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TROY

OHIO

Pedestrian Safety Review

Main St & Market St, City of Troy, Ohio

November 2021, Revised May 31, 2022

WOOLPERT

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References

FHWA Pedestrian Safety Guide and Countermeasure Selection System
http://pedbikesafe.org/PEDSAFE/

FHWA Safe Transportation for Every Pedestrian (STEP) -
https://safety.fhwa.dot.gov/ped_bike/step/resources/

Ohio Manual on Uniform Traffic Control Devices (OMUTCD), 2012, Ohio Department of Transportation (ODOT).

1 Background

This study is being prepared at the request of The City of Troy to analyze the pedestrian safety conditions at the intersection of Main Street and Market Street and to determine what, if any, improvements can be made to improve pedestrian safety. The intersection, known as "The Square", is located in the center of Troy's downtown area and provides multimodal access to local restaurants and shops.

1.1 Existing Conditions

Main Street (SR 41) and Market Street (SR 55) intersect within The Square at a single lane roundabout (Figure 1) with bypass right turn lanes on all four approaches. Overhead lane use signs are provided for each approach with striped splitter islands. Both roadways are classified as urban minor arterials with posted speed limits of 25 mph within the study area, though the north leg of Market Street is a 35 mph four-lane roadway only one block north of The Square. Angled parked is provided on both sides of all four legs with additional parking in all four external quadrants of The Square.

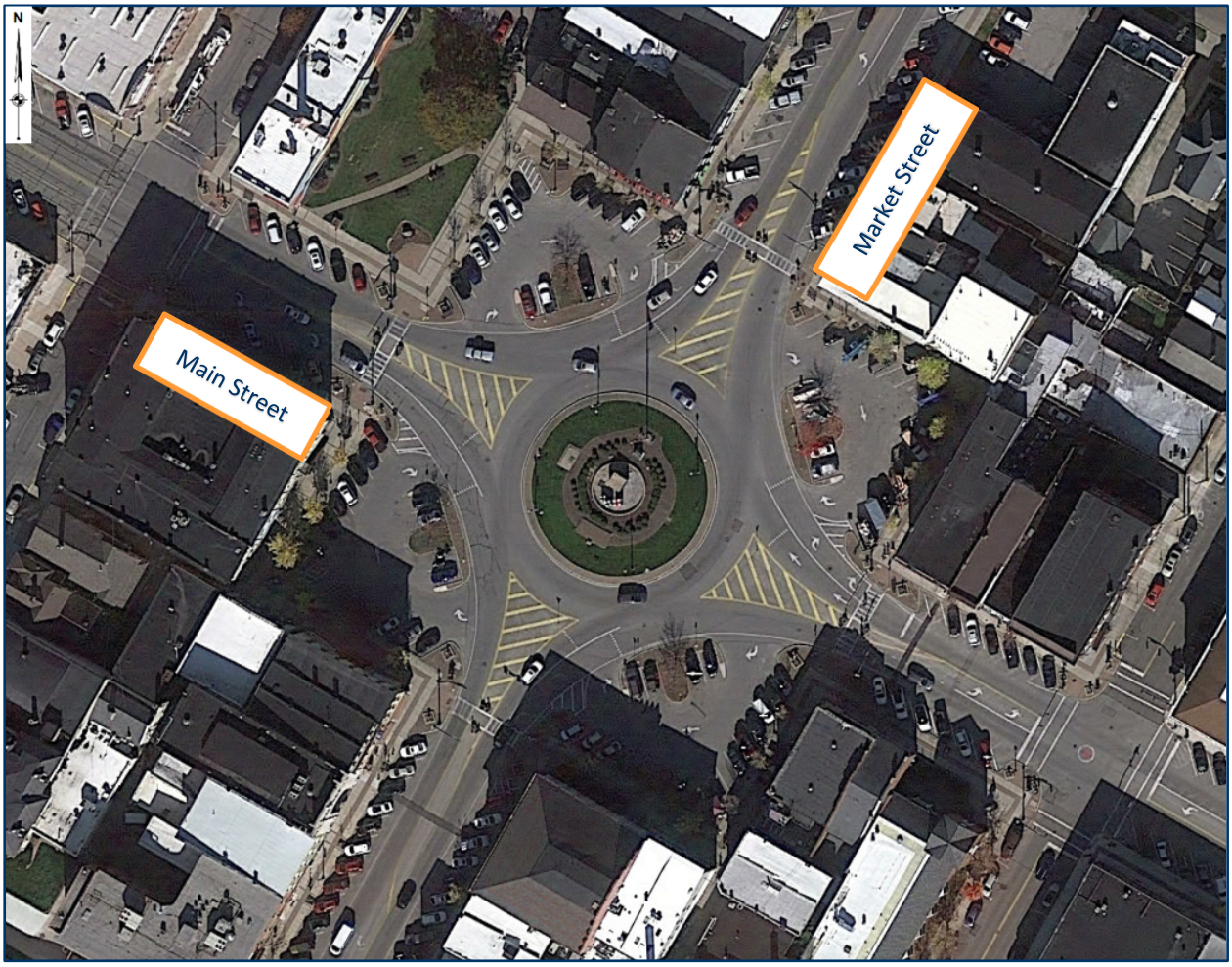


Figure 1: Study Area

Pedestrian crossings are provided on all four legs, with continental crosswalks through the striped splitter islands, approximately 60 ft. in advance of the yield lines. Concrete planters and flashing in-street pedestrian crossing signs (R1-6) are provided in the striped splitter islands to delineate the crosswalks. Fluorescent pedestrian crossing signs are also provided on one side of the road at each crosswalk. Most of the existing curb ramps appeared to be ADA compliant though several could use repairs to the brick pavers and two ramp slopes were non-compliant on the northeast corner and southeast corner.

1.2 Crash Analysis

Analysis of crash data from the last three years was completed within one block of The Square to identify trends and contributing factors. The analysis was also compared to the 2017 Parking and Traffic Assessment to determine if new issues have appeared or if existing trends have continued or been resolved. Following the recommendations in the 2017 study, pedestrian actuated signals were removed from the roundabout. The signals would stop all roundabout vehicular traffic while pedestrians crossed. Four lane approaches on Market Street were also converted to three lanes to increase space for angled parking in an effort to reduce crashes associated with vehicles sticking out of parking stalls.

Analysis of crash data between 2018 and 2020 showed a total of 93 crashes, or 31 crashes per year on average within the four-block area including the roundabout and four approaches. It should be noted that 2020 showed a slightly lower crash rate than the previous two years, potentially the result of COVID lockdowns and less traffic on the road. Without the 2020 data, the yearly crash rate for 2018-2019 was approximately 35 crashes. Crashes appeared to correlate with peak hour traffic, particularly for the midday peak (14% of crashes) and PM peak (15% of crashes), as shown in Figure 2. There was no correlation between crash data and the month of year or day of week.

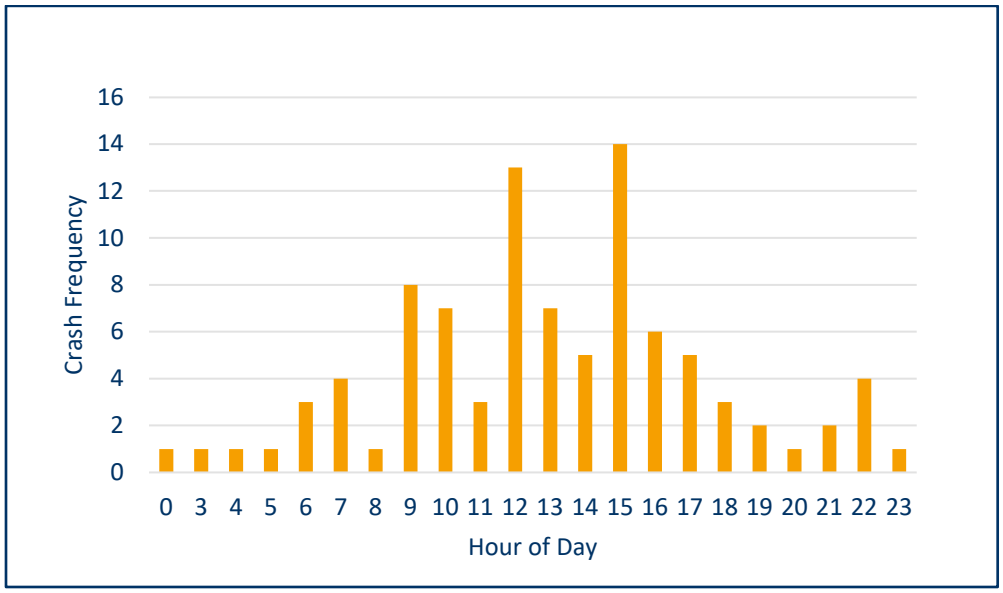


Figure 2: Total Crashes by Hour of Day

A further breakdown of the data shows that 16 of the crashes occurred within the roundabout, 22 crashes occurred between the crosswalks and yield lines, 49 crashes occurred approaching the crosswalks, and the remaining six crashes occurred outside the influence of the roundabout. No fatalities or serious injury crashes were observed in the last three years.

Within the roundabout, crashes showed no general correlation to the time of day. The leading crash types were rear end, right turn, and fixed object, though there was no distinct difference between the types. Of the 16 total crashes in the roundabout, only two crashes resulted in possible injury with the rest causing property damage only.

Between the crosswalks and yield lines, there also appeared to be no correlation between time of day and crash frequency. The most frequent crash types were rear end, backing, angle, and fixed object crashes, though none of the four types were significantly more common than the others. Within this area, one bicycle collision occurred in the past three years within the west leg crosswalk. Two minor injury crashes occurred in this time period in this area.

Finally, of the 49 crashes beyond the crosswalks, the midday and early afternoon hours showed the highest crash rates, and the leading types were rear end, parked vehicle, and backing (combined for 73% of the crashes). Rear end crashes (14) could include crosswalk

related crashes. Only three possible injury crashes occurred during the time period. The west to east direction accounted for over half of the 49 crashes. Table 1 shows a breakdown of the crash data from the last three years by roundabout area and crash type.

Speed data collected by the City of Troy did not show speed to be an issue at the crosswalks. The average speeds on all legs approaching the intersection were approximately 20 mph between 10 and 11 AM and approximately 18 mph between 2 and 3 PM. The circulating speeds in the roundabout ranged between 14 mph and 19 mph for both time periods. City of Troy speed data is contained within **Appendix A**.

No pedestrian crashes were reported in the last three years., Observations from the field found no obvious violations with general requirements of the MUTCD and observed a high rate of motorists yielding to pedestrians at all four crosswalks. Potential improvements to further improve pedestrian safety were noted, as discussed later in Section 1.4.

Table 1: Crashes by Type and Roundabout Area

Crash Type	Roundabout	Crosswalks to Yield Lines	Approaching Crosswalks
Rear End	5	6	14
Backing	1	5	9
Parked Vehicle	0	0	14
Angle	1	4	3
Fixed Object	3	4	1
Right Turn	3	1	3
Sideswipe – Passing	1	1	3
Other Object	1	0	1
Left Turn	1	0	2
Bicycles	0	1	0
Total	16	22	49

Table 2 shows a full breakdown of the crash data by crash type with a comparison to the 2017 study results. Crash data shows 2018-2020 crashes are down by 38% over 2013-15. Without considering 2020 data (COVID influences), crashes are down by 31% compared to the 2017 study. Rear end crashes, parked vehicle crashes, angle crashes, and sideswipe-passing crashes have substantially dropped since the 2017 study, providing further evidence that the roundabout is now operating well and that the recent improvements have benefited safety. Removing the overhead signals has reduced unexpected stops that led to rear end crashes and restriping the intersection approaches to widen parking stalls significantly reduced the potential for collisions with parked or backing vehicles.

Table 2: Crashes by Type

Crash Type	2018 – 2020 Crashes	2013 – 2015 Crashes	Crash Type	2018 – 2020 Crashes	2013 – 2015 Crashes
Rear End	26 (28%)	37 (25%)	Sideswipe – Passing	5 (5%)	18 (12%)
Backing	19 (20%)	25 (17%)	Left Turn	3 (3%)	3 (2%)
Parked Vehicle	13 (14%)	31 (21%)	Other Object	2 (2%)	-
Angle	8 (9%)	27 (18%)	Other Non-Collision	1 (1%)	-
Fixed Object	8 (9%)	8 (5%)	Bicycles	1 (1%)	-
Right Turn	7 (8%)	-	Sideswipe-Meeting	-	1 (1%)

The dash " – " indicates the crash type category was not observed in the crash reports.

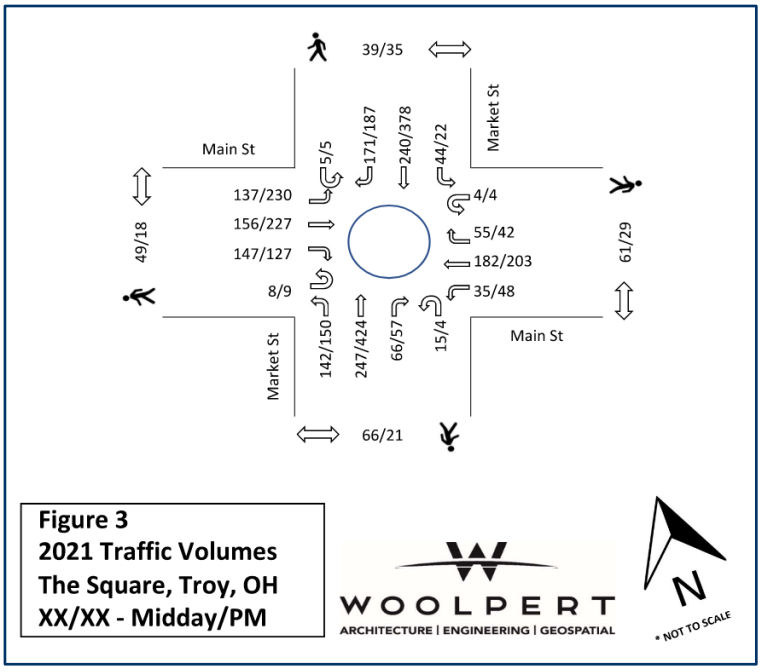
Overall, the crash data suggests congestion and the provided on-street angled parking may be the biggest contributing factors to the recent crash data. Crashes on segments approaching the roundabout are heavily affected by the congestion during peak hours (rear end crashes) and angled parking. Within the roundabout (inside of the crosswalks), 38 crashes is not insignificant. Crashes are most influenced by congestion and the parking areas in the corners. Vehicles exiting the corner parking areas have limited sight distance to vehicles approaching the roundabout that may or may not be stopping to yield. Some crashes within the parking areas themselves may have also been included in the crash data.

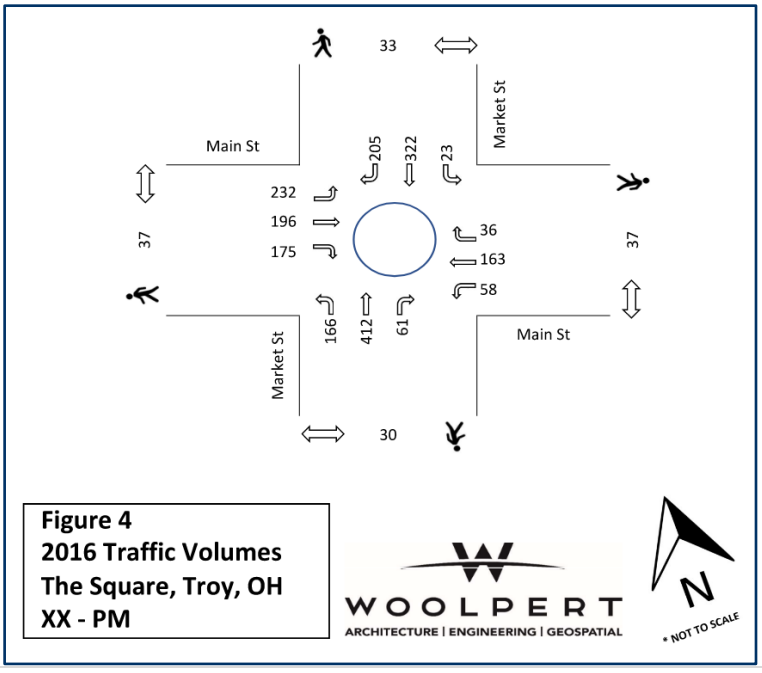
The overall number of crashes, particularly rear end crashes and parked vehicle crashes, has reduced significantly since 2018 improvements, suggesting the intersection improvements made following the previous study have improved vehicular safety at the roundabout. Overall crash data is provided in **Appendix B.**

1.3 Traffic Counts

Vehicular and pedestrian data was collected for the midday peak period (11:15 AM – 1:15 PM) and PM peak period (4:15 PM – 6:15 PM) on Thursday, August 19, 2021. Video recordings of the roundabout were provided by the City of Troy, from which the vehicular and pedestrian volumes were counted in 15-minute intervals to obtain peak hour volumes. The peak hour volumes for both periods are shown in Figure 3 and the 2016 PM peak hour count is shown in Figure 4. Turning movement counts are included in **Appendix C**.

Pedestrian and vehicular traffic showed minimal changes between the 2016 counts and 2021 counts. Pedestrian volume was generally higher in the midday peak while vehicular volume was higher in the PM. Vehicular traffic was heavier on the northbound and southbound Market Street approaches while pedestrian traffic was consistent across all four legs.





1.4 Observations

Woolpert conducted a field visit on Monday September 13, 2021. Pedestrian and vehicular behaviors were observed, and site measurements were taken. The site visit yielded several areas of opportunity to improve pedestrian safety, as described below.

1.4.1 Intersection Configuration

Conventional crosswalk design at roundabouts generally places the crosswalks approximately one car length (20-25 ft.) behind the yield lines for vehicles entering the roundabout. At the Square, the crosswalk lines are located about 60’ behind the yield lines, or about three car lengths (Figure 5). Crosswalks are located at along the local pedestrian paths, along the building faces. This added distance moves the crosswalk nearly out of the intersection, creating additional conflict points and limiting visibility of a pedestrian for a vehicle exiting the roundabout if there are multiple cars waiting to enter the roundabout. This also creates a situation where vehicles are planning to stop (breaking) approximately 60’ beyond the crosswalk before entering the roundabout.

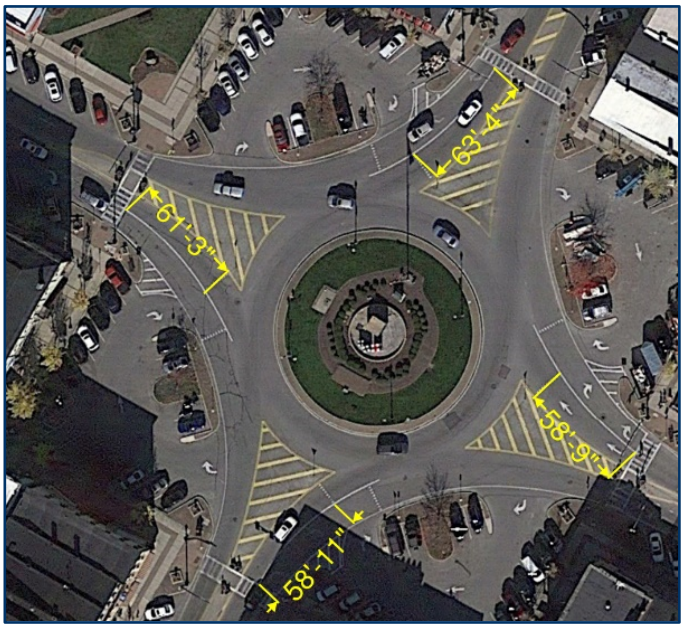


Figure 5: Crosswalk Setbacks

Splitter islands at a roundabout are typically raised (with curb) to slow vehicle speeds entering the roundabout. The striped splitter islands here do not provide that control, but measured speeds were not excessive, likely due to the downtown environment or possibly the planters.

The parking within the square, with entrance and exit drives directly onto the roundabout is not conventional, and does cause some crashes, particularly at the exit drives, with very limited sight distance to the left (Figure 6). Crashes backing in and out of spaces in the parking areas are low-speed, property damage only.

Figure 6: Sight distance looking left out of corner parking areas

The existing right turn lane design forces drivers to make a lane choice right at the crosswalk on three of the four approaches; the eastbound right turn lane is the only approach that introduces the right turn lane in advance of the crosswalk (Figure 7). Not only does this increase the crossing distance for pedestrians in the crosswalk, but it also increases the decisions drivers must make in the vicinity of the crosswalk. The longer crossing distance is exacerbated by the design of the existing curb bump outs, which do not extend fully out to the right turn bays (Figure 8).
However, collected traffic data and field observations suggest the roundabout is operating correctly with no major safety issues.

Figure 7: EB Right Turn Lane

Figure 8: Curb Setback and On-Street Parking

1.4.2 Visibility

The biggest noticeable safety concern for pedestrians in the study area was limited visibility, both in terms of visual obstruction by physical objects and sight distance restrictions. As drivers approach the crosswalk, pedestrians waiting to cross and/or already in the crosswalk should be the only thing a driver sees. In the field, it was noted that concrete planters in the median and at the curb obscure the view of pedestrians. While the planters (Figure 8) improve aesthetics in the area, they are not standard traffic control devices meant to protect pedestrians within the roadway. The height of the flowers during the site visit proved to greatly obscure a 5'-7" adult pedestrian (Figure 9) with the top of flowers at about chest level. Although a portion of an adult pedestrian can be seen if behind the planter, a child or a person in a wheelchair would be completely obstructed.

Figure 9: Median Planters

Similarly, pedestrians waiting to cross are hidden from view if larger vehicles are parked in the angled on-street parking in the spaces closest to the crosswalk (Figure 7). While sight distance for the approaching driver to the crosswalk is adequate when those spaces are empty or occupied by compact vehicles, the sight distance is substantially reduced when SUVs, trucks, and other large vehicles are parked. Drivers often can't see pedestrians at the curb until they are at the crosswalk or just ahead of it.

The crosswalk lines on the pavement are also very worn and faded. The flashing median crosswalk signs do serve as an active attention grabber to an unfamiliar driver in the area to warn them of the crosswalk. These flashing lights are more useful in the nighttime but could have the reverse effect on a driver that frequents the square since they flash constantly and drivers could start to ignore them.

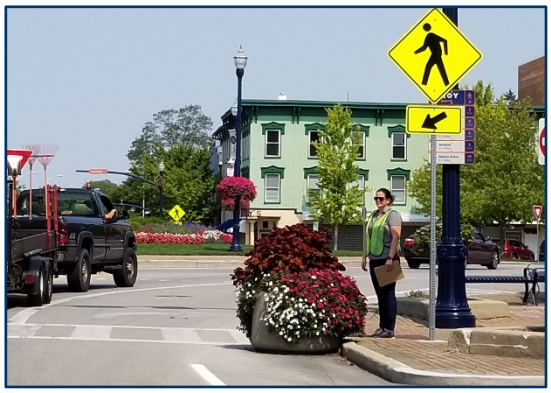


Figure 10: Curbside Planters

1.4.3 Driver Distraction

In addition to visibility concerns, numerous visual distractions draw the driver's attention away from pedestrians at the crosswalks. As a driver approaches, their eyesight may be drawn to several visual cues (Figure 11), including:

1. Overhead lane use signs
2. Parking availability
3. Parked vehicles backing out of spaces
4. Wayfinding signage
5. Landscaping within The Square
6. Art work
7. Someone sitting on a bench within The Square
8. Advertising on the sidewalk or store front

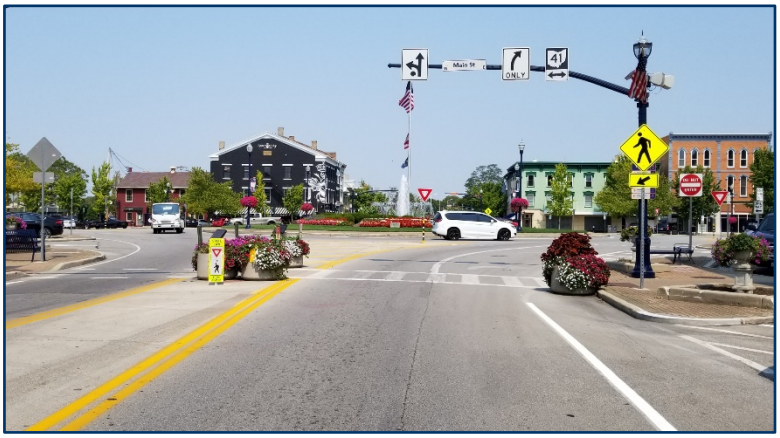


Figure 11: Visual Clutter

In the area of the crosswalk, it is imperative that the driver's vision be free of unnecessary distractions that divert their attention away from pedestrians waiting to cross or those already crossing. The American Association of State Highway and Transportation Officials (AASHTO) indicates a standard perception time is 1.5 seconds and a standard reaction time is 1.0 seconds. With the additional visual distractions and confusion at The Square roundabout, there is far more for a driver to perceive before being able to react – potentially resulting in insufficient time to stop after recognizing a pedestrian in the crosswalk.

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2 Findings

2.1 Areas of Concern and Contributing Factors

The intent of this study is to identify if pedestrian safety issues exist at The Square and to provide alternatives to remedy these issues. Quantitatively, the recent crash data and speed data suggest there is minimal concern for pedestrian safety at the intersection. There have been no pedestrian crashes in the past three years and speed data collected at the approaches to the roundabout show vehicles are not traveling at unsafe speeds. However, while the recent crash and speed data shows limited quantitative data suggesting conditions to address, the site visit showed several areas of concern. These areas and recommended improvements are summarized in Table 3. Additional improvements that were considered but are not recommended are included in **Appendix D**.

Table 3: Pedestrian Safety Summary

Area of Concern	Contributing Factors	Improvement Alternatives	Priority
Visibility	Median Planters – vegetation in the concrete median planters obscure pedestrians waiting to cross.	- Restrict planter locations and restrict maximum height of planter and planting to under 3' (3.1.1)	Immediate
	Ground Mounted Signage – roadside ground mounted pedestrian warning signs provides little warning of crossing pedestrians	- Install double sided pedestrian signage (3.1.2)	Immediate
	Crosswalk markings- existing markings are faded and do not stand out.	- Apply thermoplastic markings to update the crosswalk markings. (3.1.3)	Immediate
	On-Street Parking – angled on street parking on approach legs limits sight distance for pedestrians waiting to cross, particularly when trucks and SUVs are parked in spaces closest to the crosswalks.	- Remove on-street parking in proximity to crosswalks (3.1.4) OR - Restrict parking by vehicle type in proximity to crosswalks (3.1.4)	Immediate
Intersection Configuration	Splitter Islands – painted rather than raised medians provide less protection for pedestrians waiting to cross while in median.	- Provide raised pedestrian refuge islands (3.2.1)	When Feasible
	Right Turn Lanes – turn bay opening occurs at or ahead of crosswalk, creating a decision point.	- Shorten right turn bays (3.2.2)	When Feasible
	Curb Setback – curb location at crossings is located behind angled parking, increasing the distance pedestrians need to walk.	- Increase curb extension (3.1.4)	When Feasible
Visibility	Ground Mounted Signage – roadside ground mounted pedestrian warning signs provides little warning of crossing pedestrians	- Install Rectangular Rapid Flashing Beacons (RRFBs) (3.3.1)	If additional measures are required

3 Recommendations

3.1 Improve Pedestrian Visibility – Immediate Priority

3.1.1 Reduce the impact of Median Planters

Concrete planters in the median do provide a physical identification of the crosswalk location, but the height should remain low – ideally less than 3 feet tall – to avoid distracting oncoming motorists from the most important thing they need to see – pedestrians crossing the roadway. Planters 3 to 5 feet tall not only physically block visibility of pedestrians in the roadway, they can also hinder visibility of pedestrians by adding to the "clutter" within the median. In other words, tall planters can hinder visibility of pedestrians, even if they don't physically hide the pedestrian, just by their very presence and physical size.

The planters on the right side of the crosswalk (curbside) should be removed for the same reasons as noted above.

3.1.2 Modified Signage

The existing crosswalk warning signs are only located on the right side of the roadway when typical application also includes signage on the left side of the roadway. Signing both sides of the road increases visibility, particularly for drivers who may already be looking forward to the roundabout for conflicting traffic. The existing in-street pedestrian crossing sign (R1-6) is an effective reminder for drivers to yield to pedestrians, but the benefit is reduced by the median planters blocking visibility for vehicles.

3.1.3 Install Thermoplastic Pavement Markings at Crosswalks

A simple improvement should be to replace the painted crosswalks with thermoplastic material at all locations to improve durability, reflectivity, and visibility. Several of the crosswalks are faded or non-existent in areas, diminishing the benefit of the high visibility crosswalks.

3.1.4 Improve Sight Distance to the Right / Sidewalk

The existing curb line sits back 3-4 feet from the traveled edge of traffic. When vehicles are parked in the angled spaces nearest the crosswalk, they can obstruct visibility of pedestrians waiting to cross, particularly when the vehicle is a larger SUV or truck. Parking should be removed in the nearest 3 spaces to improve the stopping sight distance for vehicles approaching the crosswalks. In lieu of this, the City could try limiting parking to "Compact" vehicles.

Curb extensions, commonly called curb bump outs, reduce the effective crossing distance by extending the curb to the edge of the parking lane. The shortened crossing distance reduces the time pedestrians spend in the crosswalk, improves pedestrian visibility, and contributes to traffic calming by reducing roadway width. Existing curb bump outs are provided on some of the approaches to the roundabout but do not extend the full width of the parking stalls. If right turn lanes were removed, the curb bump outs could be extended even further. See Figure 12 showing distance from the edge line to the curb line. The curb line would be reconstructed to be at the edge line without a planter, decreasing the pedestrian crossing distance and increasing the visibility of the pedestrian.

Figure 12: Available Curb Bump Out Space

3.2 Minor Intersection Reconfigurations – When Feasible

3.2.1 Pedestrian Refuge Islands (Raised Median)

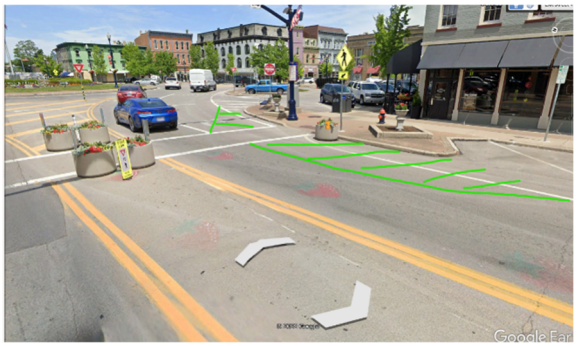
According to the Federal Highway Administration (FHWA), pedestrian refuge areas at pedestrian crossings with marked crosswalks have been shown to reduce pedestrian crashes by 46%. Unlike typical midblock crossings and signalized intersections, gaps in traffic at roundabouts can be unpredictable and it can be difficult for pedestrians to decide when to cross. With refuge islands, pedestrians only need to cross one direction of traffic at a time and are provided a safe waiting space in the median. Refuge islands also provide physical barriers for visually impaired pedestrians to indicate they have reached a median. Figure 13 shows a typical application of refuge islands at a roundabout. Pedestrian refuge islands require a raised splitter island that can be landscaped with grass or other low-level vegetation. Construction of pedestrian refuge islands could be completed in 3 to 5 years in conjunction with the City's downtown streetscape refresh/reconstruction plan.

Refuge islands also act as speed reducers for vehicles by providing physical boundaries compared to striped splitter islands.

Figure 13: Pedestrian Refuge Islands (Source: FHWA)

3.2.2 Right Turn Lane Design

The existing right turn lane design forces drivers to make a lane choice at the crosswalk on all approaches except for eastbound Main Street, adding to the driver distraction and confusion in proximity to pedestrians.



An improved design would be shortening the right turn bay to create the taper after the crosswalk. The roundabout was analyzed in HCS to determine the level of service and queueing with and without a right turn lane on each approach. HCS allows inputs such as the number of entry lanes, bypass lanes, circulating lanes, and turning movement volumes. Level of Service (LOS) are based delay (Table 4). Table 5 summarizes the findings. HCS reports for level of service and queueing are included in **Appendix F.**

Table 4: Unsignalized/Rdbt. Criteria

Level of Service	Control Delay (seconds/vehicle)
A	0-10
B	>10-15
C	>15-25
D	>25-35
E	>35-50
F	>50

Table 5: HCS Roundabout Analysis (Main Street and Market Street Square)

Direction	Movement	Midday Peak Hour				PM Peak Hour			
		LOS (Delay in Sec)		Queue (ft)		LOS (Delay in Sec)		Queue (ft)	
		Existing	Build (No-Right Turn)	Existing	Build (No-Right Turn)	Existing	Build (No-Right Turn)	Existing	Build (No-Right Turn)
Eastbound (Main Street)	Left/Through	A (8.1)	B (11.3)	43	83	C (15.6)	D (25.5)	118	223
	Right	A (5.4)		15		A (6.1)		15	
	Approach	A (7.2)				B (13.5)			
Westbound (Main Street)	Left/Through	A (9.4)	B (11.0)	38	53	C (17.0)	C (20.3)	78	103
	Right	A (4.9)		5		A (6.5)		5	
	Approach	A (8.5)				C (15.5)			
Northbound (Market Street)	Left/Through	B (10.5)	B (12.3)	70	95	D (27.6)	E (37.9)	233	313
	Right	A (4.0)		5		A (4.1)		5	
	Approach	A (9.6)				D (25.5)			
Southbound (Market Street)	Left/Through	A (8.4)	B (12.8)	43	98	B (11.8)	C (21.6)	80	195
	Right	A (6.0)		20		A (6.4)		23	
	Approach	A (7.5)				B (10.1)			
Intersection LOS		A (8.2)	B (12.0)			C (16.4)	D (27.4)		

Generally, anything above level of service D is considered acceptable, and levels of service E and F are unacceptable. The results of the analysis show that removing the right turn lane would be feasible for the eastbound, westbound, and southbound approaches. The results of the queueing analysis shows that a right turn lane with storage for a single vehicle would work for all approaches. An example schematic of the shortened right turn lane is shown on the right.

3.3 Improve Pedestrian Warning – If Additional Measures Required

3.3.1 Install Rectangular Rapid Flashing Beacons (RRFBs)

RRFBs are used in combination with pedestrian warning signs to provide higher visibility warning to drivers when pedestrians are using the crosswalk. According to FHWA, installation of RRFBs can reduce pedestrian crashes by 47% at uncontrolled pedestrian crossing locations. RRFBs are generally actuated by a pedestrian button and the flashing time is determined by crossing speed/distance. They are intended to increase pedestrian crossing visibility but do not prohibit vehicles from passing when pedestrians have cleared the crosswalk. Figure 14 shows a typical application of RRFBs and Figure 15 shows a proposed application at The Square (flashers off).

Figure 14: RRFB (Source: FHWA)

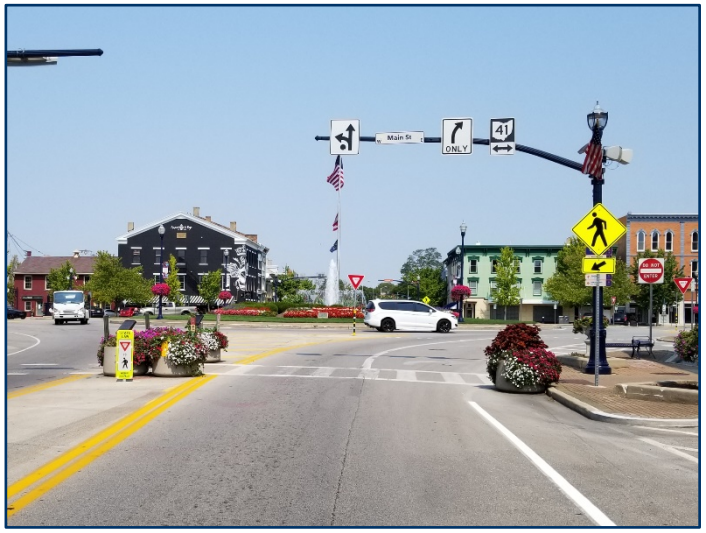


Figure 15: Proposed RRFB Application

4 Improvement Alternatives Summary

The recommended improvements are summarized in Table 6 below. Short-term improvements have the highest priority due to lower costs and higher importance. The medium-term improvements are recommended but can completed when funding is available and construction is feasible, and the long-term improvements are only recommended if it's discovered that additional measures are required. While the roundabout operates safely and efficiently in existing condition, the proposed improvements would enhance the safety benefits for pedestrians in the Troy downtown area. Woolpert recommends the City continue to monitor the safety of both pedestrians and vehicles within the Square to identify if any additional countermeasures are necessary.

Table 6: Improvement Alternatives Summary

Improvement	Area of Concern Addressed	Benefit	Issue	Average Cost
Short Term – Immediate (<1 year to 3 years)				
Restrict planter height (3.1.1)	Visibility	- Improve pedestrian visibility	- Allows for a wider throat width which could increase speeds.	$100 each
Improved Signage and Markings (3.1.2 & 3.1.3)	Visibility	- Improved visibility of markings and signage (Thermoplastic and double-sided signs)		$10,000
Parking Restrictions (3 spots) (3.1.4)	Visibility	- Fewer driver decisions at crosswalk. - Improved pedestrian visibility.	- Fewer parking spaces for nearby businesses	$2,000
Correct ADA issues at existing curb ramps	Configuration	- Provides ADA compliant ramps. - Eliminates tripping hazards		$4,000 each
Medium Term – When Feasible (3 to 5 years)				
Curb Bump outs (3.1.4)	Configuration, Visibility	- Reduced crossing distance - Improved visibility around parked cars	- Requires reduced curb height to maintain positive sidewalk drainage.	$20,000 each
Pedestrian Refuge Islands (3.2.1)	Configuration	- Increased pedestrian protection in median - Traffic calming - Can include low level landscaping - Could allow for zig-zag crosswalk	- More restrictive for truck turns and potentially large farm equipment - Tripping hazard during street festivals.	$13,250 each per FHWA
Alter Bypass Right Turn Lane (3.2.2)	Configuration	- Striping change only - Fewer driver decisions at crosswalk - Removes an additional conflict point	- Decreased intersection vehicular capacity	$2,000 each
Long Term – If Additional Measures are Required				
Rectangular Rapid Flashing Beacons (3.3.1)	Visibility	- Improved pedestrian visibility - Easily installed - Can be solar powered	- Requires pedestrian actuation, not automatic	$22,250 each per FHWA

APPENDIX A: SPEED DATA

10/8/21 10am-11am

Troy Square Speed Checks			Date Collected:	
			Time Period Collected:	
Location	**Description**	**Speeds (Survey a minimum of 10 vehicles per spot)**		
1	Just South of Crosswalk; Collection of Northbound traffic	23 @ 205.5 ft, 23 @ 238.8 ft, 17 @ 173.1 ft, 15 @ 110.8 ft, 18 @ 184 ft 26 @ 239.4 ft, 15 @ 186.5 ft, 29 @ 216.3 ft, 16 @ 207.3, 15 @ 161.2 ft		
2	Just North of Crosswalk; Collection of Southbound traffic	18 @ 58.7 ft, 14 @ 58.8 ft, 17 @ 63.7 ft, 18 @ 59.4 ft, 17 @ 73.5 18 @ 64.4 ft, 18 @ 67.9 ft, 20 @ 68.9 ft, 16 @ 66.4 ft, 18 @ 90.7 ft		
3	Inside the circulating road; south side of circle	16 @ 79.3 ft, 15 @ 121.9ft; 13 @ 125 ft, 16 @ 106 ft, 15 @ 81.2, 16 @ 114.8 ft, 16 @ 89.2 ft, 13 @ 112 ft, 16 @ 80.1 ft, 12 @ 76.7 ft		
4	Inside the circulating road; north side of circle	13 @ 137.2 ft, 15 @ 129.4 ft, 16 @ 123.6 ft, 15 @ 135.8 ft, 15 @ 128.4 ft, 12 @ 150.8 ft, 17 @ 141.8 ft, 14 @ 125.1 ft, 14 @ 124.2 ft, 16 @ 123.6 ft		
5	Just South of Crosswalk; Collection of Northbound traffic	21 @ 131.0 ft, 17 @ 137.6 ft, 18 @ 121.6 ft, 19 @ 143.6 ft, 19 @ 135.3 ft, 23 @ 139.3 ft, 18 @ 128 ft, 19 @ 134.2 ft, 20 @ 121.6 ft, 19 @ 128.1 ft		
6	Just North of Crosswalk; Collection of Southbound traffic	20 @ 193.4 ft, 19 @ 173.0 ft, 17 @ 194.0 ft, 21 @ 206.4 ft, 21 @ 182.1 ft, 21 @ 197.4 ft, 19 @ 187.1 ft, 27 @ 271.1 ft, 21 @ 162.4 ft, 20 @ 132.0 ft		
7	Just East of Crosswalk; Collection of Westbound traffic	12 @ 118.6 ft, 24 @ 105.9 ft, 21 @ 124.2 ft, 15 @ 113.5 ft, 18 @ 118.4 ft, 19 @ 117.0 ft, 18 @ 113.6 ft, 22 @ 106.5 ft, 22 @ 130.1 ft, 23 @ 115.2 ft		
8	Just West of Crosswalk; Collection of Eastbound traffic	24 @ 133.5 ft, 18 @ 102.6 ft, 23 @ 173.5 ft, 18 @ 151.7 ft, 19 @ 168.4 ft, 21 @ 182.2 ft, 18 @ 150.3 ft, 20 @ 120.8 ft, 20 @ 140.6 ft, 17 @ 197.9 ft		

Troy Square Speed Checks

Date Collected: 10 | 12

Time Period Collected: 2-3 pm

Location	Description	Speeds (Survey a minimum of 10 vehicles per spot)				
1	Just South of Crosswalk; Collection of Northbound traffic	19 @ 153.8 16 @ 208.4 18 @ 185.9	18 @ 211.3 14 @ 169.2 10 @ 148.7	26 @ 184.2 19 @ 211.7 14 @ 177.4	15 @ 162.9	
2	Just North of Crosswalk; Collection of Southbound traffic	18 @ 130.2 13 @ 140.6 16 @ 138.1	17 @ 123.3 13 @ 142.0 21 @ 122.7	15 @ 181.1 21 @ 172.9 17 @ 220.5	15 @ 159.9 15 @ 211.3 18 @ 194.0	17 @ 195.9 16 @ 15 @ 217.2 242 19 @ 173.4
3	Inside the circulating road; south side of circle	13 @ 118.9 11 @ 114.6 11 @ 143.7	18 @ 116.4 21 @ 110.2 17 @ 99.5	19 @ 113.2 20 @ 130.7 14 @ 158.7	20 @ 134.3 11 @ 143.2 19 @ 101.8	
4	Inside the circulating road; north side of circle	~~16 @ 114.5~~ 15 @ 140.1 12 @ 128.8	17 @ 186.8 15 @ 141.2 13 @ 162.4	15 @ 147.1 18 @ 128.3 14 @ 142.0	~~15 @ 147.~~ 17 @ 129	13 @ 148.7
5	Just South of Crosswalk; Collection of Northbound traffic	16 @ 119.5 18 @ 141.3 20 @ 119.6	20 @ 136.5 18 @ 119.2 14 @ 126.2	16 @ 104.8 12 @ 140.0 16 @ 136.2	19 @ 135.0	
6	Just North of Crosswalk; Collection of Southbound traffic	15 @ 192.8 9 @ 165.6 15 @ 133.9	12 @ 165.3 25 @ 139.8 18 @ 186.5	26 @ 197.1 20 @ 212.5 15 @ 153.3	17 @ 199.0	
7	Just East of Crosswalk; Collection of Westbound traffic	17 @ 130.2 18 @ 130.4 18 @ 133.3	18 @ 155.5 14 @ 138.2 20 @ 130.8	21 @ 139.6 20 @ 147.0 19 @ 141.2	17 @ 149.0	
8	Just West of Crosswalk; Collection of Eastbound traffic	15 @ 149.9 15 @ 138.6 21 @ 157.2	16 @ 193.4 21 @ 197.7 22 @ 146.4	20 @ 190.0 20 @ 179.5 11 @ 157.8	22 @ 185.3	

APPENDIX B: CRASH DATA

Troy Pedestrian Safety Review

Crash Summary Sheet

Fatalities	0
Serious Injuries	0
Other Injuries	9

Crashes Per Year	31.00
Fatal and All Injury Crashes	8
Percent Injury	8.6%
Equivalent PDO Index Value	1.45

Crash Severity	Crashes	%
(3) Minor Injury Suspected	3	3.23%
(4) Injury Possible	5	5.38%
(5) PDO/No Injury	85	91.40%
Grand Total	93	100.00%

Year	Crashes	%
2018	40	43.01%
2019	29	31.18%
2020	24	25.81%
Grand Total	93	100.00%

Day of Week	Crashes	%
(1) Sunday	6	6.45%
(2) Monday	17	18.28%
(3) Tuesday	12	12.90%
(4) Wednesday	16	17.20%
(5) Thursday	12	12.90%
(6) Friday	14	15.05%
(7) Saturday	16	17.20%
Grand Total	93	100.00%

Hour of Day	Crashes	%
0	1	1.08%
3	1	1.08%
4	1	1.08%
5	1	1.08%
6	3	3.23%
7	4	4.30%
8	1	1.08%
9	8	8.60%
10	7	7.53%
11	3	3.23%
12	13	13.98%
13	7	7.53%
14	5	5.38%
15	14	15.05%
16	6	6.45%
17	5	5.38%
18	3	3.23%
19	2	2.15%
20	1	1.08%
21	2	2.15%
22	4	4.30%
23	1	1.08%
Grand Total	93	100.00%

Crash Type	Crashes	%
Rear End	26	27.96%
Backing	19	20.43%
Parked Vehicle	13	13.98%
Angle	8	8.60%
Fixed Object	8	8.60%
Right Turn	7	7.53%
Sideswipe - Passing	5	5.38%
Left Turn	3	3.23%
Other Object	2	2.15%
Other Non-Collision	1	1.08%
Pedalcycles	1	1.08%
Grand Total	93	100.00%

Month	Crashes	%
1	7	7.53%
2	8	8.60%
3	4	4.30%
4	5	5.38%
5	2	2.15%
6	6	6.45%
7	10	10.75%
8	12	12.90%
9	8	8.60%
10	7	7.53%
11	11	11.83%
12	13	13.98%
Grand Total	93	100.00%

Troy Pedestrian Safety Review

Crash Summary Sheet

Weather Condition	Crashes	%
Clear	54	58.06%
Cloudy	25	26.88%
Rain	9	9.68%
Snow	3	3.23%
Unknown	1	1.08%
Severe Crosswinds	1	1.08%
Grand Total	93	100.00%

Road Condition	Crashes	%
Dry	66	70.97%
Wet	27	29.03%
Grand Total	93	100.00%

Light Condition	Crashes	%
Daylight	74	79.57%
Dark - Lighted Roadway	17	18.28%
Dawn/Dusk	2	2.15%
Grand Total	93	100.00%

Number of Units	Crashes	%
2	75	80.65%
1	14	15.05%
3	4	4.30%
Grand Total	93	100.00%

ODOT Location	Crashes	%
Not An Intersection	46	49.46%
Traffic Circle/Roundabout	31	33.33%
Four-Way Intersection	10	10.75%
T-Intersection	2	2.15%
Driveway/Alley Access	2	2.15%
On Ramp	1	1.08%
5 Or More Point Intersection	1	1.08%
Grand Total	93	100.00%

Work Zone Related	Crashes	%
No	93	100.00%
Grand Total	93	100.00%

Alcohol Related	Crashes	%
No	91	97.85%
Yes	2	2.15%
Grand Total	93	100.00%

Drug Related (Inc. Marijuana)	Crashes	%
No	92	98.92%
Yes	1	1.08%
Grand Total	93	100.00%

Contour	Crashes	%
Curve Grade	1	1.08%
Curve Level	16	17.20%
Straight Grade	3	3.23%
Straight Level	73	78.49%
Grand Total	93	100.00%

Marijuana Related	Crashes	%
No	93	100.00%
Grand Total	93	100.00%

Roadway Departure	Crashes	%
No	69	74.19%
Yes	24	25.81%
Grand Total	93	100.00%

Older Driver (65+)	Crashes	%
No	74	79.57%
Yes	19	20.43%
Grand Total	93	100.00%

Intersection Related	Crashes	%
Yes	54	58.06%
No	39	41.94%
Grand Total	93	100.00%

Young Driver (15-25)	Crashes	%
No	54	58.06%
Yes	39	41.94%
Grand Total	93	100.00%

Speed Related	Crashes	%
No	90	96.77%
Yes	3	3.23%
Grand Total	93	100.00%

Motorcycle Involved	Crashes	%
No	91	97.85%
Yes	2	2.15%
Grand Total	93	100.00%

Troy Pedestrian Safety Review
Crash Summary Sheet
Unit 1 Summary

Unit 1 Pre-Crash Action	Crashes	%
Straight Ahead	44	47.31%
Backing	19	20.43%
Negotiating a Curve	6	6.45%
Changing Lanes	6	6.45%
Making Right Turn	5	5.38%
Entering Traffic Lane	4	4.30%
Slowing or Stopped In Traffic	3	3.23%
Making Left Turn	2	2.15%
Other / Unknown	2	2.15%
Parked	1	1.08%
Data Not Valid or Not Provided	1	1.08%
Grand Total	93	100.00%

Unit 1 Contributing Factor	Crashes	%
Following Too Closely/ACDA	25	26.88%
Other Improper Action	22	23.66%
Improper Backing	16	17.20%
Failure to Yield	12	12.90%
None	6	6.45%
Improper Lane Change	4	4.30%
Ran Red Light	2	2.15%
Improper Start From a Parked Position	2	2.15%
Left of Center	1	1.08%
Swerving to Avoid	1	1.08%
Improper Crossing	1	1.08%
Improper Turn	1	1.08%
Grand Total	93	100.00%

Unit 1 Object Struck	Crashes	%
Nothing Struck	82	88.17%
Traffic Sign Post	4	4.30%
Other Fixed Object	2	2.15%
Curb	2	2.15%
Other / Unknown	1	1.08%
Light/Luminaries Support	1	1.08%
Median Concrete Barrier	1	1.08%
Grand Total	93	100.00%

Unit 1 Traffic Control	Crashes	%
No Control	55	59.14%
Roundabout	20	21.51%
Signal	11	11.83%
Yield Sign	6	6.45%
Flasher	1	1.08%
Grand Total	93	100.00%

Unit 1 Posted Speed	Crashes	%
0	2	2.15%
10	1	1.08%
15	1	1.08%
25	84	90.32%
35	3	3.23%
40	1	1.08%
70	1	1.08%
Grand Total	93	100.00%

Unit 1 Direction From	Crashes	%
West	42	45.16%
North	23	24.73%
South	13	13.98%
East	7	7.53%
Southwest	2	2.15%
Unknown	2	2.15%
Northwest	2	2.15%
Northeast	1	1.08%
Southeast	1	1.08%
Grand Total	93	100.00%

Unit 1 Direction To	Crashes	%
East	43	46.24%
South	19	20.43%
North	12	12.90%
West	9	9.68%
Southeast	4	4.30%
Northwest	4	4.30%
Northeast	1	1.08%
Unknown	1	1.08%
Grand Total	93	100.00%

Troy Pedestrian Safety Review

Crash Summary Sheet

Unit 1 Summary

Unit 1 Type	Crashes	%
Passenger Car	40	43.01%
Sport Utility Vehicle	26	27.96%
Pick up	8	8.60%
Cargo Van	4	4.30%
Unknown or Hit/Skip	4	4.30%
Passenger Van (minivan)	4	4.30%
Semi-Tractor	3	3.23%
Bicycle	1	1.08%
Bus (16+ Passengers)	1	1.08%
Motorcycle 2 Wheeled	1	1.08%
Single Unit Truck	1	1.08%
Grand Total	93	100.00%

Unit 1 Special Function	Crashes	%
None	86	92.47%
Other / Unknown	5	5.38%
School Transport	1	1.08%
Fire	1	1.08%
Grand Total	93	100.00%

Troy Pedestrian Safety Review
Crash Summary Sheet

Unit 2 Summary

Unit 2 Pre-Crash Action	Crashes	%
Slowing or Stopped In Traffic	31	33.33%
Straight Ahead	26	27.96%
Parked	16	17.20%
	14	15.05%
Backing	3	3.23%
Negotiating a Curve	2	2.15%
Making Right Turn	1	1.08%
Grand Total	93	100.00%

Unit 2 Contributing Factor	Crashes	%
None	68	73.12%
	14	15.05%
Stopped or Parked Illegally	6	6.45%
Failure to Yield	2	2.15%
Improper Backing	2	2.15%
Swerving to Avoid	1	1.08%
Grand Total	93	100.00%

Unit 2 Direction From	Crashes	%
	14	15.05%
East	14	15.05%
North	24	25.81%
Northeast	3	3.23%
Northwest	2	2.15%
South	10	10.75%
Southwest	1	1.08%
West	25	26.88%
Grand Total	93	100.00%

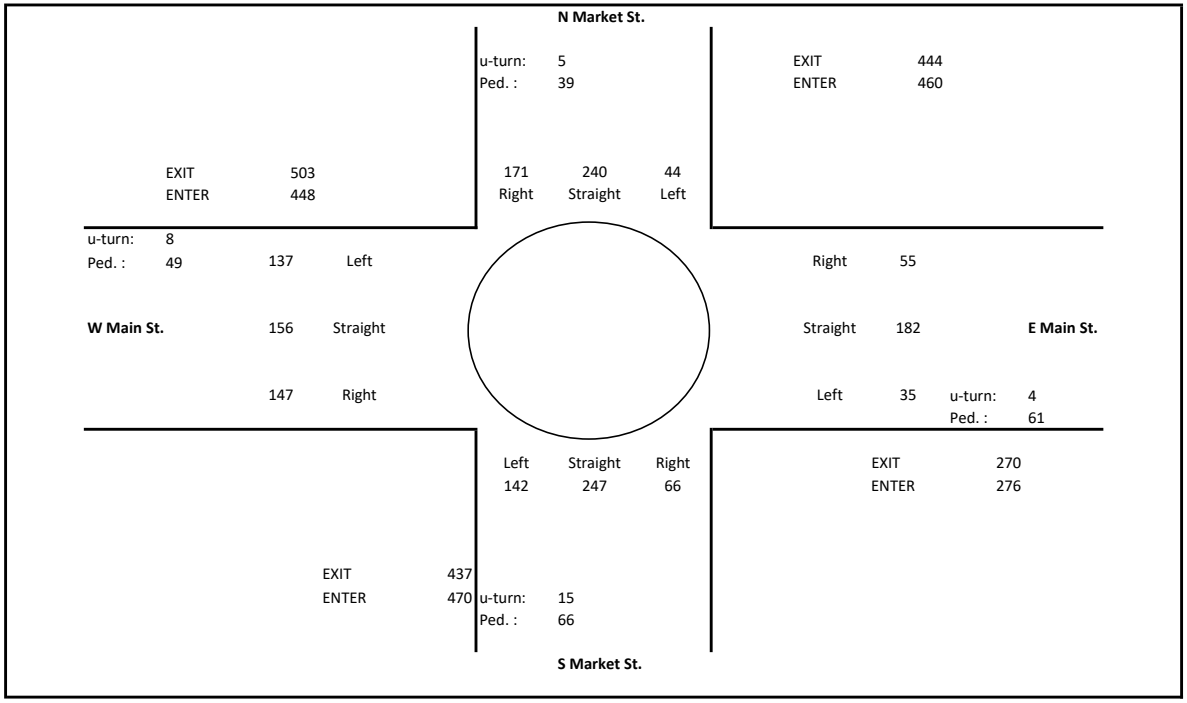
Unit 2 Direction To	Crashes	%
	14	15.05%
East	28	30.11%
North	9	9.68%
Northeast	1	1.08%
Northwest	1	1.08%
South	20	21.51%
Southeast	2	2.15%
Southwest	2	2.15%
West	16	17.20%
Grand Total	93	100.00%

Unit 2 Type	Crashes	%
Passenger Car	42	45.16%
Pick up	15	16.13%
	14	15.05%
Sport Utility Vehicle	13	13.98%
Passenger Van (minivan)	3	3.23%
Cargo Van	2	2.15%
Unknown or Hit/Skip	1	1.08%
Motorcycle 2 Wheeled	1	1.08%
Bus (16+ Passengers)	1	1.08%
Other Vehicle	1	1.08%
Grand Total	93	100.00%

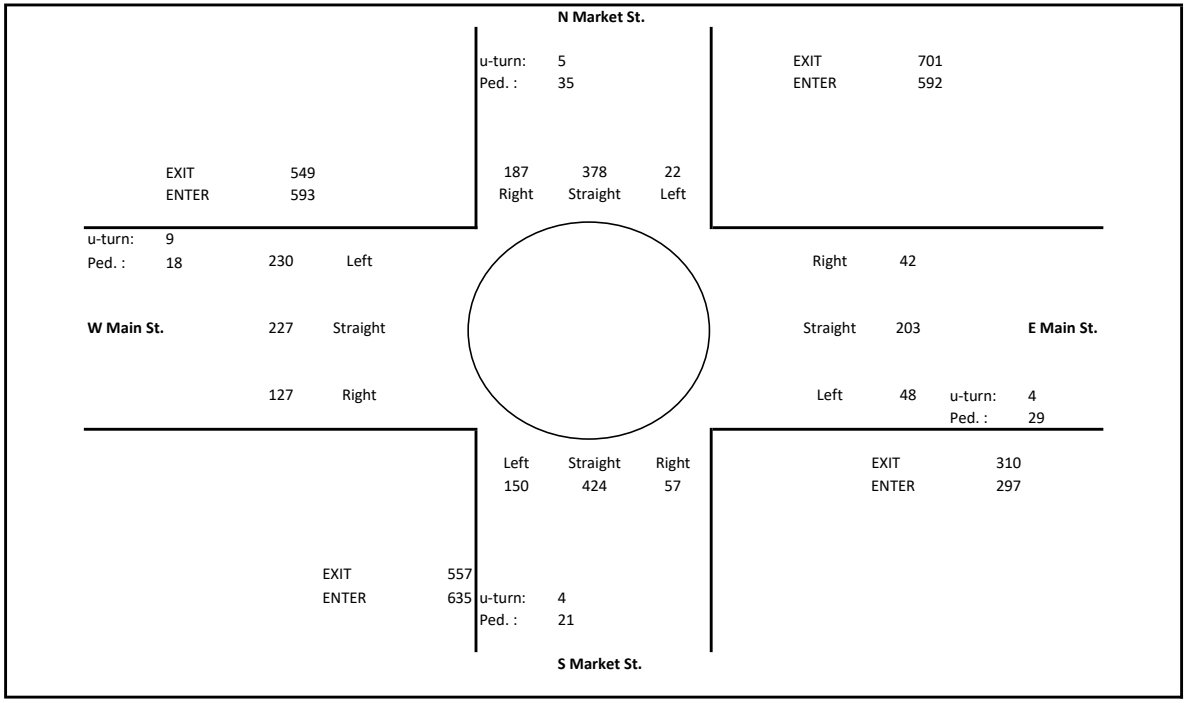
Unit 2 Special Function	Crashes	%
None	75	80.65%
	14	15.05%
Other / Unknown	2	2.15%
Towing	1	1.08%
School Transport	1	1.08%
Grand Total	93	100.00%

APPENDIX C: TURNING MOVEMENT COUNTS

	N Market St					E Main St					S Market St					W Main St				
	Southbound					Westbound					Northbound					Eastbound				
Start Time	Right	Thru	Left	U-Turn	Peds	Right	Thru	Left	U-Turn	Peds	Right	Thru	Left	U-Turn	Peds	Right	Thru	Left	U-Turn	Peds
11:15 AM	38	59	5	2	9	5	39	12	3	8	18	58	32	9	9	25	36	27	3	5
11:30 AM	32	61	13	1	13	5	35	9	3	9	17	63	31	3	5	37	41	34	4	3
11:45 AM	50	63	10	2	12	17	53	5	0	21	22	71	33	5	20	44	43	36	1	19
12:00 PM	38	49	7	1	7	15	49	7	0	16	18	47	42	1	19	32	42	36	1	13
12:15 PM	40	65	16	2	9	16	45	10	1	9	13	63	41	4	17	30	26	30	3	6
12:30 PM	43	63	11	0	11	7	35	13	3	15	13	66	26	5	10	41	45	35	3	11
12:45 PM	56	74	11	1	16	6	43	9	1	21	22	60	45	5	13	28	44	44	1	7
1:00 PM	42	67	16	1	10	11	41	3	1	9	13	59	32	5	14	25	30	42	1	9



	N Market St					E Main St					S Market St					W Main St				
	Southbound					Westbound					Northbound					Eastbound				
Start Time	Right	Thru	Left	U-Turn	Peds	Right	Thru	Left	U-Turn	Peds	Right	Thru	Left	U-Turn	Peds	Right	Thru	Left	U-Turn	Peds
4:15 PM	28	90	10	0	7	22	52	13	1	2	17	105	37	4	2	34	54	53	1	7
4:30 PM	26	86	6	1	1	18	34	3	2	5	20	92	28	0	7	34	52	56	2	9
4:45 PM	36	98	3	2	9	12	56	14	1	15	18	116	34	0	8	44	60	55	1	6
5:00 PM	49	110	9	0	6	8	53	10	2	3	16	103	34	0	3	30	61	69	1	4
5:15 PM	51	81	5	3	12	13	53	11	0	5	11	113	41	1	2	27	62	54	5	6
5:30 PM	51	89	5	0	8	9	41	13	1	6	12	92	41	3	8	26	44	52	2	2
5:45 PM	35	61	6	1	15	14	40	5	0	11	13	96	23	2	2	18	45	53	2	5
6:00 PM	47	51	4	4	18	11	43	4	3	6	18	74	38	1	4	38	45	48	0	10



APPENDIX D: ADDITIONAL IMPROVEMENTS DISCUSSION

1.1 Other Potential Alternatives

1.1.1 Install Raised Crosswalks

Raised crosswalks are ramped speed tables that allow pedestrians to cross at grade with the sidewalk and act as traffic calming devices. They lower vehicle speeds and improve yielding at crosswalks, and per FHWA they reduce pedestrian crashes by 45%. Figure 2 shows a typical application of raised crosswalks and Figure 1 shows a local application of raised crosswalks at a roundabout in Hilliard, OH.

Figure 2: Raised Crosswalk (Source: FHWA)

Figure 1: Raised Crosswalk at Main St + Scioto Darby Rd in Hilliard, OH

1.1.2 Pedestrian Hybrid Beacons (PHBs)

Pedestrian hybrid beacons are like RRFBs in that they are actuated by pedestrians and increase visibility. Hybrid beacons, however, are mast arm mounted over the crosswalk and further increase invisibility beyond RRFBs. They have been shown to reduce pedestrian crashes by 69% and overall crashes by 29% (rear end collisions are reduced for vehicles stopping suddenly when pedestrians cross). Figure 3 shows a standard pedestrian hybrid beacon.

Unlike RRFBs, which are still relatively new and only have interim approval, hybrid beacons have been accepted by most regulating agencies; the MUTCD provides warrant criteria for the use of PHBs based on peak hour vehicular and pedestrian volumes. Using the traffic volumes collected from the intersection videos, the warrant analysis was completed for the midday peak and PM peak. The warrants showed that only the north leg crosswalk warranted a PHB in the PM peak hour, primarily due to high vehicular volume crossing the walk. This matches the warrant that was completed as part of the 2017 Parking and Traffic Assessment. **Appendix D** includes the MUTCD warrant for a pedestrian hybrid beacon.

Figure 3: Pedestrian Hybrid Beacon (Source: FHWA)

1.1.3 In-Roadway Warning Lights

In-roadway warning lights are similar to PHBs except that they are installed in the pavement along both sides of the crosswalk rather than overhead. They are actuated by pedestrian pushbuttons and flash only while pedestrians are crossing. Figure 4 shows an application of in-roadway lighting at the Dayton Airport.

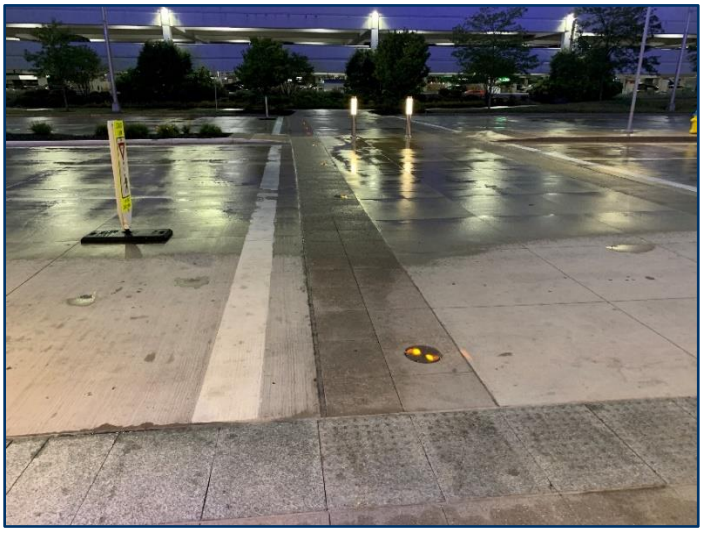


Figure 4: In-Pavement Warning Lights at Dayton Airport

1.1.4 Flexible Traffic Pylons

While the existing planters in the striped splitter islands offer projection to pedestrians waiting to cross, they also reduce the visibility of the pedestrian to approaching drivers. Flexible traffic pylons would provide similar delineation without the decreased visibility. Additionally, the pylons can be driven over if required for large truck turns, farm equipment, or in case of emergency vehicles needing space to get around traffic backups. Figure 5 shows flexible traffic pylons being used at crosswalks. Alternatively, the existing planters could be replaced with smaller planters to maintain the aesthetic but improve visibility of pedestrians waiting to cross.

Figure 5: Flexible Traffic Pylons (Source: Barrier Solutions)

1.1.5 Crosswalk Relocation or Redesign

Crosswalks are generally preferred to be located one-vehicle length behind the roundabout yield lines to reduce stop-start patterns for vehicles. Rather than slowing at the crosswalk and again at the yield line, vehicles can slow for both simultaneously. A minimum of one-vehicle length is required to provide space for a vehicle exiting the roundabout to wait for pedestrians crossing. Figure 7 shows typical pavement markings for a roundabout. Another option would be to move the curb ramp on the exiting leg and restripe the crosswalks with a "zig-zag" pattern; rather than crossing in one continuous segment, the crosswalk turns 90 degrees inside the pedestrian refuge island before crossing the second lane, as shown in Figure 6. A painted zig-zag crosswalk line though would be less likely to keep a pedestrian within the crosswalk and would be problematic to a visually impaired person, this is why curbing along the center area would be beneficial.

Figure 6: Zig Zag Crosswalk

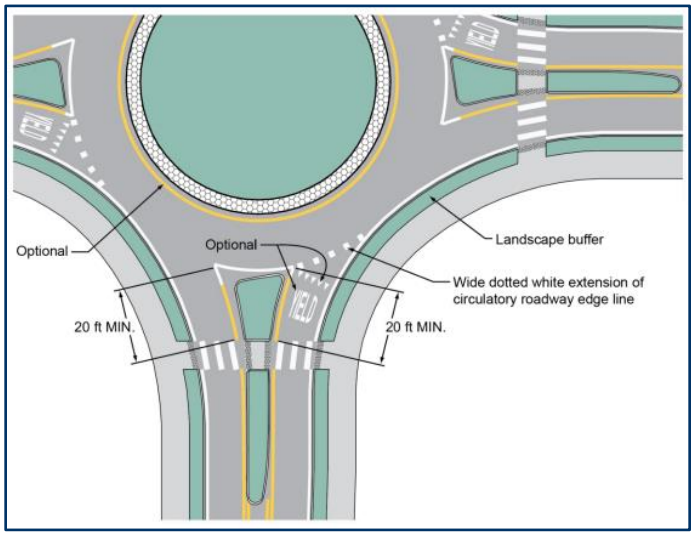


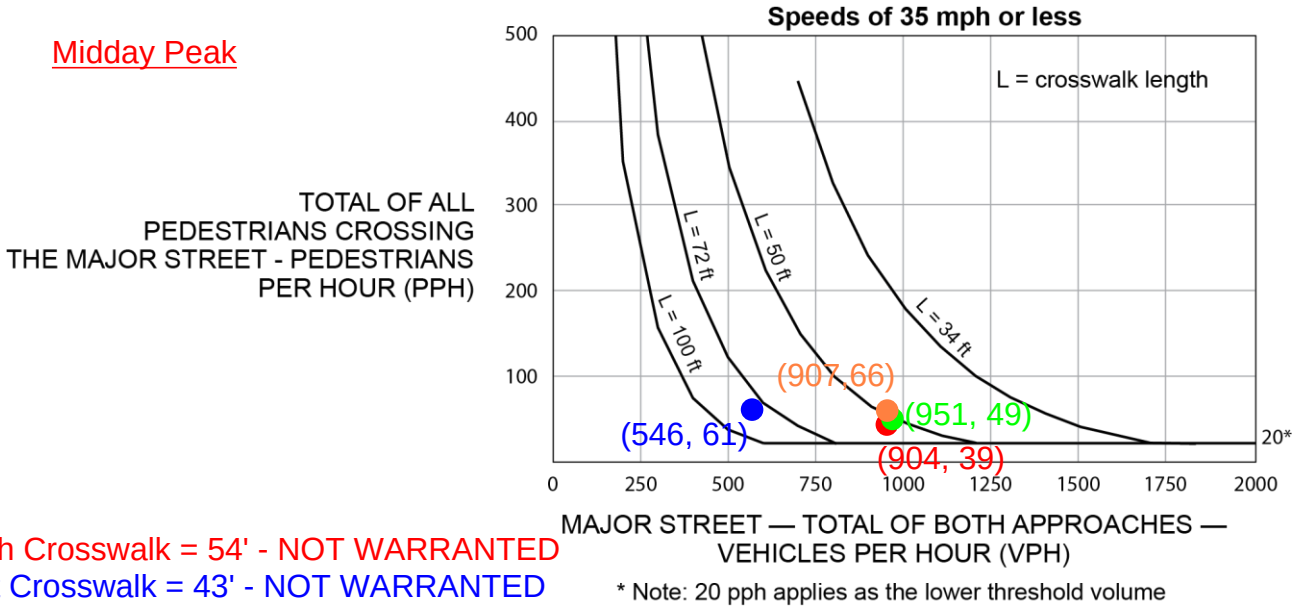
Figure 7: Roundabout Design Elements (Source: OMUTCD)

Table 1: Other Improvement Summary					
Improvement	Area of Concern Addressed	Pros	Cons	Average Cost	Priority
Flexible Traffic Pylons	Visibility	- Improve pedestrian visibility compared to planters - Low cost	- May require consistent maintenance if consistently drove over.	$1,500 each	Low
Raised Crosswalks	Visibility	- Improved pedestrian visibility - Traffic calming	- Potential drainage issues - Noise - Snowplowing - Public opposition	$8,170 each per FHWA	High
Pedestrian Hybrid Beacons	Visibility	- Can be mounted on existing mast arms - Improved pedestrian visibility	- Additional visual clutter	$57,680 each per FHWA (minus cost of mast arm)	Medium
Crosswalk Relocation	Design, Driver Distraction	- Pavement marking and curb ramp change only - Fewer driver decisions at crosswalk	- Pedestrians may cross at unmarked locations - Done without curbing could be hazardous to the visually impaired.	$15,000 per crosswalk and curb ramps	Low
In-Roadway Warning Lights	Visibility	- Improved pedestrian visibility	- Additional visual clutter	$15,000	Low
Remove benches at entry/exit of roundabout	Driver Distraction	- One less thing for drivers to take in. - Less people congregating near the pedestrian crossing	- Less aesthetic	$100	Low

APPENDIX E: PEDESTRIAN HYBRID BEACON WARRANT

Figure 4F-1. Guidelines for the Installation of Pedestrian Hybrid Beacons on Low-Speed Roadways

Midday Peak

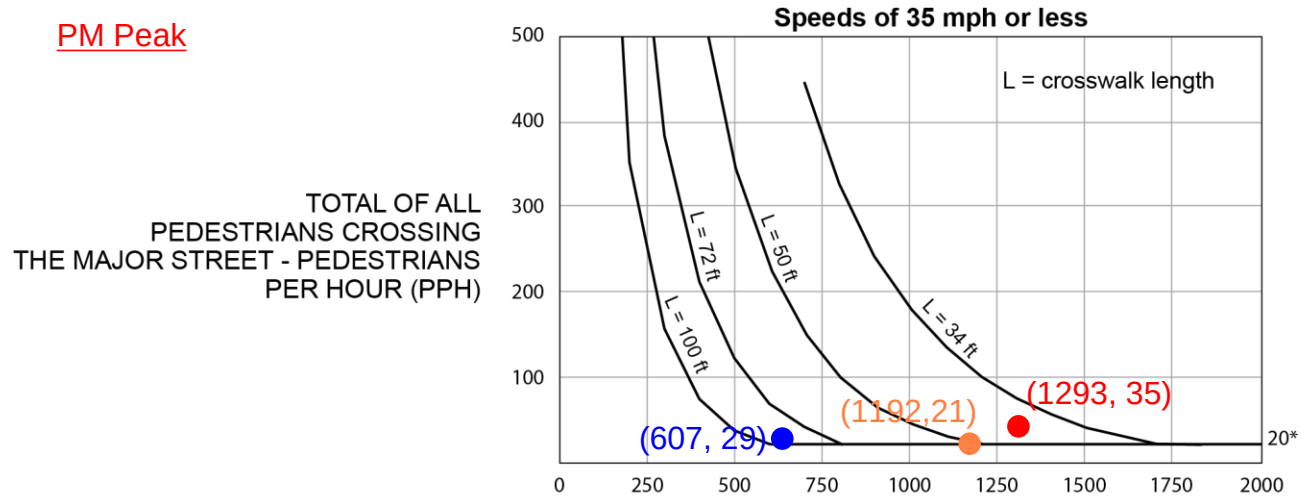


* Note: 20 pph applies as the lower threshold volume

North Crosswalk = 54' - NOT WARRANTED
East Crosswalk = 43' - NOT WARRANTED
South Crosswalk = 41' - NOT WARRANTED
West Crosswalk = 44' - NOT WARRANTED

Figure 4F-1. Guidelines for the Installation of Pedestrian Hybrid Beacons on Low-Speed Roadways

PM Peak



* Note: 20 pph applies as the lower threshold volume

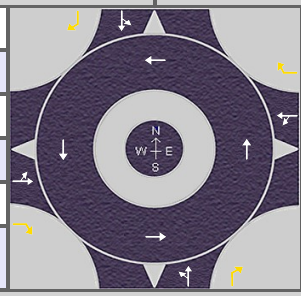
North Crosswalk = 54' - WARRANTED
East Crosswalk = 43' - NOT WARRANTED
South Crosswalk = 41' - NOT WARRANTED
West Crosswalk = 44' - NOT WARRANTED
(18 peds < 20 minimum)

APPENDIX F: CAPACITY AND QUEUE REPORTS

HCS7 Roundabouts Report

General Information

Analyst	KWA
Agency or Co.	Woolpert, Inc.
Date Performed	9/30/2021
Analysis Year	2021
Time Analyzed	Midday Peak
Project Description	Troy Ped Study



Site Information

Intersection	Main St and Market St
E/W Street Name	Main St
N/S Street Name	Market St
Analysis Time Period (hrs)	0.25
Peak Hour Factor	0.92
Jurisdiction	Troy, OH

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LT				LT				LT				LT	
Volume (V), veh/h	8	137	156	147	4	35	182	55	15	142	247	66	5	44	240	171
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	9	153	175	165	4	39	204	62	17	159	277	74	6	49	269	191
Right-Turn Bypass	Yielding				Yielding				Yielding				Yielding			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	49				61				66				39			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763	4.9763		4.9763	4.9763		4.9763	4.9763		4.9763	4.9763
Follow-Up Headway (s)		2.6087	2.6087		2.6087	2.6087		2.6087	2.6087		2.6087	2.6087

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		337	165		247	62		453	74		324	191
Entry Volume, veh/h		327	160		240	60		440	72		315	185
Circulating Flow (v_c), pc/h	384			621			396			432		
Exiting Flow (v_{ex}), pc/h	228			372			436			325		
Capacity (c_{pce}), pc/h		933	991		732	885		921	1094		888	944
Capacity (c), veh/h		900	955		705	852		886	1052		858	912
v/c Ratio (x)		0.36	0.17		0.34	0.07		0.50	0.07		0.37	0.20

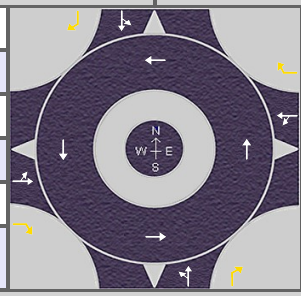
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		8.1	5.4		9.4	4.9		10.5	4.0		8.4	6.0
Lane LOS		A	A		A	A		B	A		A	A
95% Queue, veh		1.7	0.6		1.5	0.2		2.8	0.2		1.7	0.8
Approach Delay, s/veh	7.2			8.5			9.6			7.5		
Approach LOS	A			A			A			A		
Intersection Delay, s/veh | LOS	8.2						A					

HCS7 Roundabouts Report

General Information

Analyst	KWA
Agency or Co.	Woolpert, Inc.
Date Performed	9/30/2021
Analysis Year	2021
Time Analyzed	Midday Peak
Project Description	Troy Ped Study



Site Information

Intersection	Main St and Market St
E/W Street Name	Main St
N/S Street Name	Market St
Analysis Time Period (hrs)	0.25
Peak Hour Factor	0.92
Jurisdiction	Troy, OH

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LT				LT				LT				LT	
Volume (V), veh/h	9	230	227	127	4	48	203	42	4	150	424	57	5	22	378	187
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	10	258	254	142	4	54	227	47	4	168	475	64	6	25	423	209
Right-Turn Bypass	Yielding				Yielding				Yielding				Yielding			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	18				29				21				35			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763	4.9763		4.9763	4.9763		4.9763	4.9763		4.9763	4.9763
Follow-Up Headway (s)		2.6087	2.6087		2.6087	2.6087		2.6087	2.6087		2.6087	2.6087

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		522	142		285	47		647	64		454	209
Entry Volume, veh/h		507	138		277	46		628	62		441	203
Circulating Flow (v_c), pc/h	516			921			557			467		
Exiting Flow (v_{ex}), pc/h	283			405			739			481		
Capacity (c_{pce}), pc/h		815	845		539	649		782	1034		857	913
Capacity (c), veh/h		790	818		524	630		757	1001		828	882
v/c Ratio (x)		0.64	0.17		0.53	0.07		0.83	0.06		0.53	0.23

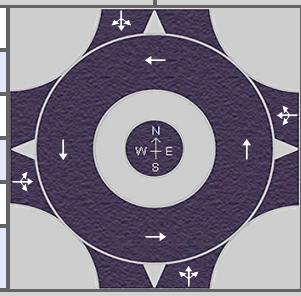
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		15.6	6.1		17.0	6.5		27.6	4.1		11.8	6.4
Lane LOS		C	A		C	A		D	A		B	A
95% Queue, veh		4.7	0.6		3.1	0.2		9.3	0.2		3.2	0.9
Approach Delay, s/veh	13.5			15.5			25.5			10.1		
Approach LOS	B			C			D			B		
Intersection Delay, s/veh | LOS	16.4						C					

HCS7 Roundabouts Report

General Information

Analyst	KWA
Agency or Co.	Woolpert, Inc.
Date Performed	9/30/2021
Analysis Year	2021
Time Analyzed	Midday Peak
Project Description	Troy Ped Study



Site Information

Intersection	Main St and Market St
E/W Street Name	Main St
N/S Street Name	Market St
Analysis Time Period (hrs)	0.25
Peak Hour Factor	0.92
Jurisdiction	Troy, OH

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	8	137	156	147	4	35	182	55	15	142	247	66	5	44	240	171
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	9	153	175	165	4	39	204	62	17	159	277	74	6	49	269	191
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	49				61				66				39			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway (s)		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		502			309			527			515	
Entry Volume, veh/h		487			300			512			500	
Circulating Flow (v_c), pc/h	384			621			396			432		
Exiting Flow (v_{ex}), pc/h	302			563			498			490		
Capacity (c_{pce}), pc/h		933			732			921			888	
Capacity (c), veh/h		900			705			886			858	
v/c Ratio (x)		0.54			0.43			0.58			0.58	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		11.3			11.0			12.3			12.8	
Lane LOS		B			B			B			B	
95% Queue, veh		3.3			2.1			3.8			3.9	
Approach Delay, s/veh	11.3			11.0			12.3			12.8		
Approach LOS	B			B			B			B		
Intersection Delay, s/veh | LOS	12.0						B					

HCS7 Roundabouts Report

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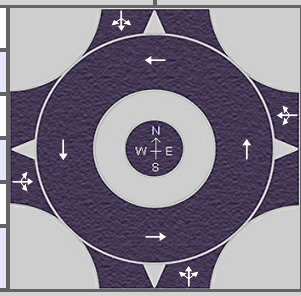

Site Information

Intersection	Main St and Market St
E/W Street Name	Main St
N/S Street Name	Market St
Analysis Time Period (hrs)	0.25
Peak Hour Factor	0.92
Jurisdiction	Troy, OH

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	9	230	227	127	4	48	203	42	4	150	424	57	5	22	378	187
Percent Heavy Vehicles, %	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Flow Rate (v_{PCE}), pc/h	10	258	254	142	4	54	227	47	4	168	475	64	6	25	423	209
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	18				29				21				35			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway (s)		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		664			332			711			663	
Entry Volume, veh/h		645			322			690			644	
Circulating Flow (v_c), pc/h	516			921			557			467		
Exiting Flow (v_{ex}), pc/h	347			614			786			623		
Capacity (c_{pce}), pc/h		815			539			782			857	
Capacity (c), veh/h		790			524			757			828	
v/c Ratio (x)		0.82			0.62			0.91			0.78	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		25.5			20.3			37.9			21.6	
Lane LOS		D			C			E			C	
95% Queue, veh		8.9			4.1			12.5			7.8	
Approach Delay, s/veh	25.5			20.3			37.9			21.6		
Approach LOS	D			C			E			C		
Intersection Delay, s/veh | LOS	27.4						D					