

North Winchester Area Safety and Operational Analysis Report



North Winchester Area Safety and Operational Analysis Report

MEMORANDUM

To: John Madera
Winchester-Frederick County Metropolitan Planning Organization (WinFred MPO)

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Date: August 2020

Subject: North Winchester Area Safety and Operational Analysis Report
Frederick County, Virginia

1 INTRODUCTION

The Virginia Department of Transportation (VDOT) and the Northern Shenandoah Valley Regional Commission (NSVRC) identified existing and future traffic operational and safety challenges at the I-81 at US 11 (Martinsburg Pike) interchange in Frederick County, Virginia. In 2018 the WinFred MPO initiated a study to identify fundable solutions that target these issues in the vicinity of the interchange to help alleviate congestion and improve safety.

Two interchange alternatives were identified to carry forward from the concept screening process to improve the safety and operations at the interchange while providing more efficient access to and from I-81:

- Partial Cloverleaf Interchange (Parclo)
- Diverging Diamond Interchange (DDI)

Additionally, arterial intersection improvements were identified adjacent to the interchange. This report summarizes the findings from the traffic operational analysis and design constraints for the interchange and arterial improvements.

2 STUDY BACKGROUND

I-81 at US 11 (Exit 317) is a critical regional connection in the North Winchester area, since it provides access to/from Route 37 (Winchester Bypass), US 50 (Northwestern Turnpike), US 522 (N. Frederick Pike), and the City of Winchester via US 11. US 11 links I-81 with nearby industrial parks, commercial, and residential land uses and serves a large volume of truck traffic. The close spacing and configuration of intersections, surrounding street network, and I-81 interchange contribute to existing congestion and safety issues.

In May 2018, analysis was conducted to identify targeted improvements to mitigate existing traffic operations and safety issues from the northbound I-81 off-ramp to Old Charles Town Road, resulting in a FY2020 SMART SCALE application to relocate the existing northbound I-81 off-ramp to the current Red Bud Road alignment opposite the northbound I-81 on-ramp, and intersection improvements at Old Charles Town Road. As part of those efforts, the study team identified the need for more extensive Exit 317 interchange improvements to accommodate future growth along the US 11 corridor, which led to the additional analysis and documentation phase in early 2019.

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The North Winchester Area Safety and Operational Analysis Report was prepared to document the existing and future traffic operations analysis, interchange and arterial concept screening, and selection of the preferred alternatives to support the FY2022 SMART SCALE application.

2.1 Existing Interchange

The I-81 at US 11 interchange is a modified traditional diamond configuration consisting of two on-ramps and two-off ramps servicing US 11 and I-81. There are three signalized intersections within the footprint of the interchange, since the northbound I-81 ramps do not meet at the same ramp terminal. Instead, the northbound I-81 on-ramp from US 11 is opposite Red Bud Road. The interchange is bounded by developed property containing retail, dining, and hotels to the north and south. I-81 crosses over US 11 via a two-lane divided bridge overpass.

The study area also includes US 11 from just south of the Crown Lane/Pactiv Way intersection to just north of the Snowden Bridge Boulevard intersection. The study area includes the following ramps and intersections as shown in **Figure 1**.

Interchange Ramps

- I-81 Northbound off-ramp to US 11
- I-81 Northbound on-ramp from US 11
- I-81 Southbound off-ramp to US 11
- I-81 Southbound on-ramp from US 11

Intersections

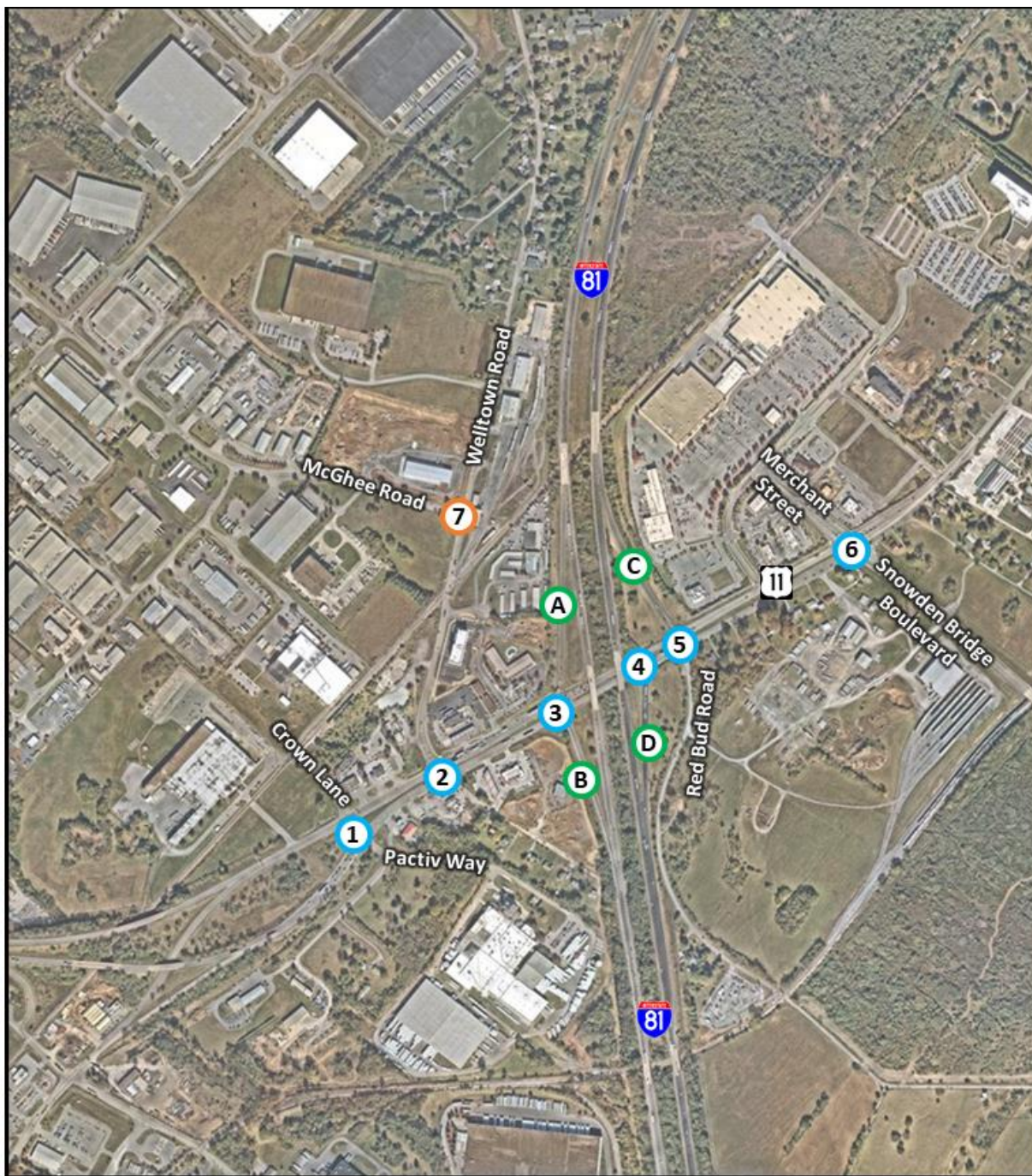
- US 11 at Crown Lane/Pactiv Way (signalized)
- US 11 at Welltown Road/Amoco Lane (signalized)
- US 11 at I-81 Exit 317 southbound on and off ramps (signalized)
- US 11 at I-81 Exit 317 northbound off-ramp (signalized)
- US 11 at Red Bud Road/I-81 northbound on-ramp (signalized)
- US 11 at Snowden Bridge Boulevard (signalized)
- Welltown Road at McGhee Road (unsignalized)

Corridors

- US 11 from Crown Lane/Pactiv Way to Snowden Bridge Boulevard
- Northbound I-81 from south of the off-ramp to US 11 to north of the on-ramp from US 11
- Southbound I-81 from north of the off-ramp to US 11 to south of the on-ramp from US 11

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Figure 1: Study Area



Study Area Intersections

1. US 11 at Crown Lane/Pactiv Way
2. US 11 at Welltown Road/Amoco Lane
3. US 11 at I-81 Southbound Ramps
4. US 11 at I-81 Northbound Off-Ramp
5. US 11 at Red Bud Road/I-81 Northbound On-Ramp
6. US 11 at Snowden Bridge Boulevard
7. Welltown Road at McGhee Road

Study Area Ramps

- A. I-81 Southbound Off-Ramp
- B. I-81 Southbound On-Ramp
- C. I-81 Northbound On-Ramp
- D. I-81 Northbound Off-Ramp

Legend

- Study Area Ramp
- Unsignalized Intersection
- Signalized Intersection

2.2 Adjacent Corridors

The roadways within the study area, varying from interstates to local roads, are described below.

- **Interstate 81 (I-81)** is a limited-access highway functionally classified as an Interstate. I-81 serves as a major north-south corridor between the Tennessee state line to the south and the West Virginia state line to the north. To the north and south of the interchange, I-81 is a divided facility with 12-foot lanes in each direction and a posted speed limit of 70 mph. The closest interchanges along I-81 are two miles or greater away (outside the study area)—Exit 315 (Route 7/Berryville Pike) to the south and Exit 321 (Route 672/Hopewell Rd) to the north.
- **US 11 (Martinsburg Pike)** is a two-lane, north-to-south, undivided facility classified as an other principal arterial south of the interchange and a major collector north of the interchange. There are minimal pedestrian facilities and no bicycle or transit facilities along this corridor within the study area.
- **Route 37 (Winchester Bypass)** is a two-lane, north-to-south, divided facility that connects to I-81 at both the northern and southern end. It is classified as an other freeway or expressway with a posted speed limit of 65 mph.

3 EXISTING CONDITIONS

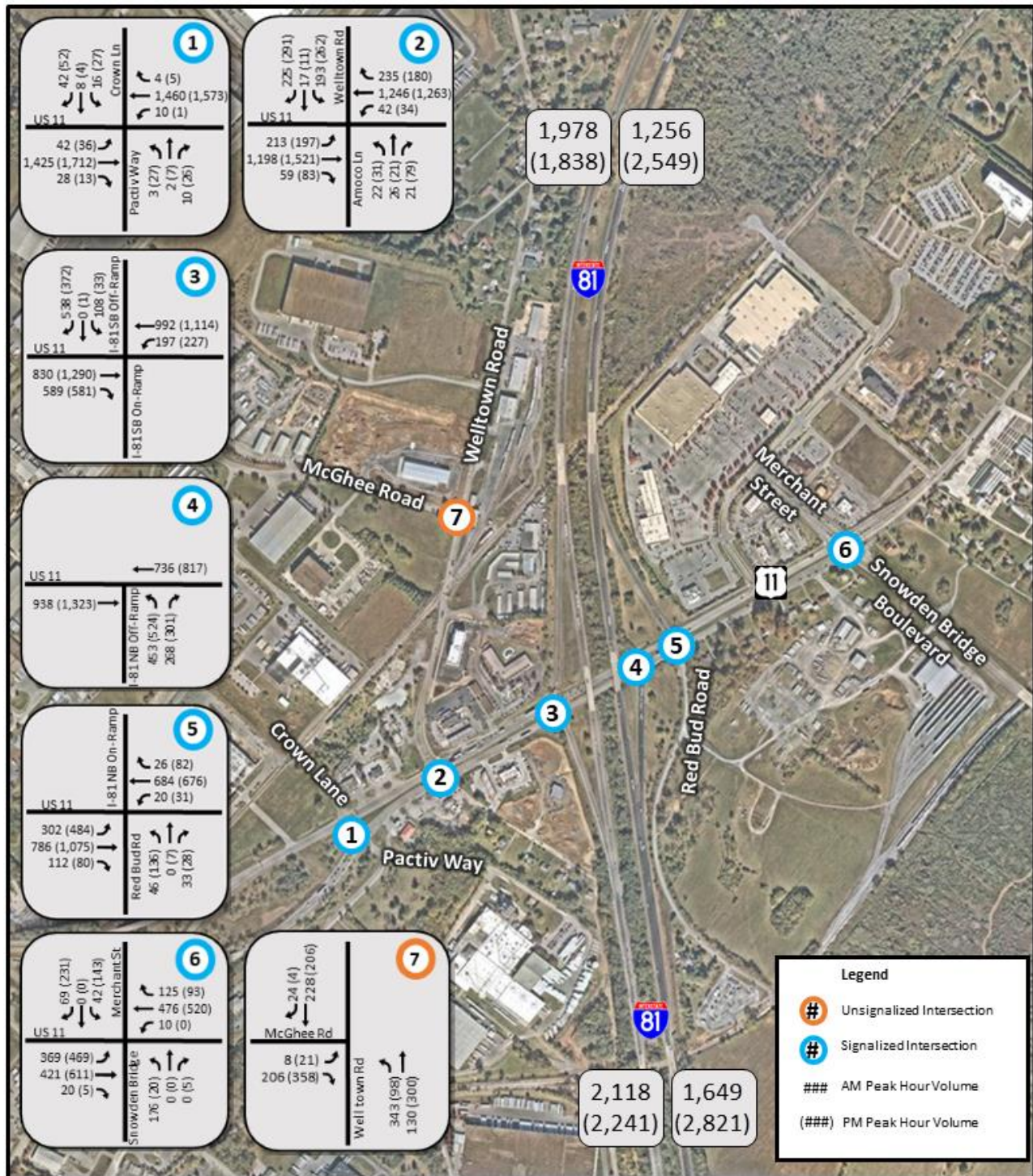
3.1 Traffic Data Collection

Traffic volumes, peak hour factors, heavy vehicle percentages, acceleration and deceleration lane lengths, turn-lane storage lengths, speed data, and crash data were established and collected from data collection efforts in May 2016. The traffic volumes for Martinsburg Pike at Welltown Road/McGee Road were collected in February 2019. The AM and PM peak hours were determined to be 7:15 AM to 8:15 AM and 4:30 PM to 5:30 PM, respectively.

For I-81 traffic volumes, 2019 continuous count station data were obtained and compared against the previously collected 72-hour traffic data from 2016. It was determined that the 2019 traffic volumes on I-81 were comparable to the 2016 data; therefore, the 2016 data was used for the freeway traffic analysis. The balanced existing (2016) traffic volumes within the study area are displayed in **Figure 2**.

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Figure 2: Existing Conditions (2016) Traffic Volumes



3.2 Existing Intersection Traffic Operations Analysis

Intersection traffic analysis was performed using Synchro 10 to determine intersection delay, measured in seconds per vehicle, and level of service (LOS). LOS illustrates the relative difference in delay and ranges from A to F. LOS A indicates a condition of little or no congestion and LOS F indicates a condition of severe congestion, unstable traffic flow, and stop-and-go conditions. **Table 1** summarizes the delay associated with each LOS for both signalized and unsignalized intersections. All input and analysis methodologies were consistent with VDOT’s Traffic Operations and Safety Analysis Manual (TOSAM) Version 2.0.

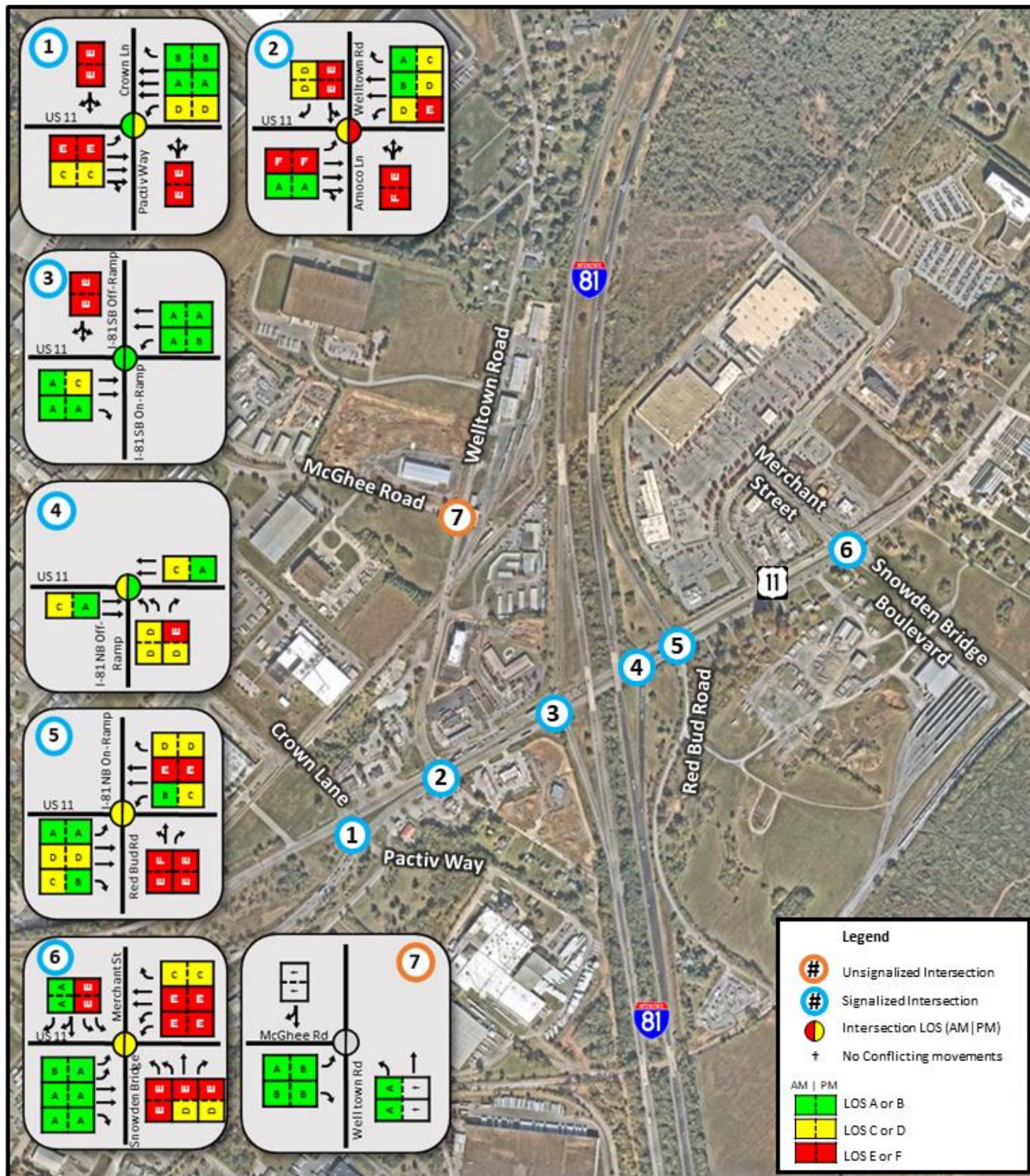
Table 1: Intersection Level of Service (LOS) Analysis Criteria

| LOS | Average Stopped Delay (seconds/vehicle) | | Description of Traffic Conditions |
|----------|---|----------------|--|
| | Signalized | Unsignalized | |
| A | ≤ 10.0 | ≤ 10.0 | Very low delay, progression is extremely favorable; most vehicles arrive during green phase. |
| B | > 10.0 to 20.0 | > 10.0 to 15.0 | Generally good progression, low delays, more vehicles must stop at intersection red phases. |
| C | > 20.0 to 35.0 | > 15.0 to 25.0 | Fair progression, increasing number of vehicles must stop; signal cycle fails to process all traffic. |
| D | > 35.0 to 55.0 | > 25.0 to 35.0 | Traffic congestion more noticeable, increasing cycle failures, unfavorable progression, and longer delays. |
| E | > 55.0 to 80.0 | > 35.0 to 50.0 | Poor progression, generally high v/c ratios, frequent cycle failures, intersection traffic approaching capacity. |
| F | ≥ 80.0 | ≥ 50.0 | Arrival flow exceeds intersection capacity, many cycle failures, poor progression, and high delays. |

Figure 3 summarizes the existing (2016) conditions intersection LOS results. The northbound I-81 on-ramp/Red Bud Road intersection is signalized and currently operates at an overall LOS D in both the AM and PM peak hours. The northbound I-81 off-ramp operates at a LOS D and LOS E on the off-ramp approach in the AM and PM peak hours, respectively. Additionally, the southbound I-81 off-ramp operates at a LOS E in both the AM and PM peak hours. See **Appendix A** for tabular results of LOS, delay, and 95th percentile queue results.

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Figure 3: Existing (2016) Conditions LOS Summary



3.3 Existing Freeway Traffic Operations Analysis

Freeway traffic operations analysis was conducted using the HCS 7 freeway facilities module to analyze the I-81 interchange at US 11 under existing (2016) conditions.

The volume counts used in this HCS analysis were equivalent hourly volumes from the 15-minute peak hour counts. Additionally, the ramp acceleration and deceleration lengths for the US 11 interchange were obtained from aerial photography. The truck percentages were obtained from VDOT traffic counts for the I-81 mainline and were calculated for the ramps using the three-day ramp traffic counts.

The level of service (LOS) criteria for merge, diverge, weave, and freeway segments are defined by the Highway Capacity Manual 6th Edition shown in **Table 2**. Tabular results of the existing HCS analyses are presented in **Table 3**.

Table 2: LOS Criteria for HCM Analysis

| LOS | Merge/Diverge/Weave Segments | Freeway Segments |
|-----|------------------------------|-----------------------|
| | Density (pc/ln/mi) | |
| A | ≤ 10 | ≤ 11 |
| B | > 10 – 20 | > 11 – 18 |
| C | > 20 – 28 | > 18 – 26 |
| D | > 28 – 35 | > 26 – 35 |
| E | > 35 | > 35 – 45 |
| F | $v_d/c > 1.0$ | > 45 or $v_d/c > 1.0$ |

During the AM peak hour all freeway segments operate at LOS B or better. During the PM peak hour all segments operate at LOS C or better in the southbound direction.

In the PM peak hour in the northbound direction, volumes on the freeway prior to the off-ramp to US 11 are approximately 50% higher than the AM peak hour, which results in LOS D for this diverge segment. North of the off-ramp to US 11 the LOS returns to LOS C or better.

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Table 3: Existing (2016) Conditions HCS Segment Results

| ID | Location Description | Segment Type | AM Peak Hour | | PM Peak Hour | |
|-------------------|--|--------------|------------------|--------------------|------------------|--------------------|
| | | | Level of Service | Density (pc/mi/ln) | Level of Service | Density (pc/mi/ln) |
| Southbound | | | | | | |
| 1 | Southbound I-81 north of US 11 interchange | Basic | B | 15.6 | B | 14.4 |
| 2 | Southbound I-81 off-ramp to US 11 | Diverge | B | 18.5 | B | 17.0 |
| 3 | Southbound I-81 between off-ramp to US 11 and on-ramp from US 11 | Basic | B | 10.7 | B | 11.4 |
| 4 | Southbound I-81 on-ramp from US 11 | Merge | B | 19.2 | C | 20.2 |
| 5 | Southbound I-81 south of US 11 interchange | Basic | B | 16.7 | B | 17.6 |
| Northbound | | | | | | |
| 6 | Northbound I-81 south of US 11 interchange | Basic | B | 13.0 | C | 24.5 |
| 7 | Northbound I-81 off-ramp to US 11 | Diverge | B | 16.8 | D | 28.8 |
| 8 | Northbound I-81 between off-ramp to US 11 and on-ramp from US 11 | Basic | A | 7.9 | B | 16.8 |
| 9 | Northbound I-81 on-ramp from US 11 | Merge | B | 12.0 | C | 24.8 |
| 10 | Northbound I-81 north of US 11 interchange | Basic | B | 10.4 | C | 22.0 |

3.4 Existing Crash Analysis

A crash analysis was conducted to review and document crash patterns and trends within the study area roadway network. Crash data from 2013 to 2017 was used to evaluate safety and identify crash patterns along US 11 and I-81.

All intersections and roadway segments within the VDOT linear referencing system (LRS) are evaluated annually by VDOT for their potential for safety improvement (PSI) based on the Highway Safety Manual (HSM). The crash frequency, severity of crashes, volume, and length of segment are contributing factors in the predictive analyses. PSI estimates how much the long-term crash frequency could be reduced at an intersection or roadway segment and is based on the safety performance function (SPF) crash data files. PSI intersections and roadway segments are ranked within each District, but the crash prediction and PSI values are not released by VDOT. Within the study area, there were three intersections and two segments identified in VDOT Staunton District's 2018 list for PSI. These locations are shown in **Table 4**.

Table 4: 2018 PSI Segments and Intersections

| Location | Type | 2018 PSI Rank (Staunton District) |
|--|--------------|-----------------------------------|
| US 11 at Northbound I-81 Off-Ramp | Intersection | 52 |
| US 11 at Red Bud Road/Northbound I-81 On-Ramp | Intersection | 19 |
| US 11 at Welltown Road/Amoco Lane | Intersection | 5 |
| US 11 from Welltown Road to Southbound I-81 Ramps | Segment | 134 |
| US 11 from Northbound I-81 On-Ramp to Snowden Bridge Boulevard | Segment | 226 |

220 crashes occurred over the five-year period for which crash data was collected. Out of those crashes, approximately 84% occurred between Welltown Road and Red Bud Road. 48% of crashes in the study area were congestion related rear-end crashes, 71% of which were attributed to heavy traffic or signal operations in the crash description. The highest frequency of angle crashes happened at the I-81 Southbound Ramps intersection, where 55% of these crashes were due to vehicles making a left-turn during a permissive left-turn phase. One fatality occurred at US 11 at the I-81 Southbound Ramps in 2015. The fatal angle crash was due to a vehicle making a left-turn during a permissive left-turn phase.

US 11 at Northbound I-81 Off-Ramp

The majority (67%) of the 43 total crashes at this intersection were rear-end crashes which is characteristic of signalized intersections. 63% of the crashes were attributed to traffic or signal operations in the crash description. Additionally, 10 crashes resulted in injury.

US 11 at Red Bud Road/Northbound I-81 On-Ramp

A total of 28 crashes occurred at US 11 at Redbud Road/Northbound I-81 On-Ramp, the majority (75%) of which were angle crashes. A high number of angle crashes can be attributed to vehicles making left-turns during the permissive left-turn phase. Rear-end crashes comprised 18% of the total crashes. Four crashes resulted in injury.

US 11 at Welltown Road/Amoco Lane

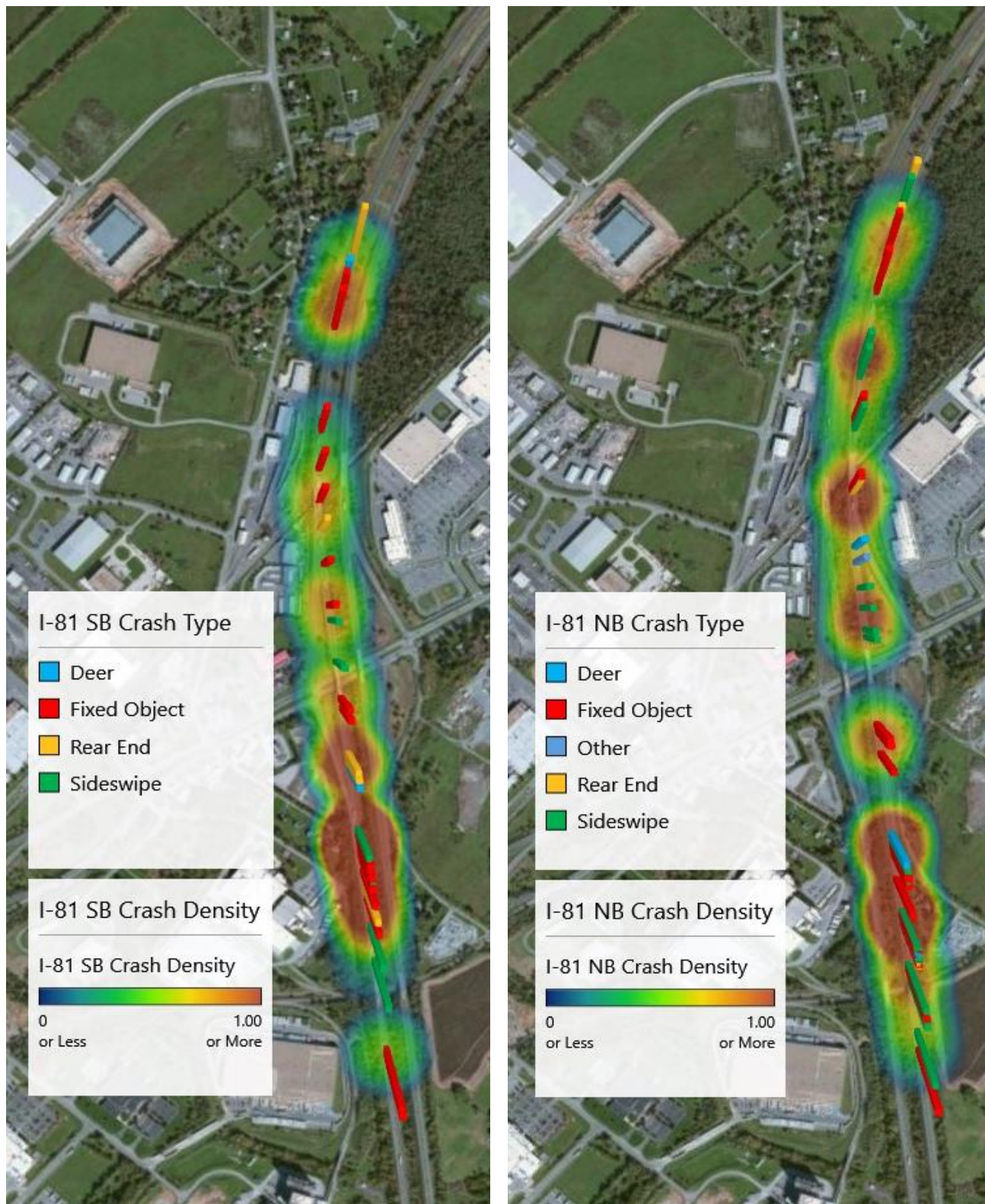
Out of the 51 crashes that occurred at the intersection of US 11 at Welltown Road/Amoco Lane, 27 (53%) were rear-end crashes and 22 (43%) were angle crashes. According to the crash descriptions, 70% of the rear end crashes were due to traffic or signal operations. 21% of the angle crashes were attributed to failure to stop for red traffic lights while 17% were attributed to failure to yield right-of-way. Nine crashes resulted in injury.

Mainline I-81

A total of 76 crashes occurred on I-81 within the study area between 2013-2017. 47% of these crashes were a result of hitting a fixed object off the road (15 in the northbound direction and 21 in the southbound direction). These crashes tended to occur near the merge and diverge areas along I-81, the highest concentration being at the I-81 Southbound On-Ramp. Sideswipes were also a common crash type, making up 30% of the total crashes. Sideswipes occurred in higher frequency on northbound I-81 at the on- and off-ramps. Crash density maps are show in **Figure 4**.

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Figure 4: I-81 Crash Density Heat Maps (2013-2017)



3.5 MetroQuest Survey Results

The North Winchester Interchange Study MetroQuest Survey was launched to collect public feedback about the corridor. This feedback included safety issues, traffic concerns, and individual usage of the corridor. The results of the survey are summarized in **Appendix B**.

Most of the feedback indicated that congestion is the issue of most concern in the study area. Users specified that the southbound I-81 on-ramp intersection experiences the largest amount of congestion. Users also commented that signal coordination, queues extending onto the freeway, and aggressive driving are contributors to the poor performance of the interchange.

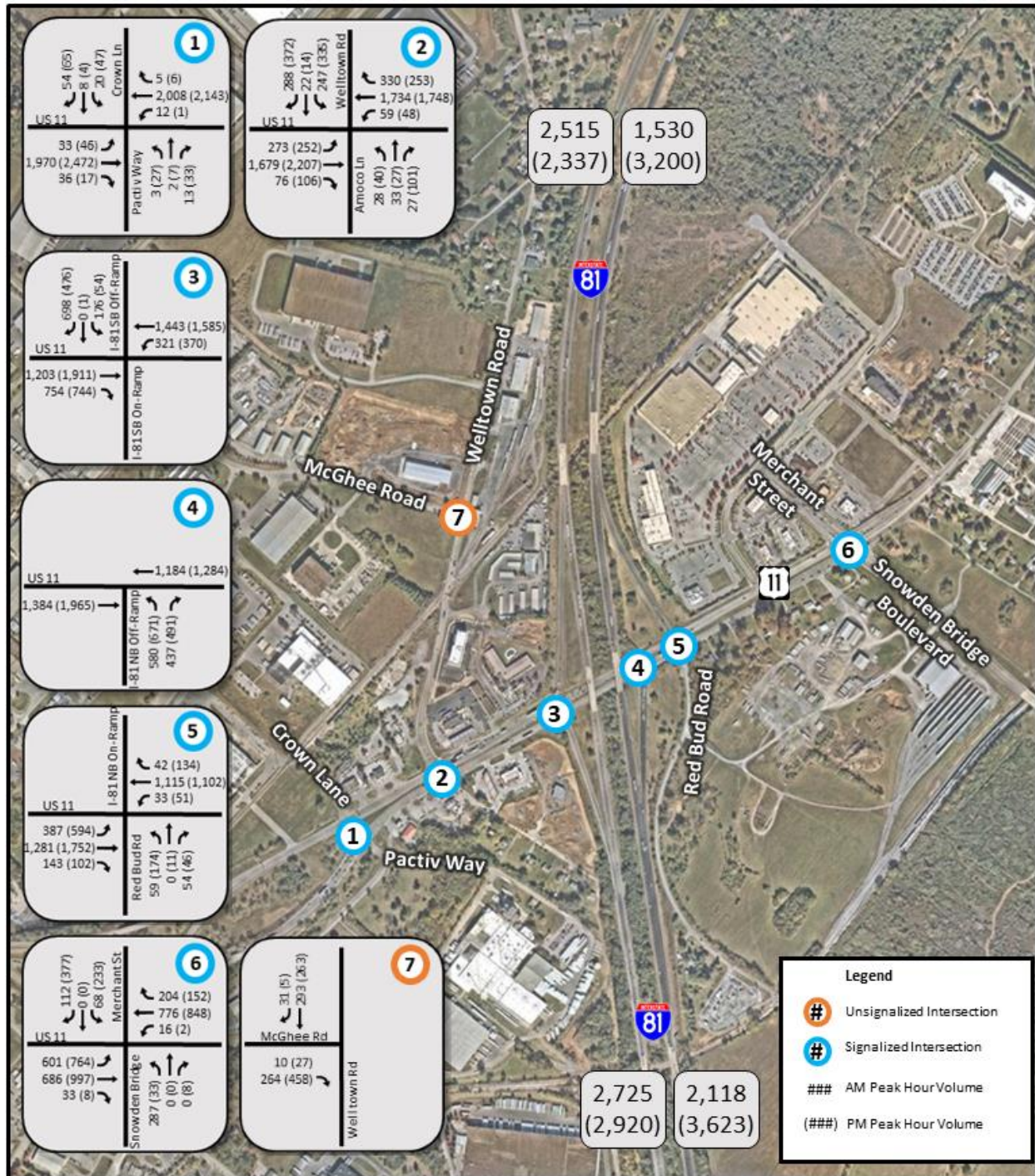
4 FUTURE TRAFFIC VOLUME DEVELOPMENT

Future (2030) traffic growth rates were developed by VDOT Staunton District using the latest WinFred MPO Travel Demand Model (TDM). Ultimately, a 2.0% linear annual growth rate was applied to the balanced existing (2016) arterial intersection volumes south of the I-81 ramps and a 4.5% linear annual growth rate was applied to the balanced arterial intersection volumes north of the I-81 ramps.

The balanced I-81 existing (2016) freeway traffic counts were grown using the approved linear annual growth rates provided by VDOT, which were determined to be 2.03% on I-81 south of the US 11 interchange and 1.94% on I-81 north of the US 11 interchange. Future (2030) freeway traffic volumes were balanced with the 2030 intersection ramp volumes to develop balanced traffic volumes throughout the I-81 corridor. The final balanced future (2030) traffic volumes are shown in **Figure 5**.

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Figure 5: No-Build (2030) Peak Hour Traffic Volumes



5 NO-BUILD CONDITIONS

No-Build conditions were analyzed using Synchro 10 and HCS to provide an understanding of baseline future intersection and freeway traffic conditions to evaluate the effectiveness of potential future improvements. There are no background improvements planned on the arterial; therefore, the same intersection and interchange geometry as existing was assumed along US 11. One background improvement was identified along I-81, which includes widening I-81 to include an additional lane on northbound and southbound I-81 south of the US 11 interchange.

5.1 No-Build Intersection Traffic Operations Analysis

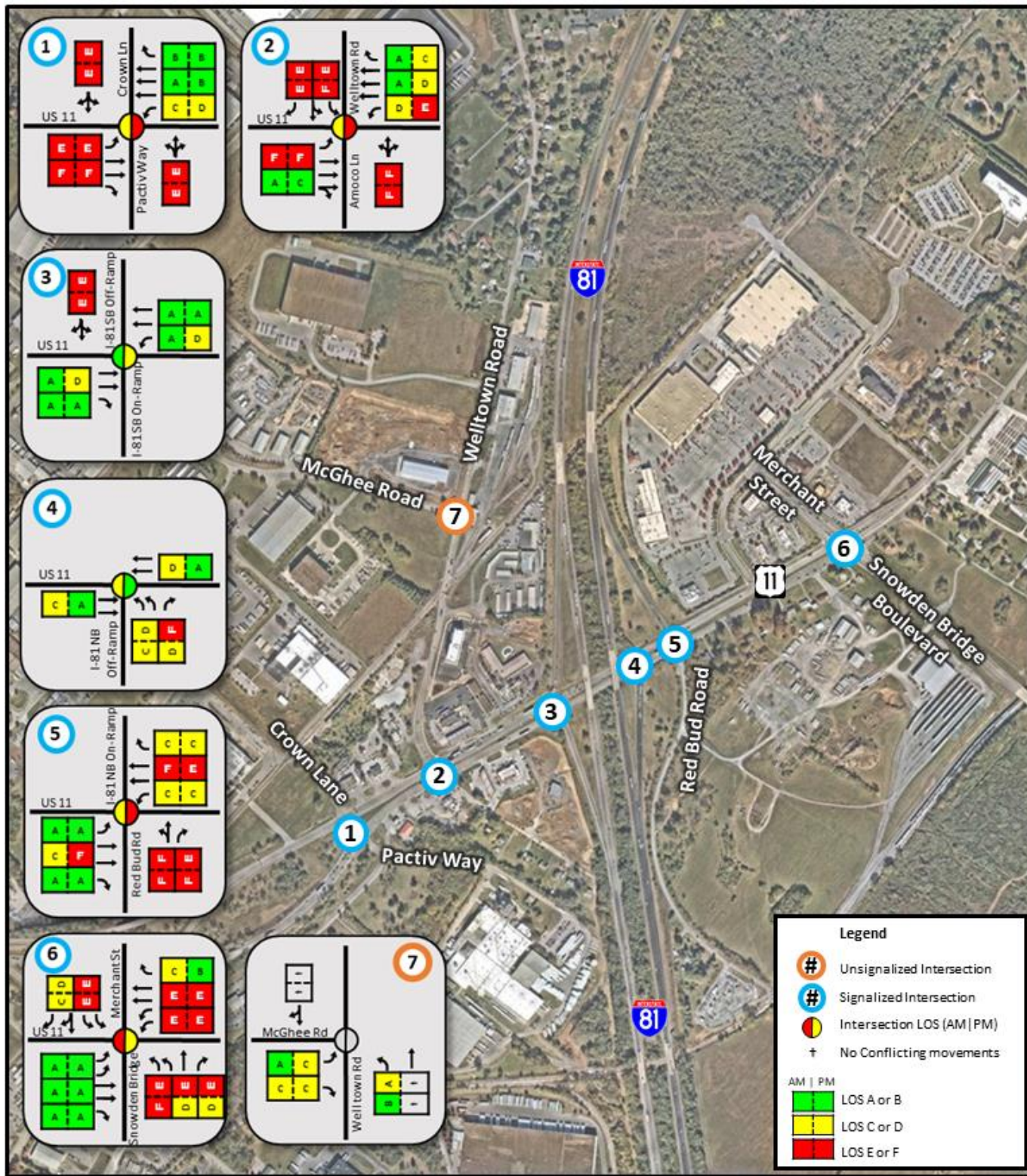
Figure 6 illustrates the No-Build (2030) intersection LOS results using Synchro 10. In summary, the I-81 at US 11 interchange will not be able to accommodate the projected 2030 traffic volumes. The following critical movements were projected to operate over capacity:

- Northbound and southbound through movements at the US 11 and northbound I-81 on-ramp
- Right turn movements from the northbound I-81 off-ramp to US 11
- Right and left turn movements from the southbound I-81 off-ramp to US 11

See **Appendix C** for tabular results of LOS, delay, and 95th percentile queue results.

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Figure 6: No-Build (2030) Conditions LOS Summary



5.2 No-Build Freeway Traffic Operations Analysis

Freeway traffic operations analysis was conducted using the HCS 7 freeway facilities module. The No-Build (2030) analysis assumes the Interstate 81 Corridor Improvement Plan improvement will be constructed by 2030. This background improvement includes widening I-81 to include an additional lane on northbound and southbound I-81 south of the US 11 interchange. This additional lane was modeled in the No-Build (2030) analysis to represent the baseline future conditions of the interchange. The existing heavy vehicle percentages were assumed to be the same as no-build. Tabular results of the no-build (2030) HCS analyses are presented in **Table 5**.

In the 2030 AM peak hour, all freeway segments were projected to operate at LOS C or better in the southbound direction and LOS B or better in the northbound direction.

In the PM peak hour, all freeway segments were projected to operate at LOS C or better in the southbound direction. In the northbound direction in the PM peak hour, all segments operate at LOS B until the basic segment downstream of the off-ramp to US 11, where the LOS worsens to LOS C. Downstream of the on-ramp from US 11, the LOS then worsens to LOS D.

Table 5: No-Build (2030) Conditions HCS Segment Results

| ID | Location Description | Segment Type | AM Peak Hour | | PM Peak Hour | |
|-------------------|--|--------------|------------------|--------------------|------------------|--------------------|
| | | | Level of Service | Density (pc/mi/ln) | Level of Service | Density (pc/mi/ln) |
| Southbound | | | | | | |
| 1 | Southbound I-81 north of US 11 interchange | Basic | C | 20.7 | B | 18.8 |
| 2 | Southbound I-81 off-ramp to US 11 | Diverge | C | 23.8 | C | 21.7 |
| 3 | Southbound I-81 between off-ramp to US 11 and on-ramp from US 11 | Basic | B | 13.4 | B | 14.4 |
| 4 | Southbound I-81 on-ramp from US 11 | Merge | B | 14.1 | C | 22.0 |
| 5 | Southbound I-81 south of US 11 interchange | Basic | B | 14.2 | B | 15.1 |
| Northbound | | | | | | |
| 6 | Northbound I-81 south of US 11 interchange | Basic | B | 11.1 | B | 19.9 |
| 7 | Northbound I-81 off-ramp to US 11 | Diverge | B | 11.1 | B | 19.9 |
| 8 | Northbound I-81 between off-ramp to US 11 and on-ramp from US 11 | Basic | A | 9.5 | C | 21.9 |
| 9 | Northbound I-81 on-ramp from US 11 | Merge | B | 14.7 | D | 33.6 |
| 10 | Northbound I-81 north of US 11 interchange | Basic | B | 12.7 | D | 31.2 |

6 CONCEPT DEVELOPMENT AND SCREENING

Potential geometric improvements for the I-81 and US 11 interchange were developed to address existing and anticipated operational, geometric, maintenance, and safety deficiencies identified in the existing and no-build conditions analysis. The concept screening focused on the interstate ramp termini and the adjacent arterial intersections. Initial concepts for interchange and intersection improvements were presented to the study team in September 2019. The materials presented during that meeting are included in **Appendix D**.

6.1 Interchange Alternatives Screening

The following concepts at the I-81 and US 11 interchange were developed during the concept screening process and evaluated for traffic operations, cost, and geometric feasibility:

- Dual northbound US 11 left turn lanes onto northbound I-81 (short- to mid-term improvement)
- Diverging Diamond Interchange (DDI) (two lanes northbound and southbound)
- DDI (three lanes northbound and two lanes southbound)
- DDI (three lanes northbound and southbound)
- Partial Cloverleaf Interchange (southeast quadrant only)
- Partial Cloverleaf Interchange (northwest and southeast quadrants)

Constructing dual northbound US 11 left turn lanes onto I-81 provided targeted traffic operations and safety benefits to the Exit 317 interchange and could be pursued for funding as a short- to mid-term improvement; however, it was determined that more extensive interchange improvements to accommodate future growth along the US 11 corridor was necessary for the long-term. Based on the initial concept screening using Synchro and SimTraffic 10, two concepts were identified as having the most potential to accommodate future traffic growth in the study area and were moved forward for additional analysis:

- DDI (three lanes northbound and two lanes southbound)
- Partial Cloverleaf interchange (northwest and southeast quadrants)

Detailed concept screening results and the interchange alternatives screening matrix is provided in **Appendix D**. Although the eliminated alternatives were able to maintain or mitigate impacts to the existing bridge structures, it was found that they were unable to accommodate the anticipated future growth and operated unacceptably under future conditions.

6.2 Arterial Alternatives Screening

The following arterial concepts along US 11 between Crown Lane/Pactiv Way and Welltown Road/Amoco Lane were developed during the concept screening process:

- Dual northbound left turns on US 11 at Welltown Road/Amoco Lane and widen Welltown Road to two lanes
- Restricted Crossing U-Turn (RCUT) intersection at Welltown Road/Amoco Lane
- Dual left turns from Welltown Road to US 11, single left turn from Amoco Lane to US 11, convert outside Amoco Lane to a shared through/left lane, and remove split phasing from intersection
- Realign Welltown Road to Crown Lane/Pactiv Way
- Realign Crown Lane/Pactiv Way to Welltown Road
- Lenoir Drive access point break onto southbound Route 37
- Construct a U-turn only lane from northbound US 11 to Route 37 at Crown Lane/Pactiv Way

Based on the initial concept screening using Synchro and SimTraffic 10, the following arterial concepts were identified as having the potential to accommodate future traffic growth in the study area and were moved forward for additional analysis:

- Dual left turns from Welltown Road to US 11, single left turn from Amoco Lane to US 11, convert outside Amoco Lane to a shared through/left lane, and remove split phasing from intersection
- Construct a U-turn only lane from northbound US 11 to Route 37 at Crown Lane/Pactiv Way

Detailed concept screening results and the arterial alternatives screening matrix is provided in **Appendix D**.

7 BUILD CONDITIONS

The no-build (2030) traffic volumes were adjusted based on the selected proposed interchange configurations outlined in **Section 6** and used to analyze future build (2030) conditions within the study area. The future build (2030) conditions traffic analyses were conducted using Synchro 10, SimTraffic 10, and HCS.

7.1 Proposed Alternatives

The two interchange alternatives identified during the concept screening process were further evaluated for traffic operations, cost, and geometric feasibility. The advantages, disadvantages, and considerations for the following alternatives were reviewed.

- Alternative 1: Partial Cloverleaf Interchange (Parclo)
- Alternative 2: Diverging Diamond Interchange (DDI)

Additionally, one set of arterial intersection improvements were evaluated at the US 11 and Crown Lane/Pactiv Way and US 11 at Welltown Road/Amoco Lane intersections. The proposed arterial improvements were identical for both alternatives and are shown in **Appendix E** along with the two interchange alternatives.

7.2 Alternative 1 (Parclo)

Alternative 1 at the Exit 317 interchange proposes reconfiguring the existing diamond interchange with a partial cloverleaf (parclo) interchange as shown in **Appendix E**. The modifications include:

- Relocate the existing northbound I-81 off-ramp to the current Red Bud Road alignment opposite the northbound I-81 on-ramp (Red Bud Road relocation to be done by others)
- Remove the northbound US 11 left turn movement to northbound I-81 and replace it with a free-flow northbound loop ramp to northbound I-81 in the southeast quadrant of the interchange
- Remove the southbound US 11 left turn movement to southbound I-81 and replace it with a free-flow southbound loop ramp to southbound I-81 in the northwest quadrant of the interchange
- Dual left turns from Welltown Road to US 11, single left turn from Amoco Lane to US 11, convert outside Amoco Lane to a shared through/left lane, and remove split phasing from intersection
- Construct a U-turn only lane from northbound US 11 to Route 37 at Crown Lane/Pactiv Way

The Parclo alternative requires widening of both the northbound and southbound I-81 bridges over US 11 to accommodate the acceleration lanes associated with the two proposed loop ramps. The conceptual design shows substandard acceleration lanes for both proposed loop ramps. In order to meet AASHTO standards, the existing northbound and southbound I-81 on-ramps would need to be realigned to provide adequate separation between successive ramps, which would impact the bridge structure over the railroad to the north. Widening under the I-81 overpasses to accommodate three lanes in both directions

on US 11 was assumed to be achievable at a planning level analysis with bridge pier protection systems and design waivers for reduced shoulder widths and vertical clearance (an existing condition).

It is expected that some right-of-way acquisition would be required in the southeast quadrant; however, most of the right-of-way impacts occur in the northwest quadrant of the interchange to accommodate the southbound US 11 to southbound I-81 loop ramp and realigned southbound I-81 off-ramp to southbound I-81. It is also expected that the existing transmission tower adjacent to the southbound I-81 off-ramp would need to be relocated.

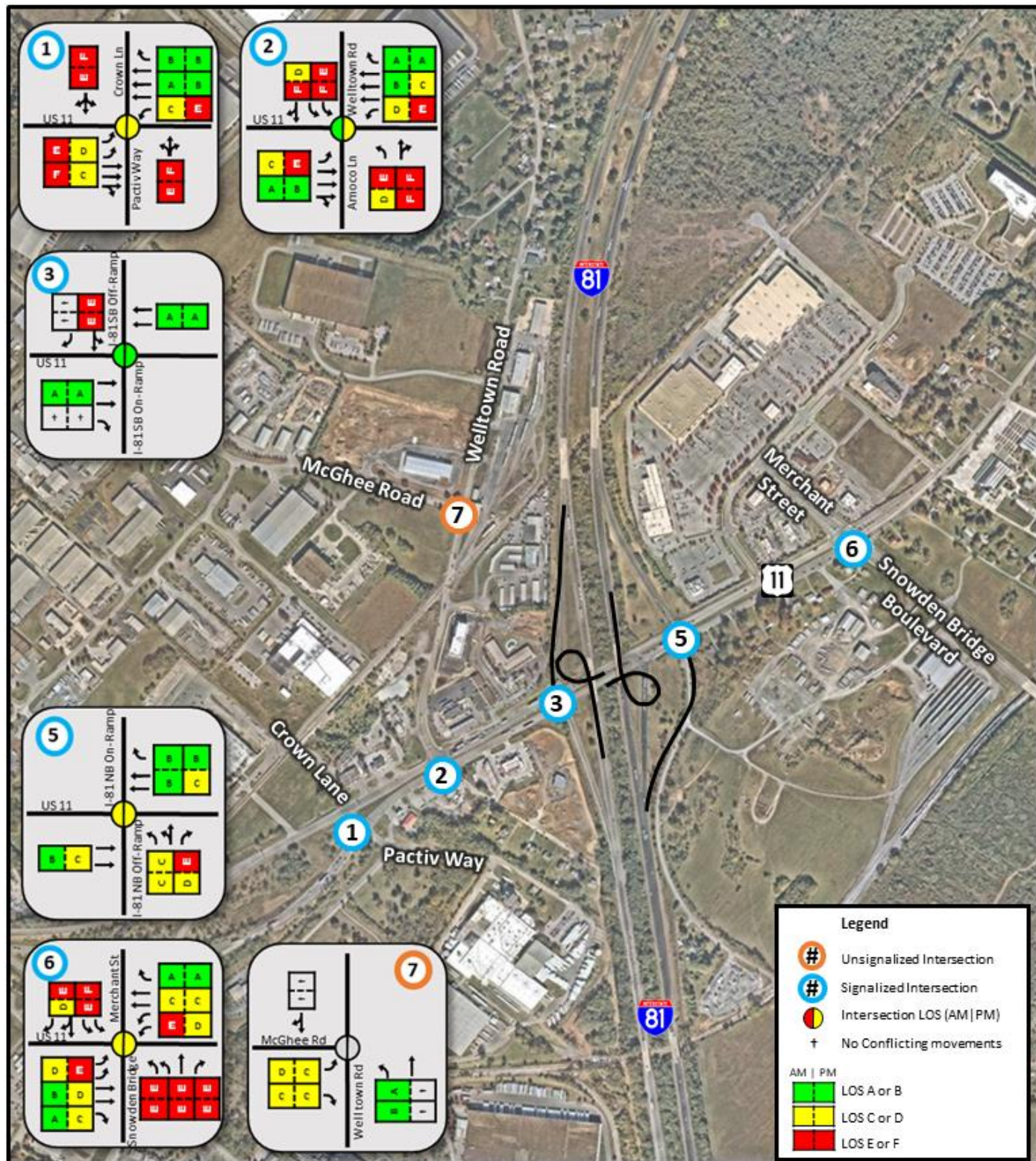
7.2.1 Alternative 1 (Parclo) Intersection Traffic Operations Analysis

Future traffic analysis was performed for the Parclo interchange to determine intersection delay, measured in seconds per vehicle, and LOS. Additionally, maximum queues from SimTraffic were reported along the arterial. The traffic operational results for Alternative 1 are displayed in **Figure 7**. See **Appendix F** for tabular results of LOS, delay, and maximum queues.

Under 2030 Alternative 1 (Parclo) conditions, all intersections were projected to operate with similar or better overall intersection delays in the AM and PM peak hours compared to No-Build operations. The exception is US 11 at Snowden Bridge Boulevard/Merchant Street which operated with an increased delay of 23 seconds in the PM peak hour. During the PM peak hour, the US 11 at Pactiv Way/Crown Lane and US 11 at Amoco Lane/Welltown Road intersections were both projected to operate at LOS E under No-Build conditions, whereas they are expected to improve to LOS C with the proposed arterial improvements. US 11 at the I-81 Northbound Ramps intersection is expected to improve from LOS F to LOS C in the PM peak hour.

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Figure 7: Alternative 1 - Partial Cloverleaf (2030) Conditions LOS Summary



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7.2.2 Alternative 1 (Parclo) Freeway Traffic Operations Analysis

Freeway traffic operations under the Parclo alternative were analyzed using HCS 7. Traffic volumes were updated to reflect the modified on-ramp conditions. These updated volumes are included in **Appendix F**. To analyze the partial cloverleaf merge onto I-81, 300 feet of the basic segment was coded as a part of the merge segment to meet the influence area requirements. Tabular results of the Parclo freeway traffic analysis results are presented in **Table 6**.

Table 6: Alternative 1 - Partial Cloverleaf (2030) HCS Segment Results

| ID | Location Description | Segment Type | AM Peak Hour | | PM Peak Hour | |
|-------------------|--|--------------|------------------|--------------------|------------------|--------------------|
| | | | Level of Service | Density (pc/mi/ln) | Level of Service | Density (pc/mi/ln) |
| Southbound | | | | | | |
| 1 | Southbound I-81 north of US 11 interchange | Basic | C | 20.7 | C | 20.7 |
| 2 | Southbound I-81 off-ramp to US 11 | Diverge | C | 23.8 | C | 23.8 |
| 3 | Southbound I-81 between off-ramp to US 11 and on-ramp from US 11 | Basic | B | 13.4 | B | 13.4 |
| 4 | Southbound I-81 Cloverleaf on-ramp from US 11 | Merge | B | 17.8 | B | 17.8 |
| 5 | Southbound I-81 on-ramp from US 11 | Merge | B | 14.3 | B | 14.3 |
| 6 | Southbound I-81 south of US 11 interchange | Basic | B | 14.3 | B | 15.2 |
| Northbound | | | | | | |
| 7 | Northbound I-81 south of US 11 interchange | Basic | B | 11.1 | B | 19.9 |
| 8 | Northbound I-81 off-ramp to US 11 | Diverge | B | 11.1 | B | 19.9 |
| 9 | Northbound I-81 between off-ramp to US 11 and on-ramp from US 11 | Basic | A | 9.6 | C | 21.9 |
| 10 | Northbound I-81 Cloverleaf on-ramp from US 11 | Merge | B | 14.4 | D | 30.9 |
| 11 | Northbound I-81 on-ramp from US 11 | Merge | B | 14.7 | D | 33.5 |
| 12 | Northbound I-81 north of US 11 interchange | Basic | B | 12.7 | D | 31.1 |

In the AM peak hour, all freeway segments were projected to operate comparable to No-Build (2030) conditions at LOS C or better.

In the southbound direction in the PM peak hour, freeway segments were projected to operate at LOS C or better. Similar to No-Build conditions, the freeway operates at LOS D in the northbound direction north of the US 11 off-ramp. Overall, the freeway was expected to operate comparable to No-Build conditions in both directions in both peak hours.

7.3 Alternative 2 (DDI)

Alternative 2 at the Exit 317 interchange proposes reconfiguring the existing diamond interchange with a Diverging Diamond Interchange (DDI) as shown in **Appendix E**. The modifications include:

- Relocate the existing northbound I-81 off-ramp to the current Red Bud Road alignment opposite the northbound I-81 on-ramp (Red Bud Road relocation to be done by others)
- Reconstruct the existing traditional diamond interchange with a DDI
- Dual left turns from Welltown Road to US 11, single left turn from Amoco Lane to US 11, convert outside Amoco Lane to a shared through/left lane, and remove split phasing from intersection
- Construct a U-turn only lane from northbound US 11 to Route 37 at Crown Lane/Pactiv Way

Widening under the I-81 overpasses to accommodate three lanes in both directions on US 11 is assumed to be achievable at a planning level analysis with bridge pier protection systems and design waivers for reduced shoulder widths and vertical clearance (an existing condition). Additional analysis is required to determine the horizontal and vertical clearances underneath the I-81 overpasses; however, it is expected that the existing northbound US 11 substandard vertical clearance under I-81 would remain.

The conceptual design assumes that the commercial driveway entrance into the Econo Lodge/Quality Inn from southbound US 11 would be closed to improve access management spacing to the I-81 interchange. Access would remain to these parcels via existing interparcel access from Welltown Road. Minor right-of-way impacts are expected in the northeast, southeast, and southwest quadrants to accommodate additional turn lanes.

7.3.1 Alternative 2 (DDI) Intersection Traffic Operations Analysis

Future traffic analysis was performed for the DDI to determine intersection delay, measured in seconds per vehicle, and LOS. Additionally, maximum queues from SimTraffic were reported along the arterial. The traffic operational results for Alternative 2 are displayed in **Figure 8**. See **Appendix F** for detailed tabular results.

Under 2030 Alternative 2 (DDI) conditions, all intersections were projected to operate with better overall intersection delays in the AM and PM peak hours compared to the 2030 No-Build conditions. The DDI performs better at the I-81 Northbound and Southbound Off-Ramps than the Parclo in both the AM and PM peak hours. The I-81 Northbound Off-Ramp is expected to operate at LOS D under the Parclo alternative, compared to LOS C with the DDI.

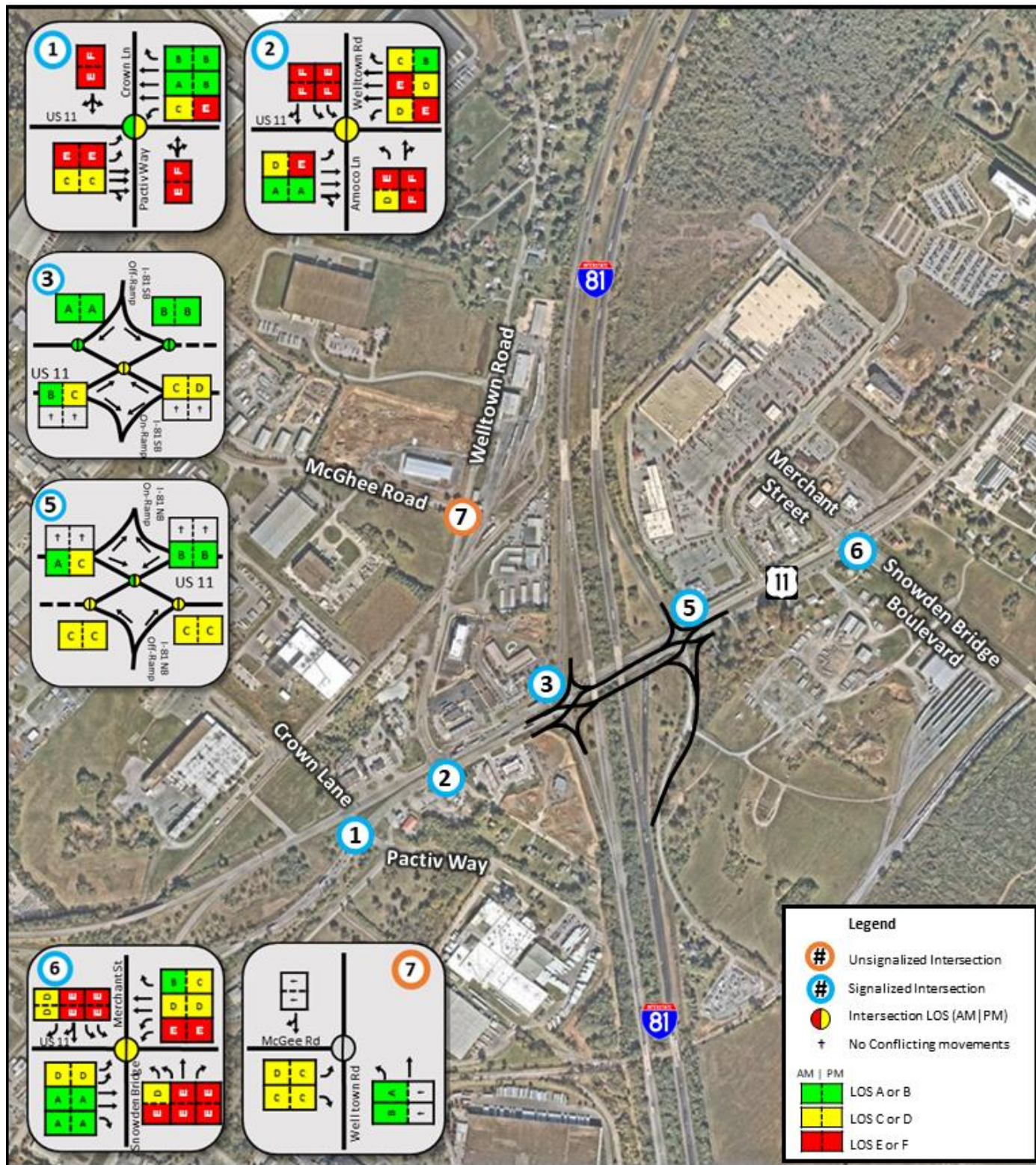
Additionally, the I-81 Southbound Off-Ramp is expected to operate at LOS E with a Parclo compared to LOS B with a DDI. The maximum queues at the I-81 Northbound and Southbound off-ramps are lower for the DDI as compared to the Parclo, although, the DDI was projected to experience slightly longer queues on US 11 at the intersection of Amoco Lane/Welltown Road. Alternative 2 assumes the same arterial improvements as Alternative 1, and the results show they would operate similarly.

7.3.2 Alternative 2 (DDI) Freeway Traffic Operations Analysis

The proposed DDI freeway geometry along I-81 is identical to the No-Build (2030) conditions. Therefore, the I-81 freeway operations under No-Build conditions are identical to the Alternative 2 (2030) conditions. Refer to **Section 5.2** for the No-Build freeway analysis results summary.

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Figure 8: Alternative 2 - DDI (2030) Conditions LOS Summary



7.4 Build Safety Analysis

A qualitative approach to compare the safety benefits between the 2030 No-Build and the 2030 Build conditions was developed based on the proposed improvements.

The existing interchange at US 11 and I-81 is a diamond interchange and has 28 conflict points. The traffic signal at US 11 and I-81 Northbound Off-Ramp operates with protective-permissive left-turn phasing and the traffic signal at US 11 and I-81 Southbound Off-Ramp operates with permissive left-turn phasing. The permissive phasing at the ramps have resulted in a high frequency of angle crashes at both intersections.

By converting the interchange to a Partial Cloverleaf (Parclo), the conflict points would reduce to 18 and would eliminate the need for left turns on US 11 to I-81. Additionally, rerouting the left turns to a loop ramp would reduce the number of phases needed at the traffic signals which would reduce congestion and decrease the number of rear-end crashes occurring along US 11.

Similarly, converting the interchange to a Diverging Diamond Interchange (DDI) would decrease the conflict points from 28 to 18 and would remove the need to cross opposing lanes of traffic to enter or exit the freeway. A DDI can operate with a two-phase signal which would allow increased volume to pass through the interchange. This would reduce congestion and the possibility of rear-end crashes along US 11.

The Parclo and DDI are expected to improve safety at the interchange than a traditional diamond interchange. While the safety along the arterial would be improved with a Parclo, the addition of the loop ramps would add additional merging segments along I-81 which could result in an increase of crashes along the freeway. The DDI does not add any additional merging segments on the freeway; therefore, it is expected that the DDI would provide more safety benefits compared to the Parclo.

Arterial improvements along US 11 are a combination of restriping and adding additional lanes. Adding a dedicated U-turn lane on northbound US 11 at Crown Ln/Pactiv Way would help alleviate the long queues that occur due to vehicles attempting to make a U-Turn. The lane would also allow vehicles to safely maneuver through the intersection and decrease the possibility of angle crashes.

Improvements at the intersection of US 11 and Welltown Road/Amoco Lane includes adding a dedicated westbound left turn lane on Amoco Lane and restriping Welltown Road to have two dedicated left turn lanes and a shared through right lane. These improvements would allow the intersection to remove the split phasing which would decrease delay and congestion at the intersection. Reducing the amount of time a vehicle must wait at a red light would aid in decreasing the number of crashes that occur due to failure to obey traffic signals. Less congestion would also decrease the possibility of rear-end crashes.

8 PREFERRED ALTERNATIVE

The North Winchester Area Safety and Operational Analysis Report analyzed future-year travel demand for two interchange alternatives to improve safety and capacity at the interchange. An evaluation matrix, shown in **Table 7**, was developed to compare the no-build and build alternatives based on a range of criteria:

- Right-of-way and utility impacts (10 possible points)
- Safety (30 possible points)
- Operations (30 possible points)
- Constructability (10 possible points)
- Planning-Level Cost (20 possible points)

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Using the evaluation criteria, each alternative (including No-Build) was evaluated on a plus or minus scale. A plus means that the alternative is generally better or provides a positive effect (gains all the available points), a zero means that the alternative has no effect (gains half of the available points), and a minus means that the alternative is generally worse or has a negative effect (gains none of the available points). A low total score reflects a less-preferable ranking, whereas a high score reflects a preferable ranking. Ultimately, the alternative with the highest resultant score value out of 100 was determined to be the recommended alternative to consider for future funding. The scores for each alternative are presented in **Table 7**.

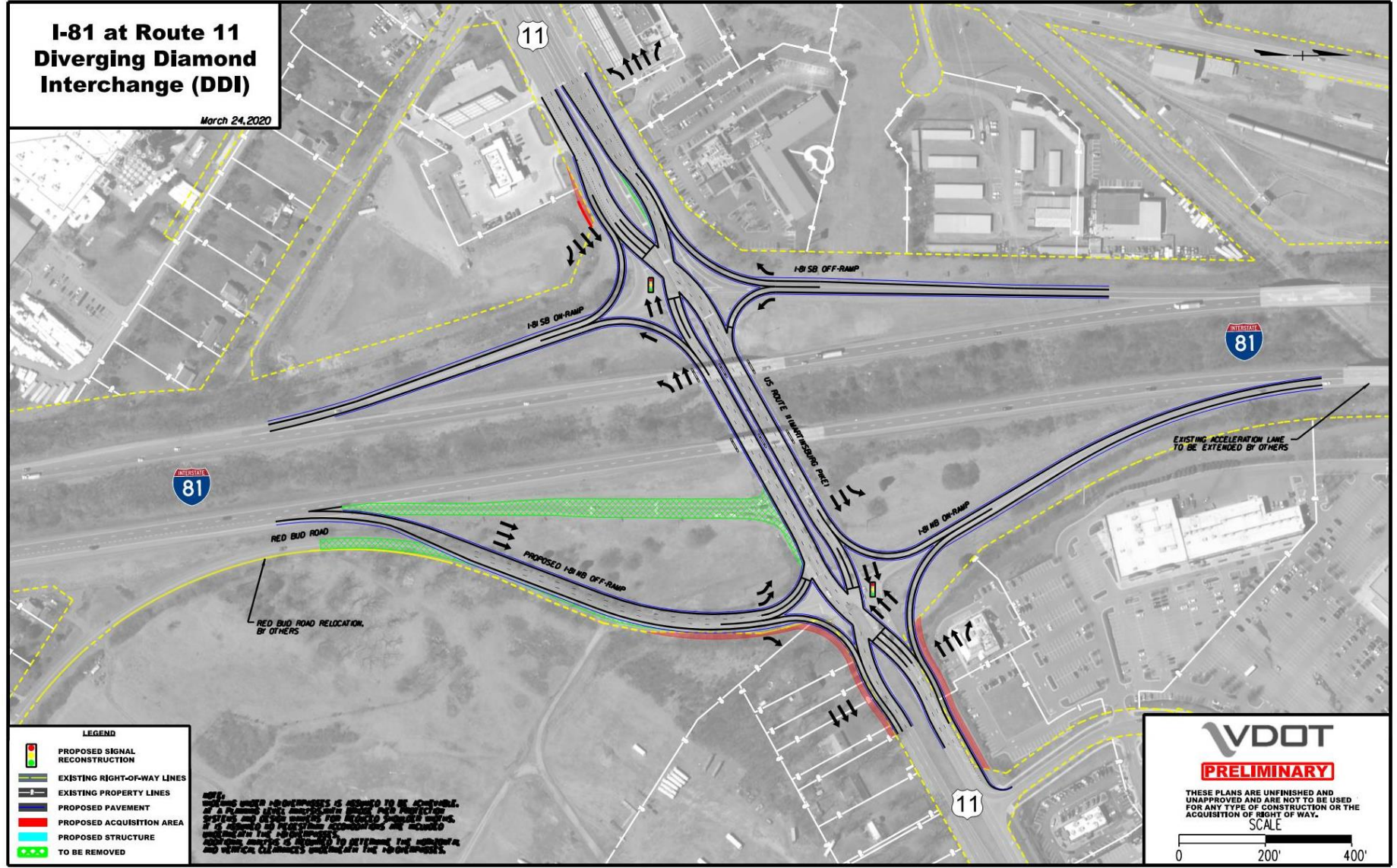
Table 7: Alternative Screening Results

| Alternatives | | Evaluation Criteria | | | | | Score | |
|-------------------------|--------------------------------|-------------------------|-----------|------------|------------------|---------------------|------------|-----------------|
| | | ROW and Utility Impacts | Safety | Operations | Constructability | Planning Level Cost | Total | Rank |
| Available Points | | 10 | 30 | 30 | 10 | 20 | 100 | Out of 3 |
| No-Build | | + | - | - | + | + | 40 | 3 |
| | | 10 | 0 | 0 | 10 | 20 | | |
| Alternative 1 | Partial Cloverleaf Interchange | - | + | 0 | - | - | 45 | 2 |
| | | 0 | 30 | 15 | 0 | 0 | | |
| Alternative 2 | Diverging Diamond Interchange | 0 | + | + | 0 | 0 | 80 | 1 |
| | | 5 | 30 | 30 | 5 | 10 | | |

Based on a combination of safety, operations and cost, the DDI was determined to be the preferred alternative. The conceptual sketch for the preferred interchange alternative is shown in **Figure 9**. The arterial improvements are illustrated in **Figure 10**.

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Figure 9: Preferred Interchange Alternative (DDI)



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Figure 10: Preferred Arterial Improvements

