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Alternative Intersection Analysis at Route 60 and Woolridge Road

Chesterfield County, VA

Final Report

COMMONWEALTH OF VIRGINIA
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1. Executive Summary

JMT conducted an alternative intersection analysis of the US Route 60 and North Woolridge Road/Old Buckingham Road intersection, which is located in the Midlothian area of Chesterfield County, VA. The intersection experiences peak hour congestion and is ranked 14th in the Richmond District's 2015 ranking of top 100 intersections based on Potential for Safety Improvement (PSI).

12-hour weekday vehicular turning movement and pedestrian counts were collected at the intersection, and three years of crash data were reviewed. A site visit was conducted to evaluate the existing operations during peak hours, road geometry, lane configurations, travel patterns, and to collect queues at the study intersection. An operational analysis was conducted using Synchro to evaluate the existing (2018) conditions for weekday AM and PM peak hours. The model was calibrated based on site visit observations and the requirements defined in VDOT's Traffic Operations and Safety Analysis Manual (TOSAM).

An Alternative Intersection Analysis was conducted using VDOT's Junction Screening Tool (VJuST), and three alternative intersections were identified for further analysis:

- Restricted Crossing U-Turn (RCUT)
- Partial Displaced Left Turn (DLT)
- Modified Quadrant Roadway (QR)

Planning level concept sketches were developed for the three proposed intersection alternatives, and a future operational analysis was conducted for 2038 No-Build conditions and the three alternatives. Planning-level cost estimates were then prepared for each of the three alternatives using information in VDOT's 2015 Transportation and Mobility Planning Division (TMPD) cost estimates and Highway Safety Improvement Program (HSIP) worksheets. Crash modification factors were identified for each proposed alternative, and Benefit/Cost (B/C) ratios were calculated using VDOT's HSIP worksheets to evaluate the relative safety benefits of the alternatives. The operational and B/C analysis results were utilized to evaluate the proposed alternatives and determine the respective B/C ratios for each scenario, as summarized in Table 1.

Recommendations

Alternative 1 – RCUT and Alternative 2 – Partial DLT provide clear safety benefits and improved LOS over projected future 2038 No Build conditions; however, their planning-level costs exceed the calculated benefits (significantly so for Alternative 1). Alternative 3 – Modified QR provides improved LOS over the 2038 No Build conditions (although less so than Alternatives 1 and 2); however, because of a lack of applicable CMFs, further research is required to calculate a B/C ratio for Alternative 3 – Partial QR.

Table 1: 2038 Alternatives Comparison

ALTERNATIVE INTERSECTION ANALYSIS AT ROUTE 60 AND N. WOOLRIDGE ROAD							
2038 Analysis Alternative	Primary Intersections		Secondary Intersections		Benefit ($)	Cost ($)	B/C
	AM Level of Service & Overall Intersection Delay (Seconds)	PM Level of Service & Overall Intersection Delay (Seconds)	AM Level of Service & Overall Intersection Delay (Seconds)	PM Level of Service & Overall Intersection Delay (Seconds)			
No-Build	F 104.2	F 149.9	N/A	N/A	N/A	N/A	N/A
Alternative 1 - Restricted Crossing U-turn (RCUT)	Rte. 60/Old Buckingham Rd. A 9.8 Rte. 60/N. Woolridge Rd. E 59.7	Rte. 60/Old Buckingham Rd. E 58.7 Rte. 60/N. Woolridge Rd. B 13.5	Rte. 60 – EB-to-WB U-Turn B 10.3 Rte. 60 – WB-to-EB U-Turn B 17	Rte. 60 - EB-to-WB U-Turn B 16.3 Rte. 60 - WB-to-EB U-Turn C 27.8	$1,001,000	$7,930,000	0.13
Alternative 2 - Partial Displaced Left-Turn Lane	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. B 19.4	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. D 42.87	Rte. 60 - WBL Crossover B 12.75	Rte. 60 - WBL Crossover C 32.18	$1,953,000	$3,240,000	0.60
Alternative 3 - Modified Quadrant Roadway (QR)	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. E 64.8	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. F 126.8	N. Woolridge at Browns Way Rd. A 7.6 Rte. 60 - East at Proposed Connector Rd. B 10	N. Woolridge at Browns Way Rd. B 10.3 Rte. 60 - East at Proposed Connector Rd. B 16.7	$0 / Undetermined	$3,660,000	Undetermined

2. Introduction

Per VDOT's request, JMT conducted an alternative intersection analysis of US Route 60 and North Woolridge Road/Old Buckingham Road located in the Midlothian area of Chesterfield County, VA. The intersection experiences peak hour congestion and is ranked 14th in the Richmond District's ranking of top 100 intersections based on Potential for Safety Improvement (PSI). The study intersection is currently a signalized 4-leg intersection. Route 60 is a four-lane divided roadway classified as Other Principal Arterial with an average annual daily traffic (AADT) of 41,000 vehicles per day (VPD) and a posted speed of 45 mph. Woolridge Road is a four-lane divided roadway classified as a Minor Arterial with an AADT of 16,000 VPD and a posted speed limit of 45 mph. Old Buckingham Road is a Major Collector with an AADT of 11,000 VPD and a posted speed limit of 35 mph. The study intersection is shown in Figure 1.

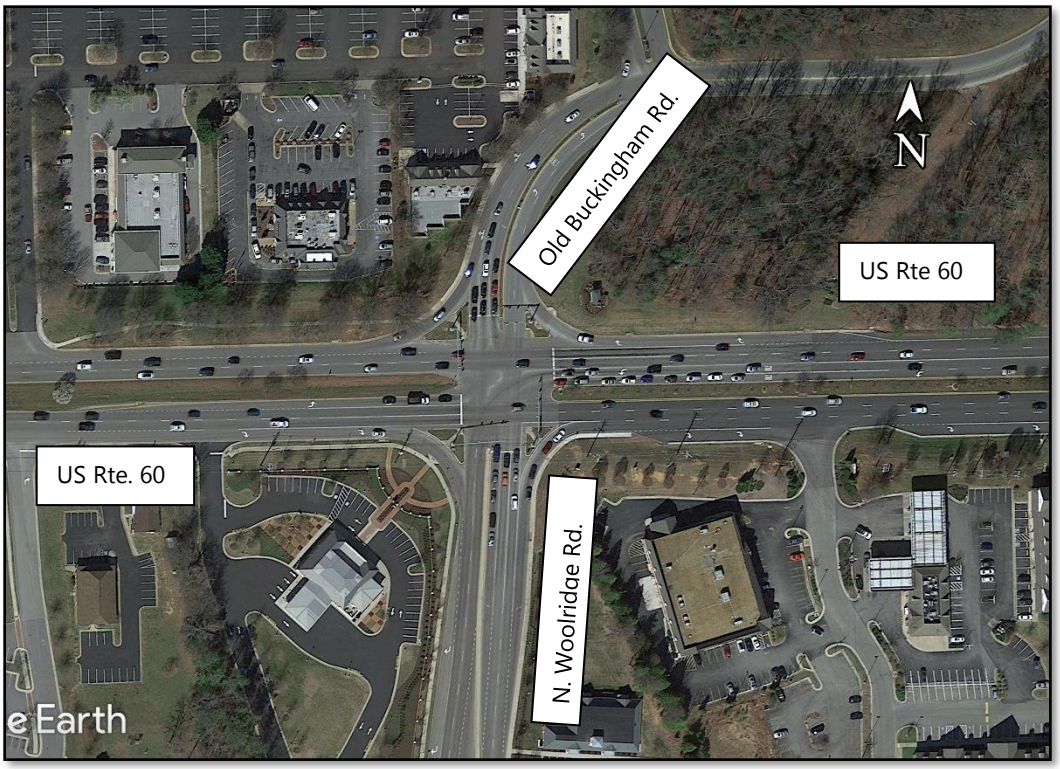


Figure 1: Study Intersection (Source: Google Earth)

JMT utilized the services of a subconsultant (Peggy Malone and Associates) to collect 12-hour Turning Movement Counts (TMCs) at the study intersection. Three-year crash history data was collected from January 1st, 2015 to December 31st, 2017 from VDOT's crash database Tableau. Additionally, VDOT provided the FR 300 crash forms for the same period. The crash patterns were identified within the intersection to develop collision diagrams and crash summaries.

A site visit was conducted to evaluate the existing operations during peak hours, road geometry, lane configurations, travel patterns, and to collect queues at the study intersection. Digital photos and videos were captured for the intersection and items of interest.

An operational analysis was conducted using Synchro to evaluate the existing (2018) conditions for weekday AM and PM peak hours. The model was calibrated based on site visit observations and the requirements defined in VDOT's Traffic Operations and Safety Analysis Manual (TOSAM). Measures of Effectiveness (MoEs) were collected from the model are the vehicle control delays for determining the Level of Service (LOS) for the entire intersection, approaches, and vehicular movements. The Existing Condition MoEs are incorporated into the report.

An Alternative Intersection Analysis was conducted using VDOT's Junction Screening Tool (VJuST) to select three alternative intersections based on the projected traffic data for future year (2038). Three alternative intersections were selected based on the overall expected improvements in safety, congestion, pedestrian, construction cost, and right of way impacts.

Planning level concept sketches were developed for the three proposed intersection alternatives for initial review and approval by VDOT Richmond District Traffic Engineering staff. Following approval by VDOT, a future operational analysis was conducted using Synchro and VISSIM for 2038 No-Build conditions and the three alternatives. Planning-level cost estimates were prepared for each of the three alternatives using information in VDOT's 2015 Transportation and Mobility Planning Division (TMPD) cost estimates. As applicable, crash modification factors were identified for each proposed alternative, and benefit/cost (B/C) ratios were calculated using VDOT's Highway Safety Improvement Program (HSIP) worksheets to evaluate the relative safety benefits of the alternatives. The operational and B/C analysis results were reviewed to identify a preferred solution to resolve congestion and safety issues at the study intersection.

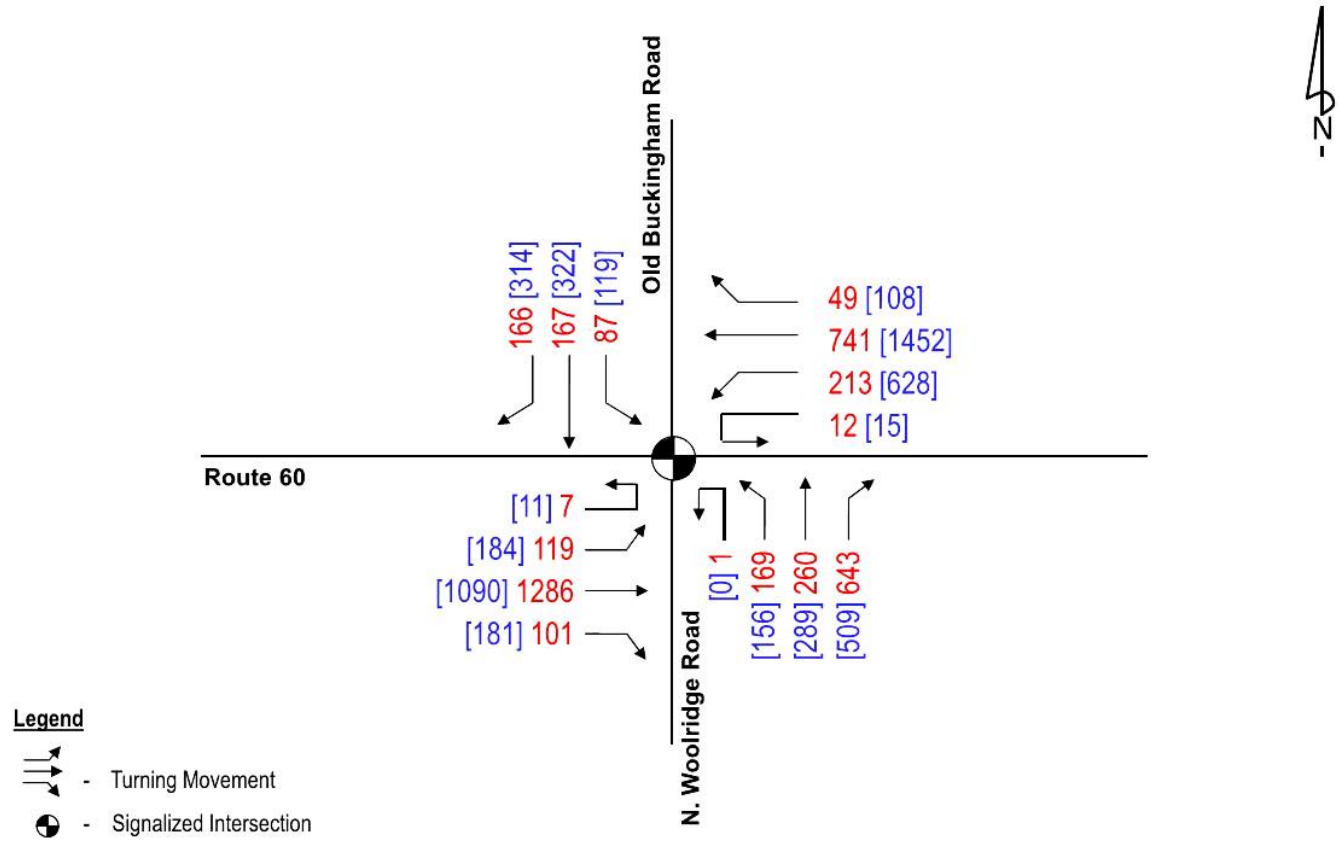
3. Traffic Data Collection

12-hour weekday vehicular and pedestrian counts and weekday AM and PM peak hour observations were collected to develop a baseline understanding of existing traffic conditions at the study intersection.

3.1 Turning Movement Counts

Vehicle and pedestrian data at the study intersection were obtained from a 12-hour weekday count performed on Thursday, April 19th by Peggy Malone & Associates, Inc. The data collection period was from 6:00 AM to 6:00 PM. The raw 12-hour existing vehicular traffic data is shown in Appendix A, and the AM and PM peak hour counts are illustrated in Figure 2. Only seven pedestrians were observed crossing through the intersection during the 12-hour period.

Based on the traffic counts, the AM peak hour was determined to be 7:30 – 8:30 AM and the PM peak period was identified as 4:45 – 5:45 PM. The EB/WB directional split on Route 60 was calculated to be approximately 60% / 40% during the AM peak hour and approximately 40% / 60% during the PM peak hour. The NB/SB directional split along N. Woolridge Road/Old Buckingham Road was calculated to be approximately 70% / 30% during the AM peak hour and approximately 55% / 45% during the PM peak hour.



JMT	Alternative Intersections Analysis at Route 60 and Woolridge Road JMT Project #: 17-0127-116 VDOT Project No. 0000-964-456, UPC# 108890	2018 Peak Hour Turning Movement Counts NOT TO SCALE	FIGURE 2

3.2 Site Visit

A site visit was conducted on May 3, 2018 to observe the existing operations during peak hours, road geometry, lane configurations, travel patterns, and to collect queue observations at the study intersection. Digital photos and videos of items of interest were captured at the intersection. The following are an overview of the AM and PM peak hour observations.

3.2.1 Signing and Paving Conditions

NB Approach (N. Woolridge Rd.)

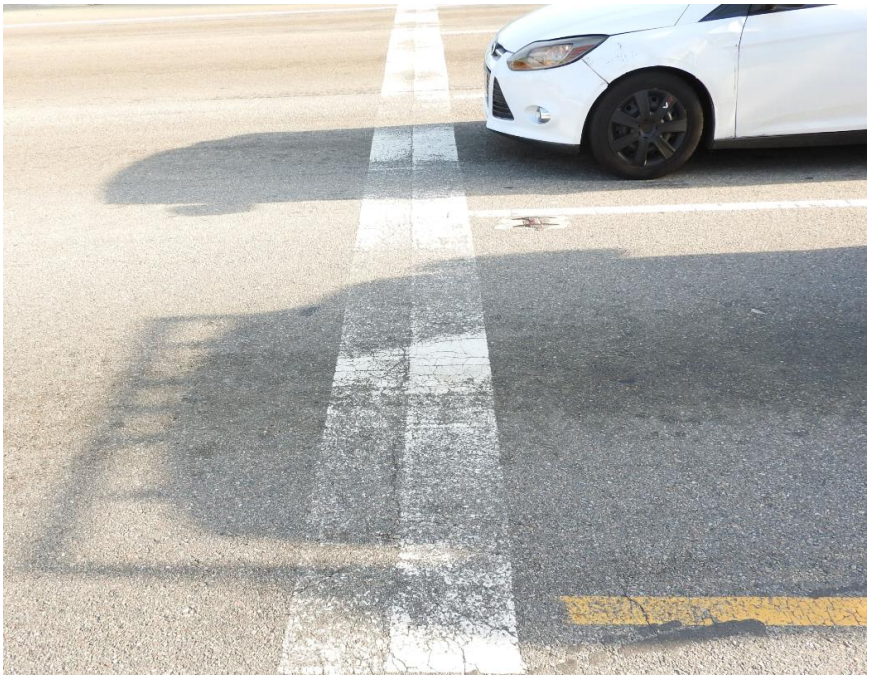
- Signs appeared to be in good condition
- Asphalt and pavement markings are in good condition with no signs of imperfections or hazards (this section of N. Woolridge Road was recently repaved/restriped by VDOT), as shown in Picture 1.

Picture 1: N. Woolridge Road (NB Approach)

SB (Old Buckingham Rd.) and EB/WB (Route 60) Approaches

- Asphalt pavement showed signs of alligator cracking
- Signs appeared to be in good condition
- Pavement markings are faded and nearly removed in some areas, as shown in Picture 2 and Picture 3

Picture 2: Asphalt Cracking and Faded Pavement Markings on Old Buckingham Rd. (SB approach)



Picture 3: Faded Stop bar on EB Rte. 60

3.2.2 AM Peak Hour Observations

During the AM peak hour, the intersection was unsaturated. The northbound and eastbound directions were observed to have the heaviest traffic volumes. Within those approaches, the eastbound through and northbound right-turn movements were the heaviest. The westbound and southbound approaches were observed to have less traffic. All the vehicles observed made it through the intersection within one cycle length.

The northbound right-turn movement operates with Yield control and has a channelized lane. This lane configuration is illustrated in Picture 4 and Picture 5:

Picture 4: Aerial of Right-turn of NB Movement

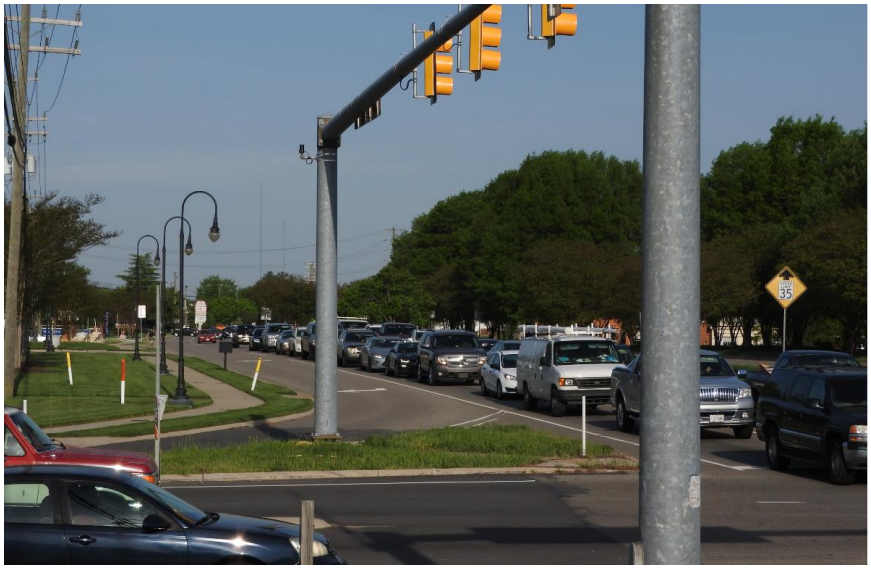
Picture 5: NB Channelized Right-turn (Looking East)

From visual observation, it appears drivers are yielding to eastbound through and southbound left-turning vehicles even though the northbound right-turn vehicles have their own receiving lane. Northbound right-turning vehicles were observed coming to a complete stop, causing unnecessary queuing (observed up to approx. 350'+) for that movement, as shown in Picture 6:

Picture 6: NB Right-turn Queue during AM Peak Hour (looking south)

The following are the queue observations for the AM peak hour:

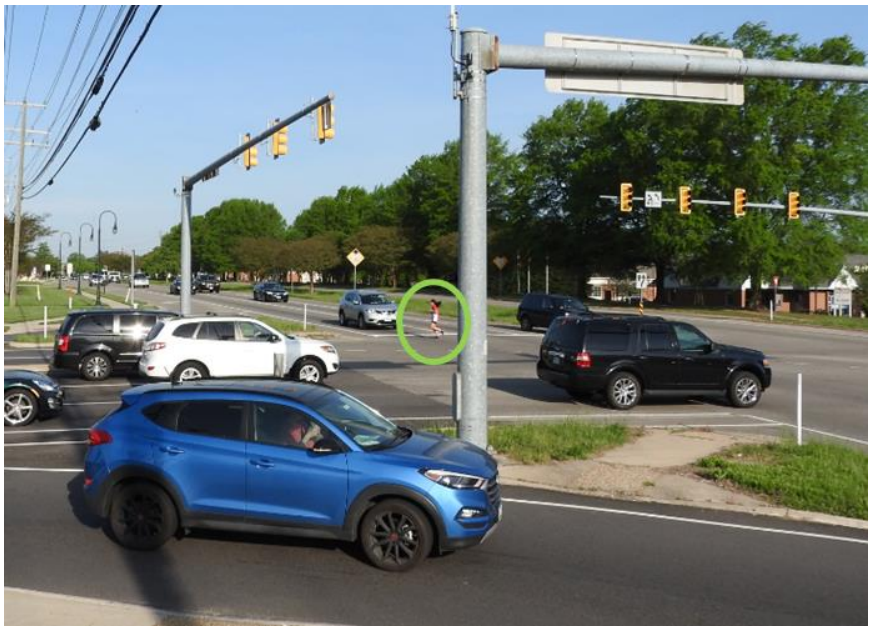
- NB (N. Woolridge Road)
  - Heavy right-turn and moderately heavy left-turn (~350'+)
  - Right-turn queuing caused by driver confusion/indecision at yield sign
  - Through had light queuing (~180')
- SB (Old Buckingham Road)
  - Fairly light, all movements (~100')
- WB (Route 60)
  - Fairly light, all movements (~120')
  - Moderate left-turn queuing (~250')
- EB (Route 60)
  - Heavy throughs (~500'+) – see Picture 7
  - Light right- and left-turn movements (~100')



Picture 7: EB Rte. 60 Queuing during AM Peak Hour

Pedestrian Activity

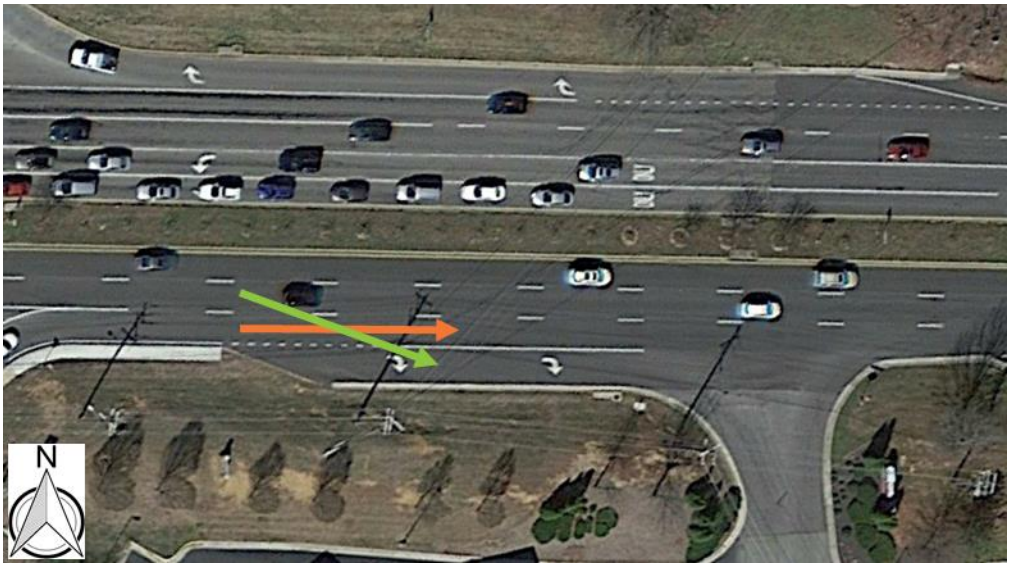
During the AM peak hour two pedestrians were observed. One pedestrian made a crossing across Rte. 60 to access the sidewalk that runs along N. Woolridge Rd. Picture 8 shows the subject pedestrian:



Picture 8: Pedestrian Crossing Rte. 60

Safety Concerns

- Northbound Right-turn operates with Yield control. Vehicles tend to yield to EB through and SB left drivers even though northbound right-turners have their own dedicated receiving lane.
- Some weaving issues were observed between drivers merging to the Sunoco/Walgreens entrance on EB Route 60 and northbound right-turn drivers as shown in Picture 9.



Picture 9: Weaving section at the Sunoco/Walgreens Entrance on EB Route 60

- One driver was observed merging out of the rightmost left-turn lane on WB Route 60 and into the WB through lane. This left-turn lane is a "trap lane" as the three WB Route 60 through lanes transition to two through lanes at the approach of the study intersection. This observation is consistent with those of other JMT staff who live in and/or commute through the area on a regular basis and presents increased issues during heavier (PM) traffic.

3.2.3 PM Peak Hour Observations

During the PM peak hour, the intersection was observed to be slightly over saturated. The eastbound and westbound directions were observed to have the highest volumes. Within those approaches, the eastbound through and westbound left-turn/through movements were observed to be the heaviest. The northbound and southbound approaches were observed to have moderate to heavy traffic. The westbound approach had instances where the left-turn and through vehicles did not make it through the intersection during one cycle. As in the AM peak hour, drivers exhibited confusion/indecision at the northbound right-turn movement. Drivers were observed to be angry/frustrated at those who were stopped at the northbound right-turn yield. The southbound approach traffic repeatedly failed to make it through the intersection in one cycle.

The following are the queue observations for the PM peak hour:

- NB (N. Wooldridge Road)
    - Heavy right-turn and moderate-heavy left-turn (~350'+)
    - Right-turn queuing caused by driver confusion/indecision at yield sign
    - Through had light queue (~200')
- SB (Old Buckingham Road)
    - Significantly heavy; vehicles near back of queue had to wait two full cycles to pass through (~550'+)
- WB (Route 60)
    - Heavy lefts; some vehicles near back of queue had to wait two full cycles to pass through (~800'+)
    - Heavy through; some vehicles near back of queue had to wait two full cycles to pass through (~850'+)
- EB (Route 60)
    - Heavy through; queues cleared after one cycle (~800'+)
    - Moderate Left-turn queue (~300')

Pedestrian Activity

During the PM peak hour observation period, there were no pedestrians observed.

Safety Concerns

Observations from the PM peak hour caused the same safety concerns documented during the AM peak hour.

4. Crash Analysis

A crash analysis was conducted for the study intersection of Route 60 Midlothian Turnpike at North Woolridge Road. The study used crash history data collected from VDOT's Tableau database for the most recent three-year period available, covering January 1, 2015 through December 31, 2017.

A review of the Tableau data and accompanying FR 300 forms showed that there were a total of 72 crashes recorded at this intersection within that three-year time period. A breakdown of all the crashes by severity and other common categories of factors is shown in Table 2. The majority of these crashes (61) resulted in property damage only, while the remaining 11 involved injuries at various severities. Tableau categorizes crash injuries as either K: Fatal Injury, A: Ambulatory Injury, B: Visible Injury, C: Non-visible Injury, and PDO: Property Damage Only. Figure 3 shows a breakdown by crash severity for each of the three years of data.

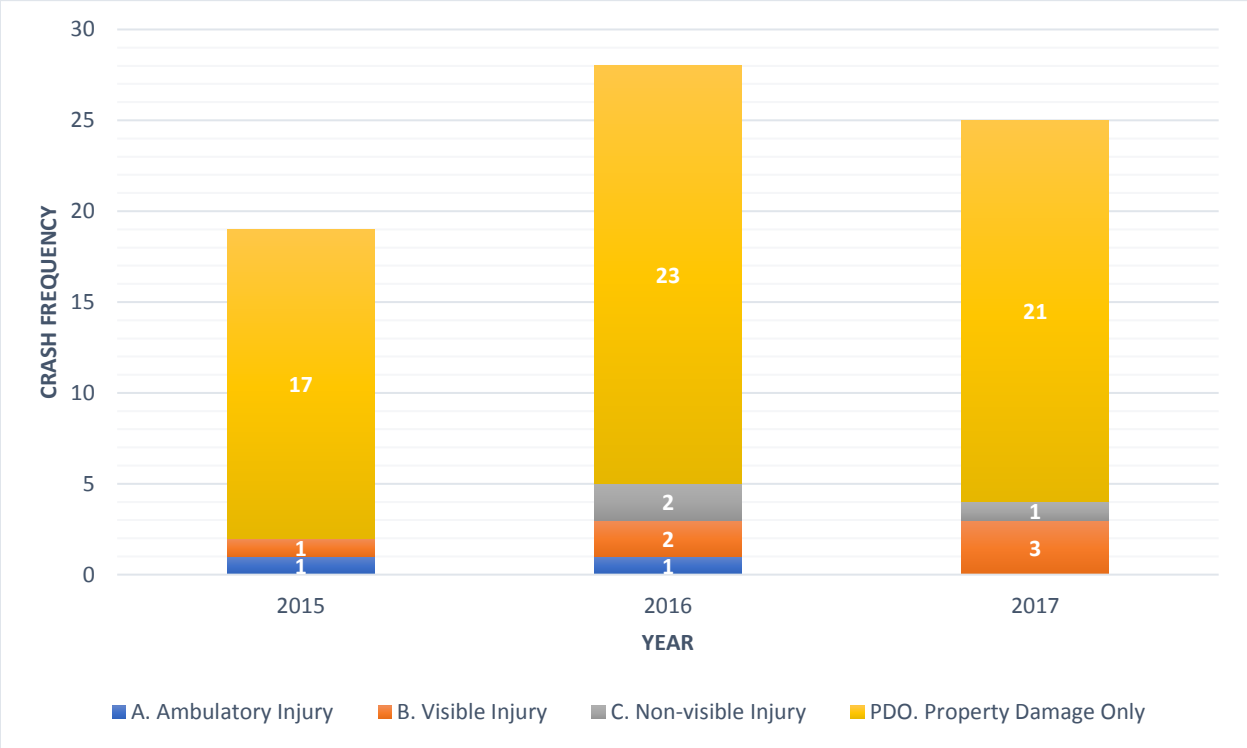


Figure 3: Crash Severity by Year

Table 2 also shows that only two of the crashes involved deer. Likewise, speed and alcohol were each contributing factors in only two crashes each. Additionally, Table 2 shows that the majority of crashes resulting in Property Damage Only involved multiple vehicles and included 47 rear-end type crashes. Rear-end crashes alone account for 55 of the 72 total crashes at this intersection (76%).

Table 2: Crash Types and Severity

Crash Type Categories		Crash Severity					
		All	Fatal (K)	Incapacitating Injury (A)	Minor Injury (B+C)	Property Damage (O)	Not specified
Total Crashes	All	72	0	2	9	61	0
	Primary Crash Categories						
Roadway Departure or Intersection	Cross Median	0	0	0	0	0	0
	Fixed Object - In Road	1	0	0	0	1	0
	Fixed Object - Off Road	0	0	0	0	0	0
	Head-on	0	0	0	0	0	0
	Non-Collision	0	0	0	0	0	0
	Sideswipe	3	0	0	0	3	0
	Angle	11	0	0	3	8	0
	Rear end	55	0	2	6	47	0
Non-Motorized	Pedestrian	0	0	0	0	0	0
	Bicycle	0	0	0	0	0	0
	Deer	2	0	0	0	2	0
	Secondary Crash Categories						
Environmental Factors	Nighttime	9	0	1	2	6	0
	Wet Weather	6	0	1	1	4	0
Number of Vehicles	Single Vehicle	2	0	0	0	2	0
	Multiple Vehicle	70	0	2	10	58	0
Driver Behavior	Speed Related	2	0	1	0	1	0
	Unbelted	1	0	1	0	0	0
	Alcohol Related	2	0	0	0	2	0

The crash history was also sorted based on environmental factors, namely lighting, weather, and roadway surface conditions. Lighting was categorized as either daylight, dawn/dusk, or darkness. Weather was classified as clear, fog, rain, or snow. The roadway surface conditions were defined as either dry, wet, or snow/icy. Table 3 shows the crash breakdown by environmental factors.

Table 3: Crash History by Environment

January 1, 2015 - December 31, 2017													
Crash Type	Lighting			Weather				Surface			Total		
	Daylight	Dawn/Dusk	Dark	Clear/Cloudy	Fog	Mist/Rain	Snow	Dry	Wet	Snow/Icy	Number	%	
Rear-end	49	3	3	51	0	4	0	51	4	0	**55**	**76%**	
Angle	6	2	3	10	0	1	0	10	1	0	**11**	**15%**	**92%**
Fixed Object - Off Road	0	0	0	0	0	0	0	0	0	0	**0**	**0%**	
Sideswipe - Same Direction	3	0	0	3	0	0	0	3	0	0	**3**	**4%**	
Sideswipe - Opposite Direction	0	0	0	0	0	0	0	0	0	0	**0**	**0%**	
Non-collision	0	0	0	0	0	0	0	0	0	0	**0**	**0%**	**8%**
Deer	1	0	1	1	0	1	0	1	1	0	**2**	**3%**	
Other	0	0	1	1	0	0	0	1	0	0	**1**	**1%**	
Total (frequency)	**59**	**5**	**8**	**66**	**0**	**6**	**0**	**66**	**6**	**0**	**72**	**100%**	
Total (%)	**82%**	**7%**	**11%**	**92%**	**0%**	**8%**	**0%**	**92%**	**8%**	**0%**			
		18%			**8%**				**8%**				
% of crashes occurred during a combination of daylight, clear weather, and dry surface conditions				**76%**									

As Table 3 shows, the majority of crashes (76%) occurred during normal conditions of daylight, clear weather, and dry pavement surface, at a total of 55 crashes. Only 18% of crashes occurred when the lighting was not full daylight, and only 8% occurred under rainy weather with wet pavement.

The majority of crashes at this intersection are rear-end collisions, making up 76% of the total. The next most frequent crash type are angle collisions, where 11 crashes comprise 15% of the total. Together, rear-end and angle crashes represent 92% of the crashes at the intersection. Only three crashes were the result of sideswipes, and there was one "Other" case of a collision with a Fixed Object in the Roadway – a drunk driver hitting the light pole in the channelized right-turn island.

Figure 4 shows a breakdown of the crash types by year. The graph shows that rear-end collisions consistently make up the overwhelming majority of crashes at this intersection, and they increased from 17 in 2015 to 19 in both 2016 and 2017. The total number of crashes increased as well from 2015 to 2016, which saw a spike in the number of angle crashes at the intersection, with 7 compared to only 1 in 2015.

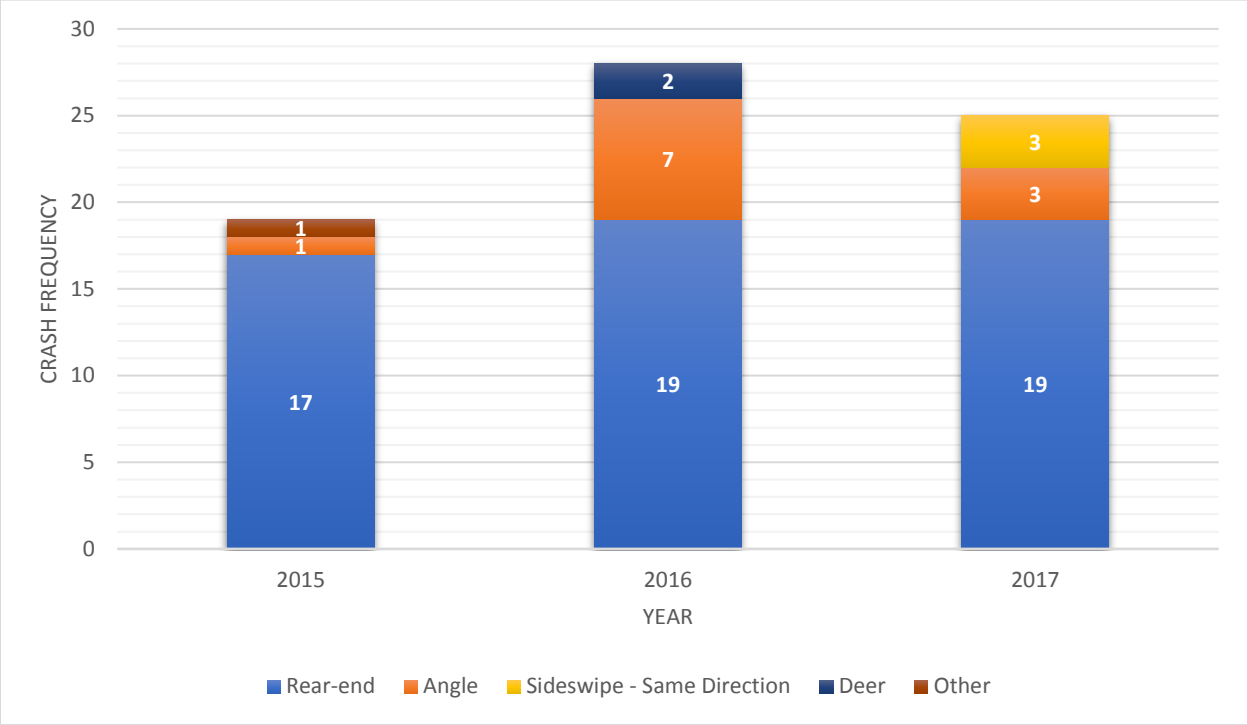


Figure 4: Crash Types by Year

The intersection is ranked 14th in the Richmond District's 2015 ranking of top 100 intersections based on Potential for Safety Improvement (PSI).

In order to determine possible trends or deficiencies at the intersection that may be contributing to the number of collisions, the two most common crash types present – rear-end and angle – were further broken down by *where* they tended to occur within the intersection. Together with the detailed descriptions from the FR 300 forms, it is possible to determine whether or not the crashes are the result of factors at the intersection that can be remedied with engineering improvements. Figure 5 shows the types of crashes based on their location at the intersection. Location was broken down at each approach leg as either in the through/left lanes, or in the channelized right turn lanes with yield control. Several of the crashes also occurred at various conflict points in the middle of the intersection, and for some crashes, their locations could not be determined from the available data.

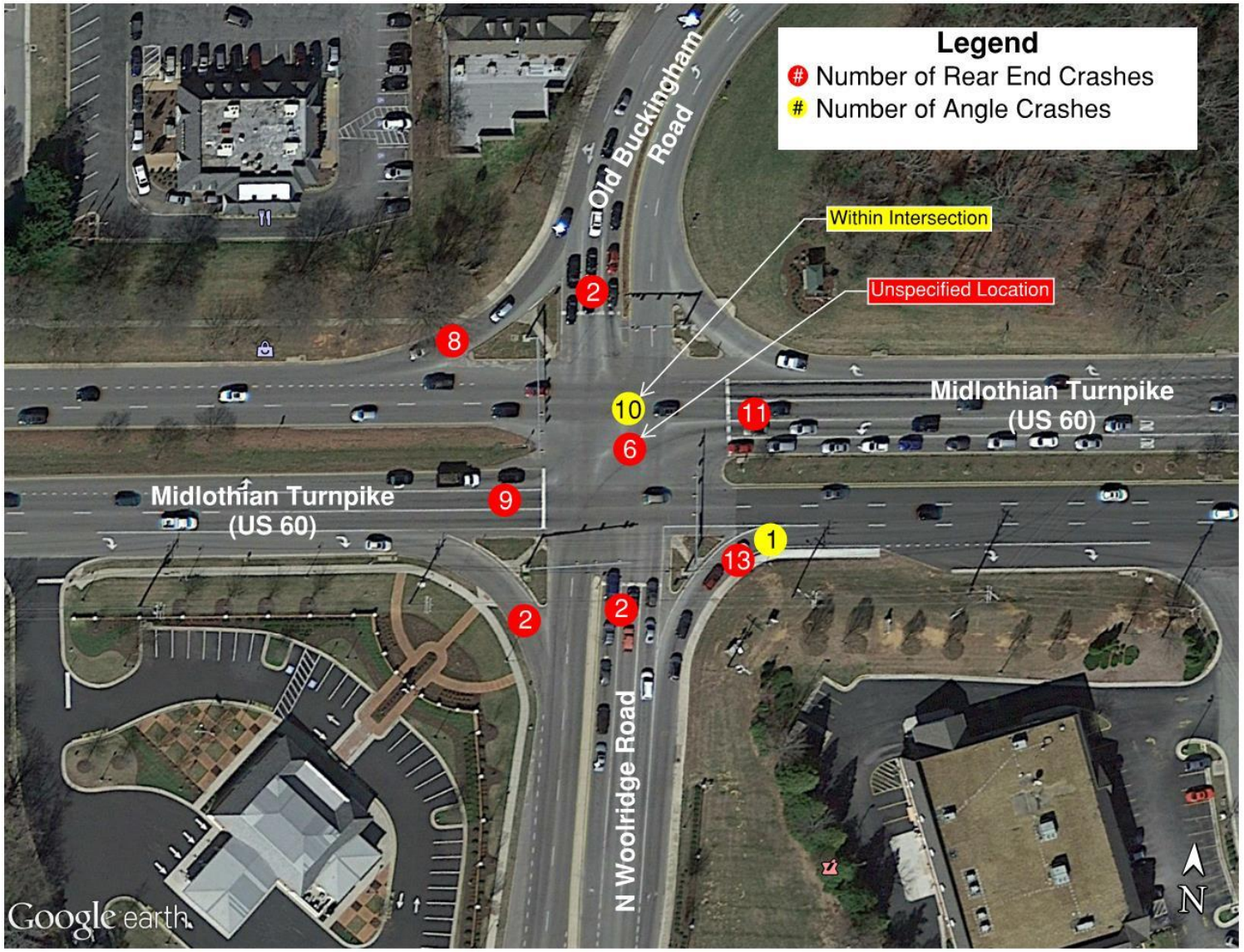


Figure 5: Crashes by Location Within Intersection

Figure 5 shows the highest concentration of crashes occurs at the northbound right turn from Woolridge Road to eastbound Route 60, which in the last three years saw 13 rear-end collisions and 1 angle collision. The rear-end collisions are usually caused by inattentive drivers crashing into vehicles waiting to merge at the yield sign, or when those vehicles begin to merge and then decide to stop and wait again. The angled collision was also related to this merging maneuver, as it was caused by an eastbound vehicle in the through lane attempting to merge over two lanes into the right turn bay east of the intersection and colliding with a car attempting to merge after the yield sign.

The southbound right turn from Old Buckingham Road to westbound Route 60 also saw a significant number (8) of rear-end collisions in that same time period, similarly caused by inattentive drivers colliding with vehicles waiting to merge at the yield sign. The curvature of Old Buckingham Road on the approach to this intersection may present sight distance issues contributing to this crash pattern.

The eastbound and westbound through movements on Route 60 had nine and 11 rear-end collisions, respectively. A review of the FR-300 forms indicates these were usually the result of inattentive or distracted drivers missing the stopped cars in front of them or moving forward too early into stopped cars when the left-turning lanes next to them began to move on their green arrow. An additional six of the reported rear-end collisions at this intersection did not provide enough information to determine their exact location in the intersection.

Almost all of the angle collisions reported at this intersection (10 of the 11) occurred in the middle of the intersection as a result of collisions between turning movements. A review of the FR 300 crash reports, however, indicates most of these may be the result of driver error as opposed to intersection deficiencies. Of those 10 angled collisions, seven occurred as the result of a driver running through a red light, and an eighth potentially caused by a driver making a turn while distracted on their phone. As noted, however, the curvature of Old Buckingham Road may create sight distance issues that contribute to the collisions between northbound and southbound turning movements.

5. Existing Operational Analysis

Existing Operational Analysis was conducted using Synchro to evaluate the existing (2018) conditions for weekday AM and PM peak hours using existing lane configurations, traffic control, and traffic counts. Traffic signal timings were obtained from VDOT for use in the Synchro model. It is noted that the existing traffic signal does *not* have pedestrian phases. The Synchro model was calibrated based on site visit observations and the requirements defined in VDOT's Traffic Operations and Safety Analysis Manual (TOSAM). The main calibration adjustment was applied to the northbound right-turn movement, which currently operates in the field as a Yield-controlled channelized right-turn lane with a free-flow receiving lane on EB Route 60. When the Synchro model was coded to match this geometry and operation, modeled vehicles were observed moving freely through this right-turn movement. However, field observations identified significant driver confusion and indecision at this movement, resulting in delays and queuing. To more accurately represent the queue and delay observed during the site visit, the NB right-turn movement was modeled as a signalized overlap phase.

Measures of Effectiveness (MoEs) collected from the model are the vehicle control delays for determining the Level of Service (LOS) for the entire intersection, approaches, and vehicular movements. The LOS results are summarized in Table 4, and the detailed LOS Synchro outputs are included in Appendix B. The overall intersection level of service for the AM and PM peak hours are D and E, respectively.

Table 4: 2018 Existing Levels of Service

Peak Hour	Approach		Movement Delay (s/veh)	Movement LOS	Approach Delay (s/veh)	Approach LOS	Intersection Delay (s/veh)	Intersection LOS
7:30-8:30AM	Route 60 (EB)	L	55.5	E	42.8	D	43.7	D
		T	44.6	D				
		R	4.3	A				
	Route 60 (WB)	L	42.4	D	25.8	C		
		T	22.4	C				
		R	0.2	A				
	Woolridge Rd (NB)	L	68.9	E	64.8	E		
		T	47.6	D				
		R	70.6	E				
	Old Buckingham Rd (SB)	L	56.1	E	36.2	D		
		T	30.9	C				
4:45-5:45PM	Route 60 (EB)	L	62.6	E	35.6	D	65	E
		T	36.1	D				
		R	4	A				
	Route 60 (WB)	L	115.3	F	77	E		
		T	65.4	E				
		R	4.9	A				
	Woolridge Rd (NB)	L	68	E	49.7	D		
		T	51.3	D				
		R	43.1	D				
	Old Buckingham Rd (SB)	L	60.7	E	106.6	F		
		T	115.2	F				

6. Alternative Intersections Analysis

Alternative Intersections Analysis was conducted using VDOT's Junction Screening Tool (VJuST) to select three alternative intersections based on the projected traffic data for future year (2038). Three alternative intersections were selected based on the overall expected improvements in safety, congestion, pedestrian, construction cost, and right of way impacts.

Per the VJuST worksheet results, the three alternative intersections selected for future operational analysis are:

- Restricted Crossing U-Turn (RCUT)
- Partial Displaced Left Turn (DLT)
- Modified Quadrant Roadway (QR)

The full VJuST worksheets for the AM and PM peak hours are provided in Appendix C. A description of the purpose and benefits of each of these alternative intersection types is provided in the following subsections:

6.1 Alternative 1 – Restricted Crossing U-Turn (RCUT):

A Restricted Crossing U-Turn intersection, shown in Figure 6, is an intersection where all side street movements begin with a right turn. The side street left-turn and through vehicles turn right and make a U-turn at a dedicated downstream median opening to complete the desired movement. The main intersection and median U-turns can be designed as signalized, stop controlled, or yield controlled. For this analysis, the RCUT alternative is evaluated as signalized.

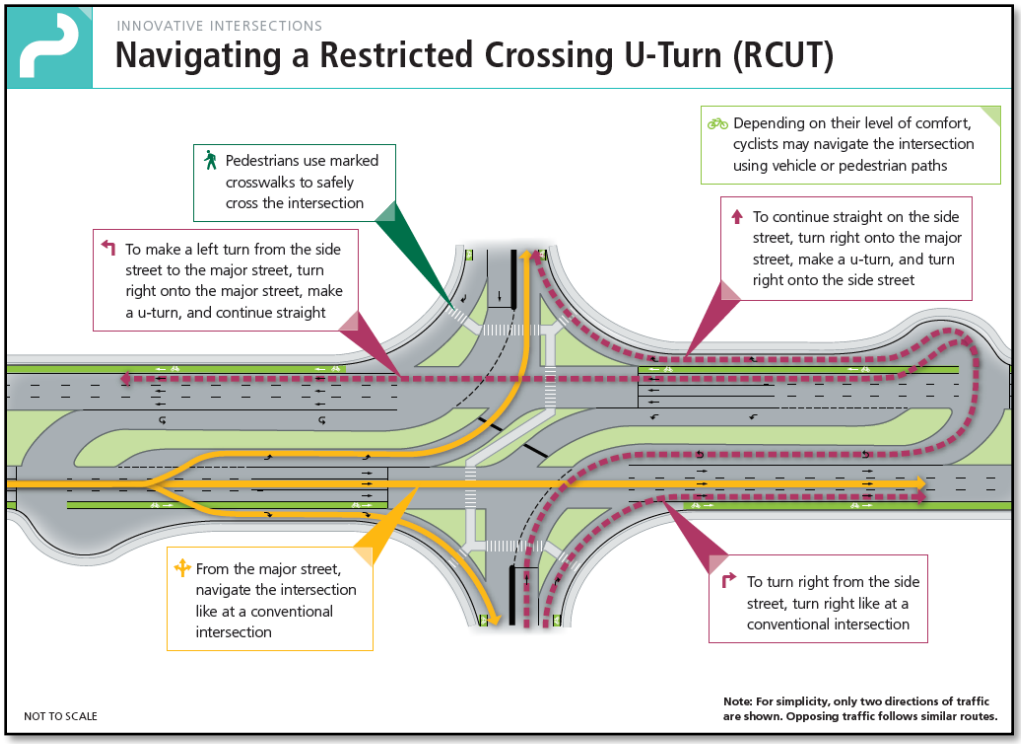


Figure 6: Restricted Crossing U-Turn (RCUT)
(Source: www.virginiadot.org/innovativeintersections)

Restricted Crossing U-turn intersections should be considered on median-divided highways at intersections with:

- Heavy through and/or left-turn traffic volumes on the major street
- Low through and left-turn volumes on the side street
- Three or four legs

The benefits of a Restricted Crossing U-turn intersection include:

Improved safety: Reduces the number of points where vehicles cross paths and eliminates the potential for head-on crashes

Increased efficiency: Each direction of the major street can operate independently, creating two one-way streets and increasing the overall intersection capacity

Shorter wait times: Fewer Traffic signal phases means less stopping for arterial vehicles and allowing only right turns from side streets means less waiting.

Cost-effective: An RCUT can be more cost effective than adding lanes to improve capacity.

6.2 Alternative 2 – Displaced Left Turn (DLT)

A Displaced Left Turn intersection, shown in Figure 7, is an intersection that moves left-turning vehicles at an intersection to the other side of the roadway several hundred feet in advance of the main intersection. This allows the protected left turns to occur simultaneously with the opposing through movements at the intersection, allowing for two- (full) or three-phase (partial) signal control. Intersections can be designed as a partial Displaced Left Turn, with crossovers for left turns only on the major street, or a full DLT, with crossovers for left turns on both the major and side streets. This analysis is only considering a displaced left turn for the WB Route 60 approach only.

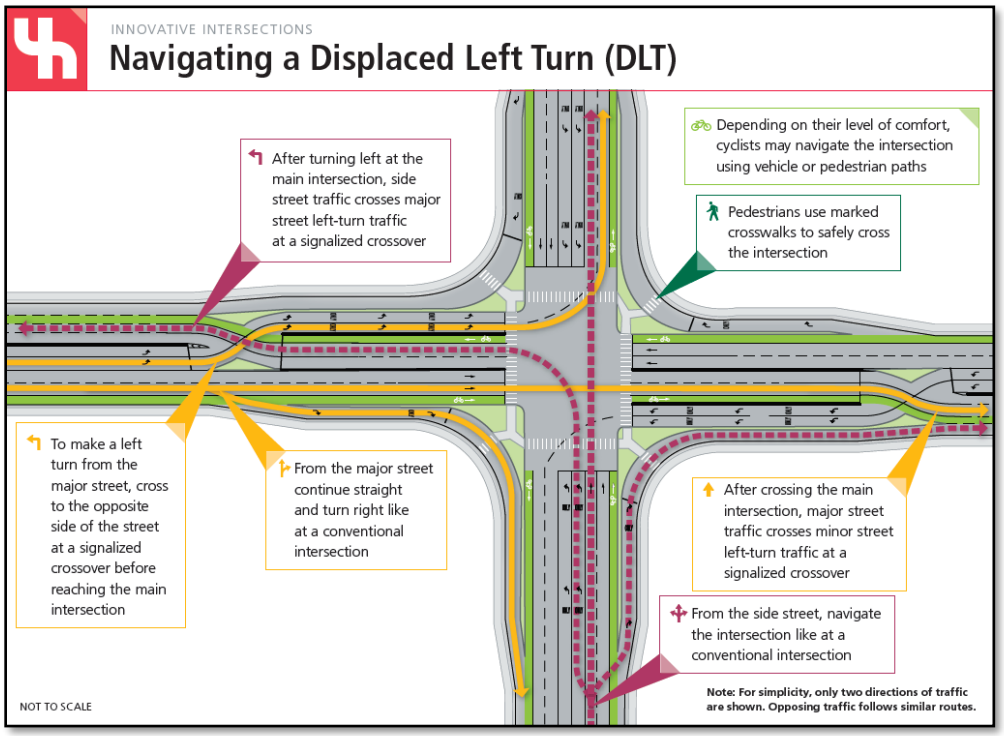


Figure 7: Displaced left Turn (DLT) (Source: www.virginiadot.org/innovativeintersections)

Displaced Left Turn Intersections should be considered at intersections:

- With moderate to heavy traffic volumes in all directions
- Where opposing legs have similar through traffic volumes
- With heavy left-turn traffic volumes
- With a limited number of driveways or access points near the intersection

Benefits of a Displaced Left Turn intersection:

Improved Safety: Reduces and spreads out the number of potential conflict points where vehicles may cross paths

Increased Efficiency: Simultaneous movement of protected left turns and opposing through-movements allows for only two traffic signal phases rather than the typical four phases, which reduces delay.

Better Synchronization: Elimination of left-turn traffic signal phases and synchronization of the main intersection and crossover traffic signals allows through-traffic to spend less time stopped, which improves corridor travel times.

6.3 Alternative 3 – Quadrant Roadway (QR)

A Quadrant Roadway intersection, shown in Figure 8, is an intersection that reroutes left-turn movements onto a connector road in one quadrant. This allows the signal at the main intersection to favor non left-turning movements and a three-phase signal control at the intersections with the connector road.

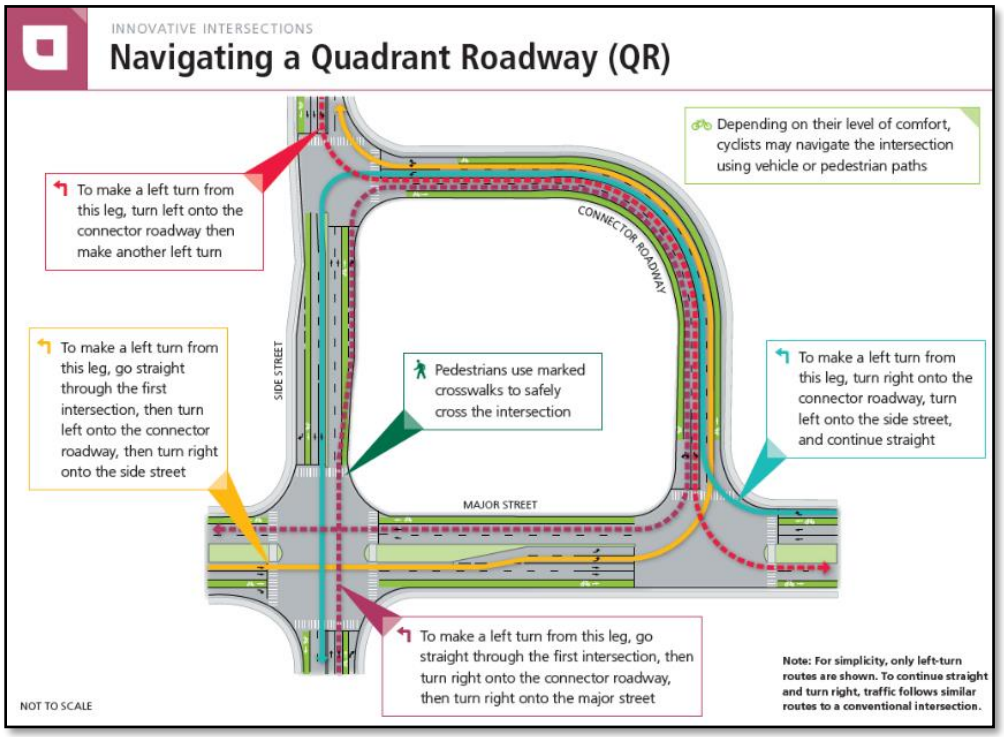


Figure 8: Quadrant Roadway (QR) (Source: www.virginiadot.org/innovativeintersections)

A Quadrant Roadway (QR) intersection should be considered at locations with an existing roadway that can be used as the connector roadway, and at intersections with:

- Four legs
- Heavy through and left-turn traffic volumes on the major and side streets.

Benefits of a Quadrant Roadway intersection:

Improved Safety: Reduces and spreads out the number of points where vehicles may cross paths.

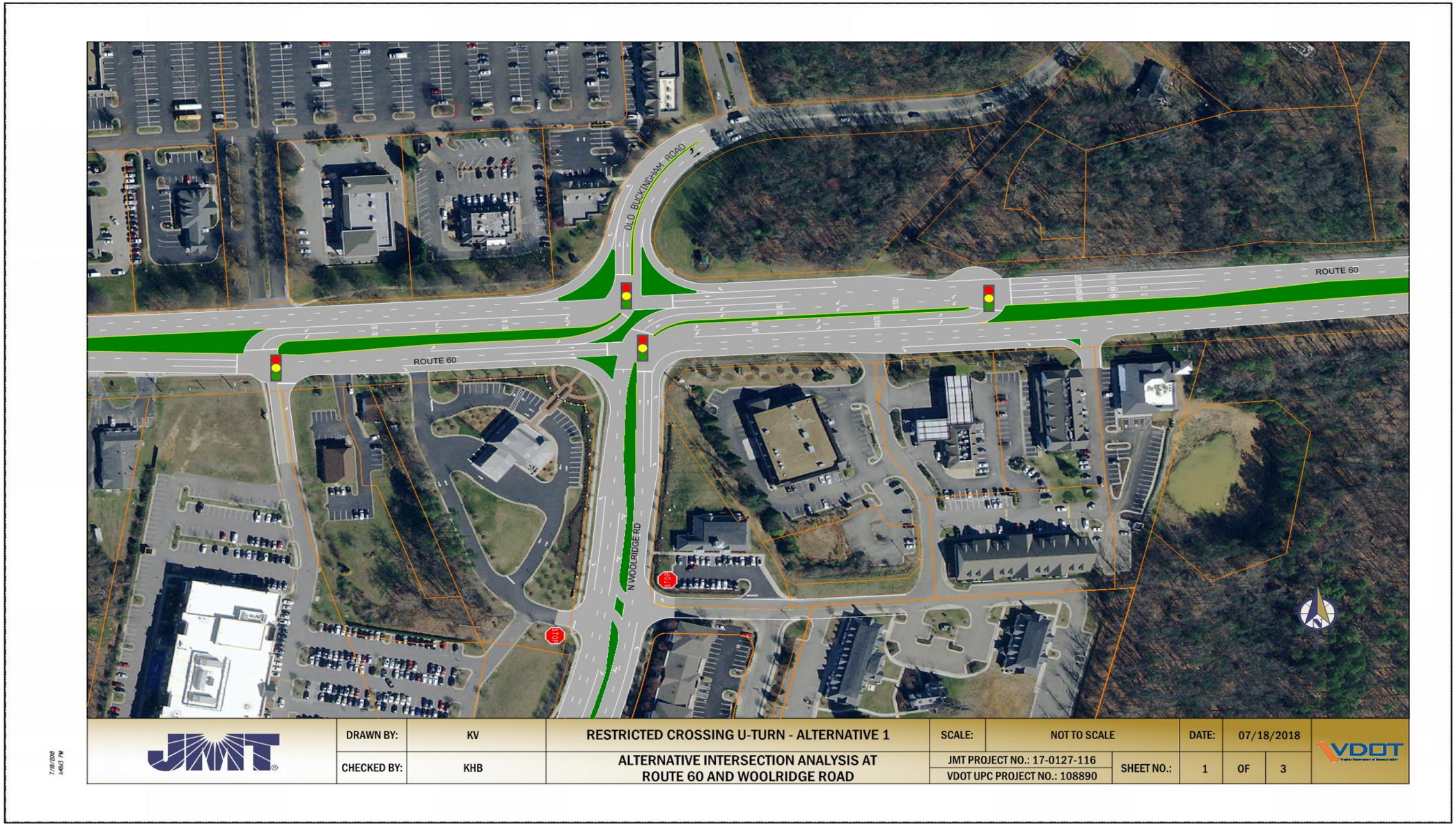
Increased Efficiency: Rerouting left turns allows for fewer traffic signal phases at the main intersection, which means less time waiting for through and right-turn vehicles.

Better Synchronization: Synchronization of three signalized intersection improves corridor travel times on both the major and side streets.

7. Concept Sketches

Planning level concept sketches for the three proposed intersection alternatives were developed using CADD. The concept sketches show proposed lane configurations, intersection control, vehicle routing, and estimated ROW boundaries. The three concept sketches were submitted to VDOT on 5/21/18 and approved for use in the Future Operational Analysis. The concept sketches for each alternative are illustrated as follows:

- Figure 9: Alternative 1 – Restricted Crossing U-Turn (RCUT) Concept
- Figure 10: Alternative 2 – Partial Displaced Left Turn Concept
- Figure 11: Modified Quadrant (QR) Roadway Concept



JMT	DRAWN BY:	KV	RESTRICTED CROSSING U-TURN - ALTERNATIVE 1	SCALE:	NOT TO SCALE		DATE:	07/18/2018		VDOT
	CHECKED BY:	KHB	ALTERNATIVE INTERSECTION ANALYSIS AT ROUTE 60 AND WOOLRIDGE ROAD	JMT PROJECT NO.: 17-0127-116 VDOT UPC PROJECT NO.: 108890		SHEET NO.:	1	OF	3	

Figure 9: Alternative 1 – Restricted Crossing U-Turn (RCUT) Concept

Figure 10: Alternative 2 – Partial Displaced Left Turn Concept

JMT	DRAWN BY:	CA	QUADRANT ROADWAY - ALTERNATIVE 3	SCALE:	NOT TO SCALE	DATE:	07/02/2018		VDOT
	CHECKED BY:	KHB	ALTERNATIVE INTERSECTION ANALYSIS AT ROUTE 60 AND WOOLRIDGE ROAD	JMT PROJECT NO.: 17-0127-116 VDOT UPC PROJECT NO.: 108890	SHEET NO.:	3	OF	3	

Figure 11: Alternative 3 – Modified Quadrant (QR) Roadway Concept

8. Future Operational Analysis

The Future Operational Analysis was conducted assuming a 20-year horizon year with all scenarios evaluated in projected 2038 conditions. The Future Operational Analysis was built from the existing intersection model to develop the future 2038 No Build model in Synchro, featuring existing roadway geometry/control and projected future volumes for both AM and PM peak hours. This model served as a baseline to compare the performance of the three alternative intersection designs shown in the concept sketches.

8.1 2038 No-Build

The 2038 No-Build model projected the existing traffic to the future year (2038) based on the following growth rates provided by VDOT:

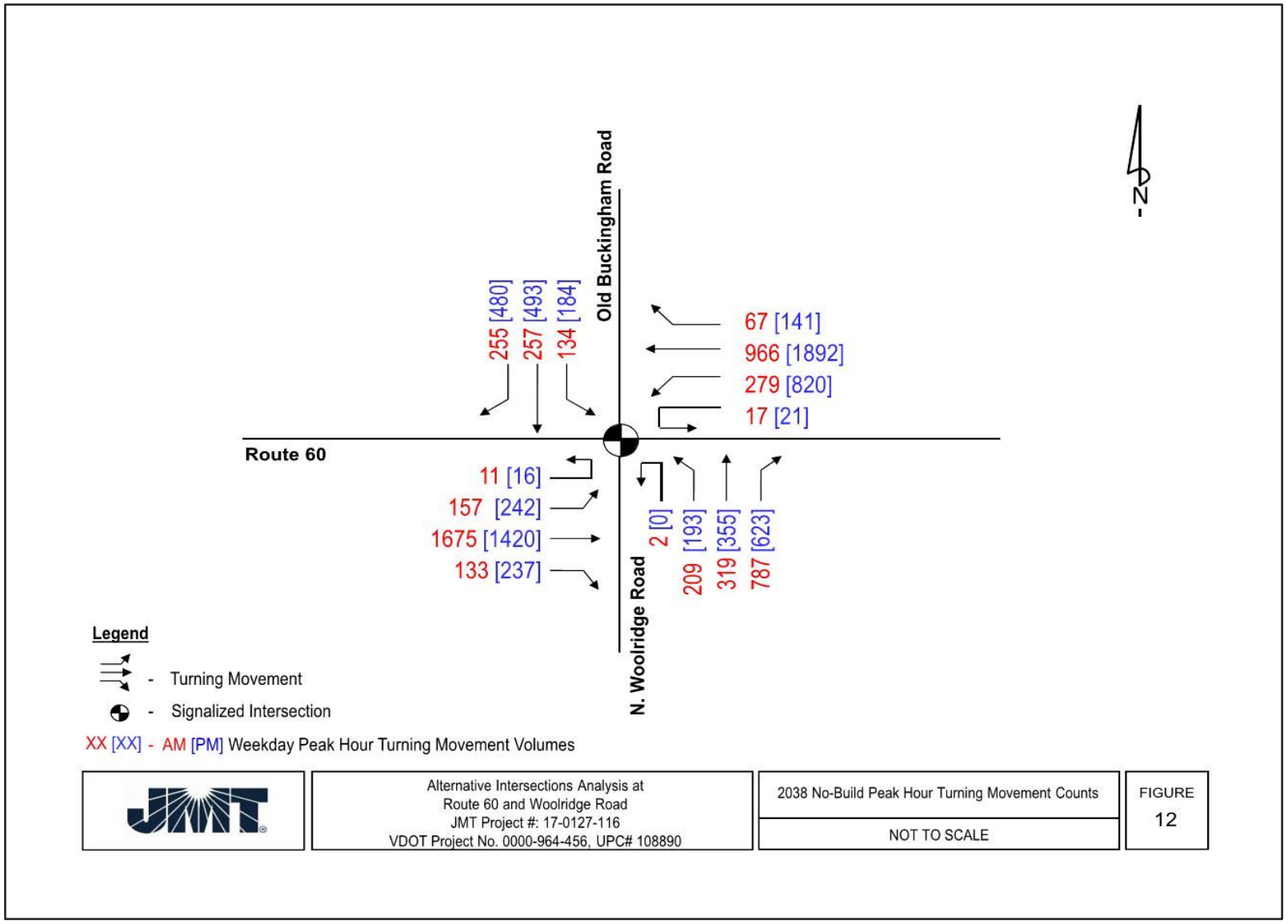
- Route 60 1.326% / year
- N. Woolridge Rd. 1.000% / year
- Old Buckingham Rd. 2.133% / year

Figure 12 shows the projected 2038 No-Build weekday AM and PM peak hour traffic volumes.

The intersection geometry in the 2038 No Build model was assumed to remain the same as under Existing conditions. The study intersection signal timings were optimized for cycle length and splits under the 2038 No Build scenario. The LOS results are summarized in Table 5, and the detailed LOS Synchro outputs are included in Appendix D.

Table 5: 2038 No-Build Levels of Service

Peak Hour	Approach		Movement Delay (s/veh)	Movement LOS	Approach Delay (s/veh)	Approach LOS	Intersection Delay (s/veh)	Intersection LOS
7:30-8:30AM	Route 60 (EB)	L	56	E	85.9	F	104.2	F
		T	94.7	F				
		R	12.9	B				
	Route 60 (WB)	L	40.8	D	23.8	C		
		T	19.4	B				
		R	12.5	B				
	Woolridge Rd. (NB)	L	145.8	F	227.1	F		
		T	42.8	D				
		R	323.6	F				
	Old Buckingham Rd. (SB)	L	61	E	74.9	E		
		T	78.6	E				
4:45-5:45PM	Route 60 (EB)	L	239.4	F	120.2	F	149.9	F
		T	113.5	F				
		R	30.7	C				
	Route 60 (WB)	L	200.1	F	156.8	F		
		T	147.6	F				
		R	22.6	C				
	Woolridge Rd. (NB)	L	194.2	F	94.5	F		
		T	60.2	E				
		R	83	F				
	Old Buckingham Rd. (SB)	L	93.3	F	237.9	F		
		T	265.3	F				


Old Buckingham Road
Route 60
N. Woolridge Road
N
255 [480]
257 [493]
134 [184]
67 [141]
966 [1892]
279 [820]
17 [21]
11 [16]
157 [242]
1675 [1420]
133 [237]
2 [0]
209 [193]
319 [355]
787 [623]
Legend
- Turning Movement
- Signalized Intersection
XX [XX] - AM [PM] Weekday Peak Hour Turning Movement Volumes
Alternative Intersections Analysis at
Route 60 and Woolridge Road
JMT Project #: 17-0127-116
VDOT Project No. 0000-964-456, UPC# 108890
2038 No-Build Peak Hour Turning Movement Counts
NOT TO SCALE
FIGURE
12

8.2 Alternative 1 – RCUT

For comparative purposes, JMT conducted an operational analysis for the Alternative 1 – RCUT concept illustrated in Figure 9. The 2038 No-Build traffic volumes shown in Figure 12 were reassigned to reflect the proposed trip routings dictated by the geometry of the RCUT Alternative. Because of the planning-level nature of this study, commercial driveway turning movements within the study area that would be affected by the proposed RCUT alternative were not included in this analysis. Figure 13 depicts the projected 2038 weekday AM and PM peak hour traffic volumes for Alternative 1 – RCUT. For analysis purposes, the following intersection geometry and operational assumptions were utilized in the 2038 Alternative 1 – RCUT model:

Intersection Geometry Assumptions

- The Alternative 1 intersection geometry follows the standard R-CUT geometric pattern shown in Figure 6.
- It is noted that the EB and WB median U-turn movements on Route 60 are double-lane.
- A shoulder "bulb-out" (or "loon") is provided on the north side of Route 60 to accommodate the EB to WB U-turn movement.
- A new median opening is proposed along N. Woolridge Road approximately 525' south of Route 60.
    - The new opening aligns with existing commercial entrances on NB and SB of N. Woolridge Road.
    - The crossover would reduce the available SB double-left-turn storage at the next signalized intersection to the south (N. Woolridge Rd. and Walton Park Rd.).
    - NB left-turns from N. Woolridge Rd. would not be permitted at the new median opening.

Intersection Operations Assumptions

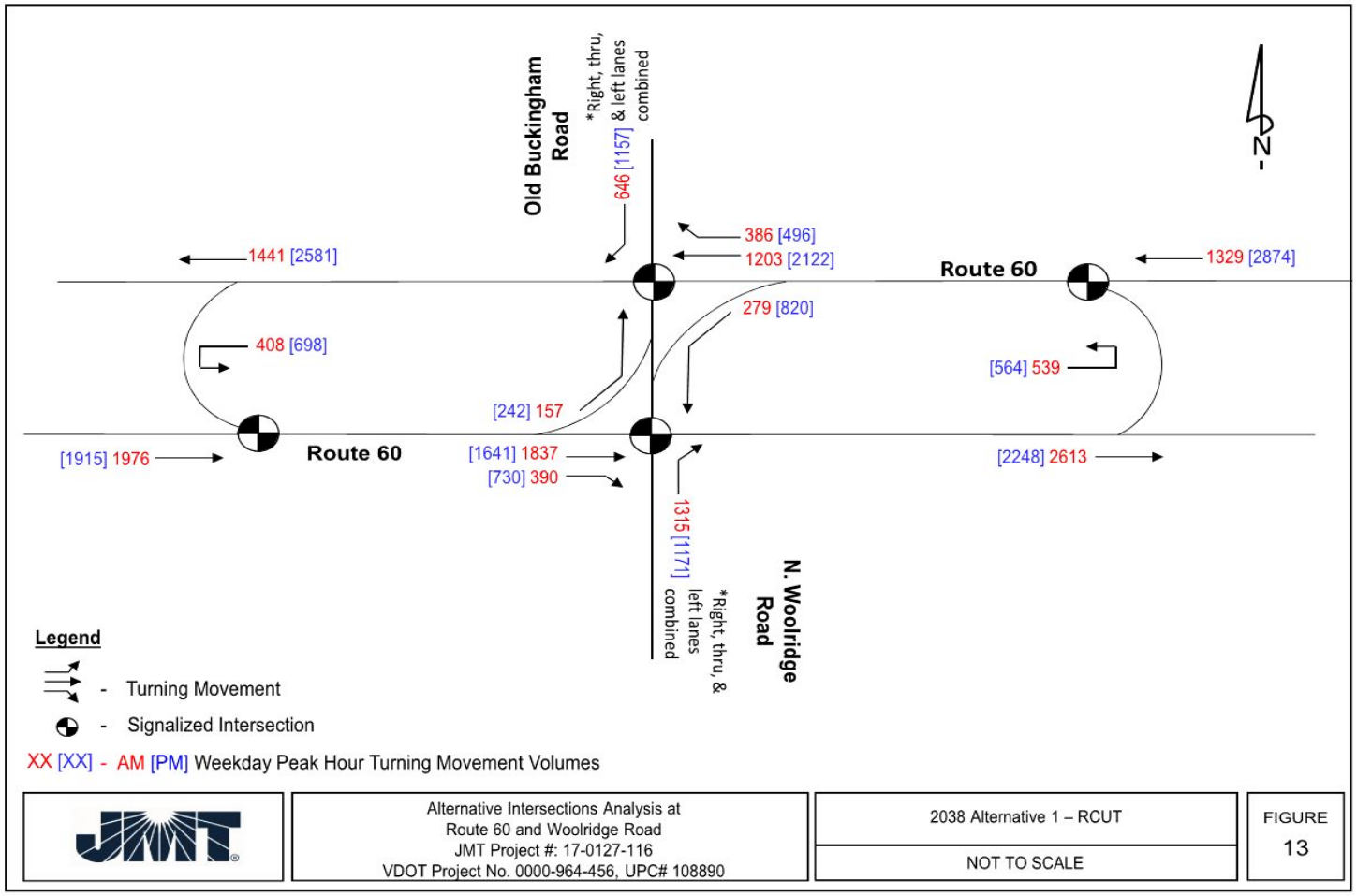
- The Route 60/N. Woolridge intersection remains signalized, and both median U-turns on Route 60 are signalized.
- The EB Route 60 Right-in/Right-out entrance to Browns Way Road is closed in this alternative.
- The existing WB Route 60 left-turn crossover into the existing commercial entrance (just east of the proposed WB to EB U-turn) is closed in this alternative, and the entrance is converted to a Right-in/Right-out only.
- The existing Right-in/Right-out entrance on EB Route 60 at the WB to EB U-turn remains open, but it is not signalized.
- The new median opening on N. Woolridge Rd. would be unsignalized with stop-control on the side street (commercial entrance) approaches.

- The overall cycle lengths for all traffic signals were optimized for the AM and PM peak periods, and offsets were coded between the Route 60/N. Woolridge intersection and the EB and WB Route 60 median U-turn intersections to optimize progressions.

The RCUT Alternative's signalized intersections shown in Figure 13 were analyzed with Synchro for the projected 2038 traffic volumes. Given the planning-level nature of this analysis, unsignalized intersection operations for driveways, etc. within the study limits of Alternative 1 were not analyzed. The LOS results for Alternative 1 – RCUT are summarized in Table 6, and detailed LOS from Synchro outputs are included in Appendix E.1.

Table 6: 2038 Alternative – 1 (RCUT) Levels of Service

Peak Hour	Approach		Movement Delay (s/veh)	Movement LOS	Approach Delay (s/veh)	Approach LOS	Intersection Delay (s/veh)	Intersection LOS
AM Peak Hour 7:30-8:30AM	**Intersection 1 - Rte. 60 and Old Buckingham Rd.**							
	Route 60 (EB)	L	14.1	B	14.1	B	9.8	A
		T	-	-				
		R	-	-				
	Route 60 (WB)	L	-	-	6.45	A		
		T	10.5	B				
		R	2.4	A				
	Old Buckingham Rd. (SB)	L	13.5	B	13.5	B		
		T						
	Intersection 2 - Rte. 60 WB U-turn and Rte. 60 EB							
	Route 60 (EB)	L	-	-	13.8	A	17	B
		T	13.8	A				
		R	-	-				
	Route 60 (WB)	L	32.7	C	32.7	C		
		T	-	-				
		R	-	-				
	Intersection 3 - N. Woolridge Rd. and Rte. 60							
	Route 60 (EB)	L	-	-	80	E	59.7	E
		T	80	E				
		R	-	-				
	Route 60 (WB)	L	6.4	A	6.4	A		
		T	-	-				
		R	-	-				
	Woolridge Rd (NB)	L	17.5	B	17.5	B		
		T						
	Intersection 4 - Rte. 60 EB U-turn and Rte. 60 WB							
	Route 60 (EB)	L	0.7	A	0.7	A	10.3	B
		T	-	-				
		R	-	-				
	Route 60 (WB)	L	-	-	14.2	B		
		T	14.2	B				
		R	-	-				
PM Peak Hour 4:45-5:45PM	**Intersection 1 - Rte. 60 and Old Buckingham Rd.**							
	Route 60 (EB)	L	39.9	D	39.9	D	58.7	E
		T	-	-				
		R	-	-				
	Route 60 (WB)	L	-	-	58.5	E		
		T	71.4	E				
		R	3.3	A				
	Old Buckingham Rd. (SB)	L	66	E	66	E		
		T						
	Intersection 2 - Rte. 60 WB U-turn and Rte. 60 EB							
	Route 60 (EB)	L	-	-	22.3	C	27.8	C
		T	22.3	C				
		R	-	-				
	Route 60 (WB)	L	42.9	D	42.9	D		
		T	-	-				
		R	-	-				
	Intersection 3 - N. Woolridge Rd. and Rte. 60							
	Route 60 (EB)	L	-	-	12.5	B	13.5	B
		T	12.5	B				
		R	-	-				
	Route 60 (WB)	L	15.6	B	15.6	B		
		T	-	-				
		R	-	-				
	Woolridge Rd (NB)	L	13.3	B	13.3	B		
		T						
	Intersection 4 - Rte. 60 EB U-turn and Rte. 60 WB							
	Route 60 (EB)	L	17.4	B	17.4	B	16.3	B
		T	-	-				
		R	-	-				
	Route 60 (WB)	L	-	-	16.1	B		
		T	16.1	B				
		R	-	-				


Old Buckingham Road
*Right, thru, & left lanes combined
646 [1157]
386 [496]
1203 [2122]
1441 [2581]
Route 60
1329 [2874]
279 [820]
408 [698]
[564] 539
[242] 157
[1915] 1976
Route 60
[1641] 1837
[730] 390
[2248] 2613
1315 [1171]
*Right, thru, & left lanes combined
N. Woolridge Road
N
Legend
- Turning Movement
- Signalized Intersection
XX [XX] - AM [PM] Weekday Peak Hour Turning Movement Volumes
Alternative Intersections Analysis at
Route 60 and Woolridge Road
JMT Project #: 17-0127-116
VDOT Project No. 0000-964-456, UPC# 108890
2038 Alternative 1 – RCUT
NOT TO SCALE
FIGURE
13

8.3 Alternative 2 – Partial Displaced Left Turn Lane

For comparative purposes, JMT conducted an operational analysis for the Alternative 2 – Partial Displaced Left Turn Lane concept illustrated in Figure 10. The 2038 No-Build traffic volumes shown in Figure 12 were reassigned to reflect the proposed trip routings dictated by the geometry of the Partial Displaced Left Turn Lane Alternative. Because of the planning-level nature of this study, commercial driveway turning movements within the study area that would be affected by the proposed Partial Displaced Left Turn alternative were not included in this analysis. Figure 14 depicts the projected 2038 weekday AM and PM peak hour traffic volumes for Alternative 2 – Partial Displaced Left Turn Lane.

For analysis purposes, the following intersection geometry and operational assumptions were utilized in the 2038 Alternative 2 – Partial Displaced Left Turn Lane model:

Intersection Geometry Assumptions

- The Alternative 2 intersection geometry is a Partial DLT and deviates from the standard configuration discussed in Section 6.2 because only one approach's left-turn movements (WB Route 60 to SB N. Woolridge Rd.) is displaced (instead of all 4).
- The existing WB left-turn movement on Route 60 has double-left turn lanes; however, it is noted that the displaced WB left-turn movement was analyzed as a single left-turn lane because the operational analysis demonstrated its ability to handle the projected 2038 traffic demand.
- A new median opening is proposed along N. Woolridge Road approximately 525' south of Route 60.
    - The new opening aligns with existing commercial entrances on NB and SB N. Woolridge Road
    - The SB left-in movement replaces the Right-in/Right-out access that was eliminated on EB Route 60 at Browns Way Road.
    - The crossover would reduce the available SB double-left-turn storage at the next signalized intersection to the south (N. Woolridge Rd. and Walton Park Rd.).

Intersection Operations Assumptions

- The Route 60/N. Woolridge intersection remains signalized, and the WB displaced left-turn crossover movement across EB Route 60 is signalized.
- The EB Route 60 Right-in/Right-out entrance to Browns Way Road is closed in this alternative.
- The existing WB Route 60 left-turn crossover into the existing commercial entrance (just east of the proposed WB displaced left-turn crossover) is closed in this alternative, and the entrance is converted to a Right-in/Right-out only operation.

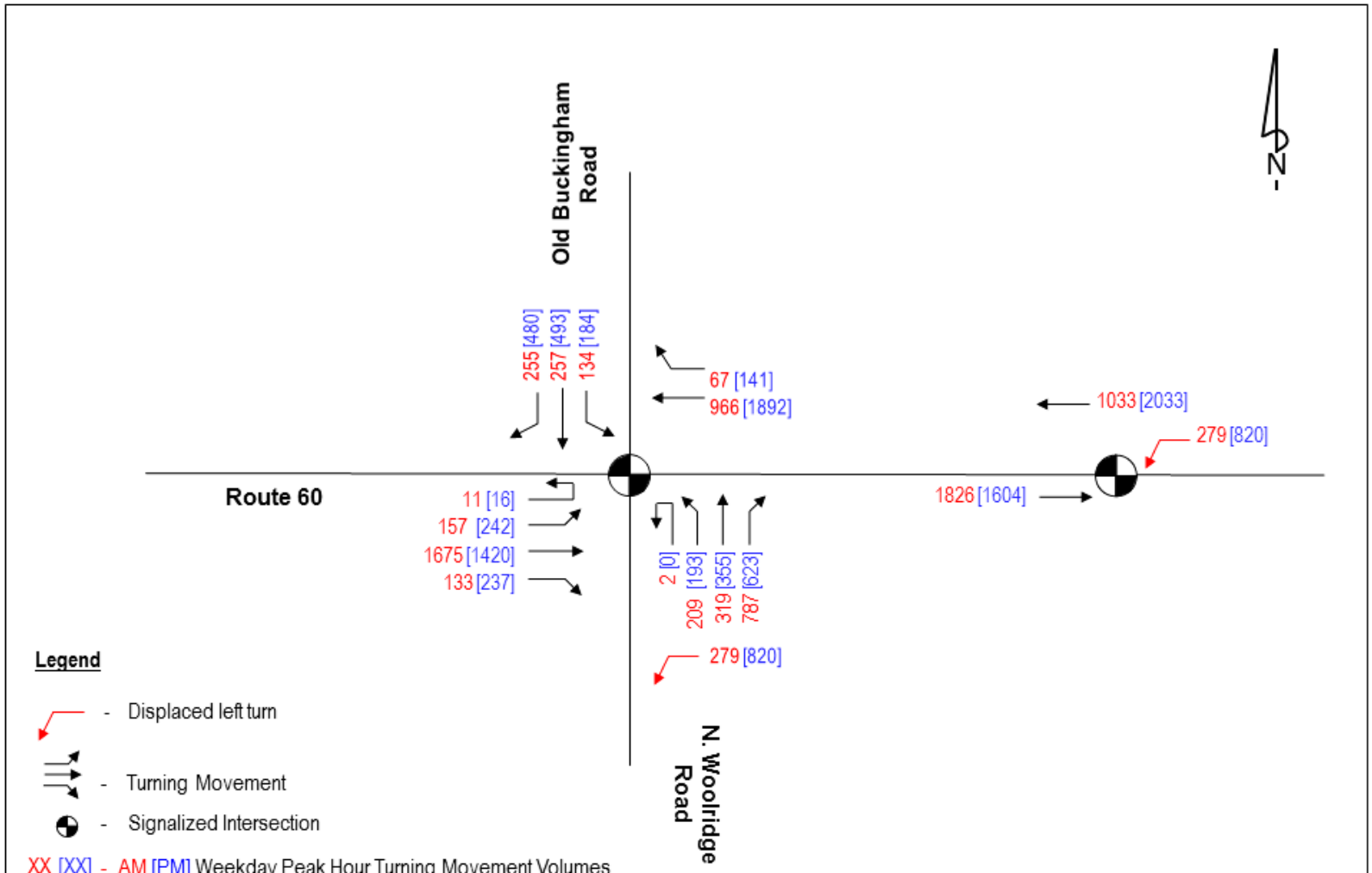
- The existing Right-in/Right-out entrance on EB Route 60 at the WB to EB U-turn remains open, but it is not signalized.
- The new median opening on N. Woolridge Rd. would be unsignalized with stop-control on the side street (commercial entrance) approaches.
- The traffic signals for the displaced left-turn intersection were optimized for the AM and PM peak periods, and offsets were coded between the Route 60/N. Woolridge intersection and the WB Route 60 displaced left-turn crossover.

The Partial Displaced Left Turn Lane Alternative's signalized intersections shown in Figure 14 were analyzed with VISSIM for the projected 2038 traffic volumes. Given the planning-level nature of this analysis, unsignalized intersection operations for driveways, etc. within the study limits of Alternative 2 were not analyzed.

The LOS results for Alternative 2 – Partial Displaced Left Turn Lane are summarized in Table 7, and also included in Appendix E.2.

Table 7: 2038 Alternative 2 – Partial Displaced Left Turn Lane Levels of Service

Peak Hour	Approach		Movement Delay (s/veh)	Movement LOS	Approach Delay (s/veh)	Approach LOS	Intersection Delay (s/veh)	Intersection LOS
7:30-8:30AM	**Intersection 1 - Rte. 60 and Woolridge Rd./Old Buckingham Rd.**							
	Route 60 (EB)	L	32.28	C	-	-	19.4	B
		T	14.59	B				
		R	2.13	A				
	Route 60 (WB)	L	4.02	A	-	-		
		T	18.5	B				
		R	1.61	A				
	Woolridge Rd. (NB)	L	50.71	D	-	-		
		T	33.64	C				
		R	6.43	A				
	Old Buckingham Rd. (SB)	L	55.2	E	-	-		
		T	49.59	D				
	Intersection 2 - Rte. 60 WBL Crossover and Rte. 60 EB							
	Route 60 (EB)	L	-	-	-	-	12.75	B
		T	7.04	A				
		R	-	-				
	Route 60 (WB)	L	18.51	B	-	-		
		T	-	-				
		R	-	-				
4:45-5:45PM	**Intersection 1 - Rte. 60 and Woolridge Rd./Old Buckingham Rd.**							
	Route 60 (EB)	L	197.98	F	-	-	42.87	D
		T	28.3	C				
		R	4.51	A				
	Route 60 (WB)	L	24.82	C	-	-		
		T	32.81	C				
		R	3.25	A				
	Woolridge Rd. (NB)	L	270.81	F	-	-		
		T	51.45	D				
		R	6.17	A				
	Old Buckingham Rd. (SB)	L	66.89	E	-	-		
		T	53.14	D				
	Intersection 2 - Rte. 60 WBL Crossover and Rte. 60 EB							
	Route 60 (EB)	L	-	-	-	-	32.175	C
		T	41.66	D				
		R	-	-				
	Route 60 (WB)	L	22.69	C	-	-		
		T	-	-				
		R	-	-				


Old Buckingham Road
N
255 [480]
257 [493]
134 [184]
67 [141]
966 [1892]
1033 [2033]
279 [820]
Route 60
11 [16]
157 [242]
1675 [1420]
133 [237]
2 [0]
209 [193]
319 [355]
787 [623]
1826 [1604]
279 [820]
N. Woolridge Road
Legend
- Displaced left turn
- Turning Movement
- Signalized Intersection
XX [XX] - AM [PM] Weekday Peak Hour Turning Movement Volumes
Alternative Intersections Analysis at
Route 60 and Woolridge Road
JMT Project #: 17-0127-116
VDOT Project No. 0000-964-456, UPC# 108890
2038 Alternative 2 - Partial DL
NOT TO SCALE
FIGURE
14

8.4 Alternative 3 – Modified Quadrant Roadway

For comparative purposes, JMT conducted an operational analysis for the Alternative 3 – Modified Quadrant Roadway concept illustrated in Figure 11. The 2038 No-Build traffic volumes shown in Figure 12 were reassigned to reflect the proposed trip routings dictated by the geometry of the Modified Quadrant Roadway (QR) Alternative. Because of the planning-level nature of this study, commercial driveway turning movements within the study area that would be affected by the proposed Modified QR alternative were not included in this analysis. Figure 15 depicts the projected 2038 weekday AM and PM peak hour traffic volumes for Alternative 3 – Modified Quadrant Roadway.

For analysis purposes, the following intersection geometry and operational assumptions were utilized in the 2038 Alternative 3 – Modified Quadrant Roadway model:

Intersection Geometry Assumptions

- The Alternative 3 intersection geometry is a Modified QR and deviates from the standard configuration discussed in Section 6.3 because only one approach's left-turn movements (WB Route 60 to SB N. Woolridge Rd.) access the QR (instead of all 4).
- The proposed WB left-turn movement from Route 60 onto the QR has double-left turn lanes, which matches the existing WB left-turn movement on Route 60.
- The proposed QR has two lanes in the SB and WB directions (from Route 60 to N. Woolridge Road) and one lane in the EB and NB directions from N. Wooldridge Rd. to Route 60.
- The QR alignment would significantly impact parking at existing businesses near Route 60. In addition, significant grading and parking impacts would occur in the southeast corner of the QR.

Intersection Operations Assumptions

- The Route 60/N. Woolridge intersection remains signalized.
- The WB Route 60 left-turn movement across EB Route 60 is signalized and replaces the existing unsignalized left-turn movement.
- The EB Route 60 Right-in/Right-out entrance to Browns Way Road remains open in this alternative.
- A new median opening with signalized control is proposed along N. Woolridge Road approximately 525' south of Route 60. The new opening aligns with existing commercial entrances on NB and SB N. Woolridge Road. The crossover would reduce the available SB double-left-turn storage at the next signalized intersection to the south (N. Woolridge Rd. and Walton Park Rd.).

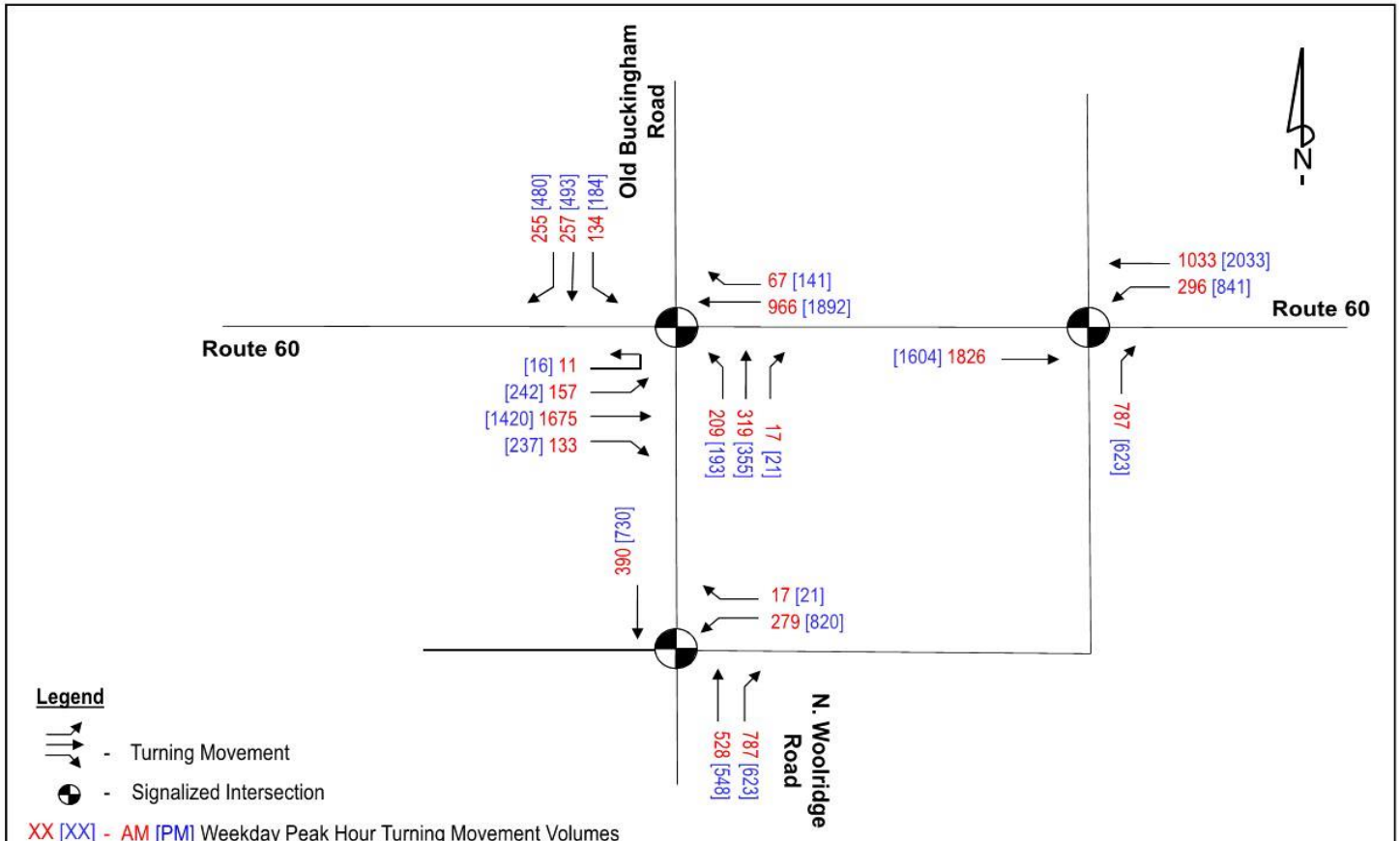
- The traffic signals for the QR alternative were optimized for the AM and PM peak periods, and offsets were coded between all three intersections to promote throughput of the heaviest volume platoons.

The Modified Quadrant Roadway Alternative's signalized intersections shown in Figure 15 were analyzed with Synchro for the projected 2038 traffic volumes. Given the planning-level nature of this analysis, unsignalized intersection analysis for driveways, etc. within the study limits of Alternative 3 were not analyzed.

The LOS results for Alternative 3 – Modified Quadrant Roadway are summarized in Table 8, and the LOS from Synchro outputs are included in Appendix E.3.

Table 8: 2038 Alternative 3 – Modified Quadrant Roadway Levels of Service

Peak Hour	Approach		Movement Delay (s/veh)	Movement LOS	Approach Delay (s/veh)	Approach LOS	Intersection Delay (s/veh)	Intersection LOS
AM Peak Hour 7:30-8:30AM	**Intersection 1 - Rte. 60 and Woolridge Rd./Old Buckingham Rd.**							
	Route 60 (EB)	L	131.5	F	28.3	C	64.8	E
		T	20.1	C				
		R	1.5	A				
	Route 60 (WB)	L	-	-	77.6	E		
		T	82.7	F				
		R	3.9	A				
	Woolridge Rd. (NB)	L	161.8	F	109	F		
		T	80.1	F				
		R	0.5	A				
	Old Buckingham Rd. (SB)	L	91.9	F	118.6	F		
		T	125.6	F				
	Intersection 2 - N. Woolridge Rd. and Browns Way Rd.							
	Bank Entrance/Exit(EB)	L	15.6	B	15.6	B	7.6	A
		T	-	-				
		R	-	-				
	Browns Way Rd. (WB)	L	27.1	B	77.6	B		
		T	22.3	B				
		R	-	-				
	Woolridge Rd. (NB)	L	-	-	4.3	A		
		T	5.7	A				
		R	3.4	A				
	Woolridge Rd. (SB)	L	-	-	5.4	A		
		T	5.4	A				
	Intersection 3 - Rte. 60 and Proposed Connector Road							
	Route 60 (EB)	L	-	-	10.6	B	10	B
		T	10.6	C				
		R	-	-				
	Route 60 (WB)	L	30.2	C	30.2	C		
		T	-	-				
		R	-	-				
PM Peak Hour 4:45-5:45PM	**Intersection 1 - Rte. 60 and Woolridge Rd./Old Buckingham Rd.**							
	Route 60 (EB)	L	172	F	39.3	D	126.8	F
		T	21.4	C				
		R	1.8	A				
	Route 60 (WB)	L	-		156.1	F		
		T	167.2	F				
		R	6	A				
	Woolridge Rd. (NB)	L	243.4	F	119.3	F		
		T	58.6	E				
		R	2.8	A				
	Old Buckingham Rd. (SB)	L	99.2	F	224	F		
		T	247.7	F				
	Intersection 2 - N. Woolridge Rd. and Browns Way Rd.							
	Bank Entrance/Exit(EB)	L	11	B	11	B	10.3	B
		T	-	-				
		R	-	-				
	Browns Way Rd. (WB)	L	11.5	B	12.4	B		
		T	13.3	B				
		R	-	-				
	Woolridge Rd. (NB)	L	-	-	9.1	A		
		T	14.6	B				
		R	4.2	A				
	Woolridge Rd. (SB)	L	-	-	9.9	A		
		T	9.9	A				
	Intersection 3 - Rte. 60 and Proposed Connector Road							
	Route 60 (EB)	L	-	-	12.5	B	16.7	B
		T	12.5	B				
		R	-	-				
	Route 60 (WB)	L	36.5	D	36.5	D		
		T	-	-				
		R	-	-				


Old Buckingham Road
255 [480]
257 [493]
134 [184]
67 [141]
966 [1892]
1033 [2033]
296 [841]
Route 60
Route 60
[16] 11
[242] 157
[1420] 1675
[237] 133
209 [193]
319 [355]
17 [21]
[1604] 1826
787 [623]
390 [730]
17 [21]
279 [820]
N
Legend
- Turning Movement
- Signalized Intersection
XX [XX] - AM [PM] Weekday Peak Hour Turning Movement Volumes
528 [548]
787 [623]
N. Woolridge Road
Alternative Intersections Analysis at
Route 60 and Woolridge Road
JMT Project #: 17-0127-116
VDOT Project No. 0000-964-456, UPC# 108890
2038 Alternative 3 – Modified QR
NOT TO SCALE
FIGURE
15

9. Cost Estimate

Planning-level cost estimates were prepared for each of the three alternatives using VDOT's 2015 Transportation and Mobility Planning Division (TMPD) Cost Estimating spreadsheet and VDOT's Highway Safety Improvement Program (HSIP) Worksheets. The cost estimates include the three phases of preliminary engineering, right of way, and construction. The base construction cost and estimated costs for right of way and utilities were each developed in VDOT's 2015 TMPD spreadsheet for input into the HSIP Worksheets. An inflation factor of 3% per year was included to escalate the 2015 TMPD estimates to 2018 values. Estimated costs for preliminary engineering and contingency line items were developed using the HSIP worksheets equations. Table 9 contains a summary of the planning-level costs for each alternative:

Table 9: Planning-Level Cost and B/C Ratio Summary for Alternatives

Deficiency	Planning-Level Cost		
	Alt. 1 - RCUT	**Alt. 2 - Partial DLT**	**Alt. 3 - Modified QR**
Traffic Signalization[1]	$800,000	$400,000	$500,000
Roadway Improvements/Additions[2]	$3,100,000	$1,200,000	$1,300,000
Construction Cost Subtotal[3]	**$3,900,000**	**$1,600,000**	**$1,800,000**
PE Cost[4]	$395,000	$165,000	$185,000
R/W & Utility Cost[5]	$3,120,000	$1,280,000	$1,440,000
Contingency (10%)[6]	$390,000	$160,000	$180,000
Life Cycle & Annual Maintenance Costs (PV)[7]	$125,000	$30,000	$55,000
Total Cost	**$7,930,000**	**$3,240,000**	**$3,660,000**
B/C	**0.13**	**0.60**	**Undetermined***

* Crash Modification Factor(s) (CMF) for elements of Alternative 3 – Modified Quadrant Roadway were not able to be determined based on existing CMF Clearinghouse and internet research.

[1] Costs from VDOT's TMPD spreadsheet (25% built in PE costs removed)
[2] Costs from VDOT's TMPD spreadsheet (25% built in PE costs removed)
[3] Sum of Traffic Signalization Costs & Roadway Improvements/Additions Costs
[4] Costs from HSIP worksheets (10% of construction cost + $5,000)
[5] Costs from TMPD worksheet (Used 'Outlying business/suburban high density', 60%-low estimate, 100%-high estimate.
[6] Contingency from HSIP worksheet (10% of HSIP Construction Cost).
[7] Present Value costs from HSIP worksheets

The HSIP worksheets are included in the Appendix of this report, as follows:

- Appendix F: Alternative 1 – RCUT Concept HSIP Worksheet
- Appendix G: Alternative 2 – Partial Displaced Left Turn Concept HSIP Worksheet
- Appendix H: Alterative 3 – Modified Quadrant Roadway (QR) Concept HSIP Worksheet

The HSIP worksheets were used to determine each alternative's B/C ratio, which are summarized in Table 10 (see next section).

10. Conclusions and Recommendations

Based on the data collection, field observations, assumptions, methodologies and analysis contained in this report, the following conclusions and recommendations for the Route 60 / N. Woolridge Road intersection are offered (refer to Table 10 for a summary of all LOS results and B/C ratio calculations):

Conclusions

- **Existing 2018 Conditions**: Under existing conditions, the Route 60 / N. Woolridge Road intersection operates with overall LOS D and E during the weekday AM and PM peak hours, respectively. The intersection is ranked 14th in the Richmond District's 2015 ranking of top 100 intersections based on Potential for Safety Improvement (PSI). The crash issues at this intersection are related to peak hour congestion and driver confusion that is caused by a combination of intersection geometry and access management issues near the intersection.

- **2038 No Build Conditions**: Under projected 2038 No Build conditions (with signal optimization but without physical improvements), the existing operational and safety issues are expected to worsen at the intersection as follows:
  - Projected 2038 AM/PM weekday peak hour overall levels of service are expected to degrade from existing D/E to F/F.
  - Average vehicle delays are expected to increase by more than double, as follows:
    - AM Peak Hr. delays increase from ± 45 sec./veh. to over 100 sec./veh.
    - PM Peak Hr. delays increase from ± 65 sec./veh. to nearly 150 sec./veh.
  - It is reasonable to anticipate a continued increase in crashes at this intersection.

- **Alternative 1 – RCUT**: Under projected future 2038 conditions with Alternative 1 – RCUT:
  - The North and South signals at the Route 60 / N. Woolridge Rd. / Old Buckingham Rd. intersection operate with LOS A and E, respectively, during the AM peak hour and LOS E and B, respectively, during the PM peak hour. These LOS represent an improvement over the No Build condition, but additional delays will be incurred by vehicles required to make median U-Turns on Route 60.
  - The secondary intersection signals for the median U-Turns on Route 60 east and west of the main intersection operate with LOS C or better under AM and PM peak hour conditions.
  - The planning-level cost for Alternative 1 – RCUT is approximately $7.9M, which is more than twice the planning-level costs for Alternative 2 or Alternative 3.

- The calculated B/C ratio for Alternative 1 is 0.13, which is approximately ¼ the B/C ratio for Alternative 2.
- Similar to Alternative 2, Alternative 1 will close the Browns Way Road entrance on EB Route 60, significantly affecting access to existing commercial uses in the SE quadrant of the study intersection, and it will require further evaluation of a proposed median break along N. Woolridge Road approximately 525' south of Route 60.
- Alternative 1 introduces 2 new signalized intersections along Route 60, which could lead to additional rear-end collisions.

- **Alternative 2 – Partial Displaced Left-Turn Lane (DLT)**: Under projected future 2038 conditions with Alternative 2 – Partial DLT:
  - The Route 60 / N. Woolridge Rd. intersection operates with overall LOS B and D during the AM and PM peak hours, respectively.
  - The secondary intersection signal for the WB Route 60 median crossover movement (east of the main intersection) operates with LOS C or better under AM and PM peak hour conditions.
  - The planning-level cost for Alternative 2 – Partial DLT is approximately $3.2M, which is approx. half the planning-level cost of Alternative 1 and approx. equal to the planning-level cost for Alternative 3.
  - The calculated B/C ratio for Alternative 2 is 0.60, which is approximately 4 times higher than the B/C ratio for Alternative 1.
  - Similar to Alternative 1, Alternative 2 will close the Browns Way Road entrance on EB Route 60, significantly affecting access to existing commercial uses in the SE quadrant of the study intersection, and it will require further evaluation of a proposed median break along N. Woolridge Road approximately 525' south of Route 60.
  - Alternative 2 introduces 1 new 2-phased signal along Route 60, which could lead to additional rear-end collisions.

- **Alternative 3 – Modified Quadrant Roadway (QR)**: Under projected future 2038 conditions with Alternative 3 – Modified QR:
  - The Route 60 / N. Woolridge Rd. intersection operates with overall LOS E and F during the AM and PM peak hours, respectively. In comparison to the No Build delays, the delays associated with the LOS from Alt. 3 are significantly improved in the AM peak hour, but only slightly improved in the PM peak hour.
  - The secondary intersection signals on Route 60 (east of the main intersection) and on N. Woolridge Road (south of the main intersection) operates with overall LOS B or better under AM and PM peak hour conditions.

- The planning-level cost for Alternative 3 – Modified QR is approx. $3.7M, which is approx. half the planning-level cost of Alternative 1 and approx. equal to the planning-level cost for Alternative 2.
- Significant caution is recommended when evaluating the planning-level cost for this alternative for the following reasons:
  - There are significant topography issues in the SE corner of the QR, where it turns from a north-south alignment to an east-west alignment.
  - This alternative will have the highest impact to existing commercial parking immediately south of Route 60, and continuing along the length of the QR. The damages to existing businesses along the QR alignment may not be reflected in the planning-level costs. Adjustment of the QR alignment further to the east (to avoid the businesses immediately south of Route 60) was briefly considered, however, the median crossover on Route 60 is significantly bi-furcated in this area, and there are more severe slopes along that alignment.
- No applicable Crash Modifications Factors (CMFs) could be located for the Modified QR; therefore, a B/C ratio could not be calculated.
- Alternative 3 is the only alternative (other than the No Build) that will maintain all existing access points on EB Route 60. Alternative 3 will require further evaluation of a proposed median break along N. Woolridge Road approximately 525' south of Route 60.
- Alternative 3 introduces two new signalized intersections (1 each on Route 60 and N. Woolridge Road), which could lead to additional rear-end collisions.

Recommendations

Alternative 1 – RCUT and Alternative 2 – Partial DLT provide clear safety benefits and improved LOS over projected future 2038 No Build conditions; however, their planning-level costs exceed the calculated benefits (significantly so for Alternative 1). Alternative 3 – Modified QR provides improved LOS over the 2038 No Build conditions (although less so than Alternatives 1 and 2); however, because of a lack of applicable CMFs, further research is required to calculate a B/C ratio for Alternative 3 – Partial QR.

Table 10: 2038 Alternatives Comparison

ALTERNATIVE INTERSECTION ANALYSIS AT ROUTE 60 AND N. WOOLRIDGE ROAD							
2038 Analysis Alternative	Primary Intersections		Secondary Intersections		Benefit ($)	Cost ($)	B/C
	AM Level of Service & Overall Intersection Delay (Seconds)	PM Level of Service & Overall Intersection Delay (Seconds)	AM Level of Service & Overall Intersection Delay (Seconds)	PM Level of Service & Overall Intersection Delay (Seconds)			
No-Build	F 104.2	F 149.9	N/A	N/A	N/A	N/A	N/A
Alternative 1 - Restricted Crossing U-turn (RCUT)	Rte. 60/Old Buckingham Rd. A 9.8 Rte. 60/N. Woolridge Rd. E 59.7	Rte. 60/Old Buckingham Rd. E 58.7 Rte. 60/N. Woolridge Rd. B 13.5	Rte. 60 – EB-to-WB U-Turn B 10.3 Rte. 60 – WB-to-EB U-Turn B 17	Rte. 60 - EB-to-WB U-Turn B 16.3 Rte. 60 - WB-to-EB U-Turn C 27.8	$1,001,000	$7,930,000	0.13
Alternative 2 - Partial Displaced Left-Turn Lane	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. B 19.4	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. D 42.87	Rte. 60 - WBL Crossover B 12.75	Rte. 60 - WBL Crossover C 32.18	$1,953,000	$3,240,000	0.60
Alternative 3 - Modified Quadrant Roadway (QR)	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. E 64.8	Rte. 60 at N. Woolridge Rd. and Old Buckingham Rd. F 126.8	N. Woolridge at Browns Way Rd. A 7.6 Rte. 60 - East at Proposed Connector Rd. B 10	N. Woolridge at Browns Way Rd. B 10.3 Rte. 60 - East at Proposed Connector Rd. B 16.7	$0 / Undetermined	$3,660,000	Undetermined

Appendix A

2018 Existing Traffic Counts

Peggy Malone & Associates

(800) 247-8602

File Name : Woolridge Rd_Old Buckingham Rd and Rt 60
Site Code :
Start Date : 4/19/2018
Page No : 1

Groups Printed- Car

	Route 60 Eastbound					Route 60 Westbound					Woolridge Rd Northbound					Old Buckingham Rd Southbound					
Start Time	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Int. Total
06:00 AM	7	114	1	0	122	8	38	0	0	46	6	9	39	0	54	7	8	9	0	24	246
06:15 AM	5	128	3	0	136	12	56	4	0	72	3	9	52	0	64	11	7	9	0	27	299
06:30 AM	6	173	6	1	186	14	90	4	0	108	23	18	76	0	117	12	14	17	0	43	454
06:45 AM	6	214	3	1	224	26	147	1	0	174	14	29	74	0	117	16	19	40	0	75	590
Total	24	629	13	2	668	60	331	9	0	400	46	65	241	0	352	46	48	75	0	169	1589
07:00 AM	13	251	8	3	275	26	133	2	1	162	50	30	108	1	189	16	16	33	0	65	691
07:15 AM	20	306	11	2	339	19	119	4	0	142	35	69	150	0	254	20	22	33	0	75	810
07:30 AM	19	319	18	2	358	46	176	13	2	237	35	72	167	0	274	17	27	33	0	77	946
07:45 AM	28	312	13	1	354	59	201	10	6	276	49	58	179	1	287	24	57	48	0	129	1046
Total	80	1188	50	8	1326	150	629	29	9	817	169	229	604	2	1004	77	122	147	0	346	3493
08:00 AM	31	305	38	3	377	45	169	9	2	225	43	72	149	0	264	17	44	46	0	107	973
08:15 AM	35	302	27	1	365	61	165	13	2	241	37	53	143	0	233	26	36	37	0	99	938
08:30 AM	29	257	8	0	294	50	149	7	3	209	30	43	116	1	190	14	30	34	0	78	771
08:45 AM	22	243	7	3	275	51	157	9	2	219	30	67	146	0	243	22	30	39	0	91	828
Total	117	1107	80	7	1311	207	640	38	9	894	140	235	554	1	930	79	140	156	0	375	3510
09:00 AM	28	248	18	4	298	67	154	6	0	227	30	48	108	0	186	10	24	36	0	70	781
09:15 AM	38	254	17	1	310	69	130	5	1	205	39	57	114	0	210	16	30	40	0	86	811
09:30 AM	37	211	13	2	263	58	165	10	0	233	38	34	93	0	165	18	42	24	0	84	745
09:45 AM	23	243	15	2	283	57	165	20	2	244	29	45	114	1	189	13	38	39	0	90	806
Total	126	956	63	9	1154	251	614	41	3	909	136	184	429	1	750	57	134	139	0	330	3143
10:00 AM	26	225	14	1	266	54	141	24	1	220	30	39	100	0	169	19	28	46	0	93	748
10:15 AM	32	222	14	3	271	67	171	17	7	262	20	27	110	0	157	28	31	29	0	88	778
10:30 AM	34	226	11	5	276	96	183	16	1	296	30	44	97	0	171	13	38	50	0	101	844
10:45 AM	37	261	13	3	314	90	205	12	6	313	30	61	128	0	219	29	40	50	0	119	965
Total	129	934	52	12	1127	307	700	69	15	1091	110	171	435	0	716	89	137	175	0	401	3335
11:00 AM	32	229	17	1	279	73	189	15	3	280	31	53	99	0	183	21	42	48	0	111	853
11:15 AM	50	251	14	6	321	73	209	25	2	309	30	54	118	1	203	15	46	50	0	111	944
11:30 AM	42	282	16	1	341	89	239	21	3	352	25	50	121	0	196	23	43	54	0	120	1009
11:45 AM	54	248	23	3	328	91	225	25	6	347	38	47	136	2	223	16	47	54	0	117	1015
Total	178	1010	70	11	1269	326	862	86	14	1288	124	204	474	3	805	75	178	206	0	459	3821
12:00 PM	38	300	23	4	365	88	232	15	6	341	39	40	117	1	197	35	60	55	0	150	1053
12:15 PM	45	250	14	4	313	104	266	17	2	389	45	44	132	1	222	22	54	56	0	132	1056
12:30 PM	44	242	32	5	323	114	235	31	2	382	39	41	125	0	205	29	64	54	0	147	1057
12:45 PM	45	245	23	0	313	106	252	24	4	386	35	52	117	0	204	23	56	64	0	143	1046
Total	172	1037	92	13	1314	412	985	87	14	1498	158	177	491	2	828	109	234	229	0	572	4212
01:00 PM	37	236	30	3	306	108	247	20	4	379	41	45	100	1	187	35	44	49	0	128	1000
01:15 PM	42	228	16	7	293	93	271	25	4	393	36	36	102	0	174	42	50	61	0	153	1013
01:30 PM	35	254	24	8	321	119	263	15	4	401	31	56	100	0	187	22	56	54	0	132	1041
01:45 PM	32	230	27	2	291	113	273	21	4	411	24	42	140	0	206	25	49	52	0	126	1034
Total	146	948	97	20	1211	433	1054	81	16	1584	132	179	442	1	754	124	199	216	0	539	4088
02:00 PM	37	205	25	2	269	116	254	28	3	401	32	39	95	0	166	34	71	59	0	164	1000
02:15 PM	41	238	38	1	318	118	250	31	2	401	38	49	133	3	223	19	68	52	0	139	1081
02:30 PM	41	257	27	3	328	115	277	20	8	420	32	48	94	0	174	24	59	62	0	145	1067
02:45 PM	39	251	22	1	313	105	244	24	4	377	29	44	117	0	190	29	67	52	0	148	1028
Total	158	951	112	7	1228	454	1025	103	17	1599	131	180	439	3	753	106	265	225	0	596	4176
03:00 PM	41	278	45	2	366	130	290	21	3	444	25	38	90	0	153	20	50	61	0	131	1094
03:15 PM	42	256	54	5	357	119	288	27	2	436	41	47	119	0	207	30	75	64	0	169	1169
03:30 PM	43	266	35	1	345	138	294	21	3	456	35	42	106	1	184	30	61	73	0	164	1149
03:45 PM	32	265	38	3	338	126	306	23	5	460	36	45	124	0	205	29	62	53	0	144	1147
Total	158	1065	172	11	1406	513	1178	92	13	1796	137	172	439	1	749	109	248	251	0	608	4559
04:00 PM	41	226	37	0	304	152	300	19	3	474	44	53	106	0	203	28	81	59	0	168	1149
04:15 PM	36	258	29	1	324	124	338	25	3	490	31	33	101	0	165	37	84	68	0	189	1168
04:30 PM	45	259	49	1	354	151	327	21	5	504	41	69	119	0	229	21	63	66	0	150	1237
04:45 PM	43	244	34	3	324	152	313	25	5	495	41	75	138	0	254	31	73	83	0	187	1260
Total	165	987	149	5	1306	579	1278	90	16	1963	157	230	464	0	851	117	301	276	0	694	4814
05:00 PM	47	281	72	1	401	159	391	25	5	580	35	53	127	0	215	27	84	86	0	197	1393
05:15 PM	54	287	41	3	385	185	358	33	2	578	47	96	131	0	274	30	78	70	0	178	1415
05:30 PM	37	267	33	4	341	129	375	23	3	530	33	65	109	0	207	31	84	74	0	189	1267
05:45 PM	47	235	33	4	319	174	338	23	1	536	39	67	115	0	221	18	66	68	0	152	1228
Total	185	1070	179	12	1446	647	1462	104	11	2224	154	281	482	0	917	106	312	298	0	716	5303
Grand Total	1638	11882	1129	117	14766	4339	10758	829	137	16063	1594	2307	5494	14	9409	1094	2318	2393	0	5805	46043
Apprch %	11.1	80.5	7.6	0.8		27	67	5.2	0.9		16.9	24.5	58.4	0.1		18.8	39.9	41.2	0		
Total %	3.6	25.8	2.5	0.3	32.1	9.4	23.4	1.8	0.3	34.9	3.5	5	11.9	0	20.4	2.4	5	5.2	0	12.6	

Peggy Malone & Associates

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File Name : Woolridge Rd_Old Buckingham Rd and Rt 60
Site Code :
Start Date : 4/19/2018
Page No : 2

	Route 60 Eastbound				Route 60 Westbound				Woolridge Rd Northbound				Old Buckingham Rd Southbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 11:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:30 AM																	
07:30 AM	19	**319**	18	356	46	176	**13**	235	35	**72**	167	274	17	27	33	77	942
07:45 AM	28	312	13	353	59	**201**	10	**270**	**49**	58	**179**	**286**	24	**57**	**48**	**129**	**1038**
08:00 AM	31	305	**38**	**374**	45	169	9	223	43	72	149	264	17	44	46	107	968
08:15 AM	**35**	302	27	364	**61**	165	13	239	37	53	143	233	**26**	36	37	99	935
Total Volume	113	1238	96	1447	211	711	45	967	164	255	638	1057	84	164	164	412	3883
% App. Total	7.8	85.6	6.6		21.8	73.5	4.7		15.5	24.1	60.4		20.4	39.8	39.8		
PHF	.807	.970	.632	.967	.865	.884	.865	.895	.837	.885	.891	.924	.808	.719	.854	.798	.935
Peak Hour Analysis From 12:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 04:45 PM																	
04:45 PM	43	244	34	321	152	313	25	490	41	75	**138**	254	**31**	73	83	187	1252
05:00 PM	47	281	**72**	**400**	159	**391**	25	575	35	53	127	215	27	**84**	**86**	**197**	1387
05:15 PM	**54**	**287**	41	382	**185**	358	**33**	**576**	**47**	**96**	131	**274**	30	78	70	178	**1410**
05:30 PM	37	267	33	337	129	375	23	527	33	65	109	207	31	84	74	189	1260
Total Volume	181	1079	180	1440	625	1437	106	2168	156	289	505	950	119	319	313	751	5309
% App. Total	12.6	74.9	12.5		28.8	66.3	4.9		16.4	30.4	53.2		15.8	42.5	41.7		
PHF	.838	.940	.625	.900	.845	.919	.803	.941	.830	.753	.915	.867	.960	.949	.910	.953	.941

Peggy Malone & Associates

(800) 247-8602

File Name : Woolridge Rd_Old Buckingham Rd and Rt 60
Site Code :
Start Date : 4/19/2018
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Groups Printed- Truck

	Route 60 Eastbound					Route 60 Westbound					Woolridge Rd Northbound					Old Buckingham Rd Southbound					
Start Time	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Int. Total
06:00 AM	0	5	0	0	5	0	1	0	0	1	0	1	2	0	3	0	0	1	0	1	10
06:15 AM	1	8	1	0	10	1	6	0	0	7	0	0	0	0	0	0	1	0	0	1	18
06:30 AM	0	8	0	0	8	1	0	2	0	3	0	1	1	0	2	0	2	0	0	2	15
06:45 AM	1	3	0	0	4	1	8	0	0	9	0	0	0	0	0	0	1	0	0	1	14
Total	2	24	1	0	27	3	15	2	0	20	0	2	3	0	5	0	4	1	0	5	57
07:00 AM	1	8	0	0	9	0	4	0	0	4	1	0	1	0	2	0	0	0	0	0	15
07:15 AM	1	4	0	0	5	1	9	1	0	11	0	0	0	0	0	0	0	0	0	0	16
07:30 AM	2	9	1	0	12	0	8	1	0	9	0	0	3	0	3	2	0	0	0	2	26
07:45 AM	0	9	0	0	9	1	8	1	0	10	1	1	1	0	3	0	0	1	0	1	23
Total	4	30	1	0	35	2	29	3	0	34	2	1	5	0	8	2	0	1	0	3	80
08:00 AM	0	12	0	0	12	1	8	1	0	10	3	1	1	0	5	1	0	0	0	1	28
08:15 AM	4	18	4	0	26	0	6	1	0	7	1	3	0	0	4	0	3	1	0	4	41
08:30 AM	0	12	1	0	13	1	8	1	0	10	1	2	4	0	7	1	0	1	0	2	32
08:45 AM	0	6	2	0	8	1	7	0	0	8	0	0	0	0	0	1	1	1	0	3	19
Total	4	48	7	0	59	3	29	3	0	35	5	6	5	0	16	3	4	3	0	10	120
09:00 AM	1	11	0	0	12	1	8	0	0	9	0	0	1	0	1	0	2	0	0	2	24
09:15 AM	1	8	0	0	9	0	8	1	0	9	0	0	0	0	0	0	1	5	0	6	24
09:30 AM	0	10	0	0	10	2	11	0	0	13	1	0	2	0	3	0	0	2	0	2	28
09:45 AM	0	8	1	0	9	1	10	1	0	12	0	1	1	0	2	0	0	0	0	0	23
Total	2	37	1	0	40	4	37	2	0	43	1	1	4	0	6	0	3	7	0	10	99
10:00 AM	0	10	0	0	10	4	8	0	0	12	0	0	0	0	0	0	1	0	0	1	23
10:15 AM	0	13	0	0	13	2	8	0	0	10	0	1	0	0	1	1	0	1	0	2	26
10:30 AM	0	6	0	0	6	3	8	1	0	12	0	0	1	0	1	1	0	1	0	2	21
10:45 AM	1	12	0	0	13	1	9	0	0	10	0	0	2	0	2	0	0	1	0	1	26
Total	1	41	0	0	42	10	33	1	0	44	0	1	3	0	4	2	1	3	0	6	96
11:00 AM	0	10	0	0	10	4	7	0	0	11	0	0	0	0	0	0	0	0	0	0	21
11:15 AM	1	6	0	0	7	2	9	0	0	11	0	0	1	0	1	2	0	0	0	2	21
11:30 AM	0	10	0	0	10	1	6	1	0	8	0	0	0	0	0	1	2	0	0	3	21
11:45 AM	0	5	0	0	5	1	7	1	0	9	1	0	0	0	1	2	1	0	0	3	18
Total	1	31	0	0	32	8	29	2	0	39	1	0	1	0	2	5	3	0	0	8	81
12:00 PM	0	8	1	0	9	1	8	2	0	11	0	0	4	0	4	0	0	1	0	1	25
12:15 PM	0	6	0	0	6	4	13	0	0	17	1	0	0	0	1	0	1	0	0	1	25
12:30 PM	0	8	0	0	8	2	6	1	0	9	1	0	1	0	2	1	0	3	0	4	23
12:45 PM	2	9	0	0	11	1	4	1	0	6	1	2	2	0	5	1	0	0	0	1	23
Total	2	31	1	0	34	8	31	4	0	43	3	2	7	0	12	2	1	4	0	7	96
01:00 PM	0	7	0	0	7	0	7	0	0	7	0	0	2	0	2	1	0	2	0	3	19
01:15 PM	2	8	4	0	14	1	8	0	0	9	0	0	1	0	1	0	2	0	0	2	26
01:30 PM	1	7	0	0	8	1	9	0	0	10	0	0	1	0	1	0	0	1	0	1	20
01:45 PM	0	6	1	0	7	0	3	0	0	3	0	0	2	0	2	0	0	0	0	0	12
Total	3	28	5	0	36	2	27	0	0	29	0	0	6	0	6	1	2	3	0	6	77
02:00 PM	2	9	1	0	12	4	4	0	0	8	0	0	2	0	2	0	0	1	0	1	23
02:15 PM	0	6	0	0	6	1	8	1	0	10	1	0	1	0	2	1	2	2	0	5	23
02:30 PM	0	10	0	0	10	3	11	0	0	14	0	1	6	0	7	1	0	0	0	1	32
02:45 PM	0	4	2	0	6	1	12	0	0	13	2	0	3	0	5	0	1	0	0	1	25
Total	2	29	3	0	34	9	35	1	0	45	3	1	12	0	16	2	3	3	0	8	103
03:00 PM	0	2	2	0	4	1	5	0	0	6	0	0	1	0	1	1	2	1	0	4	15
03:15 PM	0	7	4	1	12	1	4	2	0	7	0	0	2	0	2	0	1	1	0	2	23
03:30 PM	0	5	2	0	7	1	13	0	0	14	0	3	1	0	4	1	0	0	0	1	26
03:45 PM	0	13	0	0	13	0	5	0	0	5	0	1	2	0	3	0	1	0	0	1	22
Total	0	27	8	1	36	3	27	2	0	32	0	4	6	0	10	2	4	2	0	8	86
04:00 PM	0	1	1	0	2	3	4	0	0	7	0	1	0	0	1	0	2	0	0	2	12
04:15 PM	1	5	0	0	6	0	0	1	0	1	1	0	5	0	6	0	1	2	0	3	16
04:30 PM	2	4	0	0	6	0	5	0	0	5	2	0	0	0	2	1	1	2	0	4	17
04:45 PM	2	1	1	0	4	1	5	1	0	7	0	0	1	0	1	0	3	0	0	3	15
Total	5	11	2	0	18	4	14	2	0	20	3	1	6	0	10	1	7	4	0	12	60
05:00 PM	1	3	0	0	4	1	1	1	0	3	0	0	2	0	2	0	0	1	0	1	10
05:15 PM	0	3	0	0	3	1	4	0	0	5	0	0	0	0	0	0	0	0	0	0	8
05:30 PM	0	4	0	0	4	0	5	0	0	5	0	0	1	0	1	0	0	0	0	0	10
05:45 PM	0	4	1	0	5	1	2	0	0	3	0	0	1	0	1	0	0	0	0	0	9
Total	1	14	1	0	16	3	12	1	0	16	0	0	4	0	4	0	0	1	0	1	37
Grand Total	27	351	30	1	409	59	318	23	0	400	18	19	62	0	99	20	32	32	0	84	992
Apprch %	6.6	85.8	7.3	0.2		14.8	79.5	5.8	0		18.2	19.2	62.6	0		23.8	38.1	38.1	0		
Total %	2.7	35.4	3	0.1	41.2	5.9	32.1	2.3	0	40.3	1.8	1.9	6.2	0	10	2	3.2	3.2	0	8.5	

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File Name : Woolridge Rd_Old Buckingham Rd and Rt 60
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	Route 60 Eastbound				Route 60 Westbound				Woolridge Rd Northbound				Old Buckingham Rd Southbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 11:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:45 AM																	
07:45 AM	0	9	0	9	**1**	**8**	**1**	**10**	1	1	1	3	0	0	**1**	1	23
08:00 AM	0	12	0	12	1	8	1	10	**3**	1	1	5	**1**	0	0	1	28
08:15 AM	**4**	**18**	**4**	**26**	0	6	1	7	1	**3**	0	4	0	**3**	1	**4**	**41**
08:30 AM	0	12	1	13	1	8	1	10	1	2	**4**	**7**	1	0	1	2	32
Total Volume	4	51	5	60	3	30	4	37	6	7	6	19	2	3	3	8	124
% App. Total	6.7	85	8.3		8.1	81.1	10.8		31.6	36.8	31.6		25	37.5	37.5		
PHF	.250	.708	.313	.577	.750	.938	1.00	.925	.500	.583	.375	.679	.500	.250	.750	.500	.756
Peak Hour Analysis From 12:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 02:00 PM																	
02:00 PM	**2**	9	1	**12**	**4**	4	0	8	0	0	2	2	0	0	1	1	23
02:15 PM	0	6	0	6	1	8	**1**	10	1	0	1	2	**1**	**2**	**2**	**5**	23
02:30 PM	0	**10**	0	10	3	11	0	**14**	0	**1**	**6**	**7**	1	0	0	1	**32**
02:45 PM	0	4	**2**	6	1	**12**	0	13	**2**	0	3	5	0	1	0	1	25
Total Volume	2	29	3	34	9	35	1	45	3	1	12	16	2	3	3	8	103
% App. Total	5.9	85.3	8.8		20	77.8	2.2		18.8	6.2	75		25	37.5	37.5		
PHF	.250	.725	.375	.708	.563	.729	.250	.804	.375	.250	.500	.571	.500	.375	.375	.400	.805

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(800) 247-8602

File Name : Woolridge Rd_Old Buckingham Rd and Rt 60
Site Code :
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Groups Printed- Pedestrians

	Route 60 Eastbound					Route 60 Westbound					Woolridge Rd Northbound					Old Buckingham Rd Southbound					
Start Time	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Left	Thru	Right	U-Turn	App. Total	Int. Total
06:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:30 AM	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
08:45 AM	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
09:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
11:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
03:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:45 PM	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
04:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	7
Apprch %	0	0	0	100		0	0	0	0		0	0	0	0		0	0	0	100		
Total %	0	0	0	71.4	71.4	0	0	0	0	0	0	0	0	0	0	0	0	0	28.6	28.6	

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File Name : Woolridge Rd_Old Buckingham Rd and Rt 60
Site Code :
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	Route 60 Eastbound				Route 60 Westbound				Woolridge Rd Northbound				Old Buckingham Rd Southbound				
Start Time	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Int. Total
Peak Hour Analysis From 06:00 AM to 11:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 06:00 AM																	
06:00 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:30 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:45 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Volume	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% App. Total	0	0	0		0	0	0		0	0	0		0	0	0		
PHF	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Peak Hour Analysis From 12:00 PM to 05:45 PM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 12:00 PM																	
12:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:15 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:30 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Volume	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
% App. Total	0	0	0		0	0	0		0	0	0		0	0	0		
PHF	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Appendix B

2018 Existing Operational Analysis

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Lane Configurations												
Traffic Volume (vph)	7	119	1286	101	12	213	741	49	1	169	260	643
Future Volume (vph)	7	119	1286	101	12	213	741	49	1	169	260	643
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.0		4.0	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		1.00	0.95	1.00		0.97	0.95	1.00		1.00	0.95	1.00
Frt		1.00	1.00	0.85		1.00	1.00	0.85		1.00	1.00	0.85
Flt Protected		0.95	1.00	1.00		0.95	1.00	1.00		0.95	1.00	1.00
Satd. Flow (prot)		1770	3539	1583		3433	3539	1583		1770	3539	1583
Flt Permitted		0.95	1.00	1.00		0.95	1.00	1.00		0.95	1.00	1.00
Satd. Flow (perm)		1770	3539	1583		3433	3539	1583		1770	3539	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	8	129	1398	110	13	232	805	53	1	184	283	699
RTOR Reduction (vph)	0	0	0	64	0	0	0	28	0	0	0	78
Lane Group Flow (vph)	0	137	1398	46	0	245	805	25	0	185	283	621
Turn Type	Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot	Prot	NA	pm+ov
Protected Phases	1	1	6		5!	5	2		3	3	8	5!
Permitted Phases				6				2				8
Actuated Green, G (s)		13.9	45.1	45.1		20.0	51.2	51.2		14.2	17.1	37.1
Effective Green, g (s)		14.9	47.1	47.1		21.0	53.2	53.2		15.2	18.1	39.1
Actuated g/C Ratio		0.13	0.42	0.42		0.19	0.47	0.47		0.13	0.16	0.35
Clearance Time (s)		5.0	6.0	6.0		5.0	6.0	6.0		5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)		233	1477	660		639	1669	746		238	567	604
v/s Ratio Prot		0.08	c0.40			0.07	0.23			c0.10	0.08	c0.19
v/s Ratio Perm				0.03				0.02				0.20
v/c Ratio		0.59	0.95	0.07		0.38	0.48	0.03		0.78	0.50	1.03
Uniform Delay, d1		46.1	31.6	19.7		40.2	20.4	16.0		47.2	43.2	36.8
Progression Factor		1.00	1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		3.8	13.7	0.2		0.4	1.0	0.1		14.7	0.7	44.1
Delay (s)		49.8	45.4	19.9		40.6	21.4	16.1		61.9	43.9	81.0
Level of Service		D	D	B		D	C	B		E	D	F
Approach Delay (s)			44.0				25.4				68.9	
Approach LOS			D				C				E	

Intersection Summary					
HCM 2000 Control Delay	46.5	HCM 2000 Level of Service		D	
HCM 2000 Volume to Capacity ratio	1.02				
Actuated Cycle Length (s)	112.8	Sum of lost time (s)		16.0	
Intersection Capacity Utilization	99.9%	ICU Level of Service		F	
Analysis Period (min)	15				

! Phase conflict between lane groups.

c Critical Lane Group

Movement	SBL	SBT	SBR
Lane Configurations			
Traffic Volume (vph)	87	167	166
Future Volume (vph)	87	167	166
Ideal Flow (vphpl)	1900	1900	1900
Total Lost time (s)	4.0	4.0	
Lane Util. Factor	1.00	0.95	
Frt	1.00	0.93	
Flt Protected	0.95	1.00	
Satd. Flow (prot)	1770	3275	
Flt Permitted	0.95	1.00	
Satd. Flow (perm)	1770	3275	
Peak-hour factor, PHF	0.92	0.92	0.92
Adj. Flow (vph)	95	182	180
RTOR Reduction (vph)	0	158	0
Lane Group Flow (vph)	95	204	0
Turn Type	Prot	NA	
Protected Phases	7	4	
Permitted Phases			
Actuated Green, G (s)	9.6	12.5	
Effective Green, g (s)	10.6	13.5	
Actuated g/C Ratio	0.09	0.12	
Clearance Time (s)	5.0	5.0	
Vehicle Extension (s)	3.0	3.0	
Lane Grp Cap (vph)	166	391	
v/s Ratio Prot	0.05	0.06	
v/s Ratio Perm			
v/c Ratio	0.57	0.52	
Uniform Delay, d1	48.9	46.6	
Progression Factor	1.00	1.00	
Incremental Delay, d2	4.7	1.3	
Delay (s)	53.6	47.9	
Level of Service	D	D	
Approach Delay (s)		49.1	
Approach LOS		D	

Intersection Summary

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBL	NBT	NBR	SBL
Lane Configurations												
Traffic Volume (vph)	11	184	1090	181	15	628	1452	108	156	289	509	119
Future Volume (vph)	11	184	1090	181	15	628	1452	108	156	289	509	119
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lane Util. Factor		1.00	0.95	1.00		0.97	0.95	1.00	1.00	0.95	1.00	1.00
Frt		1.00	1.00	0.85		1.00	1.00	0.85	1.00	1.00	0.85	1.00
Flt Protected		0.95	1.00	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95
Satd. Flow (prot)		1770	3539	1583		3433	3539	1583	1770	3539	1583	1770
Flt Permitted		0.95	1.00	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95
Satd. Flow (perm)		1770	3539	1583		3433	3539	1583	1770	3539	1583	1770
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	200	1185	197	16	683	1578	117	170	314	553	129
RTOR Reduction (vph)	0	0	0	116	0	0	0	64	0	0	64	0
Lane Group Flow (vph)	0	212	1185	81	0	699	1578	53	170	314	489	129
Turn Type	Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot	NA	pm+ov	Prot
Protected Phases	1	1	6		5!	5	2		3	8	5!	7
Permitted Phases				6				2			8	
Actuated Green, G (s)		17.4	45.0	45.0		20.0	47.6	47.6	13.9	16.2	36.2	12.7
Effective Green, g (s)		18.4	47.0	47.0		21.0	49.6	49.6	14.9	17.2	38.2	13.7
Actuated g/C Ratio		0.16	0.41	0.41		0.18	0.43	0.43	0.13	0.15	0.33	0.12
Clearance Time (s)		5.0	6.0	6.0		5.0	6.0	6.0	5.0	5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		283	1447	647		627	1527	683	229	529	581	211
v/s Ratio Prot		0.12	0.33			c0.20	c0.45		c0.10	0.09	0.15	0.07
v/s Ratio Perm				0.05				0.03			0.16	
v/c Ratio		0.75	0.82	0.12		1.11	1.03	0.08	0.74	0.59	0.84	0.61
Uniform Delay, d1		46.0	30.2	21.1		47.0	32.6	19.2	48.2	45.6	35.5	48.1
Progression Factor		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		10.4	5.3	0.4		71.7	32.1	0.2	12.2	1.8	10.6	5.2
Delay (s)		56.4	35.5	21.5		118.7	64.8	19.4	60.4	47.4	46.2	53.2
Level of Service		E	D	C		F	E	B	E	D	D	D
Approach Delay (s)			36.5				78.3			48.9		
Approach LOS			D				E			D		

Intersection Summary			
HCM 2000 Control Delay	70.0	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.05		
Actuated Cycle Length (s)	114.9	Sum of lost time (s)	16.0
Intersection Capacity Utilization	99.9%	ICU Level of Service	F
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

Movement	SBT	SBR
Lane Configurations		
Traffic Volume (vph)	322	314
Future Volume (vph)	322	314
Ideal Flow (vphpl)	1900	1900
Total Lost time (s)	4.0	
Lane Util. Factor	0.95	
Frt	0.93	
Flt Protected	1.00	
Satd. Flow (prot)	3277	
Flt Permitted	1.00	
Satd. Flow (perm)	3277	
Peak-hour factor, PHF	0.92	0.92
Adj. Flow (vph)	350	341
RTOR Reduction (vph)	151	0
Lane Group Flow (vph)	540	0
Turn Type	NA	
Protected Phases	4	
Permitted Phases		
Actuated Green, G (s)	15.0	
Effective Green, g (s)	16.0	
Actuated g/C Ratio	0.14	
Clearance Time (s)	5.0	
Vehicle Extension (s)	3.0	
Lane Grp Cap (vph)	456	
v/s Ratio Prot	c0.16	
v/s Ratio Perm		
v/c Ratio	1.19	
Uniform Delay, d1	49.5	
Progression Factor	1.00	
Incremental Delay, d2	103.6	
Delay (s)	153.0	
Level of Service	F	
Approach Delay (s)	137.3	
Approach LOS	F	

Intersection Summary

Appendix C

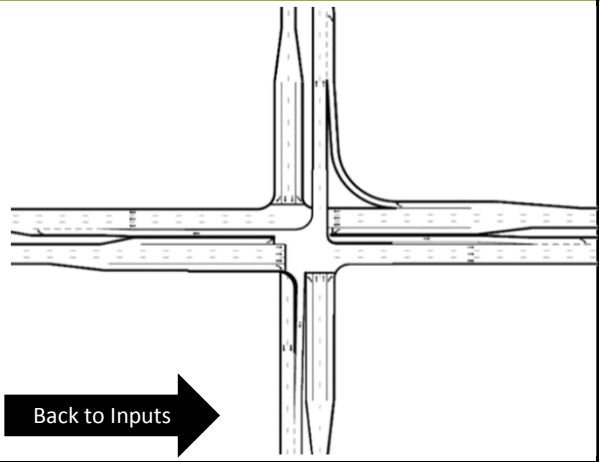
VJuST Worksheets

VJuST
VDOT Junction Screening Tool

DESIGN CONSIDERATIONS

Intersection Designs

Echelon



Back to Inputs

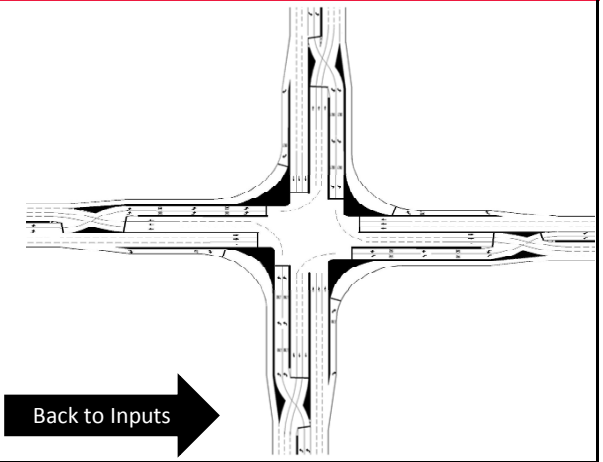
Description

One approach on both the major and minor roadways is elevated to create two grade-separated intersections of two one-way roads. Each intersection operates under two-phase signal control.

When Should This Design Be Considered?

The echelon intersection should be considered at high-volume urban or suburban intersections where the major and minor roadways have similar volumes.

Full/Partial Displaced Left Turn (DLT)



Back to Inputs

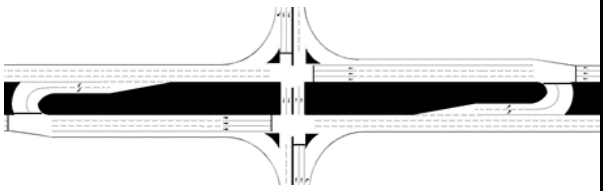
Description

Left-turning vehicles cross over to the other side of the roadway at a signalized intersection several hundred feet in advance of the main intersection. The protected left turns occur simultaneously with the opposing through movements at the main intersection, allowing for two- (full) or three-phase (partial) signal control. This design is also referred to as a Continuous Flow Intersection or Crossover Displaced Left Intersection.

When Should This Design Be Considered?

The displaced left turn intersection should be considered if opposing approaches have high and balanced through and left-turn volumes.

Full/Partial Median U-Turn (MUT)



Back to Inputs

Description

Left-turn movements from the major roadway (partial) or both roadways (full) are removed from the main intersection. These vehicles instead execute a U-turn at a median opening on the major roadway downstream of the main intersection. Removing the left-turn movements allows for two- (full) or three-phase (partial) signal control. This tool assumes all intersections are signalized. However, this intersection can be designed as partially unsignalized.

When Should This Design Be Considered?

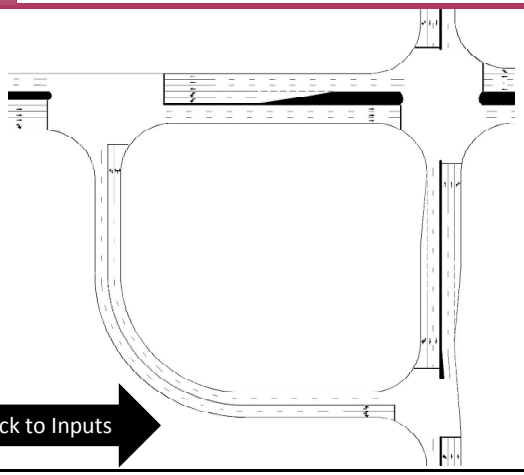
The median U-turn intersection should be considered on high-speed, median-divided highways with moderate left-turn volumes on the major roadway and minor left-turn volumes on the minor roadway.

VJuST
VDOT Junction Screening Tool

DESIGN CONSIDERATIONS

Intersection Designs

Quadrant Roadway (QR)



Back to Inputs

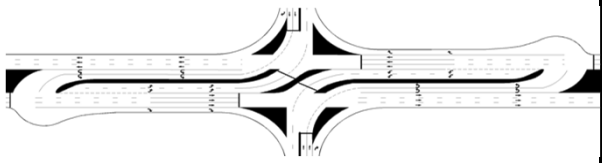
Description

All four left-turn movements are rerouted onto a connector road in one quadrant, allowing for two-phase signal control at the main intersection and three-phase signal control at the intersections with the connector road. This tool assumes all intersections are signalized. However, this intersection can be designed as partially unsignalized.

When Should This Design Be Considered?

The quadrant roadway intersection should be considered if an existing roadway can be used as a connection roadway or there are heavy left-turn and through volumes on the major and minor roadways. The ratio of minor road volume to total intersection volume is typically less than or equal to 0.35.

Restricted Crossing U-Turn (RCUT)



Back to Inputs

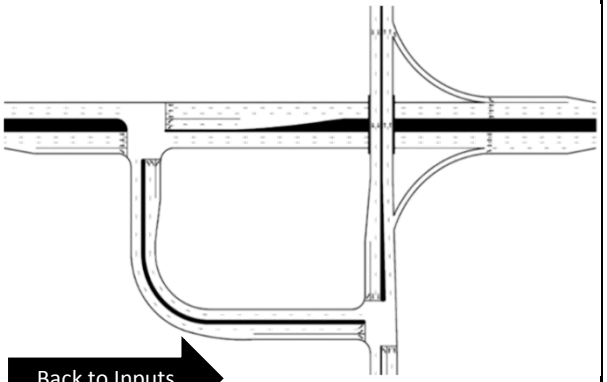
Description

Minor roadway left-turn and through movements are removed from the main intersection. These vehicles turn right onto the major roadway before making a U-turn at a downstream median opening. Removing these movements allows for two-phase signal control at the main intersection. This design is also referred to as a super street intersection. This tool assumes all intersections are signalized. However, this intersection can be designed as partially or fully unsignalized.

When Should This Design Be Considered?

The restricted crossing U-turn intersection should be considered on high-speed, median-divided highways with high through and left-turn volumes on the major roadway and low through volumes on the minor roadway.

Single Loop



Back to Inputs

Description

All four left-turn movements and some right-turn movements are rerouted onto a connector road in one quadrant, while the major and minor roadways are grade-separated. This design allows for three-phase signal control at the intersections with the connector road.This tool assumes all intersections are signalized. However, this intersection can be designed as fully unsignalized.

When Should This Design Be Considered?

The single loop intersection should be considered for roadways with low to medium left-turn volumes.

VDOT Junction Screening Tool

Results Worksheet

General Information	
Project Title:	Alternative Intersection Analysis - AM
EW Facility:	Route 60
NS Facility:	Woolridge Road & Old Buckingham Road
Date:	April 27, 2018

Volumes (veh/hr)	U-Turn / Left	Through	Right
Eastbound	126	1286	101
Westbound	225	741	49
Northbound	170	260	643
Southbound	87	167	166

General Instructions: All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.

Intersection Results

Type	Dir	Maximum V/C (Congestion)	Accommodation Compared to Conventional (Pedestrian)	Weighted Total Conflict Points (Safety)	Notes
Conventional	-	0.74		48	
Bowtie	-	0.90	+	24	
Full Displaced Left Turn	-	0.60	-	40	
Median U-Turn	-	0.62	+	20	
Partial Displaced Left Turn	-	0.60	-	44	1
Partial Median U-Turn	-	0.67	+	28	
Quadrant Roadway	N-E	0.68		40	
	S-E	0.96		40	2
Restricted Crossing U-Turn	-	0.84		20	3
50 Mini Roundabout	-	1084.00		8	
75 Mini Roundabout	-	1084.00		8	
Roundabout	-	1.02		8	
Two-Way Stop Control	-	40.25		48	

Information

Congestion	The maximum v/c ratio represents the worst v/c of all zones that make up an intersection.
Pedestrian	Compares the potential of each design to accommodate pedestrians based on safety, wayfinding, and delay. Potential is qualitatively defined as better (+), similar (blank cell), or worse (-) than a conventional intersection or traditional diamond interchange.
Safety	Weighted Total = (2 x Crossing Conflicts) + Merging Conflicts + Diverging Conflicts

VDOT Junction Screening Tool

Results Worksheet

General Information	
Project Title:	Alternative Intersection Analysis - PM
EW Facility:	Route 60
NS Facility:	Woolridge Road & Old Buckingham Road
Date:	April 27, 2018

Volumes (veh/hr)	U-Turn / Left	Through	Right
Eastbound	195	1090	181
Westbound	643	1452	108
Northbound	156	289	509
Southbound	119	322	314

General Instructions: All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.

Intersection Results

Type	Dir	Maximum V/C (Congestion)	Accommodation Compared to Conventional (Pedestrian)	Weighted Total Conflict Points (Safety)	Notes
Conventional	-	0.98		48	
Bowtie	-	1.59	+	24	
Full Displaced Left Turn	-	0.81	-	40	
Median U-Turn	-	0.83	+	20	
Partial Displaced Left Turn	-	0.81	-	44	1
Partial Median U-Turn	-	0.97	+	28	
Quadrant Roadway	N-E	0.81		40	
	S-E	0.87		40	2
Restricted Crossing U-Turn	-	0.87		20	3
50 Mini Roundabout	-	1481.00		8	
75 Mini Roundabout	-	1481.00		8	
Roundabout	-	1.98		8	
Two-Way Stop Control	-	1.20		48	

Information

Congestion	The maximum v/c ratio represents the worst v/c of all zones that make up an intersection.
Pedestrian	Compares the potential of each design to accommodate pedestrians based on safety, wayfinding, and delay. Potential is qualitatively defined as better (+), similar (blank cell), or worse (-) than a conventional intersection or traditional diamond interchange.
Safety	Weighted Total = (2 x Crossing Conflicts) + Merging Conflicts + Diverging Conflicts

Appendix D

Future 2038 No-Build Operational Analysis

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Lane Configurations												
Traffic Volume (vph)	11	157	1675	133	17	279	966	67	2	209	319	787
Future Volume (vph)	11	157	1675	133	17	279	966	67	2	209	319	787
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.0		4.0	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		1.00	0.95	1.00		0.97	0.95	1.00		1.00	0.95	1.00
Frt		1.00	1.00	0.85		1.00	1.00	0.85		1.00	1.00	0.85
Flt Protected		0.95	1.00	1.00		0.95	1.00	1.00		0.95	1.00	1.00
Satd. Flow (prot)		1770	3539	1583		3433	3539	1583		1770	3539	1583
Flt Permitted		0.95	1.00	1.00		0.95	1.00	1.00		0.95	1.00	1.00
Satd. Flow (perm)		1770	3539	1583		3433	3539	1583		1770	3539	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	171	1821	145	18	303	1050	73	2	227	347	855
RTOR Reduction (vph)	0	0	0	80	0	0	0	40	0	0	0	82
Lane Group Flow (vph)	0	183	1821	65	0	321	1050	33	0	229	347	773
Turn Type	Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot	Prot	NA	pm+ov
Protected Phases	1	1	6		5!	5	2		3	3	8	5!
Permitted Phases				6				2				8
Actuated Green, G (s)		9.0	34.0	34.0		9.0	34.0	34.0		8.0	9.0	18.0
Effective Green, g (s)		10.0	36.0	36.0		10.0	36.0	36.0		9.0	10.0	20.0
Actuated g/C Ratio		0.12	0.45	0.45		0.12	0.45	0.45		0.11	0.12	0.25
Clearance Time (s)		5.0	6.0	6.0		5.0	6.0	6.0		5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)		221	1592	712		429	1592	712		199	442	474
v/s Ratio Prot		0.10	c0.51			0.09	0.30			c0.13	0.10	c0.20
v/s Ratio Perm				0.04				0.02				0.28
v/c Ratio		0.83	1.14	0.09		0.75	0.66	0.05		1.15	0.79	1.63
Uniform Delay, d1		34.2	22.0	12.6		33.8	17.2	12.4		35.5	34.0	30.0
Progression Factor		1.00	1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		21.8	72.7	0.3		7.0	2.2	0.1		110.3	8.9	293.6
Delay (s)		56.0	94.7	12.9		40.8	19.4	12.5		145.8	42.8	323.6
Level of Service		E	F	B		D	B	B		F	D	F
Approach Delay (s)			85.9				23.8				227.1	
Approach LOS			F				C				F	

Intersection Summary			
HCM 2000 Control Delay	104.2	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.42		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	124.2%	ICU Level of Service	H
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

Movement	SBL	SBT	SBR
Lane Configurations			
Traffic Volume (vph)	134	257	255
Future Volume (vph)	134	257	255
Ideal Flow (vphpl)	1900	1900	1900
Total Lost time (s)	4.0	4.0	
Lane Util. Factor	1.00	0.95	
Frt	1.00	0.93	
Flt Protected	0.95	1.00	
Satd. Flow (prot)	1770	3275	
Flt Permitted	0.95	1.00	
Satd. Flow (perm)	1770	3275	
Peak-hour factor, PHF	0.92	0.92	0.92
Adj. Flow (vph)	146	279	277
RTOR Reduction (vph)	0	193	0
Lane Group Flow (vph)	146	363	0
Turn Type	Prot	NA	
Protected Phases	7	4	
Permitted Phases			
Actuated Green, G (s)	7.0	8.0	
Effective Green, g (s)	8.0	9.0	
Actuated g/C Ratio	0.10	0.11	
Clearance Time (s)	5.0	5.0	
Vehicle Extension (s)	3.0	3.0	
Lane Grp Cap (vph)	177	368	
v/s Ratio Prot	0.08	0.11	
v/s Ratio Perm			
v/c Ratio	0.82	0.99	
Uniform Delay, d1	35.3	35.4	
Progression Factor	1.00	1.00	
Incremental Delay, d2	25.7	43.2	
Delay (s)	61.0	78.6	
Level of Service	E	E	
Approach Delay (s)		74.9	
Approach LOS		E	

Intersection Summary

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Lane Configurations												
Traffic Volume (vph)	11	157	1675	133	17	279	966	67	2	209	319	787
Future Volume (vph)	11	157	1675	133	17	279	966	67	2	209	319	787
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.0	4.0		4.0	4.0	4.0		4.0	4.0	4.0
Lane Util. Factor		1.00	0.95	1.00		0.97	0.95	1.00		1.00	0.95	1.00
Frt		1.00	1.00	0.85		1.00	1.00	0.85		1.00	1.00	0.85
Flt Protected		0.95	1.00	1.00		0.95	1.00	1.00		0.95	1.00	1.00
Satd. Flow (prot)		1770	3539	1583		3433	3539	1583		1770	3539	1583
Flt Permitted		0.95	1.00	1.00		0.95	1.00	1.00		0.95	1.00	1.00
Satd. Flow (perm)		1770	3539	1583		3433	3539	1583		1770	3539	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	171	1821	145	18	303	1050	73	2	227	347	855
RTOR Reduction (vph)	0	0	0	80	0	0	0	40	0	0	0	82
Lane Group Flow (vph)	0	183	1821	65	0	321	1050	33	0	229	347	773
Turn Type	Prot	Prot	NA	Perm	Prot	Prot	NA	Perm	Prot	Prot	NA	pm+ov
Protected Phases	1	1	6		5!	5	2		3	3	8	5!
Permitted Phases				6				2				8
Actuated Green, G (s)		9.0	34.0	34.0		9.0	34.0	34.0		8.0	9.0	18.0
Effective Green, g (s)		10.0	36.0	36.0		10.0	36.0	36.0		9.0	10.0	20.0
Actuated g/C Ratio		0.12	0.45	0.45		0.12	0.45	0.45		0.11	0.12	0.25
Clearance Time (s)		5.0	6.0	6.0		5.0	6.0	6.0		5.0	5.0	5.0
Vehicle Extension (s)		3.0	3.0	3.0		3.0	3.0	3.0		3.0	3.0	3.0
Lane Grp Cap (vph)		221	1592	712		429	1592	712		199	442	474
v/s Ratio Prot		0.10	c0.51			0.09	0.30			c0.13	0.10	c0.20
v/s Ratio Perm				0.04				0.02				0.28
v/c Ratio		0.83	1.14	0.09		0.75	0.66	0.05		1.15	0.79	1.63
Uniform Delay, d1		34.2	22.0	12.6		33.8	17.2	12.4		35.5	34.0	30.0
Progression Factor		1.00	1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2		21.8	72.7	0.3		7.0	2.2	0.1		110.3	8.9	293.6
Delay (s)		56.0	94.7	12.9		40.8	19.4	12.5		145.8	42.8	323.6
Level of Service		E	F	B		D	B	B		F	D	F
Approach Delay (s)			85.9				23.8				227.1	
Approach LOS			F				C				F	

Intersection Summary			
HCM 2000 Control Delay	104.2	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.42		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	124.2%	ICU Level of Service	H
Analysis Period (min)	15		

! Phase conflict between lane groups.
c Critical Lane Group

Movement	SBL	SBT	SBR
Lane Configurations			
Traffic Volume (vph)	134	257	255
Future Volume (vph)	134	257	255
Ideal Flow (vphpl)	1900	1900	1900
Total Lost time (s)	4.0	4.0	
Lane Util. Factor	1.00	0.95	
Frt	1.00	0.93	
Flt Protected	0.95	1.00	
Satd. Flow (prot)	1770	3275	
Flt Permitted	0.95	1.00	
Satd. Flow (perm)	1770	3275	
Peak-hour factor, PHF	0.92	0.92	0.92
Adj. Flow (vph)	146	279	277
RTOR Reduction (vph)	0	193	0
Lane Group Flow (vph)	146	363	0
Turn Type	Prot	NA	
Protected Phases	7	4	
Permitted Phases			
Actuated Green, G (s)	7.0	8.0	
Effective Green, g (s)	8.0	9.0	
Actuated g/C Ratio	0.10	0.11	
Clearance Time (s)	5.0	5.0	
Vehicle Extension (s)	3.0	3.0	
Lane Grp Cap (vph)	177	368	
v/s Ratio Prot	0.08	0.11	
v/s Ratio Perm			
v/c Ratio	0.82	0.99	
Uniform Delay, d1	35.3	35.4	
Progression Factor	1.00	1.00	
Incremental Delay, d2	25.7	43.2	
Delay (s)	61.0	78.6	
Level of Service	E	E	
Approach Delay (s)		74.9	
Approach LOS		E	

Intersection Summary

Appendix E.1

Future 2038

Alternative 1 – RCUT Operational Analysis

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL	NER
Lane Configurations											
Traffic Volume (vph)	0	0	0	0	1203	386	0	0	391	157	0
Future Volume (vph)	0	0	0	0	1203	386	0	0	391	157	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.5	4.5			4.5	4.5	
Lane Util. Factor					0.95	1.00			0.88	1.00	
Frt					1.00	0.85			0.85	1.00	
Flt Protected					1.00	1.00			1.00	0.95	
Satd. Flow (prot)					3539	1583			2787	1770	
Flt Permitted					1.00	1.00			1.00	0.95	
Satd. Flow (perm)					3539	1583			2787	1770	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	1308	420	0	0	425	171	0
RTOR Reduction (vph)	0	0	0	0	0	217	0	0	36	0	0
Lane Group Flow (vph)	0	0	0	0	1308	203	0	0	389	171	0
Turn Type					NA	Perm			Perm	Prot	
Protected Phases					8					2	
Permitted Phases						8			6		
Actuated Green, G (s)					26.6	26.6			19.4	19.4	
Effective Green, g (s)					26.6	26.6			19.4	19.4	
Actuated g/C Ratio					0.48	0.48			0.35	0.35	
Clearance Time (s)					4.5	4.5			4.5	4.5	
Vehicle Extension (s)					3.0	3.0			3.0	3.0	
Lane Grp Cap (vph)					1711	765			983	624	
v/s Ratio Prot					c0.37					0.10	
v/s Ratio Perm						0.13			c0.14		
v/c Ratio					0.76	0.27			0.40	0.27	
Uniform Delay, d1					11.6	8.4			13.4	12.8	
Progression Factor					0.63	1.02			1.00	1.01	
Incremental Delay, d2					1.9	0.2			1.2	0.6	
Delay (s)					9.2	8.8			14.6	13.5	
Level of Service					A	A			B	B	
Approach Delay (s)		0.0			9.1		14.6			13.5	
Approach LOS		A			A		B			B	

Intersection Summary			
HCM 2000 Control Delay	10.4	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.61		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	Err%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑	↱						↱	↰↰		
Traffic Volume (vph)	0	1976	0	0	0	0	0	0	0	408	0	0
Future Volume (vph)	0	1976	0	0	0	0	0	0	0	408	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.5								4.5		
Lane Util. Factor		0.95								0.97		
Frt		1.00								1.00		
Flt Protected		1.00								0.95		
Satd. Flow (prot)		3539								3433		
Flt Permitted		1.00								0.95		
Satd. Flow (perm)		3539								3433		
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	2148	0	0	0	0	0	0	0	443	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	32	0	0
Lane Group Flow (vph)	0	2148	0	0	0	0	0	0	0	411	0	0
Turn Type		NA	Perm						Perm	Prot		
Protected Phases		4								6		
Permitted Phases			4						2			
Actuated Green, G (s)		80.5								20.5		
Effective Green, g (s)		80.5								20.5		
Actuated g/C Ratio		0.73								0.19		
Clearance Time (s)		4.5								4.5		
Vehicle Extension (s)		3.0								3.0		
Lane Grp Cap (vph)		2589								639		
v/s Ratio Prot		c0.61								c0.12		
v/s Ratio Perm												
v/c Ratio		0.83								0.64		
Uniform Delay, d1		10.1								41.4		
Progression Factor		1.00								0.73		
Incremental Delay, d2		2.3								4.7		
Delay (s)		12.4								35.0		
Level of Service		B								C		
Approach Delay (s)		12.4			0.0			0.0			35.0	
Approach LOS		B			A			A			C	

Intersection Summary			
HCM 2000 Control Delay	16.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	90.2%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBR	NBR2	SWL	SWR
Lane Configurations		↑↑							↱↱	↰↰	
Traffic Volume (vph)	0	1837	0	0	0	0	0	0	528	279	0
Future Volume (vph)	0	1837	0	0	0	0	0	0	528	279	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.5							4.5	4.5	
Lane Util. Factor		0.95							0.88	0.97	
Frt		1.00							0.85	1.00	
Flt Protected		1.00							1.00	0.95	
Satd. Flow (prot)		3539							2787	3433	
Flt Permitted		1.00							1.00	0.95	
Satd. Flow (perm)		3539							2787	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1997	0	0	0	0	0	0	574	303	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	20	0	0
Lane Group Flow (vph)	0	1997	0	0	0	0	0	0	554	303	0
Turn Type		NA							Perm	Prot	
Protected Phases		4								6	
Permitted Phases									2		
Actuated Green, G (s)		27.5							18.5	18.5	
Effective Green, g (s)		27.5							18.5	18.5	
Actuated g/C Ratio		0.50							0.34	0.34	
Clearance Time (s)		4.5							4.5	4.5	
Vehicle Extension (s)		3.0							3.0	3.0	
Lane Grp Cap (vph)		1769							937	1154	
v/s Ratio Prot		c0.56								0.09	
v/s Ratio Perm									c0.20		
v/c Ratio		1.13							0.59	0.26	
Uniform Delay, d1		13.8							15.1	13.3	
Progression Factor		1.01							1.00	0.43	
Incremental Delay, d2		62.7							2.7	0.5	
Delay (s)		76.6							17.9	6.3	
Level of Service		E							B	A	
Approach Delay (s)		76.6			0.0		17.9			6.3	
Approach LOS		E			A		B			A	

Intersection Summary			
HCM 2000 Control Delay	57.5	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	Err%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations				↑↑↑↑	↰↰	
Traffic Volume (vph)	0	0	0	1329	539	0
Future Volume (vph)	0	0	0	1329	539	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.5	4.5	
Lane Util. Factor				*1.00	0.97	
Frt				1.00	1.00	
Flt Protected				1.00	0.95	
Satd. Flow (prot)				7451	3433	
Flt Permitted				1.00	0.95	
Satd. Flow (perm)				7451	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	1445	586	0
RTOR Reduction (vph)	0	0	0	0	8	0
Lane Group Flow (vph)	0	0	0	1445	578	0
Turn Type				NA	Perm	
Protected Phases				8		
Permitted Phases					2	
Actuated Green, G (s)				20.1	25.9	
Effective Green, g (s)				20.1	25.9	
Actuated g/C Ratio				0.37	0.47	
Clearance Time (s)				4.5	4.5	
Vehicle Extension (s)				3.0	3.0	
Lane Grp Cap (vph)				2723	1616	
v/s Ratio Prot				c0.19		
v/s Ratio Perm					c0.17	
v/c Ratio				0.53	0.36	
Uniform Delay, d1				13.7	9.3	
Progression Factor				1.00	0.02	
Incremental Delay, d2				0.2	0.5	
Delay (s)				13.9	0.7	
Level of Service				B	A	
Approach Delay (s)	0.0			13.9	0.7	
Approach LOS	A			B	A	

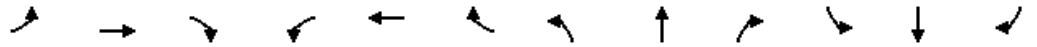
Intersection Summary			
HCM 2000 Control Delay	10.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.43		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	42.1%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	SBL	SBR	SBR2	NEL	NER
Lane Configurations											
Traffic Volume (vph)	0	0	0	0	2122	496	0	0	677	242	0
Future Volume (vph)	0	0	0	0	2122	496	0	0	677	242	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)					4.5	4.5			4.5	4.5	
Lane Util. Factor					0.95	1.00			0.88	1.00	
Frt					1.00	0.85			0.85	1.00	
Flt Protected					1.00	1.00			1.00	0.95	
Satd. Flow (prot)					3539	1583			2787	1770	
Flt Permitted					1.00	1.00			1.00	0.95	
Satd. Flow (perm)					3539	1583			2787	1770	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	0	2307	539	0	0	736	263	0
RTOR Reduction (vph)	0	0	0	0	0	107	0	0	11	0	0
Lane Group Flow (vph)	0	0	0	0	2307	432	0	0	725	263	0
Turn Type					NA	Perm			Perm	Prot	
Protected Phases					8					2	
Permitted Phases						8			6		
Actuated Green, G (s)					71.5	71.5			29.5	29.5	
Effective Green, g (s)					71.5	71.5			29.5	29.5	
Actuated g/C Ratio					0.65	0.65			0.27	0.27	
Clearance Time (s)					4.5	4.5			4.5	4.5	
Vehicle Extension (s)					3.0	3.0			3.0	3.0	
Lane Grp Cap (vph)					2300	1028			747	474	
v/s Ratio Prot					c0.65					0.15	
v/s Ratio Perm						0.27			c0.26		
v/c Ratio					1.00	0.42			0.97	0.55	
Uniform Delay, d1					19.2	9.3			39.8	34.6	
Progression Factor					0.97	0.54			1.00	1.00	
Incremental Delay, d2					15.4	0.2			26.5	4.6	
Delay (s)					34.0	5.2			66.3	39.2	
Level of Service					C	A			E	D	
Approach Delay (s)		0.0			28.5		66.3			39.2	
Approach LOS		A			C		E			D	

Intersection Summary			
HCM 2000 Control Delay	36.5	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.99		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	Err%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑	↱						↱	↰↰		
Traffic Volume (vph)	0	1915	0	0	0	0	0	0	0	698	0	0
Future Volume (vph)	0	1915	0	0	0	0	0	0	0	698	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.5								4.5		
Lane Util. Factor		0.95								0.97		
Frt		1.00								1.00		
Flt Protected		1.00								0.95		
Satd. Flow (prot)		3539								3433		
Flt Permitted		1.00								0.95		
Satd. Flow (perm)		3539								3433		
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	2082	0	0	0	0	0	0	0	759	0	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	19	0	0
Lane Group Flow (vph)	0	2082	0	0	0	0	0	0	0	740	0	0
Turn Type		NA	Perm						Perm	Prot		
Protected Phases		4								6		
Permitted Phases			4						2			
Actuated Green, G (s)		64.9								26.1		
Effective Green, g (s)		64.9								26.1		
Actuated g/C Ratio		0.65								0.26		
Clearance Time (s)		4.5								4.5		
Vehicle Extension (s)		3.0								3.0		
Lane Grp Cap (vph)		2296								896		
v/s Ratio Prot		c0.59								c0.22		
v/s Ratio Perm												
v/c Ratio		0.91								0.83		
Uniform Delay, d1		15.0								34.8		
Progression Factor		1.00								1.00		
Incremental Delay, d2		5.6								8.6		
Delay (s)		20.6								43.4		
Level of Service		C								D		
Approach Delay (s)		20.6			0.0			0.0			43.4	
Approach LOS		C			A			A			D	

Intersection Summary			
HCM 2000 Control Delay	26.7	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	106.2%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBR	NBR2	SWL	SWR
Lane Configurations		↑↑↑							↱↱	↰↰	
Traffic Volume (vph)	0	1641	0	0	0	0	0	0	548	820	0
Future Volume (vph)	0	1641	0	0	0	0	0	0	548	820	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.5							4.5	4.5	
Lane Util. Factor		0.91							0.88	0.97	
Frt		1.00							0.85	1.00	
Flt Protected		1.00							1.00	0.95	
Satd. Flow (prot)		5085							2787	3433	
Flt Permitted		1.00							1.00	0.95	
Satd. Flow (perm)		5085							2787	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	1784	0	0	0	0	0	0	596	891	0
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	20	0	0
Lane Group Flow (vph)	0	1784	0	0	0	0	0	0	576	891	0
Turn Type		NA							Perm	Prot	
Protected Phases		4								6	
Permitted Phases									2		
Actuated Green, G (s)		21.5							19.5	19.5	
Effective Green, g (s)		21.5							19.5	19.5	
Actuated g/C Ratio		0.43							0.39	0.39	
Clearance Time (s)		4.5							4.5	4.5	
Vehicle Extension (s)		3.0							3.0	3.0	
Lane Grp Cap (vph)		2186							1086	1338	
v/s Ratio Prot		c0.35								c0.26	
v/s Ratio Perm									0.21		
v/c Ratio		0.82							0.53	0.67	
Uniform Delay, d1		12.5							11.7	12.6	
Progression Factor		0.86							1.00	1.00	
Incremental Delay, d2		1.1							1.9	2.6	
Delay (s)		11.9							13.6	15.2	
Level of Service		B							B	B	
Approach Delay (s)		11.9			0.0		13.6			15.2	
Approach LOS		B			A		B			B	

Intersection Summary			
HCM 2000 Control Delay	13.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	50.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	Err%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations				↑↑↑↑	↰↰	
Traffic Volume (vph)	0	0	0	2874	564	0
Future Volume (vph)	0	0	0	2874	564	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)				4.5	4.5	
Lane Util. Factor				*1.00	0.97	
Frt				1.00	1.00	
Flt Protected				1.00	0.95	
Satd. Flow (prot)				7451	3433	
Flt Permitted				1.00	0.95	
Satd. Flow (perm)				7451	3433	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	0	0	0	3124	613	0
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	0	0	0	3124	613	0
Turn Type				NA	Perm	
Protected Phases				8		
Permitted Phases					2	
Actuated Green, G (s)				27.5	18.5	
Effective Green, g (s)				27.5	18.5	
Actuated g/C Ratio				0.50	0.34	
Clearance Time (s)				4.5	4.5	
Vehicle Extension (s)				3.0	3.0	
Lane Grp Cap (vph)				3725	1154	
v/s Ratio Prot				c0.42		
v/s Ratio Perm					c0.18	
v/c Ratio				0.84	0.53	
Uniform Delay, d1				11.8	14.7	
Progression Factor				1.00	1.00	
Incremental Delay, d2				1.8	1.8	
Delay (s)				13.6	16.5	
Level of Service				B	B	
Approach Delay (s)	0.0			13.6	16.5	
Approach LOS	A			B	B	

Intersection Summary			
HCM 2000 Control Delay	14.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	55.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	65.2%	ICU Level of Service	C
Analysis Period (min)	15		

c Critical Lane Group

Appendix E.2

Future 2038

Alternative 2 – Partial Displaced Left Turn Operational Analysis

2038 Alternative 2 - Partial DL Levels of Service

Peak Hour	Approach		Movement Delay (s/veh)	Movement LOS	Approach Delay (s/veh)	Approach LOS	Intersection Delay (s/veh)	Intersection LOS
7:30- 8:30AM	**Intersection 1 - Rte. 60 and Woolridge Rd./Old Buckingham Rd.**							
	Route 60 (EB)	L	32.28	C	-	-	19.4	B
		T	14.59	B				
		R	2.13	A				
	Route 60 (WB)	L	4.02	A	-	-		
		T	18.5	B				
		R	1.61	A				
	Woolridge Rd. (NB)	L	50.71	D	-	-		
		T	33.64	C				
		R	6.43	A				
	Old Buckingham Rd. (SB)	L	55.2	E	-	-		
		T	49.59	D				
	Intersection 2 - Rte. 60 WBL Crossover and Rte. 60 EB							
	Route 60 (EB)	L	-	-	-	-	12.75	B
		T	7.04	A				
		R	-	-				
	Route 60 (WB)	L	18.51	B	-	-		
		T	-	-				
		R	-	-				
4:45- 5:45PM	**Intersection 1 - Rte. 60 and Woolridge Rd./Old Buckingham Rd.**							
	Route 60 (EB)	L	197.98	F	-	-	42.87	D
		T	28.3	C				
		R	4.51	A				
	Route 60 (WB)	L	24.82	C	-	-		
		T	32.81	C				
		R	3.25	A				
	Woolridge Rd. (NB)	L	270.81	F	-	-		
		T	51.45	D				
		R	6.17	A				
	Old Buckingham Rd. (SB)	L	66.89	E	-	-		
		T	53.14	D				
	Intersection 2 - Rte. 60 WBL Crossover and Rte. 60 EB							
	Route 60 (EB)	L	-	-	-	-	32.175	C
		T	41.66	D				
		R	-	-				
	Route 60 (WB)	L	22.69	C	-	-		
		T	-	-				
		R	-	-				

Appendix E.3

Future 2038

Alternative 3 – Modified Quadrant Roadway Operational Analysis

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	5	0	0	279	0	17	0	528	787	0	390	0
Future Volume (vph)	5	0	0	279	0	17	0	528	787	0	390	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.5		4.5	4.5			4.5	4.5		4.5	
Lane Util. Factor		1.00		0.95	0.95			0.95	1.00		0.95	
Frt		1.00		1.00	0.98			1.00	0.85		1.00	
Flt Protected		0.95		0.95	0.96			1.00	1.00		1.00	
Satd. Flow (prot)		1770		1681	1666			3539	1583		3539	
Flt Permitted		0.64		0.75	0.75			1.00	1.00		1.00	
Satd. Flow (perm)		1199		1335	1299			3539	1583		3539	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	5	0	0	303	0	18	0	574	855	0	424	0
RTOR Reduction (vph)	0	0	0	0	21	0	0	0	317	0	0	0
Lane Group Flow (vph)	0	5	0	161	139	0	0	574	538	0	424	0
Turn Type	Perm	NA		Perm	NA			NA	Perm	Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8					2	6		
Actuated Green, G (s)		12.1		12.1	12.1			35.8	35.8		35.8	
Effective Green, g (s)		12.1		12.1	12.1			35.8	35.8		35.8	
Actuated g/C Ratio		0.21		0.21	0.21			0.63	0.63		0.63	
Clearance Time (s)		4.5		4.5	4.5			4.5	4.5		4.5	
Vehicle Extension (s)		3.0		3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)		254		283	276			2226	995		2226	
v/s Ratio Prot								0.16			0.12	
v/s Ratio Perm		0.00		c0.12	0.11				c0.34			
v/c Ratio		0.02		0.57	0.50			0.26	0.54		0.19	
Uniform Delay, d1		17.7		20.1	19.7			4.7	5.9		4.4	
Progression Factor		1.00		1.00	1.00			1.00	1.00		1.00	
Incremental Delay, d2		0.0		2.6	1.4			0.3	2.1		0.2	
Delay (s)		17.7		22.7	21.2			5.0	8.0		4.6	
Level of Service		B		C	C			A	A		A	
Approach Delay (s)		17.7			21.9			6.8			4.6	
Approach LOS		B			C			A			A	

Intersection Summary			
HCM 2000 Control Delay	8.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	56.9	Sum of lost time (s)	9.0
Intersection Capacity Utilization	60.4%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	11	157	1675	133	0	966	67	209	319	17	134	257
Future Volume (vph)	11	157	1675	133	0	966	67	209	319	17	134	257
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	6.0	6.0		6.0	6.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95
Frt		1.00	1.00	0.85		1.00	0.85	1.00	1.00	0.85	1.00	0.93
Flt Protected		0.95	1.00	1.00		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1770	3539	1583		3539	1583	1770	3539	1583	1770	3275
Flt Permitted		0.27	1.00	1.00		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		508	3539	1583		3539	1583	1770	3539	1583	1770	3275
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	12	171	1821	145	0	1050	73	227	347	18	146	279
RTOR Reduction (vph)	0	0	0	48	0	0	52	0	0	16	0	121
Lane Group Flow (vph)	0	183	1821	97	0	1050	21	227	347	2	146	435
Turn Type	custom	Prot	NA	Perm		NA	Perm	Prot	NA	Perm	Prot	NA
Protected Phases		1	6			2		3	8		7	4
Permitted Phases	1			6			2			8		
Actuated Green, G (s)		51.0	100.0	100.0		44.0	44.0	17.0	18.0	18.0	16.0	17.0
Effective Green, g (s)		51.0	100.0	100.0		44.0	44.0	17.0	18.0	18.0	16.0	17.0
Actuated g/C Ratio		0.34	0.67	0.67		0.29	0.29	0.11	0.12	0.12	0.11	0.11
Clearance Time (s)		5.0	6.0	6.0		6.0	6.0	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	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		172	2359	1055		1038	464	200	424	189	188	371
v/s Ratio Prot			0.51			c0.30		c0.13	0.10		0.08	c0.13
v/s Ratio Perm		c0.36		0.06			0.01			0.00		
v/c Ratio		1.06	0.77	0.09		1.01	0.05	1.14	0.82	0.01	0.78	1.17
Uniform Delay, d1		49.5	17.2	8.9		53.0	38.0	66.5	64.4	58.2	65.3	66.5
Progression Factor		1.00	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2		86.6	2.5	0.2		30.8	0.2	104.7	11.7	0.0	18.0	103.0
Delay (s)		136.1	19.7	9.0		83.8	38.2	171.2	76.1	58.2	83.3	169.5
Level of Service		F	B	A		F	D	F	E	E	F	F
Approach Delay (s)			28.9			80.8			112.0			151.6
Approach LOS			C			F			F			F

Intersection Summary			
HCM 2000 Control Delay	71.3	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.07		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	21.0
Intersection Capacity Utilization	86.5%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	255
Future Volume (vph)	255
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.92
Adj. Flow (vph)	277
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	1826	0	296	0	0	787
Future Volume (vph)	1826	0	296	0	0	787
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0			5.0
Lane Util. Factor	0.95		0.97			1.00
Frt	1.00		1.00			0.86
Flt Protected	1.00		0.95			1.00
Satd. Flow (prot)	3539		3433			1611
Flt Permitted	1.00		0.95			1.00
Satd. Flow (perm)	3539		3433			1611
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1985	0	322	0	0	855
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	1985	0	322	0	0	855
Turn Type	NA	Perm	Prot			Perm
Protected Phases	4		3			
Permitted Phases		4				3 4
Actuated Green, G (s)	40.9		8.8			59.7
Effective Green, g (s)	40.9		8.8			59.7
Actuated g/C Ratio	0.69		0.15			1.00
Clearance Time (s)	5.0		5.0			
Vehicle Extension (s)	3.0		3.0			
Lane Grp Cap (vph)	2424		506			1611
v/s Ratio Prot	c0.56		0.09			
v/s Ratio Perm						c0.53
v/c Ratio	0.82		0.64			0.53
Uniform Delay, d1	6.7		23.9			0.0
Progression Factor	1.00		1.00			1.00
Incremental Delay, d2	2.3		2.6			0.3
Delay (s)	9.0		26.6			0.3
Level of Service	A		C			A
Approach Delay (s)	9.0			26.6	0.3	
Approach LOS	A			C	A	

Intersection Summary			
HCM 2000 Control Delay	8.5	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.82		
Actuated Cycle Length (s)	59.7	Sum of lost time (s)	10.0
Intersection Capacity Utilization	107.5%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	5	0	0	820	0	21	0	548	623	0	730	0
Future Volume (vph)	5	0	0	820	0	21	0	548	623	0	730	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.5		4.5	4.5			4.5	4.5		4.5	
Lane Util. Factor		1.00		0.95	0.95			0.95	1.00		0.95	
Frt		1.00		1.00	0.99			1.00	0.85		1.00	
Flt Protected		0.95		0.95	0.95			1.00	1.00		1.00	
Satd. Flow (prot)		1770		1681	1677			3539	1583		3539	
Flt Permitted		0.30		0.75	0.73			1.00	1.00		1.00	
Satd. Flow (perm)		561		1335	1288			3539	1583		3539	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	5	0	0	891	0	23	0	596	677	0	793	0
RTOR Reduction (vph)	0	0	0	0	13	0	0	0	359	0	0	0
Lane Group Flow (vph)	0	5	0	454	447	0	0	596	318	0	793	0
Turn Type	Perm	NA		Perm	NA			NA	Perm	Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8					2	6		
Actuated Green, G (s)		30.8		30.8	30.8			35.2	35.2		35.2	
Effective Green, g (s)		30.8		30.8	30.8			35.2	35.2		35.2	
Actuated g/C Ratio		0.41		0.41	0.41			0.47	0.47		0.47	
Clearance Time (s)		4.5		4.5	4.5			4.5	4.5		4.5	
Vehicle Extension (s)		3.0		3.0	3.0			3.0	3.0		3.0	
Lane Grp Cap (vph)		230		548	528			1660	742		1660	
v/s Ratio Prot								0.17			c0.22	
v/s Ratio Perm		0.01		0.34	c0.35				0.20			
v/c Ratio		0.02		0.83	0.85			0.36	0.43		0.48	
Uniform Delay, d1		13.1		19.7	20.0			12.7	13.2		13.6	
Progression Factor		1.00		0.22	0.25			1.00	1.00		0.67	
Incremental Delay, d2		0.0		5.0	6.0			0.6	1.8		0.1	
Delay (s)		13.2		9.3	11.1			13.3	15.0		9.2	
Level of Service		B		A	B			B	B		A	
Approach Delay (s)		13.2			10.2			14.2			9.2	
Approach LOS		B			B			B			A	

Intersection Summary			
HCM 2000 Control Delay	11.7	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	50.2%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Traffic Volume (vph)	16	242	1420	237	0	1892	141	193	355	21	184	493
Future Volume (vph)	16	242	1420	237	0	1892	141	193	355	21	184	493
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		5.0	6.0	6.0		6.0	6.0	5.0	5.0	5.0	5.0	5.0
Lane Util. Factor		1.00	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95
Frt		1.00	1.00	0.85		1.00	0.85	1.00	1.00	0.85	1.00	0.93
Flt Protected		0.95	1.00	1.00		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Satd. Flow (prot)		1770	3539	1583		3539	1583	1770	3539	1583	1770	3277
Flt Permitted		0.95	1.00	1.00		1.00	1.00	0.95	1.00	1.00	0.95	1.00
Satd. Flow (perm)		1770	3539	1583		3539	1583	1770	3539	1583	1770	3277
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	17	263	1543	258	0	2057	153	210	386	23	200	536
RTOR Reduction (vph)	0	0	0	98	0	0	72	0	0	20	0	117
Lane Group Flow (vph)	0	280	1543	160	0	2057	81	210	386	3	200	941
Turn Type	Prot	Prot	NA	Perm		NA	Perm	Prot	NA	Perm	Prot	NA
Protected Phases	1	1	6			2		3	8		7	4
Permitted Phases				6			2			8		
Actuated Green, G (s)		20.0	93.0	93.0		68.0	68.0	13.0	21.8	21.8	19.2	28.0
Effective Green, g (s)		20.0	93.0	93.0		68.0	68.0	13.0	21.8	21.8	19.2	28.0
Actuated g/C Ratio		0.13	0.62	0.62		0.45	0.45	0.09	0.15	0.15	0.13	0.19
Clearance Time (s)		5.0	6.0	6.0		6.0	6.0	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	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)		236	2194	981		1604	717	153	514	230	226	611
v/s Ratio Prot		c0.16	0.44			c0.58		c0.12	0.11		0.11	c0.29
v/s Ratio Perm				0.10			0.05			0.00		
v/c Ratio		1.19	0.70	0.16		1.28	0.11	1.37	0.75	0.01	0.88	1.54
Uniform Delay, d1		65.0	19.2	12.0		41.0	23.6	68.5	61.5	54.9	64.3	61.0
Progression Factor		1.00	1.00	1.00		1.00	1.00	0.82	0.79	1.00	1.00	1.00
Incremental Delay, d2		118.3	1.9	0.4		132.0	0.3	201.7	5.8	0.0	31.0	251.1
Delay (s)		183.3	21.1	12.4		173.0	24.0	257.9	54.6	54.9	95.3	312.1
Level of Service		F	C	B		F	C	F	D	D	F	F
Approach Delay (s)			41.9			162.7			123.6			277.6
Approach LOS			D			F			F			F

Intersection Summary			
HCM 2000 Control Delay	141.4	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.33		
Actuated Cycle Length (s)	150.0	Sum of lost time (s)	21.0
Intersection Capacity Utilization	123.8%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Movement	SBR
Lane Configurations	
Traffic Volume (vph)	480
Future Volume (vph)	480
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.92
Adj. Flow (vph)	522
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	1604	0	841	0	0	623
Future Volume (vph)	1604	0	841	0	0	623
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.0		5.0			5.0
Lane Util. Factor	0.95		0.97			1.00
Frt	1.00		1.00			0.86
Flt Protected	1.00		0.95			1.00
Satd. Flow (prot)	3539		3433			1611
Flt Permitted	1.00		0.95			1.00
Satd. Flow (perm)	3539		3433			1611
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	1743	0	914	0	0	677
RTOR Reduction (vph)	0	0	0	0	0	0
Lane Group Flow (vph)	1743	0	914	0	0	677
Turn Type	NA	Perm	Prot			Perm
Protected Phases	4		3			
Permitted Phases		4				3 4
Actuated Green, G (s)	42.3		22.7			75.0
Effective Green, g (s)	42.3		22.7			75.0
Actuated g/C Ratio	0.56		0.30			1.00
Clearance Time (s)	5.0		5.0			
Vehicle Extension (s)	3.0		3.0			
Lane Grp Cap (vph)	1995		1039			1611
v/s Ratio Prot	c0.49		c0.27			
v/s Ratio Perm						0.42
v/c Ratio	0.87		0.88			0.42
Uniform Delay, d1	14.1		24.9			0.0
Progression Factor	0.59		1.00			1.00
Incremental Delay, d2	3.2		8.7			0.1
Delay (s)	11.5		33.5			0.1
Level of Service	B		C			A
Approach Delay (s)	11.5			33.5	0.1	
Approach LOS	B			C	A	

Intersection Summary			
HCM 2000 Control Delay	15.2	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.88		
Actuated Cycle Length (s)	75.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	91.2%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Appendix F

Alternative 1 – RCUT

HSIP Worksheet

Highway Safety Improvement Program

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Project #: xxxxxxxxxxx
Receive #:xxxxxxxx
HSIP File:xxxxxxxxx
Date Received: Month x, 2017

Safety Improvement Proposal (FY2019)

View Read-Me File for methodology for considering multiple CMFs

PROJECT INFORMATION

Agency	Project Sponsor	Address	City	State	Zip
JMT	VDOT	9201 Arboretum Pkwy Suite 310	Richmond	VA	23236

Email Address	Phone	Priority Number	State Milepoint	VDOT District	VDOT Region
HSIProgram@VirginiaDOT.org	804-323-9900	TBD	0.00 - 1.70	Richmond	Central

Program Type	Project Type	Functional Class Code	Area Location Code	Fed. Sys. Code	Study Period Begins	Study Period Ends
Regular	Segment	Urban Interstate	Urbanized (50,000 - 199,999)	Non-NHS	4/9/2018	8/9/2018

County	Safety Proposal Location / Route	System	Traffic Control	From / Major Road	To / Cross Street
Henrico	I-295 Northbound	Interstate	> 35MPH Segment	Nuckols Road	I-64
	(Include Name)			(RNS Node-Offset If Applicable)	

STEP 1 :: CRASH HISTORY (Define crashes by type and severity)

APPLICABLE CRASH TYPE AND SEVERITY

		Crash Severity						Automated Check	Link to SHSP
Crash Type Categories		All	Fatal (K)	Incapacitating Injury (A)	Minor Injury (B+C)	Property Damage (O)	Not specified		
Total Crashes	All	72	0	2	9	61	0	Yes	
Primary Crash Categories (sum of all 3 must equal total crashes)									
Roadway Departure or Intersection	Cross median	0	0	0	0	0	0	Yes	
	Fixed object	1	0	0	0	1	0	Yes	
	Run off road	0	0	0	0	0	0	Yes	
	Head on	0	0	0	0	0	0	Yes	
	Non-Collision	2	0	0	0	2	0	Yes	✓
	Sideswipe	3	0	0	0	3	0	Yes	
	Angle	11	0	0	3	8	0	Yes	
	Left turn	0	0	0	0	0	0	Yes	
	Right turn	0	0	0	0	0	0	Yes	
	Rear end	55	0	2	6	47	0	Yes	
Non-Motorized	Pedestrian	0	0	0	0	0	0	Yes	
	Bicycle	0	0	0	0	0	0	Yes	
Secondary Crash Categories									
Environmental Factors	Nighttime	9	0	1	2	6	0	Yes	
	Wet weather	6	0	1	1	4	0	Yes	
Number of Vehicles	Single vehicle	2	0	0	0	2	0	Yes	
	Multiple vehicle	70	0	2	10	58	0	Yes	
Driver Behavior	Speed related	2	0	1	0	1	0	Yes	
	Unbelted	1	0	1	2	1	0	No	✓
	Alcohol related	2	0	0	0	2	0	Yes	
Automated Check (i.e., does total crashes match the sum of RD, INT, and NM crash types?)									
		Yes	Yes	Yes	Yes	Yes	Yes		
		Number of years in crash history:	3		Discount Rate:	3%			

Highway Safety Improvement Program

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Receive #:xxxxxxxx
HSIP File:xxxxxxxxx
Inititate Date: Month x, 2014

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STEP 2 :: COST (Compute the economic cost of each improvement)

Proposed Improvement	Service Life	PE Cost + $5000 (*)	Right-of-Way & Utility Cost	Construction Cost	Total Construction Cost (PV)	Contingency (10%)	Annual Maintenance	Maintenance Cost (PV)	Total Cost (PV)
Install J-Turn intersection	20	$395,000	$3,120,000	$3,900,000	$7,415,000	$390,000	$8,400	$124,971	$7,929,971

STEP 3 :: BENEFIT (Compute the economic benefit of each improvement)

Proposed Improvement	CMF Value	Applicable Crash Type	Applicable Crash Severity Type	Include CMF in Final Analysis? (Yes/No)	Reference Link to CMF ID from CMF Clearinghouse	Other Notes
Install J-Turn intersection	0.877	All	All	Yes	http://www.cmfclearinghouse.org/detail.cfm?facid=	
•						
•						
•						
•						
•						

STEP 4 :: B/C RATIO (Compute the B/C ratio for specific combinations of CMFs)

Proposed Improvement	Include in Analysis? (Yes/No)	Present Value of Benefit	Present Value of Cost	B/C by CMF	B/C Ratio	Annual Estimated Lives Saved and Injuries Prevented	Other Notes
Install J-Turn intersection	Yes	$1,000,898	$7,929,971	0.13	**0.13**	0	1. VDOT District and Central Office personnel charge review and administration time to project managed by localities. Safety Projects not managed by VDOT shall include a minimum of $5,000 for VDOT PE costs.
				-		0	

PROJECT SCHEDULE (AFTER STIP APPROVAL)

Begin PE	Target Advert.	Begin Construction	Estimated Complete Date	Type of Plan	Project Administered By

SIGNATURE OF SPONSOR

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Name (Print):

Signature: **Date:**

Appendix G

Alternative 2 – Partial Displaced Left Turn
HSIP Worksheet

Highway Safety Improvement Program

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Project #: xxxxxxxxxxx
Receive #:xxxxxxxx
HSIP File:xxxxxxxxx
Date Received: Month x, 2017

Safety Improvement Proposal (FY2019)

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PROJECT INFORMATION

Agency	Project Sponsor	Address	City	State	Zip
JMT	VDOT	9201 Arboretum Pkwy Suite 310	Richmond	VA	23236

Email Address	Phone	Priority Number	State Milepoint	VDOT District	VDOT Region
HSIProgram@VirginiaDOT.org	804-323-9900	TBD	0.00 - 1.70	Richmond	Central

Program Type	Project Type	Functional Class Code	Area Location Code	Fed. Sys. Code	Study Period Begins	Study Period Ends
Regular	Segment	Urban Interstate	Urbanized (50,000 - 199,999)	Non-NHS	4/9/2018	8/9/2018

County	Safety Proposal Location / Route	System	Traffic Control	From / Major Road	To / Cross Street
Henrico	I-295 Northbound	Interstate	> 35MPH Segment	Nuckols Road	I-64
	(Include Name)			(RNS Node-Offset If Applicable)	

STEP 1 :: CRASH HISTORY (Define crashes by type and severity)

APPLICABLE CRASH TYPE AND SEVERITY

Crash Type Categories		Crash Severity: All	Fatal (K)	Incapacitating Injury (A)	Minor Injury (B+C)	Property Damage (O)	Not specified	Automated Check	Link to SHSP
Total Crashes	All	72	0	2	9	61	0	Yes	
Primary Crash Categories (sum of all 3 must equal total crashes)									
Roadway Departure or Intersection	Cross median	0	0	0	0	0	0	Yes	
	Fixed object	1	0	0	0	1	0	Yes	
	Run off road	0	0	0	0	0	0	Yes	
	Head on	0	0	0	0	0	0	Yes	
	Non-Collision	2	0	0	0	2	0	Yes	
	Sideswipe	3	0	0	0	3	0	Yes	✓
	Angle	11	0	0	3	8	0	Yes	
	Left turn	0	0	0	0	0	0	Yes	
	Right turn	0	0	0	0	0	0	Yes	
	Rear end	55	0	2	6	47	0	Yes	
Non-Motorized	Pedestrian	0	0	0	0	0	0	Yes	
	Bicycle	0	0	0	0	0	0	Yes	
Secondary Crash Categories									
Environmental Factors	Nighttime	9	0	1	2	6	0	Yes	
	Wet weather	6	0	1	1	4	0	Yes	
Number of Vehicles	Single vehicle	2	0	0	0	2	0	Yes	
	Multiple vehicle	70	0	2	10	58	0	Yes	
Driver Behavior	Speed related	2	0	1	0	1	0	Yes	
	Unbelted	1	0	1	2	1	0	No	✓
	Alcohol related	2	0	0	0	2	0	Yes	
Automated Check (i.e., does total crashes match the sum of RD, INT, and NM crash types?)		Yes	Yes	Yes	Yes	Yes	Yes		

Number of years in crash history: 3 — Discount Rate: 3%

Highway Safety Improvement Program

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HSIP File:xxxxxxxxx
Initiate Date: Month x, 2014

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STEP 2 :: COST (Compute the economic cost of each improvement)

Proposed Improvement	Service Life	PE Cost + $5000 (*)	Right-of-Way & Utility Cost	Construction Cost	Total Construction Cost (PV)	Contingency (10%)	Annual Maintenance	Maintenance Cost (PV)	Total Cost (PV)
Install displaced left-turn intersection	20	$165,000	$1,280,000	$1,600,000	$3,045,000	$160,000	$2,000	$29,755	$3,234,755

STEP 3 :: BENEFIT (Compute the economic benefit of each improvement)

Proposed Improvement	CMF Value	Applicable Crash Type	Applicable Crash Severity Type	Include CMF in Final Analysis? (Yes/No)	Reference Link to CMF ID from CMF Clearinghouse	Other Notes
Install displaced left-turn intersection	0.76	All	All	Yes	https://www.fhwa.dot.gov/publications/research/s	Clearinghouse does not provide CMF information for a Displaced left turn intersection (or Continuous flow intersection). This CMF was found from a 2010 report the FHWA link provided.

STEP 4 :: B/C RATIO (Compute the B/C ratio for specific combinations of CMFs)

Proposed Improvement	Include in Analysis? (Yes/No)	Present Value of Benefit	Present Value of Cost	B/C by CMF	B/C Ratio	Annual Estimated Lives Saved and Injuries Prevented	Other Notes
Install displaced left-turn intersection	Yes	$1,952,972	$3,234,755	0.60	**0.60**	1	1. VDOT District and Central Office personnel charge review and administration time to project managed by localities. Safety Projects not

PROJECT SCHEDULE (AFTER STIP APPROVAL)

Begin PE	Target Advert.	Begin Construction	Estimated Complete Date	Type of Plan	Project Administered By

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Name (Print):

Signature: **Date:**

Appendix H

Alternative 3 – Modified Quadrant Roadway
HSIP Worksheet

Highway Safety Improvement Program

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Project #: xxxxxxxxxxx
Receive #:xxxxxxxx
HSIP File:xxxxxxxxx
Date Received: Month x, 2017

Safety Improvement Proposal (FY2019)

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PROJECT INFORMATION

Agency	Project Sponsor	Address	City	State	Zip
JMT	VDOT	9201 Arboretum Pkwy Suite 310	Richmond	VA	23236

Email Address	Phone	Priority Number	State Milepoint	VDOT District	VDOT Region
HSIProgram@VirginiaDOT.org	804-323-9900	TBD	0.00 - 1.70	Richmond	Central

Program Type	Project Type	Functional Class Code	Area Location Code	Fed. Sys. Code	Study Period Begins	Study Period Ends
Regular	Segment	Urban Interstate	Urbanized (50,000 - 199,999)	Non-NHS	4/9/2018	8/9/2018

County	Safety Proposal Location / Route	System	Traffic Control	From / Major Road	To / Cross Street
Henrico	I-295 Northbound	Interstate	> 35MPH Segment	Nuckols Road	I-64
	(Include Name)			(RNS Node-Offset If Applicable)	

STEP 1 :: CRASH HISTORY (Define crashes by type and severity)

APPLICABLE CRASH TYPE AND SEVERITY

		Crash Severity						Automated Check	Link to SHSP
Crash Type Categories		All	Fatal (K)	Incapacitating Injury (A)	Minor Injury (B+C)	Property Damage (O)	Not specified		
Total Crashes	All	72	0	2	9	61	0	Yes	
Primary Crash Categories (sum of all 3 must equal total crashes)									
Roadway Departure or Intersection	Cross median	0	0	0	0	0	0	Yes	
	Fixed object	1	0	0	0	1	0	Yes	
	Run off road	0	0	0	0	0	0	Yes	
	Head on	0	0	0	0	0	0	Yes	
	Non-Collision	2	0	0	0	2	0	Yes	✓
	Sideswipe	3	0	0	0	3	0	Yes	
	Angle	11	0	0	3	8	0	Yes	
	Left turn	0	0	0	0	0	0	Yes	
	Right turn	0	0	0	0	0	0	Yes	
	Rear end	55	0	2	6	47	0	Yes	
Non-Motorized	Pedestrian	0	0	0	0	0	0	Yes	
	Bicycle	0	0	0	0	0	0	Yes	
Secondary Crash Categories									
Environmental Factors	Nighttime	9	0	1	2	6	0	Yes	
	Wet weather	6	0	1	1	4	0	Yes	
Number of Vehicles	Single vehicle	2	0	0	0	2	0	Yes	
	Multiple vehicle	70	0	2	10	58	0	Yes	
Driver Behavior	Speed related	2	0	1	0	1	0	Yes	
	Unbelted	1	0	1	2	1	0	No	✓
	Alcohol related	2	0	0	0	2	0	Yes	
Automated Check (i.e., does total crashes match the sum of RD, INT, and NM crash types?)									
		Yes	Yes	Yes	Yes	Yes	Yes		
		Number of years in crash history:	3		Discount Rate:	3%			

Highway Safety Improvement Program

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Receive #:xxxxxxxx
HSIP File:xxxxxxxxx
Inititate Date: Month x, 2014

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STEP 2 :: COST (Compute the economic cost of each improvement)

Proposed Improvement	Service Life	PE Cost + $5000 (*)	Right-of-Way & Utility Cost	Construction Cost	Total Construction Cost (PV)	Contingency (10%)	Annual Maintenance	Maintenance Cost (PV)	Total Cost (PV)
Install Quadrant Roadway Intersection	20	$185,000	$1,440,000	$1,800,000	$3,425,000	$180,000	$3,720	$55,344	$3,660,344

STEP 3 :: BENEFIT (Compute the economic benefit of each improvement)

Proposed Improvement	CMF Value	Applicable Crash Type	Applicable Crash Severity Type	Include CMF in Final Analysis? (Yes/No)	Reference Link to CMF ID from CMF Clearinghouse	Other Notes
Install Quadrant Roadway Intersection	1	All	All	Yes		CMF Data was not found for installing a Quadrant Roadway Intersection.

STEP 4 :: B/C RATIO (Compute the B/C ratio for specific combinations of CMFs)

Proposed Improvement	Include in Analysis? (Yes/No)	Present Value of Benefit	Present Value of Cost	B/C by CMF	B/C Ratio	Annual Estimated Lives Saved and Injuries Prevented	Other Notes
Install Quadrant Roadway Intersection	Yes	$0	$3,660,344	-	**0.00**	0	1. VDOT District and Central Office personnel charge review and administration time to project managed by localities. Safety Projects not managed by VDOT shall include a minimum of $5,000 for VDOT PE costs.

PROJECT SCHEDULE (AFTER STIP APPROVAL)

Begin PE	Target Advert.	Begin Construction	Estimated Complete Date	Type of Plan	Project Administered By

SIGNATURE OF SPONSOR

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Signature: **Date:**