ROSSER AVENUE (US 340) CORRIDOR STUDY

Waynesboro, VA

October 2018

Kimley»Horn

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1. Introduction

The Staunton-Augusta-Waynesboro MPO ("SAWMPO"), in cooperation with the Virginia Department of Transportation (VDOT) and the City of Waynesboro, retained Kimley-Horn and Associates, Inc. (Kimley-Horn) through the Central Shenandoah Planning District Commission (CSPDC) to examine existing signalized intersection performance, develop updated coordinated signal timing plans, and identify operational and safety improvements along the US 340 Corridor (Rosser Avenue) between Tiffany Drive and Ladd Road in Waynesboro, Virginia (or the study corridor). The intersections included in the study corridor are shown in **Table 1**.

Table 1: Signal System Intersection List

Intersection
US 340 (Rosser Avenue) at Tiffany Drive
US 340 (Rosser Avenue) at Lennox Place
US 340 (Rosser Avenue) at Lucy Lane
US 340 (Rosser Avenue) at Lew Dewitt Boulevard/Windigrove Drive
US 340 (Rosser Avenue) at the I-64 Exit 94 West Ramps*
US 340 (Rosser Avenue) at the I-64 Exit 94 East Ramps*
US 340 (Rosser Avenue) at Shenandoah Village Drive
US 340 (Rosser Avenue) at Town Center Drive
US 340 (Rosser Avenue) at Ladd Road*

*VDOT managed & maintained traffic signal

Traffic signals along this corridor are managed and operated by two separate entities. VDOT manages the eastbound and westbound I-64 Ramp (Exit 94) signals and the signal located at Ladd Road. The City of Waynesboro operates and maintains the six other traffic signals within the study corridor. The intersections from Tiffany Drive to Lew Dewitt Boulevard operate as a closed-loop system via wireless communication; however, the existing traffic signal equipment at the remaining intersection do not communicate as a full system resulting in inefficient operations.

Figure 1 and **Figure 2** illustrate the signal system boundaries on a map and the overall project schedule, respectively.

Figure 1: Signal System Map

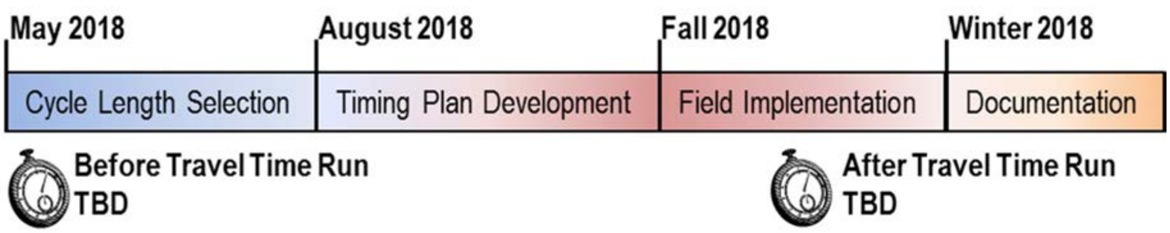

Figure 2: Project Schedule

Corridor Description

Rosser Avenue is a four-lane, divided corridor oriented generally in a north/south direction within the signal system boundaries. The posted speed limit along Rosser Avenue is 45 MPH. Interstate 64 has an interchange (Exit 94) with Rosser Avenue in the approximate midpoint of the study area corridor. Rosser Avenue has a major intersection with Lew Dewitt Boulevard just north of Exit 94.

The traffic signals along Rosser Avenue currently operate a 100-second cycle length coordination plan from Town Center Drive to Tiffany Drive. Splits and offsets vary by time of day but the cycle length remains constant. Rosser Avenue/Ladd Road currently operates uncoordinated in Free. As described above, communication is limited and does not exist for the full system. Therefore, local controller clocks drift resulting in stop-and-go conditions although the cycle lengths are the same.

The land use within the study area is primarily commercial and retail with limited residential development to the north. Many of the study area intersections serve large commercial shopping centers with major retail anchors. Significant commercial and retail growth has occurred along this corridor and traffic often experiences vehicle delays, reduced vehicle throughput, and crashes that occur from the stop-and-go traffic patterns created by inefficient traffic signal timing plans.

2. Project Approach

Data Collection

Turning Movement Counts (TMC)

Turning movement counts (TMC) were conducted at seven of the nine study intersections by Peggy Malone and Associates, Inc. (PMA). Turning movement counts were collected during the AM, MIDDAY, and PM peak hours (6:30 AM to 9:30 AM, 11:00 AM to 1:00 PM, and 3:00 PM to 6:00 PM, respectively). The TMC at the intersections of Rosser Avenue / Shenandoah Village Drive and Rosser Avenue / Town Center Drive were collected on March 22, 2017 and supplied to Kimley-Horn by VDOT.

The peak period counts were used to determine the appropriate volumes for use in developing AM, MIDDAY, and PM timing plans. These counts were summarized and peak hour totals were used in the development of timing plans using Synchro 9.0.

Average Daily Traffic (ADT) Counts

Peggy Malone and Associates, Inc. collected directional ADT counts for seven consecutive days at two locations along the Rosser Avenue corridor within the signal system. The counters were in the northbound and southbound directions between Grandview Drive and Town Center Drive and between Lew Dewitt Boulevard and Lucy Lane. This information was used to validate peak hour turning movement counts as well as identify peaking characteristics of the corridor to develop time of day clocks for the new timing plans.

Per 2018 traffic count data obtained during this study, Rosser Avenue carries approximately 18,700 vehicles per day during the weekday between Lucy Lane and Lew Dewitt Boulevard and approximately 18,200 vehicles per day between Grandview Drive and Town Center Drive. Per 2017 VDOT traffic count data obtained from VDOT’s website, Lew Dewitt Boulevard carries an estimated 12,000 vehicles per day.

Field Observations

Kimley-Horn observed traffic patterns not apparent with count data such as vehicle progression, driver tendencies, sub peaks, excessive queuing, and lane utilization during the primary weekday peak periods to coincide with the new timing plans to be developed. These observations were performed on April 12, 2018.

During the AM peak hour, commercial activity was relatively low and the primary travel patterns appeared to be motorists destined to Interstate 64. As a result, vehicle progression traveling along the corridor was relatively good considering most intersections were not experiencing left-turn or side street phase actuations. It was noted that the southbound left-turn lane onto eastbound I-64 experienced queueing that extended beyond the available storage lane.

During the MIDDAY peak hour, progression declined as left-turn and side street actuations increased with vehicle activity. Vehicle trips appeared more local (i.e., Lew Dewitt Boulevard to Shenandoah Village Drive) based on how the vehicle platoons dispersed opposed to vehicles driving the full limits of the corridor. Turning movements at Shenandoah Village Drive which access the Town Center development were noticeably higher than in the AM peak hour. There were several times where vehicles required two signal cycles to be served indicating inadequate split time.

During the PM peak hour, progression was poor between Town Center Drive and Lew Dewitt Boulevard. Furthermore, heavy queuing and lengthy delays were observed along the westbound off-ramp and the left-turn movements from Rosser Avenue onto I-64 eastbound and westbound. Most cycles, vehicle queues exceeded the available storage capacity at the ramps which impacted vehicle progression along Rosser Avenue. As expected from the TMC, the northbound left-turn onto Lew Dewitt Boulevard experienced high traffic volumes and filled and/or exceeded available storage capacity most cycles throughout the peak hour. There was also increased pedestrian activity to the north of the corridor near the residential community at Tiffany Drive.

Timing Plan Development

Timing plans for coordinated signal systems were developed with several objectives:

- To minimize overall system and turning movement vehicular delay and the frequency of stop-and-go conditions
- To develop timing plans that accommodate increased traffic volumes and changes in travel patterns associated with growth along the corridor
- To progress through movements on Rosser Avenue
- To facilitate progression of vehicles between Tiffany Drive, Lew Dewitt Boulevard, and Ladd Road
- To reduce system recovery times associated with unsynchronized and inefficient traffic signal timing plans
- To reduce the occurrence of queue spillback along Rosser Avenue
- Subsequent to these objectives is to ultimately reduce rear-end and angle crashes

The Synchro 9.0 signal optimization program was used as a tool to develop optimized timing plans. The plan development included determining cycle lengths, developing phase splits, phase sequencing, and offsets. Phase splits were determined at each intersection using Synchro 9.0 and manually verified using a technique based on the Poisson distribution. Phase sequence changes were recommended to optimize two-way progression and varied by time-of-day at each intersection.

Using turning movement count data and other field observations, three base timing plans were developed for the system as follows:

- AM Peak Plan – 1/1/1 – 90 second cycle length
- Midday Peak Plan – 2/1/1 – 100 second cycle length
- PM Peak Plan – 3/1/1 – 116 second cycle length

3.Operational Improvements Summary

The measure of effectiveness for the signal timing improvements are typically documented and summarized using three methods: Intersection vehicular delay and level of service (LOS) per Highway Capacity Manual calculations, 95^{th} percentile queueing, and travel time comparisons. These methods compare results using the "before" signal timings and "after" signal timings; however, their purposes are somewhat different. The intersection delay, LOS, and 95^{th} percentile queueing illustrates peak hour results for individual turning movements at each intersection. Whereas, the travel time comparisons illustrate actual mainline system performance averaged for several peak periods as a driver travels the limits of the signal system. Before/after travel times will be collected once the new timing plans are implemented so results are not provided below but will be supplemented once collected and analyzed.

Intersection Delay and LOS

Level of service describes the amount of traffic congestion at an intersection or on a roadway and ranges from A to F (e.g., 'A' indicating a condition of little to no congestion and 'F' a condition with severe congestion, unstable traffic flow, and stop-and-go conditions).

Intersection and arterial LOS were assessed using Highway Capacity Manual (HCM) 2000 methodologies in Synchro 9.0 software. Due to limitations within the HCM 2010 and HCM 6^{th} Edition and their requirement for strict NEMA phasing and shorter clearance interval time than actual, the HCM 2000 was used for all intersections. The following table illustrates ranges of delay as defined in the HCM 2000.

Table 2: LOS Control Delay Thresholds

LOS	Signalized Intersections Control Delay Per Vehicle [sec/veh]	Unsignalized Intersections Average Control Delay [sec/veh]	Relative Delay
A	≤ 10	≤ 10	Short Delays
	Free-flow traffic operations at average travel speeds. Vehicles completely unimpeded in ability to maneuver. Minimal delay at signalized intersections.		
B	> 10 – 20	> 10 – 15	
	Reasonably unimpeded traffic operations at average travel speeds. Vehicle maneuverability slightly restricted. Low traffic delays.		
C	> 20 – 35	> 15 – 25	
	Stable traffic operations. Lane changes becoming more restricted. Travel speeds reduced to half of average free flow travel speeds. Longer intersection delays.		
D	>35 – 55	> 25 – 35	Moderate Delays
	Small increases in traffic flow can cause increased delays. Delays likely attributable to increase traffic, reduced signal progression and adverse timing.		
E	>55 – 80	> 35 – 50	
	Significant delays. Travel speeds reduced to one third of average free flow travel speed.		
F	> 80	> 50	Long Delays
	Extremely low speeds. Intersection congestion. Long delays. Extensive traffic queues at intersections.		

Source: Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010

To evaluate existing (before) conditions, existing traffic volumes, existing lane configurations, and existing signal timings and phasing were used to analyze the intersections within the signal system. Model inputs were consistent with assumptions and methodology defined in VDOT's Traffic Operations and Safety Analysis Manual (TOSAM).

To evaluate proposed (after) conditions, existing traffic volumes, existing lane configurations, and proposed signal timings with optimized cycle lengths, splits, offsets, and phase sequencing were used to analyze the intersections within the signal system. It is important to note that the results shown below reflect operations with synchronized clocks and communication. Due to the lack of communications between the intersections, observed vehicle progression and movement delays were impacted by the clock drift. Clocks will be reset and synchronized prior to the new timings being deployed.

The goal of coordinated signal timing plans is to provide for the optimal progression of mainline traffic while minimizing average delay. Therefore, LOS for some minor movements may degrade from existing conditions. Furthermore, field adjustments will be made to improve field-observed conditions changing the results depicted below.

Queuing

The queuing tables summarize the 95th percentile simulated queues for each movement during the AM, MIDDAY and PM peak hours as they compare to the effective storage lengths. Effective storage lengths represent the amount of distance available for vehicles to queue without generally impacting the adjacent lanes and consist of the full width storage, plus half of the taper distance. Movements without storage (i.e., through lanes) are shown as "cont." for continuous in the tables. As depicted, values highlighted as "**bold"** represent queue lengths that exceed the available storage lengths/spill back to an upstream intersection. As part of the queuing analysis, "percent blocking" was noted in instances where significant queues impact adjacent turn- and/or through-lanes. This percentage represents the approximate amount of time during the peak hour when a lane was observed to be blocked (i.e., 10% blocking on a left-turn lane with 100 turning vehicles means that 10 vehicles were blocked from entering that turn lane during the peak hour).

Table 3: US 340 (Rosser Avenue) and Ladd Road LOS and Delay

<table>
<tr><th colspan="2" rowspan="4">Scenario</th><th rowspan="4">Overall LOS</th><th colspan="10">Level of Service by Approach
(Delay in sec/veh)</th></tr>
<tr><th colspan="2">Ladd Rd</th><th colspan="2">Ladd Rd</th><th colspan="3">Rosser Ave</th><th colspan="3">Rosser Ave</th></tr>
<tr><th colspan="2">Eastbound</th><th colspan="2">Westbound</th><th colspan="3">Northbound</th><th colspan="3">Southbound</th></tr>
<tr><th>LT/TH</th><th>RT</th><th>LT/TH</th><th>RT</th><th>LT</th><th>TH</th><th>RT</th><th>LT</th><th>TH</th><th>RT</th></tr>
<tr><td rowspan="4">AM Peak Hour</td><td rowspan="2">Existing</td><td rowspan="2">**C (33.9)**</td><td>D (43.1)</td><td>D (37.9)</td><td>D (44.0)</td><td>D (36.8)</td><td>D (47.2)</td><td>C (32.5)</td><td>C (23.7)</td><td>D (48.0)</td><td>C (26.0)</td><td>C (22.8)</td></tr>
<tr><td colspan="2">D (41.3)</td><td colspan="2">D (40.5)</td><td colspan="3">C (32.5)</td><td colspan="3">C (29.0)</td></tr>
<tr><td rowspan="2">Proposed</td><td rowspan="2">**C (32.8)**</td><td>D (47.2)</td><td>D (36.1)</td><td>D (47.0)</td><td>C (34.5)</td><td>D (43.7)</td><td>C (29.5)</td><td>C (21.0)</td><td>C (34.8)</td><td>C (28.7)</td><td>B (19.6)</td></tr>
<tr><td colspan="2">D (43.3)</td><td colspan="2">D (41.0)</td><td colspan="3">C (29.5)</td><td colspan="3">C (29.1)</td></tr>
<tr><td rowspan="4">MIDDAY Peak Hour</td><td rowspan="2">Existing</td><td rowspan="2">**C (29.2)**</td><td>D (39.5)</td><td>C (34.7)</td><td>D (39.5)</td><td>D (37.0)</td><td>D (49.3)</td><td>C (27.9)</td><td>C (23.7)</td><td>D (39.4)</td><td>C (20.6)</td><td>B (18.1)</td></tr>
<tr><td colspan="2">D (38.9)</td><td colspan="2">D (38.0)</td><td colspan="3">C (28.5)</td><td colspan="3">C (24.2)</td></tr>
<tr><td rowspan="2">Proposed</td><td rowspan="2">**C (28.4)**</td><td>D (45.0)</td><td>D (38.5)</td><td>D (43.8)</td><td>D (40.8)</td><td>D (50.5)</td><td>C (29.8)</td><td>C (24.9)</td><td>C (32.7)</td><td>B (13.9)</td><td>B (17.1)</td></tr>
<tr><td colspan="2">D (44.2)</td><td colspan="2">D (42.1)</td><td colspan="3">C (30.3)</td><td colspan="3">B (17.9)</td></tr>
<tr><td rowspan="4">PM Peak Hour</td><td rowspan="2">Existing</td><td rowspan="2">**C (34.1)**</td><td>D (46.7)</td><td>D (39.4)</td><td>D (46.8)</td><td>D (39.8)</td><td>D (53.2)</td><td>C (33.1)</td><td>C (27.7)</td><td>D (47.3)</td><td>C (26.3)</td><td>C (21.3)</td></tr>
<tr><td colspan="2">D (45.3)</td><td colspan="2">D (43.8)</td><td colspan="3">C (33.8)</td><td colspan="3">C (29.5)</td></tr>
<tr><td rowspan="2">Proposed</td><td rowspan="2">**D (35.0)**</td><td>D (54.1)</td><td>D (44.3)</td><td>E (56.5)</td><td>D (45.3)</td><td>D (54.5)</td><td>C (29.8)</td><td>C (25.1)</td><td>E (70.4)</td><td>C (21.2)</td><td>C (20.7)</td></tr>
<tr><td colspan="2">D (52.3)</td><td colspan="2">D (51.8)</td><td colspan="3">C (30.8)</td><td colspan="3">C (29.9)</td></tr>
</table>

As shown in **Table 3**, the overall delay in seconds/vehicle improves in the AM and MIDDAY Peak Hour Periods. The AM and PM Peak periods show reductions in delays along the northbound approach, and the MIDDAY Peak period shows reduction in delay along the southbound approach. However, the minor approaches and the PM peak period overall delay increase due to the introduction of a coordinated cycle length. During the PM peak hour, the southbound left-turn movement degrades to LOS E due to the platoon arrival within the cycle. It is not anticipated that additional storage length will be required, and adequate operations can be achieved through field fine-tuning. For example, operating this phase as a lagging left-turn would service the phase closer to the platoon arrival and improve this to a LOS D (47.3 seconds/vehicle delay). This phase modification will be field-observed to determine optimal operations.

Table 4: US 340 (Rosser Avenue) and Ladd Road Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)									
		Ladd Rd Eastbound		Ladd Rd Westbound		Rosser Ave Northbound			Rosser Ave Southbound		
		LT/TH	RT	LT/TH	RT	LT	TH	RT	LT	TH	RT
Effective Storage Length (Existing/No Build)		Cont.	200	Cont.	120	240	Cont.	150	265	Cont.	110
AM Peak Hour											
2018 Existing	Signal	141	43	191 ***(4%)*	**127**	90	265 ***(10%)*	130	98	132 ***(3%)*	59
Proposed	Signal	134	47	204 **(6%)	**134**	80	219 **(5%)	127	90	129 ***(3%)*	52
Midday Peak Hour											
2018 Existing	Signal	117	25	96	68	51	162 ***(1%)*	46	119	126 ***(2%)*	46
Proposed	Signal	148	29	104 *(1%)	83	47	147 **(1%)	31	124	118 **(2%)	52
PM Peak Hour											
2018 Existing	Signal	167	52	170 ***(4%)*	116	83	208 ***(5%)*	117	182	233 ***(15%)*	**128**
Proposed	Signal	183 **(1%)	52	194 **(6%)	**124**	88	199 ***(4%)*	114	191	224 ***(15%)*	**125**

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 4**, changes in the mainline, turning movements, and side street movement queues between existing and proposed signal timings are minimal and are generally within approximately one vehicle length increase or decrease.

Table 5: US 340 (Rosser Avenue) and Town Center Drive LOS and Delay

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)					
			Town Center Dr Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT	RT	TH	RT	LT	TH
AM Peak Hour	Existing	**A (5.7)**	D (48.2)	D (44.8)	A (5.5)	A (4.2)	D (36.4)	A (1.9)
			D (47.3)		A (5.4)		A (2.4)	
	Proposed	**A (3.2)**	D (42.2)	D (39.6)	A (2.2)	A (0.5)	E (56.9)	A (0.9)
			D (41.5)		A (2.0)		A (1.8)	
MIDDAY Peak Hour	Existing	**B (11.8)**	D (45.1)	D (39.7)	A (8.5)	A (7.4)	D (35.6)	A (2.0)
			D (42.2)		A (8.3)		A (3.8)	
	Proposed	**A (9.3)**	D (45.0)	D (39.6)	A (1.7)	A (0.1)	D (49.4)	A (2.4)
			D (42.0)		A (1.5)		A (4.9)	
PM Peak Hour	Existing	**B (10.7)**	D (45.0)	D (40.0)	A (8.8)	A (7.4)	C (26.9)	A (2.1)
			D (42.1)		A (8.5)		A (3.5)	
	Proposed	**A (8.8)**	D (52.2)	D (46.6)	A (2.2)	A (0.3)	D (35.0)	A (1.4)
			D (48.9)		A (1.9)		A (3.3)	

As shown in **Table 5,** the overall intersection delay decreases for each of the peak hour scenarios with minor changes to the turning and side street movements. The northbound approach shows the largest reduction in delay in the MIDDAY peak period, which reduced from 8.3 seconds/vehicle to 1.5 seconds/vehicle. Only two approaches showed increases in delay – the southbound approach during the MIDDAY peak period and the westbound approach during the PM peak period which are attributable to the platoon arrival within the cycle and serves a limited traffic volume. **Table 6** below indicates queueing results of two vehicles or less during all peak hours for this movement.

Table 6: US 340 (Rosser Avenue) and Town Center Drive Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)					
		Town Center Dr Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT	RT	TH	RT	LT	TH
Effective Storage Length (Existing/No Build)		Cont.	195	Cont.	230	305	Cont.
AM Peak Hour							
2018 Existing	Signal	54	5	136	23	26	60
Proposed	Signal	69	-	67	-	28	42
Midday Peak Hour							
2018 Existing	Signal	133	46	127	-	50	74
Proposed	Signal	129	29	54	-	54	74
PM Peak Hour							
2018 Existing	Signal	126	34	160	33	63	109
Proposed	Signal	137	42	72	-	64	95

Notes:

**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*

***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*

^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 6**, changes in queues between the existing and proposed signal timings are minimal and generally within approximately one vehicle length increase or decrease.

Table 7: US 340 (Rosser Avenue) and Shenandoah Village Drive LOS and Delay

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)									
			Shenandoah Village Dr	Shenandoah Village Dr			Rosser Ave			Rosser Ave		
			Eastbound	Westbound			Northbound			Southbound		
			LT/TH/RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
AM Peak Hour	Existing	**B (16.2)**	D (53.6)	D (48.3)	A (0.0)	C (32.8)	A (0.0)	B (11.8)	B (12.5)	D (38.4)	A (1.5)	A (3.9)
			D (53.6)	D (35.5)			B (11.8)			B (16.0)		
	Proposed	**B (13.2)**	D (46.0)	D (42.4)	A (0.0)	C (29.4)	A (0.0)	A (5.6)	B (12.9)	D (35.2)	A (4.3)	A (4.1)
			D (46.0)	C (31.7)			A (6.2)			B (16.4)		
MIDDAY Peak Hour	Existing	**C (20.4)**	D (54.2)	D (46.9)	D (42.6)	C (28.3)	A (0.0)	B (12.9)	B (16.2)	D (40.6)	A (1.8)	A (4.6)
			D (54.2)	C (31.1)			B (13.2)			C (20.4)		
	Proposed	**B (17.1)**	D (51.9)	D (46.0)	D (42.1)	C (26.8)	A (0.0)	B (12.5)	B (17.3)	C (26.9)	A (2.8)	A (4.5)
			D (51.9)	C (29.6)			B (12.9)			B (14.4)		
PM Peak Hour	Existing	**B (16.9)**	D (53.4)	D (48.0)	D (41.0)	C (25.0)	D (53.0)	B (16.5)	B (19.2)	C (26.2)	A (3.8)	A (8.1)
			D (53.4)	C (29.3)			B (16.8)			B (11.7)		
	Proposed	**B (16.9)**	E (60.0)	D (51.6)	D (46.4)	C (28.9)	E (60.3)	B (12.7)	C (20.9)	C (28.3)	A (3.6)	A (8.0)
			E (60.0)	C (33.1)			B (13.4)			B (12.2)		

As shown in **Table 7**, the overall intersection delays are reduced for the AM and MIDDAY peak period scenarios and remain the same for the PM peak period scenario with generally minor changes to the turning and side street movements. The greatest improvement occurs during the MIDDAY peak period from LOS C to LOS B due to the improvement for the southbound left-turn movement. During the PM peak hour, the northbound left-turn lane degraded from LOS D to LOS E; however, the movement only carries two vehicles per hour.

Table 8: US 340 (Rosser Avenue) and Shenandoah Village Drive Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)									
		Shenandoah Village Dr	Shenandoah Village Dr			Rosser Ave			Rosser Ave		
		Eastbound	Westbound			Northbound			Southbound		
		LT/TH/RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Effective Storage Length (Existing/No Build)		Cont.	Cont.	Cont.	Cont.	165	Cont.	250	535	Cont.	125
AM Peak Hour											
2018 Existing	Signal	20	57	-	76	-	211	79	142	20	2
Proposed	Signal	20	55	-	72	-	112	39	127	43	2
Midday Peak Hour											
2018 Existing	Signal	22	88	9	156	-	164 ***(1%)*	40	192	38	4
Proposed	Signal	26	87	5	148	-	154 ***(1%)*	39	178	66	4
PM Peak Hour											
2018 Existing	Signal	19	118	11	194	11	178 ***(1%)*	39	173	85	3
Proposed	Signal	22	124	10	214	12	130	32	173	71	2

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 8**, all queues are contained within the effective storage length. In most instances, the mainline queueing decreased with the most significant decrease occurring in the northbound through-movement, which decreased from 211 feet to 112 feet during the AM peak hour. Generally, changes in turning and side street movement queues between the existing and proposed signal timings are minimal and generally within approximately one vehicle length increase or decrease.

Table 9: US 340 (Rosser Avenue) and I-64 EB Ramp LOS and Delay

<table>
<tr><th colspan="2" rowspan="4">Scenario</th><th rowspan="4">Overall LOS</th><th colspan="6">Level of Service by Approach
(Delay in sec/veh)</th></tr>
<tr><th colspan="2">I-64 EB</th><th colspan="2">Rosser Ave</th><th colspan="2">Rosser Ave</th></tr>
<tr><th colspan="2">Westbound</th><th colspan="2">Northbound</th><th colspan="2">Southbound</th></tr>
<tr><th>LT</th><th>RT</th><th>TH</th><th>RT</th><th>LT</th><th>TH</th></tr>
<tr><td rowspan="4">AM Peak Hour</td><td rowspan="2">Existing</td><td rowspan="2">C
(30.0)</td><td>D
(43.5)</td><td>D
(39.6)</td><td>B
(10.4)</td><td>B
(11.0)</td><td>F
(120.1)</td><td>A
(2.9)</td></tr>
<tr><td colspan="2">D
(40.8)</td><td colspan="2">B
(10.6)</td><td colspan="2">D
(46.3)</td></tr>
<tr><td rowspan="2">Proposed</td><td rowspan="2">B
(12.0)</td><td>D
(38.6)</td><td>D
(35.2)</td><td>A
(7.3)</td><td>A
(4.8)</td><td>C
(20.8)</td><td>A
(1.6)</td></tr>
<tr><td colspan="2">D
(36.2)</td><td colspan="2">A
(6.4)</td><td colspan="2">A
(8.7)</td></tr>
<tr><td rowspan="4">MIDDAY Peak Hour</td><td rowspan="2">Existing</td><td rowspan="2">B
(16.1)</td><td>D
(43.6)</td><td>D
(36.6)</td><td>B
(12.5)</td><td>A
(6.9)</td><td>D
(46.1)</td><td>A
(3.5)</td></tr>
<tr><td colspan="2">D
(39.4)</td><td colspan="2">B
(11.6)</td><td colspan="2">B
(11.4)</td></tr>
<tr><td rowspan="2">Proposed</td><td rowspan="2">B
(14.1)</td><td>D
(47.1)</td><td>D
(37.6)</td><td>B
(11.4)</td><td>B
(14.6)</td><td>C
(24.2)</td><td>A
(0.9)</td></tr>
<tr><td colspan="2">D
(41.4)</td><td colspan="2">B
(11.9)</td><td colspan="2">A
(5.3)</td></tr>
<tr><td rowspan="4">PM Peak Hour</td><td rowspan="2">Existing</td><td rowspan="2">B
(15.7)</td><td>D
(43.0)</td><td>D
(38.4)</td><td>B
(13.0)</td><td>B
(12.8)</td><td>D
(40.6)</td><td>A
(2.4)</td></tr>
<tr><td colspan="2">D
(39.7)</td><td colspan="2">B
(13.0)</td><td colspan="2">A
(8.7)</td></tr>
<tr><td rowspan="2">Proposed</td><td rowspan="2">B
(16.2)</td><td>D
(52.8)</td><td>D
(45.4)</td><td>B
(11.4)</td><td>A
(3.1)</td><td>D
(49.0)</td><td>A
(2.1)</td></tr>
<tr><td colspan="2">D
(47.5)</td><td colspan="2">A
(9.7)</td><td colspan="2">A
(9.9)</td></tr>
</table>

As shown in **Table 9**, the overall intersection delays decrease for the AM and MIDDAY peak hour periods, with the greatest improvement in the AM Peak Period going from a LOS C (30 seconds/vehicle) to LOS B (12 seconds/vehicle). The mainline approaches in the northbound and southbound direction for most peak periods show improvements, with the greatest improvement in the southbound direction during the AM Peak hour, where the delay reduces from 46.3 seconds/vehicle (LOS D) to 8.7 seconds/vehicle (LOS A), mostly due to improvements to the southbound left-turn movement onto I-64. The overall intersection delay for the PM peak hour period increases slightly, while still operating at a LOS B.

Table 10: US 340 (Rosser Avenue) and I-64 EB Ramp Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)					
		I-64 EB Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT	RT	TH	RT	LT	TH
Effective Storage Length (Existing/No Build)		Cont.	275	Cont.	530	250	Cont.
AM Peak Hour							
2018 Existing	Signal	128	-	138	49	**292** **(26%)*	823 ***(9%)*
Proposed	Signal	126	-	151	-	212	105
Midday Peak Hour							
2018 Existing	Signal	187	49	218	-	184	105
Proposed	Signal	189	27	203	-	163	150
PM Peak Hour							
2018 Existing	Signal	165	65	223	-	201	143
Proposed	Signal	180	47	214	-	209	96

**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 10**, all queues are contained within the effective storage length, except for the southbound left-turn movement in the AM peak period under existing conditions which is consistent with observed conditions. With the proposed timings, this queue is anticipated to be contained within the storage and the blockage time is fully reduced from 26-percent of the peak hour which is a major improvement. Furthermore, this blockage reduction results in a major reduction of the adjacent through movement. Although queuing was observed because of the left-turn blockage, queues didn't approach the adjacent traffic signal as suggested by the simulation. Otherwise, changes in turning and side street movement queues between the existing and proposed signal timings are minimal and generally within approximately one vehicle length increase or decrease.

Table 11: US 340 (Rosser Avenue) and I-64 WB Ramp LOS and Delay

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)					
			I-64 WB Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT/TH	RT	LT	TH	TH	RT
AM Peak Hour	Existing	**C (21.5)**	D (44.9)	C (33.7)	C (32.5)	A (4.3)	B (19.6)	D (35.1)
			D (39.9)		A (8.4)		C (25.3)	
	Proposed	**B (12.6)**	D (38.0)	C (29.5)	D (37.2)	A (2.7)	B (10.1)	A (6.5)
			C (34.2)		A (7.6)		A (8.8)	
MIDDAY Peak Hour	Existing	**C (20.7)**	D (44.0)	D (36.8)	C (30.3)	A (3.6)	C (22.0)	D (45.0)
			D (40.1)		A (7.5)		C (27.0)	
	Proposed	**B (13.8)**	D (40.9)	D (36.6)	D (42.5)	A (1.9)	B (11.7)	A (6.6)
			D (38.5)		A (7.8)		B (10.6)	
PM Peak Hour	Existing	**C (26.8)**	C (30.0)	C (34.4)	C (29.0)	A (6.6)	D (40.8)	D (37.8)
			C (32.6)		A (9.9)		D (40.0)	
	Proposed	**C (24.2)**	D (42.2)	E (60.8)	D (45.7)	A (3.3)	C (21.6)	B (19.4)
			D (53.0)		A (9.6)		C (21.0)	

As shown in **Table 11**, the overall intersection delays decrease for all peak hour scenarios, with the greatest improvement in the AM Peak Period going from a LOS C (21.5 seconds/vehicle) to LOS B (12.6 seconds/vehicle). It is noted the southbound approach was observed to function better than reported and the southbound right-turn movement functioned with no delay, not with LOS D as reported per the HCM calculation.

The northbound and southbound mainline approaches for most peak periods show improvements. During the PM peak hour, the westbound right-turn movement degrades from LOS C to LOS E; however, the split allocation for this approach includes 17 seconds of extra green time in the proposed timing plan. Therefore, operations are anticipated to improve. During field implementation, this movement will be monitored and additional split time will be allocated as necessary to minimize any impacts to mainline I-64.

Table 12: US 340 (Rosser Avenue) and I-64 WB Ramp Queuing

Scenario	Traffic Control	Maximum Queue Length by Movement (feet)					
		I-64 WB Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT/TH	RT	LT	TH	TH	RT
Effective Storage Length (Existing/No Build)		Cont.	250	205	Cont.	Cont.	Cont.
AM Peak Hour							
2018 Existing	Signal	209	115	146	127	208	-
Proposed	Signal	203	107	150	74	115	-
Midday Peak Hour							
2018 Existing	Signal	176	116	169	214	272	-
Proposed	Signal	180	126	162	106	129	-
PM Peak Hour							
2018 Existing	Signal	419 *^(4%)*	**288** **(4%)*	180	256 **(2%)	338	17
Proposed	Signal	441 **(4%)	***293*** **(4%)*	197 **(1%)*	233 ***(1%)*	220	17

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 12**, all queues are contained within the effective storage length, except for the westbound right-turn movement in the PM peak period under existing and proposed conditions. In most instances, the mainline queueing decreased with the biggest improvement in the southbound through-movement, which decreased from 272 feet to 129 feet during the Midday peak hour. Otherwise, changes in the mainline, turning movements, and side street movement queues between existing and proposed signal timings are minimal and are generally within approximately one vehicle length increase or decrease.

As noted above, the westbound off-ramp will be observed and timings will be field-adjusted to reduce the occurrence of operational impacts to mainline I-64. The existing and proposed signal timing queue results are generally consistent although delay is calculated to degrade with additional green time.

Table 13: US 340 (Rosser Avenue) and Lew Dewitt Boulevard LOS and Delay

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)											
			Lew Dewitt Blvd Eastbound			Windigrove Dr Westbound			Rosser Ave Northbound			Rosser Ave Southbound		
			LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
AM Peak Hour	Existing	**C (28.6)**	D (48.2)	D (42.2)	C (31.5)	D (44.1)	D (40.7)	D (39.5)	D (50.1)	B (18.0)	B (12.9)	E (61.4)	B (15.1)	B (18.3)
				D (35.5)			D (43.1)			C (28.9)			B (17.3)	
	Proposed	**C (22.9)**	D (44.9)	D (38.2)	C (24.1)	D (40.3)	D (36.9)	D (35.7)	C (20.5)	A (7.0)	B (15.5)	C (33.4)	C (25.9)	C (25.4)
				C (29.1)			D (39.2)			B (12.5)			C (26.1)	
MIDDAY Peak Hour	Existing	**C (33.4)**	D (45.3)	D (42.6)	C (25.1)	D (42.7)	D (44.0)	D (40.7)	D (47.2)	C (25.3)	E (67.8)	E (61.3)	B (16.9)	B (10.4)
				C (31.5)			D (42.6)			D (41.7)			B (19.9)	
	Proposed	**C (26.0)**	D (45.5)	D (42.7)	C (24.5)	D (43.1)	D (44.6)	D (41.1)	C (28.8)	B (11.7)	C (21.5)	D (41.6)	C (20.2)	C (27.8)
				C (31.2)			D (43.1)			C (21.0)			C (23.5)	
PM Peak Hour	Existing	**C (30.8)**	D (45.1)	D (42.0)	C (25.5)	D (43.3)	D (43.4)	D (41.1)	D (45.5)	C (23.6)	D (43.2)	E (57.2)	B (19.2)	A (6.6)
				C (30.4)			D (42.8)			D (35.5)			B (19.7)	
	Proposed	**C (33.8)**	E (57.1)	D (50.6)	C (28.1)	D (51.8)	D (52.0)	D (48.9)	D (37.0)	B (14.9)	B (12.1)	E (64.1)	C (27.6)	F (125.5)
				D (35.2)			D (51.2)			C (23.3)			D (46.7)	

As shown in **Table 13**, the overall intersection delays decrease for the AM and MIDDAY peak hour periods. The mainline approach in the northbound direction shows improvement in delays for each peak hour scenario, with the greatest improvement occurring in the MIDDAY peak period reducing from 41.7 seconds/vehicle to 21.0 seconds/vehicle.

During the PM peak hour, the southbound right-turn movement is reported to degrade to LOS F. This is apparently attributable to the double cycles (58 second cycle length) proposed at Lucy Lane and Lennox Place and the impacts to the southbound platoon arrivals during the "off" cycle. When the double cycles are removed, the movement functions at LOS A and the overall intersection delay improves. Actual operations are anticipated to function acceptably even with the double cycle.

Table 14: US 340 (Rosser Avenue) and Lew Dewitt Boulevard Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)											
		Lew Dewitt Blvd Eastbound			Windigrove Dr Westbound			Rosser Ave Northbound			Rosser Ave Southbound		
		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Effective Storage Length (Existing/No Build)		250	Cont.	425	380	Cont.	138	370	Cont.	480	135	Cont.	215
AM Peak Hour													
2018 Existing	Signal	113	50	86	57	75	48	147	113	12	64	158	44
Proposed	Signal	106	45	86	151	64	45	110	92	9	69	*170*	42
Midday Peak Hour													
2018 Existing	Signal	129	94	106	95	114	67	205	107	34	111	188 ***(3%)*	53
Proposed	Signal	122	106	117	100	106	66	166	80	23	117 *(1%)	167 **(2%)	64
PM Peak Hour													
2018 Existing	Signal	124	96	150	107	85	52	250	160	52	110	185 ***(4%)*	53
Proposed	Signal	153	105	164	113	93	53	223	128	34	120	210 ***(11%)*	74

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 14**, all queues are contained within the effective storage length. Changes in the mainline, turning movements, and side street movement queues between existing and proposed signal timings are minimal and are generally within approximately one vehicle length increase or decrease. The southbound right-turn movement queue is supportive of acceptable operations unlike the delay calculation impacted by the intersections functioning with double cycles.

Table 15: US 340 (Rosser Avenue) and Lucy Lane LOS and Delay

Scenario		Overall LOS	Lucy Ln Eastbound LT	Lucy Ln Eastbound RT	Rosser Ave Northbound LT	Rosser Ave Northbound TH	Rosser Ave Southbound TH	Rosser Ave Southbound RT
			Level of Service by Approach (Delay in sec/veh)					
AM Peak Hour	Existing	**A (6.2)**	E (59.1)	D (43.5)	D (52.9)	A (0.2)	A (6.6)	A (7.7)
			D (48.4)		A (3.1)		A (6.6)	
	Proposed	**A (4.2)**	D (49.1)	D (38.1)	E (58.3)	A (0.2)	A (2.6)	A (1.8)
			D (41.6)		A (3.3)		A (2.6)	
MIDDAY Peak Hour	Existing	**B (13.0)**	D (46.2)	B (33.9)	D (46.5)	A (0.4)	B (11.8)	B (17.6)
			D (38.1)		A (6.4)		B (12.3)	
	Proposed	**B (10.9)**	D (45.6)	C (33.2)	C (34.9)	A (2.3)	A (7.6)	A (9.8)
			D (37.4)		A (6.5)		A (7.8)	
PM Peak Hour	Existing	**B (12.7)**	D (46.3)	C (33.8)	D (48.9)	A (0.3)	B (13.3)	B (17.2)
			D (38.4)		A (5.2)		B (13.6)	
	Proposed	**A (5.2)**	C (26.9)	B (18.1)	B (19.5)	A (2.5)	A (1.5)	A (0.1)
			C (21.3)		A (4.2)		A (1.5)	

As shown in **Table 15**, the overall intersection delays decrease for all peak hour scenarios, with the greatest improvement in the PM Peak Period going from a LOS B (12.7 seconds/vehicle) to LOS A (5.2 seconds/vehicle) which is attributable to the function of a double cycle (58 second cycle length) during the PM peak hour. Minor changes to the turning movements and side street are anticipated for all peak hours and will operate acceptably.

Table 16: US 340 (Rosser Avenue) and Lucy Lane Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)					
		Lucy Ln		Rosser Ave		Rosser Ave	
		LT	RT	LT	TH	TH	RT
Effective Storage Length (Existing/No Build)		260	Cont.	110	Cont.	Cont.	115
AM Peak Hour							
2018 Existing	Signal	31	33	60	10	74	12
Proposed	Signal	32	32	56	25	55	9
Midday Peak Hour							
2018 Existing	Signal	88	55	100 *(2%)*	43	138	55
Proposed	Signal	82	55	89	64	128	54
PM Peak Hour							
2018 Existing	Signal	103	55	104 *(1%)*	43	155	62
Proposed	Signal	82	61	90 *(1%)	77	98	37

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 16**, all queues are contained within the effective storage length. Changes in the mainline, turning movements, and side street movement queues between existing and proposed signal timings are minimal and are generally within approximately one vehicle length increase or decrease.

Table 17: US 340 (Rosser Avenue) and Lennox Place LOS and Delay

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)					
			Lennox Pl Eastbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT	RT	LT	TH	TH	RT
AM Peak Hour	Existing	**A (4.9)**	D (47.3)	D (41.9)	D (53.9)	A (1.3)	A (3.8)	A (2.1)
			D (43.8)		A (3.5)		A (3.8)	
	Proposed	**A (3.9)**	D (42.7)	D (36.5)	D (51.0)	A (0.3)	A (3.2)	A (1.9)
			D (38.7)		A (2.5)		A (3.1)	
MIDDAY Peak Hour	Existing	**A (8.2)**	D (48.4)	D (39.6)	D (52.8)	A (2.3)	A (4.8)	A (2.4)
			D (42.0)		A (5.5)		A (4.7)	
	Proposed	**A (7.1)**	D (47.0)	D (38.3)	D (50.1)	A (0.3)	A (4.6)	A (2.5)
			D (40.7)		A (3.5)		A (4.5)	
PM Peak Hour	Existing	**A (8.3)**	D (46.3)	D (36.6)	D (50.0)	A (2.2)	A (6.0)	A (2.7)
			D (40.8)		A (5.9)		A (5.9)	
	Proposed	**A (7.0)**	C (25.4)	B (17.9)	C (32.0)	A (1.7)	A (8.2)	A (6.9)
			C (21.2)		A (4.1)		A (8.1)	

As shown in **Table 17**, the overall intersection delays decrease for all peak hour scenarios. All approach delays, except for the southbound approach in the PM peak period, experienced decreased delays.

Table 18: US 340 (Rosser Avenue) and Lennox Place Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)					
		Lennox Pl Eastbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT	RT	LT	TH	TH	RT
Effective Storage Length (Existing/No Build)		200	Cont.	150	Cont.	Cont.	250
AM Peak Hour							
2018 Existing	Signal	31	38	43	35	62	13
Proposed	Signal	28	39	50	31	61	14
Midday Peak Hour							
2018 Existing	Signal	54	50	64	53	94	18
Proposed	Signal	60	52	60	34	81	16
PM Peak Hour							
2018 Existing	Signal	75	49	90	66	120	25
Proposed	Signal	63	48	75	81	133	27

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 18**, all queues are contained within the effective storage length. Changes in the mainline, turning movements, and side street movement queues between existing and proposed signal timings are minimal and are generally within approximately one vehicle length increase or decrease.

Table 19: US 340 (Rosser Avenue) and Tiffany Drive LOS and Delay

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)							
			Tiffany Dr Eastbound		Tiffany Dr Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT	TH/RT	LT	TH/RT	LT	TH/RT	LT	TH/RT
AM Peak Hour	Existing	**B (10.9)**	D (46.4)	D (42.9)	D (46.2)	D (43.4)	A (5.9)	A (7.1)	A (4.3)	A (5.0)
			D (44.7)		D (44.6)		A (7.0)		A (5.0)	
	Proposed	**B (10.0)**	D (40.6)	D (37.9)	D (39.9)	D (37.9)	A (1.9)	A (5.0)	A (4.8)	A (6.6)
			D (39.3)		D (38.7)		A (4.9)		A (6.5)	
MIDDAY Peak Hour	Existing	**B (15.8)**	D (45.1)	D (38.3)	D (39.3)	D (38.6)	B (10.8)	B (10.8)	A (7.5)	A (9.2)
			D (41.8)		D (38.8)		B (10.8)		A (9.1)	
	Proposed	**B (15.1)**	D (45.1)	D (38.3)	D (38.8)	D (38.1)	A (3.9)	A (9.0)	A (6.7)	B (10.2)
			D (41.8)		D (38.4)		A (8.2)		B (10.1)	
PM Peak Hour	Existing	**B (15.9)**	D (45.6)	D (37.2)	D (37.8)	D (37.4)	B (11.1)	B (12.6)	A (8.0)	A (9.7)
			D (41.7)		D (37.5)		B (12.5)		A (9.6)	
	Proposed	**B (18.9)**	E (56.2)	D (44.1)	D (44.4)	D (43.9)	A (8.7)	B (16.6)	A (6.1)	B (10.2)
			D (50.6)		D (44.1)		B (15.8)		B (10.0)	

As shown in **Table 19**, the overall intersection delays decrease for the AM and MIDDAY peak hour periods. The overall intersection delay slightly increases for the PM peak hour period, while still operating at a LOS B and likely attributable to the minor increase in cycle length. All approaches in the PM peak hour scenario and some minor approach delays increase due to now functioning with a coordinated cycle length.

Table 20: US 340 (Rosser Avenue) and Tiffany Drive Queuing

Scenario	Traffic Control	95th Queue Length by Movement (feet)							
		Eastbound		Westbound		Northbound		Southbound	
		LT	TH/RT	LT	TH/RT	LT	TH/RT	LT	TH/RT
Effective Storage Length (Existing/No Build)		150	Cont.	100	Cont.	285	Cont.	275	Cont.
AM Peak Hour									
2018 Existing	Signal	71	62	58	56	42	94	18	62
Proposed	Signal	62	61	52	51	36	56	23	60
Midday Peak Hour									
2018 Existing	Signal	124	100	51	56	78	117	24	94
Proposed	Signal	124	87	49	62	65	79	22	119
PM Peak Hour									
2018 Existing	Signal	130	89	42	65	79	150	36	114
Proposed	Signal	145 **(1%)*	118	42	60	71	168	37	151

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

As shown in **Table 20**, all queues are contained within the effective storage length. Changes in the mainline, turning movements, and side street movement queues between existing and proposed signal timings are minimal and are generally within approximately one vehicle length increase or decrease.

4.Proposed Improvements

Operational and safety recommendations were identified along the corridor and at select intersections to provide additional improvement beyond the benefits of signal timing alone. The improvements are independent from the new signal timings and the intent of the improvements are to identity potential, low-cost improvements that the City of Waynesboro could consider for future transportation funding applications.

For intersection improvements, MOEs (delay, LOS, and queuing) for the proposed improvements are reported and compared to the results of the proposed timings described above. A one-page summary including project description, conceptual layout, and planning-level cost estimate is provided in the Appendix.

Improvement 1 – Communication Upgrades

As described above, the traffic signals along Rosser Avenue within the study area lack communication equipment and are managed separately by VDOT and the City of Waynesboro. Based on the close spacing of these nine intersections, communication equipment (wireless or fiber optic) should be installed to ensure the developed signal timing plans operate as intended. Furthermore, communications along the corridor and to the VDOT Traffic Operations Center will allow for remote access into the traffic signals to program adjustments and/or manually control the intersections to manage incidents along I-64 and increases in traffic along Rosser Avenue due to diversions. It is recommended that VDOT and the City of Waynesboro meet to discuss potential improvements regarding future signal communications and operations for the corridor.

It is also recommended to periodically observe and manually reset the local controller clocks to ensure the new signal timing plans operate as intended until the communication upgrades can be installed.

Improvement 2 – Rosser Avenue/Town Center Drive FYA

The southbound approach to the Rosser Avenue/Town Center Drive currently provides dual-left turn lanes into the Town Center development; however, peak hour traffic volumes do not warrant the need for the additional capacity of the second lane. It is recommended to close and restripe the outside left-turn lane to provide a single left-turn lane and convert the existing protected-only left-turn phasing to protected-permissive with flashing yellow arrow (FYA). This improvement will reduce delay by providing the permissive left-turn phase which will extend the time for vehicles to turn into the development after they've yielded the right-of-way to oncoming traffic. Furthermore, the protected-permissive phasing may attract traffic volumes from the southbound left-turn movement at Shenandoah Village Drive which will improve operations for that movement and overall intersection.

Prior to converting the signal phasing, a left-turn phasing analysis consistent with VDOT guidance should be performed. It is noted VDOT has implemented dual-left turn lanes with protected-permissive FYA along other corridors within the region. This improvement should be included in the phasing analysis and considered pending the analysis results. MOEs are summarized in the following tables.

Table 21: Rosser Avenue and Town Center Drive Improvement

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)					
			Town Center Dr Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT	RT	TH	RT	LT	TH
AM Peak Hour	Proposed Timings	**A (3.2)**	D (42.2)	D (39.6)	A (2.2)	A (0.5)	E (56.9)	A (0.9)
			D (41.5)		A (2.0)		A (1.8)	
	Proposed Timings w/ Improvement	**A (2.8)**	D (42.2)	D (39.6)	A (2.2)	A (0.5)	A (1.1)	A (0.8)
			D (41.5)		A (2.0)		A (0.8)	
MIDDAY Peak Hour	Proposed Timings	**A (9.3)**	D (45.0)	D (39.6)	A (1.7)	A (0.1)	D (49.4)	A (2.4)
			D (42.0)		A (1.5)		A (4.9)	
	Proposed Timings w/ Improvement	**A (8.6)**	D (45.0)	D (39.6)	A (1.7)	A (0.1)	A (4.3)	A (3.2)
			D (42.0)		A (1.5)		A (3.3)	
PM Peak Hour	Proposed Timings	**A (8.8)**	D (52.2)	D (46.6)	A (2.2)	A (0.3)	D (35.0)	A (1.4)
			D (48.9)		A (1.9)		A (3.3)	
	Proposed Timings w/ Improvement	**A (7.9)**	D (52.2)	D (46.6)	A (2.2)	A (0.3)	A (2.4)	A (1.4)
			D (48.9)		A (1.9)		A (1.5)	

Table 22: Rosser Avenue and Town Center Drive Improvement Queueing

Scenario	Traffic Control	95th Queue Length by Movement (feet)					
		Town Center Dr Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT	RT	TH	RT	LT	TH
Effective Storage Length (Existing/No Build)		Cont.	195	Cont.	230	305	Cont.
AM Peak Hour							
Proposed Timings	Signal	69	-	67	-	28	42
Proposed Timings with Improvements	Signal	62	-	55	-	15	42
Midday Peak Hour							
Proposed Timings	Signal	129	29	54	-	54	74
Proposed Timings with Improvements	Signal	133	48	44	-	42	80
PM Peak Hour							
Proposed Timings	Signal	137	42	72	-	64	95
Proposed Timings with Improvements	Signal	142	56	50	-	53	106

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

Improvement 3 – Rosser Avenue/I-64 Eastbound Ramps FYA

The southbound left-turn lane which provides access to I-64 eastbound experiences queue spillback due to the short storage lane which cannot be extended due to the bridge over I-64. It is recommended to convert the existing protected-only left-turn phasing to protected-permissive with flashing yellow arrow (FYA). This improvement will reduce delay and queuing by providing the permissive left-turn phase which will extend the time for vehicles to turn after yielding the right-of-way to oncoming traffic. Prior to converting the signal phasing, a left-turn phasing analysis consistent with VDOT guidance should be performed. MOEs are summarized in the following tables.

Table 23: Rosser Avenue and I-64 EB Improvement

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)					
			I-64 EB Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT	RT	TH	RT	LT	TH
AM Peak Hour	Proposed Timings	**B (12.0)**	D (38.6)	D (35.2)	A (7.3)	A (4.8)	C (20.8)	A (1.6)
			D (36.2)		A (6.4)		A (8.7)	
	Proposed Timings w/ Improvement	**B (10.4)**	D (38.0)	C (34.9)	A (4.9)	A (2.4)	B (10.4)	A (5.6)
			D (35.8)		A (4.0)		A (7.4)	
MIDDAY Peak Hour	Proposed Timings	**B (14.1)**	D (47.1)	D (37.6)	B (11.4)	B (14.6)	C (24.2)	A (0.9)
			D (41.4)		B (11.9)		A (5.3)	
	Proposed Timings w/ Improvement	**B (12.5)**	D (44.2)	D (36.8)	A (9.5)	B (13.3)	A (7.0)	A (3.3)
			D (39.7)		B (10.1)		A (4.0)	
PM Peak Hour	Proposed Timings	**B (16.2)**	D (52.8)	D (45.4)	B (11.4)	A (3.1)	D (49.0)	A (2.1)
			D (47.5)		A (9.7)		A (9.9)	
	Proposed Timings w/ Improvement	**B (11.9)**	D (51.8)	D (45.0)	B (8.6)	A (3.0)	A (8.1)	A (1.0)
			D (47.0)		A (7.4)		A (2.2)	

Table 24: Rosser Avenue and I-64 EB Improvement Queueing

Scenario	Traffic Control	95th Queue Length by Movement (feet)					
		I-64 EB Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT	RT	TH	RT	LT	TH
Effective Storage Length (Existing/No Build)		Cont.	275	Cont.	530	250	Cont.
AM Peak Hour							
Proposed Timings	Signal	126	-	151	-	212	105
Proposed Timings with Improvements	Signal	130	-	114	71	168	131
Midday Peak Hour							
Proposed Timings	Signal	189	27	203	-	163	150
Proposed Timings with Improvements	Signal	195	39	181	-	139	229 ***(1%)*
PM Peak Hour							
Proposed Timings	Signal	180	47	214	-	209	96
Proposed Timings with Improvements	Signal	181	40	190	-	148	147

**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

Improvement 4 – Rosser Avenue/I-64 Westbound Ramps FYA and Queue Detection

The northbound left-turn lane which provides access to I-64 westbound experiences queue spillback due to the short storage lane which cannot be extended due to the bridge over I-64. It is recommended to convert the existing protected-only left-turn phasing to protected-permissive with flashing yellow arrow (FYA). This improvement will reduce delay and queuing by providing the permissive left-turn phase which will extend the time for vehicles to turn after yielding the right-of-way to oncoming traffic. Prior to converting the signal phasing, a left-turn phasing analysis consistent with VDOT guidance should be performed. MOEs are summarized in the following tables.

It is also recommended to install an advanced loop detector along the westbound off-ramp placed at the end of the ramp prior to the gore. This detector will signal the traffic controller should queues begin to extend along the ramp and will enter a pre-emption phase to clear the traffic along the off-ramp prior to spillback into mainline I-64.

Table 25: Rosser Avenue and I-64 WB Ramp Improvement

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)					
			I-64 WB Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT/TH	RT	LT	TH	TH	RT
AM Peak Hour	Proposed Timings	**B (12.6)**	D (38.0)	C (29.5)	D (37.2)	A (2.7)	B (10.1)	A (6.5)
			C (34.2)		A (7.6)		A (8.8)	
	Proposed Timings w/ Improvement	**B (10.7)**	D (36.2)	C (28.8)	A (7.5)	A (3.7)	A (9.2)	A (4.9)
			C (32.9)		A (4.3)		A (7.6)	
MIDDAY Peak Hour	Proposed Timings	**B (13.8)**	D (40.9)	D (36.6)	D (42.5)	A (1.9)	B (11.7)	A (6.6)
			D (38.5)		A (7.8)		B (10.6)	
	Proposed Timings w/ Improvement	**B (11.0)**	D (40.8)	D (36.5)	A (7.1)	A (2.2)	A (10.0)	A (5.5)
			D (38.4)		A (2.9)		A (9.0)	
PM Peak Hour	Proposed Timings	**C (24.2)**	D (42.2)	E (60.8)	D (45.7)	A (3.3)	C (21.6)	B (19.4)
			D (53.0)		A (9.6)		C (21.0)	
	Proposed Timings w/ Improvement	**C (21.6)**	D (40.2)	D (54.7)	B (19.2)	A (4.9)	B (19.9)	B (17.9)
			D (48.6)		A (7.0)		C (19.4)	

Table 26: Rosser Avenue and I-64 WB Ramp Improvement Queues

Scenario	Traffic Control	Maximum Queue Length by Movement (feet)					
		I-64 WB Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT/TH	RT	LT	TH	TH	RT
Effective Storage Length (Existing/No Build)		Cont.	250	205	Cont.	Cont.	Cont.
AM Peak Hour							
Proposed Timings	Signal	203	107	150	74	115	-
Proposed Timings with Improvements	Signal	187	98	95	84	107	-
Midday Peak Hour							
Proposed Timings	Signal	180	126	162	106	129	-
Proposed Timings with Improvements	Signal	174	121	114	128	116	-
PM Peak Hour							
Proposed Timings	Signal	441 **(4%)	***293*** *(4%)*	197 *(1%)*	233 **(1%)*	220	17
Proposed Timings with Improvements	Signal	431 **(4%)	***290*** *(5%)*	181	214 **(1%)*	215	23

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

Improvement 5 – Rosser Avenue/Lew Dewitt Boulevard Median Improvements

There exists a two-way left-turn lane along Rosser Avenue between Lew Dewitt Boulevard and Lucy Lane for approximately 350-feet. This is the only section of Rosser Avenue that does not have a raised median. The two-way left-turn lane provides access to three parcels along the west side of Rosser Avenue and one parcel along the east side of Rosser Avenue. As such, there is high turning movement activity that occurs within the influence area of the Rosser Avenue/Lew Dewitt Boulevard intersection. It is recommended to install a raised median to improve safety through proper access management. Within the raised median, it is recommended to create back-to-back left-turn lanes that will extend the existing southbound left-turn lane onto Windigrove Avenue and create a new left-turn lane which will provide direct access the northernmost parcel (7-Eleven) and allow for U-turn movements into the other two parcels (currently Starbucks and Kentucky Fried Chicken). The improvement is depicted below in the following concept.

Figure 3: Rosser Avenue and Lew Dewitt Boulevard Median Improvement

Improvement 6 – Lennox Place Traffic Signal Removal

The Walmart-anchored commercial development located along the west side of Rosser Avenue is currently served by four signalized intersections with three along Rosser Avenue and one along Lew Dewitt Boulevard. The three traffic signals along Rosser Avenue are spaced approximately 500-feet apart; therefore, there are three traffic signals within 1,000-feet. It is recommended to remove the traffic signal at Lennox Place (middle intersection) to increase signal spacing which will benefit both safety and operations along Rosser Avenue. It is recommended to prohibit the eastbound left-turn along Lennox Place (leaving the development) through extending the existing median along Rosser Avenue and channelization along Lennox Place. As such, left-turn traffic that previously used this intersection will now use the adjacent traffic signals at Tiffany Drive or Lucy Lane. The northbound left-turn along Rosser Avenue will be permitted through a channelized unsignalized median opening. The eastbound right-turn along Lennox Place will also remain permitted. Therefore, this unsignalized intersection will function with right-in/right-out/left-in movements and stop control along Lennox Place.

Left-turn traffic that currently uses Lennox Place will be redistributed within the development as described above. As such, it is anticipated that this improvement will require traffic signal modification along the eastbound approach of Tiffany Lane to accommodate the additional traffic using this approach. It is recommended to install a protected/permissive left-turn with FYA along the eastbound approach with removal of the traffic signal at Lennox Place.

Analysis was performed on this improvement to measure the changes associated with the removal of the traffic signal. While the full benefit cannot be measured in terms of safety (although removal of conflict points and the traffic will improve the safety) and overall corridor function through the increased signal spacing and reduced occurrence of stops, the following summarizes the changes associated with the improvement. In the scenario below, all left-turn traffic along Lennox Place was redistributed to Tiffany Drive to be conservative.

Figure 4: Rosser Avenue and Lennox Place Traffic Signal Removal

Table 27: Rosser Avenue and Lennox Place Improvement

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)					
			Lennox Pl		Rosser Ave		Rosser Ave	
			Eastbound		Northbound		Southbound	
			LT	RT	LT	TH	TH	RT
AM Peak Hour	Existing	Proposed Timings	D (42.7)	D (36.5)	D (51.0)	A (0.3)	A (3.2)	A (1.9)
			D (38.7)		A (2.5)		A (3.1)	
	Proposed	Proposed Timings w/ Improvement	-	A (9.1)	A (8.2)	A (0.0)	A (0.0)	A (0.0)
			A (9.1)		A (0.3)		A (0.0)	
MIDDAY Peak Hour	Existing	Proposed Timings	D (47.0)	D (38.3)	D (50.1)	A (0.3)	A (4.6)	A (2.5)
			D (40.7)		A (3.5)		A (4.5)	
	Proposed	Proposed Timings w/ Improvement	-	A (9.7)	A (8.6)	A (0.0)	A (0.0)	A (0.0)
			A (9.7)		A (0.5)		A (0.0)	
PM Peak Hour	Existing	Proposed Timings	C (25.4)	B (17.9)	C (32.0)	A (1.7)	A (8.2)	A (6.9)
			C (21.2)		A (4.1)		A (8.1)	
	Proposed	Proposed Timings w/ Improvement	-	A (9.6)	A (8.9)	A (0.0)	A (0.0)	A (0.0)
			A (9.6)		A (0.7)		A (0.0)	

Table 28: Rosser Avenue and Lennox Place Improvement Queues

Scenario	Traffic Control	95th Queue Length by Movement (feet)					
		Lennox Pl Eastbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT	RT	LT	TH	TH	RT
Effective Storage Length (Existing/No Build)		200	Cont.	150	Cont.	Cont.	250
AM Peak Hour							
Proposed Timings	Signal	28	39	50	31	61	14
Proposed Timings with Improvements	Unsignalized	-	36	25	-	-	14
Midday Peak Hour							
Proposed Timings	Signal	60	52	60	34	81	16
Proposed Timings with Improvements	Unsignalized	-	50	36	-	-	4
PM Peak Hour							
Proposed Timings	Signal	63	48	75	81	133	27
Proposed Timings with Improvements	Unsignalized	-	48	47	-	-	-

Notes:
**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*
***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*
^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

Table 29: Rosser Avenue and Tiffany Drive Improvement

Scenario		Overall LOS	Level of Service by Approach (Delay in sec/veh)							
			Tiffany Dr Eastbound		Tiffany Dr Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
			LT	TH/RT	LT	TH/RT	LT	TH/RT	LT	TH/RT
AM Peak Hour	Proposed Timings	**B (10.0)**	D (40.6)	D (37.9)	D (39.9)	D (37.9)	A (1.9)	A (5.0)	A (4.8)	A (6.6)
			D (39.3)		D (38.7)		A (4.9)		A (6.5)	
	Proposed Timings w/ Improvement	**B (12.0)**	D (35.7)	C (28.5)	D (40.3)	D (38.1)	A (2.2)	A (4.4)	A (8.5)	B (11.9)
			C (32.6)		D (39.1)		A (4.3)		B (11.8)	
MIDDAY Peak Hour	Proposed Timings	**B (15.1)**	D (45.1)	D (38.3)	D (38.8)	D (38.1)	A (3.9)	A (9.0)	A (6.7)	B (10.2)
			D (41.8)		D (38.4)		A (8.2)		B (10.1)	
	Proposed Timings w/ Improvement	**B (16.1)**	D (48.3)	D (37.2)	D (37.5)	D (37.0)	A (3.6)	A (8.5)	A (7.2)	B (10.8)
			D (43.5)		D (37.2)		A (7.6)		B (10.7)	
PM Peak Hour	Proposed Timings	**B (18.9)**	E (56.2)	D (44.1)	D (44.4)	D (43.9)	A (8.7)	B (16.6)	A (6.1)	B (10.2)
			D (50.6)		D (44.1)		B (15.8)		B (10.0)	
	Proposed Timings w/ Improvement	**C (22.2)**	E (62.7)	D (41.9)	D (42.0)	D (41.7)	B (11.4)	C (20.4)	A (7.0)	B (11.5)
			D (54.7)		D (41.8)		B (19.4)		B (11.3)	

Table 30: Rosser Avenue and Tiffany Drive Improvement Queues

Scenario	Traffic Control	95th Queue Length by Movement (feet)							
		Tiffany Dr Eastbound		Tiffany Dr Westbound		Rosser Ave Northbound		Rosser Ave Southbound	
		LT	TH/RT	LT	TH/RT	LT	TH/RT	LT	TH/RT
Effective Storage Length (Existing/No Build)		150	Cont.	100	Cont.	285	Cont.	275	Cont.
AM Peak Hour									
Proposed Timings	Signal	62	61	52	51	36	56	23	60
Proposed Timings with Improvements	Signal	76	58	55	55	39	58	24	88
Midday Peak Hour									
Proposed Timings	Signal	124	87	49	62	65	79	22	119
Proposed Timings with Improvements	Signal	139 **(1%)*	97	52	57	63	79	26	126
PM Peak Hour									
Proposed Timings	Signal	145 **(1%)*	118	42	60	71	168	37	151
Proposed Timings with Improvements	Signal	162 **(3%)*	158 ***(1%)*	51	65	69	175	38	190

Notes:

**(X%) - Maximum queue extends full length of storage bay for X% of the analysis period*

***(Y%) - Queue in lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period*

^(Z%) - Maximum queue extends back to upstream intersection for Z% of the analysis period

Improvement 7 – Rosser Avenue/Tiffany Drive FYA and Pedestrian Improvements

It is recommended to convert the existing north/south protected-permissive left-turn phasing to protected-permissive with flashing yellow arrow (FYA) to be consistent with other FYA conversion recommendations along the corridor and current VDOT standards. This improvement should not have a direct operational improvement since it currently functions as protected-permissive, but it will improve the safety of the permissive movement.

It is also recommended to install pedestrian crosswalks, signals, and pushbuttons along the southbound and westbound approach to provide a protected pedestrian crossing between the residential community and the commercial development located west of Rosser Avenue. When pedestrian actuation occurs, it will cause the intersection to drop coordination to serve the pedestrian phase; however, this is anticipated to occur somewhat infrequently to have an impact on the reported MOEs. Furthermore, if pedestrian actuations increase due to the introduction of a pedestrian crosswalk, the signal timings should be modified to accommodate the pedestrian crossing within the vehicle split to maintain a coordinated cycle length during actuation.

5. Conclusions

The Rosser Avenue Corridor Study aimed to provide cost-effective solutions to improve corridor operations by updating signal timings plans to accommodate the demands of current traffic volumes within the study area. The project goals were achieved by improving overall traffic signal operations, mainline vehicle progression along the corridor, and reduced vehicle queues at each study area intersection. These timing plans will be implemented in Fall 2018 so the improvements quantified above will be immediately realized.

Improvements were also identified including traffic signal communications, signal phasing modifications, pedestrian improvements, and median modifications. These improvements are intended to be implemented with limited fiscal resources but yield further operational and safety improvements beyond the benefits achieved through the updated traffic signal timing plans.

Appendix A – Improvement Concepts and Planning Costs