PROJECT PIPELINE

ST-23-09: FREDERICK COUNTY
US ROUTE 50 FROM GORE ROAD (ROUTE 751) TO WARDENSVILLE GRADE (ROUTE 608)

DRPT Office of INTERMODAL Planning and Investment VDOT

DRPT Office of INTERMODAL Planning and Investment VDOT Virginia Department of Transportation PROJECT PIPELINE

US Route 50 from Gore Road (Route 751) to Wardensville Grade (Route 608)

Final Report

July 2024

Prepared for

VDOT Virginia Department of Transportation

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Needs Evaluation and Diagnosis

Introduction:

Project Pipeline is a performance-based planning program to identify cost-effective solutions to multimodal transportation needs in Virginia. Through this planning process, projects and solutions may be considered for funding through programs, including SMART SCALE, revenue sharing, interstate funding, and others. Visit the Project Pipeline webpage for additional information: vaprojectpipeline.org.

This study focuses on concepts targeting identified needs including congestion mitigation, safety improvement, pedestrian and bicycle infrastructure along the corridor, and transit access. The objectives of Project Pipeline are shown below in **Figure 1.**

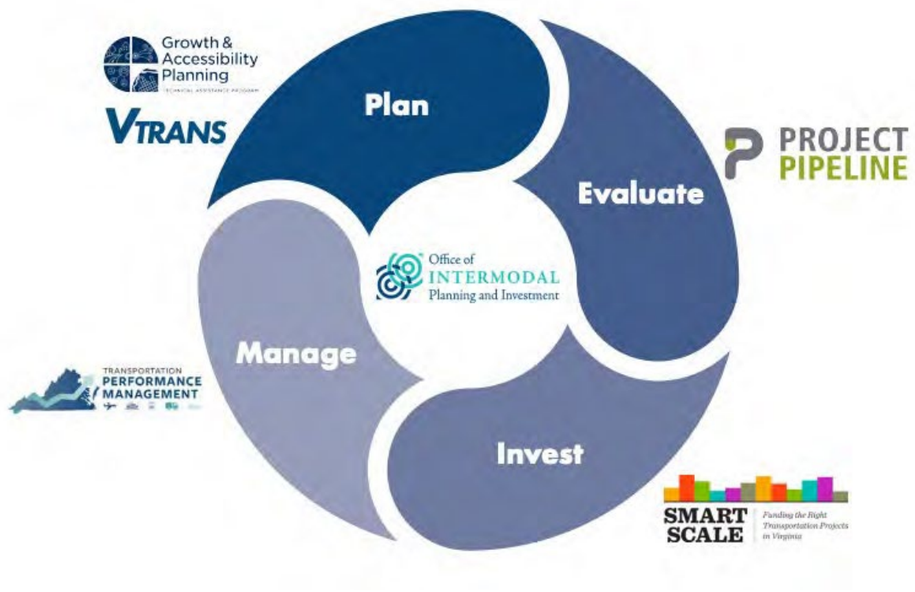


Figure 1. Project Pipeline Objectives

Background

The Office of Intermodal Planning and Investment (OIPI) prepared VTrans Virginia's statewide transportation plan for the Commonwealth Transportation Board (CTB) in which mid-term needs (0 - 10 years) were identified for different categories listed in **Table 1**. This study focuses on addressing needs identified in VTrans, and those previously identified by the localities.

Table 1. List of VTrans Needs

VTrans Needs
Safety Improvement
Transportation Demand Management
Congestion Mitigation
Pedestrian Safety Improvement
Transit Access
Capacity Preservation
Bicycle Access

Methodology

The study is broken down into three phases. Phase I is the problem diagnosis and brainstorming alternatives, Phase II is the alternative evaluation and sketch level analysis, and Phase III is the investment strategy and cost estimates. Details on methods and solutions for each study phase are outlined below in **Figure 2**.

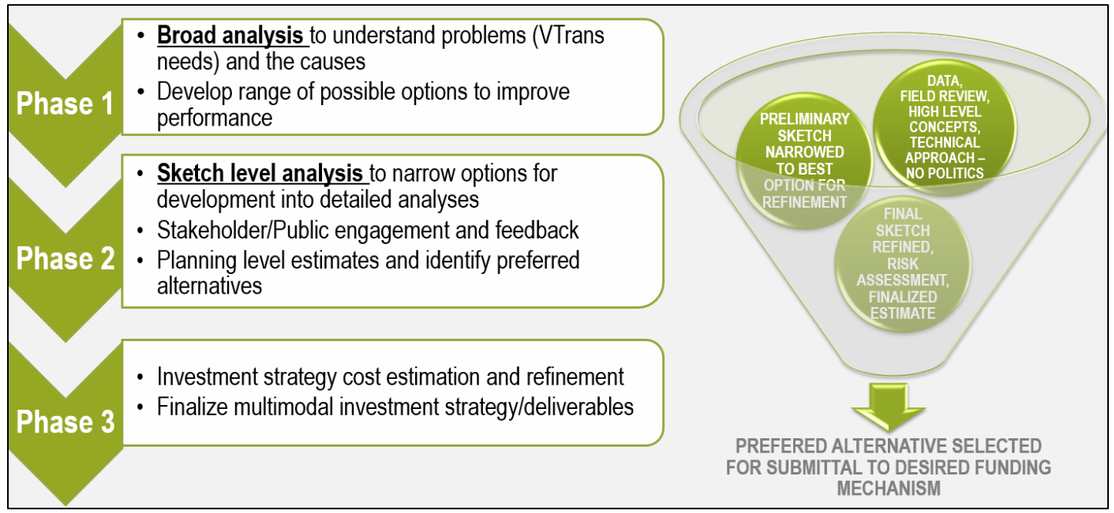


Figure 2. Study Phase Methods and Solutions

The study team is broken down into Technical Teams to improve the efficiency and effectiveness of the study process through extensive collaboration and synchronicity. To achieve the intended efficiency and consistency, it is generally expected that the same Technical Team will be responsible for all studies within a district for the duration of the cycle.

Each Technical Team will include certain leadership and technical roles that will be needed for each study, including the following:

- VDOT District Planning Project Manager – Provides leadership and direction; has overall responsibility for the study progress and outcomes.
- Consultant Team Manager – Provides direct support to the VDOT District Planning Project Manager; coordinates the work and technical efforts of consultant staff.
- District Planning Staff – Provides technical input regarding capacity, forecasting, land use, multimodal, and planning.
- District Traffic Engineering Staff – Provide technical input regarding safety and operations.
- Consultant Team Technical Staff – Provides multidisciplinary input, analysis, technical support, and expertise for the identified VTrans need categories.

A sample organizational chart, including the roles, responsibilities, and structure of a Technical Team is shown below in **Figure 3**.

Figure 3. Structure of a Technical Team

Additional team members and roles should be considered where appropriate. Certain roles may not be necessary for all studies. However, the following roles may contribute to study success during different stages and/or for different types of study areas, as shown in **Table 2**.

Table 2. Roles and Responsibilities for the Technical Team and SWGs

Phase	Responsibility	Role					
		OIPI/Program Support	District	Consultant	DRPT	Locality	VDOT Central Office
Study Selection & Initiation	Identify Study Needs and Priorities		X		X	X	
	Coordinate with CTB Members	X	X				
	Approve final study locations	X					
	Data Collection Planning		X				
	Data Dashboards	X					
	Assign Consultants & Issue Consultant Task Orders	X					X
Phase 1	Initiate Study & Hold Kickoff Meeting		X	X	X		
	Prepare Framework Document		X	X			
	Approve Framework Document		X		X	X	
	Provide Existing Data		X		X	X	
	Collect New Data			X			
	Coordinate with local leaders					X	
	Conduct & Support Initial Public Outreach (if desired)	X	X	X		X	X
	Diagnose Existing Needs			X			
	Brainstorm & Develop Preliminary Alternatives		X	X	X		X
	Present Diagnosis & Alternatives to SWG			X			
	Provide Feedback and Input on Analysis & Alternatives					X	
	Develop Phase 2 Scope of Work			X			
	Approve Scope & Issue Consultant Task Orders	X					X
Phase 2	Conduct Detailed Analysis of Alternatives			X			
	Develop Refinements to Alternatives		X	X	X		X
	Present Alternative Analysis Findings to SWG		X	X			
	Provide Feedback on Alternatives				X	X	X
	Prepare Planning Level Cost Estimates			X			
	Conduct & Support Public Outreach on Alternatives	X	X	X		X	
	Concurrence on Preferred Alternative(s)		X		X	X	X
	Develop Phase 3 Scope of Work			X			
	Approve Scope & Issue Consultant Task Orders	X					X
Phase 3	Conduct Alternative Risk Assessment		X	X			X
	Develop Practical Concept Design & Address Risk of Preferred Alternative		X	X			
	Prepare Cost Estimate with Workbook			X			
	Document Assumptions & Basis of Cost			X			
	Review & Concur with Concept & Estimate		X		X		X
Investment, Application, & Closeout	Prepare Final Study Deliverables, Design Packages, and Estimates			X			
	Apply for Funding of Preferred Alternative(s)				X	X	
	Application Support	X	X	X			
	Submit and Documentation and All Related Work			X			
	Review and approve final deliverables for public visibility		X		X		
	Program Closeout and Summary	X					

Study Area

The US Route 50 study corridor from Gore Rd (Route 751) to Wardensville Gr (Route 608) is located in Frederick County, Virginia. US Route 50 is classified as an *Other Principal Arterial* Rd within the study area. The posted speed limit is 55 MPH. There are 32 crossovers within this 7.7-mile corridor along US Route 50. A map detailing the locations of the study intersections along US Route 50 is shown below in **Figure 4.**

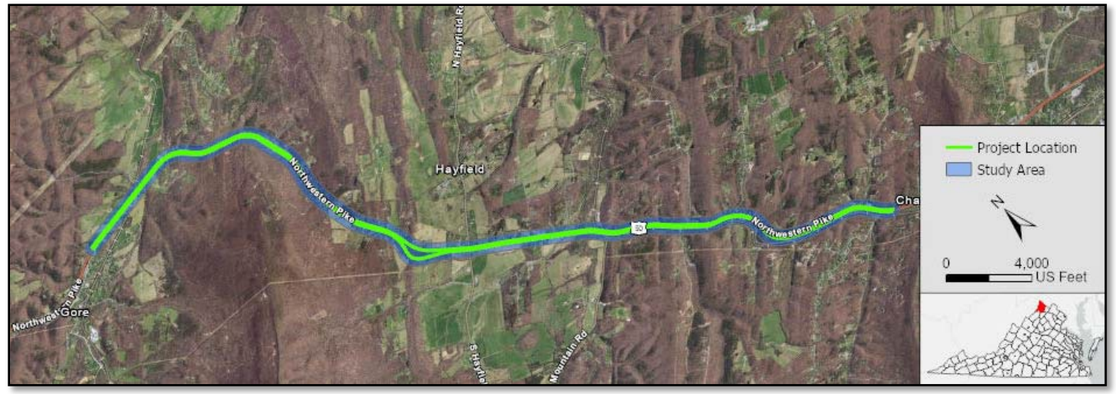


Figure 4. US Route 50 Study Area Map

VTrans is Virginia's statewide transportation plan. It identifies and prioritizes locations with transportation needs using data-informed transparent processes. The policy for identifying VTrans mid-term needs establishes multimodal need categories corresponding to the Commonwealth Transportation Board-adopted VTrans visions, goals, and objectives.[1] Each need category has one or more performance measures and thresholds to identify one or more needs. Visit the Vtrans policy guide for additional information: https://vtrans.org/resources/VTrans_Policy_Guide_v6.pdf.

The mid-term needs, as identified in VTrans for the US Route 50 study corridor, were identified as 'Very High' for Capacity Preservation, Safety Improvement, Transit Access, and Transportation Demand Management and 'Low' for Bicycle Access needs, as presented in **Table 3.**

Table 3. VTrans needs in the Study Area

VTRANS IDENTIFIED NEEDS	PRIORITIES
Bicycle Access	Low
Capacity Preservation	Very High
Congestion Mitigation	None
IEDA (UDA) Access	None
Pedestrian Access	None
Safety Improvement	Very High
Pedestrian Safety Improvement	None
Reliability	None
Rail On-time Performance	None
Transit Access	Very High
Transit Access for Equity Emphasis Areas	None
Transportation Demand Management	Very High

These mid-term needs, identified in VTrans, are prioritized on a tier from 1 to 4, with 1 being the most critical and 4 being the least critical. The segments ranked as "Priority 1" represent those with multiple categories identified as high in need. **Figure 5** presents a map of the study area with the 2019 VTrans mid-term needs prioritized for district construction**. Figure 6** provides an overview of the study area.

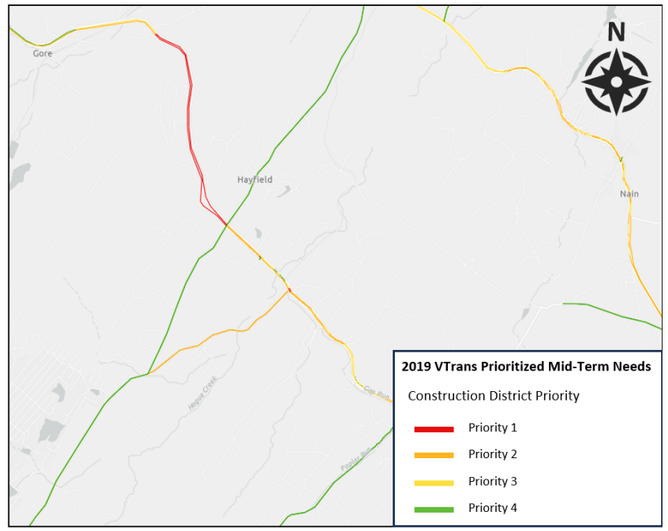
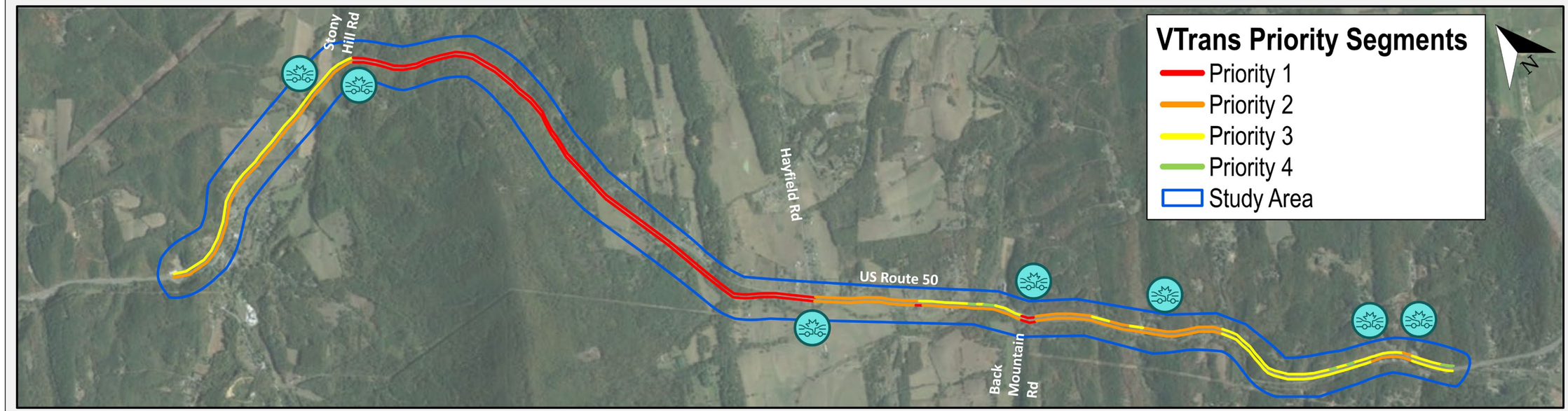


Figure 5. 2019 VTrans Prioritized Mid-term Needs in the Study Area

[1] Commonwealth Transportation Board, Actions to Approve the 2019 VTrans Vision, Goals, Objectives, Guiding Principles and the 2019 Mid-term Needs Identification Methodology and Accept the 2019 Mid-term Needs, January 15, 2020



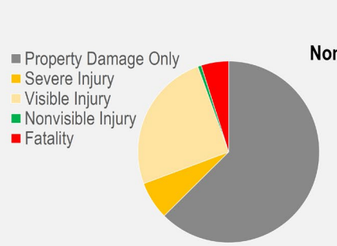
Project Purpose, Goals, & Objectives

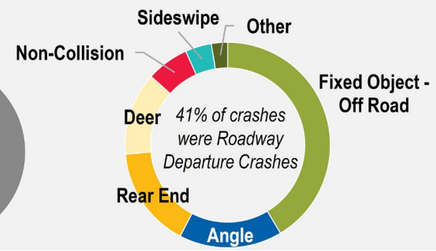
Analyze the operational and safety issues identified along US Route 50, with a focus on providing enhanced safety improvements.

Identify cost-effective preferred improvement alternatives that address the deficient conditions and prioritize safety.

Issues in the Study Area

- Significant fixed object – off road crash trend related to failure to maintain control
- Very high number of median crossovers with a rate of greater than 4 crossings per mile
- Notable number of crossovers (28) without turn lanes
- Notable number of fatal crashes (16 total crashes), with 9 crashes involving median crossovers





Project Fact Sheet	
VDOT District	Staunton
Locality	Frederick County
Corridor Length	7.7 miles
Number of Crossovers	32
Functional Classification	Other Principal Arterial
Speed Limit	55 mph

Figure 6. Project Overview for US Route 50 from Gore Rd to Wardensville Gr

Previous Study Efforts

Safety Enhancement Project on Route 50 in Frederick County

Improvements for shoulder widening, guardrail upgrades, and installation of rumble strips along the edges of the roadway were recently completed on October 31, 2022, between the Virginia/West Virginia state line and Poorhouse Rd (Route 654). The roughly 12.5-mile project encompasses the entire study area. The project was primarily funded by Highway Safety Improvement Program (HSIP) funds. It was intended to improve safety, particularly by reducing run-off-the-Rd crashes.

FHWA STEAP Tool Analysis

The Federal Highway (FHWA) Screening for Equity Analysis of Projects (STEAP) Tool was reviewed for the corridor and surrounding areas. This tool is used to discover the key population metrics and needs of the study area to raise awareness of equity needs in the selection of alternatives. The data source used for the analysis was the American Community Survey 2016 – 2020 and a 0.5-mile radius was used for the analysis buffer. The results of the STEAP Tool analysis are presented below:

- The majority of the population (65%) within the study area is between ages 18 and 64 as shown in **Figure 7**.
- There is a high personal vehicle ownership, with 46% of households owning three or more vehicles. Only 2% of households do not own a personal vehicle as shown in **Figure 8**.
- Of the non-English speakers (age 5+) at home, everyone speaks English very well as shown in **Figure 9**.
- When compared to Frederick County and the State of Virginia, the study area has a higher than average number of veterans, people with disabilities, households with no computers, and households without internet connection, as shown in **Figure 10**.
- Of all the households in the study area, 48% have household income greater than $75,000, as shown in **Figure 11**.

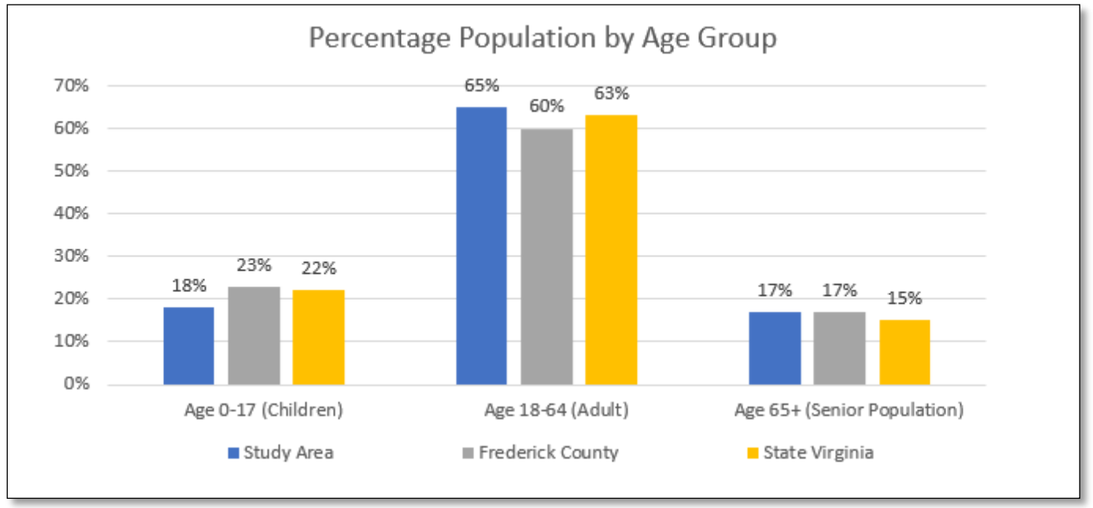


Figure 7. STEAP Tool Analysis Population by Age Group

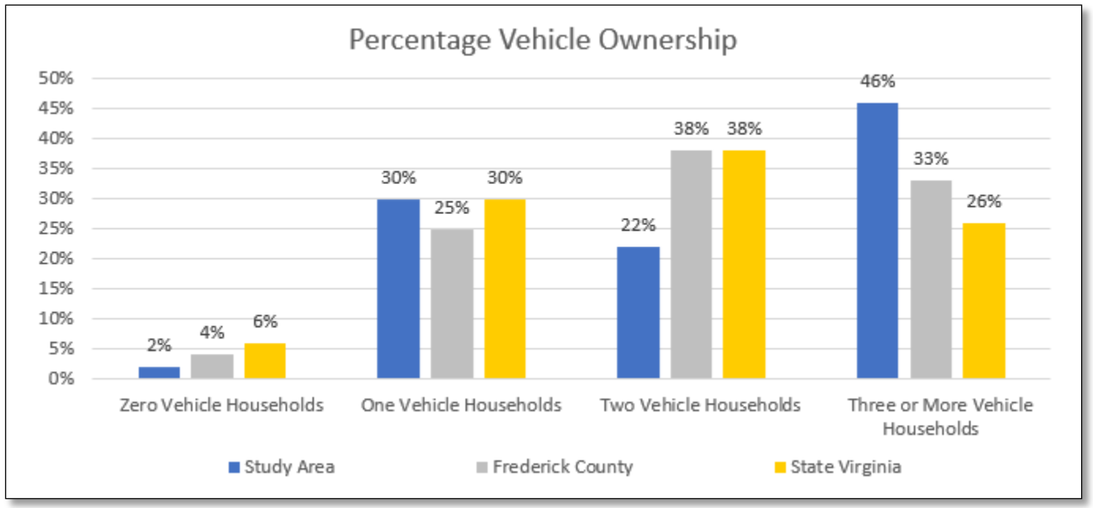


Figure 8. STEAP Tool Analysis Vehicle Ownership

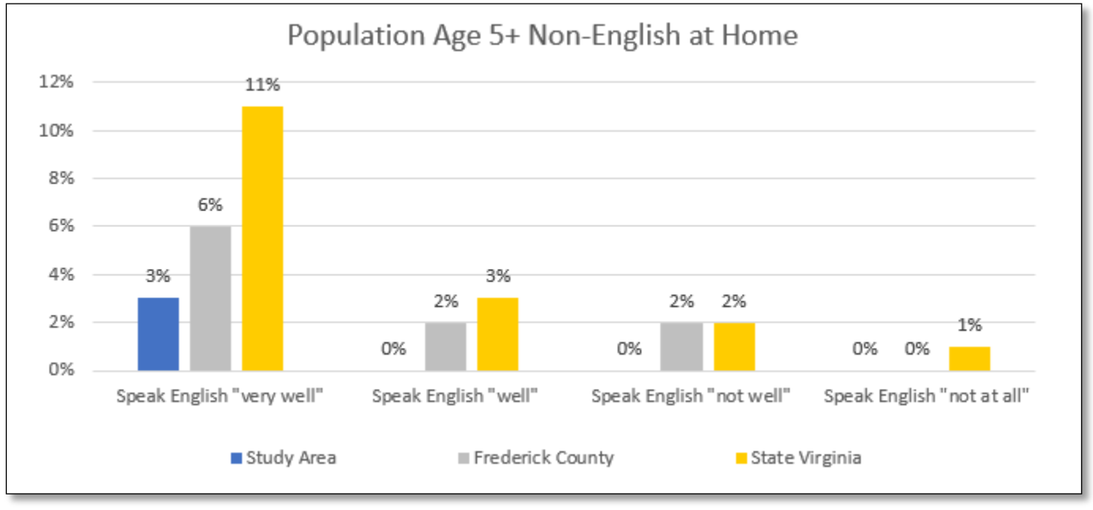


Figure 9. STEAP Tool Analysis Non-English at Home

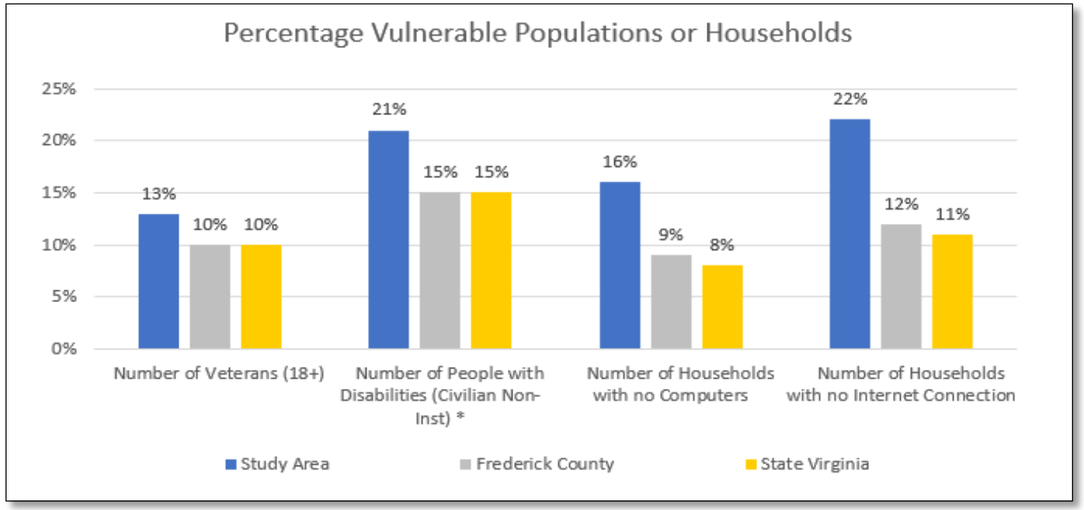


Figure 10. STEAP Tool Analysis Vulnerable Populations

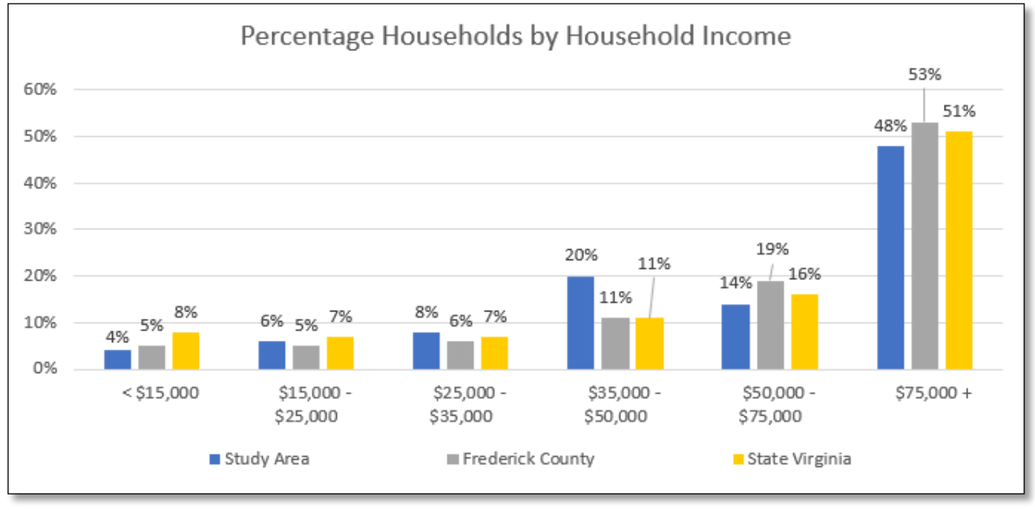


Figure 11. STEAP Tool Analysis Household Income

Traffic Operations and Accessibility:

Traffic Data

The traffic data for the study area was obtained from Turning Movement Counts (TMC) collected on Wednesday, April 19, 2023, a typical weekday when schools were in session. The morning counts were collected from 6:00 AM to 9:00 AM and the evening counts were collected from 3:30 PM to 6:30 PM. The corridor AM peak hour was determined to be 7:00 AM to 8:00 AM and the corridor PM peak hour was determined to be 4:30 PM to 5:30 PM. The AM & PM peak hour volumes are shown in **Figure 12**, **Figure 13**, and **Figure 14**.

Traffic Operations

The existing conditions of the mainline US Route 50 indicate that it operates below its capacity, thus providing reliable travel times for users in both directions, as shown in **Figure 15**. The travel time data was obtained from the Pipeline Travel Time Dashboard [2]. Based on the existing turning movement data collected, a few minor streets were found to experience a relatively high volume demand during peak hours. Some of the significant turning movements observed to and from the unsignalized minor street intersections, as per the collected TMC are presented below:

- At the unsignalized Hayfield Rd (Route 600) intersection, there is a relatively high number of vehicles crossing or turning onto US Route 50. On the Hayfield Rd southbound approach, there are 85 vehicles during the AM peak and 96 during the PM peak hour. On the northbound approach, there are 81 vehicles during the AM peak and 39 vehicles during the PM peak hour. Of the individual movements, the predominant ones are the southbound left turn during both peak hours and the northbound through movement during the AM peak hour. There are 51 left turners from the southbound approach during the AM peak and 42 during the PM peak hour. There are 56 northbound through vehicles during the AM peak hour. The individual turning movement counts at this intersection are shown in **Figure 13**, *Intersection #5*.
- There is a significantly high northbound right turn volume from the unsignalized Back Mountain Rd (Route 614) intersection onto US Route 50. A total of 396 vehicles turned right onto US Route 50 during the AM Peak and 139 vehicles during the PM peak hour, as shown in **Figure 13,** *Intersection #7*.
- Similar to the Back Mountain Rd (Route 614) intersection, a relatively high northbound right turn volume was observed from the unsignalized Wardensville Gr (Route 608) intersection onto US Route 50 during the peak hours. A total of 114 vehicles turned right onto US Route 50 from the northbound approach during the AM Peak and 67 vehicles during the PM peak hour, as shown in **Figure 14**, *Intersection #11*.

[2] https://app.powerbigov.us/groups/9c9cc467-0b2c-4264-a8a4-b757d42ad9e0/reports/cf108121-9047-4cbb-9027-ac6d895d0f65/ReportSection

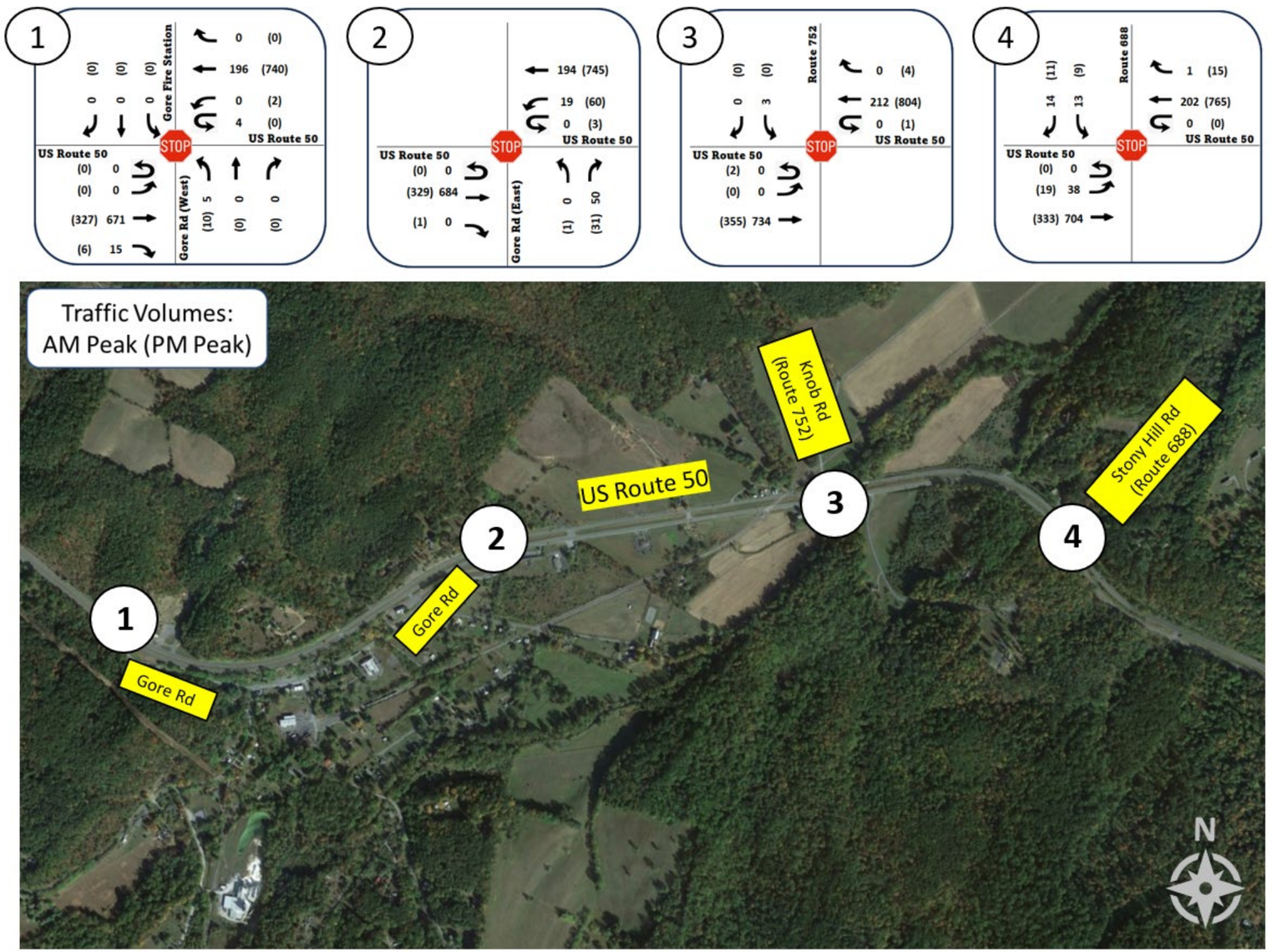


Figure 12. TMCs at intersections between Gore Rd & Stony Hill Rd

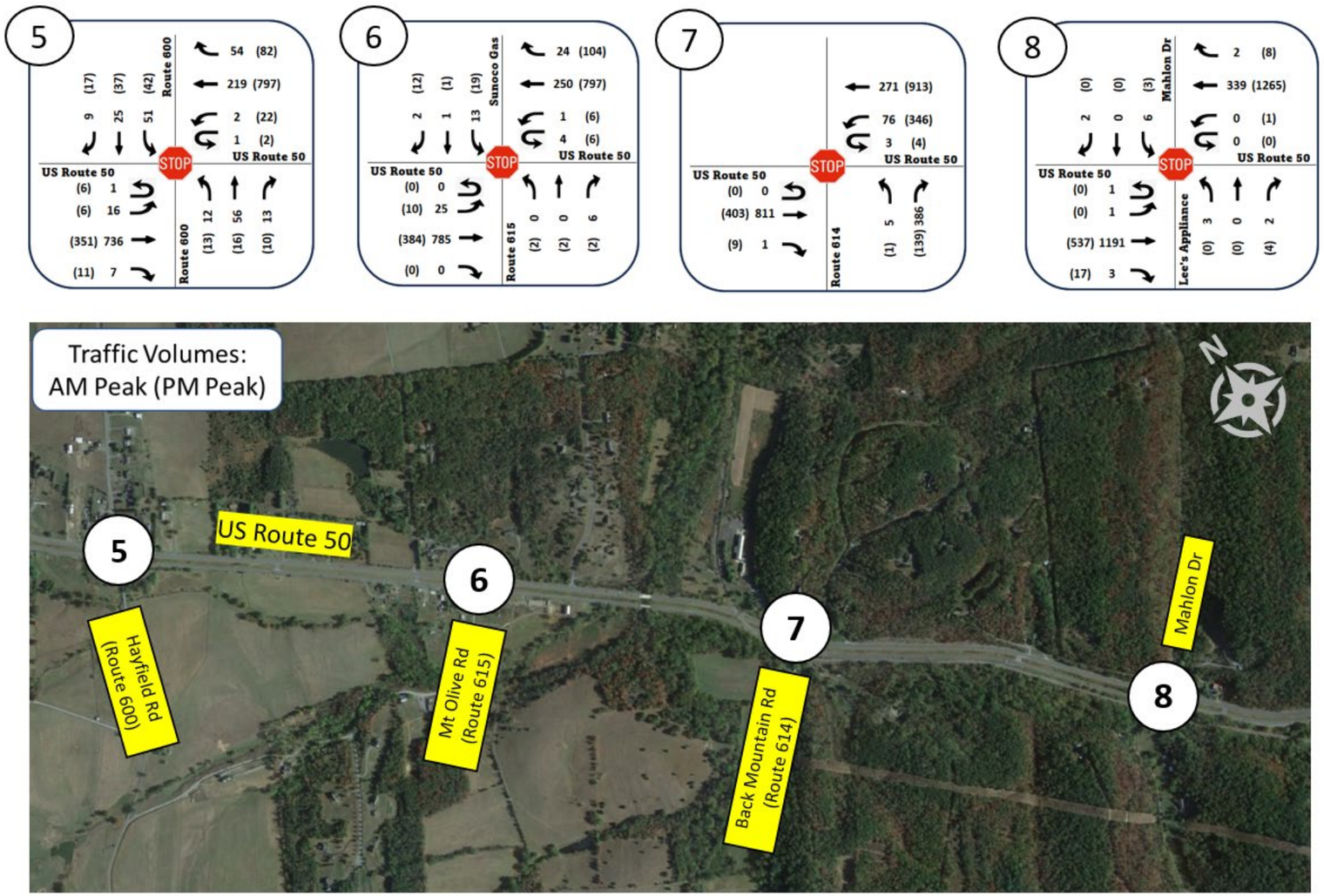


Figure 13. TMCs at intersections between Hayfield Rd and Mahlon Dr

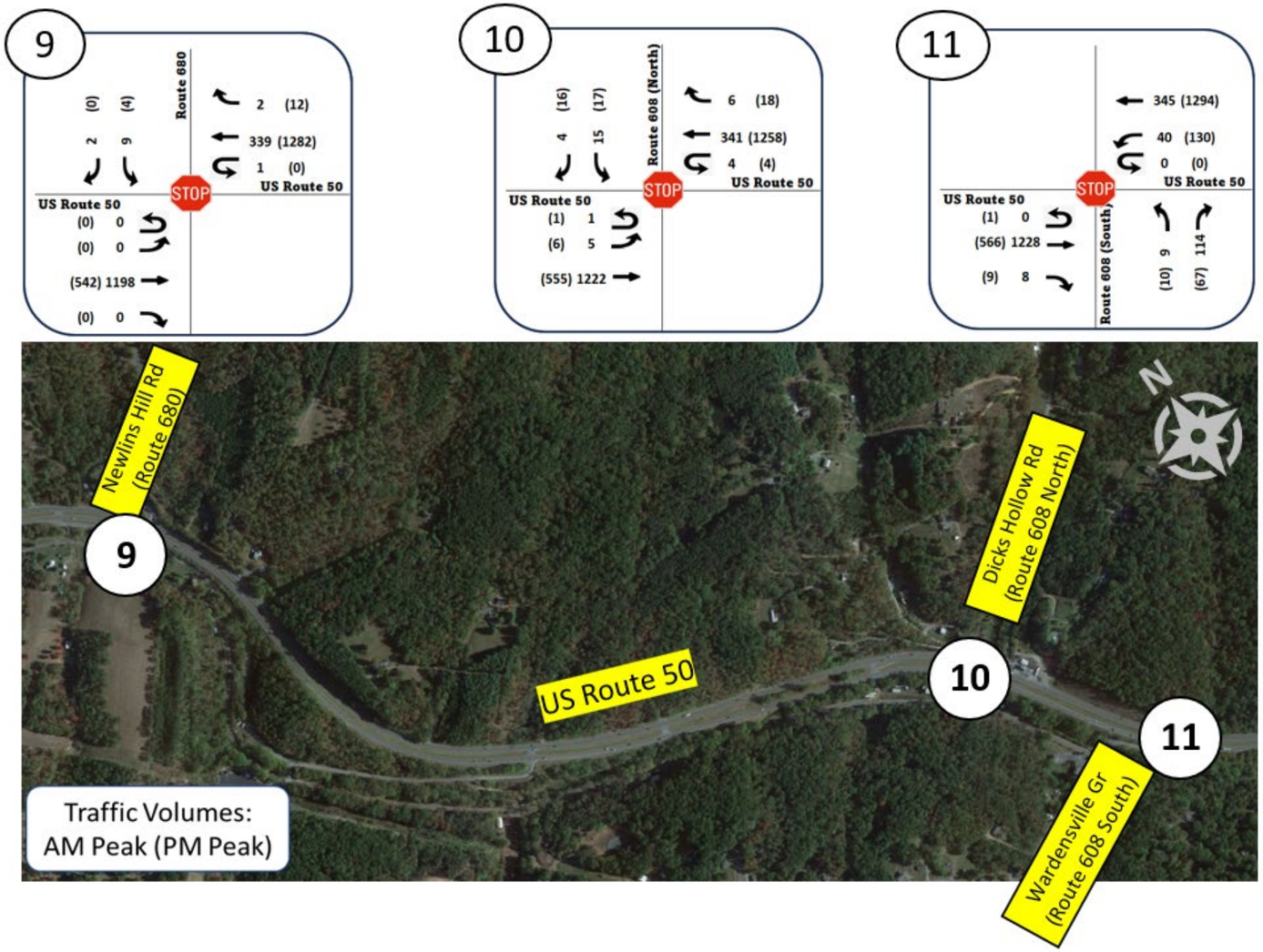


Figure 14. TMCs at intersections between Newlins Hill Rd and Wardensville Gr

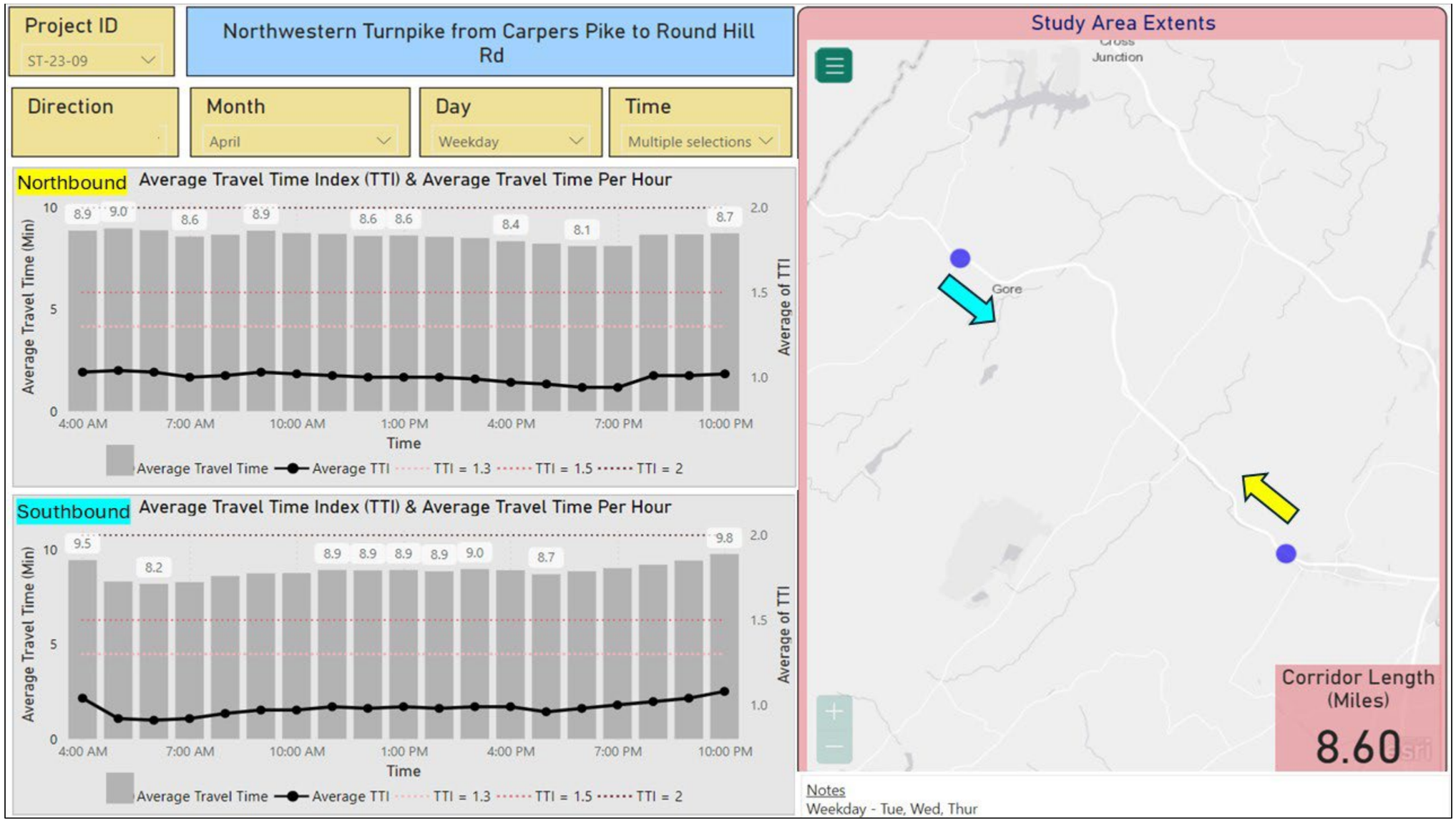


Figure 15. INRIX Average Travel Time Index (TTI) & Average Travel Time Per Hour

Safety and Reliability:

To analyze existing safety conditions, the VDOT Crash Analysis PowerBI Tool was utilized to evaluate the crash patterns at the study intersections and along the study corridor on US Route 50. Crash data was collected and analyzed for an eight-year period spanning from January 2015 to December 2022. The study team reviewed the FR-300 reports provided by VDOT to determine specific trends and "hot spot" areas for consideration in developing alternative improvement concepts. For the purposes of this analysis, "injury crashes" is defined as the sum of type A (severe injury), B (visible injury), and C (non-visible injury) crashes. Raw crash data is provided in **Appendix C**.

Corridor Safety Analysis Results

The crashes by severity within the study area are summarized by year and type in **Table 4** and **Table 5**, respectively. The number of crashes by lighting conditions, adverse weather conditions, and other related factors including, alcohol, speeding, and guardrail is summarized in **Table 6**.

Table 4. Study Area Crash Severity by Year

Crash Year and Severity	K. Fatal Injury	A. Severe Injury	B. Visible Injury	C. Nonvisible Injury	PDO. Property Damage Only	Total
2015	3	7	14	0	25	**49**
2016	1	2	12	0	19	**34**
2017	3	3	9	0	28	**43**
2018	1	3	9	0	30	**43**
2019	1	1	8	1	33	**44**
2020	3	3	8	0	22	**36**
2021	2	3	14	0	27	**46**
2022	2	0	8	1	20	**31**
Total	**16**	**22**	**82**	**2**	**204**	**326**

Table 5. Study Area Crash Severity by Type

Crash Type and Severity	K. Fatal Injury	A. Severe Injury	B. Visible Injury	C. Nonvisible Injury	PDO. Property Damage Only	Total
Rear End	0	2	7	0	41	**50**
Angle	5	2	18	0	26	**51**
Head On	1	0	1	0	0	**2**
Sideswipe – Same Direction	0	0	4	0	9	**13**
Fixed Object in Rd	0	1	0	0	1	**2**
Non-Collision	2	3	8	2	6	**21**
Fixed Object – Off Rd	7	14	37	0	72	**130**
Deer	0	0	4	0	37	**41**
Other Animal	0	0	1	0	6	**7**
Ped	1	0	0	0	0	**1**
Other	0	0	2	0	6	**8**
Total	**16**	**22**	**82**	**2**	**204**	**326**

A total of 326 crashes were reported within the US Route 50 study area during the eight-year study period. The detailed collision diagrams are shown in **Appendix A**.

Key takeaways from the crash data are as follows:

1. Year-over-year crash occurrence varies with the highest number of crashes (49) in 2015, followed by 44 in 2019.
2. The approximate average number of reported crashes per year is 41.
3. Most reported crashes within the corridor are Fixed Object – Off Road (FOOR). These constitute approximately 40% of the total crashes.
4. 122 crashes were associated with injuries, accounting for approximately 37% of the reported crashes within the corridor. 16 crashes resulted in a fatality.
5. 109 crashes (33%) occurred during the night.
6. There were 91 crashes (28%) due to speeding.
7. A guardrail was involved in 38 crashes (12%).
8. 49 crashes (15%) occurred during adverse weather conditions.

Table 6. Summary of Crash Incidents along the Study Corridor

Crash Type and Other Related Factors	Lighting Conditions		Weather Conditions						Alcohol-Related		Speeding Related		Guardrail Related	
	Daylight	Darkness	No Adverse Conditions	Fog	Mist	Rain	Snow	Sleet/Hail	Yes	No	Yes	No	Yes	No
Rear End	47	3	44	1	1	3	1	0	0	50	14	36	2	48
Angle	38	13	47	0	1	3	0	0	1	50	17	34	3	48
Head On	0	2	1	0	0	1	0	0	0	2	0	2	1	1
Sideswipe – Same Direction	11	2	11	0	0	2	0	0	0	13	2	11	2	11
Fixed Object in Rd	2	0	2	0	0	0	0	0	0	2	0	2	0	2
Non-Collision	14	7	16	0	1	3	0	1	4	17	5	16	0	21
Fixed Object – Off Rd	82	48	105	2	3	9	5	6	26	104	47	83	30	100
Deer	18	23	38	0	1	2	0	0	0	41	5	36	0	41
Other Animal	0	7	6	0	0	1	0	0	0	7	0	7	0	7
Ped	1	0	1	0	0	0	0	0	1	0	0	1	0	1
Other	4	4	6	0	0	1	1	0	1	7	1	7	0	8
Total	**217**	**109**	**277**	**3**	**7**	**25**	**7**	**7**	**33**	**293**	**91**	**235**	**38**	**288**

Crossover Analysis

There is a high density of crossovers (32) within the 7.7-mile study corridor. With such a high density, the crossovers were evaluated and categorized as candidates for closure or no change by developing a score through quantifying select categories. The categories used for crossover scoring criteria were 1) average crossover spacing, 2) presence of left-turn lanes along US Route 50, 3) peak hour turning movement count, 4) cross street Average Daily Traffic (ADT), 5) use type of the crossover, 6) Equivalent Property Damage Only (EPDO) score, and 7) crossover width. The detailed crossover analysis can be found in **Appendix E**. The locations of crossovers recommended for closure are shown in **Figure 16**. The list of crossovers recommended for closure along with their Mile Marker is provided in **Table 7**.

Figure 16. Crossover Locations along US Route 50

Table 7. Crossovers Recommended for Closure along US Route 50

ID	Crossover	Mile Marker
3	MP 4.65	4.65
8	MP 6.08	6.08
10	MP 6.57	6.57
11	MP 6.69	6.69
21	MP 9.51	9.51
23	MP 9.84	9.84
24	MP 10.00	10.00
29	MP 10.84	10.84
30	MP 11.08	11.08

A GIS-based safety analysis was performed to identify crash hotspots at the crossovers, shown in **Figure 17**. The hotspot analysis identified four major crash hotspots along the study corridor at the following locations:

1) Between Knob Rd (Route 752) and Stony Hill Rd (Route 688).
2) At Hayfield Rd (Route 600) intersection.
3) At Back Mountain Rd (Route 614) intersection.
4) Between Dick's Hollow Rd (Route 608) and Wardensville Gr (Route 608) intersections.

Due to the recommendations at the hotspots, discussed further in Chapter 2, additional crossovers are recommended where a U-turn is needed for a reduced conflict intersection (RCI). These crossover locations are shown in **Table 8**.

Table 8. Crossovers Recommended for RCI Modifications

Intersection	Proposed Improvement	Intersection Mile Marker	New Crossover Location (Mile Marker)
Hayfield Road	RCI	8.04	**7.95**
			8.13
Back Mountain Road	RCI	9.15	**9.23**
Wardensville Grade	RCI	11.45	**11.54**

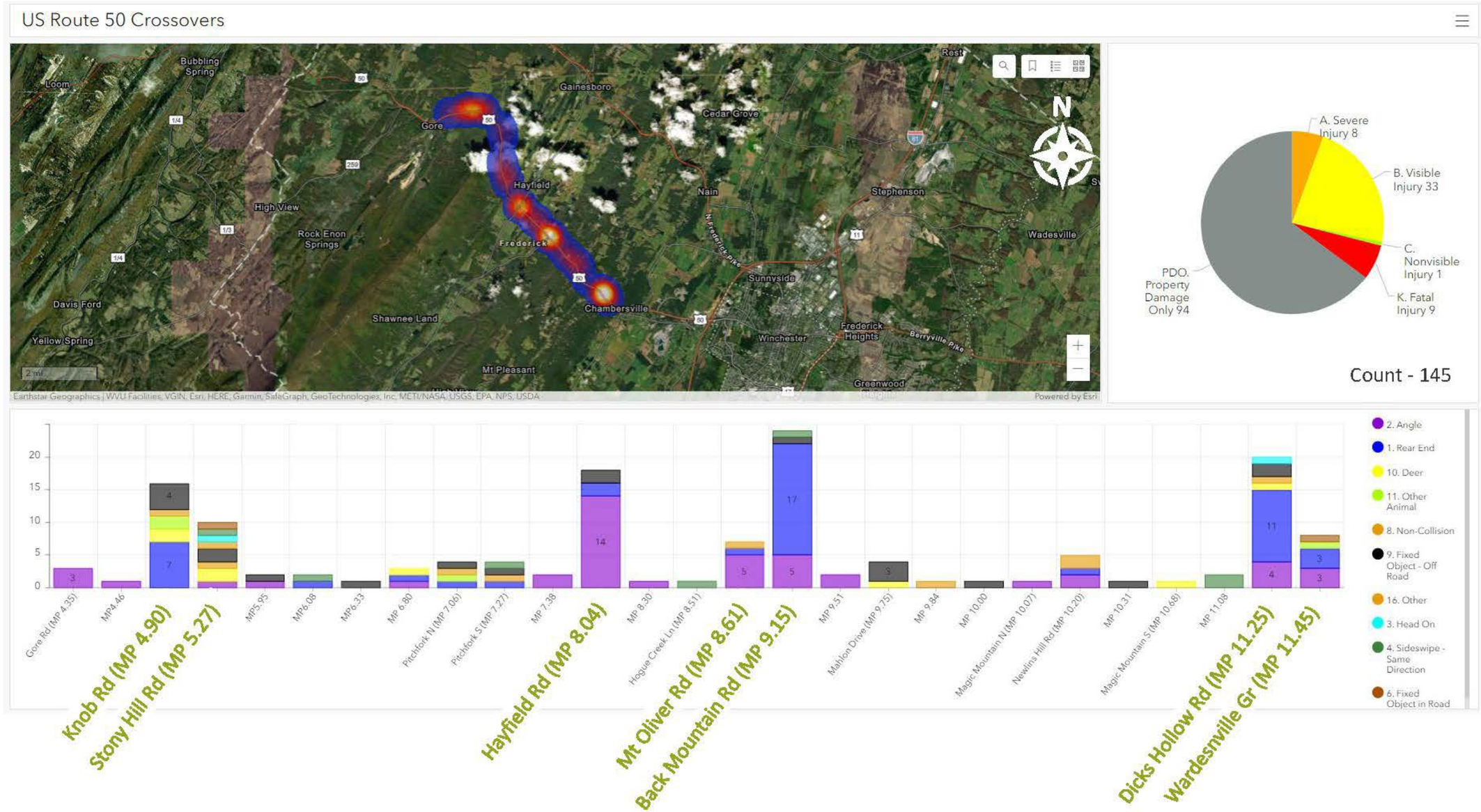


Figure 17. US Route 50 Crossover Locations and Crash Types

Rail, Transit, and Travel Demand Management (TDM):

The US Route 50 study corridor does not have any Park & Ride locations or bus stops. A few signs warning about school bus stops were found along the study corridor. As illustrated in the FHWA STEAP Analysis, there is a high percentage of personal vehicle ownership, with 98% of households owning one or more vehicles while only 2% of households do not own any personal vehicles as shown in **Figure 8**. Based on the existing conditions analysis and the stakeholder input received, it was determined that Rail, Transit, and TDM will not be evaluated further for this study corridor

Phase 1 Corridor/Existing Conditions Public Outreach & Involvement

Initial Public Outreach was conducted to inform the public of the study efforts and goals and solicit feedback on what the public's priorities and perceptions of the corridor are to include in the evaluation of potential alternatives. The survey was conducted through Publicinput.com and there were 173 participants.

The survey shows that the major needs of the corridor include safety and capacity preservation as shown in **Figure 18**.

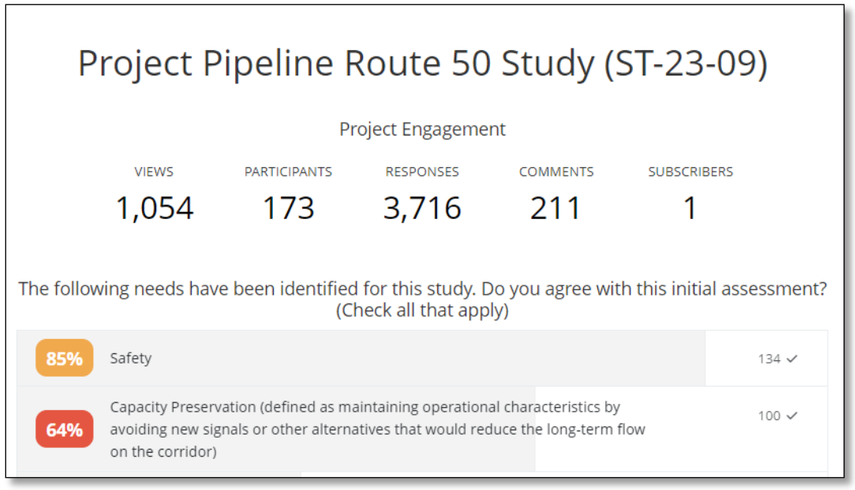


Figure 18. Public Input Survey Results

Figure 19 shows the major concerns of the respondents for the study corridor. **Figure 20** details these concerns, which include speeding, lack of turn lanes, and overall corridor safety. The majority of respondents use the corridor for shopping/errands, commuting to work, or traveling home.

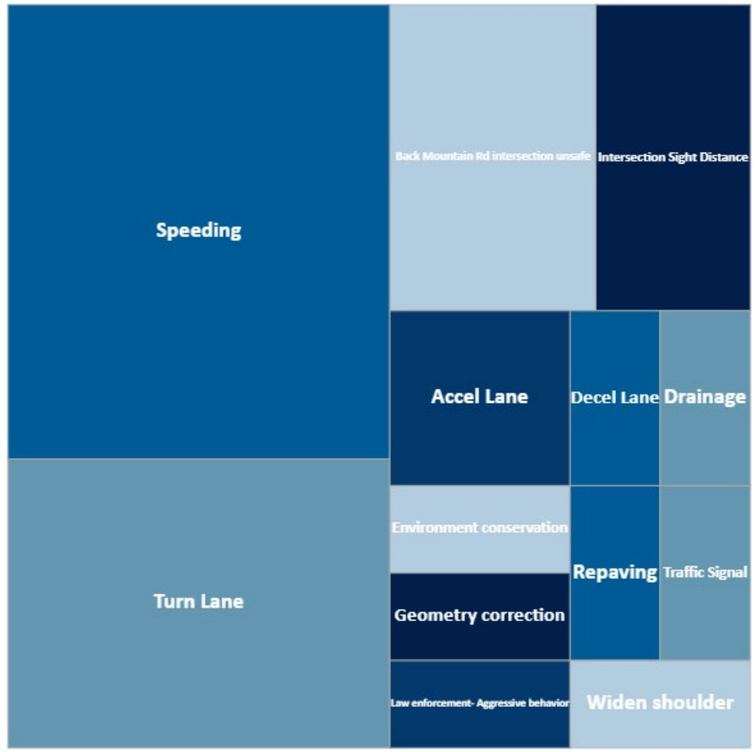


Figure 19. Major concerns of the survey respondents for the study corridor

The notable comments from the survey responses are summarized below:

- *All crossovers need left and right turn lanes, especially at the intersection of Route 615 and the Hogue Creek Market. There have been numerous accidents (with a fatality) and turn lanes would be one way to curb this.*
- *Enforce speed limit. I live in Gore and drive into Winchester 4-5 times a week and most are driving over 60! Way over! Speeding is the problem! Everyone knows where police sit to run radar, also drivers coming out of Winchester driving in left lane for 5 miles! Choking traffic causes dangerous lane changes.*
- *I think speed is a major factor in most accidents.*
- *Traffic light at Back Mountain Rd, and Hayfield Rd.*

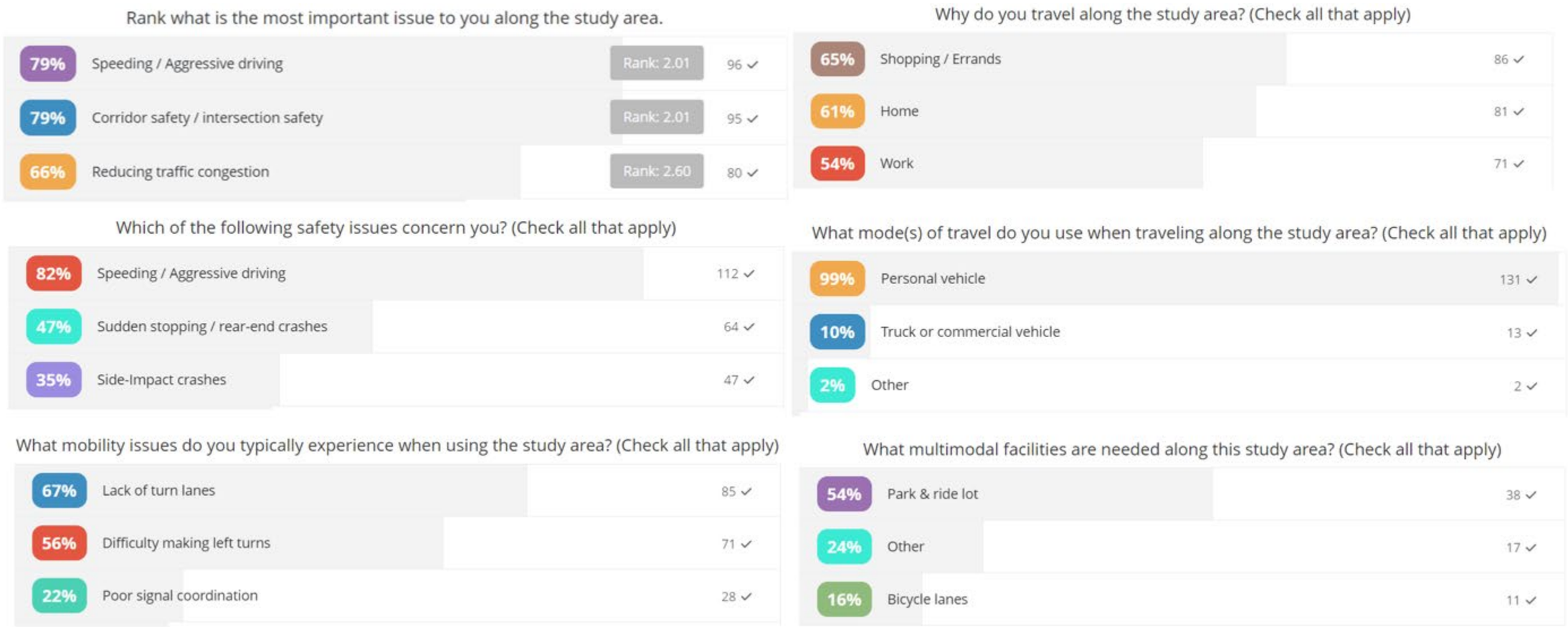


Figure 20. Public Input Survey Responses

Chapter 2:

Alternative Development and Refinement

Alternative Development and Screening:

To develop alternative concepts that address the needs and incorporate the diagnosis identified in Chapter 1, a thorough review of the existing conditions data was conducted. Based on the corridor-level GIS safety analysis conducted, the following locations were identified as safety priority areas in need of improvements, illustrated in **Figure 21**:

- US Route 50 between Knob Rd (Route 752) & Crossover at Mile Point (MP) 5.95 (Stony Hill Rd corridor)
- US Route 50 at Hayfield Rd (Route 600)
- US Route 50 at Back Mountain Rd (Route 614)
- US Route 50 at Dicks Hollow Rd (Route 608 N)
- US Route 50 at Wardensville Gr (Route 608 S)

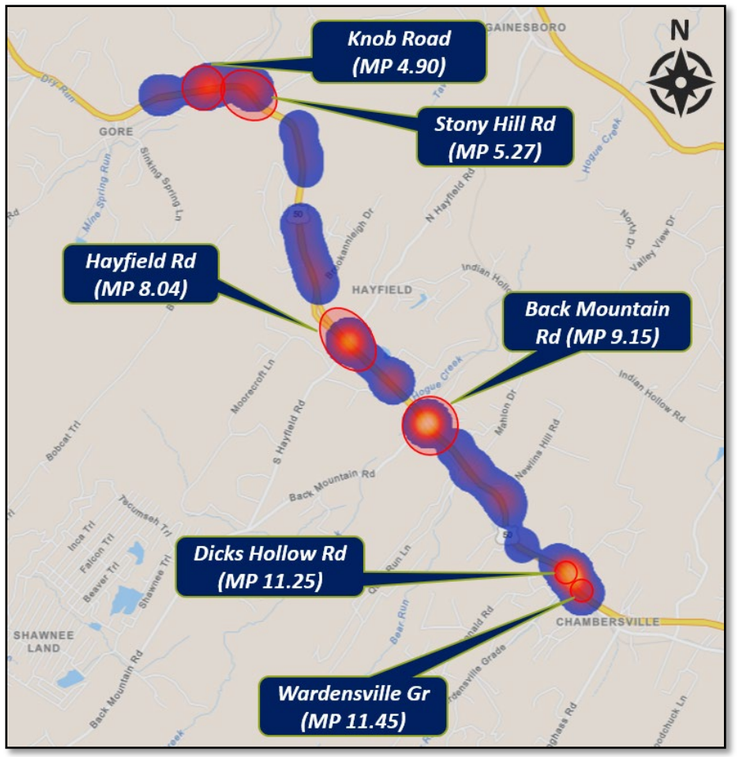


Figure 21. Safety Priority Areas along Route 50

Upon review of the crash data for the safety priority areas identified, it was determined that two of the priority areas 1) US Route 50 between Knob Rd (Route 752) & Crossover at M.P. 5.95 hereafter referred to as Stony Hill Rd corridor and 2) US Route 50 at Dicks Hollow Rd (Route 608 N) could be improved through safety improvement measures targeting the crash patterns observed at these locations. The analysis and the proposed improvements are discussed in the *Alternative Analysis* section of this chapter.

A review of the crash trends and existing TMCs at the remaining intersections of US Route 50 at 1) Hayfield Rd (Route 600), 2) Back Mountain Rd (Route 614), and 3) Wardensville Gr (Route 608 S) suggests that they could be improved via considering alternative intersection designs. A screening-level analysis was performed using VJuST on potential future alternatives for these intersections. The VJust tool intends to help identify the most appropriate intersection types to advance to further study, analysis, and design. See the *VJust Analysis* section for further details. For alternative testing and screening, the AM and PM peak hour volumes at the study intersections were forecasted for the future opening year 2034. See the following section on *Future Traffic Forecasting.* The analyses conducted are discussed in greater detail in the following sections.

Future Traffic Forecasting

Future volumes for the opening year 2034 were developed for the intersections of US Route 50 at 1) Hayfield Rd (Route 600), 2) Back Mountain Rd (Route 614), 3) Dick's Hollow Rd (Route 608 N), and 4) 4) Wardensville Gr (Route 608 S). The linear growth rate at the intersection approaches was calculated based on historical trends obtained from VDOT traffic count books via the VDOT Pathways for Planning website (Route Analysis RNS-LRS Network). The linear growth rates based on historical trend analysis for the study intersections are shown in **Table 9**.

Table 9. Linear growth rates based on historical trend analysis

Intersection	Eastbound US Route 50	Westbound US Route 50	Northbound	Southbound
US Route 50 at Hayfield Rd (Route 600)	0.50%	0.50%	2.06%	3.72%
US Route 50 at Back Mountain Rd (Route 614)	0.50%	0.50%	1.90%	-
US Route 50 at Dick's Hollow Rd (Route 608 N)	0.50%	0.50%	-	0.50%
US Route 50 at Wardensville Gr (Route 608 S)	0.60%	0.60%	0.97%	-

The linear growth rates were applied to the 2023 volumes to project the future 2034 volume forecast. The future forecast volumes at the three study intersections are shown in **Figure 22**.

Figure 22. 2034 Future forecast Volumes at the select study intersections

VJuST Analysis

As part of future alternative intersection screening, VDOT Junction Screening Tool (VJuST) analysis was completed for the intersections of US Route 50 at 1) Hayfield Rd (Route 600), 2) Back Mountain Rd (Route 614), and 3) Wardensville Gr (Route 608 S). The VJuST aids transportation engineers and planners in determining which innovative intersection might be appropriate at a specific location[3]. It is to be noted that VJuST analysis does not consider the influence of adjacent intersections on traffic patterns. Therefore, it was conducted for screening purposes only with detailed analyses performed using the Highway Capacity Manual Two Way Stop Control (TWSC) analysis methodology through Synchro 11, a macroscopic traffic analysis software. The Synchro analysis was completed for both AM and PM peak hours for the future conditions in 2034.

The v/c ratio also known as the degree of saturation, is a measure of how well an intersection can handle vehicular demand. A v/c ratio less than 0.85 generally indicates that adequate capacity is available and vehicles are not expected to experience significant queues and delays. As the v/c ratio approaches 1.0, traffic flow may become unstable, and delay and queuing conditions may occur. Once the demand exceeds the capacity, a v/c ratio greater than 1.0, traffic flow is unstable, and excessive delay and queuing are expected. **Table 10** provides a description of capacity based on the v/c ratio.

Table 10. Capacity Description based on v/c Ratio

V/C Ratio	Description of Capacity
<0.85	Under capacity
0.85-0.95	Near capacity
0.95-1.0	At capacity
>1.0	Over capacity

Source: Highway Capacity Manual 2010

Future alternatives that were considered based on their feasibility at the study intersection and by review of VJuST design considerations at the three study intersections are provided below. **Table 11** provides a comparison of the weighted total conflict points and v/c ratio for the alternatives considered with the lowest value highlighted in bold. The 2034 VJuST analysis results show that an RCI option overall provides the best operational and safety benefit at the three intersections. See **Appendix B** for 2034 AM and PM VJuST spreadsheets

1) No Build Alternative, where the existing lane configuration is maintained,
2) Signalized Intersection, where the existing lane configuration is maintained and a new traffic signal is proposed
3) Reduced Conflict Intersection (RCI), an innovative intersection design where all the side street left-turn and through vehicles turn right and make a U-turn at a dedicated downstream median opening,
4) Median U-turn (MUT), an innovative intersection design where all the side street left-turns make U-turns at dedicated median openings,
5) Thru-Cut, an innovative intersection where side streets through movements are prohibited.

Table 11. 2034 VJuST Analysis Results Summary at the select intersections

Alternative	Weighted Total Conflict Points	US Route 50 at Hayfield Rd Maximum v/c		US Route 50 at Back Mountain Rd Maximum v/c		Wardensville Gr Maximum v/c	
		AM	PM	AM	PM	AM	PM
No-Build	48	0.33	0.56	0.83	**0.34**	0.37	**0.38**
Signalized	48	0.35	0.39	0.70	0.53	0.60	0.52
RCI*	**20**	**0.22**	**0.28**	**0.24**	0.37	**0.37**	0.42
MUT**	20	0.37	0.37	0.64	0.57	0.56	0.57
Thru-Cut	28	0.37	0.36	0.64	0.40	0.56	0.47

**All intersections coded as unsignalized*
*** Only U-Turn locations coded as unsignalized*

[3] https://www.vdot.virginia.gov/about/our-system/highways/innovative-intersections/virginia-icap/

Alternative Analysis:

Alternative analysis performed for the five safety priority areas identified under the *Alternative Development and Screening* section of this report is provided in this section. The five safety priority areas identified along the US Route 50 study corridor are:

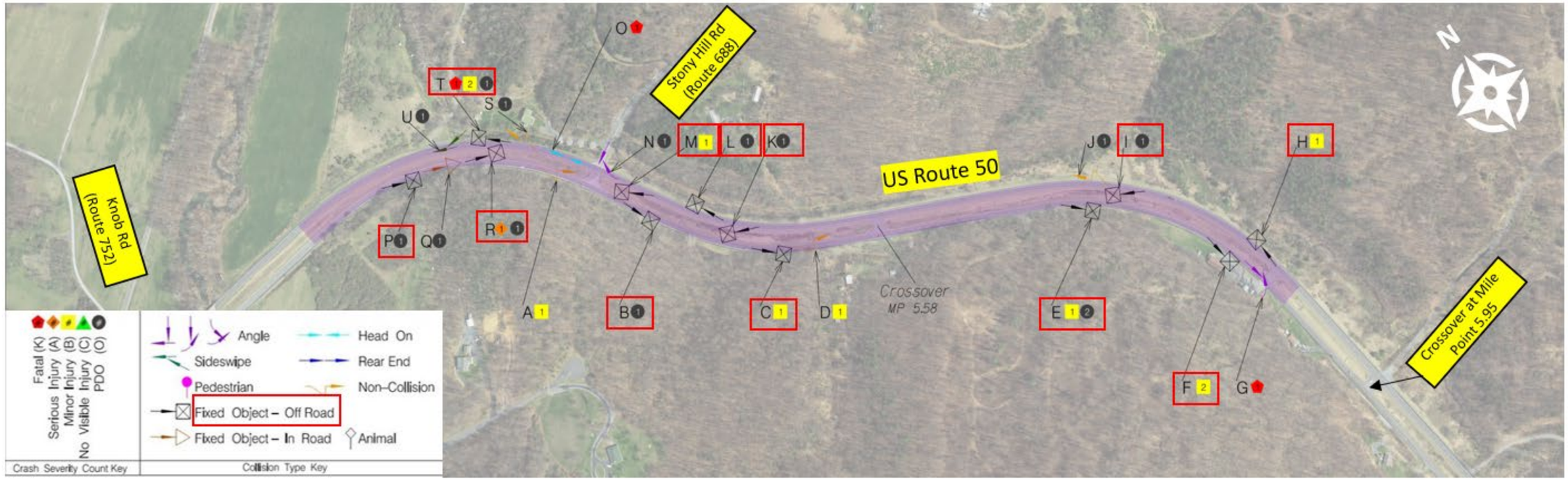
1) US Route 50 at Stony Hill Rd corridor
2) US Route 50 at Hayfield Rd (Route 600)
3) US Route 50 at Back Mountain Rd (Route 614)
4) US Route 50 at Dicks Hollow Rd (Route 608 N)
5) US Route 50 at Wardensville Gr (Route 608 S)

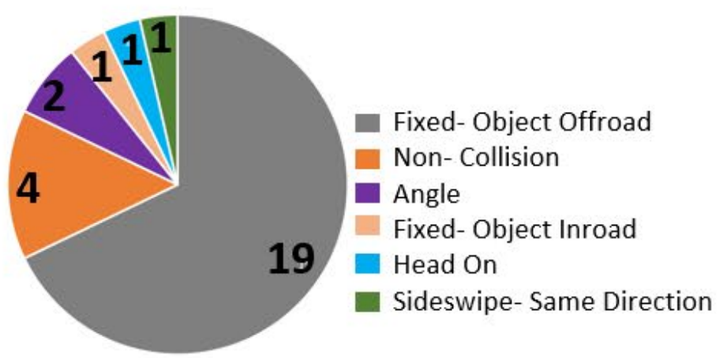
1) US Route 50 at Stony Hill Rd Corridor

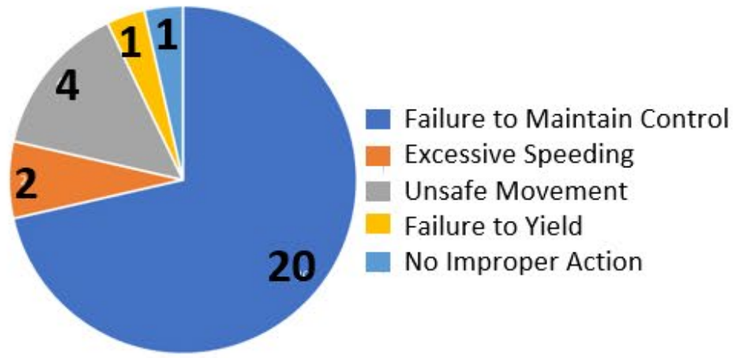
The one-mile US Route 50 corridor between Knob Rd (Route 752) & the crossover at M.P. 5.95 experienced a total of 28 crash incidents between the years 2015 to 2022. Of the 28 crash incidents, 19 were Fixed Object- Off Road crash incidents. One (1) of four (4) fatal crashes and 9 of 11 injury crashes were FOOR crashes. 72% of these crashes occurred due to failure to maintain control.

The fatal FOOR crash occurred when a tractor-trailer hauling logs failed to maintain control on a curve along the segment, colliding with a utility pole and rolling down a 30-foot embankment. The driver was ejected from the vehicle. Two (2) fatal angle crashes occurred along the segment due to drivers failing to yield to the right-of-way. One (1) of these incidents involved a vehicle attempting to turn left onto Gore Rd, and the other involved a vehicle attempting to turn left out of a business parking lot. The final fatal crash was a head-on incident that occurred when a wrong-way vehicle driving eastbound in the westbound lane collided with a westbound vehicle.

The collision diagram for the study corridor, highlighting FOOR crash incidents in red is shown in **Figure 23**. Detailed collision diagrams are provided in **Appendix A**.







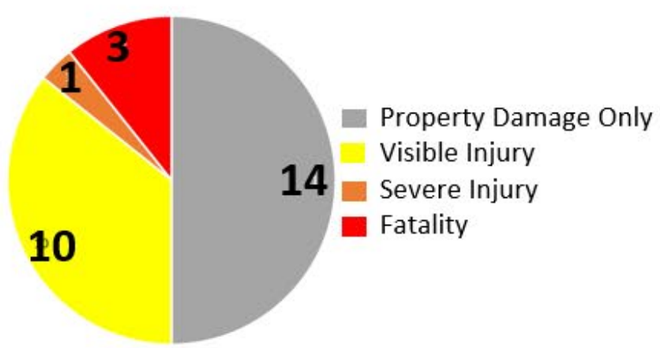


Figure 23. Collision Diagram - US Route 50 at Stony Hill Rd corridor

The proposed improvements, listed in **Table 12,** can address the high frequency of FOOR crash incidents in this study stretch. The Crash Modification Factor (CMF) associated with these countermeasures for different crash severities is also provided. A CMF is a multiplicative factor used to compute the expected number of crashes after implementing a countermeasure on a road. Combined CMFs are used to calculate the safety impact of multiple treatments. Combined CMF values are determined using the Dominant Common Residuals and Dominant Effect methods, as there is an overlap in crashes affected by treatment. Combinations are also dependent on applicable crash severity types, as seen in the table.

CMFs for shoulder widening and the installation of Dynamic Speed Feedback signs were combined to assess safety improvements for FOOR crashes that occurred on straight segments of Route 50. CMFs for High Friction Surface Treatment (HFST) and clear zone improvement on curves were combined to assess safety improvements for daytime crashes that occurred along curves. CMFs for HFST and installing chevron signs were combined to assess safety improvements for nighttime crashes that occurred along curves. Targeted crashes for each combined improvement are shown in the collision diagrams in **Appendix F**. The conceptual design for the improvements is shown in the preferred alternative summary in **Figure 32**.

Table 12. CMF table for proposed improvements along US Route 50 at Stony Hill Rd corridor

Location	Proposed Improvements	Applicable Crash Severity Type	Applicable Crash Type	CMF Value					Source
				All	K	A	BC	PDO	
US Route 50 at Stony Hill Rd Corridor	Individual CMFs								
	Shoulder widening from two to six ft	All	Head On, Fixed Obj., Opp. Dir., Single Veh.	0.77	0.77	0.77	0.77	0.77	VDOT SPL[4] HSM Table 10-9
	Improve clear zone along curves	All	All	0.78	0.78	0.78	0.78	0.78	VDOT SPL 35
	High Friction Surface Treatment (HFST)	All	All	0.76	0.76	0.76	0.76	0.76	VDOT SPL 7900
	Install chevron signs	All	Night Time	0.75	0.75	0.75	0.75	0.75	VDOT SPL 2439
	Install Dynamic Speed Feedback sign	All	All	0.95	0.95	0.95	0.95	0.95	VDOT SPL 6885
	Combined CMFs								
	Shoulder widening + Speed Sign	All	Head On, Fixed Obj., Opp. Dir., Single Veh.	**0.77**	**0.77**	**0.77**	**0.77**	**0.77**	Dominant Effect Method
	HFST + Improve Clear Zone	All	All	**0.67**	**0.67**	**0.67**	**0.67**	**0.67**	Dominant Common Residuals Method
	HFST + Install Chevrons	All	Night Time	**0.66**	**0.66**	**0.66**	**0.66**	**0.66**	Dominant Common Residuals Method

[4] https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/traffic-operations/vhsip/VA-State-Preferred-CMF-List_acc050222.pdf

The CMFs were applied to the total number of FOOR crashes during the 8-year study period to determine the expected crash reductions within the study corridor. The predicted change in the frequency of average crash incidents per year is provided in **Table 13**. The crash cost savings per year are calculated based on Virginia KABCO comprehensive crash unit costs (2020)[5]. The total crash cost savings per year after applying all safety improvements is $1,272,247. Mutually exclusive crash cost savings per year for each improvement are provided in the crash cost savings table in the preferred alternative summary in **Figure 32**.

Table 13. US Route 50 at Stony Hill Rd – Comprehensive Crash Costs

Location	Scenario	Average # of crash incidents per year, by severity		Crash cost per year	Crash cost savings per year
		All	K, A, B, C (Injury Only)	K, A, B, C (Injury Only)	
US Route 50 at Stony Hill Rd Corridor	Existing Conditions	0.9	0.1	$ 18,218	-
	Shoulder widening from 2 feet to 6 feet + Install Dynamic Speed Feedback sign	0.7	0.1	$ 14,028	$ 4,190
	Existing Conditions	2.1	0.9	$ 1,942,749	-
	HFST + Improve clear zone along curves	1.4	0.6	$ 1,301,624	$ 641,107
	Existing Conditions	1.1	0.8	$ 1,843,969	-
	HFST + Install Chevron signs	0.7	0.5	$ 1,217,019	$ 626,949
	Total Segment	**-**			**$ 1,272,247**

[5] https://www.vdot.virginia.gov/media/vdotvirginiagov/doing-business/technical-guidance-and-support/traffic-operations/vhsip/VDOT-Crash-Costs-Memo_acc050222.pdf

2) US Route 50 at Hayfield Rd

US Route 50 at Hayfield Rd experienced a total of 24 crash incidents between the years 2015 to 2022. Of the 24 crash incidents, 13 were angle crashes. 70% of these angle crash incidents occurred due to the driver Failing To Yield (FTY); the remainder are due to the driver Failing To Stop (FTS). Additionally, there was one fatal FOOR crash that involved a vehicle traveling south on Hayfield Rd. The intersection collision diagram, highlighting angle crash incidents in red, is shown in **Figure 24**. Detailed collision diagrams are provided in **Appendix A.**

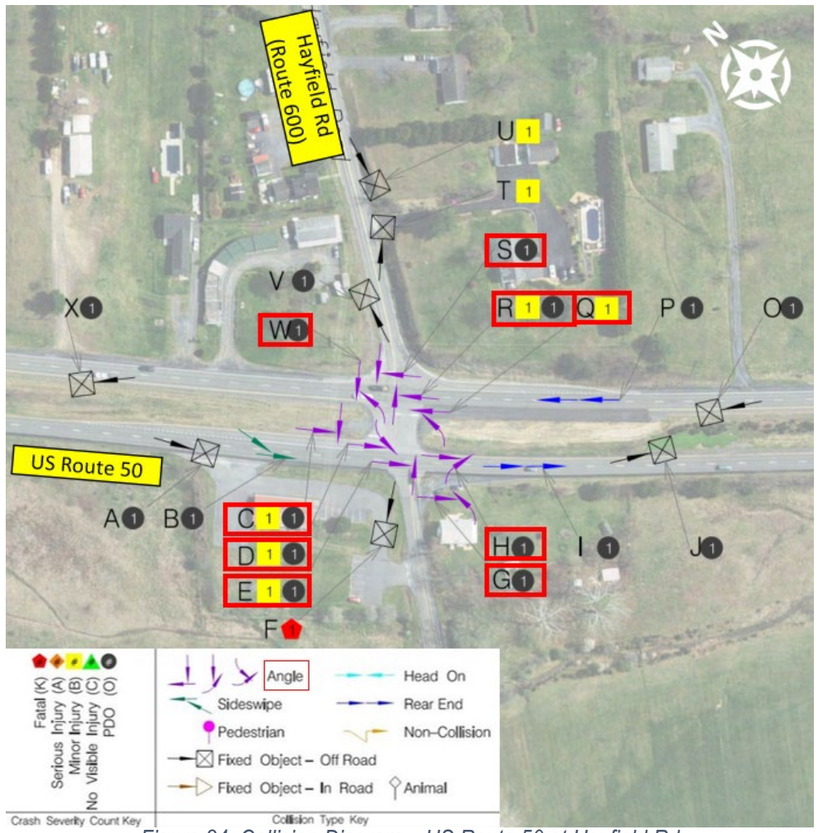


Figure 24. Collision Diagram – US Route 50 at Hayfield Rd

All 13 of the angle crashes were related to drivers from Hayfield Rd's northbound or southbound approach turning left or traveling through. Based on the alternative intersection screening performed at the study intersection using future forecast volumes, it was determined that a Reduced Conflict Intersection (RCI) provided the most desirable v/c ratio and weighted total conflict points (see **Table 11**).

An innovative intersection such as an RCI will modify the vehicle movements to reduce delay, increase efficiency, and increase safety, and in doing so, the design requires vehicles to travel a longer distance or include multiple intersections in the overall design. To compare the traffic operations analysis of this innovative intersection to the no-build scenario, the following Measures of Effectiveness (MOEs) were utilized as per TOSAM guidance –

1) v/c Ratio

2) Experienced Travel Time (ETT)- The HCM defines experienced travel time for a given origin-destination movement as "the sum of extra distance travel time (the free-flow travel time required to traverse an alternative intersection minus the hypothetical shortest-path free-flow travel time making right-angle turns) and the control delay experienced at each junction encountered with an alternative intersection is traversed."

3) 95th Percentile Queue Length - The queue length that has only a 5% probability of being exceeded during a given analysis period (expressed in feet).

The v/c ratio results for the RCI alternative, shown in **Table 11,** suggest that the intersection will benefit operationally from conversion to an RCI. The future year comparison of the MOEs – ETT and 95th Percentile Queue length for the two scenarios of No Build and RCI is provided in the following **Table 14**. The results show that the ETT for vehicles turning from Hayfield Road approaches in the future RCI scenario will be similar to the no-build conditions suggesting that there will not be added delay due to the need to travel longer distances for the minor street approach through and left turn-bound vehicles. The 95th Percentile Queue length is expected to decrease by roughly 50% on both minor street approaches in both AM and PM peak hours. Changes to the US Route 50 mainline are negligible as the lane configuration will not be significantly affected by the RCI design and turning volumes are small in comparison to through traffic. See **Appendix C** for Synchro Outputs and **Appendix D** for ETT calculations.

Table 14. US Route 50 at Hayfield Rd - Future Alternatives MOE comparison

Approach	Overall Approach	No- Build (2034)				RCI (2034)			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		ETT (s)	95th Queue (ft)	ETT	95th Queue (ft)	ETT	95th Queue (ft)	ETT	95th Queue (ft)
Hayfield Rd	NB	37	61	37	32	39	30	39	14
	SB	39	71	45	103	38	34	40	46

Note: The analysis results are based on the HCM 2000 edition. Values were rounded to the nearest integer.

A concept sketch of the proposed RCI is provided in **Figure 25**. The proposed RCI is an innovative intersection design where all turning movements from Hayfield Rd start with a right turn. Hayfield Rd left-turn and through vehicles will turn right and make a U-turn at a median opening downstream to complete the desired movement. The new median U-turns at US Route 50 will be designed as yield-controlled.

Figure 25. Proposed RCI concept sketch at US Route 50 & Hayfield Rd

Converting the study intersection to an RCI is projected to yield safety benefits. This geometric configuration will reduce the number of conflict points at the intersection from 32 to 18.[6] The CMF associated with this alternative intersection is summarized in the following **Table 15.**

Table 15. CMF for proposed RCI at US Route 50 and Hayfield Rd

Location	Proposed Improvement	Applicable Crash Type	CMF				Source
			K	A	BC	O	
US Route 50 at Hayfield Rd	Install an RCI	All	0.37	0.37	0.37	0.54	VDOT SPL 4883, 4884

The predicted change in the frequency of average crash incidents per year is provided in **Table 16**. The crash cost savings per year are calculated based on Virginia KABCO comprehensive crash unit costs (2020). The yearly crash cost savings anticipated if the study intersection is converted to an RCI is $1,161,700. A detailed summary of the RCI improvement proposed at Hayfield Rd is provided in **Figure 33**.

Table 16. US Route 50 at Hayfield Road – Comprehensive Crash Costs

Location	Scenario	Average # of crash incidents per year, by severity		Crash cost per year	Crash cost savings per year
		All	K, A, B, C (Injury Only)	K, A, B, C (Injury Only)	
US Route 50 at Hayfield Rd	Existing Conditions	2.1	0.8	$ 1,843,969	-
	RCI	1.0	0.3	$ 682,268	$ 1,161,700

[6] https://www.vdot.virginia.gov/about/our-system/highways/innovative-intersections/restricted-crossing-u-turn/

3) US Route 50 at Back Mountain Rd

US Route 50 at Back Mountain Rd experienced a total of 30 crash incidents between the years 2015 to 2022. Of the 30 crash incidents, 17 were rear-end crashes at the Back Mountain Rd northbound approach. These crashes are likely a result of the very high northbound right-turning volumes (See **Figure 13**), as 99% of the northbound traffic turns right and 1% turns left at Route 50. Additionally, there was one fatal angle crash that involved a left-turning vehicle from Back Mountain Rd approach and through vehicle along US Route 50. The collision diagram is shown in **Figure 26**, and the full collision diagrams are shown in **Appendix A.**

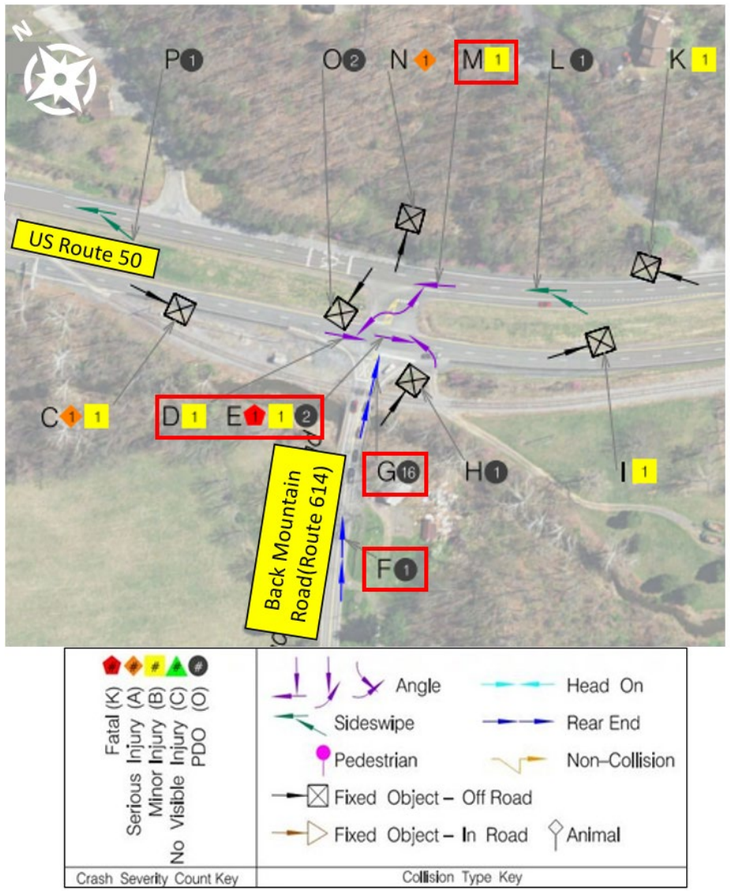


Figure 26. Collision Diagram – US Route 50 at Back Mountain Rd

The VJuST analysis of the study intersection using future volume forecast showed that converting the study intersection to an RCI would generate operational and safety benefits from the desirable minimum v/c ratio and fewer weighted total conflict points (See **Table 11).** A detailed analysis of RCI was conducted to evaluate the following MOEs as per TOSAM guidance –

- Experienced Travel Time (ETT)
- 95th Percentile Queue Length

Installation of the RCI is projected to increase capacity and improve ETT for the Back Mountain Rd approach, as shown in **Table 17**. A comparison of future 95th Percentile Queue length shows a significant reduction in queue length on the Back Mountain Rd approach in the proposed RCI alternative. Changes to the mainline of US 50 are negligible as the lane configuration will not be significantly affected by the RCI design and turning volumes are small in comparison to through traffic. See **Appendix C** for Synchro Outputs and **Appendix D** for ETT calculations.

Table 17. US Route 50 at Back Mountain Road – Future Alternatives MOE comparison

Approach	Overall Approach	No- Build (2034)				RCI (2034)			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		ETT (s)	95th Queue (ft)	ETT	95th Queue (ft)	ETT	95th Queue (ft)	ETT	95th Queue (ft)
Back Mountain Rd	NB	68	317	46	23	39	34	35	6

Note: The analysis results are based on the HCM 2000 edition. Values were rounded to the nearest integer.

A concept sketch of the proposed RCI is provided in **Figure 27**. The proposed RCI is an innovative intersection design where all turning movements from Back Mountain Rd start with a right turn. Back Mountain Rd left-turn vehicles will turn right and make a U-turn at a median opening downstream to complete the desired movement. The new median U-turns at US Route 50 will be designed as yield-controlled. In the proposed design, a dedicated right-turn lane and an acceleration lane will be provided to accommodate the heavy right-turn volume demand.

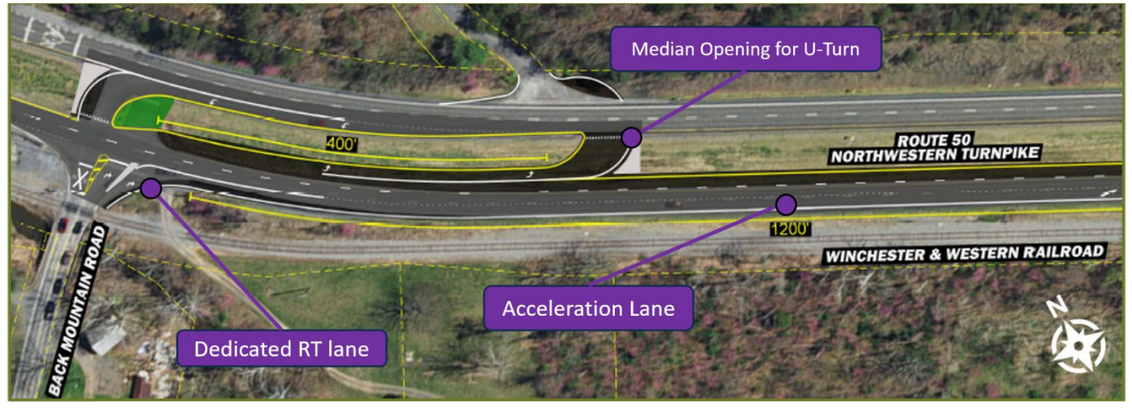


Figure 27. RCI for Route 50 at Back Mountain Rd

Converting the study intersection to an RCI is projected to yield safety benefits. This geometric configuration will reduce the number of conflict points at the intersection. The CMF associated with this alternative intersection is summarized in the following **Table 18**.

Table 18. CMF for proposed RCI at US Route 50 and Back Mountain Rd

Location	Proposed Improvement	Applicable Crash Type	CMF				Source
			K	A	BC	O	
US Route 50 at Back Mountain Rd	Install an RCI	All	0.37	0.37	0.37	0.54	VDOT SPL 4883, 4884

The predicted change in the frequency of average crash incidents per year is provided in **Table 19**. The crash cost savings per year are calculated based on Virginia KABCO comprehensive crash unit costs (2020). The yearly crash cost savings anticipated if the study intersection is converted to an RCI is $1,265,781. A detailed summary of the RCI improvement proposed at Back Mountain Road is provided in **Figure 34**.

Table 19. US Route 50 at Back Mountain Road – Comprehensive Crash Costs

Location	Scenario	Average # of crash incidents per year, by severity		Crash cost per year	Crash cost savings per year
		All	K, A, B, C (Injury Only)	K, A, B, C (Injury Only)	
US Route 50 at Back Mountain Rd	Existing Conditions	3.8	0.9	$ 2,009,177	-
	RCI	1.9	0.3	$ 743,395	$ 1,265,781

4) US Route 50 at Dicks Hollow Rd

US Route 50 at Dicks Hollow Road experienced a high number of rear-end crashes in the vicinity of the intersection, reporting eight crash incidents out of a total of 18 incidents during the study period from 2015 to 2022. These crashes are likely a result of the turning movements onto Dicks Hollow Rd from US Route 50, as there are no turn lanes present. An additional sideswipe (same direction) crash is likely the result of a vehicle attempting to merge late to make the turn onto Dicks Hollow Road. The collision diagram highlighting these incidents in red is shown in **Figure 28,** and the detailed collision diagrams are shown in **Appendix A.**

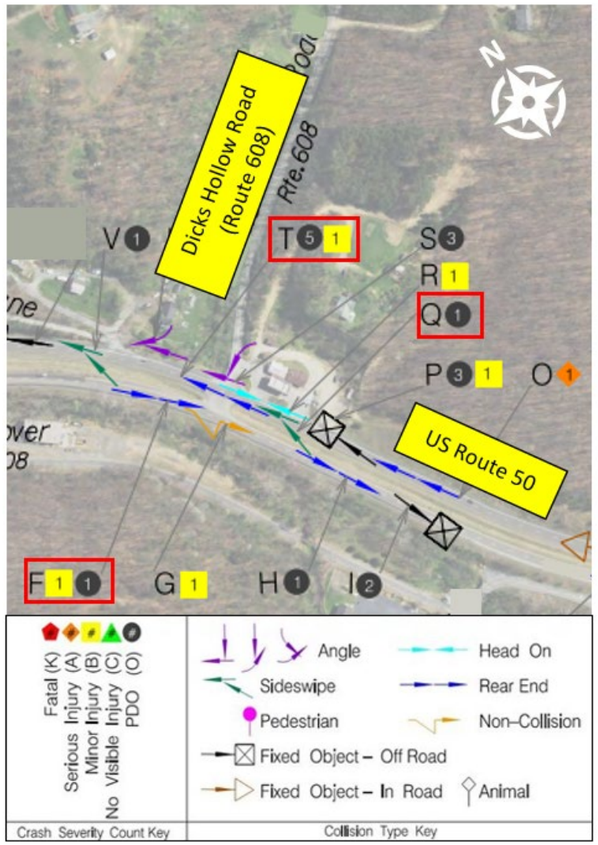


Figure 28. Collision Diagram - US Route 50 at Dicks Hollow Rd

Providing US Route 50 eastbound left turn lane and westbound right turn lane would allow vehicles heading to Dicks Hollow Rd to diverge safely without impeding the mainline traffic flow. Through this countermeasure, rear-end crash incidents at this intersection can be addressed. **Figure 29** shows the proposed concept sketch with turn lanes at the study intersection.

Figure 29. Proposed turn lanes at US Route 50 and Dicks Hollow Rd intersection

The CMF associated with the proposed countermeasure of installing turn lanes at the study intersection is summarized in **Table 20**. A cumulative CMF was generated by multiplying the individual CMFs and this was utilized in crash cost savings calculation.

Table 20. CMF for the proposed turn lanes at US Route 50 and Dicks Hollow Rd

Location	Proposed Improvement	Applicable Crash Type	CMF				Source
			K	A	BC	O	
US Route 50 at Dicks Hollow Rd	Install eastbound left-turn lane	All	0.73	0.73	0.73	0.73	CMF ID: 7852
	Install westbound right-turn lane	All	0.91	0.91	0.91	0.91	CMF ID: 5834
	Cumulative CMF	All	0.66	0.66	0.66	0.66	-

The predicted change in the frequency of average crash incidents per year is provided in **Table 21.** The crash cost savings per year are calculated based on Virginia KABCO comprehensive crash unit costs (2020). The yearly crash cost savings anticipated if turn lanes are installed at the study intersection is

$98,325. A detailed summary of the turn lane improvement proposed at Dicks Hollow Road is provided in **Figure 34**.

Table 21. US Route 50 at Dicks Hollow Road – Comprehensive Crash Costs

Location	Scenario	Average # of crash incidents per year, by severity		Crash cost per year	Crash cost savings per year
		All	K, A, B, C (Injury Only)	K, A, B, C (Injury Only)	
US Route 50 at Dicks Hollow Rd	Existing Conditions	2.6	0.9	$ 292,895	-
	Turn Lane Addition	1.7	0.6	$ 194,570	$ 98,325

5) US Route 50 at Wardensville Gr

US Route 50 at Wardensville Gr experienced a total of eight crashes during the study period from 2015 to 2022. Of the eight incidents, three were angle crashes, with one angle crash resulting in a fatality. Rear-end crashes resulting in injury occurred both on Wardensville Grade and on US 50 eastbound before the intersection. The northbound Wardensville Gr has very high right turning volumes with 90% of the northbound traffic turning right onto Route 50 and 10% of the northbound traffic turning left. See **Figure 14** The collision diagram for the study intersection is shown in **Figure 30**, and the full collision diagrams are shown in **Appendix A.**

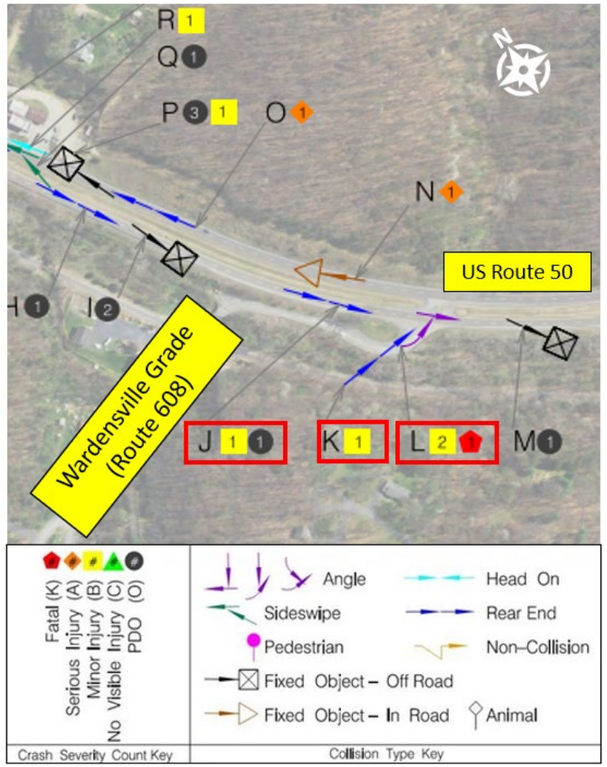


Figure 30. Collision Diagram – US Route 50 at Wardensville Gr

Both rear-end crashes on US 50 were related to drivers following too closely (FTC) while the rear-end on Wardensville Gr and the angle crashes entering the intersection were due to failure to stop (FTS) or failure to yield (FTY). Based on the alternative intersection screening performed at the study intersection using future forecast volumes, it was determined that a Reduced Conflict Intersection (RCI) provided the most desirable v/c ratio and weighted total conflict points (See **Table 11**). A detailed analysis of RCI was conducted to evaluate the following MOEs as per TOSAM guidance –

- Experienced Travel Time (ETT)
- 95th Percentile Queue Length

Installation of the RCI will make this intersection safer with fewer conflict points and shorter queue length. However, the northbound Wardensville Gr approach will experience an increase in ETT, when compared to the No-build scenario. See **Table 22**. Changes to the US Route 50 mainlines are negligible as the lane configuration will not be significantly affected by the RCI design and westbound left turning volumes

from US Route 50 are small in comparison to through traffic. See **Appendix C** for Synchro Outputs and **Appendix D** for ETT calculations.

Table 22. US Route 50 at Wardensville Grade - 2034 Future Conditions Traffic Analysis Results

Approach	Overall Approach	No- Build (2034)				RCI (2034)			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		ETT (s)	95th Queue (ft)	ETT	95th Queue (ft)	ETT	95th Queue (ft)	ETT	95th Queue (ft)
Wardensville Grade	NB	37	60	35	16	48	50	43	14

Note: The analysis results are based on the HCM 2000 edition. Values were rounded to the nearest integer.

As shown in the concept sketch **Figure 31**, the RCI would reduce the conflict points for drivers entering the intersection by forcing traffic on Wardensville Grade northbound to turn right onto Route 50. Existing left turns would instead make a U-turn at a median opening downstream.

Figure 31. RCI for Route 50 at Wardensville Gr

The conversion to an RCI is projected to yield safety benefits by reducing the number of conflict points at the intersection. The CMF associated with this alternative intersection is summarized in the following **Table 20**.

Table 23. CMF for proposed RCI at US Route 50 and Wardensville Gr

Location	Proposed Improvement	Applicable Crash Type	CMF				Source
			K	A	BC	O	
US Route 50 at Wardensville Gr	Install an RCI	All	0.37	0.37	0.37	0.54	VDOT SPL 4883, 4884

The predicted change in the frequency of average crash incidents per year is provided in **Table 24**. The crash cost savings per year are calculated based on Virginia KABCO comprehensive crash unit costs (2020). The yearly crash cost savings anticipated if the study intersection is converted to an RCI is $1,141,318. A detailed summary of the RCI improvement proposed at Wardensville Grade is provided in **Figure 36**.

Table 24. US Route 50 at Wardensville Grade – Comprehensive Crash Costs

Location	Scenario	Average # of crash incidents per year, by severity		Crash cost per year	Crash cost savings per year
		All	K, A, B, C (Injury Only)	K, A, B, C (Injury Only)	
US Route 50 at Wardensville Grade	Existing Conditions	0.9	0.6	$ 1,811,616	-
	RCI	0.4	0.2	$ 670,298	$ 1,141,318

Safety Analysis Summary

A Crash Modification Factor (CMF) is used to determine the expected number of crashes after implementing a countermeasure on a Road or intersection. CMFs for the proposed improvements were applied to the relevant crash history to evaluate the expected crash reduction at the five safety priority areas. **Table 25** presents the CMF value used for each crash severity type to calculate the individual crash reduction expected from the improvement alternatives. The crash cost savings per year anticipated from implementing the proposed improvements individually are provided in **Table 26.**

Table 25. CMFs for proposed improvements along US Route 50 study corridor

Location	Proposed Improvement	Applicable Crash Type	CMF				Source
			K	A	BC	O	
US Route 50 at Stony Hill Rd Corridor	Shoulder widening from two to six ft	Head On, Fixed Obj., Opp. Dir., Single Veh.	0.77	0.77	0.77	0.77	VDOT SPL HSM Table 10-9
	Improve clear zone along curves	All	0.78	0.78	0.78	0.78	VDOT SPL 35
	High Friction Surface Treatment (HFST)	All	0.76	0.76	0.76	0.76	VDOT SPL 7900
	Install chevron signs	Night Time	0.75	0.75	0.75	0.75	VDOT SPL 2439
	Install dynamic Speed Feedback sign	All	0.95	0.95	0.95	0.95	VDOT SPL 6885
US Route 50 at Hayfield Rd	Install an RCI	All	0.37	0.37	0.37	0.54	VDOT SPL 4883, 4884
US Route 50 at Back Mountain Rd	Install an RCI	All	0.37	0.37	0.37	0.54	VDOT SPL 4883, 4884
US Route 50 at Dicks Hollow Rd	Install eastbound left-turn lane	All	0.73	0.73	0.73	0.73	CMF ID: 7852
	Install westbound right-turn lane	All	0.91	0.91	0.91	0.91	CMF ID: 5834
US Route 50 at Wardensville Gr	Install an RCI	All	0.37	0.37	0.37	0.54	VDOT SPL 4883, 4884

Table 26: Summary of Crash Cost Savings per year for the proposed improvements

Intersection	Alternative Description	CMF (All)	Crash Cost Savings (per year)
Route 50 at Stony Hill Rd Corridor	Shoulder widening from two to six ft	0.77	$870,000
	Improve clear zone along curves	0.78	$1.2 Million
	High Friction Surface Treatment (HFST)	0.76	$1.3 Million
	Install chevron signs	0.75	$461,000
	Install dynamic Speed Feedback sign	0.95	$273,000
Route 50 at Hayfield Rd	Reduced Conflict Intersection (RCI)	0.54	$1.16 Million
Route 50 at Back Mountain Rd	Reduced Conflict Intersection (RCI)	0.54	$1.26 Million
	Acceleration lane along eastbound Route 50		
Route 50 at Dicks Hollow Rd	Eastbound left-turn and Westbound right-turn lane	0.73	$98,000
Route 50 at Wardensville Gr	Reduced Conflict Intersection (RCI)	0.54	$1.1 Million

Traffic Operations Analysis Summary

The following **Table 27** summarizes the Traffic Operations Analysis MOEs for the study intersections of US Route 50 at 1) Hayfield Rd, 2) Back Mountain Rd, and 3) Wardensville Gr.

Table 27. 2034 Future Conditions Traffic Analysis Results

Intersection	Overall Approach	No-Build (2034)				RCI (2034)			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		ETT (s)	95th Queue (ft)	ETT (s)	95th Queue (ft)	ETT (s)	95th Queue (ft)	ETT (s)	95th Queue (ft)
US Route 50 at Hayfield Rd	NB	37	61	37	32	39	30	39	14
	SB	39	71	45	103	38	34	40	46
US Route 50 at Back Mountain Rd	NB	68	317	46	23	39	34	35	6
US Route 50 at Wardensville Gr	NB	37	60	35	16	48	50	43	14

Note: The analysis results are based on the HCM 2000 edition. Values were rounded to the nearest integer.

Preferred Alternative Summary

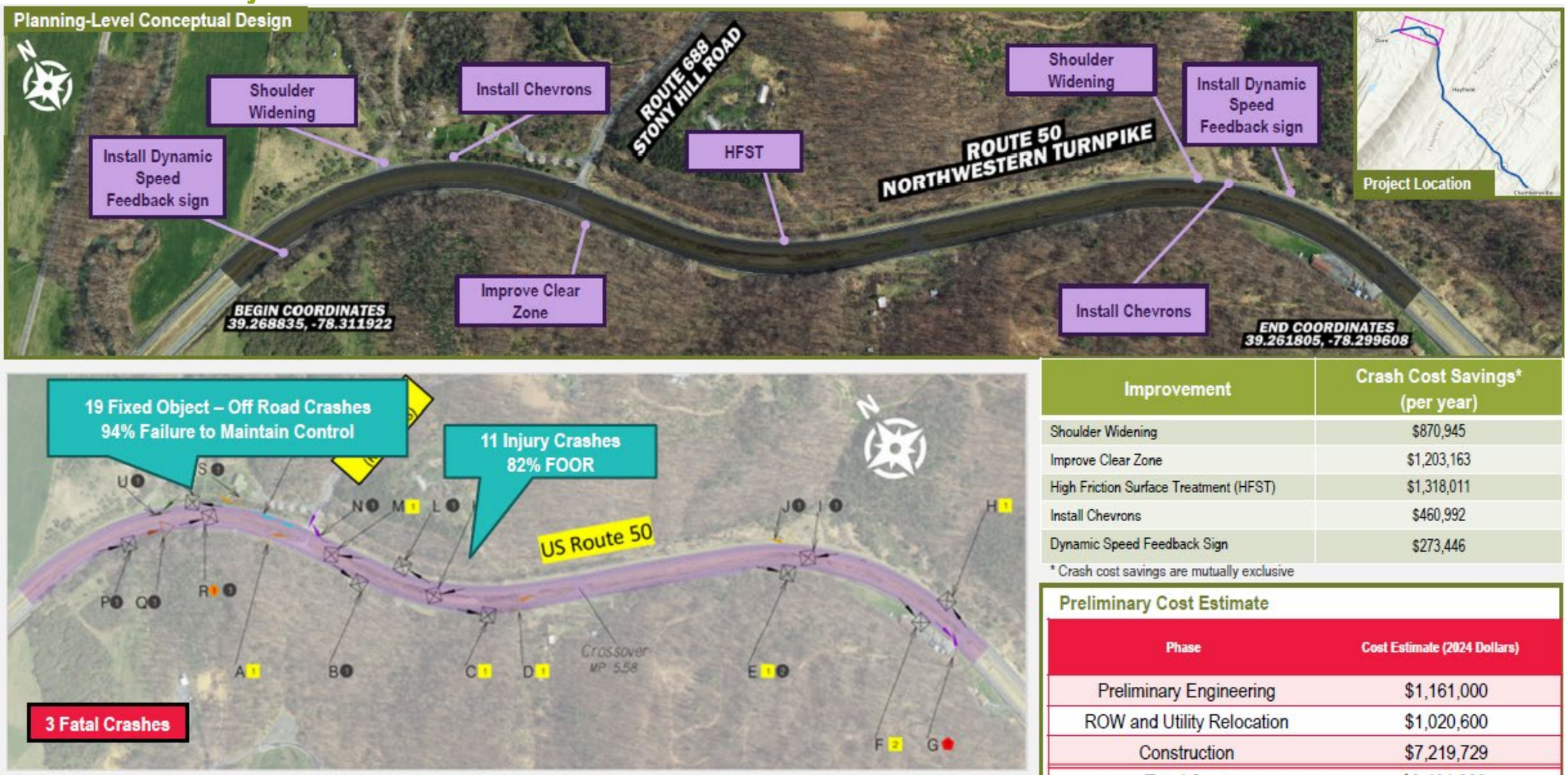
A summary detailing the proposed improvements at the five safety priority areas identified along the US Route 50 corridor is shown in **Table 28.** An overview of the Preferred Alternative and a summary of the expected operation and safety benefits for the study area are presented in **Figure 32, Figure 33, Figure 34, Figure 35,** and **Figure 36.**

Table 28. List of Preferred Alternative Improvements

Location	Description	Improvement Categories
US Route 50 at Stony Hill Rd Corridor	• Shoulder Widening from two to six ft • Improve clear zone along curves • High Friction Surface Treatment (HFST) • Install chevrons • Install dynamic speed feedback signs	Safety Improvement
US Route 50 at Hayfield Rd	• Installing a Reduced Conflict Intersection (RCI) where all side street movements begin with a right turn.	Safety Improvement Capacity Preservation
US Route 50 at Back Mountain Rd	• Installing a Reduced Conflict Intersection (RCI) where all side street movements begin with a right turn. • Installing an acceleration lane along eastbound Route 50 for northbound right turns from Back Mountain Rd.	Safety Improvement Capacity Preservation
US Route 50 at Dicks Hollow Rd	• Installing a left-turn lane along Eastbound Route 50 • Installing a right-turn lane along Westbound Route 50	Safety Improvement
US Route 50 at Wardensville Gr	• Installing a Reduced Conflict Intersection (RCI) where all side street movements begin with a right turn.	Safety Improvement

Crossover modifications recommended in Chapter 1 are also part of the preferred alternative. Considerations when implementing crossover changes vary on a case-by-case basis and will require target property owner outreach. As such, these modifications will be pursued piecemeal as maintenance-level projects.

Executive Summary



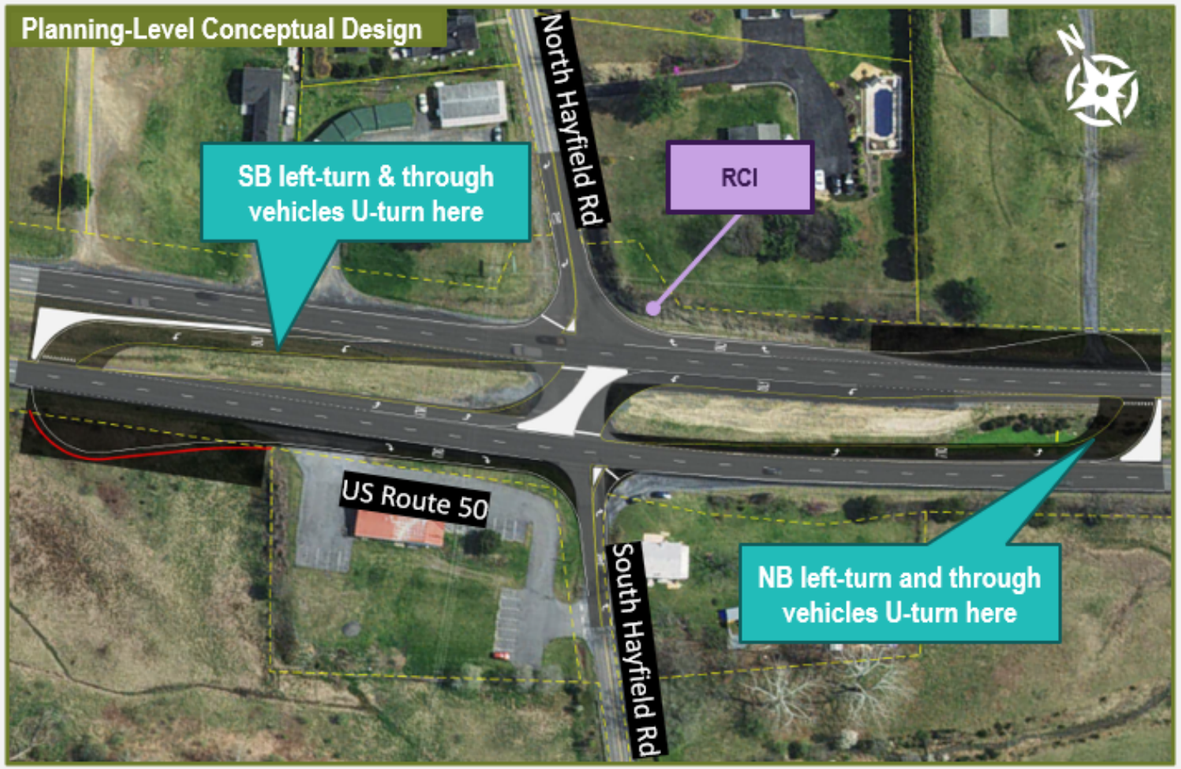
Improvement	Crash Cost Savings* (per year)
Shoulder Widening	$870,945
Improve Clear Zone	$1,203,163
High Friction Surface Treatment (HFST)	$1,318,011
Install Chevrons	$460,992
Dynamic Speed Feedback Sign	$273,446

* Crash cost savings are mutually exclusive

Preliminary Cost Estimate

Phase	Cost Estimate (2024 Dollars)
Preliminary Engineering	$1,161,000
ROW and Utility Relocation	$1,020,600
Construction	$7,219,729
Total Cost	**$9,401,330**

Figure 32. US Route 50 at Stony Hill Rd Preferred Alternative Summary



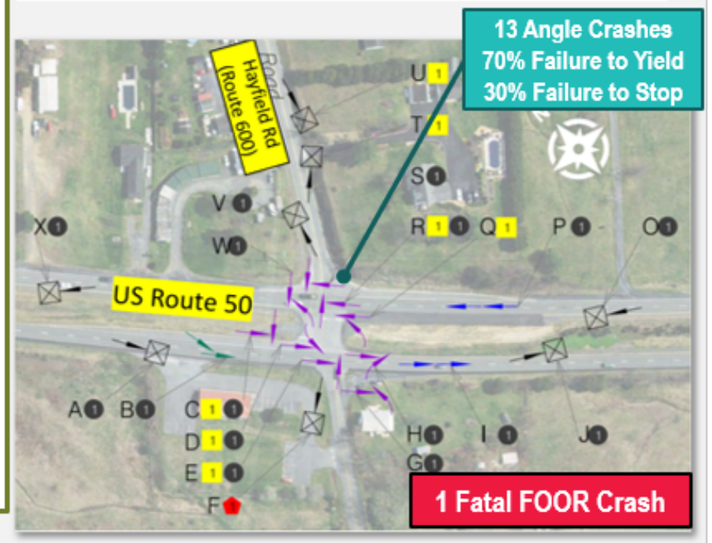
Improvement Description

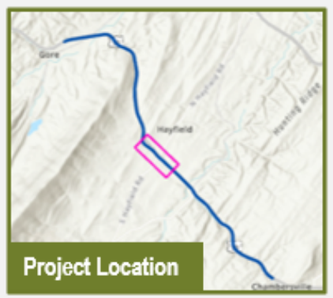
The improvement proposed at this location is the installation of a Reduced Conflict Intersection (RCI).

- Reduction in the number of conflict points from 32 to 18
- Increase in capacity by lowering the volume-to-capacity (v/c) ratio from 0.56 to 0.28 in the future year (2034) PM peak hour
- Projected to reduce the average number of future injury crash incidents by 63%

Crash Cost Savings (per year)

$1,161,700





Preliminary Cost Estimate

Phase	Cost Estimate (2024 Dollars)
Preliminary Engineering	$1,264,200
ROW and Utility Relocation	$2,124,150
Construction	$8,705,682
Total Cost	**$12,094,032**

Project schedules and cost estimates were developed based on information available at the time of study and should be reassessed before submitting funding applications.

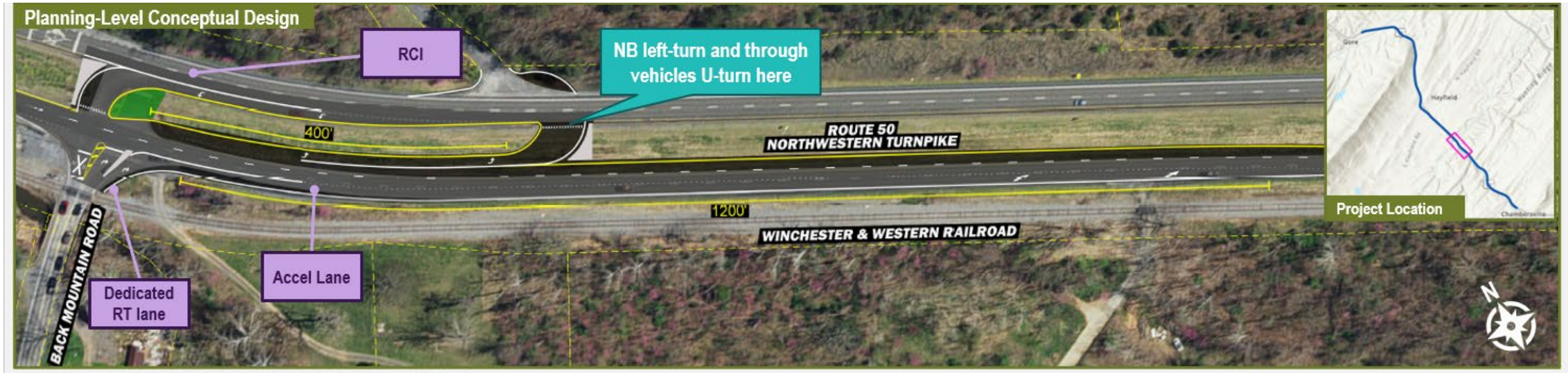
Traffic Operations Results

With the Hayfield Road left turns and thru movement being rerouted to a median opening downstream, the Experienced Travel Time (ETT) to traverse the extra distance in a future RCI was compared against the no-build scenario where existing geometric configuration is maintained. The comparison shows that the ETT is comparable between future no-build and RCI

Experienced Travel Time (in seconds)

Alternative	AM Peak		PM Peak	
	NB Hayfield Rd	SB Hayfield Rd	NB Hayfield Rd	SB Hayfield Rd
2034 No-Build	37	39	37	45
2034 RCI	39	38	39	40
Change in Travel Time	+ 2	- 1	+ 2	- 5

Figure 33. Route 50 at Hayfield Rd Preferred Alternative Summary



Improvements Description

The improvements proposed at this location include:

- Installing a Reduced Conflict Intersection (RCI)
- Installing an acceleration lane along eastbound US Route 50 for northbound right turns from Back Mountain Road.

Installation of the RCI is projected to increase capacity, decrease queue lengths, and improve the experienced travel time from the Back Mountain Rd NB approach.

Installation of the RCI is projected to decrease crashes by more than 50%.

Traffic Operations Results

With the Back Mountain Road left turn being rerouted to a median opening downstream, the Experienced Travel Time (ETT) to traverse the extra distance in a future RCI was compared against the no-build scenario where the existing geometric configuration is maintained. The comparison shows that the ETT is significantly improves from future no-build to the proposed RCI

Experienced Travel Time (in seconds) at Back Mountain Road Northbound approach

Alternative	AM Peak	PM Peak
2034 No-Build	68	46
2034 RCI	39	35
Change in Travel Time	- 29	- 11

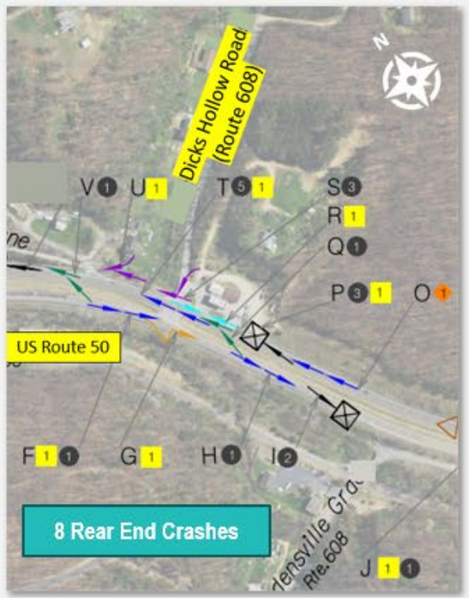
Improvement	Crash Cost Savings (per year)
RCI & Accel Lane	$1,265,781

Preliminary Cost Estimate

Project schedules and cost estimates were developed based on information available at the time of study and should be reassessed prior to submitting funding applications.

Phase	Cost Estimate (2024 Dollars)
Preliminary Engineering	$879,000
ROW and Utility Relocation	$1,023,000
Construction	$3,048,346
Total Cost	**$4,950,346**

Figure 34. Route 50 at Back Mountain Rd Preferred Alternative Summary



Improvements Description

The improvements proposed at this location include:

- Installing a turn lane for the eastbound left-turn movement.
- Installing a turn lane for the westbound right-turn movement.
- Adding stop bars and double yellow pavement markings within the median for clarity.

These improvements are expected to improve safety by creating separate lanes for the turning movements and increase efficiency by allowing US Route 50 to operate independently of the turning movements.

Installation of the turn lanes is projected to decrease crashes by more than 34%.

Improvement	Crash Cost Savings (per year)
Install Turn Lanes	$98,325

Traffic Operations Results

The proposed turn lanes at this intersection would allow vehicles heading to Dicks Hollow Rd to diverge safely without impeding the mainline traffic flow

Safety Results

Projected to reduce the average number of future injury crash incidents by 34%

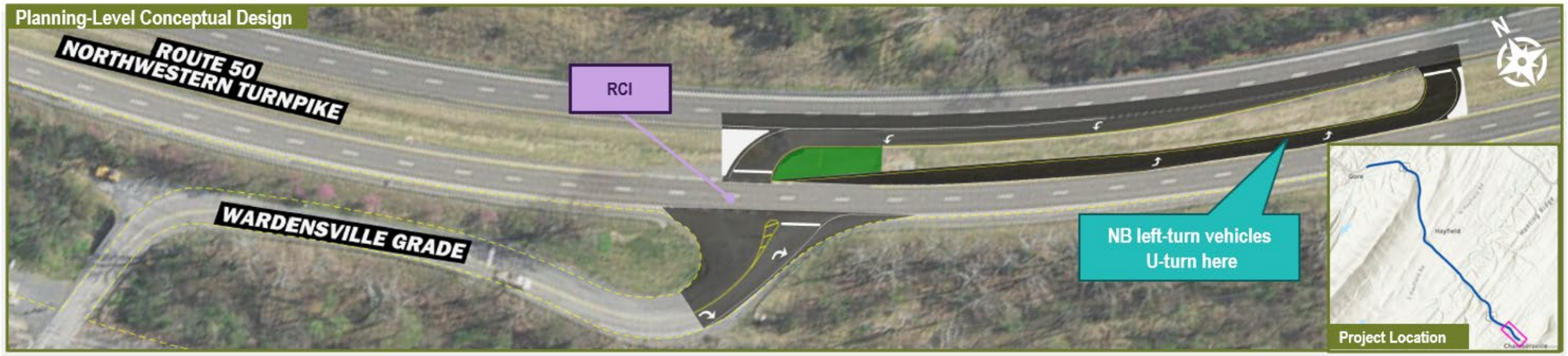
Improvement	Crash Reduction Factor
EBL Turn Lane	27%
WBR Turn Lane	9%
Cumulative	34%

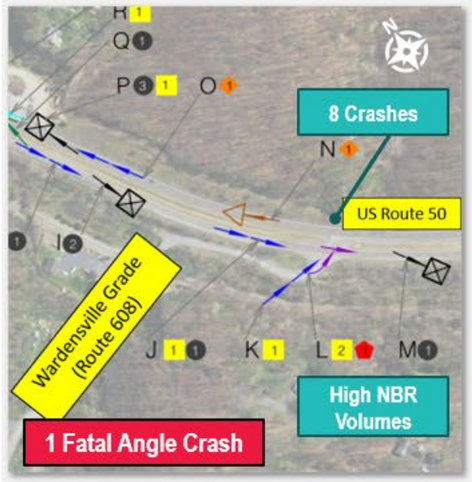
Preliminary Cost Estimate

Phase	Cost Estimate (2024 Dollars)
Preliminary Engineering	$796,500
ROW and Utility Relocation	$359,700
Construction	$2,076,520
Total Cost	**$3,232,720**

Project schedules and cost estimates were developed based on information available at the time of study and should be reassessed before submitting funding applications.

Figure 35. Route 50 at Dicks Hollow Rd Preferred Alternative Summary





Improvements Description

The improvement proposed at this location is the installation of a Reduced Conflict Intersection (RCI). The RCI benefits are provided below:

- Maintain capacity by keeping the volume-to-capacity (v/c) ratio below 0.5 in the future year peak hours
- Projected to reduce the average number of future injury crash incidents by 63%

Improvement	Crash Cost Savings (per year)
RCI	$1,141,318

Traffic Operations Results

With the Wardensville Gr left turns rerouted to a median opening downstream, the Experienced Travel Time (ETT) to traverse the extra distance in a future RCI was compared against the no-build scenario where existing geometric configuration is maintained. The comparison shows that the ETT increases by 11 sec in the AM peak and 8 sec in PM peak.

Experienced Travel Time (in seconds) at Wardensville Gr Northbound approach		
Alternative	**AM Peak**	**PM Peak**
2034 No-Build	37	35
2034 RCI	48	43
Change in Travel Time	+ 11	+ 8

Preliminary Cost Estimate

Phase	Cost Estimate (2024 Dollars)
Preliminary Engineering	$967,500
ROW and Utility Relocation	$397,800
Construction	$2,106,639
Total Cost	**$3,471,939**

Project schedules and cost estimates were developed based on information available at the time of study and should be reassessed before submitting funding applications

Figure 36. Route 50 at Wardensville Gr Preferred Alternative Summary

Chapter 3:

Public and Stakeholder Outreach and Feedback

Public Involvement:

Following the development and analysis of the Preferred Build Alternative, a public involvement survey was developed to determine the public's response to the recommended improvements and what they perceived as the relevant issues within the study area. This survey was available online for 14 days spanning from March 4, 2024 to March 18, 2024.

Survey Design

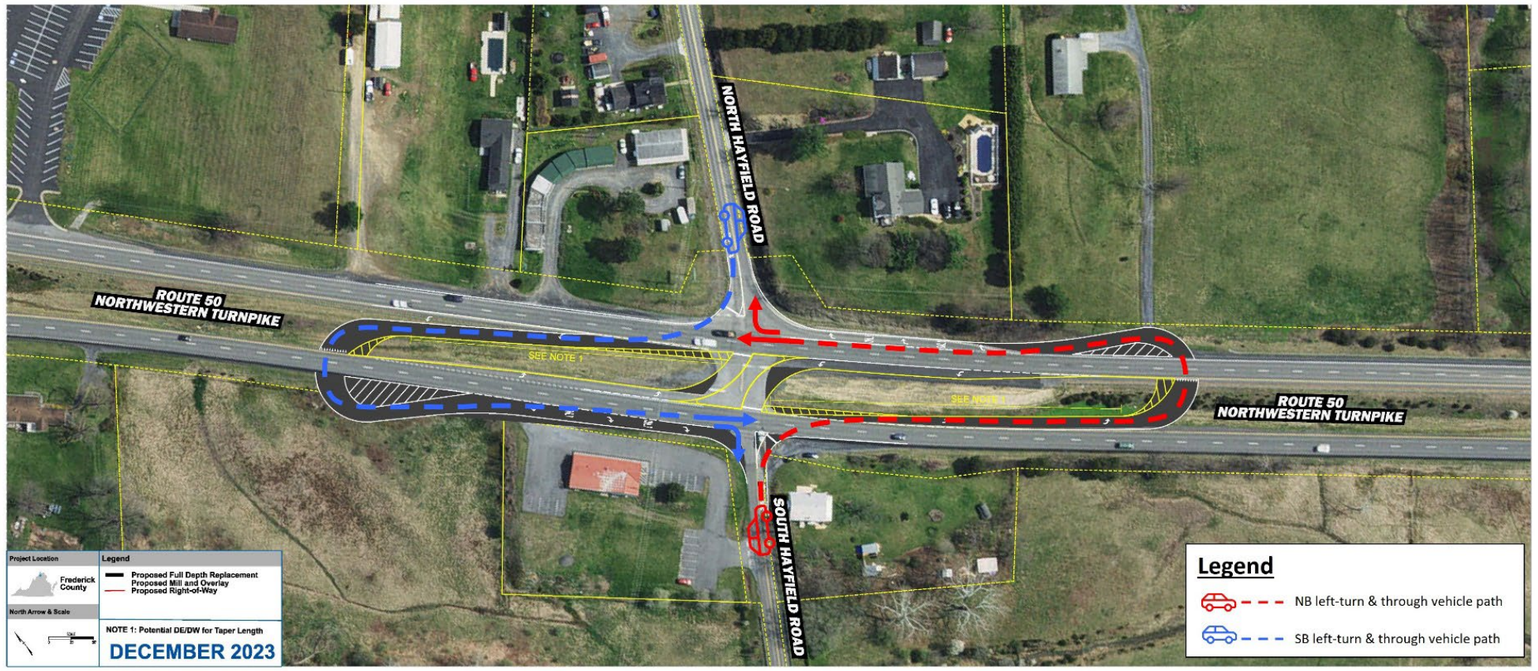
The public was involved in this study through an online survey developed on *Public Input*, an online engagement platform designed to educate the public while gathering informed feedback. This public outreach effort aimed to present relevant issues, inform the public about the recommended improvement concepts outlined in Chapter 2, and receive the public's feedback on the proposed improvements.

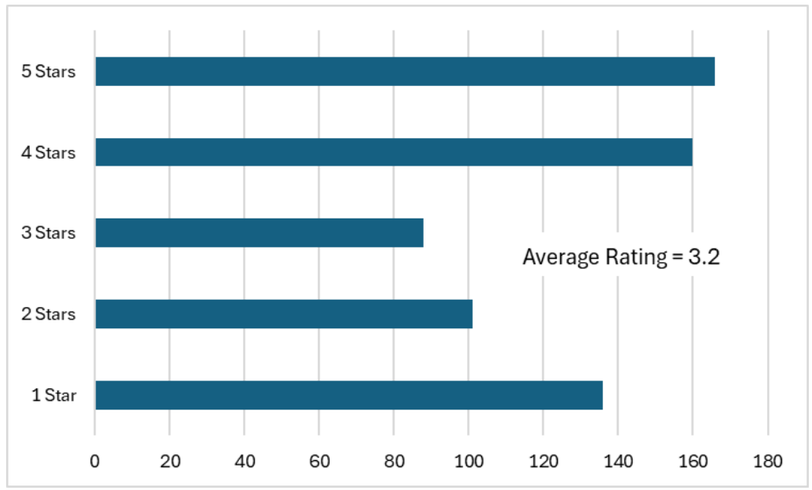
Overall, the survey is divided into four sections, which include the following:

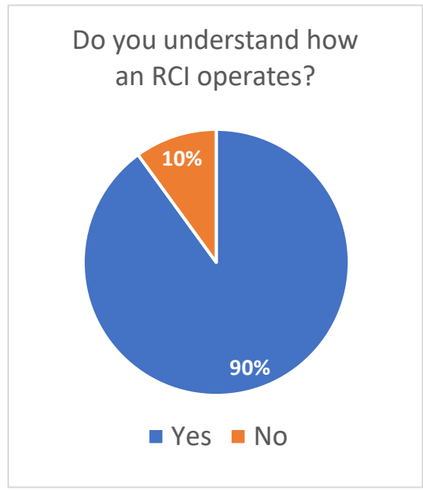
1. Welcome/introduction with an overview of the project and study area
2. Description of Existing Conditions
3. Recommended improvements in the study area & improvement feedback
4. Wrap up with demographic questions

The first section provides an overview of the study area and the project initiative. In the second section, participants were informed about the existing conditions of the corridor, including the crash data. In the following sections, a summary of the recommended improvements and benefits along the US-50 corridor was provided, as shown in **Figure 37** through **Figure 40**. For these recommended improvement concepts, participants were asked to rate them based on their opinion from one to five, one being very unfavorable, three being neutral, and five being strongly in favor. They were also provided with an option to input comments or concerns. At the end of the survey, the participants were asked a few demographic questions such as; "What is your age?" and "What is your home zip code?". A total of 746 people participated in the survey, yielding a total of 9,089 question responses.

Next, participants were presented with the Preferred Alternative design concepts for the study corridor to rate improvements in each section on a scale from one to five stars, where one is the least favorable and five is the most favorable. The design concepts that were originally provided to the participants along with the participants' responses are shown in **Figure 37** to **Figure 40**. Overall, the participants showed a favorable response to the proposed concepts.







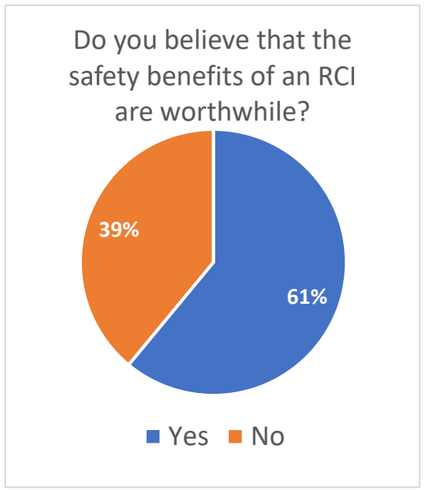
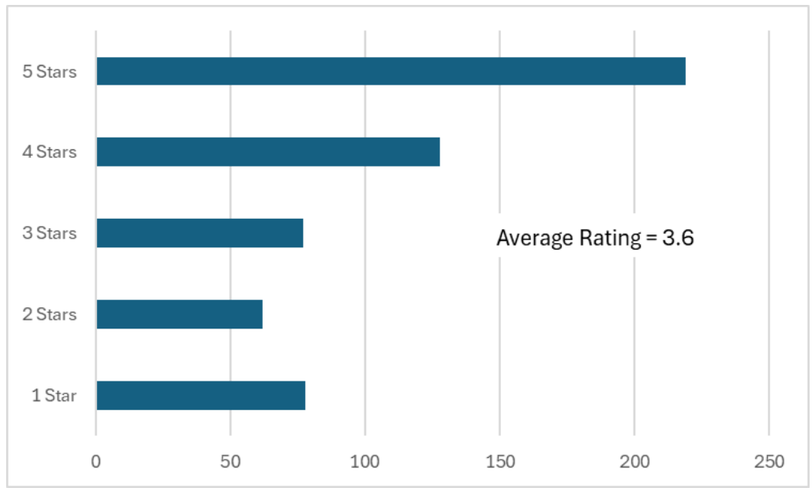
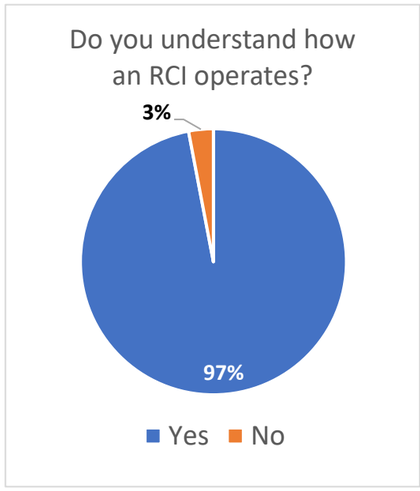


Figure 37. US Route 50 and Hayfield Rd Design and Rating





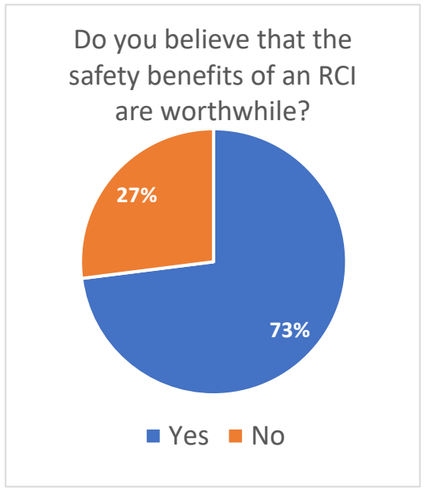


Figure 38. US Route 50 and Back Mountain Rd Design and Rating

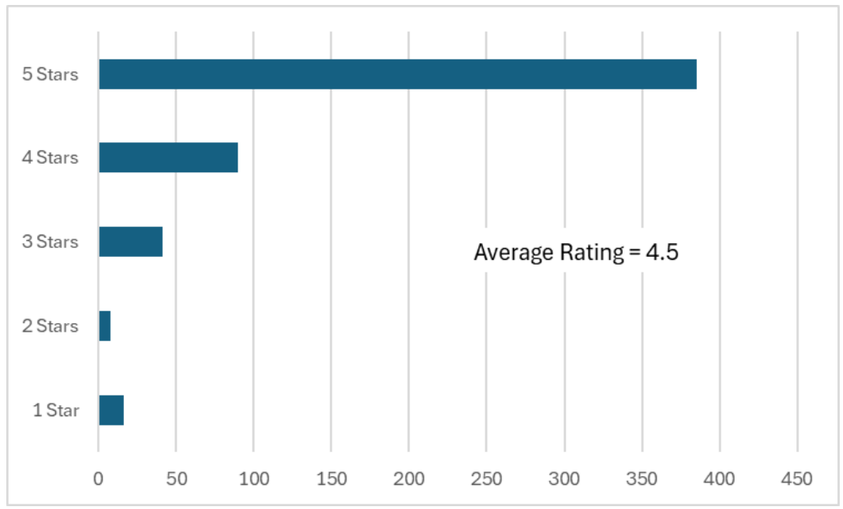
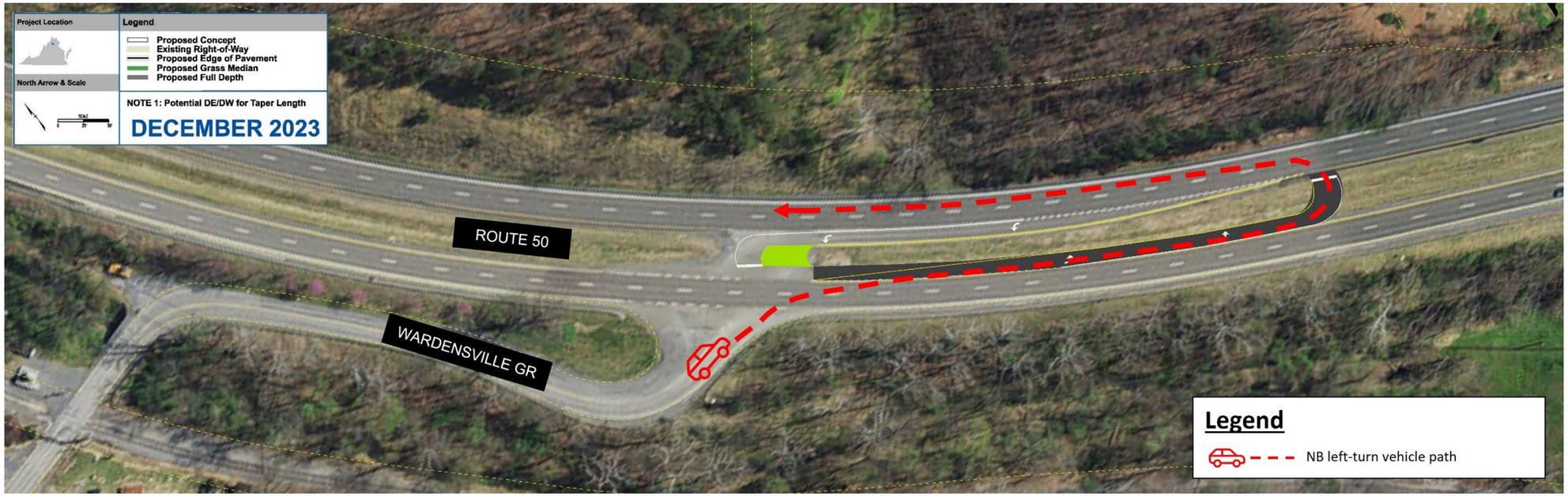
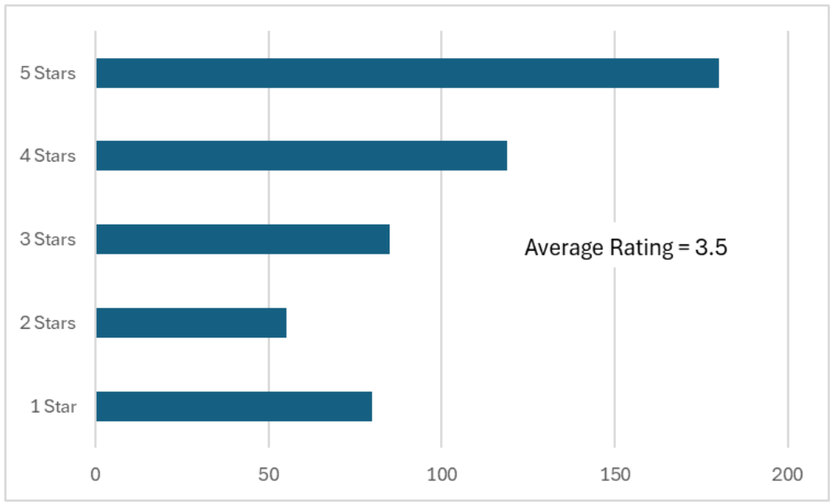
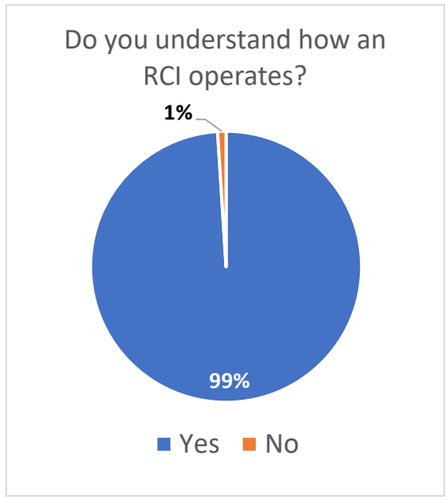


Figure 39. US Route 50 and Dicks Hollow Rd Design and Rating







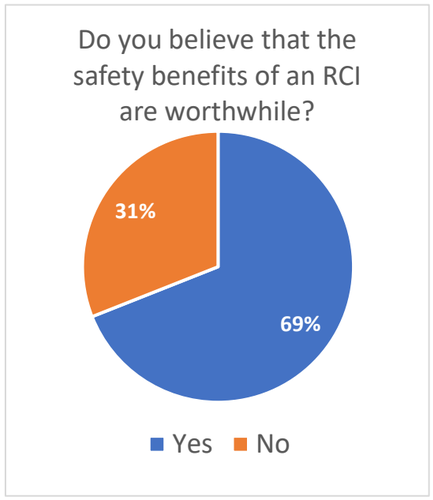


Figure 40. US Route 50 and Wardensville Gr Design and Rating

Conclusions

The summary of public survey on the Preferred Alternative improvements are shown in **Table 29**, There is overall support for all of the intersections and an understanding of how the alternatives will operate. The majority of the comments were in support of the alternative or concerning speeding and safety.

Table 29. Summary of the Representative Public Comments

Intersection	Areas of Concern	Average Rating	Public Comment Summary
US-50 and Hayfield Rd	Safety; Speeding	3.2	There is overall support for the RCI at Hayfield Road with an average rating of 3.2 out of 5. 90% of respondents understand how an RCI operates and 61% of respondents believe the safety benefits are worthwhile. The major comments were regarding concerns with safety and speeding. A representative comment is: "A U-Turn has a vehicle accelerating from 0 to 15-30 in a lane of traffic moving at 55 mph. This could result in more crashes."
US-50 and Back Mountain Rd	Safety; Speeding	3.6	There is overall support for the RCI and acceleration lane at Back Mountain Road with an average rating of 3.6 out of 5. 97% of respondents understand how an RCI operates and 73% of respondents believe the safety benefits are worthwhile. The major comments were in support of the acceleration lane and regarding concerns with safety and speeding. A representative comment is: "As a daily driver of this intersection, I really like this solution. The only issue I can see is the impatient drivers jumping into the eastbound traffic because they don't like how slowly the vehicle in front of them accelerates. This could create a new issue not experienced before. If there was a way to force eastbound traffic over into the #1 lane, that would be helpful. Otherwise due to the volume of traffic during heavy commute times, I can see people stopping in the accel lane due to unsafe merge conditions. This is no different that trying to get on I81."
US-50 and Dicks Hollow Rd	Safety; Speeding	4.5	There is overall support for the turn lane improvements at Dicks Hollow Road with an average rating of 4.5 out of 5. The major comments were in support of these changes with the belief that this will vastly increase safety. A representative comment is: "Because of the curve in the road this will improve things enormously."
US-50 and Wardensville Gr	Safety; Speeding	3.5	There is overall support for the RCI at Wardensville Grace with an average rating of 3.5 out of 5. 99% of respondents understand how an RCI operates and 69% of respondents believe the safety benefits are worthwhile. The major comments were in support of the RCI and regarding concerns with safety and speeding. A representative comment is: "The majority of the crashes are due to slow traffic merging into faster traffic. You are now having the slower traffic merge in a much more complex manner. Instead of a straight path to the center gore, you want them to go at an angle. This slow turning traffic will spend twice as much time trying to zig zag through numerous lanes of traffic."

Chapter 4:

Preferred Alternative Design Refinement & Investment Strategy

Intent of Phase 3

Phase 3 of the Pipeline Effort is intended to develop detailed concepts of the Phase 2 Preferred Alternative that will carry through to funding applications and project validation. The goal is to ensure that projects are defined to the maximum extent possible and to identify and mitigate potential risks. Utilizing technical resources of both VDOT and consultant teams, a multidisciplinary design approach is part of the overall effort that provides the needed input and problem-solving to ensure funding applications are thoroughly vetted and taken past a planning level sketch and estimate.

The goal is to develop more detailed, quantity based, deterministic estimates and designs paired with thoughtful risk assessment and mitigation. The team will use practical design and common-sense engineering methods to document the assumptions and approaches that lead to the most efficient and effective project scopes. The effort maintains focus on the purpose and needs identified through Phase 1 and 2 that address the VTRANS priorities.

Technical resources utilize Phase 3 for thorough communication and collaboration with District, Central Office, FHWA, or other key partners and stakeholders that may have decision making authority or input on final designs if projects are selected for funding. An intended outcome is that projects, if funded, will have the documentation and support for innovation and flexibility that may be necessary to achieve success.

The Phase 3 Technical Team developed the analysis, design, deliverables, and documentation that will serve as the basis for future Preliminary Engineering work on the projects. At the conclusion of Phase 3, projects should achieve a solid foundation of understanding from a planning and preliminary engineering focus that will ensure applications are well validated, reasonably scoped, meet the needs originally established in studies, and have a high probability of success.

Assumptions

The following are key design assumptions that informed the concept development and cost estimate preparation:

- Roadway geometry:
  - Back Mountain Road – The design assumes all widening on US 50 EB will be towards the median to avoid any impacts to the adjacent railroad. It is assumed the railroad crossing on Back Mountain Road will not be impacted. The widening and new left turn lane for the U-turn will impact the existing median drainage, and a curbed concrete median with storm drain inlets is proposed. The concrete median will also accommodate the regrading of the steep slopes in the median. The u-turn location was located to align with the existing entrance and limit the amount of grading and widening to be constructed on US 50 WB, where there may be significant rock.
  - Hayfield Road – The design assumes widening US 50 to the outside in both directions to add right turn lanes onto Hayfield Rd. The u-turn locations were identified based on the topography of the area to limit grading and reduce impacts to the adjacent properties. The new left turn lanes for the u-turns have been designed to be 12’ wide with 2’ shoulders for a total width of 16’. Standard curb CG-3 is proposed along the lanes with a 4’ bench and 2:1 slopes to tie into US 50. Guardrail is required as shown on the concept sketch.
  - Stony Hill Road – The design assumes 12’ lanes with 8’ paved outside shoulder and 4’ paved inside shoulder. The existing graded shoulder can accommodate the paved shoulder without significant grading for the majority of the corridor. The existing guardrail was reviewed during the field visit and found to be satisfactory. A 60 MPH design speed was assumed for the horizontal alignment changes, except for the curve on US 50 WB (PI 214+20.51) with a 55 MPH design speed. US 50 will be repaved using High Friction Surface Treatment (HFST). The existing crossovers will be maintained.
- Pedestrian accommodations:
  - No pedestrian accommodations are provided on this project.
- Stormwater management:
  - Back Mountain Road – Proposed storm drain improvements are shown on the concept sketch. Widening for the u-turn area and modifications to the median will require new inlets and culverts. It is assumed no additional stormwater management facilities are required for this project.

  - Hayfield Road – Proposed storm drain improvements are shown on the concept sketch. Widening and median changes will require regrading ditches, new inlets, and new culverts. It is assumed no additional stormwater management facilities are required for this project.
  - Stony Hill Road – For the majority of the corridor, existing storm drain facilities will be maintained. Where widening is proposed, median ditches will need to be maintained and inlets and culverts may need to be modified or replaced. It is assumed no additional stormwater management facilities are required for this project.
- Traffic:
  - Back Mountain Road – The right turn on Back Mountain Road will be free flow into the acceleration lane on US 50 EB. Traffic on Back Mountain Road traveling WB will yield to US 50 EB to get over to the u-turn location.
  - Hayfield Road – Hayfield Road will be stop controlled turning onto US 50.
  - Stony Hill Road – No changes to existing intersections and crossovers.
- Utility Impacts:
  - Back Mountain Road – Assume the existing utility poles along the railroad will not be impacted by the project. Underground utilities may be impacted by widening and drainage improvements.
  - Hayfield Road – No utilities identified in field. Underground utilities may be impacted by widening and drainage improvements.
  - Stony Hill Road – No utilities identified in the field that will be impacted. Underground utilities may be impacted by widening and drainage improvements.
- Right-of-Way:
  - Back Mountain Road – One (1) residential parcel is impacted. No property access is impacted.
  - Hayfield Road – Four (4) residential parcels are impacted. There is no clear existing entrance into parcel 02 and the entrance to parcel 04 will be modified.
  - Stony Hill Road – Assume no right-of-way impacts.
- Transit:
  - There is no existing transit along the project corridor.

Risk Assessment/Contingency

As part of the risk assessment process, a risk register was developed to identify major/high impact project risk elements. The guidance provided in VDOT's Cost Estimating Manual (Chapter 5) and IIM PMO-15.0 was followed and identified after assessing collected data, field visits, stakeholder input, and concept development. Risks were organized by broad categories including Maintenance of Traffic (MOT), Roadway Design, Right-of-Way, Utilities, Mobilization/Construction Survey, Hydraulics, Traffic, Structures/Bridge Design, Geotechnical, and Environmental. The major risks identified in this project include:

- MOT plans have not been developed at this stage; the MOT is not anticipated to be complex and the Most Likely Estimate (MLE) is recommended.
- The concept has been developed using as-built information, aerial imagery, field observations, and LIDAR data. The estimate quantified many of the major bid items, but some minor variance in quantities such as pavement is expected. MLE is recommended.
- The hydraulic design is based on field observations, GIS data, and as-built plans. The project assumes the existing storm drain system is adequate and adjustments will only be required where the existing system is impacted by widening and median changes. It is assume nutrient credits will be adequate to satisfy any stormwater management requirements. MLE is recommended.
- Construction limits and earthwork quantities are based on LIDAR surface data. The major areas requiring earthwork are along the proposed shared use path. Detailed cross sections were not performed for the project.

The project is considered Moderately Complex. However, the level of concept design development is relatively detailed (between Pre-Scoping and PFI level of design), therefore the MLE contingency would be more accurately in the 45% to 50% range. Each individual risk was "scored" based on probability, cost impacts, and time impacts. Scoring was used to assign contingencies per risk line item. These line-item risk contingencies were then aggregated to determine a contingency amount per category to include preliminary engineering, right-of-way and utilities, mobilization/construction survey, MOT, roadway design, hydraulics, traffic, and earthwork/geotechnical.

Cost Estimate

The project cost estimate was developed using the following methodology:

- Understanding the goals of the project and scope of improvements to be implemented.
- Gathering and reviewing as much information about the project as possible including site visits and stakeholder input.
- Establishing design criteria and developing a detailed design concept.
- Performing quantity takes offs and identifying unit prices based on VDOT Bid Tabs, and historical VDOT cost data (2-year District and Statewide average) to develop "defined costs".

- Developing "allowance costs" for some elements based on potential impacts and complexity. Allowances add costs for elements based on percentage of the base construction cost.
    - Back Mountain Road
        - MOT 20% Allowance.
        - $35,000 for a field office
        - Roadside Development at 2.0%
        - Additional 5% for minor roadway items not quantified
        - Stormwater Management (SWM) as 5% Allowance (assume Nutrient Credits)
        - Erosion and Sediment Control (E&SC) 5% Allowance
        - Additional 5% for minor drainage items not quantified
        - An allowance of 5% is included for pavement markings and 2.5% for signing replacement/improvements.
        - 25% allowance for grading
        - 10% allowance for potential rock excavation at the loon
    - Hayfield Road
        - MOT 40% Allowance.
        - $35,000 for a field office
        - Roadside Development at 2.0%
        - Additional 7.5% for minor roadway items not quantified (including potential guardrail upgrades)
        - SWM as 2% Allowance (assume Nutrient Credits)
        - E&SC 5% Allowance
        - Additional 5% for minor drainage items not quantified
        - An allowance of 3% is included for pavement markings and 1% for signing replacement/improvements.
        - 30% allowance for grading
    - Stony Hill Road
        - MOT 20% Allowance.
        - $50,000 for a field office
        - Roadside Development at 1.0%
        - Additional 3% for minor roadway items not quantified including potential guardrail upgrades
        - SWM Management as 2% Allowance (assume Nutrient Credits)
        - E&SC 3% Allowance
        - 10% for drainage upgrades required by widening
        - An allowance of 2% is included for pavement markings and 5% for signing replacement/improvements (including the dynamic speed signage and chevron signs)
        - 10% allowance for grading
- Identifying proposed property impacts, developing a Right of Way Data Sheet, and providing the information to VDOT to develop the right-of-way and utility budget for the project.
- Performing a risk assessment as outlined above and identifying appropriate contingency percentages by category.
- Developing Preliminary Engineering costs by category based on a percentage of the Construction cost.

Concept Revisions & Final Estimate

Based on VDOT and Stakeholder input from Phase 2 and the site visit performed at the commencement of Phase 3, the concept was advanced, refining key elements of the preferred alternative, as shown in **Figure 51**. As the design progressed, several elements were altered from the concept that resulted from Phase 2 to include:

- Correcting the horizontal alignment along US-50 in the vicinity of Stony Hill Road.

Cost Estimate Breakdown

The total project cost is estimated to be $25,721,531 and broken down by Phase/Major area as shown in **Table 30** below. This cost includes contingencies and represents uninflated 2024 dollars.

Table 30: Cost Estimate Breakdown

Phase	US 50 / Stony Hill Road Improvements	US 50 / Hayfield Road Improvements	US 50 / Back Mountain Road Improvements
Preliminary Engineering Phase	$1,666,000	$915,600	$809,200
Right-of-Way and Utilities Phase	*	*	*
Construction Phase (without CEI)	$9,718,334	$5,232,106	$3,877,430
Construction Phase (with CEI)	$11,526,397	$6,205,521	$4,598,813
Total	**$13,192,397**	**$7,121,121**	**$5,408,013**

**NOTE: Utility estimate to be provided by VDOT*

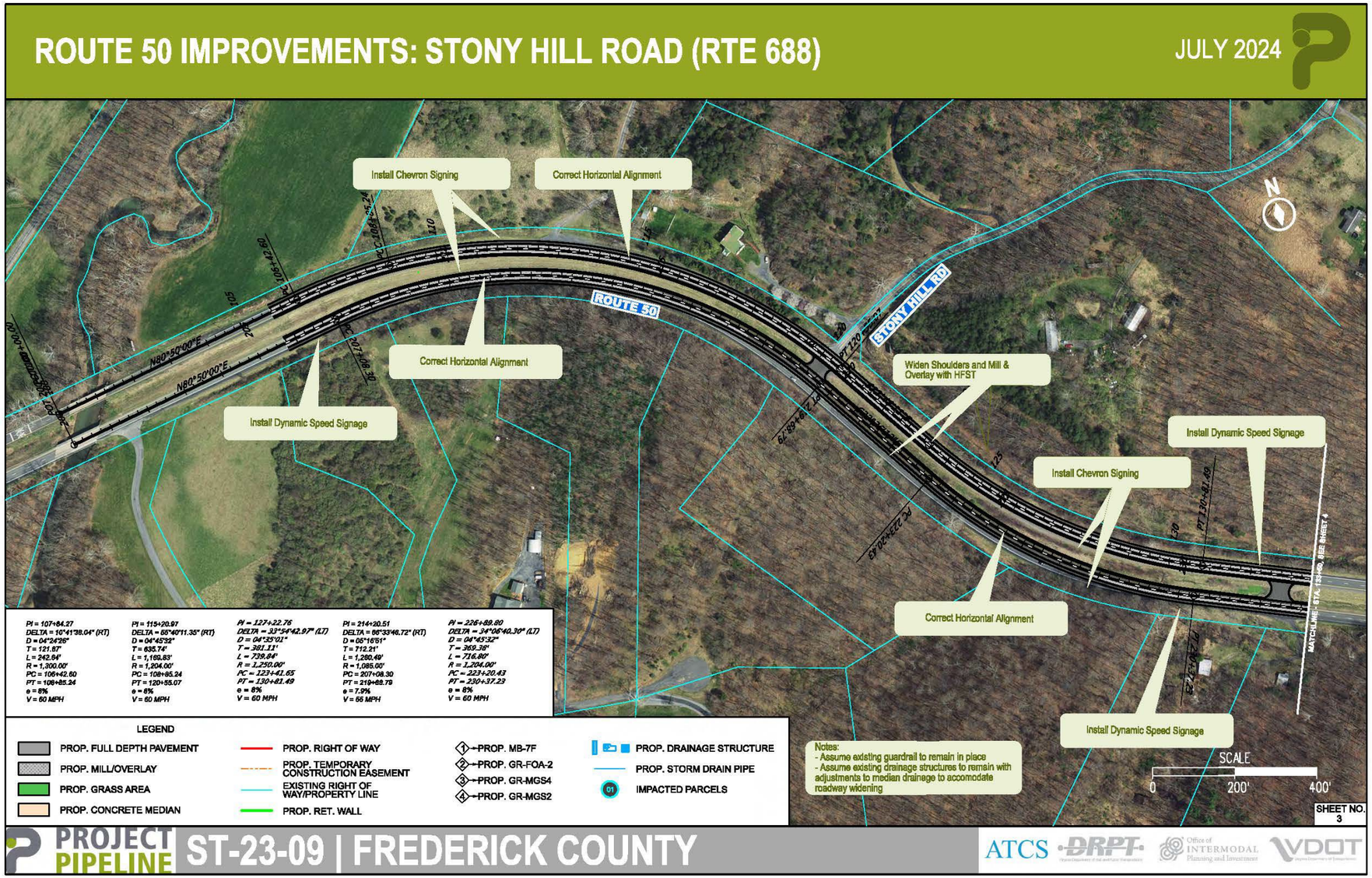


Figure 41: US 50 at Stony Hill Road Improvements

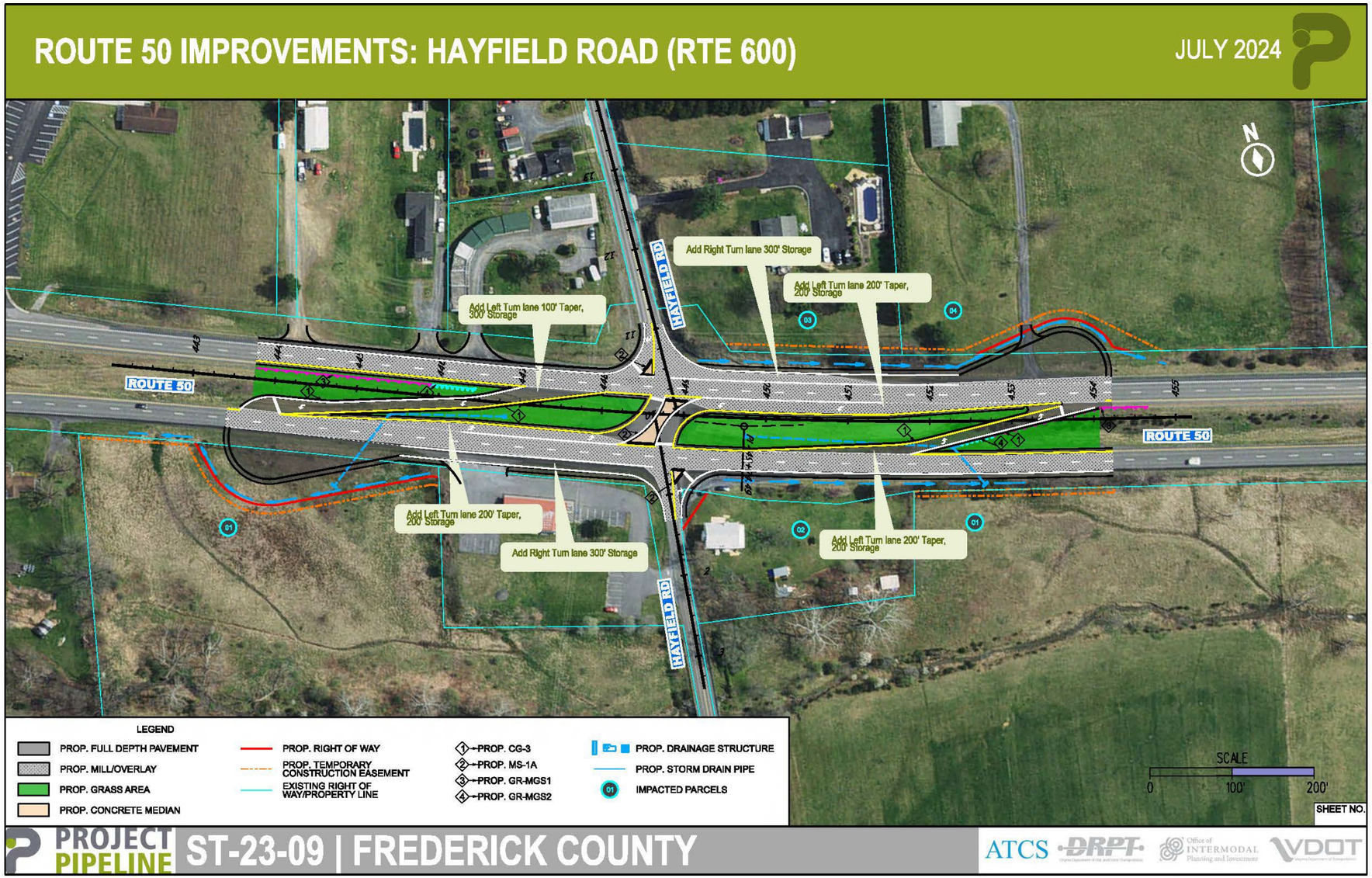


Figure 42: US 50 at Hayfield Road Improvements

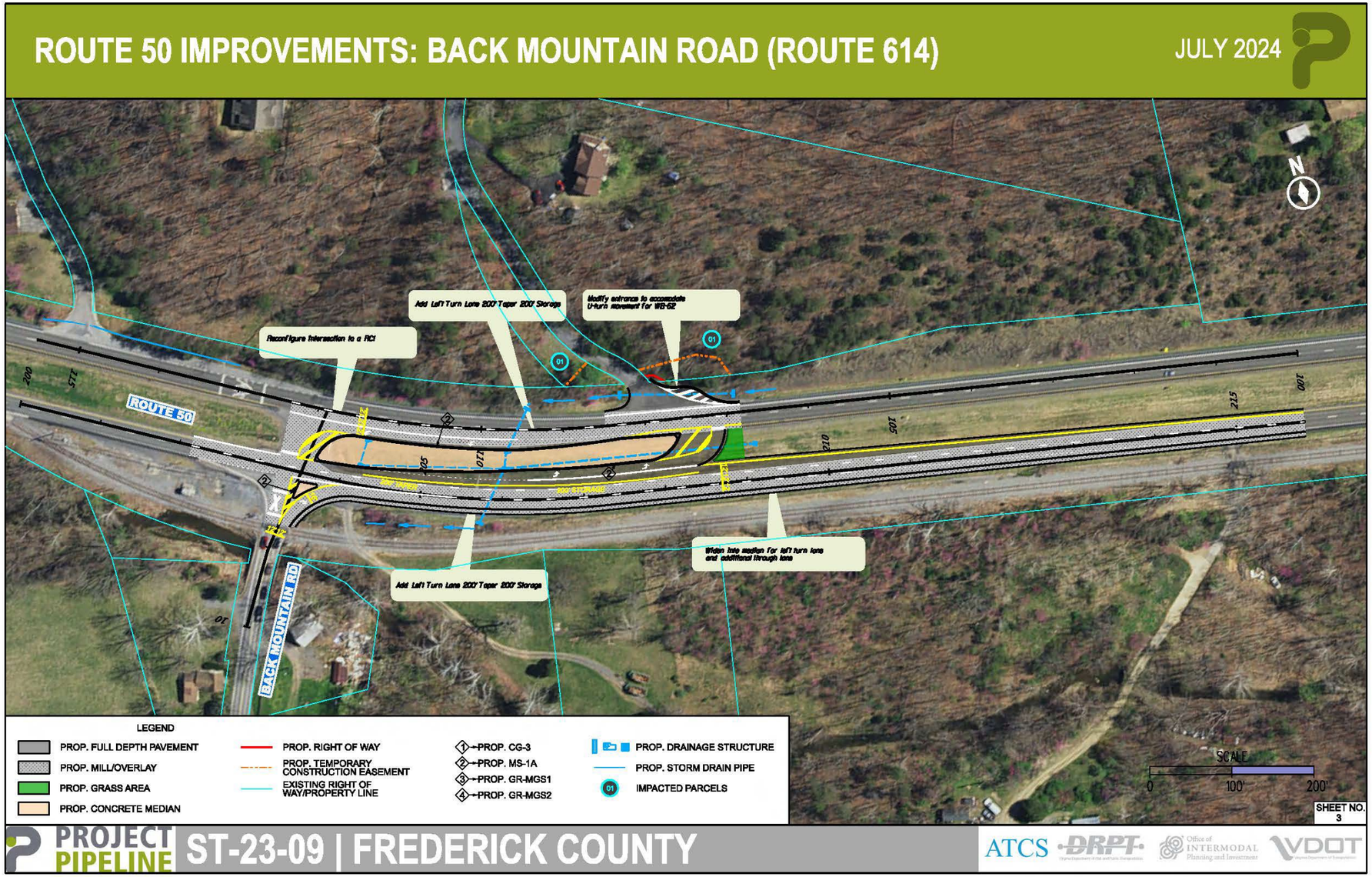


Figure 43: US 50 at Back Mountain Road Improvements