ROAD SAFETY AUDIT

GLEN AVENUE & CATHERINE STREET; GLEN AVENUE & ANN STREET; ANN STREET & ZINA PITCHER PLACE

ANN ARBOR, MI

PROJECT OWNER: SOUTHEAST MICHIGAN COUNCIL OF GOVERNMENTS (SEMCOG)
CITY OF ANN ARBOR

DATE: JULY 2025

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1 INTRODUCTION

The Southeast Michigan Council of Governments (SEMCOG) has retained WSP to facilitate a Road Safety Audit (RSA) at the intersections of Glen Avenue and Catherine Street, Glen Avenue and Ann Street, and Ann Street and Zina Pitcher Place located in the City of Ann Arbor, Michigan. The objective of this study was to conduct a formal safety performance examination of the intersection 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.

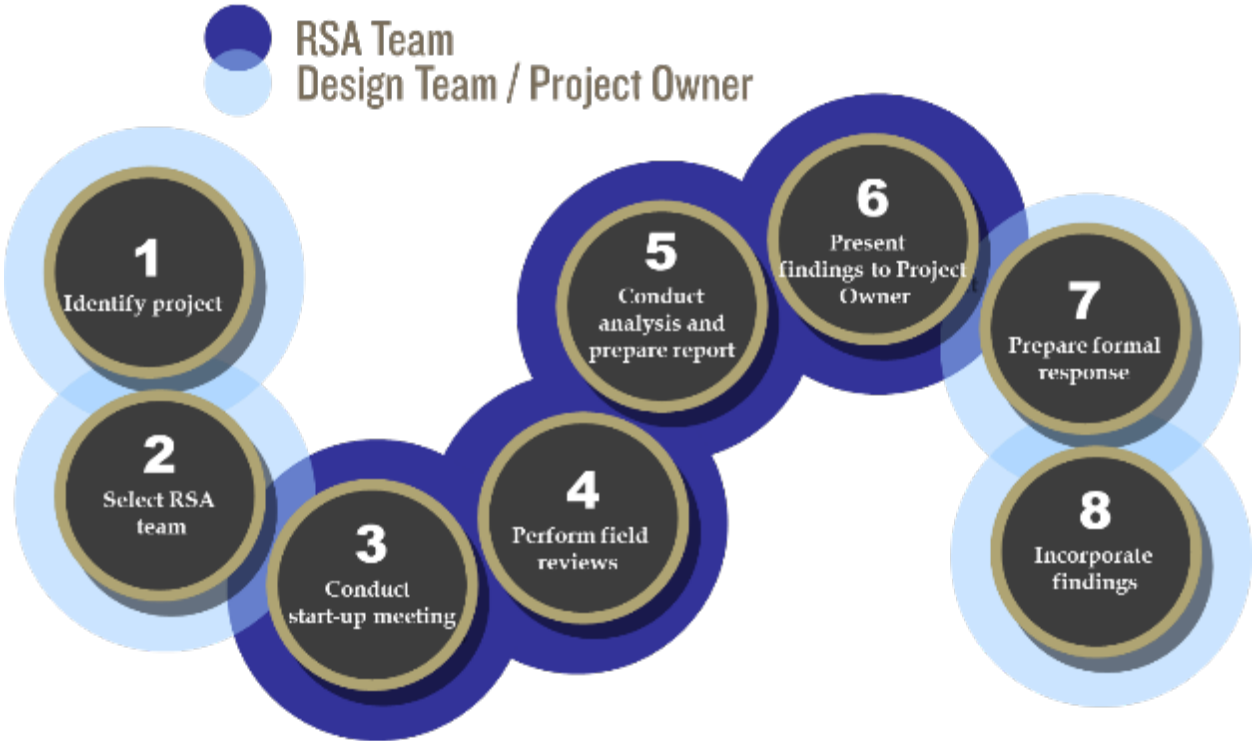


Figure 1 - RSA Eight-Step Process

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 to evaluate the study intersections for vulnerable road user related safety considerations, identify safety recommendations before scheduled repaving projects throughout the study area and proposed implementation of a two-way cycle track along Catherine Street, while considering future needs within the area as new developments are expected to be completed in the coming years. The planned future developments near the study area are shown in Figure 2[*]. With this, it was deemed important to proactively address potential safety issues that could arise from these developments. Additionally, the study area is highly diverse in transportation modes such as vehicles, pedestrians, and buses. This diversity necessitates careful planning and consideration to ensure the safety and efficiency of all users, especially vulnerable road users (VRU) – people who walk, use assistive devices, and bicycle – traveling through and within the project area.

The intersections of Glen Avenue and Catherine Street, Glen Avenue and Ann Street, and Ann Street and Zina Pitcher Place are located near the University of Michigan Medical Campus, as shown in Figure 3. The intersections connect neighborhoods and the university central campus to the medical campus. Catherine Street and Ann Street run east-west, while Glen Avenue runs north-south.

At the intersection of Glen Avenue and Catherine Street, Catherine Street is one-way that allows westbound travel on the east leg of the intersection with dual right-turn lanes. All other legs at the intersection are two-way roads with the northbound approach having a dedicated left turn lane.

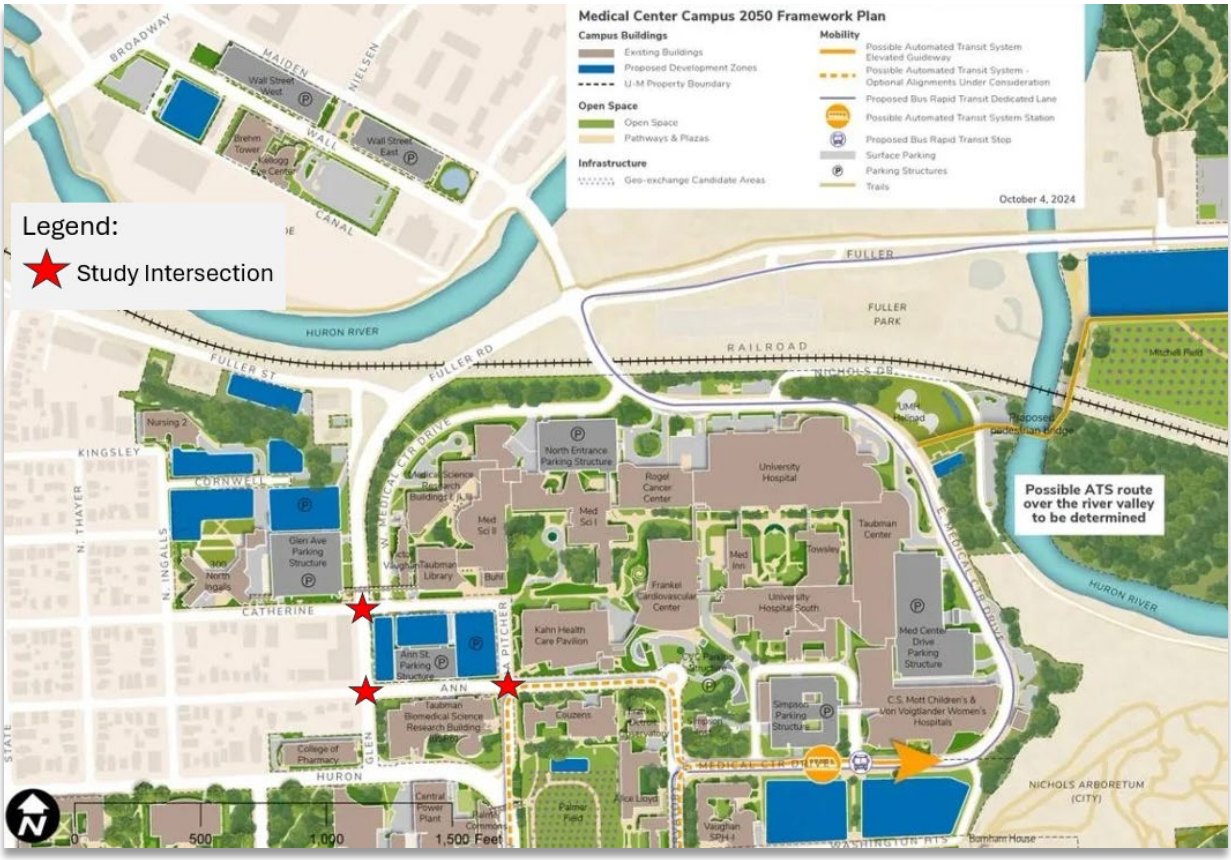
At the intersection of Glen Avenue and Ann Street, the west leg of Ann Street is a one-way road that allows eastbound travel, with the exception of approximately 150 feet to allow hotel access to the hotel located in the northwest quadrant of the intersection. Additionally, the southbound and westbound approaches at the intersection have dedicated left-turn lanes.

The intersection of Ann Street at Zina Pitcher Place is one-way on the north leg of the intersection that allows northbound travel. Furthermore, the eastbound and westbound approaches at the intersection have dedicated left-turn lanes.

Bike lanes are present along Catherine Street at Glen Avenue along both sides on the west leg of the intersection as well as along both sides of Ann Street between Glen Avenue and Zina Pitcher Place.

Furthermore, UofM bus routes and TheRide bus routes are present with bus stops located throughout the study area. At the intersection of Ann Street and Zina Pitcher Place, bus stops are located along the far side of Ann Street on the eastbound approach as well as on the far side of Zina Pitcher Place on the southbound approach. Additionally, at the intersection of Catherine Street and Glen Avenue, a bus stop is located on the far side of Glen Avenue on the northbound approach, and on the nearside of Glen Avenue on the southbound approach.

[*] *Map produced by the University of Michigan for their planned developments.*



**Map produced by the University of Michigan for their planned developments.*

Figure 2 - Planned Developments Near the Study Area*

Figure 3 - 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:	**Maple Road & Eton Street, Birmingham, MI**	
Audit Team Members:	Joyce Yassin	WSP
	Jason Pittenger	WSP
	Rachel Peters	WSP
	Eric Hanss	TYLin
Project Owner:	Southeast Michigan Council of Governments (SEMCOG) City of Ann Arbor	
Review Date:	April 15, 2025 and April 24, 2025	
Audit Stage:	Operational	
Start-up Meeting:	April 24, 2025	
Preliminary Findings Meeting:	May 8, 2025	
Attended By:	Southeast Michigan Council of Governments (SEMCOG) City of Ann Arbor Engineering, Planning & Development Police Department Fire Department University of Michigan Campus Planners TheRide Wade Trim WSP TYLin	

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: Site visits were conducted on April 15, 2025 and April 24, 2025, by the WSP team to facilitate a road safety audit during morning time, daytime, nighttime, and peak conditions. This time was spent driving and walking throughout the intersections to observe traffic operations, conflicts, and surrounding land uses. University of Michigan students were actively attending classes during field reviews, providing an idea of how the area operates during the academic term. 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 either 2020 or 2022, depending on the most recent counts available, from MDOTs Transportation Data Management System (TDMS) and provided in Table 1 below. TDMS counts were not available for Zina Pitcher Place, instead volumes from the SEMCOG traffic volume map were used.

Table 1 - AADT Counts

LOCATION	2020 AADT	2022 AADT	SEMCOG COUNTS
WB Catherine Street, between Glen Avenue and Zina Pitcher Place	N/A	2,346	N/A
EB Ann Street, between Glen Avenue and Zina Pitcher Place	2,671	N/A	N/A
WB Ann Street, between Glen Avenue and Zina Pitcher Place	2,039	N/A	N/A
NB Glen Avenue, approximately 250 feet north of Catherine Street	6,345	N/A	N/A
SB Glen Avenue, approximately 250 feet north of Catherine Street	6,693	N/A	N/A
Zina Pitcher Place	N/A	N/A	0-5,000

Crash Data: Five years of crash data (2019-2023) was obtained by the RSA team from MichiganTrafficCrashFacts.org (MTCF). Supplemental data, such as UD-10 reports, were also obtained.

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
- Traffic counts
- MTCF crash data
- Traffic signal timing permits
- City of Ann Arbor Comprehensive Plan
- Downtown Area Circulation Study
- Catherine Street bikeway concept

- Proposed University of Michigan Site Plans:
  - Parking Structure
  - Kahn Health Care Pavilion
  - College of Pharmacy
  - Hotel
- Traffic Signal Design at Zina Pitcher Place and Catherine Street
- Synchro models
- CTB 1510 Turning Radius (Aerial Tower – 236" Wheel Base) provided by the fire department
- TheRide 2045 Plan
- 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 INTERSECTION

The intersections of Glen Avenue and Catherine Street, Glen Avenue and Ann Street, and Ann Street and Zina Pitcher Place are owned by the City of Ann Arbor and are located on the University of Michigan campus. The intersections are in proximity to the medical campus which includes the university hospital, medical library, classrooms, labs, and other employment centers. The intersections within the study area connect the university medical campus and hospital to the residential neighborhood located to the west, downtown Ann Arbor located to the west, and the University of Michigan Central Campus located to the south. The study intersections play a regional role as they facilitate the daily movement of healthcare professionals, patients, and caregivers from across southeast Michigan.

Glen Avenue & Catherine Street:

The intersection is a signalized, four-leg intersection in which Glen Avenue runs north-south, and Catherine Street runs east-west. The westbound approach is a one-way road with a dedicated right turn lane, a shared right and thru lane, and a dedicated left turn lane. The eastbound approach is two-way and has a shared left/right turn lane. The southbound approach has a dedicated thru lane as well as a shared thru/right turn lane. The eastbound approach has a shared left/thru/right turn lane. The northbound approach has a dedicated left turn lane and a shared thru/right turn lane. Furthermore, the north leg of the intersection has an upgrade slope along Glen Avenue heading towards Catherine Street and the east leg has a downgrade slope along Catherine Street heading towards Glen Avenue. “No Turn on Red” restrictions are present on all legs of the intersection.

University medical buildings, including a parking structure, and a residential neighborhood are present west of the intersection while Glen Avenue to the north connects to the University of Michigan north campus. Furthermore, to the east of the intersection is the university hospital and supplemental medical buildings.

A bike lane is present along the west leg of the intersection along both sides of Catherine Street; however, the bike lanes are dropped before the intersection. A skywalk is present north of the intersection that connects the Glen Avenue parking structure, located in the northwest corner of the intersection, to the sidewalk along the north side of Catherine Street. High visibility crosswalk markings and pedestrian signal heads with countdown timers are present at the intersection. Additionally, overhead lighting is present throughout the intersection and pedestrian-scale lighting is present along all legs of the intersection, except for the southeast quadrant of the intersection. Lastly, W Medical Center Drive is located approximately 50 feet to the east of the intersection, providing right-in/right-out access onto Catherine Street.

Glen Avenue and Ann Street:

The intersection is a signalized, four-leg intersection in which Glen Avenue runs north-south, and Ann Street runs east-west. The northbound, eastbound, and westbound approaches consist of a dedicated left turn lane and a shared thru/right turn lane. The southbound approach consists of a dedicated left turn lane, dedicated thru lane, and a shared thru/right turn lane. For all movements onto the west leg of the intersection, the movement is only allowed for hotel access since the road turns into a one-way street after the hotel access, which is approximately 150 feet from the intersection. Furthermore, the east leg has a downgrade slope along Ann Street heading towards Glen Avenue. The eastbound approach has a "No Turn on Red" restriction.

A residential neighborhood is located to the west of the intersection and a parking garage that services hospital employees is located to the east of the intersection. A newly constructed hotel is located in the northwest quadrant of the intersection and a university laboratory is located in the southeast quadrant of the intersection. Furthermore, a College of Pharmacy building is being constructed south of the intersection, and is expected to increase pedestrian and transit traffic demands to the intersection.

Bike lanes are present along the east leg of the intersection along both sides of Ann Street between Glen Avenue and Zina Pitcher Place. An east-bound bike lane is also present before the west leg; however, the bike lane drops at the intersection. High visibility crosswalk markings and pedestrian signal heads with countdown timers are present at the intersection. Overhead lighting is present throughout the intersection. Lastly, pedestrian-scale lighting is present throughout the intersection, with the exception of the east side of Glen Avenue on the north leg and the west side of Glen Avenue on the south leg.

Ann Street & Zina Pitcher Place:

The intersection is a signalized, four-leg intersection in which Ann Street runs east-west and Zina Pitcher Place runs north-south. The westbound approach consists of a dedicated left turn lane, dedicated thru lane, and dedicated right turn lane. The eastbound approach has a dedicated left turn lane and a shared thru/right turn lane. The northbound approach has a dedicated right turn lane and a shared thru/right turn lane. The north leg of the intersection is a one-way street that allows for northbound travel. The eastbound and westbound approaches have "No Turn on Red" restrictions.

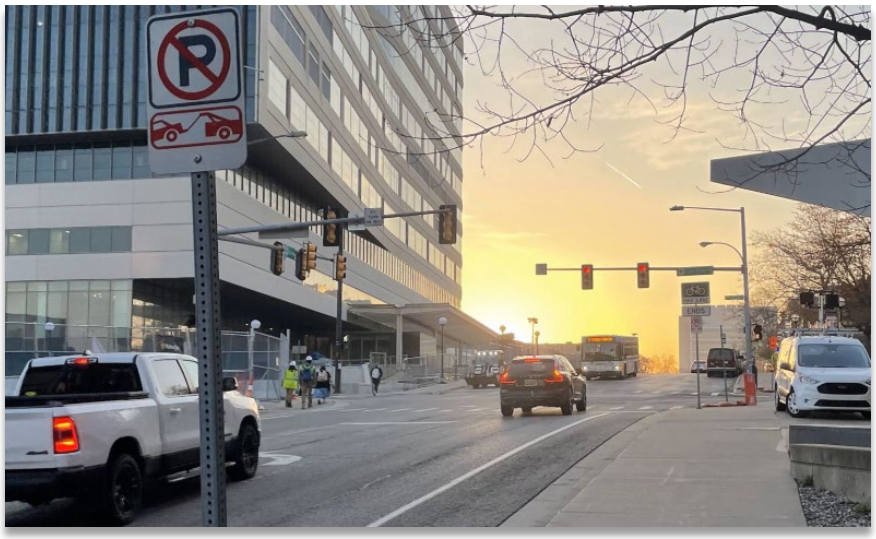
A university laboratory is located in the southwest quadrant of the intersection and a university hall is located in the southeast quadrant of the intersection. The Kahn Health Care Pavilion is being constructed in the northeast quadrant and a new parking structure is being constructed in the northwest quadrant. The new care pavilion and parking structure are expected to increase pedestrian activity levels and traffic demands at the intersection.

Bike lanes are present along both sides of Ann Street on the west leg of the intersection; however, they are dropped before the intersection. High visibility crosswalk markings are present along all legs of the intersection. Pedestrian signal heads are located at the intersection; however, they are not equipped with countdown timers, except for the signal head located in the southwest quadrant. Overhead lighting is present throughout the intersection, except for a few non-working light fixtures. Lastly, pedestrian level lighting is present along the legs of the intersection, except along the west side of Zina Pitcher Place to the south of the intersection.

Throughout the study area, sidewalks are present, except for temporarily closed sidewalks due to ongoing construction that was present at the time of field reviews. The temporarily closed sidewalk is along the north side of Ann Street to the east of the existing parking structure, stretching along the west side of Zina Pitcher Place between Ann Street and Catherine Street, as well as the south side of Catherine Street to the east of the existing parking structure. Because the study area is located on a university campus, it regularly experiences high volumes of pedestrian and bicyclist traffic. During field reviews, it was observed that pedestrians were crossing the street at locations where crosswalks were not present, indicating desire lines. The most notable location where this behavior was observed was on Ann Street between Glen Avenue and Zina Pitcher Place, likely due to the temporarily closed sidewalk along Ann Street. Another location where this behavior was present was on Catherine Street between Glen Avenue and Zina Pitcher Place. All study intersections have a box span signal configuration and backplates to increase signal conspicuity. Figure 4 provides images of the characteristics present at the study intersections.

Glen Avenue and Catherine Street Signal – Eastbound Approach

Glen Avenue and Ann Street Signal – Southbound Approach



Ann Street and Zina Pitcher Place Signal – Eastbound Approach

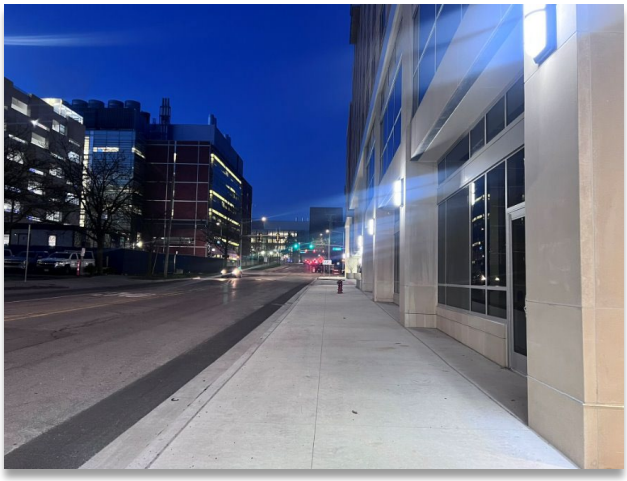
Figure 4 - Study Intersection Characteristics

SITE OBSERVATIONS

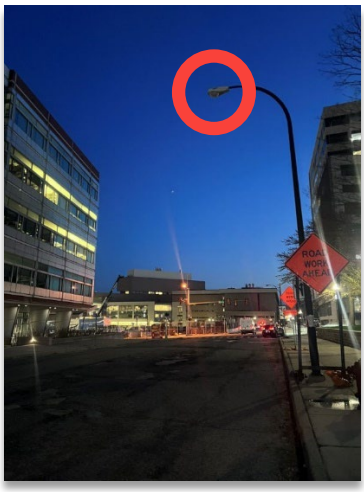
Site observations were facilitated through an in-person field review by driving and walking through the study intersections in each direction during morning shift change, AM peak, daytime, PM peak, and nighttime conditions. Figure 5 provides examples of study area characteristics and vulnerable road users.

Pedestrians Crossing the North Leg at Glen Avenue and Catherine Street

Pedestrians Walking in the Road Along the Closed Sidewalk on Ann Street



Pedestrian-scale Lighting



Non-working Light Fixture at Ann Street and Zina Pitcher Place

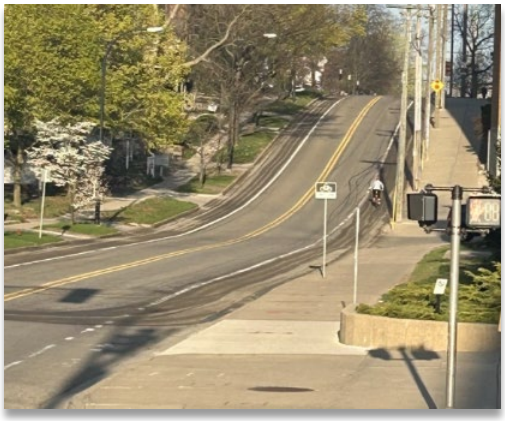
Hotel Access Signing at Glen Avenue and Ann Street

Signage Overload at Glen Avenue and Catherine Street

Traffic Congestion Turning from W Medical Center Drive

Traffic Congestion Traveling Southbound along Glen Avenue from Catherine Street to Ann Street

Cracked Pavement Throughout the Study Area



Bike Lanes and Vertical Grade Along Catherine Street

Figure 5 - Study Area Characteristics & Road Users

Study Area Observations

- Significant vulnerable road user presence
- Significant bus traffic (UofM transit and TheRide)
- High presence of unfamiliar motorists
- Traffic congestion during peak times but cleared quickly
- Vertical grades along multiple legs throughout the study area
- Sidewalks throughout the study area
- Existing intersection lighting
- Existing pedestrian-scale lighting
- Excessive signage at Glen Avenue and Catherine Street
- Poor pavement conditions within the roadway, crosswalks, and bike lanes
- Faded pavement markings
- Leading pedestrian intervals at all study intersections
- Continental high visibility crosswalks at all study intersections
- Bike lanes along Catherine Street and Ann Street

3.2 ROAD USER CHARACTERISTICS

The most recent motor vehicle traffic counts were collected in 2022 along Catherine Street and 2020[1] along Ann Street and Glen Avenue. Table 1 in Section 2.2 provides the directional AADT for the study roadways. The roadway with the highest AADT is Glen Avenue with a bi-directional AADT of approximately 13,000 vehicles.

Field observations concluded that there is a large presence of pedestrians and bicyclists traveling through the study area. During observations, all sidewalks and crosswalks in the study area were utilized by people walking and biking. Bicyclists were observed crossing with the traffic signal while in the bike lanes or with the pedestrian signal while biking on the sidewalk. Furthermore, pedestrians and bicyclists spanned all age groups and were observed traveling alone and in groups.

Additionally, a significant number of buses were observed traversing through the study area. The buses present consist of the UofM transit buses and TheRide buses. There are multiple stops for each transit service throughout the study area and the team observed multiple people waiting for the transit buses as well as entering and exiting the buses at the various stops.

3.3 CRASH ANALYSIS

The most recent five years of crash data (2019-2023) were obtained from MichiganTrafficCrashFacts.org (MTCF) for the study area. During the five-year study period, a total of 93 reported crashes occurred within 150 feet of the study intersections with 9 (10%) resulting in a serious, suspected, or possible minor injury. No fatalities were recorded in the crash reports. However, one fatal pedestrian crash occurred at Ann Street and Zina Pitcher Place in 2014, which is outside of the crash analysis timeline. The crash involved a westbound left-turning bus striking a pedestrian that was crossing the south leg of the intersection.

CRASH DEFINITIONS

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 vehicle impacts one or more vehicles while driving in reverse.
- Fixed Object: When the vehicle impacts a fixed object.

[1] Traffic counts were likely affected due to the Covid-19 Pandemic

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

- 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.

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

There were 43 reported crashes at Glen Avenue and Catherine Street, 35 reported crashes at Glen Avenue and Ann Street, and 15 reported crashes at Ann Street and Zina Pitcher Place. Figures 6 through 8 provide spatial distributions of crashes for each study intersection and Figure 9 provides the overall distribution of crashes by severity.

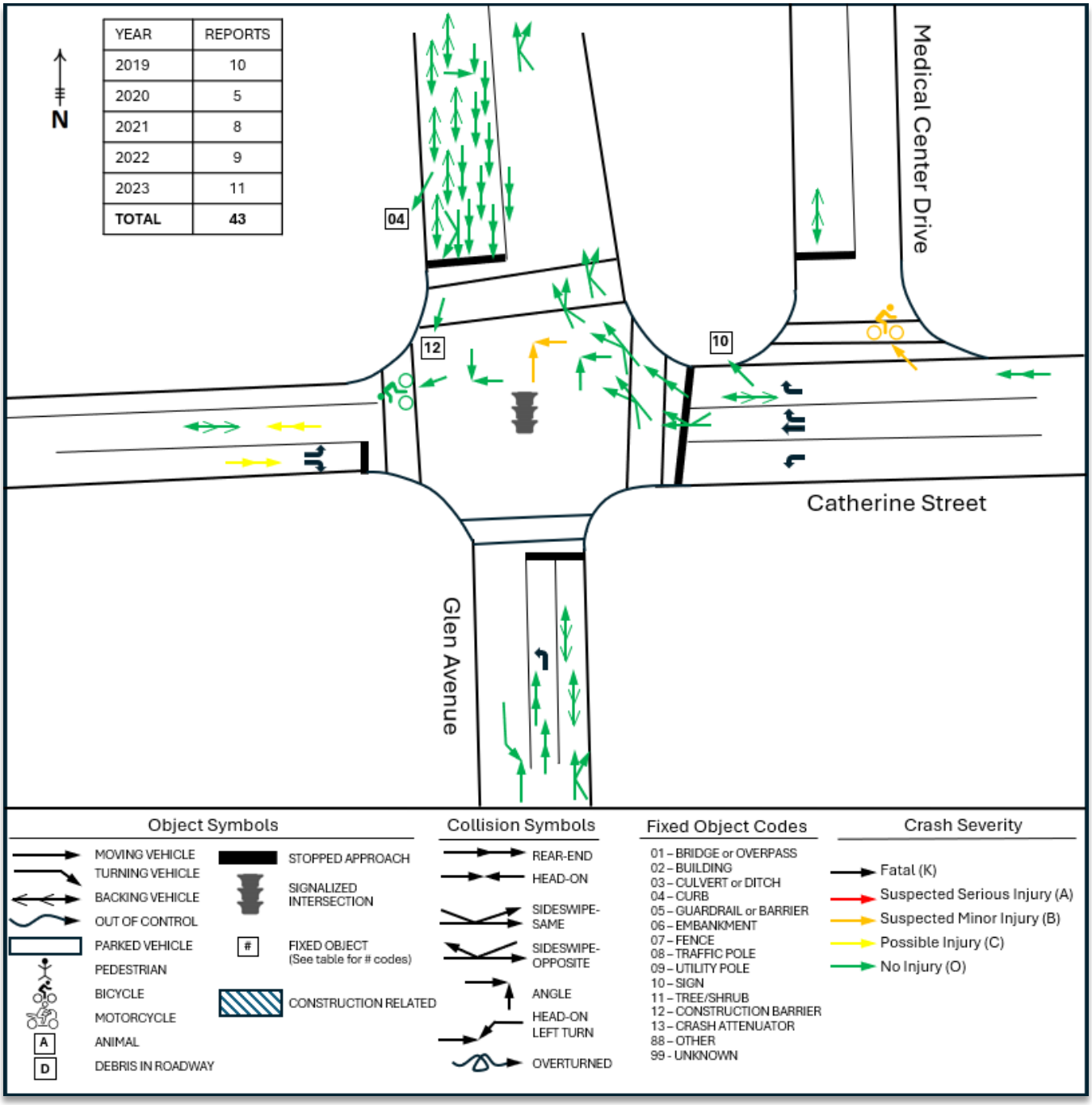


Figure 6 - Spatial Distribution of Crashes at Glen Avenue and Catherine Street from 2019-2023 (Source: MTCF)

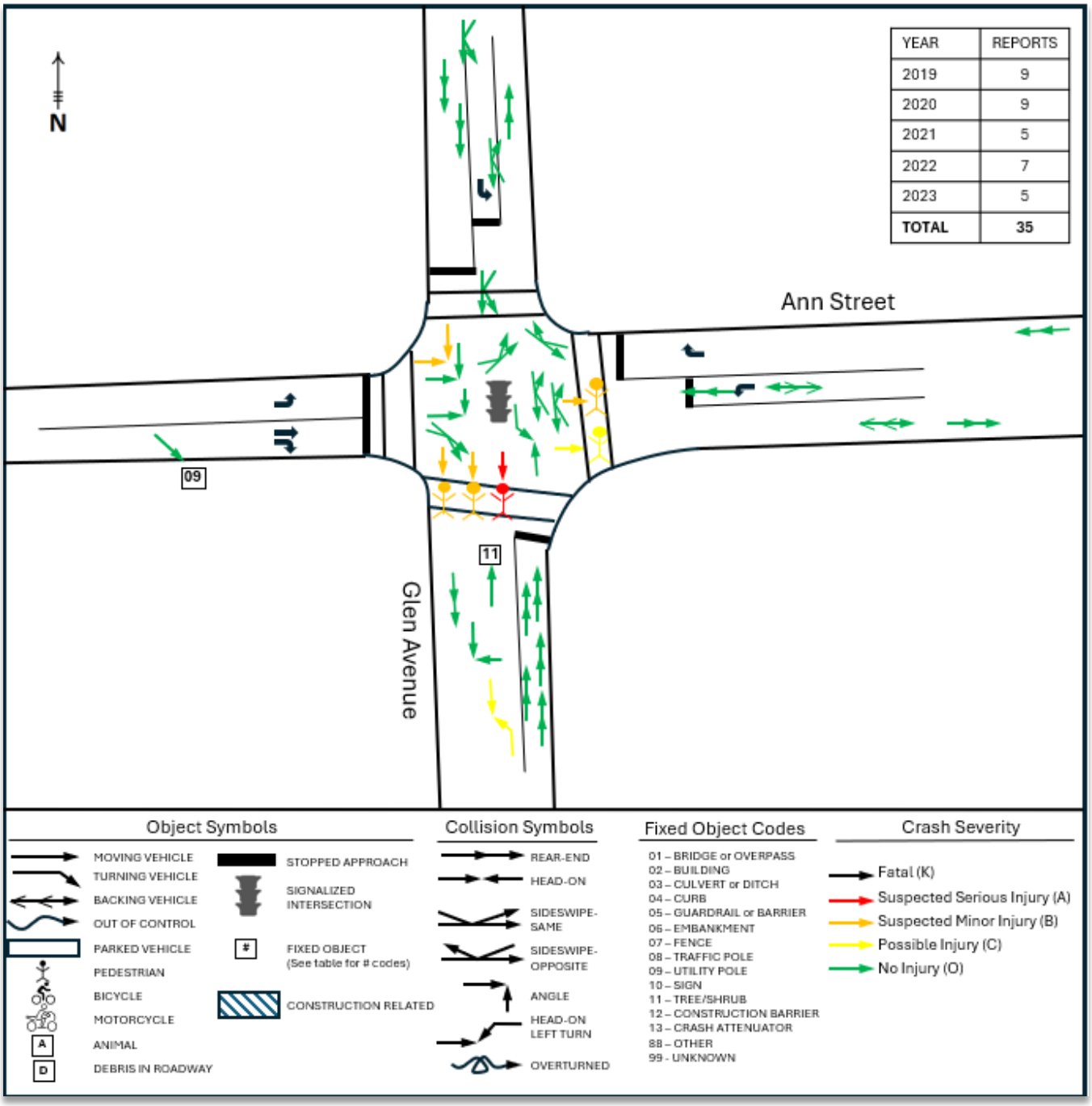


Figure 7 - Spatial Distribution of Crashes at Glen Avenue and Ann Street from 2019-2023 (Source: MTCF)

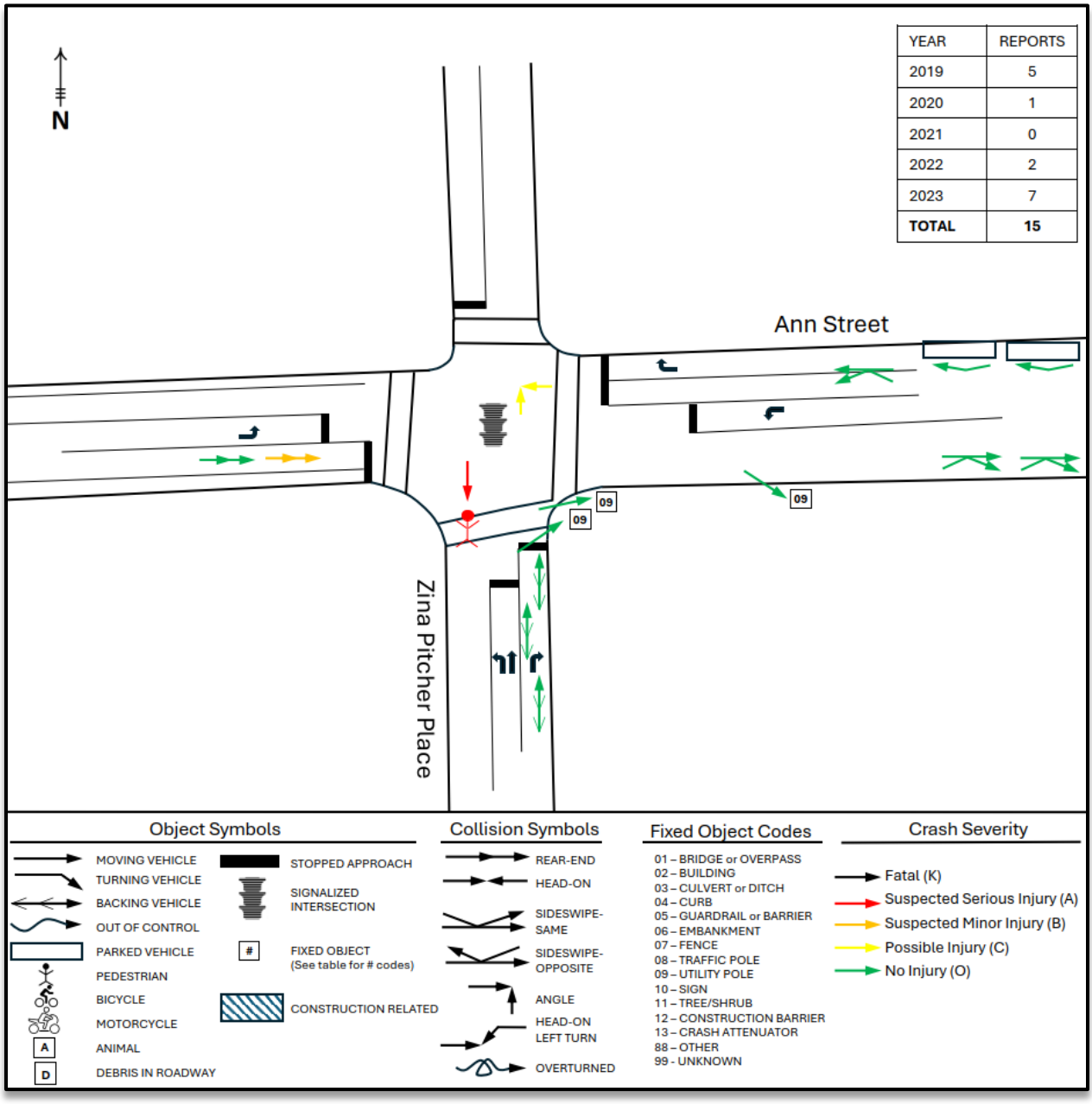


Figure 8- Spatial Distribution of Crashes at Ann Street and Zina Pitcher Place from 2019-2023 (Source: MTCF)

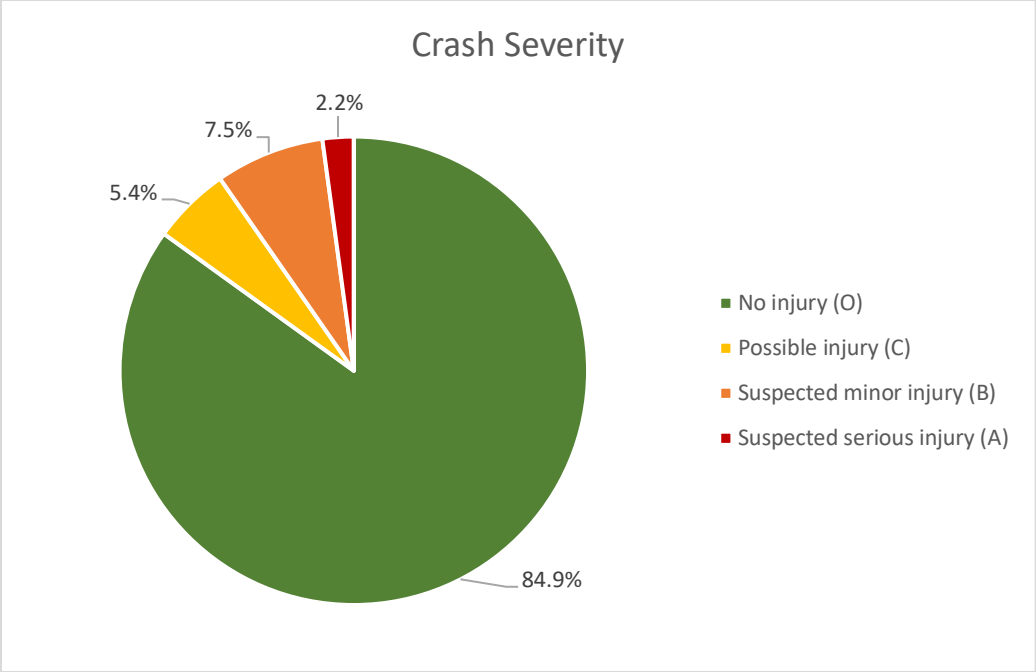


Figure 9 - Overall Crash Severity (2019-2023)

CRASH CHARACTERISTICS

In addition to the spatial distribution of crashes, UD-10s were reviewed for all the crashes reported during the study period. This information helped to ascertain some of the contributing factors to the types of crashes. Figure 10 provides the overall distribution of crashes by crash type. As shown, the top two crash types are rear-end and sideswipe-same direction crashes accounting for over 47% of the total crashes. Furthermore, non-motorized and angle crashes were the top two crash types that resulted in injuries. Rear-end crashes are common at signalized intersections, such as the three study intersections, because of the sudden stops, changes in traffic flow, and the multiple conflict points where vehicles make turns or cross paths. Additionally, sideswipe-same direction crashes are common due to lane changes leading to additional conflict points.

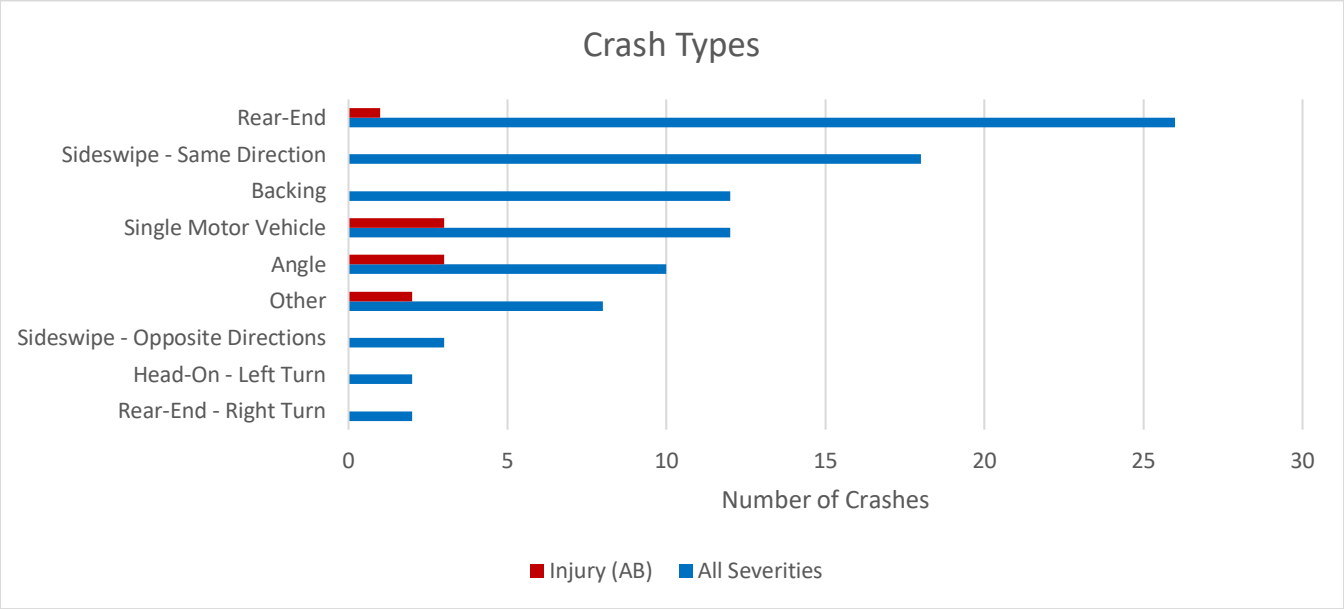


Figure 10 - Distribution of Crashes by Type

The following summarizes the crash trends which occurred from 2019 through 2023.

Glen Avenue & Catherine Street

- Rear-end crashes
  - Fourteen rear-end crashes occurred throughout the intersection. The majority of rear-end crashes (8 crashes) occurred along the north leg of Glen Ave. Two rear-end crashes that occurred along the west leg of Catherine St resulted in a possible injury while the remaining rear-end crashes resulted in property damage only.
- Backing crashes
  - Eleven backing crashes occurred throughout the intersection. The majority of backing crashes (6 crashes) occurred along the north leg of Glen Ave. The presence of a vertical slope along the north leg was noted as a contributing factor for many of the backing crash types. All of the backing crashes resulted in property damage only.
- Fixed object crashes
  - Three fixed object crashes occurred at the intersection.
  - One fixed object crash resulted from a westbound motorist losing control due to snowy and icy road conditions while attempting to turn onto Medical Center Dr. The motorist ran off the road and struck a sign. The crash resulted in property damage only.
  - One fixed object crash resulted from a driver losing control while traveling southbound through the intersection due to snowy and icy road conditions. The motorist ran off the road and struck the curb. The crash resulted in property damage only.
  - One fixed object crash occurred when a large truck struck a construction fence that was placed along the west side of Catherine St. The crash resulted in property damage only.

- Sideswipe-same direction crashes
  - Eight sideswipe-same direction crashes occurred at the intersection. Five of the crashes resulted from improper lane use or turning too tight when making the right turn onto northbound Glen Ave from westbound Catherine St. All of the crashes resulted in property damage only.
- Angle crashes
  - Four angle crashes occurred at the intersection. One crash resulted from improper lane use when making the right turn onto northbound Glen Ave from westbound Catherine St. One crash resulted from improper lane change along the north leg of Glen Ave. One resulted from a vehicle making too wide of a left turn. All crashes described above resulted in property damage only. The remaining angle crash resulted from a motorist failing to yield to another motorist. This crash resulted in a suspected minor injury.
- Bicyclist related crash
  - Two bicyclist related crashes occurred at the intersection.
  - One of the bicyclist crashes involved a bicyclist traveling along the west leg intersection crosswalk who was struck by a motorist attempting to turn right from Glen Ave. The crash resulted in property damage only.
  - One of the bicyclist crashes involved a bicyclist traveling along the Medical Center Dr crosswalk who was struck by a bus traveling along Catherine Street attempting to turn right onto Medical Center Dr. The crash resulted in a suspected minor injury.
- Head-on left-turn Crash
  - One head-on left-turn crashes occurred along the south leg of the intersection. The crash involved a southbound traveling vehicle attempting to make a left turn into a parking lot and striking a northbound traveling vehicle. The crash resulted in property damage only.

Glen Avenue & Ann Street

- Rear-end crashes
  - Twelve rear-end crashes occurred throughout the intersection. The most rear-end crashes (5 crashes) occurred along the south leg of Glen Ave. All of the rear-end crashes resulted in property damage only.
- Backing crashes
  - Two backing crashes occurred on the east leg of the intersection, of which all resulted in property damage only.
- Fixed object crashes
  - Two fixed object crashes occurred at the intersection.
  - One fixed object crash resulted from a driver traveling the wrong way along the west leg of Ann St, which is a one-way street. Once the driver realized they were traveling the wrong way, they attempted to make a U-turn and struck a utility pole. The crash resulted in property damage only.
  - One fixed object crash occurred when a large tree branch fell from a tree onto a vehicle traveling along Glen Ave. The crash resulted in property damage only.

- Sideswipe-same direction crashes
  - Four sideswipe-same direction crashes occurred at the intersection. Two of the crashes involved striking a university bus. Narrow lane widths were noted as contributing factors for many of the sideswipe crashes. All of the crashes resulted in property damage only.
- Sideswipe-opposite direction crashes
  - Four sideswipe-opposite direction crashes occurred at the intersection. Three of the crashes involved striking a university bus. Narrow lane widths were noted as contributing factors for many of the sideswipe crashes. All of the crashes resulted in property damage only.
- Angle crashes
  - Four angle crashes occurred at the intersection. Three of the crashes resulted in a collision between an eastbound vehicle along Ann St and a southbound vehicle on Glen Ave. The remaining angle crash resulted along the south leg of the intersection when a vehicle was attempting to make a left turn into a private drive. One angle crash resulted in a suspected minor injury and the remaining crashes resulted in property damage only.
- Pedestrian related crash
  - Five pedestrian related crashes occurred at the intersection. Four of the pedestrian crashes involved pedestrians traveling along the south leg of the intersection and one crash occurred along the east leg crosswalk. All crashes involved a vehicle attempting to make a left or right turn and striking a pedestrian present within the crosswalk. One crash resulted in a possible injury, three crashes resulted in a suspected minor injury, and one crash resulted in a suspected serious injury.
- Head-on left-turn Crash
  - Two head-on left-turn crashes occurred at the intersection.
  - One crash involved a vehicle attempting to make a left turn into a private drive along the south leg of the intersection and colliding with a southbound traveling vehicle. The crash resulted in a possible injury.
  - One crash involved a vehicle attempting to make a left turn onto Ann St and colliding with a northbound traveling vehicle along Glen Ave.

Ann Street & Zana Pitcher Place

- Rear-end crashes
  - Two rear-end crashes occurred on the west leg of the intersection, of which one resulted in a non-incapacitating injury crash severity.
- Backing crashes
  - Three backing crashes occurred on the south leg of the intersection, of which all resulted in property damage only.
  - One crash was caused by a driver backing up to not block a crosswalk, one crash was caused by a driver backing up to get out of snow, and one crash was caused by a driver backing up to allow room for a truck to turn.

- Fixed object crashes
  - Three fixed object crashes occurred at the intersection. Two resulted from a bus attempting to turn right from Zana Pitcher Pl onto Ann St and striking a utility pole located in the southeast corner of the intersection. The other crash occurred from a bus traveling eastbound along Ann St and striking a utility pole. All crashes resulted in property damage only.
- Sideswipe-same direction crashes
  - Five sideswipe-same direction crashes occurred along Ann St on the east leg of the intersection. Two were the result of a vehicle striking a legally parked vehicle along Ann St. The three remaining crashes involved a vehicle striking a university bus while attempting to maneuver around it. All crashes resulted in property damage only.
- Pedestrian related crash
  - A pedestrian was struck while traveling along the south leg crosswalk by a motorist attempting to make a right turn from eastbound Ann St. The crash resulted in an incapacitating injury for the pedestrian.
- Angle Crash
  - An angle crash occurred from a northbound motorist running a red light and striking a westbound motorist. The crash resulted in a possible injury.

TEMPORAL TRENDS

The following figures provide a high-level summary of the various temporal trends for crashes of all severities. As shown in Figure 11, crashes peaked between noon and 5PM which is consistent with the increase in volume typical during those times. There appears to be a strong trend by day of week, with weekdays experiencing a higher crash frequency than weekend days, as shown in Figure 12. This trend is consistent with the study location on a university campus as classes occur during weekdays. There did not appear to be a strong trend by month of the year, although January experienced the highest frequency of crashes, as shown in Figure 13.

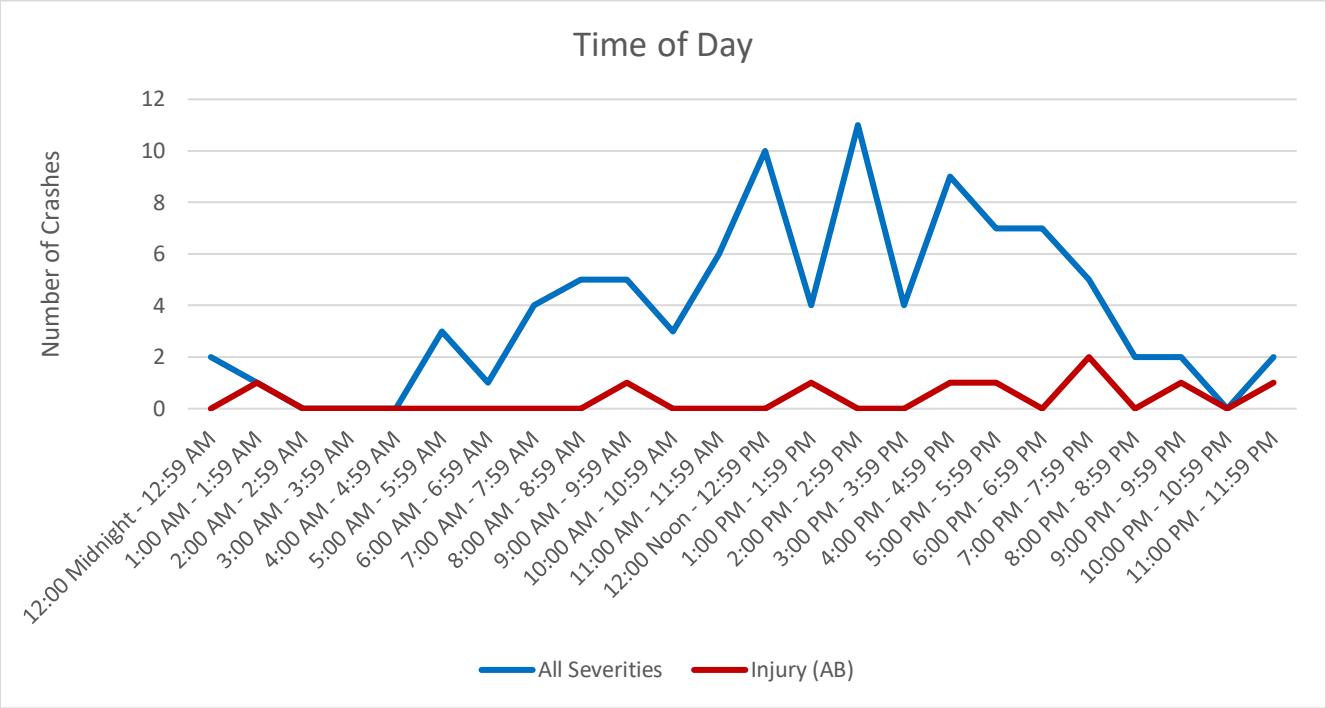


Figure 11 - Crash Distribution by Hour of Day

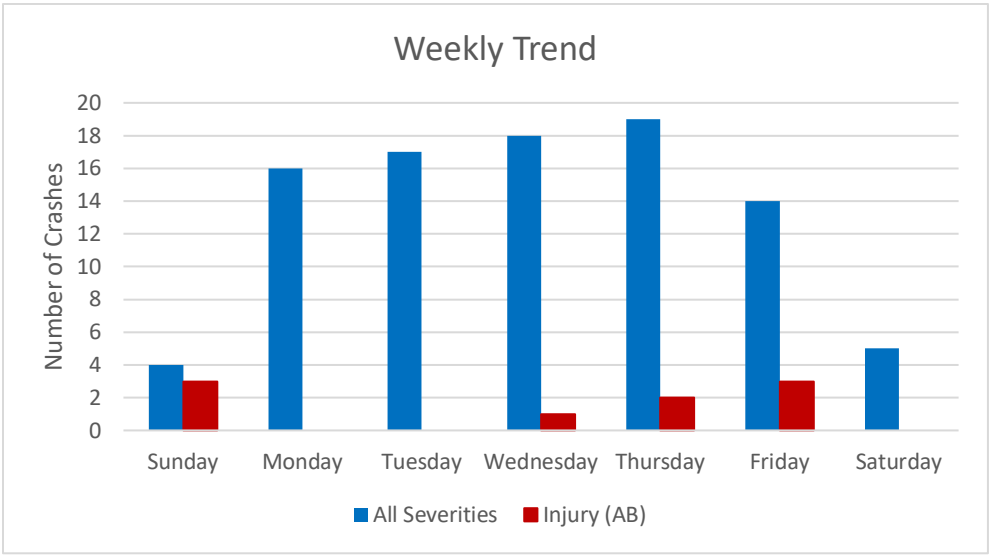


Figure 12 - Crash Distribution by Day of Week

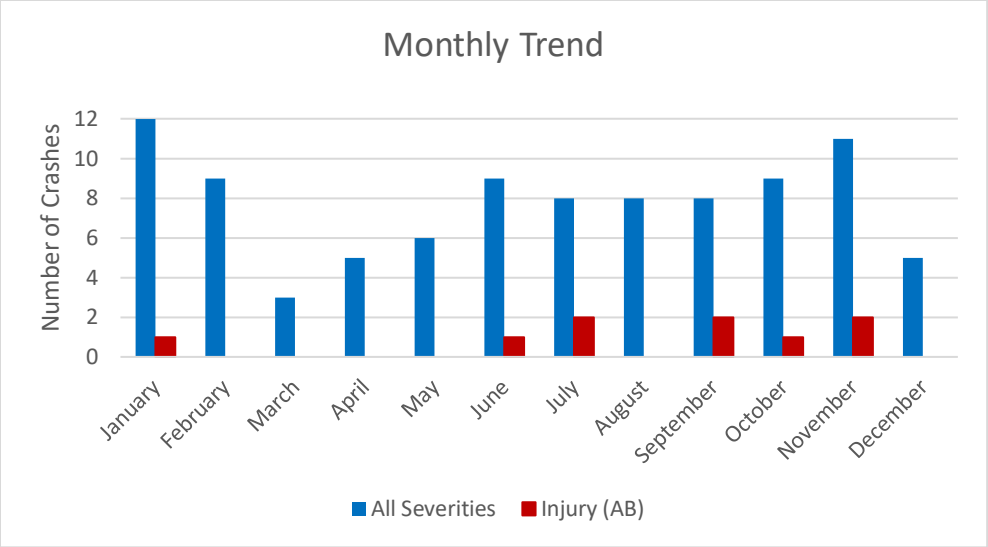


Figure 13 - Crash Distribution by Month of Year

ENVIRONMENTAL CONDITIONS

While environmental conditions are more difficult, if not impossible to control, they are important to consider as mitigating steps can still be taken to try to reduce their impacts on safety. Figure 14 provides the distribution of crashes by the lighting condition present at the time of the crash, as reported by the responding officer. Based on historic crash data, less than 25% of all crashes occurred during non-daylight conditions with no strong trend emerging.

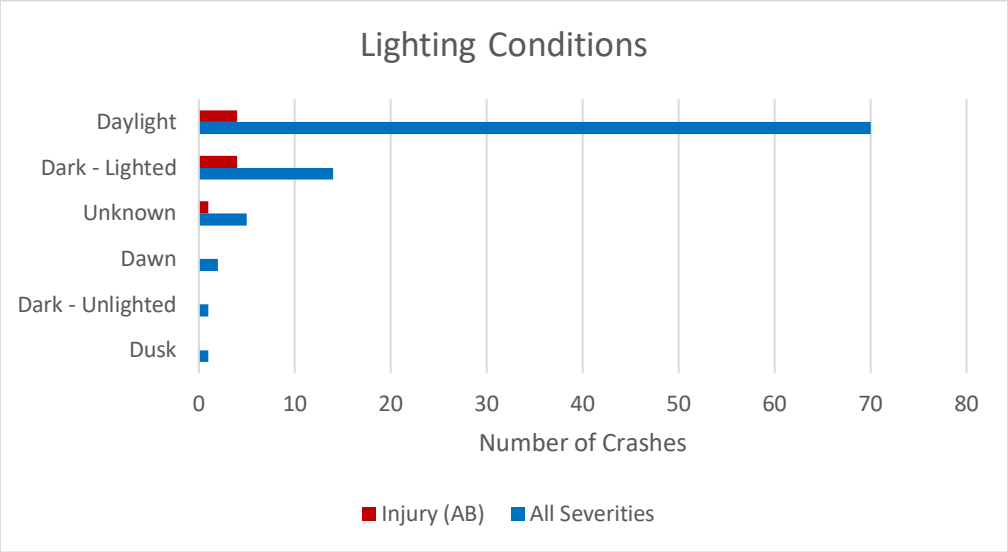


Figure 14 - Crash Distribution by Lighting Condition

When reviewing the distribution of crashes based on the surface condition of the road at the time the crash occurred, as shown in Figure 15, nearly a third of crashes occur under snow/slush, wet, or ice conditions.

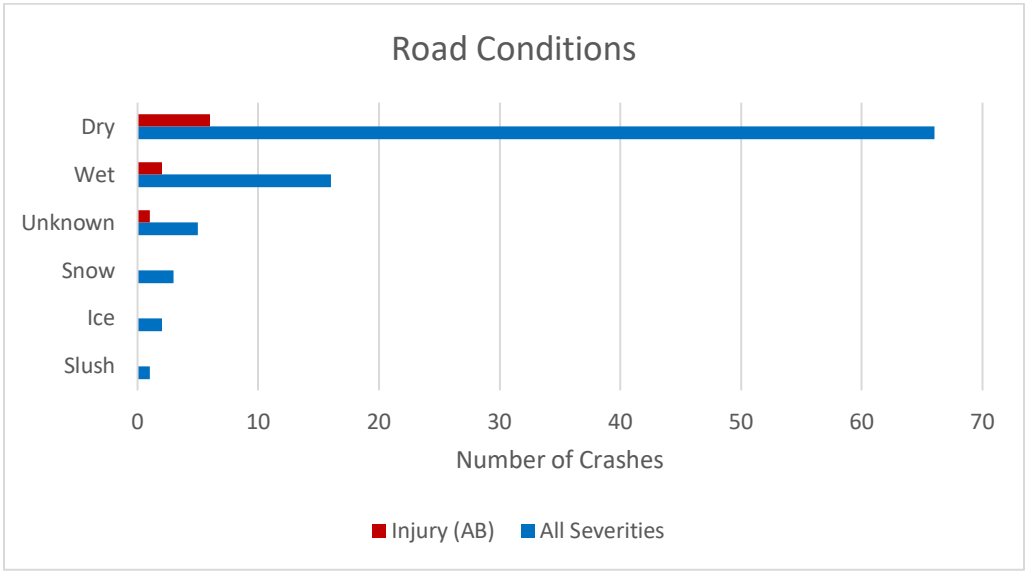
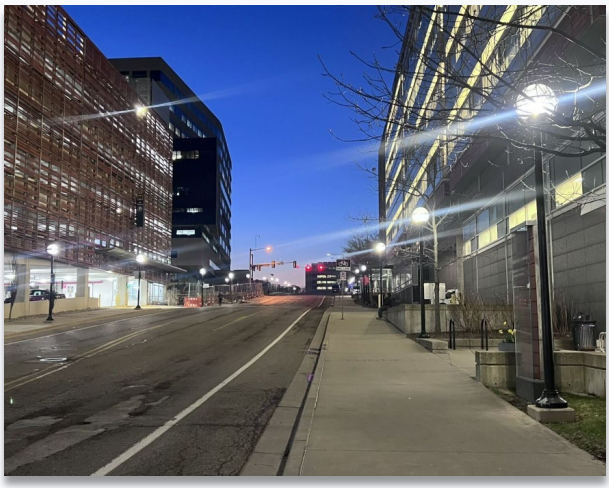


Figure 15 - Crash Distribution by Road Condition

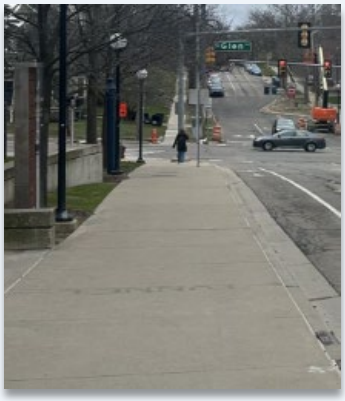
4 EXISTING SAFETY MEASURES

The existing site characteristics in the following table have been identified as having a positive impact on safety in the study area.

Existing Safety Measures	
Modern Features at the Intersections The study intersections are modernized with box span signal configurations, backplates, continental high visibility crosswalks, detectable warning pads, countdown pedestrian signals (with the exception of Ann Street and Zina Pitcher Place), and leading pedestrian intervals (LPIs). Countdown timers, high visibility markings, and leading pedestrian intervals help improve non-motorized user safety. Box span layouts align traffic signal heads with approaching vehicles and improve signal conspicuity. Backplates help delineate the signal heads against background visuals as well as low angle sun positioning for east/west approaches.	
Intersection and Pedestrian-scale Lighting Overhead lighting is present throughout the study area as well as pedestrian scale lighting located along a few places within the study area. Intersection lighting improves visibility for drivers and pedestrians. Furthermore, pedestrian-scale lighting illuminates sidewalks and crosswalks, making it easier for pedestrians to navigate safely and improving their conspicuity to drivers, especially at night.	

Sidewalk Connectivity

Sidewalks are located throughout the study area, excluding temporary construction areas, and were observed to be sufficiently wide and in good condition with minimal cracks.



No Turn on Red Restrictions

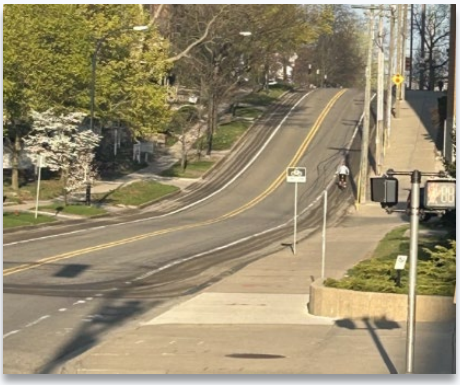
Right turn on red restrictions are present throughout Glen Avenue and Catherine Street as well as for some movements at the other study intersection. The restriction helps to eliminate conflicts between right-turning vehicles and pedestrians and bicyclists traveling through the intersection.

Pedestrian Skywalk

The pedestrian skywalk located above the north leg of Glen Avenue and Catherine Street reduces pedestrian-vehicular conflicts for pedestrians moving from the Glen Avenue parking structure towards the hospital.

Existing Bike Facilities

There are existing bike lanes along Catherine Street and Ann Street. Bike lanes provide a dedicated space for cyclists, separating them from vehicular traffic and reducing the risk of crashes.



5 SAFETY CONCERNS AND SUGGESTIONS

The following sections detail safety concerns identified during the RSA, along with targeted treatment recommendations for each. Seven 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.

In some instances, short, mid, or long-term treatments are provided. Short-term improvements typically involve low-cost treatments that can often be implemented within one year. Mid-term improvements require more planning, moderate investment, and may take up to five years to implement. Long-term improvements are more comprehensive, require major changes, significant funding, and typically require more than five years to implement.

#	Safety Concern	Rating	Suggestions
1	Non-motorized Facilities Pedestrians ▪ Injury crash trend involving permissive left-turn motorist movements ▪ Pedestrian obstacles ▪ Broken pavement in crosswalks ▪ Faded pavement markings ▪ ADA compliance issues associated with intersection corners ▪ Lack of countdown timers - Ann Street and Zina Pitcher Place Bicyclists ▪ Bicycle facilities at Catherine Street and Ann Street drop at the intersection ▪ Parallel alignment of drainage grates create a bicycle tire hazard	E	Short-term ▪ Refresh pavement markings ▪ Install hardened centerlines on the south leg and east leg of Ann Street and Glen Avenue ▪ Improve bicycle facility continuity through intersections by providing bike boxes and intersection conflict markings at Ann Street and Glen Avenue and Catherine Street and Glen Avenue ▪ Consider exclusive pedestrian phases at Glen Avenue and Catherine Street and Ann Street and Zina Pitcher Place Mid-term ▪ Pavement resurfacing ▪ Align drainage grates perpendicular to bike path of travel ▪ Modernize pedestrian facilities to ADA standards, where appropriate

#	Safety Concern	Rating	Suggestions
2	Transit ▪ Approximately 25% of crashes involved a bus ▪ Ann Street and Zina Pitcher Place ▪ 3 crashes involved a northbound right turning bus striking a signal mast arm located in the southeast quadrant ▪ Fatal pedestrian crash involving a westbound left-turning bus (outside crash data analysis period) occurred during flash operations ▪ Glen Avenue and Catherine Street Westbound dual right turn maneuver	D/E	▪ Ann Street and Zina Pitcher Place ▪ Remove overnight flash ▪ Repurpose dedicated right turn lanes and add curb bump outs – westbound and northbound approaches ▪ Modernize signal – add countdown pedestrian signals and relocate mast arm in southeast quadrant ▪ Catherine Street and Glen Avenue ▪ Remove westbound dual right maneuver ▪ Relocate bus stop location on northbound Glen Avenue further downstream of Catherine Street
3	Unfamiliar Drivers ▪ Inconsistent sign placement ▪ MUTCD non-compliant signs ▪ Driver messaging overload – Glen Avenue and Catherine Street ▪ Motorists backing up due to queuing during peak times – Glen Avenue and Catherine Street ▪ Limited visibility/ line of site limitations ▪ One-way sign placement ▪ Do Not Enter sign placement	D	▪ Universal "No Turn on Red" Restrictions ▪ Consistent sign placement ▪ Remove redundant signs ▪ Use of MUTCD compliant signs ▪ Review coordination of signal timings for improvement ▪ Install posted speed limit signs ▪ Review sign and signal mount heights
4	Low Light Conditions ▪ Faded pavement markings (stop bars, crosswalk markings, and lane markings) limiting conspicuity ▪ Nonfunctional lighting fixtures at Ann Street and Zina Pitcher Place ▪ Approx. 50% of the serious and minor injury crashes occurred during non-daylight conditions	D	▪ Refresh retroreflective pavement markings ▪ Improve lighting conditions at Ann Street and Zina Pitcher Place ▪ Provide consistent pedestrian scale lighting

#	Safety Concern	Rating	Suggestions
5	W Medical Center Drive Access ▪ Bicyclists utilizing sidewalk ▪ Unmarked crossing and lack of detectable warnings ▪ Exiting vehicles blocking pedestrian crossings and thru traffic on Catherine Street	C	▪ Provide continental high visibility crosswalk ▪ Install detectable warning pads ▪ Extend bikeway through the intersection per Catherine Street cycletrack concept ▪ Consider northbound one-way operation on W Medical Center Drive
6	Lane Use ▪ Glen Avenue and Catherine Street ▪ Eastbound approach – One shared L/R lane ▪ Westbound approach – Dual westbound right turns ▪ Southbound approach – Lack of outside lane utilization ▪ Ann Street and Zina Pitcher Place ▪ Excessive capacity	C	▪ Reduce conflict points and reallocate space for all users ▪ Educational campaign/high visibility enforcement – Blocking crosswalks ▪ Install advisory signage and audible cues for crosswalks at parking garages ▪ Convert Catherine Street west of Glen Avenue to one-way westbound ▪ Remove split phasing – Add dedicated bike phase to enable Catherine Street cycletrack
7	Vertical Grades ▪ Vehicles roll back when stopped at signal – Southbound Glen Avenue and Catherine Street	B	▪ Consider experimental tailgating treatment – Pennsylvania “Dot”

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 for each category, along with several potential treatments that cover a range of time frames and levels of investment.

NON-MOTORIZED FACILITIES

SAFETY CONCERNS

Based on conversations with local stakeholders, review of available crash data, and field observations made by the RSA team, issues related to vulnerable road users along the corridor were confirmed as a focus area. The study area, located on the University of Michigan Campus adjacent to Downtown Ann Arbor, is a significant generator of pedestrian and bicyclist activity. Figure 16 provides examples of vulnerable road users observed during the field review. The RSA team observed pedestrians utilizing all available sidewalks and bike lanes within the study area. The majority of vulnerable road user traffic appeared to be university students and medical staff walking through the area as well as pedestrians walking to and from the parking garage between Catherine Street and Ann Street. The RSA team noted multiple safety concerns for people walking, biking, and scootering.

Figure 16 - Observed Vulnerable Road Users

The crash analysis revealed a pattern of pedestrian crashes involving permissive left-turning motorists striking pedestrians in the crosswalk. This is a significant safety concern because permissive left turns require drivers to yield to oncoming traffic and pedestrians, which can be challenging in urban intersections with a high volume of pedestrian traffic. Drivers may focus on finding a gap in the oncoming traffic and fail to notice pedestrians crossing the street, leading to collisions. This crash pattern is particularly concerning as pedestrians are vulnerable road users and are at a higher risk of severe injury or fatality in the event of a crash.

During the field review, the RSA team observed pedestrian obstacles such as broken pavement in the crosswalks at the study intersections and faded pavement markings. Figure 17 depicts the pedestrian obstacles identified during the field review. Broken pavement can create tripping hazards, making it difficult for pedestrians to navigate the crosswalks safely and leading to deviations outside of marked crossings. This is particularly concerning for individuals with mobility impairments, who may struggle to maintain balance on uneven surfaces. Faded pavement markings can reduce the visibility of crosswalks and stop bars for all users, leading to confusion among pedestrians and increasing the risk of pedestrian-vehicle collisions. Without clear markings, pedestrians may not be aware of designated crossing areas, further compromising their safety. Additionally, motorists might not see a faded stop bar marking and may encroach on the crosswalk, increasing the risk of a crash involving a pedestrian.

Broken Pavement in the Crosswalk

Faded Crosswalk Markings

Figure 17 - Pedestrian Obstacles

Furthermore, it was observed that some study intersection corners may not be ADA compliant. Specifically, some intersection corners lack detectable warning pads, while others have pads that are obstructed by debris and construction equipment, hindering the tactile cues necessary for visually impaired pedestrians to navigate safely. Additionally, some corners were identified to not provide the adequate amount of space needed for pedestrians, particularly those with mobility impairments, to maneuver comfortably. Figure 18 shows these compliance issues at intersection corners. These conditions pose significant obstacles for pedestrians and compromise the accessibility and safety of the intersections.

Figure 18 - ADA Compliance Issues at Intersection Corners

At the study intersection of Ann Street and Zina Pitcher Place, it was observed that countdown pedestrian timers were not present, with the exception of the southwest corner. The pedestrian signals present at the intersection can be seen in Figure 19. Additionally, during the second day of field reviews, it was observed that the pedestrian signal in the northwest corner was broken, as shown in Figure 19. Without countdown timers, pedestrians do not have a clear indication of how much time they have left to cross the street, leading to uncertainty and potentially risky crossing decisions. This can result in pedestrians being caught in the intersection when the signal changes, increasing the risk of pedestrian-vehicle collisions. Countdown timers provide valuable information that help pedestrians make informed decisions about when to start crossing, thereby enhancing overall pedestrian safety.

Broken Pedestrian Signal Head, Northwest Corner

Pedestrian Signal Head, Northeast Corner

Figure 19 - Pedestrian Signals at Ann Street and Zina Pitcher Place

Bicycle facilities and bicyclist safety were also observed during the field review. The RSA team observed that bicycle facilities at Catherine Street and Ann Street drop at the intersections, as shown in Figure 20. This poses significant safety concerns for cyclists, as they are forced to merge with motor vehicle traffic, increasing the risk of collisions. Additionally, the sudden disappearance of dedicated bike lanes can lead to confusion and unpredictability for both cyclists and drivers, making it difficult for cyclists to navigate safely through the study area. Furthermore, the lack of continuous bike lanes can discourage cycling as a mode of transportation, reducing the overall connectivity and accessibility of the area for cyclists and contributing to observed behaviors like biking on the sidewalk.

Catherine Street at Glen Avenue

Ann Street at Zina Pitcher Place

Figure 20 - Bicycle Facilities Drop Off at Intersections

During field review, it was observed that the drainage grates within the bike lanes on Ann Street were aligned incorrectly. Currently, the drainage grates are aligned parallel to the roadway, as shown in Figure 21, when they should be aligned perpendicular. This misalignment poses significant safety concerns for cyclists. When the grates are parallel to the roadway, there is a risk that bicycle tires can get caught in the gaps of the grate, as demonstrated in Figure 21, causing the bicyclist to lose control and potentially fall into the roadway.

Drainage Grate Alignment on Ann Street

Bicycle Hazard Example[3]

Figure 21 - Incorrect Drainage Grate Alignment

[3] Source: https://www.bikeforums.net/advocacy-safety/700809-trying-ban-dangerous-drains.html

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

Expected Crash Types:	Vulnerable Road User Involved
Expected Frequency:	Occasionally
Expected Severity:	High
Rating:	**E**

POTENTIAL TREATMENTS

PEDESTRIAN TREATMENTS

Refresh Pavement Markings

Refreshing and repainting pavement markings throughout the study area would significantly enhance vulnerable road user safety and improve operations for all users. Clear and visible pavement markings, such as stop bars, crosswalks, and lane lines, play a crucial role in guiding drivers, pedestrians, and cyclists, especially during low-light conditions. By refreshing these markings, the visibility of critical road features is improved, reducing the likelihood of confusion and errors that can lead to crashes. Enhanced pavement markings also help drivers maintain proper lane placement, recognize pedestrian crossings, and adhere to traffic controls, thereby reducing the risk of collisions and promoting safer interactions among all road users.

Install Hardened Centerlines – Glen Avenue and Ann Street

A crash pattern of left-turning motorists hitting pedestrians in the east and south leg crosswalks of Ann Street and Glen Avenue during the permissive left-turn phase was noted during crash review. To reduce the risk and severity of these crashes, it is recommended to install hardened centerlines along the south and east legs of the intersection. The centerline hardening technique encourages left-turning motorists to turn at safe speeds and angles to improve their visibility of pedestrians crossing in the crosswalk. The technique involves adding physical barriers, such as flexible posts, curbs, or other objects along the centerline of the road to discourage motorists from taking shallow turns, which reduces the visibility of other users. Figure 22 depicts this technique. Additionally, it is important to design the hardened centerlines to ensure emergency vehicles, such as firetrucks needing to respond to calls at the hospital, are still able to complete the left turn maneuvers. To accommodate emergency vehicles, mountable rubber curbs should be used near the crosswalk, followed by flexible posts outside of the turning radius.

To further enhance safety, extra flexible delineators should be strategically placed along the east leg of the intersection through the first entrance to the Ann Street parking structure. By positioning these delineators far enough back, vehicles will be discouraged from making improper turns into the parking garage, a behavior that was observed during field reviews. This improper left turn maneuver into the parking garage is depicted in Figure 23. Figure 24 illustrates the recommended placement of the flexible delineators along both the east and south legs of the intersection. This configuration aims to guide vehicles more effectively, reducing the risk of collisions with non-motorized road users.

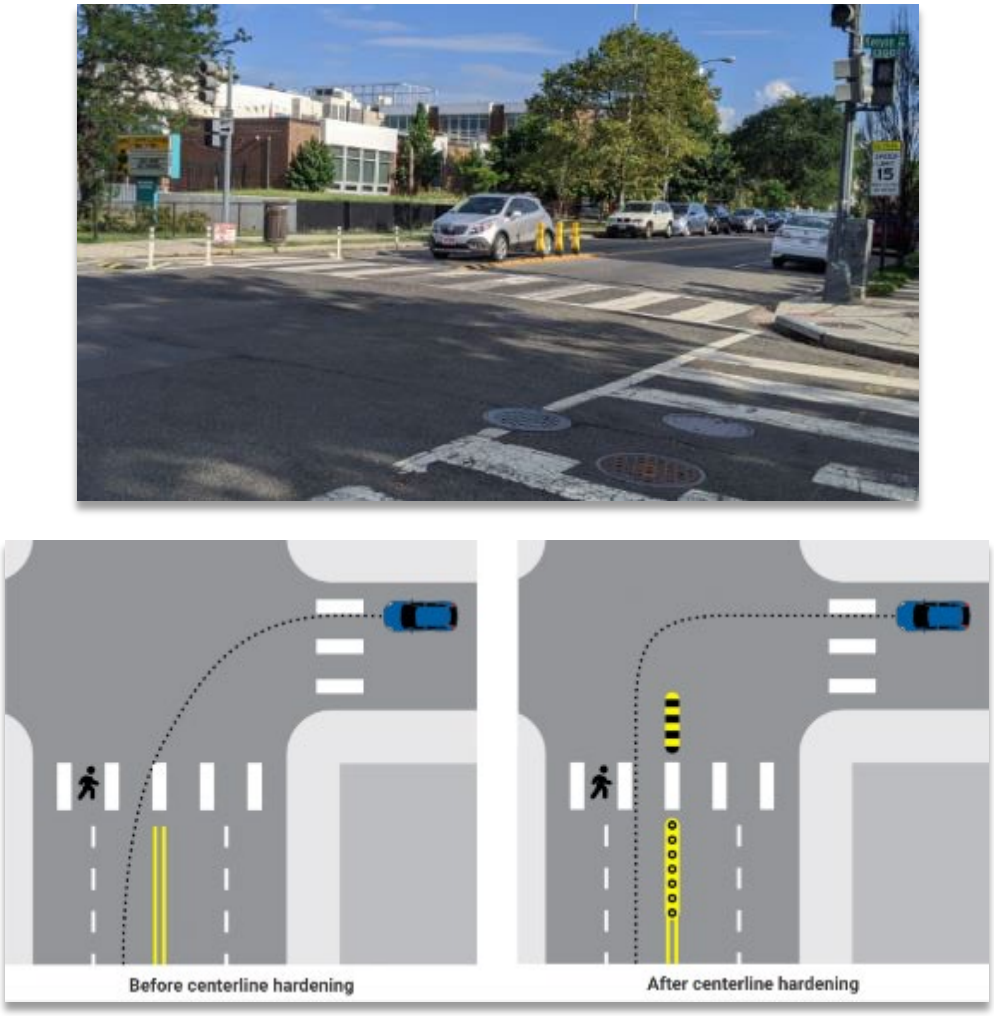


Figure 22 - Centerline Hardening Technique[4]

[4] Source: https://ssti.us/2020/07/30/centerline-hardening-protects-pedestrian-from-left-turning-vehicles/

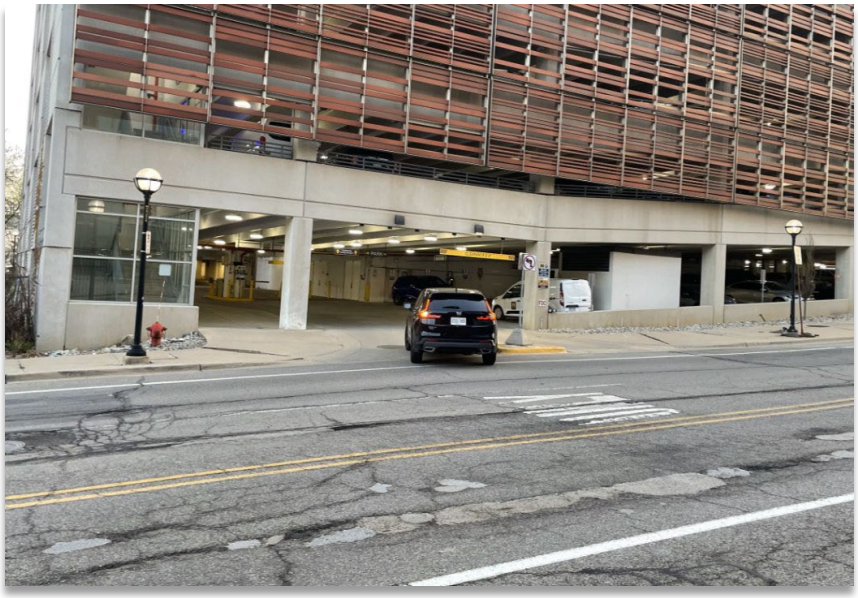


Figure 23 - Improper Left Turn into Ann Street Parking Garage

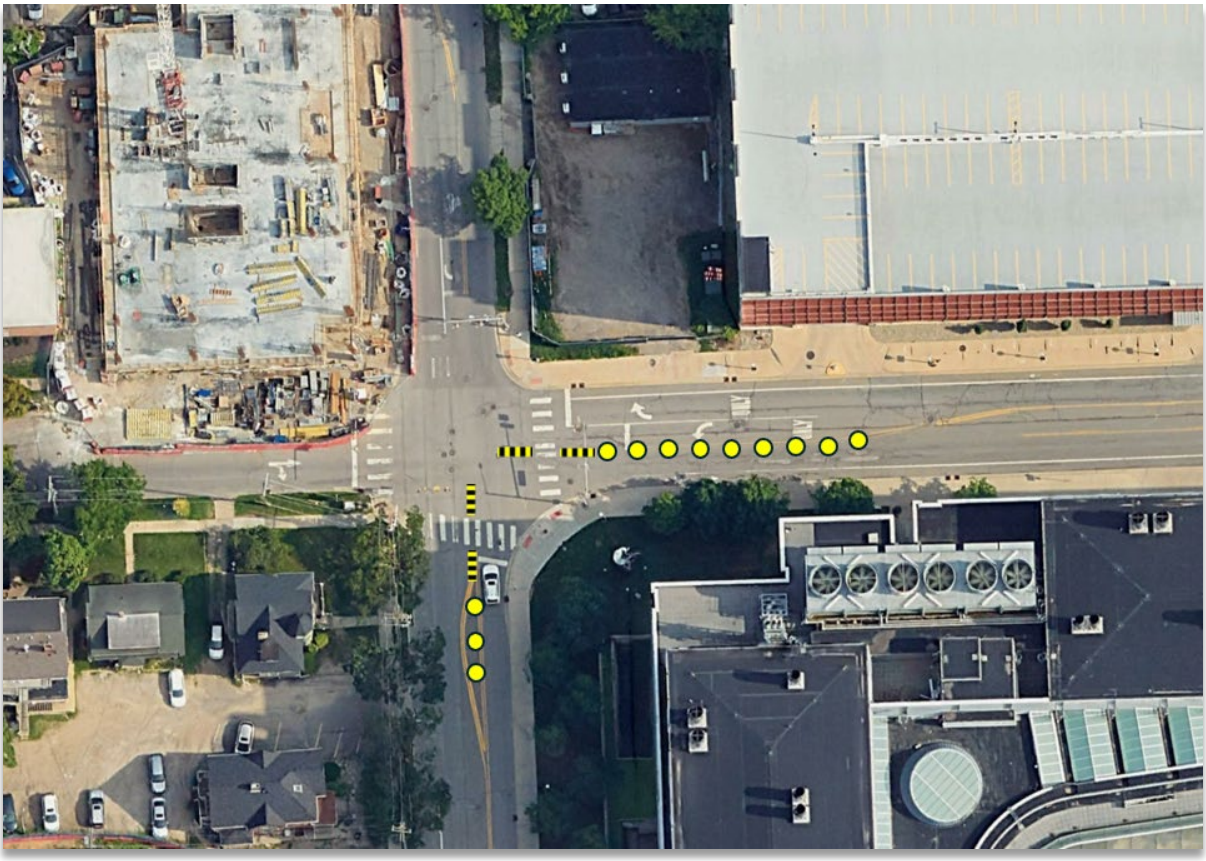


Figure 24 - Recommended Placement of Centerline Hardening at Ann Street and Glen Avenue

BICYCLIST TREATMENTS

Ensuring bicycle facility continuity is crucial for promoting cyclist safety and encouraging the use of bicycles as a mode of transportation. Bicycle facility continuity means providing uninterrupted and consistent bike lanes or paths throughout the study area, without any gaps or sudden drop-offs at intersections. This continuity allows cyclists to navigate the area smoothly and safely, reducing the need to merge with motor vehicle traffic, which can be hazardous. By maintaining continuous bike lanes, especially up to and through intersections, cyclists are less likely to encounter unexpected obstacles or confusion, leading to a safer and more predictable riding experience. Additionally, continuous bicycle facilities enhance the overall connectivity and accessibility of the area for cyclists, encouraging more people to choose cycling as a sustainable transportation option.

Provide Bike Boxes – Ann Street and Catherine Street

Installing bike boxes, as shown in Figure 25, at the intersections where bike lanes are present along Ann Street and Catherine Street would enhance cyclist safety and comfort. Bike boxes are designated areas at the front of a traffic lane at signalized intersections that allow cyclists to position themselves ahead of motor vehicles during the red signal phase. This positioning increases the visibility of cyclists to drivers, reducing the risk of collisions when the light turns green. Additionally, bike boxes provide a safe space for cyclists to make left turns, which can be particularly challenging and dangerous during peak traffic conditions. By implementing bike boxes, cyclists are given priority at intersections, promoting safer interactions between cyclists and motorists and encouraging more people to choose cycling as a mode of transportation.

Figure 25 - Example of a Bike Box at an Intersection[5]

[5] Source: https://www.ayresassociates.com/bike-boxes-boost-bicyclist-visibility/

Install Intersection Conflict Markings

It is recommended to implement intersection conflict markings, as shown in Figure 26, through intersections where bike lanes are present to enhance cyclist safety. Intersection conflict markings are designed to highlight areas where cyclists and motor vehicles may cross paths, making these zones more visible to both drivers and cyclists. By clearly delineating these conflict areas, drivers are more likely to be aware of the presence of cyclists and yield appropriately. These markings also help guide cyclists through intersections, providing a clear path and reducing confusion. This improvement promotes safer interactions between cyclists and motorists, encouraging more people to choose cycling as a mode of transportation and contributing to a more efficient and orderly traffic flow.

Figure 26 - Example of Intersection Conflict Markings at an Intersection[6]

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

Exclusive Pedestrian Phase

Consider implementing an exclusive pedestrian phase at the intersections of Glen Avenue and Catherine Street and Ann Street and Zina Pitcher Place. An exclusive pedestrian phase is a traffic signal timing strategy that temporarily halts all vehicular movements at an intersection, allowing pedestrians to cross in any direction, including diagonally, without the risk of vehicle conflicts. This phase is particularly beneficial in areas with a high volume of pedestrians as it provides dedicated time for pedestrians to cross safely, reducing the likelihood of pedestrian-vehicle collisions. By eliminating the need for pedestrians to navigate through turning vehicles, the exclusive pedestrian phase enhances overall pedestrian safety and promotes a more efficient flow of pedestrian traffic. Additionally, this strategy can improve the visibility of pedestrians to drivers, further reducing the risk of collisions and creating a safer and more pedestrian-friendly environment.

Pavement Resurfacing

It is recommended to repave the roadways within the study area to address the cracked pavement currently present. Pavement resurfacing would enhance safety by providing a smoother and more even surface for all road users, including vehicles, pedestrians, and cyclists. By resurfacing the pavement, trip hazards and detours are mitigated, leading to improved pedestrian safety. Additionally, a well-maintained roadway enhances visibility of pavement markings, further contributing to safer navigation and compliance with traffic regulations.

The RSA team was made aware that pavement resurfacing projects are scheduled at Ann Street, Catherine Street, and Zina Pitcher Place for 2026. The team encourages these repaving projects to be a priority as it will significantly enhance pedestrian and motorist safety. Furthermore, this resurfacing project presents an opportunity to update ADA corners, reallocate lanes, and make geometric improvements.

Align Drainage Grates Perpendicular to Bike Lanes

Realigning the drainage grates located in the bike lanes along Ann Street to position them perpendicular to the bike lanes, rather than parallel, is recommended. By aligning the grates perpendicular to the bike lanes, the risk of cyclist tires getting trapped in the grate is minimized, promoting a safer and more secure environment for cyclists.

Modernize Pedestrian Facilities to ADA Standards

Updating and modernizing the study intersections is recommended to enhance safety and accessibility for all road users. Installing detectable warning pads where they are currently missing or damaged will guide pedestrians, including those with visual impairments, safely across the intersections. Additionally, ensuring that the study intersections meet ADA standards will provide adequate space and tactile cues for individuals with mobility impairments, making it easier for them to navigate the area. These improvements will reduce the risk of pedestrian-vehicle collisions, promote safer interactions among all road users, and create a more inclusive and accessible environment.

SAFETY CONCERNS

The study area experiences a significant amount of bus transit traffic due to the presence of UofM transit buses and TheRide buses that have routes passing through the area. Currently, transit stops are located along Glen Avenue, Ann Street, and Zina Pitcher Place. Figure 27 shows the locations of these stops within the study area.

This high volume of bus traffic contributes to the overall congestion and complexity of the traffic patterns within the study area. Additionally, buses are larger and heavier than regular vehicles, which can lead to more severe crashes. Furthermore, buses have longer stopping distances and larger blind spots compared to smaller vehicles. This can make it more challenging for bus drivers to react quickly to sudden changes in traffic conditions, increasing the risk of crashes. Upon examination of the crash data, it was determined that approximately 25 percent of the crashes involved a bus.

Figure 27 - Transit Stops Within the Study Area

At the study intersection of Ann Street and Zina Pitcher Place, there were three crashes involving a northbound right-turning bus striking a signal mast arm pole located in the southeast quadrant. While conducting the field review, the RSA team noticed the mast arm pole was located very close to the roadway, as depicted in Figure 28. Since buses have larger turning radii than regular vehicles, it is important to keep poles and large stationary objects farther away from the roadway in areas where there is a significant presence of buses.

Furthermore, at Ann Street and Zina Pitcher Place, there was a fatal pedestrian crash in 2014 involving a pedestrian being struck by a bus. Although this crash occurred outside the time period for the crash analysis, it is known that the crash took place during nighttime flash operations for the signal.

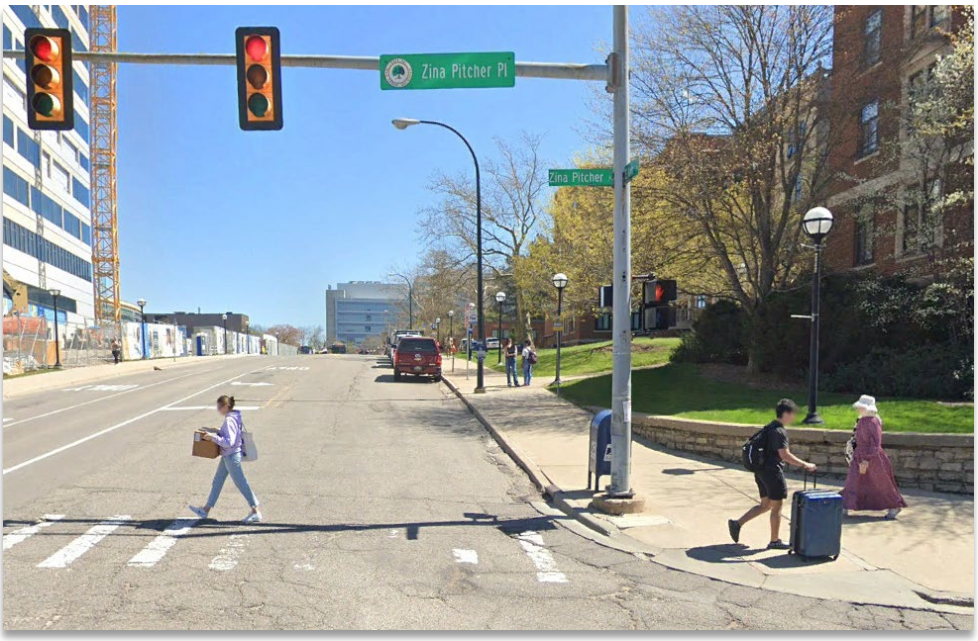


Figure 28 - Signal Mast Arm Located in the Southeast Quadrant of Ann St and Zina Pitcher Pl

During the field review, it was observed that there is a dual right-turn maneuver for the westbound approach at Glen Avenue and Catherine Street. Dual right-turn maneuvers can pose significant issues in areas with a high presence of buses due to their large turning radius and larger blind spots. Buses require more space to complete safe turns, and the presence of dual right-turn lanes can increase the likelihood of sideswipe and angle crashes. This crash pattern was observed in the crash data for the westbound approach.

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

Expected Crash Types:	Sideswipe, Angle, Fixed-object, Non-motorized
Expected Frequency:	Occasionally
Expected Severity:	Moderate/High
Rating:	**D/E**

POTENTIAL TREATMENTS

Ann Street and Zina Pitcher Place

Remove Overnight Flash Operations

Currently, overnight flash operations are present at the intersection. This is the operation that was present at the time of the fatal pedestrian crash. It is recommended to remove the flash operation at the intersection. Doing so will provide consistent signal operations and will ensure that pedestrians have clear and reliable indications for crossing the roadway safely, reducing the likelihood of pedestrian-vehicle conflicts.

Repurpose Dedicated Right Turn Lanes and Add Curb Bump Outs

Dedicated right turn lanes are present along the westbound and northbound approaches at the intersection. From field reviews, it was observed that the intersection may have excess capacity. With that, it is recommended to assess repurposing the dedicated right turn lanes along the westbound and northbound approaches if excess capacity is present in future conditions. By doing so, the turning radius along those approaches will be increased and buffer between buses and objects like signal poles, reducing the likelihood of non-motorized and fixed object crashes involving buses.

By repurposing the right turn lanes, there would be an opportunity to provide curb bump outs. Curb bump outs are a traffic calming measure that involves extending the sidewalk or curb into the roadway at intersections. This design effectively narrows the crossing distance for pedestrians and improves their visibility to motorists. By reducing the pedestrian crossing distance and increasing visibility, the risk of a pedestrian-vehicle collision is reduced. This is particularly effective in areas with a high presence of pedestrians and bus traffic, such as the intersection of Ann Street and Zina Pitcher Place. Figure 29 depicts the recommended configuration of the intersection.

Figure 29 - Curb Bump Outs at Ann Street and Zina Pitcher Place [7]

[7] Source: https://sdg.minneapolismn.gov/design-guidance/intersections/pedestrian-crossings/curb-extensions

Modernize the Traffic Signal

Add Countdown Pedestrian Signals

Countdown pedestrian signals are traffic control devices that display a numerical countdown indicating the number of seconds remaining in the flashing "DON'T WALK" interval. It is recommended to install these signals in all quadrants of the intersection, with the exception of the southwest quadrant as one is already present there. These signals can enhance pedestrian safety by providing clear and predictable information about the remaining crossing time. This helps pedestrians make informed decisions about whether they have enough time to cross the street safely. Additionally, countdown signals can reduce pedestrian confusion and improve compliance with traffic signals, leading to smoother and more efficient intersection operations.

Relocate Mast Arm in Southeast Quadrant

As shown in Figure 28, the signal mast arm located in the southeast quadrant is very close to the roadway and has been struck multiple times by buses. It is recommended to relocate the mast arm farther away from the roadway to reduce the chances of a bus striking it.

Glen Avenue and Catherine Street

Remove Westbound Dual Right Maneuver

Currently, there is a dual right maneuver present along the westbound approach of the intersection. A crash pattern of sideswipe crashes involving buses was observed from the crash analysis. To mitigate these risks, it is recommended to remove the dual right maneuver. This change will reduce the likelihood of sideswipe crashes involving buses due to their large turning radius and larger blind spots. By repurposing these lanes, the roadway can be reconfigured and optimized for safer and more inclusive traffic operations. For example, the added space gained from removing one lane can be utilized to install a cycle track as illustrated in the Catherine Street cycletrack conceptual plan.

Relocate Bus Stop Location on Northbound Glen Avenue Further Downstream

There are UofM and TheRide bus stops currently located approximately 120 feet north of the Glen Avenue and Catherine Street intersection, along Glen Avenue. These stops were observed to create disruptions in traffic flow, as vehicles would make sudden evasive maneuvers to avoid being stuck behind a bus that was preparing to stop. Additionally, multiple buses, including articulated buses, were observed stopping at the location and causing a backup into the intersection. With these observations, it is recommended to relocate the bus stops further downstream from the intersection to help mitigate these conflicts and improve traffic operations.

UNFAMILIAR DRIVERS

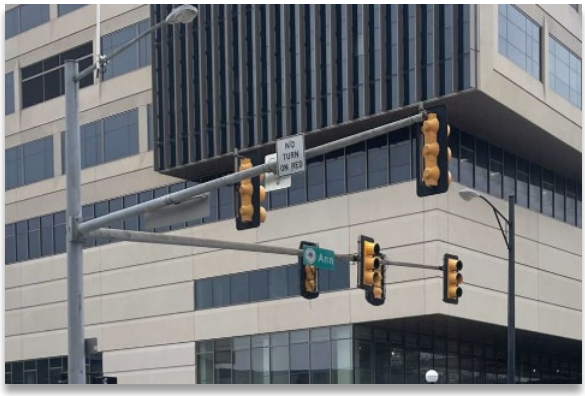
SAFETY CONCERNS

Due to the proximity of the University of Michigan Hospital Center as well as downtown Ann Arbor, a significant number of unfamiliar drivers travel through the study area. Hospital areas commonly attract unfamiliar drivers such as patients and caregivers while downtown areas commonly attract drivers traveling for business, tourism, or entertainment. This observation was confirmed through discussions with stakeholders. Unfamiliar drivers may not be familiar with the local roadways and traffic patterns, especially non-standard patterns like those in the study area. The high presence of unfamiliar drivers can lead to potential safety issues, as these drivers may be prone to making navigation errors or sudden stops. With this, it is important to have clear and concise wayfinding.

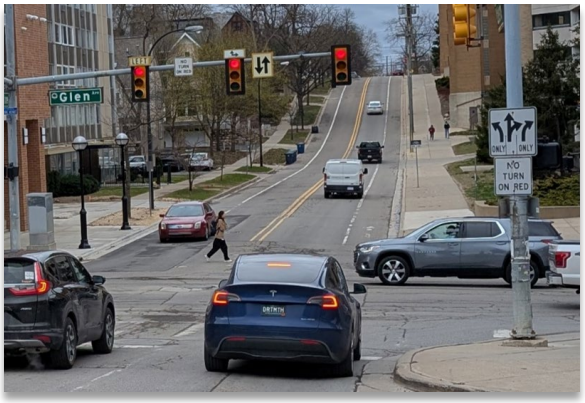
From the field observations conducted by the RSA team, it was noted that there is inconsistent sign placement as well as Manual on Uniform Traffic Control Devices (MUTCD) non-compliant signs located throughout the study area. For example, at the study intersections, "No Turn on Red" signs were located at different placements at approaches. For some approaches, the sign would be located on the mast arm pole near the roadway, while for other approaches, it would be located on the mast arm near the signal heads or mounted on signposts. Furthermore, for some approaches, signs were placed in multiple locations. Inconsistent sign placement can lead to confusion and disruptions to traffic flow which increases the likelihood of a crash. Figure 30 shows the different placements of "No Turn on Red" signs throughout the intersections.

Southbound Approach at Glen Avenue and Catherine Street

Eastbound Approach at Glen Avenue and Ann Street



Eastbound Approach at Ann Street and Zina Pitcher Place



Westbound Approach at Glen Avenue and Catherine Street

Figure 30 - No Turn on Red Sign Placements

Additionally, signs such as "No Turn on Red" and "Vehicles Must Yield to Pedestrians" signs were noted to no longer be compliant with the Manual on Uniform Traffic Control Devices (MUTCD). This non-compliance can result in confusion for drivers as drivers might not understand the signage. Figure 31 depicts the MUTCD non-compliant signs present at the study intersections.

"No Turn on Red" Sign

"Left Turn Must Yield to Pedestrians" Sign

Figure 31 - MUTCD Non-compliant Signs

At the intersection of Glen Avenue and Catherine Street, there is an abundance of signage that may lead drivers to become overwhelmed and overloaded with information while traversing the intersection. This may lead to crashes as the driver may become confused with what maneuvers are allowed at the intersection. Signs such as "No Turn on Red", "Left Turns Must Yield to Pedestrians", and lane use signage are duplicated along the approaches of the intersection. Figure 32 depicts the westbound approach of the intersection. From the figure, it can be seen that there is duplicate signage for "No Turn on Red" with one sign located on the mast arm pole near the roadway and another sign on the mast arm near the signal heads. Additionally, there are two lane use signs on the mast arm poles along both the left and right sides of the road, as well as case signs designating legal turning maneuvers. Furthermore, the case signs interchange between symbols and words, making them inconsistent.

Figure 32 - Driver messaging overload at Glen Avenue and Catherine Street

Additionally, the one-way sign, designating Catherine Street as one-way westbound at Glen Avenue, located on the mast arm pole in the northeast quadrant, was observed to be blocked occasionally by buses and by other signs at the intersection. Additionally, the "Do Not Enter" sign located on the mast arm pole in the southeast quadrant was also observed to be obstructed at some angles by other signs. Both scenarios are illustrated in Figure 33. Limited visibility of these signs can lead to drivers missing critical information, resulting in wrong-way movements and increased risk of collisions.

Bus is Taller Than the One-way Sign

One-way Sign is behind the Left Turn Must Turn Left Sign

Figure 33 - One-Way Sign Obstructions at Glen Ave and Catherine St

Furthermore, it was observed in the field by the RSA team, as well as in crash reports, that there is a pattern of motorists backing up to avoid blocking the intersection due to queuing along the southbound approach at Glen Avenue and Catherine Street during peak conditions. During the field review, a near miss was observed when a motorist attempted to back up while a pedestrian was crossing the roadway behind the vehicle.

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

Expected Crash Types:	Rear End, Sideswipe, Backing
Expected Frequency:	Frequent
Expected Severity:	Low
Rating:	**D**

POTENTIAL TREATMENTS

Universal "No Turn on Red" Restrictions

While there are "No Turn on Red" signs present along some approaches at the study intersections, it is not present along all approaches. With that, it is recommended to implement universal "No Turn on Red" restrictions along all approaches of the study intersections to prohibit motorists from turning right when the traffic light is red. With this implementation, conflicts between right-turning vehicles and pedestrians and bicyclists traveling through the intersection are reduced. This restriction and messaging is especially beneficial in reducing conflicts at locations that experience a high volume of vulnerable road users, such as the study intersections.

Consistent Sign Placement

In areas with unfamiliar drivers, such as the study area, consistent sign placement is important. Unfamiliar drivers may not be accustomed to the local roadways and traffic patterns, making it essential to have clear and predictable signage. Consistent sign placement also enhances the overall visibility and legibility of signs. It is recommended to place signs such as "No Turn on Red", "Left Turns Must Yield to Pedestrians", one-way signs, and lane use signs in consistent places throughout the study intersections. This helps reduce navigation errors and sudden stops, which can lead to improved traffic congestion and safety.

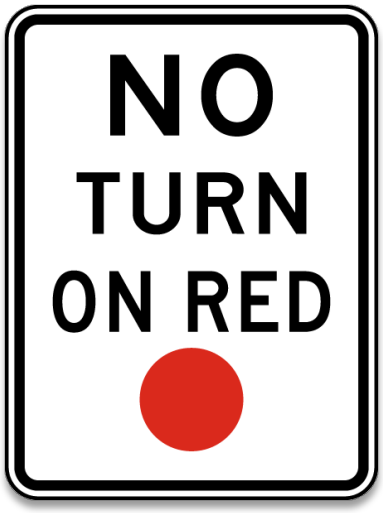
Remove Redundant Signs

As represented in Figure 32, there is significant redundant signage at the study intersections, particularly at Glen Avenue and Catherine Street. Having redundant signage at intersections can lead to information overload for drivers, causing confusion. Additionally, redundant signs can contribute to distracted driving, as drivers may become preoccupied with trying to read and interpret multiple signs, diverting their attention away from the road. This confusion and distraction can lead to crashes, particularly in busy urban intersections, such as the study intersections. Moreover, redundant signs can clutter the visual environment, making it harder for drivers to spot important signs and signals, thereby reducing the effectiveness of traffic control devices and compromising safety.

It is recommended to remove redundant signage at the study intersections which will simplify the signage at the intersections and help drivers quickly understand the traffic rules. By having fewer signs, there will be less confusion, distracted driving, and visual clutter which will allow motorists to navigate the intersection safely.

Use of MUTCD Compliant Signs

Currently, there are signs present at the study intersections that are not compliant with the MUTCD. It is recommended that these signs be replaced with MUTCD compliant signs to ensure consistency and uniformity across the roadway network. This standardization will help drivers recognize and understand the signs easier as they are driving. Signs that were non-compliant with the MUTCD include the "No Turn on Red" signs and "Left Turns Must Yield to Pedestrians" signs. Figure 34 depicts the signs that are compliant with the MUTCD.



No Turn on Red Sign (R10-11) ***Turning Vehicles Yield for Pedestrians (R10-15)***

Figure 34 - MUTCD Compliant Signage

Review of Sign and Signal Mount Heights

Due to buses and other signs blocking the one-way sign and "Do not Enter" signs at the intersection of Glen Avenue and Catherine Street it is recommended that the sign and signal mount heights get reviewed to ensure they are placed at appropriate heights. By doing so, the visibility of signs and signals may be improved for drivers, pedestrians, and bicyclists. Properly mounted signs are less likely to be obstructed by tall vehicles, pedestrians, or other fixed objects, which can help drivers quickly and accurately interpret the information provided at the intersection. This is particularly important in areas with a high presence of unfamiliar drivers.

Review Coordination of Signal Timings

As queuing was observed during peak conditions, it is recommended to review signal timing coordination throughout the study area. Specifically, queuing was observed for motorists heading southbound from Catherine Street towards Ann Street along Glen Avenue during the afternoon peak as well as along Glen Avenue and Ann Street to access the parking garage during the morning shift change peak. During future review of the signal timings in the study area, it might be noticed that coordination between the signals can be improved, which may reduce delays and improve traffic flow for motorists.

Install Posted Speed Limit Signs

During field review, the team observed that there were no speed limit signs posted in the study area. Given that the study area is within an urban downtown area and near a hospital, a *prima facie* speed limit of 25 MPH is assumed. However, drivers may not be aware of this assumed speed limit, especially drivers who are unfamiliar with the area. Therefore, it is recommended that 25 MPH speed limit signs be installed throughout the study area, particularly on Glen Avenue, to clearly inform motorists of the speed limit and ensure compliance with safe driving conditions.

LOW LIGHT CONDITIONS

SAFETY CONCERNS

During the field review completed by the RSA team, faded pavement markings of stop bars, crosswalks, and lane markings were noticed throughout the study intersections. When pavement markings are not clearly visible, drivers may have difficulty identifying stop bars, pedestrian crossings, and lane lines, especially during low light conditions. This can lead to confusion and increase the likelihood of crashes, as drivers may inadvertently encroach into other lanes leading to sideswipe crashes or failure to yield to pedestrians resulting in non-motorized crashes. Additionally, faded markings can reduce the effectiveness of traffic signals, as drivers rely on these markings to guide their movements. Figure 35 shows faded markings present at the intersections.

Glen Ave and Ann St East Leg Stop Bar and Crosswalk

Westbound Catherine St Lane Markings

Figure 35 - Faded Pavement Markings at Maple Road and Eton Street

Overall, the lighting within the study area was effective and functional. There is both intersection lighting and pedestrian scale lighting. However, some intersection light fixtures were observed to be non-functioning during the low light condition field review, specifically near the intersection of Ann Street and Zina Pitcher Place, as shown in Figure 36. Non-functional intersection lighting poses a safety concern as it reduces the motorist's visibility and makes it difficult for them to see other vehicles, pedestrians, and bicyclists increasing the risk of collisions.

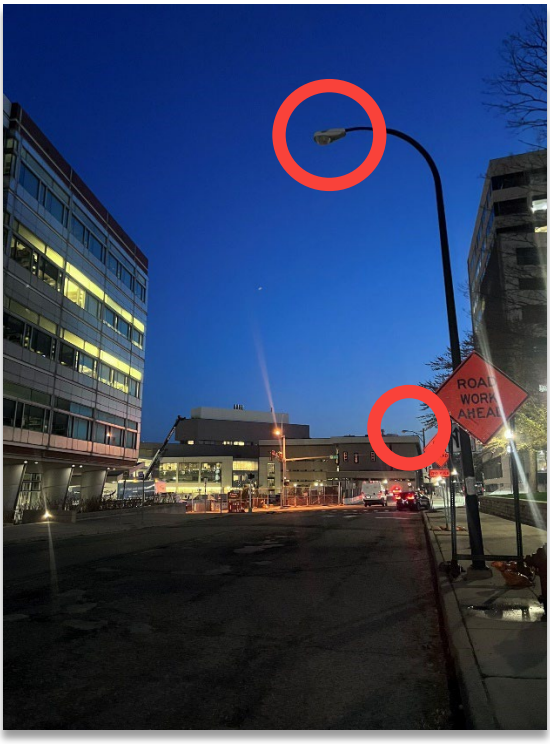


Figure 36 - Non-functional light fixtures at Ann Street and Zina Pitcher Place

Furthermore, the crash analysis completed of the study area revealed that approximately 25% of total crashes occurred during non-daylight conditions whereas 50% of the serious and minor injury crashes occurred during non-daylight conditions. This trend indicates that crashes that occur during low light conditions tend to result in more severe injuries.

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 D.

Expected Crash Types:	Rear End, Sideswipe, Non-motorized
Expected Frequency:	Occasional
Expected Severity:	Moderate
Rating:	**D**

POTENTIAL TREATMENTS

Refresh Retroreflective Pavement Markings

Consider restriping the pavement markings within the study area, specifically using retroreflective pavement markings, as it will enhance visibility of the markings and improve safety for drivers, especially during nighttime and low-light conditions. This increased visibility helps drivers to better navigate the road, identify lane lines, and recognize important road features, thereby reducing the risk of crashes. It is recommended to refresh the markings using retroreflective pavement markings, which is currently used in the study area, as they are particularly effective in adverse weather conditions, such as rain or fog, where visibility is often compromised. Figure 37 shows the suggested enhanced visibility pavement markings.

Figure 37 - Retroreflective Pavement Markings[8]

Fix the Non-functional Light Fixtures

The non-functional light fixtures located at Ann Street and Zina Pitcher Place can be fixed by contacting the energy company that maintains the light fixture.

Provide Consistent Pedestrian-scale Lighting

Currently there is pedestrian-scale lighting located within and around the study area; however, the lighting is not present throughout the entire study area. Areas in which there are gaps in pedestrian scale lighting include the east side of Glen Avenue between Catherine Street and Ann Street, the west side of Glen Avenue south of Ann Street, the south side of Catherine Street near Glen Avenue, and the west side of Zina Pitcher Place south of Ann Street. It is recommended to provide pedestrian scale lighting in the places shown in Figure 38 so that it is present throughout the study area to enhance pedestrian comfort and safety by providing adequate illumination, making it easier to see potential hazards and navigate the area safely.

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

Additionally, low-level pedestrian-scale lighting creates a more intimate and calming atmosphere, as the light sources are positioned closer to the ground and nearer to pedestrians, rather than high above. Furthermore, low-level lighting can be decorative and visually appealing, adding aesthetic value to the sidewalk and enhancing the overall ambiance of the area.

Based on the review of upcoming projects, it was understood that pedestrian-scale lighting is expected to be constructed along the sidewalks where the new parking structure is being constructed in the northwest quadrant of Ann Street and Zina Pitcher Place.

Figure 38 - Recommended Pedestrian Scale Lighting

W MEDICAL CENTER DRIVE ACCESS

SAFETY CONCERNS

W Medical Center Drive is located approximately 50 feet to the east of Glen Avenue on Catherine Street. The roadway connects to the north side of the medical campus and was observed to experience a moderate amount of traffic.[9] The two-way road is stop controlled on the southbound approach, allowing right turns onto Catherine Street. Vehicles were observed blocking pedestrian crossings and thru traffic on Catherine Street during peak conditions, as shown in Figure 39, leading to a disturbance in traffic operations.

Furthermore, the crossing along W Medical Center Drive is missing pavement markings and a detectable warning pad on the west side of the crossing, as shown in Figure 40, posing safety concerns.

Figure 39 - Vehicles blocking crossing and Disturbing Traffic Operations on Catherine Street

[9] This may have been influenced by network routing effects caused by the reconstruction of the bridge further north of the study area at Maiden Lane and Fuller Avenue.

Missing Pavement Marking

Missing Detectable Warning Pad

Figure 40 – Deficiencies at the Crossing along W Medical Center Drive

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

Expected Crash Types:	Angle, Non-motorized
Expected Frequency:	Rare
Expected Severity:	Moderate
Rating:	**C**

POTENTIAL TREATMENTS

Provide Continental High Visibility Crosswalk

Striping the crosswalk along W Medical Center Drive with a high visibility design such as continental, which is provided along all other crosswalks in the study area, is recommended. Continental crosswalks have thick, white stripes that make them more visible to both drivers and pedestrians, especially during low-light conditions, compared to traditional crosswalks. Additionally, the high visibility markings can improve compliance with pedestrian crossing rules, leading to smoother and safer intersection operations.

Install Detectable Warning Pad

Install a detectable warning pad on the west side of the crosswalk to adhere to ADA standards and provide a safe crossing for visually impaired pedestrians. By installing warning pads, it will ensure that pedestrians are aware of the crossing, even if they cannot see it, which can prevent crashes and improve the overall safety of the intersection.

Extend Bikeway Through the Intersection

Currently, directional marked bike lanes exist along both sides of Catherine Street to the west of the Glen Avenue. However, new concepts created by the City propose extending a separated two-way bikeway along the north side of Catherine Street through the intersection. It is recommended to extend the bikeway through W Medical Center Drive, as shown in Figure 41, consistent with the Catherine Street cycletrack concept. This bikeway will provide separated, two-way dedicated lanes for cyclists, thereby reducing the risk of collisions and enhancing overall cyclist safety. Additionally, the bikeway will improve connectivity and accessibility within the study area, allowing cyclists to avoid using the sidewalks.

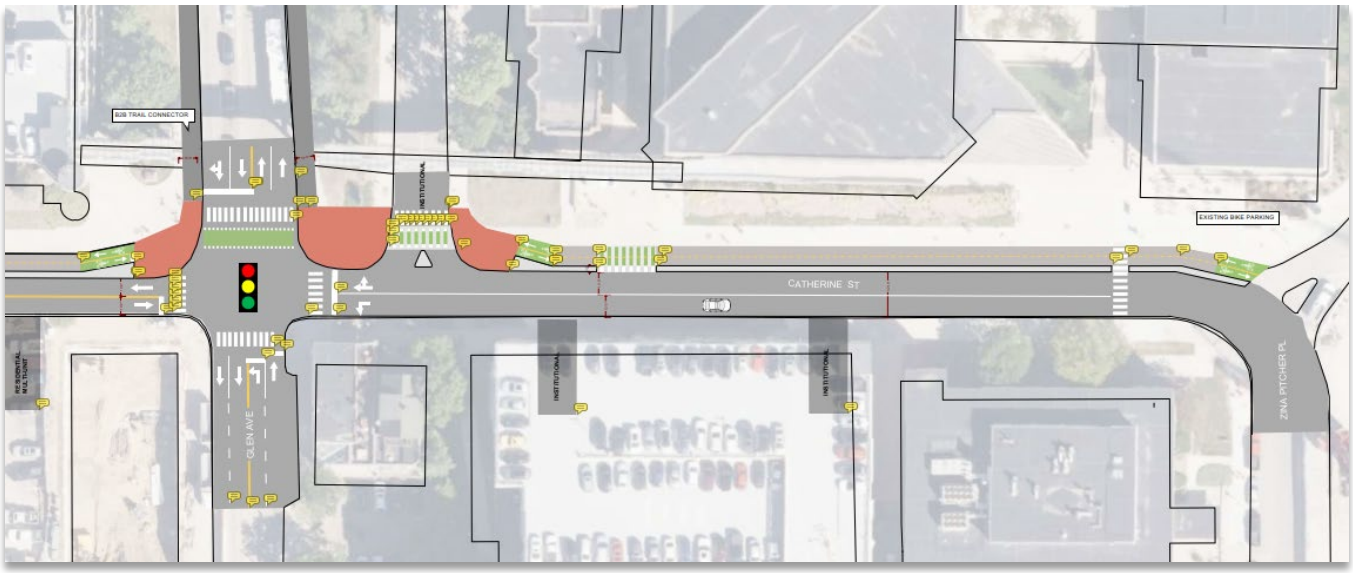


Figure 41 - Cycletrack Concept Along Catherine Street

Consider Northbound One-way Operation

It is recommended to convert W Medical Center Drive to a northbound one-way road. This conversion could help reduce traffic congestion by eliminating the potential for right-turning vehicles to block and disrupt traffic along Catherine Street. Additionally, it would eliminate conflicts between southbound vehicles and pedestrians and bicyclists attempting to cross W Medical Center Drive, thereby improving overall safety and traffic flow.

LANE USE

SAFETY CONCERNS

During the RSA field review, the team observed various lane uses within the study area, including dedicated left-turn lanes, shared thru/right turn lanes, and bike lanes. Analyzing lane use is crucial because it helps identify potential conflicts and inefficiencies in traffic flow, allowing for targeted improvements to enhance safety and operations.

The team observed that there was a lack of vehicles utilizing the outside lane on the southbound approach of Glen Avenue between Catherine Street and Ann Street. The lack of utilization of the lane could lead to inefficiencies in traffic flow and allow for a reconfiguration of the space to make the area more inclusive to other modes of transportation. Additionally, the team noted a dual right-turn movement along the westbound approach, which can pose safety issues.

At the intersection of Ann Street and Zina Pitcher Place, it was observed that the intersection did not operate at full capacity. By reallocating the space and potentially repurposing some of the lanes, the intersection can be made more inclusive to other modes of transportation, such as bicycles and pedestrians.

As new planned developments are built, it is important to recognize that lane use requirements may change. This may necessitate adjustments to lane configurations to accommodate increased traffic volumes to ensure smooth and safe navigation for all road users.

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

Expected Crash Types:	**Angle, Sideswipe**
Expected Frequency:	Frequent
Expected Severity:	Negligible
Rating:	**C**

POTENTIAL TREATMENTS

Reduce Conflict Points and Reallocate Space for All Users

To enhance safety and efficiency, it is recommended to reduce conflict points and reallocate space for all users throughout the study area, particularly where there is excess capacity. Specifically, the outside lane of Glen Avenue between Ann Street and Catherine Street and the intersection of Ann Street and Zina Pitcher Place have been identified as areas that may have excess capacity. By reallocating space in these areas, the roadway can be made more inclusive for all users, including pedestrians and cyclists. This reconfiguration will help to optimize traffic flow, reduce the likelihood of collisions, and create a safer environment for vulnerable road users. Additionally, reallocating space can provide dedicated lanes for cyclists and pedestrians, improving their visibility and safety while promoting a more balanced and efficient use of the roadway.

Educational Campaign/High Visibility Enforcement – Blocking Crosswalks

Implementing an educational campaign and high visibility enforcement in the study area may help to address pedestrian crossing concerns, specifically concerns with motorists blocking crosswalks. These initiatives have the potential to raise awareness about pedestrian safety and encourage safe behaviors among both drivers and pedestrians.

The educational campaign may focus on public awareness initiatives, community engagement, and school programs. Informational materials can be distributed, advertisements can be run, and social media can be utilized to educate the public about pedestrian safety rules and the dangers of not following them. Workshops, seminars, and events may be hosted to engage the community and educate them about safe pedestrian practices. Additionally, educating motorists about the importance of not blocking crosswalks while waiting at traffic signals will be emphasized.

High visibility enforcement involves an increased police presence in areas with high pedestrian traffic to monitor and enforce traffic laws. Law enforcement officers may issue citations to drivers who violate pedestrian right-of-way laws. Checkpoints and regular patrols may be set up to ensure compliance with pedestrian safety laws.

Install Advisory signage and Audible Cues for Crosswalks at Parking Garages

Consider installing advisory signage and audible cues at crosswalks at parking garages as it can enhance pedestrian safety. These measures are particularly important in parking garages, where visibility can be limited and vehicle traffic is often unpredictable.

Advisory signage serves as a visual reminder for both pedestrians and drivers about the presence of crosswalks. The sign, as shown in Figure 42 below, includes a clear and easily recognizable symbol, informing drivers to slow down and be cautious, while guiding pedestrians to use designated crossing points. This visual communication helps to reduce confusion and ensures that everyone is aware of the appropriate areas for crossing, thereby minimizing the risk of crashes.

Additionally, audible cues provide sound signals that alert pedestrians when it is safe to cross. These cues can include beeping sounds, spoken messages, or other auditory signals that indicate the presence of pedestrians. Audible cues are especially beneficial for individuals with visual impairments, ensuring they can safely navigate the crosswalk.

Figure 42 – Advisory Signage for Crosswalks at Parking Garages (W11-2)

Convert Catherine Street west of Glen Avenue to One-way Westbound

Catherine Street is currently two way for one block between N Ingalls Street and Glen Avenue. Converting Catherine Street west of Glen Avenue to a one-way westbound road may enhance traffic flow and safety at the intersection of Catherine Street and Glen Avenue. This change would reduce the complexity of traffic movements, minimizing the risk of collisions, and improving overall road efficiency. By limiting the direction of travel, drivers would experience fewer conflicts and clearer navigation, which is particularly beneficial at intersections with high pedestrian and cyclist activity. Additionally, this conversion would provide more space for dedicated bike lanes and pedestrian pathways, promoting safer interactions among all road users and encouraging the use of sustainable transportation modes. Furthermore, by implementing this change, the split phasing currently present at the intersection can be removed, which would improve traffic operations. Removing split phasing simplifies signal operations and reduces the waiting time for pedestrians, making crossing phases more intuitive.

Add dedicated bike phase – Glen Avenue and Catherine Street

It is recommended that a dedicated bike phase at the intersection of Glen Avenue and Catherine Street be added as it would significantly enhance safety and convenience for cyclists. This dedicated phase would allow cyclists to navigate the intersection without the risk of collision with motor vehicles, reducing the likelihood of crashes.

VERTICAL GRADES

SAFETY CONCERNS

While completing the crash analysis, a crash pattern of vehicles rolling back after being stopped on southbound Glen Avenue and Catherine Street was observed due to a vertical grade in the roadway. The grade was also observed in the field as an upward slope towards Catherine Street along Glen Avenue. This issue poses safety concerns, as drivers may not anticipate the sudden backward movement of the vehicle in front of them, causing confusion and panic among drivers, leading to abrupt evasive maneuvers that further compromise safety. This led to a pattern of rear end and backing crashes along the north leg of the intersection.

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:	Backing, Rear-end
Expected Frequency:	Occasional
Expected Severity:	Negligible
Rating:	**B**

POTENTIAL TREATMENTS

Experimental Tailgating Treatment - Pennsylvania "Dot"

If concerns persist, consider implementing an experimental tailgating technique along the southbound approach at Glen Avenue and Catherine Street. The "Dot" treatment is a traffic engineering measure designed to assist motorists in maintaining a safe following distance. This treatment involves marking a series of ellipses (dots) on the pavement at equal spacing according to the posted roadway speed. The markings are centered in the travel lane and are spaced such that a safe distance is kept between vehicles when a minimum of two markings separates them. The safe distance is determined by the two-second following rule. The treatment is particularly effective in areas with a high concentration of aggressive driving or tailgating-related crashes.

In areas with significant vertical grades, such as the southbound approach at Glen Avenue and Catherine Street, the "Dot" treatment can improve safety by providing clear visual cues that help drivers maintain a safe following distance. The vertical grade present along the approach often causes vehicles to roll back. By ensuring a safe distance between vehicles, the "Dot" treatment creates a sufficient gap between vehicles, allowing a rolling back vehicle enough time to react and stop before colliding with the vehicle behind it.

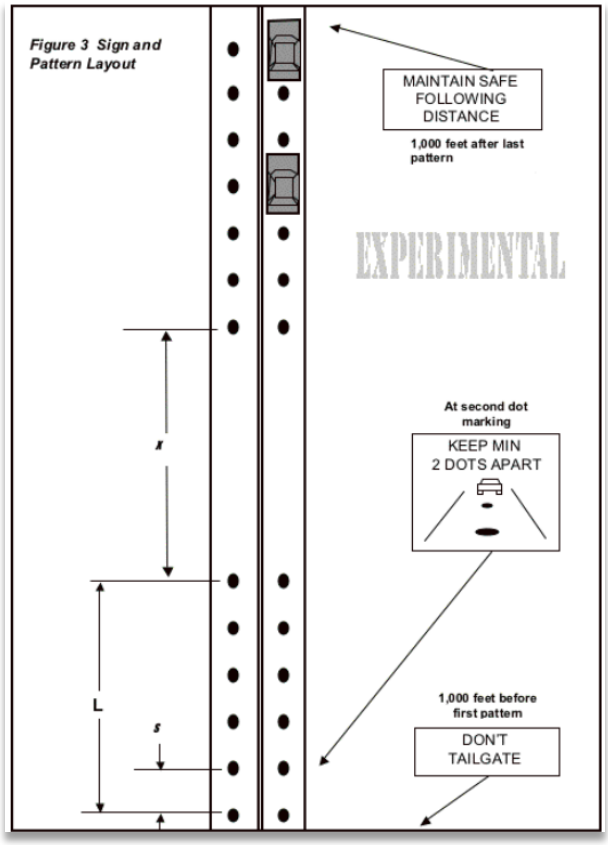


Figure 43 - Pennsylvania "Dot" Treatment Concept [10]

[10] Source: https://ops.fhwa.dot.gov/publications/low_cost_traf/appendix.htm

LONG-TERM OPPORTUNITIES

To enhance safety and clarify to all users that they are in a low-speed environment and to provide connected, all ages and abilities networks for all users, the RSA team developed several long-term recommendations. These recommendations are, in general, more costly and/or require significant supplementary analysis and coordination between stakeholders. These recommendations are summarized in Figure 47, which provides an overview of all the long-term recommendations throughout the study area.

Provide Consistent Pedestrian Scale Lighting

As mentioned previously, pedestrian-scale lighting is recommended throughout the sturdy area in all locations where it is not currently present. By doing so, pedestrian comfort and safety may be enhanced as it provides adequate illumination, making it easier for users to see potential hazards and navigate the area safely. Furthermore, consistent urban design helps to reinforce that users are entering and operating in a campus environment and communicates to drivers that they should expect pedestrians everywhere and operate with caution at lower speeds.

Raised Intersections

Is indicated in Figure 47, raised intersections should be considered at Ann Street and Zina Pitcher Place and Zina Pitcher Place and Catherine Street to calm vehicle speeds and communicate that pedestrians are the priority user at locations interior to the University of Michigan Medical Campus.

A raised intersection is a traffic calming measure where the entire intersection is elevated to the level of the adjacent sidewalks, creating a continuous surface for pedestrians. This design helps to slow down vehicular traffic as drivers approach and navigate the intersection, promoting a safer environment for all road users. The safety benefits of raised intersections include improved visibility for pedestrians, as the elevated surface makes them more noticeable to drivers. Additionally, reduced vehicle speeds at raised intersections decrease the likelihood and severity of collisions, particularly those involving vulnerable road users. Raised intersections also enhance accessibility for individuals with mobility impairments by providing a smoother and more level crossing surface.

Reconstruct and Widen Sidewalks – East Side of Glen Avenue

Future redevelopment of the parcels of land adjacent to the east side of Glen Avenue between Catherine Street and Ann Street should consider opportunities to widen the sidewalk by returning a portion of private right-of-way to the public realm. Widening the sidewalk would provide more space for pedestrians, enhancing accessibility and accommodating higher foot traffic, which is especially beneficial in a campus environment. Additionally, a wider sidewalk will expand the buffer between pedestrians and vehicular traffic, increasing comfort. Buffer space could host amenities like street trees or furnishings.

When reconstructing the sidewalk, the possibility of an at-grade bike facility or extending the shared-use path that begins at Glen Avenue north of Catherine Street should also be assessed. In concert with lane reconfiguration on Glen Avenue discussed above, this would provide a dedicated space for cyclists, connecting the Catherine Street and Ann Street facilities through the campus. A comparison of alternatives that approximate the existing condition, a scenario with a southbound separated bicycle facility with no ROW acquisition, and a scenario with bicycle facilities in both directions and limited ROW acquisition (7') are shown in Figure 44 through Figure 46.

The short- and mid-term recommendations earlier in this report, complemented by the long-term recommendation to address the remaining gap on Glen Avenue would create a complete bike network that enables students and staff to safely and comfortably access the medical campus. Figure 47 illustrates what this network could look in the context of other recommendations in this RSA report.

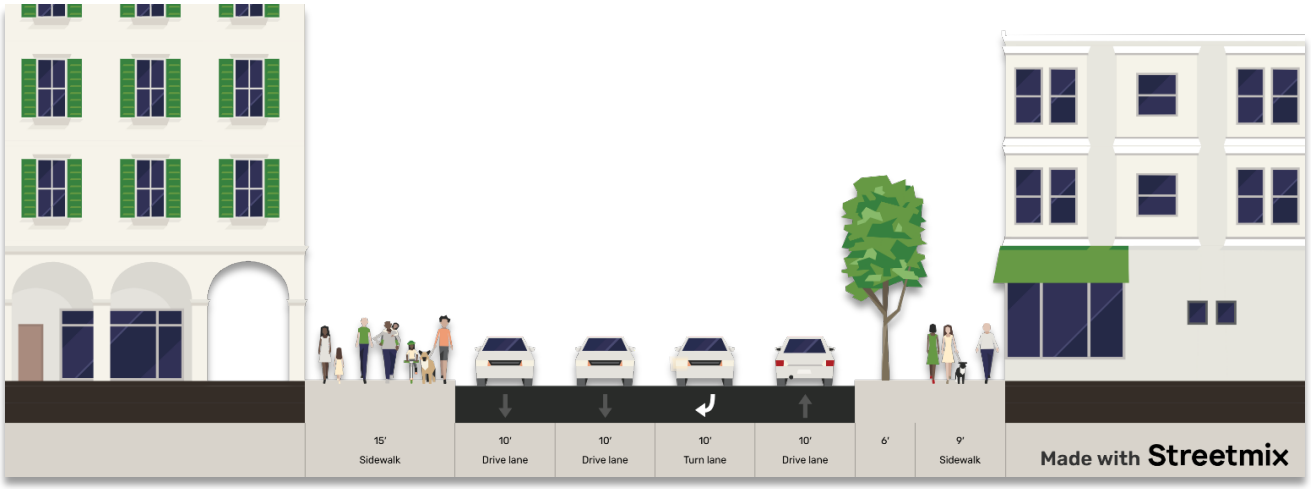


Figure 44 - Glen Avenue – Catherine Street to Ann Street, Existing Cross Section

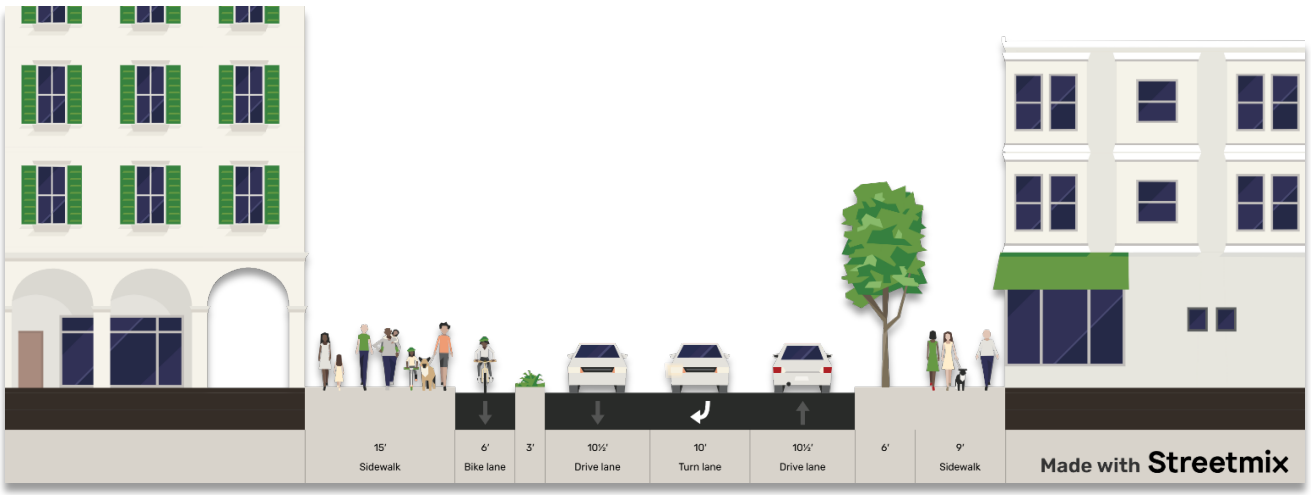


Figure 45 - Glen Avenue – Catherine Street to Ann Street, Alternative with SB Separated Bike Lane

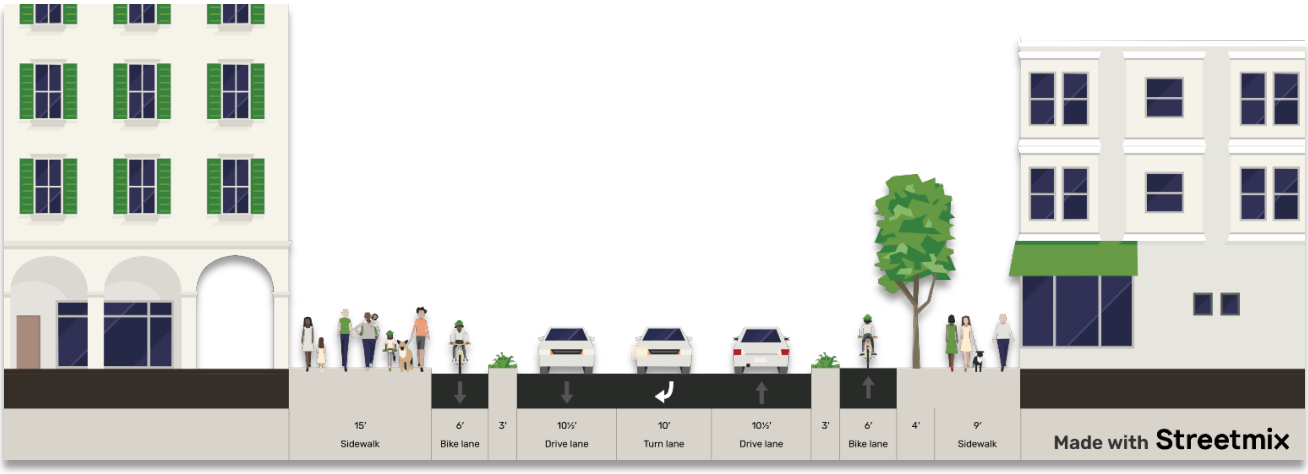


Figure 46 - Glen Avenue – Catherine Street to Ann Street, Alternative with Separated Bike Lanes, ROW

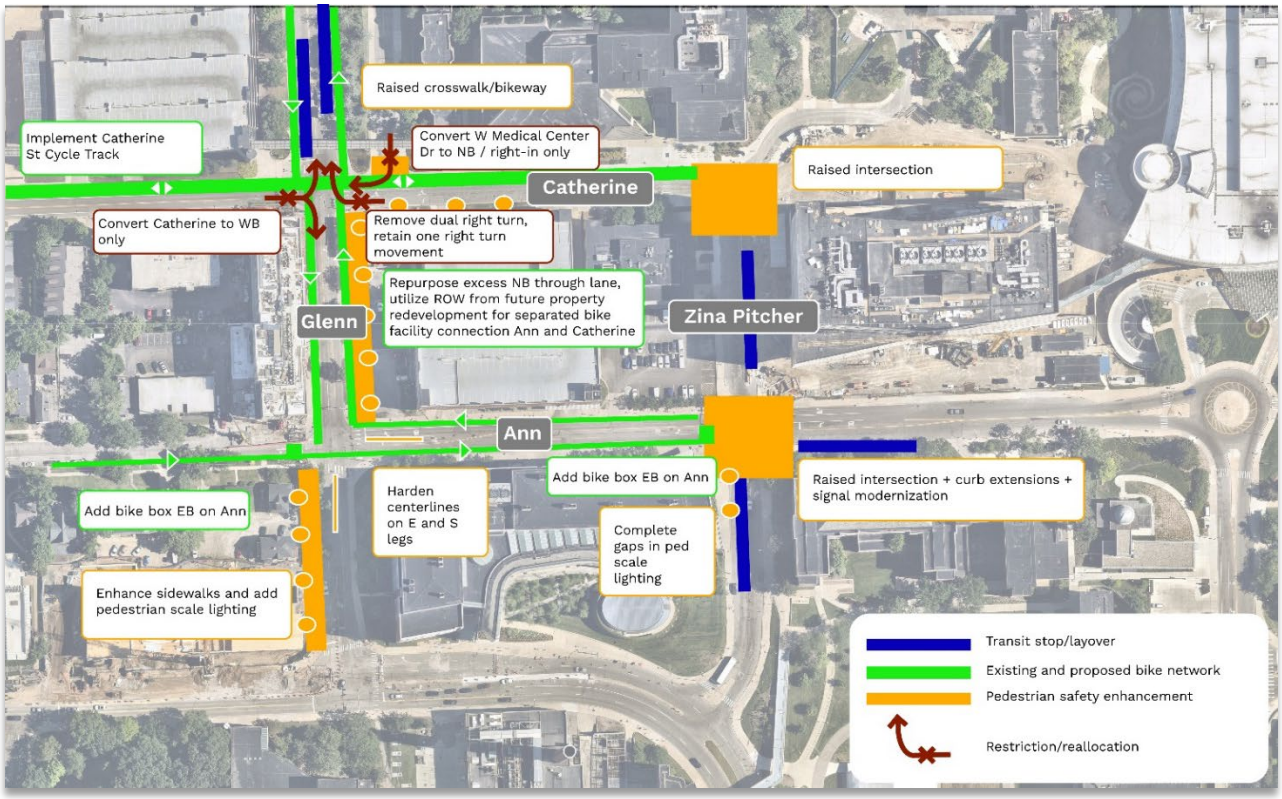


Figure 47 - Site-wide Recommendations

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 Signalized Intersection (MI) model was 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 intersections of Glen Avenue and Catherine Street, Glen Avenue and Ann Street, and Ann Street and Zina Pitcher Place. For this analysis, traffic volumes from either 2020 or 2022 and crash data from 2019 to 2023 was utilized in the evaluation.

INTERSECTION CHARACTERISTICS

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

Glen Avenue and Catherine Street

- Type: Urban/Suburban Intersection
- Traffic Control: Four-way Signal
- Major/Minor AADT: 13,000/2,300
- Major/Minor Road Flow Type: Two-way/Two-way*
- Major/Minor Median Present: Not Present/Not Present
- Intersection Lighting: Present
- Major/Minor Number of Through Lanes: 3/1
- Major Road Speed Limit: 25
- Right Turn on Red Status Prohibited
- Major Street Left Turn Lane on All Approaches: Not Present
- Additional CMF's used: None

* The westbound approach of the minor street is one-way, while the eastbound approach is two-way. Due to limitations in the spreadsheet, two-way was chosen for its more conservative nature.

These base conditions expect a total of 3.265 crashes/year, of which 0.492 would include a fatality or injury. A review of the crash data observed an average of 5.335 total crashes/year, meaning there are 2.07 excess expected crashes/year.

Glen Avenue and Ann Street

- Type: Urban/Suburban Intersection
- Traffic Control: Four-way Signal
- Major/Minor AADT: 13,000/5,000
- Major/Minor Road Flow Type: Two-way/Two-way
- Major/Minor Median Present: Not Present/Not Present
- Intersection Lighting: Present
- Major/Minor Number of Through Lanes: 3/1
- Major Road Speed Limit: 25
- Right Turn on Red Status: Prohibited
- Major Street Left Turn Lane on All Approaches: Not Present
- Additional CMF's used: None

These base conditions expect a total of 3.346 crashes/year, of which 0.65 would include a fatality or injury. A review of the crash data observed an average of 3.654 total crashes/year, meaning there are 0.308 excess expected crashes/year.

Ann Street and Zina Pitcher Place

- Type: Urban/Suburban Intersection
- Traffic Control: Four-way Signal
- Major/Minor AADT: 5,000/5,000
- Major/Minor Road Flow Type: Two-way/Two-way
- Major/Minor Median Present: Not Present/Not Present
- Intersection Lighting: Present
- Major/Minor Number of Dedicated Through Lanes: 2/1
- Major Road Speed Limit: 25
- Right Turn on Red Status: Prohibited
- Major Street Left Turn Lane on All Approaches: Not Present
- Additional CMF's used: None

These base conditions expect a total of 1.063 crashes/year, of which 0.256 would include a fatality or injury. A review of the crash data observed an average of 1.937 total crashes/year, meaning there are 0.874 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 Appendix A. 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 5 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 5 - Summary of HSM Compatible Crash Modification Factors

Proposed Treatment	**Related Intersection(s)**	**Crash Type**	**Crash Severity**	**Crash Modification Factor (CMF)** [11]
Install Bike Lanes	All	Vehicle/ Bicycle	All	0.8
*Implement Systemic Signing at Signalized Intersections ("No Turn on Red")**	All	All	All	0.955
*Implement Systemic Signing at Signalized Intersections ("Turning Vehicles Yield to Pedestrians")**	Glen Ave & Catherine St	All	All	0.955
Increase Intersection Illuminance from Low to Medium	Ann St & Zina Pitcher Pl	Nighttime	All	.48
*Retroreflective Pavement Markings**	All	All	All	.887
Improve Signal Visibility	Glen Ave & Catherine St	All	K, A, B, C	.71
*Install Pedestrian Countdown Timer**	Ann St & Zina Pitcher Pl	All	All	.912
Replace Night-Time Flash with Steady Operations	Ann St & Zina Pitcher Pl	Nighttime	All	.52

**CMF used in HSM analysis*

A number of potential treatment combinations exist for the study intersections. The following analysis considers a single scenario for each intersection to help illustrate the potential benefits when implementing some of the recommended countermeasures. The expected improvements (per the HSM) are summarized in Table 6.

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

Glen Avenue & Catherine Street –

- Implement systematic signing ("No Turn on Red")
- Implement systematic signing ("Turning Vehicles Yield to Pedestrians")
- Retroreflective Pavement Markings

Glen Avenue & Ann Street –

- Implement systematic signing ("No Turn on Red")
- Retroreflective Pavement Markings

Ann Street & Zina Pitcher Place –

- Implement systematic signing ("No Turn on Red")
- Increase intersection illuminance from low to medium
- Retroreflective Pavement Markings
- Install pedestrian countdown timers

Table 6 – Expected Crash Frequency per the HSM

Intersection	Expected Crash Frequency (Crashes/Year)				Total Percent Reduction
	Base Conditions Expected (Fatal & Injury)	Base Conditions Expected (PDO)	Expected with CMFs Applied (Fatal & Injury)	Expected with CMFs Applied (PDO)	
Glen Avenue & Catherine Street	0.492	2.773	0.406	2.352	15.5%
Glen Avenue & Ann Street	0.65	2.696	0.56	2.387	11.9%
Ann Street & Zina Pitcher Place	0.256	0.806	0.099	0.325	66.1%

The National Safety Council (NSC) calculates the cost of motor-vehicle crashes, which can be seen in Table 7.

Table 7 - 2022 NSC Crash Costs

	Cost
Fatal (K)	$1,869,000
Incapacitating Injury (A)	$162,000
Non-Incapacitating Injury (B)	$42,000
Possible Injury (C)	$26,000
No Injury (O)	$7,100
Property Damage Only (Cost per Vehicle)	$6,100

The weighted average cost of all motor-vehicle crashes (fatal, nonfatal injury, and property damage) using data from NSC is approximately $41,300. This cost was applied to the expected reduction of crashes to obtain an expected benefit as shown in Table 8. The estimated implementation costs, calculated using MDOT's Weighted Average Item Price Reports, are also detailed in the benefit/cost summary.

Table 8 - Benefit-Cost Summary

Intersection	Expected Reduction in Crashes		Benefit[12]	Implementation Cost	Assumed Service Life (Years)	B/C
	Injury	PDO				
Glen Ave & Catherine St	0.086	0.421	$20,940	$15,000	7	8.70
Glen Ave & Ann St	0.09	0.309	$16,480	$14,000	7	7.33
Ann St & Zina Pitcher Pl	0.157	0.481	$26,350	$62,000	10	3.63

[12] Based on 2022 National Safety Council Crash Cost Estimates (https://injuryfacts.nsc.org/all-injuries/costs/guide-to-calculating-costs/data-details/)

7 SUMMARY

The Southeast Michigan Council of Governments (SEMCOG) retained WSP to facilitate an Operational Service Road Safety Audit (RSA) at the intersections of Glen Avenue and Catherine Street, Glen Avenue and Ann Street, and Ann Street and Zina Pitcher Place in the city of Ann Arbor, Michigan. The RSA was conducted primarily to review the intersections for vulnerable road user related safety considerations, make suggestions before the scheduled repaving projects throughout the study area and a two-way cycle track project along Catherine Street, and assess future needs within the area as new developments are expected to be completed in the coming years.

The study area is in proximity to the University of Michigan medical campus and downtown Ann Arbor. 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 bus transit traffic
- Significant presence of unfamiliar motorists
- Queuing only during peak periods, otherwise excessive capacity
- Continuous sidewalk facilities
- Intersection lighting present

Crash data collected from 2019 through 2023 for the intersection was obtained by the RSA team from MichiganTrafficCrashFacts.org. Supplemental data, such as UD-10 reports were also obtained. During the five-year study period, 9 (10%) serious, suspected, or possible minor injury crashes were reported out of a total of 93 reported crashes. No fatalities were recorded in the crash reports. There were 43 reported crashes at Glen Avenue and Catherine Street, 35 reported crashes at Glen Avenue and Ann Street, and 15 reported crashes at Ann Street and Zina Pitcher Place. One fatal pedestrian crash occurred at Ann Street and Zina Pitcher Place outside of the crash analysis timeline. Some safety concerns raised during discussions with stakeholders and identified by the audit team included:

- Non-motorized Facilities
    - Crash trend involving permissive left-turns
    - Obstacles within pedestrian facilities
    - ADA compliance issues
    - Lack of countdown timers at Ann Street and Zina Pitcher Place
    - Obstacles within bicycle facilities
- Transit
    - Large percentage of crashes involving buses
    - Bus involved fatal crash at Ann Street and Zina Pitcher
    - Dual right turn at Glen Avenue and Catherine Street
- Unfamiliar Drivers
    - Inconsistent and overloaded sign placement
    - MUTCD non-compliant signs
    - Queueing during peak periods
- Low Light Conditions
    - Faded pavement markings
    - Nonfunctional light fixtures at Ann Street and Zina Pitcher Place
    - Crash trend of injury crashes occurring during low light conditions

- W Medical Center Dr Access
    - Bicyclists utilizing sidewalk
    - Unmarked crossing and missing detectable warning pad
    - Vehicles blocking pedestrians crossing
- Lane Use
    - Dual westbound right turn at Glen Avenue and Catherine Street
    - Lack of outside lane utilization of the southbound approach of Glen Avenue and Catherine Street
    - Excessive Capacity at Ann Street and Zina Pitcher Place
- Vertical Grades
    - Vehicles rolling back at the southbound approach of Glen Avenue and Catherine Street
    - Limited visibility/line of site limitations

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.

APPENDIX

A HSM OUTPUT

HIGHWAY SAFETY MANUAL ANALYSIS – URBAN & SUBURBAN SIGNALIZED INTERSECTION

#	Major Roadway	Minor Roadway	Jurisdiction	Intersection Type	Major Road Flow Type	Minor Road Flow Type	Major AADT	Minor AADT	Major Road Median Presence	Minor Road Median Presence	Total Major Road Through Lanes (Both Directions)	Total Minor Road Through Lanes (Both Directions)	Major Road Speed Limit	Right Turn on Red Status	Lighting Presence	Major Street Left Turn Lane on all approaches	County	1997 MDOT Region	2016 MDOT Region	Economic Prosperity Region
Existing Conditions	Glen Avenue	Catherine Street	Ann Arbor	4SG	Two-Way	Two-Way	13,000	2,300	Not Present	Not Present	3	1	25	Prohibited	Present	Not Present	Washtenaw	University	University	Southeast Michigan Prosperity Region
Existing Conditions	Glen Avenue	Ann Street	Ann Arbor	4SG	Two-Way	Two-Way	13,000	5,000	Not Present	Not Present	3	1	25	Prohibited	Present	Not Present	Washtenaw	University	University	Southeast Michigan Prosperity Region
Exisitng Conditions	Ann Street	Zina Pitcher Pl	Ann Arbor	4SG	Two-Way	Two-Way	5,000	5,000	Not Present	Not Present	1	1	25	Prohibited	Present	Not Present	Washtenaw	University	University	Southeast Michigan Prosperity Region
Recommended Conditions	Glen Avenue	Catherine Street	Ann Arbor	4SG	Two-Way	Two-Way	13,000	2,300	Not Present	Not Present	3	1	25	Prohibited	Present	Not Present	Washtenaw	University	University	Southeast Michigan Prosperity Region
Recommended Conditions	Glen Avenue	Ann Street	Ann Arbor	4SG	Two-Way	Two-Way	13,000	5,000	Not Present	Not Present	3	1	25	Prohibited	Present	Not Present	Washtenaw	University	University	Southeast Michigan Prosperity Region
Recommended Conditions	Ann Street	Zina Pitcher Pl	Ann Arbor	4SG	Two-Way	Two-Way	5,000	5,000	Not Present	Not Present	1	1	25	Prohibited	Present	Not Present	Washtenaw	University	University	Southeast Michigan Prosperity Region

					Empirical Bayes Analysis																	
					Observed Crash Frequency $N_{observed}$ (crashes/year)						Expected Crash Frequency, $N_{expected}$ (crashes/year) (Equation A-4 from Part C Appendix)											
Intersection Type	Additional CMF - 1	Additional CMF - 2	Additional CMF - 3	Additional CMF - Numeric	Multiple-Vehicle F-I Observed Crashes	Single-Vehicle F-I Observed Crashes	Multiple-Vehicle PDO Observed Crashes	Single-Vehicle PDO Observed Crashes	Motor Vehicle Only F-I Observed Crashes	Motor Vehicle Only PDO Observed Crashes	Multiple-Vehicle F-I Expected Crash Frequency	Single-Vehicle F-I Expected Crash Frequency	Motor Vehicle Only F-I Expected Crash Frequency	Multiple-Vehicle PDO Expected Crash Frequency	Single-Vehicle PDO Expected Crash Frequency	Motor Vehicle Only PDO Expected Crash Frequency	Multiple-Vehicle All-Severity Expected Crash Frequency	Single-Vehicle All-Severity Expected Crash Frequency	Motor Vehicle Only All-Severity Expected Crash Frequency	*Total Expected Crashes (crashes/year)*	Excess Expected Crashes (crashes/year) Nobserved - Nexpected
University4SG	N/A (1.000)	N/A (1.000)	N/A (1.000)	1.000	0.800	0.000	7.200	0.600	0.800	7.800	0.477	0.015	NA	2.728	0.045	NA	3.205	0.060	NA	3.265	5.335
University4SG	N/A (1.000)	N/A (1.000)	N/A (1.000)	1.000	1.400	0.000	5.200	0.400	1.400	5.600	0.633	0.017	NA	2.637	0.059	NA	3.270	0.076	NA	3.346	3.654
University4SG	N/A (1.000)	N/A (1.000)	N/A (1.000)	1.000	0.600	0.000	1.800	0.600	0.600	2.400	0.244	0.012	NA	0.763	0.043	NA	1.007	0.056	NA	1.063	1.937
University4SG	N/A (1.000)	N/A (1.000)	N/A (1.000)	0.809	0.800	0.000	7.200	0.600	0.800	7.800	0.394	0.012	NA	2.315	0.037	NA	2.709	0.049	NA	2.757	5.843
University4SG	N/A (1.000)	N/A (1.000)	N/A (1.000)	0.847	1.400	0.000	5.200	0.400	1.400	5.600	0.546	0.014	NA	2.337	0.050	NA	2.883	0.065	NA	2.948	4.052
University4SG	N/A (1.000)	N/A (1.000)	N/A (1.000)	0.371	0.600	0.000	1.800	0.600	0.600	2.400	0.094	0.005	NA	0.309	0.016	NA	0.402	0.021	NA	0.423	2.577