Traffic Impact Study
Greystone Subdivision
Calumet Avenue, St. John, Indiana

Prepared for: Schilling Development
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St. John, IN 46240

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Prepared by
First Group Engineering
February 22, 2016

I certify that this TRAFFIC IMPACT ANALYSIS has been prepared by me or under my immediate supervision in accordance with INDOT's Application Guide to Traffic Impact Studies (2015) and that I have experience and training in the field of traffic and transportation engineering.

Dennis W. Cobb

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OT\16-0002-02

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Executive Summary

A single family residential development, Greystone Subdivision, is proposed to be constructed on the east and west sides of Calumet Avenue between 101st Avenue and 109th Avenue in the Town of St. John. The subdivision will contain about 317 home sites and five office buildings. The access plan for the development is for one drive onto Calumet Avenue from each side of Calumet Avenue. The subdivision access will also include a connection to presently vacant property to the north and south of the subdivision on the west side of Calumet Avenue. On the east side of Calumet Avenue, there will be connections to the north, east and south of the subdivision.

This traffic impact study investigated the impacts of the traffic generated by the development on the Calumet Avenue intersections with the subdivision entrance and 101st Avenue.

The operational conditions of these intersections were analyzed and categorized by their Level of Service (LOS) which is a ranking from A to F. Typically, LOS D is the minimum level of service acceptable before improvements are sought.

The intersection of 101st Avenue and Calumet Avenue operates poorly at present There are very large volumes northbound in the morning turning left onto 101st Avenue and very large volumes turning south in the afternoon. These movements operate at a Level of Service F. Traffic signal warrants were investigated and were found to be met. Taking into account the future growth of traffic in the area, it is recommended that a traffic signal and an eastbound right turn lane be constructed to improve the operation of the intersection.

If the above recommendations are constructed, the intersection will handle the site traffic at the following Levels of Service:

Levels of Service:

	AM	PM
Calumet Avenue (NB)	B	C
101st Avenue (EB/WB)	C/C	C/A

The entrance to the subdivision on Calumet will meet traffic signal warrants at full build-out, which is projected to be in 10 years. A roundabout was also

investigated. The traffic signal is recommended over the roundabout because it will have more reserve capacity to handle additional traffic in the future.

The following are the recommendations for the study area:

1. A traffic signal and a eastbound right turn lane should be constructed at the intersection of 101st and Calumet Avenue. The signal should be designed with a right turn arrow for the eastbound movement.
2. The subdivision entrance approaches should be constructed with a left turn lane and a thru/right lane.
3. Calumet Avenue at the subdivision entrances should be widened to provide opposing left turn lanes on Calumet Avenue.
4. A traffic signal should be provided for the subdivision entrance. It will likely be warranted at full build-out of the development. Until that time the intersection should be operated under two-way stop control.

Traffic Impact Study
Greystone Subdivision
White Oak Avenue, St. John, Indiana

Introduction

This traffic impact study will document the impacts of the traffic generated by the development of a residential subdivision named Greystone on the west and east sides of Calumet Avenue between 109th Avenue and 101st Avenue in the Town of St. John, Indiana. The study area will include the Calumet Avenue intersections with 101st Avenue and the entrance to Greystone.

Existing Conditions

Calumet Avenue and 101st Avenue are both two lane highways. 101st Avenue has a posted speed limit of 30 miles per hour. Calumet Avenue has a speed limit of 40 miles per hour (mph). The intersection of Calumet Avenue and 101st Avenue is a "T" intersection and is controlled by an all way stop.

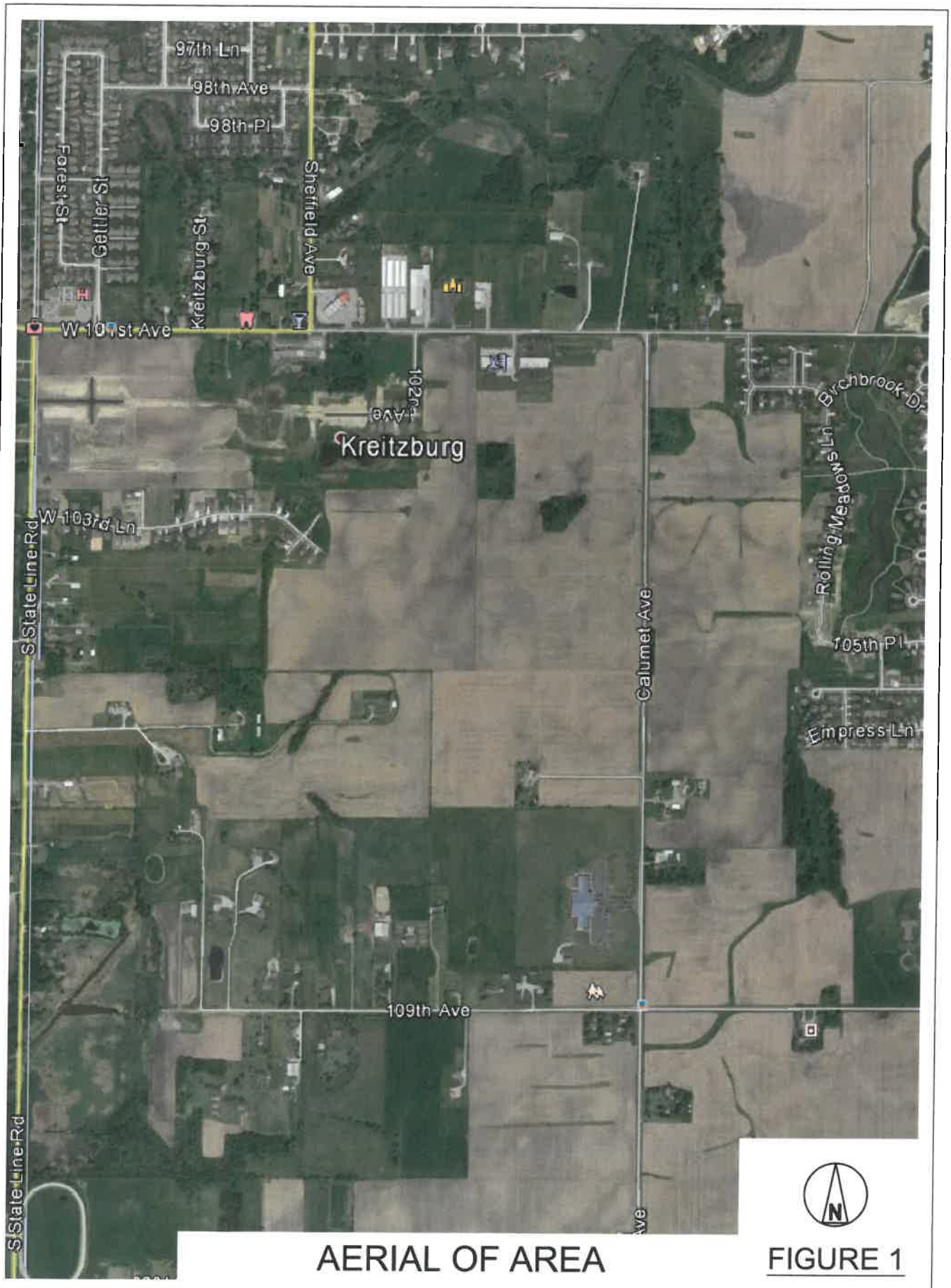
The area adjacent to the proposed development is rural.

101st Avenue feeds west directly to Illinois 394, the Calumet Expressway, which serves as a direct route into the Chicago area.

Figure 1 is an aerial photograph of the area.

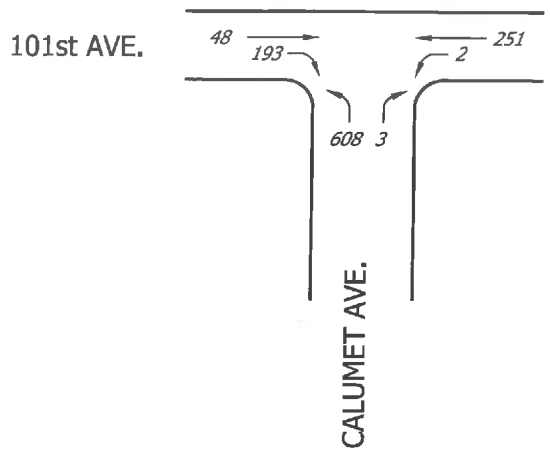
Manual turning movement counts were collected for the time periods of 6:00 am – 8:00 am and from 4:00 pm - 6:00 pm on a weekday at the intersection 101st Avenue and Calumet Avenue.The am peak hour was 6:45-7:45 am. The pm peak hour was from 4:00 - 5:00 pm. The traffic counts are contained in the Appendix.

Figure 2 depicts the traffic volumes for the am and pm peak periods for the subject intersection.

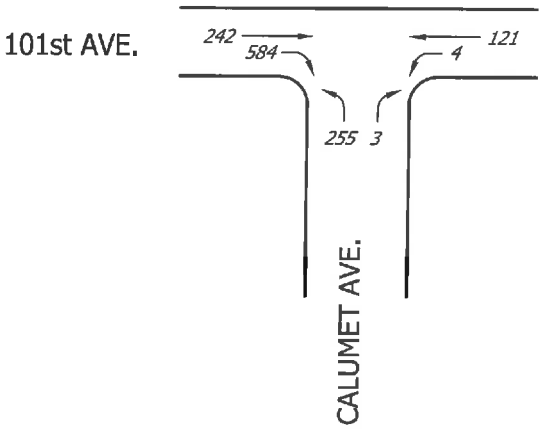


AERIAL OF AREA

FIGURE 1



EXISTING AM PEAK



EXISTING PM PEAK

N

EXISTING TRAFFIC VOLUMES

FIGURE 2

The Level of Service (LOS) of an intersection or an approach is the way the operational condition of the intersection or approach is described. Levels of Service are ranked from A to F, with A being very good. Generally LOS D is the minimum acceptable Level of Service

Intersection capacity analysis was performed on all the intersection of Calumet Avenue and 101st Avenue for the morning and afternoon peak periods (existing traffic). The results showed the following:

Levels of Service:

	AM	PM
Calumet Avenue (NB)	F	C
101st Avenue (EB/WB)	B/ C	F/B

Notes:
"EB" means Eastbound, NB means northbound, etc.

The intersection is not functioning well. There are significant back-ups on the approaches with the Levels of Service F.

A right turn lane could be added on the west approach and continued south on Calumet Avenue as a new lane. This would improve the Level of Service for that approach. There is no such improvement that could be added for the northbound left turn movement.

A traffic signal warrant analysis was investigated for the intersections by looking at Warrants 2, and 3. The analysis showed that a signal is warranted under both conditions. Since the bulk of the eastbound movement in the afternoon is right turners, the analysis was run with a right turn lane added. This allows the investigator to eliminate that movement from the analysis. The intersection still meets both warrants. If a signal was installed now, the Level of Service for the intersection would be as follows:

Levels of Service:

	AM	PM
Calumet Avenue (NB)	B	C
101st Avenue (EB/WB)	C / C	C / A

If a right turn lane is installed on the west approach, the Level of Service for the 101st roadway increases to: A / C A / A

The time horizon for the proposed development is 10 years for full build-out. An additional analysis was made with a 2% annual growth rate in the existing traffic. Without a right turn lane on the west approach the Level of Service under signal control is:

Levels of Service:

	AM	PM
Calumet Avenue (NB)	B	D
101st Avenue (EB/WB)	C / C	E/ A

If a right turn lane is installed on the west approach, the Level of Service for the 101st roadway increases to: C / C B / A

Consequently, a traffic signal is with an eastbound right turn lane on the west approach is recommended to be built now.

Proposed Development

A single family residential development, Greystone Subdivision, is proposed to be constructed on the east and west side of Calumet Avenue between 101st Avenue and 109st Avenue. It will contain about 317 home sites and five office buildings. The access plan for the development is for one drive onto Calumet Avenue from each side of Calumet Avenue. The subdivision access will also include a connection to presently vacant property to the north and south of the subdivision on the west side of Calumet Avenue. On the east side of Calumet Avenue there will be connections to the north, east and south of the subdivision.

Figure 3 depicts the site plan. Figure 4 is an aerial view of the area with the proposed site shown.

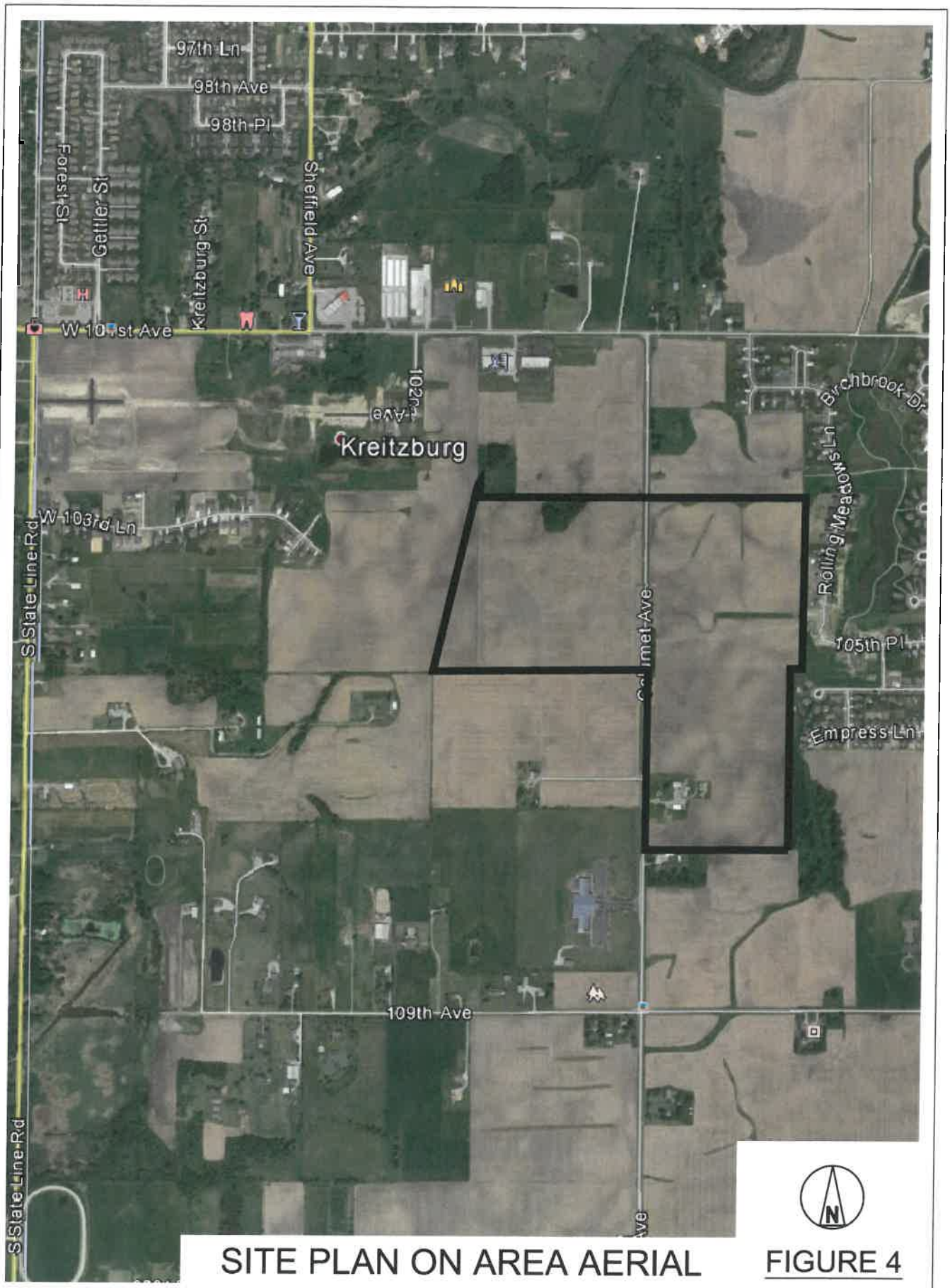
Exchange St. (to Chicago/I-394)

GREYSTONE

of Saint John

SITE PLAN

FIGURE 3



SITE PLAN ON AREA AERIAL

FIGURE 4

Trip Generation and Distribution

The ITE Trip Generation Manual (9th edition) was used as a resource document to determine the number of trips expected to be generated by this development. It is a nationally recognized resource document for predicting the number of trips expected from different types of development.

Using the Single Family Residential code, the following trips were calculated:

58 trips in and 174 trips out for the peak hour between 7:00 am – 9:00 am
187 trips in and 110 trips out for the peak hour between 4:00 pm – 6:00 pm

Using the Office Building code, 710, the following trips were calculated:

West side of Calumet Avenue
18 trips in and 3 trips out for the peak hour between 7:00 am – 9:00 am
4 trips in and 19 trips out for the peak hour between 4:00 pm – 6:00 pm

East side of Calumet Avenue
56 trips in and 8 trips out for the peak hour between 7:00 am – 9:00 am
15 trips in and 76 trips out for the peak hour between 4:00 pm – 6:00 pm

The trips generated were assigned to the two drives serving as access to the development by the number of units in each area. 50% of the residential trips were assigned to each side. 20% of the office trips were assigned to the west side and 80% to the east side. Two other considerations were considered in the distribution of the generated trips:

1. When a development contains both residential and office space, there is sometimes internal trips that go between the two uses and do not impact the adjacent street system. The value of the internal trips varies between 2% and 11%. Because of the size of the development and the location, it was assumed that none of the trips would be assigned as internal.
2. Some trips for a development originate from the existing flow of traffic on the adjacent street. Gas stations for instance, derive a high percentage of their trips from the existing traffic flow. These are called Pass-By trips. Office and residential uses generally do derive their trips from the existing flow of traffic on the adjacent street. Therefore, no reduction was taken for Pass-By trips.

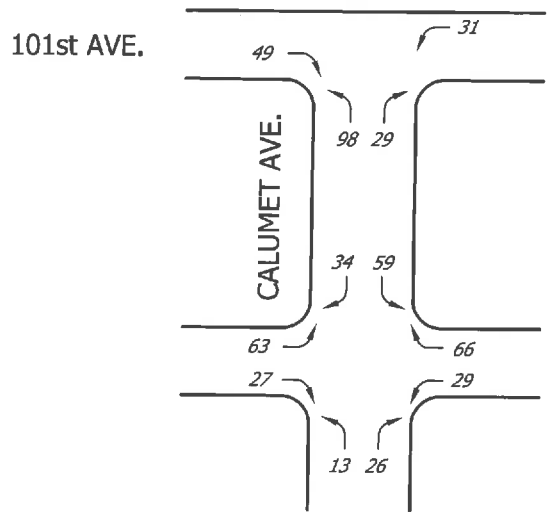
Next the trips generated were assigned an orgin/destination to determine the direction they depart and the direction they arrive from to the development. By looking at the area and the opportunities for employment within about a 25 mile radius, the following assumptions and assignments were made for the residential traffic:

1. 55% of the peak hour trips would be toward/from the Chicago area and that traffic would be using the Calumet Expressway via 101st Avenue.
2. 30% was assigned to go north to 93rd to US 41 and on north past U.S. 30. 1/3rd of this traffic would use the 101st Avenue and 2/3rd's would use the 109th Avenue.
3. 10% was assigned to go north at 93rd and U.S. 41 but then going east at U.S. 30 for points north and east. This traffic split was 50% to 101st Avenue and 50% to 109th Avenue.
4. 5% was assigned to go south to the Crown Point area and beyond using 109th Avenue.

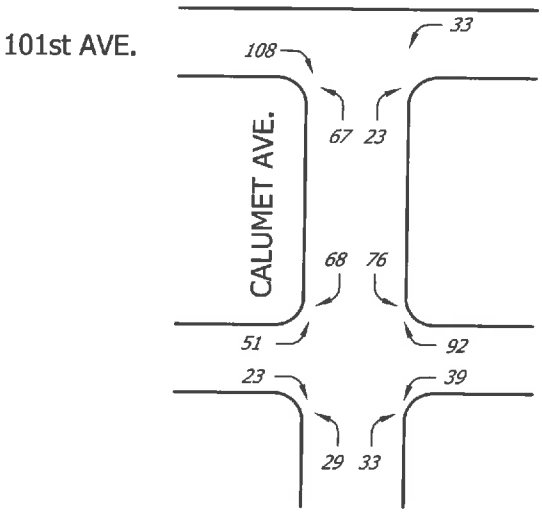
The following assumptions and assignments were made for the office traffic:

1. 30% of the peak hour trips would be toward/from the Chicago area and that traffic would be using the Calumet Expressway via 101st Avenue.
2. 55% was assigned to go north to 93rd to US 41 and on north past U.S. 30. 1/3rd of this traffic would use the 101st Avenue and 2/3rd's would use the 109th Avenue.
3. 10% was assigned to go north at 93rd and U.S. 41 but then going east at U.S. 30 for points north and east. This traffic split was 50% to 101st Avenue and 50% to 109th Avenue.
4. 5% was assigned to go south to the Crown Point area and beyond using 109th Avenue.

The resulting traffic distribution is shown on Figure 5.



AM PEAK



PM PEAK

N

DISTRIBUTION OF SITE TRIPS FIGURE 5

Analysis

The combination of the existing and the expected site generated traffic is shown on Figure 6.

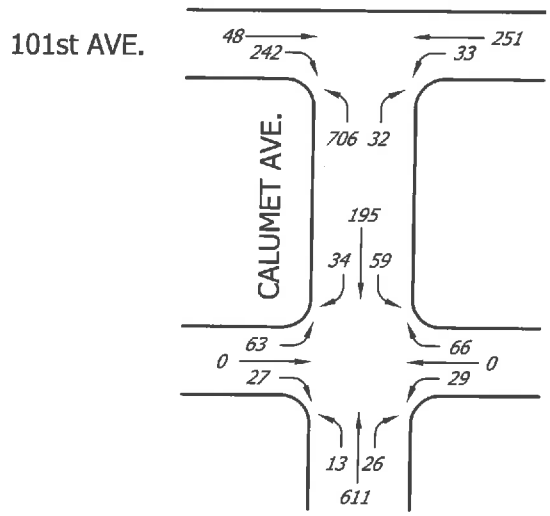
Intersection capacity analysis was performed on the intersections for the morning and afternoon peak period with these volumes from Figure 6.The analysis for the subdivision entrance intersection assumed 2-way stop control and a two lane approach to Calumet Avenue. The analysis for 101st was analyzed with a signal and an eastbound right turn lane. The results showed the following:

Levels of Service:

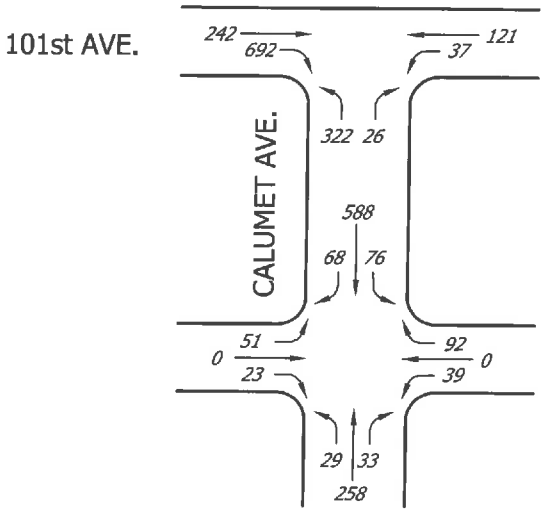
	AM	PM
Calumet Avenue (NBL/SBL)	A/A	A/A
Subdivision Entrance (EBL/EBTR)	E/A	E/B
Subdivision Entrance (WBL/WBTR)	D/B	E/B
Calumet Avenue (NB)	C	B
101st Avenue (EB/WB)	A/B	A/B

For the 101st Avenue intersection, the intersection will operate well with the addition of the site traffic.

The subdivision entrance does not operate well under 2-way stop control. 4-way stop control is not a recommended intersection control measure because that type of operation works best when the volumes for all four approaches are balanced. In this case the volumes on Calumet Avenue are as much as 10 times the volumes on the subdivision street entrance. Additionally, many times the traffic on Calumet Avenue would be stopped for no reason as there would be no traffic on either subdivision approach. Traffic signal warrants were investigated as another measure and found to be 11 vehicles short of meeting warrants at full build-out with a 2% growth in existing traffic over a 10 year period. It is felt that this is within the margin of error for the assumptions and that it is likely that at the growth in existing traffic may indeed be higher, especially if another subdivision of the same size is constructed south of Greystone. With signal control, it is recommended that the approach to Calumet Avenue consist of a left turn lane and a thru/right lane. Calumet Avenue should be widened to provide



AM PEAK



PM PEAK

EXISTING PLUS SITE TRAFFIC

FIGURE 6

opposing left turn lanes. With these geometric conditions, the Level of Service will be as follows:

Levels of Service:

	AM	PM
Calumet Avenue (NB/SB)	A/A	A/A
Subdivision Entrance (EB/WB)	B/B	B/B

The Town had requested that the developer look at a roundabout for this intersection. The Level of Service for that type of intersection will be:

Levels of Service:

	AM	PM
Calumet Avenue (NB/SB)	C/A	A/C
Subdivision Entrance (EB/WB)	A/A	A/A

This type of intersection improves the operation of the subdivision entrance and lowers the LOS of the higher volume Calumet Avenue approaches.

When the intersection is analyzed 10 years into the future, at the point of projected full build-out, the signalized intersection will operate as follows:

Levels of Service:

	AM	PM
Calumet Avenue (NB/SB)	B/A	A/B
Subdivision Entrance (EB/WB)	B/B	B/B

The roundabout will operate as follows:

Levels of Service:

	AM	PM
Calumet Avenue (NB/SB)	D/A	A/E
Subdivision Entrance (EB/WB)	A/B	B/A

Because of the lower level of service for the much higher Calumet Avenue approaches with the roundabout, it is recommended that the conventional intersection design be favored at this location.

Summary

A single family residential development, Greystone Subdivision, is proposed to be constructed on the east and west sides of Calumet Avenue between 101st Avenue and 109th Avenue in the Town of St. John. . It will contain about 317 home sites and five office buildings. The access plan for the development is for one drive onto Calumet Avenue from each side of Calumet Avenue. The subdivision access will also include a connection to presently vacant property to the north and south of the subdivision on the west side of Calumet Avenue. On the east side of Calumet Avenue there will be connections to the north, east and south of the subdivision.

This traffic impact study investigated the impacts of the traffic generated by the development on the Calumet Avenue intersections with the subdivision entrance and 101st Avenue.

The operational conditions of these intersections were analyzed and categorized by their Level of Service (LOS) which is a ranking from A to F. Typically, LOS D is the minimum level of service acceptable before improvements are sought.

The intersection of 101st Avenue and Calumet Avenue operates poorly at present. There are very large volumes northbound in the morning turning left onto 101st Avenue and very large volumes turning south in the afternoon. These movements operate at a Level of Service F. Traffic signal warrants were investigated and were found to be met. Taking into account the future growth of traffic in the area, it is recommended that a traffic signal and an eastbound right turn lane be constructed to improve the operation of the intersection providing a LOS C or better for all approaches.

If the above recommendations are constructed, the intersection will handle the site traffic at the following Levels of Service:

Levels of Service:

	AM	PM
Calumet Avenue (NB)	B	C
101st Avenue (EB/WB)	C/C	C/A

The entrance to the subdivision on Calumet Avenue will operate very poorly under two-way stop control. The traffic volumes are not balanced, consequently a 4-stop control is not recommended as an intersection control measure. A traffic signal is likely to warranted at this location at build-out, which is projected to be in 10 years. A roundabout was also investigated. Both will operate at a good Level of Service if the development was built out in one year, however the developer anticipates a 10 year build-out. By that time, the signalized intersection control provides a better level of service the does the roundabout (the critical movement comparison is the higher Calumet Avenue approach...LOS D for the roundabout vs LOS B for the traffic signal). The signal would be able to provide for more traffic in the future if another large subdivision would be constructed south of Greystone or along 109th then would the roundabout. For these reasons the traffic signal is recommended. Geometric improvements at the intersection would include a left turn lane and thru/right lane on each of the subdivision approaches and opposing left turn lanes on Calumet Avenue.

Recommendations

The following are the recommendations for the study area:

1. A traffic signal and a eastbound right turn lane should be constructed at the intersection of 101st and Calumet Avenue. The signal should be designed with a right turn arrow for the eastbound movement.
2. The subdivision entrance approaches should be constructed with a left turn lane and a thru/right lane.
3. Calumet Avenue at the subdivision entrances should be widened to provide opposing left turn lanes on Calumet Avenue.
4. A traffic signal should be provided for the subdivision entrance. It will likely be warranted at full build-out of the development. . Until that time the intersection should be operated under two-way stop control.

APPENDIX

Traffic Count and Traffic Signal Warrant analysis at
Calumet Avenue and 101st Avenue

APPENDIX 1

TRAFFIC COUNT SUMMARY SHEET

LOCATION: Calumet and 101st Street — DATE: 1/20/2016

TIME BEGIN	North Approach on Right	North Approach on Thru	Calumet Left	Calumet Total	East Approach on Right	East Approach on Thru	101st Street Left	101st Street Total	South Approach on Right	South Approach on Thru	Calumet Left	Calumet Total	West Approach on Right	West Approach on Thru	101st Street Left	101st Street Total	Total N/S	Total E/W	Total	
6:00						43		43			134	134	26	4		30	134	73	207	
6:15						77		77			140	140	29	7		36	140	113	253	
6:30						47		47			157	157	24	11		35	157	82	239	
6:45						61	1	62	2		155	157	45	16		61	157	123	280	
6:00-7:00						228	1	229	2		586	588	124	38		162	588	391	979	
7:00						65		65			147	147	36	8		44	147	109	256	
7:15						68		68			156	156	50	13		63	156	131	287	
7:30						57	1	58	1		150	151	62	11		73	151	131	282	
7:45						57		57	2		135	137	60	13		73	137	130	267	
7:00-8:00						247	1	248	3		588	591	208	45		253	591	501	1092	Total for hour
6:45						61	1	62	2		155	157	45	16		61	157	123	280	
7:00						65		65			147	147	36	8		44	147	109	256	
7:15						68		68			156	156	50	13		63	156	131	287	
7:30						57	1	58	1		150	151	62	11		73	151	131	282	
6:45-745						251	2	253	3		608	611	193	48		241	611	494	1105	AM peak hour
						0.922794	0.5	0.930147	0.375		0.974359	0.97293	0.778226	0.75		0.825342				
						0.922794	0.5	1.422794	0.375		0.974359	1.349359	0.778226	0.75		1.528226				Total for hour
4:00						29		29	1		77	78	148	52		200	78	229	307	
4:15						25	1	26	1		51	52	148	54		202	52	228	280	
4:30						27	2	29			62	62	150	66		216	62	245	307	
4:45						40	1	41	1		65	66	138	70		208	66	249	315	
4:00-5:00						121	4	125	3		255	258	584	242		826	258	951	1209	Total for hour
						0.75625	0.5	0.762195	0.75		0.827922	0.826923	0.973333	0.864286		0.956019				
5:00						36	3	39	1		69	70	130	56		186	70	225	295	
5:15						25	2	27			60	60	114	56		170	60	197	257	
5:30						31		31			53	53	131	48		179	53	210	263	
5:45						29	1	30			51	51	117	81		198	51	228	279	
5:00-6:00						121	6	127	1		233	234	492	241		733	234	860	1094	Total for hour

Warrant 2 — y=377.227-0.679x+.00035xx — YES

y (calc)	Y Actual	X	
124.8984	591	501	yes
165.2464	588	391	yes
48.03835	258	951	yes
52.147	234	860	yes

Warrant 3 — y=520.0116-.7648x+.000325xx — YES

y (calc)	Y Actual	X	
86.61713	258	951	yes

without right turns on west approach

Warrant 2 — y=377.227-0.679x+.00035xx — YES

y (calc)	Y Actual	X	
220.8852	588	267	yes
208.3272	591	293	yes
175.1752	258	367	yes
174.7534	234	368	yes

Warrant 3 e/w major — y=520.0116-.7648x+.000325xx — NO

y (calc)	Y Actual	X	
283.1039	258	367	NO
338.9789	588	267	yes
323.8261	591	293	Yes
282.578	234	368	NO

Warrant 3 n/s major — y=520.0116-.7648x+.000325xx — NO

y (calc)	Y Actual	X	
182.676	229	588	yes
181.5311	253	591	yes
344.3265	242	258	no
358.8441	241	234	NO

Highway Capacity Analysis: Calumet Avenue and 101st Avenue

Existing Condition (all way stop) AM

APPENDIX 2

HCS+: Unsignalized Intersections Release 5.4

Phone: Fax:
E-Mail:

ALL-WAY STOP CONTROL(AWSC) ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID: existing conditions
East/West Street: 101st
North/South Street: calumet

Worksheet 2 - Volume Adjustments and Site Characteristics

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	0	48	193	2	251	0	608	0	3	0	0	0
% Thrus Left Lane												

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Configuration	TR		LT		LTR			
PHF	0.85		0.93		0.97			
Flow Rate	283		271		629			
% Heavy Veh	1		1		1			
No. Lanes	1		1		1			
Opposing-Lanes	1		1		0			
Conflicting-lanes	1		1		1			
Geometry group	1		1		1			

Duration, T 1.00 hrs.

Worksheet 3 - Saturation Headway Adjustment Worksheet

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Flow Rates:								
Total in Lane	283		271		629			
Left-Turn	0		2		626			
Right-Turn	227		0		3			
Prop. Left-Turns	0.0		0.0		1.0			
Prop. Right-Turns	0.8		0.0		0.0			
Prop. Heavy Vehicle	0.0		0.0		0.0			
Geometry Group	1		1		1			
Adjustments Exhibit 17-33:								
hLT-adj	0.2		0.2		0.2			

hRT-adj	-0.6	-0.6	-0.6
hHV-adj	1.7	1.7	1.7
hadj, computed	-0.5	0.0	0.2

Worksheet 4 - Departure Headway and Service Time

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Flow rate	283		271		629			
hd, initial value	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
x, initial	0.25		0.24		0.56			
hd, final value	6.01		6.49		5.82			
x, final value	0.47		0.49		1.02			
Move-up time, m	2.0		2.0		2.0			
Service Time	4.0		4.5		3.8			

Worksheet 5 - Capacity and Level of Service

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Flow Rate	283		271		629			
Service Time	4.0		4.5		3.8			
Utilization, x	0.47		0.49		1.02			
Dep. headway, hd	6.01		6.49		5.82			
Capacity	533		521		629			
Delay	14.37		15.64		127.87			
LOS	B		C		F			
Approach:								
Delay	14.37		15.64		127.87			
LOS	B		C		F			
Intersection Delay 75.01			Intersection LOS F					

Highway Capacity Analysis: Calumet Avenue and 101st Avenue
Existing Condition (all way stop)

APPENDIX 3

HCS+: Unsignalized Intersections Release 5.4

Phone: Fax:
E-Mail:

ALL-WAY STOP CONTROL(AWSC) ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Jurisdiction:
Units: U. S. Customary
Analysis Year:
Project ID: existing conditions
East/West Street: 101st
North/South Street: calumet

Worksheet 2 - Volume Adjustments and Site Characteristics

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume	0	242	584	4	121	0	255	0	3	0	0	0
% Thrus Left Lane												

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Configuration	TR		LT		LTR			
PHF	0.96		0.76		0.83			
Flow Rate	860		164		310			
% Heavy Veh	1		1		1			
No. Lanes	1		1		1			
Opposing-Lanes	1		1		0			
Conflicting-lanes	1		1		1			
Geometry group	1		1		1			

Duration, T 1.00 hrs.

Worksheet 3 - Saturation Headway Adjustment Worksheet

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Flow Rates:								
Total in Lane	860		164		310			
Left-Turn	0		5		307			
Right-Turn	608		0		3			
Prop. Left-Turns	0.0		0.0		1.0			
Prop. Right-Turns	0.7		0.0		0.0			
Prop. Heavy Vehicle	0.0		0.0		0.0			
Geometry Group	1		1		1			
Adjustments Exhibit 17-33:								
hLT-adj	0.2		0.2		0.2			

hRT-adj	-0.6	-0.6	-0.6
hHV-adj	1.7	1.7	1.7
hadj, computed	-0.4	0.0	0.2

Worksheet 4 - Departure Headway and Service Time

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Flow rate	860		164		310			
hd, initial value	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
x, initial	0.76		0.15		0.28			
hd, final value	4.87		6.08		6.39			
x, final value	1.16		0.28		0.55			
Move-up time, m	2.0		2.0		2.0			
Service Time	2.9		4.1		4.4			

Worksheet 5 - Capacity and Level of Service

	Eastbound		Westbound		Northbound		Southbound	
	L1	L2	L1	L2	L1	L2	L1	L2
Flow Rate	860		164		310			
Service Time	2.9		4.1		4.4			
Utilization, x	1.16		0.28		0.55			
Dep. headway, hd	4.87		6.08		6.39			
Capacity	860		414		558			
Delay	331.63		11.40		17.15			
LOS	F		B		C			
Approach:								
Delay	331.63		11.40		17.15			
LOS	F		B		C			

Intersection Delay 219.18 Intersection LOS F

Highway Capacity Analysis, Calumet Avenue and 101st Avenue

Existing Conditions (Traffic Signal) AM

APPENDIX 4

HCS+: Signalized Intersections Release 5.4

Analyst:	Inter.:
Agency:	Area Type: All other areas
Date: 2/13/2016	Jurisd:
Period: AM Peak	Year :
Project ID: Existing conditions	
E/W St: 101st	N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Volume		48	193	2	251		608	0	3			
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green		25.0				45.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 80.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
TR	520	1663	0.60	0.31	25.2	C	25.2	C
Westbound								
LT	579	1854	0.48	0.31	22.9	C	22.9	C
Northbound								
LTR	997	1772	0.64	0.56	13.3	B	13.3	B
Southbound								

Intersection Delay = 18.5 (sec/veh) Intersection LOS = B

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		48	193	2	251		608	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
PK 15 Vol		16	62	1	68		157	0	2			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900			1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			
Adj Flow		311			277			635				
%InSharedLn												
Prop LTs		0.000			0.014			0.987				
Prop RTs		0.794			0.000			0.013				
Peds Bikes		0						0			0	
Buses		0			0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0			0.0				
Arriv. Type		3			3			3				
Unit Ext.		3.0			3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0			2.0			2.0				
Ext of g		2.0			2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru	A				Thru	A		
Right	A				Right	A		
Peds					Peds			
WB Left	A				SB Left			
Thru	A				Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green	25.0				45.0			
Yellow	4.0				4.0			
All Red	1.0				1.0			

Cycle Length: 80.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		48	193	2	251		608	0	3			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
Adj flow		64	247	4	273		627	0	8			
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
Lane group		TR			LT			LTR				
Adj flow		311			277			635				
Prop LTs		0.000			0.014			0.987				
Prop RTs		0.794			0.000			0.013				

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	TR			LT			LTR					
So	1900			1900			1900					
Lanes	0 1	0	0	1	0	0	1	0	0	0	0	
fW	1.000			1.000			1.000					
fHV	0.980			0.980			0.980					
fG	1.000			1.000			1.000					
fP	1.000			1.000			1.000					
fBB	1.000			1.000			1.000					
fA	1.000			1.000			1.000					
fLU	1.000			1.000			1.000					
fRT	0.893			1.000			0.998					
fLT	1.000			0.995			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000			1.000			1.000					
S	1663			1854			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	TR	311	1663	# 0.19	0.31	520	0.60
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	277	1854	0.15	0.31	579	0.48
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	635	1772	# 0.36	0.56	997	0.64
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.55
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.62

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
TR	0.60	0.31	23.3	1.000	520	0.19	1.9	0.0	25.2	C	25.2	C
Westbound												
LT	0.48	0.31	22.2	1.000	579	0.11	0.6	0.0	22.9	C	22.9	C
Northbound												
LTR	0.64	0.56	11.9	1.000	997	0.22	1.4	0.0	13.3	B	13.3	B
Southbound												

Intersection delay = 18.5 (sec/veh) Intersection LOS = B

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 80.0 sec				
Total actual green time for LT lane group, G (s)				
Effective permitted green time for LT lane group, g(s)				
Opposing effective green time, go (s)				
Number of lanes in LT lane group, N				
Number of lanes in opposing approach, No				
Adjusted LT flow rate, VLT (veh/h)				
Proportion of LT in LT lane group, PLT				
Proportion of LT in opposing flow, PLTo				
Adjusted opposing flow rate, Vo (veh/h)				
Lost time for LT lane group, tL				
Computation				
LT volume per cycle, LTC=VLTC/3600				
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)				
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g				
Opposing platoon ratio, Rpo (refer Exhibit 16-11)				
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]				
gq, (see Exhibit C16-4,5,6,7,8)				
gu=g-gq if gq>=gf, or = g-gf if gq<gf				
n=Max(gq-gf)/2,0)				
PTHo=1-PLTo				
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]				
EL1 (refer to Exhibit C16-3)				
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g				
gdiff=max(gq-gf,0)				
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)				
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT				

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 80.0 sec				
Total actual green time for LT lane group, G (s)		25.0		
Effective permitted green time for LT lane group, g(s)		25.0		
Opposing effective green time, go (s)		25.0		
Number of lanes in LT lane group, N		1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		4		
Proportion of LT in LT lane group, PLT	0.000	0.014	0.987	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		311		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		0.09		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		6.91		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		15.7		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.69		
gq, (see Exhibit C16-4,5,6,7,8)		9.49		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		9.28		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.01		
EL1 (refer to Exhibit C16-3)		1.90		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.08		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		1.00		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.995		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				

Permitted Right Turns

Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

	EBLT	WBLT	NBLT	SBLT
Cycle length, C	80.0 sec			
Adj. LT vol from Vol Adjustment Worksheet, v				
v/c ratio from Capacity Worksheet, X				
Protected phase effective green interval, g (s)				
Opposing queue effective green interval, gq				
Unopposed green interval, gu				
Red time r=(C-g-gq-gu)				
Arrival rate, qa=v/(3600(max[X,1.0]))				
Protected ph. departure rate, Sp=s/3600				
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)				
XPerm				
XProt				
Case				
Queue at beginning of green arrow, Qa				
Queue at beginning of unsaturated green, Qu				
Residual queue, Qr				
Uniform Delay, d1				

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
TR	0.0	0.00	27.5	23.3	0.00	0.0	0.0	25.2
	0.0						0.0	
Westbound								
	0.0						0.0	
LT	0.0	0.00	27.5	22.2	0.00	0.0	0.0	22.9
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	17.5	11.9	0.00	0.0	0.0	13.3
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 18.5 sec/veh Intersection LOS B

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	TR	LT	LTR	
Init Queue	0.0	0.0	0.0	
Flow Rate	311	277	635	
So	1900	1900	1900	
No.Lanes	0 1 0	0 1 0	0 1 0	0 0 0
SL	1663	1854	1772	
LnCapacity	520	579	997	
Flow Ratio	0.2	0.1	0.4	
v/c Ratio	0.60	0.48	0.64	
Grn Ratio	0.31	0.31	0.56	
I Factor	1.000	1.000	1.000	
AT or PVG	3	3	3	
Pltn Ratio	1.00	1.00	1.00	
PF2	1.00	1.00	1.00	
Q1	5.8	5.0	9.6	
kB	0.4	0.5	0.6	
Q2	0.6	0.4	1.1	
Q Average	6.5	5.4	10.7	
Q Spacing	25.0	25.0	25.0	
Q Storage	0	0	0	
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2	
BOQ	7.7	6.4	12.6	
QSRatio				
85th Percentile Output:				
fB%	1.5	1.6	1.5	
BOQ	10.0	8.4	16.2	
QSRatio				
90th Percentile Output:				
fB%	1.7	1.7	1.6	
BOQ	10.9	9.2	17.5	
QSRatio				
95th Percentile Output:				
fB%	1.9	1.9	1.8	
BOQ	12.4	10.5	19.6	
QSRatio				
98th Percentile Output:				
fB%	2.3	2.4	2.1	
BOQ	14.9	12.7	22.9	
QSRatio				

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and 101st Avenue, Existing Conditions (Traffic Signal) PM

APPENDIX 5

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: PM Peak
Project ID: Existing conditions
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Volume		242	584	4	121		255	0	3			
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green		35.0				15.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
TR	986	1691	0.90	0.58	21.6	C	21.6	C
Westbound								
LT	1048	1796	0.16	0.58	5.8	A	5.8	A
Northbound								
LTR	443	1772	0.70	0.25	25.4	C	25.4	C
Southbound								

Intersection Delay = 20.5 (sec/veh) Intersection LOS = C

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		242	584	4	121		255	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
PK 15 Vol		70	151	2	40		77	0	1			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900			1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			
Adj Flow		883			167			311				
%InSharedLn												
Prop LTs		0.000			0.048			0.987				
Prop RTs		0.682			0.000			0.013				
Peds Bikes		0						0			0	
Buses		0			0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0			0.0				
Arriv. Type		3			3			3				
Unit Ext.		3.0			3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0			2.0			2.0				
Ext of g		2.0			2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green		35.0				15.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		242	584	4	121		255	0	3			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
Adj flow		281	602	8	159		307	0	4			
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
Lane group		TR			LT			LTR				
Adj flow		883			167			311				
Prop LTs		0.000			0.048			0.987				
Prop RTs		0.682			0.000			0.013				

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	TR			LT			LTR					
So	1900			1900			1900					
Lanes	0 1	0	0	1	0	0	1	0	0	0	0	
fW	1.000			1.000			1.000					
fHV	0.980			0.980			0.980					
fG	1.000			1.000			1.000					
fP	1.000			1.000			1.000					
fBB	1.000			1.000			1.000					
fA	1.000			1.000			1.000					
fLU	1.000			1.000			1.000					
fRT	0.908			1.000			0.998					
fLT	1.000			0.964			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000			1.000			1.000					
S	1691			1796			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	TR	883	1691	# 0.52	0.58	986	0.90
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	167	1796	0.09	0.58	1048	0.16
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	311	1772	# 0.18	0.25	443	0.70
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.70
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.84

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
TR	0.90	0.58	10.9	1.000	986	0.42	10.7	0.0	21.6	C	21.6	C
Westbound												
LT	0.16	0.58	5.7	1.000	1048	0.11	0.1	0.0	5.8	A	5.8	A
Northbound												
LTR	0.70	0.25	20.5	1.000	443	0.27	4.9	0.0	25.4	C	25.4	C
Southbound												

Intersection delay = 20.5 (sec/veh) Intersection LOS = C

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)				
Effective permitted green time for LT lane group, g(s)				
Opposing effective green time, go (s)				
Number of lanes in LT lane group, N				
Number of lanes in opposing approach, No				
Adjusted LT flow rate, VLT (veh/h)				
Proportion of LT in LT lane group, PLT				
Proportion of LT in opposing flow, PLTo				
Adjusted opposing flow rate, Vo (veh/h)				
Lost time for LT lane group, tL				
Computation				
LT volume per cycle, LTC=VLTC/3600				
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)				
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g				
Opposing platoon ratio, Rpo (refer Exhibit 16-11)				
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]				
gq, (see Exhibit C16-4,5,6,7,8)				
gu=g-gq if gq>=gf, or = g-gf if gq<gf				
n=Max(gq-gf)/2,0)				
PTHo=1-PLTo				
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]				
EL1 (refer to Exhibit C16-3)				
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g				
gdiff=max(gq-gf,0)				
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)				
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT				

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)		35.0		
Effective permitted green time for LT lane group, g(s)		35.0		
Opposing effective green time, go (s)		35.0		
Number of lanes in LT lane group, N		1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		8		
Proportion of LT in LT lane group, PLT	0.000	0.048	0.987	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		883		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		0.13		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		14.72		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		22.5		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.42		
gq, (see Exhibit C16-4,5,6,7,8)		10.15		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		12.53		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.05		
EL1 (refer to Exhibit C16-3)		3.34		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.06		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.96		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.964		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

	EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0 sec			
Adj. LT vol from Vol Adjustment Worksheet, v				
v/c ratio from Capacity Worksheet, X				
Protected phase effective green interval, g (s)				
Opposing queue effective green interval, gq				
Unopposed green interval, gu				
Red time r=(C-g-gq-gu)				
Arrival rate, qa=v/(3600(max[X,1.0]))				
Protected ph. departure rate, Sp=s/3600				
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)				
XPerm				
XProt				
Case				
Queue at beginning of green arrow, Qa				
Queue at beginning of unsaturated green, Qu				
Residual queue, Qr				
Uniform Delay, d1				

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
TR	0.0	0.00	12.5	10.9	0.00	0.0	0.0	21.6
	0.0						0.0	
Westbound								
	0.0						0.0	
LT	0.0	0.00	12.5	5.7	0.00	0.0	0.0	5.8
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	20.5	0.00	0.0	0.0	25.4
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 20.5 sec/veh Intersection LOS C

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	TR	LT	LTR	
Init Queue	0.0	0.0	0.0	
Flow Rate	883	167	311	
So	1900	1900	1900	
No.Lanes	0 1 0	0 1 0	0 1 0	0 0 0
SL	1691	1796	1772	
LnCapacity	986	1048	443	
Flow Ratio	0.5	0.1	0.2	
v/c Ratio	0.90	0.16	0.70	
Grn Ratio	0.58	0.58	0.25	
I Factor	1.000	1.000	1.000	
AT or PVG	3	3	3	
Pltn Ratio	1.00	1.00	1.00	
PF2	1.00	1.00	1.00	
Q1	12.8	1.3	4.7	
kB	0.5	0.6	0.3	
Q2	3.6	0.1	0.7	
Q Average	16.4	1.4	5.5	
Q Spacing	25.0	25.0	25.0	
Q Storage	0	0	0	
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2	
BOQ	19.2	1.7	6.5	
QSRatio				
85th Percentile Output:				
fB%	1.5	1.6	1.6	
BOQ	24.2	2.2	8.5	
QSRatio				
90th Percentile Output:				
fB%	1.6	1.8	1.7	
BOQ	25.9	2.5	9.3	
QSRatio				
95th Percentile Output:				
fB%	1.7	2.1	1.9	
BOQ	28.6	2.8	10.6	
QSRatio				
98th Percentile Output:				
fB%	2.0	2.6	2.4	
BOQ	32.6	3.6	12.9	
QSRatio				

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis, Calumet Avenue and 101st Avenue

Existing Conditions (Traffic Signal with right turn lane) AM

APPENDIX 6

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: AM Peak
Project ID: Existing conditions with right turn lane
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Volume		48	193	2	251		608	0	3			
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green		25.0				45.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 80.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
T	582	1863	0.11	0.31	19.7	B	4.1	A
R	1583	1583	0.16	1.00	0.0+	A		
Westbound								
LT	581	1858	0.48	0.31	22.8	C	22.8	C
Northbound								
LTR	997	1772	0.64	0.56	13.3	B	13.3	B
Southbound								

Intersection Delay = 13.1 (sec/veh) Intersection LOS = B

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions with right turn lane
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		48	193	2	251		608	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
PK 15 Vol		16	62	1	68		157	0	2			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900	1900		1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			
Adj Flow		64	247		277			635				
%InSharedLn												
Prop LTs		0.000			0.014			0.987				
Prop RTs		0.000	1.000		0.000			0.013				
Peds Bikes		0						0			0	
Buses		0	0		0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0	0.0		0.0			0.0				
Arriv. Type		3	3		3			3				
Unit Ext.		3.0	3.0		3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0	2.0		2.0			2.0				
Ext of g		2.0	2.0		2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green		25.0				45.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 80.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		48	193	2	251		608	0	3			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
Adj flow		64	247	4	273		627	0	8			
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
Lane group		T	R		LT			LTR				
Adj flow		64	247		277			635				
Prop LTs		0.000			0.014			0.987				
Prop RTs	0.000		1.000	0.000			0.013					

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	T	R		LT			LTR					
So	1900	1900		1900			1900					
Lanes	0 1	1	0	1	0	0	1	0	0	0	0	
fW	1.000	1.000		1.000			1.000					
fHV	0.980	0.980		0.980			0.980					
fG	1.000	1.000		1.000			1.000					
fP	1.000	1.000		1.000			1.000					
fBB	1.000	1.000		1.000			1.000					
fA	1.000	1.000		1.000			1.000					
fLU	1.000	1.000		1.000			1.000					
fRT	1.000	0.850		1.000			0.998					
fLT	1.000			0.998			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000	1.000		1.000			1.000					
S	1863	1583		1858			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	T	64	1863	0.03	0.31	582	0.11
Right	R	247	1583	0.16	1.00	1583	0.16
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	277	1858	# 0.15	0.31	581	0.48
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	635	1772	# 0.36	0.56	997	0.64
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.51
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.58

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
T	0.11	0.31	19.6	1.000	582	0.11	0.1	0.0	19.7	B	4.1	A
R	0.16	1.00	0.0	0.950	1583	0.11	0.0	0.0	0.0+	A		
Westbound												
LT	0.48	0.31	22.2	1.000	581	0.11	0.6	0.0	22.8	C	22.8	C
Northbound												
LTR	0.64	0.56	11.9	1.000	997	0.22	1.4	0.0	13.3	B	13.3	B
Southbound												

Intersection delay = 13.1 (sec/veh) Intersection LOS = B

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	80.0 sec				
Total actual green time for LT lane group, G (s)					
Effective permitted green time for LT lane group, g(s)					
Opposing effective green time, go (s)					
Number of lanes in LT lane group, N					
Number of lanes in opposing approach, No					
Adjusted LT flow rate, VLT (veh/h)					
Proportion of LT in LT lane group, PLT					
Proportion of LT in opposing flow, PLTo					
Adjusted opposing flow rate, Vo (veh/h)					
Lost time for LT lane group, tL					
Computation					
LT volume per cycle, LTC=VLTC/3600					
Opposing lane util. factor, fLUo		1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)					
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g					
Opposing platoon ratio, Rpo (refer Exhibit 16-11)					
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]					
gq, (see Exhibit C16-4,5,6,7,8)					
gu=g-gq if gq>=gf, or = g-gf if gq<gf					
n=Max(gq-gf)/2,0)					
PTHo=1-PLTo					
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]					
EL1 (refer to Exhibit C16-3)					
EL2=Max((1-Ptho**n)/Plto, 1.0)					
fmin=2(1+PL)/g or fmin=2(1+Pl)/g					
gdiff=max(gq-gf,0)					
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)					
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)					
or flt=[fm+0.91(N-1)]/N**					
Left-turn adjustment, fLT					

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

		EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach					
Cycle length, C	80.0 sec				
Total actual green time for LT lane group, G (s)			25.0		
Effective permitted green time for LT lane group, g(s)			25.0		
Opposing effective green time, go (s)			25.0		
Number of lanes in LT lane group, N			1		

Number of lanes in opposing approach, No			1		
Adjusted LT flow rate, VLT (veh/h)			4		
Proportion of LT in LT lane group, PLT	0.000	0.014	0.987		
Proportion of LT in opposing flow, PLTo			0.00		
Adjusted opposing flow rate, Vo (veh/h)			64		
Lost time for LT lane group, tL			5.00		
Computation					
LT volume per cycle, LTC=VLTC/3600			0.09		
Opposing lane util. factor, fLUo	1.000	1.000		1.000	
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)			1.42		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g			16.4		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)			1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]			0.69		
gq, (see Exhibit C16-4,5,6,7,8)			0.00		
gu=g-gq if gq>=gf, or = g-gf if gq<gf			8.60		
n=Max(gq-gf)/2,0)			0.00		
PTHo=1-PLTo			1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]			0.01		
EL1 (refer to Exhibit C16-3)			1.47		
EL2=Max((1-Ptho**n)/Plto, 1.0)					
fmin=2(1+PL)/g or fmin=2(1+Pl)/g			0.08		
gdiff=max(gq-gf,0)			0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)			1.00		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00)					
or flt=[fm+0.91(N-1)]/N**					
Left-turn adjustment, fLT			0.998		

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

		EBLT	WBLT	NBLT	SBLT
Cycle length, C	80.0 sec				
Adj. LT vol from Vol Adjustment Worksheet, v					
v/c ratio from Capacity Worksheet, X					
Protected phase effective green interval, g (s)					
Opposing queue effective green interval, gq					
Unopposed green interval, gu					
Red time r=(C-g-gq-gu)					
Arrival rate, qa=v/(3600(max[X,1.0]))					
Protected ph. departure rate, Sp=s/3600					
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)					
XPerm					
XProt					
Case					
Queue at beginning of green arrow, Qa					
Queue at beginning of unsaturated green, Qu					
Residual queue, Qr					
Uniform Delay, d1					

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
T	0.0	0.00	27.5	19.6	0.00	0.0	0.0	19.7
R	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.0+
Westbound								
	0.0						0.0	
LT	0.0	0.00	27.5	22.2	0.00	0.0	0.0	22.8
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	17.5	11.9	0.00	0.0	0.0	13.3
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 13.1 sec/veh Intersection LOS B

BACK OF QUEUE WORKSHEET

	Eastbound		Westbound		Northbound		Southbound			
LaneGroup	T	R	LT		LTR					
Init Queue	0.0	0.0	0.0		0.0					
Flow Rate	64	247	277		635					
So	1900	1900	1900		1900					
No.Lanes	0 1	1	0 1	0	0 1	0	0	0	0	
SL	1863	1583	1858		1772					
LnCapacity	582	1583	581		997					
Flow Ratio	0.0	0.2	0.1		0.4					
v/c Ratio	0.11	0.16	0.48		0.64					
Grn Ratio	0.31	1.00	0.31		0.56					
I Factor	1.000		1.000		1.000					
AT or PVG	3	3	3		3					
Pltn Ratio	1.00	1.00	1.00		1.00					
PF2	1.00		1.00		1.00					
Q1	1.0		5.0		9.6					
kB	0.5	0.8	0.5		0.6					
Q2	0.1	0.2	0.4		1.1					
Q Average	1.1		5.4		10.7					
Q Spacing	25.0	25.0	25.0		25.0					
Q Storage	0	0	0		0					
Q S Ratio										
70th Percentile Output:										
fB%	1.2		1.2		1.2					
BOQ	1.3		6.4		12.6					
QSRatio										
85th Percentile Output:										
fB%	1.6		1.6		1.5					
BOQ	1.7		8.4		16.2					
QSRatio										
90th Percentile Output:										
fB%	1.8		1.7		1.6					
BOQ	1.9		9.2		17.5					
QSRatio										
95th Percentile Output:										
fB%	2.1		1.9		1.8					
BOQ	2.2		10.5		19.6					
QSRatio										
98th Percentile Output:										
fB%	2.6		2.4		2.1					
BOQ	2.8		12.7		22.9					
QSRatio										

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and 101st Avenue,
Existing Conditions (Traffic Signal with right turn lane) PM

APPENDIX 7

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: PM Peak
Project ID: Existing conditions with right turn lane
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Volume		242	584	4	121		255	0	3			
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green		35.0				15.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
T	1087	1863	0.26	0.58	6.3	A	2.1	A
R	1583	1583	0.38	1.00	0.2	A		
Westbound								
LT	1073	1839	0.16	0.58	5.8	A	5.8	A
Northbound								
LTR	443	1772	0.70	0.25	25.4	C	25.4	C
Southbound								

Intersection Delay = 7.9 (sec/veh) Intersection LOS = A

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions with right turn lane
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		242	584	4	121		255	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
PK 15 Vol		70	151	2	40		77	0	1			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900	1900		1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			
Adj Flow		281	602		167			311				
%InSharedLn												
Prop LTs		0.000			0.048			0.987				
Prop RTs		0.000	1.000		0.000			0.013				
Peds Bikes	0						0			0		
Buses		0	0		0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0	0.0		0.0			0.0				
Arriv. Type		3	3		3			3				
Unit Ext.		3.0	3.0		3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0	2.0		2.0			2.0				
Ext of g		2.0	2.0		2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru	A				Thru	A		
Right	A				Right	A		
Peds					Peds			
WB Left	A				SB Left			
Thru	A				Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green	35.0					15.0		
Yellow	4.0					4.0		
All Red	1.0					1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		242	584	4	121		255	0	3			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
Adj flow		281	602	8	159		307	0	4			
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
Lane group		T	R		LT			LTR				
Adj flow		281	602		167			311				
Prop LTs		0.000			0.048			0.987				
Prop RTs	0.000	1.000		0.000			0.013					

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	T	R		LT			LTR					
So	1900	1900		1900			1900					
Lanes 0	1	1	0	1	0	0	1	0	0	0	0	
fW	1.000	1.000		1.000			1.000					
fHV	0.980	0.980		0.980			0.980					
fG	1.000	1.000		1.000			1.000					
fP	1.000	1.000		1.000			1.000					
fBB	1.000	1.000		1.000			1.000					
fA	1.000	1.000		1.000			1.000					
fLU	1.000	1.000		1.000			1.000					
fRT	1.000	0.850		1.000			0.998					
fLT	1.000			0.987			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000	1.000		1.000			1.000					
S	1863	1583		1839			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	T	281	1863	0.15	0.58	1087	0.26
Right	R	602	1583	# 0.38	1.00	1583	0.38
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	167	1839	0.09	0.58	1073	0.16
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	311	1772	0.18	0.25	443	0.70
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.38
Total lost time per cycle, L = 0.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.38

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
T	0.26	0.58	6.1	1.000	1087	0.11	0.1	0.0	6.3	A	2.1	A
R	0.38	1.00	0.0	0.950	1583	0.11	0.2	0.0	0.2	A		
Westbound												
LT	0.16	0.58	5.7	1.000	1073	0.11	0.1	0.0	5.8	A	5.8	A
Northbound												
LTR	0.70	0.25	20.5	1.000	443	0.27	4.9	0.0	25.4	C	25.4	C
Southbound												

Intersection delay = 7.9 (sec/veh) Intersection LOS = A

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)				
Effective permitted green time for LT lane group, g(s)				
Opposing effective green time, go (s)				
Number of lanes in LT lane group, N				
Number of lanes in opposing approach, No				
Adjusted LT flow rate, VLT (veh/h)				
Proportion of LT in LT lane group, PLT				
Proportion of LT in opposing flow, PLTo				
Adjusted opposing flow rate, Vo (veh/h)				
Lost time for LT lane group, tL				
Computation				
LT volume per cycle, LTC=VLTC/3600				
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)				
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g				
Opposing platoon ratio, Rpo (refer Exhibit 16-11)				
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]				
gq, (see Exhibit C16-4,5,6,7,8)				
gu=g-gq if gq>=gf, or = g-gf if gq<gf				
n=Max(gq-gf)/2,0)				
PTHo=1-PLTo				
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]				
EL1 (refer to Exhibit C16-3)				
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g				
gdiff=max(gq-gf,0)				
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)				
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT				

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)		35.0		
Effective permitted green time for LT lane group, g(s)		35.0		
Opposing effective green time, go (s)		35.0		
Number of lanes in LT lane group, N		1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		8		
Proportion of LT in LT lane group, PLT	0.000	0.048	0.987	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		281		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		0.13		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		4.68		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		23.4		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.42		
gq, (see Exhibit C16-4,5,6,7,8)		1.33		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		11.57		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.05		
EL1 (refer to Exhibit C16-3)		1.85		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.06		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.99		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.987		

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

		EBLT	WBLT	NBLT	SBLT
Cycle length, C	60.0 sec				
Adj. LT vol from Vol Adjustment Worksheet, v					
v/c ratio from Capacity Worksheet, X					
Protected phase effective green interval, g (s)					
Opposing queue effective green interval, gq					
Unopposed green interval, gu					
Red time r=(C-g-gq-gu)					
Arrival rate, qa=v/(3600(max[X,1.0]))					
Protected ph. departure rate, Sp=s/3600					
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)					
XPerm					
XProt					
Case					
Queue at beginning of green arrow, Qa					
Queue at beginning of unsaturated green, Qu					
Residual queue, Qr					
Uniform Delay, d1					

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
T	0.0	0.00	12.5	6.1	0.00	0.0	0.0	6.3
R	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.2
Westbound								
	0.0						0.0	
LT	0.0	0.00	12.5	5.7	0.00	0.0	0.0	5.8
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	20.5	0.00	0.0	0.0	25.4
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 7.9 sec/veh Intersection LOS A

BACK OF QUEUE WORKSHEET

	Eastbound		Westbound		Northbound		Southbound				
LaneGroup	T	R	LT		LTR						
Init Queue	0.0	0.0	0.0		0.0						
Flow Rate	281	602	167		311						
So	1900	1900	1900		1900						
No.Lanes	0 1	1	0 1	0	0 1	0	0	0	0		
SL	1863	1583	1839		1772						
LnCapacity	1087	1583	1073		443						
Flow Ratio	0.2	0.4	0.1		0.2						
v/c Ratio	0.26	0.38	0.16		0.70						
Grn Ratio	0.58	1.00	0.58		0.25						
I Factor	1.000		1.000		1.000						
AT or PVG	3	3	3		3						
Pltn Ratio	1.00	1.00	1.00		1.00						
PF2	1.00		1.00		1.00						
Q1	2.3		1.3		4.7						
kB	0.6	0.7	0.6		0.3						
Q2	0.2	0.4	0.1		0.7						
Q Average	2.5		1.4		5.5						
Q Spacing	25.0	25.0	25.0		25.0						
Q Storage	0	0	0		0						
Q S Ratio											
70th Percentile Output:											
fB%	1.2		1.2		1.2						
BOQ	3.0		1.7		6.5						
QSRatio											
85th Percentile Output:											
fB%	1.6		1.6		1.6						
BOQ	3.9		2.2		8.5						
QSRatio											
90th Percentile Output:											
fB%	1.8		1.8		1.7						
BOQ	4.4		2.4		9.3						
QSRatio											
95th Percentile Output:											
fB%	2.0		2.1		1.9						
BOQ	5.0		2.8		10.6						
QSRatio											
98th Percentile Output:											
fB%	2.5		2.6		2.4						
BOQ	6.3		3.6		12.9						
QSRatio											

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis, Calumet Avenue and 101st Avenue
Existing Conditions plus site(Traffic Signal with right turn lane) AM

APPENDIX 8

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: AM Peak
Project ID: Existing conditions plus site traffic with right turn lane
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Volume		48	242	33	251		706	0	32			
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green		25.0				35.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 70.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
T	665	1863	0.10	0.36	15.0	B	2.6	A
R	1583	1583	0.20	1.00	0.1	A		
Westbound								
LT	618	1729	0.55	0.36	19.0	B	19.0	B
Northbound								
LTR	879	1758	0.92	0.50	31.4	C	31.4	C
Southbound								

Intersection Delay = 21.6 (sec/veh) Intersection LOS = C

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions plus site traffic with right turn lane
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		48	242	33	251		706	0	32			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
PK 15 Vol		16	78	17	68		182	0	21			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900	1900		1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			
Adj Flow		64	310		339			812				
%InSharedLn												
Prop LTs		0.000			0.195			0.897				
Prop RTs		0.000	1.000		0.000			0.103				
Peds Bikes		0						0			0	
Buses		0	0		0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0	0.0		0.0			0.0				
Arriv. Type		3	3		3			3				
Unit Ext.		3.0	3.0		3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0	2.0		2.0			2.0				
Ext of g		2.0	2.0		2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green		25.0				35.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 70.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		48	242	33	251		706	0	32			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
Adj flow		64	310	66	273		728	0	84			
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
Lane group		T	R		LT			LTR				
Adj flow		64	310		339			812				
Prop LTs		0.000			0.195			0.897				
Prop RTs		0.000	1.000		0.000			0.103				

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG		T	R		LT			LTR				
So		1900	1900		1900			1900				
Lanes	0	1	1	0	1	0	0	1	0	0	0	0
fW		1.000	1.000		1.000			1.000				
fHV		0.980	0.980		0.980			0.980				
fG		1.000	1.000		1.000			1.000				
fP		1.000	1.000		1.000			1.000				
fBB		1.000	1.000		1.000			1.000				
fA		1.000	1.000		1.000			1.000				
fLU		1.000	1.000		1.000			1.000				
fRT		1.000	0.850		1.000			0.986				
fLT		1.000			0.928			0.957				
Sec.												
fLpb		1.000			1.000			1.000				
fRpb		1.000	1.000		1.000			1.000				
S		1863	1583		1729			1758				
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	T	64	1863	0.03	0.36	665	0.10
Right	R	310	1583	0.20	1.00	1583	0.20
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	339	1729	# 0.20	0.36	618	0.55
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	812	1758	# 0.46	0.50	879	0.92
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.66
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.77

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
T	0.10	0.36	15.0	1.000	665	0.11	0.1	0.0	15.0	B	2.6	A
R	0.20	1.00	0.0	0.950	1583	0.11	0.1	0.0	0.1	A		
Westbound												
LT	0.55	0.36	18.0	1.000	618	0.15	1.0	0.0	19.0	B	19.0	B
Northbound												
LTR	0.92	0.50	16.3	1.000	879	0.44	15.2	0.0	31.4	C	31.4	C
Southbound												

Intersection delay = 21.6 (sec/veh) Intersection LOS = C

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 70.0 sec				
Total actual green time for LT lane group, G (s)				
Effective permitted green time for LT lane group, g(s)				
Opposing effective green time, go (s)				
Number of lanes in LT lane group, N				
Number of lanes in opposing approach, No				
Adjusted LT flow rate, VLT (veh/h)				
Proportion of LT in LT lane group, PLT				
Proportion of LT in opposing flow, PLTo				
Adjusted opposing flow rate, Vo (veh/h)				
Lost time for LT lane group, tL				
Computation				
LT volume per cycle, LTC=VLTC/3600				
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)				
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g				
Opposing platoon ratio, Rpo (refer Exhibit 16-11)				
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]				
gq, (see Exhibit C16-4,5,6,7,8)				
gu=g-gq if gq>=gf, or = g-gf if gq<gf				
n=Max(gq-gf)/2,0)				
PTHo=1-PLTo				
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]				
EL1 (refer to Exhibit C16-3)				
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g				
gdiff=max(gq-gf,0)				
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)				
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT				

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 70.0 sec				
Total actual green time for LT lane group, G (s)		25.0		
Effective permitted green time for LT lane group, g(s)		25.0		
Opposing effective green time, go (s)		25.0		
Number of lanes in LT lane group, N		1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		66		
Proportion of LT in LT lane group, PLT	0.000	0.195	0.897	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		64		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		1.28		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		1.24		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		3.7		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.64		
gq, (see Exhibit C16-4,5,6,7,8)		0.00		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		21.29		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.19		
EL1 (refer to Exhibit C16-3)		1.47		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.10		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.93		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.928		

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

	EBLT	WBLT	NBLT	SBLT
Cycle length, C 70.0 sec				
Adj. LT vol from Vol Adjustment Worksheet, v				
v/c ratio from Capacity Worksheet, X				
Protected phase effective green interval, g (s)				
Opposing queue effective green interval, gq				
Unopposed green interval, gu				
Red time r=(C-g-gq-gu)				
Arrival rate, qa=v/(3600(max[X,1.0]))				
Protected ph. departure rate, Sp=s/3600				
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)				
XPerm				
XProt				
Case				
Queue at beginning of green arrow, Qa				
Queue at beginning of unsaturated green, Qu				
Residual queue, Qr				
Uniform Delay, d1				

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
T	0.0	0.00	22.5	15.0	0.00	0.0	0.0	15.0
R	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.1
Westbound								
	0.0						0.0	
LT	0.0	0.00	22.5	18.0	0.00	0.0	0.0	19.0
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	17.5	16.3	0.00	0.0	0.0	31.4
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 21.6 sec/veh Intersection LOS C

BACK OF QUEUE WORKSHEET

	Eastbound		Westbound	Northbound	Southbound
LaneGroup	T	R	LT	LTR	
Init Queue	0.0	0.0	0.0	0.0	
Flow Rate	64	310	339	812	
So	1900	1900	1900	1900	
No.Lanes	0 1	1	0 1 0	0 1 0	0 0 0
SL	1863	1583	1729	1758	
LnCapacity	665	1583	618	879	
Flow Ratio	0.0	0.2	0.2	0.5	
v/c Ratio	0.10	0.20	0.55	0.92	
Grn Ratio	0.36	1.00	0.36	0.50	
I Factor	1.000		1.000	1.000	
AT or PVG	3	3	3	3	
Pltn Ratio	1.00	1.00	1.00	1.00	
PF2	1.00		1.00	1.00	
Q1	0.8		5.3	14.7	
kB	0.5	0.8	0.4	0.5	
Q2	0.0	0.2	0.5	4.4	
Q Average	0.9		5.8	19.0	
Q Spacing	25.0	25.0	25.0	25.0	
Q Storage	0	0	0	0	
Q S Ratio					
70th Percentile Output:					
fB%	1.2		1.2	1.2	
BOQ	1.1		6.9	22.1	
QSRatio					
85th Percentile Output:					
fB%	1.6		1.5	1.5	
BOQ	1.4		9.0	27.8	
QSRatio					
90th Percentile Output:					
fB%	1.8		1.7	1.6	
BOQ	1.6		9.9	29.6	
QSRatio					
95th Percentile Output:					
fB%	2.1		1.9	1.7	
BOQ	1.8		11.2	32.5	
QSRatio					
98th Percentile Output:					
fB%	2.6		2.3	1.9	
BOQ	2.3		13.6	36.8	
QSRatio					

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and 101st Avenue,
Existing Conditions plus site (Traffic Signal with right turn lane) PM

APPENDIX 9

HCS+: Signalized Intersections Release 5.4

Analyst:
Agency:
Date: 2/13/2016
Period: PM Peak
Project ID: Existing conditions plus site
E/W St: 101st

Inter.:
Area Type: All other areas
Jurisd:
Year :
N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Volume		242	692	37	121		322	0	26			
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination		1	2	3	4			5	6	7	8
EB	Left					NB	Left	A			
	Thru		A				Thru	A			
	Right		A				Right	A			
	Peds						Peds				
WB	Left		A			SB	Left				
	Thru		A				Thru				
	Right						Right				
	Peds						Peds				
NB	Right					EB	Right	A			
SB	Right					WB	Right				
Green			25.0					25.0			
Yellow			4.0					4.0			
All Red			1.0					1.0			

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
T	776	1863	0.36	0.42	12.3	B	3.6	A
R	1583	1583	0.45	1.00	0.2	A		
Westbound								
LT	636	1526	0.37	0.42	12.4	B	12.4	B
Northbound								
LTR	734	1761	0.58	0.42	14.6	B	14.6	B
Southbound								

Intersection Delay = 7.7 (sec/veh) Intersection LOS = A

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions plus site
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		242	692	37	121		322	0	26			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
PK 15 Vol		70	178	19	40		97	0	9			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900	1900		1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
LGConfig		T	R		LT			LTR				
Lane Width		12.0	12.0		12.0			12.0				
RTOR Vol			0						0			
Adj Flow		281	713		233			423				
%InSharedLn												
Prop LTs		0.000			0.318			0.917				
Prop RTs		0.000	1.000		0.000			0.083				
Peds Bikes		0						0			0	
Buses		0	0		0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0	0.0		0.0			0.0				
Arriv. Type		3	3		3			3				
Unit Ext.		3.0	3.0		3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0	2.0		2.0			2.0				
Ext of g		2.0	2.0		2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru	A				Thru	A		
Right	A				Right	A		
Peds					Peds			
WB Left	A				SB Left			
Thru	A				Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right	A		
SB Right					WB Right			
Green	25.0					25.0		
Yellow	4.0					4.0		
All Red	1.0					1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		242	692	37	121		322	0	26			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
Adj flow		281	713	74	159		388	0	35			
No. Lanes	0	1	1	0	1	0	0	1	0	0	0	0
Lane group		T	R		LT			LTR				
Adj flow		281	713		233			423				
Prop LTs		0.000			0.318			0.917				
Prop RTs	0.000	1.000		0.000			0.083					

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	T	R		LT			LTR					
So	1900	1900		1900			1900					
Lanes 0	1	1	0	1	0	0	1	0	0	0	0	
fW	1.000	1.000		1.000			1.000					
fHV	0.980	0.980		0.980			0.980					
fG	1.000	1.000		1.000			1.000					
fP	1.000	1.000		1.000			1.000					
fBB	1.000	1.000		1.000			1.000					
fA	1.000	1.000		1.000			1.000					
fLU	1.000	1.000		1.000			1.000					
fRT	1.000	0.850		1.000			0.989					
fLT	1.000			0.819			0.956					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000	1.000		1.000			1.000					
S	1863	1583		1526			1761					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	T	281	1863	0.15	0.42	776	0.36
Right	R	713	1583	# 0.45	1.00	1583	0.45
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	233	1526	0.15	0.42	636	0.37
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	423	1761	0.24	0.42	734	0.58
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.45
Total lost time per cycle, L = 0.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.45

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
T	0.36	0.42	12.0	1.000	776	0.11	0.3	0.0	12.3	B	3.6	A
R	0.45	1.00	0.0	0.950	1583	0.11	0.2	0.0	0.2	A		
Westbound												
LT	0.37	0.42	12.0	1.000	636	0.11	0.4	0.0	12.4	B	12.4	B
Northbound												
LTR	0.58	0.42	13.4	1.000	734	0.17	1.1	0.0	14.6	B	14.6	B
Southbound												

Intersection delay = 7.7 (sec/veh) Intersection LOS = A

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)				
Effective permitted green time for LT lane group, g(s)				
Opposing effective green time, go (s)				
Number of lanes in LT lane group, N				
Number of lanes in opposing approach, No				
Adjusted LT flow rate, VLT (veh/h)				
Proportion of LT in LT lane group, PLT				
Proportion of LT in opposing flow, PLTo				
Adjusted opposing flow rate, Vo (veh/h)				
Lost time for LT lane group, tL				
Computation				
LT volume per cycle, LTC=VLTC/3600				
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)				
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g				
Opposing platoon ratio, Rpo (refer Exhibit 16-11)				
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]				
gq, (see Exhibit C16-4,5,6,7,8)				
gu=g-gq if gq>=gf, or = g-gf if gq<gf				
n=Max(gq-gf)/2,0)				
PTHo=1-PLTo				
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]				
EL1 (refer to Exhibit C16-3)				
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g				
gdiff=max(gq-gf,0)				
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)				
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT				

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)		25.0		
Effective permitted green time for LT lane group, g(s)		25.0		
Opposing effective green time, go (s)		25.0		
Number of lanes in LT lane group, N		1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		74		
Proportion of LT in LT lane group, PLT	0.000	0.318	0.917	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		281		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		1.23		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		4.68		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		4.0		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.58		
gq, (see Exhibit C16-4,5,6,7,8)		4.05		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		20.95		
n=Max(gq-gf)/2,0)		0.04		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.32		
EL1 (refer to Exhibit C16-3)		1.85		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.11		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.82		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.819		

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

	EBLT	WBLT	NBLT	SBLT
Cycle length, C 60.0 sec				
Adj. LT vol from Vol Adjustment Worksheet, v				
v/c ratio from Capacity Worksheet, X				
Protected phase effective green interval, g (s)				
Opposing queue effective green interval, gq				
Unopposed green interval, gu				
Red time r=(C-g-gq-gu)				
Arrival rate, qa=v/(3600(max[X,1.0]))				
Protected ph. departure rate, Sp=s/3600				
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)				
XPerm				
XProt				
Case				
Queue at beginning of green arrow, Qa				
Queue at beginning of unsaturated green, Qu				
Residual queue, Qr				
Uniform Delay, d1				

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
T	0.0	0.00	17.5	12.0	0.00	0.0	0.0	12.3
R	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.2
Westbound								
	0.0						0.0	
LT	0.0	0.00	17.5	12.0	0.00	0.0	0.0	12.4
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	17.5	13.4	0.00	0.0	0.0	14.6
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 7.7 sec/veh Intersection LOS A

BACK OF QUEUE WORKSHEET

	Eastbound		Westbound		Northbound		Southbound					
LaneGroup	T	R	LT		LTR							
Init Queue	0.0	0.0	0.0		0.0							
Flow Rate	281	713	233		423							
So	1900	1900	1900		1900							
No.Lanes	0 1	1	0 1	0	0 1	0	0	0	0			
SL	1863	1583	1526		1761							
LnCapacity	776	1583	636		734							
Flow Ratio	0.2	0.5	0.2		0.2							
v/c Ratio	0.36	0.45	0.37		0.58							
Grn Ratio	0.42	1.00	0.42		0.42							
I Factor	1.000		1.000		1.000							
AT or PVG	3	3	3		3							
Pltn Ratio	1.00	1.00	1.00		1.00							
PF2	1.00		1.00		1.00							
Q1	3.2		2.7		5.4							
kB	0.5	0.7	0.4		0.4							
Q2	0.3	0.6	0.2		0.6							
Q Average	3.5		2.9		6.0							
Q Spacing	25.0	25.0	25.0		25.0							
Q Storage	0	0	0		0							
Q S Ratio												
70th Percentile Output:												
fB%	1.2		1.2		1.2							
BOQ	4.1		3.5		7.1							
QSRatio												
85th Percentile Output:												
fB%	1.6		1.6		1.5							
BOQ	5.5		4.6		9.3							
QSRatio												
90th Percentile Output:												
fB%	1.7		1.7		1.7							
BOQ	6.0		5.1		10.2							
QSRatio												
95th Percentile Output:												
fB%	2.0		2.0		1.9							
BOQ	6.9		5.9		11.6							
QSRatio												
98th Percentile Output:												
fB%	2.5		2.5		2.3							
BOQ	8.6		7.3		14.0							
QSRatio												

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis, Calumet Avenue and 101st Avenue

Future Conditions (Traffic Signal) AM

APPENDIX 10

HCS+: Signalized Intersections Release 5.4

Analyst:	Inter.:
Agency:	Area Type: All other areas
Date: 2/13/2016	Jurisd:
Period: AM Peak	Year :
Project ID: Existing conditions with future traffic	
E/W St: 101st	N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Volume		58	235	2	306		741	0	3			
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green		25.0				45.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 80.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
TR	519	1662	0.73	0.31	29.6	C	29.6	C
Westbound								
LT	579	1854	0.58	0.31	24.6	C	24.6	C
Northbound								
LTR	997	1772	0.77	0.56	17.4	B	17.4	B
Southbound								

Intersection Delay = 22.2 (sec/veh) Intersection LOS = C

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: AM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions with future traffic
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		58	235	2	306		741	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
PK 15 Vol		19	75	1	83		191	0	2			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900			1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			
Adj Flow		378			337			772				
%InSharedLn												
Prop LTs		0.000			0.012			0.990				
Prop RTs		0.796			0.000			0.010				
Peds Bikes		0						0			0	
Buses		0			0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0			0.0				
Arriv. Type		3			3			3				
Unit Ext.		3.0			3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0			2.0			2.0				
Ext of g		2.0			2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru	A				Thru	A		
Right	A				Right	A		
Peds					Peds			
WB Left	A				SB Left			
Thru	A				Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green	25.0					45.0		
Yellow	4.0					4.0		
All Red	1.0					1.0		

Cycle Length: 80.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		58	235	2	306		741	0	3			
PHF		0.75	0.78	0.50	0.92		0.97	0.92	0.38			
Adj flow		77	301	4	333		764	0	8			
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
Lane group		TR			LT			LTR				
Adj flow		378			337			772				
Prop LTs		0.000			0.012			0.990				
Prop RTs		0.796			0.000			0.010				

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	TR			LT			LTR					
So	1900			1900			1900					
Lanes 0	1	0	0	1	0	0	1	0	0	0	0	
fW	1.000			1.000			1.000					
fHV	0.980			0.980			0.980					
fG	1.000			1.000			1.000					
fP	1.000			1.000			1.000					
fBB	1.000			1.000			1.000					
fA	1.000			1.000			1.000					
fLU	1.000			1.000			1.000					
fRT	0.892			1.000			0.999					
fLT	1.000			0.995			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000			1.000			1.000					
S	1662			1854			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	TR	378	1662	# 0.23	0.31	519	0.73
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	337	1854	0.18	0.31	579	0.58
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	772	1772	# 0.44	0.56	997	0.77
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.66
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 0.76

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
TR	0.73	0.31	24.5	1.000	519	0.29	5.1	0.0	29.6	C	29.6	C
Westbound												
LT	0.58	0.31	23.1	1.000	579	0.17	1.5	0.0	24.6	C	24.6	C
Northbound												
LTR	0.77	0.56	13.6	1.000	997	0.32	3.9	0.0	17.4	B	17.4	B
Southbound												

Intersection delay = 22.2 (sec/veh) Intersection LOS = C

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 80.0 sec				
Total actual green time for LT lane group, G (s)				
Effective permitted green time for LT lane group, g(s)				
Opposing effective green time, go (s)				
Number of lanes in LT lane group, N				
Number of lanes in opposing approach, No				
Adjusted LT flow rate, VLT (veh/h)				
Proportion of LT in LT lane group, PLT				
Proportion of LT in opposing flow, PLTo				
Adjusted opposing flow rate, Vo (veh/h)				
Lost time for LT lane group, tL				
Computation				
LT volume per cycle, LTC=VLTC/3600				
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)				
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g				
Opposing platoon ratio, Rpo (refer Exhibit 16-11)				
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]				
gq, (see Exhibit C16-4,5,6,7,8)				
gu=g-gq if gq>=gf, or = g-gf if gq<gf				
n=Max(gq-gf)/2,0)				
PTHo=1-PLTo				
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]				
EL1 (refer to Exhibit C16-3)				
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g				
gdiff=max(gq-gf,0)				
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)				
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT				

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 80.0 sec				
Total actual green time for LT lane group, G (s)		25.0		
Effective permitted green time for LT lane group, g(s)		25.0		
Opposing effective green time, go (s)		25.0		
Number of lanes in LT lane group, N		1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		4		
Proportion of LT in LT lane group, PLT	0.000	0.012	0.990	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		378		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		0.09		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		8.40		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		15.7		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.69		
gq, (see Exhibit C16-4,5,6,7,8)		11.81		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		9.28		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.01		
EL1 (refer to Exhibit C16-3)		2.04		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.08		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		1.00		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.995		

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

	EBLT	WBLT	NBLT	SBLT
Cycle length, C	80.0 sec			
Adj. LT vol from Vol Adjustment Worksheet, v				
v/c ratio from Capacity Worksheet, X				
Protected phase effective green interval, g (s)				
Opposing queue effective green interval, gq				
Unopposed green interval, gu				
Red time r=(C-g-gq-gu)				
Arrival rate, qa=v/(3600(max[X,1.0]))				
Protected ph. departure rate, Sp=s/3600				
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)				
XPerm				
XProt				
Case				
Queue at beginning of green arrow, Qa				
Queue at beginning of unsaturated green, Qu				
Residual queue, Qr				
Uniform Delay, d1				

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
TR	0.0	0.00	27.5	24.5	0.00	0.0	0.0	29.6
	0.0						0.0	
Westbound								
	0.0						0.0	
LT	0.0	0.00	27.5	23.1	0.00	0.0	0.0	24.6
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	17.5	13.6	0.00	0.0	0.0	17.4
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 22.2 sec/veh Intersection LOS C

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	TR	LT	LTR	
Init Queue	0.0	0.0	0.0	
Flow Rate	378	337	772	
So	1900	1900	1900	
No.Lanes	0 1 0	0 1 0	0 1 0	0 0 0
SL	1662	1854	1772	
LnCapacity	519	579	997	
Flow Ratio	0.2	0.2	0.4	
v/c Ratio	0.73	0.58	0.77	
Grn Ratio	0.31	0.31	0.56	
I Factor	1.000	1.000	1.000	
AT or PVG	3	3	3	
Pltn Ratio	1.00	1.00	1.00	
PF2	1.00	1.00	1.00	
Q1	7.5	6.3	13.3	
kB	0.4	0.5	0.6	
Q2	1.1	0.6	2.1	
Q Average	8.6	6.9	15.3	
Q Spacing	25.0	25.0	25.0	
Q Storage	0	0	0	
Q S Ratio				
70th Percentile Output:				
fB%	1.2	1.2	1.2	
BOQ	10.1	8.2	17.9	
QSRatio				
85th Percentile Output:				
fB%	1.5	1.5	1.5	
BOQ	13.1	10.7	22.7	
QSRatio				
90th Percentile Output:				
fB%	1.7	1.7	1.6	
BOQ	14.2	11.7	24.3	
QSRatio				
95th Percentile Output:				
fB%	1.9	1.9	1.8	
BOQ	16.1	13.2	26.9	
QSRatio				
98th Percentile Output:				
fB%	2.2	2.3	2.0	
BOQ	19.0	15.8	30.8	
QSRatio				

ERROR MESSAGES

No errors to report.

Highway Capacity Analysis: Calumet Avenue and 101st Avenue,
Future Conditions (Traffic Signal) PM

APPENDIX 11

HCS+: Signalized Intersections Release 5.4

Analyst:	Inter.:
Agency:	Area Type: All other areas
Date: 2/13/2016	Jurisd:
Period: PM Peak	Year :
Project ID: Existing conditions with future traffic	
E/W St: 101st	N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Volume		295	712	4	147		311	0	3			
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green		35.0				15.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 60.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
TR	986	1691	1.09	0.58	69.7	E	69.7	E
Westbound								
LT	1045	1791	0.19	0.58	6.0	A	6.0	A
Northbound								
LTR	443	1772	0.86	0.25	36.6	D	36.6	D
Southbound								

Intersection Delay = 54.4 (sec/veh) Intersection LOS = D

Phone: Fax:
E-Mail:

OPERATIONAL ANALYSIS

Analyst:
Agency/Co.:
Date Performed: 2/13/2016
Analysis Time Period: PM Peak
Intersection:
Area Type: All other areas
Jurisdiction:
Analysis Year:
Project ID: Existing conditions with future traffic
E/W St: 101st N/S St:

VOLUME DATA

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume		295	712	4	147		311	0	3			
% Heavy Veh		2	2	2	2		2	2	2			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
PK 15 Vol		86	184	2	48		94	0	1			
Hi Ln Vol												
% Grade		0			0			0				
Ideal Sat		1900			1900			1900				
ParkExist												
NumPark												
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
LGConfig		TR			LT			LTR				
Lane Width		12.0			12.0			12.0				
RTOR Vol			0						0			
Adj Flow		1077			201			379				
%InSharedLn												
Prop LTs		0.000			0.040			0.989				
Prop RTs	0.682			0.000			0.011					
Peds Bikes	0						0			0		
Buses		0			0			0				
%InProtPhase												

Duration 0.25 Area Type: All other areas

OPERATING PARAMETERS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Init Unmet		0.0			0.0			0.0				
Arriv. Type		3			3			3				
Unit Ext.		3.0			3.0			3.0				
I Factor		1.000			1.000			1.000				
Lost Time		2.0			2.0			2.0				
Ext of g		2.0			2.0			2.0				
Ped Min g		3.2						3.2			3.2	

PHASE DATA

Phase Combination	1	2	3	4	5	6	7	8
EB Left					NB Left	A		
Thru		A			Thru	A		
Right		A			Right	A		
Peds					Peds			
WB Left		A			SB Left			
Thru		A			Thru			
Right					Right			
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green		35.0				15.0		
Yellow		4.0				4.0		
All Red		1.0				1.0		

Cycle Length: 60.0 secs

VOLUME ADJUSTMENT AND SATURATION FLOW WORKSHEET

Volume Adjustment

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Volume, V		295	712	4	147		311	0	3			
PHF		0.86	0.97	0.50	0.76		0.83	0.92	0.75			
Adj flow		343	734	8	193		375	0	4			
No. Lanes	0	1	0	0	1	0	0	1	0	0	0	0
Lane group		TR			LT			LTR				
Adj flow		1077			201			379				
Prop LTs		0.000			0.040			0.989				
Prop RTs		0.682			0.000			0.011				

Saturation Flow Rate (see Exhibit 16-7 to determine the adjustment factors)

	Eastbound			Westbound			Northbound			Southbound		
LG	TR			LT			LTR					
So	1900			1900			1900					
Lanes 0	1	0	0	1	0	0	1	0		0	0	0
fW	1.000			1.000			1.000					
fHV	0.980			0.980			0.980					
fG	1.000			1.000			1.000					
fP	1.000			1.000			1.000					
fBB	1.000			1.000			1.000					
fA	1.000			1.000			1.000					
fLU	1.000			1.000			1.000					
fRT	0.908			1.000			0.999					
fLT	1.000			0.962			0.953					
Sec.												
fLpb	1.000			1.000			1.000					
fRpb	1.000			1.000			1.000					
S	1691			1791			1772					
Sec.												

CAPACITY AND LOS WORKSHEET

Capacity Analysis and Lane Group Capacity

Appr/ Mvmt	Lane Group	Adj Flow Rate (v)	Adj Sat Flow Rate (s)	Flow Ratio (v/s)	Green Ratio (g/C)	--Lane Group-- Capacity (c)	v/c Ratio
Eastbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	TR	1077	1691	# 0.64	0.58	986	1.09
Right							
Westbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LT	201	1791	0.11	0.58	1045	0.19
Right							
Northbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru	LTR	379	1772	# 0.21	0.25	443	0.86
Right							
Southbound							
Prot							
Perm							
Left							
Prot							
Perm							
Thru							
Right							

Sum of flow ratios for critical lane groups, Yc = Sum (v/s) = 0.85
Total lost time per cycle, L = 10.00 sec
Critical flow rate to capacity ratio, Xc = (Yc)(C)/(C-L) = 1.02

Control Delay and LOS Determination

Appr/ Lane Grp	Ratios v/c	Ratios g/C	Unf Del d1	Prog Adj Fact	Lane Grp Cap	Incremental Factor k	Incremental Del d2	Res Del d3	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound												
TR	1.09	0.58	12.5	1.000	986	0.50	57.2	0.0	69.7	E	69.7	E
Westbound												
LT	0.19	0.58	5.9	1.000	1045	0.11	0.1	0.0	6.0	A	6.0	A
Northbound												
LTR	0.86	0.25	21.5	1.000	443	0.39	15.1	0.0	36.6	D	36.6	D
Southbound												

Intersection delay = 54.4 (sec/veh) Intersection LOS = D

SUPPLEMENTAL PERMITTED LT WORKSHEET
for exclusive lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)				
Effective permitted green time for LT lane group, g(s)				
Opposing effective green time, go (s)				
Number of lanes in LT lane group, N				
Number of lanes in opposing approach, No				
Adjusted LT flow rate, VLT (veh/h)				
Proportion of LT in LT lane group, PLT				
Proportion of LT in opposing flow, PLTo				
Adjusted opposing flow rate, Vo (veh/h)				
Lost time for LT lane group, tL				
Computation				
LT volume per cycle, LTC=VLTC/3600				
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)				
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g				
Opposing platoon ratio, Rpo (refer Exhibit 16-11)				
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]				
gq, (see Exhibit C16-4,5,6,7,8)				
gu=g-gq if gq>=gf, or = g-gf if gq<gf				
n=Max(gq-gf)/2,0)				
PTHo=1-PLTo				
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]				
EL1 (refer to Exhibit C16-3)				
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g				
gdiff=max(gq-gf,0)				
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)				
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)],(fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT				

For special case of single-lane approach opposed by multilane approach, see text.
* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.
** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.
For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PERMITTED LT WORKSHEET
for shared lefts

Input

	EB	WB	NB	SB
Opposed by Single(S) or Multiple(M) lane approach				
Cycle length, C 60.0 sec				
Total actual green time for LT lane group, G (s)		35.0		
Effective permitted green time for LT lane group, g(s)		35.0		
Opposing effective green time, go (s)		35.0		
Number of lanes in LT lane group, N		1		

Number of lanes in opposing approach, No		1		
Adjusted LT flow rate, VLT (veh/h)		8		
Proportion of LT in LT lane group, PLT	0.000	0.040	0.989	
Proportion of LT in opposing flow, PLTo		0.00		
Adjusted opposing flow rate, Vo (veh/h)		1077		
Lost time for LT lane group, tL		5.00		
Computation				
LT volume per cycle, LTC=VLTC/3600		0.13		
Opposing lane util. factor, fLUo	1.000	1.000		1.000
Opposing flow, Volc=VoC/[3600(No)fLUo] (veh/ln/cyc)		17.95		
gf=G[exp(- a * (LTC ** b))]-tl, gf<=g		22.5		
Opposing platoon ratio, Rpo (refer Exhibit 16-11)		1.00		
Opposing Queue Ratio, qro=Max[1-Rpo(go/C),0]		0.42		
gq, (see Exhibit C16-4,5,6,7,8)		12.63		
gu=g-gq if gq>=gf, or = g-gf if gq<gf		12.53		
n=Max(gq-gf)/2,0)		0.00		
PTHo=1-PLTo		1.00		
PL*=PLT[1+(N-1)g/(gf+gu/EL1+4.24)]		0.04		
EL1 (refer to Exhibit C16-3)		4.02		
EL2=Max((1-Ptho**n)/Plto, 1.0)				
fmin=2(1+PL)/g or fmin=2(1+Pl)/g		0.06		
gdiff=max(gq-gf,0)		0.00		
fm=[gf/g]+[gu/g]/[1+PL(EL1-1)], (min=fmin;max=1.00)		0.96		
flt=fm=[gf/g]+[gu/g]/[1+PL(EL1-1)]+[gdiff/g]/[1+PL(EL2-1)], (fmin<=fm<=1.00)				
or flt=[fm+0.91(N-1)]/N**				
Left-turn adjustment, fLT		0.962		

For special case of single-lane approach opposed by multilane approach, see text.

* If Pl>=1 for shared left-turn lanes with N>1, then assume de-facto left-turn lane and redo calculations.

** For permitted left-turns with multiple exclusive left-turn lanes, flt=fm.

For special case of multilane approach opposed by single-lane approach or when gf>gq, see text.

SUPPLEMENTAL PEDESTRIAN-BICYCLE EFFECTS WORKSHEET

Permitted Left Turns

	EB	WB	NB	SB
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Pedestrian flow rate, Vpedg (p/h)				
OCCpedg				
Opposing queue clearing green, gq (s)				
Eff. ped. green consumed by opp. veh. queue, gq/gp				
OCCpedu				
Opposing flow rate, Vo (veh/h)				
OCCr				
Number of cross-street receiving lanes, Nrec				
Number of turning lanes, Nturn				
ApbT				
Proportion of left turns, PLT				
Proportion of left turns using protected phase, PLTA				
Left-turn adjustment, fLpb				
Permitted Right Turns				
Effective pedestrian green time, gp (s)				
Conflicting pedestrian volume, Vped (p/h)				
Conflicting bicycle volume, Vbic (bicycles/h)				
Vpedg				
OCCpedg				
Effective green, g (s)				
Vbicg				

OCCbicg
OCCr
Number of cross-street receiving lanes, Nrec
Number of turning lanes, Nturn
ApbT
Proportion right-turns, PRT
Proportion right-turns using protected phase, PRTA
Right turn adjustment, fRpb

SUPPLEMENTAL UNIFORM DELAY WORKSHEET

	EBLT	WBLT	NBLT	SBLT
Cycle length, C 60.0 sec				
Adj. LT vol from Vol Adjustment Worksheet, v				
v/c ratio from Capacity Worksheet, X				
Protected phase effective green interval, g (s)				
Opposing queue effective green interval, gq				
Unopposed green interval, gu				
Red time r=(C-g-gq-gu)				
Arrival rate, qa=v/(3600(max[X,1.0]))				
Protected ph. departure rate, Sp=s/3600				
Permitted ph. departure rate, Ss=s(gq+gu)/(gu*3600)				
XPerm				
XProt				
Case				
Queue at beginning of green arrow, Qa				
Queue at beginning of unsaturated green, Qu				
Residual queue, Qr				
Uniform Delay, d1				

DELAY/LOS WORKSHEET WITH INITIAL QUEUE

Appr/ Lane Group	Initial Unmet Demand Q veh	Dur. Unmet Demand t hrs.	Uniform Delay Unadj. ds	Uniform Delay Adj. d1 sec	Initial Queue Param. u	Final Unmet Demand Q veh	Initial Queue Delay d3 sec	Lane Group Delay d sec
Eastbound								
	0.0						0.0	
TR	0.0	0.00	12.5	12.5	0.00	22.7	0.0	69.7
	0.0						0.0	
Westbound								
	0.0						0.0	
LT	0.0	0.00	12.5	5.9	0.00	0.0	0.0	6.0
	0.0						0.0	
Northbound								
	0.0						0.0	
LTR	0.0	0.00	22.5	21.5	0.00	0.0	0.0	36.6
	0.0						0.0	
Southbound								
	0.0						0.0	
	0.0						0.0	
	0.0						0.0	

Intersection Delay 54.4 sec/veh Intersection LOS D

BACK OF QUEUE WORKSHEET

	Eastbound	Westbound	Northbound	Southbound
LaneGroup	TR	LT	LTR	
Init Queue	0.0	0.0	0.0	
Flow Rate	1077	201	379	
So	1900	1900	1900	
No.Lanes	0 1 0	0 1 0	0 1 0	0 0 0
SL	1691	1791	1772	
LnCapacity	986	1045	443	
Flow Ratio	0.6	0.1	0.2	
v/c Ratio	1.09	0.19	0.86	
Grn Ratio	0.58	0.58	0.25	
I Factor	1.000	1.000	1.000	
AT or PVG	3	3	3	
Pltn Ratio	1.00	1.00	1.00	
PF2	1.00	1.00	1.00	
Q1	18.0	1.6	6.0	
kB	0.5	0.6	0.3	
Q2	15.9	0.1	1.6	
Q Average	33.9	1.7	7.7	
Q Spacing	25.0	25.0	25.0	
Q Storage	0	0	0	
Q S Ratio				
70th Percentile Output:				
fB%	1.1	1.2	1.2	
BOQ	38.7	2.0	9.1	
QSRatio				
85th Percentile Output:				
fB%	1.4	1.6	1.5	
BOQ	47.3	2.7	11.7	
QSRatio				
90th Percentile Output:				
fB%	1.5	1.8	1.7	
BOQ	49.9	3.0	12.8	
QSRatio				
95th Percentile Output:				
fB%	1.6	2.0	1.9	
BOQ	53.9	3.5	14.5	
QSRatio				
98th Percentile Output:				
fB%	1.8	2.6	2.3	
BOQ	60.1	4.4	17.3	
QSRatio				

ERROR MESSAGES

No errors to report.