



MD 924 Multi-Modal Corridor Study

Volume I – Existing Conditions





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MD 924 MULTI-MODAL CORRIDOR STUDY
VOLUME 1: EXISTING CONDITIONS

I. INTRODUCTION

A. Background

Over the last two decades, the MD 924 (Heroes Highway/Emmorton Road/S. Main Street) corridor has evolved from a quiet street serving Box Hill and Boyle Buick, which provided a link between I-95 and the Town of Bel Air, into a busy suburban arterial. The construction of MD 24 (Veterans Memorial Highway) opened the flood gates for major office, retail and residential development along MD 924. With the increased residential population came new schools, churches and a medical facility. Over the last several years, commercial development has increased along MD 924. In particular, significant development has occurred between MD 924 and MD 24 from Wheel Road to Plumtree Road. Development continues with the construction of the MedStar Office Complex, the apartment complex at Plumtree Road, the ongoing development of the Boulevard at Box Hill and the consolidation of the Homestead/Wakefield Elementary School campuses.

Although some transit options exist and limited bicycle and pedestrian facilities are provided, the MD 924 and MD 24 communities remain car-oriented for shopping, recreation and commuter trips. Upgrades along MD 24, MD 924 and the roadways connecting MD 924 to MD 24 addressed some of the commuter traffic demand and helped alleviate some congestion along the corridor. However, since the MD 24 and MD 924 corridors are within a designated Priority Funding Area and the designated development envelope for the County, traffic demands will continue to increase. The State and County can no longer use additional travel lanes as the solution to all traffic issues. The need to provide Livable Streets and Resilient Communities requires engineers to move away from focusing only on traditional capacity improvements and look for multi-modal solutions.

In an effort to address the needs of the many MD 924 corridor users, Harford County selected the team of Whitney Bailey Cox & Magnani, LLC/Jacobs Engineering Group, Inc. (WBCM/JEG) Joint Venture to conduct a review of the study area and develop multi-modal solutions to address the safety and mobility needs of the corridor. The MD 924 Corridor Study will focus on the various road users – passenger cars, trucks, pedestrians, bicycles, school buses and transit. WBCM/JEG will develop cost-effective multi-modal strategies to address system operational and safety deficiencies as well as an implementation strategy based on existing conditions, near term (2025) and long range (2040) design years. The study will focus not only on MD 924, but also the MD 24 corridor and the roadways linking the two corridors, as improved operations along MD 24 will facilitate diversion of through traffic from MD 924.

The section of MD 924 from MD 24 to Singer Road was renamed Heroes Highway by the Maryland State Highway Administration (SHA) in honor of two Harford County Deputies who lost their lives at the Boulevard at Box Hill in January 2016. As of July 2016, MD 924 is designated as Heroes Highway from MD 24 to Singer Road, Emmorton Road from Singer Road to E. MacPhail Road and S. Main Street north of E. MacPhail Road.



B. Study Area

The project study limits extend north along MD 924 from the Constant Friendship Shopping Center/Woodsdale Road intersection to West/East (W./E.) MacPhail Road and along MD 24 from Singer Road to West (W.) MacPhail Road. The study area is illustrated in Figure I.1.

In an effort to distill the 4.7 mile corridor into manageable analysis sections, the study limits were divided into three zones:

- Zone 1: MD 924 – Constant Friendship Shopping Center/Woodsdale Road to Holly Wreath Court/Holly Wreath Road
MD 24 at Singer Road
- Zone 2: MD 924 – Holly Wreath Court/Holly Wreath Road to Barrington Place/Patterson Mill Road
MD 24 – Singer Road to Plumtree Road
- Zone 3: MD 924 – Patterson Mill Road to W./E. MacPhail Road
MD 24 – Plumtree Road to W. MacPhail Road

The zones were selected based on the characteristics of the project area. The southern section, Zone 1, is dominated by the Box Hill and Constant Friendship single and multi-family residential and commercial development. The central section, Zone 2, includes major commercial developments. The northern section, Zone 3, consists of older, established single-family residential subdivisions. Several key study area intersections were identified for analysis along MD 924 and MD 24 as summarized below:

- MD 924 at Constant Friendship Shopping Center/Woodsdale Road
- MD 924 at Porter Dive/Box Hill South Parkway
- MD 924 at Singer Road/Abingdon Road
- MD 924 at Holly Wreath Court/Holly Wreath Road
- MD 924 at East and West Wheel Road
- MD 924 at Bel Air South Parkway/Laurel Bush Road
- MD 924 at Bright Oaks Drive
- MD 924 at Medstar Boulevard/Plumtree Road
- MD 924 at Barrington Place/Patterson Mill Road
- MD 924 at West and East Ring Factory Road
- MD 924 at West and East MacPhail Road
- MD 24 at Singer Road
- MD 24 at Wheel Road
- MD 24 at Bel Air South Parkway
- MD 24 at Plumtree Road
- MD 24 at West Ring Factory Road
- MD 24 at West MacPhail Road



ZONE 3

ZONE 2

ZONE 1

MACPHAIL RD TO PATTERSON MILL RD

PATTERSON MILL RD TO HOLLY WREATH RD

HOLLY WREATH RD TO WOODSDALE RD

● STUDY INTERSECTION

MARYLAND 924

STUDY AREA - ZONE 1, 2 & 3

WOODSDALE ROAD TO MACPHAIL ROAD



N.T.S. FIGURE I.1 JUNE 2017

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All the intersections selected, with the exception of Bright Oaks Drive, are currently signalized. Bright Oaks Drive was included in the study because it is anticipated that undeveloped parcels opposite Bright Oaks Drive could access MD 924 in future design years. The identified intersections are major nodes in the roadway network serving the study area and have a direct impact on corridor operations.

C. Project Elements – Existing Conditions Report

The Existing Conditions Report includes a detailed inventory of existing conditions including: major traffic generators; existing roadway infrastructure; sidewalk links along the corridor and connecting streets; existing zoning and land use; crash data; study area vehicular, transit, pedestrian and bicycle traffic; traffic control device inventory; field reviews of traffic operations; and transit routes, amenities, stops, and ridership. Field inventories were conducted to document areas of sidewalk connectivity and the location of major generators. Capacity analyses were then conducted to document existing levels of service based on Synchro Version 8.0 software modeling and the SHA’s Critical Lane Analysis (CLA) methodology.

Level of Service (LOS) is a means of quantifying intersection operations by applying a letter grade A through F to the intersection. Free flow conditions are represented by LOS A with little or no queues at signalized intersections, minimal delay and all vehicles clear during the green time allocated. The LOS gradually deteriorates with motorist delays and queues increasing from LOS B to LOS D. Levels of Service E and F indicate drivers are experiencing unacceptable delays and are queued for an extended period of time, often sitting through several signal cycles before finally clearing the intersection. Typically, LOS E and F are red flags that indicate upgrades to the intersection are required. Queue analyses were performed based on Synchro and SimTraffic modeling and the SHA’s 95% Probability Methodology. Crash history was reviewed to identify any potential crash hot spots that would indicate measures are necessary to address a safety deficiency.

Locations that were not operating acceptably were reviewed to determine if any quick fixes could be implemented to better accommodate traffic demand. The quick fixes focused on a Transportation Systems Management (TSM) approach to solving deficiencies with upgrades that can be implemented quickly and cost effectively without major construction. Typical TSM measures include modified signal phasing, reallocation of lane assignments, and turn restrictions.

Safety related elements of the report include a review of crash history to identify any potential crash hot spots that would indicate measures are warranted to address a safety deficiency. In conjunction with the review of crash history, a Road Safety Audit was conducted to determine if field conditions contributed to crash history and to identify potential safety hazards.

Review of pedestrian and bicycle related elements of the existing conditions included: data collection of existing demand, inventories of existing facilities, and a Walkability Audit of the corridor that identified measures that would improve accessibility, and promote walking and biking.



II. DATA COLLECTION

A. Data Collection Elements

A significant data collection effort was related to conducted to provide a benchmark for future elements of the study. The data collected included traffic data, roadway information, lane use, crash history and transit operations. Field inventories were conducted to define roadway typical sections, shoulder widths, lane use, turn storage bay lengths, land use, businesses, areas of pending development, signing, pavement marking, traffic signal layout and equipment, lighting, and transit stops and amenities. Field reviews were conducted during the peak and off-peak periods to identify areas of congestion, excessive queues and delays, and any major pedestrian activity. Existing zoning was retrieved from the Harford County GIS database.

B. Traffic Volume Data

The major data collection effort was traffic volume data. Analyses focused on weekday operations; however, with the significant retail development along the corridor, Saturday analyses were included as well. Traffic volume data was collected from two sources - the SHA's Data Services Engineering Division's Traffic Trends website, and WBCM field counts. The SHA's website provides a summary of all traffic data collected along the State road system. Counts were reviewed along MD 24 and MD 924 and recent weekday data was available for three locations; no Saturday count data was available. Due to the dynamic nature of development in the study area, any count older than 18 months from the July 2015 start date of the project, was considered invalid. The SHA count locations with weekday data were MD 924 at Laurel Bush Road and Bright Oaks Drive and MD 24 at Wheel Road. The other intersections were counted by WBCM on a typical weekday – Tuesday through Thursday – to ensure appropriate data was recorded. The counts included vehicles, pedestrians (school children, and adults) and bicyclists. The WBCM counts were conducted on non-rainy days to ensure that the pedestrian and bicycle counts appropriately represented demand. The weekday traffic volume counts in Zone 1 and Zone 2 for intersections 1, 3, and 6, and Saturday counts for intersections 6, 7, and 9, were collected in 2016 following the completion of roadway construction and the removal of local road closures along Woodsdale Road and Laurel Bush Road. In addition, speed and classification machine counts were conducted in each Zone. The machine classification counts included a breakdown of volumes by vehicle type to include motorcycles, passenger cars, SUV/pickup trucks, buses, single-unit trucks, and various types of tractor trailer combinations based on number of axles. The count data is provided in Appendix I.A.

C. Developing the Existing Conditions Vehicular Traffic Volumes

Upon completion of the initial round of traffic counts, weekday morning and evening peak hour and Saturday mid-day peak hour volumes were identified. Once the peak hour volumes were identified, the variance in traffic flows between intersections was reviewed. Traffic volumes vary by as much as 10% to 15% day to day; in some cases, adjacent intersections have different peak hours due to side street traffic. For the MD 924 corridor, major retail and commercial traffic generators and key access points to large subdivisions can cause major increases and decreases in traffic volumes between intersections. Also, some of the local roads can provide alternate routes to bypass key intersections. As a result, peak hour volumes were reviewed between intersections to verify appropriate trends in the volumes based on an understanding of local traffic patterns. Table II.1 provides a summary of the count dates and peak hours.



TABLE II.1

**Traffic Count Summary
MD 924 Multi-Modal Corridor Study**

Int ID No.	Zone No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes		Saturday Peak HR Volumes	
			Count Date	Peak Hour	Count Date	Peak Hour	Count Date	Peak Hour
01	ZONE 1	MD 924 @ Shopping Cntr/Woodsdale Rd	Tuesday 10/20/15	7:30 AM – 8:30 AM	Wednesday 10/14/15	4:45 PM – 5:45 PM		
02		MD 924 @ Porter Dr/ Box Hill S. Pkwy	Thursday 10/8/15	8:00 AM – 9:00 AM	Thursday 10/8/15	5:45 PM – 6:45 PM		
03		MD 924 @ Singer Rd/Abingdon Rd	Thursday 2/4/16	7:30 AM – 8:30 AM	Thursday 2/4/16	4:45 PM – 5:45 PM		
04		MD 924 @ Holly Wreath Ct/Rd	Wednesday 10/14/15	8:00 AM – 9:00 AM	Wednesday 10/21/15	4:30 PM – 5:30 PM		
05		MD 24 @ Singer Rd	Tuesday 10/14/15	7:15 AM – 8:15 AM	Tuesday 10/14/15	4:45 PM – 5:45 PM		
06	ZONE 2	MD 924 @ Wheel Rd	Thursday 2/4/16	8:00 AM – 9:00 AM	Thursday 2/4/16	4:00 PM – 5:00 PM	Saturday 6/11/16	12:45 PM – 1:45 PM
07		MD 924 @ Bel Air S. Pkwy/Laurel Bush Rd	Wednesday 5/7/14	7:00 AM – 8:00 AM	Wednesday 5/7/14	4:30 PM – 5:30 PM	Saturday 6/25/16	10:45 AM – 11:45 AM
08		MD 924 @ Bright Oaks Drive	Thursday 3/19/15	7:00 AM – 8:00 AM	Thursday 3/19/15	5:00 PM – 6:00 PM		
09		MD 924 @ Plumtree Rd/Medstar Blvd	Tuesday 9/22/15	7:00 AM – 8:00 AM	Tuesday 10/20/15	5:00 PM – 6:00 PM	Saturday 6/11/16	10:00 AM – 11:00 AM
10		MD 924 @ Barrington Pl/Patterson Mill Rd	Thursday 9/24/15	7:00 AM – 8:00 AM	Thursday 9/24/15	5:30 PM – 6:30 PM		
11		MD 24 @ Wheel Rd	Thursday 10/22/15	7:15 AM – 8:15 AM	Thursday 5/8/14	5:00 PM – 6:00 PM		
12		MD 24 @ Bel Air S. Parkway	Tuesday 9/29/15	7:30 AM – 8:30 AM	Tuesday 9/29/15	4:30 PM – 5:30 PM		
13		MD 24 @ Plumtree Rd	Wednesday 10/7/15	8:00 AM – 9:00 AM	Wednesday 10/7/15	5:00 PM – 6:00 PM		
14	ZONE 3	MD 924 @ E./W. Ring Factory Rd	Tuesday 10/20/15	8:00 AM – 9:00 AM	Tuesday 10/20/15	4:45 PM – 5:45 PM		
15		MD 924 @ W./E. MacPhail Rd	Wednesday 10/14/15	8:15 AM – 9:15 AM	Wednesday 10/14/15	4:45 PM – 5:45 PM		
16		MD 24 @ W. Ring Factory Rd	Wednesday 9/30/15	7:15 AM – 8:15 AM	Wednesday 9/30/15	5:00 PM – 6:00 PM		
17		MD 24 @ W. MacPhail Rd	Thursday 9/24/15	7:30 AM – 8:30 AM	Thursday 9/24/15	4:00 PM – 5:00 PM		



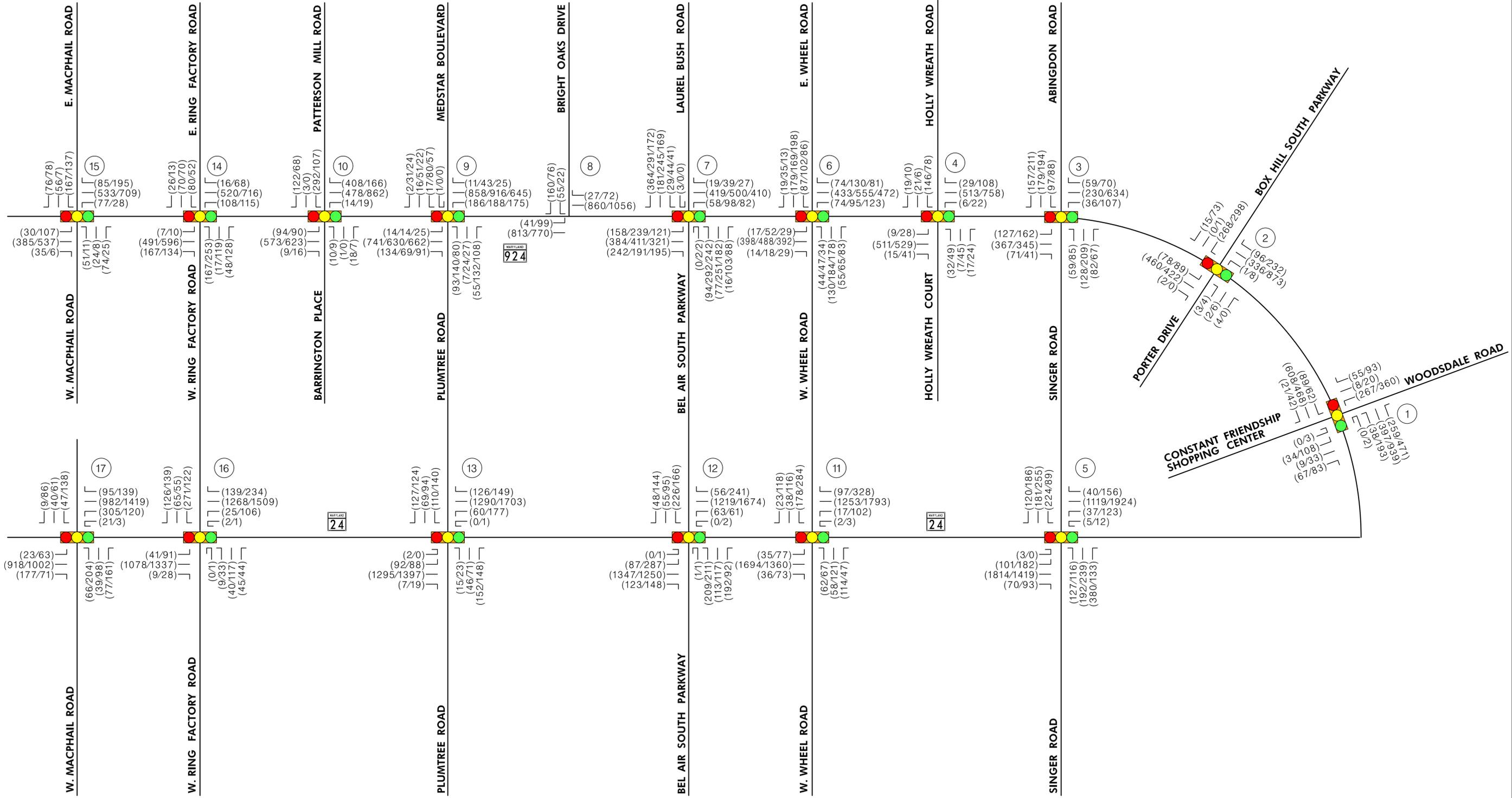
After the data was reviewed, intersections were identified for morning or evening peak period recounts to verify travel patterns. The updated data was employed if the results were more representative of adjacent intersection traffic. A conservative balancing was performed (balancing to the higher approach volumes) between intersections in areas of no intersecting streets or driveways utilizing the traffic count data to equalize the approach and departure volumes. The only areas where no intersecting streets or driveways are present are along MD 924 from Wheel Road to Bel Air South Parkway, along southbound MD 24 from Ring Factory Road to Singer Road and along northbound MD 24 from Singer Road to W. MacPhail Road. A right-in/right-out driveway to the hospital is located along southbound MD 24 south of W. MacPhail Road. Traffic counts were balanced based on the highest recorded volumes between intersections. The resultant existing conditions peak hour traffic volumes are summarized in Figure II.1.

III. ZONE 1 – EXISTING CONDITIONS SUMMARY

A. Zoning and Land Use

Zone 1 extends from Woodsdale Road to Holly Wreath Court/Holly Wreath Road. The area has major commercial development to the south with the Constant Friendship Shopping Center, the Boulevard at Box Hill, Giant Supermarket and Gas Station, and the Box Hill Corporate Office developments. A major residential development (Box Hill South) is present to the east of the commercial sites. The central portion of the Zone is single-family residential, which transitions to retail development south of Abingdon Road. To the north, the Zone is predominantly single-family residential with the Box Hill North, Laurel Woods, and Laurel Valley subdivisions accessed from Holly Wreath Court and Holly Wreath Road. In Zone 1, Singer Road provides a link between MD 924 and MD 24. Residential developments border Singer Road with subdivision access roads and direct access driveways. At the intersection of Singer Road and MD 924, commercial development is present to the north, on Singer Road, and a retirement center is located on the south side. Figure III.1 provides an overview of the Zone 1 study area illustrating major residential and commercial developments and the roadway network. The zoning for Zone 1 is provided as Figure III.2. As shown, the majority of the study area bordering MD 924 is commercial with residential development comprising the balance of the study area.

Several developments are currently proposed or under construction in Zone 1. Three parcels along MD 924 north of Box Hill South Parkway have been approved for rezoning from R2 Urban Residential and RO Residential Office to B3 General Business District. The proposed site plan for the three parcels includes several small retail uses. In addition, the Enclave at Box Hill is under construction and will include 389 apartments as part of a mixed-use center located south of Box Hill Corporate Center. The Boulevard at Box Hill Phase 2 will include additional commercial lots on the north side of Box Hill Corporate Center to the east of MD 924. The roadway upgrades required for each site are summarized in Appendix I.B. Since the mitigation measures are either constructed or bonded for construction, the associated lane geometry was considered an existing condition in the analyses.



LEGEND

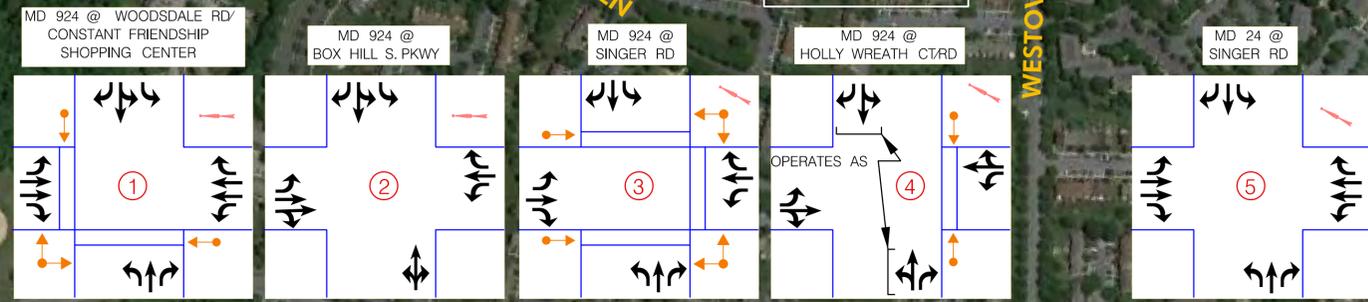
(AM/PM/SAT)
 (AM/PM/SAT)
 (AM/PM/SAT)

INTERSECTION ID NO.

SIGNALIZED INTERSECTION

MARYLAND 924		
2015 EXISTING VOLUMES		
SCALE: N.T.S.	FIGURE II. 1	JUNE 2017

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MARYLAND 924		
STUDY AREA - ZONE 1		
ZONE 1 BOX HILL WOODSDALE ROAD TO HOLLY WREATH ROAD		
N.T.S.	FIGURE III.1	JUNE 2017

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B. Typical Sections

MD 924 is classified as an Urban Minor Arterial and MD 24 is classified as an Urban Freeway/Expressway based on the SHA’s State Highway Location Reference. The typical section along MD 924 varies considerably in Zone 1. To the south, the roadway is a divided, closed section, five-lane arterial with sidewalks. At Box Hill South Parkway, a northbound through lane is dropped as an exclusive right turn lane. North of Box Hill South Parkway, a three-lane section is provided, which transitions to two lanes with a bike lane at Box Ridge Drive and continues to Holly Wreath Road. The sidewalk and bike lanes were recently constructed as part of an SHA upgrade of the corridor. The typical sections are summarized in tabular form in Appendix I.B. The review of roadway sections also included the link from MD 924 to MD 24 in Zone 1 – Singer Road. The typical section of Singer Road provides a three-lane section with sidewalks along the entire south side and sporadically along the north side.

As shown in Figure III.1, signalized intersections are present along MD 924 at Woodsdale Road, Box Hill South Parkway, Singer Road/Abingdon Road and Holly Wreath Road; MD 24 at Singer Road is also signalized. Pedestrian phasing and push buttons are present on at least one major street approach at Woodsdale Road, Abingdon Road/Singer Road and Holly Wreath Road. The Woodsdale Road and Abingdon Road/Singer Road intersections also provide signalized crossings for at least one minor street approach. The signal at Woodsdale Road is interconnected with the signals at the MD 24/MD 924 interchange. The other signalized intersections in Zone 1 operate independently. The signals along MD 24 are all interconnected. The posted speed limit along MD 924 in Zone 1 is 40 MPH.

C. Field Observations

Field reviews were conducted during morning, evening and mid-day hours on weekdays and on Saturday to provide a qualitative assessment of operations. Extensive queues were observed on the minor street approaches particularly during the evening peak hours. Although queues in excess of ten vehicles were not uncommon, the queues were typically able to clear in a single signal cycle. Excessive delays and queues were noted on the mainline of MD 924 during the morning and evening peak hours. The queues and delays were relatively balanced northbound and southbound along MD 924 in the morning. The northbound queues were acute during the evening peak period from approximately 5:00 PM to 6:00 PM with rolling queues from Box Hill South Parkway to Abingdon Road producing some multi-cycle delays. Northbound queues along MD 24 in the evening extended from the MD 24/MD 924 overpass to Singer Road, with multi-cycle delays experienced by drivers. Due to the mainline congestion, drivers were observed employing the acceleration/deceleration and right turn lanes to bypass queues. Along MD 924, the two-way left turn lanes were also used as a bypass lane for the queues, which created conflicts with turning vehicles. Queues along Box Hill South Parkway, Woodsdale Road and Singer Road were typically ten vehicles or less and would clear within one cycle.

In addition to the Boulevard at Box Hill, the Giant Supermarket and Gas Station were major traffic generators. Associated with the Giant is an alley that provides access to Abingdon Road. Field observations revealed that the alley was heavily utilized as a by-pass of the congestion along MD 924 in the evening peak hour. A 15-minute mini-count starting at 5:00 PM was conducted at the Giant parking lot. Results of the count revealed that 31 vehicles entered the parking lot from the south along MD 924, three entered from the north along MD 924, and 29 vehicles exited to



Abingdon Road via the alley. Other businesses along the east side of MD 924 have access to the alley or directly to Abingdon Road that could serve as a bypass of MD 924 during periods of peak congestion.

Weekend and weekday speed and classification counts were performed by WBCM along MD 924 north of Box Hill South Parkway; the data is provided in Appendix I.B. Review of the data reveals that total percent trucks on Saturday were 6%; weekday off-peak percentages were 5% and peak period percentages were 5%. The speed data was reviewed and the results were as expected based on the field observations. Evening peak period 85th Percentile travel speeds (the maximum speed 85% of the vehicles were traveling at or below) along MD 924 were 11 MPH versus 41 MPH off-peak. The posted speed limit in Zone 1 is 40 MPH along MD 924 and 55 mph on MD 24.

D. Level of Service Summary

Levels of Service were assessed based on the existing traffic volumes from Figure II.1, existing lane geometry or proposed upgrades included as part of an approved development, existing traffic signal phasing and cycle lengths. The analyses were conducted with Synchro/SimTraffic and the Critical Lane Analysis methodology. The Synchro/SimTraffic software was coded to optimize signal timing and switch lead (left arrow at the beginning of the phase) versus lag (left turn arrow at the end of the phase) in left turn signal phasing. Results of the Synchro/SimTraffic analyses are provided in Appendix I.B. The computation forms are also provided in Appendix I.B. Levels of Service computations were also performed employing the Critical Lane Analysis (CLA) methodology. Results of the CLA analyses are provided in Table III.1 and the computation forms are provided in Appendix I.B.

Table III.1

**Critical Lane Analysis Volume Summary for Existing Conditions – Zone 1
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
01	ZONE 1	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	A (571)	0.36	A (917)	0.57
02		MD 924 at Porter Dr/ Box Hill S. Parkway	A (584)	0.37	C (1151)	0.72
03		MD 924 at Singer Rd/ Abingdon Rd	A (646)	0.40	B (1075)	0.67
04		MD 924 at Holly Wreath Ct/ Holly Wreath Rd	A (765)	0.48	B (1071)	0.67
05		MD 24 at Singer Rd	F (1607)	1.00	F (1611)	1.01



Review of the LOS tables reveals major capacity issues along the minor street approaches and the MD 24 mainline, confirming the field observations. Although the overall levels of service may be acceptable, the Synchro output must be reviewed in detail to identify capacity constraints. Based on a review of the approach and movement delays, the high demand on the MD 924 mainline creates delays for the minor street approaches. The minor street delays are sufficient to cause failing operations for the side roads in the evening peak hour and at Woodsdale Road in the morning. In the morning peak hour along MD 24, the heavy southbound through movements and side road traffic accessing MD 24 creates unacceptable delays. In the evening, the heavy northbound traffic along MD 24 created failing conditions for the mainline and side road approaches.

Supplemental Synchro analyses were conducted to determine if acceptable intersection operations could be achieved with reasonable Transportation Systems Management (TSM) mitigation measures that would not require major roadway widening. Travel Demand Management (TDM) measures were also considered to reduce peak period congestion. The TSM and TDM actions considered included: a 5% reduction in through traffic along MD 924 and MD 24; modification of signal timing and phasing; and revised lane assignments within the existing pavement footprint. The 5% through traffic reduction was included as an assumption for a small target trip reduction goal as part of a TDM program along the corridor that could include shifting departure times, tele-commuting, minor shift to transit, etc.

Results of the Synchro analyses are provided in Table III.2 for the both existing conditions and mitigation measures. The computation forms are provided in Appendix I.B.

Table III.2

**Synchro Summary for Zone 1
MD 924 Multi-Modal Corridor Study**

Zone 1					
Int. ID No.	Intersection	EXISTING CONDITIONS LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
01	MD 924 at Constant Friendship Shopping Center/Woodsdale Rd	C 27.3	C 31.1	C 22.3	C 26.9
02	MD 924 at Porter Dr/Box Hill S. Parkway	B 17.9	C 43.0	B 18.1	D 38.3
03	MD 924 at Singer Rd/Abingdon Rd	C 25.8	C 48.7	C 22.6	D 37.4
04	MD 924 at Holly Wreath Ct/Holly Wreath Rd	B 18.9	C 21.1	B 18.9	C 20.2
05	MD 24 at Singer Rd	F 91.4	E 73.9		

The following mitigation measures were utilized in Synchro to bring all intersections and approaches up to an acceptable level of service:



01 – MD 924 at Constant Friendship Shopping Center/Woodsdale Road: Requires 5% peak period directional through volume reduction and the signal cycle length to be optimized to 110 seconds (existing cycle length is 150 seconds) during the AM and PM peak periods. It should be noted that the signal is interconnected to the MD 24/MD 924 interchange signals, which are located outside of the study limits. A full analysis of the coordinated system would need to be completed to verify that reducing the signal cycle length would benefit the system as a whole.

02 – MD 924 at Porter Drive/Box Hill South Parkway: Requires 5% peak period directional through volume reduction and the signal cycle length to be optimized to 120 seconds during the PM peak period. Splits would need to be adjusted to transfer green time from the mainline approaches to the westbound approach.

03 – MD 924 at Singer Road/Abingdon Road: Requires 5% peak period directional through volume reduction and the signal cycle length to be optimized to 120 seconds during the PM peak period.

04 – MD 924 at Holly Wreath Court/Road: No mitigation measures required.

05 – MD 24 at Singer Road: Transportation Systems Management (TSM) improvements along MD 24 were analyzed using Synchro to determine their effectiveness in improving the level of service and delay at failing intersections and approaches. Additionally, signal interconnection offset, cycle length and splits were optimized in Synchro to improve operations along MD 24. Finally, high cost alternatives, such as installing an additional mainline through lane and side street turn and through lanes, were analyzed. Synchro results showed that the TSM improvements and optimization would not produce acceptable levels of service. High cost improvements would be required to bring the study intersections and approaches up to an acceptable level of service.

E. Queue Analysis Summary

Existing conditions queues were derived from two sources – SimTraffic and the SHA’s 95% Probability Methodology. Results of the queue analyses are summarized in tables located in Appendix I.B. Review of the tables reveals that several of the intersection turning movements along the minor street approaches and the MD 924 and MD 24 mainlines exceed the available capacity. Although northbound and southbound MD 924 left-turn queues at Abingdon Road/Singer Road exceed the available storage, it should be noted that the existing two-way left turn lane provides additional storage beyond the striped turn lane.

Review of the tables also indicates the majority of the intersection queues along the minor street and MD 924 approaches would be reduced as a result of the proposed mitigation measures.



IV. ZONE 2 – EXISTING CONDITIONS SUMMARY

A. Zoning and Land Use

Zone 2 extends from Holly Wreath Court/Holly Wreath Road to Barrington Place/Patterson Mill Road. The area has major commercial development in the central section to the north and south of Bel Air South Parkway with the Festival at Bel Air, The Shops at Bel Air South and the retail center west of MD 24. Significant residential development has occurred, both single-family and multi-family, between MD 24 and MD 924 at the northern and southern Zone limits. Single-family and multi-family developments are also located to the east of MD 924. A Middle and High School are located along Patterson Mill Road to the east of MD 924. Undeveloped land is present to the north and south of the central commercial sites and is zoned for commercial use. West Wheel Road, Bel Air South Parkway, and Plumtree Road provide links from MD 924 to MD 24 and serve retail and office sites in Zone 2. Figure IV.1 provides an overview of the Zone 2 study area illustrating major residential and commercial development and the roadway network. The zoning for Zone 2 is provided as Figure IV.2. As shown, the majority of the study area bordering MD 924 and between MD 924 and MD 24 is commercial with residential development comprising the balance of the study area.

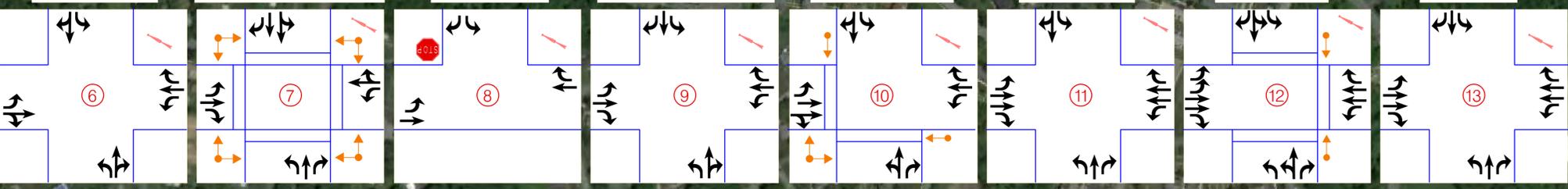
Three new developments are approved and currently under construction in Zone 2. The Laurel Ridge development is located along Laurel Bush Road north of Hookers Mill Road and will include 115 single-family and 56 townhouse units. Evergreen Woods Apartments is located west of MD 24 and along the south side of Plumtree Road and will include 198 apartments. The MedStar Building will create a total of 130,000 square feet of medical office space at full build out; the project is located opposite Plumtree Road along the east side of MD 924. The roadway upgrades associated with trip mitigation for each development are currently under construction or bonded for construction. The intersection mitigation measures were assumed to be existing conditions in the analyses. The existing traffic volumes were not redistributed based on the extension of Tollgate Road, which is included as part of the Evergreen Woods site. The mitigation associated with each development is summarized in Appendix I.C.

B. Typical Sections

The typical section along MD 924 in Zone 2 varies from a two-lane open section (no curb) road with wide shoulders and no sidewalks to a three-lane facility north of Wheel Road. Southbound between Barrington Place/Patterson Mill Road and Plumtree Road, two southbound lanes are provided along MD 924 with the second lane dropped as an exclusive right turn lane at Plumtree Road. Between MD 924 and MD 24, Wheel Road provides two westbound and one eastbound lane with turn lanes provided into the Festival at Bel Air and at the MD 924 intersection. Bel Air South Parkway is a four-lane road with a raised median and Plumtree Road is a two-lane road. Sidewalks are provided on the east and/or west side of MD 924 north of Bel Air South Parkway and along the three connecting roads – West Wheel Road, Bel Air South Parkway and Plumtree Road. A table in Appendix I.C provides a summary of the typical sections in Zone 2. As shown in Figure IV.1, the intersections of MD 924 with East/West Wheel Road, Bel Air South Parkway/Laurel Bush Road, Plumtree Road and Barrington Place/Patterson Mill Road are signalized and the intersection with Bright Oaks Drive is stop controlled. The three intersections along MD 24 in Zone 2 are signalized – West Wheel Road, Bel Air South Parkway and Plumtree



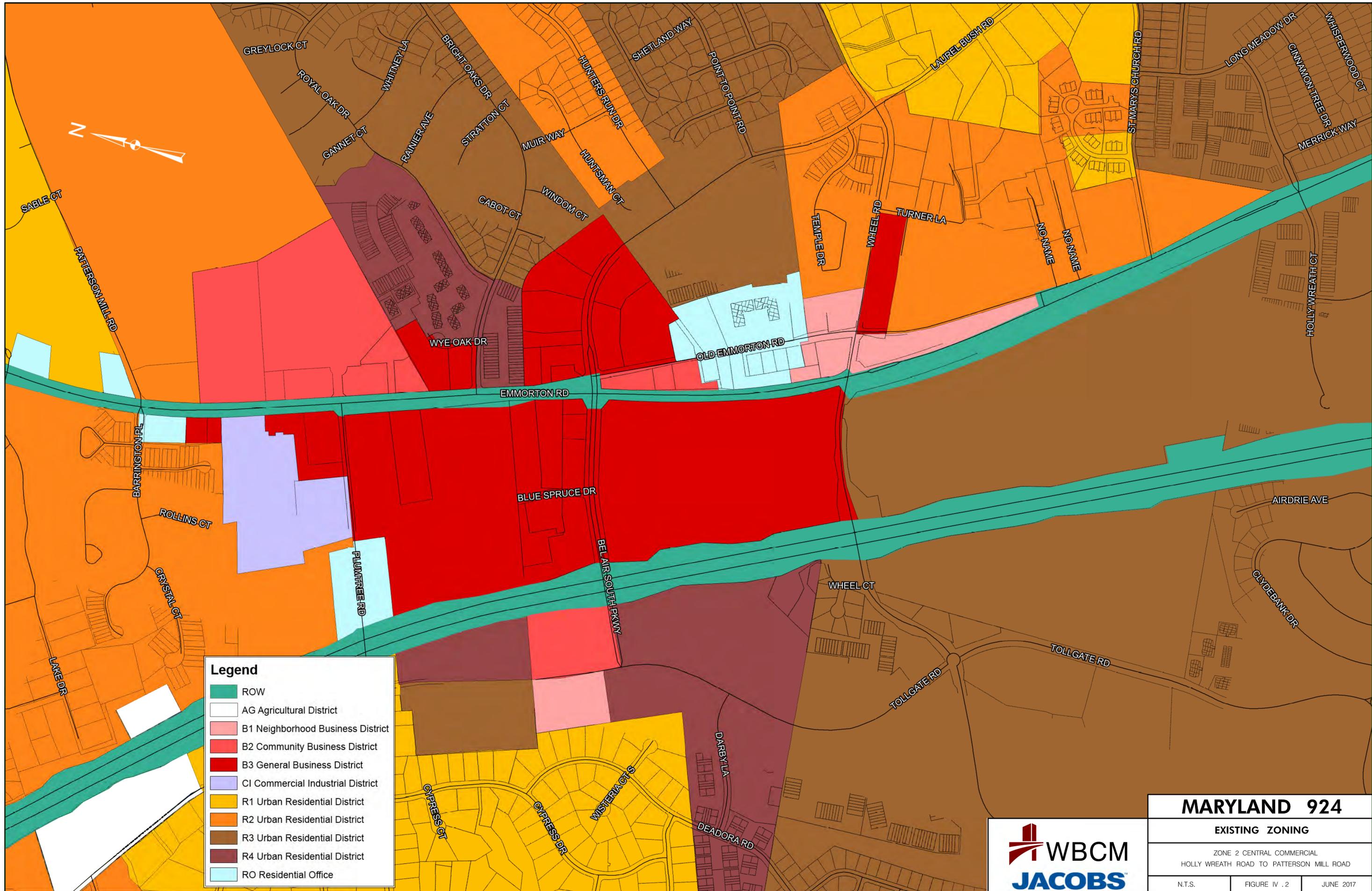
MD 924 @ E. W. WHEEL RD MD 924 @ BEL AIR S. PKWY / LAUREL BUSH RD MD 924 @ BRIGHT OAKS DR MD 924 @ PLUMTREE RD / MEDSTAR BLVD MD 924 @ PATTERSON MILL RD / BARRINGTON PLACE MD 24 @ W. WHEEL RD MD 24 @ BEL AIR S. PKWY MD 24 @ PLUMTREE RD



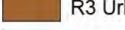
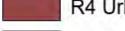
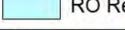
EMMORTON ELEMENTARY SCHOOL

MARYLAND 924		
STUDY AREA - ZONE 2		
ZONE 2 CENTRAL COMMERCIAL HOLLY WREATH ROAD TO PATTERSON MILL ROAD		
N.T.S.	FIGURE IV .1	JUNE 2017

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Legend

	ROW
	AG Agricultural District
	B1 Neighborhood Business District
	B2 Community Business District
	B3 General Business District
	CI Commercial Industrial District
	R1 Urban Residential District
	R2 Urban Residential District
	R3 Urban Residential District
	R4 Urban Residential District
	RO Residential Office

MARYLAND 924		
EXISTING ZONING		
ZONE 2 CENTRAL COMMERCIAL HOLLY WREATH ROAD TO PATTERSON MILL ROAD		
N.T.S.	FIGURE IV .2	JUNE 2017



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Road. The intersections along Bel Air South Parkway provide pedestrian signals and push buttons for crossing at least one major street approach and each minor street approach. The intersection of MD 924 with Barrington Place/Patterson Mill Road provides signalized crossings at the west and north legs of the intersection. The intersections of East/West Wheel Road up to Barrington Place/Patterson Mill Road along MD 924 are interconnected in a system. The signals along MD 24 are also interconnected.

C. Field Observations

Typical for the MD 924 corridor, extensive queues were observed along MD 924 in the morning and evening peak periods. Saturday operations were similar to the weekday peaks. Peak period queues along the signalized minor street approaches of MD 924 averaged ten vehicles; however, the queues typically were able to clear in one cycle with occasional two-cycle delays observed. The operations at MD 924/Barrington Place/Patterson Mill Road were observed during the 2:00 PM Patterson Mill High School dismissal. At 2:15 PM, buses leave the school. Patterson Mill Road left turn queues do not clear the intersection in one cycle at 2:15 PM. Maximum signal time allocated to Patterson Mill Road during school dismissal results in MD 924 northbound queues extending back to Plumtree Road. The northbound queues required two to three cycles to clear. All queues dissipated and operations were acceptable at 2:25 PM. The Patterson Mill Middle School dismissal at 2:45 PM has minimal impacts on traffic operations; all queues clear within one cycle at the MD 924/Barrington Place/Patterson Mill Road intersection. Peak period queues were extensive along MD 24 with multi-cycle rolling queues extending to upstream intersections during the evening peak periods. Right turn lanes and acceleration/deceleration lanes were employed by aggressive drivers as bypass lanes around the queues. Two-way left turn lanes along MD 924 were also used for queue bypass. Red light running was also noticed for the MD 24 mainline. Side street queues along MD 24 were approximately 20 vehicles during peak periods and cleared with minimal multi-cycle delays.

A machine classification and speed count was conducted by WBCM south of East/West Wheel Road along MD 924. The data is provided in Appendix I.C. The data indicates the typical weekday truck percentage is 6% off-peak and 8% during the evening peak hour in the northbound direction. Saturday truck percentages were also 6% of the total volumes. Review of the speed data indicated that, with the open section and lack of intersecting streets, driver comfort levels yielded higher speeds. The 85th Percentile speed along MD 924 midday was 50 MPH on weekdays and 49 MPH on Saturday. The posted speed limit along MD 924 is 40 MPH and 55 MPH along MD 24.

D. Level of Service Summary

Capacity analyses were conducted with both the Synchro/SimTraffic software and the CLA methodology. In conducting the analyses, existing lane configurations and phasing were employed along with the volumes from Figure II.2. The proposed mitigation measures associated with the approved developments were assumed to be complete and considered existing conditions in the analyses. Results of the level of service assessments for the Synchro/SimTraffic analyses are provided in tables located in Appendix I.C. The CLA analyses are summarized in Table IV.1; copies of the computation forms are found in Appendix I.C.



Table IV.1

**Critical Lane Analysis Summary for Existing Conditions – Zone 2
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Zone	Intersection	AM Peak HR Volumes		PM Peak HR Volumes		Saturday Peak HR Volumes	
			LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
06	ZONE 2	MD 924 at Wheel Rd	A (786)	0.49	A (955)	0.60	A (891)	0.56
07		MD 924 at Bel Air S. Parkway/Laurel Bush Rd	A (896)	0.56	C (1174)	0.73	A (918)	0.57
08		MD 924 at Bright Oaks Dr	B (1020)	0.64	C (1177)	0.74		
09		MD 924 at Plumtree Rd/ Medstar Boulevard	B (1036)	0.65	C (1166)	0.73	B (1029)	0.64
10		MD 924 at Barrington Pl/ Patterson Mill Rd	A (876)	0.55	B (1069)	0.67		
11		MD 24 at Wheel Rd	C (1226)	0.77	E (1468)	0.91		
12		MD 24 at Bel Air S. Parkway	C (1167)	0.73	D (1448)	0.91		
13		MD 24 at Plumtree Rd	B (1006)	0.63	C (1236)	0.77		

Review of the levels of service tables reveals major capacity issues along the minor street approaches, confirming the field observations. Although the overall levels of service may be acceptable, the Synchro output must be reviewed in detail to identify capacity constraints. Based on a review of the approach and movement delays, the high demand on the MD 924 mainline creates delays for the minor street approaches. The minor street delays are sufficient to cause failing operations along most of the side roads in the morning and evening peak hours. In the morning peak hour along MD 24, the heavy southbound through movements and side road traffic accessing MD 24 creates unacceptable delays. In the evening, the heavy northbound traffic along MD 24 creates failing conditions for the side road approaches.

Supplemental Synchro analyses were conducted to determine if acceptable intersection operations could be achieved with reasonable mitigation measures. Actions considered included a 5% reduction in through traffic along MD 924 and MD 24, modification of signal timing and phasing, and modification of lane assignments within the existing pavement footprint. Results of the Synchro analyses for both existing conditions and mitigation measures are provided in Table IV.2. The computation forms are provided in Appendix I.C. The specific mitigation measures for each intersection follow in the text after the tables.



Table IV.2

**Synchro Summary for Zone 2
MD 924 Multi-Modal Corridor Study**

Zone 2							
Int. ID No.	Intersection	EXISTING CONDITIONS LOS & DELAY			MITIGATION MEASURES LOS & DELAY		
		AM	PM	SAT	AM	PM	SAT
06	MD 924 at Wheel Rd	C 30.0	C 34.8	C 33.5	C 29.7	D 37.2	C 32.0
07	MD 924 at Bel Air S. Parkway/Laurel Bush Rd	C 24.6	D 49.7	C 33.4	C 23.0	D 40.9	C 29.7
08	MD 924 at Bright Oaks Dr	B	D		A	A	
09	MD 924 at Plumtree Rd/ Medstar Boulevard	B 16.1	C 22.6	B 18.8	B 19.9	D 24.6	B 18.1
10	MD 924 at Barrington Pl/ Patterson Mill Rd	C 22.3	B 13.7		C 20.5	B 12.0	
11	MD 24 at Wheel Rd	B 18.5	D 49.5				
12	MD 24 at Bel Air S. Parkway	D 48.1	D 52.3				
13	MD 24 at Plumtree Rd	B 19.4	C 31.8				

The following mitigation measures were utilized in Synchro to bring all intersections and approaches up to an acceptable level of service:

06 – MD 924 at Wheel Road: Requires 5% peak period directional through volume reduction. The splits would need to be adjusted to transfer green time from the mainline approaches to the eastbound approach during the AM and PM peak periods. The signal cycle length would change to 130 seconds in the PM peak hour.

07- MD 924 at Bel Air South Parkway/Laurel Bush Road: High cost alternatives would be required; the modification of the existing westbound left turn lane to a shared left/through lane as part of the MedStar Health project mitigation measures will not be sufficient to provide an acceptable level of service at the intersection. The intersection requires 5% peak period directional through volume reduction. A second eastbound left turn lane would be necessary from Bel Air South Parkway, along with widening of the north leg of MD 924 to provide a second receiving lane. The second northbound lane would be signed and marked as a shared through/right turn lane at Bright Oaks Drive. A lane drop at Bright Oaks Drive would not provide acceptable operations due to the close intersection spacing. A northbound right turn lane drop could be provided into Medstar Boulevard to reduce the length of the widening. However, based on volumes, the right turn lane drop should occur at Patterson Mill Road. The signal cycle length would change to 130 seconds in the PM peak hour with additional green time transferred to the minor street approaches from the mainline.



08- MD 924 at Bright Oaks Drive: No mitigation measures are required; however, the northbound approach would be a through/through-right as part of the added receiving lane and right lane drop between MD 924 at Bel Air South Parkway/Laurel Bush Road and Plumtree Road/Medstar Boulevard.

09 – MD 924 at Plumtree Road/Medstar Boulevard: Requires 5% peak period directional through volume reduction during the AM and PM peak periods. Install westbound and eastbound exclusive/permissive left turn signal phasing to reduce eastbound and westbound delay. Splits would need to be adjusted to transfer green time from the mainline approaches to the eastbound and westbound approaches. The signal cycle length would change to 130 seconds in the PM peak hour.

10 – MD 924 at Barrington Place/Patterson Mill Road: No mitigation measures required.

11 – MD 24 at Wheel Road, 12 – MD 24 at Bel Air S. Parkway & 13 – MD 24 at Plumtree Road: TSM and TDM improvements along MD 24 were analyzed using Synchro to determine their effectiveness at improving the level of service and delay at failing intersections and approaches. Signal interconnection, offset, cycle length, and splits were also optimized in Synchro to improve operations along MD 24. Finally, high cost alternatives such as installing an additional mainline through lane and side street turn and through lanes were analyzed. Synchro results showed that the TSM improvements and optimization would not produce acceptable levels of service. High cost improvements would be required to bring the study intersections and approaches up to an acceptable level of service.

E. Queue Analysis Summary

Review of the queuing tables located in Appendix I.C reveals that several of the intersection turning movements along the minor street approaches and the MD 924 and MD 24 mainlines exceed the available capacity. Although northbound and southbound MD 924 left-turn queues at Laurel Bush Road/Bel Air S. Parkway and Plumtree Road/Medstar Boulevard exceed the available storage, it should be noted that the existing two-way left turn lane provides additional storage beyond the striped turn lanes.

The SimTraffic queue results for mitigation measures are also summarized in the tables in Appendix I.C. The mitigation measure details for each intersection are provided in the previous Level of Service section. Review of the tables indicates the majority of the intersection queues along the minor street and MD 924 approaches would be reduced as a result of the proposed mitigation measures.



V. ZONE 3 – EXISTING CONDITIONS SUMMARY

A. Zoning and Land Use

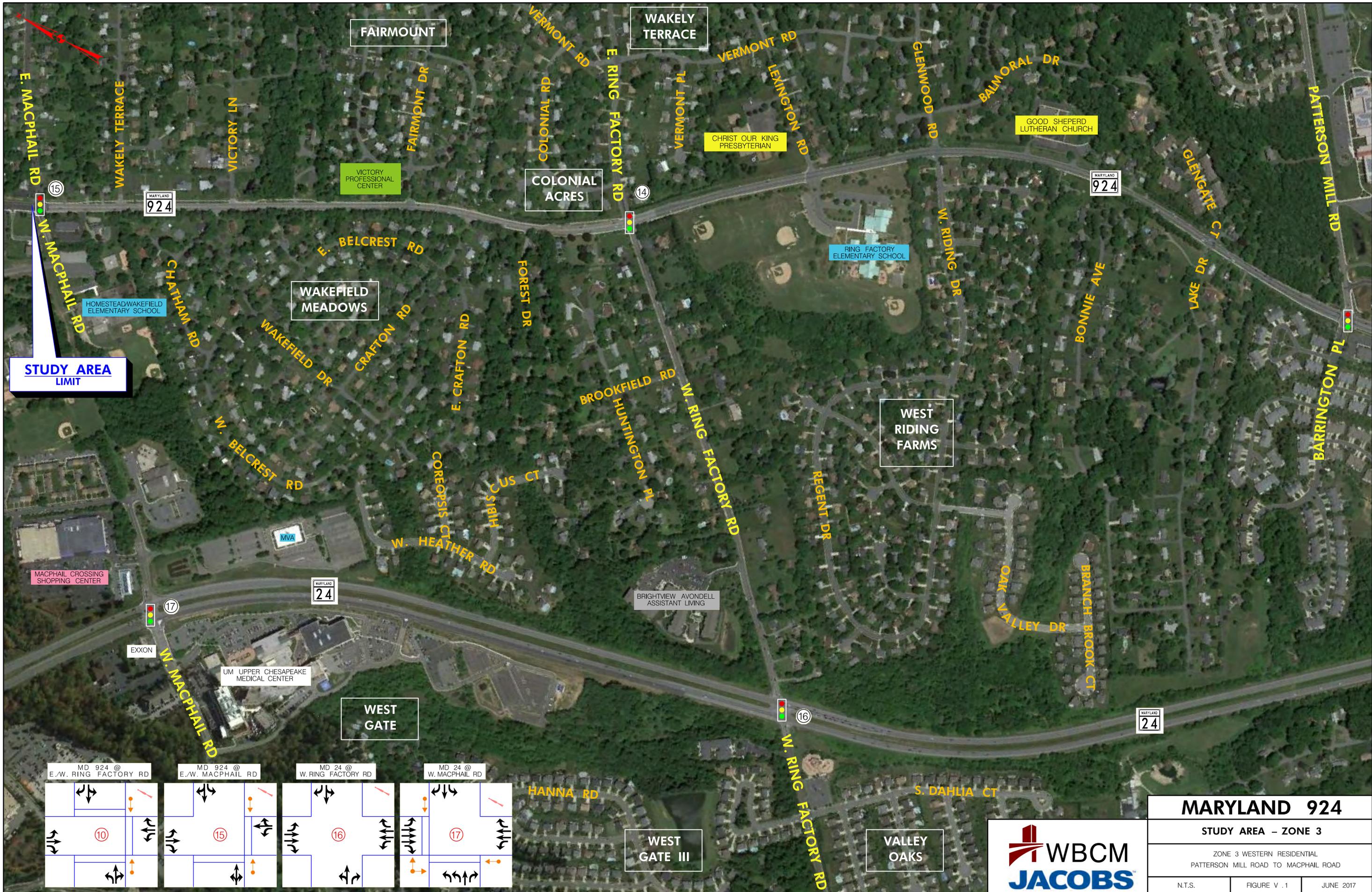
Starting at the intersection of MD 924 with Barrington Place/Patterson Mill Road, Zone 3 continues to the northern limits of the study area at East/West MacPhail Road. The area is all single-family residential with a few homes that have been converted to small office uses under the RO – Residential Office zoning. The Homestead/Wakefield Elementary School is located west of MD 924 along West MacPhail Road. Figure V.1 provides an overview of the Zone 3 study area illustrating major residential developments and the roadway network. The zoning for Zone 3 is provided as Figure V.2. As shown, the majority of the study area is zoned Urban Residential with a few parcels of RO. One new development is approved that will impact intersections in the Zone 3 study area. Magness Farms, located along the north and south sides of Ring Factory Road west of Tollgate Road, is proposed to be developed with 302 single-family dwelling units. Roadway trip mitigation for the project has not yet been bonded for construction; therefore, the associated roadway upgrades were not included in the existing conditions analyses.

B. Typical Section

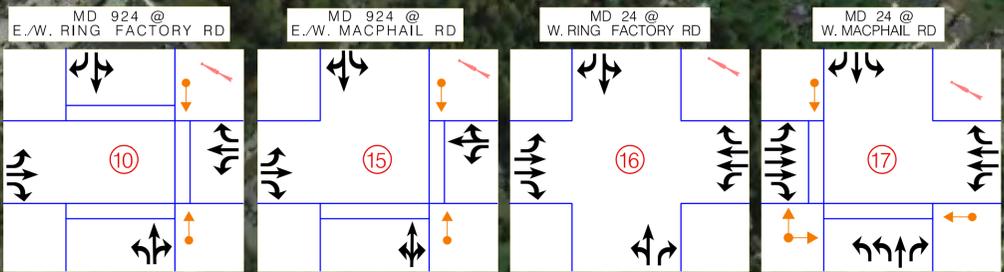
The typical section along MD 924 in Zone 3 is a consistent three-lane undivided roadway. Sidewalk is present on the east or west side of MD 924. Tables summarizing the sections along with dimensioned images are provided in Appendix I.D. The review of roadway sections also includes the link from MD 924 to MD 24 in Zone 3 – West Ring Factory Road. The typical section of West Ring Factory Road provides a bicycle-compatible two-lane section with sidewalk along the length of the roadway up to a few hundred feet west of the intersection with MD 24. Signalized intersections are present along MD 924 and MD 24 at Ring Factory Road and MacPhail Road. The signals along MD 924 operate independently. The signals along MD 24 are all interconnected. The posted speed limit changes from 40 MPH in the southern portion of Zone 3, to 30 MPH in the vicinity of Wakely Terrace.

C. Field Observations

Homestead/Wakefield Elementary School dismisses at 3:30 PM generating queuing along the eastbound approach that spills back into the elementary school parking lot and along the intersecting entrance to Bel Air Middle School. School queues required two to three signal cycles to clear. Since demand was high, maximum green time was provided to the side roads creating increased queues along MD 924 northbound, which required three cycles to clear during the 3:45 PM to 4:00 PM school dismissal period. During the typical morning and evening peak periods, rolling queues were observed on MD 924; however, multi-cycle delays were not common. Queues along the minor streets were low – only a maximum of approximately five vehicles. Southbound morning queues exceeded 20 vehicles and northbound evening queues were in excess of 40 vehicles along MD 24 at West Ring Factory Road. Northbound queues were also in excess of 30 vehicles during the afternoon school dismissal peak period. West Ring Factory Road queues were generally 14 vehicles in the morning and, at most, six vehicles during the evening peak period. Morning and evening queues along East/West MacPhail Road were six vehicles or less. Morning and evening non-school-related minor street volumes cleared in one cycle; MD 24 vehicles cleared in no more than two cycles. Vehicles were observed driving along the right turn lanes to bypass queues along MD 24, then quickly merging back into through traffic. The two-way left turn lane along MD 924 was also employed as a bypass lane.



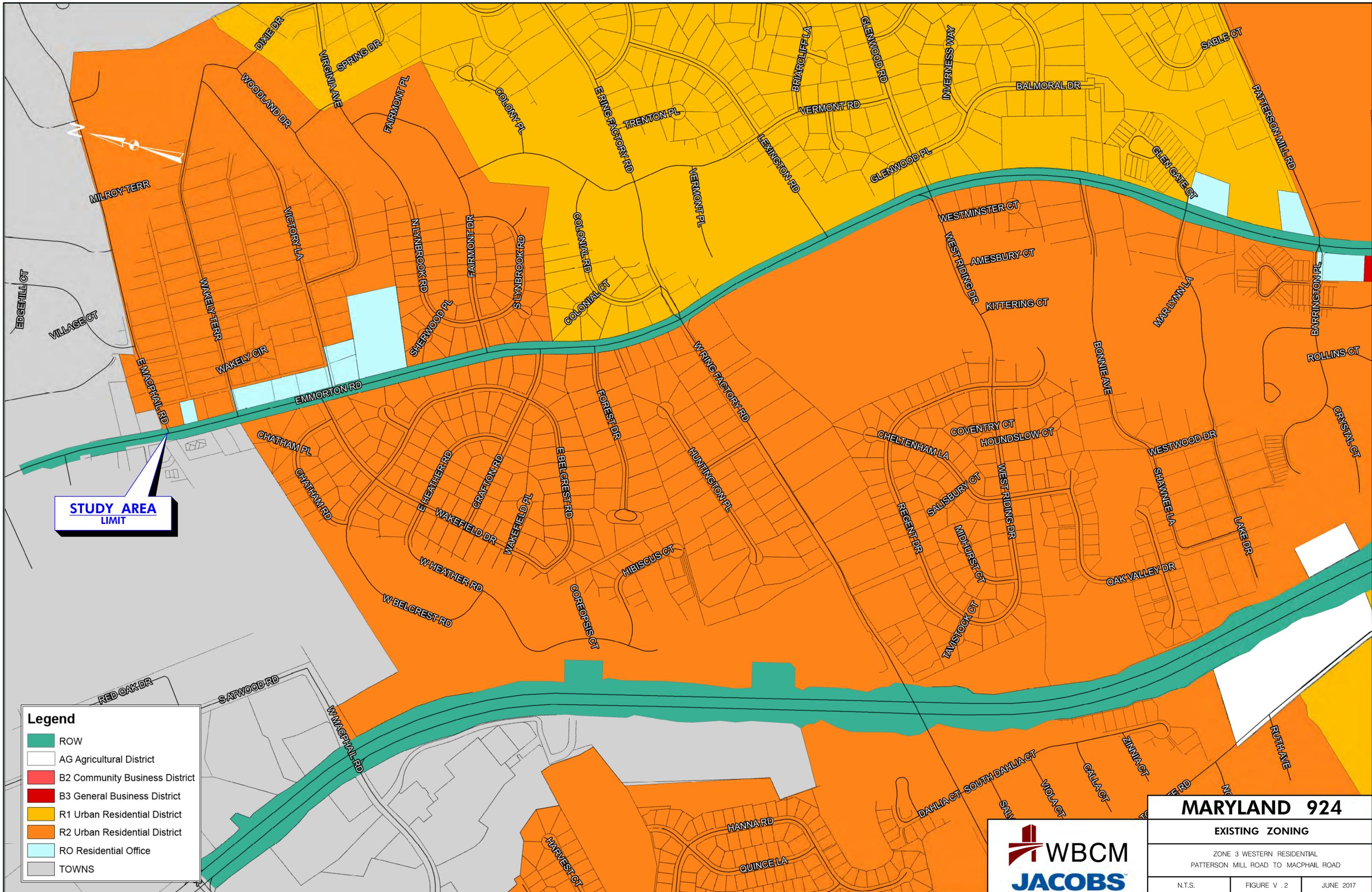
STUDY AREA LIMIT



MARYLAND 924		
STUDY AREA - ZONE 3		
ZONE 3 WESTERN RESIDENTIAL PATTERSON MILL ROAD TO MACPHAIL ROAD		
N.T.S.	FIGURE V . 1	JUNE 2017



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**STUDY AREA
LIMIT**

Legend

- ROW
- AG Agricultural District
- B2 Community Business District
- B3 General Business District
- R1 Urban Residential District
- R2 Urban Residential District
- RO Residential Office
- TOWNS



MARYLAND 924		
EXISTING ZONING		
ZONE 3 WESTERN RESIDENTIAL PATTERSON MILL ROAD TO MACPHAIL ROAD		
N.T.S.	FIGURE V . 2	JUNE 2017

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In an effort to quantify travel speeds and truck percentages, weekend and weekday machine speed and volume counts were conducted along MD 924 north of the intersection with East/West Ring Factory Road. The data sheets are provided in Appendix I.D and show that truck percentages on Saturday were 3%. Weekday truck percentages were 5% off-peak and 5% during the evening peak period. The posted speed limit changes from 40 MPH in the southern portion of the Zone to 30 MPH in the vicinity of Wakely Terrace. The Saturday 85th Percentile speeds were 42 MPH; weekday peak-period 85th Percentile speeds were 36 MPH and off-peak readings were 42 MPH.

D. Level of Service Summary

Capacity analyses were conducted in Zone 3 based on the existing traffic volumes from Figure II.2 and existing lane configurations and signal phasing. The analyses were conducted with Synchro/SimTraffic software and the Critical Lane Analysis methodology. The proposed mitigation measures associated with the approved developments were assumed to be complete and considered existing conditions in the analyses. Results of the level of service assessments for the Synchro/SimTraffic analyses are provided in tables located in Appendix I.D. The CLA analyses are summarized in Table V.1; copies of the computation forms are found in Appendix I.D.

Table V.1

**Critical Lane Analysis Summary for Existing Conditions – Zone 3
MD 924 Multi-Modal Corridor Study**

Int. ID No.	Intersection	AM Peak HR Volumes		PM Peak HR Volumes	
		LOS (CLV)	V/C RATIO	LOS (CLV)	V/C RATIO
14	MD 924 at Ring Factory Rd	A (916)	0.57	B (1101)	0.69
15	MD 924 at W. MacPhail Rd/ E. MacPhail Rd	A (970)	0.61	C (1194)	0.75
16	MD 24 at W. Ring Factory Rd	B (1123)	0.70	C (1249)	0.78
17	MD 24 at W. MacPhail Rd	A (779)	0.49	B (1079)	0.67

Review of the levels of service tables reveals minor capacity issues along the side street approaches, confirming the field observations. Although the overall levels of service may be acceptable, the Synchro output must be reviewed in detail to identify capacity constraints. Based on a review of the approach and movement delays, the demand on the MD 924 mainline creates delays for the minor street approaches. The minor street delays are sufficient to cause failing operations along some of the side roads in the morning, and all side street roads with the exception of the eastbound and westbound approaches of MD 924 at W./E. MacPhail Road and



the eastbound approach of MD 24 at W. MacPhail Road in the evening peak hours. In the morning peak hour, the heavy southbound through movements and side road traffic accessing MD 24 creates unacceptable delays. In the evening, the heavy northbound traffic along MD 24 created failing conditions for the side road approaches.

Supplemental Synchro analyses were conducted to determine if acceptable intersection operations could be achieved with reasonable mitigation measures. As noted in the previous section, the mitigation measures considered were TSM and TDM upgrades requiring no additional pavement construction. The TDM options considered included a 5% reduction in through traffic along MD 924 and MD 24 realized through trip modification or reduction. The TSM measures included modification of signal timing and phasing and modification of lane assignments within the existing pavement footprint. Results of the Synchro analyses for both existing conditions and mitigation measures are provided in Table V.2. The computation forms are provided in Appendix I.D.

Table V.2

**Synchro Summary for Zone 3
MD 924 Multi-Modal Corridor Study**

Zone 3					
Int. ID No.	Intersection	EXISTING CONDITIONS LOS & DELAY		MITIGATION MEASURES LOS & DELAY	
		AM	PM	AM	PM
14	MD 924 at Ring Factory Rd	C 34.8	D 46.4	C 22.4	C 34.3
15	MD 924 at W. MacPhail Rd/ E. MacPhail Rd	C 32.2	D 37.0	C 32.2	C 32.0
16	MD 24 at W. Ring Factory Rd	C 34.4	D 40.0		
17	MD 24 at W. MacPhail Rd	C 26.0	C 32.5		

The following mitigation measures were utilized in Synchro to bring all intersections and approaches up to an acceptable level of service:

14 – MD 924 at W./E. Ring Factory Road: Requires 5% peak period directional through volume reduction during the AM and PM peak periods. Remove eastbound and westbound split phasing and install exclusive/permissive left turn signals to reduce eastbound and westbound delay. Convert westbound shared left-through and right turn lanes to a left and shared through-right; optimize splits and cycle lengths.

15 – MD 924 at W./E. MacPhail Road: No mitigation measures required.

16 - MD 24 at W. Ring Factory Road & 17 – MD 24 at W. MacPhail Road: TSM improvements and TDM measures along MD 24 were analyzed utilizing Synchro to determine their effectiveness in improving the level of service and delay at failing intersections and approaches. Signal interconnection, offset, cycle length and splits were also optimized in Synchro to improve operations along MD 24. Finally, high cost alternatives such as installing an additional mainline



through lane and side street turn and through lanes were analyzed. Synchro results showed that the TSM and TDM improvements and optimization would not produce acceptable levels of service. High cost improvements would be required to bring the study intersections and approaches up to an acceptable level of service.

E. Queue Analysis Summary

Review of the queueing tables located in Appendix I.D reveals that several of the intersection turning movements along the minor street approaches and the MD 924 and MD 24 mainlines exceed the available capacity. Although northbound and southbound MD 924 left-turn queues at East/West MacPhail Road exceed the available storage, it should be noted that the existing two-way left turn lane provides additional storage beyond the striped turn lanes.

Review of the queueing tables located in Appendix I.D also indicates the majority of the intersection queues along the minor street and MD 924 approaches would be reduced as a result of the proposed mitigation measures.

VI. PEDESTRIAN AND BICYCLE FACILITIES

A. Background and Studies

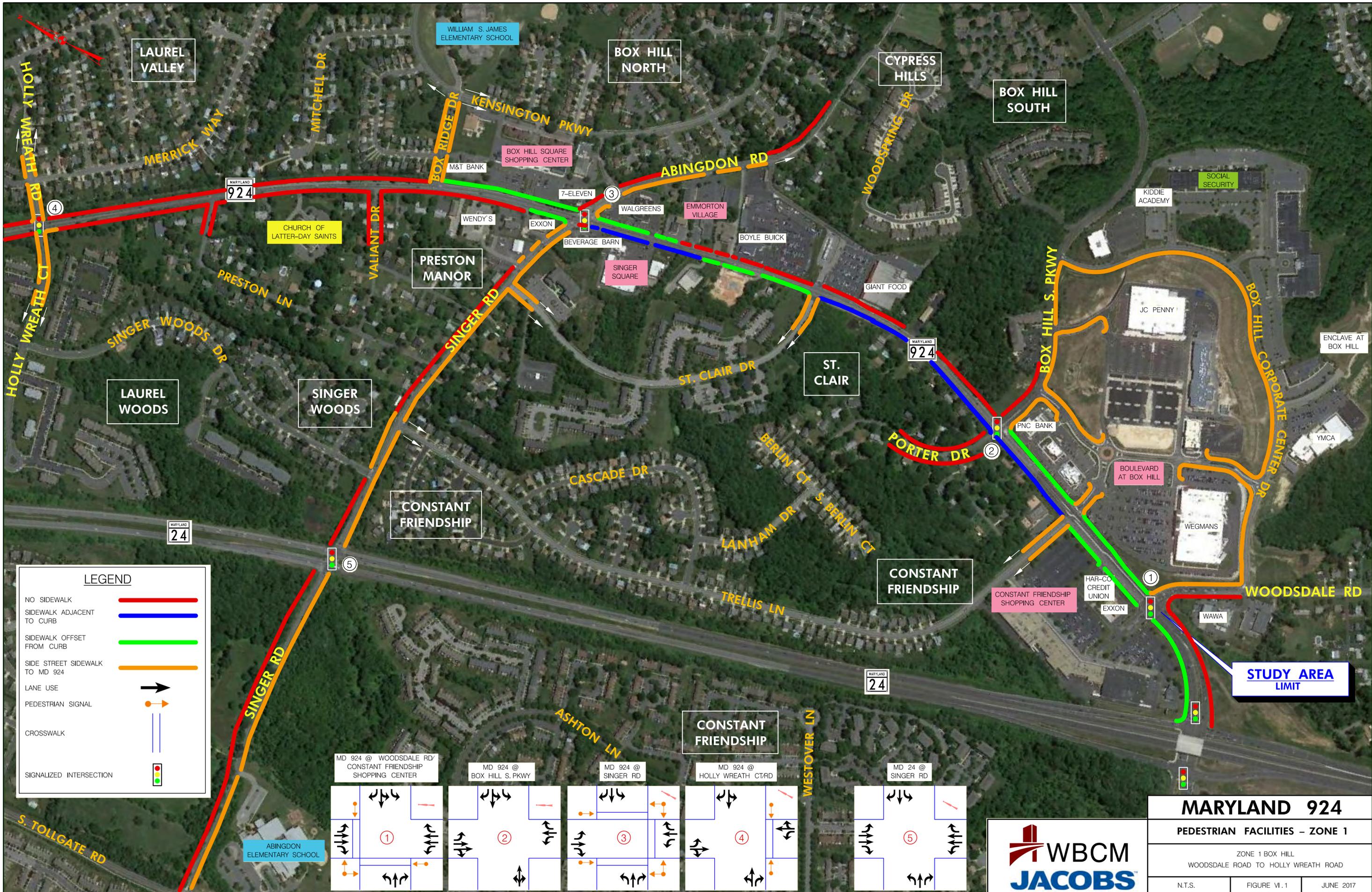
Recognizing the health and mobility benefits, Harford County has been very proactive with promoting non-motorized transportation options. Harford County conducted bike and pedestrian surveys in 2005 and 2010 and has a 2013 Bike and Pedestrian Master Plan. The MD 924 and MD 24 corridors are not on the SHA-approved bike route map; however, based on Harford County’s surveys, both routes have a significant latent demand. The survey results indicate that 42% of respondents would consider biking to work, and 60% would allow their children to walk/bike to school, if adequate infrastructure were provided. In addition, only about 13% of the respondents were aware of the Safe Routes To School (SRTS) program, and only 23% knew that Harford Transit Link’s buses accommodated bicycles. Comments specific to the MD 924 corridor were received regarding the need for bike parking and security at the Festival at Bel Air and the Boulevard at Box Hill at the southern project limits.

The Bicycle Level of Comfort (BLOC) identified in 2010 was a B for MD 924 and a C for MD 24. Based on the above average BLOC, the corridors are only a Tier 2 priority for upgrades. A study of the MD 924 corridor was included as part of the 2010 Transportation Elements Plan that provided recommendations to facilitate non-motorized transportation. Key pedestrian and bicycle links, such as along MacPhail Road, were identified in the 2013 Bike and Pedestrian Master Plan as areas for further study. Based on the previous studies, non-motorized transportation would be well received in the study area as long as safe routes are provided. In addition, connectivity between desired origins and destinations and bike accommodations would be required. Measures identified in the Master Plan included: installation of Share the Road signs; pedestrian upgrades at MD 924 at Wheel Road, Singer Road, and Bel Air South Parkway; and a review of a potential bike route along MacPhail Road from MD 924 to MD 24.



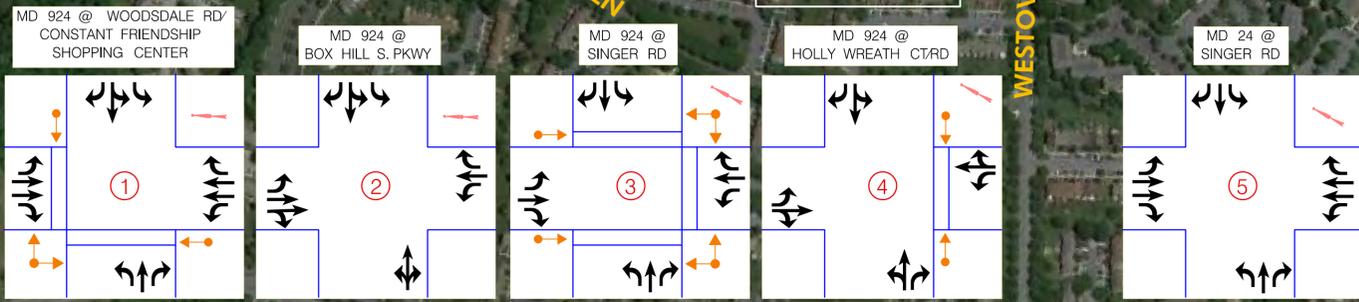
B. Pedestrian/Bicycle Features and Generators

An inventory of the sidewalks along the MD 924 corridor and intersecting streets was conducted. The results of the review are summarized in Figures VI.1 through VI.3 for each of the three analysis zones. Review of the exhibits reveals the discontinuity of sidewalks along the corridor. Neither Zone 1 nor Zone 2 have continuous sidewalks along MD 924 on the east or west side for the length of the Zone. Zone 3 has sidewalk to the east or west for the length of the zone. Sidewalks are available along at least one side of Singer Road, West Wheel Road, Bel Air South Parkway and Plumtree Road from MD 924 to the intersection with MD 24. Sidewalks extend from the intersection of MD 924 with East/West Ring Factory Road to within approximately 400 ft. of MD 24. The major pedestrian and bicycle trip generators are the retail areas along Bel Air South Parkway and Box Hill along with the schools served by MD 924.



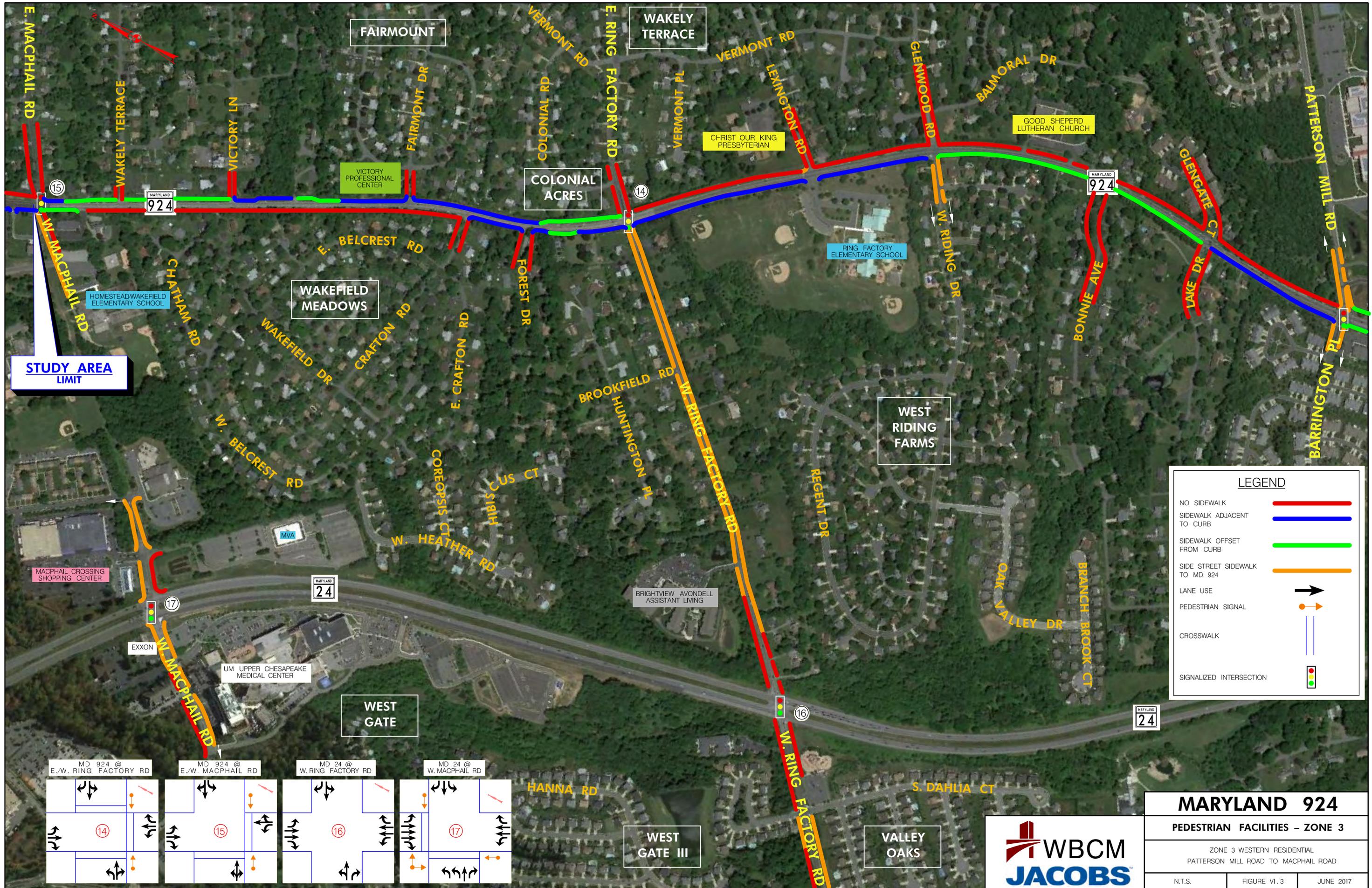
LEGEND

- NO SIDEWALK: Red line
- SIDEWALK ADJACENT TO CURB: Blue line
- SIDEWALK OFFSET FROM CURB: Green line
- SIDE STREET SIDEWALK TO MD 924: Orange line
- LANE USE: Black arrow
- PEDESTRIAN SIGNAL: Orange arrow with circle
- CROSSWALK: Blue double line
- SIGNALIZED INTERSECTION: Traffic light symbol

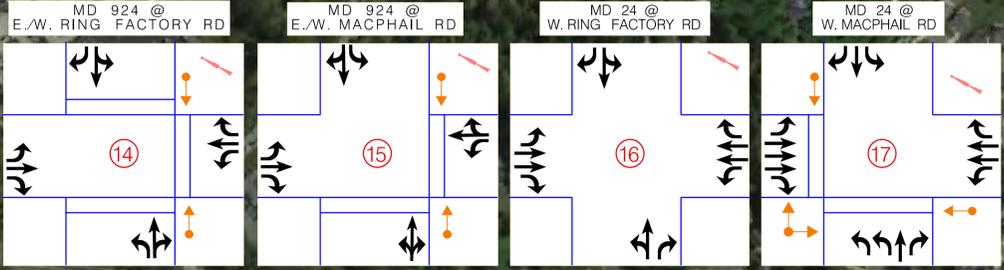


MARYLAND 924		
PEDESTRIAN FACILITIES – ZONE 1		
ZONE 1 BOX HILL WOODSDALE ROAD TO HOLLY WREATH ROAD		
N.T.S.	FIGURE VI.1	JUNE 2017

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LEGEND	
NO SIDEWALK	
SIDEWALK ADJACENT TO CURB	
SIDEWALK OFFSET FROM CURB	
SIDE STREET SIDEWALK TO MD 924	
LANE USE	
PEDESTRIAN SIGNAL	
CROSSWALK	
SIGNALIZED INTERSECTION	



MARYLAND 924		
PEDESTRIAN FACILITIES - ZONE 3		
ZONE 3 WESTERN RESIDENTIAL PATTERSON MILL ROAD TO MACPHAIL ROAD		
N.T.S.	FIGURE VI.3	JUNE 2017



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Pedestrian and bicycle facilities for the retail development include:

- **Box Hill:** Sidewalk is provided along MD 924 and within the commercial sites of The Boulevard at Box Hill to provide connectivity and facilitate pedestrian access. Pedestrian signals are not present at the MD 924/Box Hill South Parkway intersection; however, the intersection at Woodsdale Road has pedestrian push buttons and signals for crossing the north leg of the intersection. Existing roadways are not fully bicycle compatible with a lack of shoulders in the southern project limits.
- **Festival at Bel Air and the Shops at Bel Air South:** Sidewalks are provided along both sides of Laurel Bush Road and Bel Air South Parkway to serve commercial developments. Pedestrian signals, push buttons, crosswalks and ramps are available on each approach to the MD 924/Laurel Bush Road/Bel Air South Parkway intersection. The sidewalk network extends into the communities served by Laurel Bush Road. Shoulders are available for bicycles along MD 924 in the vicinity of the retail development. Laurel Bush Road and Bel Air South Parkway are not bicycle compatible. Wheel Road also serves the Festival at Bel Air and sidewalk is present on the north side adjacent to the retail development. Sidewalk is not provided along MD 924 to serve Wheel Road. Sidewalk is provided along the south side of Wheel Road east of MD 924. The intersection does not provide any crosswalks, ramps, or pedestrian signals. A cemetery on the north side of Wheel Road would prevent any sidewalk construction. A receiving sidewalk could be constructed in the northeast corner to then provide a crossing of MD 924 to the sidewalk serving the retail sites. Pedestrian signals, push buttons and crosswalks would be required at the MD 924/Wheel Road intersection.

Schools served by MD 924 and associated pedestrian and bicycle amenities include:

- **The Patterson Mill Middle and High School along Patterson Mill Road:** The schools are served by sidewalk along the west side of MD 924 to the north of the intersection and on the east and west side of MD 924 to the south of the intersection. A sidewalk is provided along both sides of Patterson Mill Road and Barrington Place along with a network of sidewalks within the communities to provide connectivity to the schools. Pedestrian signals, push buttons, crosswalks and ramps are provided on the north and west legs of the MD 924/Patterson Mill Road intersection; however, a crosswalk is not provided on the east leg of the intersection to access the south side sidewalk and the schools. MD 924 is not fully bicycle compatible to the north and south of Patterson Mill Road. Patterson Mill Road and Barrington Place are not bicycle compatible.
- **Ring Factory Elementary School:** The school is located on the west side of MD 924 opposite Lexington Road. Sidewalks are available along the west side of MD 924. No sidewalks are present along Lexington Road. A signed and marked crosswalk is present on the north leg of the intersection. Narrow shoulders are marked along MD 924 in the vicinity of the school. Lexington Road is unmarked and could be considered bicycle compatible.
- **Homestead/Wakefield Elementary School:** The school is located along West MacPhail Road on the west side of MD 924. Sidewalk is available along the east side of MD 924 to



the south of the intersection and the west side of MD 924 to the north of the intersection. Sidewalk is not present along East MacPhail Road. Shoulders have been marked along MD 924 for bicycle compatibility.

C. Pedestrian and Bicycle Demand

Two sources were employed to document pedestrian and bicycle demand in the study area. The first was the Strava Global Heat Map. The map provides a summary of routes taken by pedestrians (typically joggers) and bicyclists linked into GPS and Google accounts on their smart phones. The map records each route and the density of the data points indicates the greatest demand. The Strava information is available through the Harford County web site. Figure VI.4 and VI.5 provide screen shots from the Strava Heat map for the northern and southern halves of the study area. Review of Strava Heat Map figures reveals that pedestrian and bicycle demand is primarily recreational use not necessarily recorded during the data collection. The recorded demand for the use of the MD 924 corridor as a primary route along with the east-west roadways linking MD 924 with MD 24 and South Tollgate Road is evidenced by the red lines.

Figure VI.4

**Strava Heat Map - Pedestrian and Bicycle Demand Northern Section
MD 924 Multi-Modal Corridor Study**

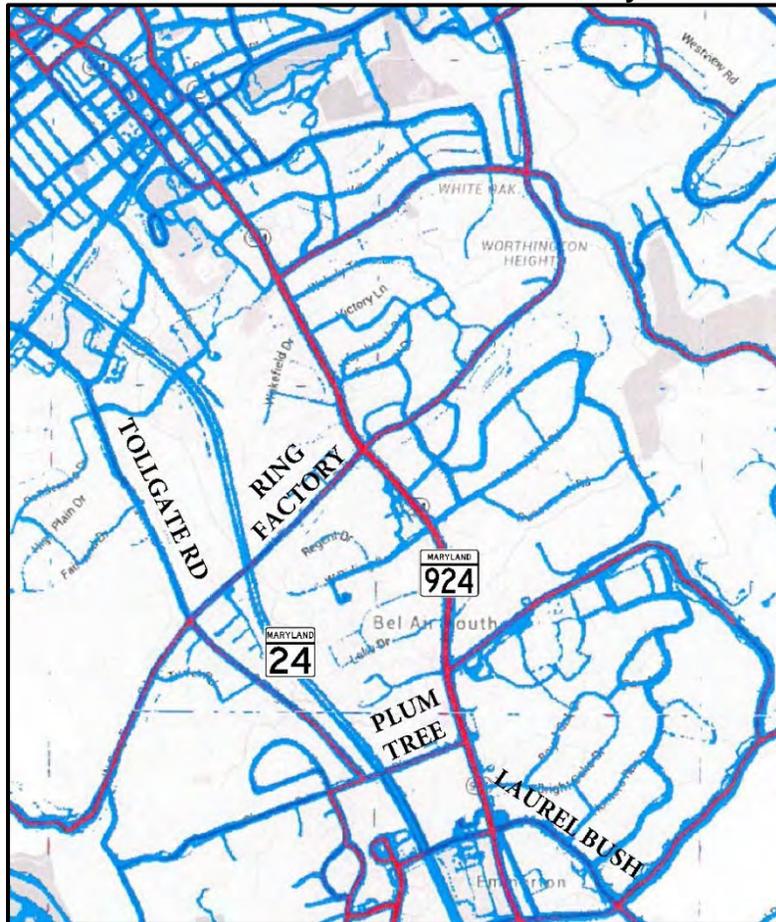
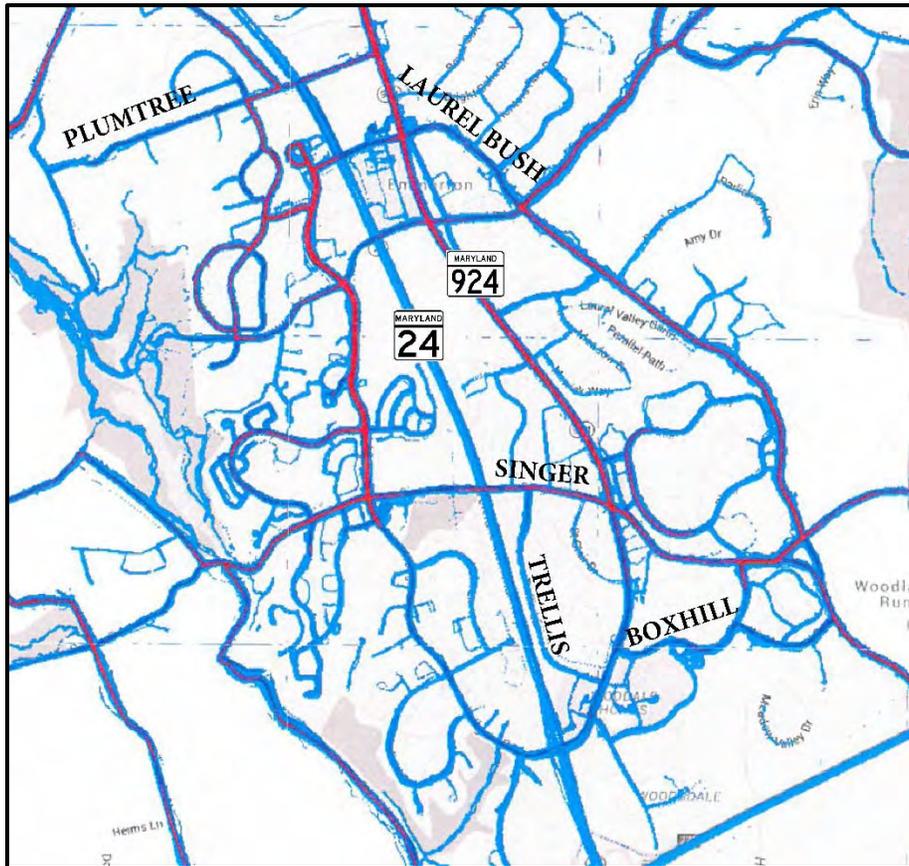




Figure VI.5

**Strava Heat Map - Pedestrian and Bicycle Demand Southern Section
MD 924 Multi-Modal Corridor Study**



In an effort to further quantify pedestrian and bicycle demand, pedestrian and bicycle traffic was recorded along with the traffic volume data. The counts were conducted on days with no rain so a representative count would be provided. The data is summarized, by Zone, in Tables VI.2, VI.3 and VI.4.



Table VI.2

**Pedestrian and Bicycle Volume Summary – Zone 1
MD 924 Multi-Modal Corridor Study**

Zone 1 – Daily School Children, Pedestrian and Bicycle Volumes					
Int. ID No.	Intersection	Leg	School Children	Pedestrian	Bicycle
01	MD 924 at Shopping Center/ Woodsdale Road	North	0	0	0
		South	3	0	0
		East	1	6	1
		West	0	0	1
02	MD 924 at Porter Drive/ Box Hill S. Parkway	North	0	0	0
		South	0	1	0
		East	0	0	0
		West	0	0	0
03	MD 924 at Singer Road/ Abingdon Road	North	0	0	0
		South	0	1	0
		East	0	0	0
		West	0	0	0
04	MD 924 at Holly Wreath Ct/ Holly Wreath Road	North	0	5	0
		South	0	19	0
		East	0	8	0
		West	0	6	0
05	MD 24 at Singer Road	North	0	0	0
		South	0	0	0
		East	0	0	0
		West	0	0	0

Review of Table VI.2 reveals that pedestrian activity is not significant. The exception is the crossing at Holly Wreath Road/Court. The catalyst for the demand is the bus stop located at MD 924 and Holly Wreath Court. Patrons park along Holly Wreath Road and utilize the bus stop on the south side of the intersection. The majority of patrons cross the south side of MD 924 from the bus stop to return to their vehicle in the evening. The low bicycle demand is most likely caused by the lack of bicycle-compatible shoulders for the full length of the Zone.



Table VI.3

**Pedestrian and Bicycle Volume Summary – Zone 2
MD 924 Multi-Modal Corridor Study**

Zone 2 – Daily School Children, Pedestrian and Bicycle Volumes					
Int. ID No.	Intersection	Leg	School Children	Pedestrian	Bicycle
06	MD 924 at Wheel Road	North	0 (0)	1 (5)	1 (0)
		South	0 (0)	1 (14)	0 (0)
		East	0 (0)	0 (5)	0 (1)
		West	0 (0)	0 (5)	2 (2)
07	MD 924 at Bel Air S. Parkway/ Laurel Bush Road	North	0 (0)	16 (2)	0 (1)
		South	0 (0)	37 (11)	0 (2)
		East	0 (0)	32 (4)	0 (1)
		West	0 (0)	13 (1)	0 (0)
08	MD 924 at Bright Oaks Drive	North	0	1	0
		South	0	2	0
		East	0	54	3
		West	0	0	4
09	MD 924 at Plumtree Road/ Medstar Boulevard	North	0 (0)	1 (1)	0 (2)
		South	0 (0)	0 (6)	0 (0)
		East	2 (0)	1 (15)	3 (0)
		West	0 (0)	0 (3)	0 (4)
10	MD 924 at Barrington Place/ Patterson Mill Road	North	0	0	2
		South	6	13	0
		East	0	6	3
		West	13	8	4
11	MD 24 at Wheel Road	North	0	6	0
		South	0	0	0
		East	0	2	0
		West	0	1	0
12	MD 24 at Bel Air S. Parkway	North	0	1	0
		South	3	43	2
		East	0	4	0
		West	2	10	1
13	MD 24 at Plumtree Road	North	0	0	2
		South	0	0	0
		East	0	0	0
		West	0	0	6

X (X) Weekday Totals (Saturday Totals)

The data in Table VI.3 illustrates the demand from the residential areas to the east of MD 924 and the Festival at Bel Air and other commercial sites to the west. Significant demand was recorded from the residential areas west of MD 24 crossing to Bel Air South Parkway. Commercial development borders both sides of Bel Air South Parkway generating the high demand.



Residential-to-commercial demand is also seen at Wheel Road and Plumtree Road. Of note is that pedestrians cross the south leg of the MD 924/Barrington Place/Patterson Mill Road intersection serving the school site along Patterson Mill Road despite the crosswalk and pedestrian indications being located on the north leg of the intersection. The low bicycle demand is most likely caused by the lack of bicycle compatible shoulders for the full length of the Zone.

Table VI.4

**Pedestrian and Bicycle Volume Summary – Zone 3
MD 924 Multi-Modal Corridor Study**

Zone 3 – Daily School Children, Pedestrian and Bicycle Volumes					
Int. ID No.	Intersection	Leg	School Children	Pedestrian	Bicycle
14	MD 924 at Ring Factory Road	North	0	1	0
		South	0	1	0
		East	0	0	0
		West	1	0	0
15	MD 924 at W. MacPhail Road/ E. MacPhail Road	North	3	25	4
		South	8	4	0
		East	2	6	1
		West	2	3	5
16	MD 24 at W. Ring Factory Road	North	0	0	0
		South	0	1	0
		East	0	1	0
		West	0	0	0
17	MD 24 at W. MacPhail Road	North	6	9	8
		South	0	0	0
		East	0	0	0
		West	1	0	1

Schools are the major generator of pedestrian traffic in Zone 3 as illustrated in Table VI.4. The intersection of MD 924 and East/West MacPhail Road serves a school site and significant pedestrian activity was noted crossing from the school on the west to the residential areas to the east. The low bicycle demand throughout the Zone is most likely caused by the lack of bicycle compatible shoulders for the full length of the Zone.



VII. ROAD SAFETY AUDIT AND WALKABILITY AUDIT

A. Overview

The best way to determine how safe a facility might be is to go out in the field and walk it. The same is true for assessing how inviting an area is for pedestrian and bicycle traffic. Road Safety Audits (RSA) are performed to identify potential hazards along the roadway that could impact safety. Typically, the RSA is done based on a set of plans; however, field reviews can also be conducted. The RSA focuses on roadway elements (sight distance, alignment, shoulders, obstructions in clear zone, drainage, driveway access, etc.), traffic control devices (signing, pavement markings, signals), lighting and transit stops. The data is summarized in checklist format to facilitate standardization of responses and to clearly define the review elements. The reviews included both intersections and mid-block segments. Similar to the RSA, the Walkability Audit (WA) is based on a series of checklist items related to how well pedestrians and bicyclists can negotiate an area. The WA includes elements such as path accessibility or obstructions, ease of crossing the street, pedestrian amenities (benches, shelters, etc.), appropriate warning signing, signals, driver behavior towards pedestrians and bicyclists, and identification of major generators. The WA is based on definitive roadway elements; however, the audit includes a subjective element relating to the pedestrian or bicyclists' comfort level using the corridor. A RSA was conducted concurrently with the WA along MD 924. The audits were conducted by members of the WBCM/Jacobs Joint Venture, Harford County Planning and Harford County Department of Public Works.

B. Road Safety Audit

The crash data did not reveal any major safety issues along the corridor. The RSA did not reveal any major corridor-wide safety deficiencies. Appendix I.E provides samples of the inventory sheets, a photo log of identified issues and a summary of proposed signing upgrades. The general results of the RSA are summarized below:

- All crosswalk and stop line markings should be refreshed throughout Zone 2 and 3 and south of St. Clair Drive in Zone 1.
- By law, all access driveways to major shopping centers and businesses must have pavement markings and signing that conform to the Maryland Manual on Uniform Traffic Control Devices (MDMUTCD). Most of the access drives have pavement markings of the wrong color or missing/faded signs.
- Guardrail should be considered along northbound MD 924 at the Truth House Ministry Church driveway about 750 feet north of Box Hill South Parkway due to the existing drainage structures.
- Install advanced signal ahead warning sign with a street name plaque and near side pedestal mounted signal head for northbound traffic at Woodsdale Road.
- Revise advanced street name signs to provide upper and lower case lettering.
- Install lane-use control signs where missing at signalized intersections.
- Install “End School Zone” and “Fines Double” signs to delineate the school zone adjacent to Ring Factory Elementary School.



C. Walkability Audit

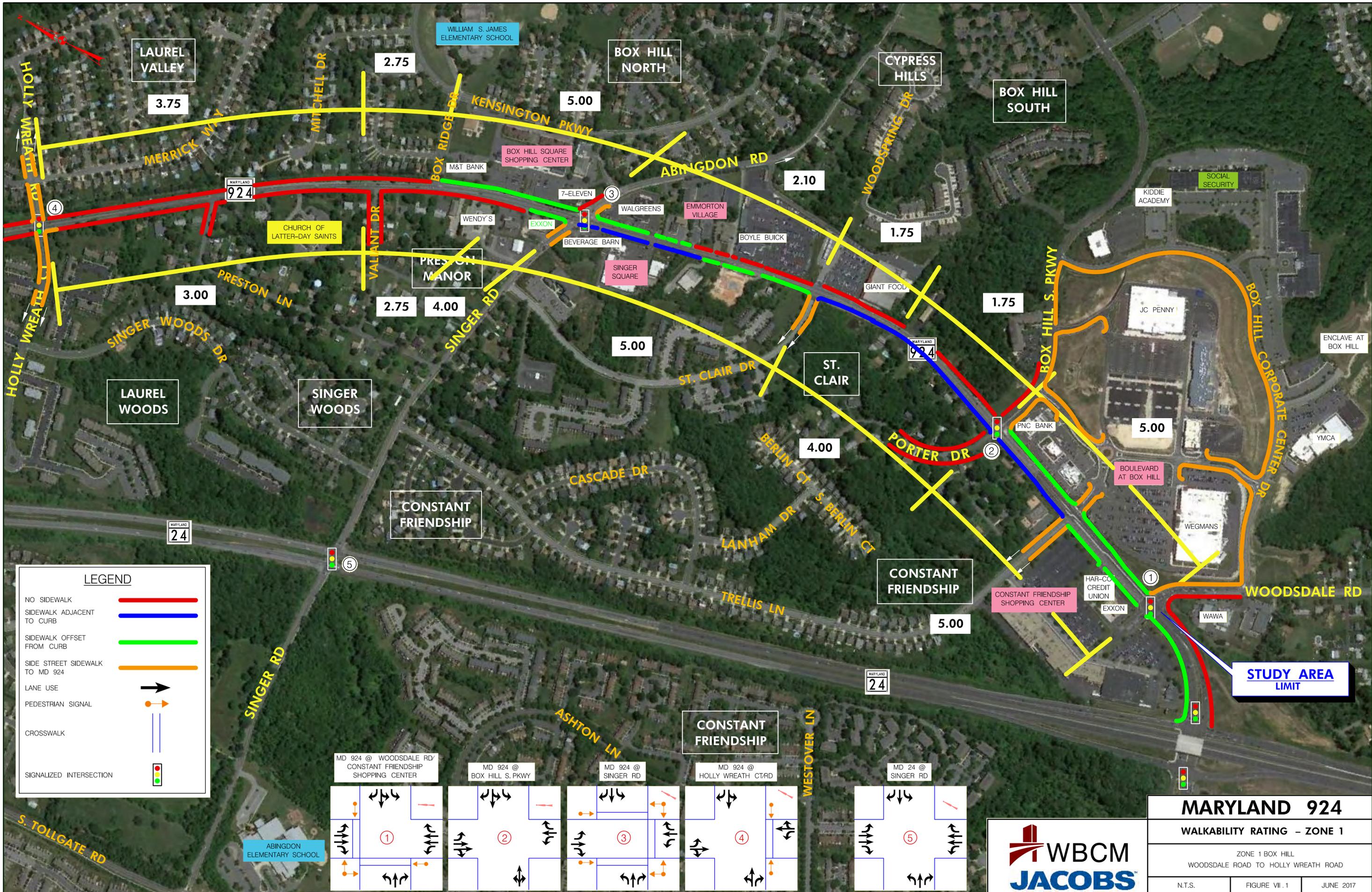
The Walkability Audit revealed that sections of MD 924 without sidewalk were still walkable based on the presence of wide shoulders. The photo log, sample field sheet, and suggested signing upgrades are provided in Appendix I.E. Major factors identified from the walk include:

- Sidewalks, in general, did not have any utility poles or signs providing obstacles.
- Many of the older sidewalks are experiencing weed growth in the construction joints.
- Most of the intersections in the northern portion of the study area do not have ADA compliant ramps.
- Several intersections lack Accessible Pedestrian Signals (APS), Countdown Pedestrian Signals (CPS) and crosswalks.
- Many of the older existing sidewalk widths north of Ring Factory Road are less than the required 5 feet to meet ADA requirements.
- In areas north of Bright Oaks Drive, the existing sidewalk is experiencing major base failures adjacent to inlets.
- A more direct diagonal route could be provided from Bel Air South Parkway to the sidewalk north of Laurel Bush Road.
- Connectivity is provided along the entire MD 924 corridor with either sidewalk on one side of the road or wide shoulders. The only exception is in Zone 1 from the end of the sidewalk north of Porter Drive to the start of the sidewalk south of Abingdon Road.
- Bike lane availability is limited to the two lane section between Holly Wreath Road and East/West Wheel Road.
- Shoulders have been marked along MD 924; however, some of the shoulders are less than 5 feet wide and are not bicycle compatible.
- None of the roadways linking MD 924 with MD 24 are bicycle compatible.

In an effort to pinpoint areas of focus, a Walkability Score ranging from 1 (poor walkability) to 5 (good walkability) was given to sections of MD 924. The scores were based on availability of sidewalk or wide shoulders, sidewalk width, sidewalk offset from roadway, ADA compliance, and sidewalk condition. Figures VII.1, VII.2 and VII.3 provide a summary of the Walkability Scores for each Zone. The requirements for each score is provided below:

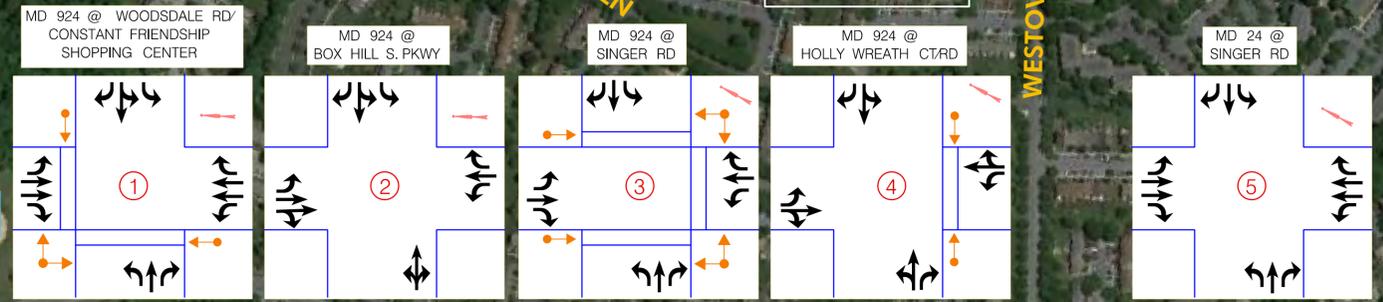
- **Rating of 5:** Sidewalk is 5 feet wide and in good condition with no upheavals or weeds and set back from the roadway thus reducing noise, improving safety, and making the walk more inviting. If the offset is only a few feet, the sidewalk is damaged or less than 5 feet the score was reduced to between 4 and 5.
- **Rating of 4:** Sidewalk adjacent to curb and in good condition.
- **Rating of 3:** No sidewalk, but wide shoulders that allow pedestrian to walk well removed from the travel way.
- **Rating of 2:** Narrow shoulders, but a relatively level grass area to walk.
- **Rating of 1:** Narrow shoulders, and no level grass area behind the curb (typically drainage ditches or embankments).

In some cases, sections were scored between whole numbers due to meeting some, but not all, of the characteristics for a given category.



LEGEND

- NO SIDEWALK: Red line
- SIDEWALK ADJACENT TO CURB: Blue line
- SIDEWALK OFFSET FROM CURB: Green line
- SIDE STREET SIDEWALK TO MD 924: Orange line
- LANE USE: Arrow symbol
- PEDESTRIAN SIGNAL: Signal symbol
- CROSSWALK: Double line symbol
- SIGNALIZED INTERSECTION: Traffic light symbol



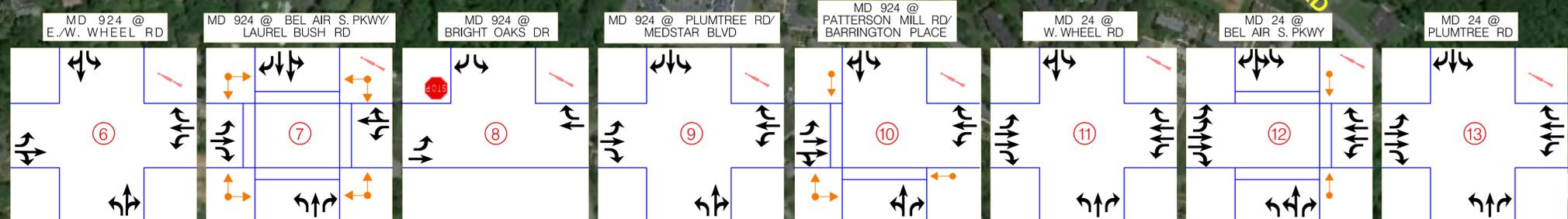
MARYLAND 924		
WALKABILITY RATING - ZONE 1		
ZONE 1 BOX HILL WOODSDALE ROAD TO HOLLY WREATH ROAD		
N.T.S.	FIGURE VII.1	JUNE 2017

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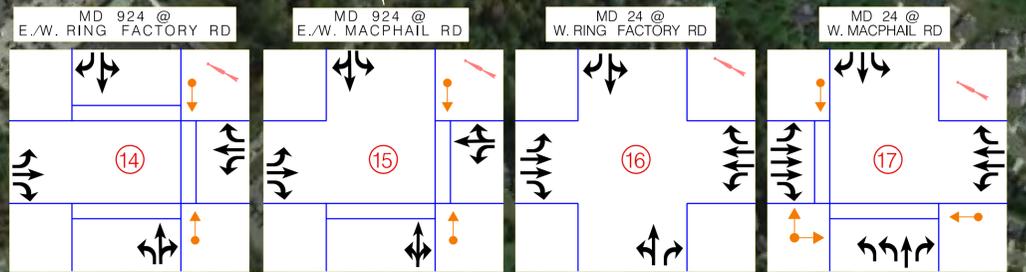
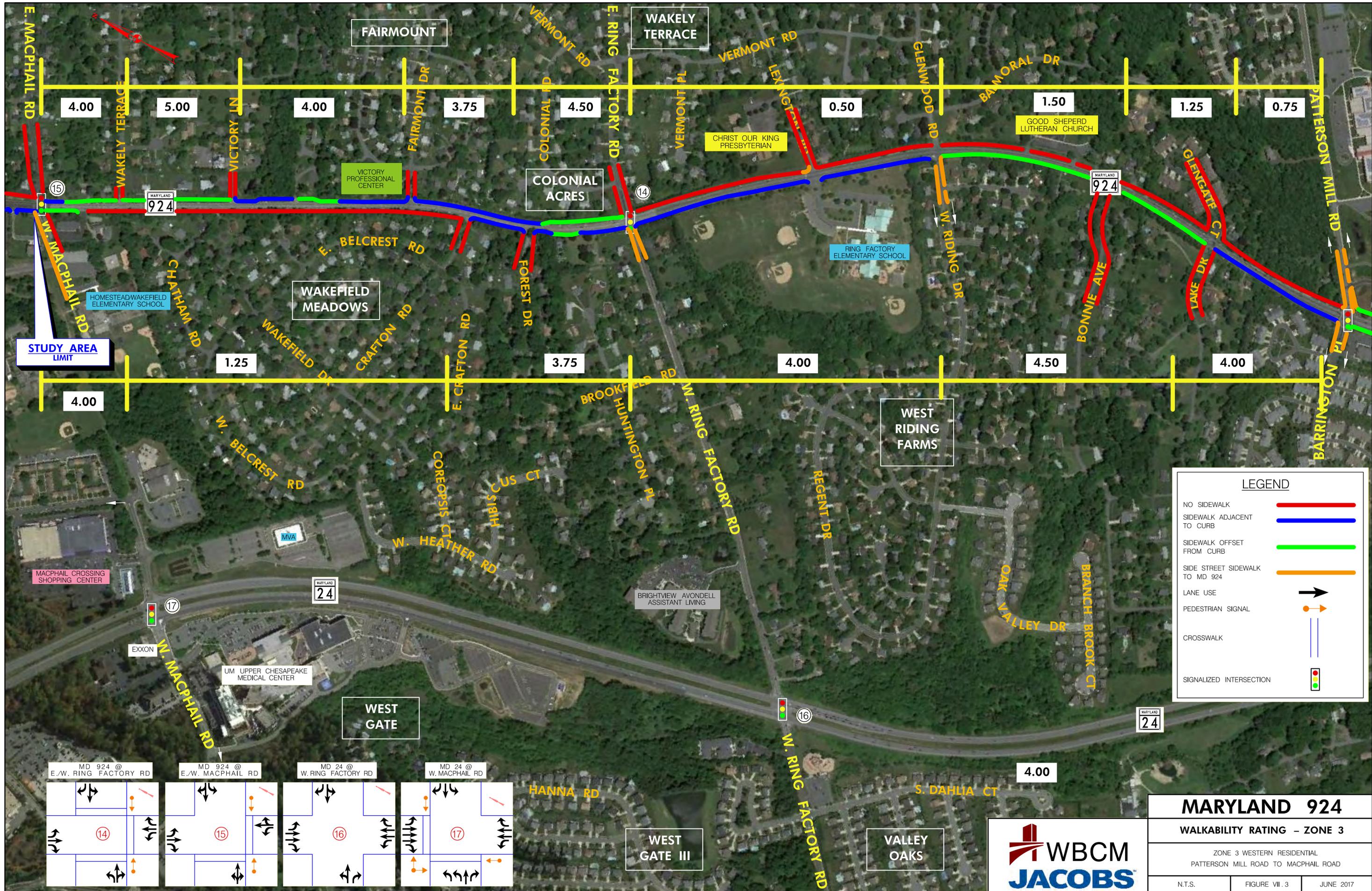
LEGEND

- NO SIDEWALK: Red line
- SIDEWALK ADJACENT TO CURB: Blue line
- SIDEWALK OFFSET FROM CURB: Green line
- SIDE STREET SIDEWALK TO MD 924: Orange line
- LANE USE: Black arrow
- PEDESTRIAN SIGNAL: Orange arrow with circle
- CROSSWALK: Blue double line
- SIGNALIZED INTERSECTION: Traffic light symbol



MARYLAND 924		
WALKABILITY RATING - ZONE 2		
ZONE 2 CENTRAL COMMERCIAL HOLLY WREATH ROAD TO PATTERSON MILL ROAD		
N.T.S.	FIGURE VII. 2	JUNE 2017

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MARYLAND 924

WALKABILITY RATING - ZONE 3

ZONE 3 WESTERN RESIDENTIAL
PATTERSON MILL ROAD TO MACPHAIL ROAD

N.T.S. FIGURE VII. 3 JUNE 2017





VIII. SAFETY REVIEW

A. Background

Crash data was received from the Maryland State Highway Administration (SHA) for the study area. The data includes the most recent three year period – January 1, 2012 through December 31, 2014 and is provided in Appendix I.F. The information provided by the SHA only covers those crashes reported to the police. Crash data includes intersection and midblock crashes along MD 924 and crash data for the key intersections along MD 24. The data includes crash type, date and time of the crash, number of injuries or fatalities, weather, pavement surface condition, lighting condition, and condition of the vehicle operator. The audits were conducted by members of the WBCM/Jacobs Joint Venture, Harford County Planning and Harford County Department of Public Works. The RSA included a review of the roadway and clear zones to determine if potential hazards exist. The signing along the corridor was also reviewed to determine if additional or revised signing was warranted. Lighting was reviewed at night as part of the RSA to determine if luminance levels appeared acceptable.

B. Crash Summary

The results of the data for the given three year study period are summarized as follows:

- A total of 212 crashes occurred in the MD 924 study area with 95 intersection-related and 117 midblock crashes.
- A total of 69 crashes occurred at the key intersections along MD 24.
- None of the study intersections were considered a high crash intersection – crash rates above statewide averages for similar intersections.
- One pedestrian crash was reported along MD 924.
- One bicycle crash was reported along MD 924.
- The percentage of night time crashes along MD 924 (24%) was below the statewide average (31%).
- The percentage of wet pavement crashes along MD 924 (15%) was below the statewide average (21%).
- The percentage of alcohol related crashes along MD 924 (2%) was below the statewide average (8%).
- Passenger cars, motorcycles, SUVs and pickup trucks accounted for 86% of the vehicles involved in the crashes along MD 924.

Predominant crash patterns are summarized in Table VIII.1 for the MD 924 Study Area corridor. As shown, the predominant crash patterns are rear end and left turn, both of which have crash rates significantly higher than the statewide average for similar facilities.



Table VIII.1

**MD 924 Corridor Crash Summary
MD 924 Multi-Modal Corridor Study**

CRASH TYPE	NUMBER OF CRASHES		INTERSECTION RELATED		MIDBLOCK	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
Opposite Dir.	1	<1%	0	0%	1	100%
Rear End	87	41%	26	30%	61	70%
Sideswipe	14	7%	8	57%	6	43%
Left Turn	35	16%	26	77%	9	23%
Angle	38	18%	27	71%	11	29%
Pedestrian	2	1%	1	50%	1	50%
Parked Vehicle	4	2%	1	25%	3	75%
Fixed Object	17	8%	0	0%	17	93%
Other Collision	14	7%	1	7%	13	93%
Total	212	100%	90	42%	122	58%

C. Data Analysis

1. Intersection Crashes

- The number of crashes at each study intersection is summarized in Table VIII.2. Review of the table reveals that none of the study intersections along MD 924 experienced a significant number of crashes. Conspicuity of traffic control devices appears adequate due to the low number of intersection crashes. Although the number of crashes were low, the collision diagrams were reviewed to verify that a dominant crash pattern was not present and that lighting or wet weather were not major contributing factors. The only two intersections along MD 924 with a noteworthy crash history were at Woodsdale Road and Singer Road/Abingdon Road. Only one intersection along MD 24 experienced more than five non-alcohol related crashes in 2014 – W. Ring Factory Road. In addition, at the MD 24/Singer Road intersection, 11 of the 20 reported crashes occurred at night.



Table VIII.2

**Intersection Crash Summary
MD 924 Multi-Modal Corridor Study**

Int. ID No.	INTERSECTION	NUMBER OF CRASHES			
		2012	2013	2014	TOTAL
ZONE 1					
01	MD 924 @ Constant Friendship Shopping Center/Woodsdale Road	4	4	5	13
02	MD 924 @ Porter Drive/Box Hill S. Parkway	2	0	3	5
03	MD 924 @ Singer Road/Abingdon Road	5	4	3	12
04	MD 924 @ Holly Wreath Court/Holly Wreath Road	2	2	1	5
05	MD 24 @ Singer Road	3	9	8	20
ZONE 2					
06	MD 924 @ Wheel Road	2	3	0	5
07	MD 924 @ Bel Air S. Parkway/Laurel Bush Road	2	2	2	6
08	MD 924 @ Bright Oaks Drive	0	1	1	2
09	MD 924 @ Plumtree Road/Medstar Boulevard	3	2	4	9
10	MD 924 @ Barrington Place/Patterson Mill Road	1	1	0	2
11	MD 24 @ Wheel Road	3	6	5	14
12	MD 24 @ Bel Air S. Parkway	4	2	5	11
13	MD 24 @ Plumtree Road	2	3	3	8
ZONE 3					
14	MD 924 @ Ring Factory Road	1	1	2	4
15	MD 924 @ W. MacPhail Road/E. MacPhail Road	1	2	1	4
16	MD 24 @ W. Ring Factory Road	1	4	8	13
17	MD 24 @ W. MacPhail Road	0	1	2	3

- The intersection of MD 924 at Woodsdale Road had five reported crashes in 2014. The crashes included two rear-end impacts and two left-turn crashes, all involving northbound through vehicles. Four of the five crashes occurred on wet pavement. The left turn movements along MD 924 operate



in Exclusive/Permissive phasing (i.e. left turns are permitted to proceed on a flashing red arrow after stop) and near side signal heads are provided. Although along a curve, the signal heads are visible from the upstream intersection at MD 24 and MD 924. With only four crashes and no other midblock wet weather crashes in the vicinity of the intersection, a review of skid resistance does not appear warranted. Precipitation could contribute to obscuring of the signals and the signal indications; a review of available 2015 data should be conducted. Subject to the recent crash trends, an advanced signal warning sign with a street name plaque could be installed along northbound MD 924 and an additional near-side pedestal mounted signal head installed for the northbound MD 924 right-turn movement with a protected right turn phase overlap to improve conspicuity through the horizontal curve.

- The intersection of MD 924 and Singer Road/Abingdon Road has seven reported crashes in 2012 and 2013 involving a northbound left turn vehicle and a southbound through vehicle. The four crashes in 2012 occurred at night. The traffic signal at the intersection was reconstructed to include upgraded lighting in 2013. The crash pattern was not present in 2014. The signal upgrade appears to have addressed the crash history.
- The intersection of MD 24 at Singer Road had 11 reported crashes that occurred at night. Further review of the data reveals that four of the nighttime crashes involved an impaired driver. Seven of the night crashes occurred in 2013 with only one non-alcohol related nighttime crash occurring in 2014. Upgrades to the intersection performed by the SHA appear to have addressed the crash history.
- The intersection of MD 24 at W. Ring Factory Road experienced eight crashes in 2014. A predominant crash pattern was not present. The existing span wire mounted traffic signal is currently under reconstruction to be replaced with a mast arm signal.

2. Corridor Crashes

- Pavement condition appears adequate due to the low number of wet weather crashes.
- Rear-end crashes accounted for 53% of the total reported crashes northbound. Northbound traffic congestion in the evening peak period could be a major contributing factor to the crash experience. Of the 58 rear-end crashes reported along northbound MD 924, 50% occurred during the evening peak period. Evening peak period rear-end crashes were especially prevalent along northbound MD 924 between Valiant Drive and Holly Wreath Road with seven reported crashes, five of which were during the evening peak period. North of Wheel Road, 66% of the reported northbound crashes were rear end and 45% occurred during the evening peak period.
- The predominant southbound crashes were left turn at 21%, angle at 21% and rear end at 28%. The remaining 30% of the crashes included side



swipe, fixed object, and “other.” The southbound crashes did not have a predominant peak time period.

- Angle or left-turn crashes were not prevalent in the two-lane section of MD 924 between Box Ridge Road and Wheel Road. Although a two-way left turn lane is not provided, sufficient shoulder width is available to bypass a left-turning vehicle.

3. Safety Lighting

Safety lighting corridor-wide appears adequate due to the low number of night time crashes; therefore, a formal lighting study with light meters to measure exact luminance levels was not conducted. However, to determine qualitative lighting levels and driver comfort at night, a subjective field review was conducted at night when the moon was only in the first quarter. The field review indicated that none of the lighting along the corridor has been upgraded to the new SHA standard of LED fixtures. Lighting is only present at intersecting streets, continuous lighting at midblock segments is not provided. The lack of continuous lighting creates dark paths, discouraging any nighttime pedestrian or bicycle activity. Several of the fixtures at key intersections were not operational. Generally, luminance levels appeared appropriate along the corridor; however, the lighting at the signalized intersections appeared lower than expected. In many cases, only a single luminaire was provided at the signalized intersection, which rendered half of the intersection shadowed. Luminance levels were lower in Zone 3 due to the residential character of the study area and the concerns with light trespass into homes. Although nighttime crashes were below statewide averages for similar roadways, the crash data was reviewed in greater detail to determine the presence of crash clusters that occurred at night. Based on the detailed review, several minor hot spots were noted:

- Approximately 250 feet south of Abingdon Road/Singer Road, along southbound MD 924, four nighttime crashes occurred – all in 2012 and all involving vehicles turning left from SB MD 924. The traffic signal at the intersection was reconstructed in December of 2012 and included improved lighting. The new lighting appears to have addressed the crash history; the crash pattern did not reoccur after 2012.
- Two crashes occurred at night along southbound MD 924 at St. Mary’s Church Road, both of which were rear-end type collisions. Although lighting is present at the intersection, only one fixture is provided and the lighting arm only extends to the shoulder. Consideration could be given to replacing the existing fixture with an LED fixture on a longer lighting arm.
- All four reported crashes along northbound MD 924 from south of Glenwood Road to Lexington Road, occurred at night. Field reviews indicate that lighting was provided and the luminance levels appeared adequate.



IX. TRANSIT OPERATIONS

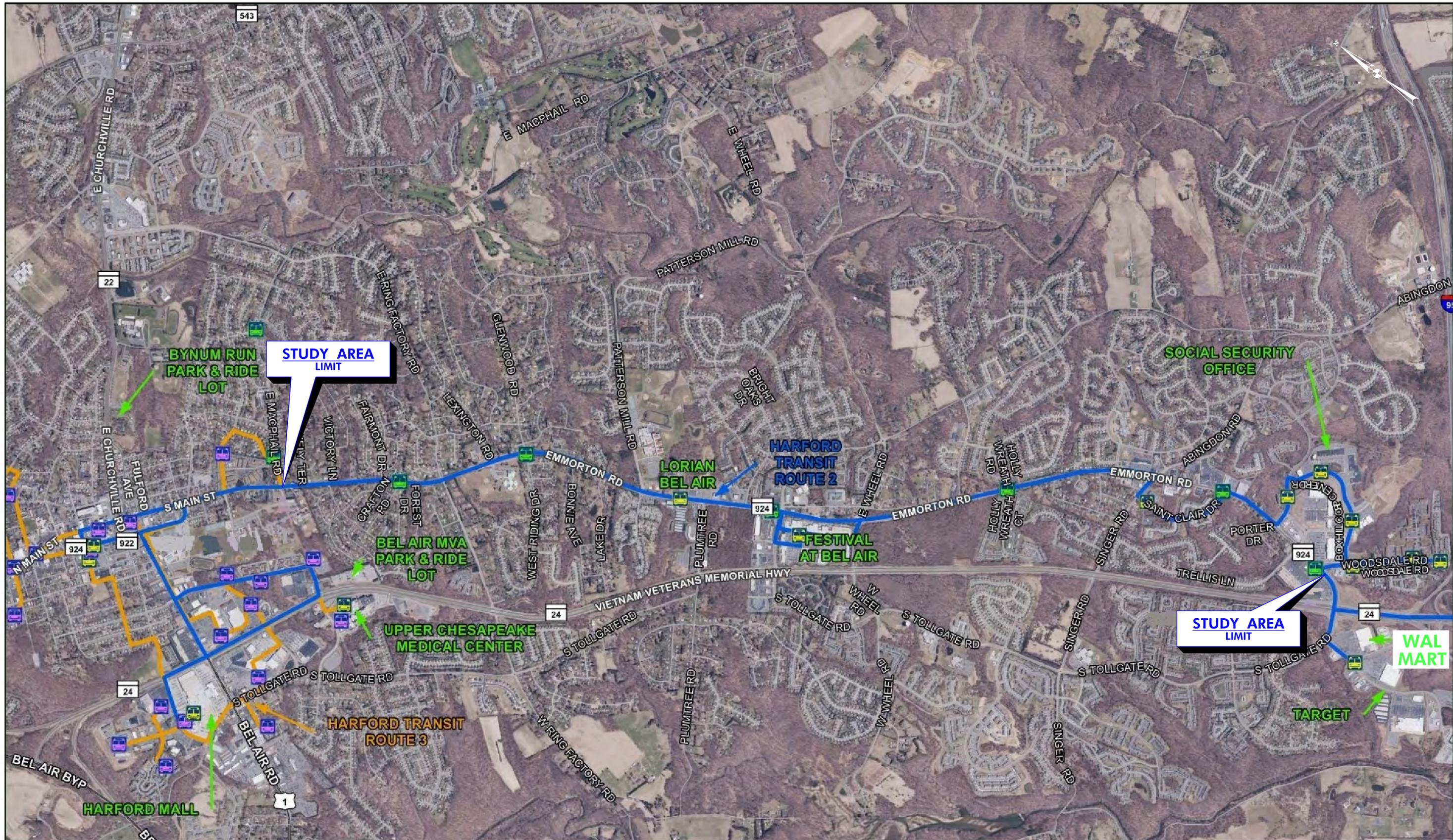
A. Overview

The 4.7 mile MD 924 corridor from Woodsdale Road to MacPhail Road consists primarily of low-density residential and commercial developments with some intermittent open space and unimproved parcels. The infrastructure that supports walking, biking, and transit use along the corridor is sporadic. Several schools, medical facilities, and linear retail centers are present that are potential destinations for residents along the corridor. As shown in Figure IX.1, one local bus route and one commuter bus route directly serve the MD 924 project corridor. Figures IX.2 through IX.4 provide a detailed diagram of each bus route by analysis Zone.

B. Harford Transit LINK

Harford Transit local bus Route 2/2A (Blue Line) is the only bus that serves the entire length of the MD 924 corridor. Northbound Route 2/2A buses terminate in downtown Bel Air and southbound buses terminate in Joppa. Route 2/2A stops at several discount stores, medical facilities, and public service agency locations. With several stops at assisted/senior living communities, Route 2/2A is designed to provide stop locations at destinations needed by the elderly and transit dependent. A Park & Ride lot along Route 2/2A is situated on MD 24 between I-95 and Philadelphia Road (MD 7). Route 2/2A has many stop locations; however, few local bus stops are located in areas of higher population density such as near Idlewild Road, Bright Oaks Road, and Holly Wreath Road. Historical ridership data shows that stops were previously provided and extremely low ridership resulted in the stops being removed.

Local bus Route 2/2A has no shared stop locations with the MTA Commuter Bus 410. None of the Route 2/2A bus stops within the MD 924 corridor include basic bus infrastructure amenities. Features such as benches, shelters, maps, and schedules would especially benefit the elderly and disabled riders that use Route 2/2A. For additional information about each bus stop within the study area, see Table IX.1. In addition to missing transit infrastructure, the long bus headways from 53 to 90 minutes make transit more unattractive to potential users. See Appendix I.G for the published Route 2/2A schedule and map. Based on site visits to the MD 924 corridor in 2015, the published map is found to be erroneous at multiple locations, which further discourages transit use.



Existing Bus Stops

-  Route 2/2A
-  410 MTA Commuter Bus
-  Route 3

MARYLAND 924

EXISTING TRANSIT MAP

FULL STUDY AREA

N.T.S. FIGURE IX .1 JUNE 2017



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ON STREET
PATRON
PARKING

BOULEVARD AT
BOX HILL

CONSTANT FRIENDSHIP
SHOPPING CENTER

Existing Bus Stops

- Route 2/2A 410 MTA Commuter Bus
- Route 3



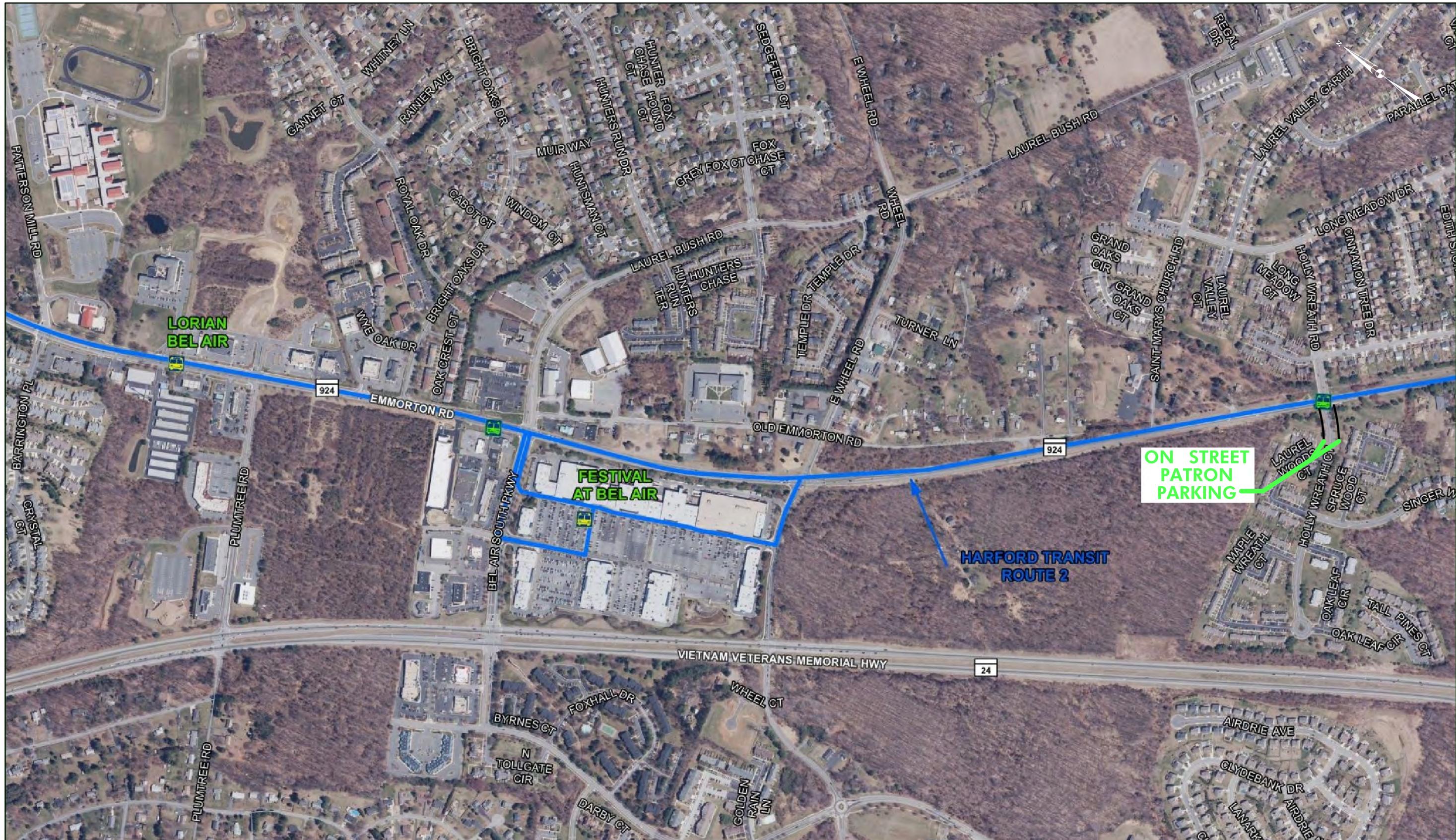
MARYLAND 924

EXISTING TRANSIT MAP

ZONE 1 BOX HILL
WOODSDALE ROAD TO HOLLY WREAH ROAD

N.T.S. FIGURE IX .2 JUNE 2017

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Existing Bus Stops

-  Route 2/A
-  410 MTA Commuter Bus
-  Route 3

MARYLAND 924

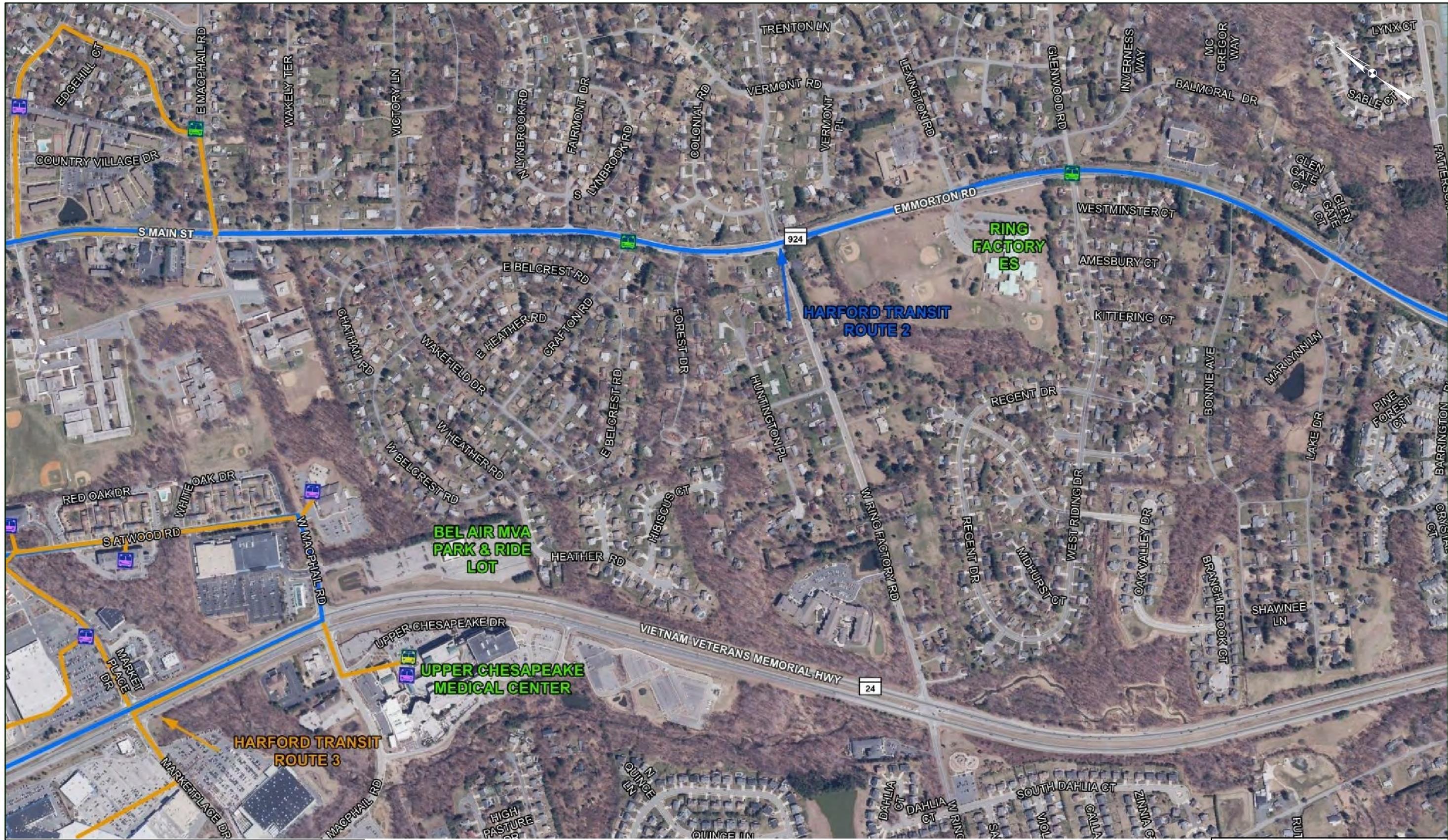
EXISTING TRANSIT MAP

ZONE 2 COMMERCIAL
HOLLY WREATH ROAD TO PATTERSON MILL ROAD

N.T.S. FIGURE IX .3 JUNE 2017



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Existing Bus Stops

-  Route 2/2A  410 MTA Commuter Bus
-  Route 3



MARYLAND 924

EXISTING TRANSIT MAP

ZONE 3 WESTERN RESIDENTIAL
PATTERSON MILL ROAD TO MACPHAIL ROAD

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Table IX.1

**Bus Stop Characteristics
MD 924 Multi-Modal Corridor Study**

Bus 2/2A Stops	Turn or Travel Lane	Boarding Access Area	Sign	Sidewalk	Crosswalk
Lorien at Bel Air SB	Travel	Grass	Yes	Yes	No
Lorien at Bel Air NB	Turn	Grass	Yes	Yes	No
Festival at Bel Air - ShopRite	Travel	Sidewalk	No	Yes	No
Abingdon Catholic Charities SB	Travel	Grass	Yes	Yes	No
Abingdon Catholic Charities NB	Travel	Grass	Yes	Yes	No
Park View - Abingdon SB	Travel	Grass	Yes	Yes	No
Park View - Abingdon NB	Travel	Grass	Yes	Yes	No
Social Security Office SB	Travel	Grass	Yes	Yes	No
Social Security Office NB	Travel	Grass	Yes	No	No
YMCA - Abingdon SB	Travel	Grass	Yes	Yes	No
YMCA - Abingdon NB	Travel	Grass	Yes	No	No
Wawa Food Market SB	Turn	Grass	Yes	Yes	Yes
Wawa Food Market NB	Travel	Grass	Yes	Yes	Yes
Woodsdale Senior Housing	Travel	Sidewalk	Yes	No	No
Woodsdale Apts	Travel	Road shoulder	Yes	No	No

Bus Route 2/2A service begins each weekday at 6:30 AM and ends at 6:30 PM. No weekend transit service is available on Route 2/2A or any other Harford County Link bus route. Unlike the MTA commuter buses, the local bus Route 2/2A has midday trips on weekdays. Based on observations in 2011, less than 50% of northbound buses were running on time. However, the 2011 observations found that over 80% of southbound buses from Bel Air were on time. Corridor congestion is especially acute along northbound MD 924 – a potential cause of the poor on-time performance.

The average daily ridership of Route 2/2A in 2011 was 177. Less than 20% of total Route 2/2A riders begin or end within the MD 924 project corridor. The bus stop at the Shop Rite store in the Festival at Bel Air has the largest average ridership with 14 daily boardings. The low daily ridership within the corridor is in part due to a combination of no bus stop infrastructure, extensive wait times, and lower concentrations of potential transit users within the corridor.

Outside the project’s MD 924 corridor, Route 2/2A has transfer stops in Bel Air that connect with local Harford County Routes 1 (Green Line) and 3 (Orange Line) at Harford Mall and at the State Office Building. Route 2/2A has one transfer stop south of I-95 at the Edgewater Village Center/Walgreens that connects with the MTA Commuter Bus 420 and local Harford County Routes 5 (Red Line) and 6 (Purple Line). The Edgewater Village Center is the only bus stop on Route 2/2A that is shared with MTA Commuter Bus 420 and is one of the few stops that has a bench and shelter.



C. Maryland Transit Administration

1. Commuter Bus Service

Although three MTA commuter buses serve Harford County during weekday morning and evening rush hours, only Route 410 includes bus stops along the MD 924 corridor from downtown Bel Air to I-95. No MTA commuter buses provide weekend service. Commuter Bus 410 has seven bus stops along MD 924, with five weekday morning trips to downtown Baltimore and five return trips in the evenings. The southbound buses depart every 20 minutes from Harford County. The earliest commuter bus arrives to the corridor (E. MacPhail Road & Edgehill Drive) at 6:15 AM and the last bus arrives at 7:35 AM. The first afternoon northbound commuter bus arrives to the corridor (MD 924 at Woodsdale Road) at 4:54 PM and the last bus arrives at 6:25 PM.

Approximately 165 people used the Commuter Bus 410 service each weekday morning in 2015, of which approximately 113 boarded in the MD 924 corridor. Most passengers are boarding at the south end of the MD 924 corridor, such as at Holly Wreath Court, St. Clair Drive, and Woodsdale Road. The stop at St. Clair Drive has the most ridership, typically serving 45 riders each weekday morning.

The seven commuter bus stops along MD 924 do not include designated Park & Ride lots and many bus stops do not have crosswalks to provide safer access. Since most stops are not easily accessed by foot, many riders park their car near the bus stop. Similar to Route 2/2A, most Route 410 commuter bus stops in the MD 924 corridor have no supporting transit infrastructure or posted maps/timetables. See Table IX.2 for additional information about each commuter bus stop in the corridor.

Table IX.2

**Commuter Bus 410 Stop Characteristics
MD 924 Multi-Modal Corridor Study**

Bus 410 Stops	Turn or Travel Lane	Boarding Access Area	NB Sign	Bench	Shelter	Sidewalk	Crosswalk
E. MacPhail Rd. & Edgehill Dr.	Travel	Grass	Yes	No	No	SB Yes, NB No	No
Emmorton Rd. & Crafton Rd.	Travel	Sidewalk	Yes	No	No	Yes	No
Emmorton Rd. & West Riding Dr.	Travel	Grass	No	No	No	Yes	No
Emmorton Rd. & Belair South Pkwy.	SB Turn, NB Travel	Grass	Yes	No	No	No	Yes
Emmorton Rd. & Holly Wreath Ct.	Travel	SB Sidewalk, NB Grass	Yes	Yes	Yes	Yes	Yes
Emmorton Rd. & St. Clair Dr.	Turn	SB Sidewalk, NB Grass	Yes	No	No	Yes	No
Emmorton Rd. & Woodsdale Rd.	SB Turn, NB Travel	SB Grass, NB Sidewalk	Yes	No	No	Yes	Yes

2. MARC Train Service

The Penn Line of the MARC commuter rail network runs from Perryville in Cecil County, through Harford County to Baltimore, BWI Airport, and Washington, DC. The Edgewood MARC Station is only four miles from the MD 924 corridor; however, no direct local bus routes connect the corridor to the station. Seven northbound and seven southbound train trips stop at Edgewood Station each weekday. An average of 293 passengers board MARC trains at Edgewood Station each weekday.



Aberdeen Station is ten miles from the MD 924 corridor and serves MARC and AMTRAK train passengers. An average of 196 riders board at Aberdeen on weekdays. The Aberdeen Station is a transit destination for residents in the corridor who want to travel northward on AMTRAK towards New York City. Transit users need access to a car to get to the station because this station is not easily accessible from MD 924 via the existing Harford County Link bus routes.

No weekend MARC train service is provided in Harford County; however, MARC does serve Martin State Airport Station in Baltimore County on Saturdays and Sundays. Martin State Airport Station is approximately 15 miles from the MD 924 corridor, and includes a Park & Ride lot. Three northbound and southbound trains serve the station each Saturday and two southbound and two northbound trains stop at the Martin State Airport Station each Sunday. For residents of the corridor that have access to a car, driving to the Martin State Airport Station is a viable option for day trips to Washington, DC or other intermediate stations, such as BWI Airport.

No direct local bus routes connect the MD 924 corridor with Edgewood or Aberdeen Stations. For residents of the MD 924 corridor, the fastest transit route from home to the Edgewood MARC station would require taking Route 2/2A to the Edgewater Village Center transfer stop, changing to local bus Route 5 (Red Line) to go to the Nuttal Avenue stop, which is a quarter of a mile from the Edgewood MARC station. Since the local bus Routes 2 and 5 run infrequently and do not have coordinated stop times at Edgewater Village Center, traveling to BWI Airport and Washington, DC via public transit is time prohibitive.

D. AMTRAK

AMTRAK does not serve the Edgewood train station; however, it does serve the Aberdeen train station that is located ten miles from the MD 924 corridor. Northeast Regional trains serve Aberdeen Station seven days a week with direct connections to Washington, DC and New York City. On weekdays, six southbound and six northbound trains stop at Aberdeen Station throughout the day. Five southbound and five northbound trains serve the station on Saturdays. Four southbound and four northbound trains serve the station on Sundays.

E. Park & Ride Lots

No Park & Ride lots exist within the MD 924 corridor from MacPhail Road to Woodsdale Road. However, at the six commuter bus stops along MD 924, daily riders often park their cars on nearby residential streets. The commuter bus stops are served by the MTA Commuter Bus Route 410. Several bus stops at the southern end of the alignment in Abingdon have more than 20 daily riders, so the parked cars occupy long segments of residential streets creating informal Park & Ride lots. St. Clair Road has the most bus commuters and the largest number of parked cars. Holly Wreath Court also serves as a de-facto Park & Ride.

Twelve Park & Ride lots are available in Harford County that are maintained by the State Highway Administration (SHA). Six of the SHA Park & Ride lots are within five miles of the MD 924 project corridor and provide a total of 815 parking spaces. Most of the parking spaces are south of the MD 924 corridor near I-95 and are located at the interchanges with MD 24, MD 152, and MD 543.



1. I-95 @ MD 152 (Joppa)

The largest Park & Ride lot in the County is at the interchange of I-95 and MD 152 with 309 available parking spaces. No commuter or local buses serve the MD 152 Park & Ride near I-95. Normal parking occupancy is 75%, one of the highest rates in the County.

2. I-95 @ MD 24 (Emmorton)

The Park & Ride lot along MD 24 near I-95 has 75 parking spaces. The MD 24 Park & Ride lot is served by the Harford County Link local bus route 2/2A. Ten northbound buses stop at the MD 24 Park & Ride each weekday from 6:45 AM to 5:43 PM. Less than 10 average daily boardings were recorded at the stop. The lot has the highest parking occupancy rate in the County at 77%.

3. I-95 @ MD 543 (Belcamp)

The Belcamp Park & Ride lot at MD 543 is served by the MTA Commuter Bus Route 420 for commuters to Baltimore City. Five southbound buses stop at the Belcamp Park & Ride from 5:43 AM to 7:23 AM on weekdays. Five northbound buses stop at this lot from 4:41 PM to 6:31 PM, plus an additional northbound bus on Fridays at 2:04 PM. The Park & Ride lot at MD 543 is one of the least used in the County with an average occupancy of less than 30% of the 133 spaces.

4. MD 152 @ MD 147 (Fallston)

Approximately five miles west of the MD 924 project corridor is the large Fallston Park & Ride lot near the intersection of MD 152 and MD 147. The lot is served by the MTA Commuter Bus 411 and has 35% occupancy rate for 15 spaces. The southbound buses on Bus Route 411 stop at the lot five times each weekday between 5:40 AM and 7:23 AM. Northbound buses from Baltimore City arrive to the lot from 4:35 PM to 6:43 PM on weekdays.

5. US 1 @ MD 24 (Marywood)

The Marywood Park & Ride lot near US 1 and MD 24 is approximately three miles north of the MD 924 corridor. The lot averages over 70% occupancy with a total of 70 parking spaces. The MTA Commuter Bus Route 411 stops at the lot several times each weekday from 5:30 AM to 7:13 AM, and from 4:42 PM to 6:50 PM.

6. MD 22 @ Bynum Park

The SHA leases the lot at Bynum Park on MD 22. It is the closest Park & Ride lot to the north end of the MD 924 corridor and to downtown Bel Air. It has 75 spaces available with an average occupancy rate of less than 5%. No local or commuter buses services the lot.

F. Bel Air MVA

In addition to the Park & Ride lots maintained by SHA, a lot is provided along MD 24 at the Bel Air MVA on West MacPhail Rd. The lot has 109 parking spaces with less than 10% average parking occupancy. No local or commuter buses serve the lot.



MD 924 Multi-Modal Corridor Study

Volume I – Existing Conditions



June 2017
