Route 1 (Jefferson Davis Highway) Corridor Study

Mine Road to Market Street

Spotsylvania County, Virginia

Final Report

STARS VDOT

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Mine Road to Market Street
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1 Introduction

1.1 Background

The Virginia Department of Transportation Fredericksburg District Office (VDOT), VDOT Transportation Mobility and Planning Division (TMPD), Spotsylvania County and the Fredericksburg Area Metropolitan Planning Organization (FAMPO) identified the need to evaluate existing and future conditions along the Route 1 corridor. This STARS corridor study focuses on evaluating the Route 1 corridor from Mine Road to Market Street, assessing measures to reduce congestion, and recommending possible spot improvements to address congestion and safety issues.

Route 1 is a critical north-south route in Spotsylvania County and is a component of the Corridor of Statewide Significance Corridor K. This section of Route 1 also acts as an incident management alternative for I-95. Traffic in the subject area frequently operates in a congested state. Both AM and PM weekday peak periods are problematic, as are Sunday peaks. The corridor has developed over the course of decades without a unifying plan to promote and preserve mobility and to control access, to the detriment of motorists, pedestrians and businesses. Spotsylvania County plans to perform a corridor revitalization study of this area in the near future.

This corridor serves both local and regional travel and has three signalized intersections at Mine Road, Market Street and at the northbound on-ramp to I-95. Weekday PM peak hour volumes in the northern portion of the corridor are approximately 2,200 vehicles per hour while at the southern end of the corridor PM peak hour volumes approach 3,500 vehicles per hour. Historical data shows that traffic levels have been increasing over the past five years by approximately 3% per year. These traffic levels result in congested operating conditions and vehicle delay on a daily basis, which can be further exacerbated by traffic diverting from I-95 due to incidents or high weekend travel during the summer months and holidays.

Apart from the challenges presented by peak period traffic flows, access management to adjacent properties has evolved over time such that there are multiple driveways with direct access to Route 1. Accordingly, this study will examine current access to Route 1 and recommend measures to improve the mobility and safety of people accessing properties and businesses along the corridor.

An analysis of safety-related conditions will also be an important element of this study. Crash data and field reviews will identify safety concerns, with mitigation strategies and actions to be recommended.

1.2 Purpose of Study

The primary goal of this study is to determine and assess measures to reduce congestion, recommend possible adjustments to signal phasing and/or spot improvements to alleviate congestion and address safety as well as access management issues.

The operational issues intended to be addressed by this study include existing and future projected congestion within the corridor. This congestion is centered at the major intersections within the corridor primarily during the PM peak hour, which are currently heavily utilized by passenger cars and some truck traffic. Reduction in intersection delays would mitigate congestion, improve mobility and reduce travel time.

This study also intends to address existing and future safety concerns within the study corridor. During the recent five-year period, 291 crashes resulting in 63 visible injuries, were reported within this corridor. The types of crashes frequently reported include rear-end, angle crashes, and sideswipe – same direction. These crash types are typically associated with recurring congestion and intersection conflict points along a corridor. Reduction in congestion along the corridor or reducing conflict points may have a corresponding safety benefit, in terms of reduction in number of crashes along the corridor.

Route 1 serves a mix of commercial, retail, residential and institutional uses. This study also intends to address access deficiencies within the limits of the study corridor by identifying and documenting driveway locations and their spacing, with the objective of recommending access management improvements in the context of VDOT Access Management Standards for Entrances and Intersections.

1.3 Study Work Group

The Study Work Group (SWG) includes local stakeholders, who provide local and institutional knowledge of the corridor, review study goals and methodologies, provide input on key assumptions, and review and approve proposed improvement concepts developed through the study process. The key members included in the SWG represent the following agencies:

- VDOT Fredericksburg Office and TMPD
- Fredericksburg Area Metropolitan Planning Organization (FAMPO)
- Spotsylvania County

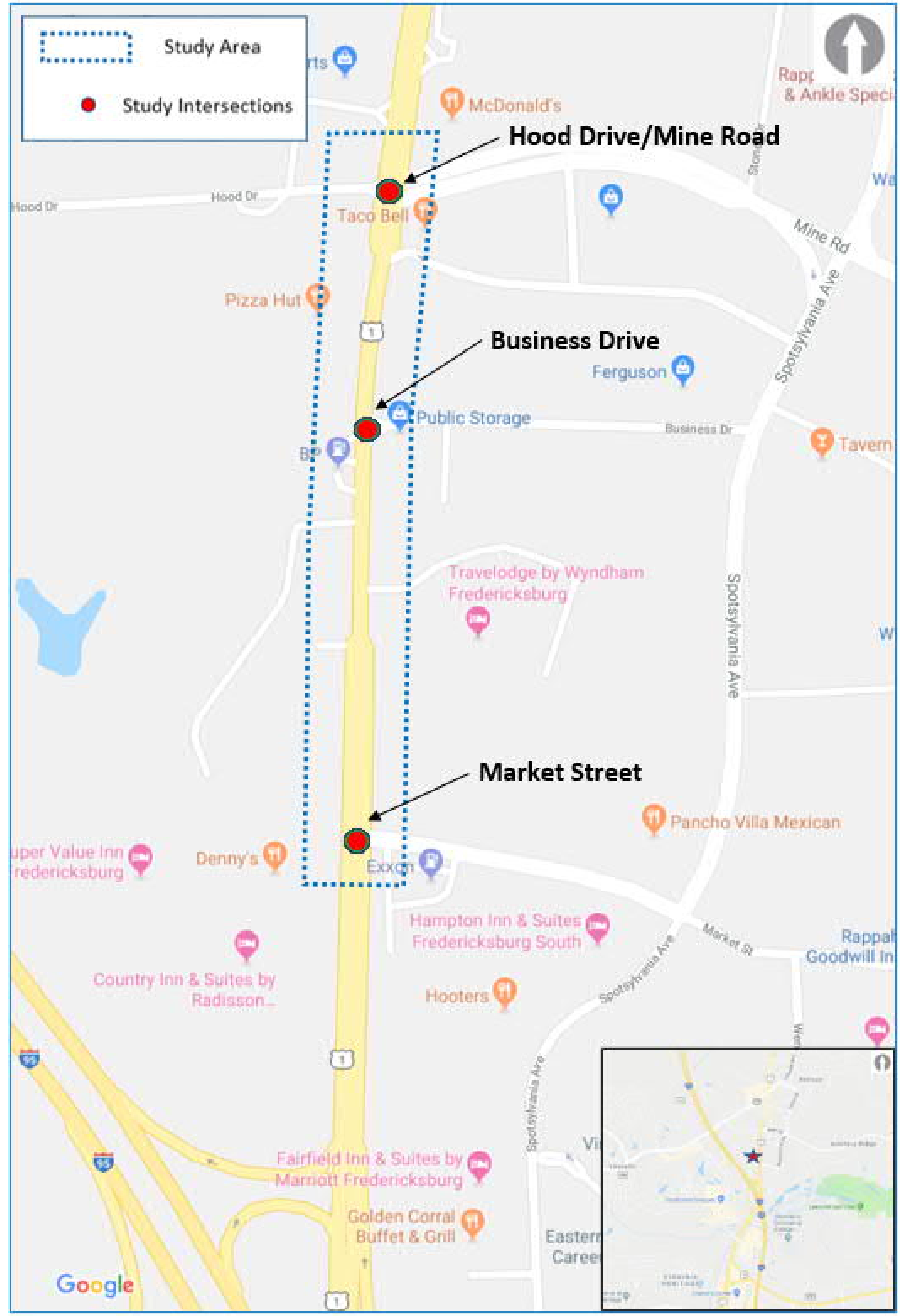
1.4 Study Area

This section of Route 1 is located within Spotsylvania County, Virginia. This north-south corridor is approximately 0.9 miles in length and includes three (3) study intersections. These study intersections are listed below and shown in Figure 1.

Study Area Intersections

1. Route 1 and Mine Road
2. Route 1 and Business Drive
3. Route 1 and Market Street

Figure 1. Study Area Map



2 EXISTING CONDITIONS

2.1 Existing Zoning and Future Land Use

A review of existing zoning and future land use plans was conducted for the areas adjacent to the Route 1 corridor. The existing zoning classification includes a range of zones including primarily, C-3 (Commercial 3), M-1 (Mixed-Use 1); and to a lesser extent, R-1 (Agricultural), R-2 (Residential), C-2 (Commercial 2), and O-1 (Office 1). Future land uses along the study corridor includes Commercial Land Use, Mixed Land Use, Open Space, Employment Centers, and Institutional.

2.2 Existing Roadway Network

An inventory of existing roadway conditions was prepared along Route 1 based on field reviews. Traffic, crash and Geographic Information System (GIS) data was used to document existing conditions. During the field review, the following data was collected and documented:

Digital photographs, videos, and observations to capture:

- Roadway geometry to include lane configuration, lane/shoulder widths
- Signs and pavement markings
- Posted speed limits
- Sight distance issues
- Safety concerns
- Existing driveway locations, their spacing and potential impact on crashes
- Observation of traffic operations (traffic mix, congestion, driver behavior)
- Inventory of existing roadway conditions to determine potential for safety improvements
- Inventory of intersection operations (signal phasing, queuing)

The study corridor includes two (2) signalized intersections and one (1) unsignalized intersection as discussed in Sections 2.2.1 through 2.2.4 below:

2.2.1 Route 1 Corridor

Route 1 in this portion of Spotsylvania County from north of Mine Road to Market Street is classified as Other Principal Arterial Highway per VDOT Functional Classification. Within the study area, Route 1 is a 4-lane undivided roadway with a two-way left turn lane throughout the corridor. The posted speed limit is 35 miles per hour along the corridor. Pedestrian facilities such as sidewalks and pedestrian crossing signals with ADA ramps are not currently present along the corridor; however, VDOT is considering improvements to the Market Street intersection that would include pedestrian improvements. No dedicated bike facilities are present within the study corridor.

2.2.2 Intersection 1: Route 1 at Mine Road

Mine Road and Hood Drive are classified as Major Collectors per VDOT Functional Classification. The intersection of Route 1 at Mine Road / Hood Drive is a 4-leg signalized intersection. The posted speed limits for Mine Road and Hood Road are 35 miles per hour. The northbound approach of Route 1 has one left-turn lane, two through lanes, and one right-turn lane. The southbound approach has one left-turn lane, two through lanes, and one right-turn lane. The eastbound approach of Hood Road has one shared left-thru lane and one right-turn lane. The westbound approach of Mine Road has one left-turn lane, one shared left-thru lane, and one right-turn lane. The signal operations include permitted-protected left turns for the northbound and southbound approaches and split phasing for the eastbound and westbound approaches. The northbound/southbound through movements are coordinated with adjacent signalized intersections. Pedestrian facilities (crosswalks, pedestrian signals) are not currently present at the intersection. Figure 2 shows an aerial view of the intersection.

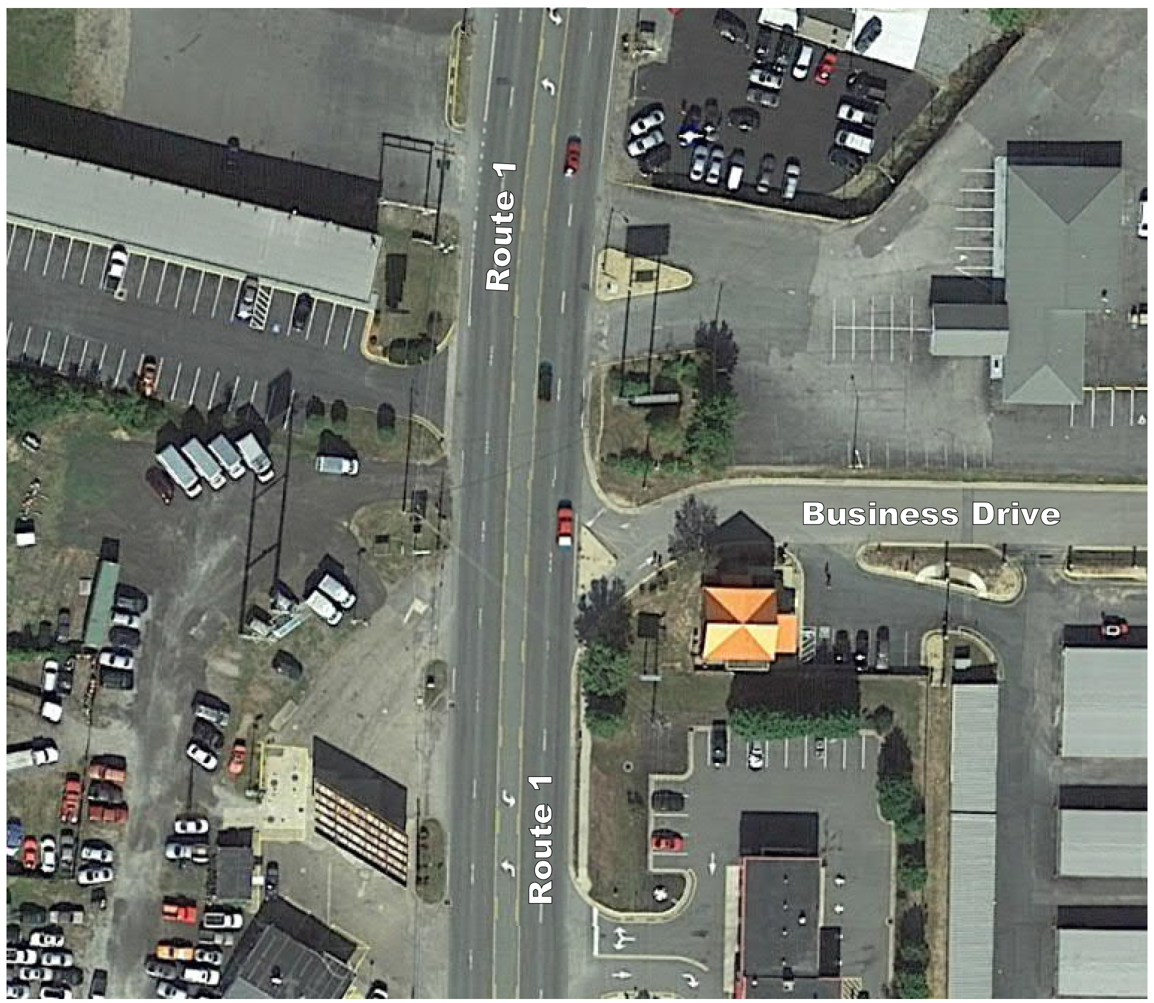
Figure 2: Route 1 at Mine Road

Source: Google Imagery

2.2.3 Intersection 2: Route 1 at Business Drive

The intersection of Route 1 at Business Drive is a 4-leg unsignalized intersection. There is no posted speed limit along Business Drive. The northbound and southbound approach of Route 1 are free-flow, while the eastbound and westbound approaches of Business Drive and the Gas Station Entrance are stop-controlled. Business Drive is a private road. The northbound approach of Route 1 has one two-way-left-turn-lane (TWLTL), one through lane one and one shared thru-right lane. The southbound approach has one TWLTL (left-in to Business Drive prohibited), one through lane and one shared thru-right lane. The eastbound approach of the Gas Station Entrance has one shared left-thru-right lane. The westbound approach of Business Drive is right-in/right-out only with a channelized right-turn lane. Pedestrian facilities (crosswalks, pedestrian signals) are currently not provided at this intersection. Figure 3 shows an aerial view of the intersection.

Figure 3: **Route 1** at Business Drive



Source: Google Imagery

2.2.4 Intersection 3: Route 1 at Market Street

Market Street is classified as a Major Collector per VDOT Functional Classification. The posted speed along Market Street is 35 miles per hour. The northbound approach of Route 1 has one left-turn lane, two through lanes, and one right-turn lane. The southbound approach has one left-turn lane, one through lane, and one shared thru-right lane. The eastbound approach of Market Street has one shared left-thru-right lane. The westbound approach has one left-turn lane and one shared left-thru lane, and one right-turn lane. The signal operations include permitted-protected left turns for the northbound and southbound approaches and split phasing for the eastbound and westbound approaches. The northbound/southbound through movements are coordinated with adjacent signalized intersections. Pedestrian signals are present across the north leg of the intersection. Figure 4 shows an aerial view of the intersection.

Figure 4: Route 1 at Market Street

Source: Google Imagery

2.3 Traffic Data

2.3.1 2018 Existing Traffic Volumes

Turning movement counts from 2017 were obtained from VDOT Fredericksburg District at the following intersection locations. The volumes were grown to 2018 using an Average Annual Growth Rate (AAGR) of 2%, which was provided by the District.

- Route 1/Mine Road
- Route 1/Market Street

In addition to analyzing weekday AM and PM peak hours, this study also analyzed a Sunday peak hour. One of the goals of this study was to analyze a Sunday peak hour that would be reflective of summer Sunday volume levels; however, given the timeframe of this study it was not possible to wait until Summer 2019 to perform the traffic counts. Instead, counts were collected on the Sunday of Thanksgiving week and then factored up based upon I-95 count station data that showed that the Thanksgiving Sunday traffic volume levels were 92% of typical Sunday volumes during July and August 2018. The Thanksgiving Sunday northbound and southbound through volumes were therefore factored up by 8% to be reflective of summer Sunday traffic volumes.

Existing traffic volume data along the study corridor was collected in November 2018:

- 8-hour turning movement classification counts were collected on a typical weekday from 6:30 am – 10:30 and 3:30 pm – 7:30 pm at the following intersections:
  - Route 1/Business Drive (only thru movements were counted along Route 1)
  - Route 1/1-95 NB Ramp
- 6-hour turning movement classification counts were collected on the Sunday after Thanksgiving from 2:00 pm to 8:00 pm at the following intersections. These mainline through volumes were then grown by 8% to reflect a typical weekend summer day:
  - Route 1/Mine Road
  - Route 1/Business Drive
  - Route 1/Market Street
  - Route 1/1-95 NB Ramps

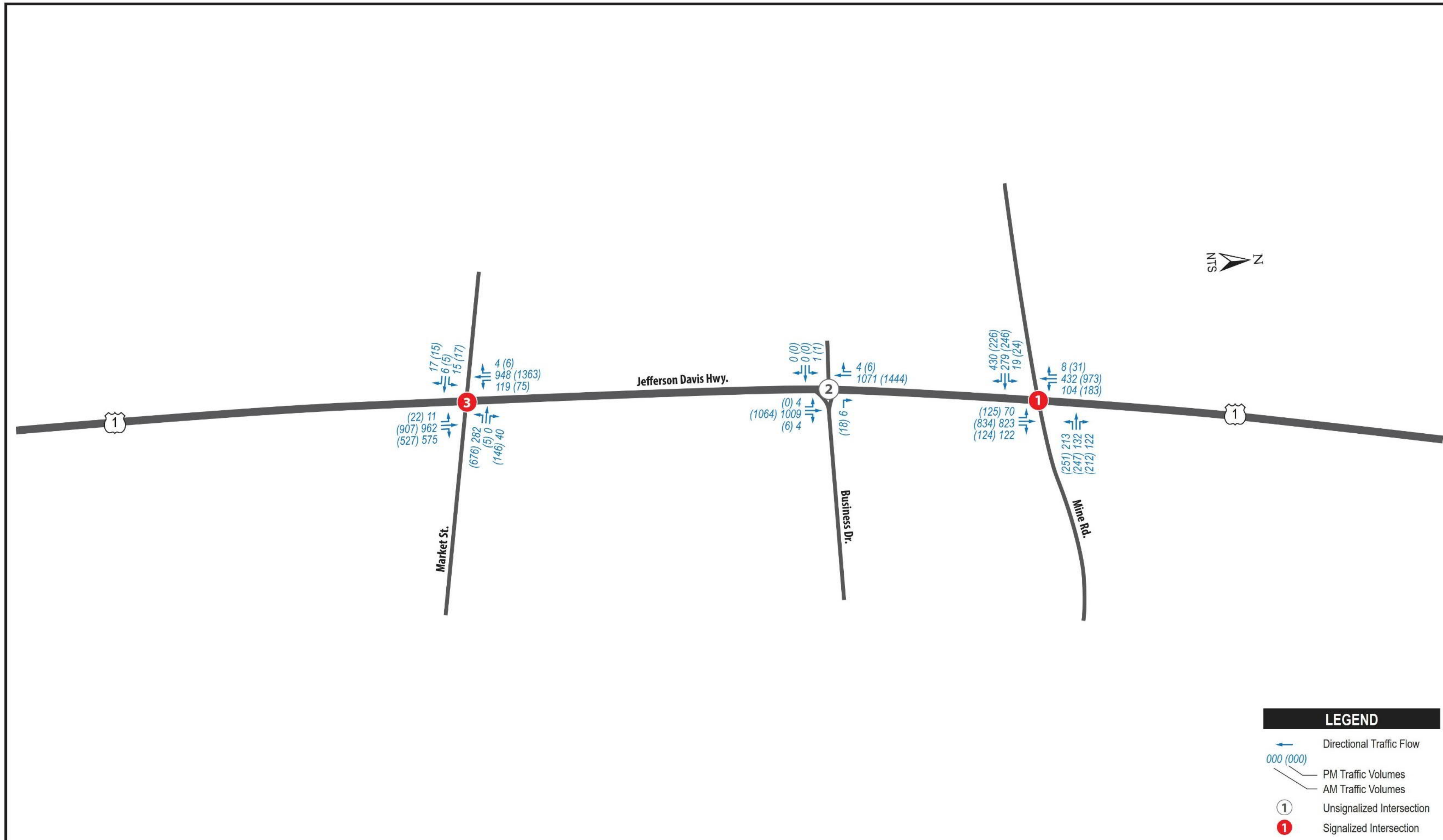
The field counts are provided in the Appendix. The existing (2018) peak hour volumes are summarized in Figures 5 and 6.

2.3.2 Additional Data

In addition to traffic volumes, the following supplemental data was collected to support this study:

- Queue length measurements at selected signalized study area intersections to be used in the calibration of the existing Synchro/Simtraffic model.
- Peak period travel time runs for the entire corridor.
- Crash data from the last five years to perform the crash analysis.
- Signal timing data from the VDOT District.

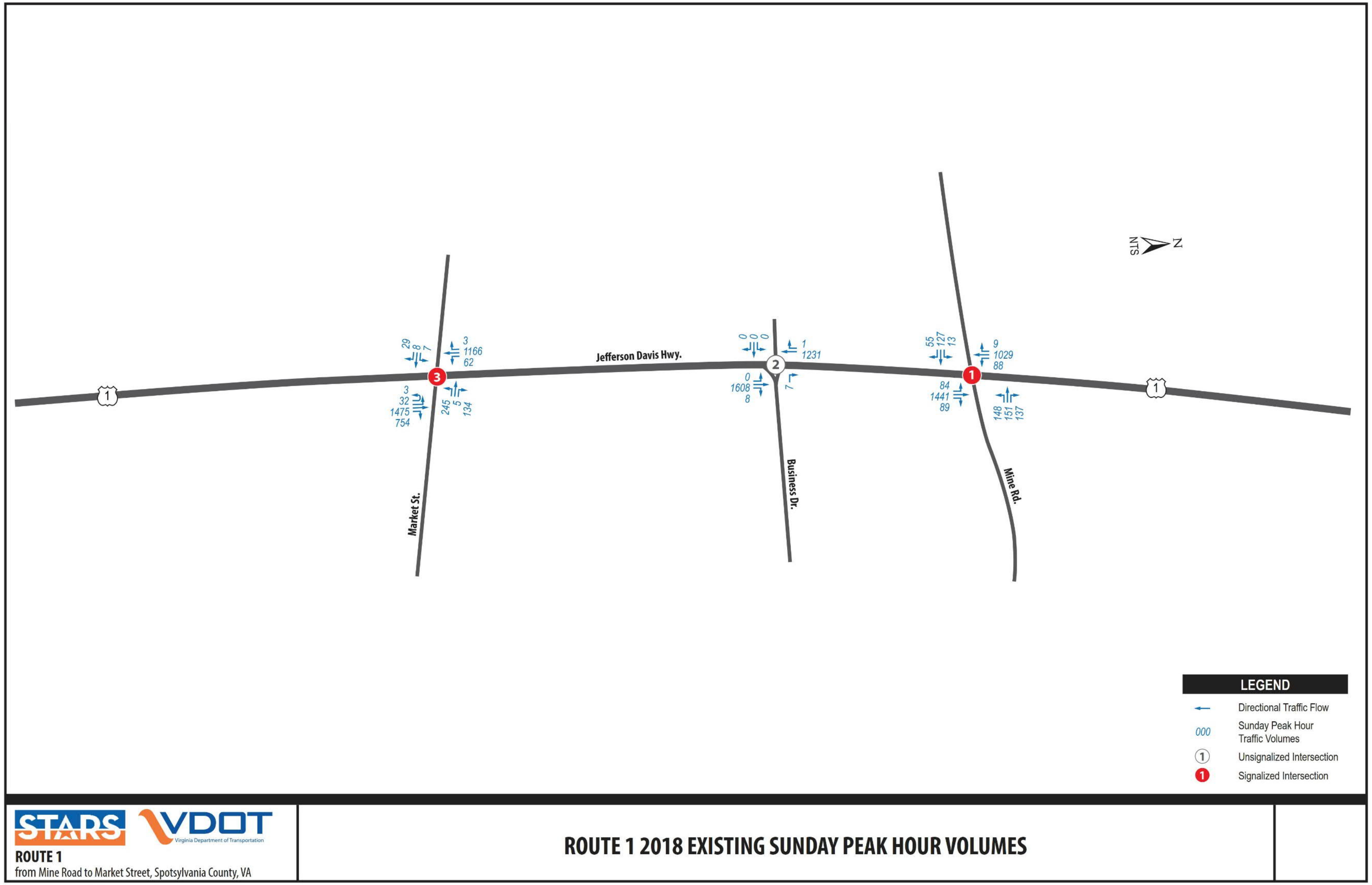
Figure 5. Existing 2018 AM (PM) Peak Hour Volumes



ROUTE 1
from Mine Road to Market Street, Spotsylvania County, VA

ROUTE 1 2018 EXISTING AM/PM PEAK HOUR VOLUMES

Figure 6. Existing 2018 Sunday Peak Hour Volumes



2.3.3 Existing Access Management

An evaluation of the existing driveways and access points along the study area corridor was completed to assess compliance with the current VDOT Access Management Design Standards for Entrances and Intersections, which is included as Appendix F of the VDOT Roadway Design Manual. This assessment involved an analysis of existing spacing of driveways and intersections and an evaluation of their compliance with VDOT minimum spacing standards for commercial entrances, intersections and median crossovers. Table 1 provides a summary of the minimum spacing requirements for a Principal Arterial with a posted speed limit of 35 mph to 45 mph.

Table 1. Minimum Spacing Standards for Commercial Entrances, Intersections, and Median Crossovers

Highway Functional Classification	Minimum Centerline to Centerline Spacing (Feet)			
	Spacing between Signalized Intersections	Spacing between Unsignalized Intersections and Full/Directional Median Crossovers and Other Intersections or Median Crossovers	Spacing between Full Access Entrances and Other Full Access Entrances, Intersections, or Median Crossovers	Spacing between Partial Access Entrances (one or two-way) and Other Entrances, Intersections, or Median Crossovers
Principal Arterial	1,320	1,050	565	305

Source: VDOT Roadway Design Manual, Appendix F (Table 2-2)

A total of 37 access points are located within the study corridor of Route 1 between Mine Road and Market Street. Most of these access points are closely spaced and serve commercial and retail parcels, with a small percentage serving residential parcels. These access points are shown graphically in the Appendix and identified as AP1 through AP37. The spacing of these access points was analyzed to assess their compliance with the VDOT minimum spacing standards shown in Table 1. Table 2 below identifies the access points that do not meet the minimum spacing standard; as well as those that are compliant with the spacing standard.

Table 2. Access Points Analysis for Route 1

Roadway	Number of Access Points	Per VDOT Spacing Guidelines	
		Compliant	Non-Compliant
Route 1	37	0 Total:	37 Total: AP1-AP37

Note: Refer to the Appendix for graphical presentation of access points.

The spacing standards are not satisfied for any of the 37 access point locations involving full/partial access driveways, entrances, median crossovers and intersections. The area serves urban/suburban land uses, with significant development along both sides of the roadway. Application of access management best practices would benefit corridor operations by reducing conflict points along the corridor.

3 Traffic Operational Analysis

3.1 Analysis Peak Periods

Weekday and Sunday peak periods were identified from the count data for the arterial segments and for each study intersection. The common AM and PM peak hours for the overall network were determined based on the hourly variations in traffic volumes at each intersection, travel patterns along the study corridor and percentage of traffic during the highest hour. Based upon a review of the traffic count data, the following peak hours were identified for this study:

- AM Peak: 7:15 AM – 8:15 AM
- PM Peak: 4:30 PM – 5:30 PM
- Sunday Peak: 4:00 PM – 5:00 PM

Peak Hour Factors (PHFs) were calculated for each overall intersection for the weekday and Sunday peak hours using the turning movement count data. Similarly, heavy vehicle percentages were calculated for the AM and PM peak hours for each movement of the study intersections.

The raw traffic counts were balanced throughout the network. Traffic volume balancing was required considering individual intersection peak hours and the resulting volume variations observed throughout the corridor. The peak hour traffic volumes were balanced using an iterative process of adjusting intersection approach and departure volumes until intersection volumes were within 10% for most movements. This 10% threshold was allowed to be exceeded for links with a significant number of access points (traffic generators or sinks) between the intersections.

3.2 Analysis Tools

Traffic operations analysis for the corridor was conducted using Synchro 9.0 (Version 9.2, build 914) analysis software, as well as SimTraffic, which is a companion microsimulation tool for Synchro. The operational analysis was based on guidance provided in VDOT Traffic Operations and Safety Analysis Manual (TOSAM), Version 1.0, November 2015 update. Synchro is based on methodologies presented in 2010 Highway Capacity Manual. SimTraffic was used to assess the traffic operations at the signalized and unsignalized intersections within the study area, as well as to evaluate arterial segments between the intersections. Section 3.3 below presents a summary of Measures of Effectiveness (MOE) that were evaluated for this study.

3.3 Measures of Effectiveness

Measures of Effectiveness (MOEs) are utilized in traffic operations analyses to quantify operational and safety objectives and provide a basis for evaluating the performance of a transportation network. Several MOEs for a corridor can be reported from Synchro and SimTraffic. For the purposes of this study, guidance for reporting MOEs for a corridor involving intersections and arterial segments as provided in VDOT TOSAM, Chapter 4 was utilized. A summary of the MOEs evaluated for the study corridor is presented below:

- SimTraffic:
  - Maximum Queue Lengths (feet)
  - Microsimulation Delay for each movement at intersections
  - Total Delay (hours), Delay/Vehicle (seconds), Travel Time (hours), Average Speed (miles/hour)

Per the TOSAM guidance under Section 8.6, Level of Service (LOS) is not reported for intersections with SimTraffic as an analysis tool. Instead, microsimulation delay is reported for individual intersection movements as well as the overall delay for the intersection. The overall intersection delay can be presented graphically by assigning color coding for ranges of microsimulation delay. This color coding, as shown in Table 3, is based on 2010 Highway Capacity Manual (HCM) delay thresholds and the associated LOS. Green, yellow and red colors were assigned to delay thresholds for each study intersection.

Table 3: Intersection Color Coding based on Intersection Delay

Signalized Intersection Delay Thresholds (sec/veh)	Unsignalized Intersection Delay Thresholds (sec/veh)	Measure of Congestion	Color
< 10	< 10	Slight Delay	Green
> 10 – 20	> 10 – 15	Slight Delay	Green
>20 – 35	>15 – 25	Moderate Delay	Yellow
>35 – 55	>25 – 35	Moderate Delay	Yellow
>55 – 80	>35 – 50	Significant Delay	Red
>80	>50	Significant Delay	Red

Source of Delay Thresholds: Highway Capacity Manual 2010

3.4 Base Model Development and Calibration

Weekday AM/PM and Sunday peak hour base Synchro models were developed using the data discussed under Section 2.3.1 and following the guidance in TOSAM. The SimTraffic input parameters were in accordance with Section 7.6.1 of VDOT TOSAM and included one 30-minute seed interval and four 15-minute recording intervals, with the PHF applied to the third interval. To account for simulation variance, 10 simulation runs were conducted and averaged together. The simulation settings remained at the default settings, with the exception of the headway factor for northbound movements in the PM peak in order to fine-tune model calibration.

To provide a more accurate representation of field conditions, the existing conditions SimTraffic models were calibrated to reasonably replicate field observed traffic volumes and intersection queue lengths. This calibration process is an essential part of the model development as it ensures that the simulation reasonably replicates existing field conditions and can be used as the basis for the evaluation of future scenarios.

A summary of the volume, queue, and travel time calibration is provided in Table 4, with supporting documentation in the Appendix.

Table 4. Calibration Summary

Peak Period	Calibration Measure	Evaluation	Criteria	Total Number Evaluated	Total Number Met	Percent Met	Target Criteria	Target Met
AM	Volume (vph)	Turning Movements	Within ± 20% for < 100 vph Within ± 15% for ≥ 100 vph to < 300 vph Within ± 10% for ≥ 300 vph to < 1000 vph Within ± 5% for ≥ 1000 vph	31	29	94%	85%	Yes
	Queue Length	Turning Movements	Within ± 20% on oversaturated arterials	13	13	100%	85%	Yes
PM	Volume (vph)	Turning Movements	Within ± 20% for < 100 vph Within ± 15% for ≥ 100 vph to < 300 vph Within ± 10% for ≥ 300 vph to < 1000 vph Within ± 5% for ≥ 1000 vph	32	32	100%	85%	Yes
	Queue Length	Turning Movements	Within ± 20% on oversaturated arterials	13	11	85%	85%	Yes
Sunday	Volume (vph)	Turning Movements	Within ± 20% for < 100 vph Within ± 15% for ≥ 100 vph to < 300 vph Within ± 10% for ≥ 300 vph to < 1000 vph Within ± 5% for ≥ 1000 vph	32	32	100%	85%	Yes
	Queue Length	Turning Movements	Within ± 20% on oversaturated arterials	13	13	100%	85%	Yes

3.4.1 Volume Calibration

The volume calibration results summary in Table 4 shows that the calibration parameters are met for the AM, PM and Sunday models. The full SimTraffic volume calibration results tables are shown in the Appendix. The volume calibration includes a comparison between simulated volumes (the average of 10 runs) and balanced field counts modeled in Synchro for the peak hours. The tables show the difference and percentage difference between field counts and the average volumes from the simulation runs.

3.4.2 Queue Length Calibration

The queue calibration results summary in Table 4 shows that the calibration parameters are met for AM, PM and Sunday models. The SimTraffic average queue calibration results tables are shown in the Appendix. The average queue length calibration includes a comparison between theoretical (simulated) average intersection queues obtained from an average of 10 simulation runs and the field measured average queues during the peak hours.

3.4.3 Microsimulation Sample Size

In addition to conducting proper model calibration, determining and applying an appropriate number of microsimulation runs is an important step in developing accurate microsimulation results. WSP followed the guidelines provided in Section 5.4 of the VDOT TOSAM and utilized the macro-enabled VDOT Sample Size Determination Tool to finalize the number of SimTraffic runs necessary for correctly reporting arterial and intersection MOEs. Ten SimTraffic microsimulation runs were initially recorded following the guidelines for SimTraffic Input Parameters found in Section 7.6 of the VDOT TOSAM. The average travel speed obtained from each of these ten runs was then input into the VDOT Sample Size Determination Tool to verify that MOEs from these runs met the required tolerance error and confidence interval. The Appendix shows the VDOT Sample Size Determination Tool.

3.5 Intersection Operations: 2018 Existing Conditions

Traffic operations analyses were conducted using SimTraffic to evaluate overall performance of the study intersections and arterial segments within the corridor. SimTraffic run output reports provided a measure of movement delays and the maximum queues formed for each movement.

Microsimulation Delay in sec/veh was reported from SimTraffic for all the signalized and unsignalized intersections within the study area. Microsimulation delay includes the sum of the total delay per vehicle (sec/vehicle) plus the denied delay per vehicle (sec/vehicle) to account for any denied vehicles into the network.

Table 5 provides a summary of the weekday AM and PM peak hour delay for each movement for the study intersections along the study corridor. Figure 7 presents the overall intersection delay graphically with color coding to represent the average overall intersection delay. SimTraffic output sheets are provided in the Appendix.

Table 6 provides a summary of the Sunday peak hour delay for each movement for the study intersections along the study corridor. Figure 8 presents the overall intersection delay graphically with color coding to represent the average overall intersection delay. SimTraffic output sheets are provided in the Appendix.

The results from Table 5 and Table 6 suggest that the following signalized intersections operate with an overall delay value that exceeds a moderate delay level of 35 sec/veh:

Intersection 1 – Route 1 and Hood Drive/Mine Road

- Microsimulation delay of 64.6 sec/veh during the weekday PM peak hour and 45.4 sec/veh during the Sunday peak hour

Intersection 3 – Route 1 and Market Street

- Microsimulation delay of 44.0 sec/veh during the Sunday peak hour

Table 5. Existing 2018 SimTraffic AM and PM Peak Hour Delay (veh/sec)

Intersection Number and Description	Type of Control	Lane Group	Eastbound		Westbound		Northbound		Southbound		Overall	
			AM	PM	AM	PM	AM	PM	AM	PM		
			Delay	Delay	Delay	Delay	Delay	Delay	Delay	Delay	AM	PM
1			Hood Drive		Mine Road		Route 1		Route 1			
Route 1 and Hood Drive/ Mine Road	Signal	Left	72.3	139.1	77.5	118.0	15.9	44.4	29.7	73.3	Delay	Delay
		Through	74.3	145.3	99.5	229.4	15.7	39.7	25.1	31.8		
		Right	21.6	32.0	14.1	31.1	4.3	8.6	2.5	5.1	33.3	64.6
		Approach	43.1	93.5	66.9	132.7	14.4	36.8	25.7	37.3		
2			Gas Station Entrance		Business Drive		Route 1		Route 1			
Route 1 and Business Drive	Two-Way Stop	Left	22.2	61.9	--	--	10.1	0.0	--	--	Delay	Delay
		Through	--	--	--	--	3.5	8.1	5.8	4.9		
		Right	0.0	0.0	1.3	1.3	4.8	8.2	2.9	4.5	4.7	6.2
		Approach	22.2	61.9	1.3	1.3	3.6	8.1	5.8	4.9		
3			Market Street		Market Street		Route 1		Route 1			
Route 1 and Market Street	Signal	Left	66.7	65.4	61.8	68.8	16.8	26.5	28.3	33.7	Delay	Delay
		Through	71.4	72.1	0.0	79.7	16.6	27.0	29.0	29.6		
		Right	32.8	35.0	35.1	34.6	7.9	7.6	30.8	28.6	24.6	33.6
		Approach	52.5	55.7	58.2	62.9	13.4	20.0	28.9	29.8		

Table 6. Existing 2018 SimTraffic Sunday Peak Hour Delay (veh/sec)

Intersection Number and Description	Type of Control	Lane Group	Eastbound	Westbound	Northbound	Southbound	Overall
			Sunday	Sunday	Sunday	Sunday	
			Delay	Delay	Delay	Delay	Sun
1			Hood Drive	Mine Road	Route 1	Route 1	
Route 1 and Hood Drive/ Mine Road	Signal	Left	62.4	54.8	60.3	42.0	Delay
		Through	58.7	61.5	60.9	23.0	
		Right	12.1	29.5	28.4	4.7	45.4
		Approach	46.0	49.4	59.2	24.4	
2			Gas Station Entrance	Business Dr	Route 1	Route 1	
Route 1 and Business Drive	Two-Way Stop	Left	0.0	--	0.0	--	Delay
		Through	--	--	36.4	3.5	
		Right	0.0	1.3	30.7	3.5	22.0
		Approach	0.0	1.3	36.4	3.5	
3			Market St	Market St	Route 1	Route 1	
Route 1 and Market Street	Signal	U-turn	--	--	57.2	0.0	Delay
		Left	78.0	52.6	50.6	38.2	
		Through	84.3	46.5	75.5	18.2	
		Right	25.4	39.8	19.4	15.0	44.0
		Approach	45.7	48.4	56.7	19.2	

Figure 7. Existing 2018 AM (PM) Peak Hour Intersection Operations Results

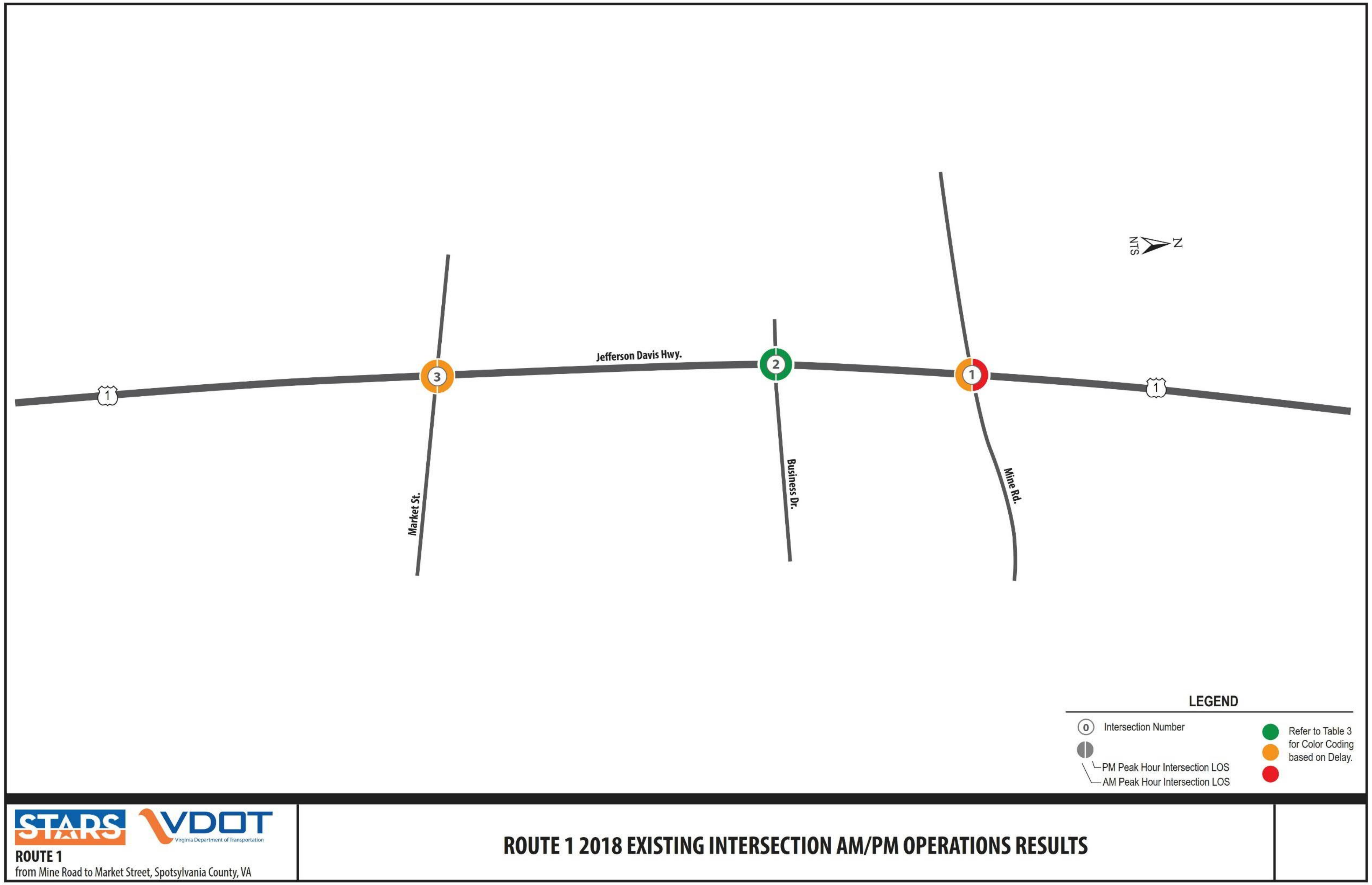
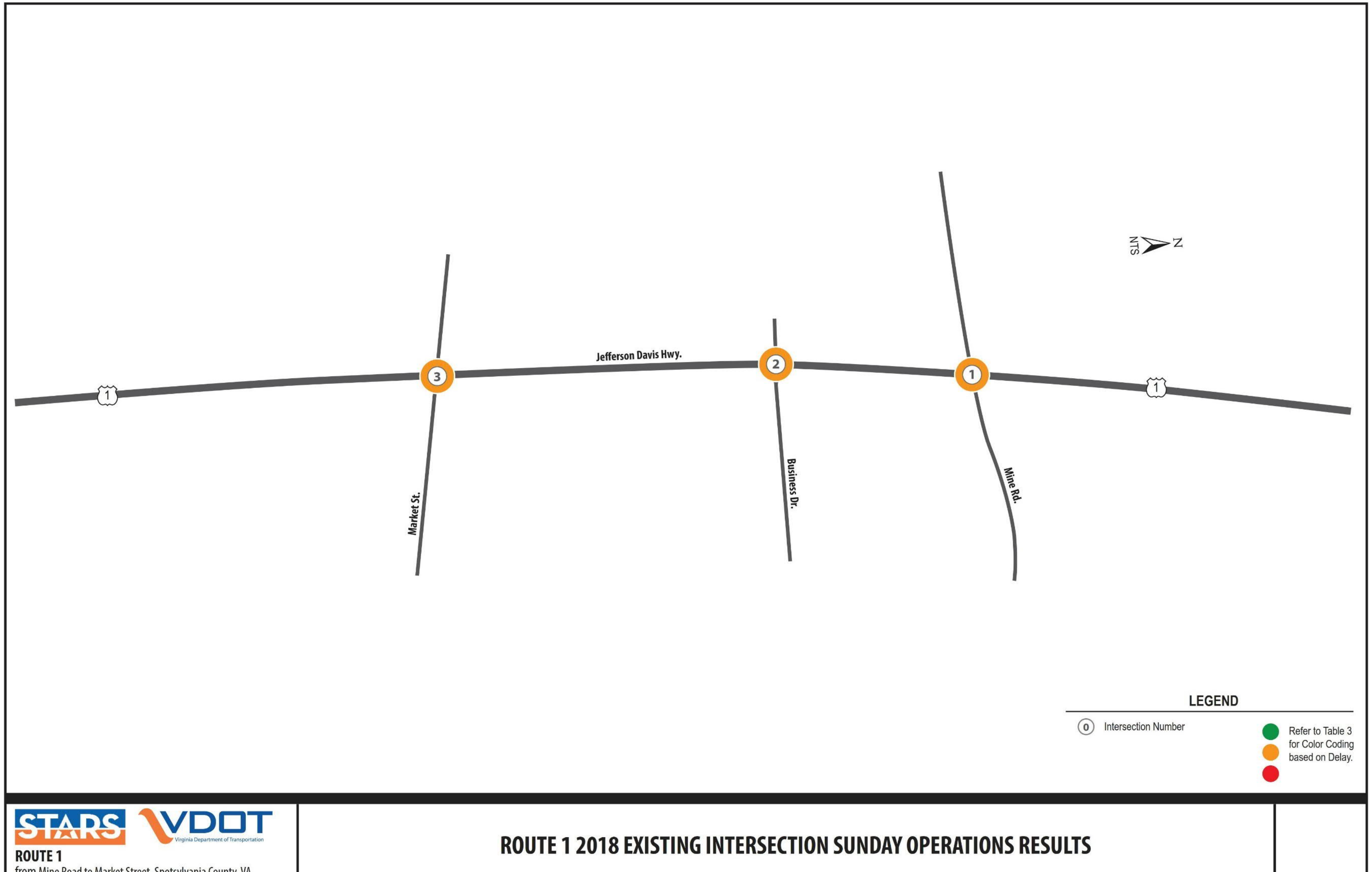


Figure 8. Existing 2018 Sunday Peak Hour Intersection Operations Results



Queue length, or the distance to which stopped vehicles accumulate in a lane at an intersection, is another performance measure of intersection operation. Lengthy queues may be indicative of intersection capacity or operational issues, such as absence of or insufficient dedicated turn lanes, inefficient signal timings or inappropriate phasing. A queuing analysis was completed for the study intersections during the peak hours. SimTraffic maximum queue lengths in feet were reported for each lane. These queue lengths are based on an average of 10 simulation runs. Table 7 provides a summary of the maximum queue lengths during the weekday AM and PM peak hours as compared to the available storage bay lengths. The queue lengths in red and bold text in Table 7 are the movements in which the reported maximum queue length value exceeds the storage length available for that turning movement. The SimTraffic output sheets including the maximum queue lengths are included in the Appendix.

Table 8 provides a summary of the maximum queue lengths during the Sunday peak hour as compared to the available storage bay lengths. The queue lengths in red and bold text in Table 8 are the movements in which the reported maximum queue lengths value exceeds the storage length available for that turning movement. The SimTraffic output sheets including the maximum queue lengths are included in the Appendix.

The movements and the time periods in which the maximum queue exceeds the available storage bay length are summarized below:

Intersection 1 – Route 1 and Hood Drive/Mine Road

- Eastbound right-turning movement (existing storage bay length of 450 ft.) indicates the maximum queue length reaches capacity in the PM peak. The Simtraffic simulation indicated right-turn bay blockage due to heavy traffic queued in the adjacent through lane.
- Northbound left-turning movement (existing storage bay length of 200 ft.) indicates the maximum queue spills back into the TWLTL in the PM peak and Sunday peak. The Simtraffic simulation indicated extensive upstream and left-turn bay blockage due to heavy traffic in the adjacent through lanes.
- Northbound right-turning movement (existing storage bay length of 335 ft.) indicates the maximum queue length reaches capacity in the Sunday peak. The Simtraffic simulation indicated extensive upstream and right-turn bay blockage due to heavy traffic in the adjacent through lanes.

Intersection 3 – Route 1 and Market Street

- Westbound left-turning movement (existing storage bay length of 400 ft.) indicates the maximum queue length reaches capacity in the PM peak. The SimTraffic model and simulation results indicate that vehicles tend to queue in the innermost left-turn lane which blocks accessibility to the outermost left-turn lane.
- Northbound left-turning movement (existing storage bay length of 315 ft.) indicates the maximum queue length reaches capacity in the Sunday peak. The Simtraffic simulation indicated extensive upstream and left-turn bay blockage due to heavy traffic in the adjacent through lanes.

Table 7. 2018 Existing Conditions: Summary of AM/PM Peak Maximum Queues (feet)

Intersection Number and Description	Type of Control	Lane Group	Eastbound			Westbound			Northbound			Southbound		
			Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)
1 Route 1 and Hood Drive/Mind Road			Hood Drive			Mine Road			Route 1			Route 1		
	Signal	Left	--	532	646	--	320	670	200	146	**200**	335	138	327
		Through	--			--	373	709	--	279	417	--	232	436
		Right	450	395	**450**	665	147	570	335	90	281	570	24	26
2 Route 1 and Business Drive			Gas Station Entrance			Business Drive			Route 1			Route 1		
	Two-Way Stop	Left	--			--	--	--	--	70	--	--	--	--
		Through	--	21	25	--	--	--	--	--	3	--	77	5
		Right	--			--	0	0	--	28	11	--	81	
3 Route 1 and Market Street			Market Street			Market Street			Route 1			Route 1		
	Signal	Left	--			400	262	**399**	315	30	94	365	227	312
		Through	--	107	102	--	308	550	--	381	371	--	433	535
		Right	--			--	86	259	--	204	167	--	479	554

NOTE: The maximum queues in feet are obtained from 10 SimTraffic simulation runs averaged together.
'--' Storage Bay Length not provided or the movements do not exist.
Red and bold text indicates queue lengths that reach or exceed the available storage lengths OR indicates turn lane storage blockage.

Table 8. 2018 Existing Conditions: Summary of Sunday Peak Maximum Queues (feet)

Intersection Number and Description	Type of Control	Lane Group	Eastbound		Westbound		Northbound		Southbound	
			Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)
1 Route 1 and Hood Drive/Mind Road			Hood Drive		Mine Road		Route 1		Route 1	
	Signal	Left	--	213	--	175	200	**200**	335	192
		Through	--		--	240	--	632	--	370
		Right	450	70	665	160	335	**335**	570	22
2 Route 1 and Business Drive			Gas Station Entrance		Business Drive		Route 1		Route 1	
	Two-Way Stop	Left	--		--	--	--	--	--	--
		Through	--	--	--	--	--	612	--	--
		Right	--		--	--	--	606	--	--
3 Route 1 and Market Street			Market Street		Market Street		Route 1		Route 1	
	Signal	Left	--		400	215	315	**314**	365	149
		Through	--	93	--	252	--	852	--	351
		Right	--		--	179	--	788	--	366

NOTE: The maximum queues in feet are obtained from 10 SimTraffic simulation runs averaged together.
'--' Storage Bay Length not provided or the movements do not exist.
Red and bold text indicates queue lengths that reach or exceed the available storage lengths OR indicates turn lane storage blockage.

3.6 Future Traffic Volumes

The future year for this study is 2035 in order to match the 2035 future year of a recent study conducted for Spotsylvania County (Route 1/208 Corridor Study, JMT, December 2018). Two of the Route 1 intersections in the Route 1/208 Corridor Study (Route 1 at Mine Road/Hood Drive and at Market Street) are the subject of this STARS study. The Route 1/208 Corridor Study includes an analysis of AM, PM, and Saturday traffic peaks. The 2035 traffic forecasts for the Sunday analysis for this STARS study were developed independently since the Route 1/208 Corridor Study did not analyze a Sunday peak hour.

Traffic Forecasting Methodology

Future Year 2035 traffic volumes were developed using the 2035 weekday peak hour traffic forecasts developed for the Route 1/208 Corridor Study and traffic growth factors derived from Fredericksburg Area Metropolitan Planning Organization (FAMPO) socioeconomic forecasts.

- Weekday volumes at Route 1 at Mine Road/Hood Drive and at Market Street match those developed for the Route 1/208 Corridor Study. The Route 1/208 Corridor Study existing and future weekday volumes at these two intersections show an approximate Average Annual Growth Rate (AAGR) of 1.7% per year between 2017 and 2035.
- Weekday volumes at interstate ramps and Business Drive were increased/balanced for consistency with the applied volumes at Route 1 at Mine Road/Hood Drive and at Market Street. Business Drive showed lower total growth (approx. 2% increase) whereas the interstate ramps showed a higher total growth (12-17% increase).
- Sunday volumes across the entire network utilized an AAGR of 1.4%, which was applied to all Sunday existing turn movement volumes. This AAGR was derived by calculating the projected AAGR for households in the study corridor using adopted FAMPO socioeconomic forecasts within the vicinity of the Route 1 study corridor.

The 2035 no-build peak hour volume projections are presented in Figures 9 and 10.

3.7 Intersection Operations: Future 2035 No-Build Conditions

Operational analysis was performed at each of the study intersections for the Future 2035 No-Build Conditions scenario using the projected volumes from Figures 9 and 10. Tables 9 and 10 summarize the average peak hour delay and LOS for each movement for the study intersections along the Route 1 corridor for the AM/PM weekday peak hours and Sunday peak hour respectively. Figures 11 and 12 summarize the overall intersection delay graphically. SimTraffic output sheets are provided in Appendix.

The results in Tables 9 and 10 suggest that, under 2035 No-Build conditions, the two signalized Route 1 study intersections at Mine Road and at Market Street experience increased delays that indicate unacceptable LOS.

Queuing analysis was completed for the study intersections during the AM, PM, and Sunday peak hour for 2035 No-Build conditions. SimTraffic Maximum Queue Lengths in feet were reported for each movement at study intersections. These queue lengths are based on an average of 10 simulation runs. Tables 11 and 12 summarize the maximum queue lengths during the AM/PM and Sunday peak hours, respectively.

Figure 9. Future 2035 AM (PM) No-Build Peak Hour Traffic Volumes

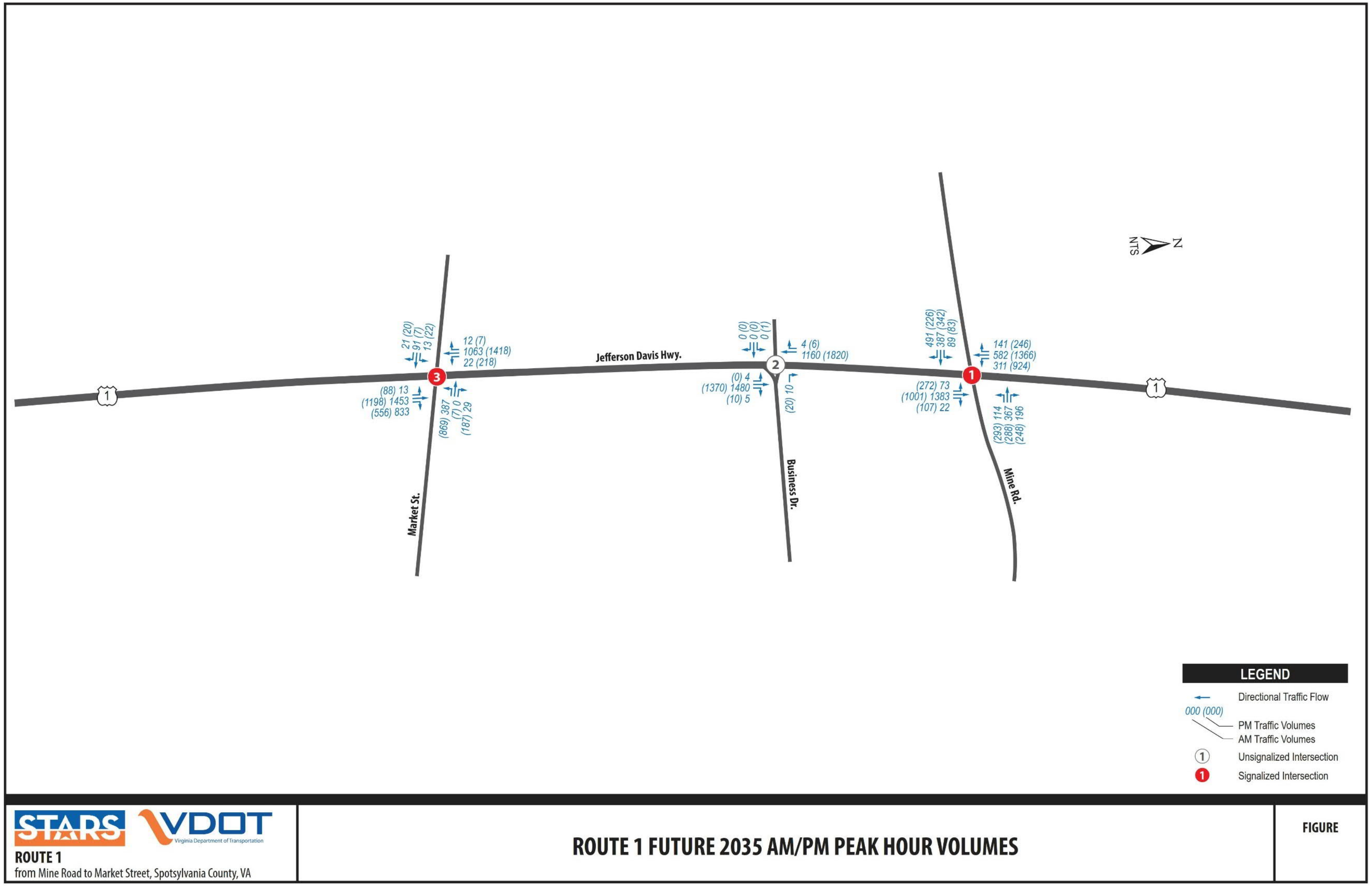


Figure 10. Future 2035 Sunday No-Build Peak Hour Traffic Volumes

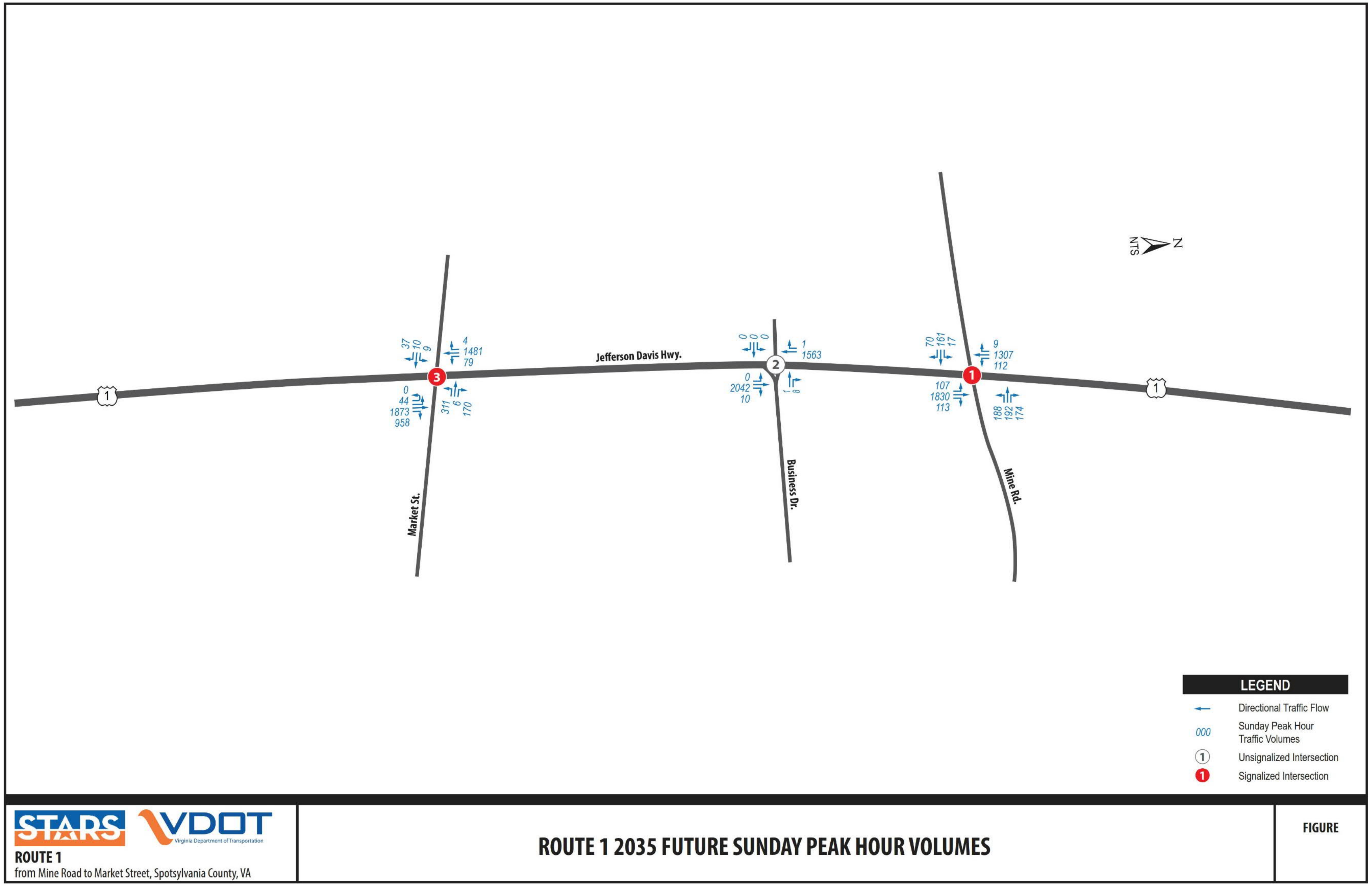


Table 9. Future 2035 No-Build Weekday AM/PM Peak SimTraffic Delay (sec/veh)

Intersection Number and Description	Type of Control	Lane Group	Eastbound		Westbound		Northbound		Southbound		Overall	
			AM	PM	AM	PM	AM	PM	AM	PM		
			Delay	Delay	Delay	Delay	Delay	Delay	Delay	Delay	AM	PM
1 Route 1 and Hood Drive/ Mine Road			Hood Drive		Mine Road		Route 1		Route 1			
	Signal	Left	846.6	1329.0	1202.5	463.3	27.3	214.2	45.8	866.9	Delay	Delay
		Through	840.2	1318.4	1452.1	623.6	26.7	93.9	20.4	540.0		
		Right	727.4	1151.8	1107.0	349.9	8.6	44.7	7.1	459.2	429.5	546.7
		Approach	783.3	1257.4	1308.1	487.8	26.4	114.3	22.5	572.6		
2 Route 1 and Business Drive			Entrance		Business Drive		Route 1		Route 1			
	Two-Way Stop	Left	0.0	1454.0	--	--	8.5	0.0	--	--	Delay	Delay
		Through	--	--	--	--	5.1	97.4	2.1	5.7		
		Right	0.0	0.0	1.4	2.9	7.6	96.1	2.0	6.1	3.8	47.4
		Approach	0.0	0.1	1.4	2.9	5.1	97.4	2.1	5.7		
3 Route 1 and Market Street			Entrance		Market Street		Route 1		Route 1			
	Signal	Left	981.2	85.2	57.3	310.5	20.8	122.3	29.8	182.4	Delay	Delay
		Through	974.2	104.0	0.0	339.2	19.2	155.5	20.8	34.4		
		Right	940.7	48.2	39.3	230.7	12.7	25.0	21.8	35.9	54.0	138.4
		Approach	971.4	73.4	56.2	297.0	16.9	115.0	21.0	52.5		

Table 10. Future 2035 No-Build Sunday Peak SimTraffic Delay (sec/veh)

Intersection Number and Description	Type of Control	Lane Group	Eastbound	Westbound	Northbound	Southbound	Overall
			Sunday	Sunday	Sunday	Sunday	
			Delay	Delay	Delay	Delay	AM
1 Route 1 and Hood Drive/ Mine Road			Hood Drive	Mine Road	Route 1	Route 1	
	Signal	Left	60.1	63.7	93.6	50.4	Delay
		Through	58.8	89.9	88.9	30.3	
		Right	22.2	31.3	46.4	6.3	59.9
		Approach	48.1	63.5	86.8	31.7	
2 Route 1 and Business Drive			Entrance	Business Dr	Route 1	Route 1	
	Two-Way Stop	Left	--	--	--	--	Delay
		Through	--	--	110.3	4.7	
		Right	0.0	1.4	114.8	4.9	56.4
		Approach	0.0	1.4	110.4	4.7	
3 Route 1 and Market Street			Market St	Market St	Route 1	Route 1	
	Signal	Left	79.4	49.1	129.7	44.3	Delay
		Through	78.3	58.8	162.6	27.5	
		Right	38.1	40.4	52.0	25.9	79.0
		Approach	51.5	46.2	126.8	28.4	

Figure 11. Future 2035 No-Build AM/PM Peak Intersection Delay

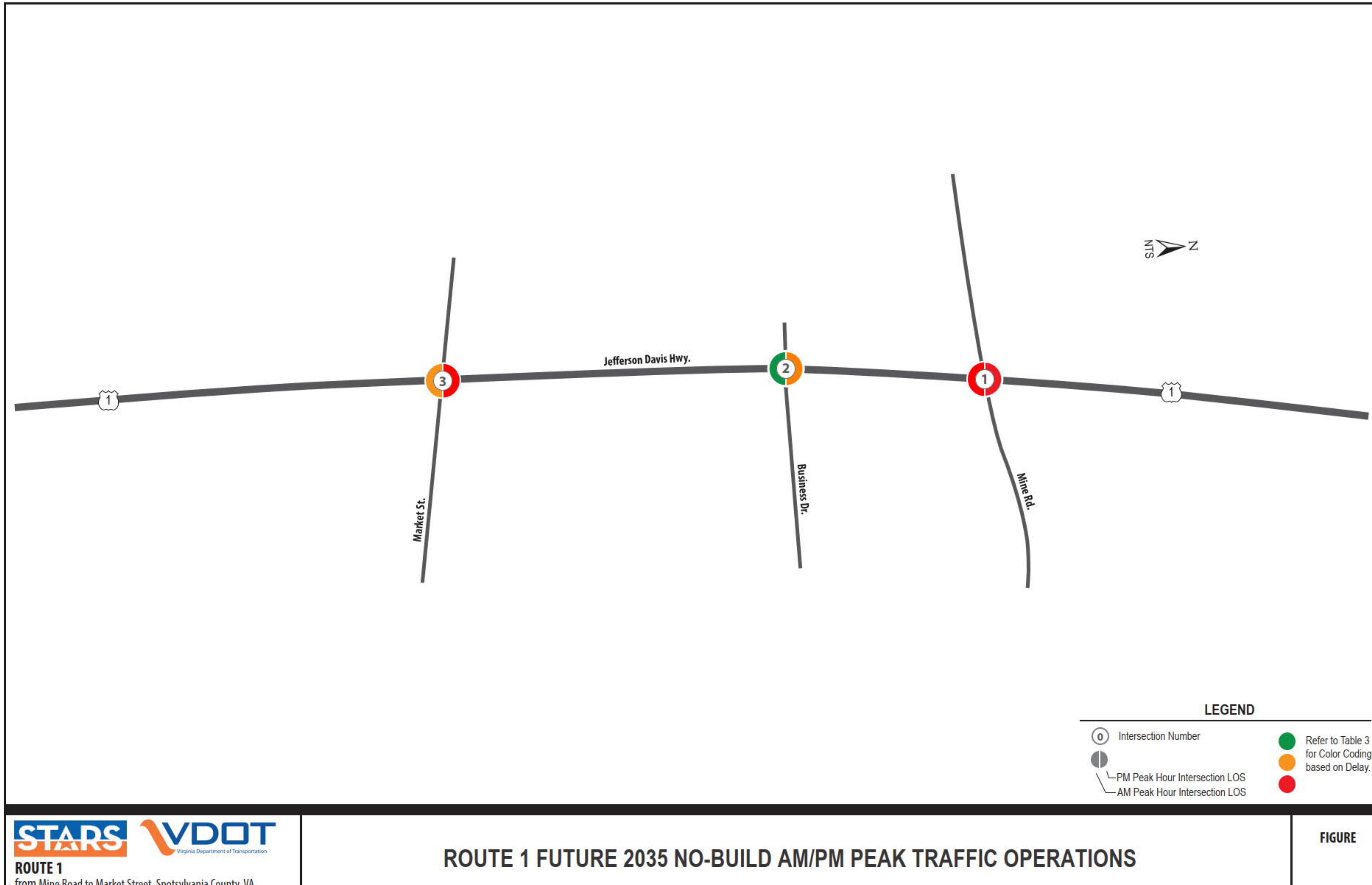
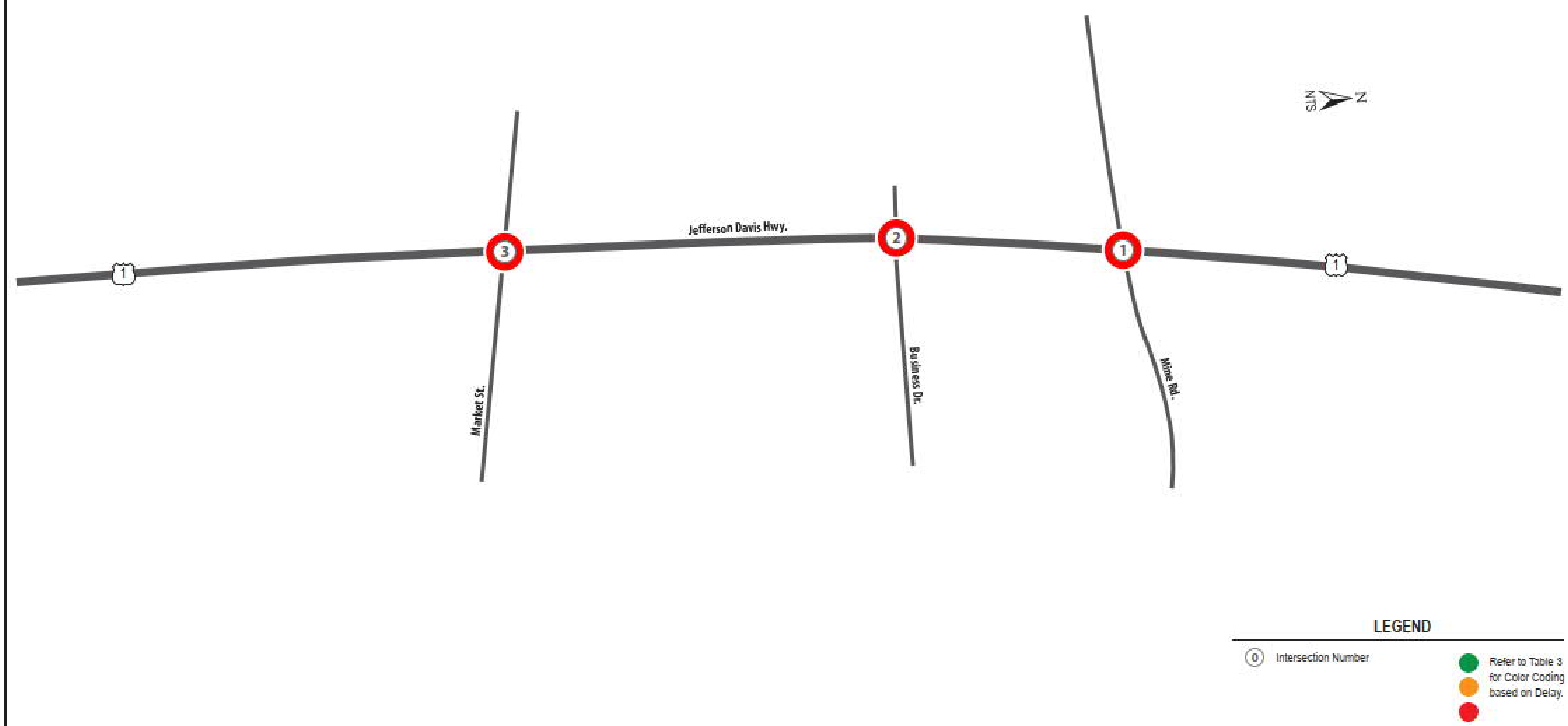


Figure 12. Future 2035 No-Build Sunday Peak Intersection Delay



ROUTE 1
from Mine Road to Market Street, Spotsylvania County, VA

ROUTE 1 2035 NO-BUILD INTERSECTION SUNDAY OPERATIONS RESULTS

FIGURE

Table 11. Future 2035 No-Build Weekday AM/PM Peak Hour: Summary of AM/PM Peak Maximum Queues (feet)

Intersection Number and Description	Type of Control	Lane Group	Eastbound			Westbound			Northbound			Southbound		
			Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)
1 Route 1 and Hood Drive/Mind Road			Hood Drive			Mine Road			Route 1			Route 1		
	Signal	Left	--	728	725	--	739	780	200	**200**	**200**	335	218	**335**
		Through	--			--	765	778	--	554	656	--	250	1,113
		Right	450	**450**	**450**	665	**665**	**665**	335	**335**	**335**	570	108	**570**
2 Route 1 and Business Drive			Entrance			Business Drive			Route 1			Route 1		
	Two-Way Stop	Left	--	0	48	--	--	--	--	97	0	--	--	--
		Through	--			--	--	--	--		860	--	--	--
		Right	--			--	0	12	--	66	849	--	--	--
3 Route 1 and Market Street			Market Street			Market Street			Route 1			Route 1		
	Signal	Left	--	523	125	400	321	**400**	315	64	**315**	365	306	358
		Through	--			--	382	629	--	653	926	--	403	571
		Right	--			--	81	620	--	551	932	--	436	587

NOTE: The maximum queues in feet are obtained from 10 SimTraffic simulation runs averaged together.
'--' Storage Bay Length not provided or the movements do not exist.
Red and bold text indicates queue lengths that reach or exceed the available storage lengths OR indicates turn lane storage blockage

Table 12. Future 2035 No-Build Weekday AM/PM Peak Hour: Summary of AM/PM Peak Maximum Queues (feet)

Intersection Number and Description	Type of Control	Lane Group	Eastbound		Westbound		Northbound		Southbound	
			Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)
1 Route 1 and Hood Drive/Mind Road			Hood Drive		Mine Road		Route 1		Route 1	
	Signal	Left	--	241	--	290	200	**200**	335	**334**
		Through	--		--	380	--	645	--	505
		Right	450	88	665	191	335	**335**	570	19
2 Route 1 and Business Drive			Entrance		Business Drive		Route 1		Route 1	
	Two-Way Stop	Left	--	--	--	--	--	--	--	--
		Through	--		--	--	--	1,101	--	--
		Right	--		--	--	--	1,111	--	--
3 Route 1 and Market Street			Market Street		Market Street		Route 1		Route 1	
	Signal	Left	--	122	400	221	315	**315**	365	319
		Through	--		--	273	--	934	--	494
		Right	--		--	208	--	946	--	514

NOTE: The maximum queues in feet are obtained from 10 SimTraffic simulation runs averaged together.
'--' Storage Bay Length not provided or the movements do not exist.
Red and bold text indicates queue lengths that reach or exceed the available storage lengths OR indicates turn lane storage blockage

4 Safety Analysis

Crash data for the most recent five (5) years (October 1, 2013 through September 30, 2018) was obtained from VDOT's Crashtools Database. The crash data were evaluated to identify crash locations and patterns, severity of crashes, and likely causes for crashes. The crash data was examined to identify crash locations on which to focus during field reviews. Field reviews were conducted, with a particular focus on the crash patterns, to evaluate conditions in the field that could be influencing the crash locations from the crash data. Field reviews were conducted, which included observations during the AM and PM peak hours (7:15AM to 8:15AM; 4:30PM to 5:30PM), to examine factors such as traffic conditions, human-vehicle interaction, geometric layout, and the presence and condition of signing, pavement markings, and delineation.

The crash data analysis and field review data were used to identify factors that could potentially contribute to crashes and to make recommendations regarding safety improvements that could mitigate future crashes.

4.1 Findings and Recommendations

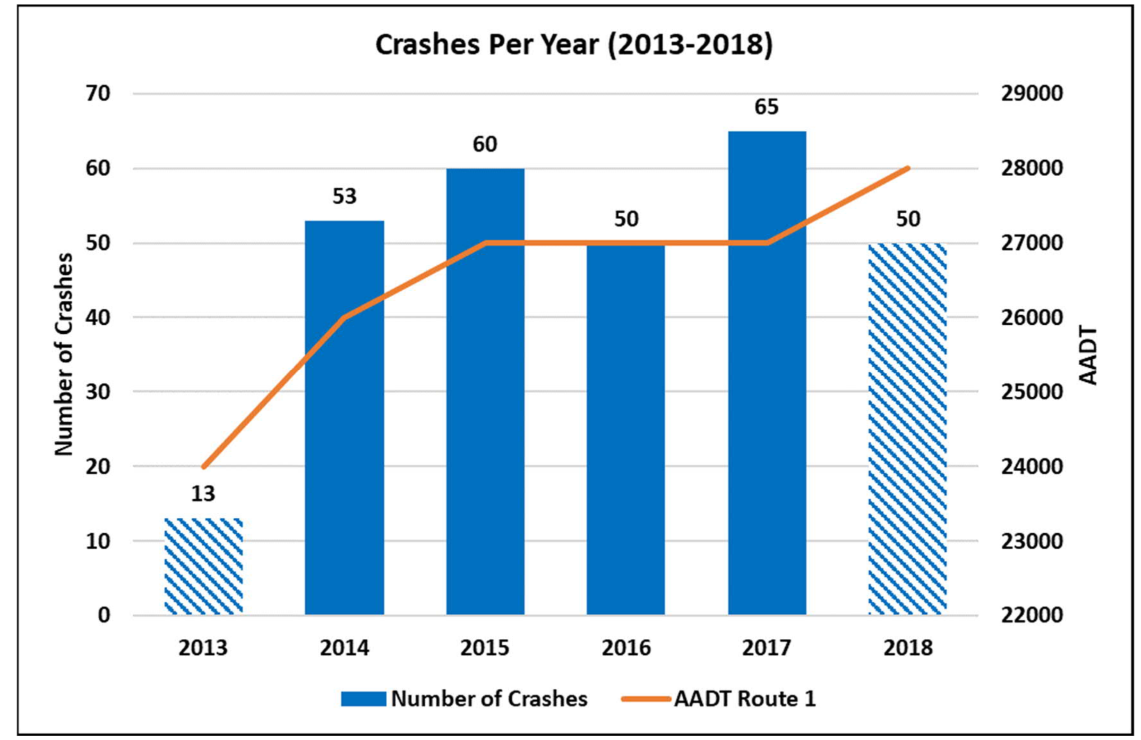
The findings for the project area are presented in terms of Crash Data Analysis findings and Field Review findings. The Crash Data Analysis findings describe trends in the data regarding the year, time of day, type of crash, and roadway condition. The Field Review findings describe the field observations and discuss how those observations may relate to trends identified in the crash data. The findings and recommendations are provided in the following sections.

4.2 Crash Data Analysis

4.2.1 Crashes by Year

A total of 291 crashes occurred from Mine Road to Market Street between October 1, 2013 and September 30, 2018, as shown in Figure 13. Note that the 2013 and 2018 bars are striped since the data does not include a full calendar year, and partial data years appear to be comparable to the adjacent full years within the five-year study period The AADT values were used to associate the traffic volume (i.e. orange trend line) with crashes per year, as shown in Figure 13. The AADT values steadily increased from 2013 to 2015, plateaued from 2015 to 2017, and increased in 2018. The total number of crashes moderately fluctuated over the five-year study period, with a peak occurring in 2017. Additionally, Figure 14 shows that the highest percentage of crashes were property damage (69%) and visible injuries (22%) occurred in the study area within the five-year period. Figure 15 shows a heat map of the corridor over the 5-year period. Based on the heat map, the Market Street intersection was shown to have the highest propensity of crashes, as indicated by the darkest red.

Figure 13. Number of Crashes per Year for the Project Study Area.



Note: AADT values were obtained from VDOT. 2018 AADT was estimated to increase by 2%

Figure 14. Severity of Crashes for the Project Study Area.

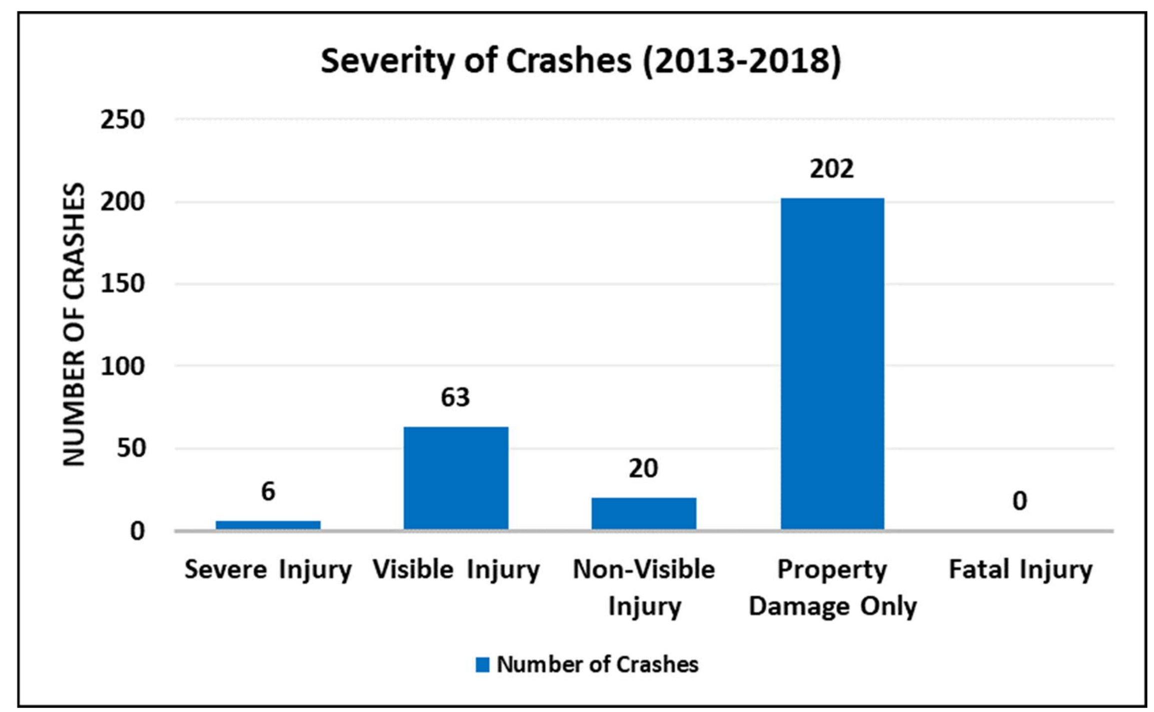
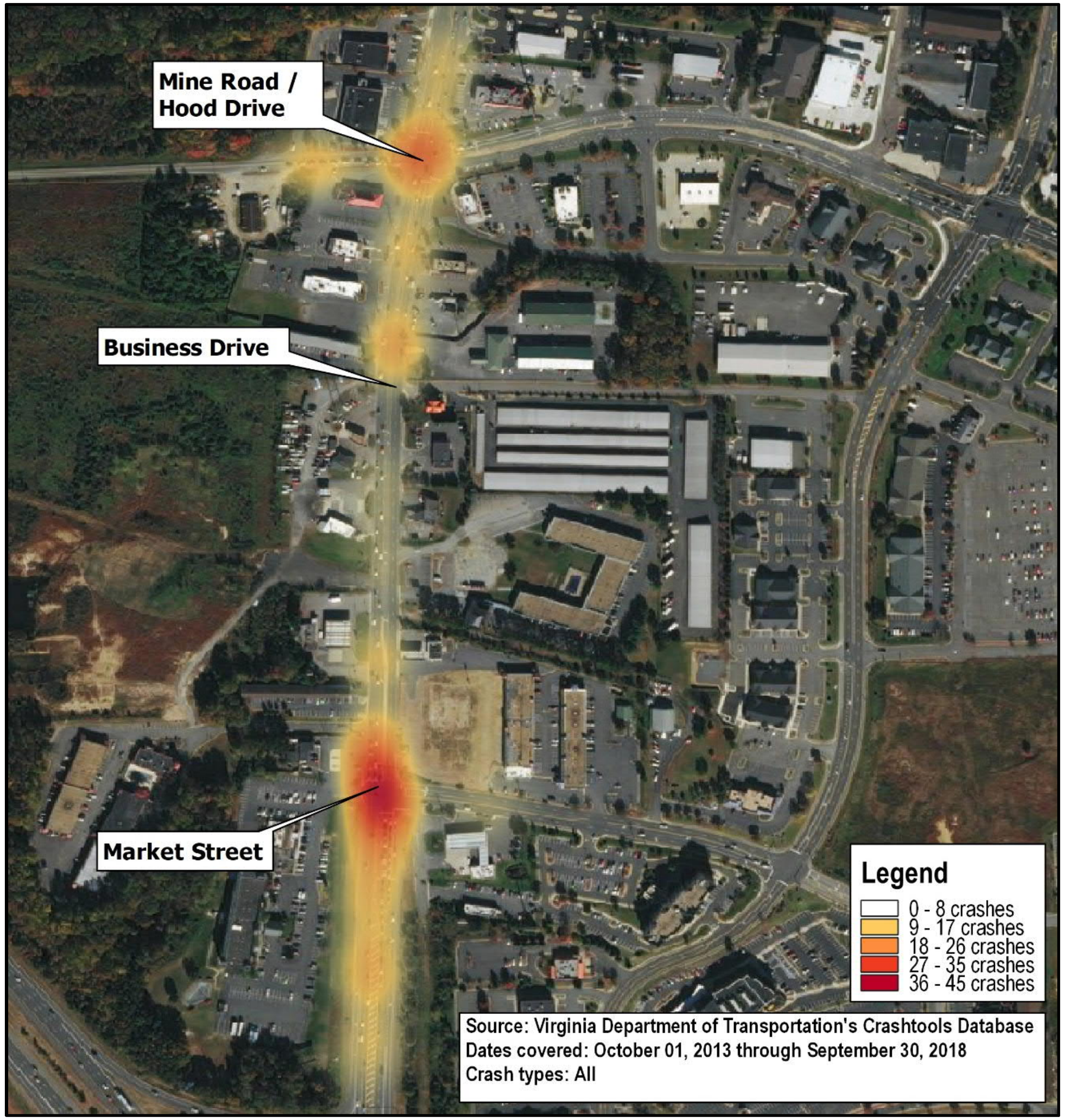


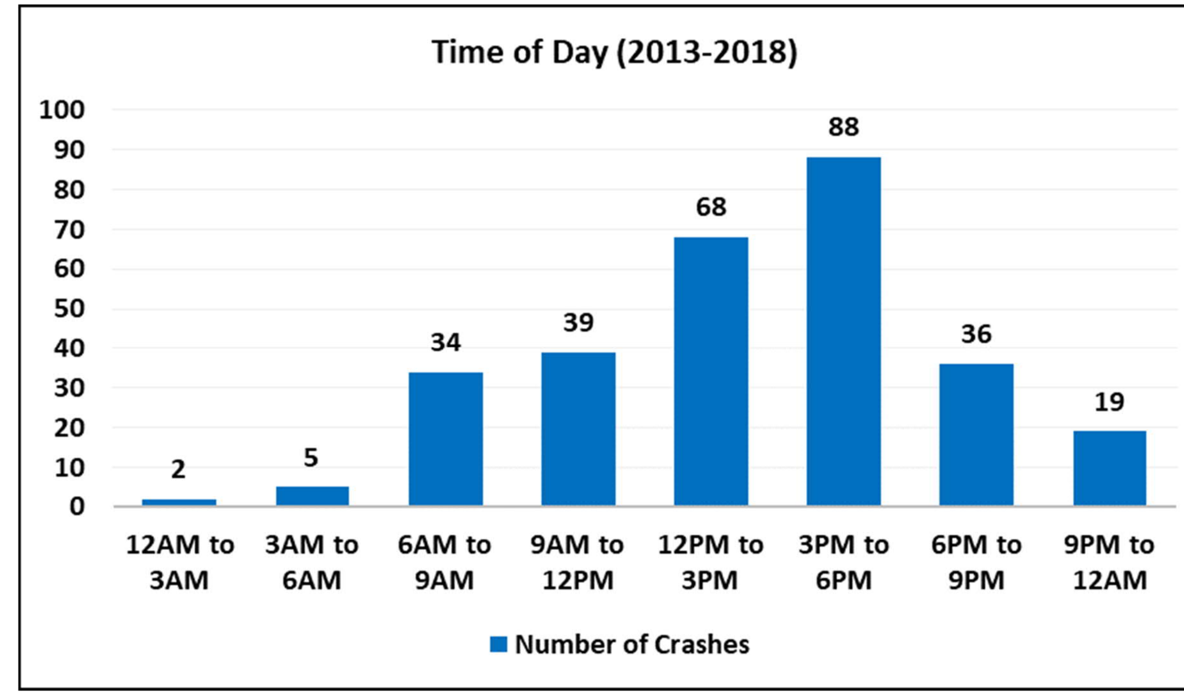
Figure 15: Crash Heat Map for Route 1/Jefferson Davis Highway (2013-2018)



4.2.2 Crashes by Time of Day

Figure 16 displays the number of crashes that occurred by time of day, presented in 3-hour increments. The frequency of crashes in descending order occurred from 3PM–6PM (30%), from 12PM–3PM (23%), from 9AM–12PM (13%), from 6PM–9PM (12%), and from 6AM-9AM (12%).

Figure 16. Number of Crashes by Time of Day for the Project Study Area



4.2.3 Crashes by Type

As shown in Figure 17, the majority of crashes that occurred were rear-end crashes (48%), followed by angle crashes (32%) and side-swipe same direction crashes (15%). This follows a typical pattern for roadways with signalized intersections, as the most common type of crashes are rear-end. The remaining crash types each accounted for less than 5% of the overall crashes. It should be noted that some of the crashes (e.g., side-swipe and angle crashes) were incorrectly categorized within the Crashtools database; therefore, crash classifications were corrected and updated, based on the crash descriptions provided within the database, to ensure the accuracy of the crash type analysis.

Figure 17. Number of Crashes by Type of Crash for the Project Study Area.

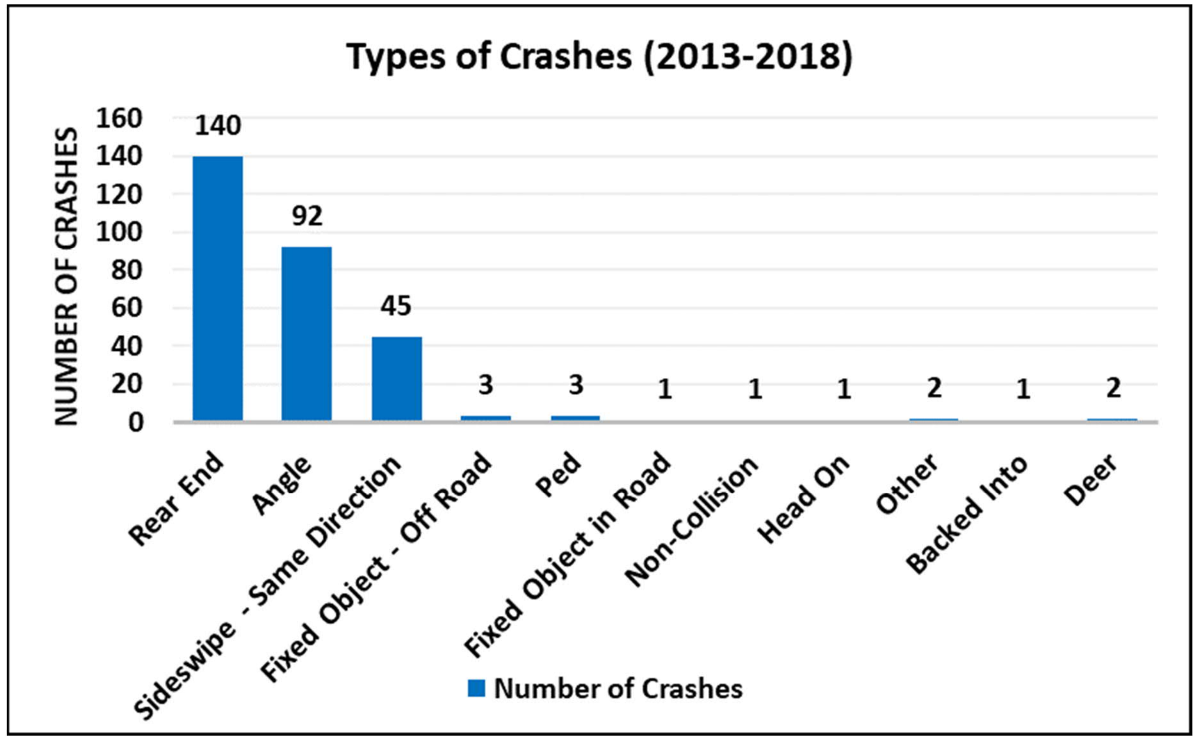


Table 13 summarizes the most prominent crash patterns along the corridor. Note that for the purposes of analyzing the most frequent crashes, not all crashes are included in the crash pattern analysis and thus the total crashes within Table 13 does not equal the total crashes observed over the five-year study period for the corridor.

Table 13. Crash Patterns along the Project Study Area.

Location (Intersection, Segment)	Intersection Approach/Leg/Ramp	Most Prominent Crash Type(s)	Vulnerable Road User Crashes	Year(s)	Total Crashes (Highest Crash Type %)
Route 1 at Market Street	NB Approach	Rear-End; Sideswipe Same Side	N/A	2014-2018	25 total (25% Rear-End; Sideswipe Same Side)
	SB Approach	Rear-End; Sideswipe Same Side	N/A	2013-2018	21 total (21% Rear-End; Sideswipe Same Side)
	SB Leg	Rear-End; Sideswipe Same Side	N/A	2013-2018	20 total (20% Rear-End; Sideswipe Same Side)
	Intersection	Angle	N/A	2013-2018	23 total (23% Angle)
Route 1 at Sunoco Gas Station/Tobacco Country Gulf Private Driveways	SB approach	Rear-End; Sideswipe Same Side	N/A	2016-2018	7 total (58% Rear-End; Sideswipe Same Side)
	Intersection	Angle	N/A	2014; 2016-2017	3 total (25% Angle)
Route 1 at Royal Inn Private Driveway	NB approach	Rear-End; Sideswipe Same Side	N/A	2015; 2017-2018	4 total (28% Rear-End; Sideswipe Same Side)
	Intersection	Angle	N/A	2014-2018	9 total (64% Angle)
Route 1 at Mine Road	NB Approach	Rear-End, Sideswipe Same Side, Ped	1 Ped	2013-2018	15 total (60% Rear-End; Sideswipe Same Side)
	EB Approach	Rear-End, Angle	N/A	2013-2018	16 total (68% Angle; 31% Rear-End)
	SB Approach	Rear-End, Ped	1 Ped	2016-2018	7 total (71% Rear-End)
	Intersection	Angle, Ped	1 Ped	2013-2018	22 total (29% Angle)

4.2.4 Crashes by Roadway and Weather Conditions

Figure 18 indicates the number of crashes by roadway surface condition. The majority (90%) of crashes occurred during dry roadway conditions. Wet conditions accounted for 10% of crashes. Additionally, Figure 19 shows that most of the collisions occurred under clear/cloudy weather conditions (91%), followed by rainy weather conditions (7%).

Figure 18. Number of Crashes by Roadway Surface Condition for the Project Study Area.

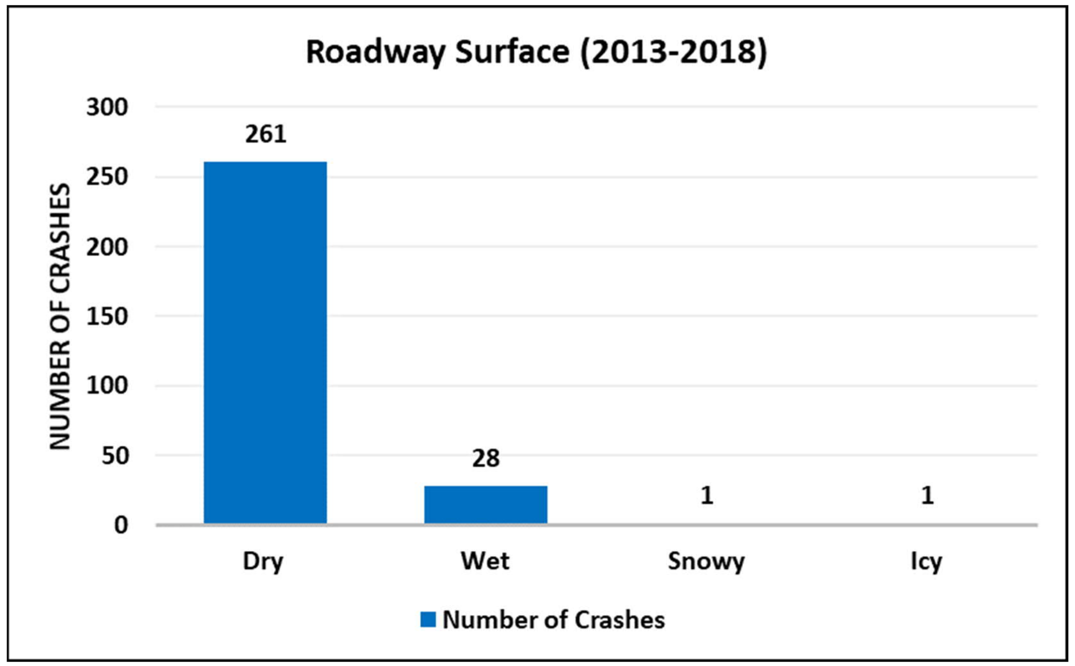
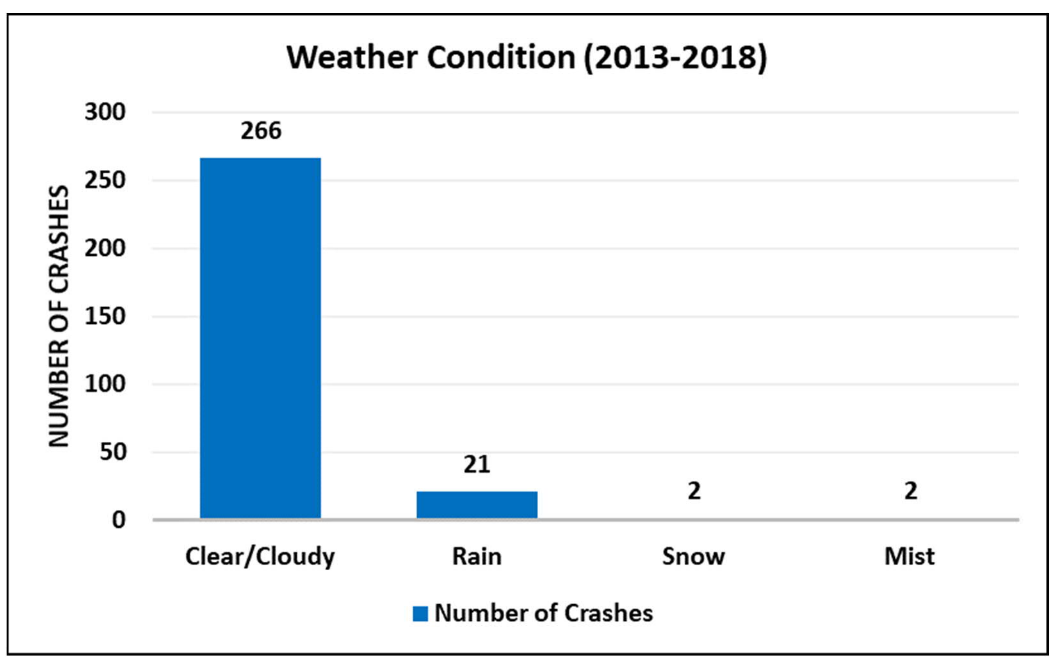


Figure 19. Number of Crashes by Weather Condition for the Project Study Area.



4.2.5 Crash Density by ¼-mile

Crash density bi-directional histograms were developed in ¼-mile increments to provide a visual representation of crashes along the corridor based on crash type, crash severity, time-of-day, and roadway conditions, and are provided in the Appendix.

4.2.6 Crash Rate (by intersection and segment)

The crash rates were calculated utilizing the rate calculations described in the Highway Safety Manual. For our project areas, crash rates were calculated by using the road segment equation and intersection equation. The intersections and roadway segments were broken up on Route 1 (Jefferson Davis Highway) to better identify and target high crash rate areas. These areas are provided in Table 14 and Table 15. Table 15 also compares the crash rates to the statewide averages on comparable road segments ("Urban Other Principal Arterials; Connecting Links of Other Rural Principal Arterial") for the most recent year data are available (2016).

Table 14. Crash Rates (Intersections)

Intersection	Total Crash Rate (Per MEV)	Fatal Crash Rate (Per MEV)	Injury Crash Rate (Per MEV)	PDO Crash Rate (Per MEV)
Market Street	1.05	0.00	0.32	0.73
Business Drive	0.03	0.00	0.00	0.03
Mine Road	0.89	0.00	0.33	0.56

Table 15. Crash Rates (Segments)

Segment	Total CR (Per 100 MVM)		Statewide Average (2016)	Fatal CR (Per 100 MVM)		Statewide Average (2016)	Injury CR (Per 100 MVM)		Statewide Average (2016)	PDO CR (Per 100 MVM)		Statewide Average (2016)
I-95 NB On/Off Ramp to Market Street	305.77	≥	173.33	0.00	≤	0.53	64.68	≤	91.63	241.09	≥	114.15
Market Street to Business Drive	126.46	≤	173.33	0.00	≤	0.53	39.94	≤	91.63	86.53	≤	114.15
Business Drive to Mine Road	310.52	≥	173.33	0.00	≤	0.53	69.00	≤	91.63	241.51	≥	114.15
Mine Road to Service Roads	215.60	≥	173.33	0.00	≤	0.53	101.46	≥	91.63	114.14	≤	114.15

Exceeds the state average crash rate

4.2.7 Crash Data Summary

The following observations were made for crashes that occurred during the five (5) year period from Mine Road to Market Street along Route 1 (Jefferson Davis Highway):

- No fatal crashes occurred along the corridor.
- Three percent (3%) of crashes involved alcohol (8 crashes).
- Fourteen percent (14%) of crashes occurred in dark lighting conditions (40 crashes), with no overhead lighting present.
- Twenty-five percent (25%) of crashes involved distracted driving (74 crashes).
- One bicycle related crash.
- Three pedestrian related crashes.
- The segment of Route 1 north of Mine Road experiences injury related crashes and could be a result of speed related issues.

4.3 Field Review

Field observations were conducted at the project study area from Tuesday, February 5, 2019 through Thursday, February 7, 2019 to assess roadway geometrics, safety, and existing signage. In addition, AM and PM peak hour conditions were observed to evaluate traffic operations, queuing, vehicle interaction conflicts, and human factors in the field. To evaluate these conditions in the field, various engineering manuals (e.g. Manual on Uniform Traffic Control Devices (MUTCD), Virginia Supplement to MUTCD, VDOT Traffic Engineering Design Manual (TEDM), 2010 ADA Standards for Accessible Design (ADA)), and IESNA standards were used to guide the recommendations. It should be noted, that while collision data was utilized to determine crash patterns and areas of focus in the field, other recommendations and/or observations were noted that may not be directly related to crash patterns. However, it was important to record all field recommendations and/or observations since they could potentially lead to improved safety conditions for road users.

The same or very similar field observations were made multiple times across various locations along the study route; Table 16 lists these common observations/recommendations and the respective standards. Note that existing standards will be cited within the Field Review and Recommendations sections for any unique observations/recommendations that are not listed within Table 16.

Table 16. Common Field Observations/Recommendations and the Associated Standards

Observation/Recommendation	Associated Standard
Tactile domes do not comply with standards and should be updated	VDOT RBS; ADA Section 705.1
Stop bar is faded and should be refurbished	MUTCD Section 3B.16
Stop sign is not present and should be installed	MUTCD Section 2B.10
Pedestrian facilities are not provided and should be installed	MUTCD Section 3B.18 and MUTCD Chapter 4E
Overhead roadway lighting is not present and should be installed	IESNA RP-8-05 Reaffirmed
Pavement markings are faded and should be refurbished.	MUTCD Section 3B

A field review reference figure has been provided in the Appendix to provide specified locations of each of the numbered field review observations listed in the following sections.

4.3.1 Route 1 (Jefferson Davis Highway) from I-95 Ramp Intersection to Market Street

- During the AM peak period, vehicles were observed extending back along the southbound lanes of the south leg, through the intersection of Route 1 at Market Street causing delays and queuing for the westbound and southbound approaches of the intersection, as shown in Figure 20. Additionally, vehicles were observed making dangerous lane changes during the peak hours to position themselves in the southbound right-turn lane. Based on the crash data, rear-end crashes and sideswipe crashes were prominent along this southbound segment, and could be due to these existing congestion problems.

Figure 20: SB US Route 1 at Market Street

4.3.2 Route 1 (Jefferson Davis Highway) at Market Street

- The signals for all approaches have backplates but do not have yellow retroreflective borders installed; however, VDOT will be installing these borders this calendar year. Based on the crash data, rear-end crashes and sideswipe crashes were prominent along the northbound, southbound, and westbound approaches. These crashes could be mitigated with improved visibility of the signal heads.
- A small street sign panel for the northbound and southbound approaches is provided on the signal pole on the northeast corner; however, is illegible due to its size and weathering. Additionally, overhead street signs are not provided on the mast arms for the eastbound and westbound approaches. (See Recommendation A1)
- The northbound and southbound approach left-turns are protective-permissive. Opposing left-turning vehicles obstruct views of approaching through moving vehicles, as shown in Figure 21. Based on the crash data, nine (9) angle crashes involving northbound and southbound left-turning vehicles occurred at the intersection and could contribute to these conditions. (See Recommendation A2)
- Currently, several private driveways exist close to the intersection along the east leg (Exxon) and southbound approach (Dominion Tire Co. and Super Value Inn). Based on the collision data, several angle crashes and sideswipes related to vehicles entering/exiting these private driveways occurred over the five-year study period and the proximity of the existing driveways could contribute to these crashes.

Figure 21: SB US Route 1 at Market Street

- Currently, pedestrian facilities (pedestrian signals) are provided across the southbound approach; however additional pedestrian facilities (i.e., crosswalk, tactile domes, ramps) are not provided on any of the approaches.
- Currently, pavement marking arrows are not provided along the southbound approach. Additionally, the eastbound approach pavement markings are faded. (See Recommendation A3)
- During the PM peak period, westbound approach vehicles were observed unable to get through the signal in one cycle.
- During the AM peak period, southbound approach congestion due to the I-95 northbound ramp south of the intersection was observed extending back along the southbound approach, as shown in Figure 22.

Figure 22: SB US Route 1 between Market Street and Mine Road

4.3.3 Route 1 (Jefferson Davis Highway) from Market Street to Mine Road

- Currently, sidewalks are not provided on the east or west sides of Route 1. Pedestrians were observed walking along the side of the road and crossing midblock, which could lead to dangerous interactions between vehicles and pedestrians. Based on the collision data, a pedestrian crash occurred in 2017 and insufficient pedestrian facilities along the corridor could contribute to these crashes.
- Currently, at the intersection of Route 1 at Business Drive, no stop control features exist along the westbound approach. (See Recommendation A4)
- Currently, a raised median island exists at the westbound approach of Route 1 at Business Drive, which serves as a right-in-right-out partition. While the raised section exists to prevent southbound and westbound left turns, vehicles were observed making left-turns to eastbound and southbound, respectively, as shown in Figure 23. (See Recommendation A5)

Figure 23: SB US Route 1 at Business Drive

4.3.4 Route 1 (Jefferson Davis Highway) at Mine Road

- The signals for all approaches have backplates but do not have yellow retroreflective borders installed; however, VDOT will be installing these borders this calendar year. Based on the crash data, rear-end crashes and sideswipe crashes were prominent along the northbound and southbound approaches. These crashes could be mitigated with improved visibility of the signal heads.
- The northbound and southbound approach left-turns are protective-permissive. Based on the crash data, eight (8) angle crashes involving northbound and southbound left-turning vehicles occurred at the intersection and could be due to these conditions. (See Recommendation A6)
- Currently, pedestrian facilities (i.e., pedestrian signals, crosswalks, ramps, tactile domes) are not provided on any of the approaches. Based on the crash data, a pedestrian crash occurred in 2014, and insufficient pedestrian facilities at the intersection could contribute to these crashes.
- Currently, an all-access driveway exists on the north side of the west leg of the intersection (former Rite Aid). The southbound right-sight distance is obstructed due to the horizontal/vertical curvature of roadway as well as vegetation. Vehicles were observed having difficulty making left-turn movements to the eastbound approach of Mine Road intersection. Based on the crash data, several angle crashes occurred at this location, and could be a result of these existing conditions. (See Recommendation A7)
- Currently, the State Route "636" sign panels and green directional sign located on the east side of the northbound approach are obstructed due to vegetation, as shown in Figure 24. (See Recommendation A8)
- During the PM peak period, eastbound, westbound, and northbound left-turning vehicles were observed unable to make it through the signal in one cycle.
- During the PM peak period, heavy congestion was observed along the westbound approach, with vehicle queues extending east of the intersection back to Stoner Drive, as shown in Figure 23.

Figure 24: NB US Route 1 at Mine Road

4.3.5 Route 1 (Jefferson Davis Highway) from Mine Road to Service Roads

- Sidewalks are provided sporadically and are discontinuous along this segment of the corridor. Based on the collision data a pedestrian crash occurred in 2016, which could be a result of these existing conditions.
- Currently, private driveways to and from the McDonald's exist on the east side of Route 1, just north of the intersection of Route 1 at Mine Road. Vehicles exiting these driveways were observed making dangerous left-turns to proceed to southbound Route 1. (See Recommendation A9)

Figure 25: WB Mine Road

4.3.6 Overall Site Review

- Signalized intersections along the corridor experienced queuing issues at some approaches, and in some scenarios prevented or blocked other movements from proceeding. These blockages could be contributing to some of the crashes as vehicles approach or proceed through the intersection. (See Recommendation A10)
- Overhead lighting was not present along segments of the corridor or at intersections, with the exception of two overhead light poles at the intersection of Route 1 at Market Street. Based on the collision data, several crashes

occurred during dark lighting conditions. Overhead lighting could minimize these crashes. (See Recommendation A11)

- Currently, sidewalks either are not present or are discontinuous along the corridor. Additionally, pedestrian facilities (i.e., pedestrian signals, crosswalks, ramps, tactile domes) are not provided at major intersections, with the exception of the pedestrian signals across the northbound leg of the intersection of Route 1 at Market Street. Based on the crash data, three (3) pedestrian crashes occurred over the five-year study period, insufficient pedestrian facilities provided along the corridor, as shown in Figure 26, could contribute to these crashes. (See Recommendation A12)
- The signals for all approaches have backplates but do not have yellow retroreflective borders installed at each of the two signalized intersections; however, VDOT will be installing these borders this calendar year. Based on the crash data, rear-end crashes and sideswipe crashes were prominent along the approaches. These crashes could be mitigated with improved visibility of the signal heads. (See Recommendation A13)
- School buses were observed making stops along the corridor between Mine Road and Market Street during the AM and PM peak periods. (See Recommendation A14)

Figure 26: SB approach US 1 at Market Street

4.4 Recommendations

4.4.1 Route 1 (Jefferson Davis Highway) from I-95 Ramp Intersection to Market Street

No recommendations for this section.

4.4.2 Route 1 (Jefferson Davis Highway) at Market Street

A1. Consider installing overhead street name signs on the mast arms for all approaches, per standards outlined in Table 16.

A2. Consider changing the phasing and signal for the northbound and southbound left-turns to include a flashing yellow arrow phase.

A3. Consider installing pavement markings (i.e., arrows) along the southbound approach, per standards outlined in Table 16. Additionally, consider refurbishing pavement markings along the eastbound approach.

4.4.3 Route 1 (Jefferson Davis Highway) from Market Street to Mine Road

A4. Consider installing a stop sign panel (R1-1) and a stop bar along the westbound approach of intersection of Route 1 at Business Drive, per standards outlined in Table 12.

A5. Consider installing "No Left Turn" sign panels (R3-2) along the southbound approach and westbound approach for to reinforce the prohibited turning movements, at the intersection of Route 1 at Business Drive.

4.4.4 Route 1 (Jefferson Davis Highway) at Mine Road/Hood Drive

A6. Consider changing the phasing and signal for the northbound and southbound left-turns to include a flashing yellow arrow phase.

A7. Consider installing a right-in-right-out raised partition to prevent vehicles from making southbound left-turns from the opening on the north side of the west leg of Hood Drive or consider restricting turn movements for southbound vehicles during the peak periods.

A8. Consider trimming the vegetation on the east side of the northbound approach.

4.4.5 Route 1 (Jefferson Davis Highway) from Mine Road to Service Roads

A9. Consider installing a right-in-right-out raised partition for the westbound approach or installing a raised median along the north leg of the intersection of Route 1 at Mine Road to prevent vehicles from making left-turns to proceed southbound along Route 1.

4.4.6 Overall Site Review

A10. Consider evaluating and/or optimizing current signal timings along the corridor to help alleviate congestion and queuing issues.

A11. Consider installing overhead lighting along the corridor segments and intersections, per standards outlined in Table 16. Improving lighting conditions along the corridor could improve or mitigate all types of crashes along the roadway or intersection(s), of which occurred during dark lighting conditions.

A12. Consider installing a continuous sidewalk along the east or west side of the roadway to provide refuge for pedestrians and safer access to establishments along Route 1. Additionally, consider installing/upgrading pedestrian facilities (i.e., crosswalk, ramps, tactile domes, pedestrian signals) across all approaches of the signalized intersections, per standards outlined in Table 16. Should pedestrian facilities be implemented, consider installing "Turning Vehicles Yield to Pedestrians" sign panels (R10-15) on the mast arms for all the approaches if right-turns will share phasing with adjacent pedestrians, or for permitted left-turning vehicles on the northbound and southbound approaches.

A13. Consider installing backplates with retroreflective borders on all traffic signal heads for all intersection approaches. It is noted that VDOT will be installing these borders this calendar year.

A14. Consider installing "School Bus Stop Ahead" sign panel (S3-1) on the east side of northbound Route 1, between Route 1 at Market Street and Route 1 at Mine Road.

5 IMPROVEMENT ALTERNATIVES

This section summarizes the improvement alternatives considered for the Route 1 corridor. The proposed improvements along Route 1 are primarily driven by a need to address existing and future safety and operational concerns. The alternatives were developed based upon the results of the Existing Conditions and Future No-Build Conditions analyses, field observation, review of prior studies/recommendations, as well as coordination with staff from the VDOT Fredericksburg District, Spotsylvania County, and the Fredericksburg Area Metropolitan Planning Organization (FAMPO). An in-person Alternatives Development Workshop was held on May 7, 2019 at the VDOT Fredericksburg Residency Conference Room.

5.1 Future Year 2035 Build Alternatives

5.1.1 Preliminary Improvement Alternatives

The approximately 0.9-mile study corridor of Route 1 is comprised of 2 signalized intersections and 1 unsignalized intersection:

- Route 1 and Mine Road/Hood Drive (Signalized)
- Route 1 and Business Drive (Unsignalized)
- Route 1 and Market Street (Signalized)

The discussion during the Alternatives Development Workshop primarily focused on these intersection locations, since the congestion and safety issues within the study corridor are centered on these intersections. Another safety improvement to be implemented for all alternatives is the installation of HVSB's at all signalized intersections.

5.1.1.1 Innovative Intersections

The improvements also considered innovative intersection concepts. Incorporating innovative intersections and interchanges into the transportation network is one strategy that VDOT is using to improve safety and mobility for congested corridors like Route 1. Preliminary screening for innovative intersections was performed using VDOT Junction Screening Tool (VJuST)[1]. This tool assists engineers and planners to screen number of innovative intersection and interchange ideas by evaluating the Critical Lane Volume (CLV) and identifies innovative intersection and interchange concepts that have potential to address congestion and safety issues. Congestion results are based on user inputs such as turning movement volumes, number of lanes and lane configurations. Safety results are based on conflict points—any points where roadway users' paths can cross with other roadway users. The screened concepts can then be analyzed further for their suitability considering site specific data such as potential right-of-way and utility impacts, potential impacts to adjacent business access points, impacts to the pedestrian movements. Figure 27 shows a screen capture of an example of VJuST screening at the intersection of Route 1/Mine Road/Hood Drive.

Figure 27. Screen Capture of VJuST Analysis: Route 1/Mine Road/Hood Drive

VDOT Junction Screening Tool

Results Worksheet

General Information	
Project Title:	Route 1 - Spotsylvania
EW Facility:	Mine Road
NS Facility:	Route 1
Date:	March 28, 2019

Volumes (veh/hr)	U-Turn / Left	Through	Right
Eastbound	83	342	266
Westbound	293	288	248
Northbound	272	1001	107
Southbound	257	1366	246

General Instructions: All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.

Intersection Results

Type	Dir	Congestion: Maximum V/C	Pedestrian: Accommodation Compared to Conventional	Safety: Weighted Total Conflict Points	Notes
Conventional	-	0.74		48	Assumes widening along all approaches
Bowtie	-	0.76	+	24	High Left turn Volumes
Center Turn Overpass	-	0.66	+	32	Promising, but expensive option
Echelon	-	0.63	+	28	Promising, but expensive option
Full Displaced Left Turn	-	0.73	-	40	To much R/W take
Median U-Turn	-	0.76	+	20	
Partial Displaced Left Turn	-	0.74	-	44	Smaller footprint than conventional
Partial Median U-Turn	-	0.86	+	28	Median U-turns along east leg seem difficult
Quadrant Roadway	N-W	0.73		40	
	S-E	0.63		40	
	S-W	0.68		40	
Restricted Crossing U-Turn	-	0.83		20	

Several preliminary improvement alternatives were presented based on the operational, safety and VJuST analysis results. The improvement alternatives were vetted and screened by the Study Work Group (SWG) and a list of "Screened Alternatives" were selected to move forward for the Future 2035 Build Analysis. A complete list of alternatives that were tested is summarized in Table 17.

[1] VDOT Innovative Intersections and Interchanges: Junction Screening Tool, Version 1.02

Table 17. Screened Improvement Alternatives for Testing

Location	Screened Improvements		
	Option 1	Option 2	Option 3
Route 1/Mine Road/Hood Drive	Conventional widening	Southwest quadrant roadway intersection layout	Northwest quadrant roadway intersection layout
Route 1/Business Drive	Access management adjacent to the intersection	Improvements to compliment concept proposed at Mine Road intersection	Improvements to compliment concept proposed at Mine Road intersection
Route 1/Market Street	Planned improvements and 3 WB left-turns and 1 thru+right-turn lane	Planned improvements and 2 WB left-turns, 1 thru+LT, 1 RT	Planned improvements and modified thru-cut intersection layout

5.1.2 Preferred Improvement Alternatives

The screened alternatives listed in Table 17 were further tested for traffic operations improvements, safety improvements as well potential cost. The results of testing were shared with the SWG via a webinar. The results of the analysis as well as pros and cons of each of the screened alternatives were discussed among the SWG. The main objective of this discussion was to select a concise list of improvement alternatives to be advanced further for submitting applications for funding. The agreed upon list of improvement alternatives, termed as “Preferred Alternatives” is shown in Table 18. The list includes improvement alternatives which are low-cost, medium-cost and high-cost. The alternatives requiring significant geometric modifications such as addition of lanes are considered as high-cost, while those involving signal re-timing, re-striping, traffic control devices upgrade are considered as low-cost.

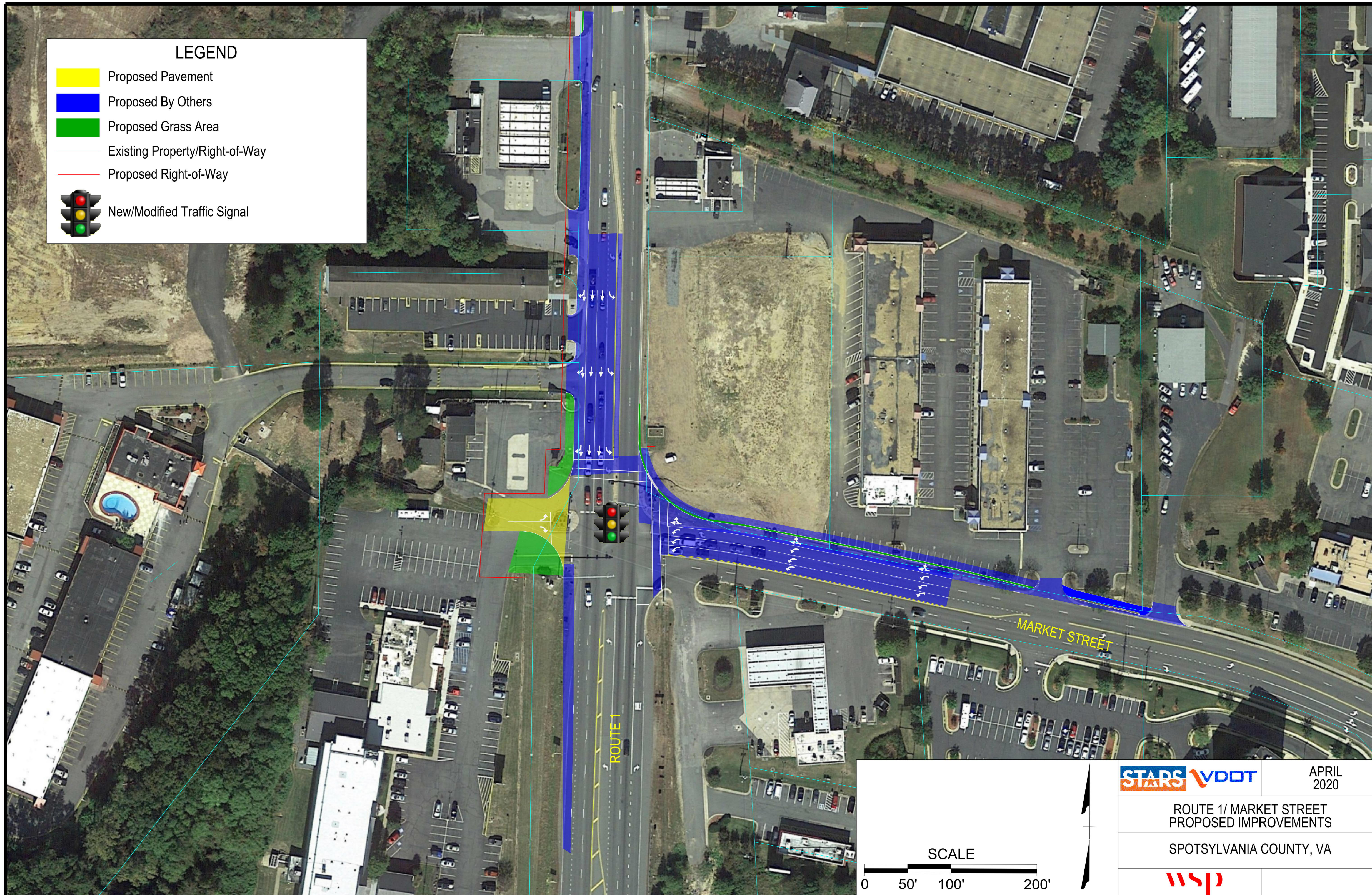
Figures 28 and 29 present the conceptual designs of the improvement alternatives that involve geometric modifications.

Table 18. Preferred Improvement Alternatives

Alternative#	Location	Preferred Improvements
1	Route 1/Mine Road/Hood Drive	1. Northwest quadrant roadway: Construct a new roadway alignment in the northwest quadrant of this intersection to connect Hood Drive and north Route 1. 2. All left turns will be prohibited at the main intersection of Route 1/Mine Road/Hood Drive intersection and will be reassigned to the two secondary intersections. 3. The secondary intersection at Quadrant Road/Hood Drive will have following lane configuration: a. EB approach: 1-LT, 2-Thru b. WB approach: 1-Thru, 1-RT c. SB approach: 1-LT, 1-RT 4. The secondary intersection at N Route 1/Quadrant Road will have following lane configuration: a. EB approach: 1-LT, 1-RT b. NB approach: 1-LT, 3-Thru c. SB approach: 2-Thru, 1-Thru+RT 5. All three intersections will be reduced to 2-phase signals
	Route 1/Business Drive	1. Construct access management improvements in the vicinity of Route 1/Business Drive intersection 2. Change the lane configuration of SB outside lane from RT only to shared thru+RT.
2	Route 1/Market Street	1. Planned improvements based on the UPC 115614 per CMAQ and HSIP funding application 2. Change the EB/WB approaches to Thru-Cut layout. 3. Prohibit EB thrus, while allowing a shared thru+RT movement from WB approach. 4. Realign EB approach with the east leg; construct access management improvements along west side of Route 1 in the vicinity of the intersection.

Figure 28. Alternative 1 – Route 1/Mine Road/Hood Drive: Northwest Quadrant Roadway Layout

Figure 29. Alternative 2 – Route 1/Market Street: Modified Thru-Cut Layout



6 FUTURE 2035 BUILD CONDITIONS

The "Preferred Alternatives" from the alternatives evaluation exercise were distributed among the members of the SWG for feedback. Their feedback was further discussed, vetted and included in the final alternative conceptual layouts. These alternatives were modeled in Synchro and evaluated using SimTraffic for the Future 2035 Build condition traffic operations.

6.1 Intersection Operations: Future 2035 Build Condition

6.1.1 2035 Build Volumes

The AM and PM peak hour volumes for 2035 Build conditions accounted for the changes in geometry and lane assignments at intersections. Traffic reassignment was implemented in accordance with the following assumptions:

Intersection 1 – Route 1 and Mine Road/Hood Drive (NW Quadrant Roadway Intersection layout)

- Prohibit all left turns at the intersection, reassign them at the secondary intersections;
- Northbound left reassigned to N Route 1 as through, Quadrant Road left northbound left, Quadrant Road southbound left/right;
- Southbound left reassigned to Quadrant Road southbound right, Quadrant Road southbound left, Hood Drive westbound through;
- Eastbound left reassigned to Quadrant Road eastbound left, Quadrant Road eastbound left;
- Westbound left reassigned to Mine Road westbound through, Quadrant Road westbound right, Quadrant Road westbound right.

Intersection 3 – Route 1 and Market Street (Thru-Cut Intersection layout)

- Prohibit EB through movements, reassign them as EB right, U-turns at adjacent median opening;
- Allow WB through movements in the outside shared thru+RT lane.

Figure 30 and 31 show the final traffic volumes for the 2035 Build condition.

6.1.2 2035 Build Traffic Operations

Operational analysis was performed at each of the study intersections for the 2035 Future Build Condition. Table 19 summarizes the average AM and PM peak hour delay for each movement for the study intersections along the corridor. Table 20 summarizes the delay results for Sunday peak. The SimTraffic outputs can be found in the Appendix. Figures 32 and 33 show the intersection delay and LOS for the preferred alternatives graphically.

Queuing analysis was completed for the study intersections during the AM and PM peak hours and Sunday peak for 2035 Build conditions. SimTraffic Maximum Queue Lengths in feet were reported for each lane. These queue lengths are based on an average of 10 simulation runs. Tables 21 and 22 summarize the maximum queue lengths during the AM and PM peak hours and Sunday peak for the preferred alternatives.

Results of the weekday AM/PM peak Build conditions SimTraffic analysis suggests the following changes in overall intersection delays:

Route 1 and Mine Road/Hood Drive (NW QRI layout, 2035 Build)

- Microsimulation delay of 18.5 sec/veh during the AM peak hour and 20.8 sec/veh during the PM peak hour (2035 No-Build delays: AM Peak – 429.5 sec/veh, PM Peak - 546.7 sec/veh);

Route 1 and Business Drive

- Microsimulation delay of 7.1 sec/veh during the AM peak hour and 6.4 sec/veh during the PM peak hour (2035 No-Build delays: AM Peak – 3.8 sec/veh, PM Peak - 47.4 sec/veh);

Route 1 and Market Street (Modified Thru-Cut Intersection layout, 2035 Build)

- Microsimulation delay of 17.5 sec/veh during the AM peak hour and 73.1 sec/veh during the PM peak hour (2035 No-Build delays: AM Peak – 54.0 sec/veh, PM Peak - 138.4 sec/veh);

The results of Sunday peak Build conditions analysis suggest the following changes in overall intersection delays:

Route 1 and Mine Road/Hood Drive (NW QRI layout, 2035 Build)

- Microsimulation delay of 18.3 sec/veh (2035 No-Build delay: 59.9 sec/veh);

Route 1 and Business Drive

- Microsimulation delay of 7.3 sec/veh (2035 No-Build delay: 56.4 sec/veh);

Route 1 and Market Street (Modified Thru-Cut Intersection layout, 2035 Build)

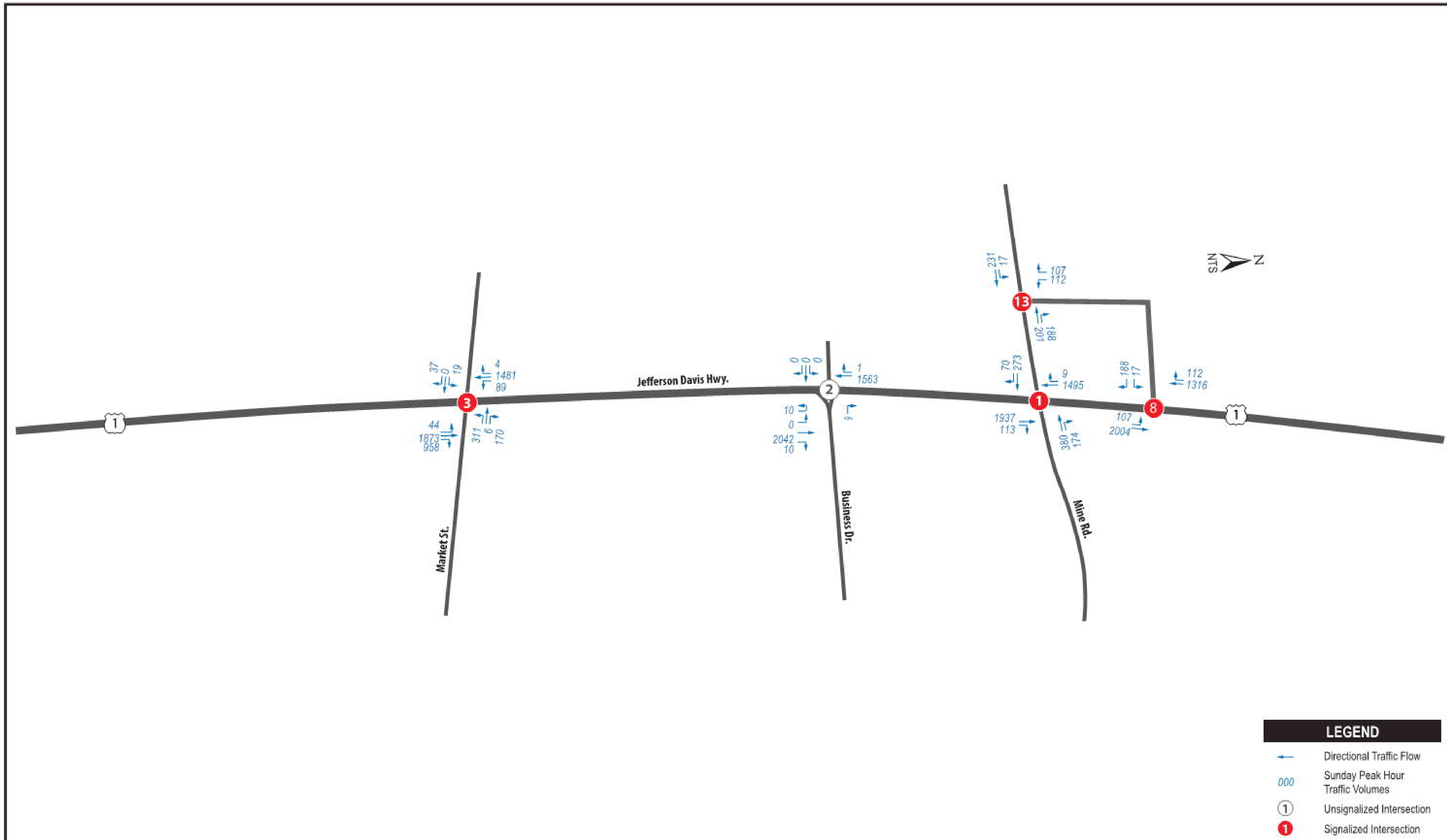
- Microsimulation delay of 31.3 sec/veh (2035 No-Build delay: 79.0 sec/veh);

The results of the analysis summarized above suggest that the overall delay reduces significantly at the intersection of Route 1/Mine Road/Hood Drive with the proposed NW QRI layout. This reduction in delay is attributable to the reduced signal phases at the main intersection and creation of two new secondary intersections that primarily serve the reassigned left turns. With this reduction in delay, the overall corridor experiences improved travel time, improved corridor progression and reduction in peak hour queues.

The intersection of Route 1/Market Street will continue to experience delays during PM peak hour, suggesting that further capacity improvements at this intersection are necessary. One possibility to address this situation would be to convert the NB outside right-only lane to a thru lane and then add an outside right-turn bay, which would help alleviate the delay in the NB direction as well as the overall intersection. This would also require widening on the north leg to accommodate the 3rd input lane at least up to some distance. There may be other innovative intersection ideas that can be implemented which may be more effective than the conventional widening, but this would need to be evaluated further through subsequent study.

Figure 30. Future 2035 Build Weekday AM/PM Peak Hour Volumes

Figure 31. Future 2035 Build Sunday Peak Hour Volumes



ROUTE 1
from Mine Road to Market Street, Spotsylvania County, VA

ROUTE 1 2035 FUTURE SUNDAY PEAK HOUR VOLUMES

FIGURE

Table 19. Future 2035 Build SimTraffic AM and PM Peak Hour Delay (veh/sec)

Intersection Number and Description	Type of Control	Lane Group	Eastbound AM Delay	Eastbound PM Delay	Westbound AM Delay	Westbound PM Delay	Northbound AM Delay	Northbound PM Delay	Southbound AM Delay	Southbound PM Delay	Overall AM	Overall PM
1			Hood Drive		Mine Road		Route 1		Route 1			
Route 1 and Hood Drive/ Mine Road	Signal	Left									Delay	Delay
		Through	30.3	43.8	36.4	36.8	13.9	14.9	7.5	9.8		
		Right	16.6	31.5	25.7	31.6	5.0	5.6	3.5	5.9	18.5	20.8
		Approach	23.8	40.0	33.3	35.3	13.8	14.2	6.9	9.3		
8			Quadrant Rd				Route 1		Route 1			
Route 1 and Quadrant Rd	Signal	Left	59.3	53.0	--	--	46.5	41.3	--	--	Delay	Delay
		Through	--	--	--	--	4.0	2.4	13.0	30.3		
		Right	7.1	20.6	--	--	--	--	10.5	21.9	10.4	21.9
		Approach	31.5	28.1	--	--	5.9	9.4	12.6	29.9		
13			Hood Drive		Hood Drive		Quadrant Rd					
Hood Dr and Quadrant Rd	Signal	Left	52.6	43.4	--	--	--	--	52.3	30.2	Delay	Delay
		Through	6.2	12.0	7.3	26.3	--	--	--	--		
		Right	--	--	3.7	5.8	--	--	10.5	23.2	12.3	19.9
		Approach	10.6	15.8	6.5	19.4	--	--	38.7	27.0		
2			Business Drive		Entrance		Route 1		Route 1			
Route 1 and Business Drive	Two-Way Stop	U-turn	--	--	--	--	34.3	0.0	--	--	Delay	Delay
		Left	0.0	39.3	--	--	24.0	0.0	--	--		
		Through	--	--	--	--	9.3	9.8	3.2	4.2		
		Right	0.0	0.0	1.4	1.4	8.2	10.1	3.4	6.2	7.1	6.4
		Approach	0.0	39.3	1.4	1.4	10.8	9.8	3.2	4.2		
3			Entrance		Market Street		Route 1		Route 1			
Route 1 and Market Street	Signal	Left	46.0	54.6	44.1	47.5	19.6	158.4	20.8	55.2	Delay	Delay
		Through	--	--	0.0	46.7	16.0	179.1	10.4	32.6		
		Right	8.0	185.1	44.1	24.6	10.2	29.6	9.0	22.1	17.5	73.1
		Approach	39.6	108.9	42.5	43.6	14.4	133.1	11.7	35.3		

NOTE: Microsimulation Delay (sec/veh) results shown represent an average of 10 SimTraffic runs.
'—' Movements not applicable OR SimTraffic does not provide level of service or delay for movements with no conflicting volumes.

Table 20. Future 2035 Build SimTraffic Sunday Peak Hour Delay (veh/sec)

Intersection Number and Description	Type of Control	Lane Group	Eastbound WKND Delay	Westbound WKND Delay	Northbound WKND Delay	Southbound WKND Delay	Overall AM
1 Route 1 and Hood Drive/ Mine Road			Hood Drive	Mine Road	Route 1		
	Signal	Left					Delay
		Through	49.9	62.5	9.8	8.7	
		Right	17.2	54.9	6.0	1.8	18.3
		Approach	43.7	60.1	9.6	8.6	
8 Route 1 and Quadrant Rd			Entrance	Business Drive	Route 1		
	Signal	Left	62.1	--	50.3	--	Delay
		Through	--	--	7.7	28.2	
		Right	37.4	--	--	3.5	17.6
		Approach	39.6	--	10.0	26.2	
13 Hood Dr and Quadrant Rd			Entrance	Business Drive	Route 1		
	Signal	Left	31.8	--	--	30.1	Delay
		Through	5.2	4.9	--	13.8	
		Right	--	6.0	--	--	10.1
		Approach	7.0	5.4	--	21.8	
2 Route 1 and Business Drive			Entrance	Business Drive	Route 1		
	Two-Way Stop	U-turn	--	--	39.6	--	Delay
		Left	0.0	--	0.0	0.0	
		Through	--	--	11.2	1.9	
		Right	0.0	1.4	12.2	3.5	7.3
		Approach	0.0	1.4	11.4	1.9	
3 Route 1 and Market Street			Market Street	Market Street	Route 1		
	Signal	Left	74.1	55.8	44.8	77.0	Delay
		Through	--	69.2	35.4	19.7	
		Right	8.0	50.1	25.3	9.5	31.3
		Approach	30.9	54.1	32.2	22.3	

NOTE: Microsimulation Delay (sec/veh) results shown represent an average of 10 SimTraffic runs.
'—' Movements not applicable OR SimTraffic does not provide level of service or delay for movements with no conflicting volumes.

Figure 32. Future 2030 Build Weekday AM/PM Peak Intersection Operations Results

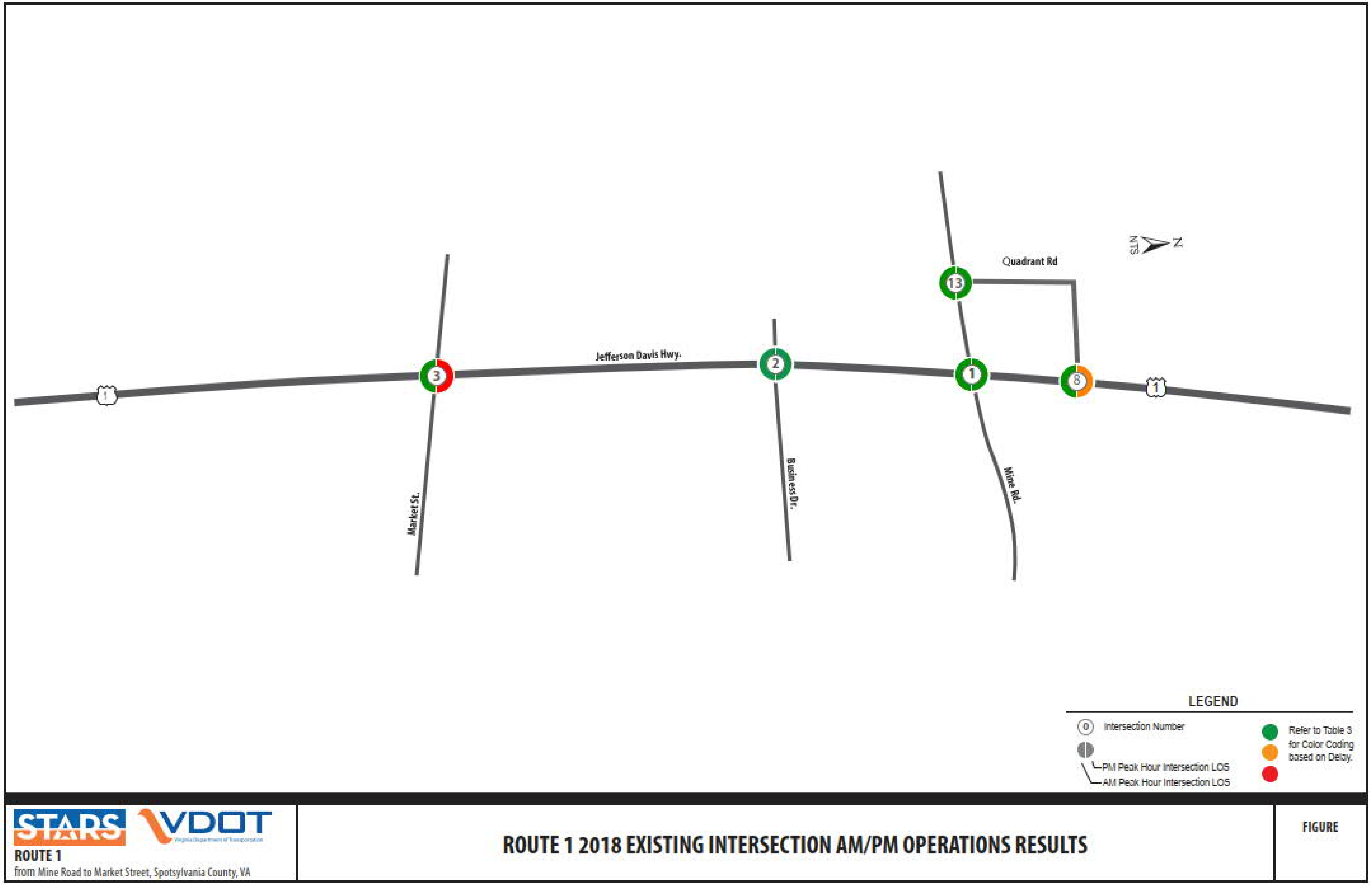


Figure 33. Future 2030 Build Sunday Peak Intersection Operations Results

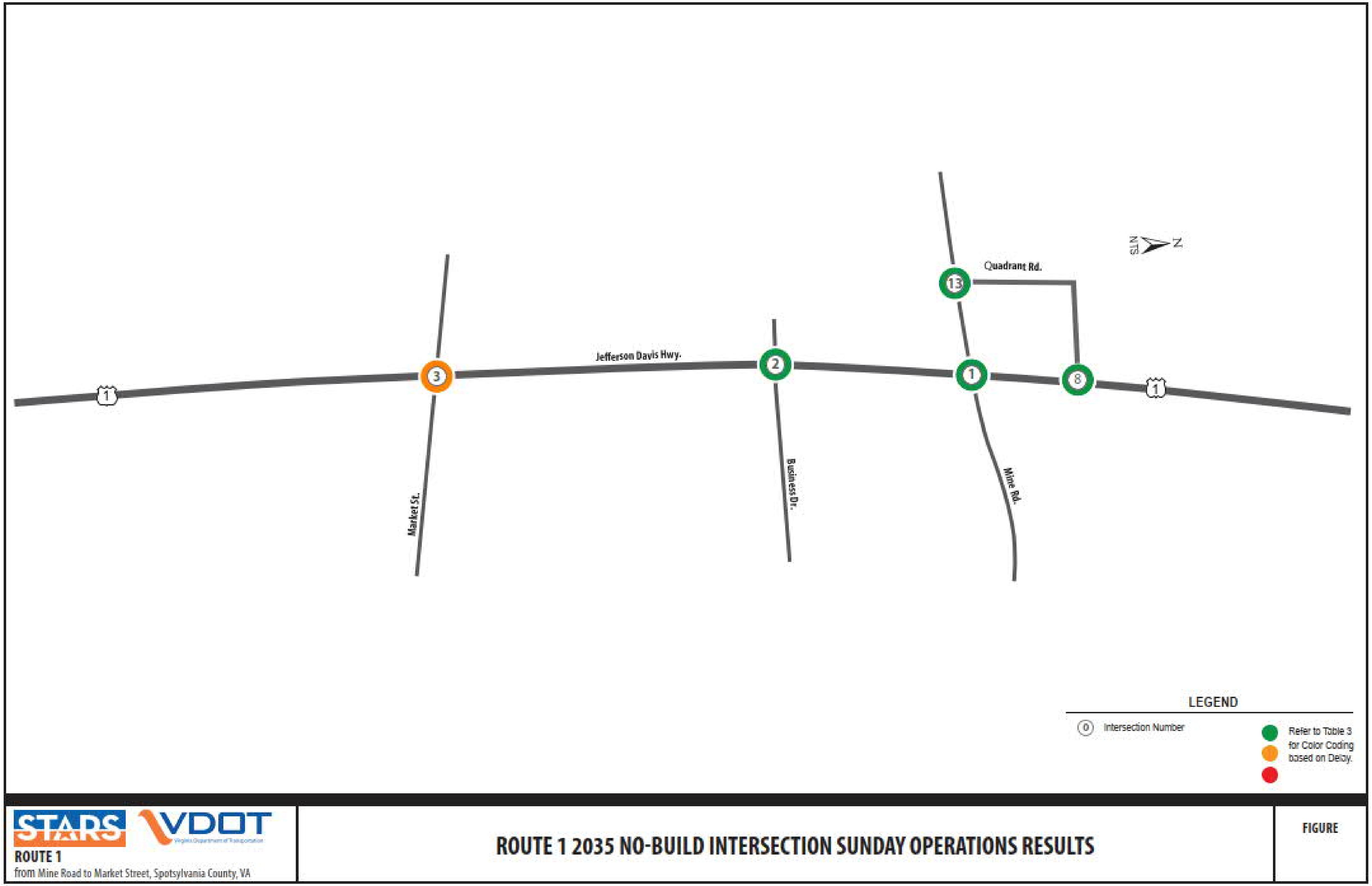


Table 21. Future 2035 Build Conditions: Summary of AM/PM Peak Maximum Queues (feet)

Intersection Number and Description	Type of Control	Lane Group	Eastbound			Westbound			Northbound			Southbound		
			Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)	Storage Bay Length	AM Queue (ft)	PM Queue (ft)
1 Route 1 and Hood Drive/Mind Road			Hood Drive			Mine Road			Route 1			Route 1		
	Signal	Left	--	--	--	--	--	--	--	--	--	--	--	--
		Through	--	364	395	--	397	346	--	374	215	--	166	291
		Right	--	410	427	665	330	270	335	35	69	--	80	82
8 Route 1 and Quadrant Rd			Quadrant Road			--			Route 1			Route 1		
	Signal	Left	250	169	187	--	--	--	250	129	242	--	--	--
		Through	--	--		--	--	--	--	211	256	--	223	667
		Right	--	91	270	--	--	--	--	--	--	200	291	200
13 Hood Dr and Quadrant Road			Hood Drive			Hood Drive			--			Quadrant Road		
	Signal	Left	150	51	134	--	--	--	--	--	--	365	132	334
		Through	--	89	195	--	97	412	--	--	--	--	317	12
		Right	--	--	--	--	70	169	--	--	--	--	382	277
2 Route 1 and Business Drive			Entrance			Business Drive			Route 1			Route 1		
	Two-Way Stop	Left	--			--	--	--	--	338	0	--	--	--
		Through	--	0	37	--	--	--	--	0	--	--	--	140
		Right	--			--	0	0	--	354	6	--	--	16
3 Route 1 and Market Street			Entrance			Market Street			Route 1			Route 1		
	Signal	Left	--	167	84	400	201	354	315	54	315	365	118	305
		Through	--	--		--	--	633	--	431	912	--	252	587
		Right	--	56	125	400	56	617	--	298	918	--	260	558

NOTE: The maximum queues in feet are obtained from 10 SimTraffic simulation runs averaged together.
'--' Storage Bay Length not provided or the movements do not exist.
Red text indicates queue lengths that reach or exceed the available storage lengths OR indicates turn lane storage blockage.

Table 22. Future 2035 Build Conditions: Summary of Sunday Peak Maximum Queues (feet)

Intersection Number and Description	Type of Control	Lane Group	Eastbound		Westbound		Northbound		Southbound	
			Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)	Storage Bay Length	Sunday Queue (ft)
1 Route 1 and Hood Drive/Mind Road			Hood Drive		Mine Road		Route 1		Route 1	
	Signal	Left	--	--	--	--	--	--	--	--
		Through	--	222	--	318	--	461	--	395
		Right	--	229	665	269	335	308	--	24
8 Route 1 and Quadrant Rd			Quadrant		--		Route 1		Route 1	
	Signal	Left	250	176	--	--	250	231	--	--
		Through	--	--	--	--	--	471	--	637
		Right	--	273	--	--	--	--	200	77
13 Hood Dr and Quadrant Road			Hood Drive		Hood Drive		--		Quadrant Road	
	Signal	Left	150	51	--	--	--	--	365	132
		Through	--	89	--	97	--	--	--	317
		Right	--	--	--	70	--	--	--	382
2 Route 1 and Business Drive			Entrance		Business Drive		Route 1		Route 1	
	Two-Way Stop	Left	--	0	--	--	--	485	--	--
		Through	--		--	--	--	0	--	--
		Right	--		--	0	--	489	--	--
3 Route 1 and Market Street			Market Street		Market Street		Route 1		Route 1	
	Signal	Left	--	75	400	237	315	290	365	260
		Through	--	--	--	--	--	925	--	436
		Right	--	57	400	261	--	923	--	382

NOTE: The maximum queues in feet are obtained from 10 SimTraffic simulation runs averaged together.
'--' Storage Bay Length not provided or the movements do not exist.
Red text indicates queue lengths that reach or exceed the available storage lengths OR indicates turn lane storage blockage.

7 CRASH REDUCTION ANALYSIS

A crash reduction analysis was conducted for Route 1 (Jefferson Davis Highway). As part of the crash reduction methodology, the Crash Modification Factor (CMF) Clearinghouse[2] and FHWA Desktop Reference for Crash Reduction Factors[3] (CRF) were utilized to calculate the Crash Reduction Factors (CRFs) associated with each proposed improvement along Route 1 in Spotsylvania, Virginia. The CRFs were applied to the crash history data from the VDOT Crashtools Database[4] to determine the expected number of crashes and the percent reduction in crashes per alternative. As part of this corridor analysis, new signalized intersections, along Route 1 and Hood Drive, will be implemented and thus will be evaluated as part of the safety analysis. In order to evaluate their benefits, safety performance functions (SPF) from VDOT's report Safety Performance Functions for Intersections on Highways Maintained by the Virginia Department of Transportation[5] were used to estimate the safety impacts of these signalized intersections.

Expected crashes were projected to the year 2035 (base build year), based on existing crash data. At this point, improvements are expected to be built and thus safety benefits can begin accruing. In order to evaluate the efficacy of the improvements, a 2055 horizon year (20-year life cycle) was selected to compare the No-Build and Build conditions.

1.1 Analysis Methodology

The following sections describe the methodology that was used to determine the crash expectancy and cost savings associated with the proposed modifications.

1.1.1 Proposed Roadway Modifications and CRFs

The CRFs were selected based on the preferred improvements designated for the 2035 Build conditions. The Appendix includes the following: 1) the countermeasures proposed, 2) categories of countermeasures obtained from the CMF Clearinghouse and/or FHWA Desktop Reference source, 3) applicable crash type and severity, 4) percent of applicable crashes, and 5) notes for selected CRFs. It should be noted that CRFs are not provided for all roadway modifications in the Crash Modification Factor Clearinghouse or FHWA Desktop Reference for Crash Reduction Factors. Appropriate CRFs were not available to be utilized for all corridor improvements and thus did not have calculated impact on the expected crashes. While a CRF may not exist for an improvement; this does not imply the improvement won't have safety benefit.

In some instances, CRF values were applicable to the intersection or segment as a whole and often involved multiple CRF values. To accurately calculate CRFs for some alternatives, a composite CRF was calculated using Equation 1. Some alternatives required combined CRFs and/or individual CRFs, depending on the specific improvements.

Equation 1. Composite CRF Calculation

$$Composite\ CRF = 1 - [(1 - CRF_1) * (1 - CRF_2) * \ldots * (1 - CRF_i)]$$

1.1.2 Applicable Crash Calculations

To properly determine how the improvements impact the 2035 and 2055 expected crashes, a detailed evaluation of historical crash data (2013-2018) was conducted. Not every crash at a specific location would be reduced due to an improvement. For example, when implementing a raised median along Route 1 from Business Drive to Mine Road/Hood Drive, angle-related related crashes, per the details of the CRF development, would be expected to be reduced the most. Therefore, the CRF should only be applied to the specific crashes that may be affected by the improvement. For each improvement with a known CRF, the number of crashes impacted by the improvement was determined by analyzing each crash within the VDOT Crashtools Database from the five (5) most recent calendar years of crash data (2013-2018). Then, the percent of applicable crashes (i.e., number of applicable crashes across the five calendar years divided by the total number of crashes) was determined for each improvement with a known CRF, as shown in Equation 2.

Equation 2. Percentage of Applicable Crashes Calculation

$$Percentage\ of\ Applicable\ Crashes = \frac{Number\ of\ Applicable\ Crashes}{Total\ Number\ of\ Crashes} * 100$$

1.1.3 Crash Reduction Evaluation

Based on the 2013-2018 crash data within the VDOT Crashtools Database, the average numbers of property damage only (PDO or O), minor/possible injury and no apparent injury (B+C), and fatal or serious injury (K+A) over the most recent five years were calculated. The existing average crashes were then projected into 2035 (i.e., 17-year projection based on the 1.7% growth rate along Route 1) to which a base build year was established. These estimates were then projected out to the year 2055 (i.e., 20-year projection) to estimate the expected number of (PDO), (B+C), and (K+A) crashes for the Build conditions over the 20-year life cycle, based on the 1.7% growth rate for Route 1.

To calculate the expected number of (O), (B+C), and (K+A) crashes for the Build conditions where 100% of the crashes were applicable, the appropriate composite CRFs were implemented where improvements were proposed, as shown in Equation 3.

Equation 3. Expected Crashes for the 2035 Build Conditions (100% Applicable Crashes)

$$2035\ Build\ Expected\ Crashes = 2035\ No\ Build\ Expected\ Crashes - [2035\ No\ Build\ Expected\ Crashes * (CRF)]$$

To calculate the expected number of (O), (B+C), and (K+A) crashes for the Build conditions where only a portion of the crashes were applicable, the appropriate composite CRFs were implemented where improvements were proposed, as shown in Equation 4.

[2] Federal Highway Administration. (2017). Crash Modification Factors Clearinghouse. Washington, DC. Retrieved from http://www.cmfclearinghouse.org/.
[3] Federal Highway Administration. (2014). Desktop Reference for Crash Reduction Factors. Washington, DC. Retrieved from https://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/.
[4] Virginia Department of Transportation. (2017). Crash Analysis Tool. Retrieved from https://public.tableau.com/profile/tien.simmons#!/vizhome/Crashtools8_2/Main.
[5] Garber, N. J. & Rivera, G. (2010). Safety Performance Functions for Intersections on Highways Maintained by the Virginia Department of Transportation (Contract Report No. FHWA/VTRC 11-CR1). Retrieved from: http://vtrc.virginiadot.org/PubDetails.aspx?PubNo=11-CR1.

Equation 4. Expected Crashes for the 2035 Build Conditions (<100% Applicable Crashes)

$$2035\ Build\ Expected\ Crashes =$$

$$2035\ No\ Build\ Expected\ Crashes - [2035\ No\ Build\ Expected\ Crashes * \%\ Applicable\ Crashes * (CRF)]$$

The percent reduction in (O), (B+C), and (K+A) crashes between the 2055 No-Build and Build conditions per alternative was calculated for each intersection/segment for Route 1 over the 20-year cycle life.

Projected crashes and crash reductions to the base build year (2035) is provided in the Appendix. This base condition was then projected each year over the 20-year life cycle to determine the crash reductions through 2055.

1.1.4 Safety Performance Functions

SPFs from Safety Performance Functions for Intersections on Highways Maintained by the Virginia Department of Transportation were used to estimate the safety-related impacts due to the addition of new signalized intersections along the study corridor. The SPFs for urban 3-leg signalized intersection was used in this study, with the annual average daily traffic specific to each proposed location and a distribution of crash severities based on the crash data used for this study.

1.2 Analysis Results

The total crash reduction values over the 20-year cycle life (i.e., from 2035 to 2055) for each alternative are provided in Table 2323.

Table 23. Total Crash Reduction (20-year Cycle Life)

Alternative	PDO Crashes (Reduction)	B+C Crashes (Reduction)	K+A Crashes (Reduction)
ALTERNATIVE 1: Route 1/Mine Road/Hood Drive NW QRI Route 1/Business Drive Access Management	-54.40	-27.10	-1.98
ALTERNATIVE 2: Route 1/Market Street Thru-Cut Intersection	117.24	50.75	1.75

[1] Crash Rate reduction percentages are assumed to remain the same over the 17-year and 20-year projections due to the assumed constant growth rate over the corridor.

It can be seen from Table 23 that the crashes are projected to reduce with the proposed improvements as part of Alternative 2, while they are projected to grow under Alternative 1. This increase is primarily attributable to creation of two new signalized intersections to facilitate the NW quadrant intersection layout. The resulting reassignment of traffic to the two secondary intersections creates new conflicts. This increase in crashes, is, however considered acceptable given the delay reductions obtained by this innovative intersection layout.

8 Improvement Prioritization

The Improvement Prioritization process involved development of planning level cost estimates for the preferred alternatives, development of 20-year life-cycle operational and safety benefits for each improvement alternative and calculation of the Benefit-Cost ratios. These elements are described in the following sections.

8.1 Planning Level Cost Estimates

Planning level cost estimates were developed for all the preferred improvement alternatives following the guidance from VDOT Fredericksburg District Location and Design (L&D) on developing planning level cost estimates for SMART SCALE. A coordination meeting on development of the methodology of such cost estimates was held on January 7, 2020 at the VDOT Fredericksburg Residency. The methodology was further reviewed and finalized in coordination with VDOT L&D. The cost estimates included Construction (CN), Right-of-Way and Utilities Relocation (ROW) and Preliminary Engineering (PE) costs. Table 24 summarizes the cost estimates for each improvement alternative proposed and are expressed in year 2035 dollars.

Table 24. Planning Level Cost Estimates (Year 2035 USD)

Alternative/Location	Cost Estimate			
	Preliminary Engineering (PE)	Right-of-Way/Utilities (ROW)	Construction (CN)	Total
ALTERNATIVE 1: Route 1/Mine Road/Hood Drive NW QRI Route 1/Business Drive Access Management	$1,268,832	$8,193,331	$16,258,596	$25,720,759
ALTERNATIVE 2: Route 1/Market Street Thru-Cut Intersection	$344,760	$381,907	$2,120,280	$2,846,947
			Total	$28,567,706

The planning level cost estimates were developed to get a preliminary idea of the funding requirements for the proposed improvements along the corridor.

8.2 Planning Level Schedule Estimates

Planning level schedules were developed for all improvement alternatives. Schedule estimates were based on familiarity with complexity of projects within the Fredericksburg District as well as discussions with the SWG. Table 25 summarizes schedules by phases of project: Preliminary Engineering (PE), ROW and Utility Relocation (ROW) and Construction (CN).

Table 25. Planning Level Schedules (months)

Alternative/Location	Schedule Estimate			
	Preliminary Engineering (PE)[1]	Right-of-Way/Utilities (ROW)[3]	Construction (CN)[2]	Total[4]
ALTERNATIVE 1: Route 1/Mine Road/Hood Drive NW QRI Route 1/Business Drive Access Management	12	18	12	42
ALTERNATIVE 2: Route 1/Market Street Thru-Cut Intersection	6	6	9	21

Notes:

1. PE durations assume 3 design submittals with 3-week review period
2. Construction duration includes pre-submittals (1.5 month) and close out/punch list items (1 month)
3. ROW for access management includes permit modifications
4. Total duration does not include time for procurement and award

8.3 Benefit-Cost Analysis

A Benefit-Cost (B/C) analysis was conducted for the candidate projects to evaluate their cost effectiveness. An analysis period of 20-years was used to evaluate the life cycle benefits. 20-year period is typically used for small to medium size transportation projects. The following factors were considered in the B/C calculations for each of the improvement alternatives evaluated:

8.3.1 Operational Benefit

The determination of operational benefit for each improvement alternative was based on the methodology of calculating reduction in travel delay because of the proposed improvements. This methodology converts the vehicle delay into person delays by accounting for the vehicle occupancy. Consistent with the 2017 National Household Travel Survey (NHTS)[6], average vehicle occupancies of 1.18 and 1.82 were assumed for work trips and non-work trips, respectively, assuming 250 work days per year and 60% of peak hour volumes are work trips.

Similarly, USDOT's "Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis, 2016"[7], Table 4 was used to determine the hourly values for travel time savings for each occupant in a vehicle as $25.40/hour and $13.60/hour for work and non-work trips, respectively.

To determine annual peak hour delay savings, the calculated delay reduction per vehicle (SimTraffic analyses) in each respective peak hour was multiplied by the peak hour traffic volume at each intersection to obtain a compounded delay. Using the compounded delay savings and identified values for travel time savings, the annual cost benefits for each alternative were determined. The Present Value of Benefits (PVB_D) of the annual delay reduction benefits over a 20-year life-cycle was calculated using Equation 5:

[6] FHWA Report No. FHWA-PL-11-022, Summary of Travel Trends: 2009 National Household Travel Survey

[7] USDOT Guidance: "The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations, Revision 2 (2016 Update)"

Equation 5. Present Value of Benefits (PVB_D)

$$(P/A, i, n) = \frac{(1+i)^n - 1}{i(1+i)^n}$$

Where,

$(P/A, i, n)$ = Factor that converts a series of uniform annual amounts to its present value
i = Minimum attractive rate of return or discount rate = 3%
n = Years in the service life of the improvements = 20 years

8.3.2 Safety Benefit

As part of the crash analysis, the differences in crashes between the 2055 No-Build and Build conditions were calculated for PDO, (B+C), and (K+A) crashes over the 20-year life cycle. To further analyze the impact of the proposed alternatives, societal costs were applied to the crash reduction values, as provided by the VDOT Highway Safety Improvement Program (HSIP)[8]. Cost savings per crash type are provided below:

- K+A = $923,829
- B+C = $82,160
- PDO = $10,549

Total cost savings per alternative are provided in Error! Reference source not found.6. Additionally, the breakdown of the crash reduction and cost savings over the 20-year life cycle are provided in Appendix.

Table 26. Crash Cost Savings Analysis (PVB_S over 20-Year Cycle Life)

Alternative	PDO (NPV)	B+C (NPV)	K+A (NPV)	Total Cost Savings (NPV)
1	($426,036)	($1,653,055)	($1,358,033)	($3,437,126)
2	$917,750	$3,093,832	$1,615,766	$5,211,165

8.3.3 Benefit-Cost Ratio (BCR)

The 2035 cost estimate for each alternative as summarized in Table 24 was used in the calculation of B/C ratios. The following equation was used to develop the B/C ratios:

Equation 6. Benefit/Cost Ratio (BCR)

$$BCR = PVB/PVC$$

Where,

PVB = Present Value of Combined Benefits = $PVB_D + PVB_S$

PVC = Present Value of Costs = 2030 Cost Estimate

[8] Virginia Department of Transportation (VDOT) Highway Safety Improvement Program (HSIP) VA Specific Crash Cost Table

Table 27 summarizes the calculated BCR for each of the improvement alternatives.

Table 27. BCR per Improvement Alternative

Alternative	Delay Reduction Benefit (PVB_D)	Safety Benefit (PVB_S)	Present Value of Costs (PVC)	Benefit-Cost Ratio (BCR)
Alternative 1	$161,371,685.00	-$3,437,126.00	$25,720,759.00	6.14
Alternative 2	$16,537,980.00	$5,211,165.00	$2,846,947.00	7.64

8.3.4 Project Prioritization

Improvement projects should be prioritized at a regional level. The following factors should be considered while evaluating the proposed improvement alternatives to be advanced further for funding and construction:

- B/C Ratio: Typically, projects with B/C ratios greater than or equal to 1.00 indicate cost effectiveness of the improvements and are preferred by the Agencies;
- Safety Improvements and their Benefits;
- Geometric Improvements;
- No anticipated ROW Impacts: Projects that require additional right-of-way are typically costly and are not preferred.

Table 28 summarizes these factors for each improvement alternative proposed by this study.

Table 28. Project Prioritization Criteria

Alternative	B/C Ratio	Safety Improvements	Geometric Improvements	No Anticipated ROW Impacts
Alternative 1	6.14	✓	✓	
Alternative 2	7.64	✓	✓	

✓ Indicates the criteria for the corresponding improvement alternative is fulfilled

Based on the review of the criteria and the calculated BCR, both the improvement alternatives proposed can potentially be submitted for SMART SCALE or seek other funding sources due to the operational improvements they offer. The VDOT Fredericksburg District in coordination with the localities may choose to advance some or all these projects at their discretion.

9 Conclusions And Recommendations

The STARS Route 1 (Jefferson Davis Highway) Corridor Study identifies operational, safety, access management and congestion issues along the corridor. This study also evaluates potential mitigation measures and improvement alternatives to address those issues. This study should be used as a planning level document to establish the next steps of planning, programming, designing and constructing the identified safety, operational and access management improvements within the corridor. Following are the specific steps that may be followed:

Gain Consensus and Prioritize Improvements

It is recommended to conduct outreach meetings with stakeholders who were not part of the SWG of this study to gain their consensus on the proposed candidate improvement alternatives. Prioritization of the improvements is suggested by considering the following factors:

- Benefit-Cost
- Local/District Preference
- Safety Benefits
- Geometric Improvements
- ROW Impacts

Prepare Projects for Advancement

Upon identifying and prioritizing the improvements at the regional level, the projects with the highest priority should be advanced to be included in the following plans:

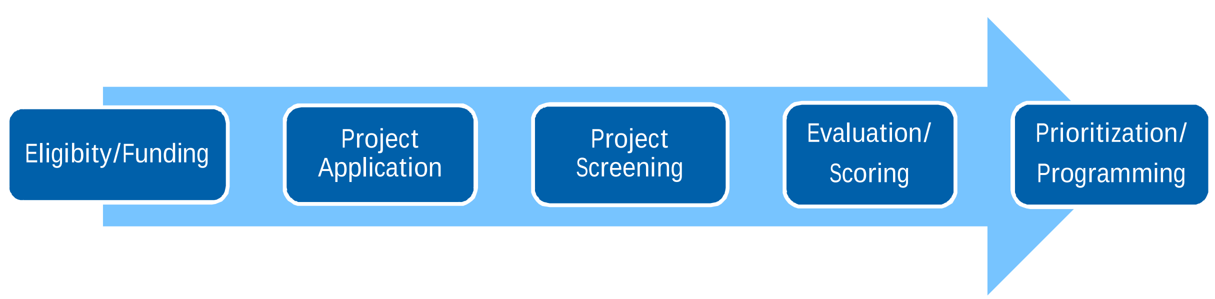
- Constrained Long Range Transportation Plan (CLRP)
- Transportation Improvement Plan (TIP)
- Statewide Transportation Improvement Plan (STIP)
- VDOT Six-Year Improvement Program (SYIP)

Secure Funding

There are several funding sources or revenue sharing programs that can be tapped into to fund the improvements identified in this study:

9.1.1.1.1 SMART SCALE

Virginia's SMART SCALE Process facilitates selecting the right transportation projects for funding and ensuring the best use of limited tax dollars. It includes five overreaching steps as depicted below:



Per the SMART SCALE Technical Guide, the scoring process evaluates, scores and ranks projects based on congestion mitigation, economic development, accessibility, safety, environmental quality and land use factors. The location of the project determines the weight of each of these scoring factors. For the projects in the Fredericksburg District, the scoring factors with the highest weight are:

- Accessibility (15%)
- Economic Development (5%)
- Safety (5%)
- Environmental Quality (10%)
- Congestion Mitigation (45%)
- Efficient Land Use (20%)

All the improvement alternatives identified in this study are candidate projects for SMART SCALE funding. Several of these projects can also be packaged together into one SMART SCALE application to achieve better project score and to recognize cost savings associated with completing the projects concurrently.

The SMART SCALE funding may be accompanied by other sources of funding as listed below:

- Construction District Grants Program (DGP)
- High Priority Projects Program (HPPP)
- Congestion Mitigation and Air Quality Funding (CMAQ)
- Regional Surface Transportation Block Grant Program (RSTBG)
- Revenue Sharing
- Transportation Alternatives (TA) Set-Aside Funds
- Highway Safety Improvement Program (HSIP) and Other Safety Program Funds
- Tele-fees and Unpaved Road Related Funds
- State of Good Repair

SMART SCALE projects can be submitted by regional entities including counties, cities and towns that maintain their own infrastructure. Once the project has been screened, scored and selected for funding by the Commonwealth Transportation Board (CTB), it remains in the SYIP as a funding priority.

Project Completion

Once the funding is secured and improvements are ready for construction, the projects should be advanced and implemented with close coordination among the affected stakeholders in the region.