	745	900	0.83	0.83	D	D
17	657	739	900	0.73	0.82	C	D
18	538	500	900	0.6	0.56	A	A
19	390	428	900	0.43	0.48	A	A
20	279	393	900	0.31	0.44	A	A
21	194	265	900	0.22	0.29	A	A
22	142	149	900	0.16	0.17	A	A
23	48	99	900	0.05	0.11	A	A

5.2 2031 AADT Forecasts

The assessment of the AADT traffic reveals a similar pattern. With 1.8% growth rate maintained over the next 20 years the AADT traffic will increase by 75% based on a 1.8% exponential growth rate over 21 years. County Road 2 will approach the 0.85 volume to capacity threshold in the pm peak period from 2:00PM to 4:00PM. This is shown in **Table 5-2**.

Table 5-2: Assessment with 1.8% Growth Rate, 2031 AADT

Hour	Volume (vehicles)		Capacity (vehicles)	Volume to Capacity		Level of Service	
	Eastbound	Westbound		Eastbound	Westbound	Eastbound	Westbound
0	0	26	900	0	0.03	A	A
1	14	21	900	0.02	0.02	A	A
2	5	5	900	0.01	0.01	A	A
3	9	8	900	0.01	0.01	A	A
4	12	11	900	0.01	0.01	A	A
5	56	42	900	0.06	0.05	A	A
6	200	157	900	0.22	0.17	A	A
7	348	347	900	0.39	0.39	A	A
8	481	476	900	0.53	0.53	A	A
9	535	448	900	0.59	0.5	A	A
10	576	615	900	0.64	0.68	B	B
11	650	635	900	0.72	0.71	C	C
12	737	724	900	0.82	0.8	D	C
13	716	733	900	0.8	0.81	C	D
14	**666**	**757**	**900**	**0.74**	**0.84**	**C**	**D**
15	**720**	**757**	**900**	**0.8**	**0.84**	**C**	**D**
16	707	707	900	0.79	0.79	C	C
17	626	702	900	0.7	0.78	B	C
18	511	476	900	0.57	0.53	A	A
19	371	407	900	0.41	0.45	A	A
20	265	374	900	0.29	0.42	A	A
21	184	253	900	0.2	0.28	A	A
22	136	142	900	0.15	0.16	A	A
23	45	95	900	0.05	0.11	A	A

5.3 Air Quality

Transportation sources produce emissions that directly impact the health of humans and change the climate. Worldwide emission estimates of substances that cause climate change indicate transportation sources account for approximately 24% of equivalent carbon dioxide

(CO_2) emissions. The most significant green-house gas (GHG) in the context of climate change is carbon dioxide, and therefore the contributions by the other greenhouse gases are usually expressed as CO_2 equivalents.

In 2008 drivers on County Road 2 have produced an estimated 3,500 tonnes of CO_2 per year (based on the AADT data). By 2031 the CO_2 emissions from forecast vehicles traveling along County Road 2 will increase to 5,700 tonnes/year. The 2031 GHG value has been decreased by 24% to account for the expected GHG decrease resulting from improvements in engines and fuel performance.

The increased emissions will have negative impacts on the air quality by increasing green house gas emissions from idling vehicles. Intersection improvements can be implemented to optimize the traffic movements through intersections so that driver delay and vehicle idling is minimized.

6. INTERSECTION OPERATIONS

The following intersections have been reviewed and assessed:

- County Road 2 and Hamilton Road,
- County Road 2 and New Amherst Boulevard / Lovshin Road, and
- County Road 2 / Elgin Street and Burnham Street / William Street

Based on the assessment of intersections, the collision analysis and the results of the 2002 and 2003 traffic reports, the signalized intersections will continue to operate at an acceptable level of service within the study horizon and with reserve capacity provided there are signal timing adjustments. Synchro analysis was undertaken for the intersections at Hamilton Road and William Street. The signalized intersection at County Road 2 and Hamilton Road intersection has a LOS B; the County Road and Burham Street intersection has a LOS of D. The Synchro results are provided in **Appendix A**.

The other unsignalized intersections operate at an acceptable level of service and do not warrant a signal, with a LOS A. Traffic demand management techniques should also be considered as an additional improvement, where feasible.

7. ALTERNATIVE ROUTES

There are few continuous alternative routes that connect the Municipality of Port Hope, the Township of Hamilton and the Town of Cobourg within Northumberland County. These include:

- Highway 401 (approximately 2 km north of County Road 2 and Hamilton Road intersection and approximately 0.88 km north of County Road 2 and Burnham Street intersection)
- Telephone Road (approximately 2 km north of County Road 2)

- Highway 401 Emergency Detour Route (EDR) on Dale Road (approximately 4 km north of County Road 2, shown in **Exhibit 7-1**

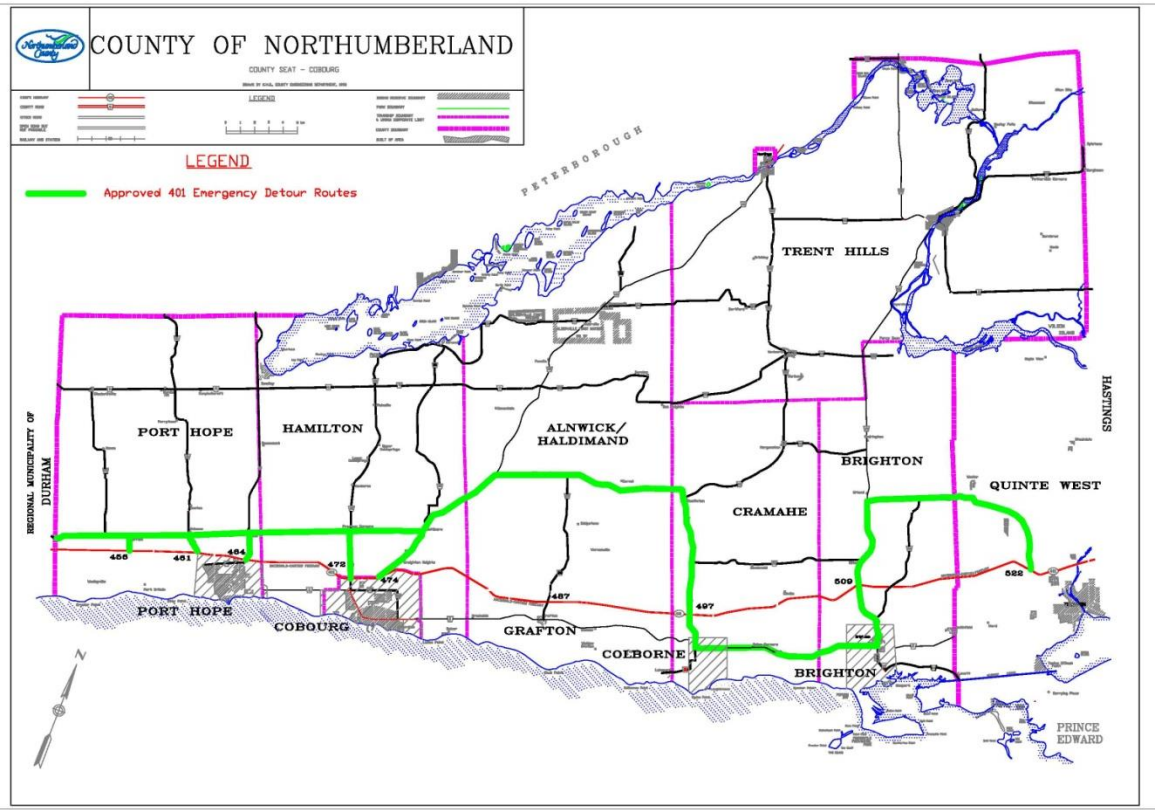


Exhibit 7-1: Highway 401 EDR

The majority of drivers would accept the level of service on County Road 2, even during the peak period in the forecast 2031 horizon year (LOS D), and would be unlikely to take the identified alternative routes. Given the considerable distance that drivers would need to travel (between 2 and 4 km north) to access Telephone Road or Dale Road it is unlikely that drivers would use these as alternative routes to County Road 2. Likewise, it would be unlikely for drivers who are travelling between the Municipality of Port Hope and the Town of Cobourg to use Highway 401 as an alternative route to County Road 2 since this would require travelling approximately 2 km north and there is no direct on/off ramps to Highway 401 from Hamilton Road. It is noted that there are ramps from Highway 401 at Burnham Street. Furthermore, at the times when County Road 2 is congested, it would be expected that Highway 401 would concurrently experience congestion.

8. CONCLUSION AND RECOMMENDATIONS

The volume to capacity forecasts for the County Road 2 study corridor suggest that there is still sufficient capacity on County Road 2, from Hamilton Road in Port Hope to west of Rogers Road to accommodate the projected 2031 traffic movements within a two-lane corridor. A minor increase in delay is expected because of the forecast increase in traffic; however, the delay is still within an acceptable level of service (LOS D) for the study corridor. This occurs in the worst case condition (summer traffic during the afternoon peak period).

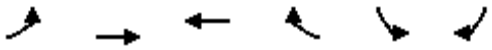
A LOS D can be considered a worst case condition for the study corridor within the planning horizon because of the conservative assumptions made as a part of the analysis. These assumptions include:

- The traffic growth rate will match that of the previous decade even though the traffic growth rate is almost double the projected population growth rates in the Municipality of Port Hope and Town of Cobourg
- The County Road 2 capacity was assumed to be 53% of the maximum base capacity specified by HCM to account for larger trucks and farming equipment travelling along the study corridor.

A centre two-way turning lane should also be considered. This third lane will not add additional capacity to the roadway; however, it would facilitate through traffic movement and alleviate some queuing at private and commercial entrances.

The County should monitor the AADT following the filing of the County Road 2 ESR at 5 year intervals to confirm whether there is a need based on actual traffic volumes observed on County Road 2. If the observed traffic volumes exceed those in the 2031 forecasts, this may constitute a change in the environmental setting for the project that occured after the filing of the ESR. An addendum to the ESR shall be written as per the *Municipal Class Environmental Assessment Manual* (MEA, 2007). The addendum shall describe the circumstances necessitating the change (e.g., insufficient traffic capacity), the environmental implications of the change (e.g., a deterioration in the level of service on County Road 2 and air quality impacts), and what, if anything can and will be done to mitigate any negative environmental impacts (e.g., adding extra capacity on County Road 2 by widening the road).

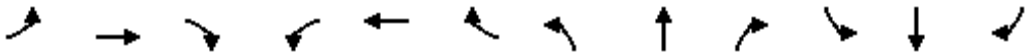
Appendix A
Intersection Capacity Analysis



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	20	245	234	90	111	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0		6.0	
Lane Util. Factor		0.95	0.95		1.00	
Frt		1.00	0.96		0.96	
Flt Protected		1.00	1.00		0.97	
Satd. Flow (prot)		3389	3254		1597	
Flt Permitted		0.90	1.00		0.97	
Satd. Flow (perm)		3070	3254		1597	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93
Growth Factor (vph)	122%	122%	122%	122%	122%	122%
Adj. Flow (vph)	26	321	307	118	146	58
RTOR Reduction (vph)	0	0	67	0	24	0
Lane Group Flow (vph)	0	347	358	0	180	0
Heavy Vehicles (%)	20%	5%	8%	2%	11%	9%
Turn Type	Perm					
Protected Phases		4	8		6	
Permitted Phases	4					
Actuated Green, G (s)		23.0	23.0		25.0	
Effective Green, g (s)		23.0	23.0		25.0	
Actuated g/C Ratio		0.38	0.38		0.42	
Clearance Time (s)		6.0	6.0		6.0	
Lane Grp Cap (vph)		1177	1247		665	
v/s Ratio Prot			0.11		c0.11	
v/s Ratio Perm		c0.11				
v/c Ratio		0.29	0.29		0.27	
Uniform Delay, d1		12.9	12.8		11.5	
Progression Factor		1.00	1.00		1.00	
Incremental Delay, d2		0.6	0.6		1.0	
Delay (s)		13.5	13.4		12.5	
Level of Service		B	B		B	
Approach Delay (s)		13.5	13.4		12.5	
Approach LOS		B	B		B	

Intersection Summary			
HCM Average Control Delay	13.3	HCM Level of Service	B
HCM Volume to Capacity ratio	0.28		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	46.2%	ICU Level of Service	A
Analysis Period (min)	15		

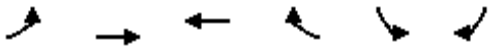
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	258	191	121	325	159	190	273	141	169	363	82
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	4.0	6.0		5.0	6.0		5.0	6.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		0.97	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.95		1.00	0.95		1.00	0.97	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1719	3406	1568	1703	3248		3400	3305		1736	3343	
Flt Permitted	0.29	1.00	1.00	0.39	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	516	3406	1568	705	3248		3400	3305		1736	3343	
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
Growth Factor (vph)	122%	122%	122%	122%	122%	122%	122%	122%	122%	122%	122%	122%
Adj. Flow (vph)	80	342	253	160	431	211	252	362	187	224	481	109
RTOR Reduction (vph)	0	0	0	0	46	0	0	51	0	0	15	0
Lane Group Flow (vph)	80	342	253	160	596	0	252	498	0	224	575	0
Heavy Vehicles (%)	5%	6%	3%	6%	5%	7%	3%	4%	3%	4%	5%	5%
Turn Type	pm+pt		Free	pm+pt			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		Free	8								
Actuated Green, G (s)	36.0	29.0	130.0	47.0	36.0		17.0	36.0		30.0	49.0	
Effective Green, g (s)	36.0	29.0	130.0	47.0	36.0		17.0	36.0		30.0	49.0	
Actuated g/C Ratio	0.28	0.22	1.00	0.36	0.28		0.13	0.28		0.23	0.38	
Clearance Time (s)	4.0	6.0		4.0	6.0		5.0	6.0		5.0	6.0	
Lane Grp Cap (vph)	208	760	1568	362	899		445	915		401	1260	
v/s Ratio Prot	0.02	0.10		c0.05	c0.18		0.07	c0.15		c0.13	0.17	
v/s Ratio Perm	0.09		0.16	0.11								
v/c Ratio	0.38	0.45	0.16	0.44	0.66		0.57	0.54		0.56	0.46	
Uniform Delay, d1	36.0	43.6	0.0	29.6	41.6		53.0	40.0		44.2	30.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	5.3	1.9	0.2	3.9	3.8		5.1	2.3		5.5	1.2	
Delay (s)	41.3	45.5	0.2	33.5	45.5		58.2	42.3		49.7	31.7	
Level of Service	D	D	A	C	D		E	D		D	C	
Approach Delay (s)		28.0			43.1			47.3			36.6	
Approach LOS		C			D			D			D	

Intersection Summary			
HCM Average Control Delay	39.2	HCM Level of Service	D
HCM Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.0
Intersection Capacity Utilization	65.8%	ICU Level of Service	C
Analysis Period (min)	15		

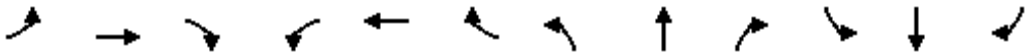
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	76	294	270	182	234	65
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)		6.0	6.0		6.0	
Lane Util. Factor		0.95	0.95		1.00	
Frt		1.00	0.94		0.97	
Flt Protected		0.99	1.00		0.96	
Satd. Flow (prot)		3481	3267		1695	
Flt Permitted		0.71	1.00		0.96	
Satd. Flow (perm)		2481	3267		1695	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93
Growth Factor (vph)	122%	122%	122%	122%	122%	122%
Adj. Flow (vph)	100	386	354	239	307	85
RTOR Reduction (vph)	0	0	147	0	16	0
Lane Group Flow (vph)	0	486	446	0	376	0
Heavy Vehicles (%)	9%	1%	3%	5%	3%	11%
Turn Type	Perm					
Protected Phases		4	8		6	
Permitted Phases	4					
Actuated Green, G (s)		23.0	23.0		25.0	
Effective Green, g (s)		23.0	23.0		25.0	
Actuated g/C Ratio		0.38	0.38		0.42	
Clearance Time (s)		6.0	6.0		6.0	
Lane Grp Cap (vph)		951	1252		706	
v/s Ratio Prot			0.14		c0.22	
v/s Ratio Perm		c0.20				
v/c Ratio		0.51	0.36		0.53	
Uniform Delay, d1		14.2	13.2		13.1	
Progression Factor		1.00	1.00		1.00	
Incremental Delay, d2		2.0	0.8		2.9	
Delay (s)		16.1	14.0		16.0	
Level of Service		B	B		B	
Approach Delay (s)		16.1	14.0		16.0	
Approach LOS		B	B		B	

Intersection Summary			
HCM Average Control Delay	15.2	HCM Level of Service	B
HCM Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	60.0	Sum of lost time (s)	12.0
Intersection Capacity Utilization	64.5%	ICU Level of Service	C
Analysis Period (min)	15		

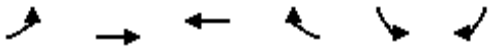
c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	123	507	299	123	448	145	280	269	123	222	310	96
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	4.0	6.0		5.0	6.0		5.0	6.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95		0.97	0.95		1.00	0.95	
Frt	1.00	1.00	0.85	1.00	0.96		1.00	0.95		1.00	0.96	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1719	3406	1568	1703	3296		3400	3317		1736	3316	
Flt Permitted	0.18	1.00	1.00	0.27	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	329	3406	1568	482	3296		3400	3317		1736	3316	
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Growth Factor (vph)	122%	122%	122%	122%	122%	122%	122%	122%	122%	122%	122%	122%
Adj. Flow (vph)	152	625	368	152	552	179	345	331	152	274	382	118
RTOR Reduction (vph)	0	0	0	0	24	0	0	41	0	0	23	0
Lane Group Flow (vph)	152	625	368	152	707	0	345	442	0	274	477	0
Heavy Vehicles (%)	5%	6%	3%	6%	5%	7%	3%	4%	3%	4%	5%	5%
Turn Type	pm+pt		Free	pm+pt			Prot			Prot		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		Free	8								
Actuated Green, G (s)	53.0	39.0	130.0	51.0	38.0		20.0	25.0		32.0	37.0	
Effective Green, g (s)	53.0	39.0	130.0	51.0	38.0		20.0	25.0		32.0	37.0	
Actuated g/C Ratio	0.41	0.30	1.00	0.39	0.29		0.15	0.19		0.25	0.28	
Clearance Time (s)	4.0	6.0		4.0	6.0		5.0	6.0		5.0	6.0	
Lane Grp Cap (vph)	284	1022	1568	311	963		523	638		427	944	
v/s Ratio Prot	c0.06	0.18		0.05	c0.21		0.10	c0.13		c0.16	0.14	
v/s Ratio Perm	0.16		c0.23	0.14								
v/c Ratio	0.54	0.61	0.23	0.49	0.73		0.66	0.69		0.64	0.51	
Uniform Delay, d1	27.0	39.0	0.0	27.2	41.4		51.8	48.9		43.9	38.9	
Progression Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	7.1	2.7	0.4	5.4	5.0		6.4	6.1		7.2	1.9	
Delay (s)	34.1	41.7	0.4	32.6	46.4		58.2	55.0		51.1	40.8	
Level of Service	C	D	A	C	D		E	E		D	D	
Approach Delay (s)		27.4			44.0			56.3			44.4	
Approach LOS		C			D			E			D	

Intersection Summary			
HCM Average Control Delay	41.7	HCM Level of Service	D
HCM Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	130.0	Sum of lost time (s)	21.0
Intersection Capacity Utilization	75.5%	ICU Level of Service	D
Analysis Period (min)	15		

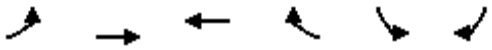
c Critical Lane Group



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	18	307	283	41	39	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)	26	444	409	59	56	30
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	468				905	409
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	468				905	409
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				81	95
cM capacity (veh/h)	1104				302	636

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	SB 1
Volume Total	26	444	409	59	87
Volume Left	26	0	0	0	56
Volume Right	0	0	0	59	30
cSH	1104	1700	1700	1700	370
Volume to Capacity	0.02	0.26	0.24	0.03	0.23
Queue Length 95th (m)	0.6	0.0	0.0	0.0	7.2
Control Delay (s)	8.3	0.0	0.0	0.0	17.7
Lane LOS	A				C
Approach Delay (s)	0.5		0.0		17.7
Approach LOS					C

Intersection Summary			
Average Delay	1.7		
Intersection Capacity Utilization	32.7%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	37	513	546	68	62	20
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)	53	742	789	98	90	29
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	888				1638	789
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	888				1638	789
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	93				14	93
cM capacity (veh/h)	771				104	394

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	SB 1
Volume Total	53	742	789	98	119
Volume Left	53	0	0	0	90
Volume Right	0	0	0	98	29
cSH	771	1700	1700	1700	127
Volume to Capacity	0.07	0.44	0.46	0.06	0.93
Queue Length 95th (m)	1.8	0.0	0.0	0.0	49.4
Control Delay (s)	10.0	0.0	0.0	0.0	129.0
Lane LOS	B				F
Approach Delay (s)	0.7		0.0		129.0
Approach LOS					F

Intersection Summary			
Average Delay	8.8		
Intersection Capacity Utilization	53.8%	ICU Level of Service	A
Analysis Period (min)	15		