City of Salisbury
MARYLAND

Technical Report

Riverside Traffic Circle Feasibility Study

September 2017

Prepared by:

WALLACE MONTGOMERY
10150 YORK ROAD, SUITE 200
HUNT VALLEY, MARYLAND 21030
(410) 494-9093 - (410) 667-0925 fax

Table of Contents

Introduction

The Riverside Traffic Circle Feasibility Study is an analysis of the existing intersection of Mill Street, Riverside Drive, Camden Avenue, and West Carroll Street in the City of Salisbury, Maryland. The purpose of the study is to examine existing conditions at the intersection and to investigate the potential suitability of the site for a roundabout as a means of reducing traffic congestion and improving the quality of life for local residents and visitors alike.

The study included an investigation of existing conditions including the physical geometry of the intersection as well as traffic volumes and patterns within the general vicinity. Potential concepts developed were analyzed for their effects on traffic patterns and impacts to surrounding properties. Cost estimates were also prepared.

This report summarizes the study effort and documents its discoveries and findings. It concludes with recommendations for addressing the needs associated with the intersection.

Existing Conditions

Location

The study area is the intersection of Mill Street to the North, West Carroll Street to the East, Camden Avenue to the South, and Riverside Drive to the West, and is located on the south bank of the Wicomico River in the City of Salisbury, Maryland. It is approximately 750 feet south of the intersection of Mill Street and West Salisbury Parkway (US 50 Business), and approximately 475 feet south of the intersection of Mill Street and W. Main Street. The intersection's location is shown in Figure 1**.** Because of the close proximity of the study intersection to Main Street and US 50 Business, all three intersections have been considered during the evaluation of the study intersection.

The study intersection is located on the western edge of the Salisbury Central Business District separated by the Wicomico River, which runs west to east through the study area. To the west and southwest of the intersection along Riverside Drive, there are areas that are currently undeveloped as well as marinas and other residential and commercial land uses. Directly to the south along Camden Avenue, there are primarily residential areas containing single-family homes. The St. Francis de Sales Church and school is located approximately 1,000 feet south of the intersection, with entrances off Riverside Drive and Camden Avenue. To the east, adjacent to West Carroll Street, are primarily commercial areas, with the Peninsula Regional Medical Center located approximately a quarter of a mile away on West Carroll Street.

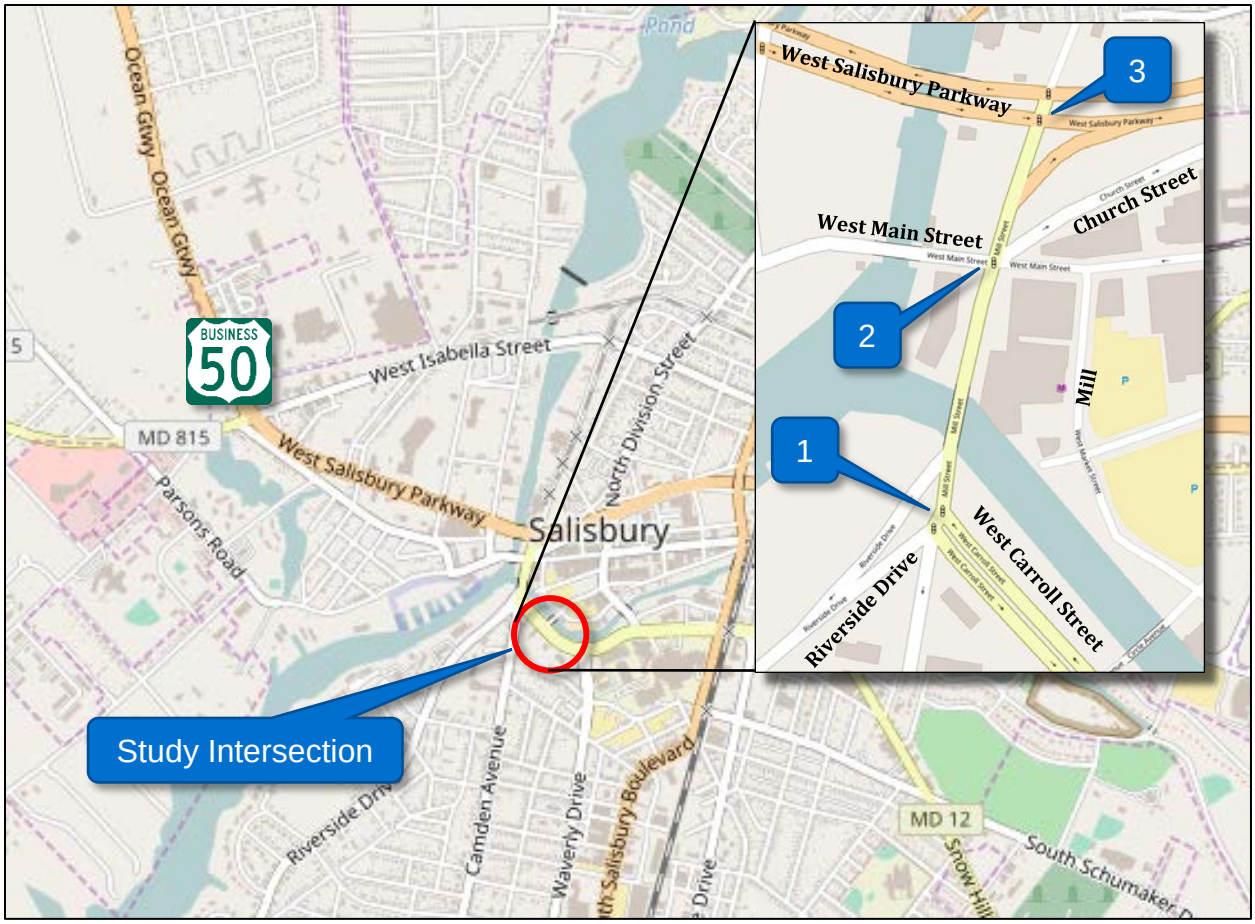

Figure 1 – Study Location

Intersection Geometry and Control

The study intersection is asymmetrical, four-legged, and signal controlled:

- Riverside Drive is a three-lane undivided roadway on the southwest leg, with two signalized northbound through/right lanes, and one southbound receiving lane.
- Mill Street is a four-lane undivided road on the northern leg that crosses the Wicomico River on a three-span bridge structure immediately adjacent to the intersection. It has five lanes near the intersection, two are northbound receiving lanes, one is a right turn bypass lane for the southbound movement to southbound Riverside Drive with a yield condition, and two are southbound through/left lanes.

- Camden Avenue is a one-lane, one-way street on the southern leg with traffic travelling away from the intersection. Street parking is permitted on the west side of Camden Avenue.
- West Carroll Street is a five-lane undivided road with a center turn lane on the southeastern leg of the intersection, with one left/through lane and one right/through lane, and two receiving lanes headed east.

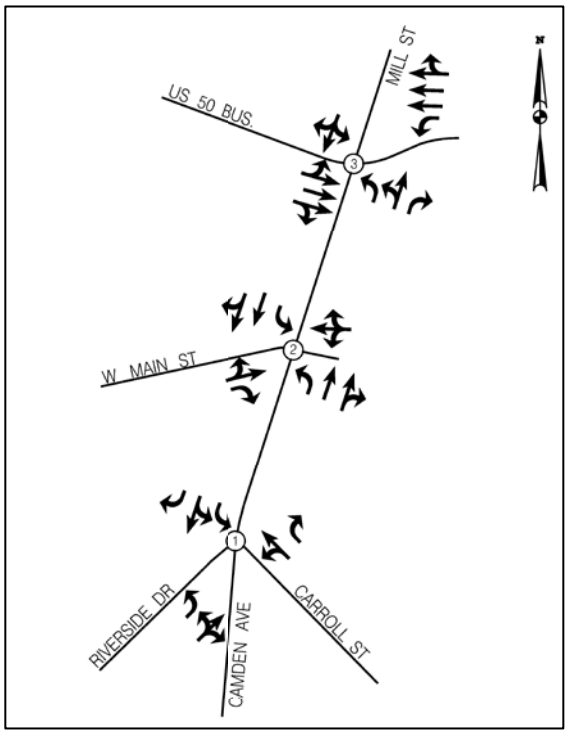

Figure 2 - Existing Lane Configurations

The posted speed limit along all approaches to the intersection is 30 mph, with a 25 mph posted speed along Camden Avenue exiting the intersection.

Sidewalks are provided on both sides of all approaches with a 10-foot wide path adjacent to the southbound Mill Street to westbound Riverside Drive bypass lane. The one marked pedestrian crosswalk at the intersection is across West Carroll Street; however pedestrians were observed using all approaches except Mill Street to cross. None of the crossings include pedestrian signals or ADA compliant ramps. No bicycle facilities are present within the intersection limits. However, Riverside Drive has a southbound striped bike lane 500' south of the intersection.

The signal at the study intersection has three phases and operates as a split-phase intersection to allow for the heavy left turn movements. The Mill Street at Main Street intersection also has three phases, with the Mill Street movements operating under split-phase and the Main Street movements operating concurrently. The Mill Street at US 50 Business intersection has an exclusive-permissive westbound left turn along US 50 Business and concurrently operations for the northbound and southbound movements, even though there is a double left-turn on the northbound approach. All three signals are coordinated and operate with a 120 second cycle length during both the AM and PM peak periods. The lane configurations for all three intersections are shown in Figure 2.

Intersection Condition

The pavement at the study intersection is in good condition with very little cracking and rutting present. There is some cracking present at the southern bridge joint along Mill Street past the intersection. The signing and pavement markings at the intersection are also in good condition with the exception of the stop bar and crosswalk across West Carroll

Street and the "No Trucks" sign at Camden Avenue, which both show significant fading. There are no significant vertical grades in the study area that would cause any sight distance issues. Corridor lighting is present along all three approaches and intersection lighting is present at all three study locations.

Field Observations

Observations of the study area were performed on Wednesday, March 1, 2017 during traffic data collection. Observations specifically focused on driver behavior, traffic patterns, and roadway geometry. Pictures of the intersection are included in the Appendix**,** and the following information summarizes the observations:

a. Vehicular sight distances were measured and current conditions meet or exceed the AASHTO intersection and stopping sight distance criteria based on the intersection speeds and geometry.

b. Queues formed in the both directions along Mill Street for vehicles wishing to turn left during peak periods. Vehicles seem to over-utilize the right lane in both directions leaving the center lanes empty.

c. There was significant unsafe weaving present on the bridge all day long, likely due to driver confusion about lane use and hesitation.

d. Vehicles travelling along Mill Street and turning from US 50 Business onto Mill Street consistently run red lights and pull into the middle of the intersection to avoid being delayed at the intersection waiting for the next green light.

e. At approximately 8:00 AM, southbound Mill Street backed up all the way to US 50 Business in the right lane. Vehicles were unable to clear through Main Street at Mill Street.

f. Vehicles used the parking lot in the Northwest quadrant of the Mill Street and Main Street intersection as cut through to bypass the red light along southbound Mill Street.

g. Vehicles approaching from Riverside Drive turn right on red onto Camden Avenue when southbound Mill Street has the green light, with little regard for approaching traffic.

h. During the midday peak period, left turns from eastbound Riverside Drive to northbound Mill Street began to back up through the intersection. Vehicles pulled into the middle of the intersection to avoid being delayed at the intersection waiting for the next green light.

i. The northbound left turn pocket on Mill Street Bridge to Main Street spilled out into adjacent lane blocking through traffic, multiple times throughout the day.

j. Northbound Mill Street left turns onto westbound US 50 Business showed significant hesitation when there was a vehicle approaching from the North. This may be due to the fact that there is a permissive double left-turn movement, and they must yield to oncoming though traffic.

Traffic Volume Data and Analysis

Traffic Data Collection

On Wednesday March 1, 2017, 12-hour (6:30 AM to 6:30 PM) a vehicular turning movement, pedestrian and bicycle count was conducted at the study intersection. The peak hours measured at the study intersection occurred from 8:00 AM to 9:00 AM and 4:45 PM to 5:45 PM. The volumes at the US 50 Business and Main Street intersections were developed using a 13-hour vehicular turning movement count conducted at the intersection on Tuesday, February 3, 2015. These volumes and the (2013/2014) volumes in the Synchro files from the Maryland State Highway Administration (MSHA) were grown to balance with the 2017 count at the study intersection based on percent splits. Figure 3 shows the existing individual peak hour movement volumes, and the Appendix includes the turning movement count worksheets.

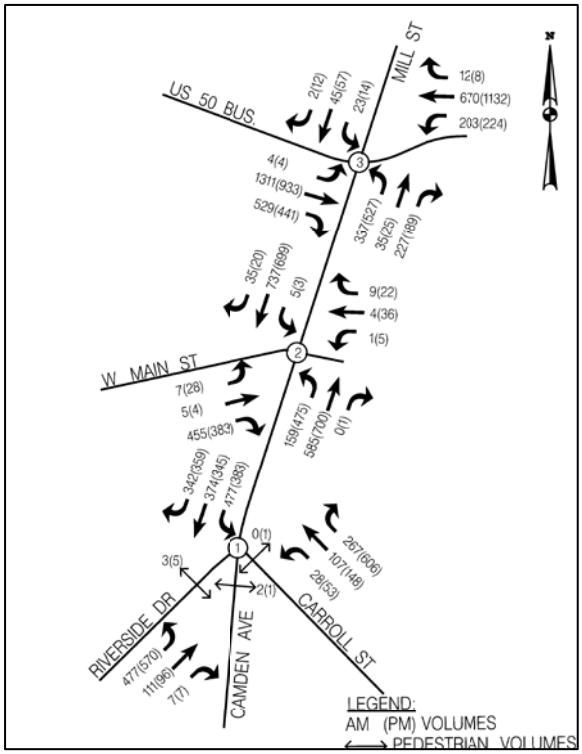

Figure 3 - Existing Peak Hour Volumes

As seen in Figure 3, the southbound Mill Street volume is the heaviest of all the approaches during both peak hours. During the morning peak hour, the majority of traffic either turns left from Southbound Mill Street to West Carroll Street or turns left from eastbound Riverside Drive onto Northbound Mill Street. In the evening, the majority of traffic either turns left from eastbound Riverside Drive or turns right from westbound West Carroll Street onto Northbound Mill Street.

During the twelve-hour field observation, approximately fourteen (14) individuals used the crosswalk across West Carroll Street, with the number of pedestrians outweighing the bicyclists 11 to 3. Many individuals crossed the other three approaches where there is not a marked crosswalk. Sixty-two (62) individuals crossed Riverside Drive, twelve (12) individuals crossed Camden Avenue, and two (2) individuals crossed Mill Street.

Capacity and Operational Analysis

Capacity analyses were performed on the existing peak hour volumes of the study intersection in accordance with the Critical Lane Volume Technique (CLV). Additionally, operational analyses were developed for the study intersection and the intersections of Mill Street at Main Street and Mill Street at US 50 Business with the Highway Capacity Manual (HCM) Technique using Synchro and SimTraffic software. Detailed worksheets are included in the Appendix with the results summarized in **Tables 1 and 2**.

Intersection	Movement	HCM				CLV	
		AM LOS	AM Delay (sec)	PM LOS	PM Delay (sec)	AM (PM) LOS	AM (PM) v/c Ratio
1. Camden Ave/Mill St at Riverside Dr/ West Carroll St	EB Riverside Drive	D	54.4	D	50.4	B(B)	0.63(0.65)
	WB West Carroll Street	C	23.8	C	24.1		
	SB Mill Street	A	8.5	B	14.5		
	Overall	C	23.8	C	26.9		
2. Mill St at Main St	EB Main St	D	51.0	C	26.7	-	-
	WB Main St	D	47.3	D	52.5		
	NB Mill St	C	33.5	C	27.3		
	SB Mill St	B	11.9	B	16.5		
	Overall	C	29.3	C	24.6		
3. Mill St at US 50 Business	EB US 50 Bus	B	20.0	C	30.7	-	-
	WB US 50 Bus	B	19.0	B	19.8		
	NB Mill St	D	53.7	C	32.7		
	SB Mill St	C	34.4	C	25.2		
	Overall	C	26.4	C	26.7		

Table 1 - Existing Capacity Analysis Summary

Intersection	Approach	Movement	Turn Bay Length (ft)	AM (ft)	PM (ft)
1. Camden Ave/Mill St at Riverside Dr/ West Carroll St	EB	L	315	**563***	**344***
		LTR	315	**562***	**398***
	WB	LT	310	170	79
		R	310	91	269
	SB	L	375	164	181
		LT	385	235	256
		R	300	185	205
2. Mill St at Main St	EB	LT	350	309	261
		R	80	79	**83***
	WB	LTR	105	42	99
	NB	L	160	109	**284***
		T	385	227	217
		TR	385	270	263
	SB	L	110	22	5
		T	200	189	167
		TR	200	199	196
3. Mill St at US 50 Business	EB	LT	400	316	290
		T	400	294	289
		TR	400	327	321
	WB	L	200	**230***	**223***
		T	-	49	112
		T	-	132	137
		TR	-	78	128
	NB	L	200	194	**211***
		LTR	200	**235***	**218***
	SB	LTR	-	132	305

***Notes queue lengths longer than the provided turning bay length, or extending through the adjacent intersection.**

Table 2 - Existing 95th Percentile Queuing Analysis Summary

The analysis in Table 1 and 2 indicate that the signalized intersection operates at acceptable levels with the overall level of service (LOS) during both the morning and evening peak hours being LOS C for all three intersections. Queues are largest along Riverside Drive and extend beyond the turn lane. Additionally, the northbound left turns at Main Street and US 50 Business extend beyond the turn bay length during the PM peak.

Bicycle Level of Comfort

Bicycle Level of Comfort is a measure that aims to provide an objective evaluation of the quality of bicycle accommodation on shared roadways. This method may not be an ideal measure of the existing bicycle facilities at the study intersection, but it can serve as a way to evaluate any proposed improvements. The formula calculates a level of comfort rating based on the daily traffic, the posted speed of the roadway, the width of the outer travel lane and any striped bike lane or shoulder, and the condition of the pavement. This analysis is detailed in BLOC Rating:

- A: ≤ 1.5 (high)
- B: > 1.5 and ≤ 2.5
- C: > 2.5 and ≤ 3.5
- D: > 3.5 and ≤ 4.5
- E: > 4.5 and ≤ 5.5
- F: > 5.5 (low)

Table 3 below.

Bicycle Level of Comfort Analysis														
				Lanes (L)		Traffic Data				Width of Pavement		Pavement Condition	BLOC	
Route Name	From	To	Len. (Ls) (Mi)	Th #	Con.	Vol. (ADT) (vpd)	Dir. Split (D)	Pct. (HV) (%)	Post. Spd. (SPp) mph	(Wt) (ft)	(WI) (ft)	(PRs) (1.5)	Score	Grade (A-F)
Mill Street	Main Street	Riverside Dr	0.09	4	U	11,200	1.00	4	30	12.0	0.0	3.0	4.67	E
Riverside Drive	Mill Street	500; South of Int.	0.09	3	U	6,020	1.00	4	30	12.0	0.0	3.0	4.36	D
W. Carroll Street	Mill Street	Circle Avenue	0.08	4	U	6,300	1.00	4	30	12.0	0.0	3.0	4.03	D
Camden Avenue	Mill Street	Camden Court	0.10	2	U	3,839	1.00	1	25	12.0	0.0	3.0	3.69	D

BLOC Rating:

- A: ≤ 1.5 (high)
- B: > 1.5 and ≤ 2.5
- C: > 2.5 and ≤ 3.5
- D: > 3.5 and ≤ 4.5
- E: > 4.5 and ≤ 5.5
- F: > 5.5 (low)

Table 3 - Existing Bicycle Level of Comfort

Crash History

Police reported crash data was provided by the Maryland Department of Transportation State Highway Administration (MDOT SHA) from January 2013 through September 2016 for this study intersection and the US 50 Business at Mill Street intersections, and January 2013 to December 2016 for the corridor along Mill Street between the two intersections. The crash data is summarized in Table 4, and detailed crash data is provided in the Appendix.

Crash History Summary			
	Mill Street Corridor (From US 50 Business to Riverside Dr/W. Carroll St/Camden Ave	Riverside Dr/W. Carroll St at Camden Ave/ Mill St	US 50 Business at Mill St
Year	Amount	Amount	Amount
2013	7	5	11
2014	7	4	6
2015	6	0	10
2016 (Jan-Dec)	12	6	10
Total	23	15	37
Time	Amount	Amount	Amount
0:00 - 6:00	2	0	1
6:00 – 12:00	6	5	**15**
12:00 – 18:00	**19**	**8**	**15**
18:00 – 0:00	5	2	6
Day	26	13	30
Night	6	2	7
Severity	Amount	Amount	Amount
Property Damage	22	10	25
Injury	10	5	12
Fatal	0	0	0
Type	Amount	Amount	Amount
Rear End	**9**	**9**	**12**
Angle	**9**	1	5
Sideswipe	5	1	1
Left Turn	3	0	**13**
Pedestrian	2	1	0
Fixed Object	2	2	3
Other	2	0	0

Table 4 - Crash History Summary

Along the corridor there were 32 crashes reported, with 19 of the 32 (59%) being at the Mill Street and Main Street intersection. The most common types of crashes were Rear End and Angle collisions, with a total of nine (9) each. The majority of these 18 crashes occurred at the Mill Street and Main Street intersection, with the Rear Ends mostly occurring along the southbound approach. While 19 crashes occurred along the corridor between 12:00 PM and 6:00 PM, 17 of the 19 (89%) occurred between 1:00 PM and 5:00 PM. Only one alcohol related collision occurred along the corridor and it was an angle crash at the Mill Street and Main Street intersection.

At the Mill Street and US 50 Business intersection, the majority of crashes were Left Turn crashes, which mostly occurred when vehicles turned from westbound US 50 Business to southbound Mill Street and collided with vehicles going eastbound on US 50 Business. Many of the Rear End collisions at this intersection also occurred along the eastbound approach. There was only one alcohol related crash at this intersection and it was a fixed object collision with the curb.

At the study intersection, there were 15 crashes reported, with the most common type being Rear End collisions along the westbound approach, and the most common cause being Failure to Give Full Attention. This is in accordance with the high congestion and long queues in the study area, which cause driver behavior to become more aggressive due to impatience.

There were no fatal crashes reported at any of the intersections.

Project Objective

The project objectives set by the City of Salisbury are as follows:

Vehicle Operational and Capacity Improvements

The primary objective of this study is to develop concepts that improve traffic operations and capacity. This objective will be measured by comparing the existing and modelled future level of service (LOS) as well as 95th percentile queue lengths at the study intersection. There is no specific goal for LOS and queue lengths for this study, but maintaining or improving LOS will be deemed a success. In general, an LOS of "D" or better and queue lengths that do not encroach on adjacent intersections would indicate that the intersection will operate at a satisfactory level.

Roundabout Feasibility

The secondary objective of this study is to assess the feasibility of a roundabout at this intersection. Aspects analyzed and considered by the study include geometric suitability, current and future traffic operational efficiency, and pedestrian accommodations. This study has concluded that a roundabout is feasible and reasonable for this intersection.

Future Traffic Operations

Future traffic volumes were developed for the study area. An annual growth rate of 1% was used for the Mill Street corridor from Riverside to US 50 Business, and 2.7% annual growth was used for US 50 Business. Turning movements were adjusted for potential development, and planned changes in traffic patterns.

Future capacity analysis was performed on the future anticipated peak hour volumes of the study intersection in accordance with the Critical Lane Volume Technique (CLV). Additionally, operational analyses were developed for the study intersection and the

intersections of Mill Street at Main Street and Mill Street at US 50 Business with the Highway Capacity Manual (HCM) Technique using Synchro and SimTraffic software.

The following table summarizes the existing and future anticipated operations at the study intersection:

Existing and Future No-Build Capacity Analysis Summary												
		EB			WB			SB			Overall	
		Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS
Existing	AM	54.4	D	606	23.8	C	222	8.5	A	259	23.8	C
	PM	50.4	D	462	24.1	C	346	14.5	B	270	26.9	C
2026 No Build	AM	59	E	576	25.1	C	212	9.2	A	256	25.6	C
	PM	52.3	D	557	27.4	C	462	16	B	272	29.1	C
2036 No Build	AM	69	E	1067	27.3	C	347	9.5	A	263	28.9	C
	PM	59.5	E	650	32.8	C	639	17.3	B	320	33.2	C

Table 5 - Existing and Future No-Build Capacity Analysis Summary

Assumptions

The study team made a number of assumptions prior to commencing concept development based on prior guidance from the city, or from known restrictions outlined in the original proposal. During the course of the concept development, clarification was sought from the city regarding certain unknown aspects of the study area and concept designs.

The assumptions noted for the study include:

- The existing bridge structure over the Wicomico River is to remain in place and unaltered
- Proposed concepts would be limited to the study intersection and its immediate vicinity
- The lot immediately to the west of Riverside Drive that is currently vacant may be developed in the future
- The existing pedestrian crossing configuration would remain the same
- A cycle track that is currently proposed along the north side of West Carroll Street will need to be accommodated in any proposed concepts

Methods

The study team used data acquired during the field investigation and existing traffic analysis to determine the general problems currently faced by the intersection. These include the LOS performance, but also the lane utilization, geometry, roadway features, etc. Once this overall picture of the intersection was developed, methods to address the identified issues were brainstormed.

As the intersection LOS is currently fair but has an eastbound movement that is expected to fail in the future, focus was directed towards what can be done to address the failing leg in the concepts. The analysis revealed that the turning movement patterns and volumes play a significant role in creating problems today. The heavy left-turn movements from southbound Mill Street onto West Carroll Street, and from northbound Riverside Drive onto Mill Street contribute to long delays and queues. The southbound Mill Street maneuver in particular was noted for its poor lane utilization; turns are permitted from both lanes, but vehicles do not make use of the lane that is a combined left-thru.

The team considered both of these movements as being the primary movements to accommodate in any proposed concepts.

Initial Concepts

During this phase of the study, the WM team analyzed multiple options for improvements, and ruled out some that did not meet the goals of the project. The team started by analyzing a single lane roundabout, but quickly deemed that it would not be feasible, as the traffic operations were not satisfactory. The entire intersection would operate at LOS E or F at peak hours, with delays of up to 88 seconds for the West Carroll Street approach during the PM peak hour. In addition, the team analyzed a two lane roundabout with a diameter of 200'. While this alternative operated well according to the traffic analysis, the impact to private property would be significant, thereby making this concept impractical.

The following three concepts were considered feasible:

1.) Traditional Improvements and Signal Optimization

The analysis of existing traffic conditions within the study area discovered that lane utilization at the study intersection is less than ideal, as vehicles tend to queue in one lane, where two lanes are available to use. This can create a situation where the full capacity of the intersection is not being utilized, and may be improved with easy and inexpensive signing to remind drivers that both lanes may be used. This concept optimizes the existing traffic signal timing, and improves signing and marking, to improve lane utilization and operations within the existing intersection footprint.

2.) 120-Foot Diameter Roundabout with Bypass Lane

This concept proposes a multi-lane roundabout of 120-foot inscribed diameter with a bypass lane to replace the current signalized intersection. The existing bypass from Mill Street to Riverside Drive would remain in place with modifications to encourage traffic to reduce their speed to approximately 25 to 30 mph. Vehicles wishing to make any other movement would be directed to use the roundabout. Camden Avenue would remain as a one-way exit. Pedestrians would be accommodated at crossings over Riverside Drive, Camden Avenue, and West Carroll Street.

Mill Street would have a single entry lane for through movements to Camden Avenue and West Carroll Street. Riverside Drive would have two entry lanes: the left lane would be for exclusive movements to Mill Street, while the right lane would accommodate all movements. West Carroll Street would have two entry lanes: the right one would be an exclusive right onto Mill Street, while the left one would permit movements to Riverside Drive and Camden Avenue.

There is potential for conflict at the Camden Avenue exit where vehicles would cross directly in front of the entrance from Riverside Drive. A careful design to encourage entering traffic to wait for vehicles exiting to Camden is required here.

3.) 150-Foot Diameter Roundabout with Bypass Lanes

This concept proposes a multi-lane roundabout of 150-foot inscribed diameter to replace the current signalized intersection. The Camden Avenue exit would be closed and traffic redirected to Riverside Drive. Pedestrians would be accommodated at crossings over Riverside Drive, Camden Avenue, and West Carroll Street.

The roundabout would include striped bypass lanes that would direct traffic within the circumference of the roundabout but restrict any weaving with circulating traffic. The bypass lanes proposed are from Mill Street to Riverside Drive, and from Riverside Drive to West Carroll Street.

Mill Street would have two entry lanes: the left lane would direct traffic making a maneuver onto West Carroll Street, and the right lane would direct traffic into the bypass lane leading to Riverside Drive. Riverside Drive would have three entry lanes. The middle and left lanes would permit vehicles to traverse the roundabout and onto Mill Street. The rightmost lane would direct traffic onto West Carroll Street through a bypass that would permit vehicles to perform the maneuver without entering the circulatory area of the roundabout. West Carroll Street would have two entry lanes: the left lane would permit a maneuver onto Riverside Drive and Mill Street, and the right lane would exclusively direct vehicles onto Mill Street.

Closing Camden Avenue to access would be required for this configuration. An exit could not be reasonably accommodated for safety reasons, as there would be a high potential for crashes due to conflicts with the entering lanes from Riverside Drive. Closing this road would divert traffic onto Riverside Drive or West Carroll Street. It is likely that a greater percentage would use Riverside Drive. In addition, closing Camden Avenue may be advantageous for other reasons. It is generally a residential street which currently handles a significant volume of through traffic and closing this road would reduce such traffic; which may be preferred by residents. A cul-de-sac at the end of Camden Avenue would need to be constructed, and the road would be changed to a two-way road between Newton Street and the cul-de-sac. No other changes would need to be made.

Analysis

Traffic

Preliminary analysis of traditional improvements option indicates that by optimizing the signal timing and lane use, the LOS can be improved from a C/C overall, to a B/C overall. The individual leg LOS can be seen in the table below.

In addition, traffic operations were analyzed closing Camden Avenue. Closing Camden Avenue would not improve traffic operations, as this traffic would be diverted either to Riverside Drive, noted in the table as "Remove Camden (Rights)", or to West Carroll Street, noted as "Remove Camden (Lefts)".

Existing and Future Optimized Capacity Analysis Summary												
		EB			WB			SB			Overall	
		Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS	Queue	Delay	LOS
Existing Optimized	AM	29.3	C	406	16.5	B	147	7.5	A	234	15.1	B
	PM	29.1	C	432	18.3	B	255	15.8	B	289	20.1	C
Existing Remove Camden (Lefts)	AM	54.1	D	562	20.3	C	171	7.5	A	196	22.5	C
	PM	49.9	D	447	21	C	401	12.9	B	240	25.1	C
Existing Remove Camden (Rights)	AM	54.1	D	623	20.3	C	185	4.4	A	124	20.7	C
	PM	49.9	D	471	21	C	331	7.9	A	264	23	C
2036 Optimized	AM	37.5	D	566	17.1	B	170	11.3	B	242	19.5	B
	PM	38.3	D	565	30.1	C	411	19.6	B	294	27.8	C
2036 Remove Camden (Lefts)	AM	68.9	E	581	22.2	C	185	8.4	A	205	27.5	C
	PM	59.2	E	601	27.4	C	519	15.2	B	275	30.6	C
2036 Remove Camden (Rights)	AM	68.1	E	541	27	C	320	4.8	A	173	25.9	C
	PM	58.5	E	587	32.3	C	549	7.9	A	163	28.8	C

Table 6 - Existing and Future Optimized Capacity Analysis Summary

A preliminary analysis of the 120-foot diameter roundabout concept revealed that the intersection would operate at the level of service shown in the table below.

120-Foot Diameter Roundabout with Bypass Lane – 2036 Volumes							
Approach Road		Level of Service (LOS)		Vehicles per hour (VPH)		95th Percentile Queue Length	
		Left Lane	Right Lane	Left Lane	Right Lane	Left Lane	Right Lane
Mill St (N)	AM	E	-	1085	-	520	-
	PM	D	-	928	-	391	-
W. Carroll St (SE)	AM	A	B	173	341	25	59
	PM	B	F	258	773	52	575
Riverside Dr (SW)	AM	D	F	322	428	138	280
	PM	D	E	385	464	163	265
Bypass Lane: Mill St to Riverside Dr (N to SW)	AM	A		414		44	
	PM	A		481		48	
Overall	AM	E		2788		-	
	PM	F		3267			

Table 7 - 120-Foot Diameter Roundabout 2036 Volumes

Further analysis using Sidra software revealed that the volume to capacity (V/C) ratio would exceed the maximum desired value of 0.85 for all approaches during peak times by 2036. Undesirable levels would be attained by 2026 on Mill Street in the AM peak hour, and West Carroll Street in the PM peak hour. Table 8 summarizes the analysis results.

120-Foot Diameter Roundabout 2036 Detailed Analysis Summary					
Approach		2026		2036	
		v/c	Queue (ft)	v/c	Queue (ft)
Mill St (N)	AM	0.92	550	1.02	**1208***
	MID	0.66	139	0.734	200
	PM	0.84	322	0.953	618
W. Carroll St (SE)	AM	0.44	56	0.512	73
	MID	0.79	197	0.93	362
	PM	1.1	908	1.312	1810
Riverside Dr (SW)	AM	0.79	140	0.939	252
	MID	0.62	95	0.732	132
	PM	0.77	146	0.952	294

***Notes queue lengths longer than the provided turning bay length, or extending through the adjacent intersection.**

Table 8 - 120-Foot Roundabout Detailed Traffic Analysis Summary

A preliminary analysis of the 150-foot diameter roundabout concept revealed that the intersection would operate at the level of service shown in the table below.

150-Foot Diameter Roundabout with Bypass Lane – 2036 Volumes							
Approach Road		Level of Service (LOS)		Vehicles per hour (VPH)		95th Percentile Queue Length	
		Left Lane	Right Lane	Left Lane	Right Lane	Left Lane	Right Lane
Mill St (N)	AM	A	C	608	913	80	213
	PM	A	C	488	898	59	235
W. Carroll St (SE)	AM	A	B	137	341	19	59
	PM	A	F	189	773	33	575
Riverside Dr (SW)	AM	B	A	322	286	57	47
	PM	B	A	385	341	64	52
Bypass Lane: Riverside to W. Carroll St	AM	A		135		21	
	PM	A		117		15	
Overall	AM	B		2744		-	
	PM	C		3194		-	

Table 9 - 150-Foot Diameter Roundabout 2036 Volumes

Further analysis using Sidra software revealed that the volume to capacity (V/C) ratio would remain acceptable for all approaches in both 2026 and 2036 although Mill Street would exhibit ratios that are near the limit for acceptability. Table 10 summarizes these results.

150-Foot Diameter Roundabout 2036 Detailed Analysis Summary					
Approach		2026		2036	
		v/c	Queue (ft)	v/c	Queue (ft)
Mill St (N)	AM	0.758	205	0.826	305
	MID	0.486	81	0.529	93
	PM	0.759	224	0.859	**374***
W. Carroll St (SE)	AM	0.301	33	0.355	41
	MID	0.468	65	0.553	86
	PM	0.677	124	0.812	189
Riverside Dr (SW)	AM	0.39	48	0.453	60
	MID	0.328	38	0.377	46
	PM	0.408	52	0.477	68

***Notes queue lengths longer than the provided turning bay length, or extending through the adjacent intersection.**

Table 10 - 150-Foot Roundabout Detailed Traffic Analysis Summary

Geometry

The existing roadway configuration and geometry presents challenges with respect to alignment, concept layout, and location. The wide angles between Mill Street and Riverside Drive, and Mill Street and West Carroll Street are contrasted with the acute angles between Riverside Drive, Camden Avenue, and West Carroll Street. Such a disparity means that in the case of a roundabout, its center and roadway approaches must be carefully considered and located accordingly. Shallow angles of approach encourage vehicles to enter at a speed that is higher than desirable; creating knock-on effects to roundabout performance and safety. Conversely, acute angles of approach or departure cause vehicles to enter or leave a roundabout at speeds lower than desirable; causing undue delays in addition to safety concerns.

The approaches along Mill Street and Riverside Drive will require minimal reconstruction to accommodate the flared splitter islands necessary to direct traffic onto or receive traffic from the circulatory area. The West Carroll Street approach will likely require realignment in order to create a more perpendicular intersection with Mill Street. In its current form, the shallow angle between the two roads in conjunction with the close proximity of the Wicomico River and bridge structure on Mill Street means that there is not sufficient space for the circulatory area to adequately deflect vehicles. The result is that the northbound approach from West Carroll Street is directed straight onto Mill Street; a situation that would encourage an undesirable high speed maneuver. Realigning West Carroll Street would alleviate this potential problem.

The existing bypass lane from Mill Street to Riverside Drive is retained for operational purposes and is only modified slightly in the 120-foot diameter option by introducing a deflection to ensure comparable speeds between vehicles exiting the roundabout and the bypass lane where they meet on Riverside Drive. In the 150-foot diameter option, it is retained but due to the larger circulatory area of this concept, it is not physically separated.

Camden Avenue will require augmentation of its entrance alignment in order to accommodate vehicles exiting the circulatory area of the roundabout. Such realignment works should not exceed 50 feet beyond the outer limits of the roundabout.

Safety

The traditional configuration of the existing intersection exhibits traits that are found in those of its type. These include crashes caused by left-turning vehicles and red lights. The investigation of the existing conditions did not discover a deficiency that would be considered a significant factor in the cause of crashes at the intersection.

Roundabouts offer improved safety at intersections by way of their reduction of vehicle conflict points. Vehicles must also reduce speed in order to navigate the roundabout and are forced to observe circulating traffic and wait for an appropriate opportunity before

entering and performing their maneuver. Low speed approaches reduce the risk of a rear-end crash as vehicles are less likely to come to a sudden and unanticipated stop.

Pedestrian safety is also improved as people wishing to cross approach roadways are provided with refuges in the splitter islands. This enables them to only have to navigate one roadway and direction of vehicles at a time. Combined with vehicles' lower speed than a traditional intersection, this represents and improvement.

Vehicles

The proposed concepts were analyzed to determine their effect on different vehicle types. The constricted nature of the location means that some accommodations may be necessary for larger vehicles. An 18-foot wide mountable buffer in the central island is provided for this reason but other aspects may also need to be considered.

Both concepts were analyzed for passenger cars, single unit trucks (SU), and articulated tractor-trailers (WB-50 and WB-67.) Both WB vehicles may require the use of both approach lanes in order to navigate the roundabout and perform their maneuver. A WB-50 vehicle will be able to navigate both proposed concepts, however a WB-67 will not be able to perform a maneuver from northbound West Carroll Street onto Riverside Drive in the single lane concept without further accommodations in the design.

Pedestrians

The proposed concepts would retain the existing pedestrian crossing configuration. Crossings would be located no closer than 40 feet from the outer edge of the circulatory roadway and would be perpendicular to the roadway alignment. Cut-throughs would be provided on the splitter islands as a refuge for pedestrians.

There are no bicycle facilities currently provided within the intersection limits. MDOT SHA guidelines do not provide for bicycle facilities within a roundabout, instead recommending that facilities direct bicyclists into the roadway approaches and hence make use of the main circulatory area to perform a maneuver. The proposed concepts follow these guidelines.

Impacts

Noted restrictions within the study area include the Mill Street bridge structure over the Wicomico River, parkland to the north of West Carroll Street, and private parcels surrounding the remainder of the intersection. There is a building on the southern side of the intersection between Camden Avenue and West Carroll Street. The proposed roundabout concepts were located so as to remain within the existing intersection footprint as much as possible in order to minimize impacts to adjacent properties.

Property impacts could include the parcel immediately to the west of the existing bypass lane. The parcels between Riverside Drive, Camden Avenue, and West Carroll Street could also be slightly impacted by reconfigurations to the existing curbs and sidewalk geometry.

Access to properties immediately adjacent to the study intersection should not be adversely affected however the addition of splitter islands may prohibit left turns from Riverside Drive into one of the existing entrances of the Riverside Market.

The 150-foot diameter roundabout concept would have impacts to the adjacent private property, including the Riverside Market at 519 Camden Avenue, and the office building at 322 West Carroll Street. Both commercial properties would need alterations to the access and parking areas in the best case, and the entire property may potentially need to be purchased in the worst case. Modifications at a later stage of design may limit this impact.

Utility impacts include the existing overhead electric and communication lines on the west side of the bypass lane. The proposed concepts would require the relocation of between one and three poles to accommodate the increased footprint of the roundabout and realigned bypass lane. Impacts to any structures could increase the amount of utility relocations.

Existing inlets may require relocation as a result of changes to the roadway geometry.

Constructability

As an existing and important intersection within the Salisbury street network, improvements need to be considered in the context of potential disruption to existing users. The traditional improvement concept would not incur significant levels of disruption as the proposed changes are minimal and would not take long to implement.

The roundabout concepts on the other hand would require a maintenance of traffic (MOT) plan to permit construction to occur without causing undue congestion and delays to road users.

The roundabout concepts would require permits pursuant to their location within an intensely developed area. Alteration or removal of the existing signal would require coordination with the MDOT SHA.

Cost Estimates

The proposed concepts were developed to a planning-stage level of detail that includes major quantities such as paving, grading, curb and gutter, pavement markings, and preliminary signage costs. Certain categories such as mobilization, utility relocation, maintenance of traffic, and Stormwater/erosion and sediment control costs are estimated on a percentage basis. A contingency of 40% is considered acceptable at this level of detail and accounts for the many unknown aspects of the project area and undetermined aspects of the design.

Anticipated right of way costs were estimated based on the presumed limits of acquisition and not the limit of disturbance (LOD.) Costs were developed using property values as listed in the Maryland Department of Assessments and Taxation database.

Full cost estimates for each concept are included in the appendix but are summarized in table below.

	Construction Cost	Anticipated Right of Way Costs	Total Cost
Traditional improvements and signal optimization	$75,000	N/A	$75,000
120-foot diameter roundabout	$841,400	$18,000	$859,400
150-foot diameter roundabout	$967,400	$124,620	$1,092,020

Table 11 - Concept Cost Estimates Summary

Benefit Analysis

The proposed concepts all exhibit properties which make them desirable. The traditional improvements would retain the existing intersection configuration that local residents and commuters are familiar with, involve minimal disruption to traffic, and have minimal impacts to surrounding properties. The roundabouts on the other hand would offer improved levels of service in future years in addition to improving conditions at the intersection for both pedestrians and cyclists.

Disadvantages of the concepts vary according to their design and the degree to which they introduce change to the intersection. The traditional improvements would not drastically improve conditions for pedestrians or cyclists. Despite optimization measures, current concerns regarding queue lengths and level of service could be prolonged given that they are the result of driver behavior and not necessarily the design of the intersection itself.

The roundabout concepts would require a reconfiguration of the existing intersection that local users and commuters may need time to adjust to. They would also require a larger footprint than the existing intersection necessitating impacts to adjacent properties. The 150-foot diameter concept in particular may require the acquisition of an entire parcel containing an existing business. The roundabout concepts would also be more expensive to implement and require a maintenance of traffic plan to accommodate traffic during construction. Despite this, construction may cause some users to seek out alternative routes, causing congestion at other intersections in the vicinity.

The 150-foot diameter roundabout would also close off the existing one-way access to Camden Avenue. The removal of which would lessen the ability of people to enter or exit the business properties adjacent to the intersection. The closure would however result in a significant reduction in through vehicles on the primarily residential street.

Improving conditions for intersection users other than those in vehicles is a stated purpose of the study. The existing intersection provides pedestrian crossings that are less than ideal and does not provide any facilities explicitly for cyclists. Roundabouts have a proven ability to reduce pedestrian injuries as a result of vehicle collisions which stems primarily from their ability to force vehicles to approach and navigate at speeds which are lower than those usually found at a signalized intersection. The design of the approaches themselves also improves the crossing maneuver for pedestrians as they only need to cross one direction of roadway at a time. The roundabout concepts would improve safety for cyclists as they would be directed to navigate the roundabout for any turning maneuver; sharing the space with cars travelling much closer to their speed than the traditional intersection.

Additional aspects such as 'community value' can be inferred from changes to the vehicular level of service, green space, and non-automobile accommodations. In general, community value is enhanced by improvements that reduce vehicular speed and delay, provide space for landscaping or planting, and improve local resident's ability to move around their neighborhood. Either roundabout concept would provide for an improvement in community value.

Table 12 provides a comparative summary of the different concepts' aspects.

	Traditional Improvements	120-foot diameter Roundabout	150-foot diameter Roundabout
Level of Service (LOS)	Improved from C/C to B/C overall	Queuing at approaches increasing to undesirable levels by 2036	Improved
Safety	No marked improvement	Improved pedestrian crossings, minimized traffic conflict points	Improved pedestrian crossings, minimized traffic conflict points
Environmental	Negligible impacts	Minimal impacts Increased impervious area	Notable Impacts to parkland adjacent to Wicomico River Increased impervious area
Cost	Least expensive	Approximately 80% of the most expensive cost	Most Expensive
Community Value	No significant change	Improved	Improved
Access Management	No change	No significant change	Reduced
Constructability	Minimal disruption	Maintenance of Traffic plan needed	Maintenance of Traffic plan needed

Table 12 - Potential Concept Comparison of Aspects

Summary of Coordination Events

City of Salisbury Council Work Session

A work session was held by the city council on July 17, 2017 with the goal of providing an update on the project and information on some of its findings for officials and the general public.

The Department of Infrastructure and Development and Wallace Montgomery staff gave an overview of the two roundabout alternatives being considered, in addition to a signal optimization alternative used for comparison purposes. Both roundabouts are deemed feasible however the Infrastructure and Development Director for the City, Ms. Amanda Pollack, stated that the 120-foot design was preferable as it would not require the closure of Camden Avenue.

Wallace Montgomery staff also detailed the findings from the traffic analysis which indicate that the intersection currently operates at an overall Level of Service (LOS) 'B' and can be expected to operate at LOS 'C' in 2036. It was noted that current operational issues at the intersection are partly caused by inefficient lane use by drivers and not a constraint on available roadway capacity.

A member of the public provided comments which were noted.

Maryland Department of Transportation State Highway Administration (MDOT SHA)

A meeting with MDOT SHA was held on August 18, 2017 with District 1 Traffic Engineer Brett Deane. Wallace Montgomery and the City of Salisbury presented the findings of the study and discussed next steps. Overall, MDOT SHA stated that they support the project and are committed to partnering with the City. They requested regular coordination meetings during the engineering design development phase of the project.

Alterations to the existing intersections of Main Street and Mill Street, and Mill Street and US 50 Business were also discussed. It was noted that the free flow of traffic from a roundabout may adversely affect these intersections, in addition to possibly causing gridlock at the roundabout itself. Eliminating left turns at Main Street was proposed as a potential option, and overall, the next phase of the project will need to address these concerns.

Conclusion and Next Steps

The study concludes that the concepts detailed in this report represent a range of feasible options for the study intersection. During the next phase of project development, the design and traffic capacity of the 120-foot concept will be optimized to bring LOS and

queue lengths closer to those of the 150-foot roundabout. The next step for the project is to conduct preliminary and final design.

RIVERSIDE DRIVE

WICOMICO RIVER

CAMDEN AVENUE

MILL STREET

WEST CARROLL STREET

N

LEFT LANE | RIGHT LANE

LEFT LANE | RIGHT LANE

LEFT LANE | RIGHT LANE

LEGEND

- Existing Right of Way
- Existing Property
- Stream
- Tier II Catchment
- 100-Year Floodplain
- Wetland
- Historic Boundary
- Park Boundary
- Pavement
- Mountable Truck Apron
- Pavement Removal
- Edge of Road
- Edge of Shoulder

TIER II CATCHMENT

H

P

CONCEPT PLANS
NOT FOR CONSTRUCTION

RIVERSIDE TRAFFIC CIRCLE AND FEASIBILITY STUDY
120-FOOT DIAMETER ROUNDABOUT

CITY OF SALISBURY

JUNE 2017

SCALE 1" = 50'

BACKGROUND AERIAL SOURCE
MD SHA
2017

RIVERSIDE DRIVE

WICOMICO RIVER

CAMDEN AVENUE

MILL STREET

WEST CARROLL STREET

LEFT LANE | RIGHT LANE

LEFT LANE | RIGHT LANE

N

Existing Right of Way
Existing Property
Stream
Tier II Catchment (TIER II CATCHMENT)
100-Year Floodplain
Wetland
Historic Boundary (H)
Park Boundary (P)
Pavement
Mountable Truck Apron
Pavement Removal
Edge of Road
Edge of Shoulder

CONCEPT PLANS
NOT FOR CONSTRUCTION

RIVERSIDE TRAFFIC CIRCLE AND FEASIBILITY STUDY
150-FOOT DIAMETER ROUNDABOUT

CITY OF SALISBURY

JUNE 2017

SCALE 1" = 50'

BACKGROUND AERIAL SOURCE
MD SHA
2017