FINAL

US 360/ROUTE 288 INTERCHANGE AREA STUDY

CHESTERFIELD COUNTY, VA

Prepared for:

VDOT Virginia Department of Transportation

Prepared by:

Kimley»Horn

Table of Contents

List of Figures

List of Tables

List of Photographs

Appendix

1.0 Introduction

1.1 Background

The US 360/Route 288 interchange area currently experiences severe traffic congestion during the peak hours. In 2011, the Virginia Department of Transportation (VDOT) initiated a study to address operational and safety concerns immediate to the US 360/Route 288 interchange.[1] This study concluded that although some short-term improvements could help to a limited extent, this area has larger and longer-term needs which were beyond the scope of the initial study. As a result, VDOT decided to fund a more comprehensive sub-area planning study by expanding the corridor limits and including additional analysis used to identify a plan of improvements. The study will help VDOT, Chesterfield County, and other project stakeholders in identifying and developing operational and capacity improvements necessary to remedy existing operational and capacity deficiencies and support anticipated future traffic growth.

1.2 Purpose

The primary purpose of this transportation study was to identify operational and safety deficiencies and develop improvement projects to improve safety and operations in the study area. The ultimate goal of this study was to determine potential transportation improvement projects that could be considered in the VDOT Six-Year Improvement Program (SYIP) to improve safety and operations in the study area.

1.3 Study Work Group

A key to the successful completion of this study was the involvement of a number of stakeholders with both mutual and varied interest in the outcome of the study effort. The role of the Study Work Group (SWG) was to provide institutional knowledge of the corridor, review study methodologies, provide input on key assumptions, and review proposed improvements created through the study process. A full list of Study Work Group members is provided in **Appendix A**. The SWG was comprised of representatives from the following local, regional, state, and federal agencies:

- VDOT
- Chesterfield County
- Richmond Regional Planning District Commission
- Federal Highway Administration (FHWA)
- Kimley-Horn and Associates

1.4 Study Area

The US 360/Route 288 interchange is the focus of this study. The primary corridors consists of US 360 and Route 288 within Chesterfield County, as shown in **Figure 1**. Specifically, the limits of the study area are as follows:

- US 360 from Warbro Road to Otterdale Road
- Route 288 from the US 360 interchange to the Commonwealth Centre Parkway interchange

[1] STARS, Congestion Mitigation Program Pilot Phase Study, US 360 (Hull Street Road) at Route 288 (World War II Veterans Memorial Highway), Chesterfield County, Virginia (2011)

The US 360/Route 288 Interchange study area includes two interchanges, 15 ramps, and 18 at-grade intersections (15 signalized and three unsignalized). The three unsignalized intersections were included due to their proximity to the Route 288 interchange. Four additional intersections were added during the study to supplement the development of proposed improvements. The study area interchanges and intersections are listed below and shown in **Figure 1**.

Study Interchanges

1. US 360 at Route 288 – full interchange
2. Route 288 at Commonwealth Centre Parkway – partial interchange

Study Intersections

1. US 360 at Warbro Road/Bridgewood Road
2. US 360 at Memphis Boulevard/Lonas Parkway
3. US 360 at Market Square Lane
4. US 360 at Old Hundred Road/Commonwealth Centre Parkway
5. US 360 at W. Village Green Drive
6. US 360 at Wells Fargo Driveway
7. US 360 at Brad McNeer Parkway
8. US 360 at Craig Rath Boulevard
9. US 360 at Harbour Point Parkway/Mockingbird Lane
10. US 360 at Harbour View Court/Deer Run Drive
11. US 360 at Chital Drive
12. US 360 at Temie Lee Parkway/N. Spring Run Road
13. US 360 at Winterpock Road
14. US 360 at Duckridge Boulevard/Hancock Village Drive
15. US 360 at Ashlake Parkway
16. US 360 at Woodlake Village Parkway
17. US 360 at Fox Club Parkway/Hampton Park Drive
18. US 360 at Otterdale Road

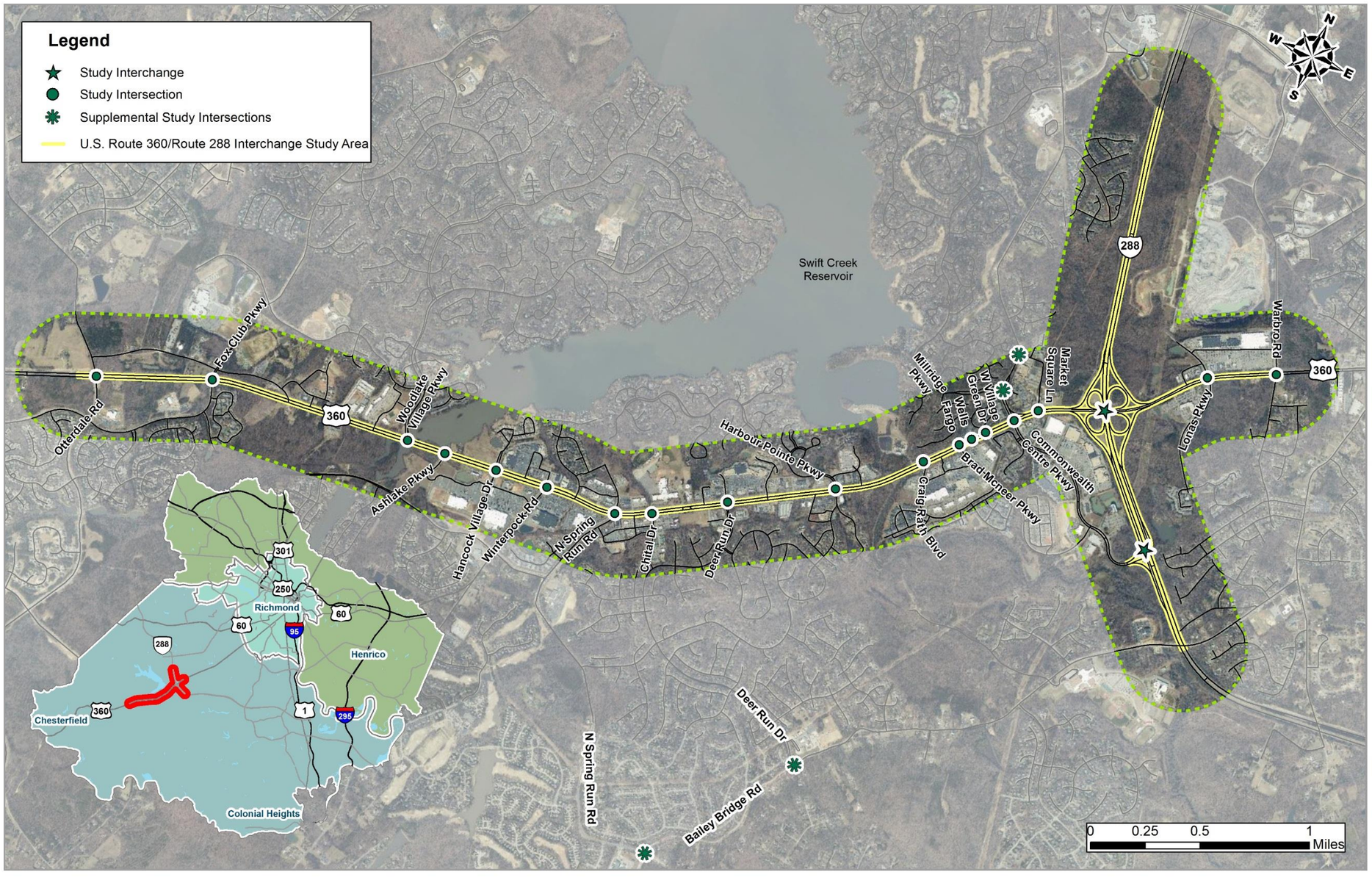
Supplemental Study Intersections

1. Old Hundred Road at Market Square Lane
2. Old Hundred Road at Millridge Parkway
3. Bailey Bridge Road at Spring Run Road
4. Bailey Bridge Road at Deer Run Drive

Photograph 1: US 360/Route 288 Interchange

Photograph 2: Eastbound US 360 Heavy AM Peak Traffic Volumes

Figure 1: Study Area



2.0 Data Collection and Inventory

Multiple field reviews of the study corridor were conducted over the course of the study to verify existing conditions and traffic control devices; and observe peak hour traffic conditions and driver behavior. In addition to the field review, existing zoning, future land use, and other relevant studies in or near the US 360 and Route 288 study corridors were obtained; traffic data was acquired from a combination turning movement counts, tube counts, and recent studies; origin-destination data was collected; and crash data were provided by VDOT. The following subsections of the report summarize data collection and field review observations.

2.1 Other Studies and Projects

The study team requested all recent and relevant studies and ongoing construction projects within the study area from the SWG. A summary of related studies described in more detail is provided in **Table 1**. Each study was reviewed for relevant data recommended improvements were reviewed for consideration. All studies are provided in **Appendix A** for reference.

Table 1: Summary of Relevant Studies

	Study	Source	Date	Description
1.	STARS Congestion Mitigation Program Pilot Phase US 360 (Hull Street Road) at Route 288 (World War II Veterans Memorial Highway) Chesterfield County, Virginia	VDOT	2011	The goal of this study was to develop short-term, low-cost congestion mitigation strategies and countermeasures aimed at solving congestion and safety related issues at the US 360/Route 288 interchange.
2.	STARS Route 360 Study Chesterfield County, Virginia	VDOT	2011	A study by VDOT to identify cost-effective measures that could be implemented quickly (< 24 months) aimed at improving safety and reducing congestion at 11 hot spots between Woodlake Village Parkway and Chippenham Parkway.
3.	Old Hundred Road Corridor Study Hull Street Road to Genito Road Chesterfield County , Virginia	Chesterfield County	2008	The goal of this study was to develop immediate, short-term, and long-term corridor improvements based on existing (2008) and future (2030) traffic volumes.

On-going, recently completed, and planned roadway projects located within the study area are summarized in **Table 2**. This list of improvements were inventoried to understand what the future roadway network assumed to be included in future network.

2.2 Zoning and Future Land Use

A review of existing zoning and future land use plans was conducted for the areas adjacent to the US 360 and Route 288 study corridors. A range of zoning classifications exists along the study corridor including residential, commercial, office, and industrial. Much of future land uses along the study corridor are consistent with existing zoning with the exception of regional mixed use designated for land adjacent to the US 360/Route 288 interchange. Existing zoning and future land use data were obtained using Chesterfield County's Online Citizen Geographic Information System (GIS).[2] Future land use is documented as part of the Chesterfield County Comprehensive Plan, as adopted by the County on April 15, 2015. Maps showing the existing zoning and future land uses in the vicinity of the study corridor are provided in **Appendix A**.

[2] Chesterfield County's Online Citizen Geographic Information System, www.citizengis.chesterfield.gov

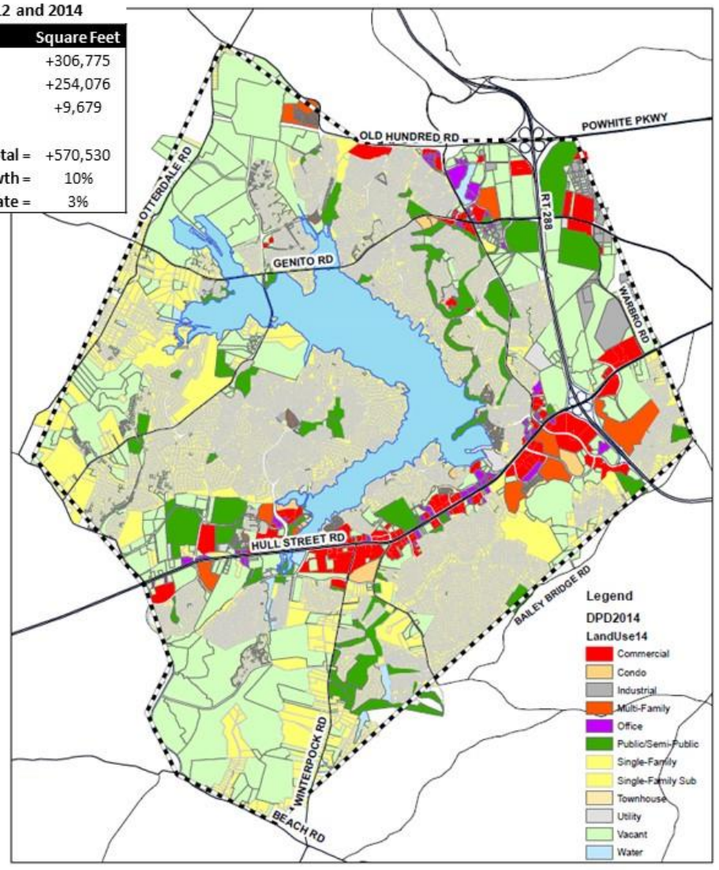
Table 2: Summary of Recently Completed, Underway, and Planned Roadway Projects

	Roadway	Source	Status	Description
1.	US 360 (westbound)	VDOT (UPC 50029 & 68725)	Complete	Construct third lane from Winterpock Road to Woodlake Village Parkway
2.	US 360	VDOT (UPC 97687)	Complete	Widen from six to eight lanes from Winterpock Road to Woodlake Village Parkway
3.	US 360	VDOT (UPC 101022)	Complete	Construct third lane from Warbro Road to Genito Road
4.	US 360 (eastbound)	VDOT (104890)	Planned	Construct third lane from Lonas Parkway to Castle Rock Road
5.	US 360 at N. Spring Run Road	VDOT (UPC 104886)	Planned	Intersection improvements
6.	Bailey Bridge Road	VDOT (UPC 17181)	Complete	Reconstruction of Bailey Bridge Road as a two-lane road from Claypoint Road to Manchester High School
7.	Powhite Parkway	Development Proffers	Planned	New four-lane facility Woolridge Road extension to Watermill Parkway
8.	Powhite Parkway	VDOT (UPC 101229)	Complete	Widen to four lanes from Route 288 to Watermill Parkway
9.	Woolridge Road	Community Development Authority	Planned	Widen to four lanes from Otterdale Road to Swift Creek
10.	Woolridge Road Extended	--	Planned	Widen to four lanes from Simsonbath to south of Powhite Parkway
11.	Woolridge Road Extended	Development Proffers	Planned	New two-lane facility from south of Powhite Parkway to Old Hundred Road
12.	Woolridge Road Extended	Development Proffers	Planned	New two-lane facility from Old Hundred Road to Route 288
13.	Otterdale Road	Community Development Authority	Planned	Widen to four lanes from US 360 to Woolridge Road
14.	Centrepointe Parkway Extended	Development Proffers	Planned	New two-lane facility (2,300 feet) west of Brandermill Parkway to Old Hundred Road
15.	East-West Arterial	Development Proffers	Planned	New two-lane facility (7,500 feet) Old Hundred Road to Woolridge Road
16.	Brandermill Parkway	Development Proffers	Underway	New two-lane facility (2,625 feet) Brandermill Parkway to Charter Colony Parkway
17.	Ashbrook Parkway	Development Proffers	Planned	New two two-lane facility between Hampton Park Drive with Shady Banks Drive
18.	Bailey Bridge Connector	Development Proffers	Planned	New two-lane facility between Bailey Bridge Road and Brad McNeer Parkway
19.	Otterdale Road Extended	Development Proffers	Planned	New two-lane facility from Harpers Mill Parkway to Beach Road
20.	Village Square Parkway	Development Proffers	Planned	New two-lane facility from Fox Club Parkway to Otterdale Road

Table 3 summarizes the amount of residential and commercial development constructed along the study corridor, during the course of this study, between 2012 and 2014. The change in growth accounts for constructed development only and does not include planned or approved development. Development growth occurred along US 360 between Otterdale Road and Warbro Road and to the north and south generally between Powhite Parkway and Bailey Bridge Road. The annual residential and commercial growth rates between 2012 and 2014 were 0.8% and 3.0% per year, respectively.

Table 3: Development Growth Between 2012 and 2014

Residential	Units	Commercial	Square Feet
Single Family	+307	Retail	+306,775
Townhouse	+23	Office	+254,076
Multi-Family	+14	Industrial	+9,679
Condominiums	+24		
Total =	+368	**Total =**	+570,530
Percent Growth =	2%	**Percent Growth =**	10%
Annual Growth Rate =	0.8%	**Annual Growth Rate =**	3%



2.3 Origin-Destination Data

Origin-destination (O-D) data was collected to document travel patterns of the PM peak period commuter through the study area during a typical weekday. This O-D information was used to assist with the development of appropriate alternatives targeted at the specific needs of the users within the study corridor. VDOT used two third-party vendors to obtain the O-D data that is summarized below. Complete O-D data is provided in **Appendix A**.

Based on existing traffic counts, field observations, and the location of existing residential land uses along the corridor, the assumption was that most commuters along westbound US 360 were destined for locations central to the corridor during the PM peak period. The reverse travel pattern was observed during the AM peak period, with the peak direction in the eastbound direction. To verify this assumption quantitatively, the O-D data collection effort was focused to the PM peak period in the westbound direction along US 360.

Automatic License Plate Recognition (ALPR), an image processing technology, was used to identify vehicles by their license plates. Cameras were deployed in the field at strategic locations — stations A through R shown in **Figure 2** and **Figure 3** — to capture images of license plates. Stations A through D represent origin locations and stations E through R represent destinations. License plate images captured were matched automatically with license plate recognition software between each origin and destination. Detailed travel patterns were captured between various points within the study area.

The license plate survey was conducted on October 12, 2012, from 2:30 PM to 7:00 PM to capture the afternoon peak period and from 5:00 PM to 6:00 PM to capture the PM peak hour identified from the turning movement counts. The percent of captured vehicles, matched from an origin to a destination, is summarized in **Figure 2** and **Figure 3**. In some instances, the percentages do not add up to 100% because some of the traffic entering the study area does not pass through the corridor. Data was collected in 15-minute increments and is provided in **Appendix A** for reference. The following conclusions regarding PM peak hour westbound travel patterns through the corridor are quantified in **Table 4** and summarized below:

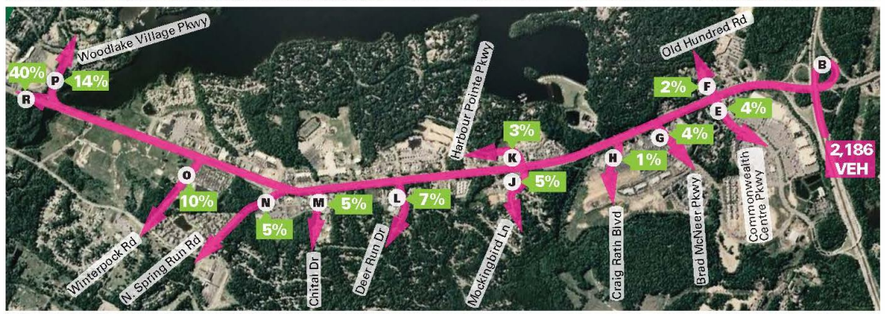
- The majority of vehicles from the north via Route 288 are destined for locations central to the corridor
- The majority of vehicles from the south are primarily through vehicles destined for far west locations
- The majority of vehicles from the east are destined for the interchange area only
- Overall, most vehicles are destined for locations west of the interchange area; therefore, considering improvements that would provide a parallel route to US 360 should reduce traffic volumes through the interchange.

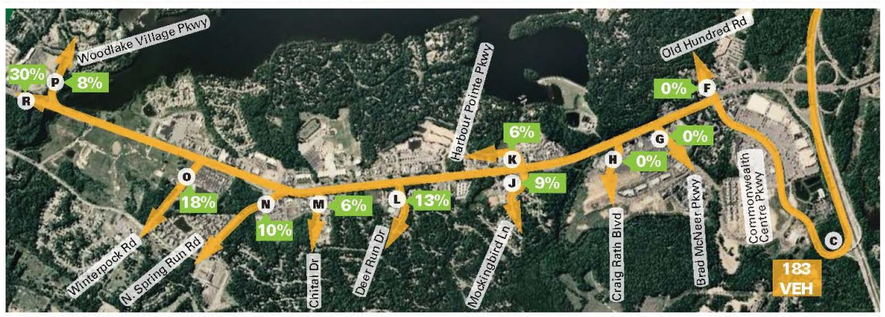
Table 4: Summary of Origin-Destination Data – PM Peak Hour (5:00 PM – 6:00 PM)

Destinations		Origins % of Vehicle License Plates Matched (Number of Vehicle License Plates Matched)			
Corridor Focus Areas	Station ID	(A) From the North via Route 288	(B) From the South via Route 288	(C) From SB Route 288 C-D Road	(D) From the East via US 360
Commonwealth to Route 288 Interchange	E thru H	7% (94)	10% (63)	0% (0)	**40% (427)**
Central Corridor – Craig Rath to Winterpock	J thru O	**55% (640)**	33% (189)	**65% (44)**	27% (297)
West of Corridor – West of Winterpock	R and P	38% (449)	**57% (336)**	35% (24)	33% (358)
Total # of Vehicle License Plates Matched =		**100% (1,183)**	**100% (588)**	**100% (68)**	**100% (1,082)**

Note: The Origin C (SB Route 288 C-D Road) sample size was much smaller than samples for other origins; therefore, less likely to be as accurate.

Figure 2: Summary of Origin-Destination Data – Afternoon Peak Period (2:30 – 7:00 PM)





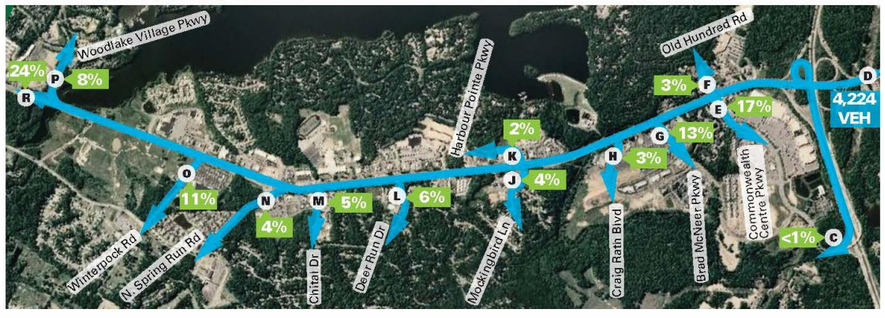
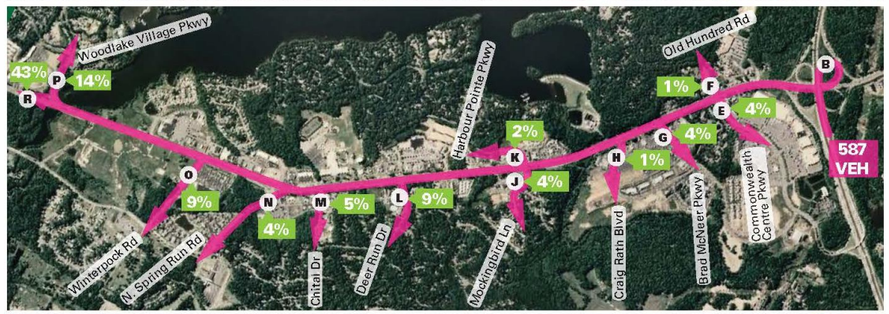
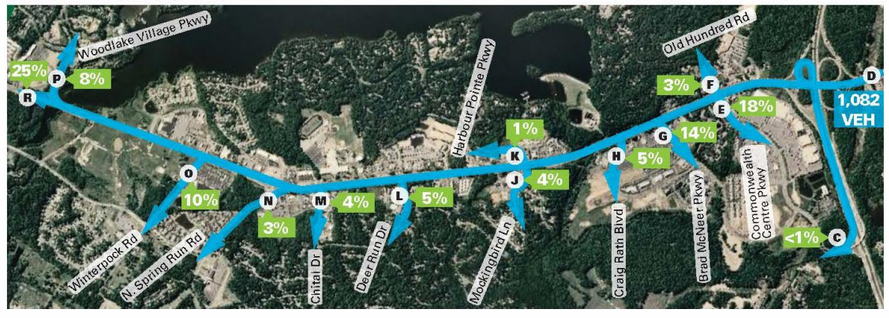


Figure 3: Summary of Origin-Destination Data – PM Peak Hour (5:00 – 6:00 PM)





2.4 Traffic Count Data

To determine existing traffic operating conditions in the corridor, traffic data was compiled from a number of sources for the Route 288 mainline sections, ramps, and US 360 study intersections. VDOT supplied directional tube and turning movement counts, both new and historical for study area intersections and ramps. Collection of turning movement count (TMC) data, including vehicle classification data, was conducted between the hours of 7:00 to 9:00 AM and 4:00 to 6:00 PM. Most of the traffic data was collected in the summer of 2012 with the exception of intersections added as the study progressed. Seventy-two-hour tube counts were conducted for ramp locations, while mainline Route 288 traffic data was obtained from VDOT published counts. Inventory of all traffic counts, including type, source, and date collected, is provided in **Appendix A.**

2.4.1 Peak Hour Determination

The traffic peak hours were reviewed to determine the common AM and PM peak hours of the study corridors. As shown in **Table 4**, Column A indicates that the observed peak hours for study intersections and US 360/Route 288 interchange ramps, while Column B shows the corresponding volume for that hour. It was determined that 13 of the 26 intersection and ramps shared a common AM peak hour from 7:15 to 8:15 AM. The remaining 13 locations with differing peak hours had at least 91% of the peak volume occurring between 7:15 and 8:15 AM. Similarly, 18 of the 26 mainline segments share a common PM peak from 5:00 to 6:00 PM. The remaining eight locations with differing peak hours have at least 97% of the peak volume occurring within the 4:30 to 5:30 PM time period, with the intersection of US 360 at Otterdale Road being the outlier. This was attributed to data collection efforts being conducted on a different date than most of the study intersections, as this intersection was added to the study corridor after the initial data collection efforts were completed. Peak hour factors (PHFs) were calculated by movement at the study intersections during the overall study area AM and PM peak hours; if 15-minute counts are not included a PHF of 0.92 was assumed. Traffic counts were conducted on weekdays during average hours while county schools were in session. The study work group determined the study corridor was not influenced by seasonal traffic; therefore, a seasonal adjustment factor was not applied to the traffic counts used for this study.

2.4.2 Heavy Vehicle Percentages

Heavy vehicle percentages by peak hour, data sources from which vehicle classification was obtained, and general assumptions applied are summarized in **Table 6**. Figures showing peak hour heavy vehicle percentages by movement and relevant data used to establish the heavy vehicle percentages is provided in **Appendix A**. US 360 is a national Surface Transportation Assistance Act (STAA) truck route, part of a network of highways allowing access for larger vehicles to the interstate highway system and certain federal-aid primary routes. The following study routes are restricted to through trucks:

- Warbro Road south of US 360
- Old Hundred Road north of US 360
- McEnnally Road from Winterpock Road to Spring Run Road
- Woodlake Village Parkway north of US 360
- Fox Club Parkway north of US 360

Table 5: Peak Hour Determination

		AM				PM			
		Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
ID	Location	Observed Peak Hour (Start)	Volume Observed in Column A	Volume from 7:15 AM - 8:15 AM	% of Column C to Column B	Observed Peak Hour (Start)	Volume Observed in Column E	Volume from 5:00 PM - 6:00 PM	% of Column G to Column F
Study Intersections									
1	US 360 at Otterdale Road	8:30 AM	1,851	1,799	97%	5:15 PM	3,645	2,325	64%
2	US 360 at Fox Club Parkway/Hampton Park Drive	7:00 AM	2,762	2,518	91%	4:45 PM	2,976	2,936	99%
3	US 360 at Woodlake Village Parkway	7:15 AM	3,344	3,344	100%	5:00 PM	4,064	4,064	100%
4	US 360 at Ashlake Parkway	7:00 AM	3,681	3,611	98%	5:00 PM	4,519	4,519	100%
5	US 360 at Duckridge Boulevard/Hancock Village	7:30 AM	3,571	3,555	100%	5:00 PM	3,552	3,552	100%
6	US 360 at Winterpock Road	7:00 AM	4,259	4,222	99%	5:00 PM	5,714	5,714	100%
7	US 360 at Temie Lee Parkway/North Spring Road	7:15 AM	4,910	4,910	100%	5:00 PM	6,133	6,133	100%
8	US 360 at Chital Drive	7:15 AM	4,973	4,973	100%	5:00 PM	5,982	5,982	100%
9	US 360 at Harbour View Court/Deer Run Drive	7:30 AM	5,573	5,566	100%	5:00 PM	6,786	6,786	100%
10	US 360 at Harbour Pointe Parkway/Mockingbird Lane	7:15 AM	5,761	5,761	100%	5:00 PM	7,269	7,269	100%
11	US 360 at Craig Rath Boulevard	7:15 AM	5,826	5,826	100%	5:00 PM	7,063	7,063	100%
12	US 360 at Brad McNeer Parkway	7:15 AM	6,166	6,166	100%	5:00 PM	7,741	7,741	100%
13	US 360 at Wells Fargo	7:30 AM	5,764	5,755	100%	4:30 PM	7,301	7277	100%
14	US 360 at Village Green Drive	7:15 AM	5,749	5,749	100%	5:00 PM	6,995	6,995	100%
15	US 360 at Old Hundred Road/Commonwealth Centre Parkway	7:15 AM	5,886	5,886	100%	5:00 PM	8,884	8,884	100%
16	US 360 at Market Square Lane	7:15 AM	1,602	1,602	100%	5:00 PM	1,496	1,496	100%
17	US 360 at Memphis Boulevard/Lonas Parkway	7:15 AM	2,966	2,966	100%	5:00 PM	4,270	4,270	100%
18	US 360 at Warboro Road/Bridgewood Road	7:30 AM	2,909	2,917	100%	5:00 PM	4,236	4,236	100%
US 360/Route 288 Interchange Ramps									
1	SB Route 288 to WB US 360	8:00 AM	661	660	100%	4:45 PM	1,722	1,662	97%
2	SB Route 288 to EB US 360	7:45 AM	182	165	91%	5:00 PM	444	444	100%
3	EB US 360 to Route 288 SB	7:00 AM	893	866	97%	5:00 PM	473	473	100%
4	EB US 360 to NB Route 288	7:15 AM	1,838	1,838	100%	4:45 PM	812	794	98%
5	NB Route 288 to EB US 360	7:30 AM	188	176	94%	4:45 PM	245	239	98%
6	NB Route 288 to WB US 360	7:30 AM	577	550	95%	4:45 PM	1,170	1,167	100%
7	WB US 360 to NB Route 288	7:15 AM	511	511	100%	4:45 PM	249	246	99%
8	WB US 360 to SB Route 288	7:15 AM	236	236	100%	5:00 PM	194	194	100%
		% AM Peak Hour Volume Captured			99%	% PM Peak Hour Volume Captured			99%

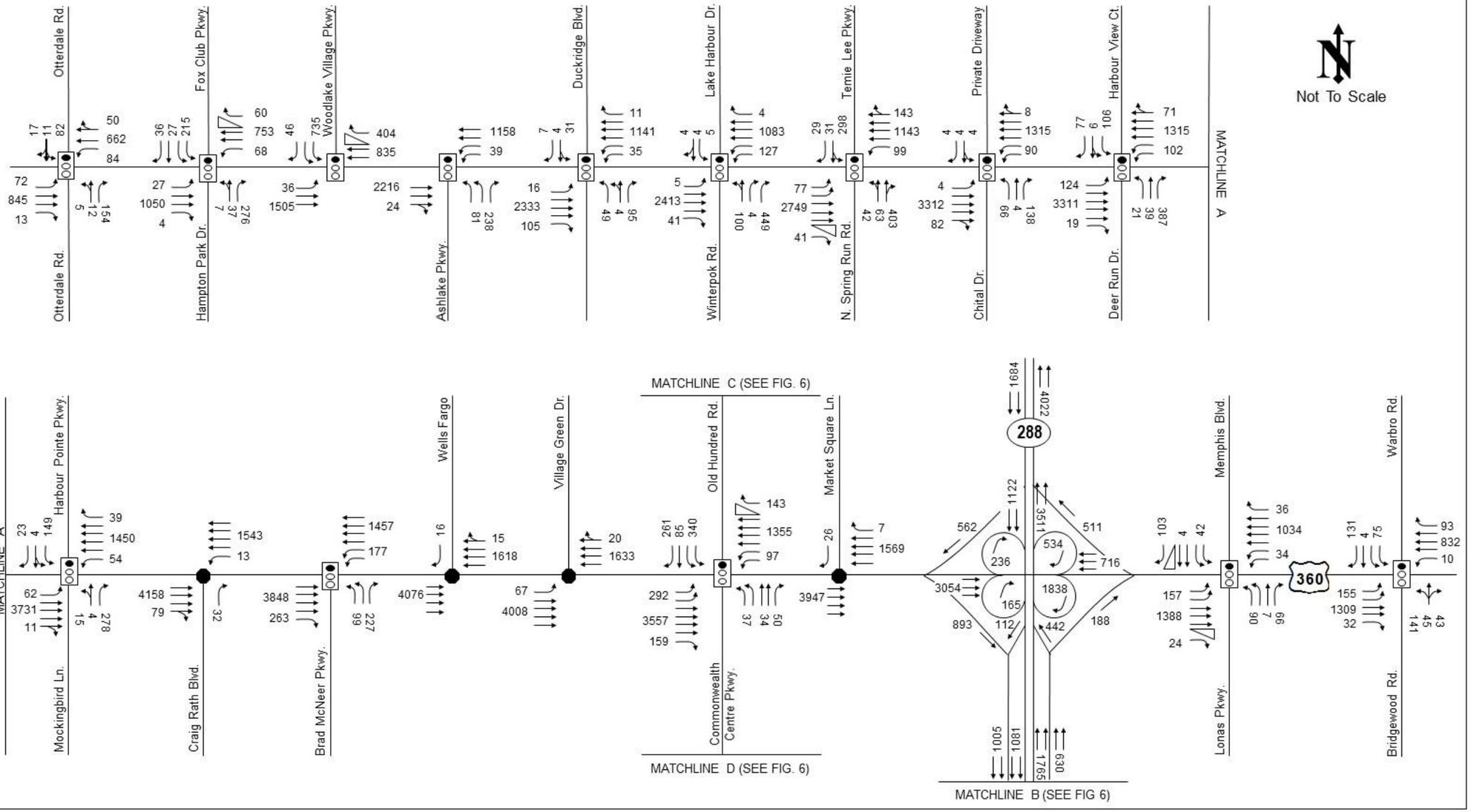
2.4.3 Traffic Volume Balancing

Using the available turning movement count data and tube count traffic data, the study team balanced the traffic volumes throughout the network in preparation for the existing conditions operational analyses. Traffic volume balancing was required due to the volume variations observed throughout the corridor. Peak hour traffic volumes were balanced using an iterative process of adjusting traffic volumes along US 360 to the east and west from the interchange until they were within a reasonable tolerance. The resulting peak hour traffic volumes, summarized in **Figures 4 - 6**, were reviewed and approved by the SWG.

Table 6: Heavy Vehicle Percentages

Study Roadway	Heavy Vehicle % AM	Heavy Vehicle % PM	Source and Assumptions
Route 288	5%	5%	– 2010 AADT Jurisdictional Counts provided by VDOT – Assumed daily heavy vehicle percentage for both AM and PM peak hours
US 360 West of Route 288	7%	2%	– Eastbound and westbound peak hour heavy vehicle percentages were calculated from the US 360 at Old Hundred Road/Commonwealth Centre Parkway turning movement counts – Both are consistent with the daily heavy vehicle percentages from the 2010 AADT Jurisdictional Counts provided by VDOT
US 360 East of Route 288	3%	2%	– 2010 AADT Jurisdictional Counts provided by VDOT – Assumed daily heavy vehicle percentage for both AM and PM peak hours
To/from Side Streets – Warbro Road – Otterdale Road	2% 11% 5%	2% 11% 5%	– Minimal heavy vehicle presence on local side streets; assumed 2% to be conservative – Assumed 11% to/from Warbro based 2010 AADT Jurisdictional Counts provided by VDOT, this is consistent with adjacent industrial land uses – Otterdale Road provides an indirect connection between Powhite Parkway and US 360; therefore, assumed 5% similar to Route 288

AADT = Annual Average Daily Traffic

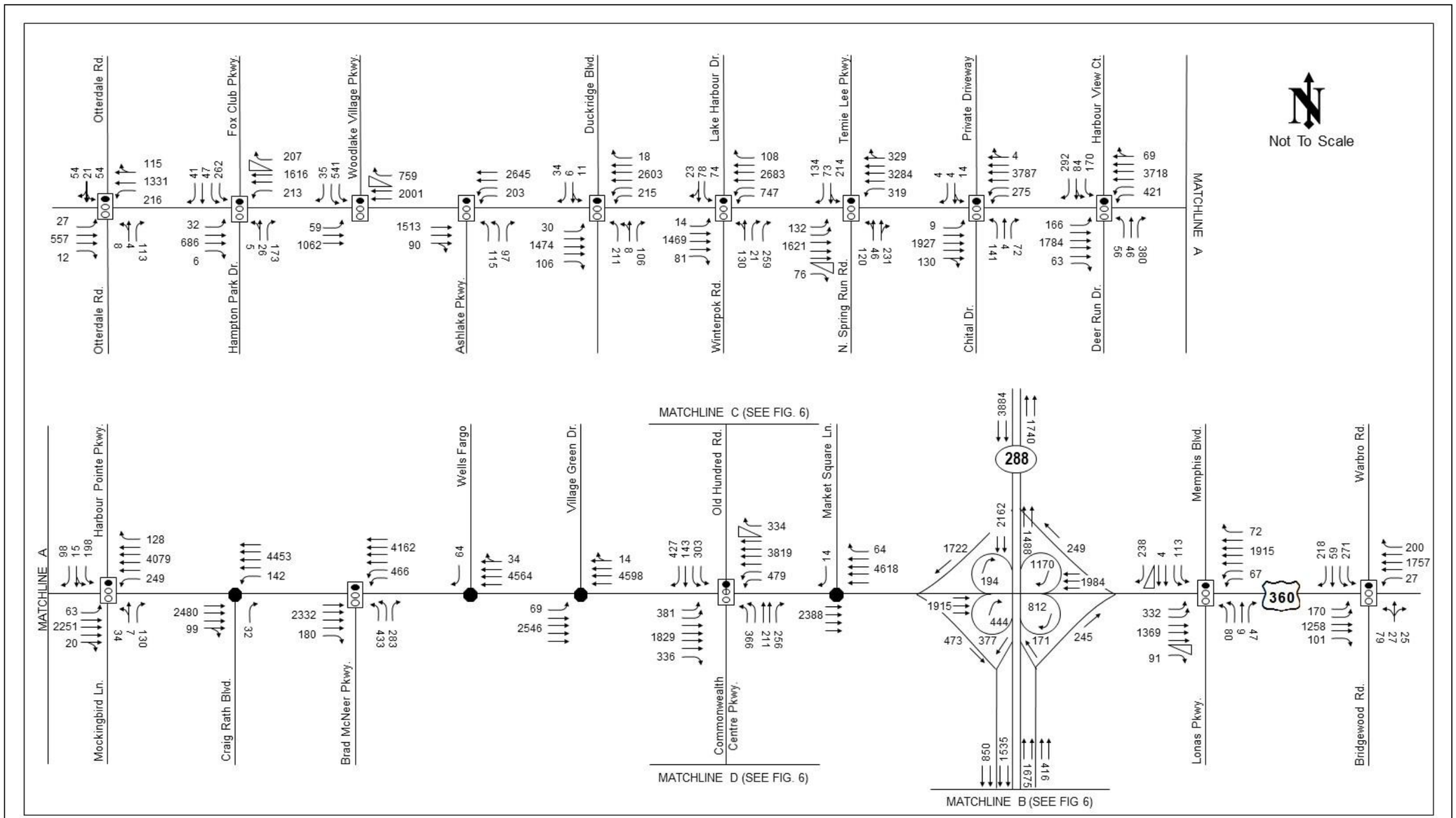


Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

Existing (2012) Traffic Volumes – AM Peak Hour
US 360/Route 288 Interchange Study

Figure 4



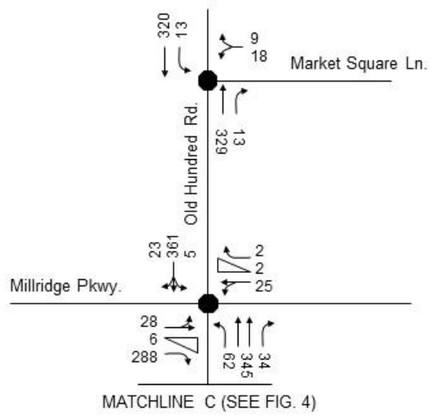
Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

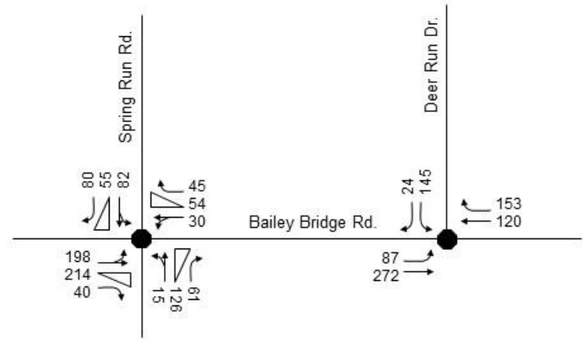
Existing (2012) Traffic Volumes – PM Peak Hour
US 360/Route 288 Interchange Study

Figure 5

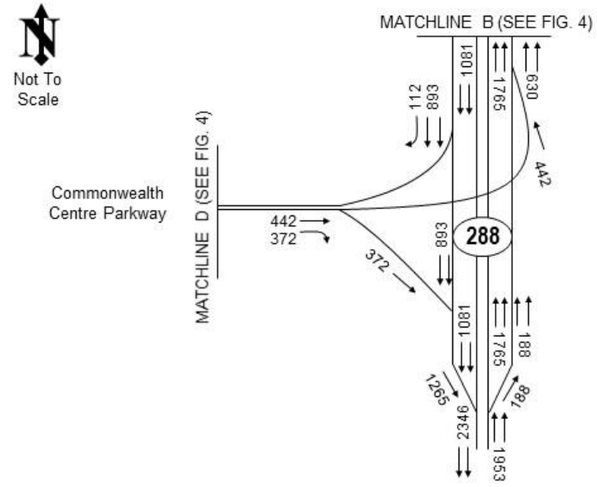
AM PEAK HOUR



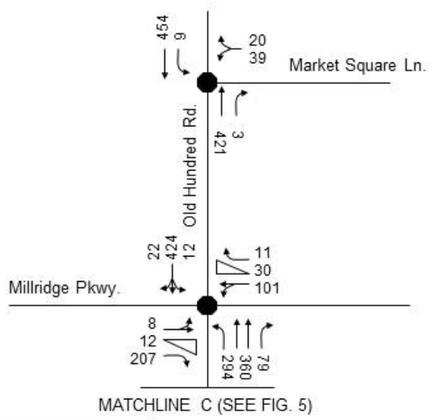
Old Hundred Road at Millridge Parkway and Market Square Lane



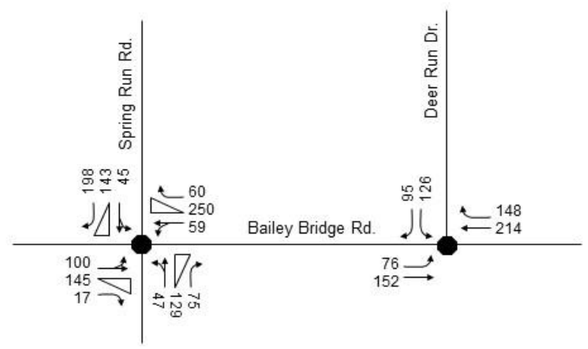
Bailey Bridge Road at Spring Run Road and Deer Run Road

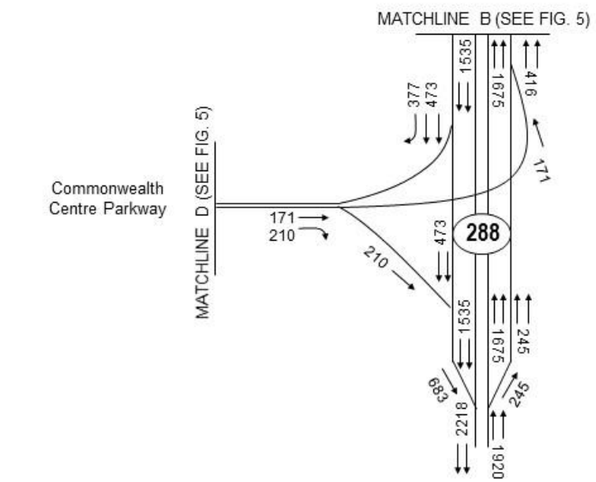


Commonwealth Centre Parkway at Route 288



PM PEAK HOUR





Legend

- Existing Lane Assignment
- Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

Existing (2012) Traffic Volumes – AM & PM Peak Hour
US 360/Route 288 Interchange Study

Figure 6

2.5 Crash Analysis

An evaluation of corridor safety was conducted based on an analysis of crash summary information and field reconnaissance. Crash data analysis for the study corridors and the associated on- and off-ramps within the study area was conducted using the latest four years of available crash data (January 1, 2010, to December 31, 2013) obtained from VDOT's Roadway Network System. The following sections summarize the crashes that occurred on US 360, Route 288, and associated intersections and ramps during the four-year crash analysis period.

2.5.1 Overall Crash Summary

During the four-year period, a total of 1,207 crashes occurred on the US 360 and Route 288 corridors within the study area. A summary of crashes by facility and year is provided in **Table 7**. Most of the Route 288 crashes occurred on the mainline portion in the southbound direction with minimal crashes occurring on the collector-distributor roads and ramps.

Table 7: Crash Summary of Study Corridors

Study Corridor	Number of Crashes				Total
	2010	2011	2012	2013	
Route 288 from 1.5 Miles South of US 360 (MP 11.50) to 2.5 Miles North of US 360 (MP 15.50)					
Northbound Mainline	11	9	11	7	**38**
Southbound Mainline	21	25	23	24	**93**
Northbound Collector-Distributor Road	0	0	0	0	**0**
Southbound Collector-Distributor Road	0	3	0	1	**4**
On- and Off-Ramps	0	3	8	2	**13**
Total	**32**	**40**	**42**	**34**	**148**
US 360 from Otterdale Road (MP 122.00) to Warbro Road (MP 127.81)					
Eastbound	137	140	122	130	**529**
Westbound	128	134	132	136	**530**
Total	**265**	**274**	**254**	**266**	**1,059**

Table 8 summarizes a breakdown of crash severity (i.e., proportion of the crashes involving an injury, fatality, or property damage only). The majority of crashes, over 60% of crashes for each corridor by direction, resulted in property damage only (PDO). Southbound Route 288 had the largest percentage of injury crashes at 38%; the remaining corridors were less than 27%. There were three fatal crashes in the study corridors during the four-year period. A summary of the circumstances surrounding each fatal crash is described below.

- Crash occurred on southbound Route 288 1.0 mile north of the US 360/Route 288 interchange at milepost 14.6 (the crash location can be referenced on Figure 14 in **Section 2.5.3.2**). The crash involved one fatality and two injuries and occurred on Monday, July 25, 2011, at 7:00 PM. It was a rear-end crash in conditions with dry roadway surface, clear weather, and daylight.
- Crash occurred on southbound Route 288 in the weave section between the westbound US 360 to southbound Route 288 on-ramp and the southbound Route 288 to eastbound US 360 off-ramp at milepost 13.6 (the crash location can be referenced on Figure 14 in **Section 2.5.3.2**). The crash involved one fatality and two injuries and occurred on Wednesday, March 2, 2011, at 5:00 PM. It was a fixed-object, off-road crash in conditions with dry roadway surface, clear weather, and daylight.
- Crash occurred on westbound US 360 just west of Otterdale Road at milepost 122.1 (the crash location can be referenced on **Figure 12** in **Section 2.5.3.1**). The crash involved one fatality and occurred on Tuesday, March 8, 2011, at 9:00 AM. It was a fixed-object, off-road crash in conditions with dry roadway surface, clear weather, under daylight.

One fatal crash occurred during the course of this study, outside of the four-year crash analysis period. It occurred on southbound Route 288 approximately half a mile north of US 360. The crash involved one fatality and occurred on Monday, April 6, 2015 at 1:07 PM. It was a rear-end crash in conditions with dry roadway surface, clear weather, under daylight.

Table 8: Crash Summary of Study Corridors

Direction	Number of Crashes (Percentage)			Total
	PDO	Injury	Fatal	
Route 288 from 1.5 Miles South of US 360 (MP 11.50) to 2.5 Miles North of US 360 (MP 15.50)				
Northbound	29 (76%)	9 (24%)	0 (0%)	**38**
Southbound	56 (60%)	35 (38%)	2 (2%)	**93**
US 360 from Otterdale Road (MP 122.00) to Warbro Road (MP 127.81)				
Eastbound	412 (78%)	117 (22%)	**0 (0%)**	**529**
Westbound	387 (73%)	142 (27%)	**1 (<1%)**	**530**

Summaries of the eastbound and westbound US 360 crashes by type are provided in **Figures 7** and **8**. The majority of crashes in the eastbound and westbound directions were rear-end crashes at 72% and 62%, respectively. Other frequent crash types included angle crashes (eastbound 14% and westbound 21%) and sideswipe – same direction (eastbound 7% and westbound 10%). An overrepresentation of rear-end and angle crashes centered at intersections is typical of congested corridors.

Figure 7: Crash Type Summary – US 360 – Eastbound

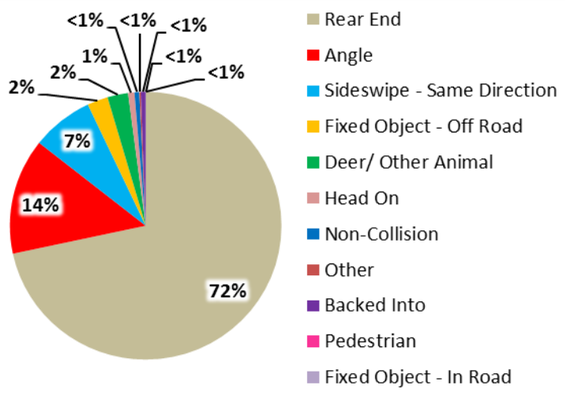
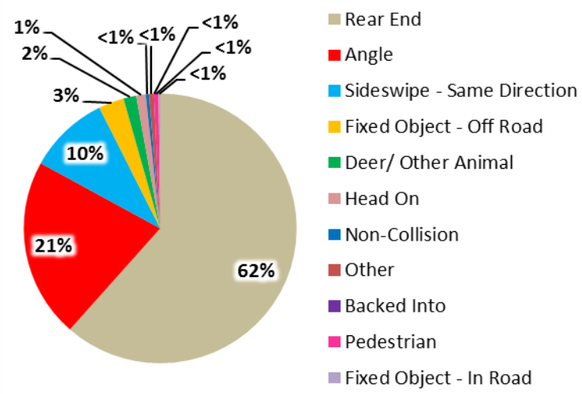


Figure 8: Crash Type Summary – US 360 – Westbound



Other crash trends on US 360 include (refer to **Appendix A)**:

- Most of the eastbound crashes (35%) occurred during the AM peak period while most of the westbound crashes (47%) occurred during the PM peak period. This trend is consistent with the peak hour directional split in traffic volumes.
- Most crashes occurred in daylight conditions (eastbound 74% and westbound 68%)
- Most crashes occurred in clear weather conditions (eastbound 85% and westbound 87%)

Summaries of the northbound and southbound Route 288 crashes by type are provided in **Figures 9** and **10**. The majority of crashes in the northbound and southbound directions, were rear-end crashes at 47% and 53%, respectively. The second most frequent crash type were fixed-object, off-road crashes (northbound 21% and southbound 23%). Fixed-object, off-road crashes are typical of limited access facilities; however, an overrepresentation of rear-end crashes on a limited access facility is a strong indication of congestion potentially associated with queueing, merging/diverging, and weaving movements at interchanges.

Figure 9: Crash Type Summary – Route 288 Mainline – Northbound

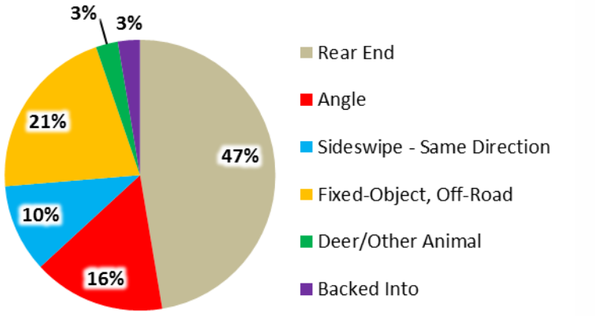
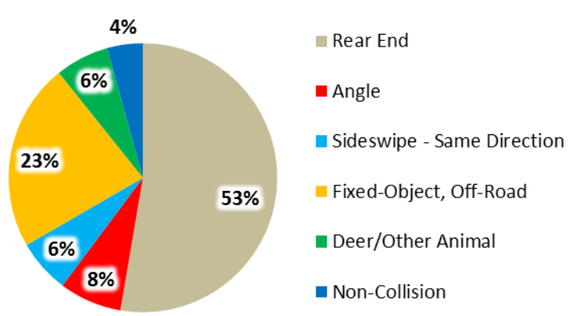


Figure 10: Crash Type Summary – Route 288 Mainline – Southbound



Other crash trends on Route 288 include (refer to **Appendix A**):

- Most of the northbound crashes occurred during the AM peak period (29%) and PM peak period (53%). This trend is consistent with the heavy AM (eastbound US 360 to northbound Route 288) and PM (northbound Route 288 to westbound US 360) movements through the interchange.
- Most of the southbound crashes occurred during the PM peak period (56%). This trend is consistent with the heavy southbound Route 288 to westbound US 360 movements through the interchange.
- Most crashes occurred in daylight conditions (northbound 74% and southbound 59%)
- Most crashes occurred in clear weather conditions (northbound 84% and southbound 90%)

2.5.2 Crash Rates

Directional crash rates were computed for the study corridors for the four-year study period as shown **Table 9**. Crash rates are based on the number of crashes on the specified section, the AADT on the roadway, the time period of analysis, and the length of the section. **Table 2** compares the overall crash rate, injury crash rate, and fatal crash rate for each study corridor to the latest available (2012) average statewide crash rates for four-lane, divided highways with full control of access (Route 288) and six-lane, divided roadways with partial control of access (US 360) provided by VDOT. All crash rates are expressed in terms of crashes per 100 million vehicle-miles traveled.

Table 9: Crash Rate Summary

Crash Severity	Number of Crashes	Crash Rate (Crashes per 100 Million Vehicle-Miles Traveled)		
		Route 288 (2010-2013)		Statewide Average (2012)*
Route 288 from 1.5 Miles South of US 360 (MP 11.50) to 2.5 Miles North of US 360 (MP 15.50) - Northbound				
Injury	9	5.00	≤	**31.01**
Fatal	0	0.00	≤	**0.30**
Total	38	21.13	≤	**61.44**
Route 288 from 2.5 Miles North of US 360 (MP 15.50) to 1.5 Miles South of US 360 (MP 11.50) - Southbound				
Injury	35	19.46	≤	**31.01**
Fatal	2	**1.11**	≥	**0.30**
Total	93	51.71	≤	**61.44**
Crash Severity	**Number of Crashes**	**Crash Rate (Crashes per 100 Million Vehicle-Miles Traveled)**		
		US 360 (2010-2013)		**Statewide Average (2012)^**
US 360 from Otterdale Road (MP 122.00) to Warbro Road (MP 127.81) - Eastbound				
Injury	117	**49.77**	≥	47.34
Fatal	0	0.00	≤	**0.24**
Total	529	**225.05**	≥	81.03
US 360 from Warbro Road (MP 127.81) to Otterdale Road (MP 122.00) - Westbound				
Injury	142	**60.41**	≥	47.34
Fatal	1	**0.43**	≥	0.24
Total	530	**225.47**	≥	81.03

MP = Milepost

Analysis Period = Four Years (January 1, 2010 to December 31, 2013)

* Statewide average for a four-lane, divided roadway with full control of access

^ Statewide average for a six-lane, divided roadway with partial control of access

Crash rate = Total Crashes/[(ADT) x (365) x (Time Frame of Analysis (Years)) x (Section Length)]/100,000,000

	Section Length	Bi-Directional Four Year Average Annual Daily Traffic (AADT)
Route 288	4.00 miles	61,600 vehicles per day
US 360	5.81 miles	55,500 vehicles per day

Based on this comparison, the southbound Route 288 fatal crash rate was greater than the statewide average crash rate for four-lane, divided roadways with full control of access. All other Route 288 crash rates were below the statewide average crash rate.

The US 360 total and injury crash rates, in the eastbound and westbound directions, were greater than the statewide average crash rate for six-lane, divided roadways with partial control of access. The eastbound and westbound total crash rates were almost three times higher than the statewide average.

2.5.3 Crash Hot Spots

Crash activity by quarter-mile segments of roadway, or crash density, along the US 360 and Route 288 study corridors between 2010 and 2013 are represented as crash histograms in **Figures 11** through **14**. Crash histograms based on crash type and severity are provided for both corridors. Critical crash density, defined as the average crash density plus two standard deviations per quarter-mile was determined for each roadway and shown in **Figures 11** through **14**. Quarter-mile segments with more crashes than the critical crash density were considered crash "hot spots". Based on this criterion, the following five hot spots were identified:

2.5.3.1 US 360 Corridor

Hot Spot 1 & 2: Eastbound and Westbound at Old Hundred Road/Commonwealth Centre Parkway (MP 126.50 - 126.75)

Hot Spot 1 (eastbound) and Hot Spot 2 (westbound) are centered on the intersection of US 360 and Old Hundred Road/Commonwealth Centre Parkway. During the four-year crash analysis period, there were 131 reported crashes along this segment (eastbound and westbound combined), of which 28 (21%) resulted in injury. Rear-end crashes were the predominant crash type and accounted for 66% of all crashes (eastbound and westbound combined). It should be noted that this hot spot effectively extends west to Craig Rath Boulevard (MP 126.0), particularly in the eastbound direction, even though it is below the critical crash density due to significant crash activity in this section.

Hot Spot 3 – Westbound at Winterpock Road (MP 124.25 – 124.50)

Hot Spot 3 is centered on the intersection of US 360 and Winterpock Road. During the four-year crash analysis period, there were 76 reported crashes along this segment in the westbound direction, of which 20 (26%) resulted in injury. Rear-end and angle crashes were the predominant crash types and accounted for 57% and 35% of all crashes, respectively.

2.5.3.2 Route 288 Interchange Area

Hot Spot 4 – Northbound Route 288 Weave Segment (MP 12.75 – 13.00)

Hot Spot 4 is the weave segment between northbound Route 288 to westbound US 360 and eastbound US 360 to Northbound Route 288 Southbound Route 288 to Westbound US 360 Off-Ramp. During the four-year crash analysis period, there were 16 reported crashes along this segment, of which 3 (19%) resulted in injury. Rear-end and sideswipe crashes were the predominant crash types and accounted for 69% and 19% of all crashes, respectively.

Hot Spot 5 – In the Vicinity of the Southbound Route 288 to Westbound US 360 Off-Ramp (MP 13.75 – 14.00)

Hot Spot 5 is located in the influence area of the southbound Route 288 to Westbound US 360 off-ramp. During the four-year crash analysis period, there were 21 reported crashes along this segment, of which seven (33%) of resulted in injury. Rear-end crashes were the predominant crash types and accounted for 81% of all crashes. It should be noted that this hot spot effectively extends north into the adjacent quarter-mile segment (MP 14.00 – 14.25) due to the crash activity in this section.

Additional locations with crash activities above the corridor average include:

- The eastbound weave section on US 360 between the southbound Route 288 to eastbound US 360 off-ramp and the eastbound US 360 to northbound Route 288 on-ramp
- Multiple intersections along US 360 between Mockingbird Lane and Woodlake Village Parkway in both the eastbound and westbound directions
- On US 360 east of Warbro Road, in both directions, where the number of lanes on US 360 transitions

2.5.4 Potential for Safety Improvement (PSI) Areas

VDOT analyzed each intersection and roadway segment throughout Virginia using the predictive methods outlined in the *Highway Safety Manual* (*HSM*). Each intersection and roadway segment was ranked based on its potential for safety improvement (PSI). According to the *HSM*, PSI "estimates how much the long-term crash frequency could be reduced at a particular site" and is based on a crash prediction that was calculated based on the safety performance function (SPF) crash data files. The top 100 intersections and the top 100 miles of segments ranked by the PSI value are included. **Table 10** displays the five study intersections and one segment that were identified based on PSI.

Table 10: Potential for Safety Improvement (PSI) Areas

Study Location	Type	PSI Ranking	
		Total Crashes	Fatal + Injury Crashes
US 360 at Winterpock Road	Intersection	2	9
US 360 at Lonas Parkway	Intersection	5	35
US 360 at Otterdale Road	Intersection	27	6
US 360 at Bailey Bridge Road	Intersection	21	31
US 360 at Ashlake Parkway	Intersection	49	88
US 360 from Cosby to Woodlake Village	Segment	103	67

2.5.5 Crash Analysis Summary

Corridor improvements should focus improvements on reducing the number and severity of crashes and mitigating the following congestion-related safety issues:

» Statistics for the US 360 corridor show injury and overall crash rates that are significantly higher than rates for similar roadways across the state. In general, these rates were found to be 1.3 to over 1.5 times higher.
» An overrepresentation of rear-end crashes on a limited access facility (Route 288) is a strong indication of congestion potentially associated with queueing, merging/diverging, and weaving movements at the interchange.
» Multiple high crash intersections, with patterns of rear-end crashes, along US 360 in both the eastbound and westbound directions is a measure of the level of congestion through the corridor.

It should be noted that the direct relationship between traffic congestion and crash frequency should provide added reason to ongoing efforts to identify and provide funding for near- and long-term transportation projects that minimize traffic congestion in the study area.

Figure 11: US 360 Crash Density Histogram – By Crash Type

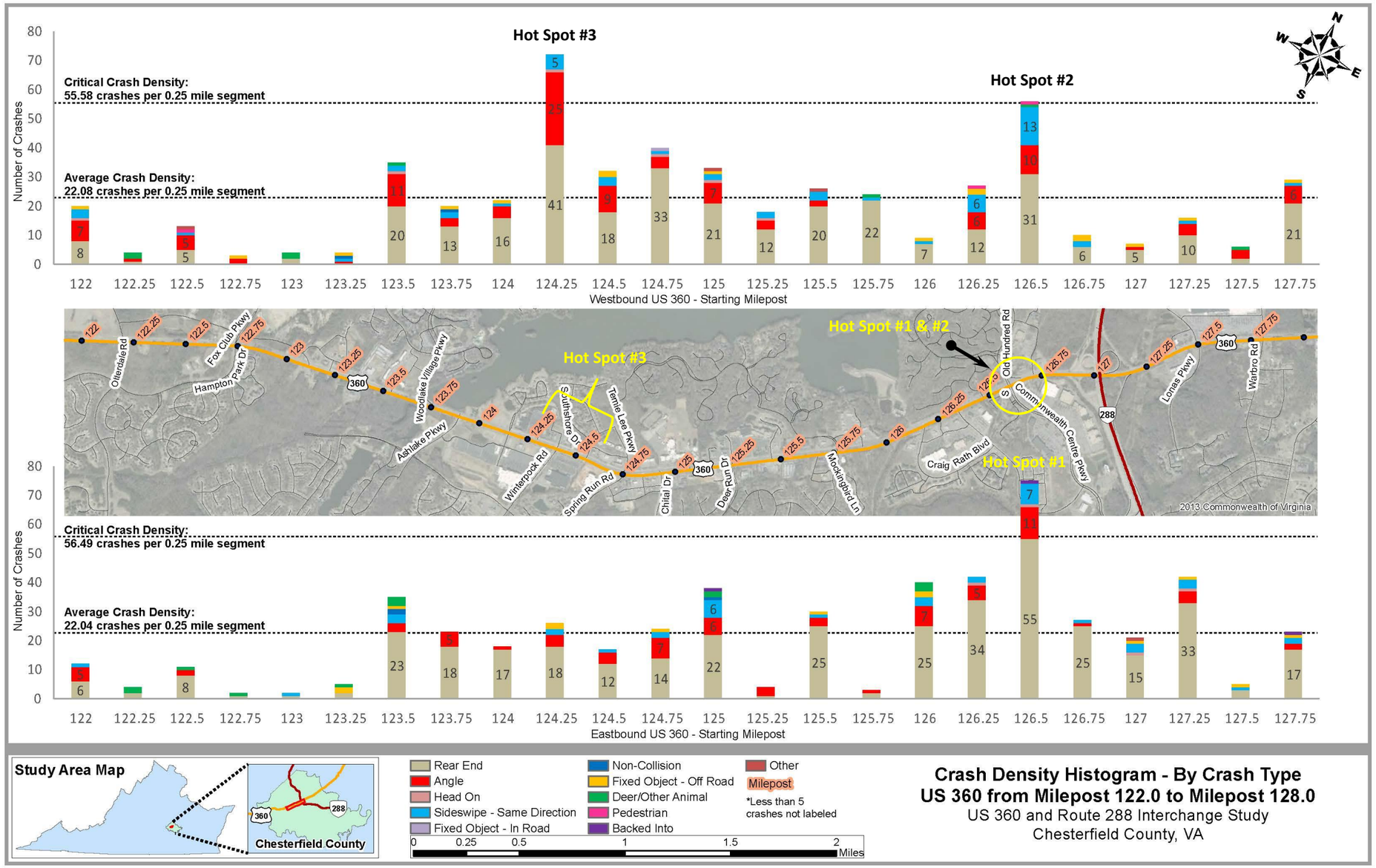


Figure 12: US 360 Crash Density Histogram – By Severity

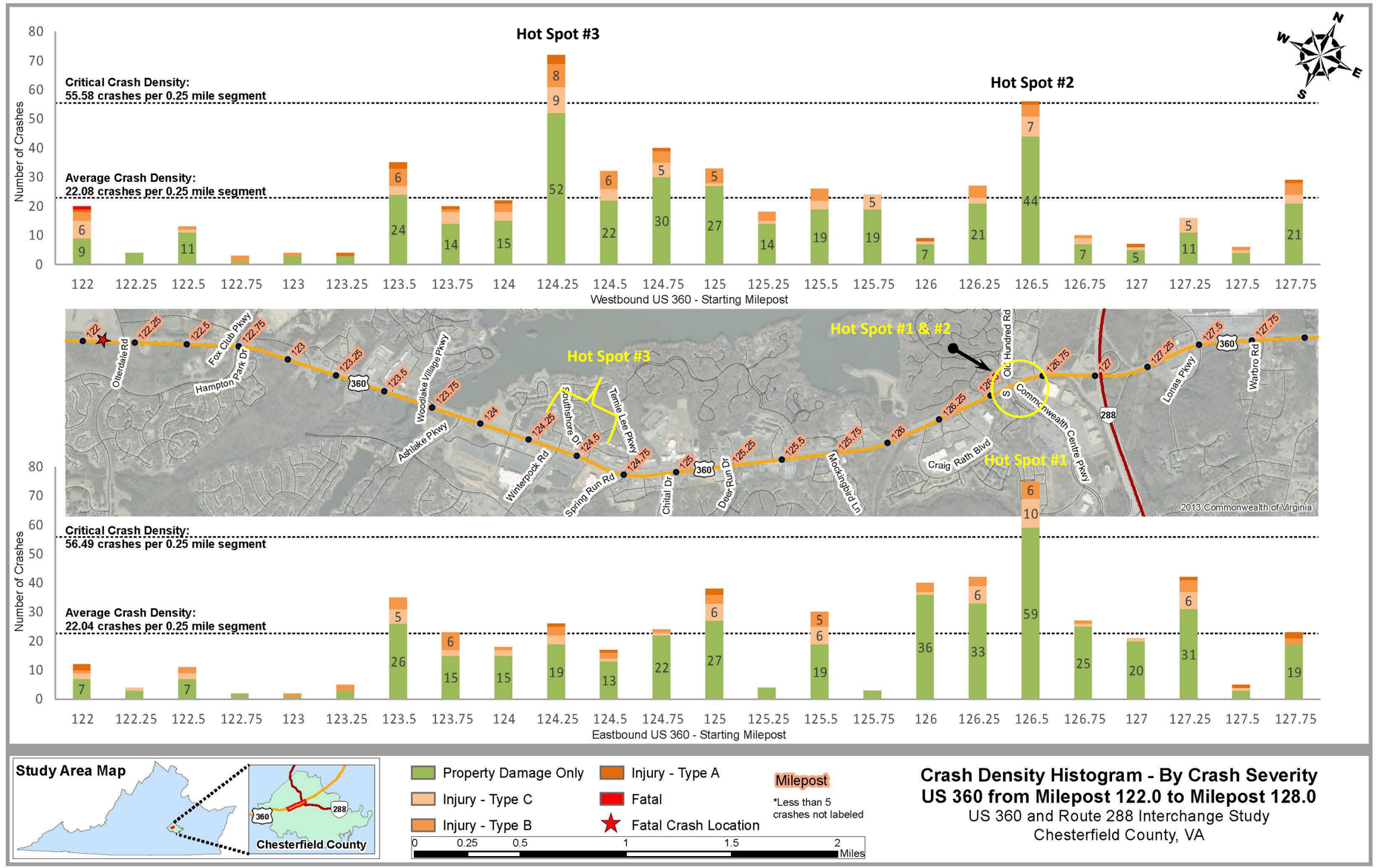


Figure 13: Route 288 Crash Density Histogram – By Crash Type

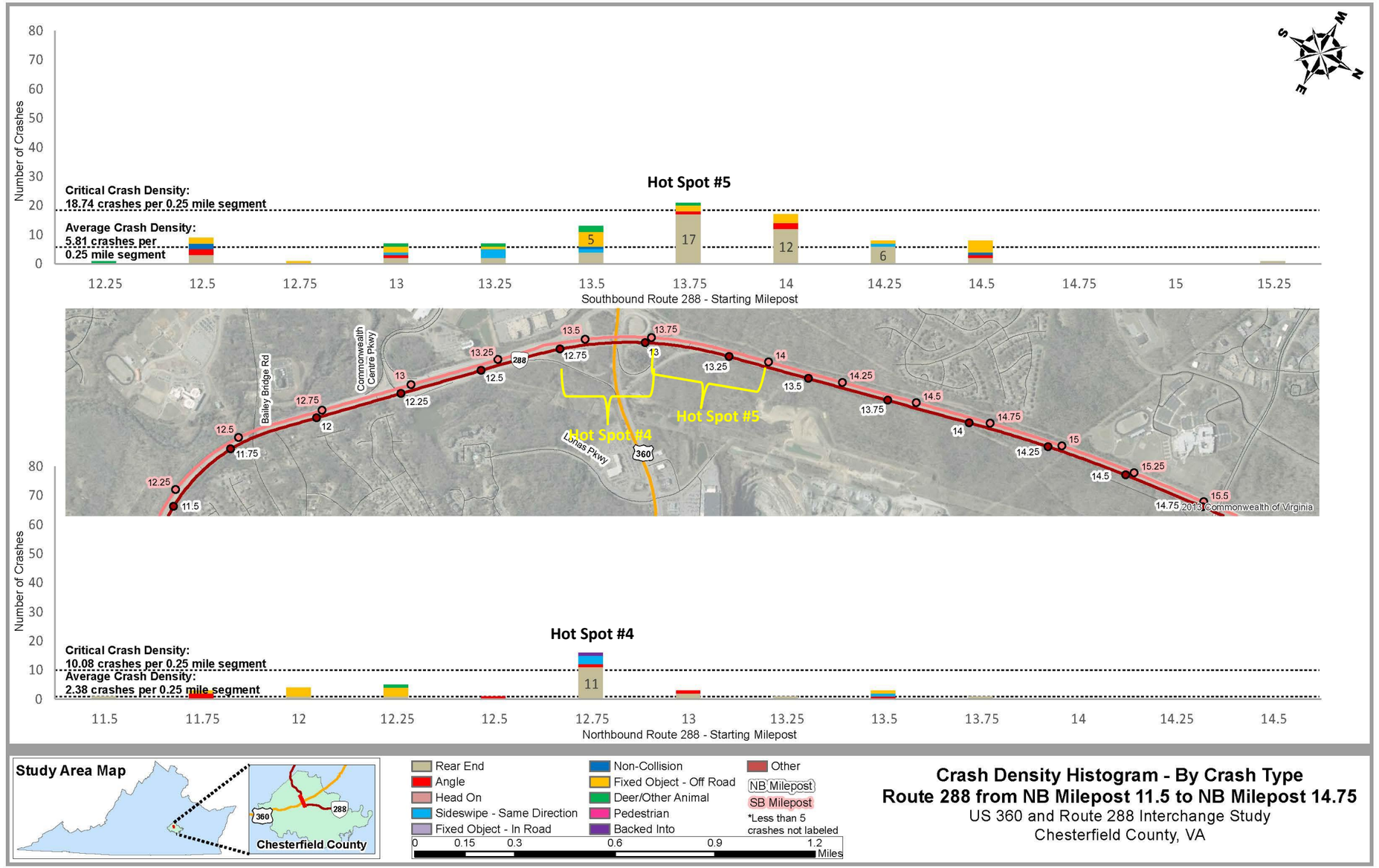
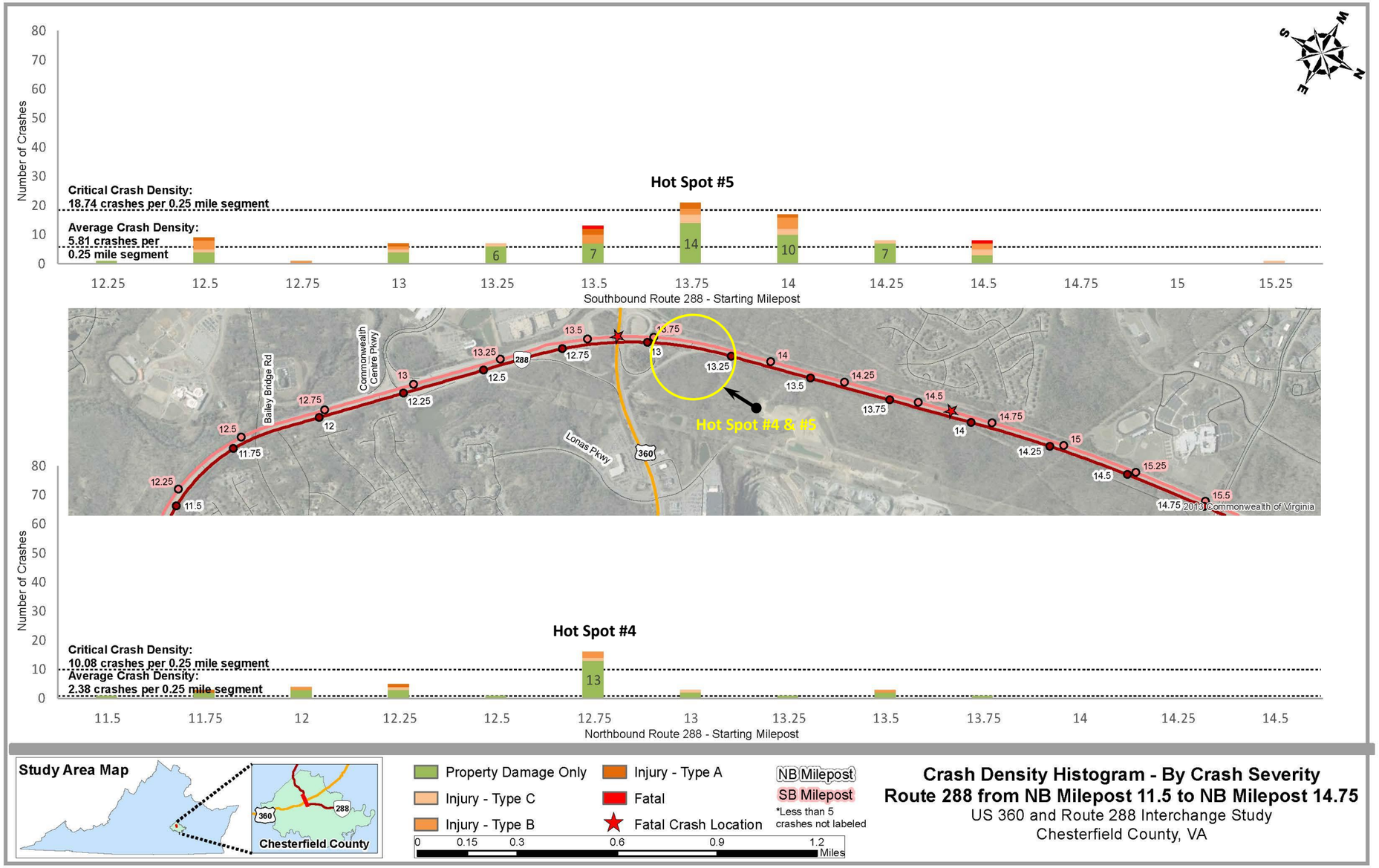


Figure 14: Route 288 Crash Density Histogram – By Severity



3.0 Geometric Conditions

3.1 Existing Roadway Network

The study area for this includes roadways of varying types, ranging from freeways to local facilities. The following section provides information on the study corridors, interchanges, and other study roadways within the vicinity of the study area (inventory of local streets is provided in **Table 11**. The roadway network surrounding US 360 was taken into consideration when developing concepts to mitigate congestion on US 360 and at the US 360/Route 288 interchange. The functional classifications for each roadway were based on VDOT's Richmond District 2014 Functional Classification map for Chesterfield County.

3.1.1 Study Corridors

- **US 360 (Hull Street Road)** is classified as a principal arterial and extends regionally through Chesterfield County between the City of Richmond and Amelia County. US 360 is an eight-lane, divided roadway between Chital Drive and Route 288. The cross-section transitions to a four-lane divided roadway west of Chital to the western limit of the corridor at Otterdale Road. East of Route 288, US 360 transitions to a five-lane divided roadway to the eastern limit of the study area at Warbro Road (there are three westbound travel lanes). At the time of this study, Chesterfield County has programmed widening projects intended to widen US 360 to a six-lane divided facility throughout the study area. The US 360 corridor is approximately 5.6 miles long with a rolling terrain exhibited by vertical changes in grade throughout the corridor (refer to **Photograph 3**). The travel lanes are 12 feet wide in each travel direction and there is a grass median of variable width throughout the study area. US 360 is oriented in a general northeast/southwest direction with a posted speed limit of 45 MPH east of Woodlake Village Parkway and 50 MPH west of Woodlake Village Parkway. For the purposes of this study, the corridor was considered to have an east/west alignment and is referred to only as US 360 throughout the study. Based on the latest (2012) published VDOT traffic volume data, the approximate annual average daily traffic (AADT) on US 360 ranges from 77,000 vehicles per day at the Route 288 interchange to 33,000 vehicles per day at the western end of the study area.

Photograph 3: Eastbound US 360 Approaching Brad McNeer Parkway

Photograph 4: Southbound Route 288 Approaching US 360

- **Route 288 (World War II Veterans Memorial Highway)** is classified as an urban freeway or expressway and intersects regionally with Powhite Parkway, Midlothian Turnpike, W. Broad Street (US 250), I-64, and I-95. It is a four-lane, divided roadway with two 12-foot lanes in each travel direction separated by a 60-foot-wide grass median (refer to **Photograph 4**). There are collector-distributor (CD) roads with two lanes, in the northbound and southbound directions, between US 360 and Commonwealth Centre Parkway. Route 288 is oriented in a general northwest/southeast direction with a posted speed limit of 65 MPH throughout the study area. For the purposes of this study, the corridor was considered to have a north/south alignment and is referred to only as Route 288 throughout the study. Based on the latest (2012) published VDOT traffic volume data, the approximate annual average daily traffic (AADT) on Route 288 ranges from 39,000 vehicles per day south of US 360 to 53,000 vehicles per day north of US 360.

3.1.2 Other Study Roadways

- **Powhite Parkway (Route 76)** is a tolled, limited-access facility that is classified by VDOT as an urban freeway within the study area. Powhite Parkway is a major east-west facility that intersects with Route 288, Courthouse Road, Midlothian Turnpike and Chippenham Parkway. Powhite Parkway provides access to the City of Richmond and Henrico County from Chesterfield County. The segment of Powhite Parkway in the study area has a posted speed limit of 55 MPH. Powhite Parkway terminates at Old Hundred Road/Charter Colony Parkway.
- **Warbro Road (Route 907)** is a north-south road classified as an urban collector. Warbro Road is a two-lane undivided road with a posted speed limit of 45 MPH and provides access to commercial, industrial, and residential land uses.
- **Old Hundred Road (Route 754)** is a north-south road classified as an urban minor arterial within the study area. The segment of Old Hundred Road in the study area is a two-lane undivided road with a posted speed limit of 35 MPH. Old Hundred Road provides access to residential and commercial land uses. Old Hundred Road serves the Brandermill Community, which is comprised of more than 3,700 homes.
- **North Spring Run Road (Route 662)** is a north-south road classified as an urban collector within the study area. The segment of North Spring Run Road in the study area is a two-lane undivided road with a posted speed limit of 45 MPH. North Spring Run Road serves commercial land uses to the north and residential land uses to the south.
- **Winterpock Road (Route 621)** is a north-south road classified as a minor arterial. The segment of Winterpock Road the study area is a two-lane undivided road with a posted speed limit of 35 MPH. Winterpock Road serves commercial land uses to the north and residential land uses to the south.
- **Otterdale Road (Route 667)** is a north-south road classified as an urban collector. Otterdale Road is a two-lane undivided road with a posted speed limit of 45 MPH north of US 360 and 45 MPH south of US 360. Otterdale Road primarily serves residential land uses within the vicinity of the study area; however, Otterdale Road carries a significant amount of truck traffic that bypasses US 360.
- **Woolridge Road (Route 668)** is an east-west road classified as an urban collector within the study area. Woolridge Road is a two-lane undivided road with a posted speed limit of 45 MPH; the portion of Woolridge Road that crosses the Swift Creek Reservoir has been constructed as a four-lane divided section. There are plans to widen Woolridge Road to a four-lane, divided roadway between Genito Road and Otterdale Road. Woolridge Road provides access to residential land uses; however, it carries a significant amount of truck traffic that bypasses US 360.

- **Genito Road (Route 604)** is an east-west road classified as an urban minor arterial. Genito Road is a four-lane divided road with a posted speed limit of 45 MPH east of Old Hundred Road. Genito Road is a two-lane undivided road with a posted speed limit of 35 MPH west of Old Hundred Road. Genito Road provides access to residential and commercial land uses.
- **Bailey Bridge Road (Route 654)** is an east-west road classified as an urban collector. Bailey Bridge Road is a two-lane undivided road with a posted speed limit of 35 MPH. Bailey Bridge Road primarily serves residential and school land uses. Access is provided to Thelma Crenshaw Elementary School, Manchester High School, Bailey Bridge Middle School, and Alberta Smith Elementary School from Bailey Bridge Road. Spring Run Elementary School is located at the west end of the Bailey Bridge Road corridor and has direct access from N. Spring Run Road and Springford Parkway. Bailey Bridge Road crosses under Route 288; however, there is no direct access to/from Route 288.
- **Spring Run Road (Route 654)** is an east-west road classified as an urban collector. The segment of Spring Run Road in the study area is a two-lane undivided road with a posted speed limit of 45 MPH. Spring Run Road primarily serves residential land uses between Bailey Bridge Road and Qualla Road.
- **Claypoint Road (Route 651)** is a north-south road classified as an urban minor arterial. Claypoint Road is a two-lane undivided road with a posted speed limit of 45 MPH. Claypoint Road primarily serves residential land uses. Claypoint Road crosses underneath Route 288; however, there is no direct access to/from Route 288.
- **Qualla Road (Route 653)** is a north-south road classified as an urban minor arterial to the north of Claypoint Road and an urban collector to the south of Claypoint Road. The segment of Qualla Road in the study area is a two-lane undivided road with a posted speed limit of 35 MPH north of Claypoint Road and a posted speed limit of 45 MPH south of Claypoint Road. Qualla Road runs adjacent to Pocahontas State Park and primarily services residential land uses in the vicinity of the study area. Qualla Road crosses over Route 288; however, there is no direct access to/from Route 288.

3.1.3 Interchanges

- **US 360/Route 288 Interchange** is a traditional cloverleaf configuration consisting of four loop ramps and four directional ramps. The interchange is bound by high-tension power lines to the east, Commonwealth Centre to the southwest, and undeveloped property to the northwest.
- **Route 288/Commonwealth Centre Parkway Interchange** is a directional interchange configuration located at the terminus of Commonwealth Centre Parkway. A directional flyover serves the eastbound Commonwealth Centre Parkway to northbound Route 288 movement. This interchange is serviced by northbound and southbound collector-distributor (CD) roads. The northbound CD road extends from 300 feet north of Commonwealth Centre Parkway to 800 feet south of the US 360/Route 288 interchange eastbound to northbound loop ramp. The southbound CD road extends from 750 feet south of the US 360/Route 288 interchange southbound to eastbound loop ramp to 1,300 feet south of Commonwealth Centre Parkway.

Table 11: Inventory of Local Roadways

Local Roadway	Posted Speed Limit	Description
Four-Lane, Divided Roadways		
Memphis Boulevard	25 MPH	– Serves commercial land uses
Commonwealth Centre Parkway	35 MPH	– Serves the Commonwealth Centre retail center, Hunter's Chase apartments and general office – Connection between US 360 and Route 288
Deer Run Drive	35 MPH	– Serves the Deer Run subdivision and commercial land uses
Chital Drive	35 MPH	– Serves the Deer Run subdivision and commercial land uses.
Hancock Village	25 MPH	– Serves the Hancock Village shopping center
Ashlake Parkway	35 MPH	– Ashlake Parkway serves the Ashbrook neighborhood
Woodlake Village Parkway	35 MPH	– Serves the more than 2,700 home Woodlake Community
Two-Lane, Undivided Roadways		
Bridgewood Road	25 MPH	– Serves residential land uses
Lonas Parkway	45 MPH	– Serves residential and commercial land uses. – Lonas Parkway will provide access to the undeveloped land in the southeast quadrant the US 360/Route 288 interchange
Market Square Lane	Not Posted	– Provides access to Market Square retail center and Tomahawk Baptist Church – Has direct access to US 360 and Old Hundred Road
Village Green Drive	25 MPH	– Provides access to office, hotel, and residential land uses
Brad McNeer Parkway	35 MPH	– Provides access to commercial and residential land uses
Craig Rath Boulevard	25 MPH	– Provides access to commercial and residential land uses
Harbour Pointe Parkway	25 MPH	– Provides access to commercial and residential land uses
Mockingbird Lane	25 MPH	– Provides access to commercial and residential land uses
Bayside Lane	25 MPH	– Provides access to Harbour Point Village and residential land uses
Harbour View Court	25 MPH	– Provides access to the Harbour Pointe Village shopping center
Temie Lee Parkway	25 MPH	– Provides access to commercial and residential land uses
Lake Harbour Drive	25 MPH	– Provides access to commercial land uses, including Winterpock Crossing
Duckridge Boulevard	25 MPH	– Provides access to commercial and residential land uses
Cosby Road	25 MPH	– Serves residential and recreational land uses
Fox Club Parkway	45 MPH	– Serves residential land uses and Cosby High School
Hampton Park Drive	35 MPH	– Serves Hampton Park subdivision and Woodlake United Methodist Church
Millridge Parkway	30 MPH	– Serves the Brandermill community
Springford Parkway	45 MPH	– Serves residential land uses – Connects Bailey Bridge Road and Winterpock Road
McEnnally Road	25 MPH	– Connects North Spring Run Road to Winterpock Road
Ashbrook Parkway	35 MPH	– Serves the Ashbrook neighborhood
Harpers Mill Parkway	35 MPH	– Serves the Harpers Mill neighborhood
Two-Lane, Divided Roadways		
Royal Birkdale Boulevard	25 MPH	– Serves as an entrance into the Birkdale neighborhood

3.1.4 Interchange Spacing

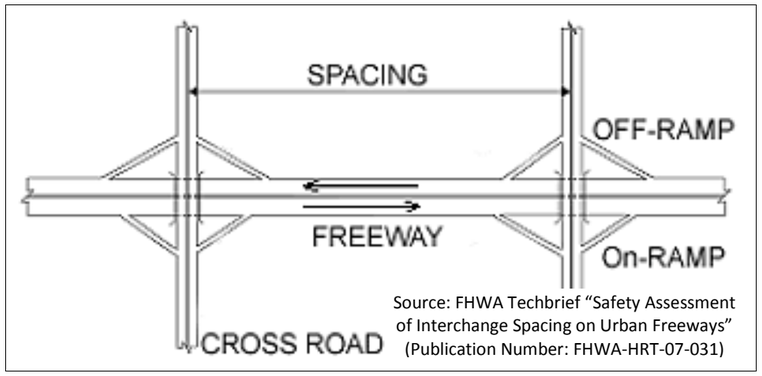
Existing interchange spacing between crossroads within the study area is summarized in **Table 12**. According to the AASHTO Green Book, the general rule of thumb for minimum interchange spacing is one mile for urban freeways. FHWA's Techbrief "Safety Assessment of Interchange Spacing on Urban Freeways" (Publication Number FHWA-HRT-07-031), defines interchange spacing as the distance between interchange crossroads as shown in **Figure 15**. Route 288 meets AASHTO's one-mile interchange spacing criterion between each interchange with the exception of US 360 and Commonwealth Centre Parkway; however, this is mitigated by the existing low-speed CD road provided access between the two roadways.

Table 12: Interchange Spacing

From	To	Interchange Spacing (mile)	Deficient Distance (mile)
Powhite Parkway	US 360	2.65	-
US 360	Commonwealth Centre Parkway	0.70	0.30*
Commonwealth Centre Parkway	Courthouse Road	3.30	-

*A CD road is provided to serve the Commonwealth Centre Parkway interchange

Figure 15: Interchange Spacing Measurement



Source: FHWA Techbrief "Safety Assessment of Interchange Spacing on Urban Freeways" (Publication Number: FHWA-HRT-07-031)

3.1.5 Acceleration/Deceleration Lane Lengths

An inventory of existing freeway acceleration and deceleration lane lengths is provided in **Table 12**. A summary of weaving segment lengths and number of lanes is provided in **Table 14**.

3.1.6 Existing Lane Assignments

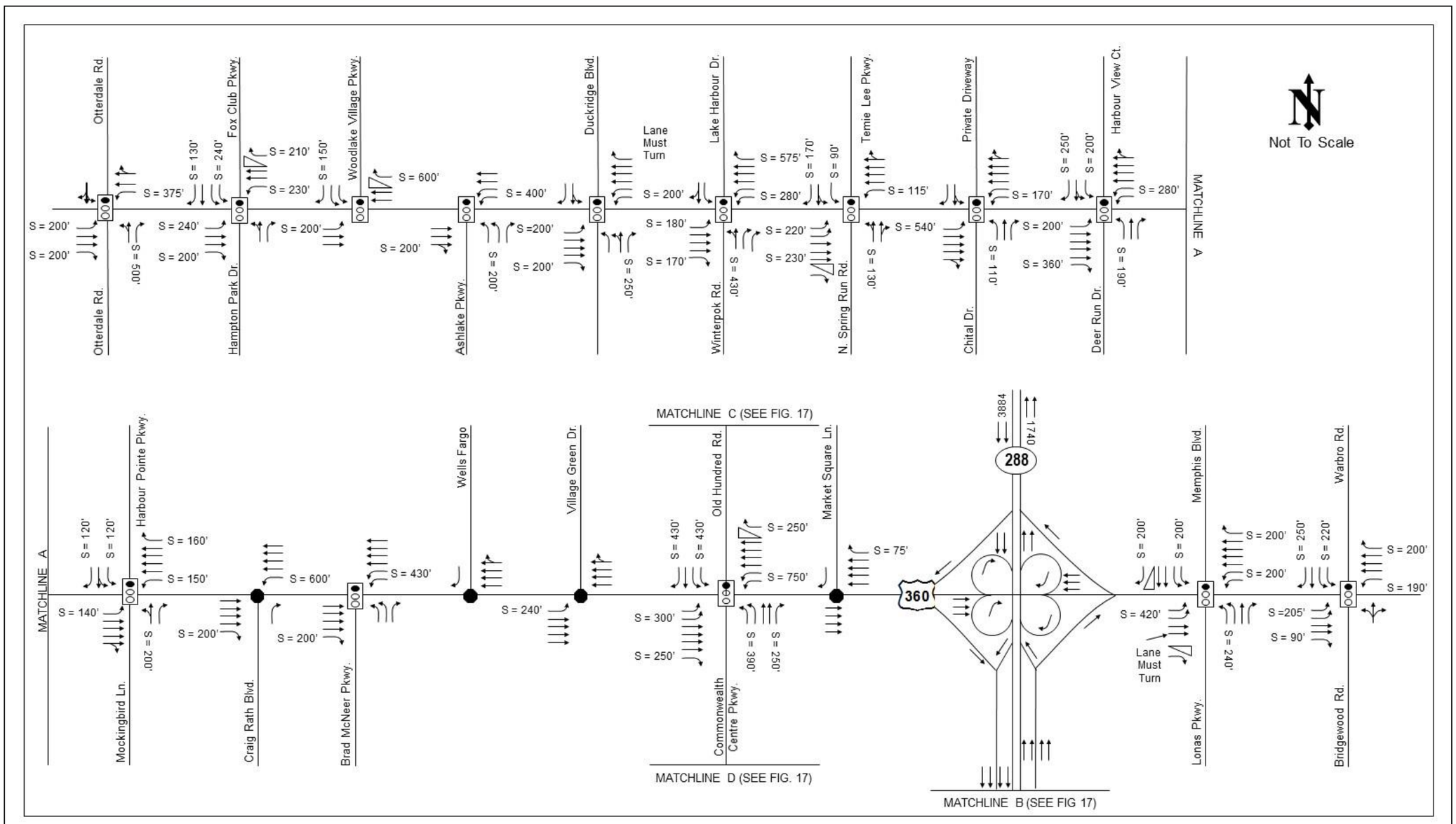
An inventory of existing turn lane geometry including turn-lane storage lengths was conducted for the US 360 study area. Detailed existing (2012) lane configurations, storage lengths, and traffic control at each of the 22 study area intersections is summarized in **Figure 16** and **Figure 17**. These geometric features were used as input for the analysis of the existing conditions.

Table 13: Acceleration and Deceleration Lanes

Route 288 Interchange	Direction of Travel	Number of Deceleration Lanes	Deceleration Lane Length	Number of Acceleration Lanes	Acceleration Lane Length
US 360	SB to WB	1	525 feet	-	-
	EB to SB	-	-	1	>1,500 feet
	NB to EB	1	>1,500 feet	-	-
	WB to NB	-	-	1	625 feet
Route 288 CD Road to/from Commonwealth Centre Parkway	SB 288 to SB CD	1	Taper Only	-	-
	SB CD to SB 288	-	-	1	400 feet
	NB 288 to NB CD	-	Taper Only	-	-
	NB CD to NB 288	-	-	-	Taper Only
Commonwealth Centre Parkway	SB CD to WB	1	1000 feet	-	-
	EB to SB CD	-	-	1	400 feet

Table 14: Weaving Segments

Roadway	Weaving Segment	Number of Weaving Lanes	Weaving Segment Length
US 360	EB to SB	3	600 feet
	SB to EB	3	600 feet
	EB to NB	3	650 feet
	NB to WB	3	650 feet
Commonwealth Centre Parkway	EB to NB	2	950 feet

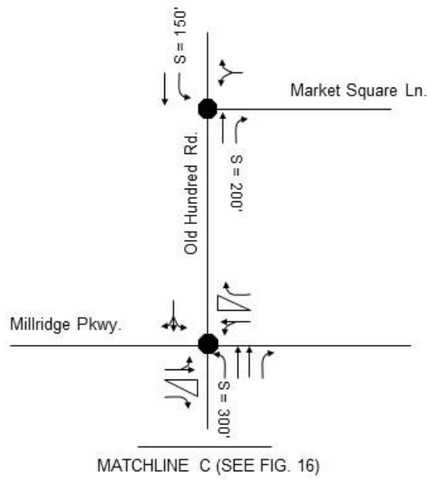


Legend

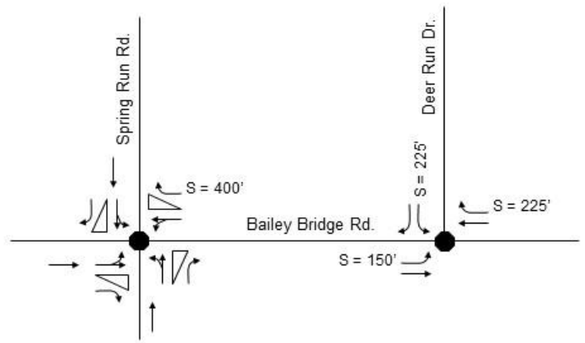
- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

Existing (2012) Lane Configurations (1 of 2)
US 360/Route 288 Interchange Study

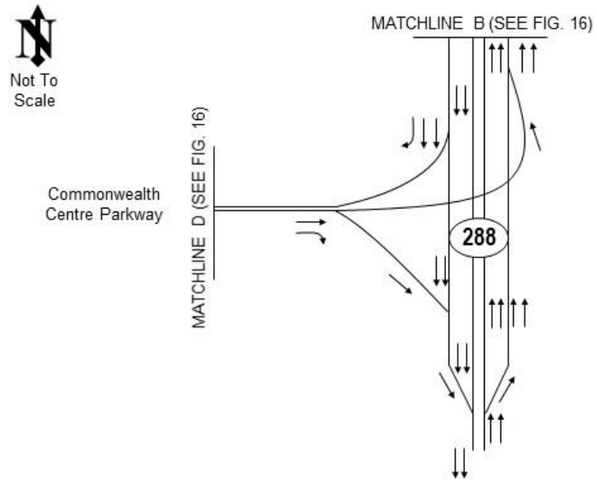
Figure 16



Old Hundred Road at Millridge Parkway and Market Square Lane



Bailey Bridge Road at Spring Run Road and Deer Run Road



Commonwealth Centre Parkway at Route 288

Legend

- Existing Lane Assignment
- Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

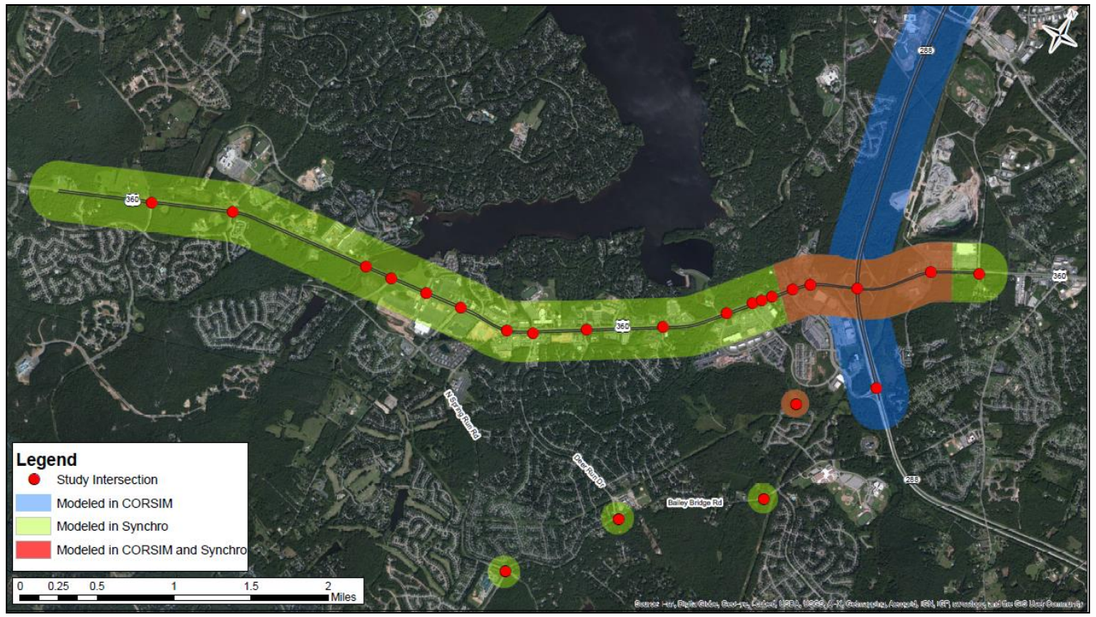
Existing (2012) Lane Configurations (2 of 2)
US 360/Route 288 Interchange Study

Figure 17

4.0 Existing (2012) Conditions

Two traffic analysis tools— CORSIM, Version 6.3 and Synchro, Version 8—were used to evaluate traffic operations within the study area. CORSIM was used to simulate freeway operations and Synchro was used to simulate arterial operations. The signalized intersections adjacent to the US 360/Route 288 interchange were modeled in both CORSIM and Synchro. **Figure 18** graphically depicts where each tool was used in the study area.

Figure 18: Application of Analysis Tools



4.1 Existing (2012) Conditions Interchange Operational Results

4.1.1 CORSIM Modeling Assumptions

A base CORSIM model was developed using existing scaled aerial photography for the project study area and the necessary coding to simulate the mainline freeway segments and ramps. Signal timings for the existing intersections at US 360 at Old Hundred Road/Commonwealth Centre Parkway and US 360 at Memphis Boulevard/Lonas Parkway were utilized. The existing AM and PM peak hour volumes, summarized in **Figures 4** through **6**, were then input into CORSIM. The model was setup to run for a 1-hour recording period with a preceding 15-minute seeding period. After correcting any errors, the average of 10 simulation runs was used to record statistics to determine how closely calibrated the simulation model matched the field observed traffic volumes and specified traffic speeds. Posted speed limits were coded on freeway and arterial links. Field-observed AM and PM peak traffic volumes were compared to the simulated volumes for the corresponding AM and PM peak CORSIM models for each of the freeway and ramp segments. The target threshold of ±10% was achieved for traffic volumes.

4.1.2 CORSIM Results

The existing (2012) operations along Route 288 were evaluated using CORSIM. The analysis results, which include the average of 10 CORSIM analysis runs, for the freeway segments within the study area during both AM and PM peaks are presented in **Figure 19** and **Figure 20**. Freeway operations results are presented in graphical format which depicts vehicle travel speeds and densities by segment and by lane are provided in **Appendix B**.

Three ramp movements critical to the operation of the US 360/Route 288 interchange were identified based on the operational analysis results. Specific operational and safety measures are summarized in **Table 15**. The following key conclusions were determined from the AM and PM peak hour analysis results:

Southbound Route 288 to Westbound US 360 Off-Ramp

- Travel speeds decrease and freeway densities increase at the southbound Route 288 to westbound US 360 exit ramp during the PM peak hour. This impacts the mainline operations of southbound Route 288, including exiting vehicle queues extending beyond the existing deceleration lane to westbound US 360.

Eastbound US 360 to Northbound Route 288 On-Ramp

- In the AM peak hour, analysis results indicate travel speeds decrease and densities increase at the eastbound US 360 to northbound Route 288 on-ramp. This impacts the mainline operations of northbound Route 288 through reduced travel speeds north of US 360.

Northbound Route 288 to Westbound US 360 Off-Ramp

- In the PM peak hour, analysis results indicate densities increase at the northbound Route 288 to westbound US 360 off-ramp. Travel speeds slow down within the weaving area of northbound Route 288 at US 360.

4.2 Existing (2012) Conditions Intersection Operational Results

A Synchro, Version 8, model was developed to analyze the 24 study area intersections located on the arterials within the study area. HCM 2000 methodology was used for all analyses using Synchro. Existing signal timing parameters were provided by VDOT and are included in **Appendix A** for reference.

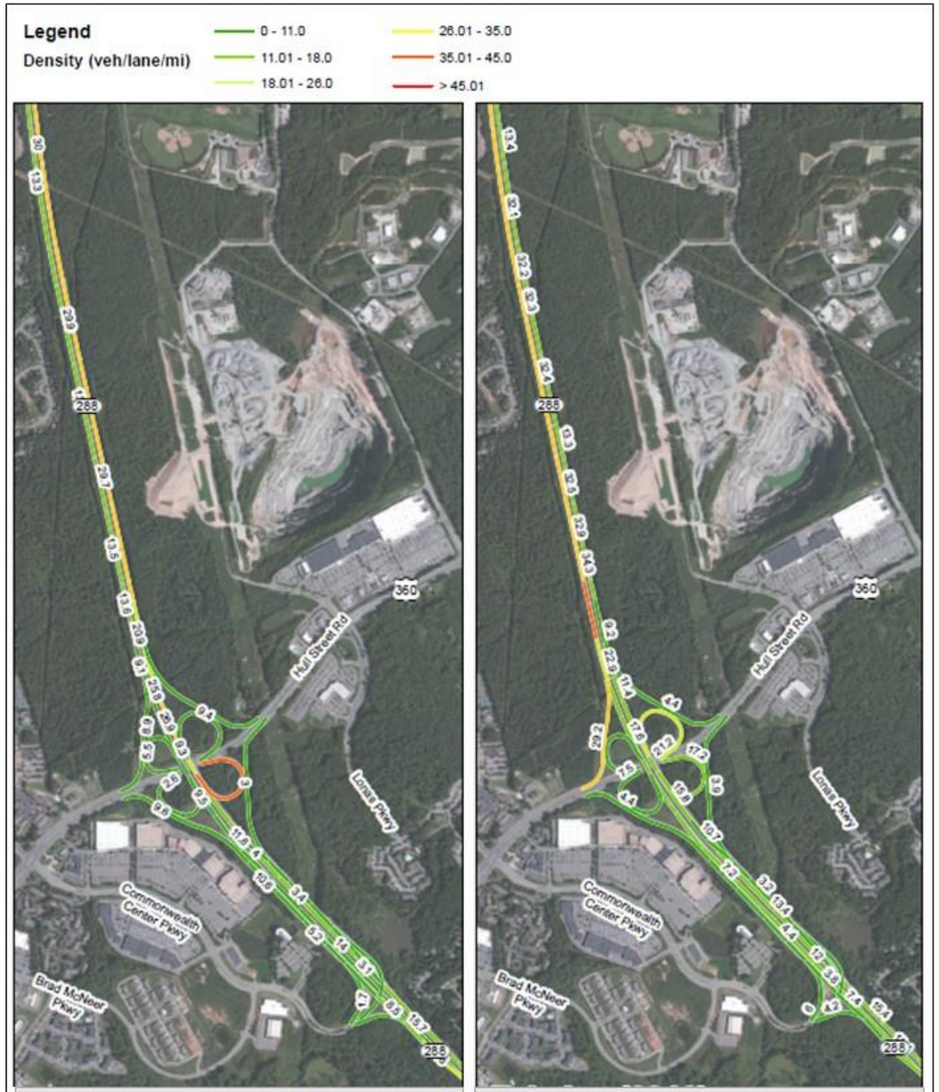
4.2.1 Synchro Modeling Assumptions

The Synchro model was calibrated to reflect the existing traffic conditions observed during the field review. The signal timing results for each peak hour from Synchro were then input into each peak hour model in CORSIM. For this operational analysis, the following assumptions were used:

- 12-foot lane widths
- Heavy vehicle percentages by approach from turning movement count data
- Peak hour factors (PHFs) by approach from turning movement count data
- Existing lane geometry (shown in **Figure 16** and **Figure 17**)
- Existing traffic signal timings and phasing for all signalized intersections
- Balanced existing peak hour traffic volume data
- Field review observations of existing queue lengths and corridor operations

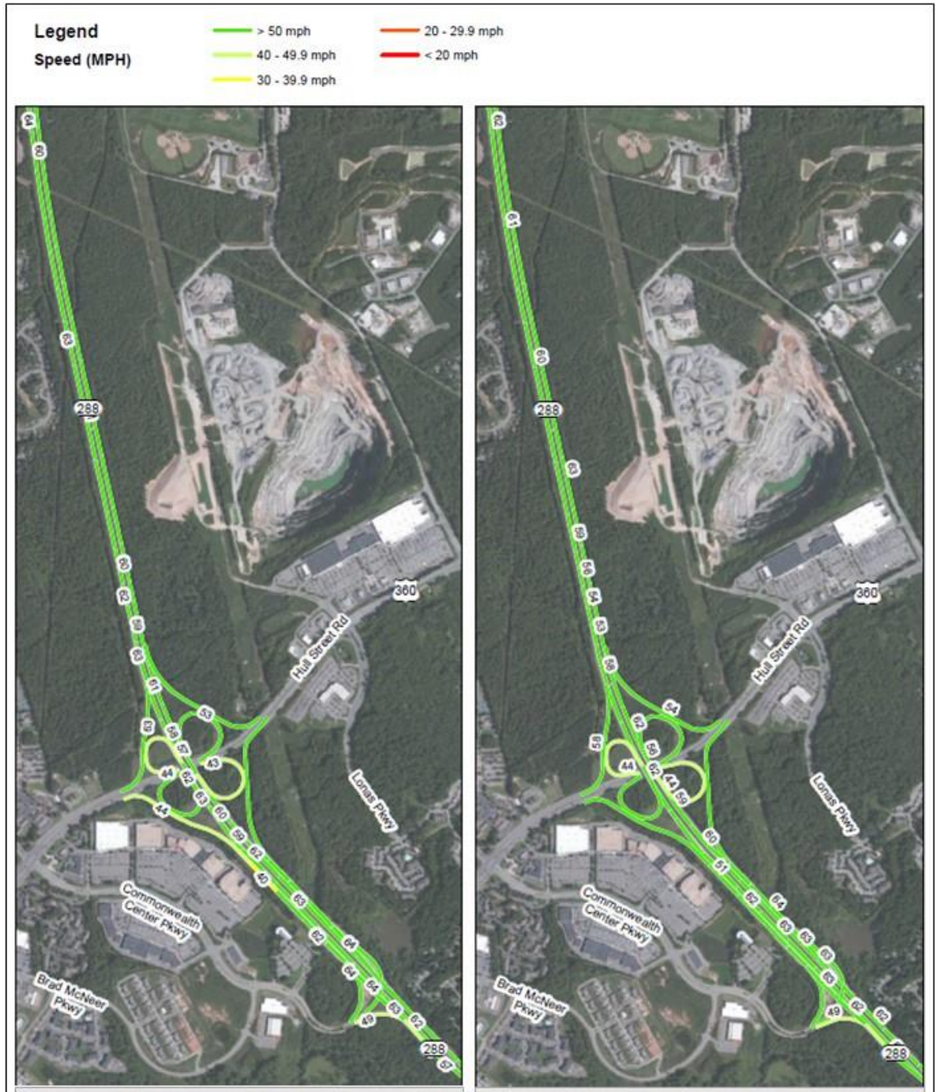
Table 15: US 360/Route 288 Interchange Critical Ramps – Existing (2012)

Southbound Route 288 to Westbound US 360 Off-Ramp	Eastbound US 360 to Northbound Route 288 On-Ramp	Northbound Route 288 to Westbound US 360 Off-Ramp
Peak Hour Issue ▪ PM Peak Hour Traffic Volumes ▪ Existing (2012): 1,722 vehicles per hour Queues ▪ Existing (2012): 1,500 feet – Extends beyond the southbound Route 288 deceleration lane Speeds ▪ Existing (2012): between 55 and 60 MPH Crashes ▪ Existing (from 2010 to 2013) during PM peak period (3:00 to 7:00 PM): – One ramp crash and 41 crashes on Route 288 mainline upstream » Predominant crash type: 35 rear-end crashes » Severity: 12 injury, 29 property damage only (PDO), one fatal (description of fatal crash is provided in **Section 2.5.1**)  **Photograph 5: Southbound Route 288 to Westbound US 360 Off-Ramp – PM Peak Hour**	Peak Hour Issue ▪ AM Peak Hour Traffic Volumes ▪ Existing (2012): 1,838 vehicles per hour Queues ▪ Existing (2012): – None on Route 288 (contained within weave area) – Approximately 1 mile on eastbound US 360 Speeds ▪ Existing (2012): between 10 and 20 MPH ▪ No-Build (2040): between 10 and 16 MPH Crashes ▪ Existing (from 2010 to 2013) during AM peak period (6:00 to 10:00 AM): – One ramp crash and 28 in weave section » Predominant crash type: 26 rear-end crashes » Severity: Four injury, 25 PDO  **Photograph 6: Eastbound US 360 to Northbound Route 288 – AM Peak Hour**	Peak Hour Issue ▪ PM Peak Hour Traffic Volumes ▪ Existing (2012): 1,170 vehicles per hour Queues ▪ Existing (2012): – None on Route 288 (contained within weave area) Speeds ▪ Existing (2012): between 55 and 60 MPH Crashes ▪ Existing (from 2010 to 2013) during PM peak period (3:00 to 7:00 PM): – Zero ramp crashes and eight in weave section » Predominant crash type: Six rear-end crashes » Severity: Two injury, six property damage only



Existing (2012) – Route 288 CORSIM Results - Density
US 360/Route 288 Interchange Study

Figure 19



Existing (2012) – Route 288 CORSIM Results - Speed
US 360/Route 288 Interchange Study

Figure 20

4.2.2 Synchro Model Results

The following MOEs were selected to measure the quantitative performance of the intersections within the network:

» Average vehicle delay and High Capacity Manual (HCM) level of service (LOS) by movement, approach, and intersection (measured in seconds per vehicle)
» Maximum queue length (measured in feet)

Tables summarizing the delay, HCM LOS, and queuing results for the study area intersections are included in **Appendix B**. **Figure 21** and **Figure 22** show a graphical representation of the LOS results in the study area. Key findings for the intersection analysis are summarized in the subsequent sections

4.2.2.1 Delay and Level of Service

Delays and associated LOS for both signalized and unsignalized intersections are reported from the Synchro analysis. The results, provided in **Appendix B**, indicate that a majority of the signalized intersections operate at LOS D or worse during the AM and PM peak hours. The following key delay and level of service conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- Existing traffic signal timings prioritize mainline progression, which results in longer side street delays
  - Delays on mainline US 360 operate at LOS C or better at every intersection with the exception of Old Hundred Road/Commonwealth Centre Parkway and Harbour Pointe Parkway/Mockingbird Lane due to timing priority
- Side-street approaches generally operate at LOS D or worse
- Intersections west of Temie Lee Parkway operate at overall LOS C or better

PM Peak Hour

- Existing traffic signal timings prioritize mainline progression, which results in longer side street delays
  - Delays on mainline US 360 operate at LOS C or better at every intersection with the exception of Old Hundred Road/Commonwealth Centre Parkway and Harbour Pointe Parkway/Mockingbird Lane due to timing priority
- Side-street approaches generally operate at LOS D or worse
- Intersections west of Temie Lee Parkway operate at overall LOS C or better

4.2.2.2 Queue Lengths

The maximum queues are reported from an average of 10 simulation runs in SimTraffic. Tables in **Appendix B** summarizes the average AM and PM peak hour 95th percentile and maximum queue lengths for each lane group at all study area intersections. The following key queuing conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- US 360 queues are heavier in the eastbound direction due to the heavier eastbound volumes in the AM peak hour
- US 360 at Old Hundred Road/Commonwealth Centre Parkway is a critical intersection along the facility
  - Eastbound traffic on US 360 queue from Harbour Pointe Parkway/Mockingbird Lane
- Vehicles queue on eastbound US 360 from Temie Lee Parkway/North Spring Run Road to Duckridge Boulevard/Lake Harbour Drive

PM Peak Hour

The following key conclusions were determined from the PM peak hour analysis results:

- US 360 queues are heavier in the westbound direction during the PM peak hour
- US 360 at Old Hundred Road/Commonwealth Centre Parkway is a critical intersection along the facility
  - The westbound queue on US 360 extends upstream through the southbound Route 288 to westbound US 360 off-ramp
- Westbound left-turn lane queues on US 360 from Harbour Pointe Parkway/Mockingbird Lane to Winterpock Road extend beyond the existing storage lane lengths
- Queues on the side street approaches along US 360 west of Route 288 extend beyond the existing storage lengths

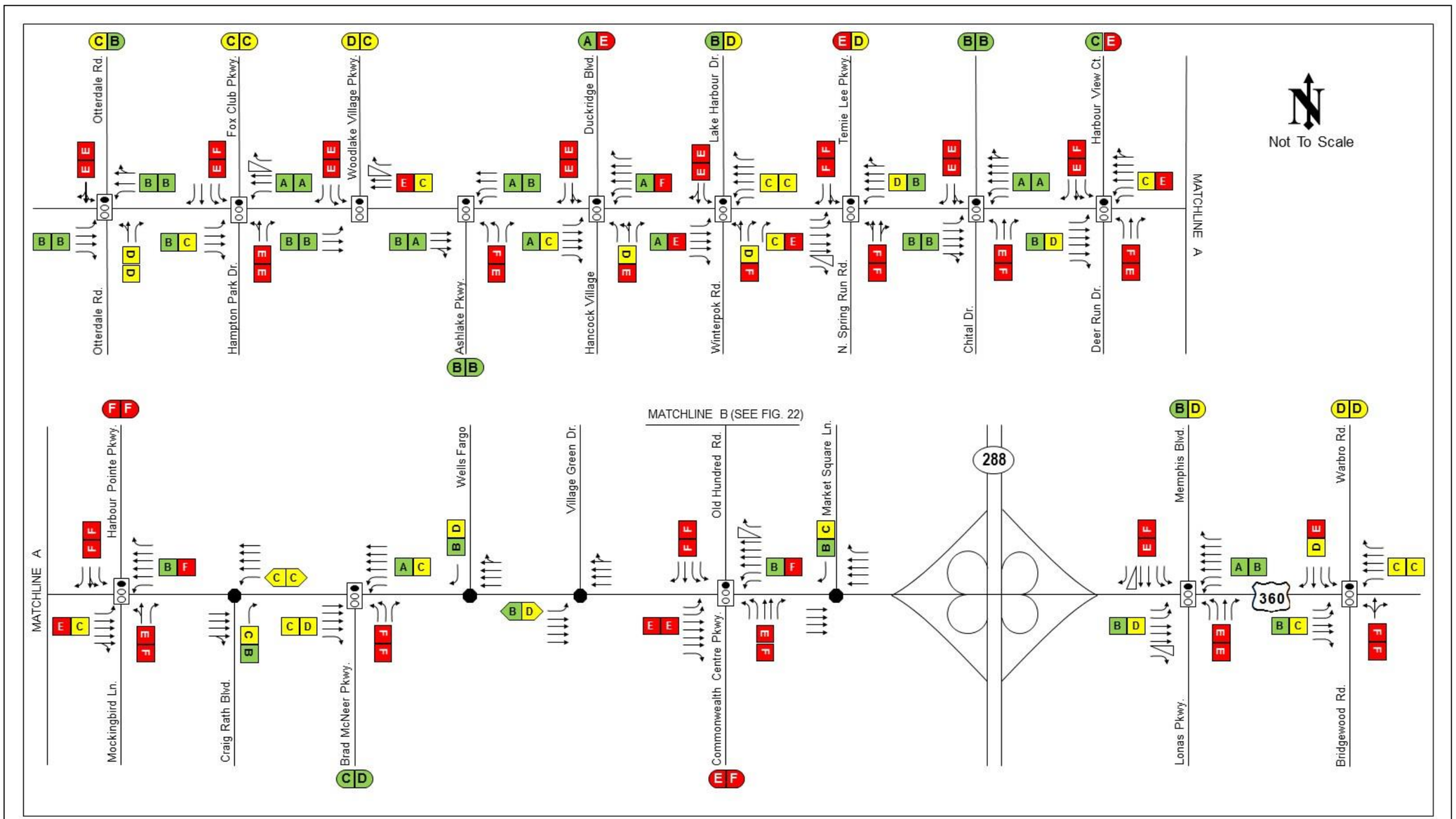
4.3 Summary of Existing (2012) Conditions

Analysis results indicate that three ramps at the US 360/Route 288 interchange are critical to the operations of Route 288:

» Southbound Route 288 to westbound US 360 off-ramp
» Eastbound US 360 to northbound Route 288 on-ramp
» Northbound US 360 to westbound US 360 off-ramp

These ramps are operating at or above capacity under existing conditions, which is consistent with field observations. Analysis results conclude that the intersection of US 360 at Old Hundred Road/Commonwealth Centre Parkway is a critical intersection to the operations of US 360 and the US 360/Route 288 interchange. Westbound queues during the PM peak hour have an impact on the southbound Route 288 to westbound US 360 off-ramp.

Many of the intersections along US 360 west of Route 288 are operating at capacity. US 360 experiences directional splits in traffic volumes; however, intersection delays are generally higher during the PM peak hour.

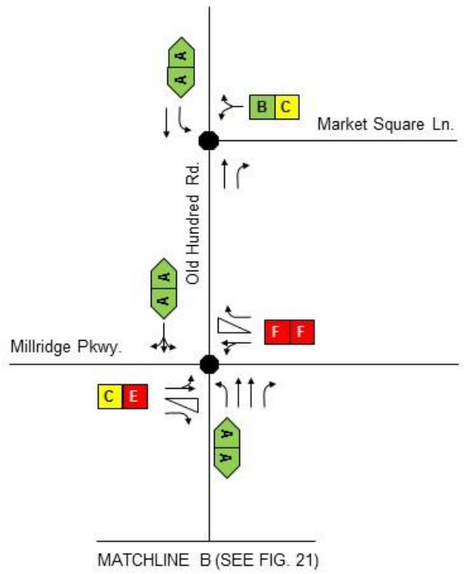


Existing (2012) – Intersection Level of Service
US 360/Route 288 Interchange Study

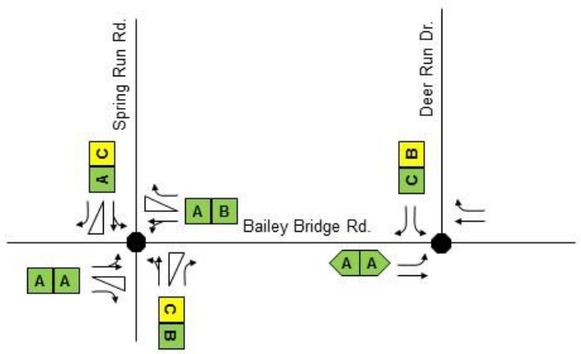
Figure 21

N
Not To Scale

Old Hundred Road at Millridge Parkway and Market Square Lane



Bailey Bridge Road at Spring Run Road and Deer Run Road



Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal
- AM | PM Intersection LOS
- AM | PM Approach LOS
- AM | PM Movement LOS

Existing (2012) – Intersection Level of Service
US 360/Route 288 Interchange Study

Figure 22

5.0 Future Year 2040 Traffic Volumes

In order to understand future traffic conditions on the study corridors, traffic volumes were forecasted for the future year analysis. VDOT identified 2040 as the Design Year for traffic analysis. The following sections describe the methodology for developing growth rates and projecting future traffic volumes for the study corridor.

5.1 Sub-Area Travel Demand Model

Using Citilabs' CUBE/Voyager software, VDOT staff developed a sub-area travel demand model for the Route 288/360 study from the Richmond/Tri-Cities regional travel demand model, which had a base year of 2008 and a future forecast year of 2035. A screenshot showing the sub-area model interface is shown in **Figure 23**. The sub-area model had a base year of 2008, an existing year of 2012, and a future forecast year of 2035. The model study area is shown in **Figure 24**. The area of western Chesterfield County covered by the sub-area model is shaded in green, with the regional model transportation analysis zones (TAZs) outlined in orange. Seventy regional model TAZs were covered by the sub-area model, which were disaggregated into 106 sub-area model TAZs for the study effort. The regional model TAZs outlined in red in **Figure 24** were the TAZs which were disaggregated; these TAZs were concentrated in the core area of the study. The sub-area model included a daily and peak period model component and was calibrated to simulate average weekday traffic (AWDT). The sub-area model was developed with an existing year of 2012 and a forecast year of 2035.

Figure 23: Study Sub-Area Travel Demand Model Interface

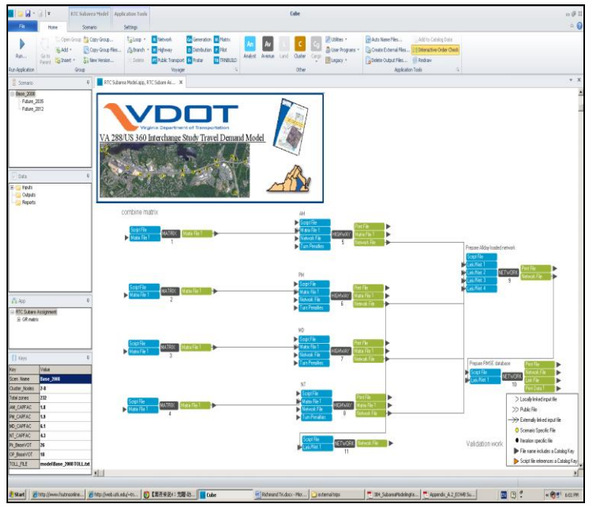
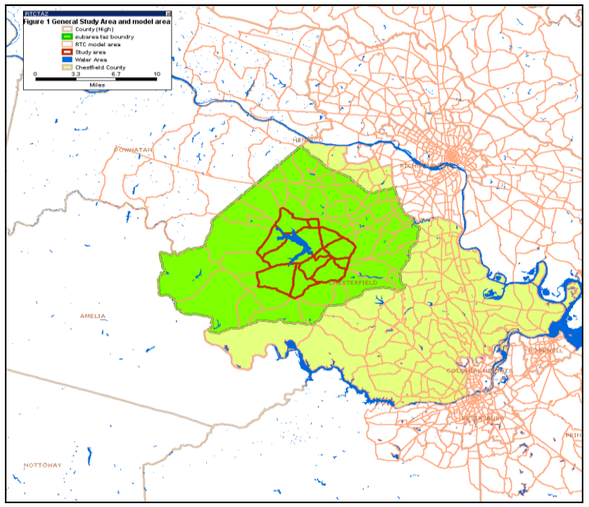


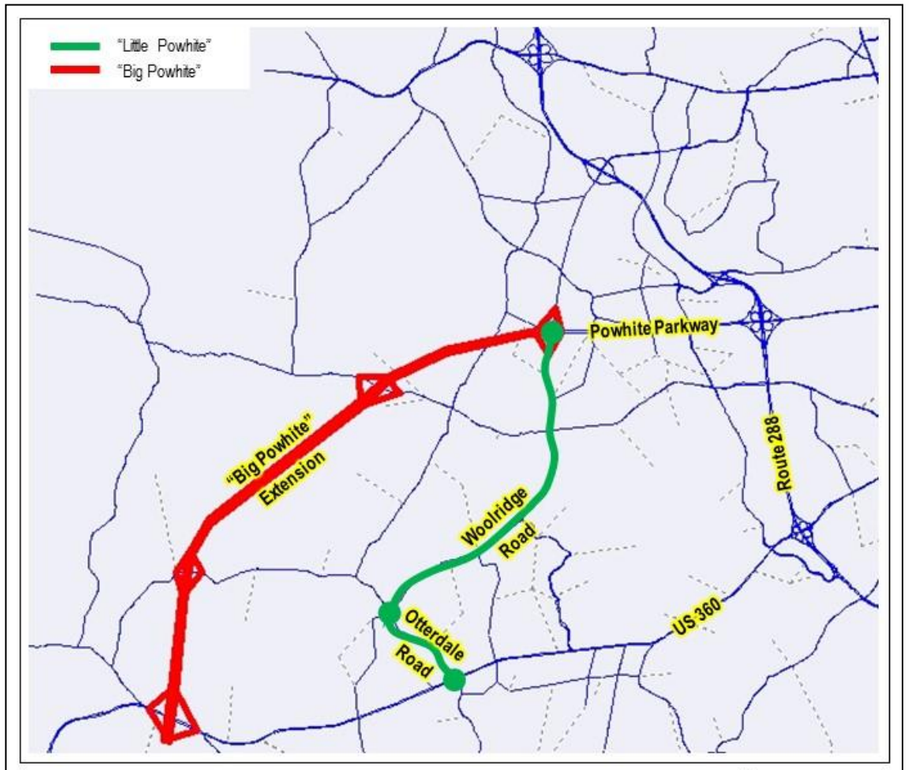
Figure 24: Study Sub-Area Travel Demand Model Area



VDOT worked cooperatively with the Richmond Regional Planning District Commission (RRPDC) and Richmond Regional Transportation Planning Organization (RRTPO) to develop study area land use consistent with the 2035 MPO Constrained Long Range Plan (CLRP). Land use was updated and disaggregated into smaller sub-area model TAZs based on RRPDC available data as of July 2012. Land use data types used for the sub-area modeling effort were the same as those used in the regional Richmond/Tri-Cities travel demand model. Origin-destination data, daily traffic counts, and turning movement counts collected in 2012 for study area were used to calibrate the sub-area model to 2012 existing conditions. The network for the subarea was extracted from the Richmond/Tri-Cities regional model and refined to accommodate additional TAZs and secondary roadway connections not included in the regional model network. The 2035 RRTPO MPO CLRP served as the basis for the additional projects included in the sub-area model network.

5.1.1 "Little Powhite" vs. "Big Powhite"

At the request of Chesterfield County, the study team performed travel demand modeling analysis to determine what the benefit of the "Little Powhite" vs. the "Big Powhite" was to traffic operations in the US 360/Route 288 interchange area. **Figure 25** illustrates "Little Powhite" and "Big Powhite" as shown in the Chesterfield County Comprehensive Plan. The "Little Powhite" is a planned four-lane roadway extending from Powhite Parkway to US 360 via Woolridge Road and Otterdale Road. Much of the planned "Little Powhite" already exists today as a two-lane roadway. The "Big Powhite" is envisioned to extend south as a limited access facility and intersect US 360 just west of Beaver Bridge Road.

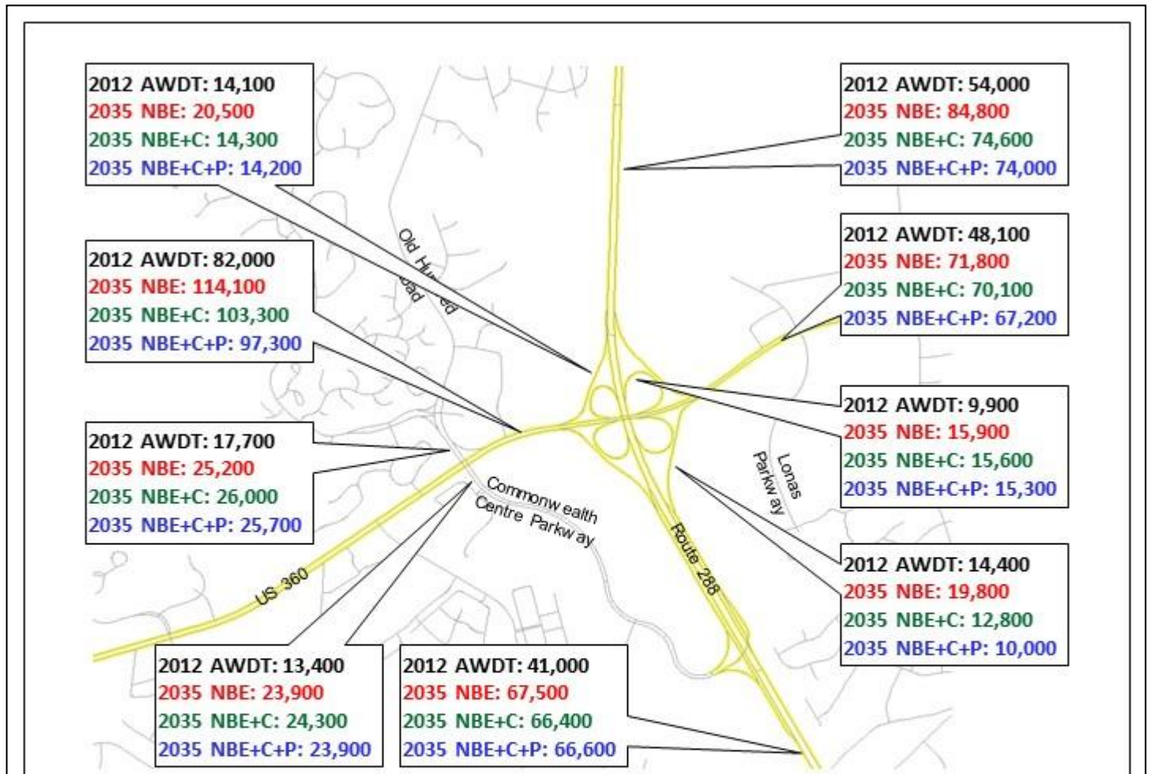


"Big Powhite" vs. "Little Powhite"
US 360/Route 288 Interchange Study

Figure 25

The results of this analysis is shown in for the area near the US 360/Route 288 interchange. **Figure 26** summarizes the refined traffic forecasts, rounded to the nearest 100 vehicles, for the following four travel demand model scenarios:

- Scenario 1 – 2012 AWDT and existing 2012 roadway network
- Scenario 2 – 2035 projected No-Build AWDT and existing 2012 roadway network
- Scenario 3 – Scenario 2 + Fiscal Year 13–18 Committed Projects (includes "Little Powhite")
- Scenario 4 – Scenario 3 + "Big Powhite" Extension



"Big Powhite" vs. "Little Powhite" - Projected 2035 AWDT
US 360/Route 288 Interchange Study

Figure 26

The following conclusions were reached based on the travel demand modeling results:

- Implementing the Little Powhite (Scenario 3) results in a significant reduction in traffic volumes at the US 360/Route 288 interchange area when compared to the future 2035 projected No-Build traffic volumes (Scenario 2).
- The additional benefit of building the "Big Powhite" (Scenario 4) versus the "Little Powhite" (Scenario 3) to traffic operations at the Route 288/360 interchange area was found to be small. Further analysis suggested that the reason for this was that the percentage of traffic passing through the US 360/Route 288 interchange to points west of the proposed Big Powhite interchange with US 360 was only in the range of 10 to 15 percent.
- Fiscal Year 13-18 Committed roadway projects, which includes "Little Powhite", will significantly reduce but not eliminate additional traffic growth through the US 360/Route 288 interchange from 2012 to 2035.
- "Big Powhite" results in little additional reduction to traffic through Route 288/US 360 interchange beyond the benefits already achieved through the Fiscal Year 13–18 Committed roadway projects which includes the "Little Powhite".
- Other Fiscal Year 13–18 Committed roadway projects (e.g., Ashbrook Parkway) which improve connectivity can significantly reduce traffic along portions of US 360.

The "Big Powhite" was found to have little success reducing traffic volumes through the US 360/Route 288 interchange beyond the "Little Powhite." The "Little Powhite" is currently planned, while there is no timeline to implement the "Big Powhite." For these reasons, future traffic volume projections were developed assuming only the "Little Powhite" is implemented by the future year 2035.

5.2 Projected No-Build (2040) Traffic Volumes

A future (2040) traffic conditions analysis was required to evaluate how a proposed improvement (e.g., roadway widening, interchange modification, construction of an acceleration/deceleration lane, etc.) would operate under future traffic conditions. Future (2040) traffic projections were developed from a process involving a review of traffic volumes from several sources, including existing VDOT counts, the calibrated US 360/Route 288 sub-area travel demand model, and counts conducted as a part of this study.

The existing (2012) existing and future (2035) projected traffic volumes were used to develop growth rates as needed for study area locations. The exponential growth rates was generally used and rounded to the nearest tenth of a percentage point. Initially, all future year forecasts for the study effort were developed for the year 2035; however, in mid-2014, the Study Work Group (SWG) decided to update the future year to 2040 to better align with other long-range regional planning efforts. As a result, all final study forecasts were developed for a 2040 year using the 2012 to 2035 growth rate from the sub-area model. **Figure 27** shows the resulting growth rates developed for US 360/Route 288 study area locations. **Table 16** summarizes the resulting projected 2035 average daily traffic volumes on study area roadways.

Existing (2012) peak hour traffic volumes were exponentially grown using the growth rates shown in **Figure 27** to generate 2040 traffic volumes. The projected volumes were re-balanced throughout the study network. The projected 2040 AM and PM peak hour volumes for the study corridors are summarized in **Figures 28** through **30**. SWG members approved the process, and consensus was reached on the derived traffic volumes.

Figure 27: No-Build (2040) Growth Rates

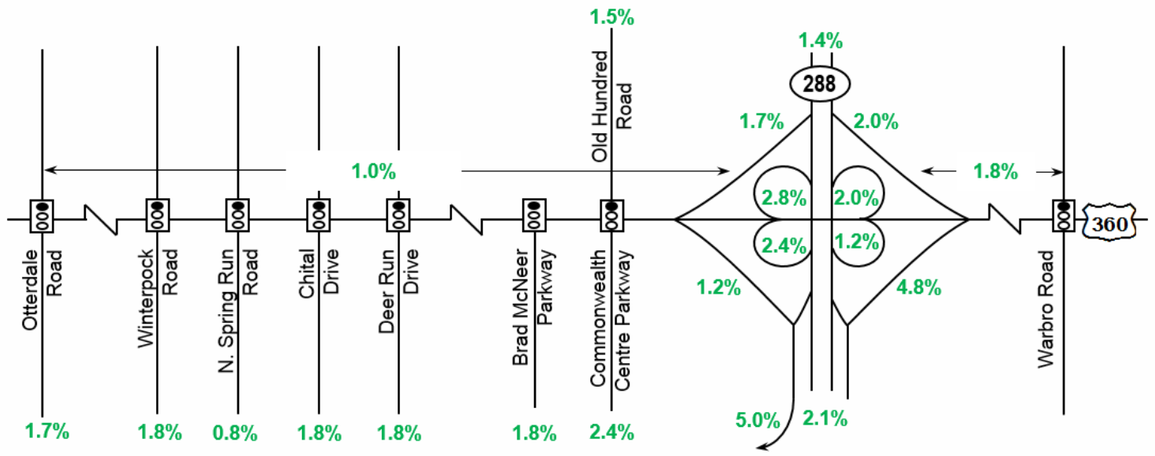
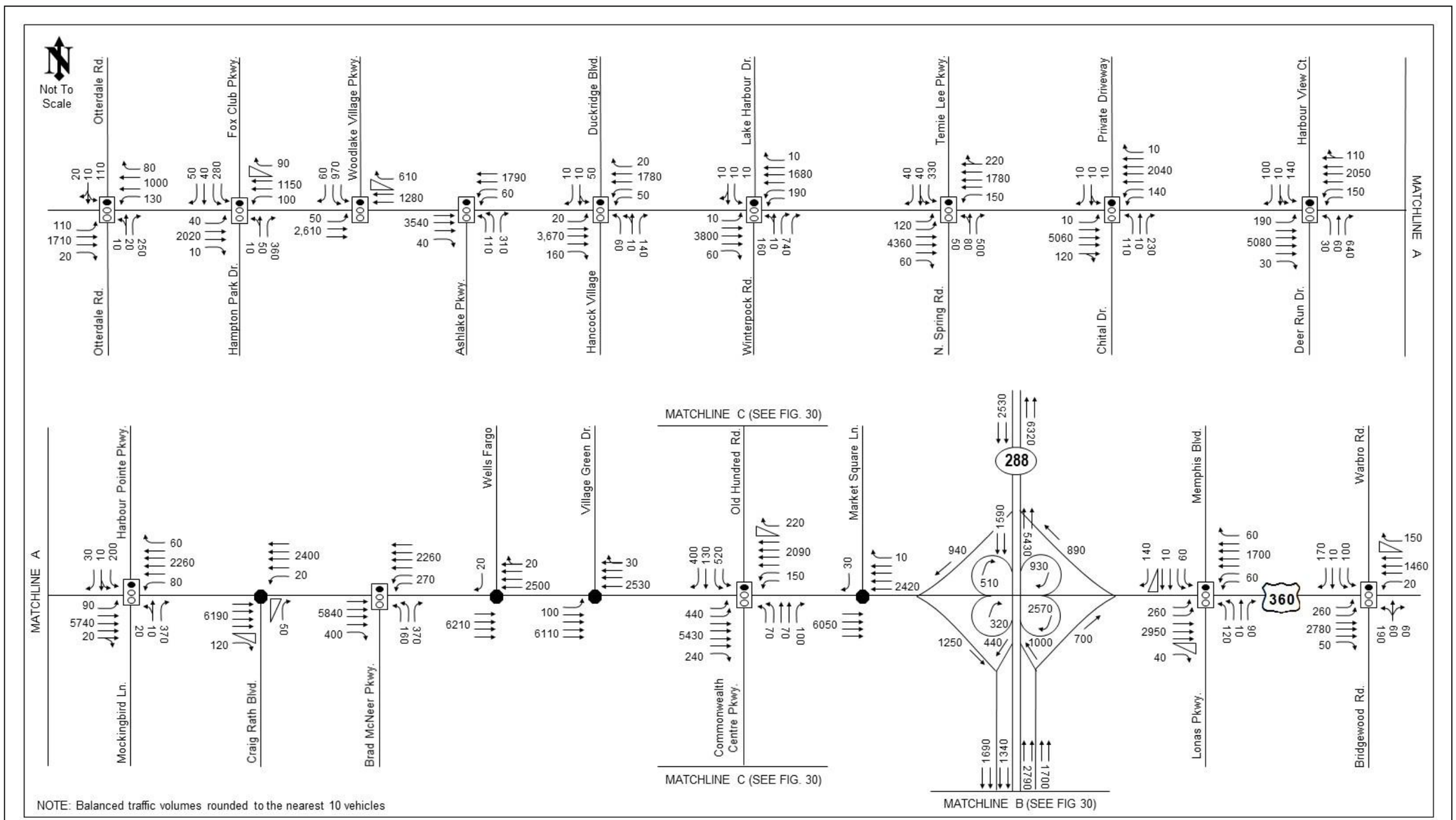


Table 16: No-Build (2035) Growth Rates and Average Annual Daily Traffic (AADT)

Roadway		Traffic Counts (AADT)				Sub-Area Model Results for 2012 and 2035 No-Build					Annual	Est. 2040
		2011	2012	2012	2035	2012	2035	Difference	Growth Rate		Growth	No-Build
From	To	VDOT	VDOT	Study	Trendline	AADT	AADT	2035-2012	Linear	Exponential	Rate	AADT
Route 288												
Courthouse	Commonwealth	43,045	41,000	41,000	77,728	48,890	81,374	32,484	2.89%	2.24%	**2.2%**	**76,300**
US 360	Powhite	57,624	54,000	54,000	125,107	62,615	100,038	37,423	2.60%	2.06%	**2.1%**	**95,600**
Route 288 Ramps at US 360												
SB Route 288	WB US 360	NA	14,100	14,100	NA	13,828	20,178	6,350	2.00%	1.66%	**1.7%**	**22,400**
EB US 360	SB Route 288	NA	8,000	8,000	NA	7,752	10,109	2,357	1.32%	1.16%	**1.2%**	**11,100**
NB Route 288	EB US 360	NA	2,600	2,600	NA	2,353	6,914	4,561	8.43%	4.80%	**4.8%**	**9,700**
WB US 360	NB Route 288	NA	3,800	3,800	NA	3,632	5,684	2,052	2.46%	1.97%	**2.0%**	**6,600**
WB US 360	SB Route 288	NA	2,600	2,600	NA	2,711	5,060	2,349	3.77%	2.75%	**2.8%**	**5,600**
SB Route 288	EB US 360	NA	3,400	3,400	NA	3,146	5,431	2,285	3.16%	2.40%	**2.4%**	**6,700**
EB US 360	NB Route 288	NA	14,400	14,400	NA	13,900	18,150	4,250	1.33%	1.17%	**1.2%**	**20,000**
NB Route 288	WB US 360	NA	9,900	9,900	NA	9,762	15,465	5,703	2.54%	2.02%	**2.0%**	**17,400**
US 360												
Memphis	Route 288	39,064	48,100	48,100	69,930	42,564	63,930	21,366	2.18%	1.78%	**1.8%**	**79,000**
Route 288	Old Hundred	64,734	82,000	82,000	123,333	75,963	104,744	28,781	1.65%	1.41%	**1.4%**	**121,300**
Old Hundred	Village Green	64,734	82,000	82,000	123,333	74,072	104,297	30,225	1.77%	1.50%	**1.5%**	**124,400**
Craig Rath	Harbor Pointe	64,734	79,400	79,400	123,333	76,129	105,556	29,427	1.68%	1.43%	**1.4%**	**118,200**
Duckridge	Ashlake	43,639	45,000	45,000	68,265	48,446	67,073	18,627	1.67%	1.42%	**1.4%**	**66,900**
Woodlake Village	Fox Club	27,162	36,300	36,300	67,986	35,191	51,602	16,411	2.03%	1.68%	**1.7%**	**57,900**
Commonwealth Centre												
US 360	Route 288	13,380	13,400	NA	NA	14,120	24,427	10,307	3.17%	2.41%	**2.4%**	**26,100**
Old Hundred Rd												
US 360	Millridge	17,683	17,700	NA	34,476	23,952	33,419	9,467	1.72%	1.46%	**1.5%**	**26,600**
Millridge	Market Square	9,812	9,800	NA	NA	17,508	23,702	6,194	1.54%	1.33%	**1.3%**	**14,200**
Market Square	Brandermill	9,812	9,800	NA	NA	17,508	23,702	6,194	1.54%	1.33%	**1.3%**	**14,200**
Route 288 Ramps at Commonwealth Centre												
SB Route 288	Commonwealth	2,100	2,100	NA	NA	2,104	6,487	4,383	9.06%	5.02%	**5.0%**	**8,300**
EB Commonwealth	NB Route 288	1,700	1,700	NA	NA	1,636	5,216	3,580	9.51%	5.17%	**5.2%**	**7,000**
EB Commonwealth	SB Route 288	2,100	2,100	NA	NA	1,932	4,934	3,002	6.76%	4.16%	**4.2%**	**6,600**
Bailey Bridge/North Spring Run												
US 360	Claypointe	10,910	10,910	NA	NA	15,680	18,399	2,719	0.75%	0.70%	**0.7%**	**13,300**
Deer Run	Spring Run	5,489	4,742	5,380	NA	4,635	5,531	896	0.84%	0.77%	**0.8%**	**6,700**
Bailey Bridge	Royal Birkdale	7,196	7,533	7,053	NA	7,011	8,592	1,581	0.98%	0.89%	**0.9%**	**9,100**
Springford/Spring Run												
W. of Bailey Bridge		6,326	NA	6,200	NA	1,641	3,641	2,000	5.30%	3.53%	**3.5%**	**16,700**
S. of Bailey Bridge		4,164	NA	4,081	NA	5,682	7,444	1,762	1.35%	1.18%	**1.2%**	**5,800**
Deer Run												
W. of Bailey Bridge		4,659	NA	4,566	NA	3,785	4,583	798	0.92%	0.84%	**0.8%**	**5,900**
Brad McNeer												
US 360	S. of US 360	NA	13,620	NA	NA	12,475	18,821	6,346	2.21%	1.80%	**1.8%**	**22,500**
Deer Run												
US 360	S. of US 360	NA	10,080	NA	NA	6,605	9,901	3,296	2.17%	1.78%	**1.8%**	**16,600**
Chital Drive												
US 360	S. of US 360	NA	5,610	NA	NA	6,605	9,901	3,296	2.17%	1.78%	**1.8%**	**9,200**
N. Spring Run												
US 360	S. of US 360	NA	8,428	NA	NA	17,871	21,334	3,463	0.84%	0.77%	**0.8%**	**10,500**
Winterpock												
US 360	S. of US 360	NA	11,208	NA	NA	20,894	27,046	6,152	1.28%	1.13%	**1.1%**	**15,400**
Otterdale												
US 360	S. of US 360	NA	3,388	NA	NA	7,217	10,640	3,423	2.06%	1.70%	**1.7%**	**5,500**

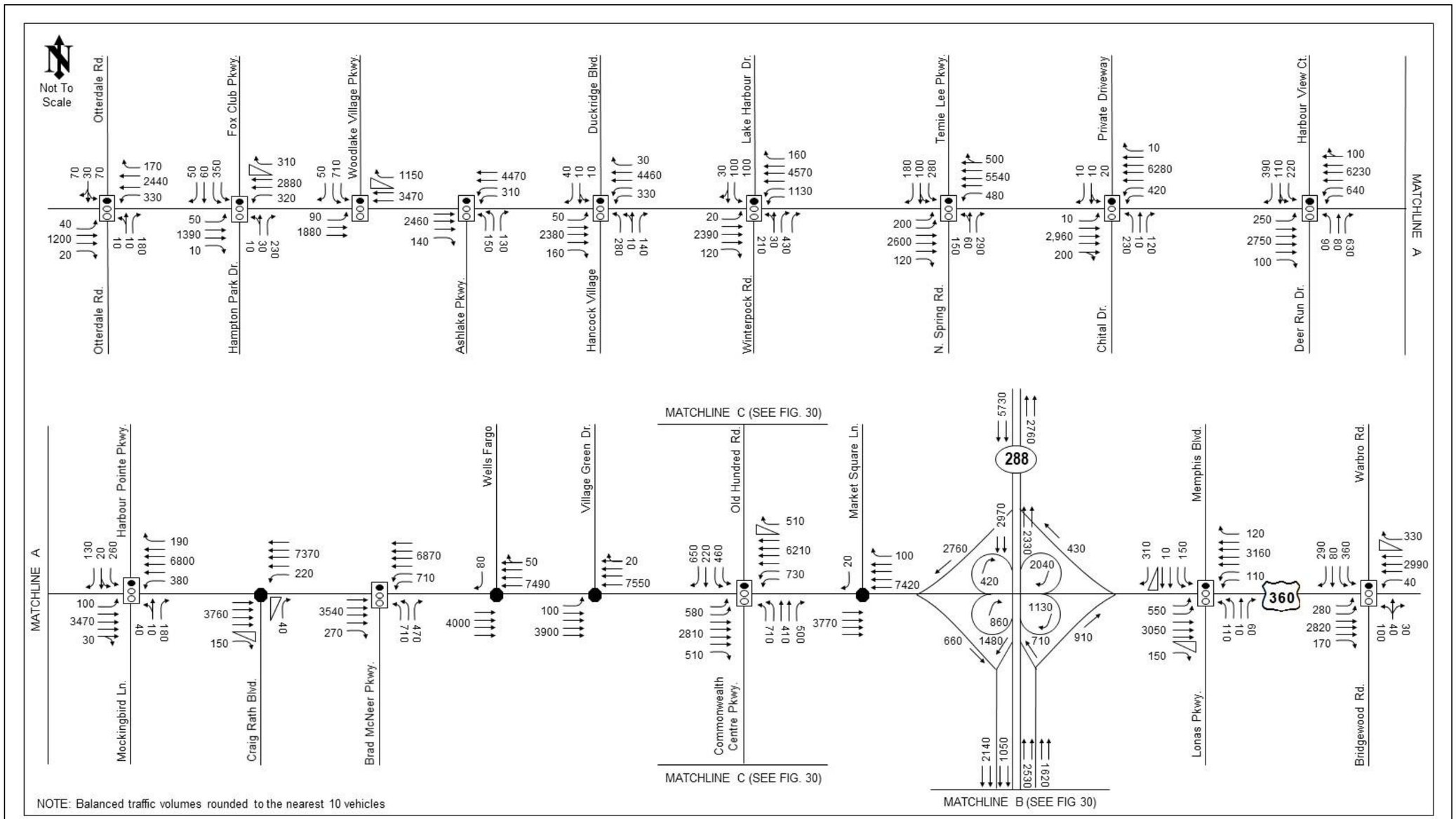


Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

No-Build (2040) Traffic Volumes – AM Peak Hour
US 360/Route 288 Interchange Study

Figure 28



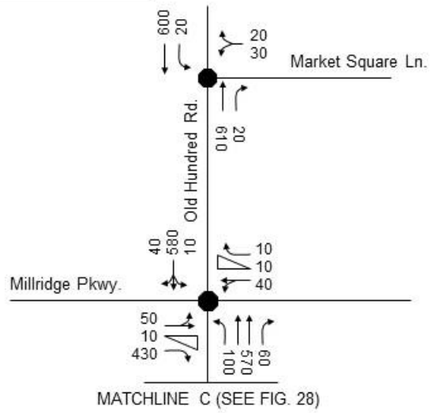
Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

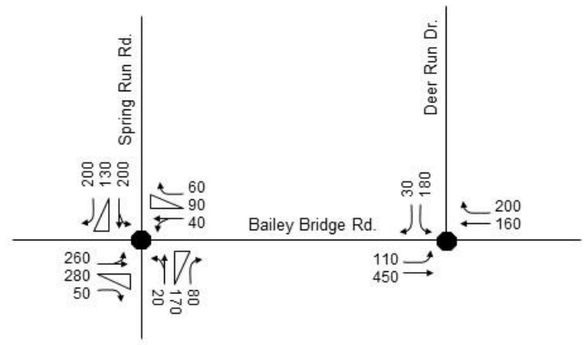
No-Build (2040) Traffic Volumes – PM Peak Hour
US 360/Route 288 Interchange Study

Figure 29

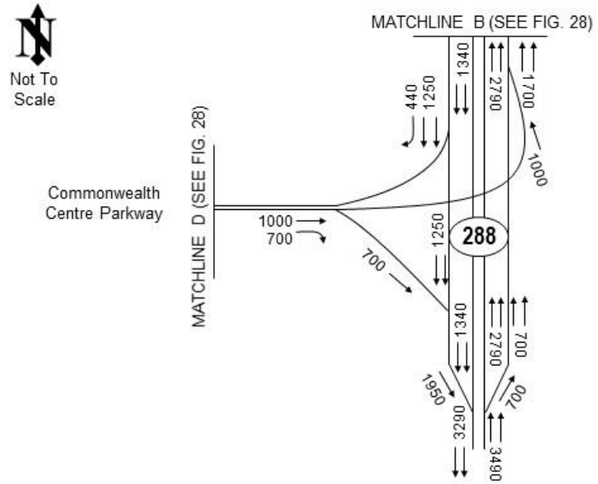
AM PEAK HOUR



Old Hundred Road at Millridge Parkway and Market Square Lane

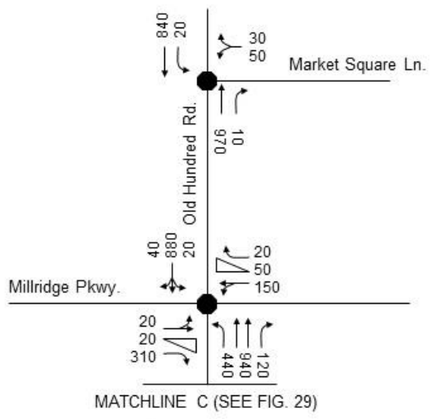


Bailey Bridge Road at Spring Run Road and Deer Run Road

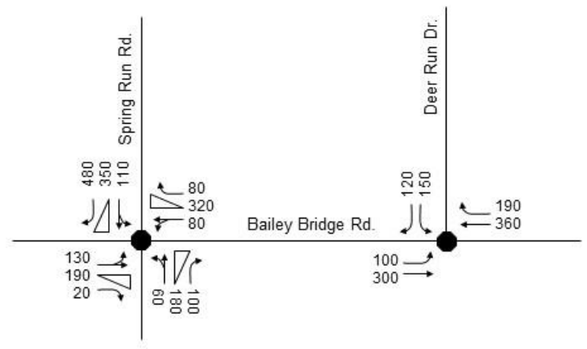


Commonwealth Centre Parkway at Route 288

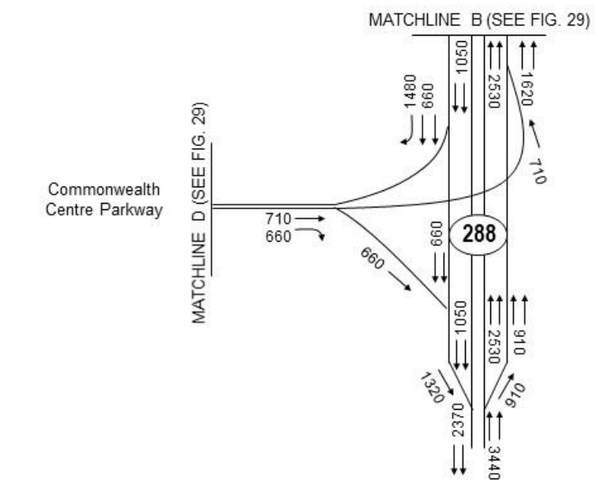
PM PEAK HOUR



Old Hundred Road at Millridge Parkway and Market Square Lane



Bailey Bridge Road at Spring Run Road and Deer Run Road



Commonwealth Centre Parkway at Route 288

NOTE: Balanced traffic volumes rounded to the nearest 10 vehicles

Legend

- Existing Lane Assignment
- Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal

No-Build (2040) Traffic Volumes – AM & PM Peak Hour
US 360/Route 288 Interchange Study

Figure 30

6.0 No-Build (2040) Conditions

No-Build conditions were analyzed to evaluate the results of future (2040) traffic demand on the existing roadway network. The intent of the No-Build conditions analysis was to provide a general understanding of baseline future traffic conditions to be used to evaluate the effectiveness of potential future improvement strategies. CORSIM and Synchro modeling assumptions and analysis results for No-Build conditions in the Design Year 2040 are described in the following sections.

6.1 No-Build (2040) Interchange Operational Results

6.1.1 CORSIM Modeling Assumptions

The existing conditions CORSIM model was used to develop the No-Build conditions model. Signal timings for the intersections at US 360 at Old Hundred Road/Commonwealth Centre Parkway and US 360 at Memphis Boulevard/Lonas Parkway were optimized using Synchro and input into the CORSIM network. The No-Build AM and PM peak hour volumes, summarized in **Figures 28** through **30**, were coded into CORSIM. The model was setup to run for a one-hour recording period with a preceding 15-minute seeding period. After correcting any errors, the average of 10 simulation runs was used to record statistics to determine how closely calibrated the simulation model matched the field observed traffic volumes and specified traffic speeds.

6.1.2 CORSIM Results

The No-Build (2040) operations along Route 288 were evaluated using CORSIM. The analysis results, which include the average of 10 CORSIM analysis runs, for the freeway segments within the study area during both AM and PM peaks are presented in **Figure 31** and **Figure 32**. The three critical US 360/Route 288 interchange ramps identified under Existing (2012) conditions further degrade under No-Build (2040) traffic conditions. Specific peak hour findings are as follows:

Southbound Route 288 to Westbound US 360 Off-Ramp

- Travel speeds decrease to below 10 MPH and freeway densities increase well beyond acceptable levels at the southbound Route 288 to westbound US 360 exit ramp during the PM peak hour. This impacts the mainline operations of southbound Route 288 causing travel speeds to decrease below 10 MPH. Southbound Route 288 queues extend beyond the study area towards the Powhite Parkway interchange. Simulation results indicate that only a portion of the projected traffic volumes make it through the network due to congested conditions.

Eastbound US 360 to Northbound Route 288 On-Ramp

- In the AM peak hour, analysis results indicate travel speeds decrease and densities increase at the eastbound US 360 to northbound Route 288 on-ramp. This impacts the mainline operations of northbound Route 288 through reduced travel speeds to the north and south of US 360. Operations of the eastbound US 360 to northbound Route 288 on-ramp cause speeds on northbound Route 288 and the northbound Route 288 CD road to operate below 10 MPH during the AM peak hour.

Northbound Route 288 to Westbound US 360 Off-Ramp

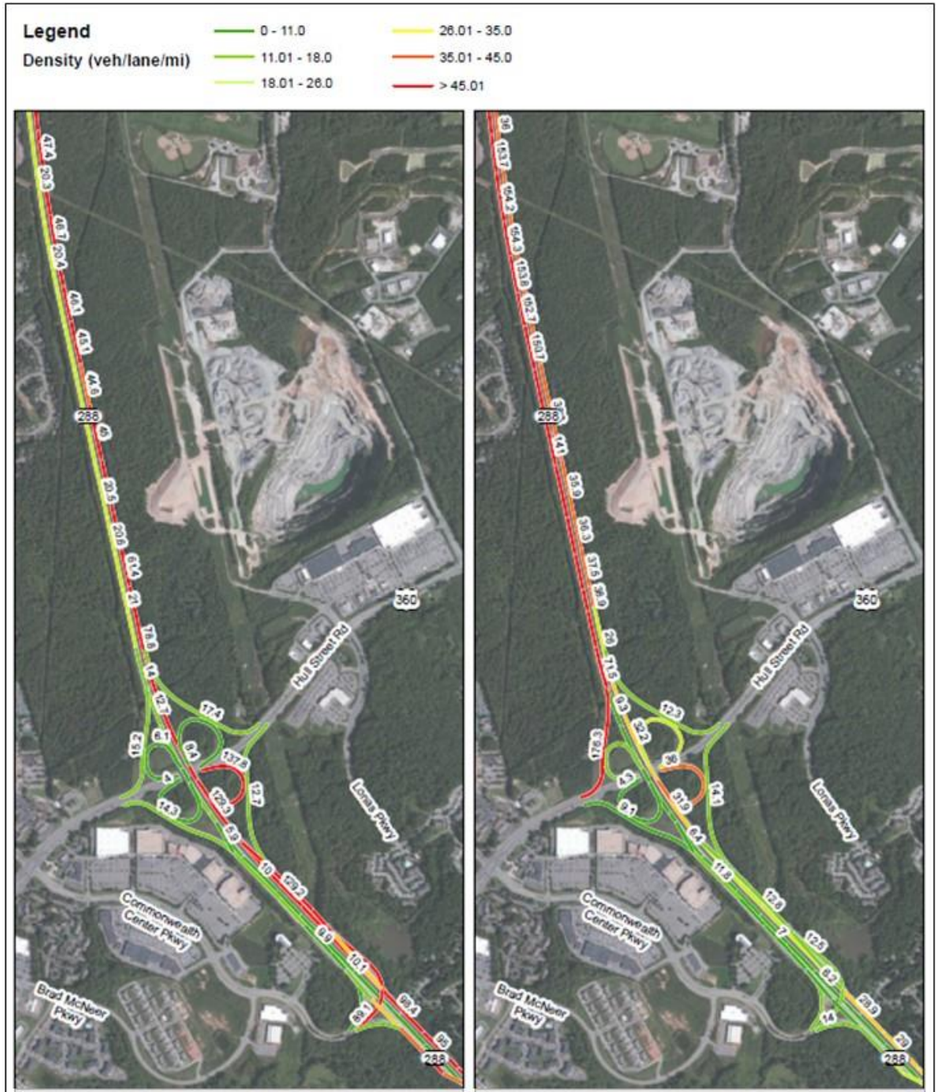
- In the PM peak hour, analysis results indicate densities increase at the northbound Route 288 to westbound US 360 off-ramp. Travel speeds slow down within the weaving area of northbound Route 288 at US 360.

In addition to the three critical ramp locations, travel speeds on northbound Route 288 decrease to approximately 55 MPH due to the freeway approaching capacity.

Specific No-Build (2040) operational measures for the three critical ramp movements as compared to Existing (2012) conditions are summarized in **Table 17**. Freeway operations results are presented in **Appendix B** in a graphical format that depicts vehicle travel speeds and densities by segment and by lane.

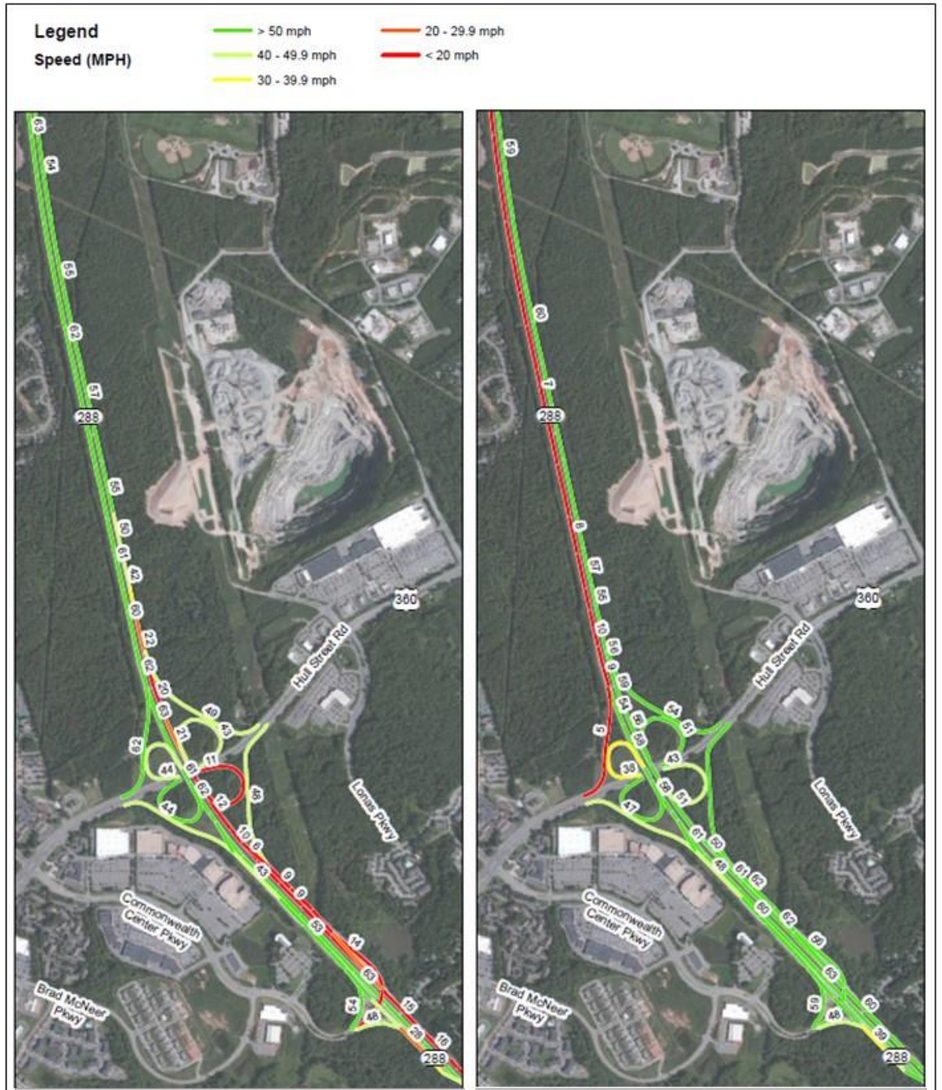
Table 17: US 360/Route 288 Interchange Critical Ramps – No-Build (2040)

Southbound Route 288 to Westbound US 360 Off-Ramp	Eastbound US 360 to Northbound Route 288 On-Ramp	Northbound Route 288 to Westbound US 360 Off-Ramp
Peak Hour Issue ■ PM Peak Hour Traffic Volumes ■ Existing (2012): 1,722 veh/hr ■ **No-Build (2040): 2,760 veh/hr** Queues ■ Existing (2012): 1,500 feet – Extends beyond the southbound Route 288 deceleration lane ■ **No-Build (2040): > 2 miles** – **Extends north to Powhite Parkway** Speeds ■ Existing (2012): 55–60 MPH ■ **No-Build (2040): 5–10 MPH** Crashes ■ Existing (from 2010 to 2013) during PM peak period (3:00 to 7:00 PM): – One ramp crash and 41 crashes on Route 288 mainline upstream » Predominant crash type: 35 rear-end crashes » Severity: 12 injury, 29 PDO, one fatal (description of fatal crash provided in **Section 2.5.1**)	Peak Hour Issue ■ AM Peak Hour Traffic Volumes ■ Existing (2012): 1,838 veh/hr ■ **No-Build (2040): 2,570 veh/hr** Queues ■ Existing (2012): – None on Route 288 (contained within weave area) – Approximately 1 mile on eastbound US 360 ■ **No-Build (2040):** – **> 1.5 miles on Route 288 (extending to Bailey Bridge Rd)** – **Queues extend throughout EB US 360 to Otterdale Rd** Speeds ■ Existing (2012): 10–20 MPH ■ **No-Build (2040): 10–16 MPH** Crashes ■ Existing (from 2010 to 2013) during AM peak period (6:00 to 10:00 AM): – One ramp crash and 28 in weave section » Predominant crash type: 26 rear-end crashes » Severity: Four injury, 25 PDO	Peak Hour Issue ■ PM Peak Hour Traffic Volumes ■ Existing (2012): 1,170 veh/hr ■ **No-Build (2040): 2,040 veh/hr** Queues ■ Existing (2012): – None on Route 288 (contained within weave area) ■ **No-Build (2040):** – **None on Route 288 (contained within weave area)** Speeds ■ Existing (2012): 55–60 MPH ■ **No-Build (2040): 55–60 MPH** Crashes ■ Existing (from 2010 to 2013) during PM peak period (3:00 to 7:00 PM): – Zero ramp crashes and eight in weave section » Predominant crash type: six rear-end crashes » Severity: Two injury, six PDO



No-Build (2040) – Route 288 CORSIM Results - Density
US 360/Route 288 Interchange Study

Figure 31



No-Build (2040) – Route 288 CORSIM Results - Speed
US 360/Route 288 Interchange Study

Figure 32

6.2 No-Build (2040) Intersection Operational Results

6.2.1 Synchro Modeling Assumptions

The existing Synchro model used as a base model to develop the No-Build model. Traffic signal timings were optimized for No-Build conditions. The signal timing results for each peak hour from Synchro were then input into each peak hour model in CORSIM. The following assumptions were used in addition to existing conditions assumptions:

- Heavy vehicle percentages by approach from TMC data
- A peak hour factor (PHF) of 0.92 or higher was assumed for all turning movements
- Optimized traffic signal timings for all signalized intersections
- US 360 was assumed to be widened from a four-lane divided facility to a six-lane divided facility east of Memphis Boulevard/Lonas Parkway

6.2.2 Synchro Model Results

The following measures of effectiveness (MOEs) were selected to measure the quantitative performance of the intersections within the network:

- Average vehicle delay and HCM LOS by movement, approach, and intersection—measured in seconds per vehicle
- Maximum queue length—measured in feet

Tables summarizing the delay, HCM LOS, and queuing results for the study area intersections are included in **Appendix B**. **Figure 33** and **Figure 34** show a graphical representation of the LOS results in the study area. Key findings for the intersection analysis are summarized in the subsequent sections.

6.2.2.1 Delay and Level of Service

Delays and associated LOS for both signalized and unsignalized intersections are reported from the Synchro analysis. The results provided in **Appendix B** indicate that a majority of the signalized intersections operate at LOS E or worse during the AM and PM peak hours. The following key delay and level of service conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- Delays on eastbound US 360 operate at LOS F from Winterpock Road to Old Hundred Road/Commonwealth Centre Parkway
- Side-street approaches generally operate at LOS E or worse
- Intersections west of Route 288 operate at overall LOS D or worse

PM Peak Hour

- Delays on westbound US 360 operate at LOS F from Old Hundred Road/Commonwealth Centre Parkway to Fox Club Parkway/Hampton Park Drive
- Side-street approaches generally operate at LOS E or worse
- Intersections on US 360 west of Route 288 operate at overall LOS E or worse

6.2.2.2 Queue Lengths

The maximum queues are reported from an average of 10 simulation runs in SimTraffic. Tables in **Appendix B** summarizes the average AM and PM peak hour 95th percentile and maximum queue lengths for each lane group at all study area intersections. The following key queuing conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- Eastbound US 360 queues extend from Otterdale Road to Route 288
- US 360 at Old Hundred Road/Commonwealth Centre Parkway is a critical intersection along the facility
  - Eastbound traffic on US 360 queues from Harbour Pointe Parkway/Mockingbird Lane
- Vehicles queue on eastbound US 360 from Temie Lee Parkway/N. Spring Run Road to Duckridge Boulevard/Lake Harbour Drive

PM Peak Hour

- US 360 queues are heavier in the westbound direction due to the heavier westbound volumes in the PM peak hour
- The critical intersection of US 360 at Old Hundred Road/Commonwealth Centre Parkway is over capacity with queues extending to Route 288 where queues extend over a mile on both northbound and southbound Route 288
- A majority of the turn-lane queues on US 360 west of Route 288 extend beyond their storage lengths
- Queues on the side-street approaches along US 360 west of Route 288 extend beyond the existing storage lengths

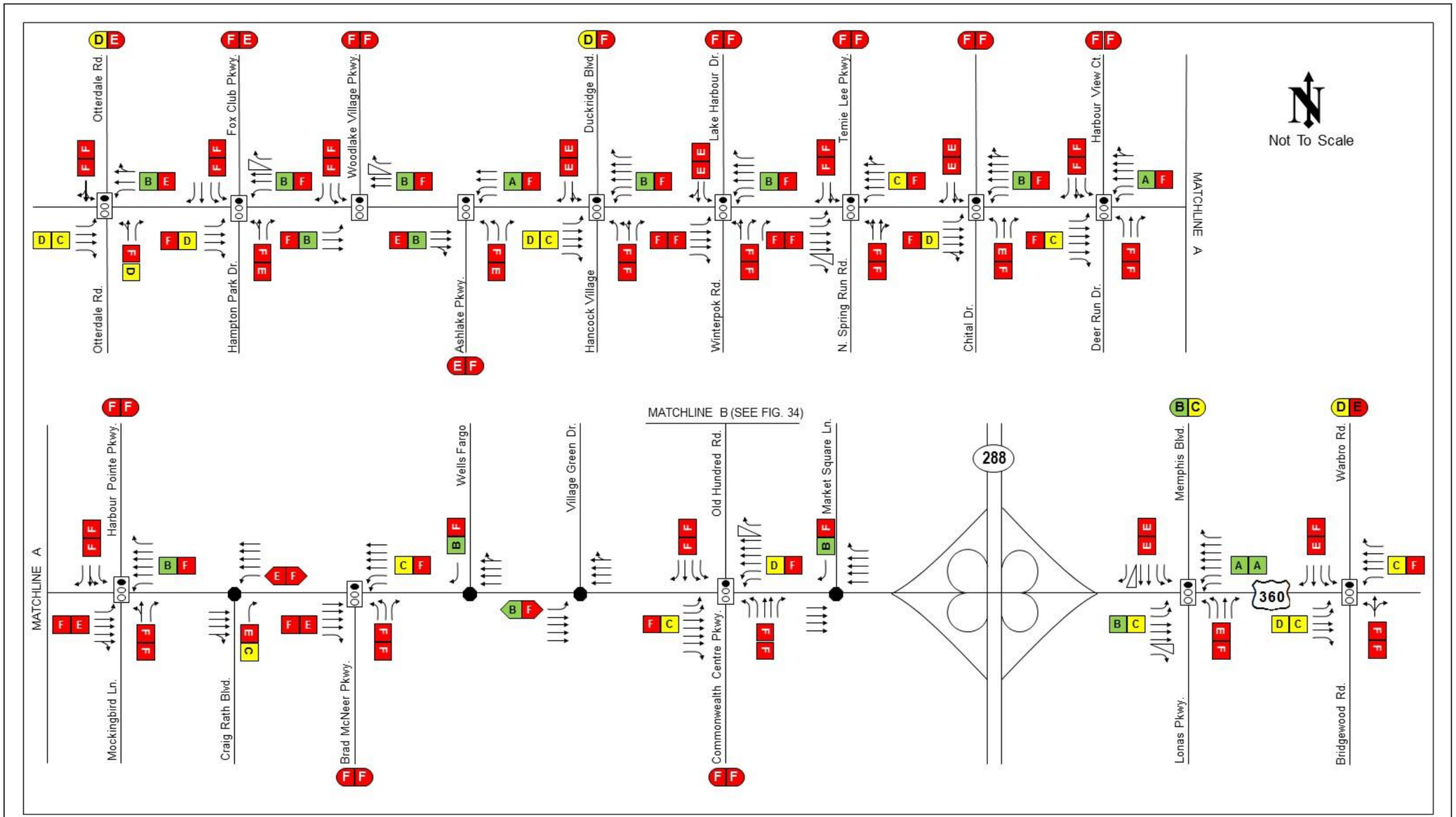
6.3 Summary of No-Build (2040) Conditions

Analysis results indicate that the critical intersection of US 360 at US 360 at Old Hundred Road/Commonwealth Centre Parkway is projected to operate above capacity in the future. Queues from this intersection in the PM peak hour impact the operations of both northbound and southbound Route 288. In the PM peak hour, queues are projected to extend from US 360 to Powhite Parkway on southbound Route 288 and beyond Bailey Bridge Road on northbound Route 288. The intersection of US 360 at Old Hundred Road/Commonwealth Centre Parkway will require capacity improvements to remove the bottleneck and prevent queues from backing onto Route 288.

Each of the following critical ramps are projected to operate over capacity in the future:

- Southbound 288 to Westbound US 360 Off-Ramp
- Eastbound US 360 to Northbound Route 288 On-Ramp
- Northbound US 360 to Westbound US 360 Off-Ramp

Capacity improvements are required at the US 360/Route 288 interchange. Results indicate additional capacity is required on both the southbound Route 288 to westbound US 360 off-ramp and the eastbound US 360 to northbound Route 288 on-ramp. The eastbound US 360 to northbound Route 288 on-ramp is projected to create queues on eastbound US 360 in the AM peak hour due to capacity constraints.



Legend

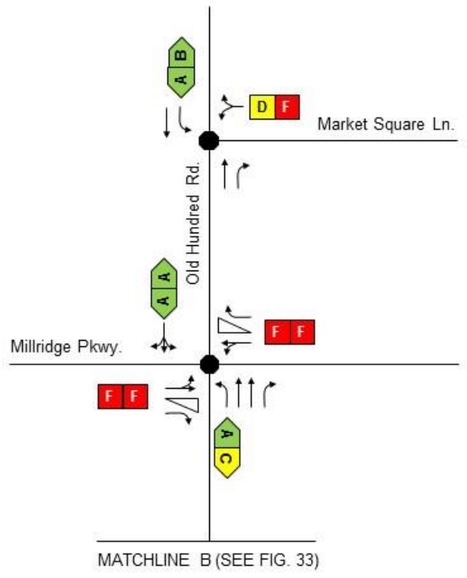
- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal
- AM | PM Intersection LOS
- AM | PM Approach LOS
- AM | PM Movement LOS

No-Build (2040) – Intersection Level of Service
US 360/Route 288 Interchange Study

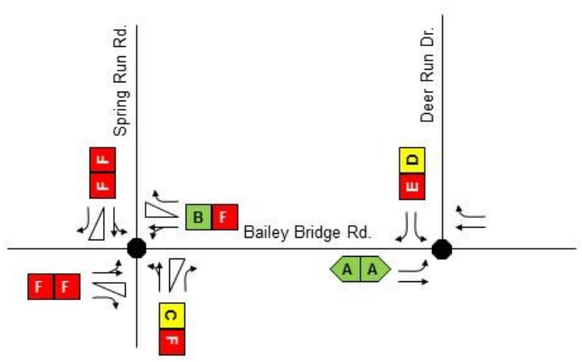
Figure 33

Not To Scale

Old Hundred Road at Millridge Parkway and Market Square Lane



Bailey Bridge Road at Spring Run Road and Deer Run Road



Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal
- AM | PM Intersection LOS
- AM | PM Approach LOS
- AM | PM Movement LOS

No-Build (2040) – Intersection Level of Service
US 360/Route 288 Interchange Study

Figure 34

7.0 Alternative Development and Screening Process

Potential improvement concepts for the US 360/Route 288 Interchange study were developed to address operational, geometric, maintenance, and safety deficiencies identified in the Existing (2012) and No-Build (2040) analyses. An initial list of candidate improvements was developed in coordination with the Study Work Group and screened through a series of meetings and workshops. Candidate improvements were screened based on a two-phased—qualitative and quantitative—screening process. The purpose of this screening process was to narrow down the list of potential improvements to projects that can be programmed into the VDOT SYIP and implemented in the near- and long-term. The following sections describe concept development, screening of alternatives, and selection of the candidate projects.

7.1 Step 1 – Alternative Development

The SWG developed a list of 66 potential improvements during the concept development phase. Mitigation measures were identified within the US 360/Route 288 interchange study area based on deficiencies identified from the 2035 No-Build analysis.

» **Primary Improvements** – These improvements were in keeping with the study goals of improving interchange deficiencies and accommodating future-year traffic. Improvements that addressed the following existing and future-year critical issues were considered primary improvements:

- Southbound 288 to westbound US 360 Off-Ramp – PM peak hour issue
- Eastbound US 360 to northbound Route 288 On-Ramp – AM peak hour issue
- Northbound US 360 to westbound US 360 Off-Ramp – PM peak hour issue
- US 360 at Old Hundred Road/Commonwealth Centre Parkway – AM and PM peak hour issue

» **Secondary Improvements** – Improvements targeted at mitigating congestion and safety issues at locations other than the critical issues listed above were considered to be a secondary improvement. Secondary improvements could be stand alone or support a primary improvement.

The initial list of improvements reflected a fiscally unconstrained vision in keeping with project goals to mitigate operational and safety issues at the US 360/Route 288 interchange and was not limited by air quality, environmental, or financial planning constraints in developing concept solutions. A full list of potential improvement concepts is provided in the Improvement Matrix Table in **Appendix D**. The initial list of potential improvements ranged from minor intersection improvements to major interchange reconfiguration concepts. Examples of the varied types of improvements considered include:

- Geometric Improvements
  - Minor ramp widening
  - Minor extension and installation of deceleration/acceleration lanes
  - Major interchange reconfiguration concepts
  - New roadways and extensions of existing roadways to improvement connectivity
- Access Management Recommendations
- Intersection Improvements
  - Alternative intersection configurations
  - Signal timing and signal modifications
  - Turn lane improvements
- Travel Demand Management (TDM) Concepts
  - Pedestrian accommodations
  - Transit
  - Park-and-ride facilities

7.2 Step 2 – Qualitative Screening

The first step of the screening process included a qualitative analysis to determine the feasibility of each improvement and was based on the following factors:

- Potential impacts to safety
- Potential impacts to traffic operations
- Order of magnitude cost
- Constructability considerations
- Environmental considerations
- Impact to adjacent roadways and intersections
- Anticipated public response and acceptance
- Useful life of improvement

Conceptual sketches, developed by hand or in GIS, were used to supplement the qualitative screening of improvements. This information is provided in **Appendix D**. The SWG vetted each improvement and eliminated those from deemed unwarranted or infeasible based on a fatal flaw identified in any of the above screening factors.

7.3 Step 3 – Quantitative Screening

Concepts that were not eliminated as part of the qualitative screening process were refined in this step to the level of detail necessary to estimate approximate costs, to identify potential environmental and property impacts, to assess potential maintenance of traffic during construction concepts, and to determine the traffic operational benefit of each improvement. The second screening process was quantitative and based on the following criteria:

1. **Travel Demand Modeling** – Interchange improvements and roadway connections with the potential to reduce future traffic volumes through the interchange and along US 360 were tested using the sub-area travel demand model to estimate the level of impact, if any (described in **Section 7.6**).
2. **Planning Level Cost Estimates** – Planning level cost estimates were developed for all improvements considered. Cost estimates were refined throughout the study based on input from the SWG on the methodology (described in **Section 9.0**)
3. **Traffic Operations Analysis** – Each geometric improvement was analyzed to further screen improvements that provided an operational benefit (described in **Section 8.0**).

Improvements were further reduced and refined based on the results of the travel demand modeling and review of the planning level cost estimates. This additional information was used to identify which potential improvements would be analyzed for operational impacts. Interchange and intersection geometric improvements with the best potential of improving traffic operations were identified by the SWG and carried forward to the traffic operations analysis stage.

CORSIM, Synchro, SimTraffic, and SIDRA results were used to assess operational benefits of proposed improvements. Two models were used to analyze the potential improvement concepts and, therefore, only two concepts could be modeled at each location. At locations where more than two potential improvement concepts progressed beyond the initial screening process, the SWG qualitatively screened to two preferred concepts. Modeled improvements were aggregated into two concepts—Concept 1 and Concept 2—which are described in **Section 7.7**. Concept 1 and 2 analysis was performed under 2040 PM peak hour traffic conditions. The purpose of the alternative analysis was to compare the operational benefits of potential improvement concepts, especially those at the same location.

7.4 Step 4 – Candidate Project Selection

The final step of the screening process was the selection of candidate projects to carry further in the project development process. The selection of candidate projects was based on a review of the operational results, anticipated benefits to safety, and project feasibility. Conceptual figures were drafted for each preferred improvement using aerial photography and can be referenced in **Appendix D**. Planning level cost estimates were finalized, a benefit-cost analysis was completed, phasing recommendations were documented, and one-page project summary sheets were completed to be used as tools to advance each project beyond this study.

7.5 Qualitative Screening – Initial Concept Development

The study team developed 66 preliminary concepts for consideration within the study area, which are listed in **Table 18**. Types of improvements ranged from constructing new interchanges; modifications to existing interchanges; corridor improvements; intersection improvements; and travel demand management improvements. Concept descriptions and supplemental sketches are included in **Appendix D**. Conceptual sketches were developed by hand, or using GIS, and referenced in SWG discussions during the qualitative screening process.

Concepts were screened qualitatively given their anticipated ability to accommodate existing and future traffic movements; the amount of right-of-way required; perceived cost; and anticipated construction and phasing issues. Concepts not eliminated were advanced and quantitatively screened into primary and secondary improvements, as documented in subsequent sections of this report. Primary improvements were determined to have the most impact at mitigating safety and operational issues at the US 360/Route 288 interchange. Secondary improvements were determined to provide operational and safety benefits outside of US 360/Route 288 interchange area. **Appendix D** documents eliminated, primary, and secondary improvements.

7.6 Quantitative Screening – Based on Travel Demand Modeling

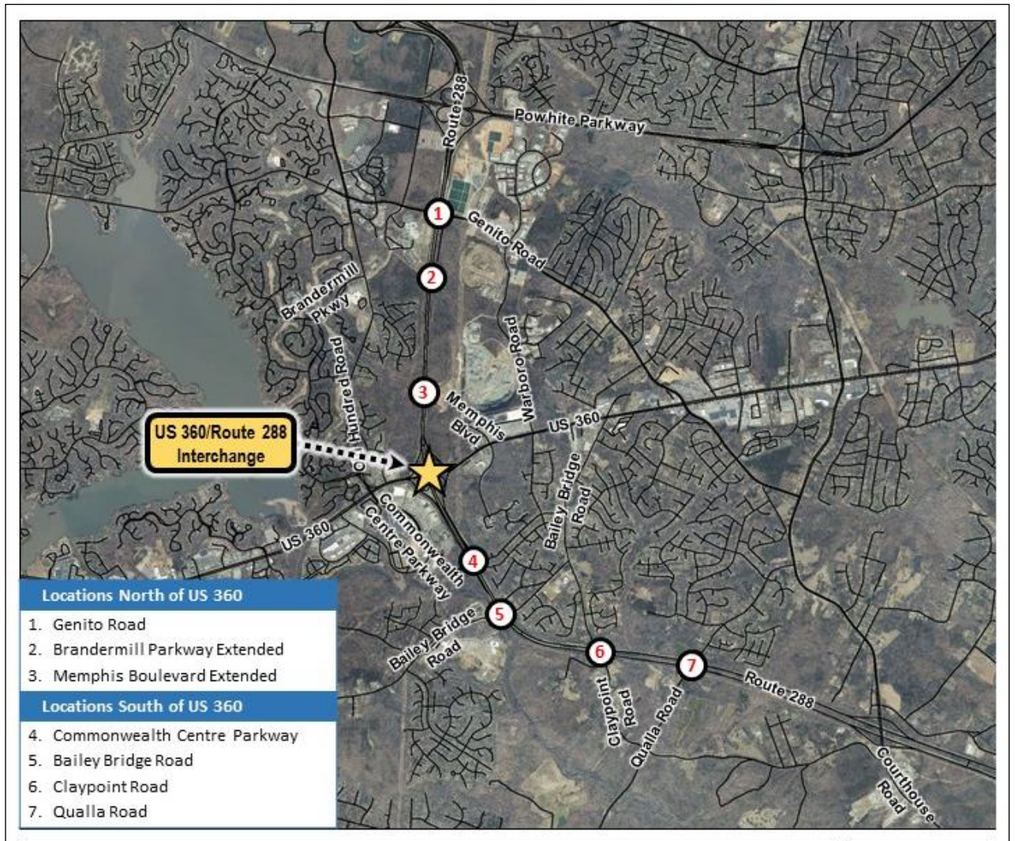
Specific interchange improvements and roadway connections with the potential to reduce future traffic volumes through the US 360/Route 288 interchange and along US 360 were evaluated using the sub-area travel demand model. The following section summarizes the results of this analysis and used quantitatively to screen candidate improvements.

7.6.1 Route 288 Interchange Concepts

The study team evaluated the seven potential interchange locations shown on **Figure 35** as alternatives to alleviating traffic in the vicinity of the US 360/Route 288 interchange and the intersection of US 360 and Old Hundred Road/Commonwealth Centre Parkway.

The following conclusions were determined from the sub-area travel demand model results:

- The initial modeling analysis showed that the Memphis Boulevard Interchange concepts (**Concepts 4** and **5**) were the most effective northern interchange options at alleviating US 360/Route 288 interchange traffic and that Commonwealth Centre Parkway (**Concepts 11 - 14**) and Bailey Bridge Road (**Concepts 7 - 10**) interchange concepts were the most effective southern interchange options.
- Further analysis revealed that either of the southern interchange options would be more effective at alleviating US 360/Route 288 interchange area than the Memphis Boulevard Interchange option because of their potential to provide travelers with an alternate east-west travel route to US 360.
- The Memphis Boulevard options could not provide an alternate travel route to US 360 west of Old Hundred Road because of the geographic constraint of the Swift Creek Reservoir and therefore was eliminated.
- The modeling results for improving the Commonwealth Centre Parkway interchange versus constructing a new interchange at Bailey Bridge Road were similar in their benefit to alleviating US 360/Route 288 interchange traffic, but the Commonwealth Centre Parkway interchange improvements (**Concepts 11 - 14**) were significantly less expensive to build because they could take advantage of some existing infrastructure and right-of-way. In comparison, the Bailey Bridge Road interchange concepts (**Concepts 7 - 10**) would have been significantly more costly due to several challenges including a large elevation difference between Route 288 and Bailey Bridge Road and the proximity of the proposed interchange to the existing Commonwealth Centre Parkway interchange (< 1 mile). As a result, the Bailey Bridge Road interchange improvements were not carried forward with the preferred southern interchange improvements focused at Commonwealth Centre Parkway.



Route 288 Interchange Concept Locations
US 360/Route 288 Interchange Study

Figure 35

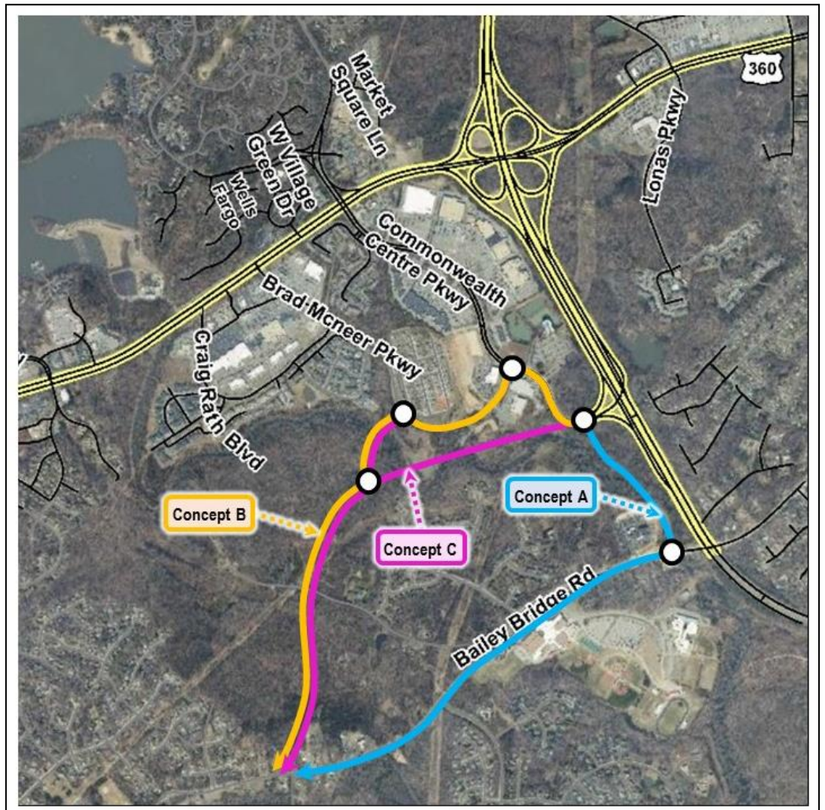
Table 18: Preliminary Concepts

Concept	Description	Screening Result
	Interchange Improvements	
2	Route 288 at Genito Road Extension – Partial Cloverleaf Interchange	Eliminated
3	Route 288 at Brandermill Parkway Extension – Modified Diamond/Partial Cloverleaf Interchange	Eliminated
4	Route 288 at Memphis Boulevard Extension Southbound Off-Ramp	Eliminated
5	Route 288 at Memphis Boulevard Extension – Partial Cloverleaf Interchange	Eliminated
6	Route 288 at Old Hundred Road Relocated – Partial Interchange	Eliminated
7	Route 288 at Bailey Bridge Road – Northbound Route 288 Off-Ramp to Bailey Bridge Road	Eliminated
8	Route 288 at Bailey Bridge Road – Partial Interchange with Northbound Route 288 Flyover	Eliminated
9	Southbound Route 288 Partial Interchange South of Bailey Bridge Road	Eliminated
10	Route 288 at Bailey Bridge Road – Diamond Interchange	Eliminated
11	Route 288 at Commonwealth Centre Parkway – Directional Interchange	Primary
12	Route 288 at Commonwealth Centre Parkway – Directional Interchange with Slip Ramp	Primary
13	Route 288 at Commonwealth Centre Parkway – Urban Diamond Interchange	Eliminated
14	Route 288 at Commonwealth Centre Parkway – Urban Diamond Interchange with Lonas Parkway Extension	Eliminated
15	Route 288 at Claypoint Road – Diamond Interchange	Eliminated
16	Route 288 at Qualla Road – Full Diamond Interchange	Eliminated
17	Southbound Route 288 to Westbound US 360 Ramp Widening	Primary
18	Market Square Ramp from Southbound Route 288	Eliminated
19	Route 288 at US 360 – Cloverleaf Interchange with Collector-Distributor (CD) Roads	Eliminated
20	Route 288 at US 360 – Semi-Directional Interchange with Loop Ramp Improvements	Primary
26	Southbound Route 288 to Westbound US 360 Extended Flyover Off-Ramp	Eliminated
27	US 360 – Elevated Roadway	Eliminated
28	US 360 – Reversible Elevated Roadway	Eliminated
	Corridor Improvements	
1	Route 288 Roadway Widening	Primary
21	US 360 Roadway Widening	Secondary
22	US 360 at Memphis Boulevard/Lonas Parkway – Median Barrier	Eliminated
	Intersection Improvements	
23	US 360 at Market Square Lane – Access Management	Primary
24	US 360 at Old Hundred Road – At-Grade Displaced Left-Turn (DLT) Intersection	Primary
25	US 360 at Old Hundred Road – At-Grade Displaced Left-turn (DLT) Intersection with Additional Capacity	Primary
29	US 360 at Old Hundred Road – Grade-Separated Intersection	Eliminated
30	US 360 at Old Hundred Road – Grade-Separated Diverging Diamond Interchange (DDI)	Primary
31	US 360 at Old Hundred Road – Grade-Separated Single-Point Urban Interchange (SPUI)	Eliminated
32	US 360 at Old Hundred Road – Grade-Separated Roundabout	Eliminated
33	US 360 at Old Hundred Road – Grade-Separated Urban Diamond Interchange	Eliminated
34	US 360 at West Village Green Drive	Primary
35	US 360 at Brad McNeer Parkway – Triple Northbound Left-Turn Lanes from Brad McNeer Parkway	Primary
36	US 360 at Brad McNeer Parkway – Continuous Green-T (CGT) Intersection	Primary
	Intersection Improvements	
37	US 360 Corridor – Remove Split Phase Operations	Secondary
38	US 360 Corridor – Additional Turn Lanes	Secondary
39	US 360 Corridor – Superstreet Intersections (from Harbour Pointe Parkway to Winterpock Road)	Secondary
40	US 360 Corridor – Safety Improvements	Secondary
41	US 360 Corridor – Access Management Improvements	Secondary
55	Bailey Bridge Road/Spring Run Road at Springford Parkway – Continuous Green-T (CGT) Intersection	Eliminated
	Network Connectivity Improvements	
42	Powhite Parkway Extension to Woolridge Road Extended (“Little Powhite”)	Primary
43	Powhite Parkway Extension to US 360 (“Big Powhite”)	Eliminated
44	Bailey Bridge Road Connector	Primary
45	Connector Road from Brad McNeer Parkway to Bailey Bridge Road	Eliminated
46	Commonwealth Centre Parkway Extended	Primary
47	Commonwealth Centre Parkway to Brad McNeer Parkway Connector	Eliminated
48	Craig Rath Boulevard to Full Rack Drive Connector	Eliminated
49	Buffalo Springs Drive Extension	Eliminated
50	Battlecreek Drive Extension	Secondary
51	Bailey Bridge Road Widening	Eliminated
52	Bailey Bridge Road Extension to Winterpock Road	Eliminated
53	Springford Parkway Widening	Eliminated
54	Spring Run Road Widening	Eliminated
56	North Spring Run Road Widening	Eliminated
57	McEnnally Road Widening	Eliminated
58	Harpers Mill Parkway Extension	Secondary
59	Springford Road Extension	Eliminated
60	Ashbrook Parkway Connection	Secondary
61	Harpers Mill Parkway Extension	Secondary
62	Hampton Park Drive Extension	Secondary
63	Baldwin Creek Road Extension	Secondary
	Travel Demand Management (TDM) Improvements	
64	Pedestrian and Bicycle Accommodations	Secondary
65	Transit	Secondary
66	Park & Ride Facilities	Secondary

- **Primary** – Recommended improvements determined to have the most impact at mitigating safety and operational issues at the US 360/Route 288 interchange.
- **Secondary** – Recommended improvements determined to provide operational and safety benefits outside of US 360/Route 288 interchange area.
- **Eliminated** – Concept vetted by study work group and eliminated for further consideration.

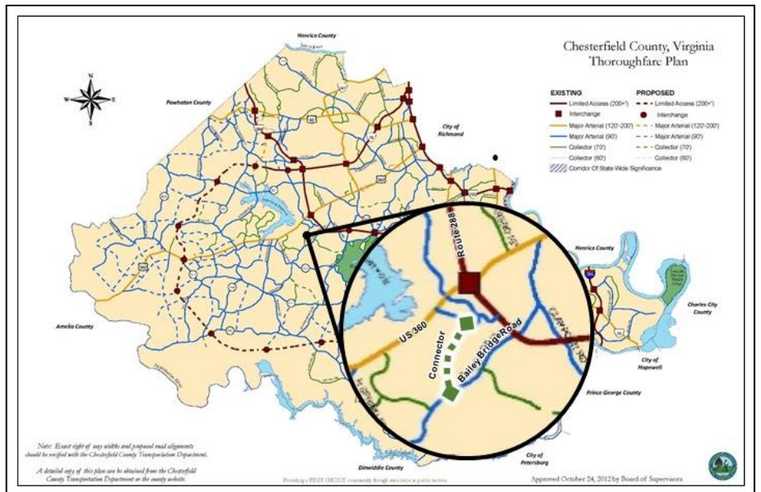
7.6.2 Bailey Bridge Connector

The next step was to determine the most effective way to connect the Commonwealth Centre Parkway with points to the west of Route 288 and south of US 360. Planning efforts focused on creating a connection between the Commonwealth Centre Parkway Interchange with Bailey Bridge Road. This new road connection was referred to as the "Bailey Bridge Connector." The three concepts of the Bailey Bridge Connector considered in the study are shown in **Figure 36**. Initial planning efforts focused on building this new connector road south to Bailey Bridge Road and then upgrading Bailey Bridge Road to the west as shown as Concept A. This concept had challenges as the proposed new road connection lacked unobstructed right-of-way to make the connection without potentially impacting some existing structures and planned development. Efforts next turned to a planned road connection from the Chesterfield County Thoroughfare Plan which proposed a new two-lane roadway connection between Brad McNeer Parkway and Bailey Bridge Road shown as Concept B in **Figure 37**.



Bailey Bridge Connector Concepts
US 360/Route 288 Interchange Study
Figure 36

Based on the travel demand model, Concept B performed better than Concept A, but there were concerns due to the large number of northbound left turns forecasted during the PM peak hour from Commonwealth Centre Parkway to Brad McNeer Parkway. This led to Concept C, which extended the direct connection from Bailey Bridge Road east directly to the Commonwealth Centre Parkway interchange without using Brad McNeer Parkway. Concept C also includes a two-lane connection from the Bailey Bridge Connector directly to Brad McNeer Parkway, referred to as the "Brad McNeer Connector." Concept C performed better than Concept B based on the travel demand modeling results; therefore, Concepts A and B were eliminated from further consideration. Additional analysis was performed to estimate capacity, or the number of travel lanes, the Bailey Bridge Connector needs to be based on the forecasted demand for 2040. The modeling analysis proved that four-lanes were only needed between the Commonwealth Centre Parkway and the Brad McNeer Connector. Two lanes were adequate for the segment from Brad McNeer Parkway to Bailey Bridge Road and for existing Bailey Bridge Road to points west. The TDM results also showed the Bailey Bridge Connector would reduce daily traffic on the existing northbound Route 288 to westbound US 360 by 63%. Therefore, the proposed northbound Route 288 to westbound US 360 directional off-ramp included in **Concept 20** was eliminated from further consideration.



Chesterfield County Thoroughfare Plan (Approved 10/24/12)
US 360/Route 288 Interchange Study
Figure 37

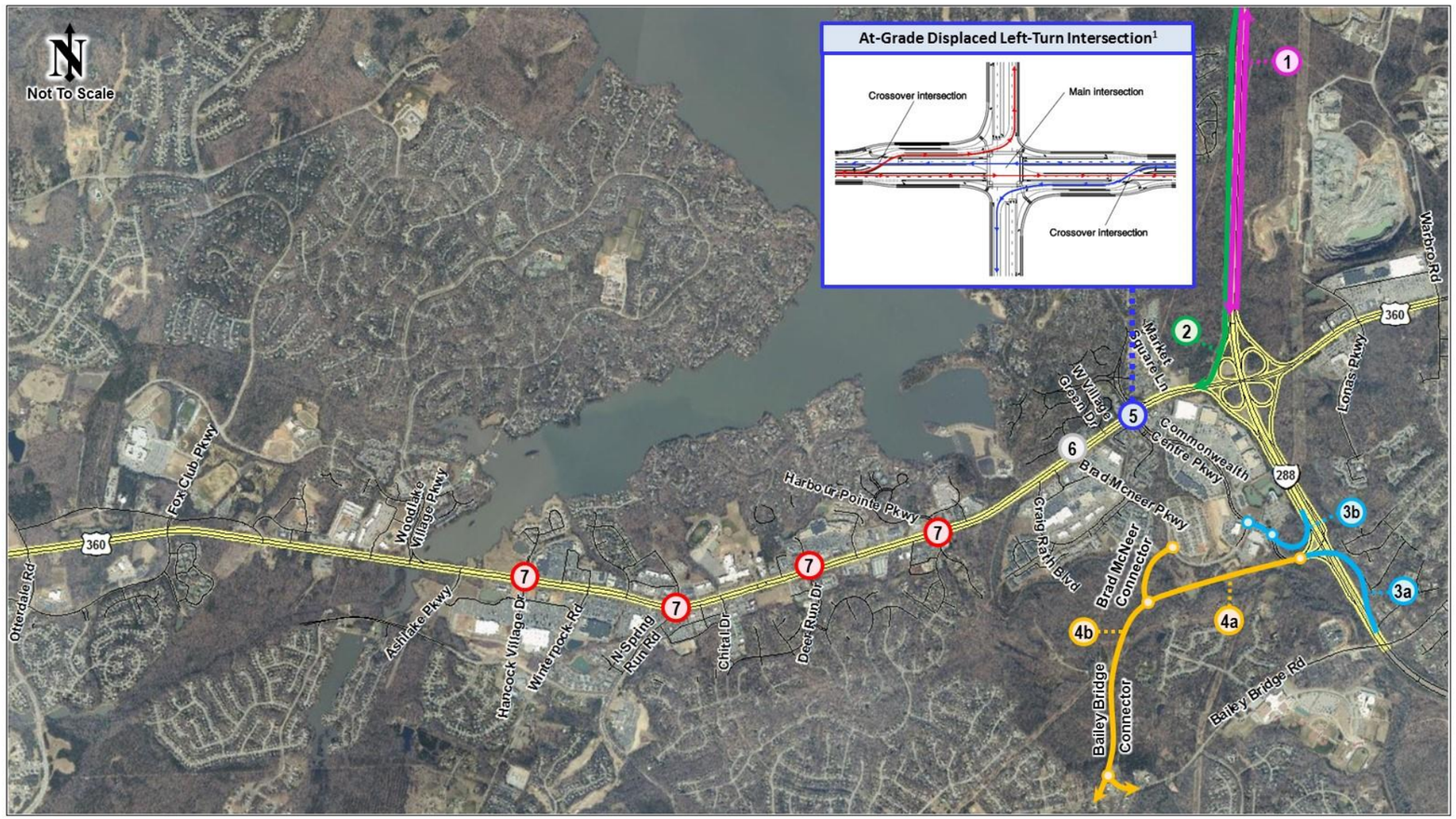
7.7 Quantitative Screening – Alternative Operational Analysis

In coordination with the SWG, the 66 preliminary concepts were pared down based on the conclusions of the qualitative analysis, results of the travel demand modeling, and review of the preliminary planning level cost estimates (shown in **Appendix F**). Interchange and intersection geometric improvements with the best potential for improving traffic operations were identified by the SWG and carried forward to the quantitative screening stage based on traffic analysis results. Two traffic analysis models were used to analyze the potential improvement concepts; therefore, only two concepts were modeled at each location. At locations where more than two potential improvement concepts progressed beyond the initial screening process, the SWG qualitatively screened them to two preferred concepts. Modeled improvements were aggregated into two concepts, Concept 1 and Concept 2, as described below. The purpose of the alternatives analysis was to compare the operational benefits of potential improvement concepts, especially those at the same location within the study area. **Section 8.0** documents operational results of alternative improvements.

7.7.1 Concept 1

Concept 1 was developed from a combination of preliminary improvements and is shown in **Figure 38**. Features of this concept are:

1	▪ Widen Route 288 from four to six lanes between US 360 and Genito Road
2	▪ Widen southbound Route 288 to westbound US 360 off-ramp to two lanes and extend deceleration lane
3a	▪ Add missing northbound Route 288 to Commonwealth Centre Parkway off-ramp
3b	▪ Construct southbound Route 288 to Commonwealth Centre Parkway off-ramp
4a	▪ Construct Bailey Bridge Connector as a four-lane, divided roadway from Route 288 to Brad McNeer Connector
4b	▪ Construct Bailey Bridge Connector as two-lane, undivided roadway from Brad McNeer Connector to existing Bailey Bridge Road ▪ Include bike and pedestrian accommodations along 4a and 4b
5	▪ Construct an at-grade displaced left-turn intersection at US 360 and Old Hundred Road/Commonwealth Centre Parkway
6	▪ Restripe existing northbound approach to provide triple left turns at US 360 and Brad McNeer Parkway
7	▪ Elimination of split phase signal operation at four traffic signals; requires additional turn lanes and modifications to existing lane assignment



[1]Source: FHWA, Displaced Left Turn Intersection Informational Guide, August 2014

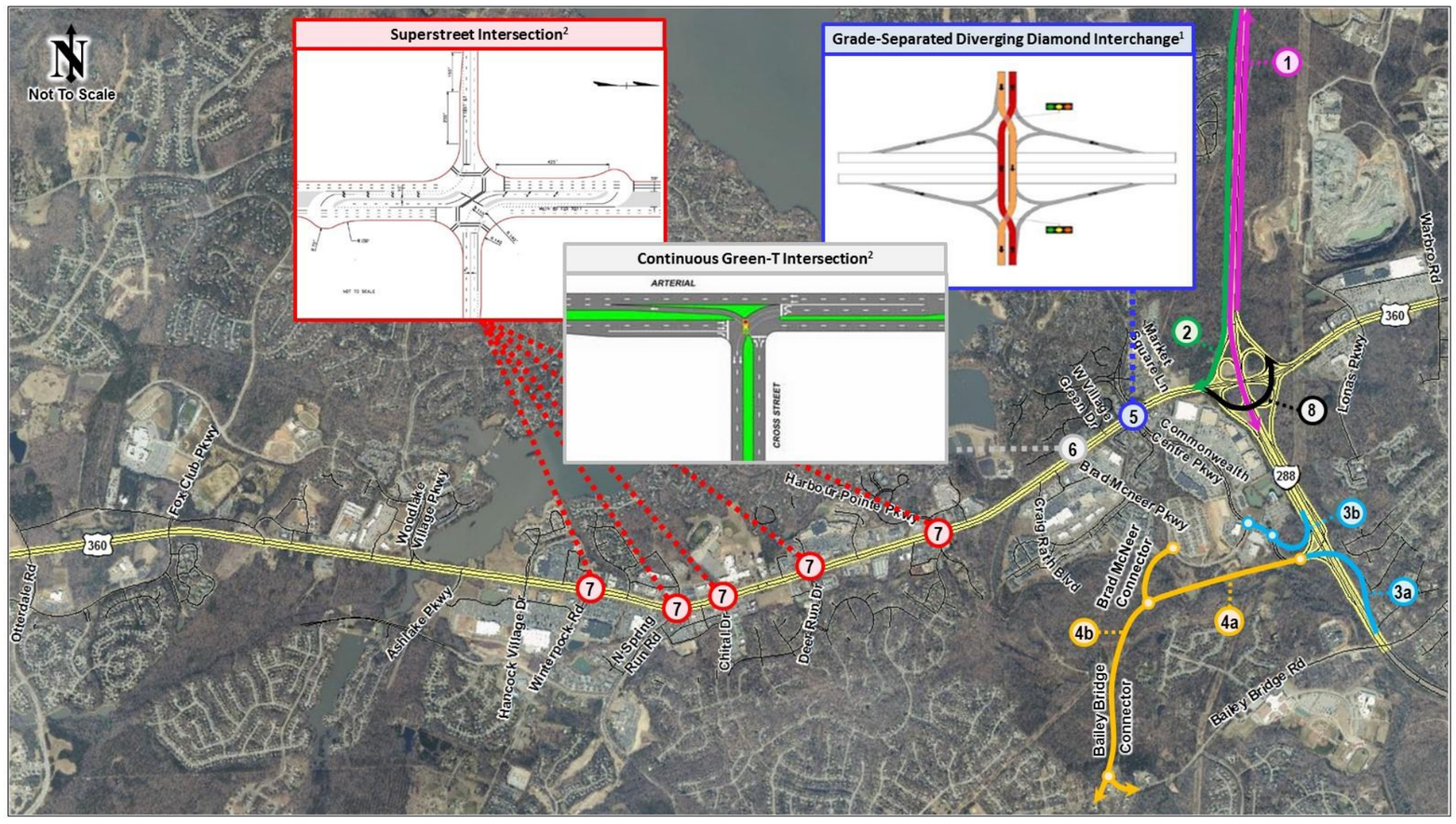
Concept 1
US 360/Route 288 Interchange Study

Figure 38

7.7.2 Concept 2

Concept 2 was developed from a combination of preliminary improvements and is shown in **Figure 39**. Features of this concept are:

1	▪ Widen Route 288 from four to six lanes between US 360 and Genito Road ▪ Construct a two-lane southbound CD road; includes reconstruction of the remaining following loop ramps: 1. Westbound US 360 to southbound Route 288 2. Northbound Route 288 to westbound US 360 3. Southbound Route 288 to eastbound US 360
2	▪ Widen southbound Route 288 to westbound US 360 off-ramp to two lanes and extend deceleration lane
3a	▪ Add missing northbound Route 288 to Commonwealth Centre Parkway off-ramp
3b	▪ Construct southbound Route 288 to Commonwealth Centre Parkway off-ramp
4a	▪ Construct Bailey Bridge Connector as a four-lane, divided roadway from Route 288 to Brad McNeer Connector
4b	▪ Construct Bailey Bridge Connector as two-lane, undivided roadway from Brad McNeer Connector to existing Bailey Bridge Road ▪ Include bike and pedestrian accommodations along 4a and 4b
5	▪ Construct a grade-separated DDI interchange at US 360 and Old Hundred Road/ Commonwealth Centre Parkway
6	▪ Construct a CGT intersection at US 360 and Brad McNeer Parkway
7	▪ Construct Superstreet intersections at the following five intersections: 1. US 360 and Harbour Pointe Parkway 2. US 360 and Deer Run Road 3. US 360 and Chital Drive 4. US 360 and N. Spring Road 5. US 360 and Winterpock Road
8	▪ Construct a two-lane eastbound US 360 to northbound Route 288 directional on-ramp



¹Source: FHWA, Diverging Diamond Interchange Information Guide, August 2014
²Source: FHWA, Alternative Intersections/Interchanges: Informational Report (AIIR), August 2014

Concept 2
US 360/Route 288 Interchange Study

Figure 39

8.0 Build Conditions (2040) – Analysis of Concept 1 and Concept 2

Operational analyses were performed for the candidate SYIP Projects under 2040 Build traffic conditions. The intent of the Build analysis was to evaluate the operational impacts of the proposed improvements to assess the effectiveness and benefits of the concepts. The modeling assumptions and analysis results for Build conditions are described in the following sections.

8.1 Build (2040) Conditions – Sub-Area Travel Demand Model

Travel demand modeling methodology, as described in **Section 5.0** was used to develop Build growth rates; however, the Bailey Bridge Connector was included in the 2035 sub-area model since it was included in both Build (2040) Concept 1 and Build (2040) Concept 2. Travel demand modeling results show that the Bailey Bridge Connector is projected to reduce the growth rates along US 360 west of Brad McNeer Parkway and reduce traffic volumes on two of the US 360/Route 288 interchange critical ramp movements (northbound Route 288 to westbound US 360 and eastbound US 360 to northbound Route 288).

The existing (2012) and future (2035) traffic volumes were used to develop growth rates as needed for study area locations. The exponential growth rates were generally used and rounded to the nearest tenth of a percentage point. Initially, all future year forecasts for the study effort were developed for the year 2035. However, in mid-2014 the Study Work Group decided to update the future year to 2040 to better align with other long-range regional planning efforts. As a result, all final study forecasts were developed for a 2040 year using the 2012 to 2035 growth rate from the sub-area model. **Figure 40** shows the resulting growth rates developed for US 360/Route 288 study area locations. **Table 19** summarizes the resulting projected 2040 average daily traffic volumes on study area roadways. The difference between the No-Build (2040) and Build (2040) growth rates and ADTs are provided in **Appendix E**.

Existing (2012) peak hour traffic volumes were exponentially grown using the growth rates shown in **Figure 40** to generate 2040 traffic volumes. The projected volumes were assigned throughout the study network based on build configurations. The projected 2040 AM and PM peak hour volumes for the study corridors are summarized in **Figures 41** through **46**. The difference between the No-Build (2040) and Build (2040) peak our volumes for Concepts 1 and 2 are illustrated in **Appendix A** for reference.

Figure 40: Build (2040) Growth Rates

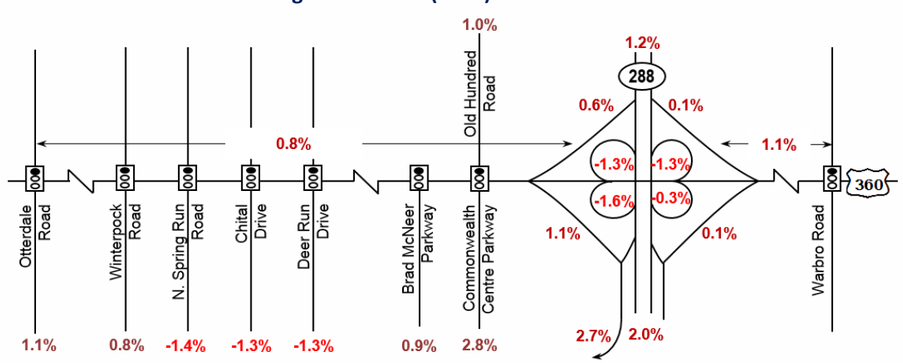
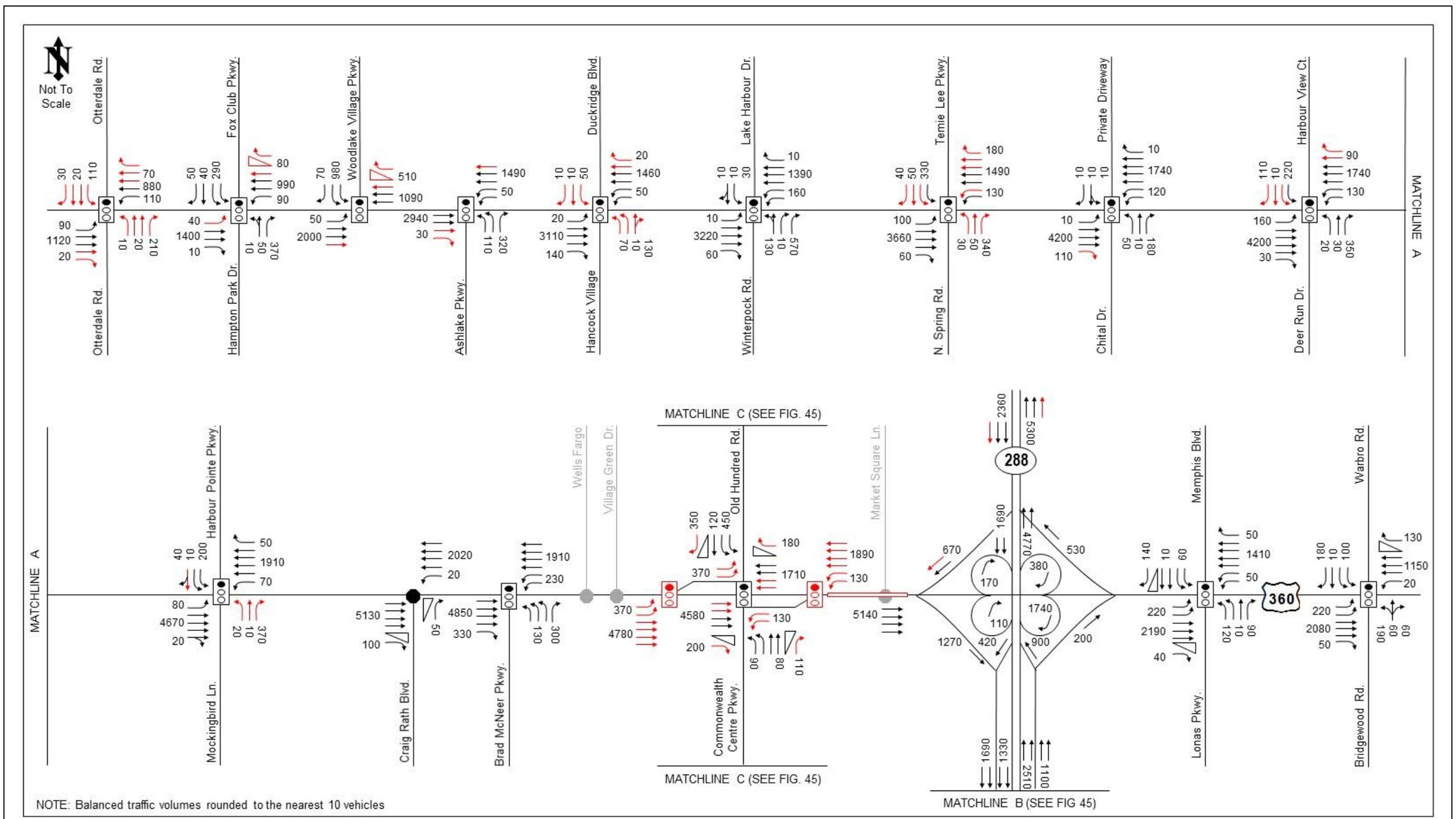


Table 19: Build (2040) Growth Rates and Average Annual Daily Traffic (AADT)

Roadway		Traffic Counts (AADT)				Sub-Area Model Results for 2012 and 2035 Build					Proposed	Estimated
		2011	2012	2012	2035	2012	2035	Difference	Growth Rate		Annual	2040 Build
From	To	VDOT	VDOT	Study	Trendline	AADT	AADT	2035-2012	Linear	Exponential	Growth Rate	AADT
Route 288												
Courthouse	Commonwealth	43,045	41,000	41,000	77,728	48,890	77,434	28,544	2.54%	2.02%	**2.0%**	**71,800**
US 360	Powhite	57,624	54,000	54,000	125,107	62,615	82,404	19,789	1.37%	1.20%	**1.2%**	**75,500**
Route 288 Ramps at US 360												
SB Route 288	WB US 360	NA	14,100	14,100	NA	13,828	15,735	1,907	0.60%	0.56%	**0.6%**	**16,600**
EB US 360	SB Route 288	NA	8,000	8,000	NA	7,752	9,879	2,127	1.19%	1.06%	**1.1%**	**10,800**
NB Route 288	EB US 360	NA	2,600	2,600	NA	2,353	2,387	34	0.06%	0.06%	**0.1%**	**2,700**
WB US 360	NB Route 288	NA	3,800	3,800	NA	3,632	3,722	90	0.11%	0.11%	**0.1%**	**4,000**
WB US 360	SB Route 288	NA	2,600	2,600	NA	2,711	2,025	-686	-1.10%	-1.26%	**-1.3%**	**1,900**
SB Route 288	EB US 360	NA	3,400	3,400	NA	3,146	2,176	-970	-1.34%	-1.59%	**-1.6%**	**2,200**
EB US 360	NB Route 288	NA	14,400	14,400	NA	13,900	12,841	-1,059	-0.33%	-0.34%	**-0.3%**	**13,100**
NB Route 288	WB US 360	NA	9,900	9,900	NA	9,762	7,282	-2,480	-1.10%	-1.27%	**-1.3%**	**7,000**
US 360												
Memphis	Route 288	39,064	48,100	48,100	69,930	42,564	54,155	11,591	1.18%	1.05%	**1.1%**	**64,500**
Route 288	Old Hundred	64,734	82,000	82,000	123,333	75,963	89,582	13,619	0.78%	0.72%	**0.7%**	**100,300**
Old Hundred	Village Green	64,734	82,000	82,000	123,333	74,072	91,061	16,989	1.00%	0.90%	**0.9%**	**105,500**
Craig Rath	Harbor Pointe	64,734	79,400	79,400	123,333	76,129	NA	NA	NA	NA	**0.8%**	**99,300**
Duckridge	Ashlake	43,639	45,000	45,000	68,265	48,446	NA	NA	NA	NA	**0.8%**	**56,300**
Woodlake Village	Fox Club	27,162	36,300	36,300	67,986	35,191	NA	NA	NA	NA	**0.8%**	**45,400**
Commonwealth Centre												
US 360	Route 288	13,380	13,400	NA	NA	14,120	26,883	12,763	3.93%	2.84%	**2.8%**	**29,400**
Old Hundred Rd												
US 360	Millridge	17,683	17,700	NA	34,476	23,952	30,270	6,318	1.15%	1.02%	**1.0%**	**23,600**
Millridge	Market Square	9,812	9,800	NA	NA	17,508	NA	NA	NA	NA	**1.0%**	**13,000**
Market Square	Brandermill	9,812	9,800	NA	NA	17,508	NA	NA	NA	NA	**1.0%**	**13,000**
Route 288 Ramps at Commonwealth Centre												
SB Route 288	Commonwealth	2,100	2,100	NA	NA	2,104	3,875	1,771	3.66%	2.69%	**2.7%**	**4,500**
SR 288 NB	Bailey Connector WB	NA	NA	NA	NA	NA	9,694	NA	NA	NA	**NA**	**NA**
EB Commonwealth	NB Route 288	1,700	1,700	NA	NA	1,636	3,153	1,517	4.03%	2.89%	**2.9%**	**3,800**
EB Commonwealth	SB Route 288	2,100	2,100	NA	NA	1,932	5,267	3,335	7.51%	4.46%	**4.5%**	**7,200**
Bailey Bridge/North Spring Run												
US 360	Claypointe	10,910	10,910	NA	NA	15,680	13,678	-2,002	-0.56%	-0.59%	**-0.6%**	**9,300**
Claypointe	Bailey Bridge Connector	10,189	10,189	NA	NA	8,360	7,464	-896	-0.47%	-0.49%	**-0.5%**	**8,900**
Bailey Bridge Connector	Deer Run	7,274	7,466	7,129	NA	2,992	4,199	1,207	1.75%	1.48%	**1.5%**	**10,800**
Deer Run	Spring Run	5,489	4,742	5,380	NA	4,635	4,728	93	0.09%	0.09%	**0.1%**	**5,600**
Bailey Bridge	Royal Birkdale	7,196	7,533	7,053	NA	7,011	7,572	561	0.35%	0.34%	**0.3%**	**7,800**
Springford/Spring Run												
W. of Bailey Bridge		6,326	NA	6,200	NA	1,641	1,969	328	0.87%	0.80%	**0.8%**	**7,900**
S. of Bailey Bridge		4,164	NA	4,081	NA	5,682	6,250	568	0.43%	0.42%	**0.4%**	**4,700**
Deer Run												
W. of Bailey Bridge		4,659	NA	4,566	NA	3,785	5,041	1,256	1.44%	1.25%	**1.3%**	**6,700**
Bailey Bridge Connector												
CC Pkwy	Brad McNeer Connector	NA	NA	NA	NA	NA	16,658	NA	NA	NA	**NA**	**NA**
Brad McNeer												
US 360	S. of US 360	NA	13,620	NA	NA	12,475	15,410	2,935	1.02%	0.92%	**0.9%**	**17,700**
Brad McNeer	Bailey Bridge Connector	NA	NA	NA	NA	NA	11,069	NA	NA	NA	**NA**	**NA**
Deer Run												
US 360	S. of US 360	NA	10,080	NA	NA	6,605	4,884	-1,721	-1.13%	-1.30%	**-1.3%**	**7,000**
Chital Drive												
US 360	S. of US 360	NA	5,610	NA	NA	6,605	4,884	-1,721	-1.13%	-1.30%	**-1.3%**	**3,900**
N. Spring Run												
US 360	S. of US 360	NA	8,428	NA	NA	17,871	12,918	-4,953	-1.21%	-1.40%	**-1.4%**	**5,700**
Winterpock												
US 360	S. of US 360	NA	11,208	NA	NA	20,894	24,845	3,951	0.82%	0.76%	**0.8%**	**13,900**
Otterdale												
US 360	S. of US 360	NA	3,388	NA	NA	7,217	9,263	2,046	1.23%	1.09%	**1.1%**	**4,600**

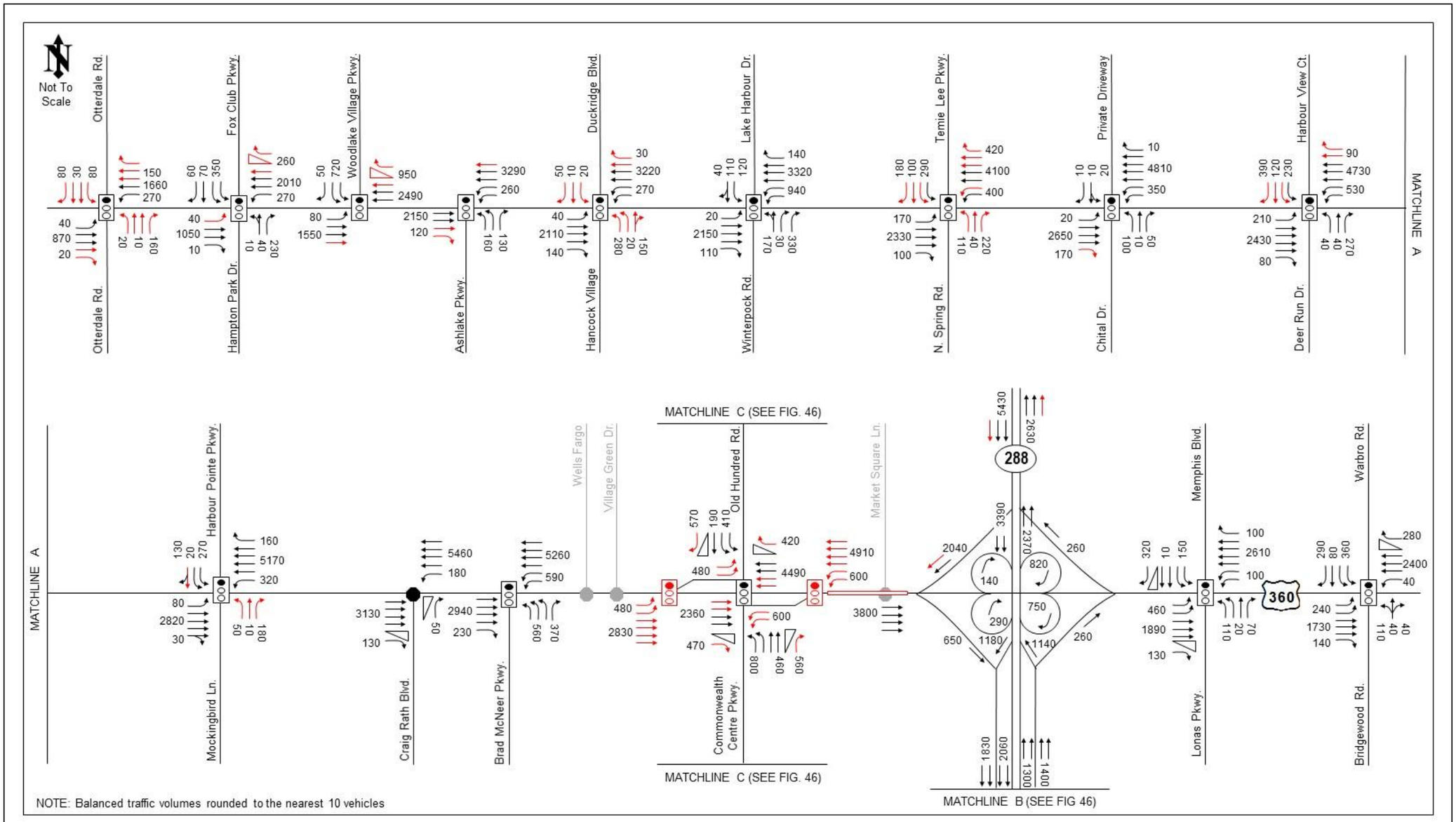


Legend

- Existing Lane Assignment
- Proposed Lane Assignment
- Stop Controlled Movement
- Existing Traffic Signal
- Proposed Traffic Signal
- Existing Concrete Channelizing Median
- Proposed Concrete Channelizing Median

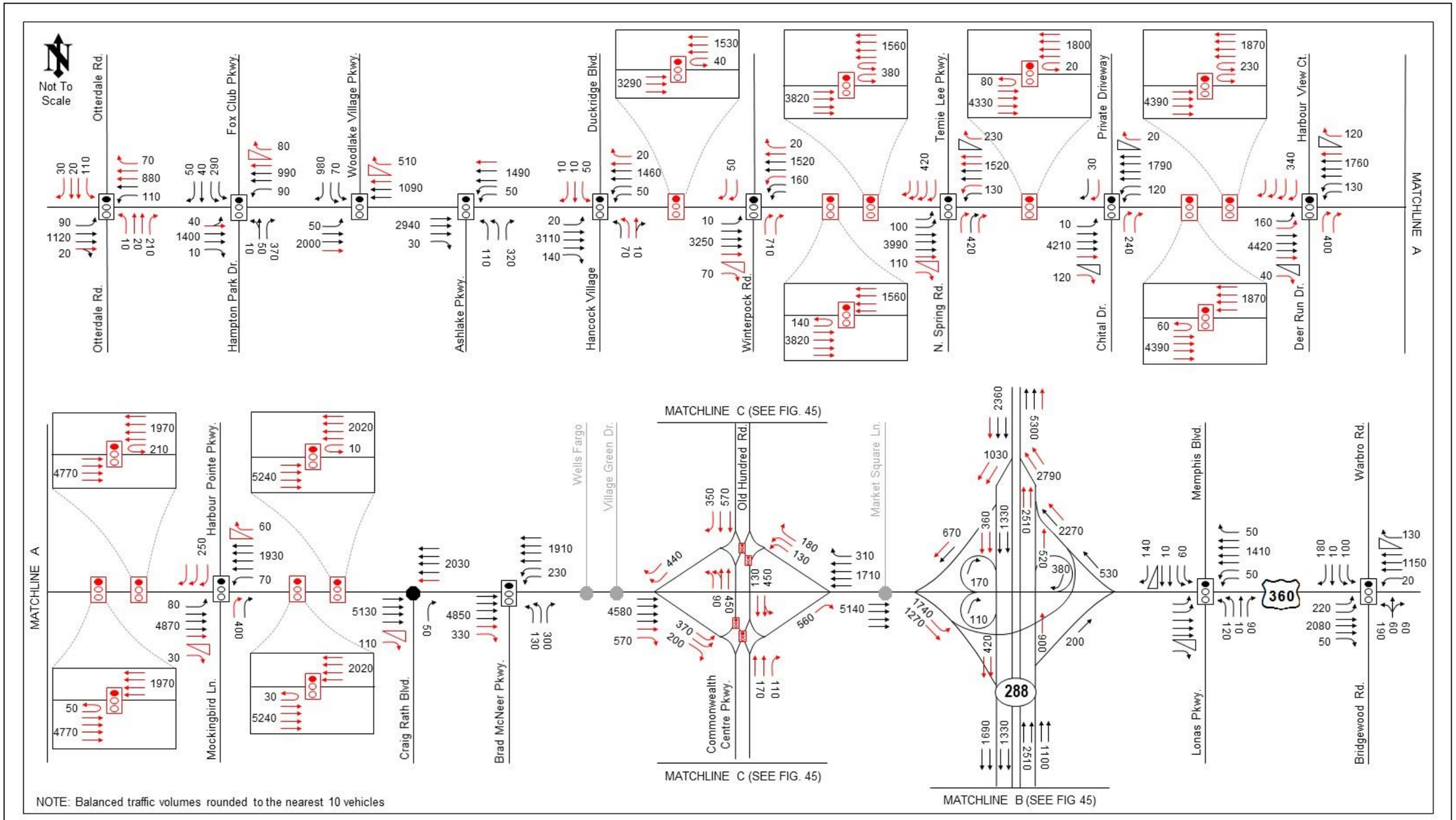
Build (2040) Traffic Volumes – AM Peak Hour – Concept 1
US 360/Route 288 Interchange Study

Figure 41



Build (2040) Traffic Volumes – PM Peak Hour – Concept 1
US 360/Route 288 Interchange Study

Figure 42

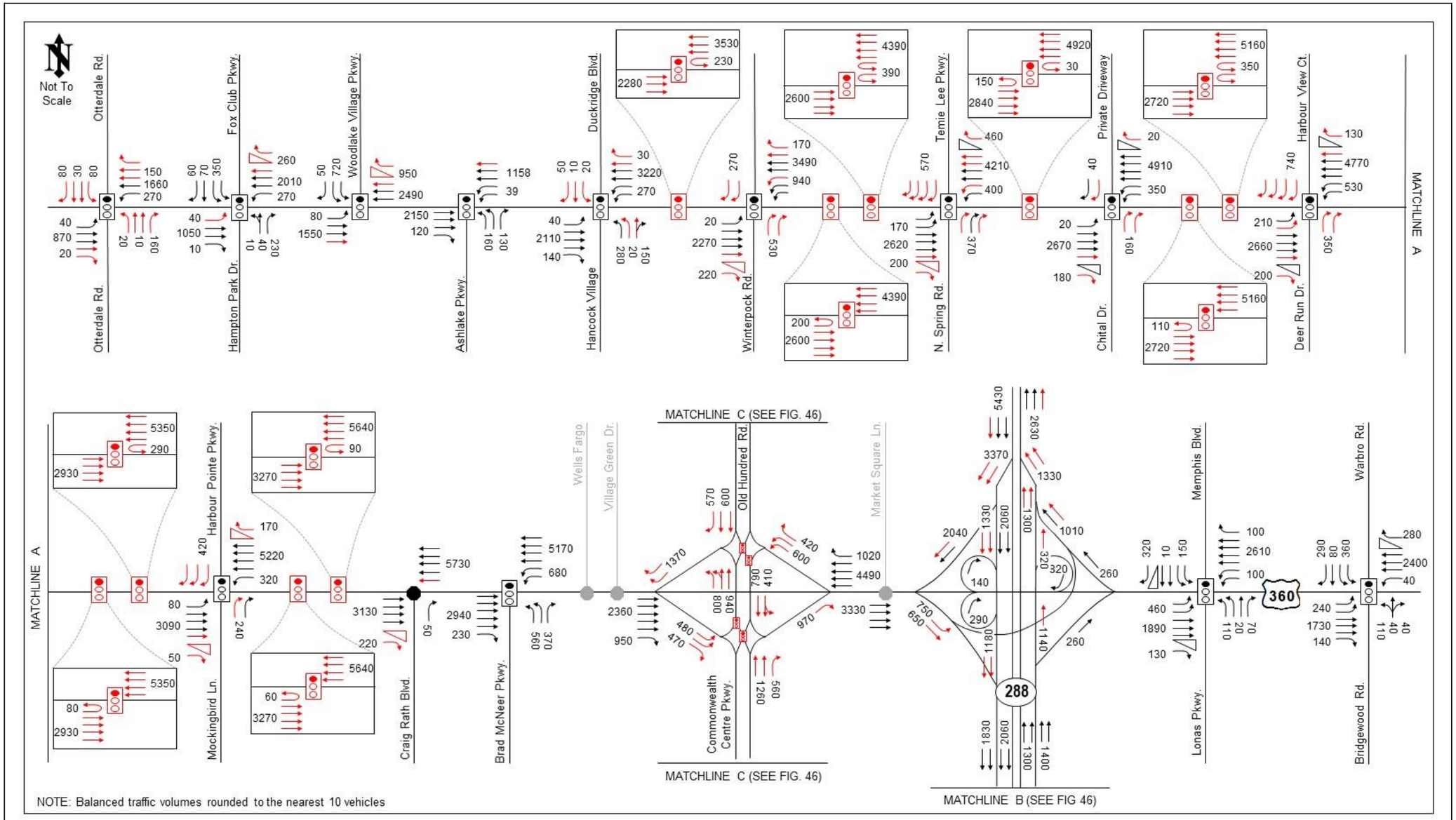


Legend

- Existing Lane Assignment
- Proposed Lane Assignment
- Stop Controlled Movement
- Existing Traffic Signal
- Proposed Traffic Signal
- Existing Concrete Channelizing Median
- Proposed Concrete Channelizing Median

Build (2040) Traffic Volumes – AM Peak Hour – Concept 2
US 360/Route 288 Interchange Study

Figure 43



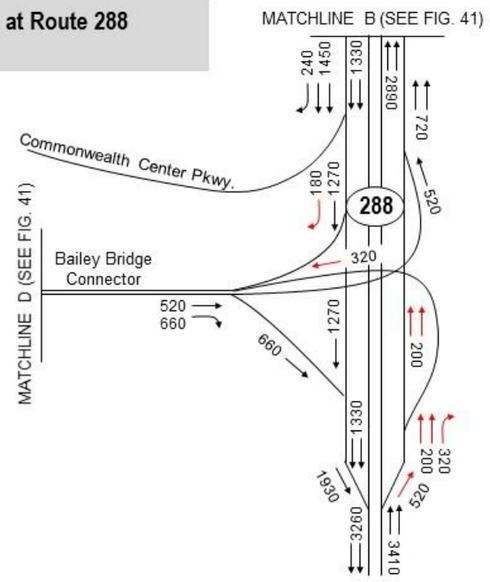
Legend

- Existing Lane Assignment
- Proposed Lane Assignment
- Stop Controlled Movement
- Existing Traffic Signal
- Proposed Traffic Signal
- Existing Concrete Channelizing Median
- Proposed Concrete Channelizing Median

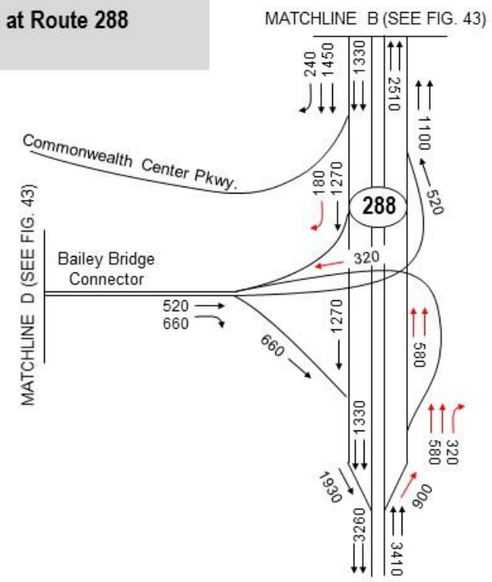
Build (2040) Traffic Volumes – PM Peak Hour – Concept 2
US 360/Route 288 Interchange Study

Figure 44

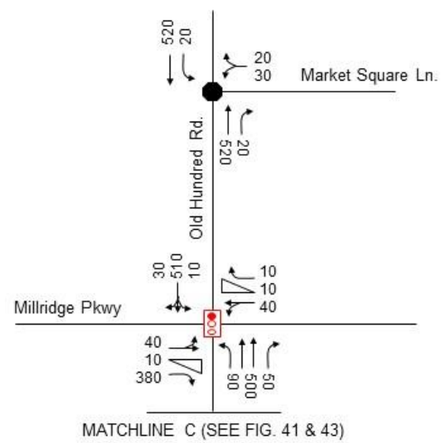
Commonwealth Centre Parkway at Route 288
(Concept 1)



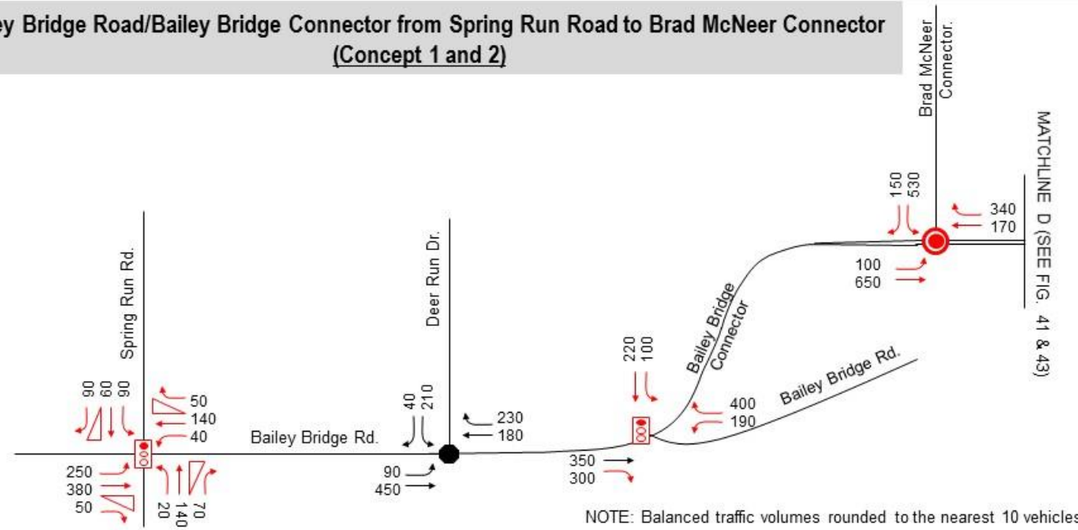
Commonwealth Centre Parkway at Route 288
(Concept 2)



Old Hundred Road at Millridge Parkway and Market Square Lane
(Concept 1 and 2)



Bailey Bridge Road/Bailey Bridge Connector from Spring Run Road to Brad McNeer Connector
(Concept 1 and 2)



NOTE: Balanced traffic volumes rounded to the nearest 10 vehicles

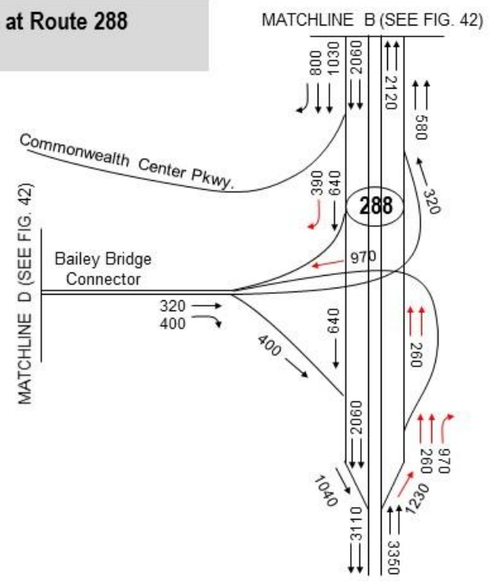
Legend

- Existing Lane Assignment
- Proposed Lane Assignment
- Stop Controlled Movement
- Existing Traffic Signal
- Proposed Traffic Signal
- Existing Concrete Channelizing Median
- Proposed Concrete Channelizing Median
- Proposed Roundabout

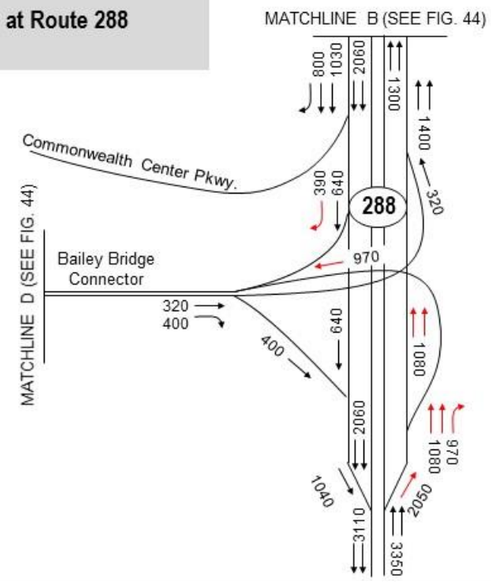
Build (2040) Traffic Volumes – AM Peak Hour
US 360/Route 288 Interchange Study

Figure
45

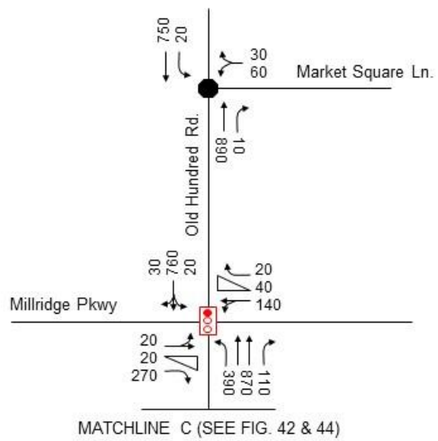
Commonwealth Centre Parkway at Route 288
(Concept 1)



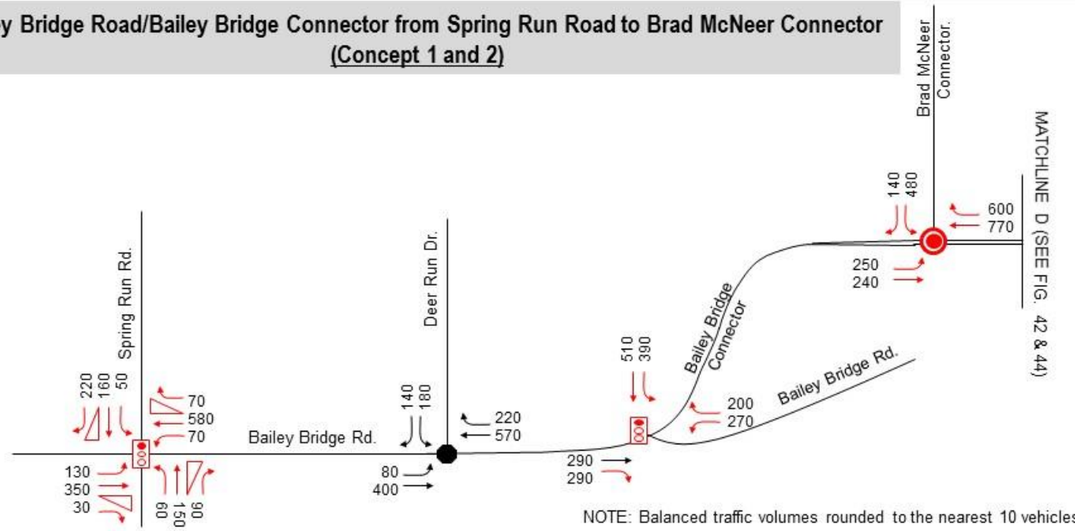
Commonwealth Centre Parkway at Route 288
(Concept 2)



Old Hundred Road at Millridge Parkway and Market Square Lane
(Concept 1 and 2)



Bailey Bridge Road/Bailey Bridge Connector from Spring Run Road to Brad McNeer Connector
(Concept 1 and 2)



NOTE: Balanced traffic volumes rounded to the nearest 10 vehicles

Legend

- Existing Lane Assignment
- Proposed Lane Assignment
- Stop Controlled Movement
- Existing Traffic Signal
- Proposed Traffic Signal
- Existing Concrete Channelizing Median
- Proposed Concrete Channelizing Median
- Proposed Roundabout

Build (2040) Traffic Volumes – PM Peak Hour
US 360/Route 288 Interchange Study

Figure
46

8.2 Build (2040) – Concept 1 – Interchange Operational Results

8.2.1 CORSIM Modeling Assumptions

The No-Build CORSIM model was modified to develop the Build (2040) Concept 1 conditions model. The following improvements were coded into the CORSIM model:

- Optimized traffic signal timings for all signalized intersections
- Six-lane Route 288 between the US 360 north ramps to where the Powhite Parkway auxiliary lanes terminate just south of the Genito Road bridge over Route 288
- Two-lane southbound Route 288 to Westbound US 360 Off-Ramp with an extended deceleration lane
- Northbound Route 288 to Commonwealth Centre Parkway Off-Ramp
- Southbound Route 288 to Commonwealth Centre Parkway Off-Ramp
- Displaced left-turn (DLT) intersection at US 360 and Old Hundred Road/Commonwealth Centre Parkway

Signal timings for the intersections at US 360 at Old Hundred Road/Commonwealth Centre Parkway and US 360 at Memphis Boulevard/Lonas Parkway were optimized. The Build (2040) Concept 1 AM and PM peak hour volumes, summarized in **Figures 41**, **42**, **45**, and **46** were coded into CORSIM. The model was setup to run for a one hour recording period with a preceding 15-minute seeding period. The model was setup to run for a one hour recording period with a preceding 15-minute seeding period. After correcting any errors, the average of 10 simulation runs was used to record statistics to determine how closely the simulation model matched the projected traffic volumes and specified traffic speeds.

8.2.2 CORSIM Results

The Build (2040) Concept 1 operations along Route 288 was evaluated using CORSIM. The analysis results, which include the average of 10 CORSIM analysis runs, for the freeway segments within the study area during both AM and PM peaks are presented in **Figure 47** and **Figure 48**. The following section details how the three critical US 360/Route 288 interchange ramps identified under Existing (2012) and No-Build (2040) traffic conditions are projected operate under Build (2040) Concept 1 conditions:

Southbound Route 288 to Westbound US 360 Off-Ramp

- Travel speeds improve at the southbound Route 288 to westbound US 360 exit ramp during the PM peak hour. The density on the ramp is reduced by 50%; however, exiting vehicle queues are projected to extend beyond the ramp. Mainline operations of southbound Route 288 are impacted due to queues extending beyond the southbound Route 288 to westbound US 360 off-ramp. The queues are due to queuing from the US 360 at Old Hundred Road/ Commonwealth Centre Parkway DLT. The DLT does not provide an ultimate long-term solution to queueing issues on westbound US 360.

Eastbound US 360 to Northbound Route 288 On-Ramp

- In the AM peak hour, analysis results indicate improved travel speeds and reduced densities at the eastbound US 360 to northbound Route 288 on-ramp. Density on this ramp is reduced by 75% and mainline northbound Route 288 operations are improved. The reduced traffic volumes due to the Bailey Bridge Connector factor into improved operational results. However, the loop ramp is still projected to operate over capacity in the future and travel speeds in the weave area are projected to be around 40 mph.

Northbound Route 288 to Westbound US 360 Off-Ramp

- In the PM peak hour, analysis results indicate improved operations at the northbound Route 288 to westbound US 360 off-ramp. The Bailey Bridge Connector reduces projected traffic volumes on this ramp which improves operations. Additionally, queues from the US 360 at Old Hundred Road/Commonwealth Centre Parkway are not anticipated to extend to this ramp.

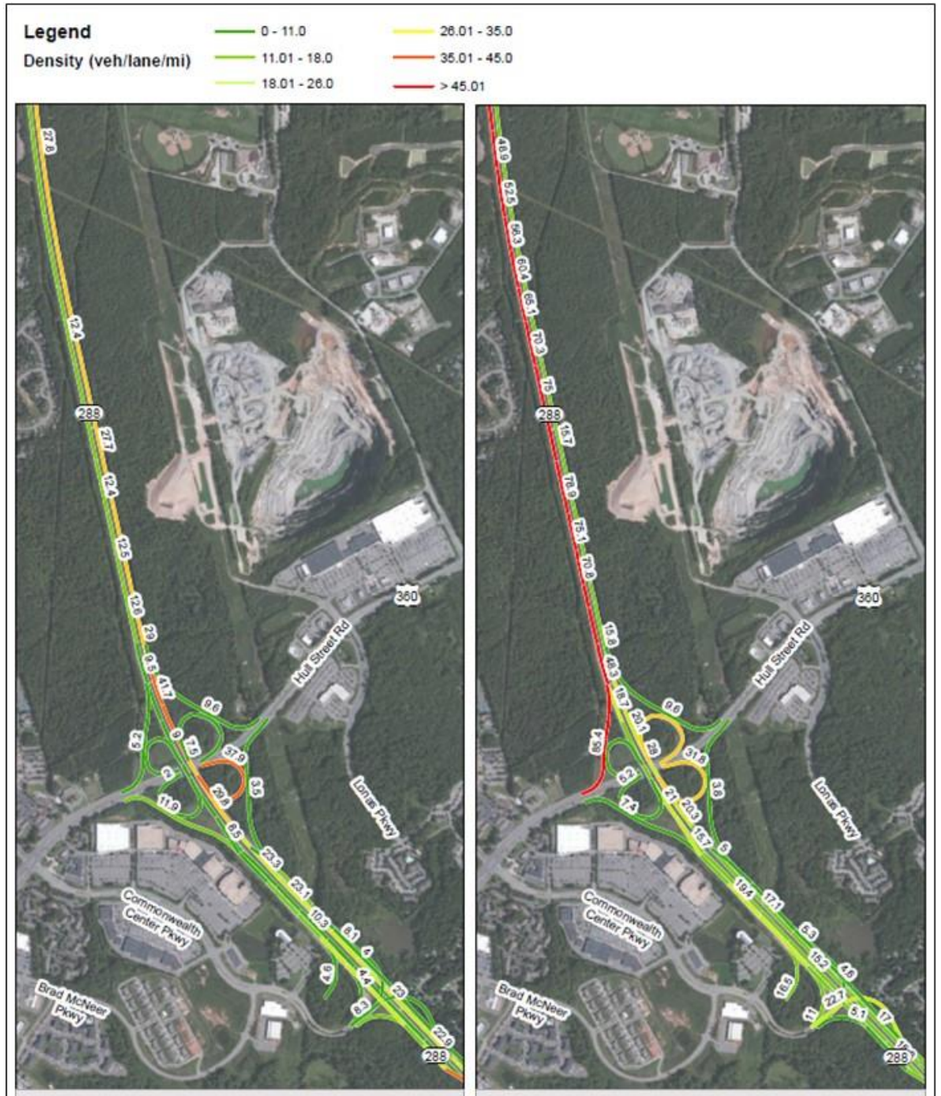
Summary of Concept 1 CORSIM Results

Table 20 illustrates whether or not the Concept 1 interchange improvements address each of the operational issues at the critical ramp locations. Each of the Concept 1 improvements are expected to increase travel speeds and reduce vehicle densities on Route 288; however, Concept 1 improvements ultimately do not the solve congestion within the study area.

Table 20: Build (2040) Concept 1 – Critical Ramp Summary

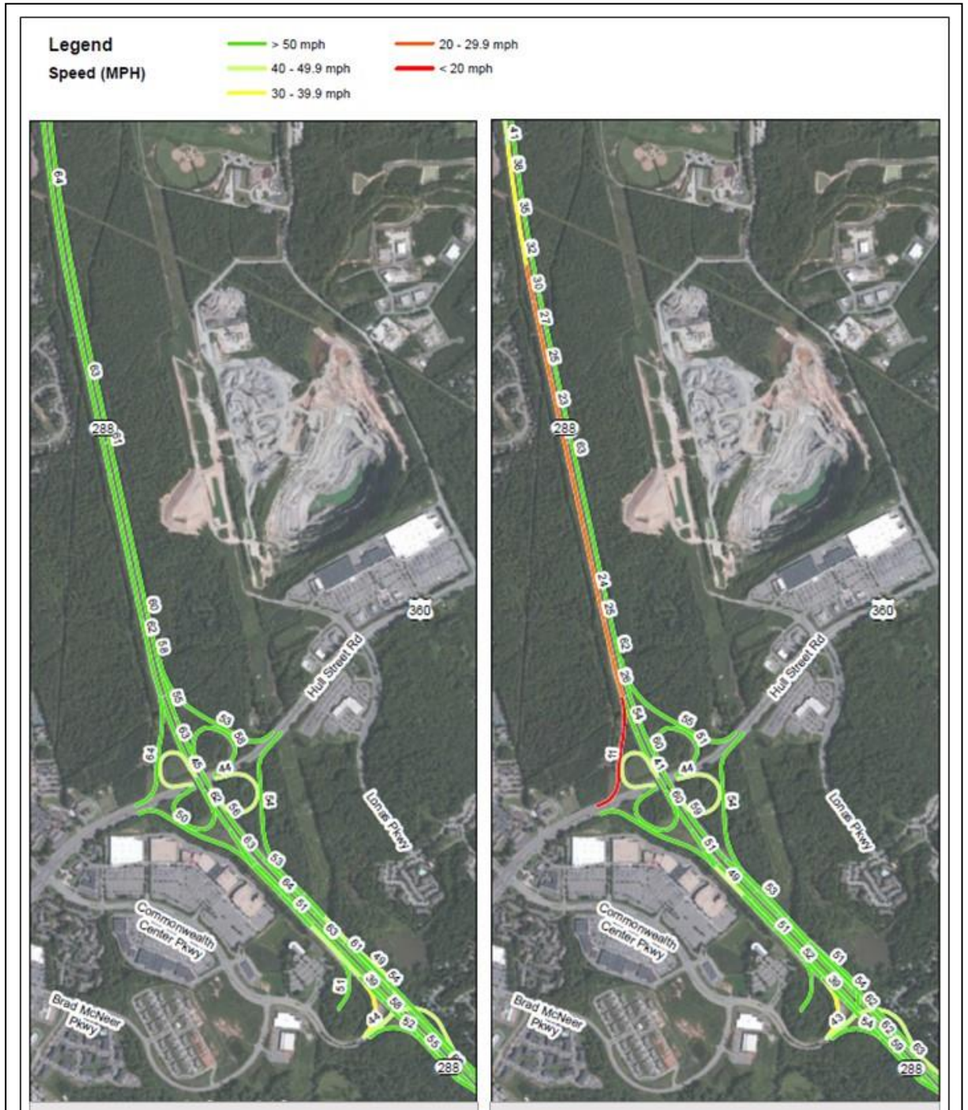
Primary Issues	Does it Mitigate?
US 360 at Route 288 Interchange	
SB to WB Off-Ramp – PM	✗
EB to NB On-Ramp – AM	✗
NB to WB Off-Ramp – PM	✓
Better than No-Build?	✓

In addition to the three critical ramp locations, Route 288 is projected to operate at near free-flow speeds south of US 360, including the Route 288 at Commonwealth Centre Parkway interchange. Freeway operations results are presented in graphical format which depicts vehicle travel speeds and densities by segment and by lane are provided in **Appendix C**.



Build (2040) – Concept 1 – Route 288 CORSIM Results - Density
US 360/Route 288 Interchange Study

Figure 47



Build (2040) – Concept 1 – Route 288 CORSIM Results - Speed
US 360/Route 288 Interchange Study

Figure 48

8.3 Build (2040) – Concept 1 – Intersection Operational Results

A Synchro, Version 8, model was developed to analyze the 24 study area intersections located on the arterials within the study area. HCM 2000 methodology was used for all analyses using Synchro.

8.3.1 Synchro Modeling Assumptions

The No-Build Synchro model was modified to reflect Build (2040) Concept 1 lane configurations. For this operational analysis, the following assumptions were used:

- Optimized traffic signal timings for all signalized intersections
- Two-lane southbound Route 288 to westbound US 360 Off-Ramp
- Four-lane Bailey Bridge Connector from Route 288 to Brad McNeer Connector
- Two-lane Bailey Bridge Connector from Brad McNeer Connector to existing Bailey Bridge Road
- Displaced left-turn intersection at US 360 and Old Hundred Road/Commonwealth Centre Parkway
- Northbound triple left turns at US 360 and Brad McNeer Parkway
- Convert split phase signal operations to eight-phase operations at four traffic signals:
  1. US 360 and Harbour Pointe Parkway/Mockingbird Lane
  2. US 360 and Harbour View Court/Deer Run Road
  3. US 360 and Temie Lee Parkway/North Spring Run Road
  4. US 360 and Hancock Village Drive
- Additional turn lanes and revised lane assignments along US 360

8.3.2 Synchro Model Results

The following MOEs were selected to measure the quantitative performance of the intersections within the network:

- Average vehicle delay and High Capacity Manual (HCM) level of service (LOS) by movement, approach, and intersection (measured in seconds per vehicle)
- Maximum queue length (measured in feet)
- 95th percentile queue length (measured in feet)

Tables summarizing the delay, HCM LOS, and queuing results for the study area intersections are included in **Appendix B**. **Figure 49** and **Figure 50** show a graphical representation of the LOS results in the study area. Key findings for the intersection analysis are summarized in the subsequent sections.

8.3.2.1 Delay and Level of Service

Delays and associated LOS for both signalized and unsignalized intersections are reported from the Synchro analysis. The results are provided in **Appendix B**. The following key delay and level of service conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- Intersections on US 360 between Old Hundred Road / Commonwealth Centre Parkway and Winterpock Road operate at LOS E or worse
- The US 360 at Old Hundred Road/Commonwealth Centre Parkway DLT reduces overall delay by 15% when compared to No-Build (2040) despite operating at LOS F
- The northbound triple left turns at US 360 and Brad McNeer reduce delay by 46% but the intersection is projected to operate at LOS F
- Additional capacity on US 360 west of Winterpock Road improves overall intersection operation to LOS D or better
- The intersection of Bailey Bridge Connector at the Brad McNeer Connector is projected to operate at LOS C as a signalized intersection and LOS A as a roundabout
- Intersections on Bailey Bridge Road west of Brad McNeer Connector are projected to operate at LOS B or better

PM Peak Hour

- Intersections on US 360 between Old Hundred Road/Commonwealth Centre Parkway and Winterpock Road are projected to operate at LOS E or worse
- The US 360 at Old Hundred Road/Commonwealth Centre Parkway DLT reduces overall delay by 66% despite operating at overall LOS F
- The northbound triple left turns at US 360 and Brad McNeer reduce delay by 63% but the intersection is projected to operate at LOS F
- Removing split phase operations slightly improves overall intersection operations as shown in **Table 21**
- Additional capacity on US 360 west of Winterpock Road improves overall intersection operation to LOS E or better
- The intersection of Bailey Bridge Connector at the Brad McNeer Connector is expected to operate at LOS E as a signalized intersection and LOS B as a roundabout
- Intersections on Bailey Bridge Road west of the Brad McNeer Connector are projected to operate at LOS B or better

Table 21: Build (2040) Concept 1 – Remove Split Phase Operations

US 360 Cross-Street	Overall Intersection LOS (Delay, seconds/vehicle)					
	No-Build (2040) Split Phased Operation		Build (2040) Concept 1 Removal of Split Phase Operation		Difference in Delay Percent (seconds/vehicle)	
	AM	PM	AM	PM	AM	PM
Mockingbird Lane/Harbour Pointe Parkway	F (296.3)	F (242.9)	F (121.7)	F (142.3)	-59% (-174.6)	-49% (-118.6)
Deer Run Drive/Harbour View Court	F (198.8)	F (252.8)	E (79.5)	F (111.0)	-60% (-119.3)	-56% (-141.8)
N. Spring Run Road/Temie Lee Parkway	F (246.4)	F (255.9)	F (109.4)	F (82.6)	-56% (-137.0)	-68% (-173.3)
Duckridge Boulevard/Hancock Village	D (39.2)	F (296.0)	B (11.6)	C (22.8)	-70% (-27.6)	-92% (-273.2)

8.3.2.2 Queue Lengths

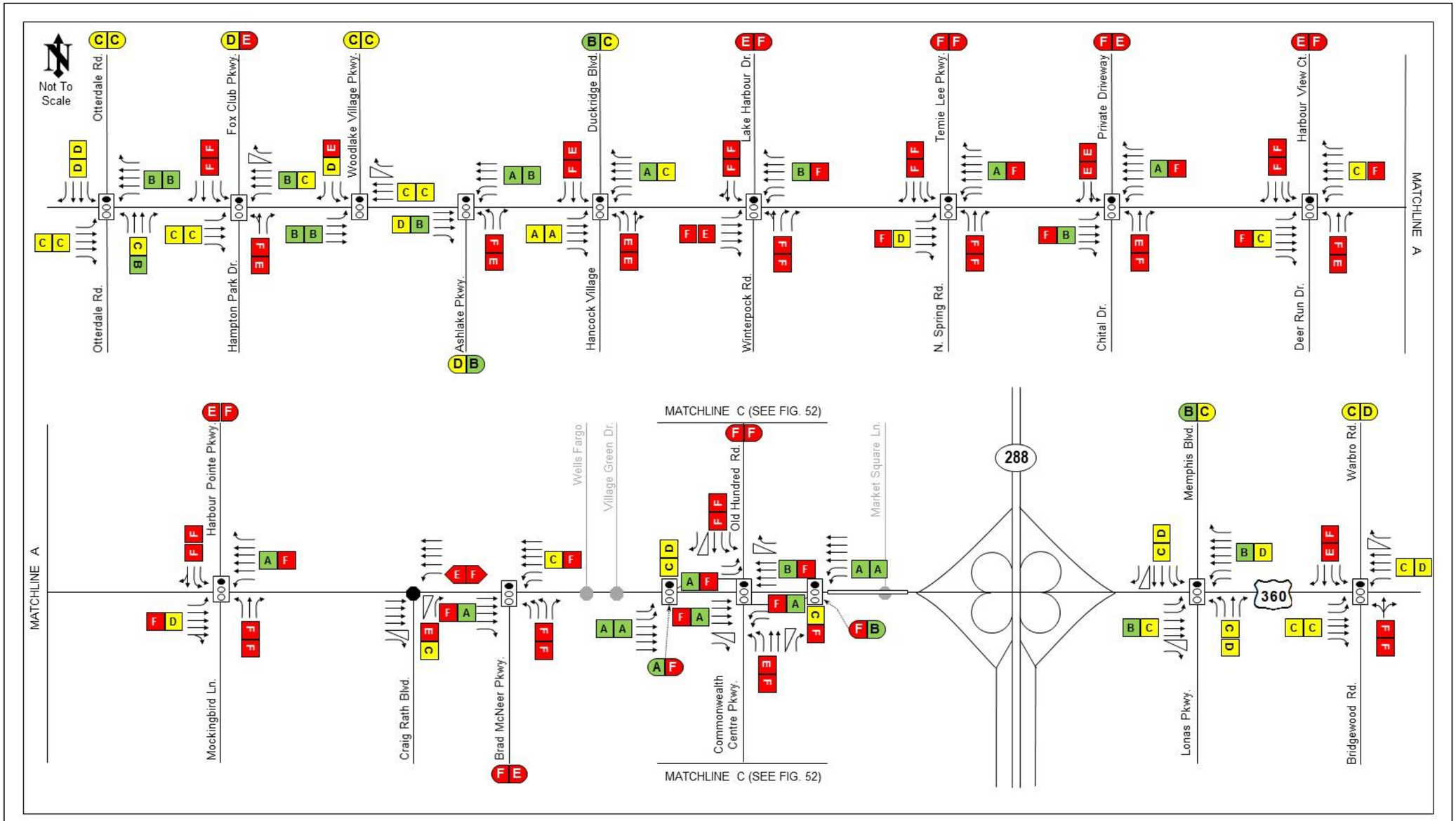
The maximum queues are reported from an average of 10 simulation runs in SimTraffic. **Appendix B** summarizes the average AM and PM peak hour 95th percentile and maximum queue lengths for each lane group at all study area intersections. The following key queuing conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- US 360 queues are reduced compared to No-Build (2040) conditions; however, eastbound congestion spans from Old Hundred Road/Commonwealth Centre Parkway to Duckridge Boulevard/Hancock Village Drive
- The US 360 at Old Hundred Road/Commonwealth Centre Parkway DLT is projected to have queues that exceed proposed storage lengths
- Northbound queues at the intersection of US 360 and Brad McNeer Parkway are reduced by 90%
- Eastbound and south bound queues at the intersection of US 360 at North Spring Run Road/Temie Lee Parkway exceed existing storage capacity

PM Peak Hour

- US 360 queues are reduced compared to No-Build (2040) conditions; however, queues from the US 360 at Old Hundred Road/Commonwealth Centre Parkway DLT are still projected to back up to the southbound Route 288 to westbound US 360 ramp
- The northbound queues at the US 360 and Old Hundred Road/Commonwealth Centre Parkway intersection are projected to exceed 1,000 feet
- Northbound queues at the intersection of US 360 and Brad McNeer Parkway are reduced by 70%
- Queues at the intersection of US 360 at North Spring Road/Temie Lee Parkway exceed storage lengths
- Westbound left turn queues are projected to exceed the storage length at US 360 and Winterpock Road



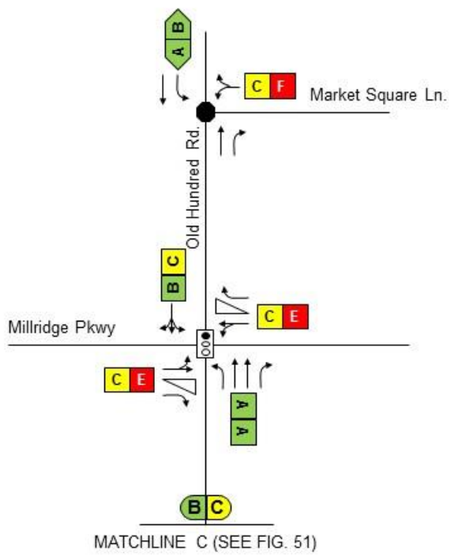
Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal
- AM | PM — Intersection LOS
- AM | PM — Approach LOS
- AM | PM — Movement LOS

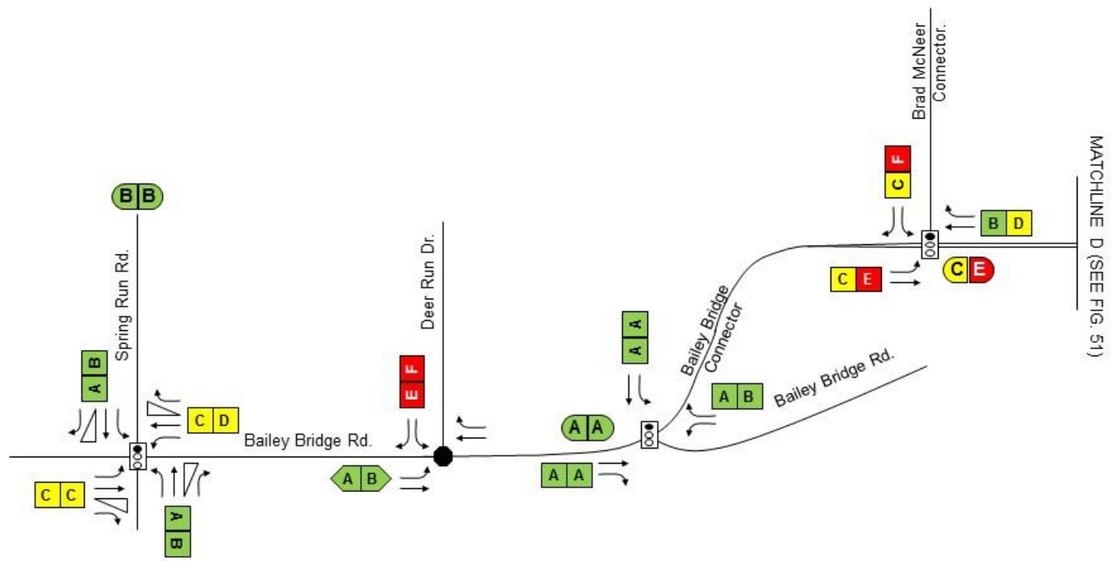
Build (2040) – Concept 1 – Intersection Level of Service
US 360/Route 288 Interchange Study

Figure 49

Old Hundred Road at Millridge Parkway and Market Square Lane



Bailey Bridge Road/Bailey Bridge Connector from Spring Run Road to Brad McNeer Connector



Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal
- AM | PM — Intersection LOS
- AM | PM — Approach LOS
- AM | PM — Movement LOS

Build (2040) – Concept 1 – Intersection Level of Service
US 360/Route 288 Interchange Study

Figure 50

8.4 Build (2040) – Concept 2 – Interchange Operational Results

8.4.1 CORSIM Modeling Assumptions

The No-Build CORSIM model was modified to develop the Concept 2 Build (2040) conditions model. The following improvements were coded into the CORSIM model:

- Six-lane Route 288 between the US 360 north ramps to where the Powhite Parkway auxiliary lanes terminate just south of the Genito Road bridge over Route 288
- Two-lane southbound Route 288 CD road
- Two-lane southbound Route 288 to westbound US 360 off-ramp with an extended deceleration lane
- Northbound Route 288 to Commonwealth Centre Parkway Off-Ramp
- Southbound Route 288 to Commonwealth Centre Parkway Off-Ramp
- DDI interchange at US 360 and Old Hundred Road/Commonwealth Centre Parkway
- Eastbound US 360 to northbound Route 288 directional ramp

Signal timings for the intersections at US 360 at Old Hundred Road/Commonwealth Centre Parkway and US 360 at Memphis Boulevard/Lonas Parkway were optimized. The Build (2040) Concept 2 AM and PM peak hour volumes, summarized in **Figures 43** through **46**, were coded into CORSIM. The model was setup to run for a one hour recording period with a preceding 15-minute seeding period. After correcting any errors, the average of 10 simulation runs was used to record statistics to determine how closely the simulation model matched the projected traffic volumes and specified traffic speeds.

CORSIM Results

The Build (2040) Concept 2 operations along Route 288 was evaluated using CORSIM. The analysis results, which included the average of 10 CORSIM runs, for the freeway segments within the study area during both AM and PM peak hours are presented in **Figure 51** and **Figure 52**. The following section details how the three critical US 360/Route 288 interchange ramps identified under Existing (2012) and No-Build (2040) traffic conditions are projected operate under Build (2040) Concept 2 conditions.

Southbound Route 288 to Westbound US 360 Off-Ramp

- Travel speeds improve at the southbound Route 288 to westbound US 360 exit ramp during the PM peak hour. No exiting vehicle queues are projected on the US 360 off-ramp. The southbound Route 288 mainline and CD road are expected to operate at or near free-flow speeds.

Eastbound US 360 to Northbound Route 288 On-Ramp

- In the AM peak hour, analysis results indicate improved travel speeds and reduced densities at the eastbound US 360 to northbound Route 288 on-ramp. The flyover ramp operates at improved travel speeds compared to No-Build conditions. The eastbound US 360 to northbound Route 288 on-ramp was analyzed with one travel lane; however, to be conservative and provide additional capacity, two travel lanes were recommended due to projected traffic volumes and reported densities.

Northbound Route 288 to Westbound US 360 Off-Ramp

- In the PM peak hour, results indicate improved operations at the northbound Route 288 to westbound US 360 off-ramp. The removal of the eastbound to northbound loop and the Bailey Bridge Connector improves the operations of the ramp.

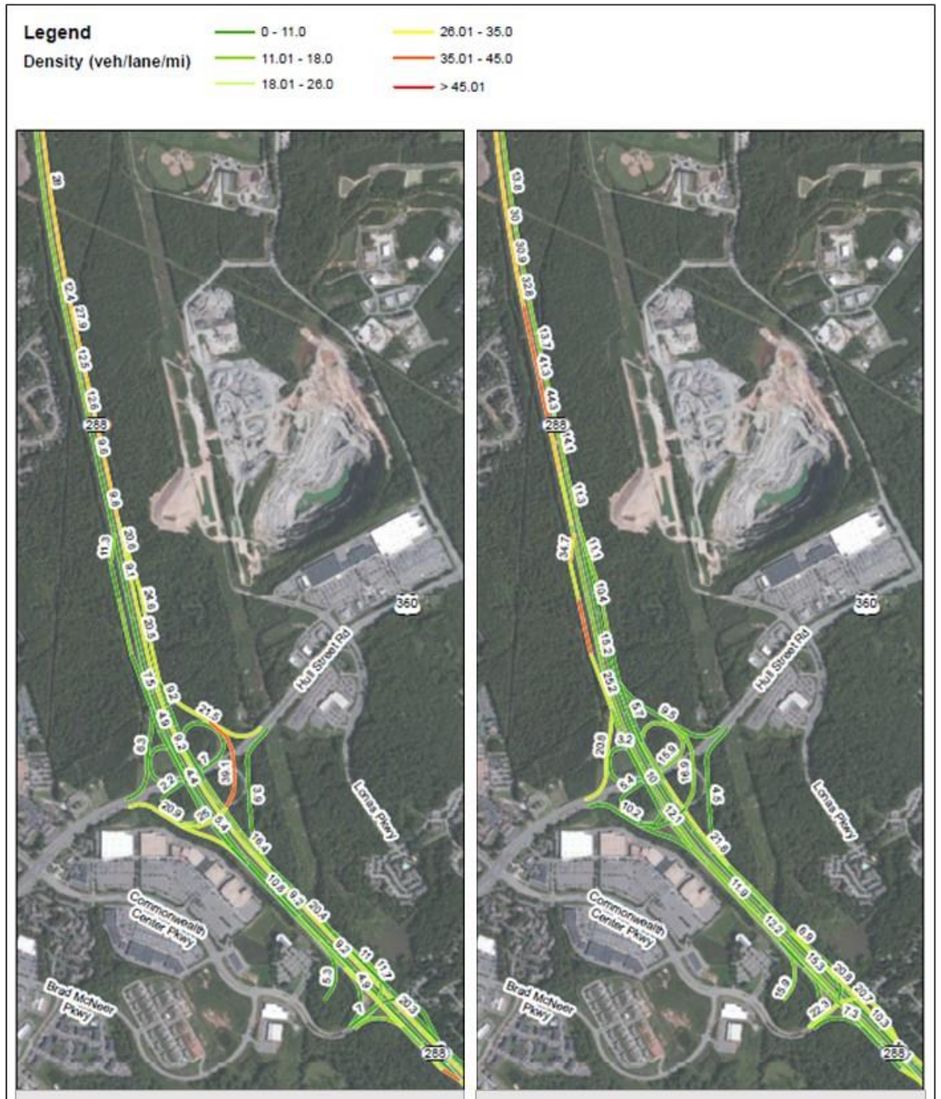
Summary of Concept 1 CORSIM Results

- **Table 22** illustrates whether or not the Concept 2 interchange improvements address each of the operational issues at the critical ramp locations. The collection of Concept 2 improvements are ultimately projected to improve congestion within the study area.

Table 22: Build (2040) Concept 2 – Critical Ramp Summary

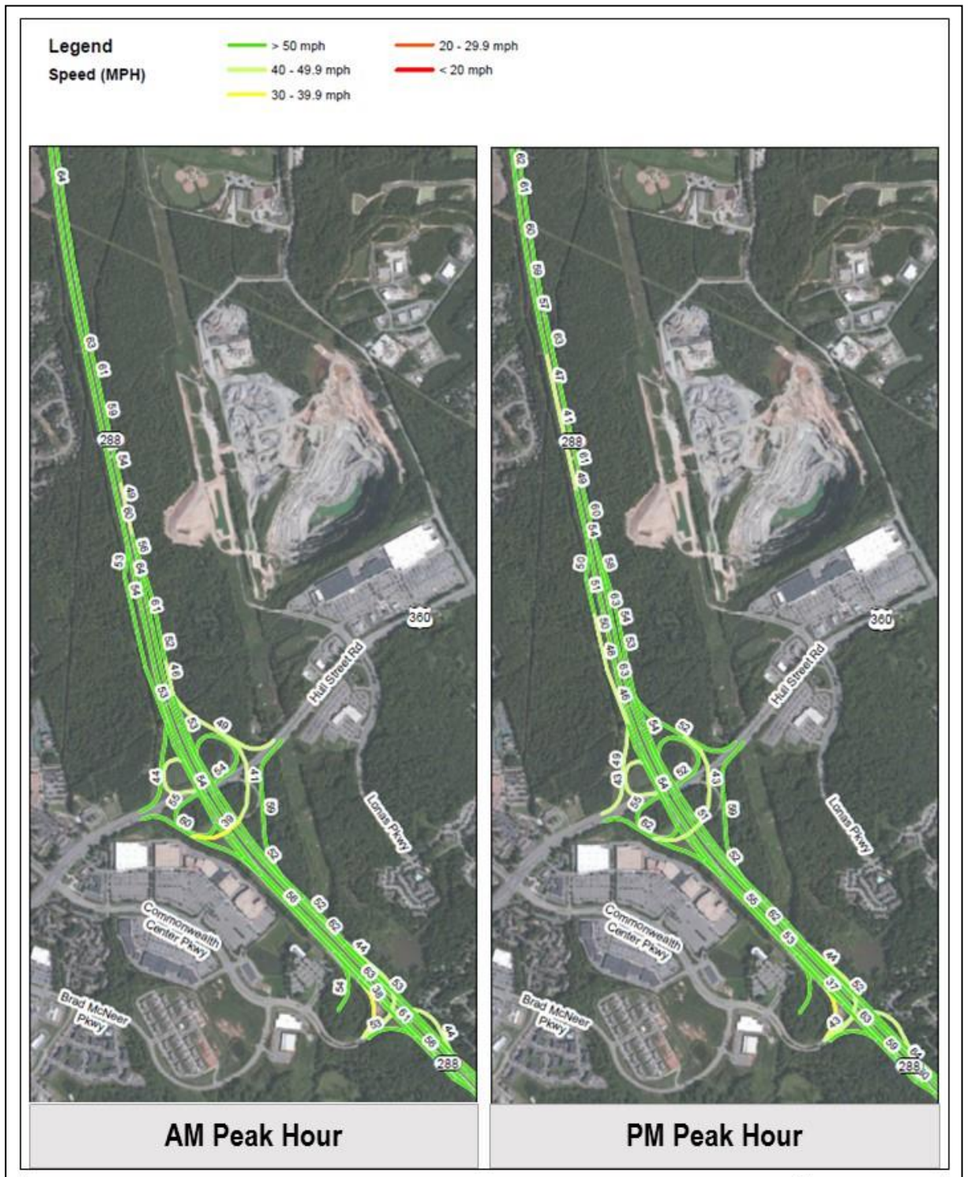
Primary Issues	Does it Mitigate?
US 360 at Route 288 Interchange	
SB to WB Off-Ramp – PM	✅
EB to NB On-Ramp – AM	✅
NB to WB Off-Ramp – PM	✅
Better than No-Build?	✅

In addition to the three critical ramp locations, Route 288 is projected to operate near free-flow conditions south of US 360, including the Route 288 at Commonwealth Centre Parkway interchange. Freeway operations results are presented in graphical format which depicts vehicle travel speeds and densities by segment and by lane are provided in **Appendix C**.



Build (2040) – Concept 2 – Route 288 CORSIM Results - Density
US 360/Route 288 Interchange Study

Figure 51



Build (2040) – Concept 2 – Route 288 CORSIM Results - Speed
US 360/Route 288 Interchange Study

Figure 52

8.5 Build (2040) – Concept 2 – Intersection Operational Results

A Synchro, Version 8, model was developed to analyze the 24 study area intersections located on the arterials within the study area. HCM 2000 methodology was used for all analyses using Synchro.

8.5.1 Synchro Modeling Assumptions

The No-Build Synchro model was modified to reflect Build (2040) Concept 2 lane configurations. For this operational analysis, the following assumptions were used:

- Optimized traffic signal timings for all signalized intersections
- Two-lane southbound Route 288 to westbound US 360 off-ramp and extended deceleration lane
- Four-lane, divided Bailey Bridge Connector from Route 288 to Brad McNeer Connector
- Two-lane Bailey Bridge Connector from Brad McNeer Connector to existing Bailey Bridge Road
- DDI interchange at US 360 and Old Hundred Road/Commonwealth Centre Parkway
- Continuous Green-T Intersection at US 360 and Brad McNeer Parkway
- Superstreet intersections at the following five intersections:
  1. US 360 and Harbour Pointe Parkway/Mockingbird Lane
  2. US 360 and Harbour View Court/Deer Run Road
  3. US 360 and Chital Drive
  4. US 360 and N. Spring Road
  5. US 360 and Winterpock Road
- Eastbound US 360 to northbound Route 288 directional ramp

8.5.2 Synchro Model Results

The following MOEs were selected to measure the quantitative performance of the intersections within the network:

- Average vehicle delay and High Capacity Manual (HCM) level of service (LOS) by movement, approach, and intersection (measured in seconds per vehicle)
- Maximum queue length (measured in feet)
- 95th percentile queue length (measured in feet)

Tables summarizing the delay, HCM LOS, and queuing results for the study area intersections are included in **Appendix C**. **Figure 53** and **Figure 54** shows a graphical representation of the LOS results in the study area. Key findings for the intersection analysis are summarized in the subsequent sections.

8.5.2.1 Delay and Level of Service

Delays and associated LOS for both signalized and unsignalized intersections are reported from the Synchro analysis. The results are provided in **Appendix C**. The following key delay and level of service conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- Intersections along US 360 operate at LOS D or better
- The US 360 at Old Hundred Road/Commonwealth Centre Parkway DDI ramp terminals operate at LOS B
- The US 360 and Brad McNeer CGT reduces delay by 68% and operates at LOS D
- The super street improvement at Harbour Pointe Parkway/Mockingbird Lane is projected to operate at LOS D since the heavy movement is on eastbound US 360, which is not a free-flow movement
- The super street improvements between Harbour View Court/Deer Run Road and Winterpock Road are projected to operate at LOS B or better
- Intersections west of Winterpock Road are projected to operate at LOS C
- The intersection of Bailey Bridge Connector at the Brad McNeer Connector is projected to operate at LOS C as a signalized intersection and LOS A as a roundabout
- Intersections on Bailey Bridge Road west of Brad McNeer Connector are projected to operate at LOS B or better

PM Peak Hour

- Intersections along US 360 operate at LOS D or better
- The US 360 at Old Hundred Road/Commonwealth Centre Parkway DDI ramp terminals operate at LOS B
- The US 360 and Brad McNeer CGT reduces delay by 88% and operates at LOS C since the heavy movement on westbound US 360 is allowed to operate as free-flow
- The super street improvements at Harbour Pointe Parkway/Mockingbird Lane and Harbour View Court/Deer Run Road are projected to operate at LOS D which are improvements to operations
- The super street improvements between Chital Drive and Winterpock Road are projected to operate at LOS B or better
- Intersections west of Winterpock Road are projected to operate at LOS D or better
- The intersection of Bailey Bridge Connector at the Brad McNeer Connector is projected to operate at LOS E as a signalized intersection and LOS B as a roundabout
- Intersections on Bailey Bridge Road west of Brad McNeer Connector are projected to operate at LOS B or better

8.5.2.2 Queue Lengths

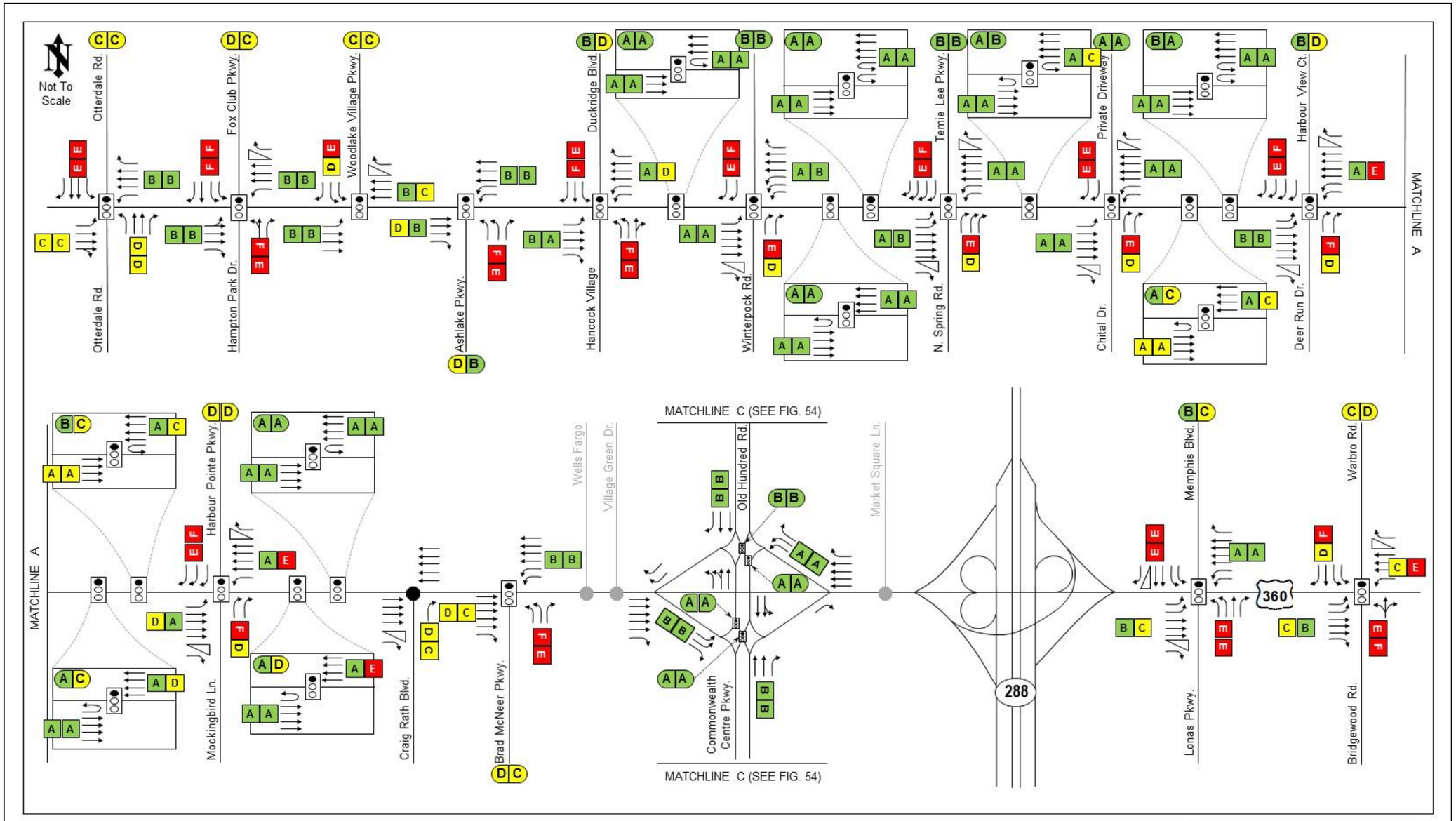
The maximum queues are reported from an average of 10 simulation runs in SimTraffic. **Appendix C** summarizes the average AM and PM peak hour 95th percentile and maximum queue lengths for each lane group at all study area intersections. The following key queuing conclusions were determined from the AM and PM peak hour analysis results:

AM Peak Hour

- Recurring congestion on eastbound US 360 is reduced compared to No-Build (2040) conditions and
- Queues are predominantly contained within turn lane storage bays

PM Peak Hour

- US 360 queues are reduced compared to No-Build (2040) conditions; however, westbound queues from the US 360 at Harbour Pointe Parkway/Mockingbird Lane are projected to increase due to US 360 traffic volumes being allowed to flow unconstrained to this location (this intersection is the first signalized location where westbound traffic is signalized west of Route 288)
- Queues are reduced significantly from No-Build (2040) conditions



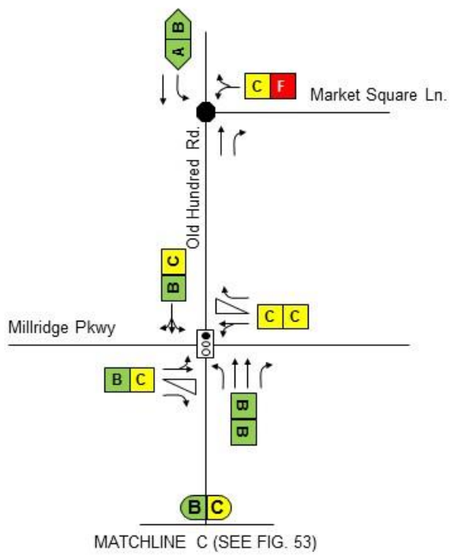
Legend

Existing Lane Assignment
Existing Concrete Channelizing Median
Stop Controlled Movement
Existing Traffic Signal
AM | PM Intersection LOS
AM | PM Approach LOS
AM | PM Movement LOS

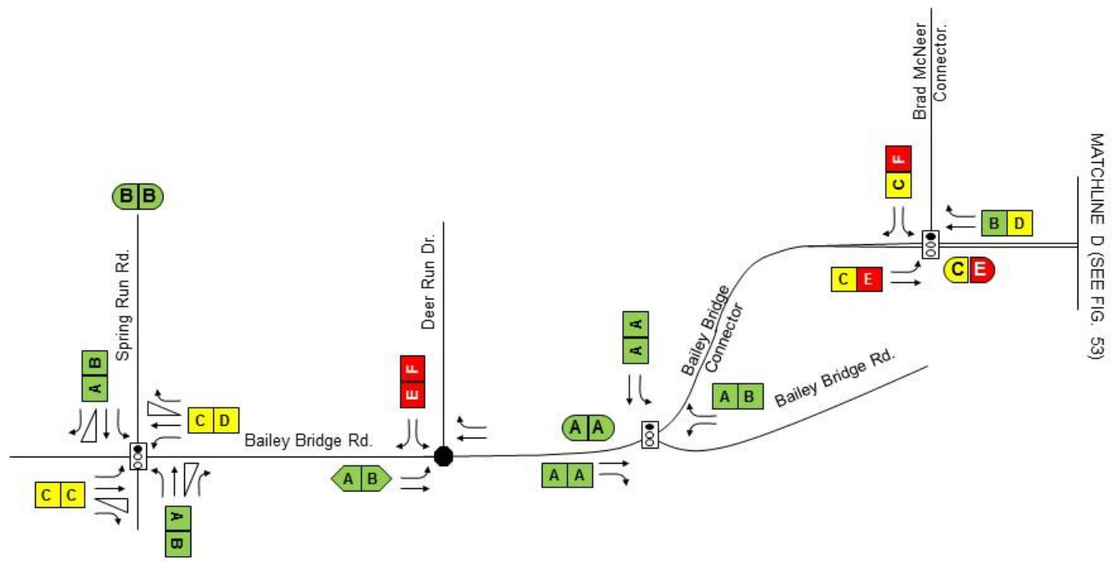
Build (2040) – Concept 2 – Intersection Level of Service
US 360/Route 288 Interchange Study

Figure 53

Old Hundred Road at Millridge Parkway and Market Square Lane



Bailey Bridge Road/Bailey Bridge Connector from Spring Run Road to Brad McNeer Connector



Legend

- Existing Lane Assignment
- Existing Concrete Channelizing Median
- Stop Controlled Movement
- Existing Traffic Signal
- AM | PM — Intersection LOS
- AM | PM — Approach LOS
- AM | PM — Movement LOS

Build (2040) – Concept 2 – Intersection Level of Service
US 360/Route 288 Interchange Study

Figure 54

8.6 Summary of Build (2040) Conditions

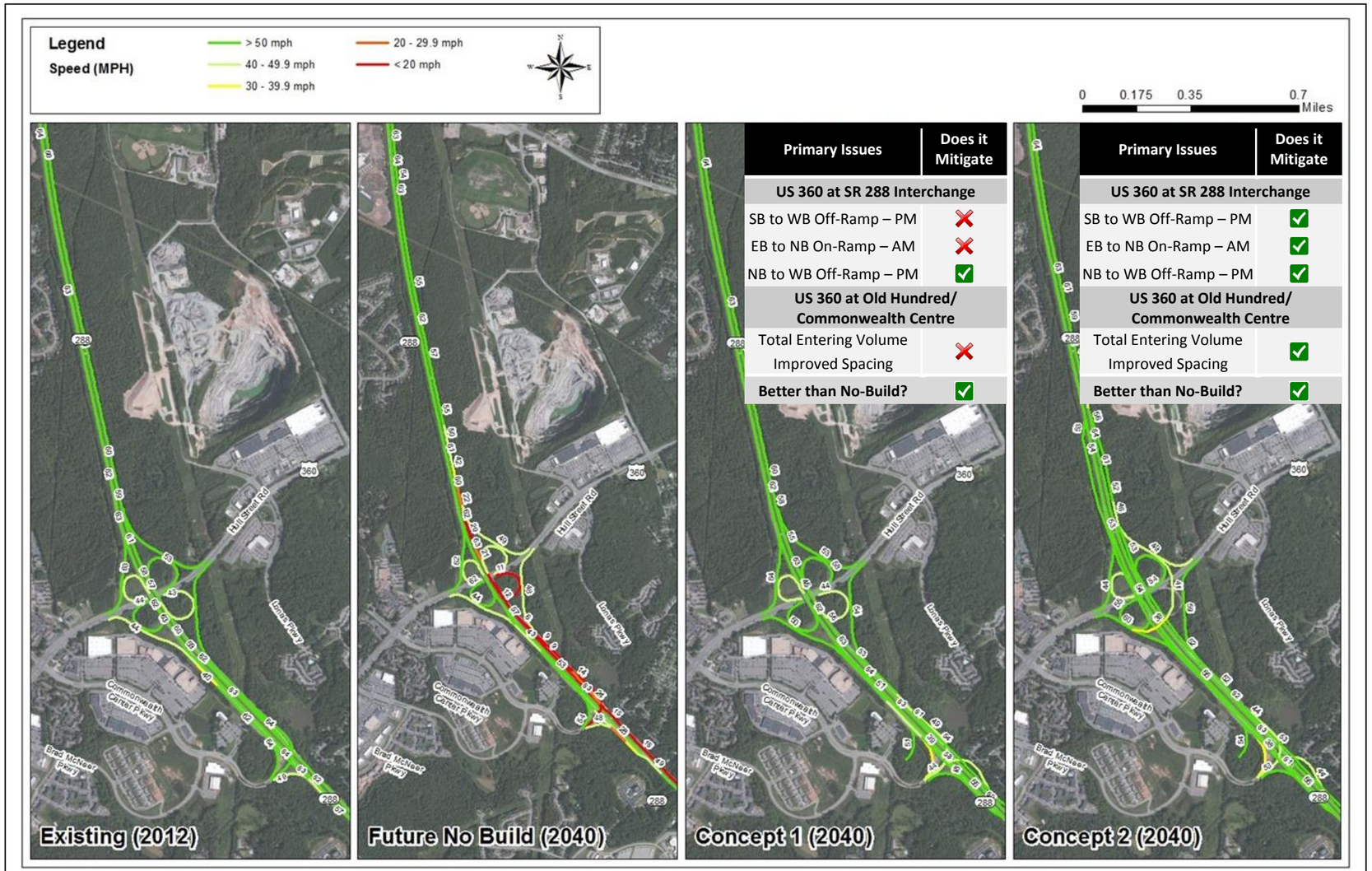
A comparison of Concept 1 and Concept 2 peak hour speeds is summarized in **Figure 55** and **Figure 56**, density figures are provided in **Appendix C** for reference. Some of the key operational differences between Concept 1 and Concept 2 are as follows:

Concept 1

- **PROs**
  - Density is reduced on the southbound Route 288 to westbound US 360 off-ramp during PM peak hour by 50%
  - Density is reduced on the eastbound US 360 to northbound Route 288 On-Ramp during the AM peak hour by 75%
  - The US 360 at Brad McNeer Parkway intersection delays are reduced by 63% in the PM peak hour
  - Travel times are reduced on US 360
- **CONs**
  - The US 360 at Old Hundred Road/Commonwealth Centre Parkway DLT does not prevent queues from backing up onto the southbound Route 288 to US 360 westbound ramp
  - Removing split phase operations on US 360 improve operations; however, most intersections remain over capacity

Concept 2

- **PROs**
  - The US 360 at Old Hundred Road/Commonwealth Centre Parkway DDI operates at LOS B and removes westbound US 360 queues from impacting Route 288
  - Density is reduced on the southbound Route 288 to westbound US 360 off-ramp during PM peak hour by 85%
  - The eastbound US 360 to northbound Route 288 fly-over on-ramp accommodates AM peak hour volumes
  - The US 360 at Brad McNeer CGT reduces delay during the PM peak hour by 88%
  - Travel times are reduced on US 360
- **CONs**
  - The bottleneck on westbound US 360 is moved from Old Hundred Road/Commonwealth Centre Parkway to Harbour Pointe Parkway/Mockingbird Lane



Comparison of Concept 1 and Concept 2 Improvements – AM Peak Hour – Speed
US 360/Route 288 Interchange Study

Figure 55

Some of the key operational differences between Concept 1 and Concept 2 are as follows:

» The DDI (Concept 2) at US 360 and Old Hundred Road/ Commonwealth Centre Parkway has a greater reduction in delay than the DLT (Concept 1) when compared to No-Build (2040) traffic volumes as shown in **Table 23**.

Table 23: US 360 at Old Hundred Road/Commonwealth Centre Parkway – Comparison of DDI and DLT

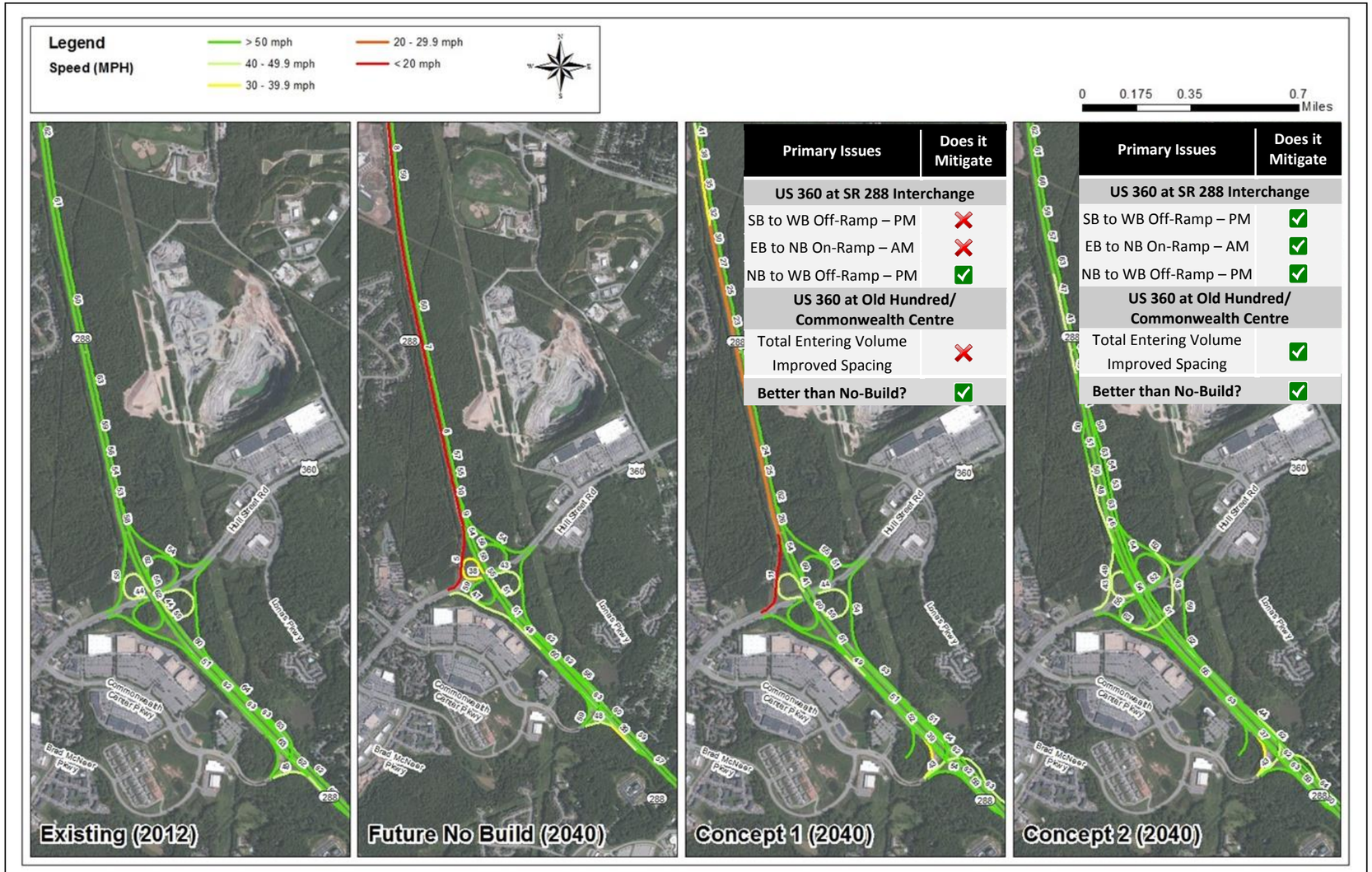
Overall Intersection Delay (Seconds/Vehicle)					
No-Build (2040)		Build (2040) Concept 1: At-Grade DLT^		Build (2040) Concept 2: Grade-Separated DDI*	
AM	PM	AM	PM	AM	PM
138.6	345.0	279.9	277.5	32.8	38.7
Compared to No-Build		**+102%**	**-20%**	**-76%**	**-89%**

^DLT – Total delay at three signalized DLT intersections
*DDI – Eastbound/westbound through traffic on US 360 operates under free conditions due to grade-separated DDI configuration.

» The CGT (Concept 2) at US 360 and Brad McNeer Parkway has a greater reduction in delay than the NB triple left-turns (Concept 1) when compared to No-Build (2040) traffic volumes as shown in **Table 24**.

Table 24: US 360 at Brad McNeer Parkway – Comparison of Triple Left-Turns and CGT

Overall Intersection LOS and Delay (Seconds/Vehicle)					
No-Build (2040)		Build (2040) Concept 1: NB Triple Left-Turns		Build (2040) Concept 2: Continuous Green-T	
AM	PM	AM	PM	AM	PM
F 149.2	F 174.1	F 80.4	E 63.6	D 47.2	C 21.5
Compared to No-Build		**-46%**	**-63%**	**-68%**	**-88%**



Comparison of Concept 1 and Concept 2 Improvements – PM Peak Hour – Speed
US 360/Route 288 Interchange Study

Figure 56

8.7 Supplemental Analysis

The purpose of this analysis is to supplement the US 360/Route 288 Interchange Area Study by providing additional traffic analysis focused on individual components of Build (2040) Concept 1 and Build (2040) Concept 2. The modeling process for Concept 1 and Concept 2 focused on the cumulative impacts of improvements, whereas, it is important to identify the individual impact of projects for the determining the phasing of improvements.

An independent utility analysis was conducted for the Bailey Bridge Connector and the US 360 at Old Hundred Road/ Commonwealth Centre Parkway DLT improvements. The primary goal of the analysis was to determine the benefits of the Bailey Bridge Connector if it were to be constructed as a standalone project. Ultimately, projects of independent utility need to demonstrate that they provide benefit as compared to the No-Build condition. The independent utility evaluation for each of these improvements is detailed in the following sections.

8.7.1 Independent Utility Analysis – Bailey Bridge Connector

Based on travel demand modeling results, it was concluded that the Bailey Bridge Connector would reduce the future growth rate on US 360; therefore, the improvement was included in both Concept 1 and Concept 2. The Bailey Bridge Connector was identified for independent utility analysis since it is difficult to assess the individual impact of the Bailey Bridge Connector with the other capacity improvements. The Bailey Bridge Connector improvement includes the following improvements:

- Northbound Route 288 to Commonwealth Centre Parkway off-ramp
- Southbound Route 288 to Commonwealth Centre Parkway off-ramp
- Two-lane southbound Route 288 to westbound US 360 off-ramp and extended deceleration lane
- Four-lane, divided Bailey Bridge Connector from Route 288 to Brad McNeer Connector
- Two-lane Bailey Bridge Connector from Brad McNeer Connector to existing Bailey Bridge Road

Additionally, the two-lane southbound Route 288 to westbound US 360 off-ramp with an extended deceleration lane was assumed to be in place since this improvement was also included in both Concept 1 and Concept 2.

To assess the impact of the Bailey Bridge Connector, the No-Build (2040) conditions model was analyzed using the volumes developed for US 360 with the Bailey Bridge Connector improvement. Additionally, the two lane southbound Route 288 to westbound US 360 off-ramp with an extended deceleration lane was assumed to be in place, since this improvement was also included in both Concept 1 and Concept 2.

Table 25 summarizes the Synchro modeling results for the Bailey Bridge Connector Independent Utility Analysis. The Bailey Bridge Connector, without other improvements, were projected to reduce delay at 12 of the 14 signalized intersections during both the AM and PM peak hours. Delays would be reduced by 45% and 40% in the AM and PM peak hours, respectively. The analysis results conclude that the Bailey Bridge Connector improvements have independent utility and provides one of the most widespread benefits.

Table 25: Intersection LOS with and without Bailey Bridge Concept

US 360 Cross-Street	Overall Intersection LOS (Delay [seconds/vehicle])			
	Future No-Build (2040) without Bailey		Future Build (2040) with Bailey	
	AM	PM	AM	PM
Old Hundred Road/Commonwealth Centre Parkway	F (138.6)	F (345.0)	E (79.8)	F (225.1)
Brad McNeer Parkway	F (149.2)	F (174.1)	E (74.0)	E (68.5)
Mockingbird Lane/Harbour Pointe Parkway	F (296.3)	F (242.9)	F (268.4)	F (401.8)
Deer Run Drive/Harbour View Court	F (198.8)	F (252.8)	E (73.1)	F (137.2)
Chital Drive	F (135.3)	F (187.5)	C (28.2)	E (64.9)
N. Spring Run Road/Temie Lee Parkway	F (246.4)	F (255.9)	F (148.7)	F (135.9)
Winterpock Road	F (153.7)	F (187.5)	E (73.0)	F (94.7)
Duckridge Boulevard/Hancock Village Drive	D (39.2)	F (296.0)	B (16.0)	F (136.7)
Ashlake Parkway	E (59.8)	F (187.6)	C (24.2)	E (68.8)
Woodlake Village Parkway	F (83.6)	F (169.3)	D (39.1)	F (81.9)
Hampton Park Drive/Fox Club Parkway	F (80.9)	F (103.8)	C (34.9)	C (27.7)
Otterdale Road	D (37.4)	E (66.3)	C (27.2)	C (23.8)
Lonas Parkway	B (15.0)	C (23.2)	B (16.4)	C (21.0)
Warbro Road	D (42.4)	E (71.4)	C (28.1)	D (50.0)
Total Delay (seconds/vehicle) =	**1,676.6**	**2,563.3**	**931.1**	**1,538.0**

8.7.2 Independent Utility Analysis – US 360 at Old Hundred Road/Commonwealth Centre Parkway Displaced Left-Turn

Based on the Build (2040) analysis results, it was determined that the US 360 at Old Hundred Road/Commonwealth Centre Parkway DLT would improve operations when compared to No-Build traffic conditions. Operational results indicate that the DLT improvement was not as effective as the DDI; however, this improvement is not as costly with fewer impacts to adjacent properties. Therefore, the DLT was identified for independent utility analysis.

To assess the impact of the Bailey Bridge Connector on the operations of the DLT, the No-Build (2040) PM peak hour traffic volumes (without the Bailey Bridge Connector) were coded into the Concept 1 Synchro model. This model consisted of the DLT and the two lane southbound Route 288 to westbound US 360 off-ramp since this improvement was also included in both Concept 1 and Concept 2. The following independent utility analysis focused on the PM peak hour because it was the worst case operational scenario.

Without Bailey Bridge Connector

The primary criteria for evaluation was to determine whether or not the DLT improvement had independent utility; however, it was determined that this concept would not prevent queues from backing up onto southbound Route 288 under Build (2040) conditions. A subsequent interim year analysis was conducted to estimate how long the DLT improvement would prevent vehicles from queuing on southbound Route 288. The first interim year of 2025 was selected for evaluation. The study team determined that queues are projected to back up onto southbound Route 288. The findings of this analysis are presented **Figure 57.**

The conclusion was that the Bailey Bridge Connector is a key improvement in extending the life of the DLT improvement at the US 360 and Old Hundred Road/Commonwealth Centre Parkway intersection. Therefore, the independent utility analysis was modified to assume the Bailey Bridge Connector was in place to determine how long queues would not extend to southbound Route 288.

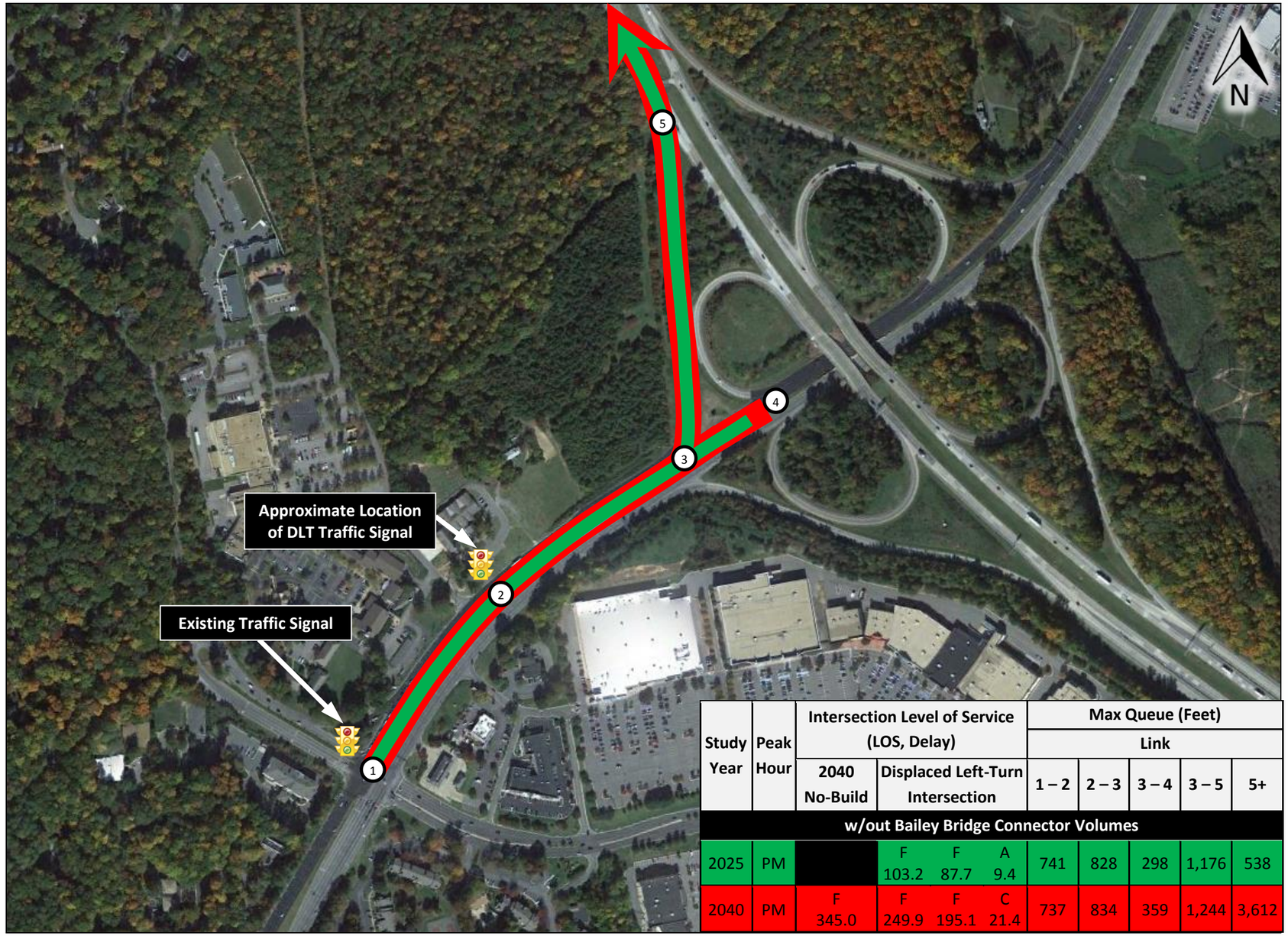
With Bailey Bridge Connector

Build (2040) Concept 1 volumes, which assume the Bailey Bridge Connector is constructed, were used to analyze the DLT. An iterative analysis was conducted in five-year increments to identify when westbound queues would reach southbound Route 288.

The first interim year of 2025 was selected for evaluation and determined that queues are not projected to extend to the southbound Route 288 mainline. An interim year of 2030 was also modeled and determined that projected queues would extend to the southbound Route 288 to westbound US 360 off-ramp ramp gore. A subsequent analysis of interim year 2035 determined that queues would extend beyond the ramp onto the southbound Route 288 mainline. The findings of this analysis are presented in Figure 58.

The analysis results conclude that the DLT concept with the Bailey Bridge Connector will prevent queues from extending onto southbound Route 288 until approximately 2030. This means that this improvement will have an effective life of approximately 9 to 14 years, assuming a build year of 2021, which is the last year in the next SYIP funding cycle.

Figure 57: DLT PM Peak Hour Queue – without Bailey Bridge Connector



Study Year	Peak Hour	Intersection Level of Service (LOS, Delay)		Max Queue (Feet)				
				Link				
		2040 No-Build	Displaced Left-Turn Intersection	1 – 2	2 – 3	3 – 4	3 – 5	5+
w/out Bailey Bridge Connector Volumes								
2025	PM		F 103.2 / F 87.7 / A 9.4	741	828	298	1,176	538
2040	PM	F 345.0	F 249.9 / F 195.1 / C 21.4	737	834	359	1,244	3,612

The Bailey Bridge Connector reduces the growth rate on US 360 and could help extend the life of the DLT improvement at the US 360 and Old Hundred Road/Commonwealth Centre Parkway intersection. Therefore, the independent utility analysis was modified to assume the Bailey Bridge Connector was in place to determine how long queues would be kept off of the southbound Route 288 mainline.

Overall, the DLT with the Bailey Bridge Connector reduces overall intersection delays and queues; therefore, the improvement was evaluated one more time to identify whether or not additional capacity improvements could be made to extend the life of the DLT. The following additional capacity improvements were assumed for evaluation:

- Additional westbound US 360 through travel lane
- Additional eastbound US 360 through travel lane
- Additional northbound left-turn lane on Commonwealth Centre Parkway to accommodate triple lefts

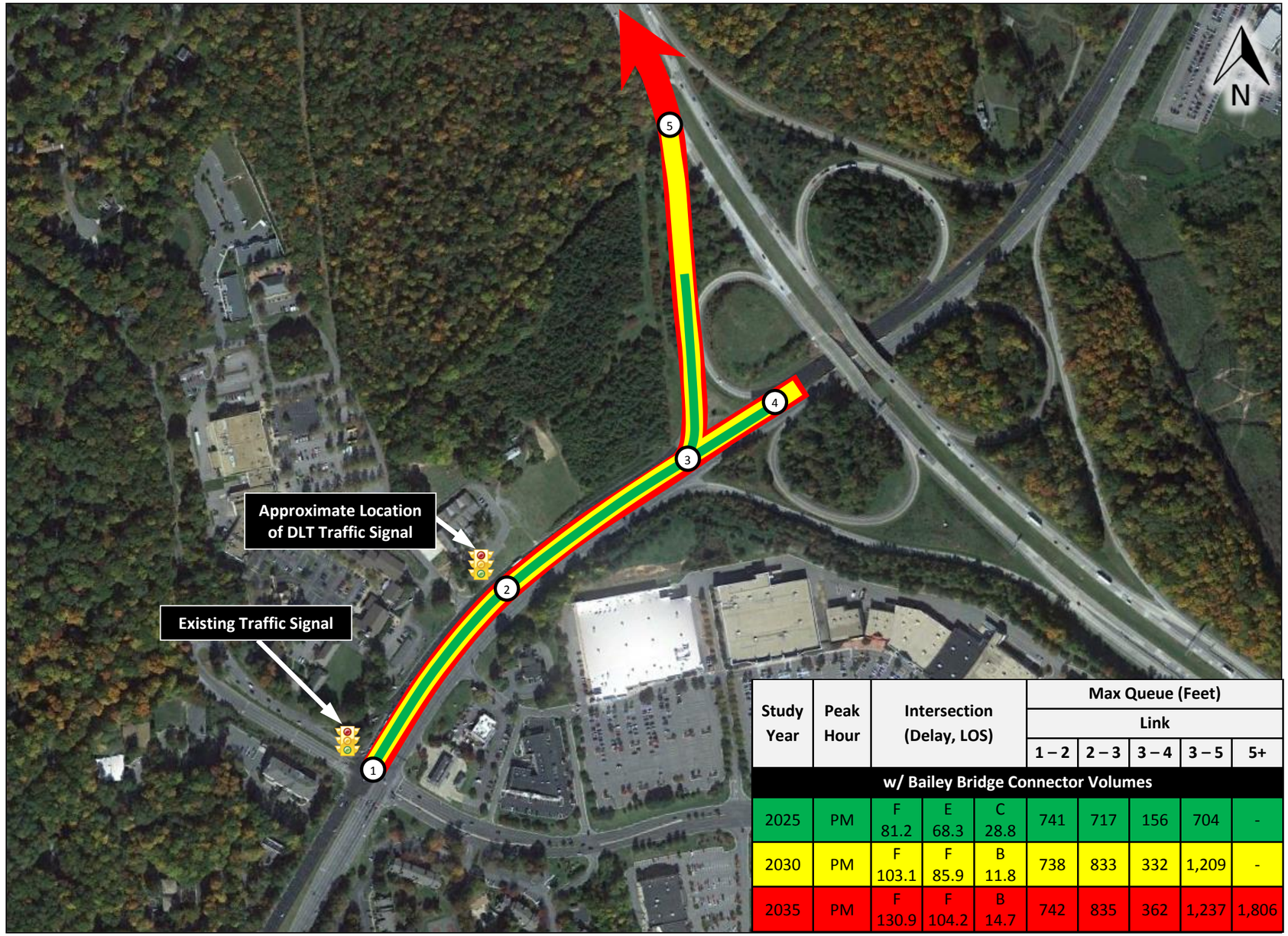
An iterative analysis was conducted for the DLT with additional capacity improvements. The analysis years of 2025, 2030, 2035 and 2040 were evaluated using the Build (2040) traffic volumes, which assume the Bailey Bridge Connector. Analysis results are displayed in **Figure 59** and conclude that the DLT with additional improvements will prevent queues from extending onto southbound Route 288 through 2040.

Summary of Iterative Analysis

- **DLT without Bailey Bridge Connector**
  - DLT at US 360 at Old Hundred Road/Commonwealth Centre Parkway
  - Includes 2-lane southbound Route 288 to westbound US 360 off-ramp
  - Results:
    - Westbound US 360 queues extend to southbound Route 288 in 2025
    - Bailey Bridge Connector is likely required to reduce the growth on US 360

- **DLT with Bailey Bridge Connector**
  - DLT at US 360 at Old Hundred Road/Commonwealth Centre Parkway

Figure 58: DLT PM Peak Hour Queue – with Bailey Bridge Connector

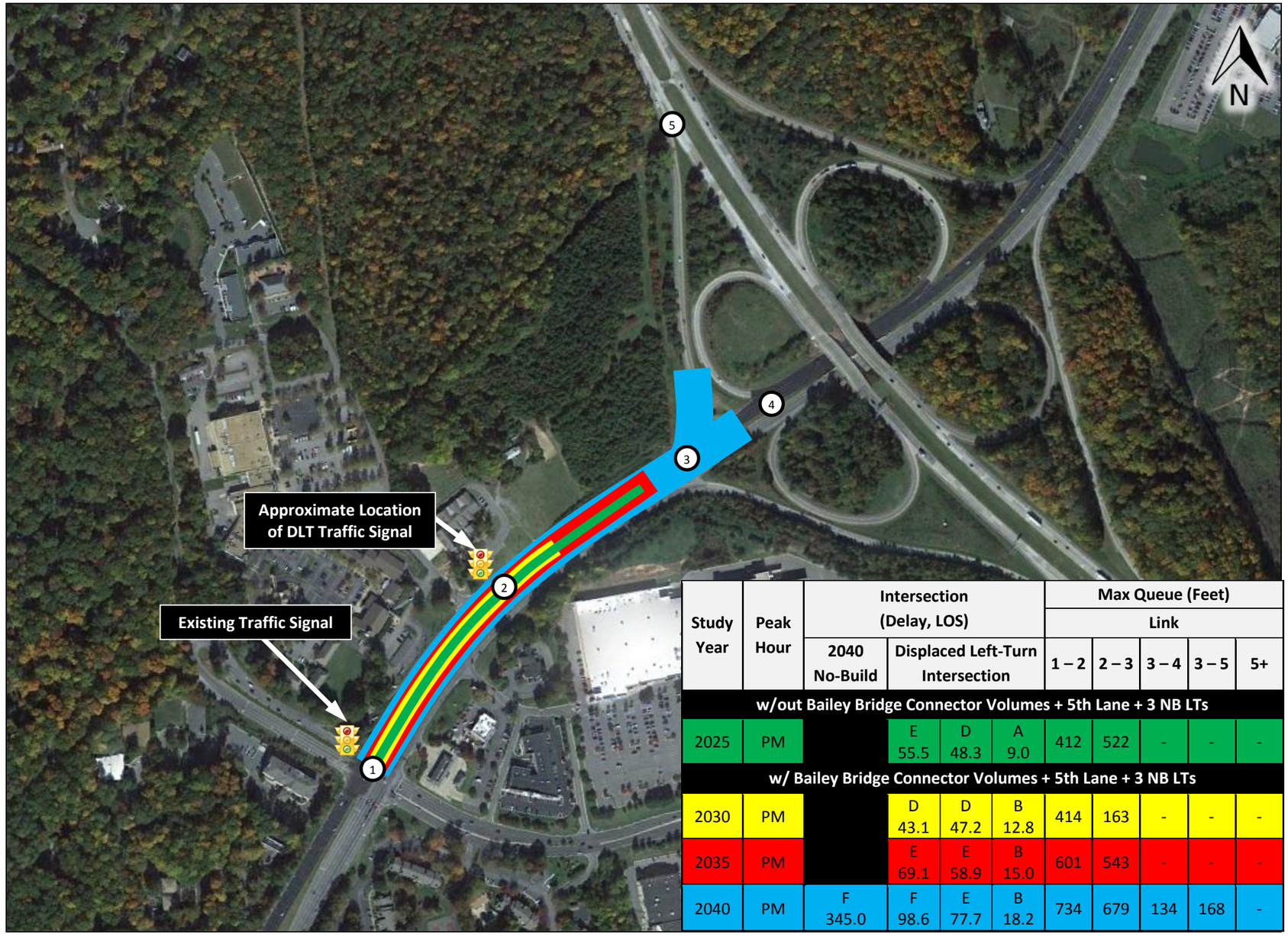


Study Year	Peak Hour	Intersection (Delay, LOS)			Max Queue (Feet)				
					Link				
					1 – 2	2 – 3	3 – 4	3 – 5	5+
w/ Bailey Bridge Connector Volumes									
2025	PM	F 81.2	E 68.3	C 28.8	741	717	156	704	-
2030	PM	F 103.1	F 85.9	B 11.8	738	833	332	1,209	-
2035	PM	F 130.9	F 104.2	B 14.7	742	835	362	1,237	1,806

  - Includes 2-Lane SB RT 288 to WB US 360 Off-Ramp
  - Assumed Bailey Bridge Connector improvements are in place
  - Results:
    - Westbound US 360 queues extend to southbound Route 288 between 2030 and 2035
    - Life of the improvement is projected to be 9 to 15 years (assumed construction year of 2021)

- **DLT with Additional Improvements**
  - DLT at US 360 at Old Hundred Road/Commonwealth Centre Parkway with added capacity – 5th through lane on US 360 (eastbound and westbound) and northbound triple left turns on Commonwealth Centre Parkway
  - Includes 2-lane southbound Route 288 to westbound US 360 off-ramp
  - Assumed Bailey Bridge Connector improvements are in place
  - Results:
    - Westbound US 360 queues do not extend to southbound Route 288 in the year 2040
    - Life of the improvement is projected to be more than 19 years (assumed construction year of 2021)

Figure 59: DLT w/Additional Improvements - PM Peak Hour Queue – with Bailey Bridge Connector



Study Year	Peak Hour	Intersection (Delay, LOS)		Max Queue (Feet)				
				Link				
		2040 No-Build	Displaced Left-Turn Intersection	1 – 2	2 – 3	3 – 4	3 – 5	5+
w/out Bailey Bridge Connector Volumes + 5th Lane + 3 NB LTs								
2025	PM		E 55.5 / D 48.3 / A 9.0	412	522	-	-	-
w/ Bailey Bridge Connector Volumes + 5th Lane + 3 NB LTs								
2030	PM		D 43.1 / D 47.2 / B 12.8	414	163	-	-	-
2035	PM		E 69.1 / E 58.9 / B 15.0	601	543	-	-	-
2040	PM	F 345.0	F 98.6 / E 77.7 / B 18.2	734	679	134	168	-

9.0 Planning Level Cost Estimates

Planning level cost estimates were developed for all primary improvements considered and were refined throughout the screening process based on input from the Study Work Group (SWG). Estimates were developed in context to the level of detail available in this study and provided in a range from low to high were broken down into the three categories: preliminary engineering (PE), right-of-way (RW), and construction (CN). Initial estimates were developed using the VDOT Transportation & Mobility Planning Division (TMPD) Statewide Planning Level Cost Estimates, assuming Year 2021 dollars to correspond with the next possible Six-Year Improvement Program (SYIP) funding cycle (Fiscal Year 2016–2021). TMPD construction unit costs and assumptions used to apply them are provided in **Table 26**. CN costs includes 25% for PE and construction costs contingencies; it does not include construction engineering and inspection (CEI) costs.

Table 26: Planning Level 2021 Construction Unit Costs and Assumptions

Improvements	Unit	Unit Cost Low	Unit Cost High	Source and Assumptions
Urban Four-Lane Undivided	MI	3.6 M	5.4 M	TMPD Statewide Planning Level Cost
Urban Three-Lane Undivided	MI	5.1 M	7.7 M	TMPD Statewide Planning Level Cost
Urban Four-Lane Undivided	MI	8.4 M	12.5 M	TMPD Statewide Planning Level Cost
Urban Four-Lane Dived w/16' Raised Median	MI	8.9 M	13.5 M	TMPD Statewide Planning Level Cost
Urban Eight-Lane Divided w/28' Raised Median	MI	12.5 M	17.2 M	TMPD Statewide Planning Level Cost
Mainline Widening (One Lane)	MI	4.5 M	6.7 M	No applicable TMPD unit cost[3]
Mainline Widening (Two Lane)	MI	6.0 M	9.0 M	No applicable TMPD unit cost[3]
Collector-Distributor (CD) Road (Two Lane)	MI	5.0 M	7.4 M	No applicable TMPD unit cost[3]
CD Road (Three Lane)	MI	6.3 M	9.4 M	No applicable TMPD unit cost[3]
Directional Ramp (One Lane)	MI	4.0 M	6.0 M	TMPD Statewide Planning Level Cost, assumed Rural 2 Lane Undivided (24')
Roundabout (One Lane)	EA	0.75 M	1.25 M	TMPD Statewide Planning Level Cost
Roundabout (Two Lane)	EA	1.75 M	2.5 M	TMPD Statewide Planning Level Cost
Displaced Left-Turn (DLT) - Minimum	EA	10.0 M	15.0 M	Low cost per input provided by VDOT, assumed 50% increase for High
DLT - Maximum	MI	25.0 M	34.4 M	Assumed Urban 8 LD with 28' Raised Median cost multiplied by 2
Superstreet Intersection	EA	5.0 M	8.0 M	Low based on example costs, High cost provided by VDOT
Continuous Green T-Intersection (CGT)	EA	5.0 M	8.0 M	Assumed same unit cost as Superstreet improvement
10-foot Paved Shared Use Path	MI	0.72 M	0.72 M	TMPD Statewide Planning Level Cost (same cost provided for Low and High)
Improve Grade Separated Interchange	EA	25.0 M	40.0 M	TMPD Statewide Planning Level Cost, assumed cost for Diamond Interchange
Grade Separated Interchange (Rural)	EA	30.0 M	55.0 M	TMPD Statewide Planning Level Cost, assumed cost for DDI
Grade Separated Interchange (Urban)	EA	35.0 M	65.0 M	TMPD Statewide Planning Level Cost, assumed cost for SPUI
Bridge	SF	0.21 M	0.31 M	TMPD Statewide Planning Level Cost
Sound Barrier Wall	SF	0.07 M	0.07 M	TMPD Statewide Planning Level Cost

Notes:
1. All costs are in Year 2021 dollars.
2. Cost include 25% for PE and Construction Contingencies
3. Developed High unit cost, Low based on 50% increase
4. Does not include CEI costs

Abbreviations:
MI = Miles
EA = Each
SF = Square Feet
M = Millions of Dollars
DDI = Diverging Diamond Interchange
SPUI = Single-Point, Urban Interchange

Using the TMPD cost estimation tool, PE and RW costs were developed based on the percent of construction costs shown in **Table 27**. The resulting cost estimates developed for all primary improvements based on the TMPD cost estimating tool used to screen improvements is provided in **Appendix F** for reference.

Table 27: PE and RW Percent of Construction Costs

Low Estimate		High Estimate	
PE	RW	PE	RW
14%	50%	14%	65%

Nine primary improvements were identified based on the qualitative and quantitative screening process. Conceptual layouts for each improvement were drafted using aerial photography (provided in **Appendix D**) and cost estimates refined accordingly. Based on a review of the TMPD based estimates, the SWG determined estimating RW costs as a percent of construction cost was too high level. The SWG determined that the RW estimate was most at risk due to the lack of a more detailed design and many unknown details (e.g., impacts to utilities, environmental permitting and mitigation requirements, etc.). Particular concern was for improvements identified at the intersection of US 360 at Old Hundred Road/Commonwealth Centre Parkway (an at-grade displaced left-turn intersection and a grade-separated diverging diamond interchange) due to the urban environment adjacent to the intersection. Therefore, a revised methodology was determined to develop the RW costs for four specific improvements. Improvements 1 through 4 were identified as those most likely to be funded and implemented first due to their estimated impacts to traffic operations at the US 360/Route 288 interchange; proposed phasing options are described in **Section 12.1**. VDOT's Project Cost Estimating System (PCES) was used to develop RW cost for these critical improvements. PCES RW costs and the assumptions used to develop them were coordinated with VDOT and are documented in **Appendix F** for reference. Based on a comparison between the TMPD and PCES RW costs, a low and high range was established as ±10% of the PCES estimates for Improvements 1 through 4 and ±10% of the midpoint from the TMPD estimates used for the remaining five improvements.

Table 28: Planning Level Cost Estimate Methodology

Improvement	Low Estimate PE	Low Estimate RW	Low Estimate CN	High Estimate PE	High Estimate RW	High Estimate CN
1 US 360 at Old Hundred Road/Commonwealth Centre Parkway - At-Grade DLT Intersection - Maximum	Statewide Planning 14% of CN	PCES Estimate -10%	Statewide Planning Unit Costs	Statewide Planning 14% of CN	PCES Estimate +10%	Statewide Planning Unit Costs
2 US 360 at Old Hundred Road/Commonwealth Centre Parkway - Grade-Separated Diverging Diamond Interchange (DDI)						
3 Southbound Route 288 to Westbound US 360 Off-Ramp Improvements						
4 Bailey Bridge Connector Improvements						
5 US 360 Superstreets - Five Intersections		Statewide Planning Midpoint of Range, -10%			Statewide Planning Midpoint of Range, +10%	
6 US 360 at Brad McNeer Parkway - Continuous Green T-Intersection (CGT)						
7 Widen Northbound and Southbound Route 288 from Four Lanes to Six Lanes						
8 Southbound Route 288 CD Road (Two Lanes)						
9 Eastbound US 360 to Northbound Route 288 Directional On-Ramp (Two Lanes)						

A summary of the final planning level costs rounded to the nearest $100,000 are shown in **Table 29**. A breakdown of the planning level cost estimates, for each candidate SYIP Project is provided in **Appendix F**. Estimated costs range from $2,600,000 to $136,500,000 with a total as high as $504,500,000. The nine proposed primary improvements can be implemented in phases; refer to **Section 12.1** for phasing options.

Table 29: Planning Level Cost Estimates

Improvement	2021 Dollars ($1,000,000s)							
	Low Estimate				High Estimate			
	PE	RW	CN	Total	PE	RW	CN	Total
1 US 360 at Old Hundred Road/Commonwealth Centre Parkway - At-Grade Displaced Left-Turn Intersection (DLT) - Maximum	$5.0	$24.1	$35.6	**$64.7**	$6.9	$29.5	$49.0	**$85.4**
2 US 360 at Old Hundred Road/Commonwealth Centre Parkway - Grade-Separated Diverging Diamond Interchange (DDI)	$6.0	$38.5	$42.8	**$87.3**	$11.0	$47.1	$78.4	**$136.5**
3 Southbound Route 288 to Westbound US 360 Off-Ramp Improvements	$1.0	$1.3	$7.2	**$9.5**	$1.5	$1.5	$10.7	**$13.7**
4 Bailey Bridge Connector Improvements	$5.9	$22.3	$42.1	**$70.3**	$7.6	$27.2	$53.6	**$88.4**
- Northbound Route 288 to Bailey Bridge Connector - Directional Off-Ramp (1 Lane)	$1.8	$6.9	$13	**$21.7**	$2.5	$8.9	$17.5	**$28.9**
- Southbound Route 288 Slip Ramp to Commonwealth Centre Parkway (1 Lane)	$0.2	$0.8	$1.6	**$2.6**	$0.3	$1.2	$2.4	**$3.9**
- Bailey Bridge Connector, Four Lanes (Route 288 to Brad McNeer Connector)	$3.0	$11.2	$21.1	**$35.3**	$3.5	$12.5	$24.6	**$40.6**
- Bailey Bridge Connector, Two Lanes (Brad McNeer Connector to Bailey Bridge)	$0.9	$3.4	$6.4	**$10.7**	$1.3	$4.6	$9.1	**$15.0**
5 US 360 Superstreets - Five Intersections	$3.1	$14.2	$21.7	**$39.0**	$4.5	$17.4	$31.9	**$53.8**
6 US 360 at Brad McNeer - Continuous Green T-Intersection (CGT)	$0.6	$2.8	$4.3	**$7.7**	$0.9	$3.5	$6.4	**$10.8**
7 Widen Northbound and Southbound Route 288 from Four Lanes to Six Lanes	$2.4	$11.3	$17	**$30.7**	$3.6	$13.8	$25.3	**$42.7**
8 Southbound Route 288 CD Road (Two Lanes)	$2.4	$11.6	$17.5	**$31.5**	$3.6	$14.1	$26.0	**$43.7**
9 Eastbound US 360 to Northbound Route 288 Directional On-Ramp (Two Lanes)	$1.7	$7.8	$11.8	**$21.3**	$2.5	$9.5	$17.5	**$29.5**
	$28.1	**$133.9**	**$200.0**	**$362.0**	**$42.1**	**$163.6**	**$298.8**	**$504.5**

10.0 Improvement Prioritization Process

10.1 Benefit-Cost Analysis

A benefit-cost (B-C) analysis was conducted for the candidate primary improvements to compare the cost effectiveness of each project. For consistency, a construction year of 2021 was assumed for each improvement concept and a 20-year period (2021–2040) was used to analyze and compare improvements. The following sections summarize the B-C methodology and results. A detailed description of the methodology is provided in **Appendix G**.

10.1.1 Benefit-Cost Methodology

Three factors were considered in the B-C calculation for each candidate SYIP improvement concept: operational benefit, safety benefit, and total improvement concept cost. The B-C of each improvement concept was calculated by dividing the total operational and safety benefit over the 20-year analysis period by the 20-year cost of the improvement concept.

10.1.1.1 Operational Benefit

The operational benefit of each improvement was calculated based on the time savings between No-Build and Build conditions. For improvement concepts on limited access facilities (Route 288) the operational benefit was based on the travel time savings in the area of influence of the improvement. For intersection improvement concepts the operational benefit was based on the overall intersection delay. Travel times and delays from 2012 Existing, 2040 No-Build, and 2040 Build analyses were used as the basis for projecting travel time and delay in intermediate years in order to compare No-Build and Build operational conditions over the 20-year analysis period. Annual changes in travel time were assumed to be proportional to volume changes.

Time savings were only evaluated during the AM and PM peak hours. Operational data was not available for other times of the day; however, travel time savings outside of the peak hours are expected to be minimal since congestion in the study area was observed to mainly occur within the AM and PM peak hours. The total daily time savings for each improvement was taken as the sum of the AM and PM peak hour time savings. Due to the close proximity of a shopping mall and other weekend trip destinations, time savings were assumed to be constant all weekdays of the year (250 days), not including weekends.

Truck and auto operational benefits were calculated separately due to the different average occupancy rates and monetary value of time for trucks and autos. An occupancy rate of 1.00 person/vehicle was assumed for trucks and an occupancy rate of 1.63 people/vehicle was assumed for autos. Value of time was used to convert time savings to a monetary amount. For this analysis, the value of time for trucks and autos were taken as $24.20/hour and $22.80/hour, respectively. Assumptions used in the calculation of the value of time are provided in **Appendix G**.

The total operational benefit for each improvement concept was the total value of time savings for trucks and autos in the AM and PM peak hours over the 20-year analysis period.

10.1.1.2 Safety Benefit

The safety benefit of each improvement was calculated based on the projected reduction in crashes between No-Build and Build conditions due to the SYIP Project. The safety benefit was projected based on the crash reduction factor (CRF) from various available sources provided below. Crash data from 2008 to 2013 was used as the baseline for predicting the number of crashes in the future. For each improvement concept, all related crashes within the influence area of the improvement were considered. Related crashes are crashes that are expected to be reduced by the implementation of the improvement concept. Crashes were separated based on severity [fatal, injury, and property damage only (PDO)] and divided by three to determine the baseline average yearly crash rate for each severity type. Annual changes in the number of crashes were assumed to be proportional to projected traffic volume changes.

The following CRFs were applied to the related crashes to project the reduction in the number of crashes under Build conditions:

- Convert signalized intersection to displaced left-turn (DLT) intersection CRF: 19 (all crash types, fatal and injury crashes)[3]
- Convert signalized intersection to a signalized superstreet configuration CRF: 56 (all crash types, all crash severities)[4]
- Convert signalized intersection to a continuous green T-intersection (CGT) CRF: 97 (angle crashes, all severities)[5]
- Increase number of lanes CRF: 31 (all crash types, all crash severities)[6]
- Change number of lanes on freeway exit ramp from 1 to 2 CRF: 42 (all crash types, all crash severities)[4]
- Convert at-grade intersection into grade-separated interchange CRF: 42 (all crash types, all crash severities)[4]
- Provide straight ramp instead of cloverleaf ramp CRF: 45 (all crash types, all crash severities) [4]
- Provide an auxiliary lane between an entrance ramp and exit ramp CRF: 20 (all crash types, all crash severities) [4]

Crash reductions were converted to a monetary value using crash societal costs. Crash societal costs used for this analysis were based on the FY2013-14 VDOT Highway Safety Improvement Program (HSIP) costs per crash and projected to Year 2021 dollars assuming a 3% annual inflation rate and are listed below:

- Fatal crash = $6,100,000
- Injury crash = $200,000
- PDO crash = $10,000

The total safety benefit for each improvement was the total societal cost of the projected reduction in crashes associated with the improvement concept over the 20-year analysis period.

10.1.1.3 Total Cost

The total cost for each improvement was the total initial cost (CN, PE, and RW) only. Anticipated maintenance costs over the 20-year analysis period was not included.

[3] FHWA TechBrief Displaced Left-turn Intersection (FHWA-HRT-09-055)
[4] Crash Modification Factors Clearinghouse, www.cmfclearinghouse.org

[5] FHWA CGT Intersection Safety Case Study (FHWA-SA-09-016)
[6] Crash Reduction Factors from FHWA Desktop Reference

10.1.2 Benefit-Cost Results

The total operational and safety benefits were divided by the total cost to calculate a B-C ratio for each improvement. A summary of the operational B-C ratio for each SYIP improvement concept is provided in **Table 30**. Additional breakdown of the B-C calculation is included in **Appendix G**.

Table 30: Benefit-Cost Summary

	Improvement	Total 20-Year Benefit	Total 20-Year Cost (Midpoint)	B-C Ratio
1	US 360 at Old Hundred Road/Commonwealth Centre Parkway - At-Grade DLT Intersection - Maximum	$166,530,520	$75,100,000	**2.2**
2	US 360 at Old Hundred Road/Commonwealth Centre Parkway - Grade-Separated Diverging Diamond Interchange (DDI)	$249,404,969	$111,900,000	**2.2**
3	Southbound Route 288 to Westbound US 360 Off-Ramp Improvements	$108,259,727	$11,600,000	**9.3**
4	Bailey Bridge Connector Improvements	$441,435,052	$79,400,000	**5.6**
5	US 360 Superstreets - Five Intersections	$348,556,249	$46,400,000	**7.5**
6	US 360 at Brad McNeer Parkway – CGT	$61,017,760	$9,300,000	**6.6**
7	Widen Northbound and Southbound Route 288 from Four Lanes to Six Lanes	$180,568,545	$36,700,000	**4.9**
8	Southbound Route 288 CD Road (Two Lanes)	$101,796,813	$37,600,000	**2.7**
9	Eastbound US 360 to Northbound Route 288 Directional On-Ramp (Two Lanes)	$11,723,266	$25,400,000	**0.5**

11.0 Phasing Recommendations

The preferred improvements were analyzed to determine how a plan of projects could be developed and programmed in phases. Based on the results of the analysis, the study team determined that nine concepts adequately handled the projected future year traffic volumes. The next step was to determine how these nine concepts could be phased, if feasible, and how much each phase would cost.

Programming a project with multiple phases has several advantages. First, it allows more control over cost and schedule. Second, it results in a smoother transition of construction from phase to phase, which reduces impacts on the traveling public. . Duration of the improvement construction would be increased as a result of the stopping and starting the different projects.

The SWG recommended the development of a phased plan of projects. This plan included the construction of improvements that would accommodate critical interchange movements and operations at the intersection of US 360 and Old Hundred Road/Commonwealth Centre Parkway, since these projects or phases would likely provide the most benefit relative to their

cost and potential for alleviating problems cited as "worst" by the SWG. Subsequent projects or phases could then be built, incrementally improving the study corridors.

Two phasing options, Option A and Option B, were developed based on the two alternatives at the intersection of US 360 and Old Hundred Road/Commonwealth Centre Parkway—an at-grade DLT and a grade-separated DDI, respectively. Proposed phasing options and planning level costs associated with each phase is summarized in **Figure 60** and **Figure 61**.

12.0 Conclusions and Next Steps

The study team determined that significant operational and safety deficiencies exist within the study area as evidenced by the delays, queuing, slow travel speeds, and associated crash patterns during the peak hours. Feasible, cost-effective solutions were considered for correcting the deficiencies and improving traffic operations.

In coordination with the stakeholders, a plan comprised of eight phased concepts was developed to provide long-term solutions to address network challenged posed by future year (2040) traffic volumes. These concepts improve operations and safety providing a better quality of life to the traveling public.

The total cost of all improvements ranges from $274.7 million to $419.2 million in Year 2021 dollars. The plan of improvements can be built in phases, with the following first three phases prioritized by the SWG to mitigate the "worst" operational and safety issues within the corridor.

- Phase 1: Southbound Route 288 to Westbound US 360 Off-Ramp Improvements ($9.5 Million - $13.7 Million)
- Phase 2: Bailey Bridge Connector Improvements ($70.3 Million - $88.5 Million)
- Phase 3: US 360 at Old Hundred Road/Commonwealth Centre Parkway
  - At-Grade Displaced Left-Turn ($64.7 Million - $85.4 Million)
  - Grade-Separated Diverging Diamond ($95.0 Million - $147.3 Million)

The US 360 at Route 288 Interchange Area Study should be used as a planning tool to achieve the next steps of planning, programming, designing, and constructing the identified safety and operational improvements in the study corridor. Specific steps include:

1. Develop Consensus for Priority Improvements

- Develop local, regional, and state support for priority concepts supported by Chesterfield County, Richmond Regional TPO, and VDOT
- Conduct outreach meetings to stakeholders who were not part of the SWG for this study to gain acceptance for the proposed candidate improvement projects
- Through the combined efforts of local governments and community leaders working with the Commonwealth Transportation Board (CTB), as well as local legislators, identify funding for improvements and program individual projects
- At the request of VDOT, one-page project summaries were developed for each project to provide a quick reference to document the improvements. Project summaries include a description of the project, the estimated project cost, and anticipated project schedule. The one-page project summary sheets are included in **Appendix H**.

2. Prepare Projects for Advancement

- Once projects have been prioritized at the regional level, priority projects should be advanced to the following regional and state plans:
  - Constrained Long Range Transportation Plan (CLRP)
  - Transportation Improvement Plan (TIP)
  - Statewide Transportation Improvement Plan (STIP)
  - VDOT Six-Year Improvement Program (SYIP)

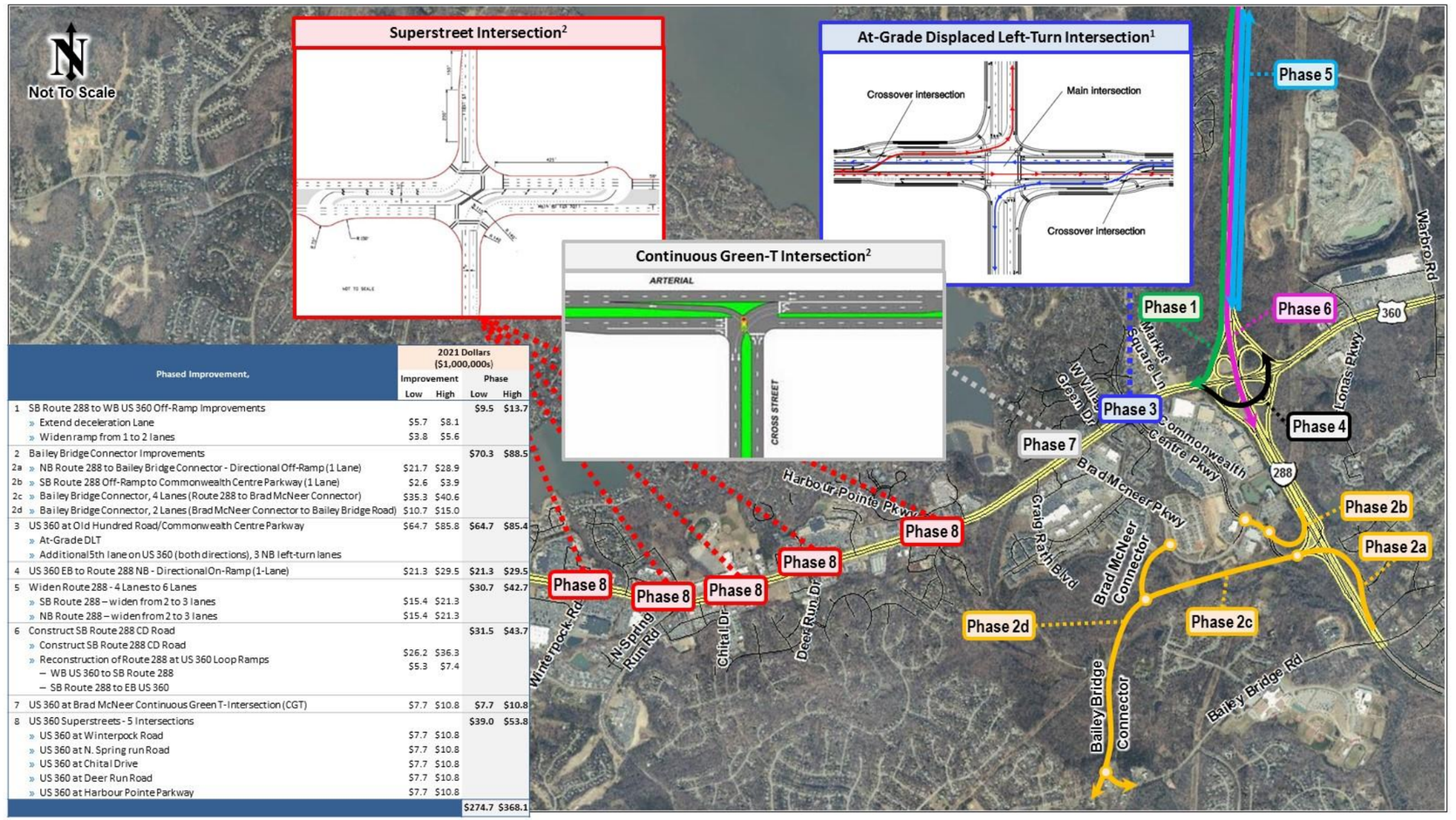
- Consider the following funding sources to obtain dedicated funding for improvement projects identified in this study:
  - Revenue Sharing
  - Regional Surface Transportation Program (RSTP)
  - Congestion Mitigation and Air Quality Improvement (CMAQ)
  - House Bill 2 (HB2)
  - Highway Safety Improvement Program (HSIP)
    - HSIP funding will not likely be available in sufficient quantities to support the scale of proposed projects. Additionally, a standalone analysis would be necessary to verify that the safety benefit-to-cost ratio would exceed 1.0. HSIP funding should be considered for more systemic corridor improvements.

3. Further Studies and Preliminary Engineering

- Currently, the only project listed in the current SYIP (Fiscal Year 16-21) related to the study area is preliminary engineering for improvements at the US 360/Route 288 interchange (UPC 104862) for approximately $1.5 million. The next logical step would be to leverage this funding to conduct preliminary engineering and further study (environmental impacts, refined concept development and cost estimates, etc.) for recommended improvements identified in the first three phases.
- Candidate improvement projects for further study and preliminary engineering:
  - **Phase 1: Southbound Route 288 to Westbound US 360 Off-Ramp Improvements** – Conduct preliminary engineering design to extend deceleration lane and widen from one to two lanes
  - **Phase 2: Bailey Bridge Connector –** Conduct Interchange Modification Report (IMR) to evaluate the missing northbound Route 288 to Commonwealth Centre Parkway off-ramp for VDOT approval
  - **Phase 3: US 360 at Old Hundred Road/Commonwealth Centre Parkway** – Conduct further study to refine the two proposed intersection concepts (at-grade DLT and grade-separated DDI). Study should define impacts in more detail and refine cost estimates accordingly to determine a preferred improvement at this location.

12.1 Phasing Option A

- **Phase 1: SB Route 288 to WB US 360 Off-Ramp Improvements**
  - Targets critical southbound Route 288 to westbound US 360 off-ramp movement, which is heaviest during PM peak hour
  - Alleviates southbound Route 288 to westbound US 360 queuing onto southbound Route 288 , which was cited as "worst" problem by SWG members
  - Smaller scale improvement based on cost and schedule provides highest benefit-to-cost ratio
  - Has independent utility, i.e., usable and reasonable expenditure even if no additional improvements are made
- **Phase 2: Bailey Bridge Connector**
  - Only improvement to reduce traffic volumes along US 360 and at Route 288 interchange
  - Reduces traffic volumes on eastbound US 360 to northbound Route 288 on-ramp movement, which is heaviest during AM peak hour
  - Has independent utility, i.e., usable and reasonable expenditure even if no additional improvements are made
  - Will help with maintenance of traffic during construction of Phase 3
  - Can be constructed in multiple phases (Phase 2a – 2d)
- **Phase 3: US 360 at Old Hundred Road/Commonwealth Centre Parkway – At-Grade DLT**
  - Recommended after Phase 2 because operational analysis showed DLT did not work without the Bailey Bridge Connector (see **Chapter 8**)
- **Phase 4: Eastbound US 360 to Northbound Route 288 - Directional On-Ramp (2 Lanes)**
  - Could construct southbound Route 288 third lane with Phase 1
  - Could construct northbound Route 288 third lane with Phase 4
- **Phase 5: Widen northbound and southbound Route 288 from Four Lanes to Six Lanes**
- **Phase 6: Construct southbound Route 288 CD Road (Two Lanes)**
- **Phase 7: US 360 at Brad McNeer Parkway – CGT**
  - Should be constructed after Phase 3 to progress traffic west along US 360
- **Phase 8: US 360 Superstreets - Five Intersections**
  - Improvements west along US 360 were deemed less critical than improvements at the US 360/RT 288 interchange area



	Phased Improvement,	2021 Dollars ($1,000,000s) Improvement Low	Improvement High	Phase Low	Phase High
1	SB Route 288 to WB US 360 Off-Ramp Improvements			$9.5	$13.7
	» Extend deceleration Lane	$5.7	$8.1		
	» Widen ramp from 1 to 2 lanes	$3.8	$5.6		
2	Bailey Bridge Connector Improvements			$70.3	$88.5
2a	» NB Route 288 to Bailey Bridge Connector - Directional Off-Ramp (1 Lane)	$21.7	$28.9		
2b	» SB Route 288 Off-Ramp to Commonwealth Centre Parkway (1 Lane)	$2.6	$3.9		
2c	» Bailey Bridge Connector, 4 Lanes (Route 288 to Brad McNeer Connector)	$35.3	$40.6		
2d	» Bailey Bridge Connector, 2 Lanes (Brad McNeer Connector to Bailey Bridge Road)	$10.7	$15.0		
3	US 360 at Old Hundred Road/Commonwealth Centre Parkway	$64.7	$85.8	$64.7	$85.4
	» At-Grade DLT				
	» Additional 5th lane on US 360 (both directions), 3 NB left-turn lanes				
4	US 360 EB to Route 288 NB - Directional On-Ramp (1-Lane)	$21.3	$29.5	$21.3	$29.5
5	Widen Route 288 - 4 Lanes to 6 Lanes			$30.7	$42.7
	» SB Route 288 – widen from 2 to 3 lanes	$15.4	$21.3		
	» NB Route 288 – widen from 2 to 3 lanes	$15.4	$21.3		
6	Construct SB Route 288 CD Road			$31.5	$43.7
	» Construct SB Route 288 CD Road	$26.2	$36.3		
	» Reconstruction of Route 288 at US 360 Loop Ramps	$5.3	$7.4		
	– WB US 360 to SB Route 288				
	– SB Route 288 to EB US 360				
7	US 360 at Brad McNeer Continuous Green T-Intersection (CGT)	$7.7	$10.8	$7.7	$10.8
8	US 360 Superstreets - 5 Intersections			$39.0	$53.8
	» US 360 at Winterpock Road	$7.7	$10.8		
	» US 360 at N. Spring run Road	$7.7	$10.8		
	» US 360 at Chital Drive	$7.7	$10.8		
	» US 360 at Deer Run Road	$7.7	$10.8		
	» US 360 at Harbour Pointe Parkway	$7.7	$10.8		
				$274.7	$368.1

[1]Source: FHWA, Diverging Diamond Interchange Information Guide, August 2014
[2]Source: FHWA, Alternative Intersections/Interchanges: Informational Report (AIIR), August 2014

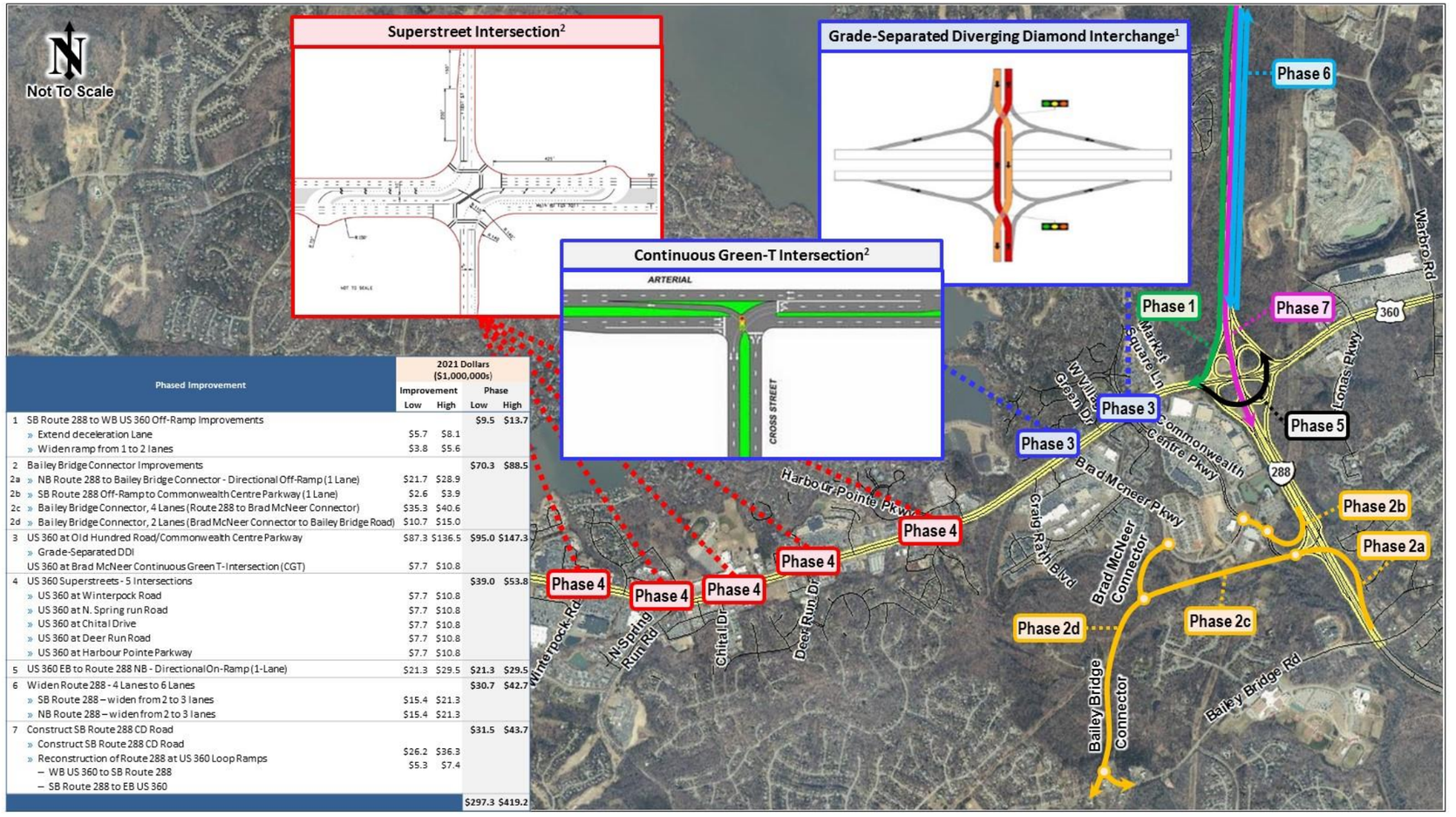
Phasing Option A
US 360 and Old Hundred Road/Commonwealth Centre Parkway - At-Grade DLT
US 360/Route 288 Interchange Study

Figure 60

12.2 Phasing Option B

Phase 1 through 3 are the same with both options because they target two of the critical interchange movements.

- **Phase 1: Southbound Route 288 to Westbound US 360 Off-Ramp Improvements**
  - Targets critical southbound Route 288 to westbound US 360 off-ramp movement, which is heaviest during PM peak hour
  - Alleviates southbound Route 288 to westbound US 360 queuing onto southbound Route 288, which was cited as "worst" problem by the SWG
  - Smaller scale improvement based on cost and schedule, provides highest benefit to cost ratio
  - Has independent utility, i.e., usable and reasonable expenditure even if no additional improvements are made
- **Phase 2: Bailey Bridge Connector**
  - Only improvement to reduce traffic volumes along US 360 and at Route 288 interchange
  - Reduces traffic volumes on eastbound US 360 to northbound Route 288 on-ramp movement, which is heaviest during AM peak hour
  - Has independent utility, i.e., usable and reasonable expenditure even if no additional improvements are made
  - Will help with maintenance of traffic during construction of Phase 3
  - Can be constructed in multiple phases (Phase 2a – 2d)
- **Phase 3: US 360 at Old Hundred Road/Commonwealth Centre Parkway – Grade-Separated DDI**
  - Mitigates bottleneck at Old Hundred/Commonwealth Centre and southbound to westbound ramp movement
  - Construction of the CGT is recommended in parallel with the grade separation improvement to prevent a bottleneck downstream at the adjacent intersection of Brad McNeer Parkway
- **Phase 4: US 360 Superstreets – 5 Intersections**
  - Superstreets will be necessary to progress westbound traffic once Phases 2 and 3 are completed
- **Phase 5: Eastbound US 360 to Northbound Route 288 – Directional On-Ramp (2 Lanes)**
  - Targets eastbound to northbound ramp movement, which is heaviest during AM peak hour
  - Could construct SB third lane with Phase 1
  - Could construct NB third lane with Phase 4
- **Phase 6: Widen NB and SB Route 288 from Four Lanes to Six Lanes**
- **Phase 7: Construct SB Route 288 CD Road (2 Lanes)**



	Phased Improvement	2021 Dollars ($1,000,000s) Improvement Low	Improvement High	Phase Low	Phase High
1	SB Route 288 to WB US 360 Off-Ramp Improvements			$9.5	$13.7
	» Extend deceleration Lane	$5.7	$8.1		
	» Widen ramp from 1 to 2 lanes	$3.8	$5.6		
2	Bailey Bridge Connector Improvements			$70.3	$88.5
2a	» NB Route 288 to Bailey Bridge Connector - Directional Off-Ramp (1 Lane)	$21.7	$28.9		
2b	» SB Route 288 Off-Ramp to Commonwealth Centre Parkway (1 Lane)	$2.6	$3.9		
2c	» Bailey Bridge Connector, 4 Lanes (Route 288 to Brad McNeer Connector)	$35.3	$40.6		
2d	» Bailey Bridge Connector, 2 Lanes (Brad McNeer Connector to Bailey Bridge Road)	$10.7	$15.0		
3	US 360 at Old Hundred Road/Commonwealth Centre Parkway	$87.3	$136.5	$95.0	$147.3
	» Grade-Separated DDI				
	US 360 at Brad McNeer Continuous Green T-Intersection (CGT)	$7.7	$10.8		
4	US 360 Superstreets - 5 Intersections			$39.0	$53.8
	» US 360 at Winterpock Road	$7.7	$10.8		
	» US 360 at N. Spring run Road	$7.7	$10.8		
	» US 360 at Chital Drive	$7.7	$10.8		
	» US 360 at Deer Run Road	$7.7	$10.8		
	» US 360 at Harbour Pointe Parkway	$7.7	$10.8		
5	US 360 EB to Route 288 NB - Directional On-Ramp (1-Lane)	$21.3	$29.5	$21.3	$29.5
6	Widen Route 288 - 4 Lanes to 6 Lanes			$30.7	$42.7
	» SB Route 288 – widen from 2 to 3 lanes	$15.4	$21.3		
	» NB Route 288 – widen from 2 to 3 lanes	$15.4	$21.3		
7	Construct SB Route 288 CD Road			$31.5	$43.7
	» Construct SB Route 288 CD Road	$26.2	$36.3		
	» Reconstruction of Route 288 at US 360 Loop Ramps – WB US 360 to SB Route 288 – SB Route 288 to EB US 360	$5.3	$7.4		
				$297.3	$419.2

[1]Source: FHWA, Diverging Diamond Interchange Information Guide, August 2014
[2]Source: FHWA, Alternative Intersections/Interchanges: Informational Report (AIIR), August 2014

Phasing Option B
US 360 and Old Hundred Road/Commonwealth Centre Parkway - Grade-Separated DDI
US 360/Route 288 Interchange Study

Figure 61