ROAD SAFETY AUDIT

PLYMOUTH ROAD

ANN ARBOR, MI

PROJECT OWNERS: CITY OF ANN ARBOR

DATE: OCTOBER 2025

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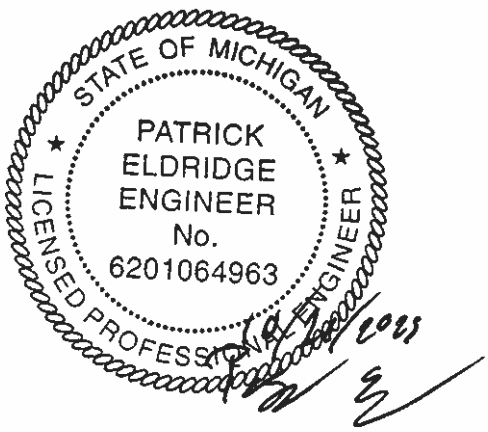

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1 INTRODUCTION

The City of Ann Arbor retained WSP to facilitate an Operational Service Road Safety Audit (RSA) along Plymouth Road located in the City of Ann Arbor, Michigan. The objective of this study was to conduct a formal safety performance examination of the corridor with an independent, multi-disciplinary team. RSAs are a proactive approach to addressing the safety of all road users and involve identifying both safety issues and developing potential mitigation measures.

The RSA followed the Federal Highway Administration's (FHWA) eight-step process which is detailed in Figure 1 below.

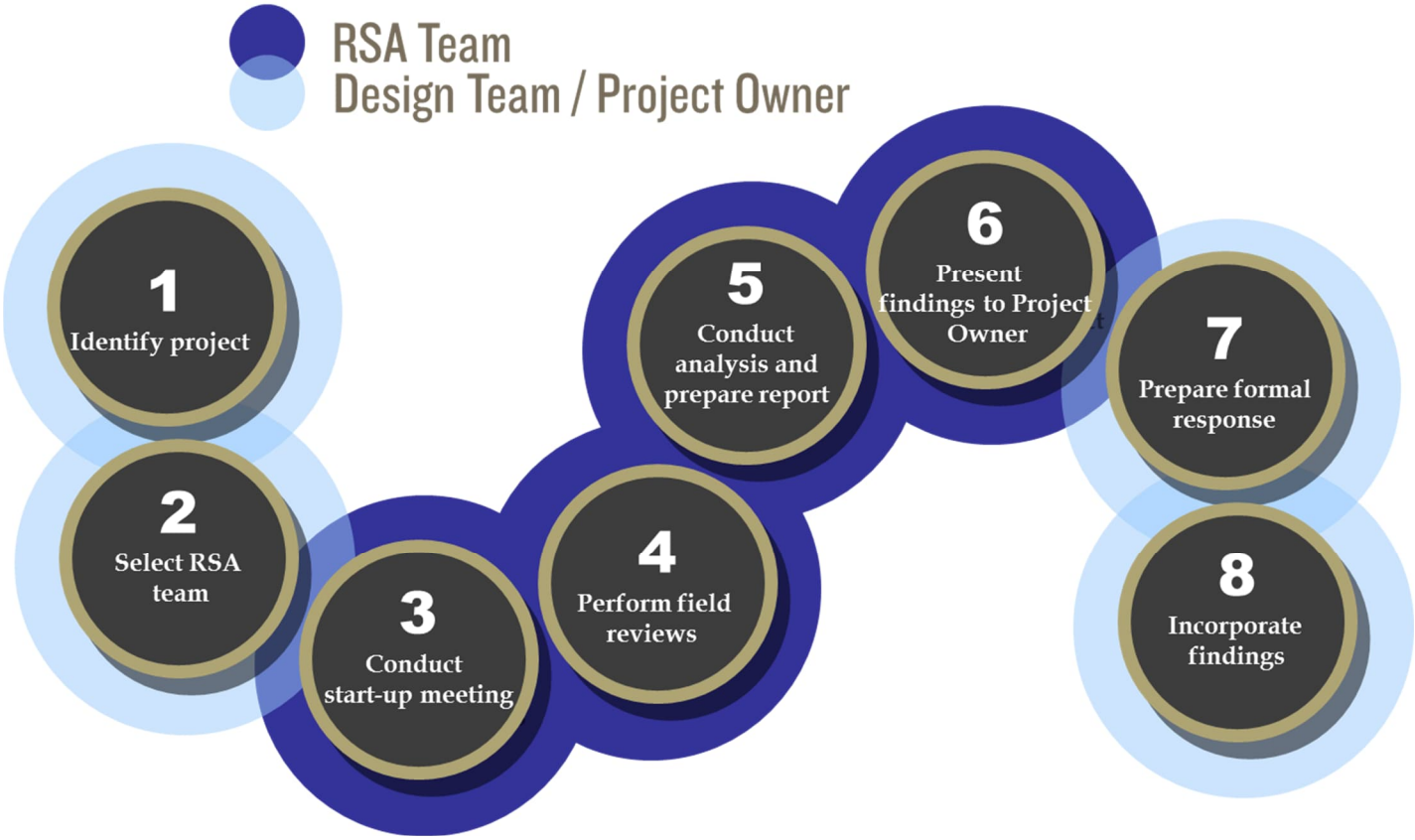


Figure 1 - RSA Eight-Step Process

The objectives of the RSA are to:

- Review road safety within the study area;
- Identify physical and operational issues that may affect road safety, and;
- Develop and provide potential countermeasures to reduce the frequency and severity of collisions.

The following sections will detail the RSA process, the methodology for this analysis, and data obtained throughout the study. The report will also present all significant findings and safety issues as well as provide recommended mitigation strategies.

1.1 BACKGROUND

This RSA was initiated in response to proactive efforts by the City of Ann Arbor to reduce the potential for fatal and incapacitating injury crashes with a specific focus on vulnerable road users (VRU) along Plymouth Road. While the focus of this study is centered on VRU safety, crashes of all types were included in the analysis. Furthermore, Plymouth Road and the US-23 interchanges are anticipated to experience continued growth, as a significant number of University of Michigan medical campus staff utilize this route. Additionally, there is consideration to install a traffic signal at the intersection of Plymouth Road and Earhart Road, located approximately 500 feet east of the study area. Given the expected increase in traffic, a comprehensive review of the area was initiated to address future traffic needs.

Plymouth Road in Ann Arbor, Michigan serves as a key east-west arterial route that connects residential, commercial, and University of Michigan-related areas with major regional corridors and highways. The segment from Green Road to the NB US-23 On Ramp is a heavily travelled stretch that provides access to numerous destinations, including shopping centers, business plazas, and park and ride lots. The study segment of Plymouth Road also provides access to the US-23 interchange. Additionally, Plymouth Road provides access to University of Michigan North Campus facilities, including academic buildings and research centers which contribute to daily traffic volumes.

The cross-section of Plymouth Road consists of 6-lanes from Green Road to the southbound US-23 on-off ramp intersection. There are three lanes in the eastbound direction, two lanes in the westbound direction, and a two-way center left-turn lane. The cross-section transitions to 4-lanes from the southbound US-23 on-off ramp intersection to the northbound US-23 On Ramp with two lanes in each direction. Additionally, right turn storage lanes are present at Green Road, southbound US-23 on-off Ramp, and northbound US-23 On Ramp. Figure 2 shows an aerial view of the study area.

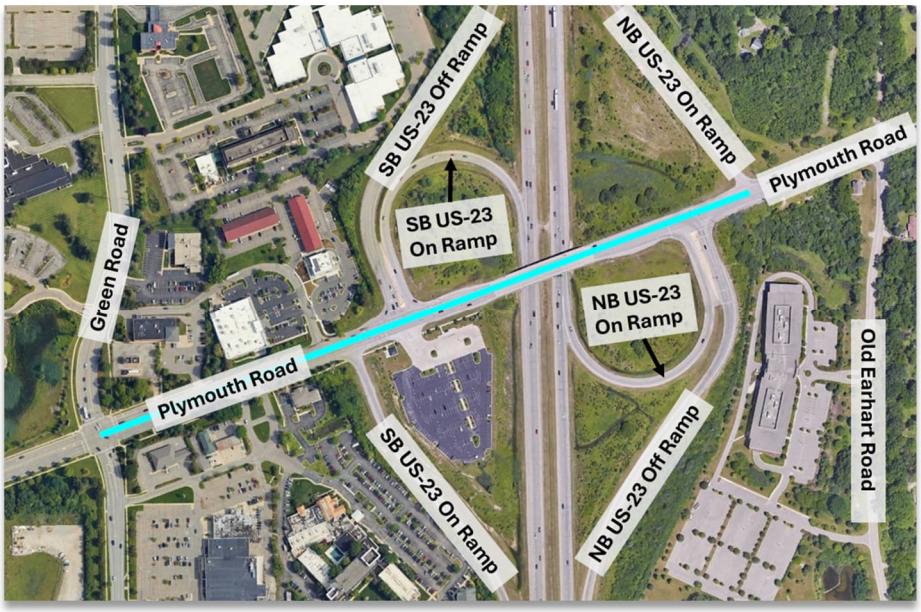


Figure 2 – RSA Study Area

2 ROAD SAFETY AUDIT

An RSA is a formal safety performance examination of an existing or future road or intersection by an independent multi-disciplinary audit team. RSAs help promote road safety by identifying safety issues during the planning, design, and implementation stages, promoting awareness of safe design practices, integrating multimodal safety concerns, and considering human factors.

2.1 ROAD SAFETY AUDIT TEAM

Location:	Plymouth Road from Green Rd through US-23 Interchange Ann Arbor, MI	
Audit Team Members:	Patrick Eldridge Ashlynn Caviness Rachel Peters	WSP WSP WSP
Project Owner:	Michigan Department of Transportation	
Review Date:	July 1, 2025	
Audit Stage:	Operational	
Start-up Meeting:	June 10, 2025 (Virtual)	
Preliminary Findings Meeting:	September 12, 2025 (Virtual)	
Attended By:	City of Ann Arbor Engineering, Planning & Development TheRide Michigan Department of Transportation University of Michigan WSP	

The RSA team members conducted this audit to the best of their professional abilities within the on-site time available and by referring to provided information. While every attempt has been made to identify significant safety issues, the project owner is reminded that responsibility for the design, construction, and performance of the roadways remains with the agency with jurisdictional authority.

2.2 ROAD SAFETY AUDIT MATERIALS

The RSA was based on the following data and analysis:

Site Review: A site visit was conducted on July 1, 2025, by WSP to facilitate a road safety audit during AM peak, off peak, and nighttime conditions. This time was spent driving and walking the corridor as well as several intersecting approaches to observe vulnerable road users, traffic operations, conflicts, and surrounding land uses. The information collected was supplemented with comments and concerns received from stakeholders during the kick-off and preliminary findings meetings. This effort helped to provide location specific context around area concerns and potential treatment considerations.

Traffic Counts: Annual Average Daily Traffic (AADT) counts were obtained from 2023 and 2024 from MDOTs Transportation Data Management System (TDMS) and provided in Table 1 below. Throughout this period, traffic counts experienced a decline from 2023 to 2024, with a more significant reduction observed in the eastbound direction.

Table 1 – AADT Counts

Location	2023 AADT	2024 AADT	Difference
EB Plymouth Road, west of Old Earhart Road	*12,984*	*10,783*	- 18.5%
WB Plymouth Road, west of Old Earhart Road	*11,672*	*11,244*	- 3.7%

Crash Data: Five years of one-line crash data (2020-2024) were obtained via Numetric and one year (2025) of UD-10 reports were provided by the City of Ann Arbor.

Identification of Countermeasures: Based on the above tasks, road safety concerns and potential contributing factors were identified. Countermeasures were identified to help mitigate the safety issues and possible crash causes, along with the crash reduction factors that are anticipated to result from their implementation.

Project Documents Available for RSA:

- Road exhibit detailing project limits
- Annual Average Daily Traffic (AADT) counts
- One-line Crash Data
- Traffic Signal Timing Permits
- Video footage and photographs of the site
- Aerial Imagery

All documents were provided to the project team prior to or during the RSA.

2.3 ROAD SAFETY AUDIT PROCESS

A road safety audit framework was applied for both the analysis and presentation of findings. The expected frequency and severity of crashes caused by each safety issue were identified and rated according to categories shown in Table 2 and Table 3. These two elements were then combined to obtain an assessment on the basis of the matrix shown in Table 4. Consequently, each safety issue was assessed on the basis of a ranking between F (highest concern and priority) and A (lowest concern and priority). For each safety issue identified, possible mitigation measures have been suggested.

Table 2 – Crash Frequency

Estimated Exposure	Estimated Probability	Frequency Rating
Medium - High	High	*Frequent*
Low - High	Medium - High	*Occasional*
Low - Medium	Low	*Rare*

Table 3 - Crash Severity

Typical Collisions Expected (per audit item)	Expected Collision Severity	Severity Rating
Collisions involving high speeds or heavy vehicles, pedestrians, or bicycles	Probable fatality or incapacitating injury	*High*
Collisions involving medium to high speed; head-on, crossing, or off-road collisions	Moderate to severe injury	*Moderate*
Collisions involving medium to low speeds; left-turn and right-turn collisions	Minor to moderate injury	*Low*
Collisions involving low to medium speeds; rear-end or sideswipe collisions	Property damage only	*Negligible*

Table 4 - Crash Concern Assessment

Frequency Rating	Severity Rating			
	Negligible	*Low*	*Moderate*	*High*
Frequent	C	D	E	F
Occasional	B	C	D	E
Rare	A	B	C	D
Concern Rankings -	*A: Lowest priority*		*F: Highest priority*	

3 SITE CHARACTERISTICS

3.1 STUDY LOCATION

Plymouth Road is classified as an "Other – Principal Arterial" per the National Functional Classification[1] (NFC) and serves as a major east-west route through the City of Ann Arbor. The corridor through the study location transitions between a six-lane cross section with a two-way center left-turn lane to a four-lane cross section at the US-23 interchange. The corridor has a posted speed limit of 45 MPH.

The corridor consists of both signalized intersections and stop-controlled driveways. The three signalized intersections within the study area include Plymouth Road at Green Road, Plymouth Road at Southbound US-23 On-off Ramp, and Plymouth Road at Northbound US-23 On Ramp. Several stop-controlled driveways servicing shopping centers and businesses are present along both sides of Plymouth Road between Green Road and southbound US-23 Ramps. Frequent pedestrian crossings occur at Green Road, the Southbound US-23 On-Ramp, and stop-controlled driveways along the corridor. Sidewalk facilities exist along the south side of Plymouth Road from Green Road to the bridge over US-23 and on the north side from Green Road to just west of the Southbound US-23 On-off Ramp intersection.

The surrounding land use along Plymouth Road on the west end near Green Road includes shopping centers, restaurants, hotels, a park and ride lot, and businesses attracting both residents and visitors. Moving eastward, the land becomes less dense with wooded areas and open land buffering the roadway. Medical facilities and a church are located just to the east of the study area. Transit infrastructure is also present along the corridor, including bus stops that serve both the Ann Arbor Area Transportation Authority (TheRide) and University of Michigan shuttles. Bus stops are located along the south side of Plymouth Road approximately 200 feet east of the Green Road intersection as well as in the Plymouth Road Park and Ride.

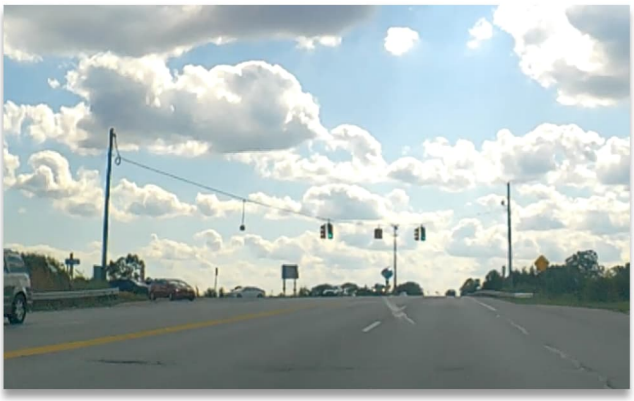
Key vulnerable road user generators include the University of Michigan's North Campus Research Complex, which brings a steady flow of students and faculty. Additionally, apartment complexes and residential neighborhoods within the area contribute to pedestrian activity. The corridor also features several shopping centers, restaurants, businesses, and bus stops that attract pedestrians and bicyclists. Lastly, there is a bicycle parking area located in the Plymouth Road Park and Ride that includes a covered area with two bike racks capable of storing approximately 20 bikes that attract cyclists to the area.

Figure 3 provides images of the characteristics present along the study corridor.

[1] As defined by the National Functional Classification (NFC). Source: Using National Functional Classifications (NFC) Maps

Plymouth Road and Green Road Intersection

Plymouth Road and Southbound US-23 Intersection



Plymouth Road and Northbound US-23 Intersection

Stop-Controlled Driveway with Crosswalk

Figure 3 - Study Area Characteristics

SITE OBSERVATIONS

Site observations were facilitated through an in-person field review by driving and recording the corridor and several intersection approaches and walking through portions of the study corridor during day and night conditions. Figures 4 through 8 provide examples of some corridor characteristics and vulnerable road users.

Vulnerable Road Users – Plymouth Road at Green Road

Cyclists along Plymouth Road

Figure 4 - Vulnerable Road User Observations

Bicycle Parking Area – Plymouth Road Park and Ride

Transit Stop at Plymouth Road Park and Ride

Figure 5 - Alternative Transit Infrastructure

Sidewalk Facilities *Sidewalk along Bridge over US-23*

Figure 6 - Sidewalk Infrastructure

Cracked Pavement on Plymouth Road *High Visibility Crosswalk – Plymouth Road at Green Road*

Figure 7 - Pavement and Pavement Marking Conditions

Vegetation Obstructing Signage ***Vegetation Obstructing Sidewalk***

Figure 8 – Vegetation Conditions

Corridor Observations

- Significant Vulnerable Road User Presence
- Significant Transit Activity (UofM Transit and TheRide)
- Six- to four-Lane Cross Section
- Existing Corridor Lighting (at western limits)
- Sidewalk Facilities (at western limits)
- Crosswalks Present at Some Intersections (high visibility markings at Green Road)
- Poor Pavement Conditions along Plymouth Road in Some Areas
- Vegetation Obstructing Signs and Sidewalks
- Access Drive Density (at western limits)

3.2 ROAD USER CHARACTERISTICS

The most recent motor vehicle traffic counts were collected in 2024 along Plymouth Road. Table 1 in Section 2.2 provides the directional AADT for the study corridor. The direction with the highest AADT is westbound Plymouth Road with approximately 500 more vehicles than the eastbound direction. However, this marks a shift from 2023, when the eastbound direction had higher traffic volumes.

Field observations concluded that there is a presence of pedestrians and bicyclists traveling through the study area. During observations, sidewalks and crosswalks in the study area were utilized by people walking, biking, and scootering. Bicyclists were observed using the pedestrian signal at intersections while biking on the sidewalk, riding in the roadway where there is no presence of bike lanes and crossing Plymouth Road where there are no crosswalks. Furthermore, pedestrians and bicyclists spanned all age groups and were observed traveling alone and in groups. Figure 9 depicts pedestrian and bicyclist activity heat maps throughout the study area.

Additionally, transit buses were observed traversing through the study corridor. The buses present consist of the UofM transit buses and TheRide buses. There are two stops for each transit service along Plymouth Road within the study limits as well as some in the surrounding area. The team observed people waiting for the transit buses as well as entering and exiting the buses at the various stops. Figure 10 shows the locations of bus stops along Plymouth as well as in the surrounding area.

Pedestrian Activity ***Bicyclist Activity***

Figure 9 - Strava Pedestrian and Bicyclist Activity Heat Maps

Figure 10 – Bus Stops Along Plymouth and in the Surrounding Area

3.3 CRASH ANALYSIS

A crash analysis was conducted for the study location utilizing the most recent six (6) years of crash data from 2020 through 2025. Five years of one-line crash data (2020-2024) were collected and UD-10 reports were provided by the City of Ann Arbor for crashes that occurred from January through May of 2025.

CRASH DEFININTIONS

The crash summaries define crashes by twelve (12) types and four (4) injury severity classifications. The definitions of the crash types are taken directly from the State of Michigan *UD-10 Traffic Crash Report Manual*[2], revised in June 2021. The manual was produced and distributed by the Michigan Department of State Police, and the Office of Highway Safety Planning. The crash types are based on the intended direction of travel, regardless of point(s) of impact or direction vehicles ultimately face after the crash.

- Angle: This will be selected when the direction of travel is basically perpendicular for both drivers and there is a side impact of approximately 90 degrees. An angle crash is a more direct impact and may stop the forward movement of one vehicle. If the side impact takes place during a "Head On-Left Turn," "Rear-end-Left Turn," or "Rear-end-Right Turn," it is not an "Angle".
- Backing: This will be marked when one vehicles impacts one or more vehicles while driving in reverse.
- Fixed Object: When the vehicle impacts a fixed object.
- Head On: The direction of travel of both vehicles must be toward each other. The determining factors are not the direction that the vehicles are facing when they come to rest or the points of impact on the vehicles.
- Head On Left Turn: When two vehicles are approaching head on and at least one is attempting a left turn.
- Other: The crash does not fit in one of the other selections.
- Unknown: No information is available for Crash Type.
- Parking: When a parked vehicle is impacted.
- Rear-end: When the vehicles are traveling in the same direction, one behind the other, and no turn is involved. The area of damage on the vehicles is not the determining factor.
  Any crash involving any vehicle backing into another is not considered a "rear-end" crash.
- Rear-end Left/Right Turn: When the intention of one driver was to make a left or right turn and was in the process of completing the turn, and the vehicle was struck by a following vehicle, not necessarily in the same lane, Rear End-Left Turn or Rear End-Right Turn will be marked accordingly.
- Sideswipe Same/Opposite Direction: Vehicles traveling in the same direction, or vehicles traveling in opposite directions, making side contact or if a vehicle spins out of control and makes contact with another vehicle traveling in the same direction. "Sideswipe" differs from "Angle" in that a sideswipe is a glancing impact and should not in itself stop the forward movement of the vehicle. An angle crash is a more direct impact and may stop the forward movement of one vehicle.
- Single Motor Vehicle: A single motor vehicle crash involves only one motor vehicle as defined in this manual. This includes those cases in which a motor vehicle was the only traffic unit and the only motor vehicle involved that collided with a bicyclist, pedestrian, engineer (railroad train), animal or any other non-motorized object.

[2] 2021-UD-10-Instruction-Manual.pdf (michigan.gov)

The definitions of the injury severity classification are taken directly from the State of Michigan *UD-10 Traffic Crash Report Manual*, revised June 2021.

- Fatal Injury (K): A fatal injury is any injury that results in death within 30 days after the motor vehicle crash in which the injury occurred. If the person did not die at the scene but died within 30 days of the motor vehicle crash in which the injury occurred, the injury classification should be changed from the attribute previously assigned to the attribute "Fatal Injury."
- Suspected Serious Injury (A): A suspected serious injury is any injury other than fatal which results in one or more of the following:
    - Severe laceration resulting in exposure of underlying tissues/muscle/organs or resulting in significant loss of blood.
    - Broken or distorted extremity (arm or leg).
    - Crush injuries.
    - Suspected skull, chest or abdominal injury other than bruises or minor lacerations.
    - Significant burns (second and third degree burns over 10% or more of the body).
    - Unconsciousness when taken from the crash scene.
    - Paralysis.
- Suspected Minor Injury (B): A minor injury is any injury that is evident at the scene of the crash, other than fatal or serious injuries. Examples include lump on the head, abrasions, bruises, minor lacerations (cuts on the skin surface with minimal bleeding and no exposure of deeper tissue/muscle).
- Possible Injury (C): A possible injury is any injury reported or claimed which is not a fatal, suspected serious or suspected minor injury. Examples include momentary loss of consciousness, claim of injury, limping, or complaint of pain or nausea. Possible injuries are those that are reported by the person or are indicated by his/her behavior, but no wounds or injuries are readily evident.
- No Injury (O): No Injury is any situation where there is no reason to believe that the person received any bodily harm from the traffic crash. Sometimes referred to as Property Damage Only (PDO).

CRASH SUMMARIES

During the study period, a total of 143 crashes were reported. Figure 11 below shows the distribution of crashes along the corridor. Over the period there were two reported bicyclist-involved crashes, two pedestrian-involved crashes, and three reported minor injury (B) crashes. Additionally, one of the pedestrian crashes resulted in a fatality.

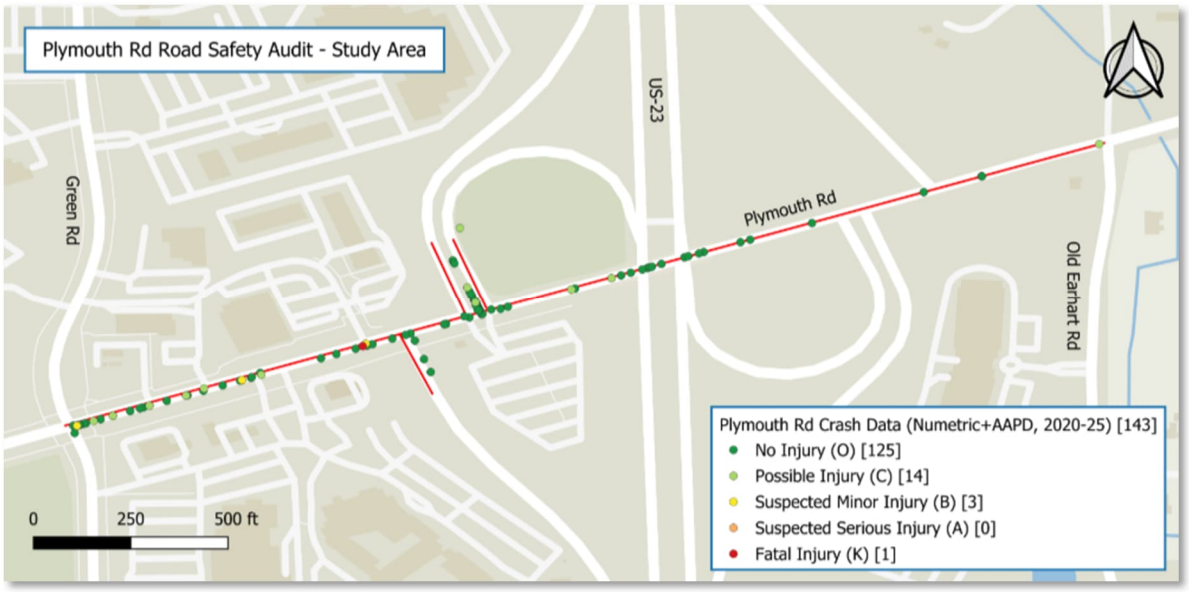


Figure 11 – Crash Distribution Map, 2020-2025

For additional context, UD-10s were reviewed for bicyclist, pedestrian, and injury crashes reported from 2020 through 2025. This information helped to provide additional context regarding contributing factors to these types of crashes. It should also be noted that near-miss incidents are not factored into the data analysis as they are not typically reported, however the feedback obtained by stakeholders during discussions was taken into consideration when evaluating the corridor. The following summarizes the narratives for the bicyclist, pedestrian, and injury crashes reported.

- ***Fatal Injury (1)***
  - *Fatal Injury | Daylight | Dry | 2025* – Pedestrian was crossing Plymouth Road west of Southbound US-23 On Ramp intersection (no marked crossing) and was struck by an eastbound travelling vehicle
- ***Bicyclist Involved (2)***
  - *Minor Injury | Daylight | Dry | 2023* – Bicyclist crossing Plymouth Road east of Green Road (no marked crossing) and was struck by an eastbound travelling vehicle
  - *No Injury | Daylight | Unknown | 2024* – Bicyclist crossing at Plymouth Road and Green Road during the WALK interval and was struck by a motorist
- ***Remaining Pedestrian Involved (1)***
  - *Minor Injury | Unknown | Unknown | 2023* – Pedestrian was crossing the east leg crosswalk at Plymouth Road / Green Road when they were struck by a northbound right turning vehicle

- ***Remaining Incapacitating Injury (1)***
    - *Minor Injury | Daylight | Dry | 2025* – Motorcyclist was travelling westbound just west of the Southbound US-23 On-Off Ramp intersection when a motorist pulled out of a private drive. The motorcyclist collided with the vehicle.

CRASH CHARACTERISTICS

In addition to the review of responding officer reports for focus areas and severe injury crashes, the overall crash dataset was reviewed to help identify potential crash trends. Figure 12 provides the overall distribution of crashes by severity, followed by Figure 13 which provides the overall distribution of crashes by crash type. As shown, the highest crash type occurrence for all severity crashes was rear end (~36% of all crashes). The next most frequent overall crash types were angle (~25%) and sideswipe – same direction (~22%). The highest crash type for injury crashes was single motor vehicle (~75% of injury crashes).

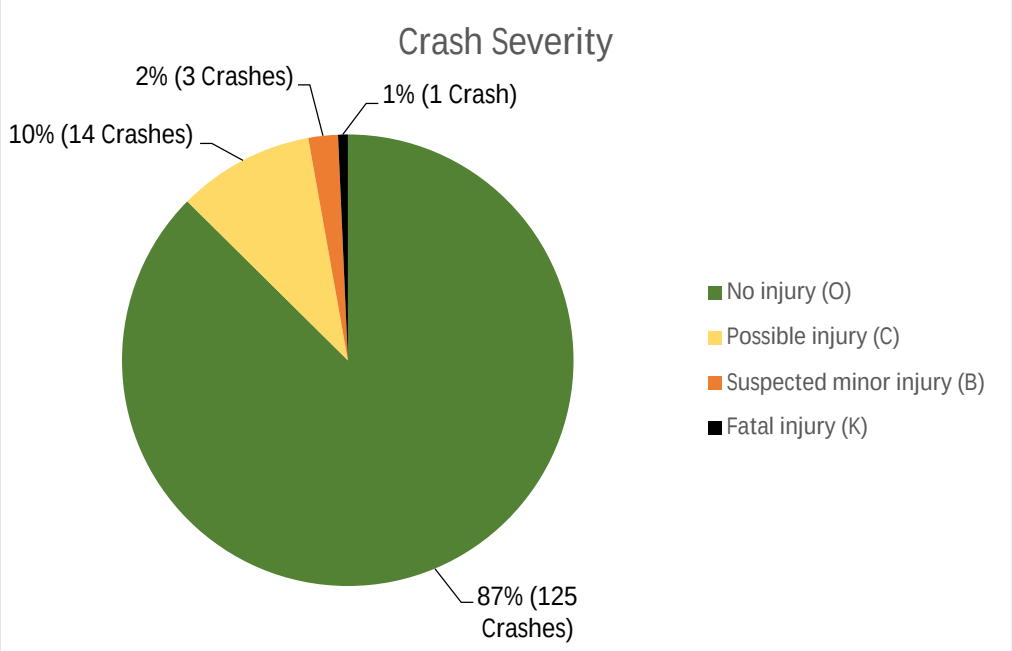


Figure 12 - Overall Crash Severity (2020-2025)

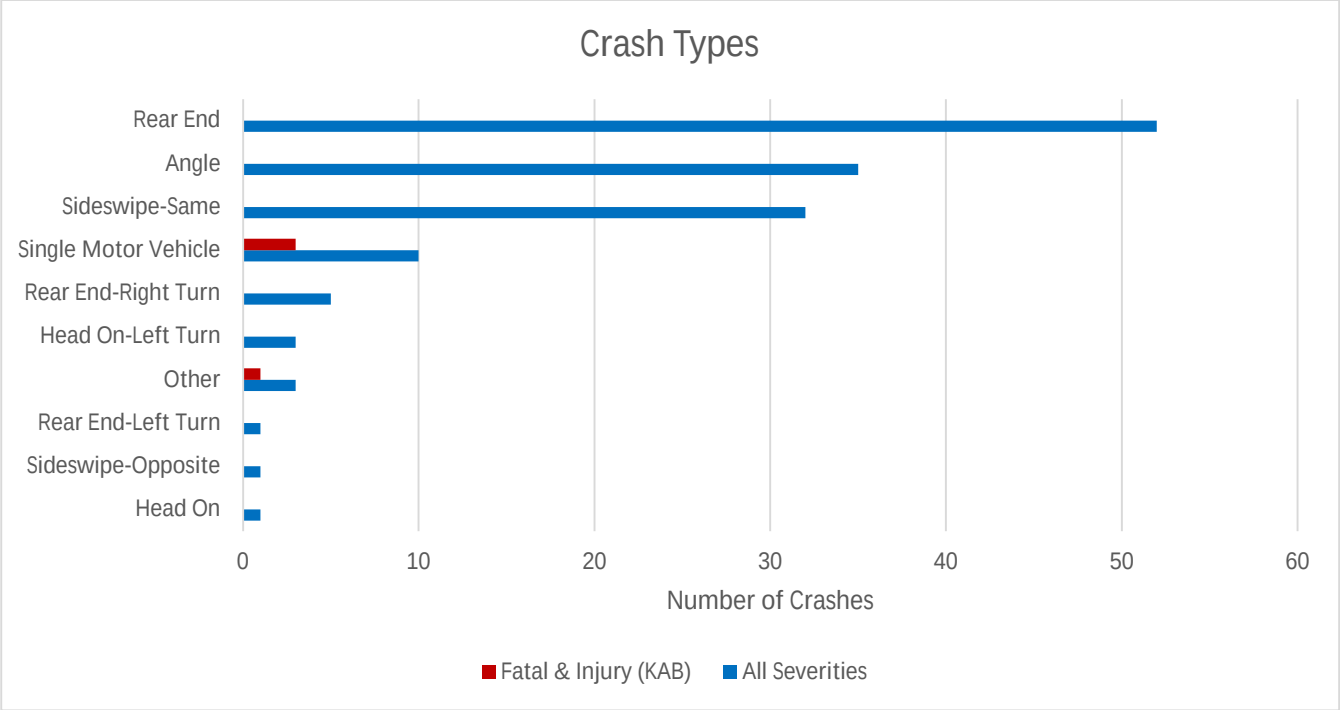


Figure 13 - Distribution of Crashes by Type

TEMPORAL TRENDS & ENVIRONMENTAL CONDITIONS

Temporal trends by month of the year, day of the week, and hour of the day for all crashes were reviewed as shown in Figure 14. The highest peaks for all severity crashes tend to align with the morning peak (8AM – 10AM) and evening peak (4PM – 6PM). These peaks are consistent with the increase in volume typical during those times. The injury crashes appear steadily to occur throughout the day. When looking at the day of the week, all severity crashes peak during the weekdays, with the highest peak occurring on Tuesdays. This suggests that regular commuter traffic may be contributing to the increased frequency of crashes during the week. When aggregating crashes by month, there did not appear to be a strong trend, although crash frequency decreased February – April. August and October experienced the highest frequency for all crash severities (~24% of all crashes). Injury crashes appear to occur steadily throughout the year.

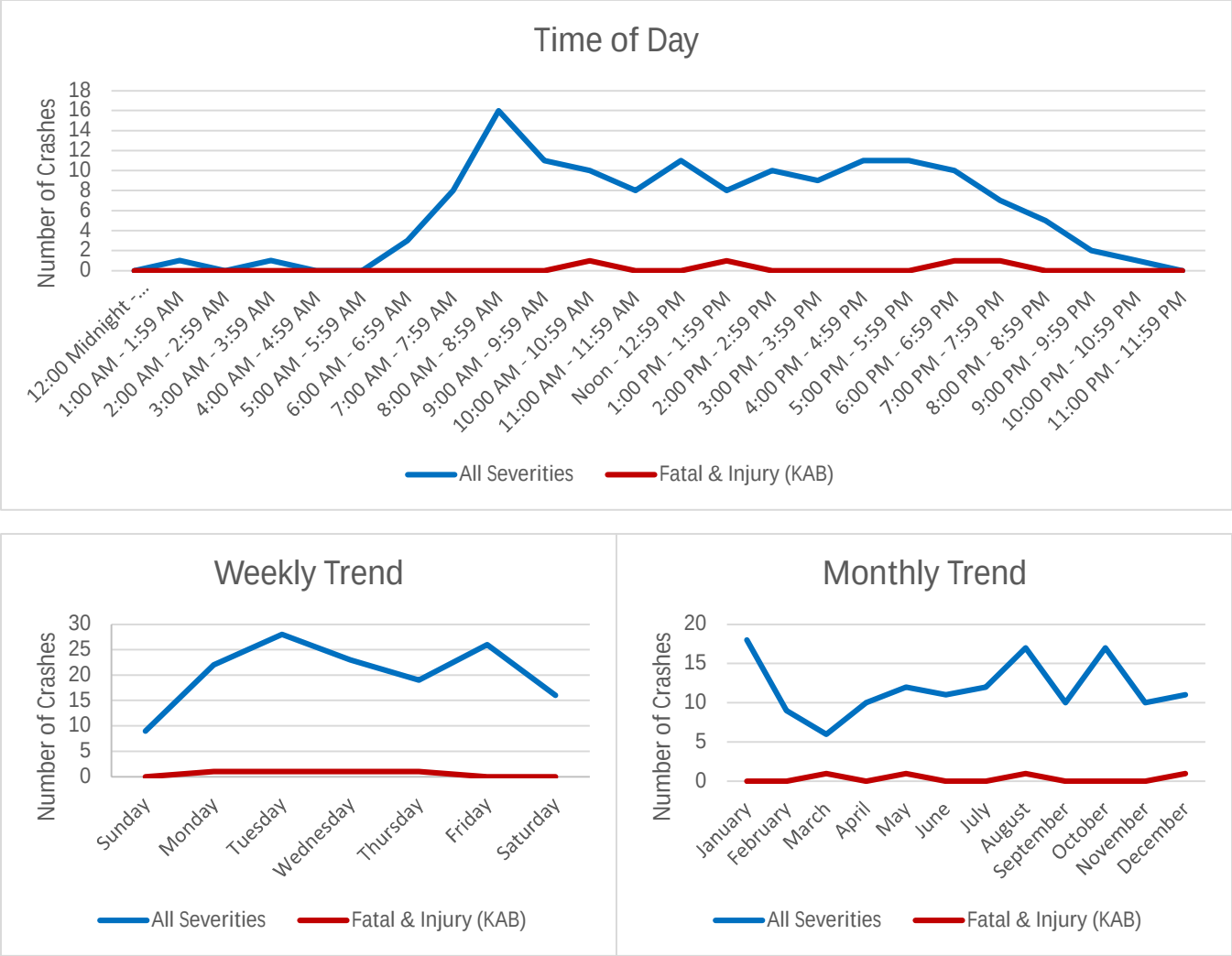
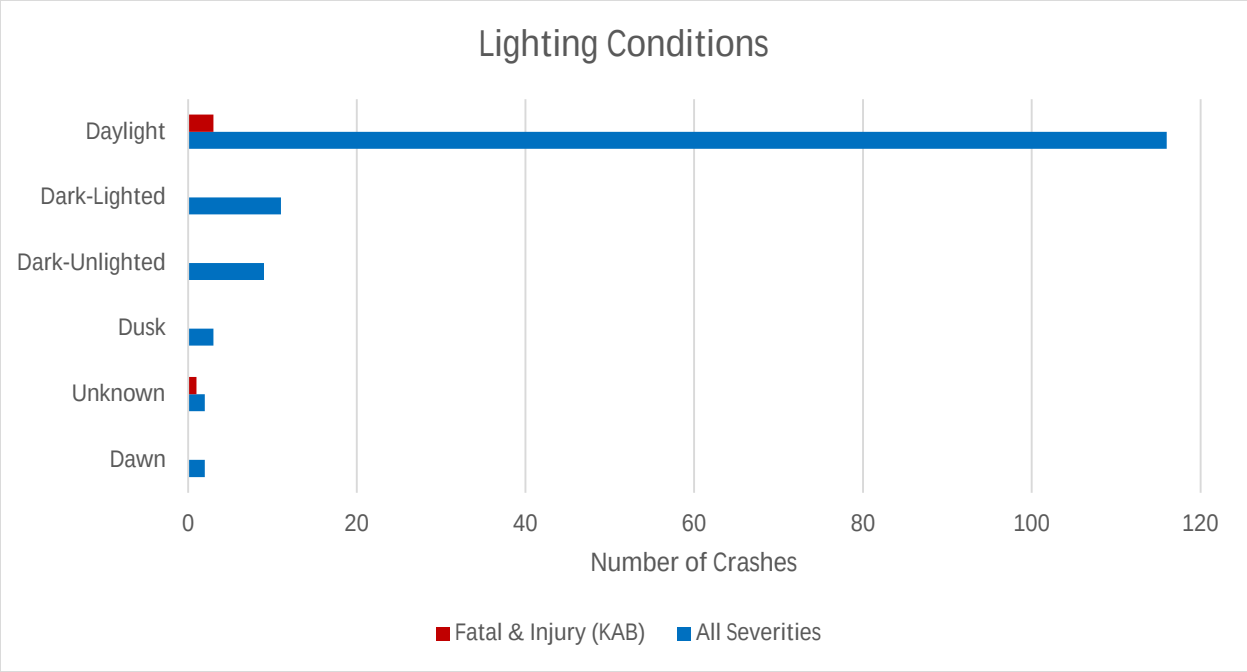


Figure 14 - Crash Distribution by Month, Day of the Week, and Hour of Day

Figure 15 provides the distribution of crashes by the lighting and road conditions present at the time of the crash, as reported by the responding officer. Based on six years of crash data, approximately 19% of all severity crashes occurred under dark or low light conditions. When considering fatal and injury crashes, approximately 75% occurred during daylight conditions. When reviewing the distribution of crashes based on the surface condition of the road at the time the crash, the majority of crashes occurred on dry road conditions (78% of all crashes and 75% of injury crashes). When focused on the fatal and serious injury crashes only, three of the four reported crashes occurred under daylight and / or dry road conditions, suggesting that while lighting and road condition play a role in crash narratives, they do not appear to be contributing to increased severity of the crashes overall.



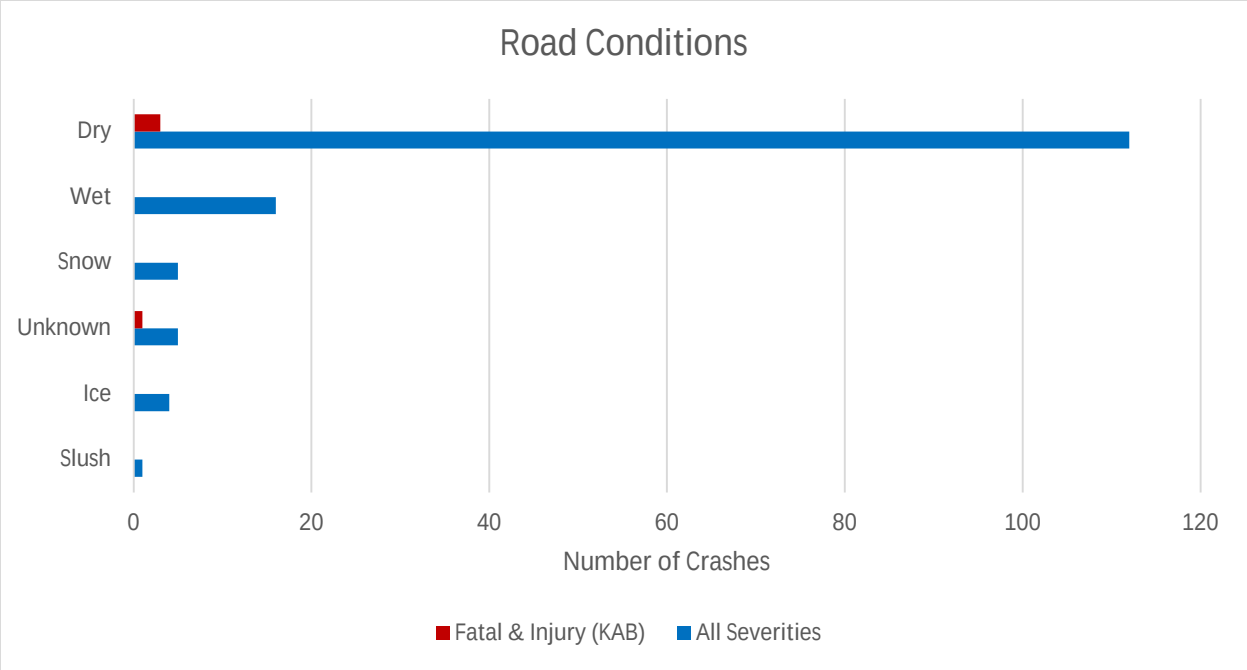


Figure 15 - Crash Distribution by Lighting & Road Condition

4 EXISTING SAFETY MEASURES

The measures and characteristics in the following table have been identified as having a presence or positive impact on safety in the study area and the City of Ann Arbor's existing focus on safety and maintenance.

Existing Safety Measures	
Modern Features at the Intersection – Plymouth Road at Green Road Plymouth Road at Green Road is modernized with a box span signal configuration, backplates, high visibility crosswalks, detectable warning pads, countdown pedestrian signals, and leading pedestrian intervals (LPIs). Countdown timers, high visibility markings, and LPIs help improve non-motorized user safety. Box span layouts align traffic signal heads with approaching vehicles while backplates help delineate the signal heads against background visuals and low angle sun positions.	
Good Sidewalk Conditions Sidewalks are present along the western limits of the study corridor. The sidewalks have minimal cracking, and in some areas, there is an adequate buffer zone between the sidewalk and the roadway. This buffer enhances pedestrian safety by providing separation between vulnerable road users and motorists.	
Adequate Signage Lane use signs, guidance signs, and regulatory signs are placed along the study corridor. Signage provides clear and timely information to road users, helping to prevent crashes and supports smooth traffic flow.	
Adequate Corridor Lighting – Western Limit Overhead lighting is present along Plymouth Road on the western limits. Well-lit corridors help reduce the potential for crashes by improving visibility for both pedestrians and motorists.	

5 SAFETY CONCERNS AND SUGGESTIONS

The following sections detail safety concerns identified during the RSA, along with targeted treatment recommendations for each. Five primary safety concerns have been identified based on existing conditions, with specific issues detailed under each category. The safety concerns, ratings, and suggestions are summarized below.

#	Safety Concern	Rating	Suggestions
1	Vulnerable Road Users ▪ Vegetation obstructing the view of pedestrians crossing at the Southbound US-23 On Ramp ▪ Faded pavement markings ▪ Broken concrete in crosswalks ▪ Broken or missing detectable warning surfaces ▪ Debris and gravel on the US-23 overpass shoulders/'sidewalk' ▪ Dimly lit pedestrian facilities ▪ Lack of mid-block crossing ▪ Non-continuous sidewalk ▪ No bicycle facilities	**F**	▪ Trim vegetation to improve pedestrian visibility ▪ Southbound US-23 On Ramp ▪ Sidewalks ▪ Refresh pedestrian crossing pavement markings ▪ Resurface pavement ▪ Replace/install detectable warning surfaces and ADA ramps and landings as needed ▪ Clear US-23 overpass debris ▪ Install pedestrian level lighting ▪ Long-term opportunities (pending supporting traffic studies) ▪ Explore mid-block crossing opportunities ▪ Build out sidewalk network to address desire lines ▪ Introducing bicycle facilities along Plymouth Road
2	Visibility Concerns ▪ Overgrown vegetation obstructions ▪ Pedestrian crossing visibility ▪ Roadway signs ▪ Sidewalks ▪ Signals ▪ Most concerning – Obstruction of pedestrians crossing southbound US-23 On Ramp ▪ Lack of corridor/intersection lighting east of the Southbound US-23 On-Off Ramp	**D**	▪ Trim vegetation where needed ▪ Install overhead roadway and/or intersection lighting ▪ Consider recessed wet reflective pavement markings

3	Intersections
	▪ Potential to modernize signals at US-23 interchanges
	▪ Debris in/along US-23 ramp medians
	▪ Plymouth Road at Green Road
	  ▪ Outdated pushbutton signs
	  ▪ Minimal pedestrian walk times
	▪ Non-illuminated case signs – Left turns at Southbound US-23 On-Off Ramp
	▪ Lane alignment shift through Southbound US-23 On-Off intersection/deteriorating pavement joints
	▪ Dual left/right turning movements
		C	▪ Modernize Intersections
			  ▪ Box span configuration
			  ▪ Backplates & tethers
			  ▪ Leading pedestrian intervals (LPIs)
			  ▪ Continental high visibility crosswalk
			  ▪ Turn guide pavement markings
			  ▪ Accessible pedestrian signal
			  ▪ Review clearance intervals
			▪ Install illuminated case signs at locations where they are currently not present
			▪ Realign by restriping westbound approach at Southbound On-Off Ramp intersection

4	Pavement Markings
	▪ Faded/missing pavement markings throughout study corridor
	▪ Gapped stop bar at the Plymouth Road Park and Ride
		C	▪ Refresh pavement markings
			  ▪ Crosswalks
			  ▪ Stop bars
			  ▪ Lane use markings
			  ▪ No entry hatching
			▪ Delineate the gapped stop bar at the Plymouth Road Park and Ride
			  ▪ Add lane use arrow pavement markings
			  ▪ Add lane use signage

5	Signage
	▪ Outdated and worn “Bridge May Be Icy” signage
	▪ Lane use signs are not present for the eastbound and westbound approaches at US-23 On-Off Ramp intersections
	▪ Worn/reduced retroreflective signs
		B	▪ Consider refreshing corridor signage
			  ▪ Install MUTCD compliant “Bridge Ices Before Road” signs in place of old signage
			  ▪ Install ‘Right Lane Must Turn Right’ or other equivalent at eastbound right turn only lane at Southbound US-23 On-Off Ramp
			  ▪ Install lane use signs where appropriate – Ensure MUTCD compliance
			  ▪ Refresh signage throughout the corridor to ensure signs are retroreflective

5.1 SAFETY CONCERNS AND TREATMENT OPTIONS

Safety concerns identified within the study area are shown in order of perceived concern, graded highest to lowest. The following sections provide detail regarding the concerns identified under each grouping, along with several potential treatments that cover a range of time frames and levels of investment.

VULNERABLE ROAD USERS

SAFETY CONCERNS

Vulnerable road user (VRU) safety concerns were noted as primary focus areas in the original road safety audit request. Based on conversations with local stakeholders, review of available crash data, and field observations made by the audit team, issues related to vulnerable road users along the corridor were confirmed as a focus area. The western limits of the study corridor in particular experience a significant amount of pedestrian and bicyclist traffic. Figure 16 provides examples of vulnerable road users observed during the field review. The majority of vulnerable road user traffic appeared to be university students and residents walking and biking through the area. The field observations occurred during the summertime, and while VRUs were observed, their presence is expected to increase during the fall and winter months as university classes are in session at those times. The RSA team noted multiple safety concerns for people walking, biking, and scootering through the study area.

Figure 16 -Vulnerable Road User Observation Examples

The field review identified overgrown vegetation obstructing sight lines at the Southbound US-23 On Ramp. This obstruction poses several safety concerns for vulnerable road users as the ramp is a free flow on ram to southbound US-23 and reduced visibility poses concerns for VRU road users making this crossing. Reduced visibility means that motorists may not be able to see pedestrians in time to react, increasing the potential for crashes. Furthermore, overgrown vegetation was observed along the sidewalks within the study area. Vegetation obstructing sidewalks creates obstacles by impeding pedestrian movement, forcing individuals to navigate around the overgrowth, which can be particularly challenging for VRU such as children, the elderly, and individuals with limited mobility. Examples of the overgrowth are depicted in Figure 17.

Vegetation Obstructing Visibility at Southbound US-23 On Ramp

Overgrown Vegetation along Sidewalk

Figure 17 - Examples of Overgrown Vegetation Throughout the Study Corridor

Furthermore, it was observed that there are faded crosswalk pavement markings and broken concrete in the crosswalks, as shown in Figure 18. The faded markings can create confusion for drivers, as they may not notice that it is a crosswalk and therefore may not be aware of the need to watch for pedestrians. This lack of awareness can increase the potential for crashes. Additionally, broken concrete can become trip hazards for pedestrians using the crosswalk.

Figure 18 - Faded Crosswalk Marking and Broken Concrete at Southbound US-23 On Ramp

Furthermore, it was observed that there are missing and broken detectable warning surfaces at several crosswalks. These surfaces are crucial for the safety of impaired vulnerable road users, such as individuals with visual impairments, as they provide tactile cues indicating the boundary between the sidewalk and the roadway. The absence or damage of these warning surfaces can lead to confusion and disorientation, increasing the potential for crashes. Without these tactile indicators, visually impaired pedestrians may inadvertently step into the roadway. A missing detectable warning surface at a driveway can be seen in Figure 19.

Figure 19 - Missing Detectable Warning Surface at Driveway Crosswalk

Debris and gravel were seen on the US-23 overpass shoulder and 'sidewalk', as shown in Figure 20. This is a safety concern for both pedestrians and cyclists. A well-travelled path from the end of the sidewalk along Plymouth Road onto the 'sidewalk' of the US-23 overpass was observed, indicating pedestrians and bicyclists regularly traverse the US-23 overpass. The presence of debris and gravel can create slip and trip hazards, making it difficult for pedestrians to maintain their footing and increasing the potential for falls. For bicyclists, the loose gravel can cause loss of traction, leading to potential crashes and injuries.

Gravel Along US-23 Overpass

Debris Along US-23 Overpass

Figure 20 - US-23 Overpass Obstructions

The pedestrian facilities were observed to be dimly lit, with no dedicated pedestrian-scale lighting. At the intersection of Plymouth Road and Green Road, the lighting is primarily focused on the intersection and quadrant landings, leaving the sidewalks with minimal illumination. It was also noted that lighting was not present along any other driveways or crosswalks throughout the study corridor. This lack of lighting can make it difficult for pedestrians to navigate safely or simply feel less comfortable, especially during nighttime or low-light conditions. Additionally, the dim lighting makes it hard for motorists to see pedestrians, further increasing the potential for a crash.

During the field review, the RSA team noticed pedestrians and bicyclists crossing Plymouth Road, particularly along the western limit of the study corridor between Green Road and the Southbound US-23 On-Off Ramp intersection. The team observed that there is no mid-block crossing present in the area, despite observing several midblock pedestrian crossing movements. Drivers are less likely to expect the present of pedestrian or bicyclists crossing the roadway at locations without marked crossings. This is further compounded by the wide six-lane cross-section and posted speed limit of 45 MPH, increasing the potential for a severe VRU involved crash.

The team observed that the sidewalk along the south side of the Plymouth Road corridor ends just before the US-23 overpass, and the sidewalk on the north side ends just before the Southbound US-23 On-Off Ramp intersection. Additionally, a desire path was identified starting at the end of the sidewalk and continuing across the US-23 overpass. This desire path indicates a need for an extended pedestrian path east of the US-23 overpass and suggests that pedestrians and bicyclists are present along the eastern limits of the corridor, which was observed by the RSA team during field review. Consequently, when pedestrians and bicyclists are forced to travel along the roadway without a dedicated sidewalk facility, they are at a higher potential for conflicts or near missed with motorists due to their proximity to the roadway.

Lastly, while bicycle parking facilities are provided at the Park and Ride, there are no dedicated bicycle facilities connecting to this location. While no cyclists were observed using the bicycle parking area during the field review, they were observed traversing the corridor along Plymouth Road. Without a dedicated facility or otherwise delineated area of the roadway, cyclists are forced to share the road with motor vehicles, increasing the potential for crashes and injuries. Drivers may also be less likely to expect the presence of cyclists without the indications provided by bike lanes, signage, or other delineation. Figure 21 shows a bicyclist riding in the roadway with no dedicated bicycle facility.

Figure 21 - Bicyclist Observed Riding in the Roadway

Members of the audit team felt that crashes related to this safety concern would occur frequently with high severity resulting in an overall rating of F.

Expected Crash Types:	Vulnerable Road User Involved
Expected Frequency:	Frequently
Expected Severity:	High
Rating:	**F**

POTENTIAL TREATMENTS

Trim Vegetation Obstructing Visibility

It is recommended that the overgrown vegetation obstructing the Southbound US-23 On Ramp intersection and sidewalk be trimmed. This action will improve pedestrian safety by enhancing the visibility of pedestrians crossing at the intersection, allowing motorists to see them more clearly and react in a timely manner. Additionally, trimming the vegetation will reduce obstacles along the sidewalk, making it easier and safer for pedestrians to navigate. Having clear and unobstructed pathways is essential for the safety and accessibility of all road users, particularly vulnerable individuals such as children, the elderly, and those with limited mobility.

Refresh Pedestrian Crossing Pavement Markings

Consider refreshing crosswalk markings, particularly at the Southbound US-23 On Ramp and Plymouth Road Park and Ride, to enhance the visibility of the crosswalks and notify motorists of possible pedestrian crossings. It is recommended to use continental or other high-visibility crosswalk markings to further enhance visibility, as opposed to the traditional crosswalk markings currently present at the crosswalk.

Resurface Pavement

Consider repaving the corridor to improve pavement condition and friction performance, with particular attention to the crosswalks along the corridor. Repaving the roadway will enhance safety for pedestrians and cyclists by providing a smoother and more even surface, reducing the potential for trips and falls. Improved pavement conditions will allow crosswalk markings to be more visible and durable, making it easier for motorists to identify pedestrian crossing areas and react accordingly.

Replace/Install Detectable Warning Surfaces and ADA Ramps and Landings as Needed

It is recommended that detectable warning surfaces and ADA ramps be replaced or installed where needed, ensuring they are fully ADA compliant. These improvements will provide safety benefits, particularly for visually impaired individuals. Detectable warning surfaces offer tactile cues that alert visually impaired pedestrians to the presence of crossings, helping them navigate safely. ADA ramps help all pedestrians, including those with mobility impairments, access sidewalks and crosswalks without difficulty. By implementing these measures, we can create a safer and more inclusive environment for all road users.

Clear US-23 Overpass Debris

It is recommended that debris and gravel be cleared from the US-23 overpass shoulder and sidewalk. Removing these obstacles will reduce the potential for trips and falls for pedestrians, leading to a safer walking environment. For bicyclists, clearing the gravel will improve traction and reduce the potential for falls, which could lead to conflicts or near misses with motorized vehicles. Having a clean and unobstructed pathway is essential for the safety and accessibility of all road users, particularly vulnerable individuals such as children, the elderly, and those with limited mobility.

Install Pedestrian Level Lighting

It is recommended that pedestrian-level lighting be installed along the corridor where sidewalks are present, such as the lighting shown in Figure 22. This improvement will enhance pedestrian visibility, making it easier for motorists to see pedestrians, especially during nighttime or low-light conditions. Proper lighting will also help pedestrians navigate safely, reducing the potential for crashes and creating a more secure environment for vulnerable road users such as children, the elderly, and individuals with disabilities. Additionally, installing pedestrian-level lighting will improve the overall aesthetic of the area, creating a more welcoming and attractive environment for all road users.

Figure 22 - Existing Pedestrian Level Lighting in Ann Arbor – Ann Street (Source: Google Earth Streetview)

Long Term Opportunities

Below are some recommendations that, while more costly and long-term, would improve vulnerable road user safety. However, for each recommendation, a road diet would likely be needed, which would require further analysis to determine if it is appropriate to implement. When considering a road diet along the corridor, it should be understood that Plymouth Road is designated as a BRT (Bus Rapid Transit) corridor in the City of Ann Arbor's long-range plan, which may affect the feasibility of a road diet due to limitations in lane use repurposing.

<u>Explore Mid-block Crossing Opportunities</u>

Based on crash data, the fatal pedestrian crash as well an injury crash occurred from a pedestrian crossing Plymouth Road between Green Road and the Southbound US-23 On Ramp. Field observations further confirmed that a significant number of pedestrians and bicyclists frequently cross in this area. By providing a designated crossing space, like the one shown in Figure 23, which is located just west of the study area, pedestrians and bicyclists have a safe and clear path to cross. The crossing may reduce the likelihood of vulnerable road user crashes and will channelize pedestrian traffic to a single location, reducing the frequency of unpredictable crossings along Plymouth Road.

Figure 23 – Pedestrian Hybrid Beacon Crossing Along Plymouth Road West of Green Road

Consideration should be given to the use of a pedestrian refuge island to support any potential midblock crossing. The west section of Plymouth Road consists of a 6-lane cross section, which increases the complexity for drivers attempting to turn left from business driveways. Left-turning drivers must find acceptable gaps across multiple lanes of oncoming high-speed traffic which can increase the potential for angle and other crash types that tend to be more severe in nature.

To decrease the risk of crashes resulting from left-turns and maintain efficient traffic operations along Plymouth Road and free space for a potential pedestrian refuge island, right-in/right-out driveway access should be considered for businesses along Plymouth Road. A right-in/right-out configuration which is shown in Figure 24, restricts left-turns out of driveways, reducing potential conflict points and the risk of severe crashes, while still allowing access to businesses. Importantly, all businesses along Plymouth Road have access from Green Road.

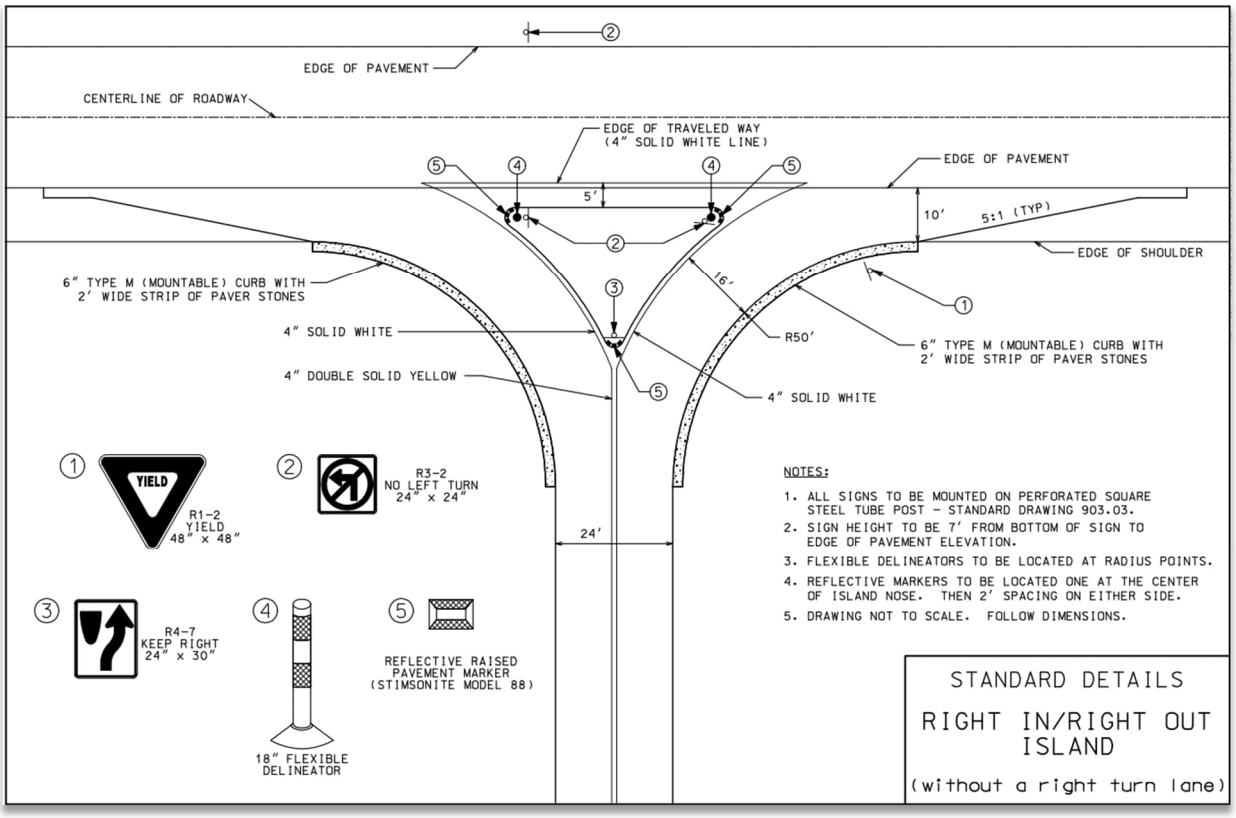


Figure 24 - Right-in/Right-out Example[3]

Build Out Sidewalk Network to Address Desire Lines

Consider extending the existing sidewalk network along Plymouth Road east of the US-23 overpass extending to Earhart Road and the medical facilities beyond, as shown in Figure 25. This would help to separate vulnerable road users from motorists, reducing the potential for VRU involved crashes. The new sidewalk would create a continuous pedestrian pathway, connecting Plymouth Road to Earhart Road and the nearby medical campuses, facilitating safer and more convenient access for all users.

It should be noted that the available right of way and existing drainage ditches may increase the level of effort required to implement this treatment. Additional review of existing right of way and coordination with property owners along this segment of Plymouth Rd would be required.

[3] Source: https://www.modot.org/sites/default/files/documents/RightInOut.pdf

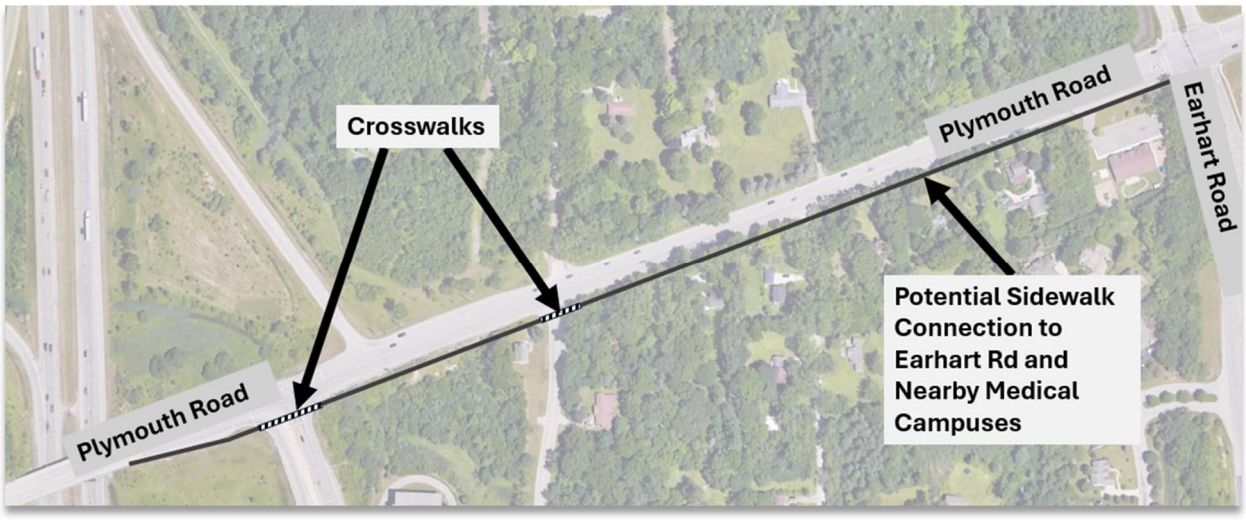


Figure 25 - Continuous Sidewalk Connection Concept

Install Bicycle Facilities Along Plymouth Road

Consider installing bicycle facilities within the roadway. If these facilities are installed, it is essential to include proper pavement markings such as intersection conflict markings and bike boxes at intersections. These markings will make bike paths more visible to motorists, improving driver awareness for the presence of cyclists and allowing motorists to navigate safely near them. By installing visible bike paths, a safer and more accessible environment for all road users is created, particularly for bicyclists who currently lack dedicated space within the roadway.

Figure 26 - Example of Bike lanes, Bike Boxes, and Conflict Markings at an Intersection[4]

[4] Source: https://www.vdot.virginia.gov/doing-business/technical-guidance-and-support/transportation-and-mobility-planning/bicycle-and-pedestrian-accommodations/bicycle-and-pedestrian-treatments/

VISIBILITY CONCERNS

SAFETY CONCERNS

During the field review, the team observed that vegetation was obstructing not only crosswalks and sidewalks, as mentioned in the vulnerable road user section, but also roadway signs and signals. This obstruction can reduce the time motorists have to identify traffic signals, signage, or other roadway conditions, limiting their ability to react and respond accordingly.

Vegetation Obstructing Signage ***Vegetation Obstructing Signal***

Figure 27 – Examples of Vegetation Obstructions

During the nighttime field review, the RSA team observed that there was no overhead or intersection lighting east of the Southbound US-23 On-Off Ramp intersection. The lack of lighting along Plymouth Road can be seen in Figure 28. This lack of lighting makes it more difficult for both motorists and pedestrians to see and be seen, increasing the potential for dark or low light condition crashes. Pedestrians, especially those who are visually impaired, may find it challenging to navigate safely in low-light conditions. Additionally, motorists may have difficulty identifying crosswalks, pedestrians, and other potential hazards, further exacerbating the need for adequate lighting. Having proper lighting in this area is essential for the safety and accessibility of all road users.

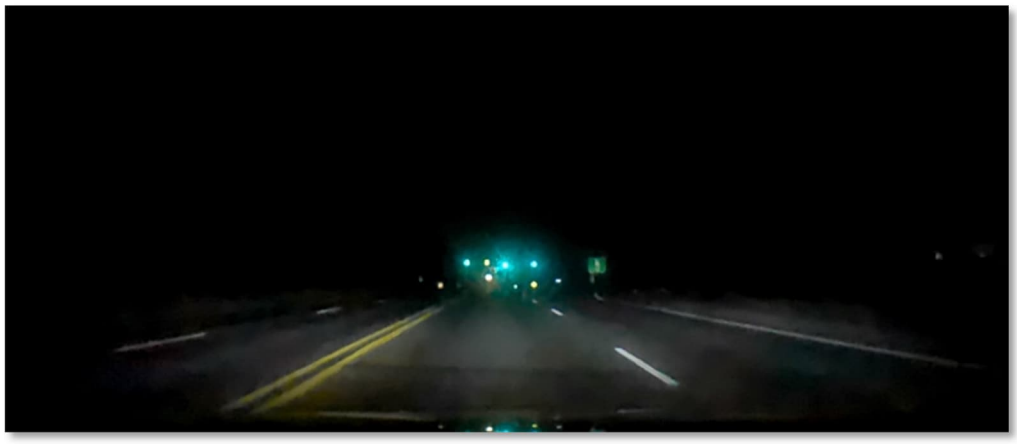


Figure 28 - Lack of Corridor Lighting Along Plymouth Road, East of Southbound US-23 On-Off Intersection

During the nighttime review it was observed that there were signs along the corridor with reduced retroreflectivity. The deterioration in the signs' visibility poses safety concerns, particularly during nighttime or adverse weather conditions when visibility is already more limited. Retroreflective signs are important components of roadside infrastructure to help inform and guide drivers, helping them see and respond to essential information promptly. A lack of clear and visible signage can lead to confusion, delayed reactions, and near misses, increasing the potential for crashes.

Members of the audit team felt that crashes related to this safety concern would occur occasionally with moderate severity resulting in an overall rating of E.

Expected Crash Types:	Vulnerable Road User Involved, Rear End, Sideswipe Same
Expected Frequency:	Occasional
Expected Severity:	Moderate
Rating:	**E**

POTENTIAL TREATMENTS

Trim Vegetation Where Needed

It is recommended that the overgrown vegetation obstructing the signs and signals along the corridor be trimmed. Trimming vegetation will enhance visibility and help drivers clearly see and respond to essential information, such as traffic signals, warning signs, and guidance signs. This is crucial for maintaining smooth traffic flow and reducing the potential for crashes. When drivers can see these indicators clearly, they can make informed decisions and react promptly to changing road conditions.

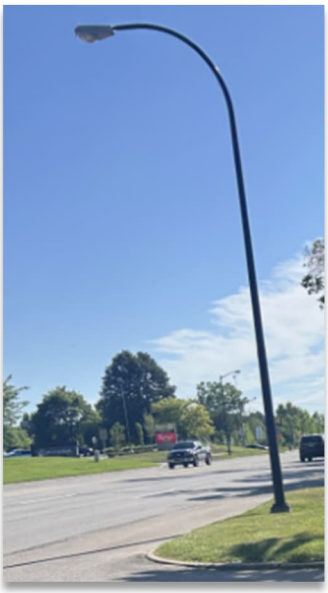


Figure 29 - Example of Existing Overhead Lighting

Install Overhead Roadway and/or Intersection Lighting

Consider installing overhead lighting east of the Southbound US-23 On-Off Ramp intersection, such as the lighting shown in Figure 29. Overhead lighting improves visibility during nighttime and adverse weather conditions, allowing drivers to see the road, signs, and potential hazards more clearly. This increased visibility can help reduce the potential for crashes by enabling drivers to react promptly to changing road conditions.

Consider Recessed Wet Reflective Pavement Markings

Consider installing recessed wet reflective pavement markings as it would enhance safety and visibility along the corridor. These markings are designed to remain visible even in wet conditions, providing clear guidance to drivers during rain or other adverse weather. This increased visibility can help prevent crashes by improving the visibility of lane boundaries and other important road indicators. Additionally, recessed markings are less prone to wear and tear from traffic, making them a durable and longer-lasting solution. Overall, installing these pavement markings would contribute to a safer and more reliable driving environment, especially during adverse weather conditions.

Figure 30 – Recessed Wet Reflective Pavement Markings[5]

[5] Source: https://pkcontracting.com/permanent-pavement-markings/

SAFETY CONCERNS

While in the field, the RSA team closely reviewed the three signalized intersections along Plymouth Road within the study limits. The three signalized intersections along Plymouth Road are Green Road, Southbound US-23 On-Off Ramp, and Northbound US-23 On-Off Ramp. The team identified several safety concerns at the intersections, which are described below.

First, the team observed that all intersections along the corridor have the potential for advanced safety features to be installed or improved. The absence of these safety features may increase driver difficulty in identifying the signal, driver confusion, and compromising pedestrian visibility.

Additionally, during the nighttime field review, it was observed that there are non-illuminated "Left-Turn" and "No Left Turn" case signs at the southbound US-23 On-Off ramp intersection. This lack of illumination reduces the visibility of the signs for drivers, which can lead to missed turns or sudden lane changes, increasing the potential for crashes to occur. Additionally, the "No Left Turn" case sign is one wrong way driving preventative measure that is not as visible under dark lighting conditions. Non-illuminated signs can also be difficult for unfamiliar drivers to see, especially in low-light conditions. Figure 31 shows the eastbound approach of the southbound US-23 On-Off Ramp intersection during daylight and nighttime conditions. From the figure, it shows the left-turn case sign visible during daytime conditions but no longer visible during nighttime conditions.

Figure 31 – Non-illuminated Left Turn Case Sign at Southbound US-23 On-Off Ramp Intersection

It was observed that there is a lane alignment shift through the westbound approach at the southbound US-23 On-Off ramp intersection, with the alignment shifting approximately 8 feet to the right. This shift could potentially create confusion for drivers, especially those unfamiliar with the area, leading to sudden lane changes or hesitation. Such actions can increase the likelihood of sideswipe same direction and rear end crashes and disrupt the smooth flow of traffic. Additionally, deteriorating pavement joints were observed in the roadway along the approach, which may be mistaken for pavement markings under inclement weather conditions or sun glare. Figure 32 below illustrates the alignment shift, with the yellow guidelines representing the alignment of the roadway if there was no shift and the green guidelines representing the transition of the lane lines along the roadway.

Figure 32 - Illustration of the Alignment Shift at Southbound US-23 On-Off Ramp Intersection

Lastly, there are multiple dual left or right turn movements at the intersections along the Plymouth Road study corridor. There is a dual southbound left turn movement at Plymouth Road, a dual southbound right turn movement at Southbound US-23 On-Off Ramp, and a dual northbound left turn movement at Northbound US-23 On-Off Ramp. At all these dual turn movements, there are no guidelines for motorists to follow while completing their turn. The lack of these guidelines may lead drivers to misjudge the appropriate turning radius and drift into the other turn lane leading to sideswipe same direction crashes. This confusion can be increased during peak traffic times when multiple vehicles are attempting to turn simultaneously.

Members of the audit team felt that crashes related to this safety concern would occur occasionally with low severity resulting in an overall rating of C.

Expected Crash Types:	Sideswipe Same, Rear End
Expected Frequency:	Occasional
Expected Severity:	Low
Rating:	**C**

POTENTIAL TREATMENTS

Modernize Signals Along Plymouth Road

Consider updating the Green Road intersection, Southbound US-23 On-Off Ramp intersection, and Northbound US-23 On-Off Ramp intersection with the following in order to improve the safety and operation of the intersection. Table 5 depicts which treatments are being recommended for each intersection with descriptions of each provided following the table. It should be noted that the shared jurisdiction with the Michigan Department of Transportation (MDOT) will require coordination to implement any recommendations discussed below.

Table 5 - Signal Modernization Recommendations Per Intersection

	INTERSECTION		
RECOMENDATION	Green Road	Southbound US-23 On-Off Ramp	Northbound US-23 On-Off Ramp
Backplates & Tethers	✗	✓	✓
Leading Pedestrian Intervals (LPIs)	✗	✓	✗
High Visibility Crosswalk	✗	✓	✗
Turn Guide Pavement Markings	✓	✓	✓
Box Span	✗	✗	✓
Accessible Pedestrian Signal (APS)	✓	✓	✗
Update Clearnce Intervals	✓	✗	✗

Backplates and Tethers – Southbound US-23 On-Off Ramp and Northbound US-23 On-Off Ramp

It is recommended to install backplates and tethers onto the traffic signals at the southbound US-23 On-Off ramp and Northbound US-23 On-Off Ramp intersection, such as what is shown in Figure 33. Adding backplates onto traffic signals enhances the visibility of the signal heads by providing a dark background that contrasts low angle sun glare and the general visual background environment. This contrast helps drivers to see the signals more clearly, especially in conditions where there might be background distractions such as store lights, signs, or sunlight. For east/west facing signals, backplates are particularly effective in mitigating sun glare, which can obscure the visibility of the signal lights during sunrise and sunset. Additionally, tethers provide stability to the signal heads, helping them remain in the correct position even in adverse weather conditions such as strong winds. This stability helps maintain clear visibility of the signals for drivers, reducing the potential for confusion and crashes.

Figure 33 – Example of Backplates and Tethers – Detroit, Gratiot Avenue & Chene Street (Source: Google Earth Streetview)

Leading Pedestrian Intervals (LPIs) – Southbound US-23 On-Off Ramp

Consider adding a Leading Pedestrian Interval (LPI) at the south leg crosswalk at the intersection with the Park and Ride entrance as they enhance pedestrian safety by providing pedestrians with a head start of a few seconds before vehicles are given a green signal to proceed. This head start allows pedestrians to establish their presence in the crosswalk, making them more visible to turning vehicles and reducing the likelihood of conflicts. Additionally, LPIs can improve traffic flow by reducing the number of pedestrian-vehicle conflicts, leading to a smoother and more efficient intersection operation.

Continental High Visibility Crosswalk – Southbound US-23 On-Off Ramp

Consider striping the Southbound US-23 On Ramp crosswalk and Plymouth Road Park and Ride crosswalk with a continental high visibility pavement marking. This striping makes pedestrian crossings more visible to drivers, especially in low-light conditions or during inclement weather, reducing the likelihood of crashes. The bright and reflective markings used in high visibility crosswalks catch drivers' attention, prompting them to slow down and yield to pedestrians. Lastly, these crosswalks provide clear guidance for pedestrians regarding appropriate crossing areas.

Turn Guide Pavement Markings – Green Road, Southbound US-23 On-Off Ramp, and Northbound US-23 On-Off Ramp

Consider installing turn guide pavement markings at the dual turning movements at the intersections. Guidelines provide clear guidance to drivers, indicating the correct lanes to use when making dual turns. This reduces confusion and helps prevent improper lane usage, which can lead to crashes. Additionally, these markings help maintain an orderly flow of traffic by helping vehicles stay within their designated lanes during the turn. Lastly, turn guide markings improve the overall visibility of the turn lanes, making it easier for drivers to navigate the intersection, especially in low-light conditions or during inclement weather.

Green Road

Southbound US-23 On-Off Ramp

Northbound US-23 On-Off Ramp

Figure 34 – Turn Guide Pavement Marking Concepts

Convert to Box Span – Northbound US-23 On-Off Ramp

It is recommended to convert the intersection signal to a box span configuration. Box span layouts offer several advantages, including improved visibility, enhanced safety, reduced maintenance, and aesthetic appeal. By positioning signal heads directly above the lanes they control, box spans create better visibility for approaching drivers, reducing the likelihood of missed signals. This uniform alignment also helps in reducing driver confusion, thereby enhancing safety. Additionally, box span signal configurations provide some maintenance benefits, as signals are typically located over individual approaches rather than the center of the intersection allowing for targeted maintenance.

Accessible Pedestrian Signal (APS) – Green Road and Southbound US-23 On-Off Ramp

It is recommended to install accessible pedestrian signals at the intersections. An APS is a device that provides auditory cues in addition to the standard visual signal and countdown timers to assist visually impaired pedestrians when crossing streets at signalized intersections. By offering clear and timely information about the walk signal status, APS reduces the potential for VRU involved crashes and promotes overall pedestrian safety. They improve crossing accessibility for a wider range of pedestrians with varying physical abilities and serve as one component supporting inclusive and equitable access to transportation infrastructure.

Review/Update Clearance Intervals – Green Road

Consider reviewing and updating the clearance intervals, specifically the pedestrian walk times, as needed at the intersection as they were last optimized in 2018. Updating the clearance intervals may enhance safety at the intersection as it will provide adequate time for pedestrians to clear the crosswalks and vehicles to clear the intersection before conflicting traffic movements begin, reducing the likelihood of crashes. This is particularly important for larger vehicles and those making left turns, as they often require more time to clear the intersection. Additionally, updated clearance intervals can improve traffic flow by reducing the number of vehicles caught in the intersection during signal changes, which can lead to congestion and delays.

Install Illuminated Case Signs at US-23 Interchange Intersections

Consider replacing the current non-illuminated case signs at the Southbound and Northbound US-23 On-Off Ramp intersections with illuminated case signs. Illuminated signs improve visibility, making them easier to see in low-light conditions, such as at night or during inclement weather. This increased visibility helps drivers make timely and accurate decisions, reducing the potential for crashes.

Realign Westbound Approach at Southbound US-23 On-Off Ramp Intersection

It is recommended to realign the westbound approach via pavement marking revisions at the Southbound US-23 On-Off Ramp intersection. Realigning the approach can improve the flow of traffic by creating smoother transitions and reducing abrupt lane shifts, which helps to minimize congestion and the likelihood of sideswipe crashes. This could be accommodated by consolidating the right-turn lane and outer through lane into a single shared through and right-turn lane. An operational analysis would be required to determine if this approach is feasible to help realign the westbound approach.

PAVEMENT MARKINGS

SAFETY CONCERNS

During the field review faded or missing pavement markings were observed throughout the study corridor, as shown in Figure 35. This lack of clear markings can lead to several safety concerns, including confusion for drivers about lane boundaries and proper turning paths. Without visible pavement markings, drivers may inadvertently drift out of their lanes or make incorrect turns, increasing the potential for crashes. Additionally, faded or missing markings can make it difficult for pedestrians to identify safe crossing areas, further compromising safety. Addressing these issues is essential to provide clear guidance for all road users and to enhance the overall safety and functionality of the corridor.

Figure 35 - Faded Pavement Markings

Furthermore, the stop bar at the Plymouth Road Park and Ride includes a gap to separate the left turn and right turn movements which is delineated by hatched pavement markings. This hatched area is significantly worn, resulting in a lack of clear delineation. Additionally, there is no signage to inform drivers of lane designation. This absence of distinct information can lead to confusion for drivers, potentially resulting in improper lane usage and increased potential for sideswipe crashes. Figure 36 depicts the gapped stop bar at the Park and Ride.

Figure 36 - Gapped Stop Bar at Plymouth Road Park and Ride

Members of the audit team felt that crashes related to this safety concern would occur occasionally with low severity resulting in an overall rating of C.

Expected Crash Types:	Sideswipe Same, Rear End
Expected Frequency:	Occasional
Expected Severity:	Low
Rating:	**C**

POTENTIAL TREATMENTS

Refresh Pavement Markings

It is recommended to refresh the pavement markings along the corridor, including crosswalks, stop bars, lane use arrows, lane use wording such as "ONLY," and hatching. When updating these markings, it is advisable to use recessed wet reflective pavement markings where feasible to improve conspicuity. Clear and well-maintained pavement markings are essential for guiding drivers and pedestrians, reducing confusion, and preventing crashes.

Delineate the Gapped Stop Bat at Plymouth Road Park and Ride

Consider adding delineators to the gapped stop bar, as well as adding arrow pavement markings and lane use signage on the approach. These improvements may enhance safety by providing clear and visible guidance to drivers, reducing confusion and the potential for crashes. Refreshed hatched markings and delineators will clearly indicate the separation of lanes, helping drivers follow the correct paths. Updated arrow markings and lane use signage will provide clear instructions on lane usage, reducing the likelihood of improper lane changes.

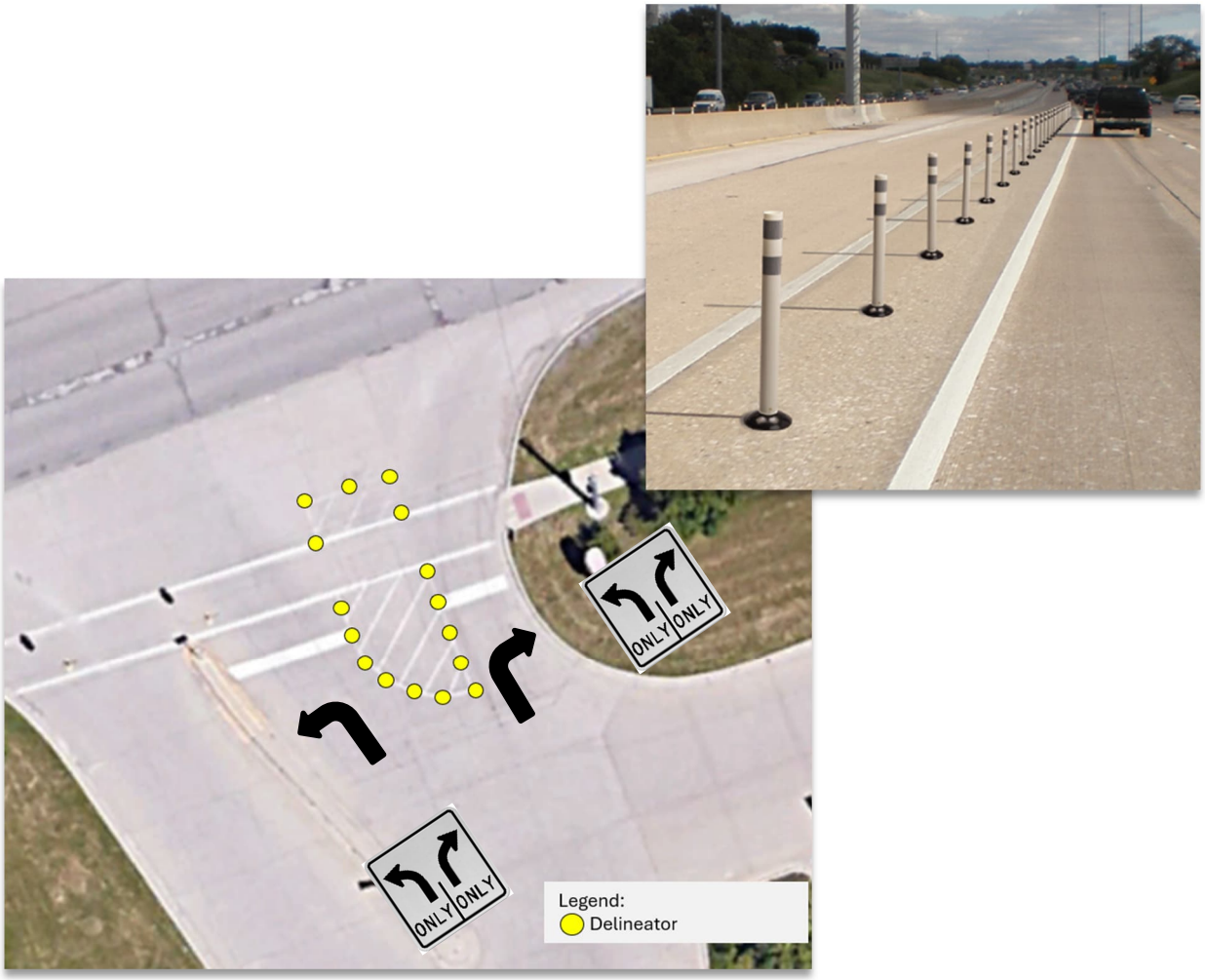


Figure 37 - Plymouth Road Park and Ride Approach Concept[6]

[6] Source: https://trafficsafetyproducts.net/blog/post/types-of-delineators

SIGNAGE

SAFETY CONCERNS

It was observed that the "Bridge May Be Icy" signs placed before the US-23 overpass were cracked and exhibited minimal retroreflectivity at nighttime. This reduced visibility and legibility increases the potential for drivers to be unaware of the presence of the bridge. Additionally, these older style signs have been replaced in the current version of the MMUTCD (Michigan Manual on Uniform Traffic Control Devices). The sign present for the eastbound traffic is shown in Figure 38.

Figure 38 - "Bridge May Be Icy" Signs at US-23 Overpass

Field reviews revealed that there were no lane use signs for the eastbound and westbound approaches at the US-23 interchange intersections. This lack of positive guidance may contribute to driver confusion and potential lane violations. Without clear lane use signs, the potential for improper lane changes and sudden maneuvers increases, which can result in rear ends and sideswipe crashes and disrupt the smooth flow of traffic.

Members of the audit team felt that crashes related to this safety concern would occur occasionally with negligible severity resulting in an overall rating of B.

Expected Crash Types:	Sideswipe Same, Rear End
Expected Frequency:	Occasional
Expected Severity:	Negligible
Rating:	**B**

POTENTIAL TREATMENTS

Install MUTCD compliant "Bridge Ices Before Road" signs in place of old signage

It is recommended to replace the current "Bridge May Be Icy" signs at the US-23 overpass, as they are worn, with reduced visibility under dark or inclement weather conditions. These should be replaced with current MMUTCD-compliant "Bridge Ices Before Road" signs, as seen in Figure 39. Updating the signs will enhance their visibility and effectiveness, helping drivers receive clear and timely warnings about potential icy conditions on the bridge.

Figure 39 - MUTCD Compliant US-23 Overpass Signage[7]

Install 'Right Lane Must Turn Right' or other equivalent at Eastbound Right Turn Only Lane at Park and Ride

It is recommended to install a "Right Lane Must Turn Right" sign or other clarifying guide signs at the Eastbound Right Turn Only Lane at the Park and Ride entrance. This signage would help to reduce the potential for last minute lane changes or driver frustration, which can lead to sideswipe same crashes. It also helps in maintaining a smooth traffic flow by guiding drivers to make the correct maneuvers well in advance. Clear signage is crucial for preventing confusion and helping all road users navigate safely and efficiently.

Alternately, consider extending the curb between the southbound US-23 on ramp and Park and Ride lot to end the eastbound right turn only lane at the southbound US-23 on ramp, pending supporting traffic operations analysis. This would clarify use of the "Right Lane Must Turn Right" sign and still allow drivers entering the Park and Ride lot to do so from the current outer through lane.

Figure 40 - Right Lane Must Turn Right (R3-7R) [8]

[7] Source: https://mutcd.fhwa.dot.gov/pdfs/11th_Edition/mutcd11thedition.pdf

[8] Source: https://mutcd.fhwa.dot.gov/pdfs/11th_Edition/mutcd11thedition.pdf

Install Lane Use Signs Where Appropriate – Ensure MUTCD Compliance

Consider installing lane use signs for the eastbound and westbound approaches at the US-23 interchange intersections, such as the ones shown in Figure 41. Lane use signs will provide clear guidance to drivers, indicating the correct lanes for turning or continuing straight, reducing the potential for last minute lane changes, potentially resulting in sideswipe same or rear end crashes.

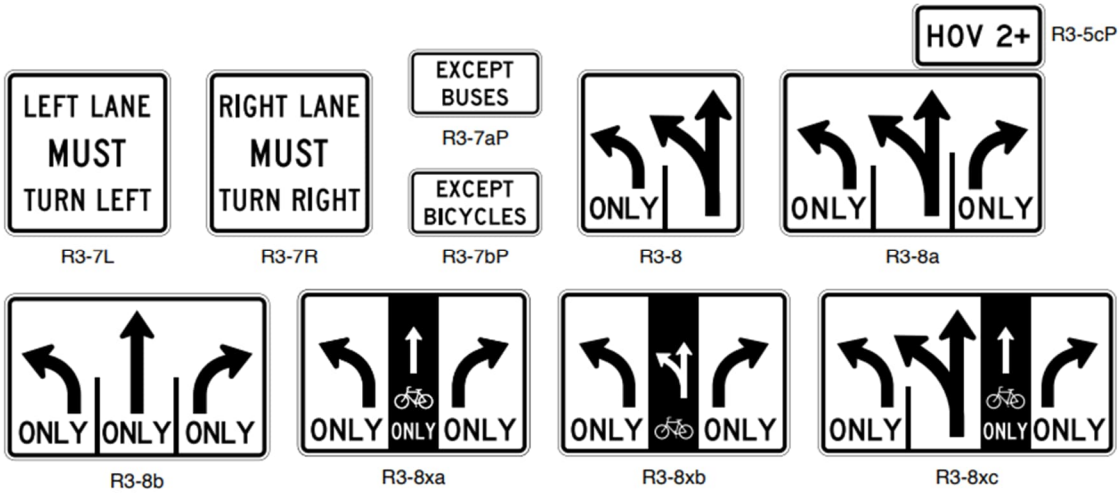


Figure 41 - Lane Use Sign Examples[9]

Consider Refreshing Signage Throughout Corridor Ensuring Signs are Retroreflective

Consider refreshing the signage throughout the corridor and ensuring that all signs are MUTCD compliant and retroreflective. This update will enhance the visibility and effectiveness of the signs, especially during nighttime and adverse weather conditions.

[9] Source: https://mutcd.fhwa.dot.gov/pdfs/11th_Edition/mutcd11thedition.pdf

5.2 OTHER CONSIDERATIONS

It was observed that there are depressions adjacent to the sidewalk where grass is missing. These depressions represent potential trip hazards for pedestrians and bicyclists, as the uneven surface increases the likelihood of someone stumbling or falling. An example of these depressions can be seen in Figure 42. It is recommended that the depressions adjacent to the sidewalk be filled in to create a smooth transition from the sidewalk to the grass throughout the study area. This improvement will enhance pedestrian and bicyclist safety by reducing the potential for trips and falls caused by the uneven surface.

Figure 42 - Depression Adjacent to Sidewalk

The team also observed debris in the medians at the US-23 interchange intersections. The debris present in the median at the Northbound US-23 On-Off Ramp intersection is shown in Figure 43. Consider cleaning the debris and gravel present at the medians (directly or in coordination with MDOT as appropriate) as it contributes to a negative perception of the roadway.

Figure 43 - Debris Present in Median at Northbound US-23 On-Off Ramp Intersection

6 SAFETY ANALYSIS

The Highway Safety Manual (HSM) introduced a science-based technical approach to incorporating safety into traditional roadway planning and safety analyses. The first edition of the HSM (2010) provides the best factual information and tools in a useful form to facilitate roadway planning, design, operations, and maintenance decisions based on precise consideration of their safety consequences. The primary focus of the HSM is the introduction and development of analytical tools for predicting the impact of transportation project and program decisions on road safety.

For this analysis, the HSM Analysis spreadsheet provided and maintained by MDOT was utilized, which allows the predicted number of crashes to be proportionally increased or decreased based on conditions in Michigan. The Urban & Suburban Segments (MI) and Urban & Suburban Intersection (MI) models were used for this analysis. Crash Modification Factors (CMF) were applied as applicable for the base conditions and proposed treatments. Given current limitations in the HSM methodology not all treatment recommendations were analyzed using the spreadsheet.

6.1 BASE CONDITIONS

An HSM analysis was completed for the length of the corridor utilizing 2024 traffic volumes and crash data from 2020 to 2024. Based on the HSM analysis detailed below, the intersections appear to be operating better than expected when compared to other intersections with similar characteristics. The segments appear to be experiencing more crashes than would be expected under similar conditions. Even if the intersections are operating better than expected, the recommended treatments are expected to provide positive safety benefits and should be considered as funding allows.

INTERSECTION CHARACTERISTICS

The base conditions used in the analysis for the study intersections are as follows:

Plymouth Road and Green Road

- Type: Urban/Suburban Intersection
- Traffic Control: Four-way Signal
- Major/Minor AADT: 24,000/8,500
- Major/Minor Road Flow Type: Two-way/Two-way
- Major/Minor Median Present: Not Present/Not Present
- Intersection Lighting: Present
- Total Major/Minor Number of Through Lanes: 5/2
- Major Road Speed Limit: 45 MPH
- Right Turn on Red Status Permitted
- Major Street Left Turn Lane on All Approaches: Present
- Additional CMF’s used: None

These base conditions expect a total of 6.971 crashes/year, of which 1.595 would include a fatality or injury. A review of the crash data observed an average of 4.8 total crashes/year, meaning there are 2.171 fewer expected crashes/year.

Plymouth Road and Southbound US-23 On-Off Ramp

- Type: Urban/Suburban Intersection
- Traffic Control: Four-way Signal
- Major/Minor AADT: 22,000/8,000
- Major/Minor Road Flow Type: Two-way/Two-way
- Major/Minor Median Present: Not Present/Present
- Intersection Lighting: Not Present
- Total Major/Minor Number of Through Lanes: 4/2
- Major Road Speed Limit: 45 MPH
- Right Turn on Red Status: Permitted
- Major Street Left Turn Lane on All Approaches: Not Present
- Additional CMF's used: None

These base conditions expect a total of 4.482 crashes/year, of which 1.051 would include a fatality or injury. A review of the crash data observed an average of 2.2 total crashes/year, meaning there are 2.282 fewer expected crashes/year.

Plymouth Road and Northbound US-23 On-Off Ramp

- Type: Urban/Suburban Intersection
- Traffic Control: Three-way Signal
- Major/Minor AADT: 21,000/8,000
- Major/Minor Road Flow Type: Two-way/Two-way
- Major/Minor Median Present: Not Present/Present
- Intersection Lighting: Not Present
- Total Major/Minor Number of Through Lanes: 2/0
- Major Road Speed Limit: 45 MPH
- Right Turn on Red Status: Permitted
- Major Street Left Turn Lane on All Approaches: Not Present
- Additional CMF's used: None

These base conditions expect a total of 2.283 crashes/year, of which 0.577 would include a fatality or injury. A review of the crash data observed an average of 0.6 total crashes/year, meaning there are 1.683 fewer expected crashes/year.

SEGMENT CHARACTERISTICS

The base conditions used in the analysis for the study segments are as follows:

Segment from Green Road to Southbound US-23 On-Off Ramp Intersection

- Cross-Section: 4-Lanes undivided with TWLTL*
- CTWLTL: Present
- Segment Length (Miles): 0.11
- AADT: 24,000
- Parallel Parking Lane: Not Present
- Segment Lighting: Present
- Lane Width: 11 ft
- Left Shoulder Width: 0 ft
- Right Shoulder Width: 0 ft
- Additional CMF's used: None

* The segment is 5-lanes undivided with a TWLTL. Due to limitations in the HSM methodology, 4-lanes undivided with a TWLTL was chosen.

These base conditions expect a total of 6.755 crashes/year, of which 0.78 would include a fatality or injury. A review of the crash data observed an average of 7.6 total crashes/year, meaning there are 0.845 excess expected crashes/year.

Segment from Southbound US-23 On-Off Ramp Intersection to Northbound US-23 On-Off Ramp Intersection

- Cross-Section: 4-Lanes undivided
- CTWLTL: Not Present
- Segment Length (Miles): 0.09
- AADT: 22,000
- Parallel Parking Lane: Not Present
- Segment Lighting: Not Present
- Lane Width: 11 ft
- Left Shoulder Width: 7 ft
- Right Shoulder Width: 7 ft
- Additional CMF's used: None

These base conditions expect a total of 9.075 crashes/year, of which 0.58 would include a fatality or injury. A review of the crash data observed an average of 10.4 total crashes/year, meaning there are 1.325 excess expected crashes/year.

6.2 RECOMMENDATION OPTIONS

A summary of HSM compatible crash modification factors (CMFs) and their estimated impact on safety operations at the study intersection are provided in the section below and the attached HSM analysis Excel files. A crash modification factor is applied to the total number of crashes to calculate the expected number of crashes after implementing a specified countermeasure. These factors are used to compare outcomes across various safety treatments, and to identify the most cost-effective measures to reduce crashes. A CMF < 1.0 indicates a decrease in expected crashes, and a CMF > 1.0 indicates an increase in expected crashes. A CMF = 1.0 indicates that no proven safety benefit has been determined. These factors are developed based on published studies on proven crash reduction countermeasures. Table 6 provides a consolidated summary of CMFs available for proposed treatments identified by the audit team. Several proposed treatments do not have CMFs but are still anticipated to provide positive safety benefits for the study intersection. Additionally, the following CMFs are listed individually, but packages of compatible treatments may provide additional deployment efficiencies.

Table 6 - Summary of HSM Compatible Crash Modification Factors

Proposed Treatment	Applicable Locations	Crash Type	Crash Severity	CMF[10]
Install Bike Lanes at Intersections (ID:3247)	All Intersections and Segments	Vehicle/ Bicycle	All	0.8
Increase Intersection Illuminance from Low to Medium (ID:8321)	- SB US-23 On-Off Ramp Int. - Segment East of SB US-23 Ramp - NB US-23 On-Off Ramp Int.	Nighttime	All	0.48
Install Wet-reflective Pavement Markings (ID:8101)*	All Intersections and Segments	All	All	0.887
Improve Signal Visibility (Backplates) (ID:3941)	- SB US-23 On-Off Ramp Int. - NB US-23 On-Off Ramp Int.	All	K, A, B, C	0.71
Install Box Span Signal (ID:8723)	NB US-23 On-Off Ramp Int.	Other	All	0.975
Adjust All-Red Clearance Interval (Review Clearance Intervals) (ID:4029)	Green Road	Angle, Head-on, Sideswipe	All	0.8
Increase Length of Signal Phases to Allow Pedestrians More Crossing Time (Review Clearance Intervals) (ID:5250)*	Green Road	All	All	0.98
Modify Signal Phasing (Implement Leading Pedestrian Intervals) (ID:9901)*	Southbound US-23 On-Off Ramp	All	All	0.9
Install a Pedestrian Hybrid Beacon (PHB or HAWK) (ID:10601)*	Segment East of Green Rd to West of SB US-23 On-Off Ramp	All	All	0.818

**CMF used in HSM analysis*

[10] Crash Modification Factors Clearinghouse (www.cmfclearinghouse.org)

A number of potential treatment combinations exist for the study intersections and segments. The following analysis considers a single scenario for each intersection and segment to help illustrate the potential benefits when implementing some of the recommended countermeasures. The expected improvements (per the HSM) are summarized in Table 7.

Intersections

Plymouth Road and Green Road

- Install wet-reflective pavement markings
- Increase length of signal phases to allow pedestrians more crossing time (Review clearance intervals)

Plymouth Road and Southbound US-23 On-Off Ramp

- Install wet-reflective pavement markings
- Modify signal phasing (Implement leading pedestrian intervals)

Plymouth Road and Northbound US-23 On-Off Ramp

- Install wet-reflective pavement markings

Segments

Green Road to Southbound US-23 On-Off Ramp Intersection

- Install wet-reflective pavement markings
- Install a pedestrian hybrid beacon (PHB or HAWK)

US-23 Interchange Area

- Install wet-reflective Pavement Markings

Table 7 - Expected Crash Frequency (HSM)

Intersection or Segment	Expected Crash Frequency (Crashes/Year)				Total Percent Reduction
	Base Conditions Expected (KABC)	Base Conditions Expected (PDO)	Expected with CMFs Applied (KABC)	Expected with CMFs Applied (PDO)	
Plymouth Road & Green Road	1.595	5.375	1.454	5.094	6.24%
Plymouth Road & Southbound US-23 On-Off Ramp	1.051	3.431	0.884	3.062	12.72%
Plymouth Road & Northbound US-23 Ramps	0.577	1.705	0.526	1.606	6.80%
Segment from Green Road to Southbound US-23 On-Off Ramp Intersection Ramps	0.78	5.975	0.70	5.740	4.77%
US-23 Interchange Area	0.58	8.495	0.57	8.456	0.54%

OPINION OF PROBABLE COST

Table 8 below provides a high-level summary of an opinion of probable cost associated with recommendation concepts where cost estimates were readily available based on MDOT's annual weight average unit price spreadsheet. These opinions include material pay items along with a 15% contingency. It should be noted that the opinion of probable cost does not include costs associated with mobilization, labor, project management, or other ancillary costs.

Table 8 - Example Treatment Opinion of Probable Cost

Suggestions	Treatment Extent	Opinion of Probable Cost
Vegetation Trimming (Pedestrian Obstructions)	Southbound US-23 On Ramp, Various Sidewalk Locations (Up to 4 Spot Locations)	$2,392
Pedestrian Crossing Pavement Marking Refresh	Southbound US-23 On Ramp (120'), Park and Ride (180')	$1,035
Pedestrian Crossing Pavement Repair	Southbound US-23 On Ramp 'Driveway Approach'	$1,308
Detectable Warning Surface Installation	Drive crossings without existing detectable warning surfaces, Southbound US-23 Ramp Pedestrian Crossing, Park and Ride Pedestrian Crossing	$3,192
US-23 Overpass Debris Clearing	US-23 Interchange & Overpass	N / A
Pedestrian Level Lighting	Existing Sidewalk (~800' per bound)	$136,390
Mid-Block Crossing	Plymouth Rd near Plum Market Drive	$201,250
Sidewalk Network Build-out	Connect Park and Ride Sidewalk end to Sidewalk at Earhart Rd at 5' width	$122,763
Bicycle Lane Installation	Road diet and addition of bike lane over half mile long segment	$54,711
Overhead Lighting	Corridor (~2,400')	$205,390
Recessed Wet Reflective Pavement Markings	Stop bars & Special Markings at US-23 Interchange / Park and Ride Traffic Signals	$15,779
Intersection Modernization (box span, backplates, tethers, etc.)	NB US-23 Interchange Ramp Signal	$402,500
Traffic Signal Backplates & Tethers	SB US-23 Ramp Signal	$28,405
Leading Pedestrian Intervals (LPIs)	Plymouth Rd at Green Rd	N / A
Turn Guide Pavement Markings	Plymouth Rd at Green Rd, SB US-23 Ramp Signal, NB US-23 Ramp Signal	$4,14
Accessible Pedestrian Signal System	Plymouth Rd at Green Rd	$11,040
Review Clearance Intervals	Plymouth Rd at Green Rd	N / A
Illuminated Case Signs	SB US-23 Ramp Signal, NB US-23 Ramp Signal	$8,556
Realign Westbound Approach Lane Pavement Markings	SB US-23 Ramp Intersection	$11,236
Delineate Park and Ride Stop Bar	Park and Ride Entrance	$1,251
Lane Use Signage	SB US-23 Ramp Signal, NB US-23 Ramp Signal (R3-8)	$1,162
Refreshing Corridor Signage	Corridor (excluding US-23 Interchange specific signs)	$4,382

7 SUMMARY

The City of Ann Arbor retained WSP to facilitate an Operational Service Road Safety Audit (RSA) along Plymouth Road from Green Road to the Northbound US-23 On Ramp. There are three signalized intersections within the study area at Green Road, Southbound US-23 On-off Ramp, and Northbound US-23 On-Off Ramp. The RSA was conducted primarily to review the corridor for vulnerable road user-related safety considerations and make suggestions.

The study area is in proximity to the University of Michigan North Campus and Medical Campuses. Shopping centers, restaurants, hotels, a park and ride lot, and businesses are located along Plymouth Road within the study area. These attractions contribute to the significant amount of vulnerable road users and vehicle traffic observed in the area. Some high-level observations made during the field review include:

- Significant Vulnerable Road User Presence
- Significant Transit Activity (UofM Transit and TheRide)
- Six- to four-Lane Cross Section
- Existing Corridor Lighting (at western limits)
- Sidewalk Facilities (at western limits)
- Crosswalks Present at Some Intersections (high visibility markings at Green Road)
- Vegetation Obstructing Signs and Sidewalks
- Access Drive Density (at western limits)

Crash data from 2020 through 2024 for the corridor was obtained by the RSA team with the first five months of sanitized 2025 crash data provided by the City of Ann Arbor. Four years of one-line crash data (2020-2024) was collected and UD-10 reports were provided by the City of Ann Arbor for crashes that occurred from January through May of 2025. During the study period, a total of 143 crashes were reported. Over the period there were two reported bicyclist-involved crashes, two pedestrian-involved crashes, and three reported minor injury (B) crashes. Additionally, one of the pedestrian crashes resulted in a fatality. Some safety concerns raised during discussions with stakeholders and identified by the audit team included:

- Vulnerable Road Users
    - Vegetations obstructing the view of pedestrian crossing at the Southbound US-23 On Ramp
    - Faded pavement markings
    - Broken concrete in crosswalks
    - Broken/Missing detectable warning surfaces
    - Debris/gravel on the US-23 overpass shoulders/’sidewalk’
    - Dimly lit pedestrian facilities
    - Lack of mid-block crossing
    - Non-continuous sidewalk
    - No bicyclist facilities
- Visibility Concerns
    - Overgrown vegetation obstructions
    - Lack of corridor/intersection lighting east of Southbound US-23 On-Off Ramp

- Intersections
    - Potential to modernize signals
    - Debris in/along US-23 ramp medians
    - Non-illuminated case signs
    - Lane alignment shift through southbound US-23 On-Off Ramp intersection/deteriorating pavement joints
    - Dual left/right turning movements
- Pavement Markings
    - Faded/ missing pavement markings
    - Gapped stop bar at the Plymouth Road Park and Ride
- Signage
    - Outdated and worn “Bridge May Be Icy” signage
    - Lane use signs not present for the eastbound and westbound approaches at US-23 interchange Intersections
    - Worn/reduced retroreflective signs

Various treatments were identified, which have been shown to have positive safety benefits and could help to reduce the potential for future crashes. These treatments are primarily focused on addressing updates to vulnerable road user safety, reducing confusion for motorists, modernizing/improving the features present at the intersections, and making the study area inclusive for all road users.