RESOURCE
SYSTEMS GROUP
INCORPORATED

MEMORANDUM

To: Justin Rabidoux
From: R. Chamberlin, J. Choi
Subject: South Winooski Avenue Lane Reduction
Date: 13 May 2002

Resource Systems Group was asked to explore the impact on traffic during the PM peak hour of converting the cross-section of South Winooski Avenue between Main Street and Pearl Street from 4 lanes to 3 lanes. This conversion would result in 1 northbound lane, 1 southbound lane, and a shared center two-way left-turn lane (TWLTL). This section of South Winooski Avenue is shown in Figure 1.

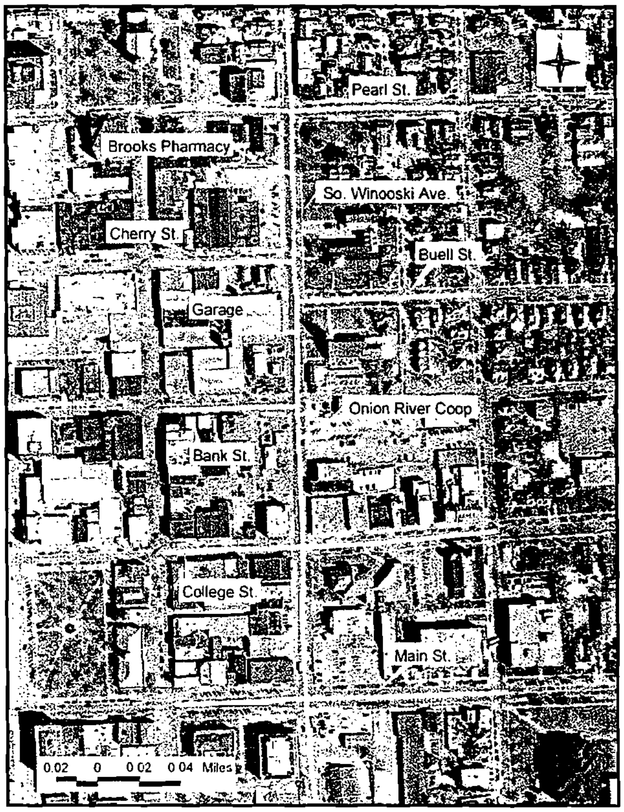
This analysis has 4 points:

- Approach
- Impacts on Congestion
- Design/Safety Issues
- Impacts on Queuing
- Recommendations

865 – 5833

331 Olcott Drive, White River Junction, Vermont 05001
TEL 802.295.4999 ▪ FAX 802.295.1006 ▪ www.rsginc.com

Figure 1: Site Map



Approach

In order to conduct our analysis, we created two scenarios:

- 2002 PM No Build – 4 lanes across with existing lane geometries
- 2002 PM Build – reduction in total lanes from 4 to 3, as described

To create the No Build scenario, raw turning movement volumes were adjusted to represent 2002 design hour volumes using data from Continuous Traffic Counter D001, located on VT 127 in Burlington, VT, and the 1994, 1997, and 2000 Continuous Traffic Counter Grouping Study & Regression Analysis (VTrans, 1994, 1997, 2000). The design hour is the 30th highest hour of traffic in a year for a specific intersection.

The following four intersections used synthesized volumes based on neighboring counts, background traffic flow, and trip generation estimates:

- South Winooski Avenue and Brooks Pharmacy

- South Winooski Avenue and Buell Street
- South Winooski Avenue and Garage Exit
- South Winooski Avenue and Onion River Cooperative

The adjusted volumes were then balanced so that the same number of vehicles that left one intersection arrived at the next intersection.

To create the Build scenario, we changed the lane geometries to account for the reduction in total lanes from 4 to 3, including a TWLTL. Figure 2 illustrates the current lane geometries and Figure 3 displays the proposed lane geometries.

All scenarios were simulated using SimTraffic 5.

Figure 2: Current Lane Geometries

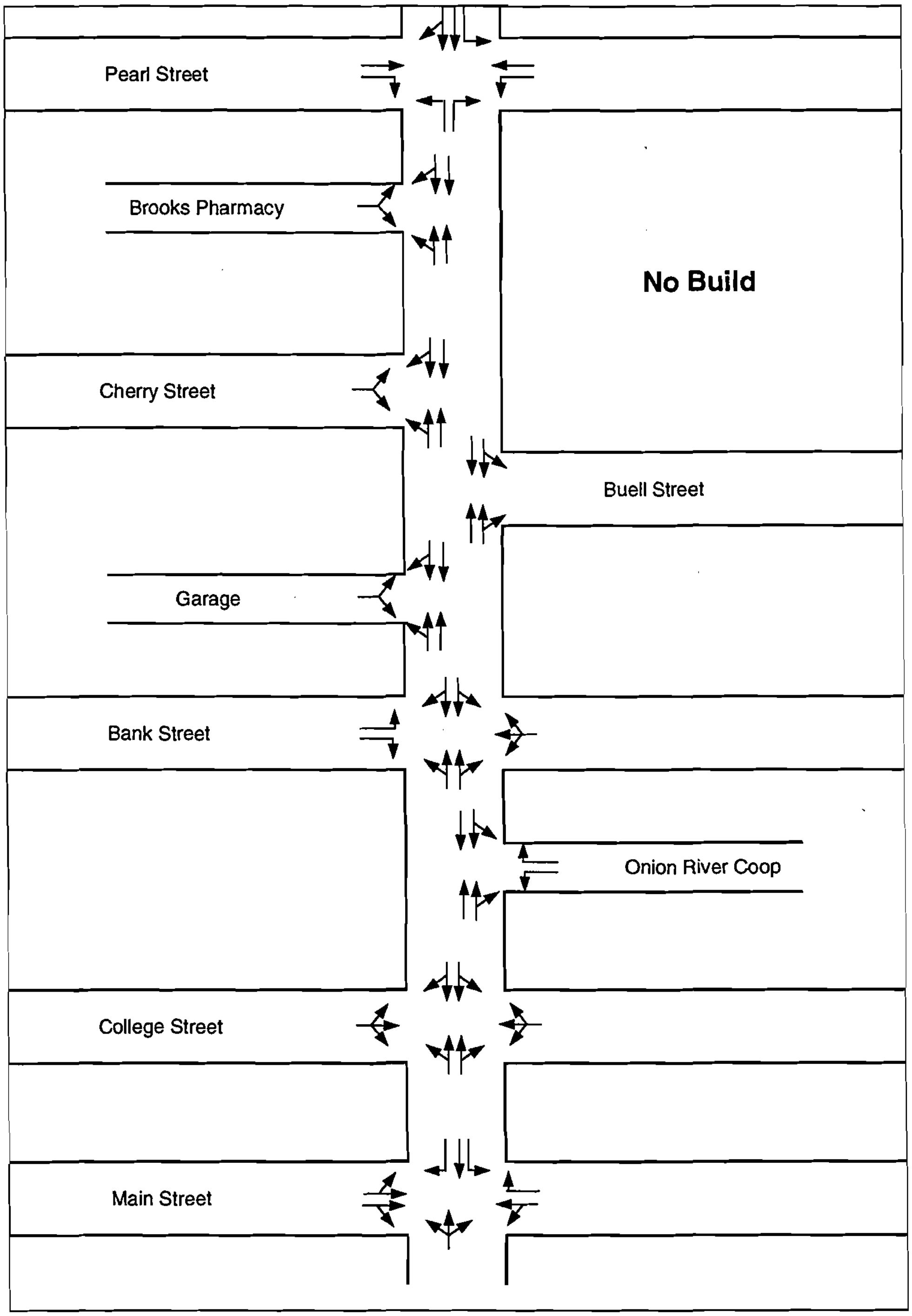
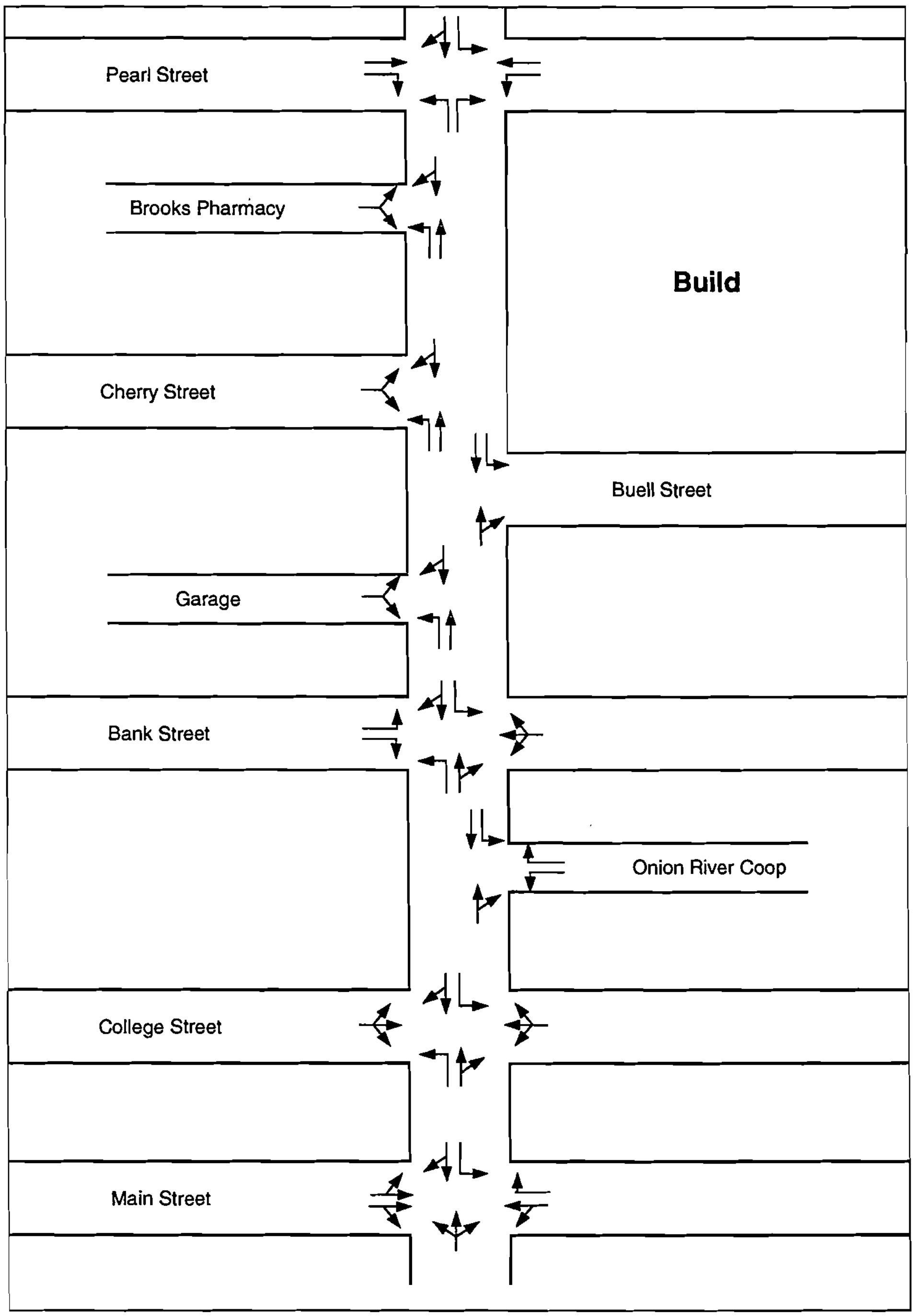


Figure 3: Proposed Lane Geometries



Impacts on Congestion

Using the balanced and adjusted volumes and the existing signal timings, we entered these data into a network rendered using the Synchro (v5) traffic software package. After the data were entered, we created Synchro HCM Signalized and Unsignalized reports to measure the levels of service for existing conditions and Build conditions. Lastly, we optimized the green time allocation to produce the best levels of service with the new geometries and the existing 90-second cycle length.

To assess the impact of the geometry changes, we compared the levels of service from the No Build scenario to the levels of service from the Build scenario. The level-of-service results for signalized and unsignalized intersections are summarized in Table 1 and Table 2, respectively.

Table 1: Signalized Level-of-Service Results

Intersection	No Build		Build		Build Optimized	
	LOS	Delay	LOS	Delay	LOS	Delay
So. Winooski Ave. & Pearl Street						
Average Intersection	C	29	C	29	C	31
EB	C	27	C	27	C	35
WB	C	25	C	25	C	28
NB	C	34	C	34	C	27
SB	C	30	C	30	D	38
So. Winooski Ave. & Cherry Street						
Average Intersection	A	10	B	12	B	12
EB	C	31	C	31	C	31
NB	A	7	A	8	A	8
SB	A	6	A	10	A	10
So. Winooski Ave. & Bank Street						
Average Intersection	B	12	B	14	B	14
EB	D	54	D	54	C	35
WB	C	32	C	32	C	27
NB	A	3	A	4	A	6
SB	A	4	A	8	B	13
So. Winooski Ave. & College Street						
Average Intersection	B	18	C	22	C	22
EB	C	34	C	34	C	34
WB	D	36	D	36	D	36
NB	A	8	A	10	A	10
SB	B	11	B	18	B	18
So. Winooski Ave. & Main Street						
Average Intersection	C	26	E	59	C	24
EB	A	8	A	8	B	19
WB	A	10	A	10	C	23
NB	D	53	F	>100	C	34
SB	D	48	F	>100	C	27

Table 2: Unsignalized Level-of-Service Results

Intersection	No Build		Build	
	LOS	Delay	LOS	Delay
So. Winooski Ave. & Buell Street				
(entering Buell Street) SBLT	A	0	A	9
So. Winooski Ave. & Garage				
(exiting garage) EBLR	C	23	D	34
So. Winooski Ave. & Brooks Pharmacy				
(exiting pharmacy) EBLR	C	17	C	22
(entering pharmacy) NBLT	A	2	A	9
So. Winooski Ave. & Onion River Coop				
(exiting Coop) WBL	C	21	D	31
(exiting Coop) WBR	A	10	B	11
(entering Coop) SBLT	A	2	A	8

Overall, the estimated delay does not significantly increase with the geometry changes. Only the South Winooski Avenue/Main Street intersection shows a significant increase in delay. However, a simple reallocation of green time appears to produce an improved level of service with only a moderate increase in delay. It is important to note that we must reallocate green time from Main Street in order to achieve this improved level of service. This may disrupt eastbound and southbound flows along the Main Street corridor.

Redistributing green time also creates a more balanced level of service for the four approaches at the South Winooski Avenue/Bank Street intersection. Thus, the effect of a reduction in lanes does not seem to have a significant negative impact on level-of-service provided that the signals are retimed. The coordination of signals along this corridor would most likely produce even shorter delays.

Design/Safety Issues

The American Association of State Highway and Transportation Officials (AASHTO) recommend two-way left-turn lanes "only in an urban setting where operating speeds are relatively low and where there are no more than two through lanes in each direction."[1] This section of South Winooski Avenue falls under this description. Thus, design policy allows for the construction of this two-way left-turn lane.

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[1] AASHTO, *A Policy on Geometric Design of Highways and Streets 2001*, 4th Edition, (Washington, D.C.: American Association of State Highway and Transportation Officials, 2001) 717.

Studies have shown that two-way left-turn lanes reduce the number of automobile crashes on arterials carrying moderate traffic volumes, an Annual Daily Traffic (ADT) volume of less than 20-25,000 VPD. The study segment of South Winooski Avenue has an ADT roughly between 11,000 and 15,000 vehicles per day. Vehicles utilizing a TWLTL on roadways with an ADT of greater than 28,000 vehicles per day will have difficulty finding acceptable gaps.[1]

A report for the Minnesota Department of Transportation found that four-lane undivided roadways had a 35% greater collision rate than three-lane roadways.[2] The reduction in accidents is a result of the limited number of conflict points and enhanced sight distance for turning and crossing traffic.[3] The TWLTL removes left-turning vehicles from the traffic stream thereby reducing the risk of rear-end collisions while also improving the flow of through traffic.[4]

However, a TWLTL does not provide the pedestrian with a refuge while crossing the street like a raised median does. Welch argues that the TWLTL actually serves as a pedestrian refuge because the lower volume of traffic and slower vehicle speeds within the lane would allow pedestrians to stop there when necessary.[5] Despite his argument, a TWLTL still does not provide as much pedestrian protection as a raised median.

Additionally, some community members are intimidated by the TWLTL because it is viewed as a "suicide lane." The lack of clearly demarcated lanes for each direction is seen to invite head-on collisions. The continuous TWLTL also is somewhat chaotic and difficult to maneuver through. Although community members in residential areas tend to prefer raised medians that limit access to

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[1] Dixon, Karen, John L. Hibbard, and Chris Mroczka. "Public Perception of Median Treatment for Developed Urban Roads." *TRB Circular E-C019: Urban Street Symposium* (1999): C-4/2.

[2] Preston, H.R. *Statistical Relationship Between Vehicular Crashes and Highway Access.* Report for Minnesota Department of Transportation, 1988, figure 1-1. As quoted in Welch, Thomas. "The Conversion of Four-Lane Undivided Urban Roadways to Three-Lane Facilities." *TRB Circular E-C019: Urban Street Symposium* (1999): F-4/3.

[3] Welch, Thomas. "The Conversion of Four-Lane Undivided Urban Roadways to Three-Lane Facilities." *TRB Circular E-C019: Urban Street Symposium* (1999): F-4/4.

[4] The Institute of Transportation Engineers Traffic Engineering Council. "Median Treatments." *Traffic Information Program Series* (c. 2001) 2.

[5] Welch, Thomas. "The Conversion of Four-Lane Undivided Urban Roadways to Three-Lane Facilities." *TRB Circular E-C019: Urban Street Symposium* (1999): F-4/6.

specific curb cuts, the business community generally advocates TWLTLs because it provides two-way access to their property.[1]

Impact on Queuing

Besides safety issues, the other concern with reducing the number of lanes along South Winooski Avenue deals with the availability of queuing space. Table 3 shows the 50^{th} percentile estimated queue lengths for each signalized intersection. The 50^{th} percentile queue represents average queue lengths during the PM peak hour.

Queue lengths that are longer than the block length are shown in red. One must keep in mind that although queue lengths may fit into the available storage length, that storage length must actually be shared between the northbound left-turn lane of one intersection and the southbound left-turn lane of the intersection neighboring on the south.

We must keep in mind the Synchro is not capable of modeling an explicit TWLTL. Thus, the software may think it only has a certain amount of left-turn storage space but because the TWLTL is continuous, storage space is actually longer.

[1] Dixon, Karen, John L. Hibbard, and Chris Mroczka. "Public Perception of Median Treatment for Developed Urban Roads." *TRB Circular E-C019: Urban Street Symposium* (1999): C-4/9, 11.

Table 3: Estimated 50th Percentile Queue Lengths for Signalized Intersections Along South Winooski Avenue

		Queue Lengths (feet) 50th Percentile		
Intersection		No Build	Build	Build Opt
So. Winooski Ave. & Pearl Street				
potential NB storage length:	NBL	101	101	97
381 ft. from Cherry St. to Pearl St.	NBR	0	0	0
So. Winooski Ave. & Cherry Street				
potential NB storage length:	NBTL	58		
102 ft. from Buell St. to Cherry St.	NBL		14	14
potential SB storage length:	NBT		105	105
381 ft. from Pearl St.to Cherry St.	SBTR	65	173	173
So. Winooski Ave. & Bank Street				
potential NB storage length:	NBLTR	25		
363 from College St. to Bank St.	NBL		8	12
potential SB storage length:	NBTR		42	61
279 ft. from Buell St. to Bank St.	SBLTR	52		
	SBL		1	1
	SBTR		151	217
So. Winooski Ave. & College Street				
potential NB storage length:	NBLTR	42		
387 ft. from Main St. to College St.	NBL		7	7
potential SB storage length:	NBTR		83	83
363 ft. from Bank St. to College St.	SBLTR	115		
	SBL		13	13
	SBTR		269	269
So. Winooski Ave. & Main Street				
potential SB storage length:	SBL	130	130	97
387 ft. from College St. to Main St.	SBT	187		
	SBR	0		
	SBTR		~352	227

~ 50th percentile volume exceeds capacity, queue is theoretically infinite
queue shown is maximum after 2 cycles

Table 3 indicates that in the average Build scenario (50th percentile), queue storage space is a problem at the following locations:

- Southbound through-right lane at South Winooski Avenue/Main Street
- Northbound through lane at South Winooski Avenue/Cherry Street

Table 3 also indicates that in the average optimized Build scenario (50th percentile), the following intersection has an excessive queue:

- Northbound through lane at South Winooski Avenue/Cherry Street

The small storage space for the northbound through lane at South Winooski Avenue/Cherry Street (102 feet) is a factor in the queue length exceeding storage space, and the simulation also shows this queue to be somewhat consistent. In the 50th percentile, the estimated queue length of 105' is approximately equal to the available stacking space, suggesting that this is not a severe problem.

Although Table 3 does not indicate a problem, the simulation also shows fairly regularly occurring queues at the following intersections:

- Northbound left-turn lane at South Winooski Avenue/Pearl Street
- Southbound through-right lane at South Winooski Avenue/Cherry Street
- Southbound through-right lane at South Winooski Avenue/College Street

While the 50th percentile queue gives an average queue length that one can expect during the PM peak hour, the 95th percentile represents the 95th percent longest queue lengths. In other words, the PM peak hour will experience queues of the lengths in the 95th percentile only 5% of the time during the PM peak hour. These 95th percentile queue lengths are shown in Table 4.

Table 4: Estimated 50[th] Percentile Queue Lengths for Signalized Intersections Along South Winooski Avenue

Intersection		Queue Lengths (feet) 95th Percentile No Build	Build	Build Opt
So. Winooski Ave. & Pearl Street				
potential NB storage length:	NBL	#210	#210	163
381 ft. from Cherry St. to Pearl St.	NBR	47	47	45
So. Winooski Ave. & Cherry Street				
potential NB storage length:	NBTL	85		
102 ft. from Buell St. to Cherry St.	NBL		36	37
potential SB storage length:	NBT		166	167
381 ft. from Pearl St.to Cherry St.	SBTR	91	279	280
So. Winooski Ave. & Bank Street				
potential NB storage length:	NBLTR	38		
363 from College St. to Bank St.	NBL		21	31
potential SB storage length:	NBTR		69	99
279 ft. from Buell St. to Bank St.	SBLTR	73		
	SBL		3	5
	SBTR		255	364
So. Winooski Ave. & College Street				
potential NB storage length:	NBLTR	64		
387 ft. from Main St. to College St.	NBL		21	21
potential SB storage length:	NBTR		134	134
363 ft. from Bank St. to College St.	SBLTR	158		
	SBL		30	30
	SBTR		433	433
So. Winooski Ave. & Main Street				
potential SB storage length:	SBL	#287	#287	158
387 ft. from College St. to Main St.	SBT	#321		
	SBR	48		
	SBTR		#551	356

\# 95 percentile volume exceeds capacity, queue may be longer
queue shown is maximum after 2 cycles

The 95[th] percentile queue lengths indicate that on occasion in the Build scenario, queues will extend beyond the available vehicle storage space in the following locations:

- Northbound left-turn lane at South Winooski Avenue/Pearl Street - We must note that the northbound lane geometries at South Winooski Avenue/Pearl Street are no different in the Build scenario than from their current configuration. Thus, these queues exist whether the lane geometries change or remain the same.

- Northbound through lane at South Winooski Avenue/Cherry Street - Both the 50th and 95th percentile queues are estimated to spill back from Cherry to Buell. This suggests that access to Buell will be frequently blocked during the PM peak hour. We suspect that this condition occurs currently and is not considered a major problem due to the low traffic volumes accessing Buell Street.
- Southbound through-right lane at South Winooski Avenue/College Street
- Southbound through-right and left-turn lanes at South Winooski Avenue/Main Street

Again, the simulation estimates the occasional queue beyond the available storage space in these lanes. However, the simulation shows that persistent queues largely exist only at the southbound approach at South Winooski Avenue/Main Street.

At the 95th percentile queue in the optimized Build scenario, Table 4 shows the following queues exceed the available vehicle storage space:

- Northbound through lane at South Winooski Avenue/Cherry Street
- Southbound through-right lane at South Winooski Avenue/Bank Street
- Southbound through-right lane at South Winooski Avenue/College Street

This suggests that access to the Onion River Cooperative, Garage, Buell Street, and Brooks Pharmacy, may be blocked during periods of the PM peak hour. However, we must remember that the lengthy queues that occur at the 95th percentile only exist during 5% of the PM peak hour.

Recommendations

Generally, this analysis shows that the reduction in cross-section can work for the northerly blocks of South Winooski Avenue, between College and Pearl. Congestion analysis indicates that operations at individual intersections can continue to be relatively efficient after lane reduction. Simulation of the reduced lane system showed generally efficient operations and confirms the LOS results reported herein.

As noted, the largest concern stemming from this analysis are the chronic queues southbound on South Winooski Avenue, at the approach to Main Street. Lane reduction is not advised for this block. We recommend maintaining the existing geometry of this block.

Generally, we would recommend delineating left turn lanes with raised medians channelizing exclusive lanes. This is clear to motorists, and eliminates the confusion inherent to the two-way left turn system. Raised medians have the added value of providing pedestrian refuges. We recognize that such medians would also obstruct mid-block accesses to small parking lots, and this fact may prevent them from being constructed for political reasons.