DRAFT MEMO

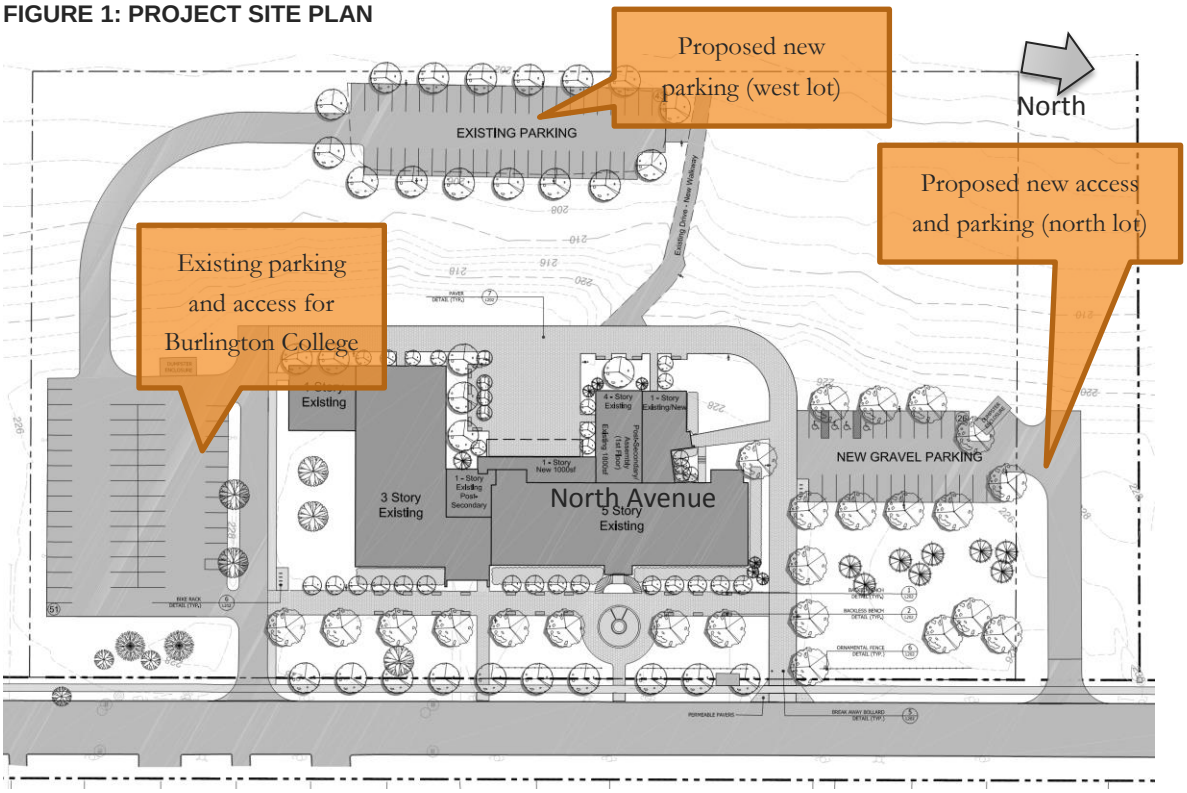
TO:	Eric Farrell
FROM:	Mark Smith, PE.
DATE:	July 10, 2015
SUBJECT:	351 North Avenue – Traffic Assessment

RSG has conducted the following analysis of traffic operations, lane warrants, and safety proximate to the proposed apartment redevelopment project on North Avenue in Burlington, Vermont.

1.0 PROJECT DESCRIPTION

This study evaluates the traffic and potential infrastructure impacts associated with this development. As shown in Figure 1, the proposed project will have one access point off North Avenue, ½ mile south of Institute Road. The project entails the redevelopment of 63 apartments in an existing 5-story building (the former Catholic Diocese orphanage), adjacent to the Burlington College administration building. Parking and access for the apartments are to the north and west, as shown in Figure 1.

FIGURE 1: PROJECT SITE PLAN



This study relies upon design standards and analysis procedures documented in the 2010 Highway Capacity Manual,[1] Trip Generation,[2] A Policy on Geometric Design of Highways and Streets,[3] Manual on Uniform Traffic Control Devices (MUTCD),[4] Traffic Impact Evaluation: Study and Review Guide,[5] and the Vermont State Design Standards,[6] which are the generally accepted traffic analysis references relied upon by traffic engineering professionals and VTrans for projects of this type in Vermont.

2.0 PROJECT SCOPE

VTrans guidelines specify that a traffic study should be considered if the proposed development will generate 75 or more peak hour trips. The geographic scope of the study should also include the immediate access points and those intersections or highway segments receiving 75 or more project-generated peak hour trips.[7] We project no intersections will meet the 75 vehicle per hour trip generation threshold. At the request of Burlington planning staff this study also looks at adjacent intersections on North Avenue to determine what if any impacts are realized.

3.0 NORTH AVENUE CORRIDOR STUDY

This project falls within the study area of the North Avenue Corridor Study, performed for the City in cooperation with the Chittenden County Regional Planning Commission. The study was published in September of 2014.

Recommendations in the study in the area of this project include:

- A new crosswalk nearby Burlington College (short term)
- Restriping North Street within the existing curbing limits for new lane and shoulder widths, to include bike lanes in either direction (short term).
- An expanded street cross section to include protected ("buffered") bike lanes (long term).

It should be noted that the existing right of way is sufficient to include these recommendations.

Findings of the study show excellent Levels of Service in both Peak Hours at all study intersections, including those discussed in this traffic impact study. Please see sections 4-5 for details of the congestion effects of this project.

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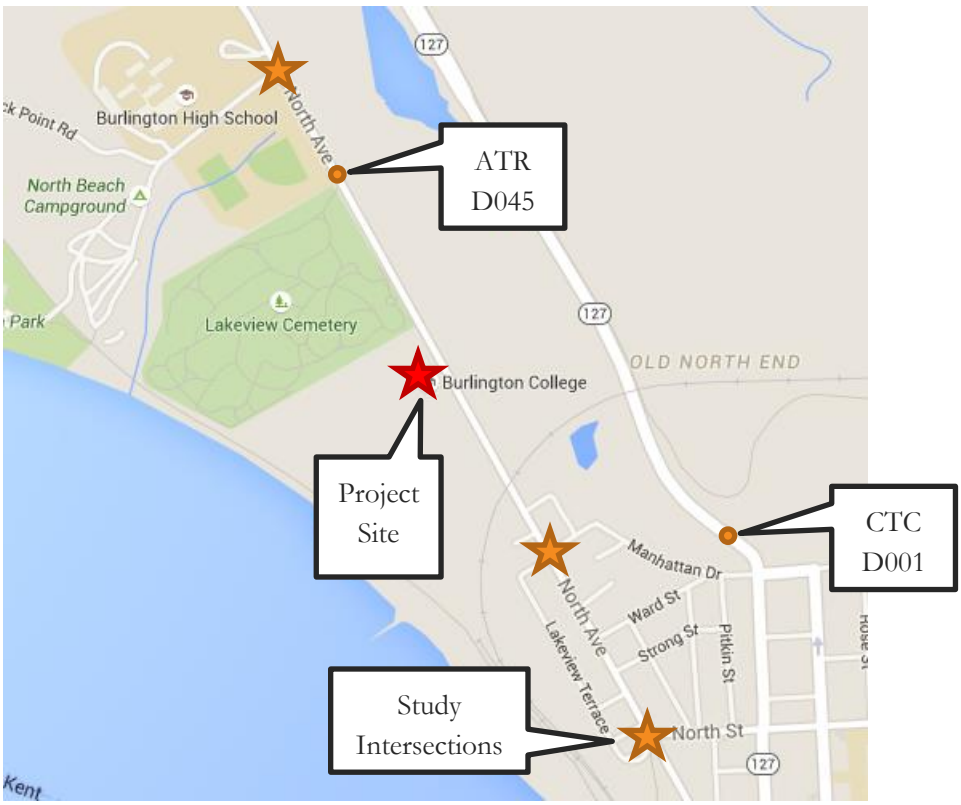
[1] Transportation Research Board, National Research Council, *Highway Capacity Manual* (Washington, DC: National Academy of Sciences, 2010).
[2] Institute of Transportation Engineers, *Trip Generation* 9th Edition (Washington, D.C.: Institute of Transportation Engineers, 2012).
[3] American Association of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets*, 6th Edition (Washington DC: AASHTO, 2011).
[4] American Traffic Safety Services Association (ATSSA), ITE, and AASHTO, *Manual on Uniform Traffic Control Devices*, 2009 Edition (Washington DC: FHWA, 2009).
[5] Vermont Agency of Transportation, Development Review Section, *Traffic Impact Evaluation Study and Review Guide* (October 2008).
[6] State of Vermont Agency of Transportation, *Vermont State Standards* (Montpelier: VTrans, 1 July 1997).
[7] Vermont Agency of Transportation, Development Review Section, *Traffic Impact Evaluation Study and Review Guide* (January 2003).

4.0 LOCAL TRAFFIC

North Avenue is a two-lane minor arterial, posted at 25 miles per hour. In 2013, VTrans recorded an Annual Average Daily Traffic Volume (AADT) of 11,600 vehicles per day along North Avenue at station D045, located 0.1 mile south of Institute Road.

FIGURE 2: PROJECT LOCATION AND STUDY AREA INTERSECTIONS



5.0 ANALYSIS TRAFFIC VOLUMES

This analysis examines AM and PM design hour vehicle delays at the project entrance.

Vehicle delays are examined first with baseline, **No Build** scenario traffic volumes, which represent the anticipated design hour conditions in the target study years without the proposed development in place. In this case, the project access is new, therefore only through traffic on North Avenue is needed to define the base condition.

Once baseline conditions are established, anticipated traffic associated with the proposed development is added to the No Build scenario volumes to create **Build** scenario traffic volumes, which are in turn used to project intersection delays and levels of service with the proposed development in place.

A detailed description of the elements that contribute to the No Build and Build scenario traffic volumes is presented below.

5.1 | BACKGROUND TRAFFIC VOLUMES AND ADJUSTMENTS

RSG obtained the most recent CCRPC turning movement count data for intersections in the influence area of the project, counted in May of 2011.

Following VTrans traffic study guidelines, raw peak hour traffic volumes were adjusted to represent the design hour volume (DHV)[8] in 2016 and 2021[9] using two adjustment factors:

1. Design hour adjustment factors are based on VTrans Continuous Count Station D001 on VT127 near Manhattan Drive and Automatic Traffic Recording station D045, which is located along VT127 just north of the project area (see Figure 2). The 2013 DHV at D001 was compared to the peak hour volumes on the date of each turning movement count to formulate DHV adjustments. DHV adjustments increased the raw count volumes by 7%.
2. An annual adjustment factor, which represents general background traffic growth, is based on historic count data at VTrans permanent count station P6D001 on VT127 near Manhattan Drive, as presented in the 2014 VTrans Red Book. Traffic volumes on VT127 decreased by 4% from 2009 to the 2014 condition. The long term trend in traffic on North Avenue is also negative, decreasing 2% since 2005. Consequently, projections for traffic growth in this area are negative, and as a conservative measure we assume background volumes to be the same in the 2016 build year and 2021 future planning time frame.

5.2 | OTHER DEVELOPMENT VOLUMES

Other development volumes (ODVs) represent trips generated by anticipated developments in the study area. Trips generated by ODVs are included in every scenario (both No Build and Build) because we assume they are already present on the road network in the analysis years.

Through communications with City Planning and Zoning staff, it was determined that the only planned project expected to affect traffic in the project area is the COTS project at the corner of North Avenue and North Street. New trips expected from this project were added to the base condition used for this analysis.

5.3 | PROJECT TRIP GENERATION

Trip generation refers to the number of new vehicle trips originating at or destined for a particular development. To estimate the number of new vehicle trips for the project, we examined trip generation rates presented in the Institute of Transportation Engineer's *Trip Generation Manual*.[10] Applying trip generation rates for ITE Land Use Code 220 (Apartment), we calculate the project will generate approximately 35 trips during the weekday AM peak hour, and 52 new vehicle trips during the PM peak hour. Figure 3 presents the projected trip generation in the weekday peak hours. There are expected to be 505 total weekday trips from the development. Note that based on the parking

[8] The DHV is the 30th highest hour of traffic for the year and is used as the design standard in Vermont.
[9] VTrans requires analysis during the year project construction is expected to be complete and in a future year scenario 5 years after project completion.
[10] Institute of Transportation Engineers, Trip Generation 9th Edition (Washington, D.C.: Institute of Transportation Engineers, 2012).

configuration proposed, approximately 63% of these trips are expected to use the existing (southern) access point, along with the existing Burlington College traffic.

FIGURE 3: PROJECT PEAK HOUR TRIP GENERATION SUMMARY

		AM PEAK		PM PEAK	
ITE Land Use	Size	Enter	Exit	Enter	Exit
Apartments (LUC 220)	63 units	7	28	34	18
total peak hour trips		35		52	

Note that the above estimate is for a generic apartment land use, which includes multi-bedroom suburban examples, and does not take in to account other mitigating circumstances such as the expected higher use of alternate transportation modes (biking, transit, walking) typically found in an urban setting such as this, nor the fact that some significant portion of apartment users are expected to attend or work at Burlington College.

5.4 | BURLINGTON COLLEGE TRAFFIC VOLUMES

As Burlington College is not in full operation during the summer months, this analysis assumes ITE trip generation estimates for existing traffic at the southern entrance. Figure 4 presents the projected trip generation in the weekday peak hours.

FIGURE 4. BURLINGTON COLLEGE PEAK HOUR TRIP GENERATION SUMMARY[11]

		AM PEAK		PM PEAK	
ITE Land Use	students	Enter	Exit	Enter	Exit
College/University (LUC 550)	216 students	29	8	12	25
		37		37	

It should be noted that recent studies of Burlington College traffic have shown this estimate to be very conservative.[12]

5.5 | SCENARIO VOLUME GRAPHICS

Figure 5 represents the peak hour traffic generated by the project, and subsequent trips through adjacent intersection on North Avenue. Note the graphics assume all project trips are combined at one entrance, for the purpose of simplicity.

[11] US News and World Report, 2014-15 enrollment
[12] 9/21/2010 Burlington College Traffic Impact Assessment by Lamoreaux and Dickenson

FIGURE 5: PROJECT PEAK HOUR TRAFFIC

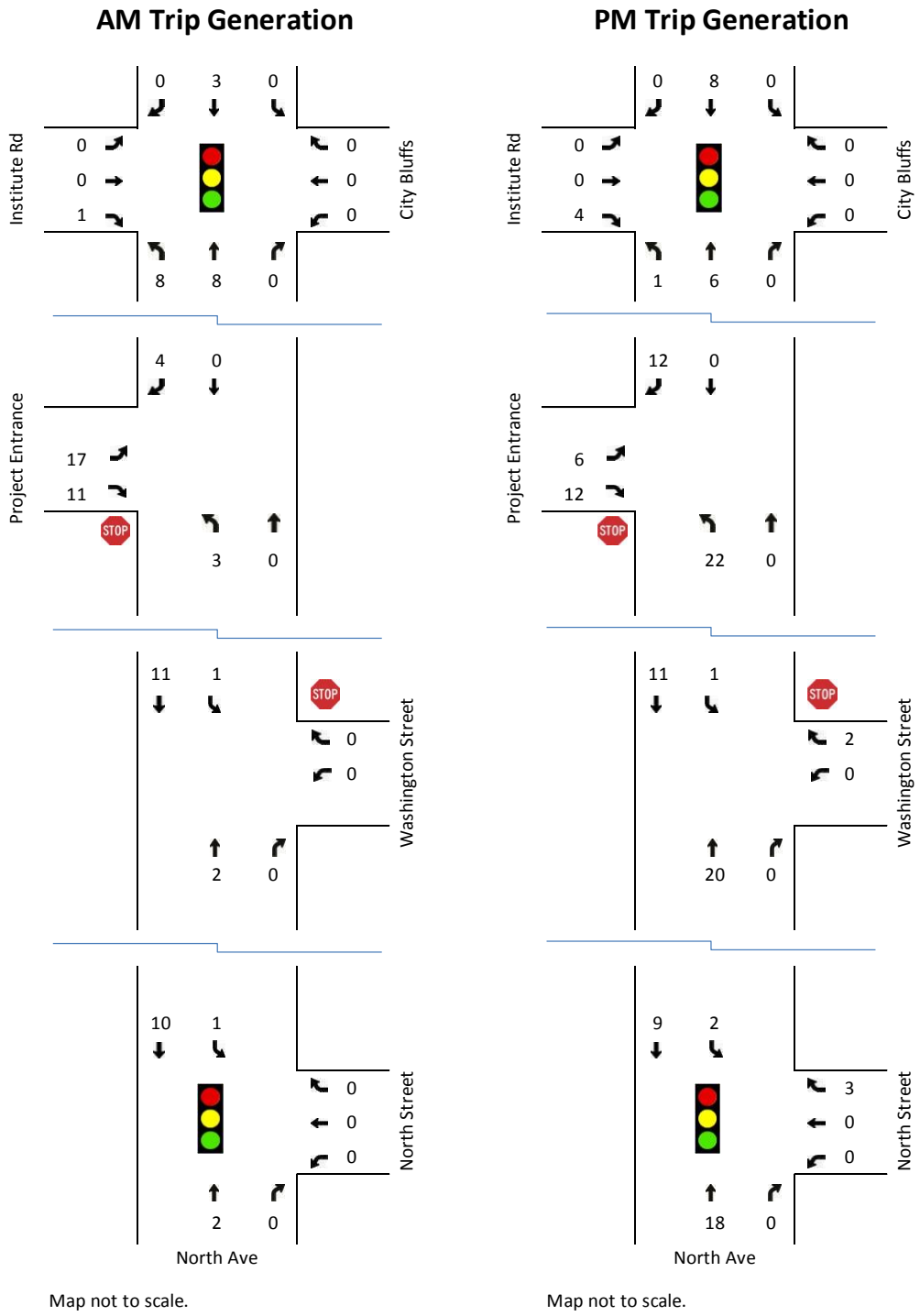
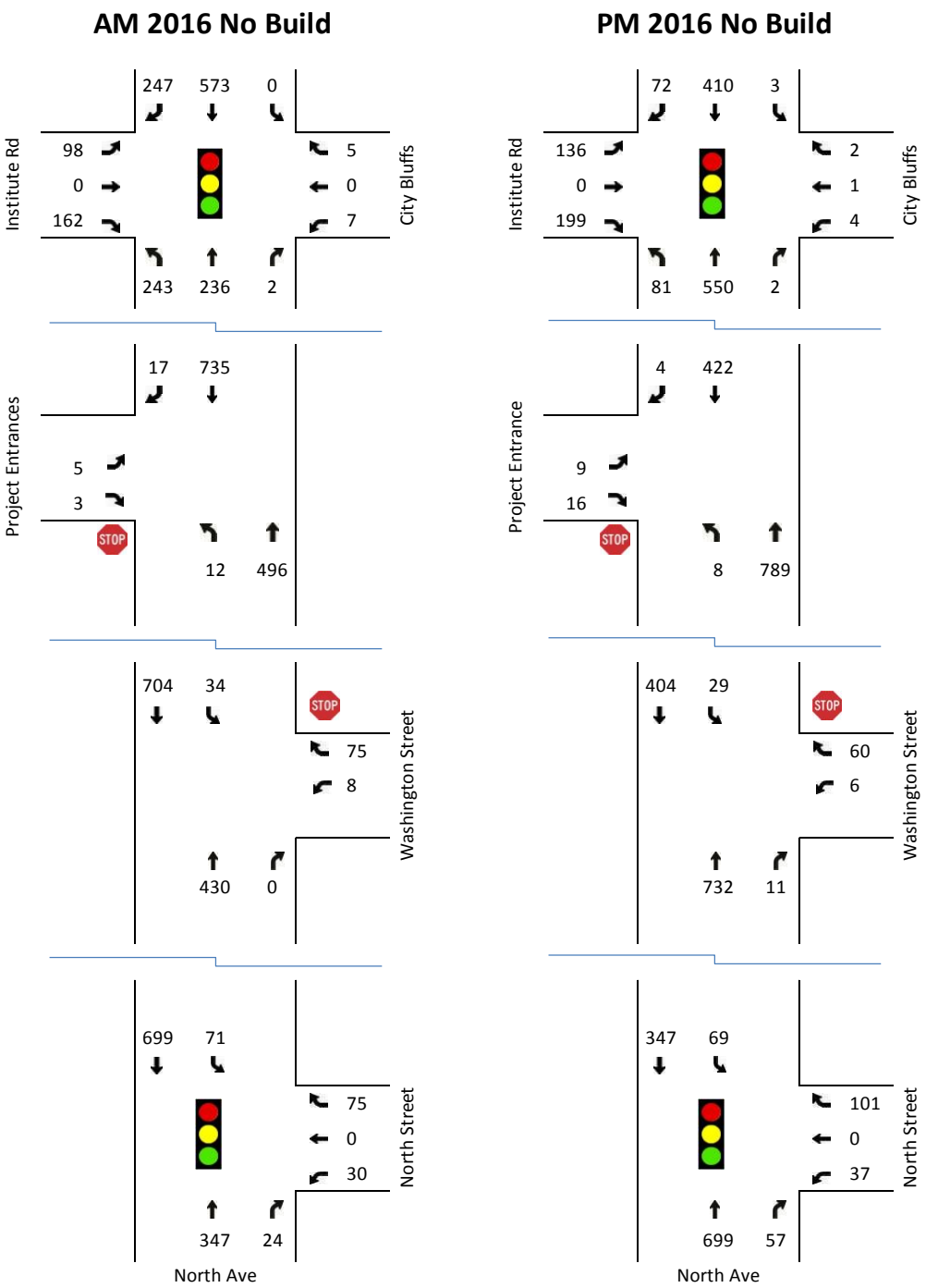


Figure 6 and 7 present the No Build and Build scenario traffic volumes at the study intersection, respectively. No Build traffic volumes include the raw count volumes, adjusted to design hour conditions, and projected traffic from recently permitted developments in the area (ODVs, if applicable). Build scenario volumes represent the addition of project-generated traffic to the No Build traffic volumes.

With the addition of site-generated traffic, volumes entering and exiting the project site increase in the Build scenario and these trips are carried out through the neighboring intersections, where applicable.

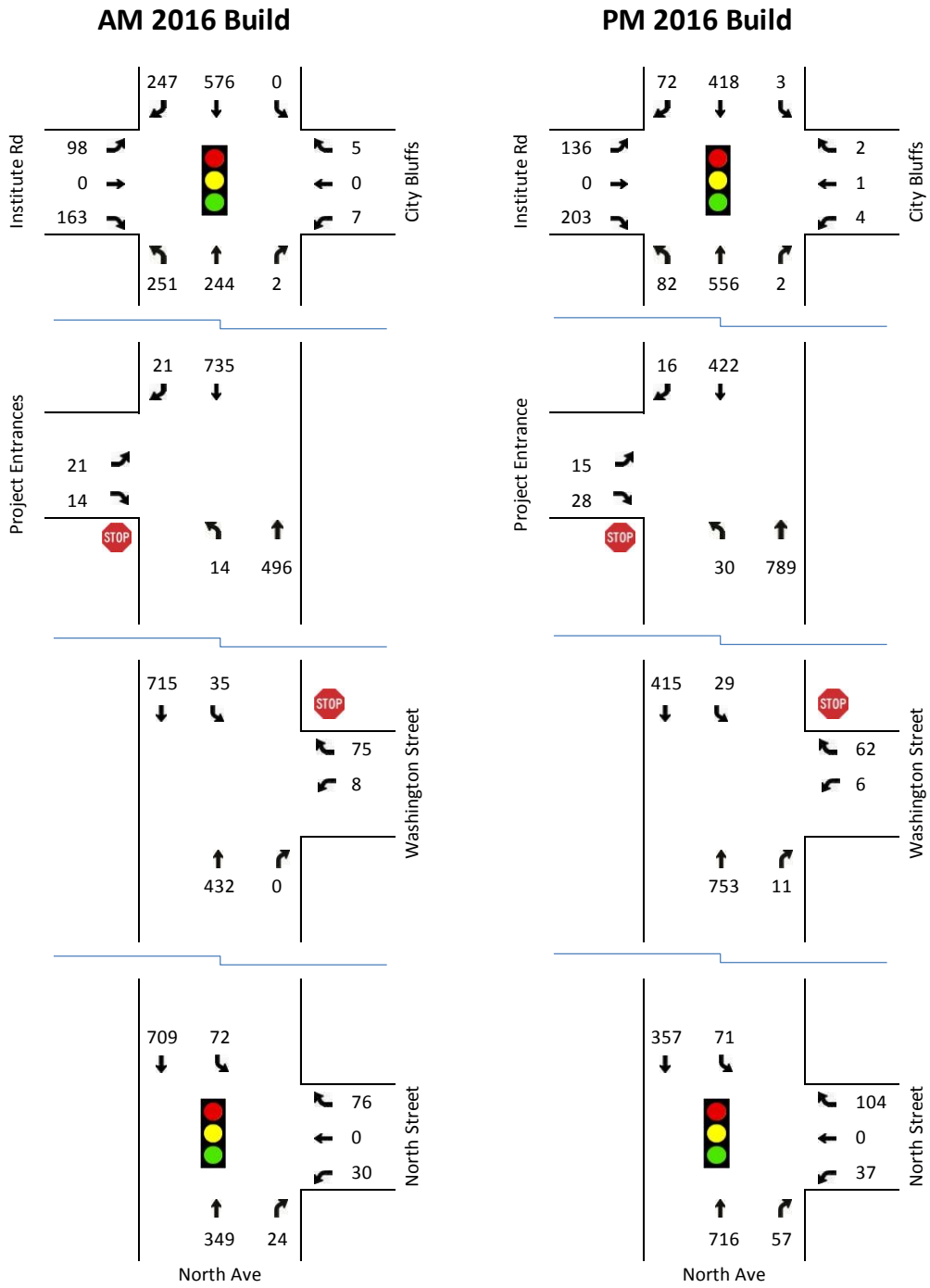
FIGURE 6: PEAK HOUR NO-BUILD TURNING MOVEMENT VOLUMES



Map not to scale.

Map not to scale.

FIGURE 7: PEAK HOUR BUILD TURNING MOVEMENT VOLUMES



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6.0 CONGESTION ANALYSIS

6.1 | LEVEL-OF-SERVICE DEFINITION

Level-of-service (LOS) is a qualitative measure describing the operating conditions as perceived by motorists driving in a traffic stream. LOS is calculated using the procedures outlined in the 2000 and 2010 Highway Capacity Manuals.[13] In addition to traffic volumes, key inputs include the number of lanes at each intersection, traffic control type (signalized or unsignalized), and the traffic signal timing plans (if applicable).

The 2010 Highway Capacity Manual defines six qualitative grades to describe the level of service at an intersection. Level-of-Service is based on the average control delay per vehicle. Figure 8 shows the various LOS grades and descriptions for signalized and unsignalized intersections.

FIGURE 8: LEVEL-OF-SERVICE CRITERIA FOR SIGNALIZED AND UNSIGNALIZED INTERSECTIONS

LOS	CHARACTERISTICS	UNSIGNALIZED TOTAL DELAY (SEC)	SIGNALIZED TOTAL DELAY (SEC)
A	Little or no delay	≤ 10.0	≤ 10.0
B	Short delays	10.1-15.0	10.1-20.0
C	Average delays	15.1-25.0	20.1-35.0
D	Long delays	25.1-35.0	35.1-55.0
E	Very long delays	35.1-50.0	55.1-80.0
F	Extreme delays	> 50.0	> 80.0

The delay thresholds for LOS at signalized and unsignalized intersections differ because of the driver's expectations of the operating efficiency for the respective traffic control conditions. According to HCM procedures, an overall LOS cannot be calculated for two-way stop-controlled intersections because not all movements experience delay. In signalized and all-way stop-controlled intersections, all movements experience delay and an overall LOS can be calculated.

The VTrans policy on level of service is:

- Overall LOS C should be maintained for state-maintained highways and other streets accessing the state's facilities
- Reduced LOS may be acceptable on a case-by-case basis when considering, at minimum, current and future traffic volumes, delays, volume to capacity ratios, crash rates, and negative impacts as a result of improvement necessary to achieve LOS C.
- LOS D should be maintained for side roads with volumes exceeding 100 vehicles/hour for a single lane approach (150 vehicles/hour for a two-lane approach) at two-way stop-controlled intersections.

Detailed Synchro LOS worksheets are attached at the end of this memo.

[13] The HCM 2010 does not provide methodologies for calculating intersection delays at certain intersection types including signalized intersections with exclusive pedestrian phases and signalized intersections with non NEMA-standard phasing. Because of these limitations, HCM 2000 methodologies are employed where necessary.

6.2 | LEVEL-OF-SERVICE RESULTS

The Highway Capacity Manual congestion reports within Synchro (v8), a traffic analysis software package from Trafficware, routinely relied upon by transportation engineering professionals, were used to assess traffic congestion at the study intersections.

Figure 9 presents the LOS, delay (seconds/vehicle), and volume/capacity ratio[14] (v/c) results during the weekday AM and PM peak hour. Since VTrans growth projections in this area are negative, the Build +5 year results are expected to be the same or less. For simplicity the traffic analysis conservatively assumes all new trips will use the existing access to be shared with Burlington College.

These results assume current traffic signal timings where applicable, obtained from the Burlington Department of Public Works,

FIGURE 9: AM AND PM PEAK HOUR LOS RESULTS

	AM Peak Hour						PM Peak Hour					
	Base Year No Build			Base Year Build			Base Year No Build			Base Year Build		
Signalized Intersections	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c	LOS	Delay	v/c
North Ave & Church / 127 Connector												
Overall	B	12	0.66	B	12	0.67	B	19	0.68	B	20	0.68
EB, Alliance Church	C	28	-	C	28	-	C	27	-	C	27	-
WB,VT127 Connector	C	28	-	C	28	-	C	30	-	C	30	-
NB, along North Ave	B	10	-	B	10	-	C	22	-	C	22	-
SB, along North Ave	A	9	-	A	9	-	A	8	-	A	8	-
North Ave & Institute Rd / City Bluffs												
Overall	B	12	0.54	B	12	0.55	B	12	0.49	B	12	0.50
EB, along Institute	C	24	-	C	24	-	C	26	-	C	26	-
WB, exiting City Bluffs	C	26	-	C	26	-	C	25	-	C	25	-
NB, along North Ave	A	5	-	A	5	-	A	5	-	A	5	-
SB, along North Ave	B	12	-	B	12	-	A	10	-	A	10	-
North Ave & 351 North Ave												
EB, exiting project	C	20	0.03	C	23	0.15	C	16	0.07	C	17	0.13
NB, along North Ave	A	0	-	A	1	-	A	0	-	A	<1	-
SB, along North Ave	A	0	-	A	0	-	A	0	-	A	<1	-
North Ave & Washington St												
WB, along Washington St	B	13	0.15	B	13	0.16	C	16	0.17	C	17	0.18
NB, along North Ave	A	0	-	A	0	-	A	0	-	A	<1	-
SB, along North Ave	A	1	-	A	1	-	A	1	-	A	1	-
North Ave & North St												
Overall	A	10	0.52	A	10	0.53	B	12	0.57	B	12	0.59
WB, along North St	C	30	-	C	30	-	C	28	-	C	28	-
NB, along North Ave	A	6	-	A	6	-	B	12	-	B	12	-
SB, along North Ave	A	9	-	A	9	-	A	7	-	A	7	-

[14] v/c, also referred to as the degree of saturation is the fraction of actual volume (v) to theoretical capacity to process vehicles for the given study period (c), thus a v/c value of 1.0 or greater indicates the traffic movement or intersection is at or over capacity.

7.0 SIGHT DISTANCE OBSERVATIONS

As defined in the *2011 Policy on Geometric Design of Highways and Streets,* sight distance is the "the length of roadway ahead that is visible to the driver."[15] Sight distances of sufficient length are necessary at all points along a roadway to ensure vehicles can safely stop or avoid colliding with potential obstructions on the roadway.

Two types of sight distance are routinely examined to ensure safe operations. The first is referred to as Stopping sight distance, and is the distance along a given roadway between a driver's eye and any potential obstruction on the roadway. The second is referred to as intersection corner sight distance and is the distance available between the driver's eye of an intersecting vehicle waiting to join mainline traffic and the driver's eye of an approaching mainline vehicle.

The provision of adequate stopping sight distance is critical for safe operations and design standards are defined based on roadway speed and gradient. For the section of North Avenue proximate to the site access, the minimum design stopping sight distance is 150 feet.

To ensure safe operation, intersection sight distances must also equal the design minimum stopping sight distance (150 feet) but longer intersection sight distances are desirable to improve overall intersection operations and minimize major route deceleration events. The *2011 Policy on Geometric Design of Highways and Streets* states that, "If the available sight distance for an entering or crossing vehicle is at least equal to the appropriate stopping sight distance for the major road, then drivers have sufficient sight distance to anticipate and avoid collisions. However, in some cases, a major-road vehicle may need to stop or slow to accommodate the maneuver by a minor-road vehicle. To enhance traffic operations, intersection sight distances that exceed stopping sight distances are desirable along the major road."[16] The target desirable intersection corner sight distance for a 25 mph roadway is presented to be 275 feet.

The available stopping sight distance approaching the project entrance was measured to be more than 400 feet from either approach. Similarly, corner sight distance from the project access exceeds 400 feet.

8.0 CRASH HISTORIES

VTrans maintains a statewide database of all reported crashes along all state highways and federal aid road segments. Crash histories were reviewed for the most recent 5 years of available data (January 2008 - December 2012). Within this 5 year period, 3 crashes were reported on North Avenue within the design stopping sight distance (150 feet at 25 mph) of the project entrance (North Avenue mile marker 0.78).

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[15] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2011). Page 3-2.

[16] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fifth Edition (Washington D.C.: American Association of State Highway and Transportation Officials, 2011). Page 9-29.

The Vermont Agency of Transportation maintains a list of high crash locations (HCL), which are intersections and roadway segments that have high crash rates over five years compared to other intersections or segments with similar functional classification and traffic levels. In order to be classified as a High Crash Location, an intersection or road segment (0.3 mile segments) must have more than 5 crashes in 5 years and must have an actual crash rate higher than the critical crash rate calculated by VTrans for similar roadways.

There are no high crash locations in the immediate vicinity of this project. The closest HCL is the segment of North Avenue from Sherman Street to North Avenue (mm 0-0.3).

9.0 TURN LANE WARRANT ANALYSIS

In assessing the site access, we conducted a turn lane warrant analysis to determine if projected peak hour traffic volumes are sufficient to meet warrant thresholds for construction of dedicated turn lanes into the project site. We found that a dedicated southbound right turn lane is not warranted in either the AM or PM peak hour build scenarios. Using the Harlmelink methodology for evaluating left turn lanes at unsignalized intersections, as suggested in VTrans' *Traffic Impact Evaluation: Study and Review Guide*, a northbound left turn lane does meet the warrants in the PM peak hour. However, alternate methods for evaluating this warrant[17], which modify the Harmelink Method with more recent queuing theory, does not support this finding. Furthermore, the volumes proposed at the project intersection are significantly less than other existing adjacent unsignalized intersections in the North Avenue corridor (e.g. Washington St. – see Figure 7) which are not experiencing operational issues (see Section 6.2). Given that the VTrans methodology is also suited to more high speed and generally rural applications, we do not recommend a turn lane at this location.

10.0 CONCLUSIONS

The project as proposed will include 63 new studio and one bedroom apartments with associated parking, and one new access point off North Avenue serving a small portion of the new parking. Based on ITE guidelines, we project this project will generate approximately 35 trips during the weekday AM peak hour, and 52 trips in the PM Peak Hour. This estimate, as well as the estimate for existing college traffic should be noted as conservative, for reasons stated in sections 5.3 and 5.4.

The main project entrance, and several adjacent intersections were evaluated for capacity and performance, and were found to meet VTrans guidelines for acceptable levels of service. In addition, no meaningful change in delay or capacity at any study intersection was realized due to the project.

After a review of warrants for additional auxiliary lanes at the project intersection, no additional lanes are recommended for the build condition.

Based on the analysis presented above we conclude that the proposed redevelopment of apartments at 351 North Avenue, as proposed, will not cause unreasonable congestion or unsafe conditions on the local roadway network and will not adversely impact the public investment in roadway infrastructure in the adjacent area.

[17] Kikuchi and Chakroborty Methodology 1991

END OF MEMO

Attachment: Synchro traffic analysis worksheets:

- 2016 AM Peak No-build
- 2016 AM Peak Build
- 2016 PM Peak No-build
- 2016 PM Peak Build

(20 pages total)

HCM Signalized Intersection Capacity Analysis
1: North Ave & Church/127 Connector

8/10/2015

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	7	2	34	11	182	1	237	20	524	671	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Frt		0.98			1.00	0.85		0.99		1.00	1.00	
Flt Protected		0.98			0.96	1.00		1.00		0.95	1.00	
Satd. Flow (prot)		1795			1795	1583		1843		1770	1862	
Flt Permitted		0.89			0.77	1.00		1.00		0.53	1.00	
Satd. Flow (perm)		1622			1434	1583		1841		996	1862	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	5	7	2	34	11	182	1	237	20	524	671	1
RTOR Reduction (vph)	0	2	0	0	0	161	0	3	0	0	0	0
Lane Group Flow (vph)	0	12	0	0	45	21	0	255	0	524	672	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8		8	2			6		
Actuated Green, G (s)		7.8			7.8	7.8		35.6		46.7	46.7	
Effective Green, g (s)		7.8			7.8	7.8		35.6		46.7	46.7	
Actuated g/C Ratio		0.11			0.11	0.11		0.52		0.68	0.68	
Clearance Time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0	3.0		3.0		3.0	3.0	
Lane Grp Cap (vph)		183			162	178		949		742	1260	
v/s Ratio Prot										c0.06	0.36	
v/s Ratio Perm		0.01			c0.03	0.01		0.14		c0.42		
v/c Ratio		0.07			0.28	0.12		0.27		0.71	0.53	
Uniform Delay, d1		27.3			28.0	27.5		9.4		7.5	5.6	
Progression Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Incremental Delay, d2		0.2			0.9	0.3		0.7		3.1	1.6	
Delay (s)		27.5			29.0	27.8		10.1		10.7	7.3	
Level of Service		C			C	C		B		B	A	
Approach Delay (s)		27.5			28.0			10.1			8.8	
Approach LOS		C			C			B			A	

Intersection Summary			
HCM 2000 Control Delay	11.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.66		
Actuated Cycle Length (s)	69.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	66.6%	ICU Level of Service	C
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	98	0	162	7	0	5	242	236	2	0	573	246
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Lane Util. Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Frt		1.00	0.85		0.94		1.00	1.00			1.00	0.85
Flt Protected		0.95	1.00		0.97		0.95	1.00			1.00	1.00
Satd. Flow (prot)		1770	1583		1708		1770	1860			1863	1583
Flt Permitted		0.75	1.00		0.83		0.30	1.00			1.00	1.00
Satd. Flow (perm)		1397	1583		1455		560	1860			1863	1583
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	98	0	162	7	0	5	242	236	2	0	573	246
RTOR Reduction (vph)	0	0	121	0	10	0	0	0	0	0	0	112
Lane Group Flow (vph)	0	98	41	0	2	0	242	238	0	0	573	134
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA			NA	Perm
Protected Phases		4	5		8		5	2			6	
Permitted Phases	4		4	8			2			6		6
Actuated Green, G (s)		9.7	17.9		9.7		50.3	50.3			38.1	38.1
Effective Green, g (s)		9.7	17.9		9.7		50.3	50.3			38.1	38.1
Actuated g/C Ratio		0.14	0.26		0.14		0.72	0.72			0.54	0.54
Clearance Time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Vehicle Extension (s)		4.0	3.0		4.0		3.0	3.0			3.0	3.0
Lane Grp Cap (vph)		193	404		201		544	1336			1014	861
v/s Ratio Prot			0.01				c0.05	0.13			c0.31	
v/s Ratio Perm		c0.07	0.01		0.00		0.27					0.08
v/c Ratio		0.51	0.10		0.01		0.44	0.18			0.57	0.16
Uniform Delay, d1		27.9	19.9		26.0		5.2	3.2			10.5	7.9
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Incremental Delay, d2		2.9	0.1		0.0		0.6	0.3			2.3	0.4
Delay (s)		30.8	20.0		26.0		5.7	3.5			12.8	8.3
Level of Service		C	C		C		A	A			B	A
Approach Delay (s)		24.1			26.0			4.6			11.5	
Approach LOS		C			C			A			B	

Intersection Summary			
HCM 2000 Control Delay	11.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.54		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	14.0
Intersection Capacity Utilization	67.7%	ICU Level of Service	C
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	4	3	11	496	735	17
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	4	3	11	496	735	17
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1262	744	752			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1262	744	752			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	98	99	99			
cM capacity (veh/h)	185	415	858			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	7	507	752
Volume Left	4	11	0
Volume Right	3	0	17
cSH	243	858	1700
Volume to Capacity	0.03	0.01	0.44
Queue Length 95th (ft)	2	1	0
Control Delay (s)	20.3	0.4	0.0
Lane LOS	C	A	
Approach Delay (s)	20.3	0.4	0.0
Approach LOS	C		

Intersection Summary			
Average Delay	0.3		
Intersection Capacity Utilization	49.7%	ICU Level of Service	A
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	7	74	429	0	34	704
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	7	74	429	0	34	704
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1201	429			429	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1201	429			429	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	96	88			97	
cM capacity (veh/h)	198	626			1130	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	81	429	738
Volume Left	7	0	34
Volume Right	74	0	0
cSH	527	1700	1130
Volume to Capacity	0.15	0.25	0.03
Queue Length 95th (ft)	14	0	2
Control Delay (s)	13.1	0.0	0.8
Lane LOS	B		A
Approach Delay (s)	13.1	0.0	0.8
Approach LOS	B		

Intersection Summary			
Average Delay	1.3		
Intersection Capacity Utilization	76.3%	ICU Level of Service	D
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	29	75	346	24	70	698
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0		6.0		6.0	6.0
Lane Util. Factor	1.00		1.00		1.00	1.00
Frt	0.90		0.99		1.00	1.00
Flt Protected	0.99		1.00		0.95	1.00
Satd. Flow (prot)	1658		1846		1770	1863
Flt Permitted	0.99		1.00		0.54	1.00
Satd. Flow (perm)	1658		1846		1001	1863
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	29	75	346	24	70	698
RTOR Reduction (vph)	68	0	1	0	0	0
Lane Group Flow (vph)	36	0	369	0	70	698
Turn Type	Prot		NA		Perm	NA
Protected Phases	8		2			6
Permitted Phases					6	
Actuated Green, G (s)	5.9		42.9		42.9	42.9
Effective Green, g (s)	5.9		42.9		42.9	42.9
Actuated g/C Ratio	0.09		0.64		0.64	0.64
Clearance Time (s)	6.0		6.0		6.0	6.0
Vehicle Extension (s)	3.0		4.0		4.0	4.0
Lane Grp Cap (vph)	145		1176		638	1187
v/s Ratio Prot	c0.02		0.20			c0.37
v/s Ratio Perm					0.07	
v/c Ratio	0.25		0.31		0.11	0.59
Uniform Delay, d1	28.6		5.5		4.8	7.1
Progression Factor	1.00		1.00		1.00	1.00
Incremental Delay, d2	0.9		0.7		0.3	2.2
Delay (s)	29.5		6.2		5.1	9.2
Level of Service	C		A		A	A
Approach Delay (s)	29.5		6.2			8.9
Approach LOS	C		A			A

Intersection Summary			
HCM 2000 Control Delay	9.8	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.52		
Actuated Cycle Length (s)	67.3	Sum of lost time (s)	16.0
Intersection Capacity Utilization	53.0%	ICU Level of Service	A
Analysis Period (min)	60		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
1: North Ave & Church/127 Connector

8/10/2015

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	7	2	34	11	182	1	244	20	524	674	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Frt		0.98			1.00	0.85		0.99		1.00	1.00	
Flt Protected		0.98			0.96	1.00		1.00		0.95	1.00	
Satd. Flow (prot)		1795			1795	1583		1843		1770	1862	
Flt Permitted		0.89			0.77	1.00		1.00		0.53	1.00	
Satd. Flow (perm)		1622			1434	1583		1841		986	1862	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	5	7	2	34	11	182	1	244	20	524	674	1
RTOR Reduction (vph)	0	2	0	0	0	161	0	2	0	0	0	0
Lane Group Flow (vph)	0	12	0	0	45	21	0	263	0	524	675	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8		8	2			6		
Actuated Green, G (s)		7.8			7.8	7.8		35.6		46.7	46.7	
Effective Green, g (s)		7.8			7.8	7.8		35.6		46.7	46.7	
Actuated g/C Ratio		0.11			0.11	0.11		0.52		0.68	0.68	
Clearance Time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0	3.0		3.0		3.0	3.0	
Lane Grp Cap (vph)		183			162	178		949		736	1260	
v/s Ratio Prot										c0.06	0.36	
v/s Ratio Perm		0.01			c0.03	0.01		0.14		c0.42		
v/c Ratio		0.07			0.28	0.12		0.28		0.71	0.54	
Uniform Delay, d1		27.3			28.0	27.5		9.4		7.6	5.7	
Progression Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Incremental Delay, d2		0.2			0.9	0.3		0.7		3.3	1.6	
Delay (s)		27.5			29.0	27.8		10.2		10.9	7.3	
Level of Service		C			C	C		B		B	A	
Approach Delay (s)		27.5			28.0			10.2			8.9	
Approach LOS		C			C			B			A	

Intersection Summary			
HCM 2000 Control Delay	11.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.67		
Actuated Cycle Length (s)	69.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	67.2%	ICU Level of Service	C
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	98	0	162	7	0	5	251	244	2	0	576	246
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Lane Util. Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Frt		1.00	0.85		0.94		1.00	1.00			1.00	0.85
Flt Protected		0.95	1.00		0.97		0.95	1.00			1.00	1.00
Satd. Flow (prot)		1770	1583		1708		1770	1860			1863	1583
Flt Permitted		0.75	1.00		0.83		0.30	1.00			1.00	1.00
Satd. Flow (perm)		1397	1583		1455		555	1860			1863	1583
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	98	0	162	7	0	5	251	244	2	0	576	246
RTOR Reduction (vph)	0	0	120	0	10	0	0	0	0	0	0	112
Lane Group Flow (vph)	0	98	42	0	2	0	251	246	0	0	576	134
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA			NA	Perm
Protected Phases		4	5		8		5	2			6	
Permitted Phases	4		4	8			2			6		6
Actuated Green, G (s)		9.7	18.0		9.7		50.3	50.3			38.0	38.0
Effective Green, g (s)		9.7	18.0		9.7		50.3	50.3			38.0	38.0
Actuated g/C Ratio		0.14	0.26		0.14		0.72	0.72			0.54	0.54
Clearance Time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Vehicle Extension (s)		4.0	3.0		4.0		3.0	3.0			3.0	3.0
Lane Grp Cap (vph)		193	407		201		542	1336			1011	859
v/s Ratio Prot			0.01				c0.05	0.13			c0.31	
v/s Ratio Perm		c0.07	0.01		0.00		0.28					0.08
v/c Ratio		0.51	0.10		0.01		0.46	0.18			0.57	0.16
Uniform Delay, d1		27.9	19.8		26.0		5.3	3.2			10.6	8.0
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Incremental Delay, d2		2.9	0.1		0.0		0.6	0.3			2.4	0.4
Delay (s)		30.8	19.9		26.0		5.9	3.5			12.9	8.4
Level of Service		C	B		C		A	A			B	A
Approach Delay (s)		24.0			26.0			4.7			11.6	
Approach LOS		C			C			A			B	

Intersection Summary			
HCM 2000 Control Delay	11.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	14.0
Intersection Capacity Utilization	67.8%	ICU Level of Service	C
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	21	14	14	496	735	21
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	21	14	14	496	735	21
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1270	746	756			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1270	746	756			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	88	97	98			
cM capacity (veh/h)	183	414	855			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	35	510	756
Volume Left	21	14	0
Volume Right	14	0	21
cSH	235	855	1700
Volume to Capacity	0.15	0.02	0.44
Queue Length 95th (ft)	13	1	0
Control Delay (s)	23.0	0.5	0.0
Lane LOS	C	A	
Approach Delay (s)	23.0	0.5	0.0
Approach LOS	C		

Intersection Summary			
Average Delay	0.8		
Intersection Capacity Utilization	50.0%	ICU Level of Service	A
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	7	75	432	0	34	714
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	7	75	432	0	34	714
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1214	432			432	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1214	432			432	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	96	88			97	
cM capacity (veh/h)	194	624			1128	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	82	432	748
Volume Left	7	0	34
Volume Right	75	0	0
cSH	525	1700	1128
Volume to Capacity	0.16	0.25	0.03
Queue Length 95th (ft)	14	0	2
Control Delay (s)	13.1	0.0	0.8
Lane LOS	B		A
Approach Delay (s)	13.1	0.0	0.8
Approach LOS	B		

Intersection Summary			
Average Delay	1.3		
Intersection Capacity Utilization	76.9%	ICU Level of Service	D
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	29	75	348	24	71	708
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0		6.0		6.0	6.0
Lane Util. Factor	1.00		1.00		1.00	1.00
Frt	0.90		0.99		1.00	1.00
Flt Protected	0.99		1.00		0.95	1.00
Satd. Flow (prot)	1658		1847		1770	1863
Flt Permitted	0.99		1.00		0.54	1.00
Satd. Flow (perm)	1658		1847		998	1863
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	29	75	348	24	71	708
RTOR Reduction (vph)	68	0	1	0	0	0
Lane Group Flow (vph)	36	0	371	0	71	708
Turn Type	Prot		NA		Perm	NA
Protected Phases	8		2			6
Permitted Phases					6	
Actuated Green, G (s)	5.9		42.9		42.9	42.9
Effective Green, g (s)	5.9		42.9		42.9	42.9
Actuated g/C Ratio	0.09		0.64		0.64	0.64
Clearance Time (s)	6.0		6.0		6.0	6.0
Vehicle Extension (s)	3.0		4.0		4.0	4.0
Lane Grp Cap (vph)	145		1177		636	1187
v/s Ratio Prot	c0.02		0.20			c0.38
v/s Ratio Perm					0.07	
v/c Ratio	0.25		0.31		0.11	0.60
Uniform Delay, d1	28.6		5.5		4.8	7.1
Progression Factor	1.00		1.00		1.00	1.00
Incremental Delay, d2	0.9		0.7		0.4	2.2
Delay (s)	29.5		6.2		5.1	9.4
Level of Service	C		A		A	A
Approach Delay (s)	29.5		6.2			9.0
Approach LOS	C		A			A

Intersection Summary			
HCM 2000 Control Delay	9.9	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	67.3	Sum of lost time (s)	16.0
Intersection Capacity Utilization	53.5%	ICU Level of Service	A
Analysis Period (min)	60		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
1: North Ave & Church/127 Connector

8/10/2015

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	6	1	20	2	524	3	659	64	272	347	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Frt		0.99			1.00	0.85		0.99		1.00	1.00	
Flt Protected		0.98			0.96	1.00		1.00		0.95	1.00	
Satd. Flow (prot)		1804			1782	1583		1840		1770	1860	
Flt Permitted		0.90			0.77	1.00		1.00		0.27	1.00	
Satd. Flow (perm)		1657			1426	1583		1839		499	1860	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	5	6	1	20	2	524	3	659	64	272	347	3
RTOR Reduction (vph)	0	1	0	0	0	426	0	3	0	0	0	0
Lane Group Flow (vph)	0	11	0	0	22	98	0	723	0	272	350	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8		8	2			6		
Actuated Green, G (s)		9.8			9.8	9.8		35.7		46.8	46.8	
Effective Green, g (s)		9.8			9.8	9.8		35.7		46.8	46.8	
Actuated g/C Ratio		0.14			0.14	0.14		0.50		0.66	0.66	
Clearance Time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0	3.0		3.0		3.0	3.0	
Lane Grp Cap (vph)		228			196	218		923		437	1224	
v/s Ratio Prot										c0.05	0.19	
v/s Ratio Perm		0.01			0.02	c0.06		c0.39		0.36		
v/c Ratio		0.05			0.11	0.45		0.78		0.62	0.29	
Uniform Delay, d1		26.6			26.8	28.2		14.5		8.2	5.1	
Progression Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Incremental Delay, d2		0.1			0.3	1.5		6.9		2.8	0.6	
Delay (s)		26.7			27.1	29.7		21.5		11.0	5.7	
Level of Service		C			C	C		C		B	A	
Approach Delay (s)		26.7			29.6			21.5			8.0	
Approach LOS		C			C			C			A	

Intersection Summary			
HCM 2000 Control Delay	19.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	71.1	Sum of lost time (s)	17.0
Intersection Capacity Utilization	87.0%	ICU Level of Service	E
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	136	0	198	4	1	2	81	550	2	3	410	71
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Lane Util. Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Frt		1.00	0.85		0.96		1.00	1.00			1.00	0.85
Flt Protected		0.95	1.00		0.97		0.95	1.00			1.00	1.00
Satd. Flow (prot)		1770	1583		1741		1770	1862			1862	1583
Flt Permitted		0.75	1.00		0.84		0.42	1.00			1.00	1.00
Satd. Flow (perm)		1403	1583		1513		778	1862			1858	1583
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	136	0	198	4	1	2	81	550	2	3	410	71
RTOR Reduction (vph)	0	0	149	0	2	0	0	0	0	0	0	32
Lane Group Flow (vph)	0	136	50	0	5	0	81	552	0	0	413	39
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA		Perm	NA	Perm
Protected Phases		4	5		8		5	2			6	
Permitted Phases	4		4	8			2			6		6
Actuated Green, G (s)		10.9	17.5		10.9		49.1	49.1			38.5	38.5
Effective Green, g (s)		10.9	17.5		10.9		49.1	49.1			38.5	38.5
Actuated g/C Ratio		0.16	0.25		0.16		0.70	0.70			0.55	0.55
Clearance Time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Vehicle Extension (s)		4.0	3.0		4.0		3.0	3.0			3.0	3.0
Lane Grp Cap (vph)		218	395		235		639	1306			1021	870
v/s Ratio Prot			0.01				0.01	c0.30				
v/s Ratio Perm		c0.10	0.02		0.00		0.08				0.22	0.02
v/c Ratio		0.62	0.13		0.02		0.13	0.42			0.40	0.04
Uniform Delay, d1		27.6	20.3		25.0		3.8	4.4			9.1	7.3
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Incremental Delay, d2		6.3	0.1		0.1		0.1	1.0			1.2	0.1
Delay (s)		34.0	20.5		25.1		3.9	5.4			10.3	7.4
Level of Service		C	C		C		A	A			B	A
Approach Delay (s)		26.0			25.1			5.2			9.9	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM 2000 Control Delay	11.6	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	14.0
Intersection Capacity Utilization	75.1%	ICU Level of Service	D
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	8	16	7	788	422	4
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	8	16	7	788	422	4
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1226	424	426			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1226	424	426			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	96	97	99			
cM capacity (veh/h)	196	630	1133			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	24	795	426
Volume Left	8	7	0
Volume Right	16	0	4
cSH	362	1133	1700
Volume to Capacity	0.07	0.01	0.25
Queue Length 95th (ft)	5	0	0
Control Delay (s)	15.6	0.2	0.0
Lane LOS	C	A	
Approach Delay (s)	15.6	0.2	0.0
Approach LOS	C		

Intersection Summary			
Average Delay	0.4		
Intersection Capacity Utilization	57.0%	ICU Level of Service	B
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	6	59	732	10	28	403
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	6	59	732	10	28	403
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1196	737			742	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1196	737			742	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	97	86			97	
cM capacity (veh/h)	199	418			865	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	65	742	431
Volume Left	6	0	28
Volume Right	59	10	0
cSH	380	1700	865
Volume to Capacity	0.17	0.44	0.03
Queue Length 95th (ft)	15	0	3
Control Delay (s)	16.4	0.0	1.0
Lane LOS	C		A
Approach Delay (s)	16.4	0.0	1.0
Approach LOS	C		

Intersection Summary			
Average Delay	1.2		
Intersection Capacity Utilization	54.9%	ICU Level of Service	A
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	36	101	698	57	69	347
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0		6.0		6.0	6.0
Lane Util. Factor	1.00		1.00		1.00	1.00
Frt	0.90		0.99		1.00	1.00
Flt Protected	0.99		1.00		0.95	1.00
Satd. Flow (prot)	1656		1844		1770	1863
Flt Permitted	0.99		1.00		0.26	1.00
Satd. Flow (perm)	1656		1844		488	1863
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	36	101	698	57	69	347
RTOR Reduction (vph)	90	0	2	0	0	0
Lane Group Flow (vph)	47	0	753	0	69	347
Turn Type	Prot		NA		Perm	NA
Protected Phases	8		2			6
Permitted Phases					6	
Actuated Green, G (s)	7.4		41.2		41.2	41.2
Effective Green, g (s)	7.4		41.2		41.2	41.2
Actuated g/C Ratio	0.11		0.61		0.61	0.61
Clearance Time (s)	6.0		6.0		6.0	6.0
Vehicle Extension (s)	3.0		4.0		4.0	4.0
Lane Grp Cap (vph)	182		1132		299	1143
v/s Ratio Prot	c0.03		c0.41			0.19
v/s Ratio Perm					0.14	
v/c Ratio	0.26		0.67		0.23	0.30
Uniform Delay, d1	27.3		8.5		5.8	6.1
Progression Factor	1.00		1.00		1.00	1.00
Incremental Delay, d2	0.8		3.1		1.8	0.7
Delay (s)	28.1		11.6		7.6	6.8
Level of Service	C		B		A	A
Approach Delay (s)	28.1		11.6			7.0
Approach LOS	C		B			A

Intersection Summary			
HCM 2000 Control Delay	11.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	67.1	Sum of lost time (s)	16.0
Intersection Capacity Utilization	67.2%	ICU Level of Service	C
Analysis Period (min)	60		
c Critical Lane Group			

HCM Signalized Intersection Capacity Analysis
1: North Ave & Church/127 Connector

8/10/2015

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	5	6	1	20	2	524	3	664	64	272	355	3
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Lane Util. Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Frt		0.99			1.00	0.85		0.99		1.00	1.00	
Flt Protected		0.98			0.96	1.00		1.00		0.95	1.00	
Satd. Flow (prot)		1804			1782	1583		1840		1770	1860	
Flt Permitted		0.90			0.77	1.00		1.00		0.27	1.00	
Satd. Flow (perm)		1658			1428	1583		1839		494	1860	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	5	6	1	20	2	524	3	664	64	272	355	3
RTOR Reduction (vph)	0	1	0	0	0	424	0	3	0	0	0	0
Lane Group Flow (vph)	0	11	0	0	22	100	0	728	0	272	358	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		pm+pt	NA	
Protected Phases		4			8			2		1	6	
Permitted Phases	4			8		8	2			6		
Actuated Green, G (s)		9.9			9.9	9.9		35.7		46.8	46.8	
Effective Green, g (s)		9.9			9.9	9.9		35.7		46.8	46.8	
Actuated g/C Ratio		0.14			0.14	0.14		0.50		0.66	0.66	
Clearance Time (s)		5.0			5.0	5.0		5.0		5.0	5.0	
Vehicle Extension (s)		3.0			3.0	3.0		3.0		3.0	3.0	
Lane Grp Cap (vph)		230			198	220		922		434	1222	
v/s Ratio Prot										c0.05	0.19	
v/s Ratio Perm		0.01			0.02	c0.06		c0.40		0.36		
v/c Ratio		0.05			0.11	0.45		0.79		0.63	0.29	
Uniform Delay, d1		26.6			26.8	28.2		14.7		8.2	5.2	
Progression Factor		1.00			1.00	1.00		1.00		1.00	1.00	
Incremental Delay, d2		0.1			0.2	1.5		7.2		2.9	0.6	
Delay (s)		26.7			27.1	29.6		21.8		11.1	5.8	
Level of Service		C			C	C		C		B	A	
Approach Delay (s)		26.7			29.5			21.8			8.1	
Approach LOS		C			C			C			A	

Intersection Summary			
HCM 2000 Control Delay	19.5	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.68		
Actuated Cycle Length (s)	71.2	Sum of lost time (s)	17.0
Intersection Capacity Utilization	87.3%	ICU Level of Service	E
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	136	0	202	4	1	2	82	555	2	3	418	71
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Lane Util. Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Frt		1.00	0.85		0.96		1.00	1.00			1.00	0.85
Flt Protected		0.95	1.00		0.97		0.95	1.00			1.00	1.00
Satd. Flow (prot)		1770	1583		1741		1770	1862			1862	1583
Flt Permitted		0.75	1.00		0.84		0.41	1.00			1.00	1.00
Satd. Flow (perm)		1403	1583		1513		767	1862			1858	1583
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	136	0	202	4	1	2	82	555	2	3	418	71
RTOR Reduction (vph)	0	0	152	0	2	0	0	0	0	0	0	32
Lane Group Flow (vph)	0	136	51	0	5	0	82	557	0	0	421	39
Turn Type	Perm	NA	pm+ov	Perm	NA		pm+pt	NA		Perm	NA	Perm
Protected Phases		4	5		8		5	2			6	
Permitted Phases	4		4	8			2			6		6
Actuated Green, G (s)		10.9	17.5		10.9		49.1	49.1			38.5	38.5
Effective Green, g (s)		10.9	17.5		10.9		49.1	49.1			38.5	38.5
Actuated g/C Ratio		0.16	0.25		0.16		0.70	0.70			0.55	0.55
Clearance Time (s)		5.0	4.0		5.0		4.0	5.0			5.0	5.0
Vehicle Extension (s)		4.0	3.0		4.0		3.0	3.0			3.0	3.0
Lane Grp Cap (vph)		218	395		235		632	1306			1021	870
v/s Ratio Prot			0.01				0.01	c0.30				
v/s Ratio Perm		c0.10	0.02		0.00		0.08				0.23	0.02
v/c Ratio		0.62	0.13		0.02		0.13	0.43			0.41	0.04
Uniform Delay, d1		27.6	20.3		25.0		3.9	4.5			9.2	7.3
Progression Factor		1.00	1.00		1.00		1.00	1.00			1.00	1.00
Incremental Delay, d2		6.3	0.1		0.1		0.1	1.0			1.2	0.1
Delay (s)		34.0	20.5		25.1		3.9	5.5			10.4	7.4
Level of Service		C	C		C		A	A			B	A
Approach Delay (s)		25.9			25.1			5.3			10.0	
Approach LOS		C			C			A			A	

Intersection Summary			
HCM 2000 Control Delay	11.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.50		
Actuated Cycle Length (s)	70.0	Sum of lost time (s)	14.0
Intersection Capacity Utilization	75.8%	ICU Level of Service	D
Analysis Period (min)	60		
c Critical Lane Group			

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	15	28	29	788	422	15
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	15	28	29	788	422	15
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1276	430	437			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1276	430	437			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	92	96	97			
cM capacity (veh/h)	179	626	1123			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	43	817	437
Volume Left	15	29	0
Volume Right	28	0	15
cSH	335	1123	1700
Volume to Capacity	0.13	0.03	0.26
Queue Length 95th (ft)	11	2	0
Control Delay (s)	17.3	0.7	0.0
Lane LOS	C	A	
Approach Delay (s)	17.3	0.7	0.0
Approach LOS	C		

Intersection Summary			
Average Delay	1.0		
Intersection Capacity Utilization	74.9%	ICU Level of Service	D
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	6	61	752	10	29	414
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00
Hourly flow rate (vph)	6	61	752	10	29	414
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1229	757			762	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1229	757			762	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	97	85			97	
cM capacity (veh/h)	190	408			850	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	67	762	443
Volume Left	6	0	29
Volume Right	61	10	0
cSH	370	1700	850
Volume to Capacity	0.18	0.45	0.03
Queue Length 95th (ft)	17	0	3
Control Delay (s)	16.9	0.0	1.0
Lane LOS	C		A
Approach Delay (s)	16.9	0.0	1.0
Approach LOS	C		

Intersection Summary			
Average Delay	1.2		
Intersection Capacity Utilization	56.4%	ICU Level of Service	B
Analysis Period (min)	60		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (vph)	36	103	716	57	70	356
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.0		6.0		6.0	6.0
Lane Util. Factor	1.00		1.00		1.00	1.00
Frt	0.90		0.99		1.00	1.00
Flt Protected	0.99		1.00		0.95	1.00
Satd. Flow (prot)	1655		1844		1770	1863
Flt Permitted	0.99		1.00		0.25	1.00
Satd. Flow (perm)	1655		1844		466	1863
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	36	103	716	57	70	356
RTOR Reduction (vph)	92	0	2	0	0	0
Lane Group Flow (vph)	47	0	771	0	70	356
Turn Type	Prot		NA		Perm	NA
Protected Phases	8		2			6
Permitted Phases					6	
Actuated Green, G (s)	7.4		41.0		41.0	41.0
Effective Green, g (s)	7.4		41.0		41.0	41.0
Actuated g/C Ratio	0.11		0.61		0.61	0.61
Clearance Time (s)	6.0		6.0		6.0	6.0
Vehicle Extension (s)	3.0		4.0		4.0	4.0
Lane Grp Cap (vph)	183		1130		285	1141
v/s Ratio Prot	c0.03		c0.42			0.19
v/s Ratio Perm					0.15	
v/c Ratio	0.26		0.68		0.25	0.31
Uniform Delay, d1	27.2		8.6		5.9	6.2
Progression Factor	1.00		1.00		1.00	1.00
Incremental Delay, d2	0.8		3.4		2.1	0.7
Delay (s)	28.0		12.0		8.0	6.9
Level of Service	C		B		A	A
Approach Delay (s)	28.0		12.0			7.1
Approach LOS	C		B			A

Intersection Summary			
HCM 2000 Control Delay	12.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.59		
Actuated Cycle Length (s)	66.9	Sum of lost time (s)	16.0
Intersection Capacity Utilization	68.4%	ICU Level of Service	C
Analysis Period (min)	60		

c Critical Lane Group