

MICHIGAN DEPARTMENT OF TRANSPORTATION

Case Study Report

Final Report

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BACKGROUND

The Michigan Department of Transportation (MDOT) desired to explore the impact that recently completed roadway projects had on automobile, pedestrian, and bicycle safety. Additionally, MDOT wanted to determine to what extent these improvements also impacted mobility for motorists, pedestrians, and bicyclists. Five recently completed roadway improvement projects, or case studies, were selected for analysis. These case studies were analyzed to determine the effect of specific improvements on safety and mobility.

Roadway improvements included a reduction in the number of travel lanes, also known as a road diet; the installation of raised, non-mountable medians; pedestrian refuge islands; installation of pedestrian signals; roundabouts; curb bump outs; beacons at pedestrian crossings, called rectangular rapid flashing beacons (RRFB); and high visibility pedestrian crosswalk pavement markings. Roadway improvements were implemented along the full length of the corridor and some case studies included specific improvements at select intersections.

KEY FINDINGS

Generally, the case study analyses did not yield clear results as to the effectiveness of reducing crashes on MDOT roadways. In some instances, sufficient crash data were lacking for the time period after the installation of improvements. In others, the control site performed nearly as well the variable site in terms of reducing crashes, calling into question the effectiveness of the improvement. In one case, a spot improvement resulted in an *increase* in crashes.

The case study analyses revealed that data collection is more difficult to perform after the installation of an improvement than as part of a specific research project. In many of the case studies, it was difficult to determine the impact that an improvement had on crashes.

For example, while the road diet and continuous median installations yielded the expected crash reduction results, the improvements that consisted more of a series of spot improvements showed mixed results. In addition, a lack of meaningful before data such as travel speeds and traffic volumes, as well as information about pedestrian and bicycle traffic, made multimodal before-and-after analysis of each corridor difficult.

CASE STUDY DESCRIPTIONS

The following is a description of case study locations and a description of the data and analysis methods that were used to complete each case study.

1. 60th Street: Division Avenue to Eastern Avenue, Cutlerville
Improvements included a road diet, reducing the roadway from four travel lanes to three lanes including a center two-way left-turn lane (TWLTL) and bike lanes in each direction.
2. Mission Street: East Bluegrass Road to East Pickard Street, Mount Pleasant
Improvements included signal modernization to include pedestrian signal heads, one intersection with pedestrian countdown clock signal heads, and a pedestrian refuge island and warning signs at Appian Way.
3. Michigan Avenue: Capitol Avenue to Pennsylvania Avenue, Lansing
Improvements included pedestrian crossing pavement markings, one intersection converted to a roundabout, and curb bump outs at intersections.
4. Livernois Avenue: Davison Avenue to 7-Mile Road, Detroit
Improvements included a raised median, upgraded signals and crosswalks, and restricted left turns at intersections.
5. Davison Avenue: Livernois Avenue to Rosa Parks Boulevard, Detroit
Improvements included improved pedestrian crossings with raised pedestrian refuge islands at two unsignalized intersections, rectangular rapid flashing beacons, and high visibility crosswalk pavement markings.

DATA AND ANALYSIS METHODS

Information was collected for each of the case studies including crash data, speed data, and field observations. Case study analysis consisted of a review of crash data for time periods before and after the installation of improvements at each location. The crashes at these locations were either compared before and after the installation of the improvement, were compared to a similar roadway location nearby where no improvements were installed. These locations were referred to as control locations, and the locations where improvements were installed are referred to as variable locations. In some case studies, both analysis methods were used. In one instance, neither a before-and-after analysis nor a comparison site analysis could be conducted; therefore, a brief analysis of crash data was provided.

CRASH DATA

Crash data was collected for each corridor for the years 2004 through 2010. On Mission Street in Mount Pleasant and Michigan Avenue in Lansing, improvements were completed in 2004, so crash data was collected for the years 2001 through 2010. Total crashes were examined as a trend over this time period and were sorted into before and after datasets to determine what

impact the roadway improvements had on crashes. Crashes involving pedestrians and bicyclists were examined as well.

SPEED DATA

Speed data was collected in the field October 2011 and historical speed and volume data was obtained from the local agencies. This data was used to determine levels of service for individual modes before and after the improvements as well as on the comparison site for study control purposes.

LEVEL OF SERVICE

Level of Service (LOS) is a measure of quality of service. It evaluates transportation facilities based on average daily traffic (ADT), facility width, traffic control, travel speed, connectivity, and delay. For the purposes of communicating quality of service concepts on a broader, less technical scale, LOS is expressed as a letter grade ranging from LOS A to LOS F. For modes of transportation traveling *along* a facility, LOS is calculated separately for automobiles, bicycles, pedestrians, and transit using the Florida Department of Transportation LOS model and handbook.

Automobile LOS is a service measure based on a model that calculates travel speed as a function of delay, traffic volume, number of lanes, and delay caused by traffic control devices. LOS A corresponds to free flow travel speeds that have are affected by little or no delay. LOS F corresponds to very low travel speeds with larger delay and high levels of congestion. While LOS A ideally would be preferable to motorists, a roadway operating at LOS C or LOS D can provide an optimum balance between the cost of providing roadway infrastructure and delay experienced by motorists.

However, a major constraint with regard to LOS is that intersection LOS is not currently available for all modes of transportation. As intersections are critical components of the transportation network in improving the quality of a pedestrian or bicycle trip, the current LOS model does not provide a comprehensive evaluation of quality of service for all of these modes.

LOS scales used for other modes are not necessarily equivalent. Pedestrian and bicycle LOS is still in development and has not consistently been applied as a measure of quality of service. Bicyclists and pedestrians are more vulnerable roadway users than motorists, and roadways on which these users are traveling may still not adequately meet user needs, even at levels of service that are considered acceptable for motorists. Bicycle, pedestrian, and transit LOS are explained below.

Bicycle LOS is a composite score which is a function of facility width, automobile traffic volume, traffic speed, heavy vehicle (truck) traffic volume, and pavement condition. Bicycle LOS A describes wide, smooth, bicycle facilities on the roadway adjacent to travel lanes with low

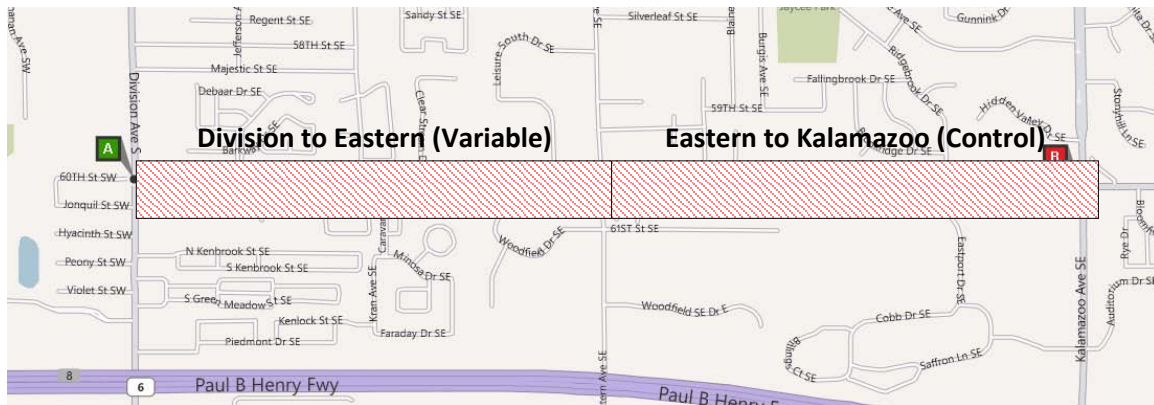
automobile speeds and traffic volumes. LOS F indicates undesirable bicycle facility conditions consisting of narrow, shared facilities with poor pavement condition, high traffic speeds and volumes.

Pedestrian LOS is a composite score which is a function of the presence of a sidewalk, lateral separation from automobile traffic, traffic volume and speed. LOS A describes pedestrian facilities that are wide with adequate separation from the roadway in areas with slow traffic speeds and low traffic volumes. LOS F describes pedestrian facilities of poor quality, sidewalks that have gaps or are not present, and insufficient separation from high speed, high traffic volume roadways.

Transit LOS is calculated based on transit vehicle frequency, access, and physical barriers to the transit stop. Transit LOS is only calculated for bus transit. LOS A describes frequent bus service with unimpeded access to bus stops. LOS F describes infrequent transit service with barriers or obstacles that impede access to bus stops.

CASE STUDY SITES

1. 60TH STREET: DIVISION AVENUE TO EASTERN AVENUE, CUTLERVILLE, MI



Improvements: Road Diet reduced travel lanes on 60th Street from four lanes to three lanes and bike lanes added between Division Avenue and Eastern Avenue.

Date: 2008

Posted Speed Limit: 35 mph

Pre-2008 ADT, Division to Eastern (Variable): 11,217

Post 2008 ADT, Division to Eastern (Variable): 10,077

Post 2008 ADT, Eastern to Kalamazoo (Control): 13,867

PROJECT DESCRIPTION

The section of 60th Street from Division to Eastern in Cutlerville, Michigan was resurfaced in 2008. The original four-lane cross-section was converted to a three-lane cross-section, known as a road diet, consisting of one travel lane and one bike lane in each direction, and a center two-way left-turn lane. A pedestrian crossing immediately west of the intersection of 60th Street and Haverhill Boulevard was upgraded in conjunction with the road diet to a high-visibility, continental-style crosswalk with stop bars and an overhead flashing pedestrian beacon. This crossing serves a school on the north side of the street. Automobile crashes occurred at this location in 2005 and 2008. Neither crash involved a pedestrian or bicyclist.

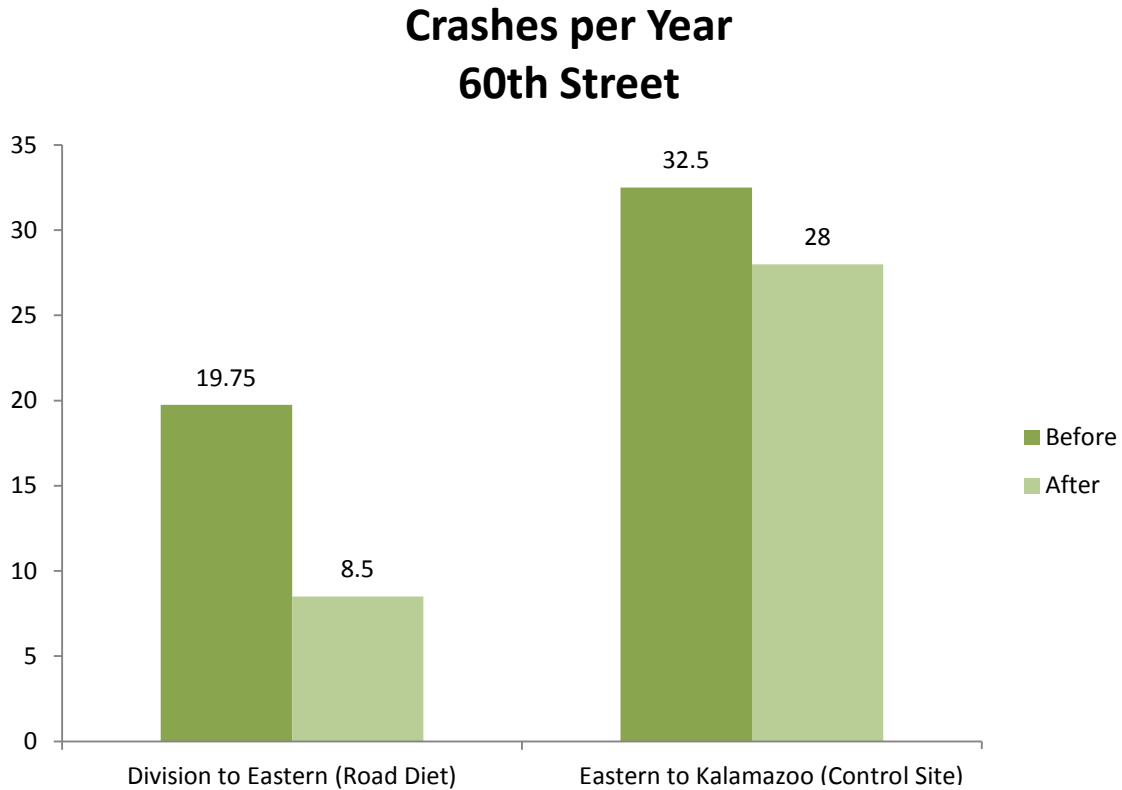
Both sides of the roadway have five-foot wide sidewalks for the length of the corridor. These existed prior to the road diet and were maintained after construction. 60th Street from Eastern to Kalamazoo was selected as the control site. This section of 60th Street has the original, four-lane cross section and no bike lanes.

ANALYSIS

Data were collected for crashes on 60th Street between Division Avenue and Kalamazoo Avenue. A before-and-after analysis was conducted for both the variable and control sections of 60th Street. Crash data from years 2004-2007 were reviewed for the before condition and years 2009-2010 were reviewed for the after condition.

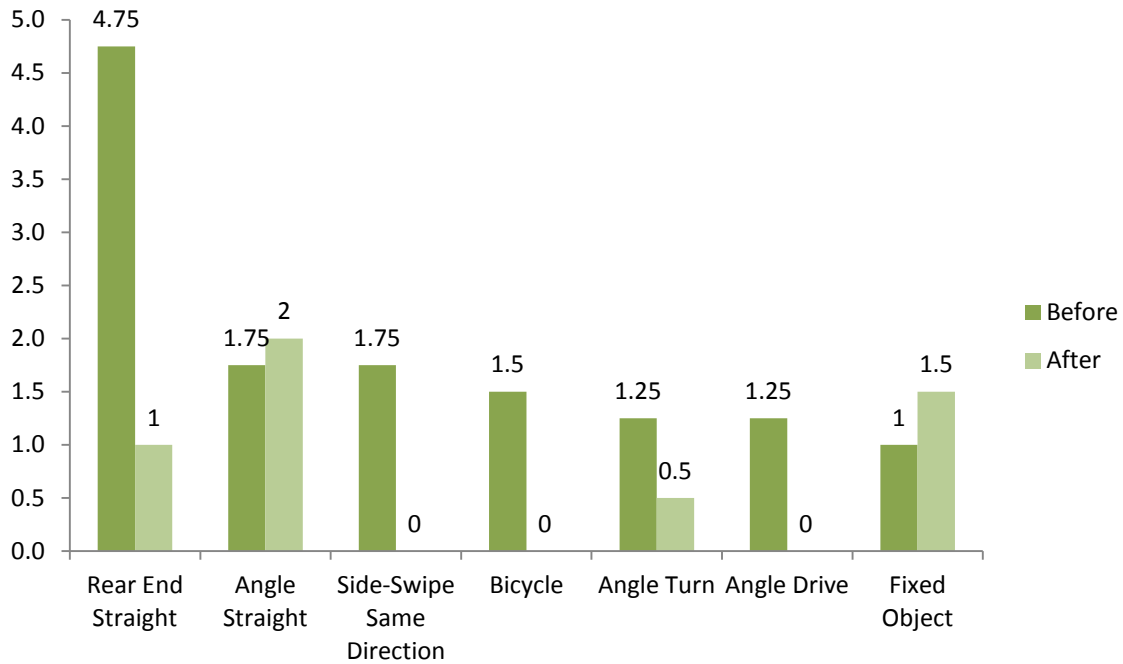
CRASH RESULTS

The crash data analysis revealed a 57% reduction in all crashes on the study corridor after the road diet. The comparison site also experienced a reduction in crashes, although a much smaller decrease at 14%. The reduction in crashes on the comparison site suggests that some of the reduction may be attributed to factors other than the infrastructure changes. A 17% reduction in crashes was also seen statewide between 2004 and 2010. Still, the improvement resulted in a significant crash reduction.



Crashes also were reviewed by crash type to determine if certain types of crashes were more affected by the road diet than others. Rear end crashes were reduced by the greatest margin, dropping by 79%. Turning crashes dropped by more than 60%. Sideswipe crashes, bicycle crashes, and angle drive crashes, which averaged between one and two crashes per year, were reduced to zero crashes following the installation of the road diet. Two crash types, angle straight crashes and fixed object crashes, showed an increase of 12% and 50%, respectively, after the road diet was completed.

Crashes per Year 60th Street - Division to Eastern



LOS RESULTS

Speed data was collected in the field October 2011. ADT, roadway width, and sidewalk information also was collected. This data was used to determine levels of service for individual modes before and after the improvements as well as on the comparison site.

	Variable: Division to Eastern		Control: Eastern to Kalamazoo
	Pre-2008	Post-2008	Current Data
Pedestrian LOS (Score)	D (3.85)	C (3.33)	C (3.08)
Bicycle LOS (Score)	E (4.73)	C (2.75)	E (4.51)
Automobile LOS	C	B	A
85th Percentile Speed	n/a	40 mph	44 mph
Average Daily Traffic (ADT)	11,217	10,077	13,867

LOS for each mode is shown in Table 1. The addition of a bike lane in the variable section created a greater separation between pedestrians and automobiles, resulting in a change of pedestrian LOS from LOS D to LOS C. The addition of bike lanes and drop in ADT both contributed to the improvement of bicycle LOS from LOS E to LOS C. Pre-2008 speed data was not available at the time of the analysis which prevented a recorded average speed comparison from being made. Automobile LOS increased from C to B.

OBSERVATIONS

Bicycle crashes were low on 60th Street before the improvement which limited the analysis. However, the reduction in other types of crashes and an improved bicycle, pedestrian, and automobile LOS supports the road diet as an improvement intended to improve bicycle facilities and calm traffic along 60th Street.

CONCLUSIONS

According to community survey data collected prior to the installation of the road diet, motivations for undertaking the road diet included a desire for traffic calming in the corridor, improved roadway safety, pedestrian safety, and reduce left-turn problems at intersections. The road diet was successful in reducing crashes and increasing bicycle LOS.

LESSONS LEARNED

The road diet on 60th Street provided a good before-and-after crash reduction case study. Because the improvement was applied along the entire length of the corridor, it produced noticeable reductions in crashes as well as improvements to bicycle and pedestrian LOS. Lacking speed data before the improvement made it difficult to determine what effect the road diet had on automobile speeds.

2. MISSION STREET (BL US127): BLUEGRASS ROAD TO PICKARD ROAD, MT. PLEASANT, MI



Improvements: Pedestrian signal upgrades, pedestrian refuge island and improved crosswalk pavement markings.

Date: Signal Upgrades: 2004, Pedestrian Refuge Island: 2008

Posted Speed Limit: 45 mph

2011 ADT: 25,400

2011 ADT (at Appian Way): 21,300

BACKGROUND

The intersection crash rates along this section of Mission Street are among the highest in the Mount Pleasant Transportation Service Center (TSC) five-county area with the Broomfield Street intersection ranking first, Preston Street second, West Campus Drive fifth, Pickard Street sixth, Bellows Street seventh, and High Street eleventh.

225 crashes were recorded within a 260-foot radius of the Mission Street/Broomfield Street intersection over a recent five-year period, and 127 crashes were recorded during that same period at the Preston Street intersection. The TSC noted that a large portion of the crashes involved left turning vehicles into and out of driveways along Mission Street.

PROJECT DESCRIPTION

Improvements along this corridor were constructed in separate contracts over several years. In 2004 pedestrian signal heads were added at signalized intersections. Only one pedestrian countdown signal was installed, at Bellows Street. In the fall of 2008, the pedestrian crossing at Appian Way was upgraded with a curbed refuge island and improved signs and lighting. In the summer of 2009, loop detectors were added in the pavement at signalized intersections that facilitated actuated signal control that adjusts the signal phase in response to traffic volumes.



Pedestrian refuge island at Appian Way



Pedestrian crossing treatment



View of crossing and overhead beacon at Appian Way

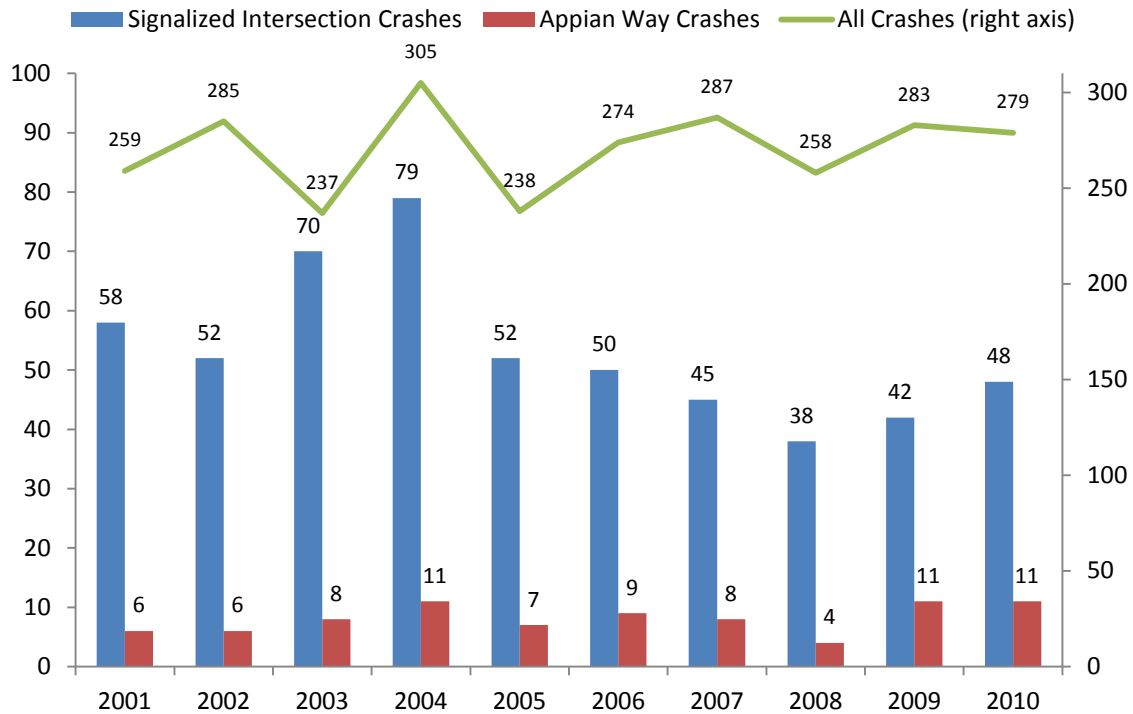
ANALYSIS

Because improvements occurred along Mission Street during two different time periods, crash data was reviewed for Mission Street between 2001 and 2010. Crash totals were calculated by year and by crash type. Intersection crashes that occurred at Appian Way were also analyzed.

CRASH RESULTS

Total crashes per year along Mission Street varied during the study period, ranging from a high of 305 crashes in 2004 to a low of 237 crashes in 2003. Signalized intersection crashes were at their lowest in 2008 with 38 crashes. Appian Way crashes were at their lowest in 2008 with only 4 crashes. Appian Way crashes increased again after 2008 when the pedestrian refuge island was completed. Additional analyses were performed to identify what factors may have contributed to this increase.

Mission Street Crashes by Type per Year



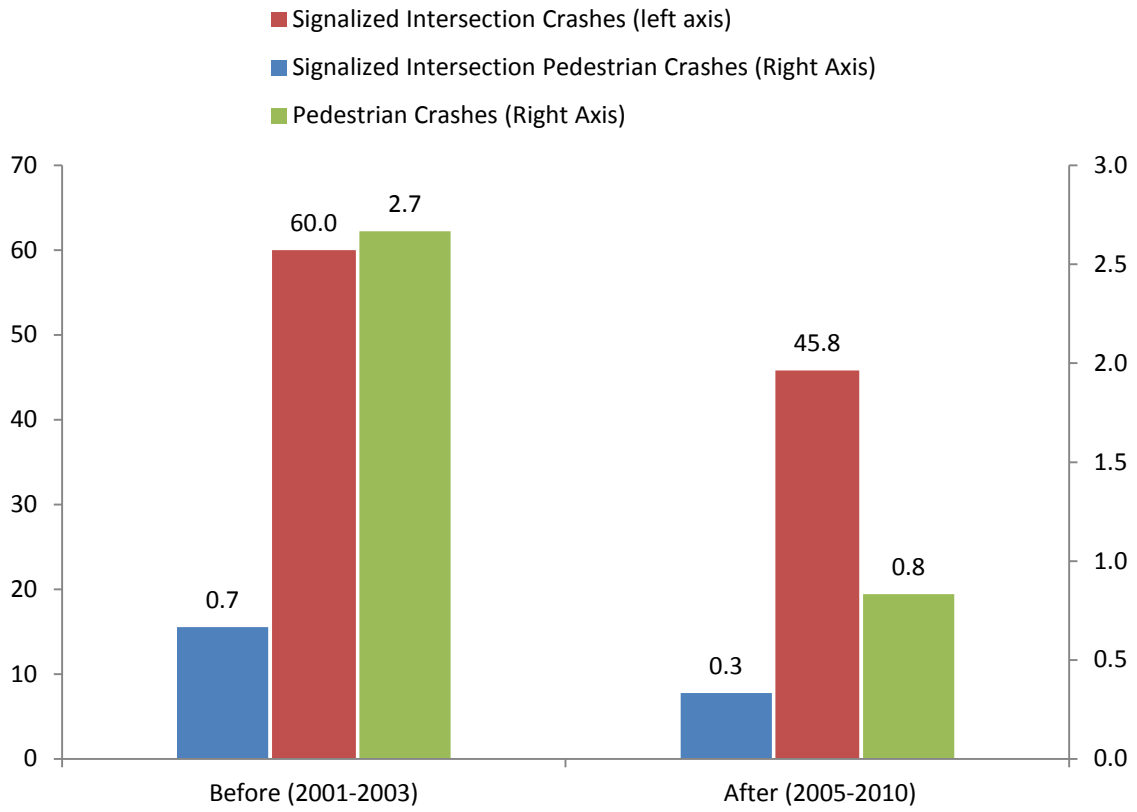
Note: Pedestrian signal heads added in 2004, pedestrian refuge island installed at Appian Way in 2008.

Generally, signalized intersection crashes were lower after the improvements were completed. Prior to the installation of pedestrian signal heads on Mission Street, signalized intersection crashes were at a low of 52 crashes in 2002. After 2004, signalized intersection crashes reached a low of 38 in 2008.

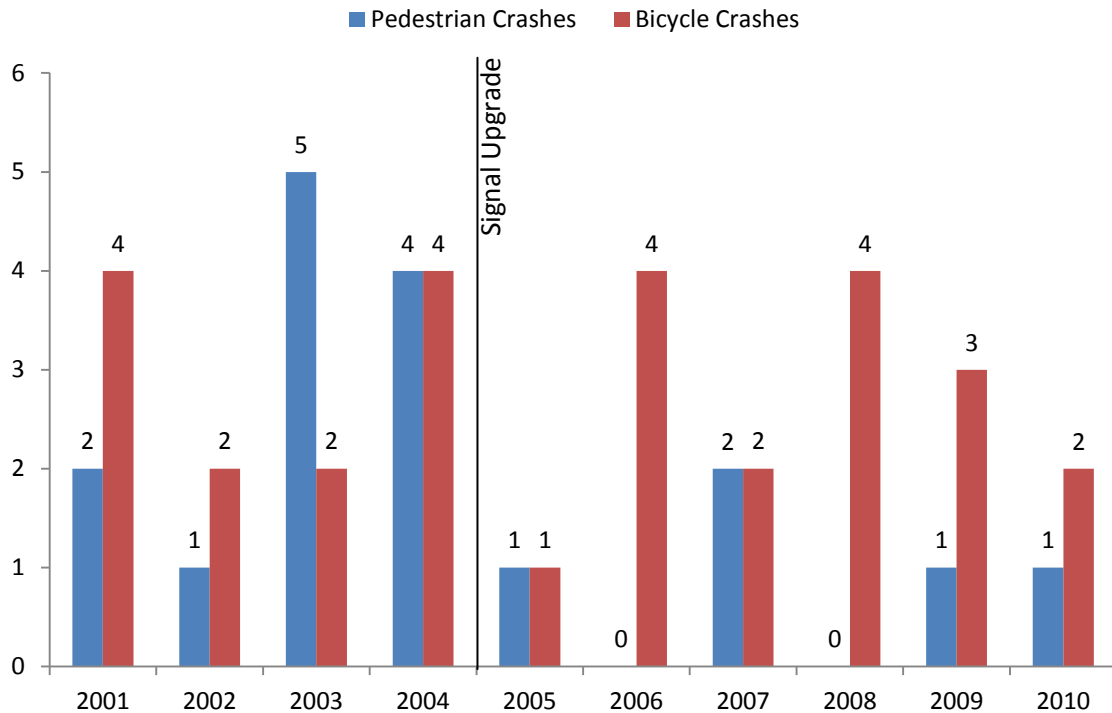
Pedestrian crashes at signalized intersections along Mission Street were reviewed to determine whether the installation of pedestrian signal heads had any effect on pedestrian crashes. According to the Federal Highway Administration desktop reference for crash reduction factors, addition of pedestrian signal heads to signalized intersections results in an average 25% reduction in all crashes. On Mission Street, all crashes at signalized intersections decreased by 21%. Statewide between 2005 and 2010, signalized intersection crashes decreased by 4%.

On Mission Street, pedestrian crash levels were low, which made it challenging to identify a pedestrian crash trend before and after the pedestrian signals were installed. After the pedestrian signals were installed, all pedestrian crashes dropped by 44%. Additionally, pedestrian intersection-related crashes dropped by 57%.

Average Annual Pedestrian Crashes at Signalized Intersections



Pedestrian and Bicycle Crashes per Year Mission Street



Note: Pedestrian signal heads added in 2004, pedestrian refuge island installed at Appian Way in 2008.

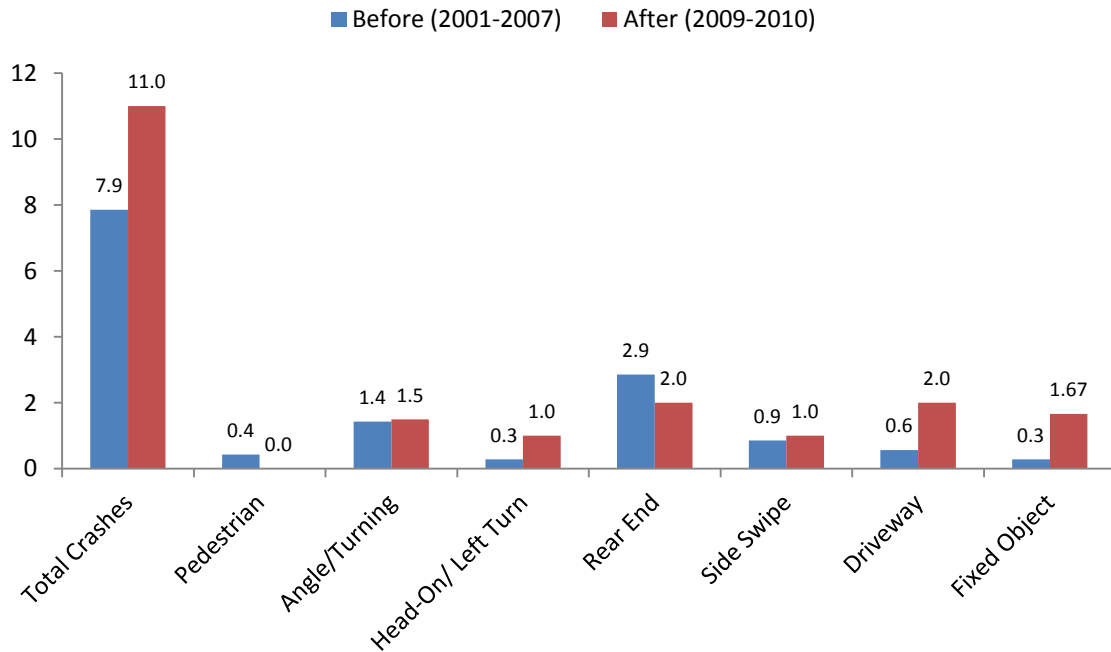
On Mission Street, pedestrian crashes reached a peak in 2003 with five pedestrian crashes. However, shortly after 2004 when the signal upgrade project was completed, pedestrian crashes dropped to between zero and two crashes per year. Bicycle crashes fluctuated between zero and four crashes per year during this time period.

Crashes by type were analyzed at the intersection of Mission Street and Appian Way to determine the impacts that the installation of the pedestrian refuge island had on crashes. As the pedestrian refuge island was installed in 2008, crashes were analyzed by type before the installation of the pedestrian refuge island (2001-2007) and after (2009-2010) and were normalized by year for the analysis. The crash impacts of the pedestrian refuge island varied. Total crashes, angle/turning, head-on/left turn, side swipe, driveway, and fixed object crashes all increased at Appian Way after the pedestrian refuge island was completed.

The most noticeable increases in crashes were fixed object crashes, since very few crashes of this type occurred before the pedestrian refuge island was installed, and driveway crashes, which more than tripled after the pedestrian refuge island was installed. A review of the crash reports revealed that motorists were crashing into the refuge island in 2009, but crashes dropped again in 2010. There were no pedestrian crashes after the installation of the pedestrian

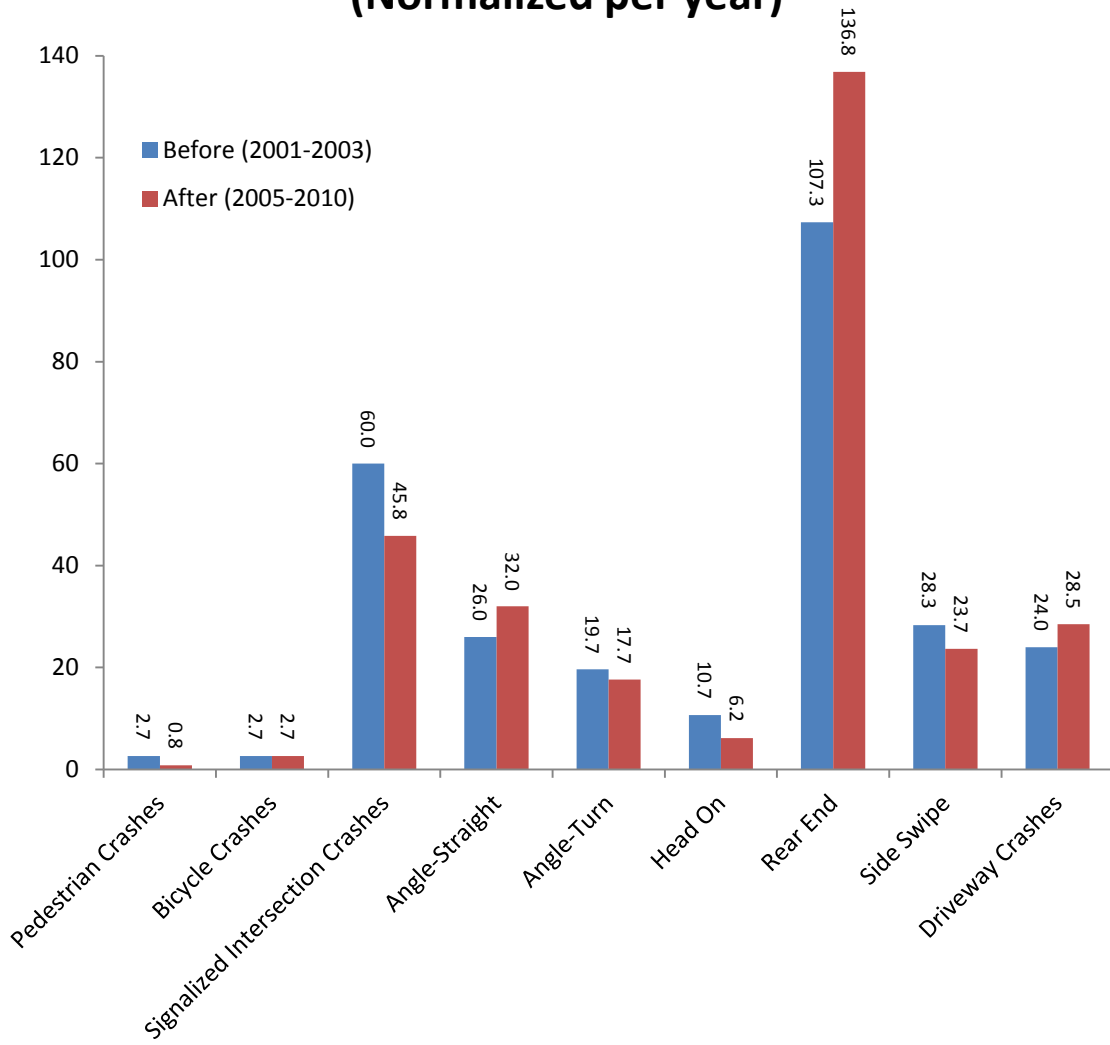
refuge island. There were no bicycle crashes reported on Mission Street between 2001 and 2010.

Crashes per Year Mission Street at Appian Way



In addition to analyzing crashes that occurred at Appian Way before and after the signal upgrade improvements were completed, crashes along the entire length Mission Street were analyzed by type. Crashes were reviewed to determine what effect, if any, the signal upgrade improvements had on different types of crashes. Pedestrian crashes, signalized intersection crashes, turning crashes, head on crashes, and side swipe crashes all decreased after the signal upgrade project was completed. Angle-straight crashes, rear end, and driveway crashes increased.

Mission Street Crashes by Type (Normalized per year)



LOS RESULTS

LOS was calculated for Mission Street between Bluegrass Road and Pickard Road as well as a shorter segment that included the pedestrian refuge island at Appian Way. It is important to note that pedestrian LOS is calculated for pedestrians walking *along* Mission Street. Because pedestrian LOS inputs primarily include automobile traffic volumes, the number of lanes, lane widths, and the separation between automobile and pedestrian traffic, the installation of a pedestrian refuge island did not have a major effect in changing LOS. The effect of intersection improvements is difficult to identify using the current LOS model. The results are shown below in Table 2.

Table 2 – Mission Street Level of Service (LOS) Calculations		
	Corridor Average (2011)	At Appian Way (2011)
Pedestrian LOS (Score)	C (3.37)	C (3.08)
Bicycle LOS (Score)	E (4.66)	E (4.68)
Automobile LOS	C	C
85 th Percentile Speed	37 mph	n/a
Average Daily Traffic (ADT)	25,400	21,300*

*ADT at Appian Way was recorded at 21,300 which is lower than the ADT for the corridor as a whole.

Pedestrian LOS averaged LOS C (3.37) throughout the corridor and was 3.08 at Appian Way. Bicycle LOS was E (4.66) at the corridor level and 4.68 at Appian Way. The construction of the pedestrian refuge island created a barrier median which is not a calculating factor in bicycle LOS.

OBSERVATIONS

A sign is posted on the side of the road that says “Cross Only When Traffic Clears”. This is contradictory to the law and is confusing to pedestrians. One police report filed for a crash at this location stated that the pedestrian “failed to yield to traffic” and cited this sign.



CONCLUSIONS

While pedestrian and angle or turning crashes were reduced at Appian Way, other types of crashes increased after the installation of the pedestrian refuge island, resulting in an increase in total crashes at Appian Way.

After fixed object crashes, the next highest crash types were rear end and driveway-related crashes. Single motor vehicle (fixed object) crashes increased briefly after the completion of the pedestrian refuge island, but decreased in the following year. MDOT should consider installing larger, longer medians in place of short standalone pedestrian refuge islands, or provide additional temporary signs and pavement markings when a pedestrian refuge island is installed.

Pedestrian LOS could not be determined for the intersection of Mission Street and Appian Way as the current LOS model does not calculate LOS for intersections.

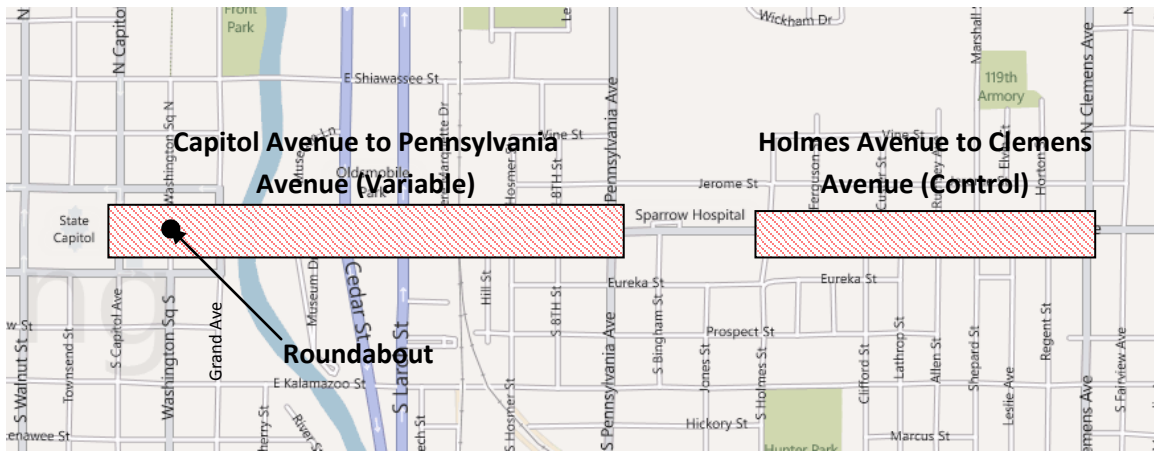
The “cross only when traffic clears” sign at Appian Way does not communicate how right-of-way is assigned at pedestrian crossings or that motorists shall yield to pedestrians in the crosswalk. MDOT should consider removing the signs and installing advance “Yield to pedestrians” sign in advance of the crossing and add advance yield pavement markings to the roadway at this location.

MDOT should monitor crashes along Mission Street to see if crashes continue to involve the island or driveway entrances along the corridor. Access control or traffic calming may be needed to further reduce crashes.

LESSONS LEARNED

The case study on Mission Street included various factors that made it difficult to reach conclusions about the crash effectiveness of a pedestrian refuge island installed at Appian Way. The placement of this spot improvement at an unsignalized location on a roadway with a posted speed of 45 mph appeared to increase crashes that appear to have been caused by the pedestrian refuge island. Also, because the total number of crashes at Appian Way was low, it was difficult to determine how much impact the pedestrian refuge island had on crashes by type.

3. MICHIGAN AVENUE: CAPITOL AVENUE TO CLEMENS AVENUE, LANSING, MI



Improvements: Streetscape improvements that included a roundabout at Capitol Avenue and Michigan Avenue, curb extensions, and improved pedestrian crossings

Date: 2004

Speed Limit: 30 mph

2011 ADT, Capitol Avenue to Pennsylvania Avenue (Variable): 11,500

2011 ADT, Holmes Avenue to Clemens Avenue (Control): 11,500

PROJECT DESCRIPTION

Between Capitol Avenue and Grand Avenue, Michigan Avenue is four lanes wide with on-street parking. Between Grand Avenue and Pennsylvania Avenue, Michigan Avenue is five lanes wide, which includes a center two-way left-turn lane and on-street parking. Between Holmes Avenue and Clemens Avenue, Michigan Avenue is five lanes wide, with a center two-way left-turn lane, and no on-street parking.

In 2004, a series of improvements were implemented on Michigan Avenue:

- Roundabout (Michigan Avenue at Capitol Avenue)
- Curb extensions (at intersections between Capitol Avenue to 8th Street)
- High-visibility crosswalks (from Capitol Avenue to Pennsylvania Avenue)

ANALYSIS

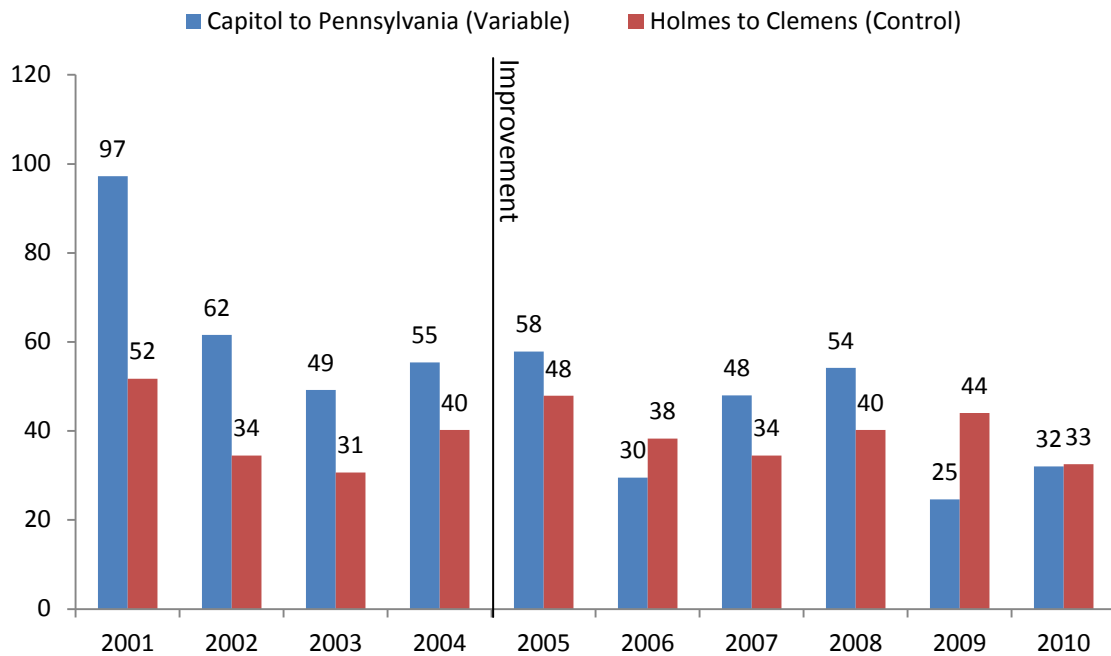
To determine the impact that the improvements had on crashes that occurred along Michigan Avenue, side-by-side and before-after analyses were used for this case study.

Michigan Avenue from Capitol Avenue to Pennsylvania Avenue was treated as the variable site. Michigan Avenue from Holmes Avenue to Clemens Avenue was treated as the control site, as its characteristics are similar to Michigan Avenue prior to the streetscape improvements that were implemented in 2004. Michigan Avenue, from Pennsylvania Avenue to Holmes Avenue, is the location of Sparrow Hospital and was excluded from the variable and control sites due to its unique roadway and land use characteristics.

Because the improvements on Michigan Avenue were completed in 2004, crash data were analyzed for the years 2001-2010. Since the two sections were of different lengths, crashes were calculated on a per mile basis to normalize data for comparison purposes. Automobile, bicycle, and pedestrian LOS were determined for each of the two sections.

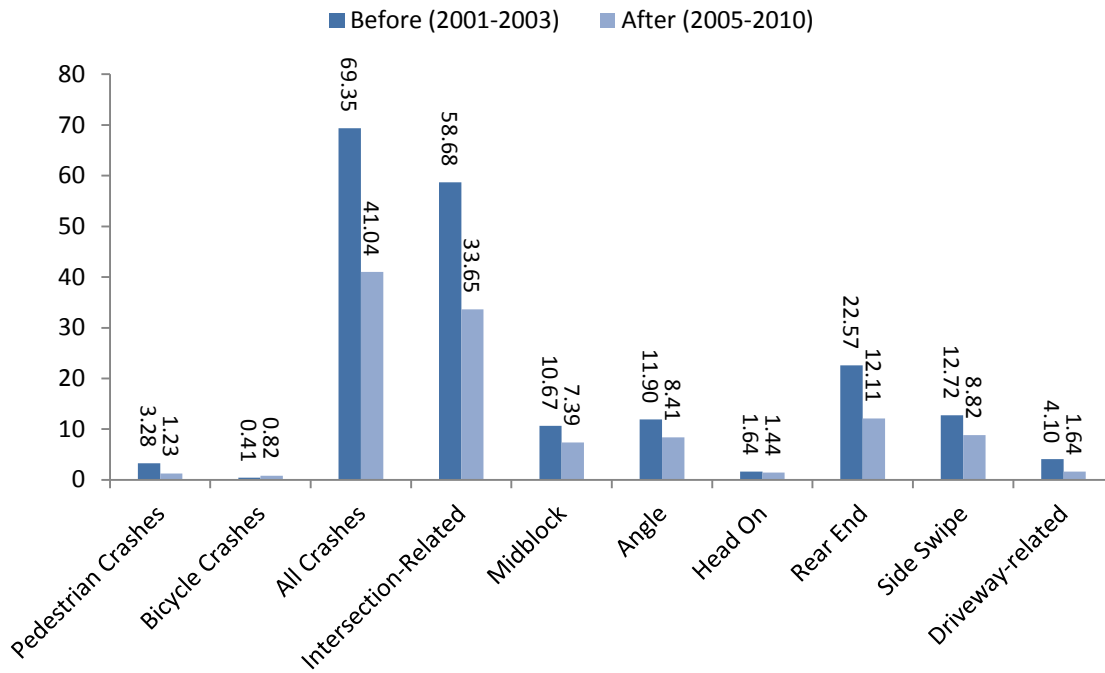
CRASH RESULTS

Michigan Avenue All Crashes (per-mile equivalent)

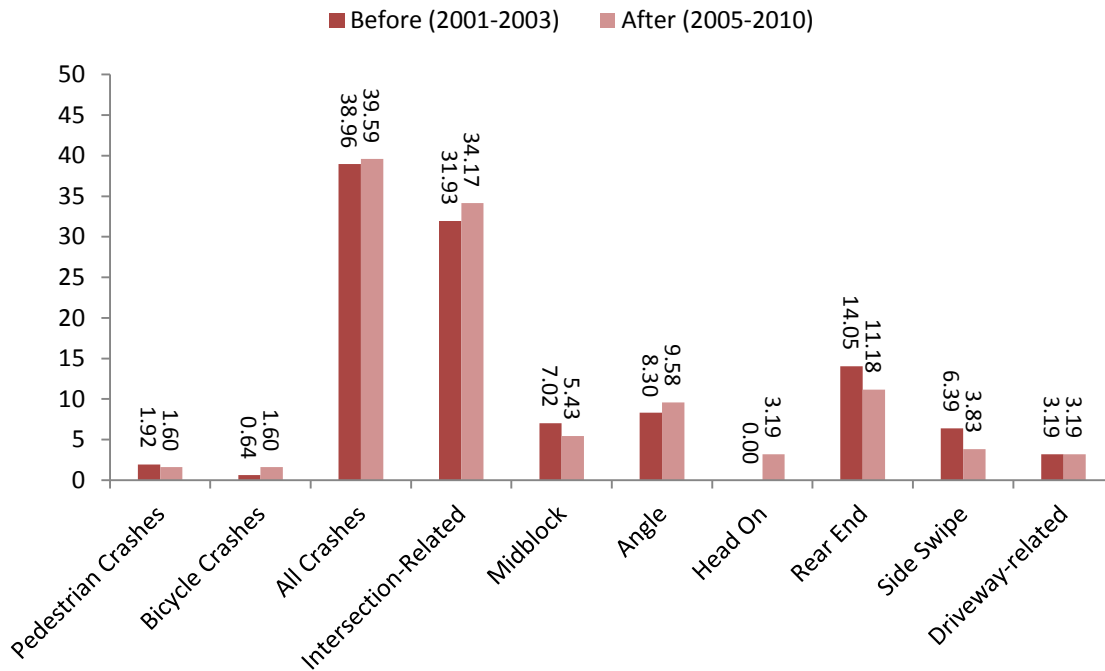


Total crashes along Michigan Avenue between Capitol Avenue and Pennsylvania varied between 2001 and 2010 but generally decreased from 97 crashes in 2001 to 32 crashes in 2010, a 67% decrease. On the control section between Holmes Avenue and Clemens Avenue, crashes dropped by a lower margin from 52 to 33, a 37% decrease. Between 2005 and 2010, total crashes in the state of Michigan dropped by 20%, and crashes on Michigan Avenue dropped by 45%.

Michigan Avenue Crashes per Mile per Year Capitol Avenue to Pennsylvania Avenue (Variable)



Michigan Avenue Crashes per Mile per Year Holmes Avenue to Clemens Avenue (Control)



After the improvements, all crashes and intersection-related crashes decreased 41% for the variable section of Michigan Avenue. There was almost no change in crashes on the control section. Intersection-related crashes decreased 43% for the variable section and increased 7% for the control section. Driveway-related crashes, midblock, angle, rear end, side swipe, and driveway-related crashes went down more for the variable section of Michigan Avenue than for the control.

Rear end crashes were reduced from 22 to 12 per mile on the variable segment of Michigan Avenue between Capitol Avenue and Pennsylvania Avenue. On the control section of Michigan Avenue between Holmes Avenue and Clemens Avenue, rear end crashes decreased from 14 to 11.

Pedestrian crashes dropped slightly for both sections of Michigan Avenue after the improvements were completed. The overall decrease was greater for the variable section of Michigan Avenue than for the control.

Bike crashes on Michigan Avenue between Capitol Avenue and Pennsylvania Avenue varied from year to year, ranging from a high of 4 crashes in 2004 to 1 crash in 2010. There was a minor increase in bicycle crashes on the control section of Michigan Avenue after the improvement.

LOS RESULTS

	Variable: Capitol to Pennsylvania	Control: Holmes to Clemens
Pedestrian LOS	B (2.00)	B (2.47)
Bicycle LOS	D (3.89)	D (3.91)
Automobile LOS	C	C
85 th Percentile Speed	42 mph	34 mph
Average Daily Traffic (ADT)	11,500	11,500

Pedestrian LOS is slightly higher in the variable section (B, 2.00) than in the control (B, 2.47). Bicycle LOS is nearly identical at D for both the control and variable sections, and automobile LOS is almost the same for both the control and variable sections of Michigan Avenue, as well. Again, improvements along Michigan Avenue are more intersection-related, which means that their effect on pedestrian and bicycle LOS is not reflected in this LOS model.

OBSERVATIONS

The width of Michigan Avenue increases from west to east from three lanes to five lanes. On-street parking occupancy was observed to be lower east of the river, ultimately decreasing to zero by the time the hospital is reached. On the block where the hospital is located, on-street parking is prohibited.

CONCLUSIONS

Pedestrian and bicycle traffic crashes were low for this case study, which limited the analysis of crashes. Multimodal LOS is calculated for travel *along* a facility and does not take into account the LOS of a crossing or intersection. It is possible that these improvements to Michigan Avenue improved the pedestrian environment, but it is difficult to determine what effect this had on pedestrian LOS because the improvements primarily affected pedestrian crossings.

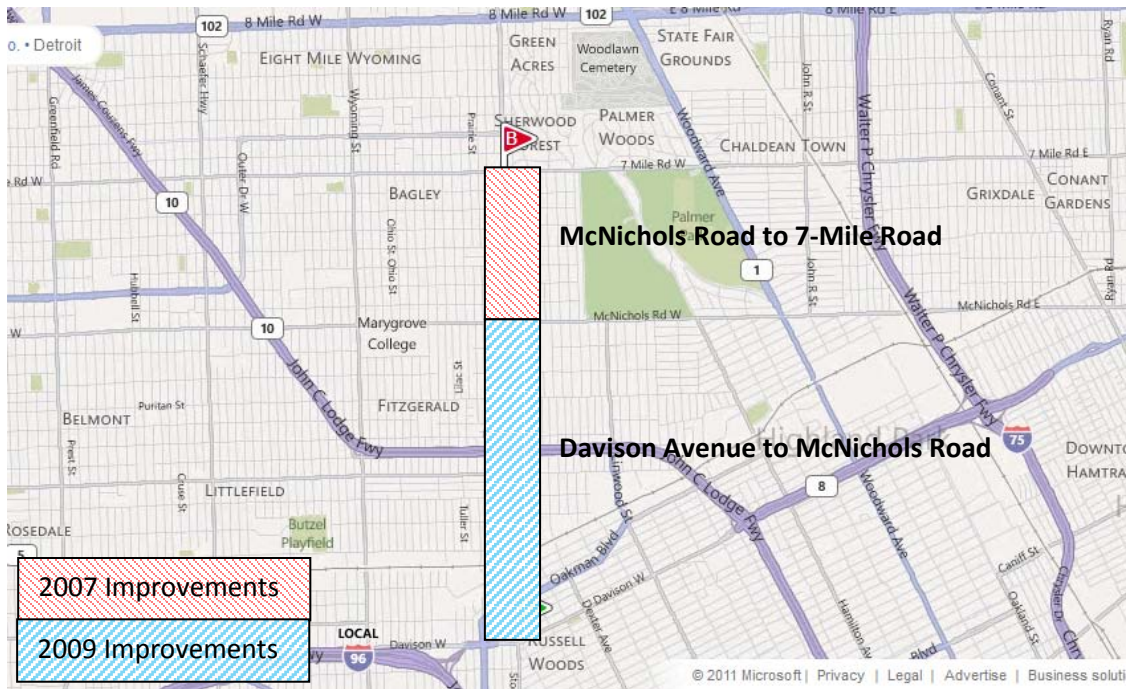
The variable section of Michigan Avenue between Capitol Avenue and Pennsylvania that was improved in 2004 generally saw a larger decrease in crashes overall than the control section of Michigan Avenue between Holmes Avenue and Clemens Avenue. The variable section of Michigan Avenue showed a greater decrease in bike crashes, driveway-related crashes, and rear end crashes than the control section. ADT was the same for both sections and the improved section of Michigan Avenue actually was shown to have a higher average vehicle speed than the unimproved section of Michigan Avenue.

LESSONS LEARNED

The improvements to Michigan Avenue had a noticeable effect on reducing crashes. By implementing improvements along the corridor, it changed the roadway geometry, which contributed to the reduction in crashes.

This case study highlights the shortcomings of pedestrian and bicycle LOS when attempting to measure LOS for persons traveling along a facility rather than attempting to cross it. The improvements, intended to improve pedestrian crossings, could not be analyzed because the pedestrian LOS model does not apply to intersections. The mixed results of this case study suggests that other methods are needed to determine the impacts on pedestrian LOS, such as observing pedestrian crossing and motorist yielding behavior, to offer greater insight into the effectiveness of improving pedestrian comfort and safety, as well as these impacts on roadway congestion.

4. LIVERNOIS AVENUE: DAVISON STREET TO 7-MILE ROAD, DETROIT, MI



Improvements: Barrier median, HAWK signal, pedestrian crossing improvements, left turn restrictions at traffic signals

Date: McNichols Road to 7-Mile Road: Fall 2007, Davison Road to McNichols Road: Fall 2009

Speed Limit: 35 mph

2006 ADT (Entire Corridor): 22,380

2011 ADT (Entire Corridor): 18,500

PROJECT DESCRIPTION

Improvements along this corridor were installed in two phases. The section from McNichols Road to 7-Mile Road included a barrier median and improved pedestrian crossings in the fall of 2007. The adjacent section to the south, from Davison Street to McNichols Road was improved with the same treatments in fall of 2009. At crosswalks, the barrier median provides a pedestrian refuge so pedestrians only have to cross one direction of travel at a time.

Left turn bays are integrated into the median at various locations for access to driveways; however, left turns are prohibited at traffic



signals. A pedestrian hybrid beacon was installed at Chalfonte Street and a two-stage pedestrian crossing was installed at Santa Clara Avenue.

ANALYSIS

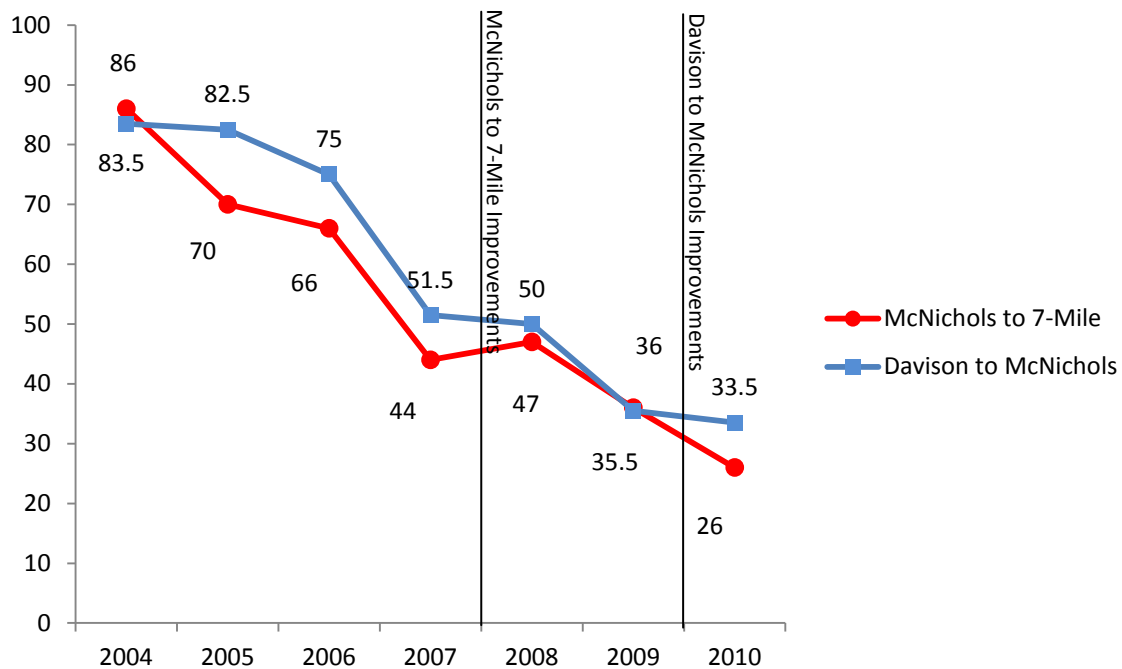
Crash data along the entire corridor was collected for years 2004 through 2010. Crashes were analyzed for before and after the improvements on the northern section, between McNichols Road and 7-Mile Road. Crashes before the improvements on the southern section were also analyzed. However, there is not sufficient data available to study the after effects of this section, as there is only one year of data after the improvements.

Signal timing data, traffic volumes, speeds, and observations of pedestrian and motorist behavior were collected to conduct level of service assessments for all transportation modes.

CRASH RESULTS

Crashes over the entire study corridor decreased 63% between 2004 and 2010, from 253 in 2004 to 93 in 2010 for all motor vehicle crashes. This rate of decrease is higher than the State of Michigan average, which was 17% for the same time period.

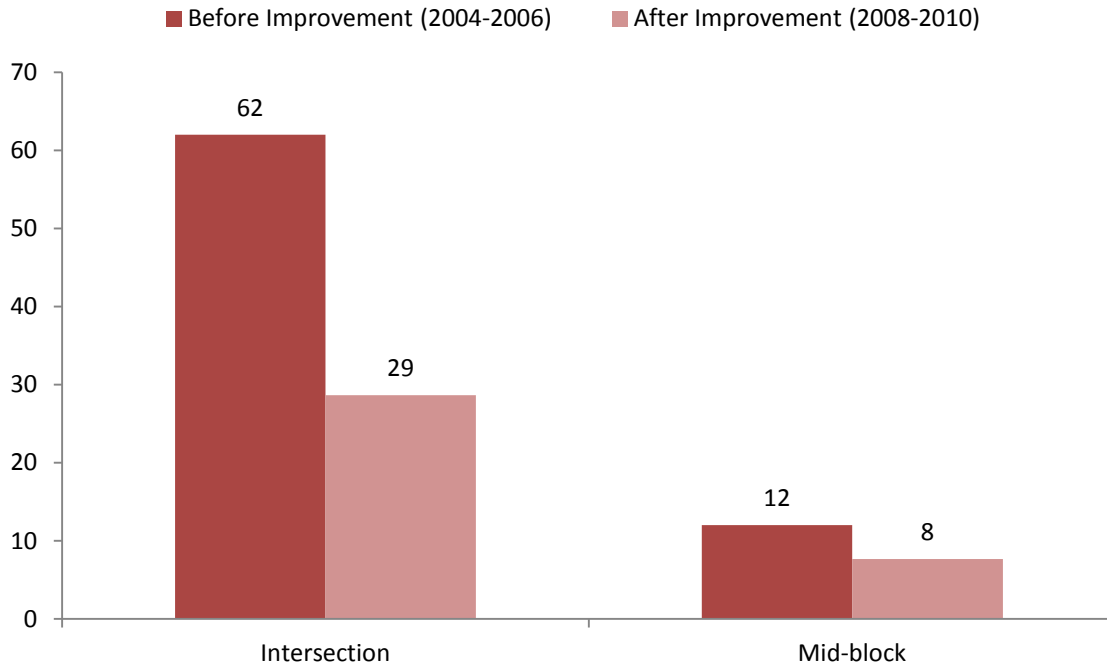
Crashes per Mile Livernois Avenue



Between McNichols Road and 7-Mile Road, there were 222 crashes before the improvements for the three-year period of 2004 through 2006. After the improvements, crashes dropped by more than half to 109 from 2008 through 2010. Crashes also dropped by 60% on the southern section between Davison and McNichols. The southern section is two miles long while the

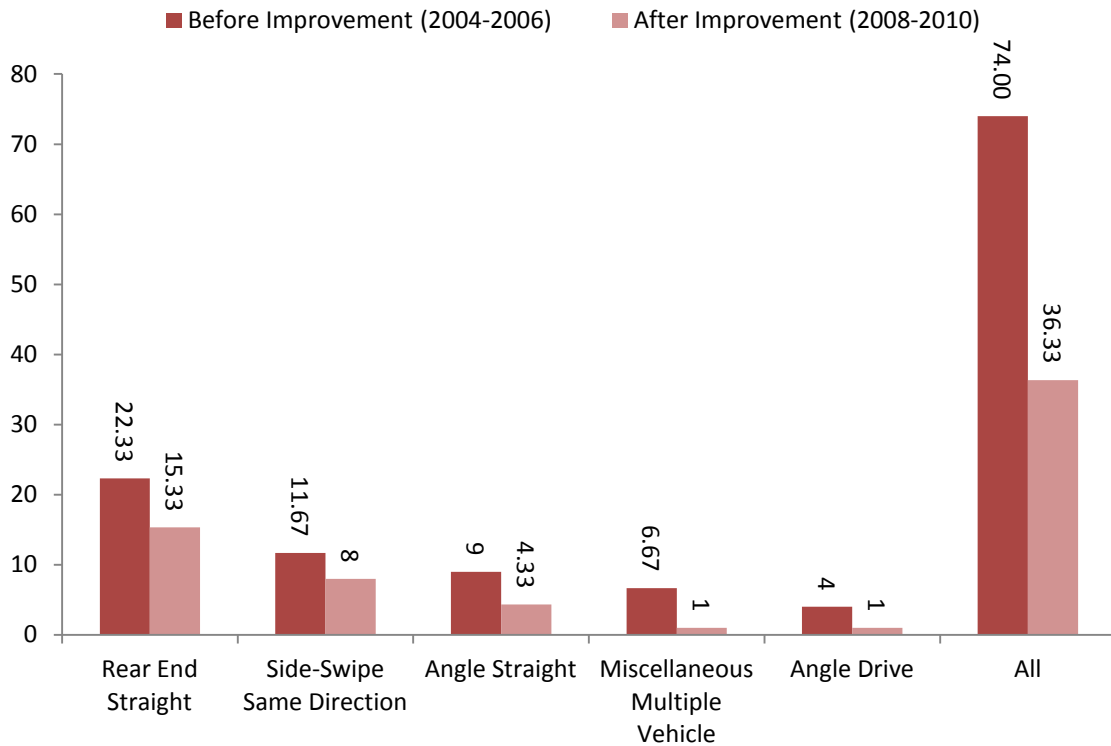
northern section is only one mile. The crashes in both sections were compared on a per-mile basis to account for the different section lengths.

Crashes per Year on Livernois Avenue between McNichols Rd. to 7-Mile Rd.



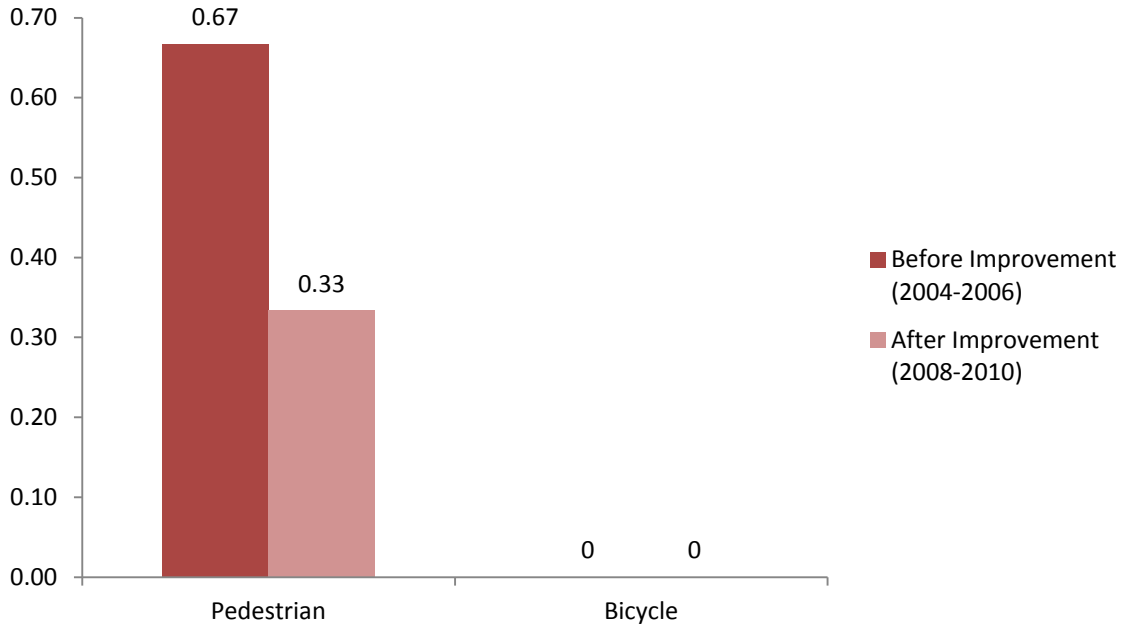
The majority of the crashes along the northern section occurred at intersections rather than mid-block and the greatest drop in crashes was seen in intersection crashes. Intersection crashes dropped by 53% and mid-block crashes dropped by 36% after the improvements were completed.

Annual Average of Crashes by Crash Type Livernois Avenue between McNichols Road and 7-Mile Road



All crashes dropped by 50% after the construction of the barrier median. Rear-end crashes were the most frequently occurring type of crash before as well as after the improvements were installed. After the improvements, rear end crashes dropped by 31%, sideswipe crashes dropped by 31%, angle crashes dropped by 51%, and driveway-related angle crashes dropped by 75%.

Average Annual Crashes by User Type Livernois Avenue between McNichols Road and 7-Mile Road



Crashes involving pedestrians or bicyclists were rare in most cases, although there were spikes in pedestrian crashes in 2004 and 2007. On Livernois Avenue between McNichols Avenue and 7-Mile Road, pedestrian crashes were lower after the improvements. No bicycle crashes were recorded on this section of Livernois Avenue.

LOS RESULTS

	McNichols Avenue to 7-Mile Road		Davison Avenue to McNichols Avenue	
	Before (2006)	After (2011)	Before (2006)	After (2011)
Pedestrian LOS (Score)	B (2.35)	C (2.57)	B (2.35)	C (2.56)
Bicycle LOS (Score)	D (3.88)	D (3.98)	D (3.88)	D (3.98)
Automobile LOS	C	B	C	D
85th Percentile Speed	n/a	31.8 mph	n/a	31.7 mph
ADT	22,380	18,500	22,380	18,500

Pedestrian and bicycle LOS were lower after the improvements than before. The Florida DOT model uses assumed speed based on ADT as one of the factors to determine LOS. Because it is not possible to adjust the calculated travel speeds in the model, a decrease in ADT increases the calculated travel speed, which decreases pedestrian and bicycle LOS. Furthermore, the inputs for the LOS model do not take into consideration the reduced width of crossing of a roadway

with a median, as the total number of roadway lanes remained unchanged before and after the improvements. Despite a drop in pedestrian crashes on Livernois Avenue between McNichols Avenue and 7-Mile Road, pedestrian LOS dropped from B to C after the improvements were completed. Bicycle LOS remained relatively the same before and after improvements. Automobile LOS improved on Livernois Avenue from McNichols Avenue to 7-Mile Road but was worse between Davison Avenue and McNichols Avenue after the improvements.

CONCLUSIONS

Crashes were reduced for all types of crashes following the improvements on Livernois Avenue. However, LOS got worse for pedestrians and bicyclists. The construction of a barrier median, known for a crash reduction factor of 40%, reduced crashes on Livernois Avenue by more than 50%. The multimodal LOS model does not allow for adjustments in speed and, as a result, bicycle and pedestrian LOS do not reflect existing conditions. Further review of multimodal LOS is needed to determine other factors that should impact LOS at crossings.

LESSONS LEARNED

The installation of the barrier median on Livernois Avenue showed that improvements along the full length of a corridor appear to have a positive impact on crash reduction. However, pedestrian and bicycle LOS results for Livernois Avenue are not reliable. This highlights the difficulty in modifying inputs to the LOS model to reflect the safety or comfort benefits of separating pedestrians and motorists. In addition, because improvements were installed in two different locations in two different years, it was difficult to determine the direct impacts of the barrier median. Additional crash data collected after 2009 would provide a better understanding about the crash impacts of installing the median.

5. DAVISON STREET (M-8): LIVERNOIS AVENUE TO ROSA PARKS BOULEVARD, DETROIT, MI



Improvements: Midblock crossings, advance stop bars at pedestrian crossings at intersections, rectangular rapid flashing beacons (RRFB) installed at unsignalized pedestrian crossings.

Date: 2010

Speed Limit: 35 mph

2011 ADT: 37,000

PROJECT DESCRIPTION

In 2008, Wayne State University prepared a report that included recommendations for improvements to Davison Avenue to reduce crashes. The limits of the study area were Davison Avenue between Livernois Avenue to Rosa Parks Boulevard. Improvement recommendations included updated pavement markings at intersections and raised barrier medians at midblock crossings. Midblock crossings were installed with high-visibility, zebra-style crosswalk markings and rectangular rapid flashing beacons (RRFB) and pedestrian refuge islands in 2010.

Davison Street contains sidewalks on both sides with a 6-12' buffer between the sidewalk and the roadway. Land use along Davison Street is primarily commercial with several automobile-oriented businesses including gas stations with multiple driveways fronting along Davison Street. Raised pedestrian refuge islands and actuated, flashing yellow beacons were provided at crossings to assist pedestrians crossing Davison Avenue.

ANALYSIS

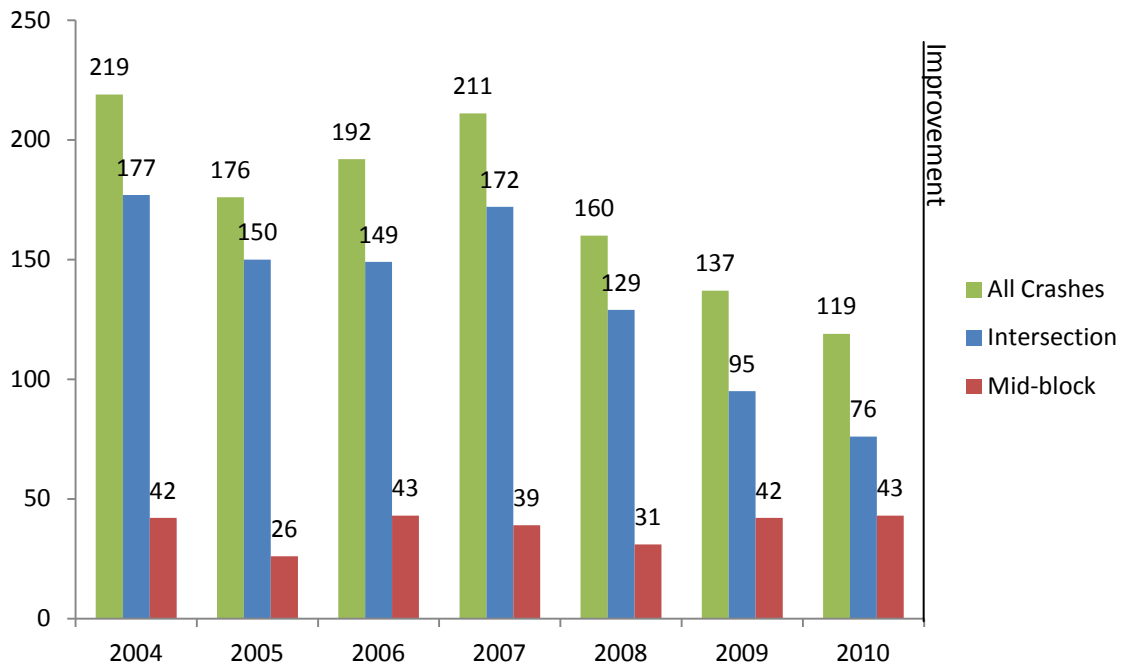
Crashes that occurred on Davison Street between 2004 and 2010 were reviewed by crash type and by year.

A site visit to Davison Street occurred on April 20, 2011 to collect information about roadway infrastructure including travel lanes, crosswalks, medians, and pavement markings. Since construction was completed in 2010, the wiring for the RRFB's was vandalized which rendered them not functional.

CRASH RESULTS

Crashes along Davison Avenue were varied between 2004 and 2010. Pedestrian crashes varied during the study period and ranged between 2 and 10 crashes in a year, reaching the peak in 2007. Bicycle crashes remained low throughout the study period with no more than one crash per year.

Davison Avenue Crashes by Crash Location



Since the improvements on Davison Avenue were completed in 2010, there was insufficient data to determine the effect that the improvements had on crashes. Between 2004 and 2010, total crashes and intersection crashes decreased along Davison Avenue. Mid-block crashes varied from year to year but an average of 38 mid-block crashes per year occurred between 2004 and 2010.

A review of the crash reports revealed that motorists were crashing into the midblock crossing islands. The site visit also revealed that the sign posts in the pedestrian refuge island were damaged and many had been removed as a result of these types of crashes.

LOS RESULTS

Table 5 – Davison Avenue Level of Service (LOS) Calculations	
Livernois Avenue to Rosa Parks Boulevard/12 th Street (2011)	
Pedestrian LOS (Score)	D (3.68)
Bicycle LOS (Score)	F (5.80)
Automobile LOS	C
85 th Percentile Speed	37 mph
Average Daily Traffic	37,000

Pedestrian and bicycle LOS for Davison Avenue were low with pedestrian LOS D (3.68) and bicycle LOS E (5.80). Improvements along Davison Avenue focused primarily on improving crossings as opposed to walking along Davison Avenue. However, since the LOS model does not calculate pedestrian LOS for crossings, pedestrian improvements are not reflected in the pedestrian LOS score.

OBSERVATIONS

After construction, the RRFBs were vandalized which rendered them inactive. The site visit revealed that the posts and curbs of the pedestrian refuge islands were damaged, suggesting that single motor vehicle crashes involved the pedestrian refuge islands. Also, pedestrians were observed not using the pedestrian refuge islands while crossing. The pedestrian refuge islands were difficult to see while traveling along Davison Avenue. Because the RRFBs were not functional, and the pedestrian refuge islands have visible crash damage, they do not appear safe or useful to pedestrians.



Photo of Davison Avenue at Lawton Avenue pedestrian refuge island

CONCLUSIONS

Improvements along this section Davison Avenue recently were completed and crash data were insufficient to determine whether the improvements had any effect on crashes. Since the improvements were vandalized shortly after they were completed in 2010, and because there is not enough crash data after 2010, Davison Avenue is not a good candidate for a before-and-after crash analysis.

LESSONS LEARNED

Davison Avenue did not have a comparison site and the improvements were completed so recently that there was no crash data available to complete the analysis. Additionally, since the improvements were not functional at the time of analysis, the reported crash impacts do not reflect the potential safety benefits of devices operating as intended.

SUMMARY CONCLUSIONS

The crash data reviewed in these case studies showed that non-traversable medians, with or without pedestrian crossings, produced the most significant decrease in pedestrian crashes. Additionally, the road diet on 60th Street in Cutlerville resulted in a reduction in travel lanes, automobile traffic volumes, and travel speeds, all of which likely contributed to a reduction in crashes.

Among the improvements that were reviewed in the case studies, the highest crash reduction factors for each crash type were identified in Table 6 below. Many case studies included more than one improvement. While it was not possible to determine which specific improvement most contributed to the reduction in crashes, it helped provide insight into what types of improvements may be beneficial given roadway conditions.

Crash Type	Crash Reduction	Case Study	Improvements
All	63%	Livernois Avenue	Barrier median, high visibility pedestrian crosswalks
Bicycle	100%	60 th Street	Road diet and bike lanes
Pedestrian	70%	Mission Street	Pedestrian signal heads, pedestrian refuge island
Intersection	40%	Mission Street	Pedestrian signal heads, pedestrian refuge island
Midblock	36%	Livernois Avenue	Barrier median, high visibility pedestrian crosswalks
Angle	52%	Livernois Avenue	Barrier median, high visibility pedestrian crosswalks
Rear End	79%	60 th Street	Road diet and bike lanes
Side Swipe	100%	60 th Street	Road diet and bike lanes

Improvements that reduced lane widths or the number of lanes along the full length of a facility appeared to have the greatest impact on crashes. The road diet on 60th Street in Cutlerville showed the most dramatic decrease in crashes after improvements were made with a 100% decrease in bicycle crashes, a 79% decrease in rear end crashes, and a 100% decrease in side swipe crashes. The median added to Livernois Avenue also resulted in significant decreases in crashes with a 63% reduction in all crashes, 35% reduction in midblock crashes, and a 52% reduction in angle crashes.

The pedestrian refuge island on Mission Street at Appian Way in Mount Pleasant or the pedestrian refuge islands on Davison Avenue in Detroit produced less clear crash reduction results. In both of these cases, recorded speeds did not decrease and the pedestrian refuge islands may have created a hazard for motorists, thereby increasing certain types of crashes, including fixed object and driveway-related crashes. Davison Avenue was completed too recently for a before and after crash analysis to be performed.

The multimodal LOS model was designed to calculate LOS for corridor improvements, but could not be used to approximate intersection LOS. Improvements that resulted in the highest LOS for each mode are shown in Table 7 below. The road diet on 60th Street reported the highest bicycle and automobile LOS. Pedestrian LOS was highest along Michigan Avenue.

Mode	Level of Service	Case Study	Improvements
Pedestrian	B (2.00)	Michigan Avenue	Curb extensions, roundabout, high visibility pedestrian crosswalks
Bicycle	C (2.75)	60 th Street	Road diet and bike lanes
Automobile	B	60 th Street	Road diet and bike lanes

A more robust crash analysis is possible when a few years of crash data can be obtained before and after construction. Furthermore, when only the construction *year* is known for a particular improvement in some cases, an entire year of crash data must be excluded in order to conduct a before and after analysis on an improvement. Access to crash reports in addition to crash data helps provide additional insight into the potential causes of crashes.

Finding control sites for each variable site in municipalities where there were few or roadways with similar characteristics was difficult. Arterials with similar width and ADT may still vary based on land use and traffic control devices, which limits the ability to compare crash results.

Future case studies would continue to help determine the crash impacts of various improvements. In order to maximize their utility, the following should be considered:

1. Collect crash data, traffic volumes for all modes (including bicycle and pedestrian traffic), and speed data for a corridor or intersection for several years prior to constructing improvements;
2. Allow several years to pass to accumulate a sufficient amount of “after improvement” data before conducting an analysis;
3. Experiment with other LOS models to more accurately reflect intersection and corridor level LOS. The Florida DOT, Highway Capacity Manual (HCS) and Synchro LOS models may be more developed by this time.