Final

Main Street (VA 42) Corridor Study

Bridgewater, VA

October 2017

Prepared For:

Harrisonburg Rockingham Metropolitan Planning Organization

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Executive Summary

The Main Street (VA 42) Corridor Study was conducted by the Harrisonburg Rockingham Metropolitan Planning Organization (HRMPO), the Virginia Department of Transportation (VDOT) Staunton District, and the Town of Bridgewater to evaluate existing conditions and identify improvement strategies to reduce congestion along the Main Street corridor. Another goal of this study was to evaluate multimodal safety and accessibility. The corridor experiences recurring congestion associated with major employers (Marshalls Distribution Center and Perdue plant), student arrival and dismissal at the two schools located on the corridor (John W. Wayland Elementary School and Turner Ashby High School), and general commuting traffic. Congestion is more significant in the afternoon, which is attributed to the simultaneous dismissal of the two schools and the shift change at the Marshalls Distribution Center during the 3:00 PM hour. Heavy vehicles also present challenges to corridor operations, particularly associated with wide turning maneuvers that conflict with through traffic along the corridor.

Prior to developing recommendations, a thorough evaluation of existing conditions was conducted to include:

- Peak period field observations
- Assessment of corridor infrastructure
- Crash analysis
- Operational analysis

From the crash analysis, it was determined that the predominant crash type along the corridor is rear end collisions with the highest occurrence being within the quarter-mile segment between Mt. Crawford Avenue and Old River Road. Angle collisions accounted for the second most common crash type. Among the recorded crashes, none involved pedestrians or bicyclists.

The results of the operational analysis, which considered the PM peak hour of 3:00 PM to 4:00 PM, indicate the greatest delay for vehicular movements is at Old River Road, Oakwood Drive, and Turner Ashby Drive, primarily among side street and mainline turning movements. This is consistent with the results of the field observations completed in May 2017. An evaluation of travel times along the corridor demonstrate that the space mean speed is below the posted speed limit of 30 mph, ranging from 17 to 19 mph during the PM peak.

Based on the results of the existing conditions evaluation, improvement were identified. High-level recommendations were made considering the assessment of existing corridor infrastructure. Pavement marking, vehicular and pedestrian traffic signal, and sidewalk ramp improvements were identified at a several locations along the corridor to enhance safety and improve conditions for vehicles, bicyclists, and pedestrians. In addition, five corridor improvement strategies were evaluated, including the following:

1. Main Street lane reassignments at Oakwood Drive

2. Marshalls site access modifications
3. Signal phasing changes at Dinkel Avenue
4. Oakwood Drive truck route
5. Coordinated signal operations along Main Street

Based on the traffic analysis and opinion of probable cost (where applicable), three of the corridor improvement strategies were found to provide a benefit to corridor operations and are recommended to be carried forward to implementation. The high level benefits of these three strategies include:

- **Marshalls site access modifications** – by shifting outbound trips to Old River Road during shift changes, there is a nominal increase in delay at this intersection with a significant reduction in delay at Oakwood Drive. Minimal infrastructure improvements would be necessary to implement this modification. The analysis assumed the construction of the signal at Old River Road, which is already planned in the next two years.
- **Signal phasing changes at Dinkel Avenue** – changing side street operations to permissive left-turn phasing reduces overall intersection delay by nearly 10 seconds. The only modification required to implement this recommendation would be the replacement of the four-section signal displays on the side street approaches; thus, little investment is required to realize an operational benefit.
- **Coordinated signal operations along Main Street** – by implementing coordinated signal timings along the corridor, drivers would experience shorter travel times, reduced delays, and lower fuel consumption. Aside from installing equipment at each signal to enhance controller operations and developing and refining signal timings, no other improvements or expenses would be necessary.

The Main Street lane reassignments, which provided an additional lane on the northbound approach to the intersection at Oakwood Drive, was found to provide little improvement in intersection operations. Given the cost and negligible change in delay, this improvement is not recommended for implementation. However, the Town may want to reevaluate the benefit of the lane reassignment should a budgeted traffic signal replacement occur at this intersection in the future.

The Oakwood Drive truck route scenario was intended to reduce truck traffic along Main Street that is currently using Dinkel Avenue travelling to and from points to the east (e.g. I-81, Route 11). A review of traffic data determined that a very low volume of trucks that currently use Dinkel Avenue could potentially be rerouted to Oakwood Drive. Considering long-term planning efforts to extend Oakwood Drive and connect with the eastern terminus of Turner Ashby Drive, a revised approach was considered. An analysis of intersection operations at the Oakwood Drive and Turner Ashby Drive intersections was completed accounting for the proposed Oakwood Drive Extension. The results indicate an equal but opposite change in delay at these two intersections. With a low volume of estimated diversion trips, there is not a strong case to be made for accelerating this capital infrastructure project.

It is recommended that the Town consider implementing the three corridor improvement strategies outlined above in addition to spot, small-scale infrastructure improvements along the corridor. These small-scale infrastructure improvements are noted in **Table E1.**

Table E1: Summary of Infrastructure Improvements

Study Intersection	Upgrade Sidewalk Ramps	Install or Replace Crosswalk Markings	Install or Replace Stop Bar Markings	Install Compliant Pedestrian Signal(s)	Install LED Traffic Signals
Turner Ashby Drive	Yes	No	No	Yes	Yes
Oakwood Drive	Yes	Yes	Yes	Yes	Yes
Dylan Circle / Old River Road	Yes	Yes	Yes	-	-
Depot Street	Yes	Yes	Yes	-	-
Quality Street	Yes	Yes	Yes	-	-
North River Road	Yes	Yes	Yes	-	-
Mt. Crawford Avenue	No	No	No	No	No
Virginia Avenue	Yes	Yes	Yes	-	-
Green Street	Yes	Yes	Yes	-	-
Dinkel Avenue	Yes	No	Yes	Yes	Yes
High Street	Yes	Yes	Yes	-	-
Broad Street	Yes	Yes	Yes	-	-
College Street	Yes	Yes	Yes	Yes	Yes
Bank Street	Yes	Yes	Yes	-	-

These intersection improvements enhance the safety of operations for all travel modes. Pavement markings designate stopping locations for vehicles and crossing areas for pedestrian access, countdown pedestrian signals clearly define the time remaining for a pedestrian to move through the intersection, and LED traffic signals provide a brighter indication to drivers and have a longer service, requiring less maintenance.

Some of the improvements could be implemented in a short period of time, such as the signal phasing changes at Dinkel Avenue. Others may require the identification of funding and engineering before implementation can occur. In addition, coordination with Marshalls would need to occur before the site access modifications could be implemented. This modification would also require the signal to be installed at Old River Road. Below is an overall summary of the recommendations and a general timeframe for implementation:

Short-Term (3 to 6 months)

- Identify funding for recommended improvements
- Begin coordination with Marshalls
- Signal phasing change at Dinkel Avenue
- Stop bar adjustments at Dinkel Avenue
- Left-turn signal phasing adjustments at Mt. Crawford Avenue (Flashing Yellow Arrow as recommended by VDOT)

Mid-Term (6 to 18 months)

- Supplemental signal and pavement marking adjustments at Dinkel Avenue
- Coordinated signal operations along Main Street
- Sidewalk, curb ramp, pavement marking, and vehicular and pedestrian signal head improvements along the corridor (see **Table 8**)

Long-Term (18+ months)

- Signal installation at Old River Road (to be done by others)
- Marshalls Site Access Modifications
- Signal replacement at Oakwood

1. Study Area Background

Purpose of Study

The HRMPO partnered with the Virginia Department of Transportation (VDOT) Staunton District and the Town of Bridgewater to evaluate existing conditions and identify improvement strategies to reduce congestion along the Main Street corridor. Another goal of this study was to evaluate multimodal safety and accessibility. The study area consists of approximately 1.75 miles of Main Street from Turner Ashby Drive to Bank Street. This study was accomplished through field observations and an analysis of existing conditions, crash data, and roadway conditions. The analysis considered intersection operations at 11 locations along the corridor.

The Main Street corridor experiences heavy traffic during the PM peak hour. Shift changes at the Marshalls Distribution Center and Perdue plant combined with the dismissal of John W. Wayland Elementary School and Turner Ashby High School result in daily afternoon congestion along much of the corridor. There is also an above average percentage of heavy vehicles traveling along the corridor throughout the day, which reduces the efficiency of corridor operations. These vehicles tend to operate more slowly than passenger vehicles and require more time to execute turning maneuvers and begin moving from a stopped condition.

This document is organized to include key components and outcomes of the Study, including the following:

- Study Area Background
- Existing Traffic Operational Conditions
- Short-Term Corridor Improvements
- Conclusions and Recommendations (to be completed at a later date)

Study Area Roadway Network (VA 42)

Main Street (VA 42/257) is a two-lane roadway that generally runs north to south in the Town of Bridgewater, Virginia. It is classified as a minor arterial south of Dinkel Avenue and a principal arterial north of Dinkel Avenue. The speed limit along the approximately 1.75-mile roadway within the study area varies between 30 mph and 45 mph as the roadway transitions between urban, industrial, and rural land uses. In 2015, Main Street daily traffic volumes averaged between 8,600 and 14,700 vehicles per day, according to VDOT published count data.

Main Street serves both local and regional traffic, including the Town of Dayton and the City of Harrisonburg to the northeast. It also serves a significant volume of heavy vehicle traffic, including school buses, farm vehicles, delivery trucks, and tractor trailers supporting the local warehouse operations. There are a significant number of driveways on both sides of Main Street from Bank Street to Turner Ashby Drive, with an average of 5 breaks in access per block, and an average distance of 95 feet between access points.

Lane widths vary, and the shoulder treatment transitions between a curb and gutter section to sections of curb-only. At the southern section of Main Street, from Bank Street to College Street, additional pavement is available beyond the single travel lane in each direction. A limited section of two-hour parking is provided on both sides of Main Street in this area from 8:00 AM to 6:00 PM. **Figure 1** illustrates a segment of Main Street in the southbound direction past College Street where additional pavement width is provided for on-street parking.

Figure 1: Two-Lane Segment of Main Street (additional pavement for parking in both directions)

Between College Street to Green Street, Main Street continues as a two-lane roadway with no on-street parking permitted. This section of the corridor consists of primarily commercial businesses, and is slightly narrower than the southernmost section. From Green Street heading north along the corridor to Oakwood Drive, Main Street continues as a two-lane roadway with a two-way left-turn lane running down the center of the roadway. **Figure 2** shows the center turning lane along this segment of the corridor. Traveling north along the remainder of the corridor from Oakwood Drive to Turner Ashby Drive, the corridor transitions to a four-lane rural highway.

Figure 2: Center Turn Lane along Main Street

As previously mentioned, the speed limit varies between 30 mph and 45 mph. The speed limit is 30 mph from Bank Street at the southern part of the corridor to just north of the intersection of Main Street and Oakwood Drive. North of this intersection to the end of the corridor, the speed limit is 45 mph. The speed limit within of the northern area of the corridor is reduced to 35 mph during school hours through the use of flashing beacons located approximately 500 feet south and 1,100 feet north of the signalized intersection of Main Street and Turner Ashby Drive. **Figure 3** illustrates the northbound approach to the school zone for John W. Wayland Elementary School and Turner Ashby High School at the northernmost section of the corridor.

Figure 3: Divided Highway segment of Main Street Approaching School Zone

Main Street serves as the primary north-south thoroughfare for the Town of Bridgewater. Several locally significant roadways tie into the study corridor including:

- **Dinkel Avenue**: two-lane, undivided principal arterial with a posted speed limit of 25 mph and an average daily traffic volume of 9,300 vehicles per day that serves Bridgewater College to the east of Main Street
- **Mt. Crawford Avenue**: two-lane, undivided major collector with a posted speed limit of 30 mph and an average daily traffic volume of 2,200 vehicles per day
- **North River Road**: two-lane, undivided major collector with a posted speed limit of 30 mph and an average daily traffic volume of 2,200 vehicles per day
- **Oakwood Drive**: two-lane, undivided major collector with a posted speed limit of 30 mph and an average daily traffic volume of 3,900 vehicles per day

Figure 4 summarizes the limits of the study area network, location of the study intersections, intersection geometry, and intersection control. As illustrated, Main Street is the only continuous north-south travel way through the Town of Bridgewater. A handful of streets run parallel to Main Street (i.e. Grove Street, Liberty Street, Chesapeake Avenue; however, these roadways are relatively short and have stop control at most cross streets. North of Old River Road, there are no parallel roadway facilities. The disjointed network of surrounding roadways limits the opportunity to divert traffic away from Main Street in an attempt to reduce congestion.

Appendix F, Access Management Design Standards for Entrances and Intersections, of the VDOT *Road Design Manual*, contains standards for the design of intersections, turning lanes, and entrances as well as the spacing of entrances, intersections, and traffic signals. These standards apply to all state highways maintained by VDOT. Table 2-2 of this document provides a summary of minimum spacing standards for entrances, intersections, and median crossovers. The minimum spacing requirement is 440 feet between any two full access entrances along a principal arterial with a posted speed limit of 30 mph or less. That distance increases to 565 feet at speeds between 35 and 45 mph. Spacing requirements increase based on the type of access, with the greatest spacing requirements applied to signalized intersections. That distance is 1,050 feet for a posted speed of 30 mph or less and 1,320 feet for a posted speed between 35 and 45 mph.

Based on the description of existing conditions along the corridor, current driveway spacing violates VDOT access management standards. Although this applies to the design of new facilities, consolidation of access points is a recommended approach to meeting these standards for existing facilities. Since many of the commercial properties along Main Street only have one point of access, principally from Main Street, opportunities for access management strategies will be limited. Should redevelopment of frontage properties occur, it is recommended that access management strategies be evaluated and implemented.

Legend

Intersection ID Symbol
- Signalized
- Unsignalized

Intersection Control
- Traffic Signal
- Stop Controlled Approach

- Limits of Corridor Study
- Lane Assignment

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Lane Designations and Traffic Control

Main Street (VA 42) Corridor Study

Figure 4

Pedestrian and Bicycle Facilities

Main Street has sidewalk along the length of the corridor on the east and west side of the roadway. However, there is no buffer area for the following segments:

- Mt. Crawford Avenue to Bank Street along the west side of the corridor
- Oakwood Drive to Dylan Circle and roughly ninety feet north of Depot Street to Bank Street along the east side of the corridor

A buffer area primarily functions as a safety barrier, protecting pedestrians from potential out-of-control vehicles. It also provides an opportunity for landscaping and an area to locate underground utilities, overhead utility poles, and signs outside the pedestrian walkway. **Figure 5** illustrates existing pedestrian facilities. There are marked crosswalks at every signalized intersection. In addition, there are crosswalk signal pushbuttons at Mt. Crawford Avenue, Dinkel Avenue, and College Street. Each signalized intersection has a north-south as well as an east-west marked crosswalk. The unsignalized intersection at Dylan Circle has a marked crosswalk, but the stop bar is located beyond the marked crosswalk (see **Figure 6**).

Currently, there are no marked bicycle facilities along the Main Street corridor.

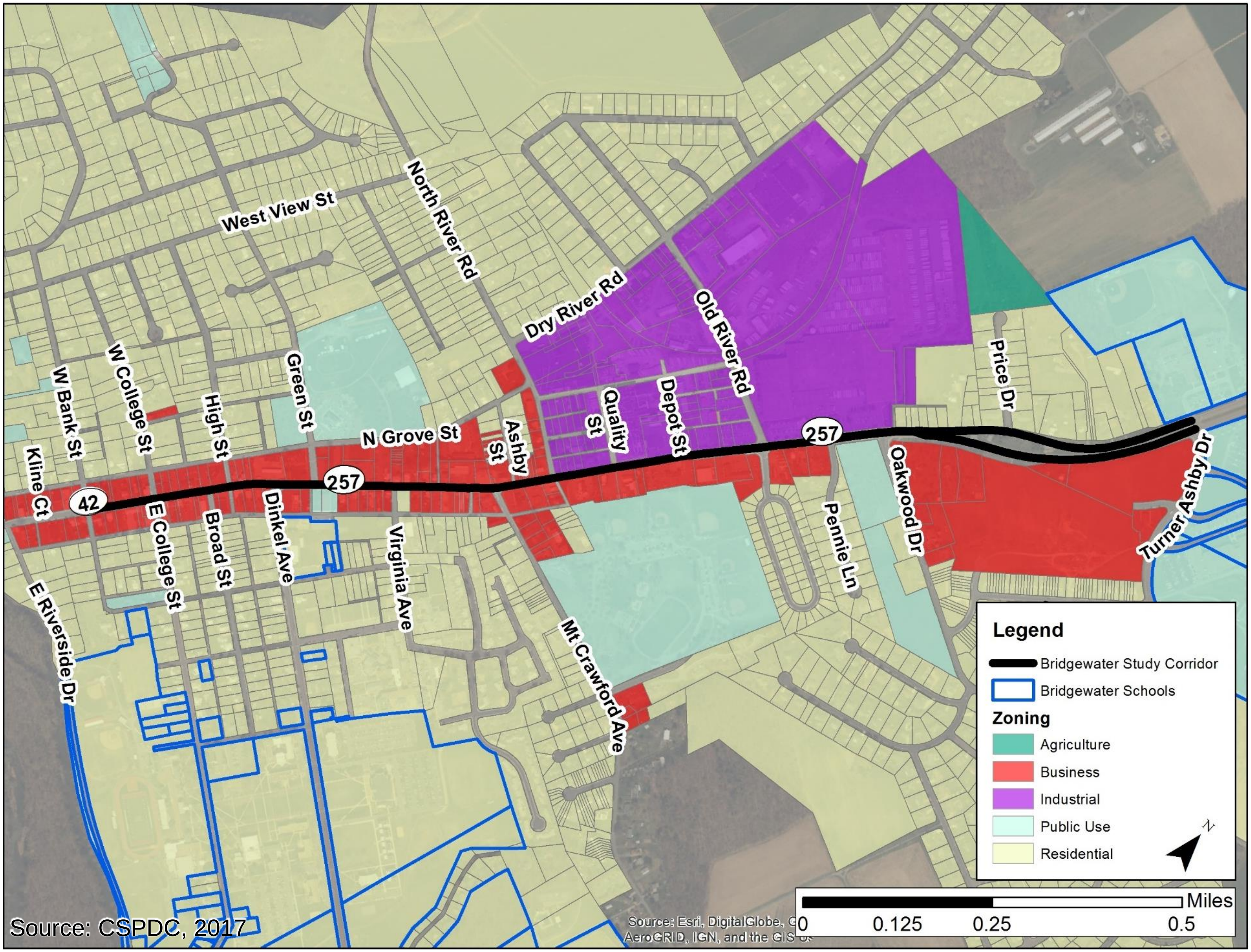
Figure 5: Sidewalk approaching Oakwood Drive northbound with no buffer

Figure 6: Crosswalk at Dylan Circle with marked crosswalk behind the stop bar

Corridor Zoning Districts

Figure 7 provides an overview of the different land uses within the Town of Bridgewater. As shown, the primary land uses along the Main Street corridor are commercial, as shown in light red as the business district. To the west of Main Street north of North River Road and East of Dry River Road, industrial land uses exist where the Perdue plant and Marshalls Distribution Center are located. At the northern limits of the corridor, the properties on which the elementary and high schools are located are zoned as public land uses. The vast majority of the surrounding area of the Town is zoned as residential. Much of Bridgewater College is located within a residentially zoned area to the east of the Main Street corridor.

Figure 7: Town of Bridgewater Zoning Districts



Crash Analysis

A crash analysis was conducted for the 1.75-mile study corridor between Turner Ashby Drive and Bank Street using the latest three years of available crash data. Crash reports from January 1, 2014 to December 31, 2016 were obtained from the VDOT database. There were 65 crashes reported within 250 feet of the study corridor in the 3-year analysis period.

Most of the crashes were concentrated near intersections along the study corridor. The intersections with the highest crash concentration were Green Street, Quality Street, and Old River Road. **Figure 8** summarizes the crash types along quarter-mile segments of the study corridor, as well as the location of the recorded crashes within the study area.

Overall, rear end crashes were the most common type of collision, with the majority located between Mt. Crawford Avenue and Old River Road, as shown on **Figure 8**. Angle crashes were the second most common crash type along the corridor. The average annual crash rate is 22 recorded crashes per year, with the highest number of crashes documented in 2016 (24 crashes), followed by 2015 (23 crashes), and 2014 (18 crashes). There were no reported bicycle or pedestrian crashes in the data collected within the VDOT database.

Below is additional information associated with the 65 crashes that occurred at the study intersections, with **Figure 9** through **Figure 11** summarizing the types of collisions, time periods that crashes occurred, and crash severity. The majority of crashes (83%) resulted in property damage only. This can be attributed to crashes occurring at low travel speeds (posted speed limit of 30 mph for most of the corridor). While the highest number of crashes were recorded in the segment of Main Street between Mt. Crawford Avenue and Old River Road, a traffic signal is planned for the intersection at Old River Road. A traffic signal has the potential to reduce collisions, particularly angle collisions; thus, the identification of safety recommendations was focused at other locations along the corridor.

As shown in **Figure 8**, three "backed into" crashes occurred along the corridor. Multiple instances of trucks oversteering beyond their lane of travel to complete a turning maneuver were observed during the field observations completed on May 31, 2017. In some cases, this required other vehicles driving in the path of the turning trucks to stop and reverse to allow the truck to complete the turn. This could be the cause of these "backed into" crashes. Aside from this, no other recurring safety patterns were identified along the corridor.

Crash data reported based on records documented between January 1, 2014 and December 31, 2016

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Crash Type Histogram and Crash Locations Map Main Street (VA 42) Corridor Study Bridgewater, Virginia

Figure 8

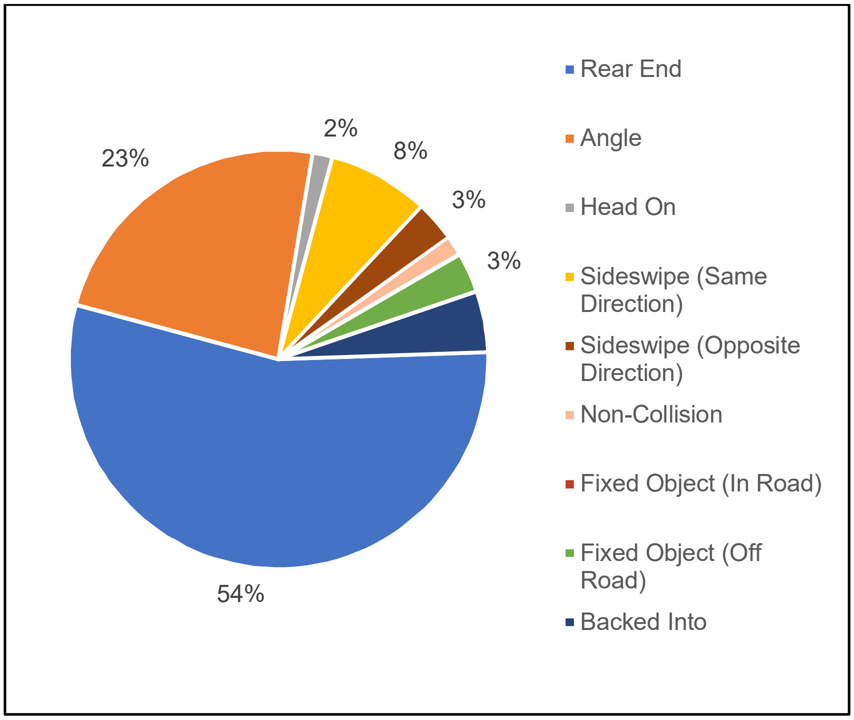


Figure 9: Type of Collision

- 36 crashes (54%) were rear end collisions
- 15 crashes (23%) were angle collisions
- 5 crashes (8%) were sideswipe (same direction) collisions
- 3 crashes (5%) were backed into collisions
- All other crash types accounted for 10% of the 65 crashes recorded along the corridor

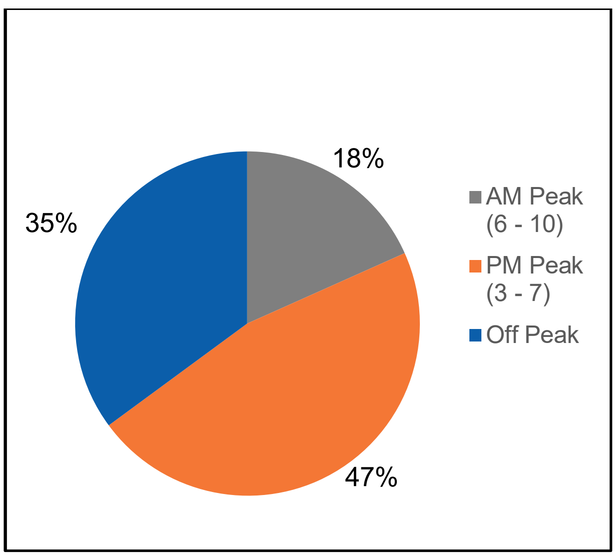


Figure 10: Time Period of Crash

- 30 crashes (47%) occurred during the PM Peak
- 23 crashes (35%) occurred during Off Peak
- 12 crashes (18%) occurred during the AM Peak

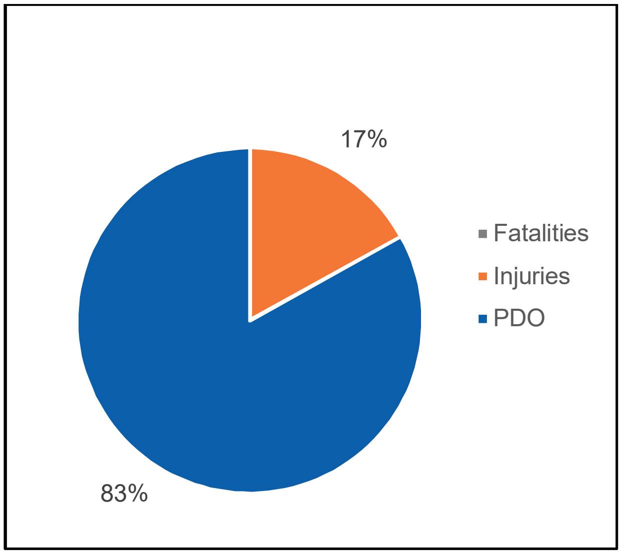


Figure 11: Crash Severity

- No fatal crashes occurred
- 11 crashes (17%) resulted in one or more injuries
- 54 crashes (83%) resulted in property damage only (PDO)

Summary of Previously Completed Studies and Design Work

A review of recently completed studies and planned development or construction projects was completed as part of the Study to identify any potential impacts to the corridor. Based upon information provided by the Town, VDOT, and the Central Shenandoah Planning District Commission (CSPDC), four relevant efforts were evaluated:

1. North Main Street Corridor Improvements (April 2017)
2. Environmental Assessment for the Bridgewater Bypass (October 2009)
3. Left Turn Phase Analysis at North Main Street and Mt. Crawford Avenue (August 2017)
4. Main Street/Route 42 Transportation Study Public Input Meeting (August 2016)

The North Main Street Corridor Improvements identified enhancements to the Main Street Corridor between North River Road and Old River Road. Improvements included spot sidewalk enhancements on both sides of the corridor as well as a new traffic signal at the intersection of Main Street and Old River Road. The proposed signal improvements include the construction of an exclusive southbound right-turn lane, installation of three signal poles and mast arms, and pedestrian accommodations across all legs of the intersection. The signal will operate with protected-permissive left-turn phasing along Main Street and permissive only left-turn phasing on Old River Road/Dylan Circle. This traffic signal is expected to be installed within the next two years. The current version of the corridor improvements is provided in **Appendix A**.

There was an Environmental Assessment (EA) completed for the Bridgewater Bypass in 2009, which would provide a new connection between Dinkel Avenue and Main Street/John Wayland Highway. The southern terminus would intersect with Dinkel Avenue in the vicinity of Don Litten Parkway to the east of Mt. Crawford Avenue and the northern terminus would intersect with John Wayland Highway to the north of Knights View. The purpose of the Bridgewater Bypass is to provide an alternate route for traffic, especially truck traffic, so that travel through the Town of Bridgewater is not required. Based upon the findings of the EA, a bypass connecting these two roads would have no significant impact on the environment; therefore, an Environmental Impact Statement is not required.

The evaluation of left-turn phasing at the intersection of Main Street and Mt. Crawford Avenue was initiated by the VDOT Harrisonburg Residency in 2017. The existing left-turn phasing is protected only for both directions of Main Street. The request was made to evaluate whether permissive phasing could be accommodated. A technical memorandum was prepared by VDOT summarizing the review of left-turn phasing for the intersection and outlines a review of sight distance, crash data, and left-turn cross-product volumes. Based on the review, VDOT determined that flashing yellow arrow (FYA) signals are appropriate for the control of left-turn movements from Main Street. Permissive only operations were recommended for the northbound left-turn movement and protected-permissive operations were recommended for the southbound left-turn movement.

There was a public input meeting held by VDOT and the Town of Bridgewater on August 30, 2016 to solicit feedback from the community regarding the Main Street corridor. Information boards were available at the meeting and a brief presentation was provided to those in attendance. Some of the comments and concerns shared by the public are listed below:

- Volume of traffic along Main Street is a benefit to support local businesses
- Install a traffic signal at Main Street and Old River Road
- Trucks and cars have been observed taking wide turns into the center lane due to small curb radii along Main Street
- Landscaping at the intersection of Green Street and Main Street causes sight distance issues when turning left from Green Street
- Extend center turning lane for left turns to the southern end of town
- Large percentage of heavy vehicles impacting congestion on Mt. Crawford Avenue as well as Main Street (many trucks travel at a high rate of speed)
- Signal at intersection of Main Street and Oakwood Drive has trouble detecting horse and buggy and bicycles waiting on Oakwood Drive
    - Town may look at adjusting video detection zones to increase sensitivity
- Consider a direct connection from Oakwood Drive to Turner Ashby Drive to help alleviate traffic on Main Street when school lets out
- Left turns on to Main Street are difficult during weekday PM Peak Period and Saturdays
- Inadequate sight distance for U-Turns at median break locations just north of Oakwood Drive
- Investigate shift changes at major employers (i.e. Marshalls, Perdue)

Materials collected during the public meeting are included in **Appendix A**.

2. Existing Traffic Operational Conditions

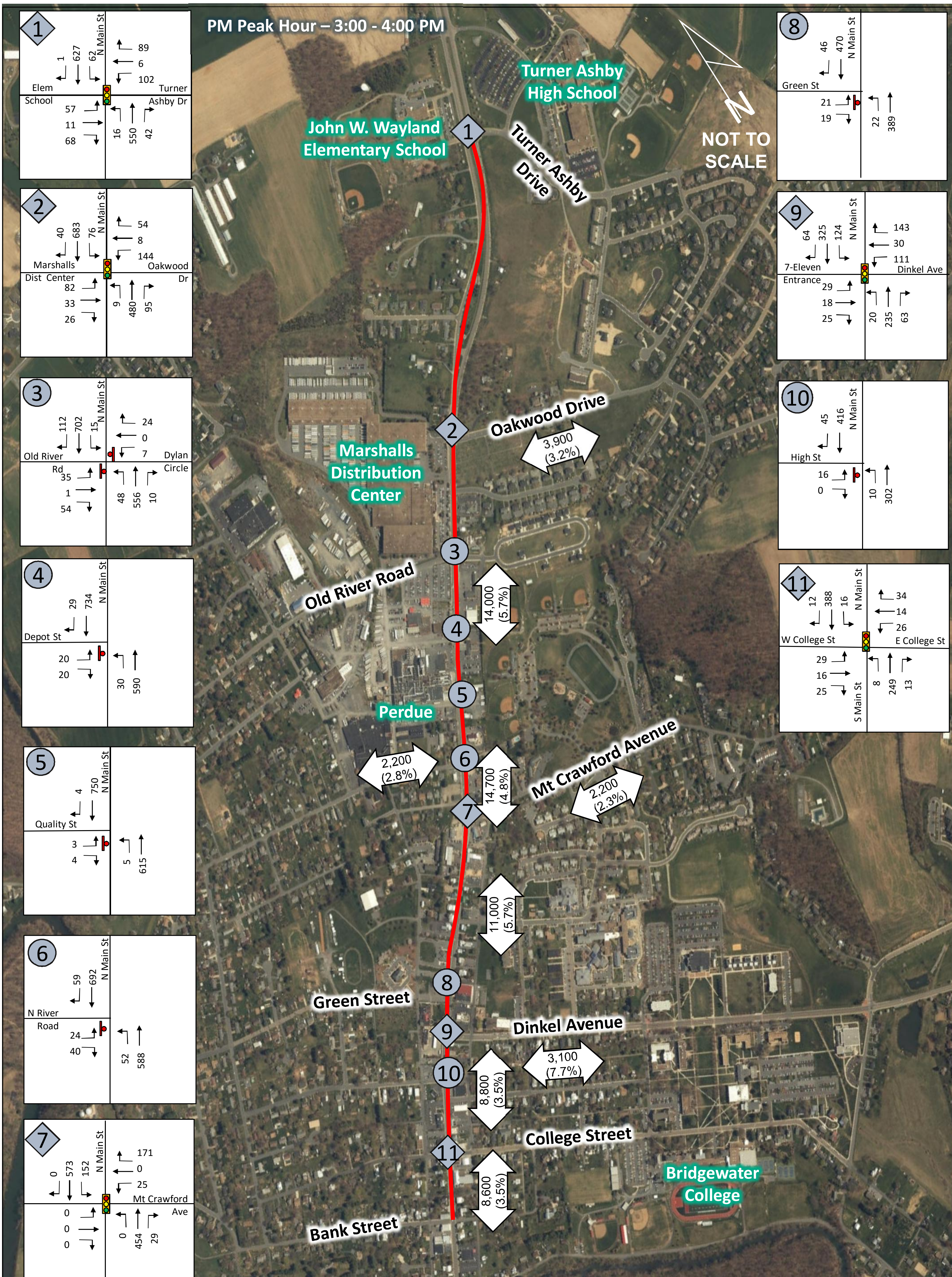
Data Collection

A variety of traffic data were collected to use in the analysis of peak period conditions along the study corridor. Intersection turning movement counts (TMCs) were collected on September 8, 2016 from 7:00 AM until 7:00 PM at eight of the study intersections, including all five signalized intersections. Directional 48-hour volume counts were also collected at several roadways intersecting the Main Street corridor. Lastly, continuous traffic volume data was obtained from the VDOT count program (e.g. continuous count stations) along Main Street and roadways intersecting Main Street to generate an average weekday traffic (AWDT) volume. Data used to calculate AWDT volumes were collected in September 2015 or early 2016.

The following 11 intersections along Main Street were analyzed as part of the existing conditions analysis:

1. College Street
2. High Street
3. Dinkel Avenue (Rt 257)
4. Green Street
5. Mt. Crawford Avenue (Rt 700)
6. North River Road
7. Quality Street
8. Depot Street
9. Dylan Circle / Old River Road
10. Oakwood Drive (Rt 704)
11. Turner Ashby Drive

Based upon a review of the TMC data, a network PM peak hour of 3:00 PM to 4:00 PM was identified. This coincides with the school release at Turner Ashby Drive at 3:00 PM and the shift change at Marshalls around 3:30 PM. **Figure 12** summarizes PM peak hour intersection turning volumes at most study intersections. Where TMC data was unavailable, 48-hour directional volume counts along side streets were used in conjunction with peak hour AWDT data along Main Street to approximate turning volumes to and from the side street. Peak hour turning volumes could not be approximated for the intersections at Bank Street, Broad Street, or Virginia Avenue; as such, these intersections were excluded from the study area. TMC and mainline count data can be found in **Appendix B.**



Legend

Intersection ID Symbol
- Signalized
- Unsignalized

Intersection Control
- Traffic Signal
- Stop Controlled Approach

XX – PM Peak Hour Turning Volume *(data collected between 2015 and 2016)*
- Turning Movement
- Limits of Corridor Study

X,XXX (X.X%) - Average Weekday Turning Volume (AWDT) (% Heavy Vehicles – Class 4 and up) *(data collected between 2015 and 2016)*

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Existing Conditions PM Peak Hour Volumes

Main Street (VA 42) Corridor Study

Figure 12

Travel Time Comparison

Travel time data was collected by VDOT on September 7, 2016 between 4:15 and 6:00 PM. Considering mainline traffic volumes, a peak hour of 4:30 to 5:30 PM was identified. Average travel time and space mean speed was calculated from the six runs completed in each direction along Main Street. Considering turning volumes at the study intersections, a different peak hour was identified between 3:00 and 4:00 PM (as noted in the previous section). Although travel time data was not collected for this interval, the PM peak hour Synchro model was used to estimate travel time and speed along the corridor using the arterial level of service (LOS) reporting tool. A comparison of northbound and southbound travel times and speeds along Main Street collected by VDOT and obtained from Synchro is provided in **Table 1** and **Table 2**, respectively. The arterial LOS report for existing PM peak hour conditions can be found in **Appendix C**.

Table 1: Northbound Travel Time and Speed Comparison

Cross Street	Travel Time (seconds)		Space Mean Speed (mph)	
	Synchro	VDOT	Synchro	VDOT
E. College St	38.2	27.0	22.5	28.0
Dinkel Ave	56.8	46.0	10.1	12.5
Mt. Crawford Ave	65.3	60.0	16.1	18.0
Oakwood Dr	108.4	73.0	17.1	25.2
Turner Ashby Dr	70.0	47.0	21.7	32.2
Total Travel Time / Corridor Space Mean Speed	338.7	256.0	17.3	22.5

Table 2: Southbound Travel Time Comparison

Cross Street	Travel Time (seconds)		Space Mean Speed (mph)	
	Synchro	VDOT	Synchro	VDOT
Turner Ashby Dr	37.0	44.0	12.2	34.4
Oakwood Dr	75.4	67.0	20.1	27.4
Mt. Crawford Ave	65.8	56.0	28.1	19.3
Dinkel Ave	64.6	48.0	16.3	12.0
E. College St	31.0	28.0	18.6	27.0
Total Travel Time / Corridor Space Mean Speed	273.8	245.0	19.9	23.5

Field Observations

Peak period field observations along the Main Street corridor were completed on May 31, 2017 while schools were still in session. During the AM peak period observations, little congestion was noted along the corridor between 7:00 AM and 8:30 AM. Side street queues were minimal, and platoons of traffic along Main Street moved at or near the posted speed limit. Traffic arriving at the elementary and high schools at Turner Ashby Drive did not have a significant impact on mainline operations.

Unlike the AM peak period, notable congestion occurred along Main Street, as noted during PM peak period observations, between 2:45 PM and 5:00 PM. The traffic signals at Oakwood Drive and Turner Ashby Drive both become congested due to the school dismissals and shift changes between the Marshalls Distribution Center and Perdue plant, respectively. The traffic signal at Turner Ashby Drive appeared to operate such that school traffic was assigned priority over mainline traffic. As a result, a rolling queue, as shown in **Figure 13**, to the north and south started building around 3:00 PM, with fewer than 10 vehicles on Main Street getting through the traffic signal per cycle.

Figure 13: Queueing on Main Street Southbound at Turner Ashby Drive

Queues were also observed heading south along Main Street approaching Oakwood Drive, extending about halfway to the upstream intersection of Turner Ashby Drive. Similar to the signal at Turner Ashby Drive, the signal at Oakwood Drive appeared to turn over frequently in order to provide green time to the Oakwood Drive and Marshalls Distribution Center driveway approaches. The height of congestion at this intersection occurred at approximately 3:45 PM.

This intersection represented the worst queuing observed along the corridor during the PM peak hour. **Figure 14** and **Figure 15** illustrate queues approaching the Oakwood Drive signal in the northbound and southbound directions, respectively. Queues along the rest of the corridor during the PM peak period were consistent in both directions of travel throughout the peak period. Little variation in queue lengths was observed during the peak period, and outside the aforementioned signals, queues were cleared during the majority of the signal cycles.

Figure 14: Queueing on Main Street Northbound at Oakwood Drive

Figure 15: Queueing on Main Street Southbound approaching Oakwood Drive

Heavy vehicles were observed to use unsignalized side streets, including Old River Road, Depot Street, and Quality Street, to access the Marshalls Distribution Center and Perdue plant. Dinkel Avenue is also a frequently used street for heavy vehicle traffic as it connects Main Street to US Route 11 and Interstate 81. A heavy vehicle making the turn from Main Street onto Dinkel Avenue is shown in **Figure 16**. In general, turning trucks to and from Main Street were observed to travel across multiple lanes in order to complete a turning maneuver (i.e. crossing into conflicting travel lanes). This was observed at Dinkel Avenue as well as the other streets listed above.

Figure 16: Heavy Vehicle Turning from Main Street onto Dinkel Avenue

A notable volume of heavy vehicles was observed traveling through the Town of Bridgewater along Main Street between points further south and the Pilgrim's Pride Corporation just north of the City of Harrisonburg. Approximately 10 to 15 vehicles were observed traveling along the corridor during the AM peak period alone. **Figure 17** illustrates the type of vehicle that was observed traveling to and from the Pilgrim's Pride Corporation facility.

Figure 17: Typical Pilgrim's Pride Corporation Transport Vehicle

There were also less than 10 farming vehicles traveling along Main Street. These were primarily short, four-wheel tractors traveling short distances in the vicinity of Quality Street. These may have been lawn maintenance equipment servicing the Bridgewater Little League ball fields. They did not have an impact on travel along Main Street. In addition, a horse and buggy was observed traveling up and down the corridor twice during the day. In both instances, it appeared to be the same horse and buggy.

Little pedestrian and bicycle activity was observed during the field observations. A handful of pedestrians were seen using the sidewalks at the southern end of the corridor in the morning and one pedestrian was observed crossing Main Street at Turner Ashby Drive during the afternoon school release period. No bicyclists were seen traveling along Main Street or on the adjacent sidewalks.

Traveling northbound along Main Street approaching the signal Dinkel Avenue, sight distance is limited due to the curvature of the roadway as well as a tree overhanging in the roadway that obstructs visibility of the signal heads. **Figure 18** demonstrates the perspective of a driver approaching the signal at Dinkel Avenue. Recommendations to improve the safety of operations for vehicles are outlined as part of the improvement strategies for this intersection.

Figure 18: Northbound Approach to Dinkel Avenue on Main Street

Intersection Capacity Analysis

Existing conditions analyses were based on the existing peak hour turning movement volumes described above, intersection geometry, peak hour factors, heavy vehicle percentages (when available), traffic control and signal timing, and speed. Data was provided by VDOT in Synchro 9 format. For the purposes of the capacity analysis, only the PM peak hour was evaluated for existing conditions. This was identified as the busiest period during the day when notable congestion was observed in the field.

All intersections were analyzed using Synchro 9 software, which provides an assessment of the operational conditions at each study intersection. The Transportation Research Board's (TRB) *Highway Capacity Manual* (HCM) methodologies govern the methodology for evaluating capacity and the quality of service provided to road users, defined as the level of service (LOS). LOS ranges from A to F— with "A" indicating a condition of little or no congestion and F indicating a condition with severe congestion, unstable traffic flow, and stop-and-go conditions. For intersections, LOS is based on the average delay experienced by all traffic using the intersection during the busiest (peak) 15-minute period. **Table 3** summarizes the delay associated with each LOS category.

Table 3: Level of Service Criteria

LOS	Delay per Vehicle (seconds per vehicle)	
	Signalized	Unsignalized
A	≤ 10	≤ 10
B	> 10 – 20	> 10 – 15
C	> 20 – 35	> 15 – 25
D	> 35 – 55	> 25 – 35
E	> 55 – 80	> 35 – 50
F	> 80	> 50

* *Source: Transportation Research Board, Highway Capacity Manual 2010*

The HCM 2000 module of Synchro was used to report LOS and delay for signalized intersections within the study area given the limitations of the HCM 2010 module to evaluate non-standard intersection configurations. The HCM 2000 module was used to report LOS and delay for unsignalized study intersections. **Table 4** summarizes the LOS and delay by movement for study intersections. Individual movements with a reported LOS F are shown in red, while those with LOS E and LOS D are shown in orange and yellow, respectively. The Synchro HCM reports can be found in **Appendix C**.

Table 4: Existing Conditions LOS and Delay (seconds per vehicle)

Intersection		Peak Hour
Approach	**Movement**	**PM**
1. North Main Street & Turner Ashby Drive (signalized)*		
Eastbound (*John Wayland ES*)	L	D (45.3)
	TR	D (40.8)
	Overall	D (42.7)
Westbound (*Turner Ashby Drive*)	LT	D (42.6)
	R	D (35.7)
	Overall	C (30.8)
Northbound (*North Main Street*)	L	E (59.3)
	T	C (26.6)
	R	C (20.7)
	Overall	C (27.1)
Southbound (*North Main Street*)	L	D (50.3)
	TR	C (22.7)
	Overall	C (25.1)
Overall Intersection		**C (30.7)**
2. North Main Street & Oakwood Drive (signalized)*		
Eastbound (*Marshalls Distribution Center*)	L	D (51.8)
	TR	D (45.1)
	Overall	D (49.0)
Westbound (*Oakwood Drive*)	LT	D (49.7)
	R	D (40.3)
	Overall	D (47.2)
Northbound (*North Main Street*)	L	C (22.6)
	TR	D (38.3)
	Overall	D (38.1)
Southbound (*North Main Street*)	L	C (20.6)
	T	D (35.3)
	R	B (15.1)
	Overall	C (32.9)
Overall Intersection		**D (38.4)**
3. North Main Street & Dylan Circle/Old River Rd (TWSC)		
Eastbound (*Old River Road*)	LT	F (114.4)
	R	C (17.6)
Westbound (*Dylan Circle*)	L	F (69.8)
	TR	B (13.1)
Northbound (*North Main Street*)	L	B (10.4)
	TR	††
Southbound (*North Main Street*)	L	A (8.9)
	TR	††

Intersection		Peak Hour
Approach	**Movement**	**PM**
4. North Main Street & Depot Street (TWSC)		
Eastbound (*Depot Street*)	LR	C (21.8)
Northbound (*North Main Street*)	L	B (10.8)
	T	††
Southbound (*North Main Street*)	TR	††
5. North Main Street & Quality Street (TWSC)		
Eastbound (*Quality Street*)	LTR	C (19.8)
Northbound (*North Main Street*)	L	B (11.1)
	T	††
Southbound (*North Main Street*)	TR	††
6. North Main Street & North River Road (TWSC)		
Eastbound (*North River Road*)	LR	C (20.0)
Northbound (*North Main Street*)	L	B (10.1)
	R	††
Southbound (*North Main Street*)	TR	††
7. North Main Street & Mt Crawford Ave (signalized)*		
Eastbound (*Driveway*)	LTR	†
Westbound (*Mt Crawford Ave*)	L	D (39.9)
	TR	D (38.9)
	Overall	D (39.0)
Northbound (*North Main Street*)	L	†
	T	C (23.7)
	R	B (14.6)
	Overall	C (23.2)
Southbound (*North Main Street*)	L	D (41.6)
	T	A (9.1)
	Overall	B (15.9)
Overall Intersection		**C (22.4)**

† LOS not reported in the absence of observed traffic volumes

†† Synchro does not provide LOS or delay for movements with no conflicting volumes

TWSC = Two-way STOP-Controlled unsignalized intersection (TWSC intersections do not have an overall LOS)

*HCM 2000 used to report delay given the limitations of HCM 2010 to evaluate non-standard intersections

Table 4: Existing Conditions LOS and Delay (continued)

8. North Main Street & Green Street (TWSC)		
Eastbound *(Green Street)*	L	C (21.5)
	R	B (11.9)
Northbound *(North Main Street)*	LT	A (0.5)
Southbound *(North Main Street)*	TR	††
9. North Main Street & Dinkel Ave (signalized)*		
Eastbound *(7-Eleven)*	LT	D (41.3)
	R	D (38.4)
	Overall	D (40.3)
Westbound *(Dinkel Ave)*	LT	D (37.1)
	R	C (32.5)
	Overall	C (34.8)
Northbound *(North Main Street)*	L	C (20.5)
	TR	C (28.7)
	Overall	C (28.1)
Southbound *(North Main Street)*	L	B (14.3)
	TR	C (23.9)
	Overall	C (21.6)
Overall Intersection		**C (27.9)**
10. North Main Street & High Street (TWSC)		
Eastbound *(High Street)*	LR	C (16.2)
Northbound *(North Main Street)*	LT	A (0.3)
Southbound *(North Main Street)*	TR	††
11. North Main Street & College Street (signalized)*		
Eastbound *(West College Street)*	LTR	B (13.5)
Westbound *(East College Street)*	LTR	B (13.4)
Northbound *(North Main Street)*	LTR	A (5.9)
Southbound *(North Main Street)*	LTR	A (7.0)
Overall Intersection		**A (8.1)**

† LOS not reported in the absence of observed traffic volumes
†† Synchro does not provide LOS or delay for movements with no conflicting volumes
TWSC = Two-way STOP-Controlled unsignalized intersection (TWSC intersections do not have an overall LOS)
*HCM 2000 used to report delay given the limitations of HCM 2010 to evaluate non-standard intersections

Unsignalized Intersections

With higher mainline traffic volumes and increased side street traffic at many study intersections, PM peak hour conditions along Main Street exhibit moderate delays with isolated occurrences of poor LOS. Higher mainline traffic volumes correspond to fewer gaps in traffic, and as a result, many of the single-lane, stop controlled side street approaches with moderate turning volumes experience greater delays for turning movements onto Main Street. The eastbound left-turn average delay from Old River Road onto Main Street is 114 seconds per vehicle, which for a stop-controlled intersection is a LOS F. The opposing westbound left turn experiences an average delay of approximately 70 seconds per vehicle, which is also LOS F. All other stop controlled approaches have low volumes and operate at LOS C or better. They are also all three-legged intersections, which reduces the number of conflict and yield points for traffic turning from the side street approach.

Signalized Intersections

Many turning movements at signalized intersections operate at LOS D or LOS E. The northbound and southbound left turns from Main Street onto Turner Ashby Drive range from 50 to 60 seconds of average delay per vehicle. Nearly all movements at Oakwood Drive operate at LOS D, including the through movements. This level of delay in the northbound direction can be attributed to the shared lane for the through and right-turn movement and moderate southbound left-turn volume, while the delay in the southbound direction can be attributed to the substantial volume being processed through the signal in a single lane. The signalized intersections at Mt. Crawford Avenue and Dinkel Avenue operate with fewer movements experiencing LOS D, while College Street operates at LOS B or better for all movements.

Future Corridor Operations

A cursory analysis of future traffic operations was completed to assess the potential increase in travel delays and congestion assuming growth in traffic volumes along the corridor. The analysis was completed by applying a growth factor to existing traffic volumes to develop 2030 traffic volumes and using Synchro to evaluate future traffic operations. A review of the regional travel demand model indicates that an annual growth rate of 1% can be expected along Main Street, with less growth anticipated on intersecting roadways. Thus, the analysis assumed an annual growth rate of 1% for through movements along Main Street north of Dinkel Avenue, and a growth rate of 0.5% for all other movements.

Table 5 and **Table 6** summarize existing and future corridor operations along Main Street. As shown, little impact to corridor operations is expected given the incremental increase in volumes by the year 2030. Travel times will increase by less than one minute while travel speeds will decrease by as much as 2 mph. Overall corridor LOS will remain the same. Given the negligible change in operations, the implementation of corridor mitigation concepts along the corridor can be expected to provide a benefit to operations considering existing and future traffic volumes. The arterial LOS report for 2030 PM peak hour conditions can be found in **Appendix C**.

Table 5: Summary of Existing and Future 2030 Corridor Operations (Northbound Main Street)

Cross Street	Travel Time (seconds)		Space Mean Speed (mph)		Arterial Level of Service	
	Existing	Future (2030)	Existing	Future (2030)	Existing	Future (2030)
E. College St	38.2	38.3	22.5	22.5	C	C
Dinkel Ave	56.8	55.8	10.1	10.3	E	E
Mt. Crawford Ave	65.3	69.6	16.1	15.1	D	D
Oakwood Dr	108.4	145.9	17.1	12.7	D	E
Turner Ashby Dr	70.0	72.1	21.7	21.0	C	C
Corridor Summary	**338.7**	**381.7**	**17.3**	**15.3**	**D**	**D**

Table 6: Summary of Existing and Future 2030 Corridor Operations (Southbound Main Street)

Cross Street	Travel Time (seconds)		Space Mean Speed (mph)		Arterial Level of Service	
	Existing	Future (2030)	Existing	Future (2030)	Existing	Future (2030)
Turner Ashby Dr	37.0	38.8	12.2	11.6	F	F
Oakwood Dr	75.4	90.0	20.1	16.8	D	E
Mt. Crawford Ave	65.8	67.7	28.1	27.3	B	C
Dinkel Ave	64.6	64.5	16.3	16.3	E	E
E. College St	31.0	31.3	18.6	18.4	D	D
Corridor Summary	**273.8**	**292.3**	**19.9**	**18.6**	**D**	**D**

3. Corridor Improvements

Improvements to Intersection Accommodations

A roadway geometry and pedestrian accommodations review was performed to identify locations where improvements may be needed based on current conditions. Recurring issues identified consist of faded pavement markings, sidewalk ramps not in compliance with the Americans with Disabilities Act (ADA), pedestrian signals missing or not in compliance with the Manual on Uniform Traffic Control Devices (MUTCD), and non-LED traffic signal displays. These elements of intersection control enhance the safety of operations for all travel modes. Pavement markings designate stopping locations for vehicles and crossing areas for pedestrian access, countdown pedestrian signals clearly define the time remaining for a pedestrian to move through the intersection, and LED traffic signals provide a brighter indication to drivers and have a longer service, requiring less maintenance. **Table 7** summarizes the condition of roadway and pedestrian accommodations at the study intersections. Where an intersection accommodation is missing or not compliant with current guidelines and standards, the table is shaded orange to indicate enhancements are recommended.

Pavement marking improvements and signal head replacements could be implemented fairly quickly with little to no engineering documents required. The installation of pedestrian signals would likely require engineering drawings to incorporate the new equipment into the existing signal infrastructure. Likewise, installing compliant sidewalk ramps may require a more detailed evaluation in order to construct a ramp that meets current design guidelines. Annual maintenance budgets may provide an opportunity to accomplish the pavement marking and signal head replacements outlined below in the near term. The Town or VDOT may need to explore other funding opportunities to accomplish pedestrian signal and sidewalk ramp upgrades, such as the Highway Safety Improvement Program (HSIP). **Table 8** summarizes the recommended spot intersection improvements at each study intersection along Main Street.

Table 7: Summary of Study Intersection Accommodations

Study Intersection	Existing Sidewalk	Compliant Sidewalk Ramps	Crosswalk(s) Present	Stop Bar(s) Present	Compliant Pedestrian Signal(s)	LED Traffic Signals
Turner Ashby Drive	Yes	No	Yes	Yes	None present	No
Oakwood Drive	Yes	No	Incomplete	Faded	None present	No
Dylan Circle / Old River Road	Yes	No	Faded	Faded	-	-
Depot Street	Yes	No	No	Faded	-	-
Quality Street	Yes	No	No	No	-	-
North River Road	Yes	No	No	No	-	-
Mt. Crawford Avenue	Yes	Yes	Yes	Yes	Yes	Yes
Virginia Avenue	Yes	No	No	Faded	-	-
Green Street	Yes	No	No	Faded	-	-
Dinkel Avenue	Yes	No	Yes	Faded	No	No
High Street	Yes	No	No	No	-	-
Broad Street	Yes	No	No	No	-	-
College Street	Yes	No	Faded	Faded	No	No
Bank Street	Yes	No	No	No	-	-

Table 8: Recommended Spot Intersection Upgrades and Improvements

Study Intersection	Upgrade Sidewalk Ramps	Install or Replace Crosswalk Markings	Install or Replace Stop Bar Markings	Install Compliant Pedestrian Signal(s)	Install LED Traffic Signals
Turner Ashby Drive	Yes	No	No	Yes	Yes
Oakwood Drive	Yes	Yes	Yes	Yes	Yes
Dylan Circle / Old River Road	Yes	Yes	Yes	-	-
Depot Street	Yes	Yes	Yes	-	-
Quality Street	Yes	Yes	Yes	-	-
North River Road	Yes	Yes	Yes	-	-
Mt. Crawford Avenue	No	No	No	No	No
Virginia Avenue	Yes	Yes	Yes	-	-
Green Street	Yes	Yes	Yes	-	-
Dinkel Avenue	Yes	No	Yes	Yes	Yes
High Street	Yes	Yes	Yes	-	-
Broad Street	Yes	Yes	Yes	-	-
College Street	Yes	Yes	Yes	Yes	Yes
Bank Street	Yes	Yes	Yes	-	-

Based on existing conditions observations, there were additional areas along the corridor where pedestrian improvements are recommended. From Oakwood Drive south to Dylan Circle and from Depot Street south to Bank Street, the sidewalk along the east side of Main Street has no buffer. The provision of a buffer space of 3 to 5 feet provides for a more comfortable walking space, enhances the safety of pedestrians, serves as a landscape area, and can also be used as a space to place underground utilities. A similar condition exists on the west side of Main Street from Mt. Crawford Avenue to Bank Street, there is no buffer between the sidewalk and the road. While a buffer space would enhance the environment for pedestrians, there are right-of-way constraints that make this type of improvement challenging. This would also require funding, not only for construction but also right-of-way acquisition.

Corridor Improvement Strategies

Based on the analysis of existing conditions and field observations, improvement strategies were identified to reduce congestion and improve safety. Some of these strategies are relatively low-cost and can be implemented in a short period of time, while others hinge on additional coordination, planning, and design beyond this study. The following sections summarize each improvemet strategy, outcome of the operational analysis, recommendations, and where applicable, planning level estimates of probable cost.

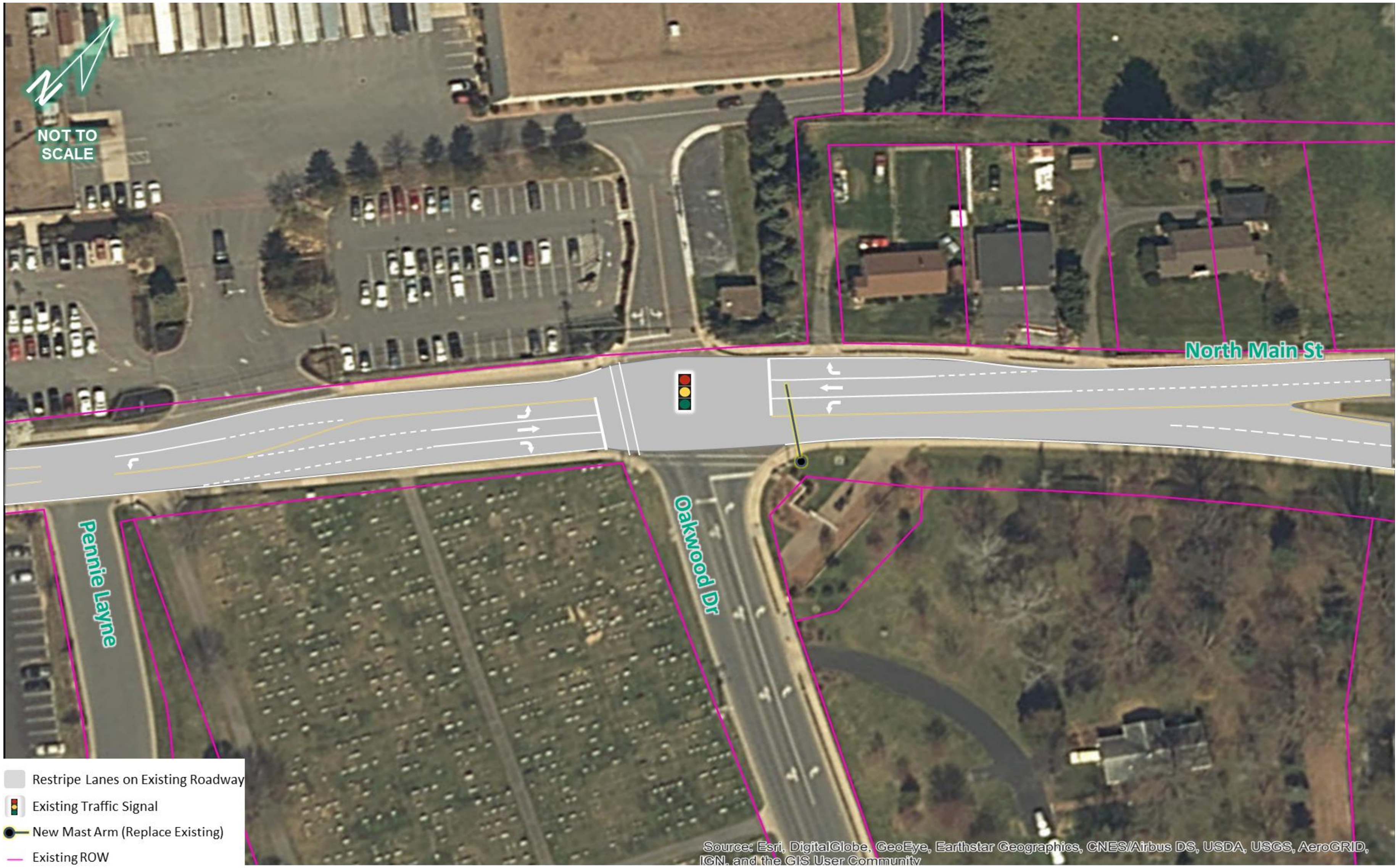
A. Main Street Lane Reassignments at Oakwood Drive

Two lane reassignment alternatives were identified at the intersection of Oakwood Drive and Main Street to help reduce delay along Main Street. The first lane reassignment (Lane Reassignment 1) would change the northbound Main Street approach from the existing configuration of an exclusive left-turn lane and a shared through and right-turn lane. The modified approach geometry would include one exclusive left-turn lane, one exclusive through lane, and one exclusive right-turn lane. All other approach geometry would remain the same.

The second lane reassignment (Lane Reassignment 2) would change the northbound and southbound approaches on Main Street. The modified northbound approach would have one exclusive left-turn lane, one exclusive through lane, and one shared through and right-turn lane. Because there is an additional northbound through lane, a second receiving lane north of the intersection would be required. To accommodate this additional lane, the southbound approach would be modified to include one exclusive left-turn lane and one shared through and right-turn lane. All other approach geometry would remain the same. **Figure 19** and **Figure 20** illustrate the two lane reassignment alternatives.

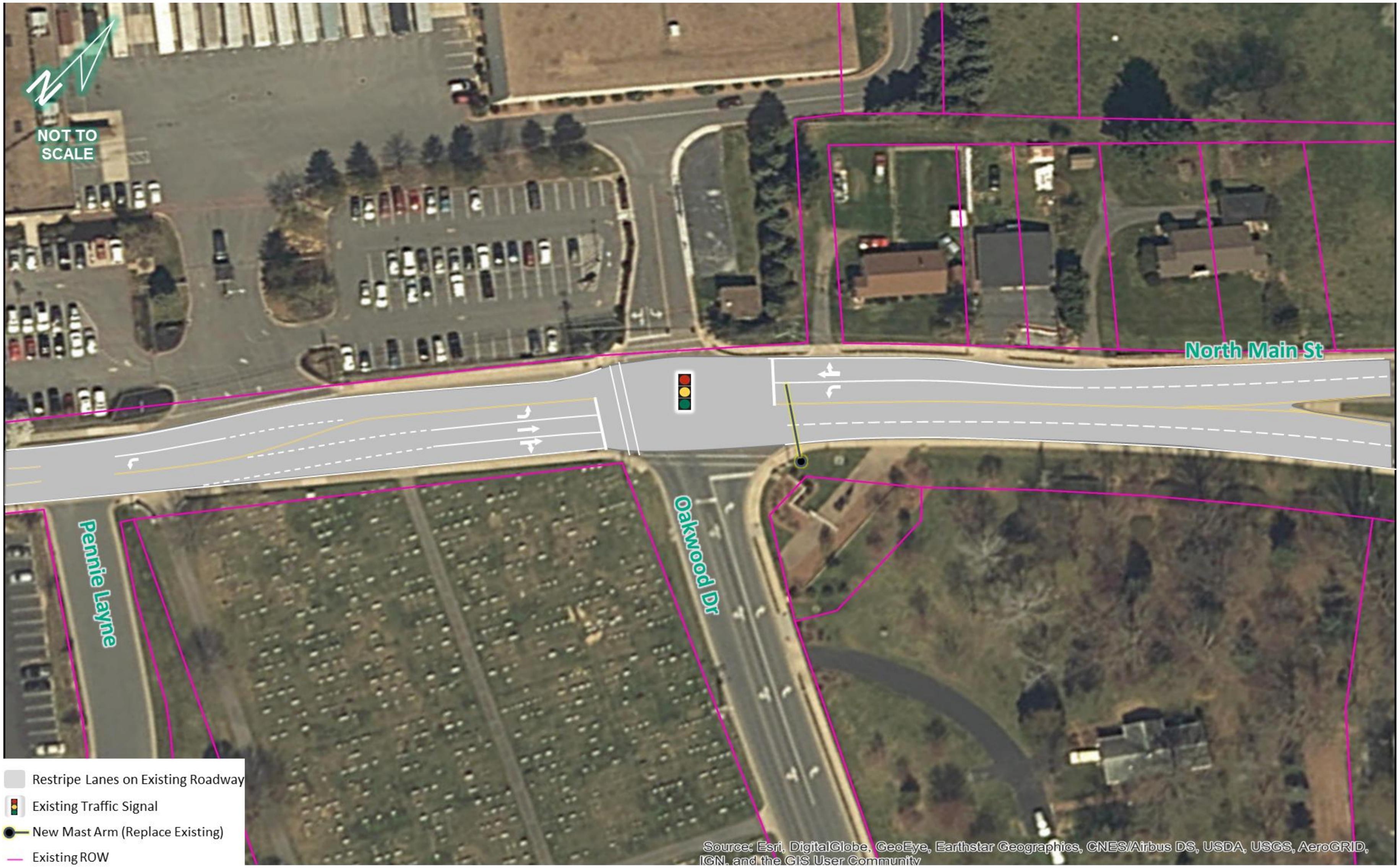
In both cases, the lane reconfiguration is assumed to occur within the existing intersection footprint, making use of pavement that previously served as a turn lane into the Marshalls access driveway that was recently closed. In addition, signal modifications would be required to extend the mast arm controlling the northbound approach in order to locate the left-turn signal in the proper location given the lane reconfiguration.

Figure 19: Lane Reassignment 1 at Main Street and Oakwood Drive



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Figure 20: Lane Reassignment 2 at Main Street and Oakwood Drive



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Table 9 summarizes the results of the operational analysis of PM peak hour conditions considering the two lane reassignment alternatives. As shown, both alternatives result in a minimal reduction in overall intersection delay. The analysis assumed a similar actuated cycle length as existing conditions. For Lane Reassignment 1, the northbound approach delay is reduced by approximately 10 seconds, while little to no change in delay is expected for all other movements. For Lane Reassignment 2, due to the consolidation of the through and right-turn movements in the southbound direction, the capacity of this approach is reduced. This demands a larger proportion of the cycle green time in order to achieve similar operations for the mainline. As a result, side street delay was increased, resulting in LOS E for the eastbound and westbound left-turn movements. Detailed LOS and delay results are included in **Appendix D**.

Table 9: LOS Summary for Main Street and Oakwood Drive Lane Reassignments

Approach	Movement	PM Peak Hour LOS (Delay)		
2. North Main Street & Oakwood Drive (signalized)*		Existing Conditons	Lane Reassignment 1	Lane Reassignment 2
Eastbound *(Marshalls Distribution Center)*	L	D (51.8)	D (51.8)	E (56.7)
	TR	D (45.1)	D (45.1)	D (48.4)
	Overall	D (49.0)	D (49.0)	D (53.3)
Westbound *(Oakwood Drive)*	LT	D (49.7)	D (49.9)	E (55.1)
	R	D (40.3)	D (40.4)	D (43.7)
	Overall	D (47.2)	D (47.4)	D (52.1)
Northbound *(North Main Street)*	L	C (22.6)	C (22.5)	C (23.3)
	T	D (38.3)	C (29.1)	C (22.7)
	R	—[1]	B (18.8)	—[2]
	Overall	D (38.1)	C (27.3)	C (22.7)
Southbound *(North Main Street)*	L	C (20.6)	B (16.8)	B (13.2)
	T	D (35.3)	C (34.9)	D (35.2)
	R	B (15.1)	B (15.0)	—[2]
	Overall	C (32.9)	C (32.2)	C (33.1)
Overall Intersection		**D (38.4)**	**C (34.7)**	**C (34.8)**

[1] Existing Conditions for the northbound approach does not have a designated right-turn lane. LOS and delay for the through and right turn movements are shown on the through movement.
[2] Lane Reassignment 2 does not have a designated right-turn lane. LOS and delay for the through and right-turn movements are shown on the through movement.
*HCM 2000 used to report delay given the limitations of HCM 2010 to evaluate non-standard intersections

A planning level estimate of probable cost was prepared for the lane reconfiguration alternatives. Cost information was based upon current Staunton District average costs for pavement marking activities published by VDOT as well as recent contractor bid information for a comparable traffic signal. The low estimate presented in **Table 10** reflects the current District average costs for pavement marking activities and assumes signal modifications would only include the replacement of the mast arm on the northeast corner. The high estimate reflects a 20% increase in the cost to complete pavement marking activities and a full signal replacement.

Table 10: Estimate of Probable Cost for Lane Reassignment 1

Improvement	Construction Activity	Low Estimate	High Estimate
Pavement Markings	Eradication of Pavement Markings	$ 700.00	$ 800.00
	Pavement Markings	$ 3,000.00	$ 3,600.00
Signal Modifications	Full Signal	-	$ 250,000.00
	Single Mast Arm	$ 40,000.00	-
	Construction Cost	$ 43,700.00	$ 254,400.00
	10% PE (Construction Cost)	$ 4,400.00	$ 25,500.00
	25% Contingency for 2016 VDOT Standards (Signal Mods Only)	$ 10,000.00	$ 62,500.00
	25% Construction Contingency (Construction Cost)	$ 11,000.00	$ 63,600.00
	TOTAL (rounded)	**$ 69,100.00**	**$ 406,000.00**

A 25% contingency was applied to the signal modifications to account for higher construction costs expected given the 2016 VDOT design standards, which have increased the cost of new signal installations statewide. In addition, a 25% construction contingency was applied to account for other construction-related costs such as mobilization and maintenance of traffic. The cost presented in **Table 10** is an estimation for the Lane Reassignment 1 option. Additional pavement marking activities would be required for Lane Reassignment 2; thus, an incrementally higher cost can be expected for this option (approximately $4,000-$5,000 more). **Appendix D** provides a breakdown of how the estimates of probable cost were developed.

Based upon the findings of the operational analysis, Lane Reassignment 1 was determined to provide a greater overall benefit to intersection operations. It also has a slightly lower estimate of probable cost. While both alternatives offer a reduction in delay for Main Street, the benefit to operations is minimal considering the potential cost to implement these improvements. In addition, the improvements would likely show a noticeable benefit only during congested periods. Outside of congested conditions, the intersection would likely operate with similar level of service and delay as it does today. It is recommended that modifications to the intersection lane assignments not be carried forward at this time. However, the Town may want to reconsider lane reassignment as part of a budgeted traffic signal replacement that may occur in the future. **Figure 21** provides a high-level overview of the two lane reassignment strategies.

Main Street (VA 42) Corridor Study

Summary of Lane Reconfiguration Alternatives at Main Street and Oakwood Drive

Harrisonburg Rockingham Metropolitan Planning Organization

Kimley»Horn

EXISTING CONDITIONS

Main Street is a principal arterial serving a daily traffic volume averaging 14,700 vehicles per day in the vicinity of Oakwood Drive. The afternoon shift change at the Marshalls Distribution Center generates a significant amount of turning traffic into and out of the site as compared to non shift-change periods. As a result, during the PM Peak hour there is heavy queueing at this intersection along Main Street. The current geometry in the northbound direction limits the amount of traffic that can be processed through the intersection (shared through and right-turn lane).

PROJECT DESCRIPTION

Two lane reconfiguration options along Main Street are proposed at this intersection.

- **Lane Reassignment 1** *(preferred)* would modify the northbound approach to provide one exclusive left-turn lane, one exclusive through lane, and one exclusive right-turn lane (three approach lanes total). All other geometry would remain the same.
- **Lane Reassignment 2** would modify the northbound approach to provide one exclusive left-turn lane, one exclusive through lane, and one shared through and right-turn lane (three approach lanes total). The southbound approach would be modified to include one exclusive left-turn lane and one shared through and right-turn lane.

Note: the lane reassignment takes advantage of the currently unused pavement on the west side of Main Street (see **Exhibit A**).

DESIGN CONSIDERATIONS

- Existing northbound left-turn lane would be shifted into the current southbound travel lane.
- The southbound travel lane south of Oakwood Drive would be shifted to the painted pavement where the old turn lane into the Marshalls Distribution Center was located .
- A new mast arm would be required to correctly position the left-turn signal head for the relocated northbound left-turn lane.
- Lane Reassignment 2 would require restriping along Main Street on the north side of Oakwood Drive to provide two receiving lanes.

PROJECT BENEFIT

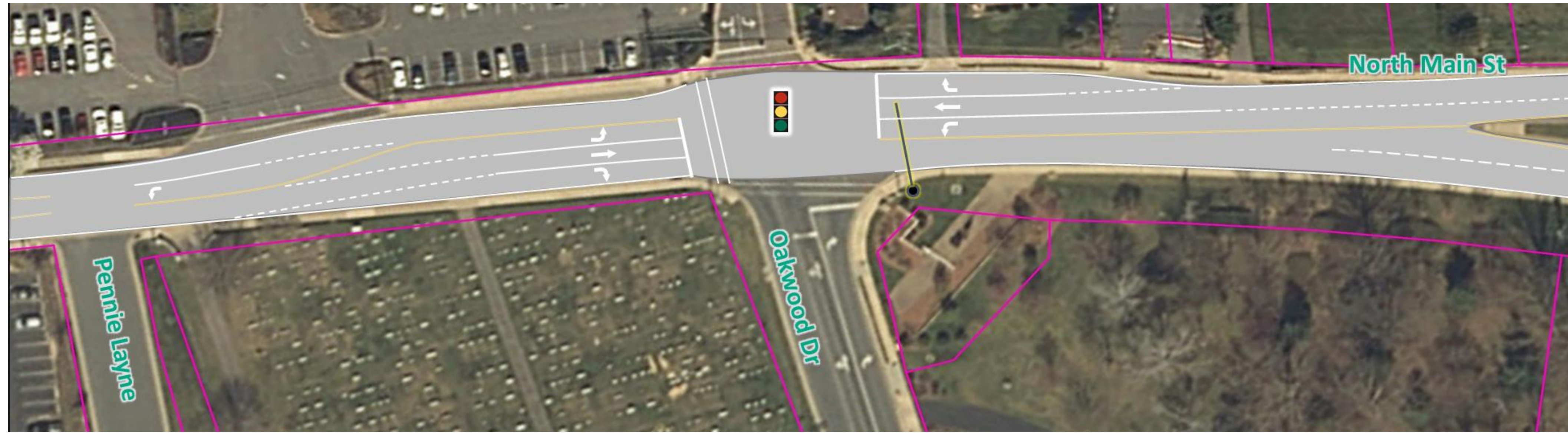
This alternative is intended to improve signal operations along the northbound approach by reducing delay and queuing. The improvement also makes full use of the available pavement at the intersection.

CHANGE IN OVERALL INTERSECTION OPERATIONS

Peak Hour Delay (seconds per vehicle)
PM Peak Hour

- Existing: D (38.4)
- Lane Reassignment 1: C (34.7) *(preferred)*
- Lane Reassignment 2: C (34.8)

-3.6 s to -3.7 s



Restripe Lanes on Existing Roadway
Existing Traffic Signal
New Mast Arm (Replace Existing)
Existing ROW

EXHIBIT A

OPINION OF PROBABLE COSTS

	Lane Reassignment 1	*Lane Reassignment 2*
Low Cost:	$69,100	$72,900
High Cost:	$406,000	$410,600

FIGURE 21

B. Marshalls Site Access Modifications

The Marshalls site access modifications would allow passenger vehicles to enter the Marshalls Distribution Center at the intersection of Oakwood Drive and Main Street as currently allowed; however, exiting vehicles would not be permitted at the intersection during the shift change, which occurs at approximately 3:30 PM. Exiting vehicles would be redirected to Old River Road and the eastbound (outbound) signal phase at Oakwood Drive would be omitted during the shift change period (approximately 3:15 to 4:00 PM). The goal of this improvement strategy is to reduce the number of vehicle phases at the intersection of Main Street and Oakwood Drive and allocate additional green time to the mainline through movements to reduce queuing on Main Street.

A tiered operational analysis was performed for the PM peak hour. The first tier of analysis reflects existing geometry, operations, and access with the inclusion of the proposed traffic signal at Old River Road. The second tier of analysis considers the volume redistribution of outbound trips from Oakwood Drive to Old River Road considering existing geometry. The third tier of analysis considers the volume redistribution as well as the Lane Reassignment 1 geometry at Oakwood Drive. The Tier 2 and Tier 3 analysis account for trip reassignments from the eastbound approach at Oakwood Drive to Old River Road.

Table 11 shows the results of operational analysis of PM peak hour conditions considering the three tiers of geometry and operations at the intersection of Main Street and Oakwood Drive as well as the intersection of Main Street and Old River Road. The analysis shows significant improvement with the Marshalls site access modifications in Tier 2 and Tier 3 at Main Street and Oakwood Drive, improving the overall intersection operations from LOS D to LOS B. This can be attributed to the reallocation of green time to Main Street. The intersection of Main Street and Old River, assumed to be operating under signal control as is planned in the next two years, showed additional delay on the eastbound and westbound side street approaches due to additional trips being redirected to the Old River Road approach. However, little impact is expected for Main Street operations and overall intersections operations remain at LOS B. Detailed LOS and delay results are included in **Appendix D**.

Table 11: LOS Summary for Marshalls Site Access Modifications

Intersection Approach	Movement	PM Peak Hour LOS (Delay)		
2. North Main Street & Oakwood Drive (signalized)*		**Tier 1**	**Tier 2**	**Tier 3**
Eastbound *(Marshalls Distribution Center)*	L	D (51.8)	-	-
	TR	D (45.1)	-	-
	Overall	D (49.0)	-	-
Westbound *(Oakwood Drive)*	LT	D (49.7)	D (44.3)	D (44.3)
	R	D (40.3)	D (35.6)	D (35.6)
	Overall	D (47.2)	D (42.0)	D (42.0)
Northbound *(North Main Street)*	L	C (22.6)	A (7.0)	A (7.3)
	T	D (38.3)	B (13.5)	B (10.5)
	R	—[1]	—[2]	A (5.8)
	Overall	D (38.1)	B (13.4)	A (9.6)
Southbound *(North Main Street)*	L	C (20.6)	A (9.8)	A (6.9)
	T	D (35.3)	B (12.6)	B (12.6)
	R	B (15.1)	A (5.9)	A (5.9)
	Overall	C (32.9)	B (12.0)	B (11.8)
Overall Intersection		**D (38.4)**	**B (16.3)**	**B (14.5)**
3. North Main Street & Dylan Circle/Old River Rd (signalized)*		**Tier 1**	**Tier 2**	**Tier 3**
Eastbound *(Old River Road)*	LT	C (34.5)	D (47.6)	D (47.6)
	R	C (31.4)	D (43.3)	D (43.3)
	Overall	C (32.6)	D (44.6)	D (44.6)
Westbound *(Dylan Circle)*	L	C (31.6)	D (43.4)	D (43.4)
	TR	C (31.2)	D (42.9)	D (42.9)
	Overall	C (31.3)	D (43.0)	D (43.0)
Northbound *(North Main Street)*	L	A (5.9)	A (5.0)	A (5.0)
	T	A (7.4)	A (7.5)	A (7.5)
	R	A (4.5)	A (4.0)	A (4.0)
	Overall	A (7.2)	A (7.3)	A (7.3)
Southbound *(North Main Street)*	L	A (5.3)	A (3.5)	A (3.9)
	T	B (11.0)	A (8.3)	A (9.8)
	R	A (5.9)	A (4.1)	A (5.5)
	Overall	B (10.2)	A (7.7)	A (9.1)
Overall Intersection		**B (10.6)**	**B (10.7)**	**B (11.4)**

[1] Tier 1 northbound approach at the intersection of Main Street and Oakwood Drive does not have a designated right-turn lane. LOS and delay for the through and right-turn movement are shown on the through movement.
[2] Tier 2 northbound approach at the intersection of Main Street and Oakwood Drive does not have a designated right-turn lane. LOS and delay for the through and right-turn movements are shown on the through movement.
*HCM 2000 used to report delay given the limitations of HCM 2010 to evaluate non-standard intersections

Based upon the findings of the operational analysis, Tier 2 and Tier 3 both show significant reduction in delay at the intersection of Main Street and Oakwood Drive. Since the signal at Main Street and Old River Road/Dylan Circle is already proposed, it would be beneficial during the peak hour to explore the implementation of the Marshalls site access modifications. This would require coordination with Marshalls to ensure adequate alternate access accommodations are provided to Old River Road and that management and employees are informed of the change. There may also be a need to mitigate potential conflicts between departing passenger vehicles and arriving trucks. One potential option may be limiting or restricting truck access during this 45-minute timeframe.

Considering the cost associated with the Tier 3 analysis geometry, the Town may want to consider implementing only the site access modifications (Tier 2). As previously mentioned, if a budgeted traffic signal replacement is proposed at Oakwood Drive, the Town may want to reconsider lane reassignments at the intersection. **Figure 22** provides a high-level overview of the two lane reassignment strategies.

Main Street (VA 42) Corridor Study

Summary of Access Modifications at the Marshalls Distribution Center

Harrisonburg Rockingham Metropolitan Planning Organization

Kimley»Horn

EXISTING CONDITIONS

The afternoon shift change at the Marshalls Distribution Center generates a significant amount of turning traffic into and out of the site as compared to non shift-change periods. As a result, during the PM Peak hour there is heavy queueing at this intersection along Main Street. The current geometry in the northbound direction limits the amount of traffic that can be processed through the intersection (shared through and right-turn lane). Furthermore, the split phase operations of the signal requires that two signal phases operate to serve side street demand, stopping mainline traffic for an extended period of time, particularly during volume surges from the Marshalls Distribution Center.

PROJECT DESCRIPTION

Prohibit outbound traffic from the Marshalls Distribution Center during the shift change period (recommend the 3:00-4:00 PM timeframe on weekdays). Outbound traffic would circulate around the front of the site to the Chesapeake Avenue point of access. Existing vehicles would then turn onto Old River Road in order to access Main Street. This modification would allow the signal phase that serves the eastbound approach (i.e. Marshalls exit) to be omitted; thus, the signal would turn over more frequently, reducing delay for all movements.

Note: the analysis of this access modification assumed a traffic signal at Old River Road, which is expected to be installed in the next two years (see **Exhibit A**).

IMPLEMENTATION CONSIDERATIONS

- Static signs should be installed to indicate the egress restriction.
- Signal operations should be adjusted to omit the outbound vehicle phase during the recommended time interval.
- Staff should be educated about the operational change prior to implementation.
- A period of enforcement may be necessary to prohibit vehicles from attempting to exit at Oakwood Drive.
- It is recommended that delivery vehicle activity be suspended during this timeframe to limit the interaction of passenger vehicles and heavy vehicles at the Chesapeake Avenue point of access.
- The proposed traffic signal at Old River Road should be installed before this access modification is implemented.

PROJECT BENEFIT

This alternative is intended to improve signal operations at Oakwood Drive by distributing turning movements between two adjacent intersections. Separating ingress and egress has a secondary benefit to internal site circulation (directional flow of traffic through the site).

EXHIBIT A

CHANGE IN OVERALL INTERSECTION OPERATIONS

Peak Hour Delay (seconds per vehicle)
PM Peak Hour

Oakwood Drive

- Existing: D (38.4)
- Access Modification: B (16.3)

-22.1 s

Old River Road

- Existing (with signal): B (10.6)
- Access Modification: B (10.7)

+0.1 s

FIGURE 22

C. Signal phasing changes at Dinkel Avenue

The side street approaches at the intersection of Main Street and Dinkel Avenue operate split phased. This requires the accommodation of two signal phases for the side street within the signal cycle, which increases queuing and delay for Main Street. The existing turning volumes along the eastbound approach (7-11 driveway) are low, with less than 30 vehicles per hour turning in a given direction and a total approach volume of 72 during the PM peak hour. This translates to roughly 1 vehicle per minute arriving at the intersection. The existing intersection geometry does not require split phased operations (e.g. conflicting left-turn vehicle paths); therefore, to improve the efficiency of the intersection, permissive side street operations were considered.

A tiered operational analysis was completed for the change in intersection operations, first considering only a change in signal phasing. An additional level of analysis was completed considering the change in signal phasing as well as lane reassignments. The lane reassignment evaluated for both side street approaches was an exclusive left-turn lane and a shared through and right-turn lane. This change in lane assignments was considered given the proposed permissive operations of the left-turn movements. By isolating the lefts from the through movements, driver expectation is improved since left-turning vehicles will only have to look for opposing conflicts in the curb-side lane. In addition, through traffic will not be delayed by left-turning vehicles yielding to opposing traffic. This also has less of an impact on right-turn movements given that right turns on red are prohibited in all directions. A comparison of these tiered operational analyses is shown in **Table 12**. Detailed LOS and delay results are included in **Appendix D**.

Table 12: LOS Summary for Dinkel Avenue Signal Phasing Changes

Approach	Movement	PM Peak Hour LOS (Delay)		
9. North Main Street & Dinkel Ave (signalized)*		Existing	Signal Phasing Changes	Signal Phasing Changes and Lane Reassigment
Eastbound *(7-Eleven)*	LT/L[1]	D (41.3)	C (24.0)	C (22.1)
	R/TR[1]	D (38.4)	C (22.8)	C (21.5)
	Overall	D (40.3)	C (23.6)	C (21.8)
Westbound *(Dinkel Ave)*	LT/L[1]	D (37.1)	C (29.6)	C (25.2)
	R/TR[1]	C (32.5)	C (23.8)	C (22.8)
	Overall	C (34.8)	C (26.7)	C (23.7)
Northbound *(North Main Street)*	L	C (20.5)	B (14.9)	B (13.3)
	TR	C (28.7)	C (21.2)	B (18.9)
	Overall	C (28.1)	C (20.8)	B (18.5)
Southbound *(North Main Street)*	L	B (14.3)	A (9.1)	A (9.1)
	TR	C (23.9)	B (16.7)	B (17.3)
	Overall	C (21.6)	B (14.9)	B (15.4)
Overall Intersection		**C (27.9)**	**B (20.0)**	**B (18.7)**

[1] The existing conditions and phase change assumption considered approach lane assignments of LT and R while the phase change and lane reassignment considered approach lane assignments of L and TR for the side street approaches
*HCM 2000 used to report delay given the limitations of HCM 2010 to evaluate non-standard intersections

Based on the results of the analysis, modifying signal operations alone results in reduced delay for the overall intersection. In particular, the eastbound approach experiences a significant reduction in delay of more than 20 seconds. Considering the change in signal phasing and lane reassignment, there is a minimal change in delay as compared to signal phasing changes alone. Considering both improvement alternatives, all movements operate at LOS C or better.

Other improvements at the Intersection of Main Street and Dinkel Avenue were identified outside of the proposed change in signal operations. Turning maneuvers for tractor trailers to and from the north were observed to be challenging, potentially contributing to crash patterns at this intersection. A turning template of a WB-67 vehicle (large tractor trailer) was evaluated using AutoCad AutoTurn software. The turning template, illustrated in **Figure 23**, demonstrates that adjustments to existing stop bar locations are needed to accommodate the turning paths of heavy vehicles which frequent the Marshalls Distribution Center and the Perdue plant. Based on the results of the AutoTurn analysis, changing the location of the current stop bars will allow tractor trailers to make turns at this intersection more safely.

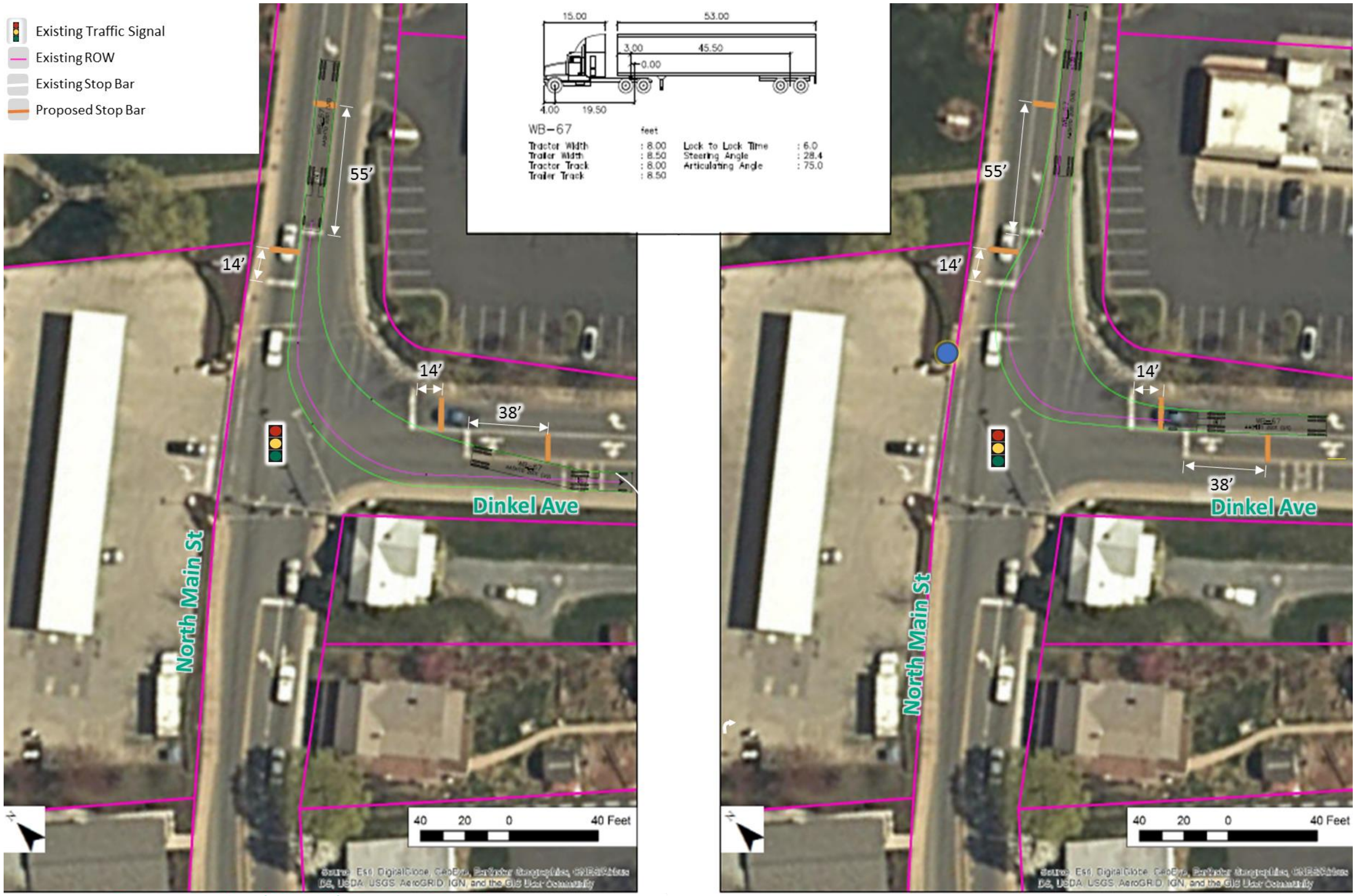
A queuing analysis was completed for the intersection to assess the potential spillback into the adjacent intersection at Green Street along with the shift in the stop bar locations for southbound Main Street. 95th percentile queue lengths were reported from Synchro for the existing signal operations and the two scenarios considering changes in signal phasing (see **Table 13**). As shown, the signal phasing adjustments reduce the queue lengths for all movements. However, by shifting the stop bar for the left-turn lane 55 feet, the effective 95th percentile queue length is 155 feet from the existing stop bar location. This distance is just shy of Green Street, which is 160 feet from the existing stop bar. Queuing impacts to Green Street operations are not expected.

Table 13: Summary of Southbound Main Street 95th Percentile Queue Lengths

Approach	Movement	PM Peak Hour 95th % Queue Length (feet)		
9. North Main Street & Dinkel Ave (signalized)		Existing	Signal Phasing Changes	Signal Phasing Changes and Lane Reassigment
Southbound *(Main Street)*	L	125	100	100
	TR	475	400	375

As noted in the field observations, sight distance of the signal along the northbound approach is limited due to the curvature in the roadway and overhanging tree canopy. A supplemental signal mounted to a new pedestal pole on the northwest corner is recommended to address the sight distance issue. Adding an additional signal display at this location will also give drivers better visibility of the signal control as they approach the intersection, which is also a safety benefit.

Figure 23: Dinkel Avenue Turning Template and Recommended Stop Bar Adjustments



Tractor-Trailer (WB-67) Turning Template
Southbound Left Turn onto Eastbound Dinkel Avenue

Tractor-Trailer (WB-67) Turning Template
Westbound Right Turn onto Northbound Main Street

A planning level estimate of probable cost was prepared for the pavement marking adjustments and signal modifications. Cost information was based upon current Staunton District average costs for pavement marking activities and signal equipment items published by VDOT. The low estimate presented in **Table 14** reflects the current District average costs for pavement marking activities and signal equipment items while the high estimate reflects a 20% increase in these costs.

A 25% construction contingency was applied to account for construction-related costs such as mobilization and maintenance of traffic. The cost presented in **Table 14** is an estimation for the change in signal phasing only. An incrementally higher cost can be expected to eradicate and reinstall arrow pavement markings assuming the lane reassignment in addition to the change in signal phasing. The arrow pavement marking adjustments are not included in the cost estimate since they are not recommended for immediate implementation as noted below. However, the cost to eradicate and replace each marking would be approximately $400.

Table 14: Cost Estimate for Dinkel Avenue Improvements

Improvement	Construction Activity	Low Estimate	High Estimate
Pavement Markings	Eradication of Pavement Markings	$ 200.00	$ 300.00
	Pavement Markings	$ 600.00	$ 700.00
Signal Modifications	Signal Displays, Signal Cable	$ 3,300.00	$ 4,000.00
	Pedestal Pole, Foundation, Conduit	$ 5,100.00	$ 6,100.00
	Construction Cost	$ 9,200.00	$ 11,100.00
	10% PE (Construction Cost)	$ 1,000.00	$ 1,200.00
	25% Construction Contingency (Construction Cost)	$ 2,300.00	$ 2,800.00
	TOTAL (rounded)	**$ 12,500.00**	**$ 15,100.00**

As shown in **Figure 8**, there are several crashes that were reported at the intersection of Main Street with Dinkel Avenue. There were three sideswipe crashes and four rear end crashes during the period between January 1, 2014 and December 31, 2016. The adjustment to stop bar locations has the potential to reduce the number of sideswipe crashes given that heavy vehicles will be provided the space necessary to complete turning maneuvers. Changes in signal operations are expected to reduce delay, thereby reducing the amount of time vehicles are stopped at the intersection. This could subsequently reduce the potential for rear end crashes. It should be noted that the shift in the southbound stop bar locations relative to Green Street and commercial driveway entrances may change driver expectation. It could also make access to commercial driveways challenging when vehicles are queued. The Town should monitor operations once stop bar locations are adjusted and consider turn restrictions if dangerous conditions are observed at the El Charro restaurant entrance.

Figure 24 provides a high-level overview of the recommended improvements at Dinkel Avenue. The lane reassignments are not shown since they are not recommended as an immediate improvement. Rather, it is recommended that the Town consider a phased implementation of the improvements. There are apparent safety and operational benefits and a relatively low implementation cost for the stop bar adjustments and signal phasing changes. The Town may want to consider a trial implementation of the signal phasing changes, installing "New Traffic Pattern Ahead" signs on the eastbound and westbound approaches. After a period of observation, a decision could be made whether to implement the identified lane reassignments. Regardless, the Town should adjust the stop bar locations as soon as possible to reduce the potential vehicle conflicts with turning tractor trailer vehicles.

Main Street (VA 42) Corridor Study

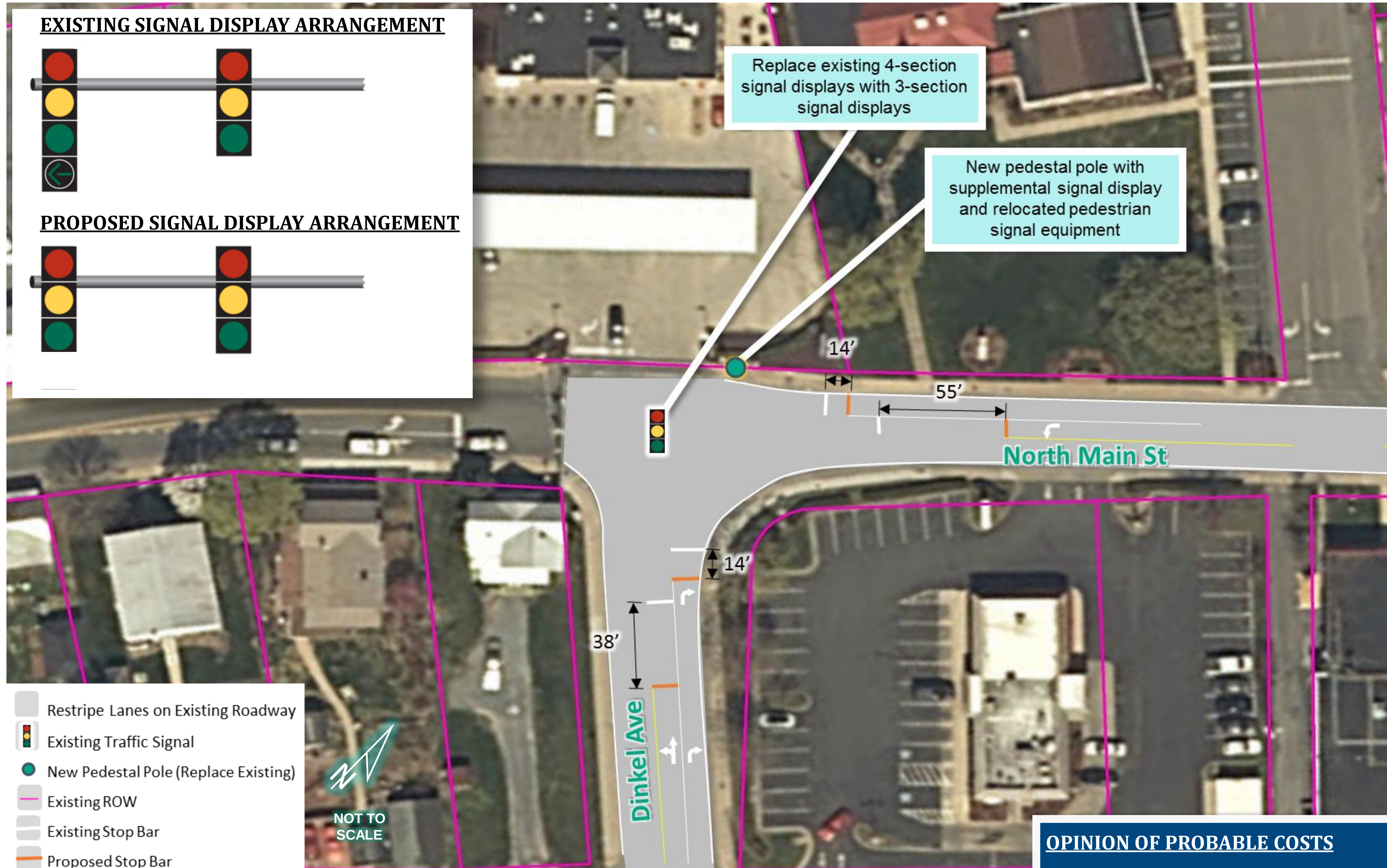
Summary of Dinkel Avenue Improvements

Harrisonburg Rockingham Metropolitan Planning Organization

Kimley»Horn

EXISTING CONDITIONS

Dinkel Avenue is a principal arterial that serves as a primary point of access to the Town of Bridgewater from the east. At its intersection with Main Street, it processes a lot of turning movements to and from the east. In addition, through movements along Main Street also account for a large proportion of intersection traffic. As a result, the intersection operates with increased delay during the PM peak period and there is significant queueing at this intersection along Main Street. The current geometry along the northbound approach includes a horizontal curve, which contributes to the poor sight distance of the traffic signal for approaching vehicles. The existing stop bars for the southbound approach on Main Street and the westbound approach on Dinkel Avenue position vehicles stopped at the intersection in the path of turning vehicles, particularly tractor trailers. As a result, there are frequent instances where stopped vehicles must maneuver out of the path of turning trucks to avoid a collision.



PROJECT DESCRIPTION

To reduce intersection delay, it is recommended that the existing side street split phase operations be modified to operate with concurrent permissive side street left-turn movements.

To address turning conflicts, new stop bar locations are proposed for the southbound approach on Main Street and the westbound approach at Dinkel Avenue. Based upon a turning template of a typical tractor trailer that travels through the intersection, recommendations for new stop bar locations were identified.

To address sight distance issues, a supplemental signal display for the northbound approach is proposed on the northwest corner.

OPINION OF PROBABLE COSTS

Low Cost:	$12,500
High Cost:	$15,100

DESIGN CONSIDERATIONS

- A new pedestal pole will be required to accommodate the proposed supplemental signal display (can be installed at the same location as the existing pole). A new pole is required to provide additional mounting height and be able to locate the pedestrian signal at the proper height above the sidewalk.
- Existing turning movement arrows as well as lane lines located currently marked beyond the proposed stop bars will need to be removed.

PROJECT BENEFIT

Drivers can expect reduced delays given the recommended signal phasing changes at the intersection. Because the side street approaches will operate concurrently, the signal will be able to turn over more frequently, which contributes to the reduction in delay. The proposed changes in stop bar locations will facilitate turning movements for tractor trailers, enhancing the safety of all users as the potential for conflicts is reduced. By adding another signal head on the northwest corner of the intersection, the northbound approach along Main Street will be able to see the signal display earlier and have more time to react accordingly before reaching the intersection.

CHANGE IN OVERALL INTERSECTION OPERATIONS

Peak Hour Delay (seconds per vehicle)
PM Peak Hour

- Existing: C (27.9)
- Proposed: B (20.0)

-7.9s

FIGURE 24

D. Oakwood Drive Extension

An alternative truck route was initially considered to prohibit heavy vehicles destined to or originating from Dinkel Avenue and points to the east (i.e. I-81, Route 11) from using Main Street through the Town of Bridgewater. The alternative truck route would require heavy vehicles to use Oakwood Drive instead of Dinkel Avenue, thereby removing truck traffic from an approximately one mile stretch of Main Street. Prior to conducting an operational analysis, traffic data was reviewed to identify the volume of trucks that might be rerouted. Considering the volume of heavy vehicles among the southbound left-turn and westbound right-turn movements at Dinkel Avenue, the numbers of trucks that would be rerouted is minimal (less than 10 during the PM peak hour). In the absence of origin-destination data, it's unclear if these trucks represent through trips to and from the north of Bridgewater or local trips to and from the Perdue plant and Marshalls Distribution Center. Regardless, the impact on traffic operations of a potential truck restriction was expected to be minimal given the relatively low hourly volume of trucks.

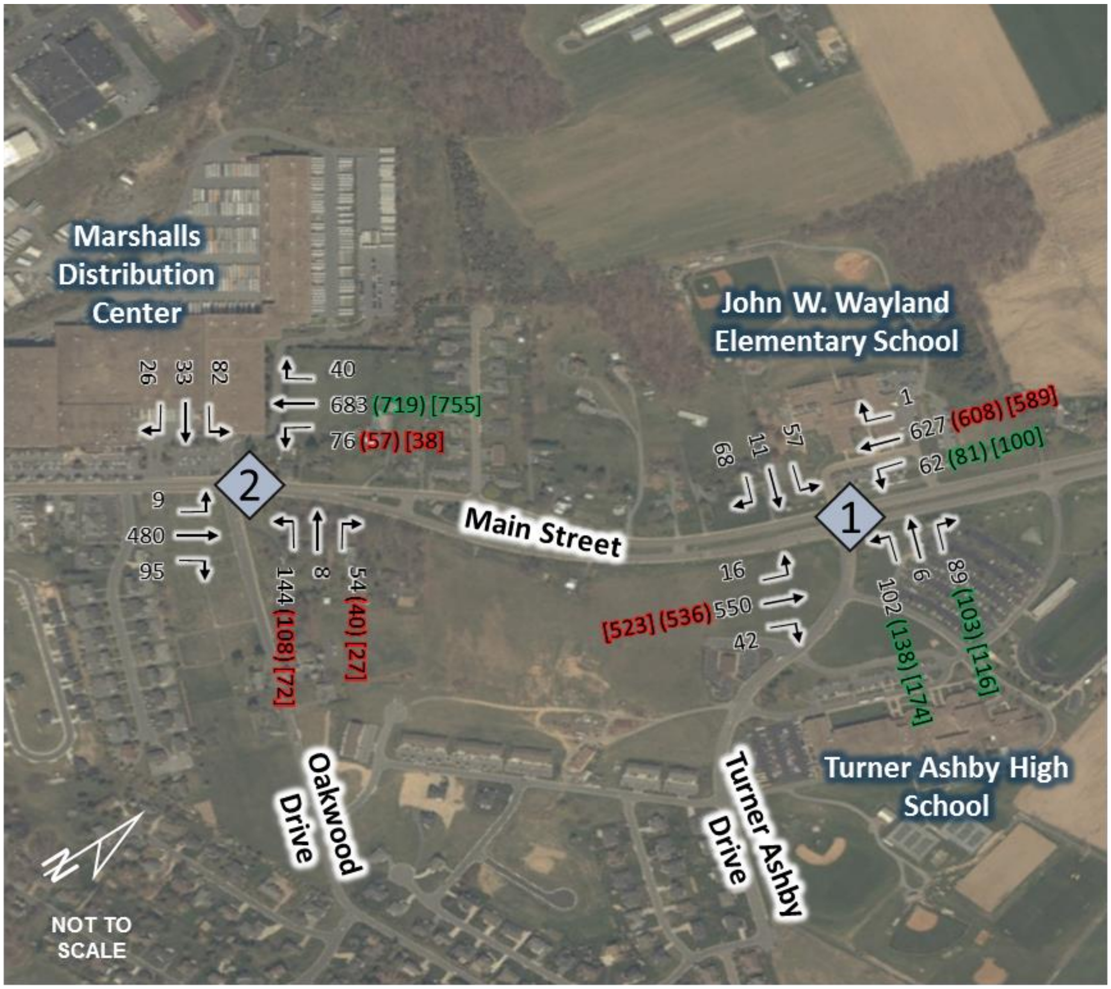
In lieu of evaluating an alternative truck route, an analysis was conducted of the intersections at Oakwood Drive and Turner Ashby Drive assuming the construction of the Oakwood Drive Extension. This extension of Oakwood Drive would link the easternmost terminus of Turner Ashby Drive to Oakwood Drive, tying into the existing alignment in the vicinity of Weeping Willow Lane. The planned extension would reconfigure Oakwood Drive such that the through movements would be to and from the proposed extension, while turning movements would be necessary to access the western segment of the existing Oakwood Drive alignment. In doing so, the Oakwood Drive extension becomes a more attractive route, resulting in some trips continuing along Turner Ashby Drive in order to access Main Street.

Two scenarios were evaluated for the Oakwood Drive Extension. Both scenarios considered a shift in traffic from the westernmost segment of Oakwood Drive to the Oakwood Drive extension given the attractiveness of the proposed connection. This shift affected the westbound left and right-turn movements as well as the southbound left-turn movement at the intersection of Main Street and Oakwood Drive. Scenario One considered a 25% shift of these turning movements to the new extension, while Scenario Two considered a 50% shift in traffic. **Figure 25** provides a summary of existing turning volumes at the two intersections as well as the turning volumes of movements affected by the shift in traffic for the two scenarios.

Table 15 shows the results of the operational analysis of PM peak hour conditions considering existing conditions and the two traffic shift scenarios described above at the intersection of Main Street and Oakwood Drive as well as the intersection of Main Street and Turner Ashby Drive. The analysis shows a nominal reduction in delay at the intersection of Main Street and Oakwood Drive for both scenarios. At Turner Ashby Drive, a nominal increase in delay is shown with the increased demand among the southbound left and westbound turning movements. Detailed LOS and delay results are included in **Appendix D**.

The impact of this shift in traffic is increased demand for signal green time at Turner Ashby Drive. Since the signal operates actuated in an uncoordinated system, this increased demand effectively lengthens the signal cycle length, thereby increasing the delay for all movements on all approaches. The results of this analysis indicate that the construction of the Oakwood Drive extension will have minimal impact on corridor operations, with roughly equal but opposite impacts on intersection operations at Turner Ashby Drive and Oakwood Drive.

Figure 25: Estimated PM Peak Hour Volumes with Oakwood Drive Extensions



Legend

Table 15: LOS Summary for Oakwood Drive Extension Scenarios

Intersection		PM Peak Hour LOS (Delay)		
Approach	Movement			
1. North Main Street & Turner Ashby Drive (signalized)*		**Existing**	**Scenario 1**	**Scenario 2**
Eastbound *(John Wayland ES)*	L	D (45.3)	D (52.1)	E (56.1)
	TR	D (40.8)	D (46.1)	D (49.2)
	Overall	D (42.7)	D (48.6)	D (52.1)
Westbound *(Turner Ashby Drive)*	LT	D (42.6)	D (47.7)	D (50.9)
	R	D (35.7)	D (37.3)	D (37.0)
	Overall	C (30.8)	D (43.4)	D (45.4)
Northbound *(North Main Street)*	L	E (59.3)	E (67.0)	E (62.2)
	T	C (26.6)	C (31.5)	D (35.8)
	R	C (20.7)	C (24.7)	C (28.1)
	Overall	C (27.1)	C (32.0)	D (35.9)
Southbound *(North Main Street)*	L	D (50.3)	D (52.2)	E (56.8)
	TR	C (22.7)	C (24.4)	C (27.9)
	Overall	C (25.1)	C (27.6)	C (32.1)
Overall Intersection		**C (30.7)**	**D (35.1)**	**D (39.1)**
2. North Main Street & Oakwood Drive (signalized)*		**Existing**	**Scenario 1**	**Scenario 2**
Eastbound *(Marshalls Distribution Center)*	L	D (51.8)	D (51.1)	D (47.3)
	TR	D (45.1)	D (44.1)	D (41.3)
	Overall	D (49.0)	D (48.2)	D (44.8)
Westbound *(Oakwood Drive)*	LT	D (49.7)	D (48.4)	D (50.0)
	R	D (40.3)	D (41.2)	D (42.7)
	Overall	D (47.2)	D (46.5)	D (48.1)
Northbound *(North Main Street)*	L	C (22.6)	C (21.6)	B (19.3)
	TR	D (38.3)	C (32.5)	C (24.4)
	Overall	D (38.1)	C (32.3)	C (24.3)
Southbound *(North Main Street)*	L	C (20.6)	B (17.8)	B (14.4)
	T	D (35.3)	C (35.0)	C (32.1)
	R	B (15.1)	B (13.7)	B (11.8)
	Overall	C (32.9)	C (32.7)	C (30.3)
Overall Intersection		**D (38.4)**	**D (36.0)**	**C (31.5)**

*HCM 2000 used to report delay given the limitations of HCM 2010 to evaluate non-standard intersections

E. Coordinated Signal Operations along Main Street

The existing traffic signals along the Main Street corridor operate as actuated intersections, providing green time to each approach based on varying vehicular demand each signal cycle. While this provides the most responsive signal operations at the intersection level, it does not benefit through travel which account for approximately 70% of vehicles along the corridor. Coordinated signal timings can provide a benefit to corridor progression by operating a consistent cycle length at all traffic signals, thereby allowing for a consistent trip along the corridor from end to end. The intent of this improvement strategy was to synchronize signal operations during the PM peak period only and improve progression, with the end goal of reducing travel times along the corridor.

Coordinated signal timings for the corridor were developed by first selecting a common cycle length. Existing signal phasing, geometry, and volumes were considered when selecting a cycle length that would accommodate all intersections and allow room for sufficient green time along Main Street to provide bidirectional progression. A relatively low cycle length of 100 seconds was selected, which provides sufficient time for progression while minimizing side street delay. After selecting a cycle length, green time at each intersection was allocated to meet volume demand and balance delay for all movements, with a preference given to mainline through movements. The last step in the analysis was adjusting the signal offsets (or cycle turnover point), which is the means through which signal coordination between intersections is achieved.

A few network assumptions were made to best represent anticipated corridor operations in a coordinated environment:

- Traffic signal at Old River Road with protected-permissive mainline left turns (consistent with North Main Street Corridor Improvements)
- Protected-permissive (Flashing Yellow Arrow) southbound left turn and permissive only northbound left-turn phasing at Mt. Crawford Avenue (consistent with recent VDOT study)
- The signal at College Street was programmed to operate at half the cycle length of the remainder of the corridor (50 seconds). The two-phase signal requires less cycle time to serve demand and will operate more efficiently at 50 seconds, while still providing coordination with the signal at Dinkel Avenue to the north.
- Exclusive pedestrian phases at Dinkel Avenue and Mt. Crawford Avenue were eliminated. In lieu of these exclusive signal phases, leading pedestrian intervals were programmed for the crosswalks across Main Street at both intersections. This modification in operations was made to balance vehicular operations and pedestrian access. The leading pedestrian interval of seven seconds provides dedicated time for pedestrians to enter the crosswalk without any vehicular movements occurring. This increases their visibility to turning vehicles, which are permitted to turn on green during the subsequent vehicle phase which will overlap with the pedestrian clearance interval.

A comparison between the actuated-uncoordinated existing conditions and the proposed coordinated signal operations is shown in **Table 16** and **Table 17** below. The results shown are based on outputs from the PM peak hour Synchro models and the speeds reported are estimated based on the Synchro Arterial LOS report.

Table 16: Northbound Travel Time and Speed Comparison (Actuated vs. Coordinated Signal Operations)

Cross Street	Travel Time (seconds)		Space Mean Speed (mph)	
	Existing	Coordinated	Existing	Coordinated
E. College St	38.2	36.7	22.5	23.4
Dinkel Ave	56.8	44.6	10.1	12.9
Mt. Crawford Ave	65.3	46.4	16.1	22.7
Old River Road*	-	50.0	-	25.8
Oakwood Drive	108.4	39.3	17.1	14.3
Turner Ashby Dr	70.0	53.6	21.7	28.3
Total Travel Time / Corridor Space Mean Speed	338.7	270.6	17.3	21.6

*Coordinated signal operations account for proposed signal at Old River Road. Existing travel time and speed reported for entire segment between Mt. Crawford Avenue and Oakwood Drive.

Table 17: Southbound Travel Time Comparison (Actuated vs. Coordinated Signal Operations)

Cross Street	Travel Time (seconds)		Space Mean Speed (mph)	
	Existing	Coordinated	Existing	Coordinated
Turner Ashby Dr	37.0	34.9	12.2	12.9
Oakwood Dr	75.4	60.7	20.1	25.0
Old River Road	-	22.4	-	25.1
Mt. Crawford Ave*	65.8	47.4	28.1	27.2
Dinkel Ave	64.6	61.8	16.3	17.0
E. College St	31.0	27.7	18.6	20.8
Total Travel Time / Corridor Space Mean Speed	273.8	254.9	19.9	21.4

*Coordinated signal operations account for proposed signal at Old River Road. Existing travel time and speed reported for entire segment between Oakwood Drive and Mt. Crawford Avenue.

The results of the analysis of coordinated signal operations indicate there is potential to reduce travel times along the corridor. Peak-direction (southbound) travel times would be reduced by approximately 20 seconds, while travel times in the opposite direction (northbound) would be reduced by nearly 70 seconds. Synchro outputs with the signal timing parameters assumed in the analysis and the Arterial LOS are provided in **Appendix D**.

Coordinated signal operations were identified as a congestion mitigation strategy for afternoon operations when traffic volumes are highest. Outside of afternoon congestion, coordinated signal operations may not be necessary and signals could operate based on actual demand. A review of daily traffic volumes along the corridor was completed to determine appropriate timeframes for coordinated signal operations. **Figure 26** summarizes the average daily traffic volume along Main Street based upon traffic data collected by VDOT 2015 and 2016. As shown, volumes are highest between 4:00 PM and 6:00 PM. The next highest period of traffic along Main Street is between 8:00 PM and 9:00 PM, followed by the two-hour period between 12:00 PM and 2:00 PM. These periods could also be considered for coordinated signal operations. It is recommended that signals operate actuated-uncoordinated outside of these timeframes.

Given the plot of mainline traffic volumes, it can be noted that volumes along Main Street are not as high during the 3:00 PM hour; however, turning volumes to and from the side street are higher during this timeframe. The higher turning volumes is what drives the need for coordination between signalized intersections. Signal delay is greater for the mainline as these heavy movements are served. By providing coordination, delay for mainline through movements can be reduced by controlling the progression along the corridor. Thus, afternoon coordination is recommended between 3:00 PM and 6:00 PM.

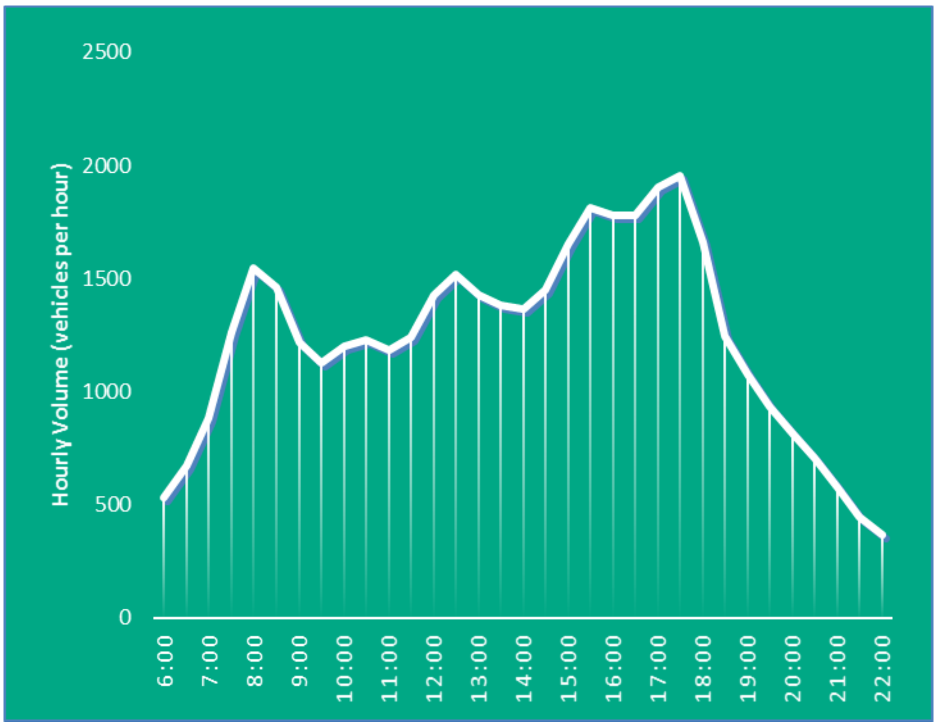


Figure 26: Main Street Average Daily Traffic Volumes

While the results of the analysis suggest these parameters would significantly improve corridor operations, it is recommended that the Town consider a more holistic evaluation of coordinated signal operations considering other timing plans that may be of value (i.e. AM and midday peak hour), field implementation, and determination of any limitations of existing signal equipment. In addition, the absence of signal communications infrastructure between intersections would result in the coordinated signal operations falling out of sync over time due to controller internal clock drift. This could have a detrimental impact on coordinated operations along the corridor. The Town may consider installing cost effective GPS time source devices at each signal to allow the controller clocks to reset consistent with one another in order to reduce the impact of clock drift.

4. Recommendations

The corridor improvement strategies evaluated as part of this study were identified to improve operations and enhance safety for all travel modes. While some of the strategies were found to offer minimal operational benefits, several have the potential improve local intersection and corridor operations as well as increase safety. It is recommended that the Town identify funding strategies to accomplish the improvements before moving forward with an implementation plan. Annual operations and maintenance budgets may be able to accommodate the pavement marking recommendations, including the stop bar adjustments and signal head replacements at Dinkel Avenue. For other improvements, such as the supplemental signal at Dinkel Avenue, sidewalk ramp replacements, and implementation of coordinated signal timings, funding for these relatively low-cost corridor enhancements could be secured through state funding programs like Smart Scale and HSIP.

With respect to the Marshalls Distribution Center, this will require coordination with facility management to implement the site access modifications. This will likely be a process that requires coordination meetings to demonstrate the benefits, education of the employees on the planned changes, and perhaps a trial period to evaluate the actual benefits. The analysis presented in this study assumed a traffic signal at Old River Road. Without the signal, this may not be a viable option given the significant side street delay that exists at the intersection today. Since the signal is expected to be in place within the next two years, it is recommended that the Town begin coordination with Marshalls now to determine a path forward to implement this modification.

Below is an overall summary of the recommendations and a general timeframe for implementation:

Short-Term (3 to 6 months)

- Identify funding for recommended improvements
- Begin coordination with Marshalls
- Signal phasing change at Dinkel Avenue
- Stop bar adjustments at Dinkel Avenue
- Left-turn signal phasing adjustments at Mt. Crawford Avenue (Flashing Yellow Arrow as recommended by VDOT)

Mid-Term (6 to 18 months)

- Supplemental signal and pavement marking adjustments at Dinkel Avenue
- Coordinated signal operations along Main Street
- Sidewalk, curb ramp, pavement marking, and vehicular and pedestrian signal head improvements along the corridor (see **Table 8**)

Long-Term (18+ months)

- Signal installation at Old River Road (to be done by others)
- Marshalls Site Access Modifications
- Signal replacement at Oakwood