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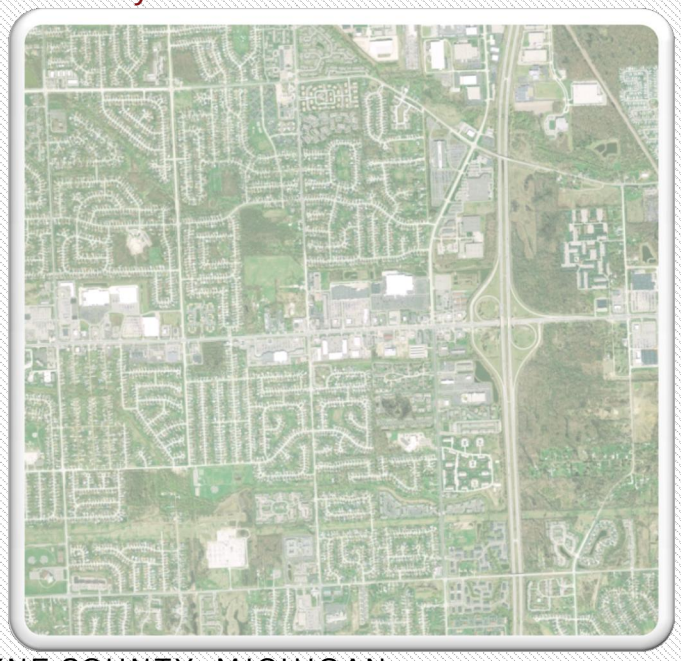
M-153 / I-275 Interchage and Surrounding Area Road Safety Audit



WAYNE COUNTY, MICHIGAN

May 8 - 10, 2012

PREPARED FOR:

Michigan Department of Transportation

MDOT Michigan Department of Transportation

& Wilbur Smith Associates

WilburSmith ASSOCIATES

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Appendices

1.0 Introduction

This document represents the final report for the Road Safety Audit (RSA) for the M-153/I-275 interchange and surrounding area. The goal of an RSA is to answer the following questions:

- What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

This RSA was performed in Wayne County, Michigan on May 8 - 10, 2012 as a formal safety performance examination of the existing roadway network. The M-153 roadway corridor from Lilley Road to Lotz Road was the primary focus of the examination however, the entire area bounded by Sheldon Road (west) to Lotz Road (east) and from Cherry Hill Road (south) to Warren Road (north) was reviewed. The Road Safety Audit was conducted in a manner consistent with FHWA Road Safety Audit Guidelines adopted by the Michigan Department of Transportation. This proactive Audit documents current and potential road safety issues and opportunities to improve safety for all potential road users as identified by the RSA Team.

2.0 Background

M-153 is classified as an urban principal arterial by the 2010 Sufficiency Report. This segment of M-153 is on the National Highway System (NHS) and is classified as a “green route” on the Priority Commercial Network (PCN). M-153 varies from five-lanes to seven-lanes (two to three lanes in each direction of travel with a center left-turn lane). The roadway is typically undivided however, between the southbound I-275 exit ramp and the northbound I-275 exit ramp, travel directions on M-153 are separated by a raised median. M-153 is an east-west roadway with a posted speed limit of 45 mph throughout the study area. Land uses surrounding the M-153 project area are highly commercial with businesses ranging from small restaurants to an IKEA big box store having access to M-153.

Roadways also reviewed during this RSA include Cherry Hill Road, Warren Road and Haggerty Road. Each of these roadways are major collector-distributor roads. Based upon field observations revealing highly residential land uses adjacent to Cherry Hill and Warren Road, these east-west corridors mainly service local traffic. Although residential land uses generally surround Haggerty Road within the project limits, commercial developments are common near M-153 and large industrial developments are located north of the project limits which make the traffic make-up of this roadway slightly more commercial in

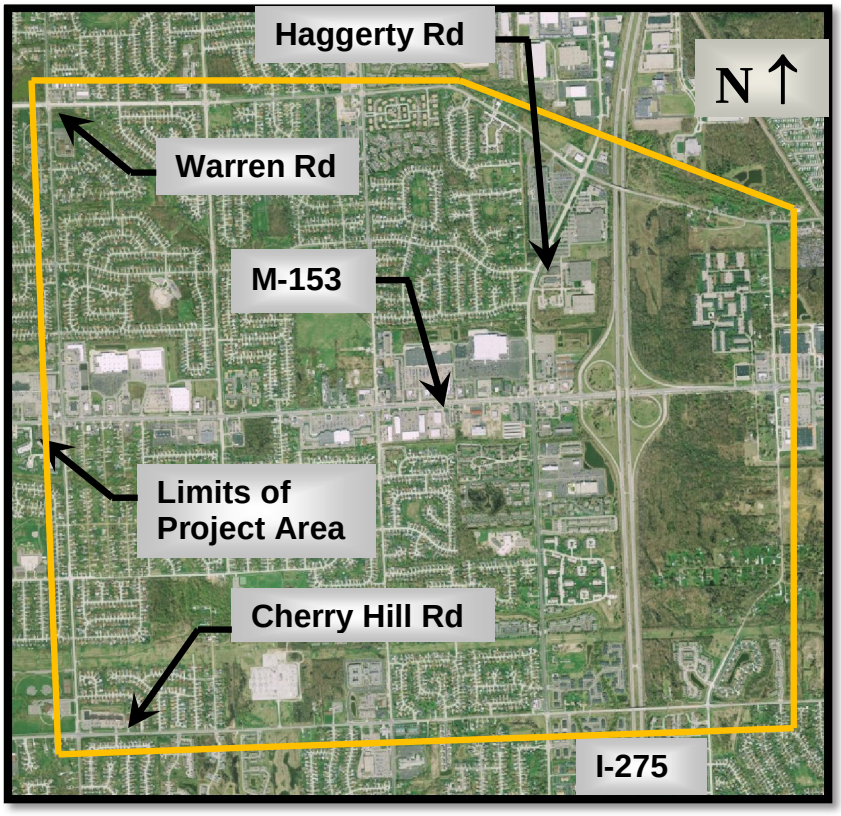
nature than Cherry Hill or Warren Roads. Cherry Hill and Warren Road are typically two-lane roadways with one lane in each direction of travel but, each roadway section varies from a two-lane section to a five-lane section. Haggerty Road is typically a five-lane roadway with two lanes in each direction of travel and a center left-turn lane however, similar to Cherry Hill and Warren Road, Haggerty varies from a two-lane section to a five-lane section throughout the project limits.

The decision was made to conduct a Road Safety Audit (RSA) within the study limits to evaluate the current safety conditions and develop potential mitigations for any identified safety issues. As stated earlier, the study area for this Road Safety Audit, as shown in **Figure 2.1**, focused primarily on the M-153 roadway corridor from Lilley Road to Lotz Road however, the entire area bounded by Sheldon Road (west) to Lotz Road (east) and from Cherry Hill Road (south) to Warren Road (north) was reviewed.

It is important to note that this RSA has been completed in conjunction with an ongoing Environmental Assessment/Interchange Feasibility Study being performed for MDOT. The limits of the study area for this Environmental/Feasibility Study are consistent with the limits of this RSA.

It is also important to note that an I-275 freeway construction project that reduced available capacity on I-275 was in effect during the field review portion of this RSA which greatly modified travel patterns through the study area. The typical travel patterns and driver behaviors were conveyed to the RSA Team via first-hand accounts from the enforcement representative (Mr. Patrick Sullivan) and based upon the operations shown in the Synchro traffic models. Through these resources, it is believed that the RSA Team gained a full understanding of the operations and associated safety issues within the study area.

Figure 2.1 – Study Area Map



2.1 RSA Team

The RSA Team was composed of private and State representatives and led by members of the consultant team. The team consisted of knowledgeable individuals with diverse areas of expertise including geometrics, safety, and operations. The RSA Team included the following individuals:

- **Rosemary Edwards**, MDOT Traffic and Safety - Geometrics
- **John Engle, PE**, MDOT Traffic Signal Operations
- **Bob Rios,** MDOT Traffic and Safety – Safety
- **Jon Myers, PE**, MDOT Traffic Operations & Safety
- **Josh DeBruyn**, MDOT Multi-Modal Specialist
- **Patrick Sullivan**, Canton Township Police
- **Matt Hunter, PE**, Wilbur Smith Associates
- **Mike Zavadil, PE**, Bergmann Associates, Inc.
- **Keith Simons**, **PE, PTOE**, Bergmann Associates, Inc.

2.2 RSA Pre-Audit Meeting/Summary

The Safety Audit started with a Pre-Audit Meeting consisting of the RSA Team, MDOT Lansing Central Office members, members of the MDOT Taylor TSC, representatives from the Federal Highway Administration, Wayne County representatives, and representatives of Canton Township to identify known issues, the concerns of local stakeholders, any constraints that the Taylor TSC would like the RSA Team to work within, and the any mitigations the Taylor TSC plans to implement in the near future.

Local Stakeholder Known Issues and Concerns

- There is an existing non-motorized path that travels along the east side of I-275 which directs users to the signalized intersection at Lotz Rd. Are users really travelling to this signalized crossing or not?
- Significant queuing on M-153 may add to crashes.
- There have been some high severity crashes involving pedestrians on the east side of the Haggerty/M-153 intersection.
- There are a high number of rear-end and left-turn-driveway related crashes.
- There has been an effort made to reduce the number of driveways along M-153, are there any other access management strategies that may be employed?
- How can this area be made safer?
- The following improvements have already been made to the project area:
    - A second right-turn lane from the SB I-275 exit ramp at M-153 and continuous right-turn lane from this SB I-275 ramp to Lilley Rd along WB M-153 were recently constructed.
    - Canton Township has been actively pursuing access management strategies including drive consolidation and zoning along M-153.

Constraints

- No constraints were imposed on the RSA Team.

A brief presentation was provided by the consultant describing the RSA process, the goals and objectives of an RSA, the steps that have already been completed by MDOT, and the steps that would be completed by the RSA Team over the three day RSA process.

The team then met to discuss the input received from the Pre-Audit Meeting attendees and reviewed the following materials:

Aerial photographs	Adjacent land uses
Traffic volume data	Known safety issues
As-built plans	Crash histories
Previous studies	Synchro models
Traffic signal timing permits	

The Audit team then conducted several field visits under varying light, environmental, and traffic conditions ranging from off-peak, daytime conditions to peak hour and night-time conditions. The RSA Team conducted its field visits by driving through the study area and via walk throughs on Tuesday, May 8th and Wednesday, May 9th. While out at the site, team members verified issues identified during the Pre-Audit Meeting, discussed additional issues, and took notes and photographs.

The field review considered all potential users of the facility (i.e. cars, trucks, motorcycles, non-motorized users, heavy vehicles, etc.).

The Audit Team reconvened on the afternoon of the second day and the morning of the third day to complete the Audit analysis. The RSA Team discussed results of the field reviews, identified potential recommendations to address issues and finalized the recommendations. The Preliminary Audit findings were then recorded and assigned levels of risk and consequence. The Team members assigned risk and consequence values to each safety issue independently, then ranked the identified safety issues from highest to lowest priority. A presentation was developed that reflected the activities and findings of the Audit Team which was presented by the Consultant moderator to the MDOT Project Manager, Taylor TSC representatives, MDOT Lansing Central Office representatives, Canton Township representatives, Federal Highway Administration representatives, and the RSA Team based upon the Audit Team's conclusions.

The consultant subsequently prepared this report, which was circulated to and commented upon by the Audit Team members, prior to being finalized.

2.3 RSA Report

This report provides information on issues identified by the RSA Team, which they deemed relevant to the stated goal of an RSA; identifying opportunities to improve road safety within the study area.

Where appropriate, an assessment of road user safety risk and suggestions for improvement are included. These suggestions should not be viewed as design

or operational recommendations. They are intended to be illustrative of potential solutions to the safety issues identified, and are presented as suggestions for consideration only.

For comparative purposes, where possible, a benefit-to-cost ratio has been calculated for the crash countermeasures that have been suggested for consideration. This ratio compares the net annual benefits resulting from an individual improvement to the annual installation cost over the expected service life of the improvement. A five step process was utilized to determine this ratio as follows:

1. Estimate the expected crash frequency at each location of interest.
2. Estimate the change in crashes by severity for each suggestion.
3. Estimate the net benefit resulting from the change in crashes for each suggestion.
4. Estimate cost for installation of each suggestion.
5. Calculate the annual benefit-to-annual cost ratio.

To estimate the expected crash frequency at each location of interest, *Chapter 12 - Predictive Methods for Urban and Suburban Arterials* of the Highway Safety Manual was utilized. This method provides a structured methodology to estimate the expected crash frequency and severity for facilities with known characteristics. For this report, it was utilized to determine the average expected crash frequencies at existing sites by using the available crash history. Once the average crash frequency was estimated, methodologies presented in *Chapter 13 – Roadway Segments* and *Chapter 14 – Intersections* of the Highway Safety Manual were used to estimate the change in crashes resulting from each countermeasure with Crash Modification Factors (CMF). CMF's quantify the change in expected average crash frequency at a site by implementing a particular countermeasure. After the change in crashes was determined for each countermeasure, traffic crash costs by casualty severity for Wayne County published by The University of Michigan Transportation Research Institute (UMTRI) were used to estimate the net benefit for each countermeasure. The installation cost for each countermeasure was estimated with current MDOT average prices and annualized assuming a twenty (20) year service life and a five percent (5.00%) discount rate. Finally, the annual benefit-to-annual cost ratio was calculated for each suggestion and can be used to compare treatments at locations within this road safety audit.

3.0 General Observations

M-153 – As stated earlier, M-153 varies between five-lanes and seven-lanes and is an arterial throughout the project limits. The entire M-153 corridor within the project limits is highly commercialized with properties ranging from small local businesses to large, nation-wide big-box stores flanking the roadway. These

businesses along with the high density of residential developments surrounding the M-153/I-275 interchange result in high traffic volumes (approximately 41,000 vpd) and high levels of congestion within the M-153 corridor. Queues develop between intersections that extend to upstream intersections greatly inhibiting travel through the corridor. Based upon first-hand accounts from the enforcement representative on the team, these high levels of traffic, congestion, and commercial development have resulted in aggressive driving behaviors throughout the corridor which may contribute to some crash types.

Lighting is present throughout the M-153 corridor with the exception of a short segment on the south side of M-153 west of Haggerty Road and through the I-275 interchange. Sidewalks are also present throughout the corridor with the exception of within the I-275 interchange.

Haggerty Road – Haggerty Road is a north-south collector-distributor road whose cross section primarily consists of a five-lane section but, varies from two to five lanes throughout the project limits. Both curbed sections without shoulders and flush shoulder segments are contained within the project limits. Commercial and residential properties bound Haggerty Road as well however, north of the project limits, Haggerty Road accesses some highly industrial properties which affects the makeup of the traffic on Haggerty Road by adding heavy vehicle traffic. The speed limit on Haggerty Road is 45 mph throughout the project limits and traffic volumes are approximately 18,000 vpd. No roadway lighting is present throughout the Haggerty corridor but, sidewalks typically flank Haggerty Road throughout the corridor with the exception of north of Hanford Road.

Warren Road – Warren Road is primarily a two-lane collector-distributor road but, its cross section varies from two to five lanes throughout the project limits. Both curbed sections without shoulders and flush shoulder segments are contained within the project limits. Commercial and residential properties bound Warren Road. The speed limit on Warren Road is 45 mph west of I-275 and 40 mph east of I-275. Traffic volumes are approximately 12,500 to 19,000 vpd. No roadway lighting is present but, sidewalks are present from Sheldon Road to east of Lilley Road.

Cherry Hill Road – Cherry Hill Road is an east-west collector-distributor road whose cross section primarily consists of a two-lane section but, varies from two to five lanes throughout the project limits. Primarily residential properties are found adjacent to Cherry Hill. The speed limit is 45 mph throughout the project limits and traffic volumes are approximately 18,500 vpd. No roadway lighting is present throughout the Cherry Hill corridor and sidewalks are typically located at the major intersections.

4.0 Audit Findings and Suggestions

Issues identified during the review of existing information and field reviews were prioritized by the RSA Team. For each safety issue identified, the team developed potential mitigation measures for review by the owner (MDOT Taylor TSC). The safety issues were prioritized based upon the observed and perceived frequency of crashes; and the anticipated and observed severity of crashes resulting from each safety issue. As a result, each safety issue was prioritized on the basis of ranking between A (lowest risk and lowest priority) to F (highest risk and highest priority). A table identifying the ranking system is shown in Table 4.1 below. This prioritization was based upon expectations and judgment of the RSA Team members.

Table 4.1 – Safety Issue Risk Assessment

Risk Category		Severity Rating			
		Negligible	Low	Medium	High
Likelihood	Frequent	C	D	E	F
	Occasional	B	C	D	E
	Infrequent	A	B	C	D
	Rare	A	A	B	C

4.1 M-153 Corridor Crash Potential

Due to the size of the project area and the differing jurisdictions (MDOT, Canton Township and Wayne County), the RSA Team provided safety issues for both the primary study area (M-153 from Lilley to Lotz Rd) and the secondary study area. The summary is separated in a similar fashion with the primary study area (M-153) safety issues being presented first followed by the secondary study area safety issues, each ranked independently.

4.1.1 Crash Potential #1(M-153) – M-153/Haggerty Road Intersection Crashes

There are a high number of crashes associated with this intersection (451) within the past five (5) years. Of these crashes, 194 rear-end, 53 angle, 36 sideswipe, and 5 pedestrian crashes were observed. The short distance (730') between Haggerty Road and the SB I-275 Exit Ramp combined with the high volume of WB M-153 traffic, SB to EB left-turn volume, and WB left-turn volumes at the Haggerty Road intersection result in excessive queuing. This excessive queuing produces aggressive driving behaviors and unanticipated stopping traffic. Aggressive driving behaviors observed during field reviews included: vehicles forcing their way through queued vehicles to turn left from driveways, extension of traffic signal phasing by travelling through red lights, and abrupt lane changing maneuvers.

Based upon the available crash data, five (5) A-Level (incapacitating) injury crashes and one (1) K-Level (fatal) crash occurred at this intersection within the last five (5) years. The following information was obtained from the UD-10 review of these crashes:

Table 4.2 – M-153 / Haggerty Road A-Level Crash Summaries

Location	Severity	Crash Type	Road Surface Condition	Weather Condition	Alcohol a factor	Notes (UD-10 Information)
MP 4.981 (5' East of Haggerty Rd)	A	Other/ Unknown	Wet	Rain	No	UD-10 information states Vehicle 2 was traveling eastbound on M-153 and had a green light when entering the intersection. Vehicle 1 was in the left hand turn lane of westbound M-153 and turned left in front of Vehicle 1. Light conditions were dark and it was rainy. The driver of Vehicle 1 was cited for a failure to yield.
MP 4.985 (25' East of Haggerty Rd)	A	Single Motor Vehicle	Dry	Clear	Yes	UD-10 information states that a pedestrian was crossing Haggerty Rd, from south to north, in the east cross walk. Vehicle 1 was traveling eastbound in the left through lane and struck the pedestrian. Light conditions were dark and the weather was clear. UD-10 does not state whether Vehicle 1 had a green light. Both the driver and the pedestrian were under the influence of alcohol.

Table 4.2 (Continued) – M-153/Haggerty Road A-Level Crash Summaries

Location	Severity	Crash Type	Road Surface Condition	Weather Condition	Alcohol a factor	Notes (UD-10 Information)
MP 4.986 (30' East of Haggerty Rd)	A	Angle	Dry	Clear	No	UD-10 crash diagram shows 4 vehicles involved in the crash. Vehicle 1 was traveling westbound on M-153 when it disobeyed a stop light and struck Vehicle 2, which was traveling northbound on Haggerty Rd in the right through lane. Vehicle 2 then hit Vehicle 3 because of the collision, which was traveling northbound in the left through lane. Vehicle 3 then hit Vehicle 4 which was in the southbound left turn lane on Haggerty Rd. The driver of Vehicle 1 was cited for disobeying a stop light.
MP 4.989 (50' East of Haggerty Rd)	A	Rear End	Wet	Rain	No	UD-10 information states Vehicles 2 & 3 were stopped at a red light at Haggerty Rd in the eastbound right hand through lane. Vehicle 1 was traveling westbound and failed to stop striking vehicle 2 which then in turn struck vehicle 3. The crash occurred at dawn and it was raining. The driver of Vehicle 1 was cited for the crash.
MP 5.037 (300' East of Haggerty Rd)	A	Single Motor Vehicle	Dry	Cloudy	Yes	UD-10 information states two pedestrians attempted to cross M-153, from south to north, 300' east of Haggerty Rd. The pedestrians were under the influence of alcohol and were crossing M-153 at an entrance drive of a pub. Vehicle 1 was traveling eastbound in the right through lane and struck one of the pedestrians. The light condition was dark and the weather was cloudy. No citations were given for this crash.

Table 4.3 – M-153/Haggerty Road K-Level Crash Summary

Location	Severity	Crash Type	Road Surface Condition	Weather Condition	Alcohol a factor	Notes (UD-10 Information)
MP 5.037 (300' East of Haggerty Rd)	K	Single Motor Vehicle	Wet	Rain	Yes	UD-10 information states that a pedestrian attempted to cross M-153, from south to north, 300 feet east of Haggerty Rd. Vehicle 1 was traveling eastbound in the left lane of M-153 and struck the pedestrian.

Due to the high number of crashes and severity of these crashes, the RSA Team developed four (4) separate suggestions for this intersection. Each of these suggestions are independent options which address some or most of the observed crash issues present at this intersection. Therefore, each of these options were provided a separate Risk Assessment and prioritized accordingly as shown below.

4.1.2 Crash Potential #1(M-153) – M-153/Haggerty Road Intersection Crashes – Suggestion #1

Expected Frequency	Expected Severity	F
Frequent	High	

Observation: There is a high number of crashes at this intersection which include rear-end, angle, and pedestrian-related crashes. In addition, it was observed that there is a high number of crashes throughout the M-153 corridor involving rear-end, angle, and driveway crashes. It was observed that many of these crashes were congestion or aggressive driving-related crashes.

Figure 4.1 – Potential Boulevard Section on M-153 at Haggerty Road

SUGGESTION: The following option should be considered:

1) **Construct a boulevard section on M-153 from west of I-275 to west of Sheldon Road.**
   a. **Results in indirect left-turn movements away from the congested intersections which will add capacity to the intersections**
   b. **Eliminates left-turns from existing driveways throughout the corridor**
   c. **Adds pedestrian refuge areas at signalized intersections.**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$4,531,000 (cost does not include Right-of-Way)**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. The results of this analysis show an annual benefit-to-annual cost (B/C) of 11.04. See Appendix C for results of this analysis.

4.1.3 Crash Potential #1(M-153) – M-153/Haggerty Road Intersection Crashes – Suggestion #2

Expected Frequency	Expected Severity	E
Frequent	Medium	

Observation: As noted earlier, there is a high number of crashes at this intersection which include rear-end, angle, and pedestrian-related crashes. It was observed that many of these crashes were congestion or aggressive driving-related crashes. In addition, five (5) pedestrian-related crashes occurred at this intersection within the past five (5) years.

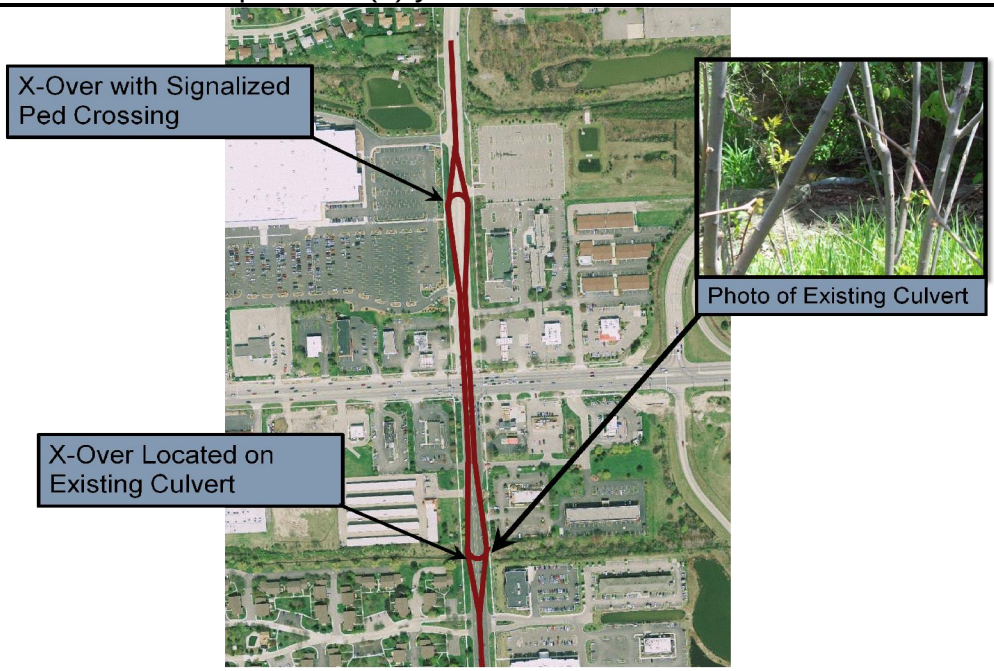


Figure 4.2 – Potential Boulevard Section on Haggerty Road at M-153

SUGGESTION: The following option should be considered:

1) **Construct a boulevard section on Haggerty Road from south of M-153 to north of M-153 and eliminate left-turn movements through the M-153/Haggerty Road intersection.**
   a. **Eliminates left-turn movements at the intersection**
   b. **Improves capacity at the intersection**
   c. **Reduces potential for angle crashes**
   d. **Provides pedestrian refuge areas on Haggerty Road**
   e. **Provides signalized pedestrian crossing with refuge area at the existing IKEA overflow parking lot north of M-153**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$871,000 (cost does not include Right-of-Way)**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. The results of this analysis show an annual benefit-to-annual cost (B/C) of 19.36. See Appendix C for results of this analysis.

4.1.4 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #3

Expected Frequency	Expected Severity	E
Frequent	Medium	

Observation: As noted earlier, there is a high number of crashes at this intersection which include rear-end, angle, and pedestrian-related crashes. It was observed that many of these crashes were congestion or aggressive driving-related crashes. Based upon first-hand observations, queues on WB M-153 routinely extend through the existing I-275 interchange and further east during the evening peak hour. In addition, queues on EB M-153 extend beyond the next upstream intersection (IKEA driveway) during the morning peak hour. Improving capacity at this intersection may reduce the potential for aggressive driving.

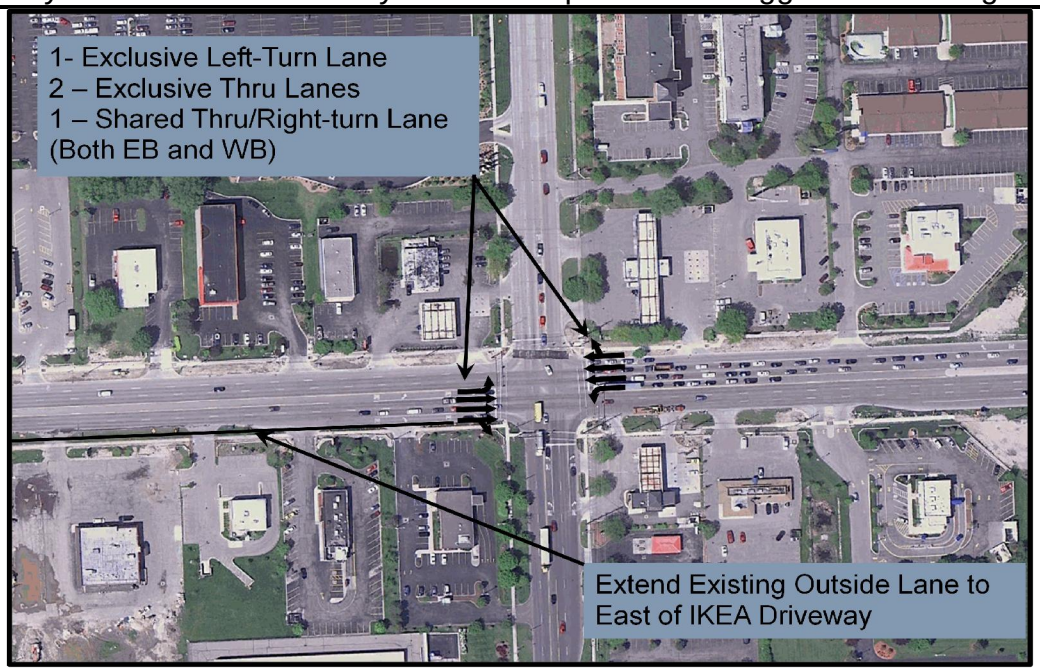


Figure 4.3 – Potential 3-Lane Section on M-153 at Haggerty Road

SUGGESTION: The following option should be considered:

1) **Construct three (3) through lanes on WB M-153 from east of I-275 to Sheldon Road.**
   a. **Improves capacity at the intersections throughout the corridor**
   b. **Reduces the potential for aggressive driving behaviors**
   c. **M-153 would generally require re-striping of the continuous right-turn lane that extends from the SB I-275 exit ramp to Lilley and signal timing modifications to implement this option**
   d. **Roadway widening east of the SB I-275 exit ramp would be required for this option**

2) **Construct three (3) through lanes on EB M-153 from west of I-275 to west of Haggerty Road**
    a. **Improves capacity at the Haggerty Road intersection**
    b. **Reduces the potential for aggressive driving behaviors at the Haggerty Road intersection**
    c. **Roadway widening west of Haggerty Road would be required for this option however signal timings and striping modifications would be required at the Haggerty Rd intersection and east.**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$201,000 (cost does not include Right-of-Way)**

A Benefit-to-Cost analysis could not be conducted per the Highway Safety Manual methodology due to the lack of a Crash Modification Factor (CMF) for the addition of a through lane at an urban signalized intersection.

4.1.5 Crash Potential #1(M-153) – M-153/Haggerty Road Intersection Crashes – Suggestion #4

Expected Frequency	Expected Severity	E
Frequent	Medium	

Observation: As noted earlier, there is a high number of crashes at this intersection which include rear-end, angle, and pedestrian-related crashes. It was observed that many of these crashes were congestion or aggressive driving-related crashes. Based upon first-hand observations, queues on WB M-153 routinely extend through the existing I-275 interchange and further east during the evening peak hour. These queues are generally developed when the WB M-153 left-turn lane queue extends beyond the available storage length and spills out into the through traffic lanes. This queue then impedes through traffic thus, extending the through queues even further. In addition, queues on EB M-153 extend beyond the next upstream intersection (IKEA driveway) during the morning peak hour. Improving capacity at this intersection may reduce the potential for aggressive driving.

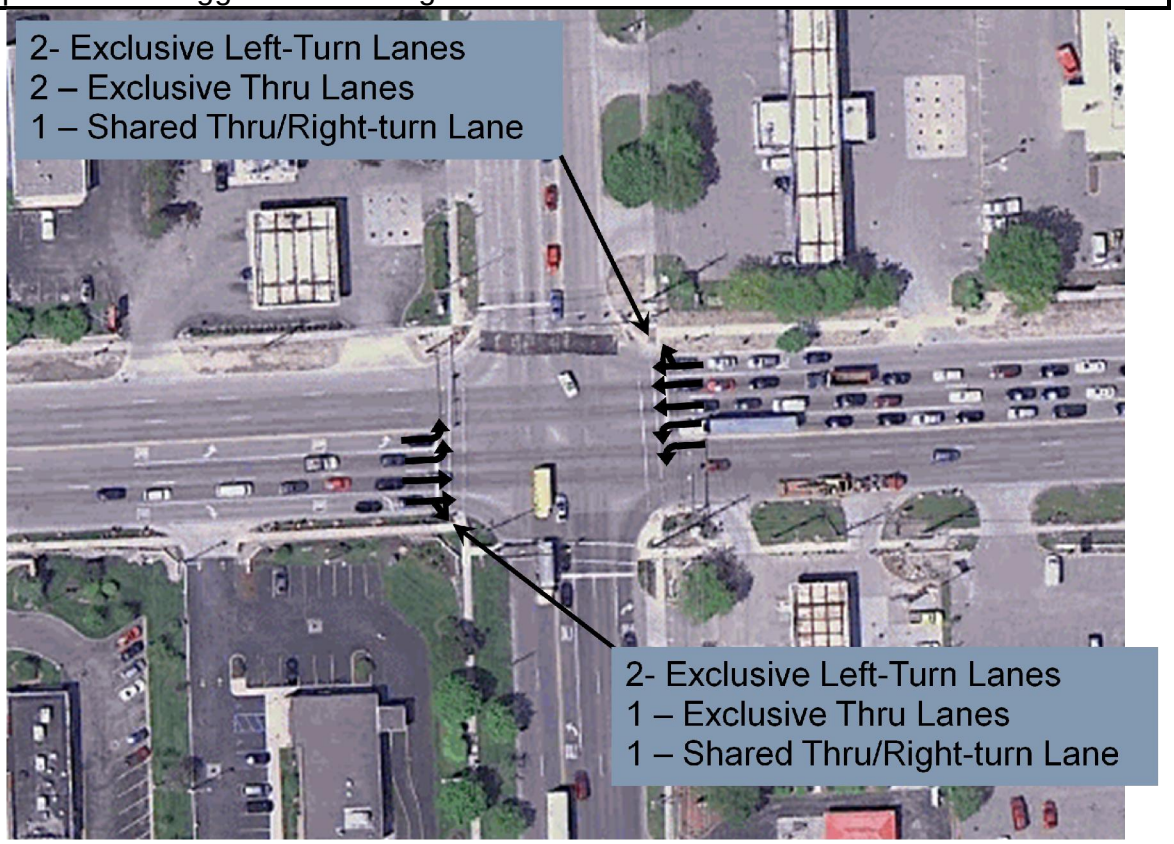


Figure 4.4 – Potential Dual Left-Turn Lane Section on M-153 at Haggerty Road

SUGGESTION: The following option should be considered:

1) **Construct dual left-turn lanes on M-153 at the M-153/Haggerty Road intersection.**
   a. **Improves capacity at the intersections throughout the corridor**
   b. **Reduces the potential for left-turn queues extending beyond the available storage**
   c. **Reduces the potential for aggressive driving behaviors**
   d. **Reduces the potential for angle crashes by providing protected only phasing for left-turn movements.**

   It is important to note that there are several alternatives to implement this option including re-striping the existing laneage to provide three through lanes in the WB direction as shown in Figure 4.4 above, re-striping the existing laneage to only provide two through lanes in the WB direction, and constructing pavement widening to provide additional laneage on M-153.

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$528,000**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. The results of this analysis show an annual benefit-to-annual cost (B/C) of 6.10. See Appendix C for results of this analysis.

4.1.6 Crash Potential #2 (M-153) – Existing Non-Motorized Path Users Crossing M-153 East of the NB I-275 Exit Ramp Intersection

Expected Frequency	Expected Severity	E
Occasional	High	

Observation: Based upon field review, several non-motorized path users were observed crossing M-153 east of the existing NB I-275 Exit Ramp intersection. This location is neither signed nor equipped for a pedestrian crossing. Pedestrians utilizing the existing non-motorized path are currently directed to travel approximately 1,700 feet east to the signalized crossing at Lotz Rd.

Figure 4.5 – Bicyclist Crossing M-153 east of the NB I-275 Exit Ramp Intersection

SUGGESTION: The following options should be considered:

1) **Provide a M-153 crossing at the existing NB I-275 ramp signalized intersection**
2) **Relocate the existing "Signalized Crossing" sign on the north side of M-153 closer to the location where the bike path connects with M-153**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$19,100**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. Due to the lack of existing pedestrian-related crashes in this location, the results of this analysis show an annual benefit-to-annual cost (B/C) of 0.00. See Appendix C for results of this analysis.

4.1.7 Crash Potential #3 (M-153) –Intersection Visibility

Expected Frequency	Expected Severity	D
Infrequent	High	
Observation: Although lighting is provided throughout the M-153 corridor, it mainly lights the pedestrian paths rather than the M-153 roadway. Based upon field reviews, it was difficult to perceive pedestrians in the crosswalks during low-light conditions. Over the five (5) year period for which crash data was reviewed, there were eight (8) pedestrian-related crashes.		

Figure 4.6 – Pedestrian Crossing M-153 at the Haggerty Road Intersection during Night Conditions

SUGGESTION: The following options should be considered:
1) Provide roadway-specific lighting at the signalized intersections

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:
- **$90,000**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. The results of this analysis show an annual benefit-to-annual cost (B/C) of 202.22. See Appendix C for results of this analysis.

4.1.8 Crash Potential #4 (M-153) – Excessive WB Left-Turn Queuing at Haggerty Road

Expected Frequency	Expected Severity	C
Occasional	Low	

Observation: Based upon first-hand observations and the available Synchro model, the existing WB M-153 left-turn queue at the Haggerty Road intersection frequently extends beyond the available 520' storage length during the evening peak hour. When these queues extend beyond the available storage, they impact WB through traffic and propagate further east which encourages aggressive driving behaviors. The available storage is limited by a raised median extending from west of the SB I-275 Exit ramp to east of the NB I-275 Exit ramp.

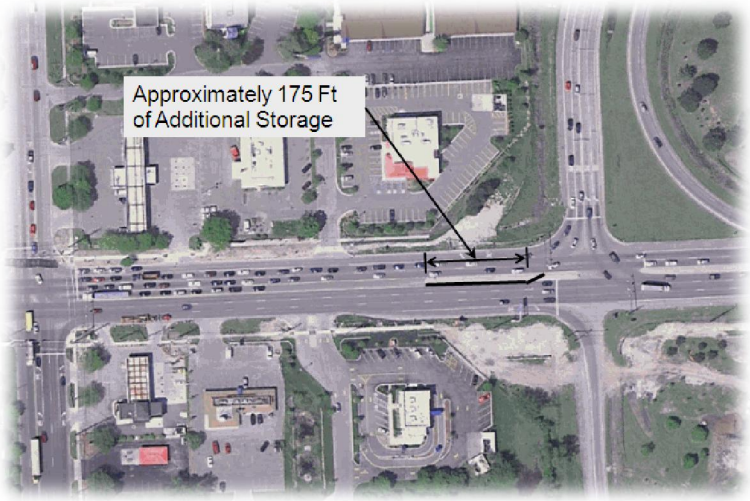


Figure 4.7 – Available Extension of WB M-153 storage at Haggerty Road

SUGGESTION: The following option should be considered:

1) **Reduce the length of the existing raised median on M-153 to provide 175' of additional storage for WB left-turn movements.**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$33,500**

A Benefit-to-Cost analysis could not be conducted per the Highway Safety Manual due to the lack of a Crash Modification Factor (CMF) for extension of an existing left-turn storage bay.

4.1.9 Crash Potential #5 (M-153) – IKEA Driveway Pedestrian Crossing at M-153

Expected Frequency	Expected Severity	
Rare	Medium	**B**

Observation: Based upon field observations, there currently is not a crossing for pedestrians across M-153 at this signalized intersection. Although no pedestrians were observed attempting this maneuver during field reviews, a sign directing pedestrians to the Haggerty Road intersection located approximately 900 feet east of the IKEA driveway, with a fine noted, implies that this has been an issue in the past.

Figure 4.8 – Potential Pedestrian Refuge Island with Signalized Cross-Walk

Figure 4.9 – Existing Signage at the IKEA Driveway Directing Pedestrians to Haggerty Road to Cross M-153

SUGGESTION: The following options should be considered:

1) **Provide a pedestrian crossing with a 50' long pedestrian refuge island on the east side of the existing signalized IKEA driveway intersection. A pedestrian pushbutton should be considered to extend the IKEA driveway timing allowing pedestrians to cross when activated.**

   Based upon review of the project area, this option may require the consolidation of the existing driveways on the south side of M-153 east of the IKEA driveway to accommodate left-turns from the driveways without interference from the proposed pedestrian refuge island.

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$22,800**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. Due to the lack of existing pedestrian-related crashes in this location, the results of this analysis show an annual benefit-to-annual cost (B/C) of 0.00. See Appendix C for results of this analysis.

Local Road Crash Potential

As noted earlier, due to the size of the project area and the differing jurisdictions (MDOT, Canton Township, and Wayne County), the RSA Team provided safety issues for both the primary study area (M-153 from Lilley to Lotz Rd) and the secondary study area. The following safety issues being presented are for the secondary study area, each ranked independently.

4.1.10 Crash Potential #1 (Local Roads) – Haggerty Road Crashes South of M-153

Expected Frequency	Expected Severity	D
Occasional	Medium	

Observation: A high number of rear end (34) and angle (18) crashes occurred on Haggerty Road south of M-153 within the four (4) year crash history that was reviewed. Based upon field review, a two-way center left-turn lane exists on Haggerty Road north of Canterbury Drive but, south of Canterbury Drive, Haggerty Road is a two-lane, two-way roadway. Of the rear end and angle crashes that occurred on this segment of Haggerty Road, twenty four (24) of the reported thirty-four (34) rear end and nine (9) of the reported eighteen (18) angle crashes occurred south of Canterbury Drive where there is not currently a center left-turn lane.

Figure 4.10 – Existing Haggerty Road Cross Section South of Canterbury Drive

SUGGESTION: The following option should be considered:

1) **Extend the existing two-way center left-turn lane south of Canterbury Drive to Cherry Hill Road. Based upon field review, it does not appear that Right-of-Way or other major impacts will be realized with this potential mitigation.**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$713,000**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. The results of this analysis show an annual benefit-to-annual cost (B/C) of 0.65. See Appendix C for results of this analysis.

4.1.11 Crash Potential #2 (Local Roads) – Existing Queuing at the Haggerty Road / Cherry Hill Road Intersection

Expected Frequency	Expected Severity	C
Occasional	Low	

Observation: Based upon first-hand accounts and the Synchro simulation models, the existing westbound Cherry Hill Road queue extends to and beyond the bridge over I-275 east of Haggerty Road which may increase the potential for rear end collisions.

SUGGESTION: The following option should be considered:

1) **Provide a roundabout at the Cherry Hill Road/Haggerty Road intersection. It is anticipated that this mitigation may improve intersection capacity; reduce the severity of crashes within the intersection by reducing vehicle speeds and reducing the angle of collision; and reduce vehicle queuing.**

ESTIMATED COST OF SUGGESTION: The following construction cost may be attributed to the option described above:

- **$1,590,000**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. The results of this analysis show an annual benefit-to-annual cost (B/C) of 3.09. See Appendix C for results of this analysis.

4.1.12 Crash Potential #3 (Local Roads) – WB Cherry Hill Road Queuing at Haggerty Road Intersection

Expected Frequency	Expected Severity	C
Occasional	Low	

Observation: Based upon first-hand accounts and the Synchro simulation models, the existing westbound Cherry Hill Road queue extends to and beyond the bridge over I-275 east of Haggerty Road which may increase the potential for rear end collisions. Based upon field review of the bridge over I-275, there are steep grades approaching the bridge which may reduce stopping sight distance for motorists approach the Haggerty Road intersection from the east.

Figure 4.11 – Existing Sight Distance Approach the Cherry Hill Road Bridge over I-275 (facing west)

SUGGESTION: The following options should be considered:

1) **Provide a vehicle sensor west of the I-275 bridge and a "Prepare to Stop When Flashing" (W3-4b) sign east of the I-275 bridge. When a vehicle is stopped on the sensor, this will activate the flashing beacon on top of the W3-4b alerting approaching motorists of queued vehicles.**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$13,750**

A Benefit-to-Cost analysis was conducted per the Highway Safety Manual methodology utilizing the predictive method for estimating average crash frequency and severity. The results of this analysis show an annual benefit-to-annual cost (B/C) of 91.33. See Appendix C for results of this analysis.

Crash Potential #4 (Local Roads) – Merging for SB Lilley Road Traffic South of M-153

Expected Frequency	Expected Severity	B
Infrequent	Low	

Observation: Field review showed that the southbound Lilley Road through movement consists of two (2) lanes but, quickly converges into a single lane immediately south of the M-153 intersection. Due to the relatively short merging distance provided (approx. 420'), aggressive merging behaviors were observed during field visits.

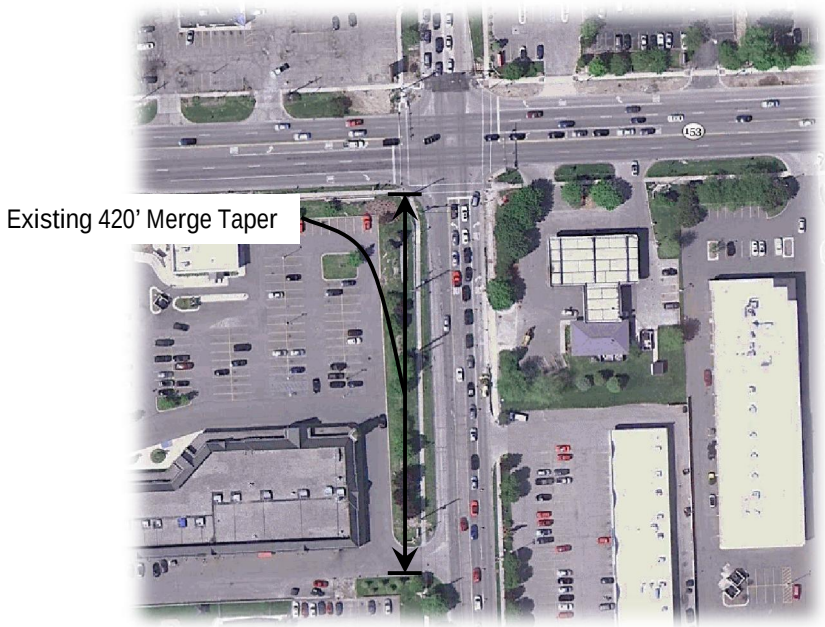


Figure 4.12 – Existing 420' Merge Taper for SB Lilley Road Traffic South of M-153

SUGGESTION: The following option should be considered:

1) **Extend the existing merge taper to extend from M-153 to Addison Avenue. This would result in an overall length of approximately 1050' which satisfies the MDOT recommended length for a lane drop.**

ESTIMATED COST OF SUGGESTION: The following construction costs may be attributed to the options described above:

- **$92,000**

A Benefit-to-Cost analysis could not be conducted per the Highway Safety Manual methodology due to the lack of crash data on the south leg of Lilley Road in this location.

5.0 Additional Safety Enhancement Opportunities

In addition to the potential safety enhancements noted earlier for both M-153 and the surrounding local road system, the RSA Team developed additional low-cost safety enhancements that, while the Team did not observe existing crashes associated with these items, could be reviewed for additional safety enhancement within the project area. These potential enhancements include:

- Hatch the gore/shoulder area at the EB M-153 to NB I-275 ramp.
  - o West of this ramp, M-153 consists of three (3) through lanes however, one (1) over these three lanes drops as an exclusive ramp lane to NB I-275. It was observed that this dropped lane could be perceived by a vehicle on the NB I-275 exit ramp (signalized intersection located immediately east) as one of the EB M-153 through lanes at the NB I-275 exit ramp, possibly causing confusion with turning vehicles regarding which lane opposing vehicles are actually occupying.

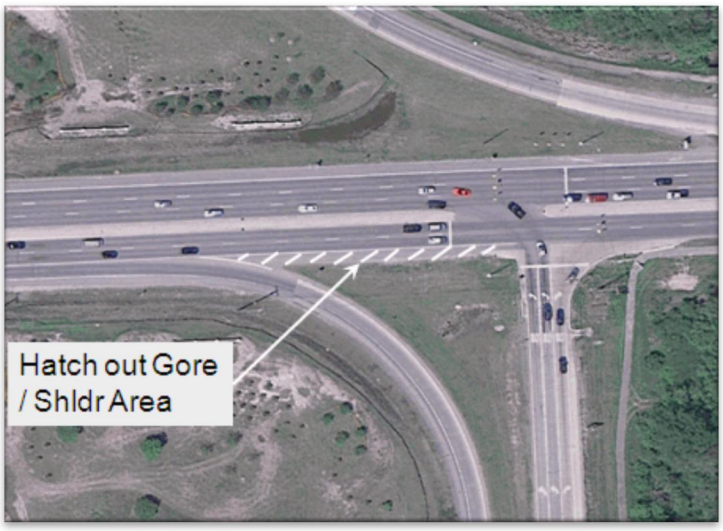


Figure 4.13 – Potential Gore/Shoulder Hatching at the EB M-153 to NB I-275 Entrance Ramp

- Install back plates on all traffic signal heads
  - o According to the FHWA publication "Signalized Intersections: Informational Guide", installation of signal back plates may reduce right-angle crashes by 32%.

- Provide better use of the existing local transportation system
  - o Pave Lotz Road between M-153 and Cherry Hill Road
  - o Connect gaps in the existing sidewalks

- Provide sidewalk/shared-use pathway through the I-275 interchange
    - Based upon field review, several pedestrians and bicyclists were seen travelling through the I-275 interchange on the existing M-153 shoulders. In addition, apparent worn paths were observed throughout the interchange area.

Figure 4.14 – Existing Worn Path through the I-275 Interchange

- Provide countdown pedestrian signals at all pedestrian crossings
    - According to the FHWA publication "Signalized Intersections: Informational Guide", installation of countdown pedestrian signals may result in a higher percentage of pedestrian crossings completed before conflicting vehicle traffic receives the right-of-way.

- Provide pedestrian pushbuttons to cross M-153 at all signals
    - Provision of pushbuttons will allow greater green time to M-153 at times when pedestrians are not crossing M-153. This could reduce the amount of congestion within the M-153 corridor and therefore, reduce the occurrence of aggressive driving behaviors.

- Pursue additional access management throughout the M-153 corridor (i.e. drive consolidation, cross access, etc.).
    - Although the RSA Team noted that it appeared that access management strategies had already been attempted (i.e. drive consolidation), additional access management should be reviewed. Reducing the number of driveways will reduce the number of conflict points and reduce the potential for driveway-related crashes.

6.0 Conclusion

This audit has been prepared to assist the responsible road authorities in the identification and actualization of opportunities to improve safety within the study area. The audit is based on observations made on May 8th through May 10th, 2012 and information available at the time of the safety review. This Road Safety Audit has been performed in accordance with the FHWA guidelines and policies. The suggestions it contains are for consideration only, and are in no way intended to serve as design or operational recommendations.

This report does not preclude the identification of additional issues pertaining to safety by the responsible road authorities, or the emergence of new issues over time.

It is recommended that the responsible agencies review this report; document their responses to the issues identified in a formal response report; and track their progress towards the implementation of safety improvements prompted by this audit.

APPENDIX A

Sign-In Sheets

BY _____ DATE _____ Bergmann associates architects // engineers // planners PROJ. NO. _____ SHT 1 OF _____

CKD _____ DATE 5-8-12 PROJ. NAME M-153/I-275 RSA

KICK OFF MEETING SIGN-IN SHEET

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BY _____ DATE _____ Bergmann associates architects // engineers // planners PROJ. NO. _____ SHT 1 OF _____

CKD _____ DATE 5-16-12 PROJ. NAME M-153/I-275

M-153/I-275 RSA FINAL PRESENTATION

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APPENDIX B
Safety Recommendation Estimates

Crash Potential #1 (M-153) - Suggestion #1 Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Curb and Gutter, Rem	2040020	Ft	17,996	$4.00	$71,984.00
Pavt, Rem	2040050	Syd	29,996	$3.00	$89,988.00
Sidewalk, Rem	2040055	Syd	5,812	$6.00	$34,872.00
Embankment, CIP	2050010	Cyd	11,409	$4.00	$45,636.00
Excavation, Earth	2050016	Cyd	30,499	$6.00	$182,994.00
Subbase, CIP (12" depth)	3010002	Cyd	20,337	$10.00	$203,370.00
Aggregate Base, 6 inch	3020016	Syd	60,992	$2.00	$121,984.00
HMA Pavement (10" depth)	-	Ton	20,554	$100.00	$2,055,360.00
Curb and Gutter, Conc, Det B2	8020016	Ft	35,992	$9.00	$323,928.00
Detectable Warning Surface	8030010	Ft	132	$27.00	$3,564.00
Sidewalk Ramp, Conc, 6 inch	8030036	Sft	924	$4.00	$3,696.00
Sidewalk, Conc, 4 inch	8030044	Sft	52,272	$2.00	$104,544.00
Pavt Mrkg & Signing	-	-	-	-	$75,000.00
Traffic Signal Work	-	-	-	-	$500,000.00
Maintenance of Traffic	-	-	-	-	$374,500.00
				Subtotal =	$4,119,436.00
				10% Contingency =	$411,943.60
				Total =	**$4,531,380.00**

Crash Potential #1 (M-153) – Suggestion #2 Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Curb and Gutter, Rem	2040020	Ft	2,354	$4.00	$9,416.00
Pavt, Rem	2040050	Syd	4,222	$3.00	$12,666.00
Embankment, CIP	2050010	Cyd	1,831	$4.00	$7,324.00
Excavation, Earth	2050016	Cyd	4,143	$6.00	$24,858.00
Subbase, CIP (12" depth)	3010002	Cyd	2,766	$10.00	$27,660.00
Aggregate Base, 6 inch	3020016	Syd	8,279	$2.00	$16,558.00
HMA Pavement (10" depth)	-	Ton	3,229	$100.00	$322,880.00
Curb and Gutter, Conc, Det B2	8020016	Ft	6,094	$9.00	$54,846.00
Detectable Warning Surface	8030010	Ft	36	$27.00	$972.00
Sidewalk Ramp, Conc, 6 inch	8030036	Sft	528	$4.00	$2,112.00
Pavt Mrkg & Signing	-	-	-	-	$25,000.00
Traffic Signal Work	-	-	-	-	$225,000.00
Maintenance of Traffic	-	-	-	-	$72,000.00
				Subtotal =	$791,876.00
				10% Contingency =	$79,187.60
				Total =	**$871,064.00**

Crash Potential #1 (M-153) – Suggestion #3 Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Curb and Gutter, Rem	2040020	Ft	583	$4.00	$2,332.00
Pavt, Rem	2040050	Syd	857	$3.00	$2,571.00
Excavation, Earth	2050016	Cyd	1,064	$6.00	$6,384.00
Subbase, CIP (12" depth)	3010002	Cyd	559	$10.00	$5,590.00
Aggregate Base, 6 inch	3020016	Syd	1,672	$2.00	$3,344.00
HMA Pavement (10" depth)	-	Ton	860	$100.00	$86,000.00
Curb and Gutter, Conc, Det B2	8020016	Ft	803	$9.00	$7,227.00
Pavt Mrkg & Signing	-	-	-	-	$5,000.00
Traffic Signal Work	-	-	-	-	$50,000.00
Maintenance of Traffic	-	-	-	-	$16,700.00
				Subtotal =	$182,816.00
				10% Contingency =	$18,281.60
				Total =	**$201,098.00**

Crash Potential #1 (M-153) – Suggestion #4 Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Pavt, Rem	2040050	Syd	1,004	$3.00	$3,012.00
Excavation, Earth	2050016	Cyd	4,807	$6.00	$28,842.00
Subbase, CIP (12" depth)	3010002	Cyd	2,158	$10.00	$21,580.00
Aggregate Base, 6 inch	3020016	Syd	6,467	$2.00	$12,934.00
HMA Pavement (10" depth)	-	Ton	2,852	$100.00	$285,160.00
Curb and Gutter, Conc, Det B2	8020016	Ft	3,300	$9.00	$29,700.00
Pavt Mrkg & Signing	-	-	-	-	$5,000.00
Traffic Signal Work	-	-	-	-	$50,000.00
Maintenance of Traffic	-	-	-	-	$43,700.00
				Subtotal =	$479,928.00
				10% Contingency =	$47,992.80
				Total =	**$527,921.00**

Crash Potential #2 (M-153) Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Curb and Gutter, Rem	2040020	Ft	20	$4.00	$80.00
Excavation, Earth	2050016	Cyd	24	$6.00	$144.00
Subbase, CIP (12" depth)	3010002	Cyd	13	$10.00	$130.00
Curb and Gutter, Conc, Det B2	8020016	Ft	20	$9.00	$180.00
Detectable Warning Surface	8030010	Ft	40	$27.00	$1,080.00
Sidewalk Ramp, Conc, 6 inch	8030036	Sft	357	$4.00	$1,428.00
Sidewalk, Conc, 4 inch	8030044	Sft	891	$2.00	$1,782.00
Pavt Mrkg & Signing	-	-	-	-	$1,000.00
Traffic Signal Work	-	-	-	-	$10,000.00
Maintenance of Traffic	-	-	-	-	$1,600.00
				Subtotal =	$17,344.00
				10% Contingency =	$1,734.40
				Total =	**$19,079.00**

Crash Potential #3 (M-153) Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Light Std Fdn	8190279	Ea	20	$600.00	$12,000.00
Light Std Shaft, 31 foot to 40 foot, Single Arm	8190291	Ea	20	$1,200.00	$24,000.00
LED Luminaire	-	Ea	20	$2,500.00	$50,000.00
Maintenance of Traffic	-	-	-	-	$7,400.00
				Subtotal =	$81,400.00
				10% Contingency =	$8,140.00
				Total =	**$89,540.00**

Crash Potential #4 (M-153) Recommendation Cost Estimate

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Pavt, Rem	2040050	Syd	258	$3.00	$774.00
Excavation, Earth	2050016	Cyd	201	$6.00	$1,206.00
Subbase, CIP (12" depth)	3010002	Cyd	86	$10.00	$860.00
Aggregate Base, 6 inch	3020016	Syd	258	$2.00	$516.00
HMA Pavement (10" depth)	-	Ton	142	$100.00	$14,170.00
Curb and Gutter, Conc, Det B2	8020016	Ft	14	$9.00	$126.00
Pavt Mrkg & Signing	-	-	-	-	$10,000.00
Maintenance of Traffic	-	-	-	-	$2,800.00
				Subtotal =	$30,452.00
				10% Contingency =	$3,045.20
				Total =	**$33,498.00**

Crash Potential #5 (M-153) Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Curb and Gutter, Rem	2040020	Ft	14	$4.00	$56.00
Pavt, Rem	2040050	Syd	293	$3.00	$879.00
Excavation, Earth	2050016	Cyd	50	$6.00	$300.00
Subbase, CIP (12" depth)	3010002	Cyd	26	$10.00	$260.00
Aggregate Base, 6 inch	3020016	Syd	74	$2.00	$148.00
HMA Pavement (6" depth)	-	Ton	25	$100.00	$2,511.00
Curb and Gutter, Conc, Det B2	8020016	Ft	137	$9.00	$1,233.00
Detectable Warning Surface	8030010	Ft	27	$27.00	$729.00
Sidewalk Ramp, Conc, 6 inch	8030036	Sft	159	$4.00	$636.00
Sidewalk, Conc, 4 inch	8030044	Sft	66	$2.00	$132.00
Pavt Mrkg & Signing	-	-	-	-	$2,000.00
Traffic Signal Work	-	-	-	-	$10,000.00
Maintenance of Traffic	-	-	-	-	$1,900.00
				Subtotal =	$20,728.00
				10% Contingency =	$2,072.80
				Total =	**$22,801.00**

Crash Potential #1 (Local Roads) Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Pavt, Rem	2040050	Syd	5,245	$3.00	$15,735.00
Excavation, Earth	2050016	Cyd	4,845	$6.00	$29,070.00
Subbase, CIP (12" depth)	3010002	Cyd	2,704	$10.00	$27,040.00
Aggregate Base, 6 inch	3020016	Syd	8,105	$2.00	$16,210.00
HMA Pavement (10" depth)	-	Ton	4,458	$100.00	$445,840.00
Pavt Mrkg & Signing	-	-	-	-	$10,000.00
Structure Widening	-	Sft	300	$150.00	$45,000.00
Maintenance of Traffic	-	-	-	-	$58,900.00
				Subtotal =	$647,795.00
				10% Contingency =	$64,779.50
				Total =	**$712,575.00**

Crash Potential #2 (Local Roads) Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
2 Lane Roundabout w/ sidewalk Construction	-	-	-	-	$1,250,000.00
Permanent Right-of-Way	-	-	-	-	$50,000.00
Pavt Mrkg & Signing	-	-	-	-	$15,000.00
Maintenance of Traffic	-	-	-	-	$131,500.00
				Subtotal =	$1,446,500.00
				10% Contingency =	$144,650.00
				Total =	**$1,591,150.00**

Crash Potential #3 (Local Roads) Recommendation Cost Estimates

M-153/I-275 Interchange and Surrounding Area Road Safety Audit
Wayne County

Summary

Item	Pay Item Code	Unit	Quantity	Unit Cost	Total Cost
Sign, Type IIIB	8100405	Sft	10	$15.00	$150.00
Flashing Beacon	8200373	Ea	1	$500.00	$500.00
Flsh Beacon, Controller & Cabinet, Solid State	8200070	Ea	1	$800.00	$800.00
Wireless Vehicle Detection System	8200422	Ea	1	$10,000.00	$10,000.00
Maintenance of Traffic	-	-	-	-	$1,200.00
				Subtotal =	$12,500.00
				10% Contingency =	$1,250.00
				Total =	**$13,750.00**

Crash Potential #4 (Local Roads) Recommendation Cost Estimates

Bergmann Associates, Inc.
M-153 / I-275 Interchange and Surrounding Area - Road Safety Audit
Crash Potential #4 (Local Roads) Mitigation Costs
JN 115117

Item	Pay Code	Unit	Total Quantity	Unit Cost	Total
Removal Items					
Curb, Rem	2040021	Ft	630	$5.50	$ 3,465.00
Excavation, Earth	2050016	Cyd	1015	$5.00	$ 5,075.00
Sidewalk, Rem	2040055	Syd	139	$6.00	$ 833.33
Fence, Rem	2040025	Ft	110	$1.00	$ 110.00
Pavt, Rem	2040050	Syd	222	$4.00	$ 888.89
				Total for Removal Pay Items =	**$ 10,372.22**
Construction Items					
Curb and Gutter, Conc, Det F6	8020040	Ft	630	$14.00	$ 8,820.00
HMA, 5E10, High Stress	5010516	Ton	92	$83.00	$ 7,669.20
HMA, 4E10, High Stress	5010510	Ton	116	$74.00	$ 8,547.00
HMA, 3E10	5010046	Ton	162	$59.00	$ 9,540.30
Subbase, CIP	3010002	Cyd	420	$9.00	$ 3,780.00
Aggregate Base, 6 inch	3020016	Syd	840	$5.00	$ 4,200.00
Dr Structure Cover, Adj, Case 1	4030005	Ea	3	$354.00	$ 1,062.00
Dr Structure Cover, Type B	4030010	Ea	3	$427.00	$ 1,281.00
Dr Structure Cover, Type K	4030050	Ea	3	$568.00	$ 1,704.00
Sewer, Cl A, 12 inch, Tr Det B	4020033	Ft	42	$33.00	$ 1,386.00
Dr Structure, 24 inch dia	4030200	Ea	3	$845.00	$ 2,535.00
Dr Structure, Tap, 12 inch	4030312	Ea	3	$257.00	$ 771.00
Pavt Mrkg, Waterborne, 4 inch, White	8110231	Ft	263	$0.06	$ 15.75
Pavt Mrkg, Waterborne, 2nd Application, 4 inch, White	8110251	Ft	263	$0.09	$ 23.63
Sidewalk, Conc, 6 inch	8030046	Sft	1250	$3.50	$ 4,375.00
HMA Approach	5010061	Ton	86	$84.00	$ 7,186.67
Pavt Mrkg, Polyurea, Rt Turn Only	8110413	Ea	1	$145.00	$ 145.00
Pavt Mrkg, Polyurea, Only	8110410	Ea	2	$240.00	$ 480.00
Fence, Chain Link, 60 inch	8080012	Ft	110	$25.00	$ 2,750.00
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
				Total for Construction Pay Items =	**$ 66,271.54**
				Maintenance of Traffic (10%) =	**$ 7,664.38**
				Contingency (10%) =	**$ 7,664.38**
				Total =	**$ 91,972.52**

APPENDIX C
Highway Safety Manual Calculations

Crash Potential #1 (M-153) - Suggestion #1 Recommendation

Highway Safety Manual Calculations

4.1.2 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #1

Benefit-to-Cost Calculation

M-153 - Sheldon Rd to Lotz Rd Boulevard			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	314.8	97.1	217.7

CMF - Provide a Median	
Serious and Minor Injury	0.61
Property Damage Only	1.09

Change in Crashes		Cost Per Crash	Net Annual Benefit
Fatal & Injury	-37.87	$ 107,924.00	$ 4,086,973.96
Property Damage Only	+19.59	$ 3,690.00	$ (72,298.17)
		Total =	**$ 4,014,675.79**

Annual Cost of Improvement	
Construction Cost	$ 4,531,000.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 363,579.16**

Benefit Cost Ratio	
Net Annual Benefit	$ 4,014,675.79
Annual Cost of Improvement	$ 363,579.16
B/C Ratio =	**11.04**

4.1.2 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #1

HSM Summary

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials - M-153 from Sheldon Rd to Lotz Rd							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes, $N_{observed}$** (crashes/year)	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency, $N_{expected}$**
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Sheldon to Morton Taylor	5.287	1.390	3.897	12.2	0.810	0.189	10.891
Morton Taylor to Lilley Rd	4.551	1.197	3.354	8	0.810	0.213	7.264
Lilley to Haggerty	4.870	1.281	3.589	35.4	0.810	0.202	29.225
N I-275 Ramp to Lotz	2.778	0.730	2.048	3.8	0.810	0.308	3.486
Single-vehicle							
Sheldon to Morton Taylor	0.870	0.178	0.692	1	0.520	0.689	0.910
Morton Taylor to Lilley Rd	0.748	0.153	0.595	1	0.520	0.720	0.819
Lilley to Haggerty	0.801	0.164	0.637	0	0.520	0.706	0.565
N I-275 Ramp to Lotz	0.451	0.092	0.359	0	0.520	0.810	0.365
						1.000	0.000
Multiple-vehicle driveway-related							
Sheldon to Morton Taylor	7.588	2.041	5.547	2	0.100	0.569	5.177
Morton Taylor to Lilley Rd	3.217	0.865	2.352	1.2	0.100	0.757	2.726
Lilley to Haggerty	6.097	1.640	4.457	5	0.100	0.621	5.682
N I-275 Ramp to Lotz	0.633	0.170	0.463	1	0.100	0.940	0.655
						1.000	0.000
INTERSECTIONS							
Multiple-vehicle							
Sheldon Rd	9.224	3.206	6.019	31	0.390	0.218	26.107
Morton Taylor Rd	9.313	3.257	6.056	19	0.390	0.216	16.752
Lilley Rd	9.379	3.249	6.129	68	0.390	0.215	55.414
Haggerty Rd	11.782	4.122	7.660	108	0.390	0.179	90.967
E M-153 / S I-275	15.315	4.457	10.857	33	0.330	0.165	30.246
N I-275 / M-153	12.017	3.687	8.330	24	0.330	0.201	21.427
						1.000	0.000
Single-vehicle							
Sheldon Rd	0.491	0.113	0.378	0	0.360	0.850	0.418
Morton Taylor Rd	0.487	0.111	0.376	0	0.360	0.851	0.414
Lilley Rd	0.504	0.117	0.387	1	0.360	0.846	0.580
Haggerty Rd	0.609	0.138	0.471	0	0.360	0.820	0.499
E M-153 / S I-275	0.809	0.241	0.568	1	0.360	0.774	0.852
N I-275 / M-153	0.639	0.182	0.458	0	0.360	0.813	0.520
COMBINED (sum of column)	108.461	32.782	75.679	355.400	--	--	311.962

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials - M-153 from Sheldon Rd to Lotz Rd					
(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**$N_{predicted}$**	**N_{ped}**	**N_{bike}**	$N_{expected\ (VEHICLE)}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
	108.5	0.91	1.95	312.0	314.8
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
	32.8	0.91	1.95	94.3	97.1
Property damage only (PDO	$(4)_{COMB}$ from Worksheet 3A	--	--	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)
	75.7	0.0	0.0	217.7	217.7

Crash Potential #1 (M-153) – Suggestion #2 Recommendation

Highway Safety Manual Calculations

4.1.3 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #2

Benefit-to-Cost Calculation

Haggerty Rd - Canterbury Circle to Hanford Rd Boulevard			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	103.2	32.7	70.5

CMF - Provide a Median	
Serious and Minor Injury	0.61
Property Damage Only	1.09

Change in Crashes		Cost Per Crash	Net Annual Benefit
Fatal & Injury	-12.75	$ 107,924.00	$ 1,376,354.77
Property Damage Only	+6.35	$ 3,690.00	$ (23,413.05)
		Total =	**$ 1,352,941.72**

Annual Cost of Improvement	
Construction Cost	$ 871,000.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 69,891.29**

Benefit Cost Ratio	
Net Annual Benefit	$ 1,352,941.72
Annual Cost of Improvement	$ 69,891.29
B/C Ratio =	**19.36**

4.1.3 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #2

HSM Summary

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials - Canterbury Circle to Hanford Rd							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes,** $N_{observed}$ (crashes/year)	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency,** $N_{expected}$
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Canterbury Circle to M-153	2.609	0.704	1.905	6.5	0.810	0.321	5.250
M-153 to Hanford Rd	1.668	0.452	1.215	2.8	0.810	0.425	2.318
Single-vehicle							
Canterbury Circle to M-153	0.669	0.158	0.511	1	0.520	0.742	0.755
M-153 to Hanford Rd	0.464	0.112	0.352	1	0.520	0.806	0.568
Multiple-vehicle driveway-related							
Canterbury Circle to M-153	1.651	0.444	1.207	0	0.100	0.858	1.417
M-153 to Hanford Rd	0.906	0.244	0.663	0	0.100	0.917	0.831
INTERSECTIONS							
Multiple-vehicle							
Haggerty Rd	11.782	4.122	7.660	108	0.390	0.179	90.967
Single-vehicle							
Haggerty Rd	0.609	0.138	0.471	0	0.360	0.820	0.499
COMBINED (sum of column)	20.358	6.374	13.984	119.500	--	--	102.605

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials- Canterbury Circle to Hanford Rd					
(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**$N_{predicted}$**	**N_{ped}**	**N_{bike}**	$N_{expected\ (VEHICLE)}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
	20.4	0.20	0.41	102.6	103.2
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
	6.4	0.20	0.41	32.1	32.7
Property damage only (PDO	$(4)_{COMB}$ from Worksheet 3A	--	--	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)
	14.0	0.0	0.0	70.5	70.5

Crash Potential #1 (M-153) – Suggestion #3 Recommendation

Highway Safety Manual Calculations

4.1.4 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #3

Benefit-to-Cost Calculation

No Crash Modification Factor available for calculation

Crash Potential #1 (M-153) – Suggestion #4 Recommendation

Highway Safety Manual Calculations

4.1.5 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #4

Benefit-to-Cost Calculation

M-153 / Haggerty Rd - Construct Dual Left Turns			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	91.8	31.8	60.0

CMF - Install Left Turn Lane (Double)	
Serious and Minor Injury	Varies
Property Damage Only	Varies

Change in Crashes		Cost Per Crash	Net Annual Benefit
Fatal & Injury	-2.05	$ 107,924.00	$ 221,244.20
Property Damage Only	-10.10	$ 3,690.00	$ 37,269.00
		Total =	**$ 258,513.20**

Annual Cost of Improvement	
Construction Cost	$ 528,000.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 42,368.09**

Benefit Cost Ratio	
Net Annual Benefit	$ 258,513.20
Annual Cost of Improvement	$ 42,368.09
B/C Ratio =	**6.10**

4.1.5 Crash Potential #1(M-153) – M-153 / Haggerty Road Intersection Crashes – Suggestion #4

HSM Summary

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials - M-153 / Haggerty Rd Intersection							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes, $N_{observed}$** (crashes/year)	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency, $N_{expected}$**
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Single-vehicle							
Multiple-vehicle driveway-related							
INTERSECTIONS							
Multiple-vehicle							
Haggerty Rd	11.782	4.122	7.660	108	0.390	0.179	90.967
Single-vehicle							
Haggerty Rd	0.609	0.138	0.471	0	0.360	0.820	0.499
COMBINED (sum of column)	12.390	4.260	8.131	108.200	--	--	91.466

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials- M-153 / Haggerty Rd Intersection					
(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**$N_{predicted}$**	**N_{ped}**	**N_{bike}**	$N_{expected\ (VEHICLE)}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
	12.4	0.01	0.32	91.5	91.8
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
	4.3	0.01	0.32	31.4	31.8
Property damage only (PDO	$(4)_{COMB}$ from Worksheet 3A	--	--	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)
	8.1	0.0	0.0	60.0	60.0

Crash Potential #2 (M-153) Recommendation

Highway Safety Manual Calculations

4.1.6 Crash Potential #2 (M-153) – Existing Non-Motorized Path Users Crossing M-153 East of the NB I-275 Exit Ramp Intersection

Benefit-to-Cost Calculation

NB I-275 / M-15 - Install Crosswalk			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	(No Existing Pedestrian Crashes)	(No Existing Pedestrian Crashes)	(No Existing Pedestrian Crashes)

CMF - Install pedestrian crossing	
Pedestrian Crashes	0.75

Change in Crashes		Cost Per Crash	Net Annual Benefit
Pedestrian Crashes	#VALUE!		-
		Total =	**$ -**

Annual Cost of Improvement	
Construction Cost	$ 19,100.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 1,532.63**

Benefit Cost Ratio	
Net Annual Benefit	$ -
Annual Cost of Improvement	$ 1,532.63
B/C Ratio =	**0.00**

Crash Potential #3 (M-153) Recommendation

Highway Safety Manual Calculations

4.1.7 Crash Potential #3 (M-153) –Intersection Visibility

Benefit-to-Cost Calculation

M-153 - Install Intersection Lighting			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	244.3	79.6	164.6

CMF - Install Lighting	
Serious and Minor Injury	0.83
Property Damage Only	0

Change in Crashes		Cost Per Crash	Net Annual Benefit
Fatal & Injury	-13.53	$ 107,924.00	$ 1,460,427.57
Property Damage Only	--	$ 3,690.00	--
		Total =	**$ 1,460,427.57**

Annual Cost of Improvement	
Construction Cost	$ 90,000.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 7,221.83**

Benefit Cost Ratio	
Net Annual Benefit	$ 1,460,427.57
Annual Cost of Improvement	$ 7,221.83
B/C Ratio =	**202.22**

4.1.7 Crash Potential #3 (M-153) –Intersection Visibility

HSM Summary

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials - Signalized Intersections on M-153 from Sheldon Rd to Lotz Rd							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes, $N_{observed}$** (crashes/year)	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency, $N_{expected}$**
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Single-vehicle							
Multiple-vehicle driveway-related							
INTERSECTIONS							
Multiple-vehicle							
Sheldon Rd	9.224	3.206	6.019	31	0.390	0.218	26.107
Morton Taylor Rd	7.168	2.361	4.808	19	0.330	0.297	15.344
Lilley Rd	9.379	3.249	6.129	68	0.390	0.215	55.414
Haggerty Rd	11.782	4.122	7.660	108	0.390	0.179	90.967
E M-153 / S I-275	15.315	4.457	10.857	33	0.330	0.165	30.246
N I-275 / M-153	12.017	3.687	8.330	24	0.330	0.201	21.427
						1.000	0.000
Single-vehicle							
Sheldon Rd	0.491	0.113	0.378	0	0.360	0.850	0.418
Morton Taylor Rd	0.396	0.106	0.290	0	0.360	0.875	0.347
Lilley Rd	0.504	0.117	0.387	1	0.360	0.846	0.580
Haggerty Rd	0.609	0.138	0.471	0	0.360	0.820	0.499
E M-153 / S I-275	0.809	0.241	0.568	1	0.360	0.774	0.852
N I-275 / M-153	0.639	0.182	0.458	0	0.360	0.813	0.520
COMBINED (sum of column)	68.333	21.979	46.354	284.800	--	--	242.720

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials Signalized Intersections on M-153 from Sheldon to Lotz Rd					
(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**$N_{predicted}$**	**N_{ped}**	**N_{bike}**	$N_{expected\ (VEHICLE)}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
	68.3	0.05	1.49	242.7	244.3
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
	22.0	0.05	1.49	78.1	79.6
Property damage only (PDO	$(4)_{COMB}$ from Worksheet 3A	--	--	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)
	46.4	0.0	0.0	164.6	164.6

Crash Potential #4 (M-153) Recommendation

Highway Safety Manual Calculations

4.1.8 Crash Potential #4 (M-153) – Excessive WB Left-Turn Queuing at Haggerty Road

Benefit-to-Cost Calculation

No Crash Modification Factor available for calculation

Crash Potential #5 (M-153) Recommendation

Highway Safety Manual Calculations

4.1.9 Crash Potential #5 (M-153) – IKEA Driveway Pedestrian Crossing at M-153

Benefit-to-Cost Calculation

IKEA Signalized Drive - Install Crosswalk			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	(No existing pedestrian crashes)	(No existing pedestrian crashes)	(No existing pedestrian crashes)

CMF - Install pedestrian crossing	
Pedestrian Crashes	0.75

Change in Crashes		Cost Per Crash	Net Annual Benefit
Pedestrian Crashes		$ 107,924.00	-
		Total =	**$ -**

Annual Cost of Improvement	
Construction Cost	$ 22,800.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 1,829.53**

Benefit Cost Ratio	
Net Annual Benefit	$ -
Annual Cost of Improvement	$ 1,829.53
B/C Ratio =	**0.00**

Crash Potential #1 (Local Roads) Recommendation

Highway Safety Manual Calculations

4.2.1 Crash Potential #1 (Local Roads) – Haggerty Road Crashes South of M-153

Benefit-to-Cost Calculation

Haggerty Rd - Add Two Way Left Turn Lane from Canterbury Circle to Cherry Hill			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	5.3	1.5	3.8

CMF - Add Two-Way Left-Turn Lane	
Serious and Minor Injury	0.80
Property Damage Only	0.65

Change in Crashes		Cost Per Crash	Net Annual Benefit
Fatal & Injury	-.30	$ 107,924.00	$ 32,377.20
Property Damage Only	-1.33	$ 3,690.00	$ 4,907.70
		Total =	**$ 37,284.90**

Annual Cost of Improvement	
Construction Cost	$ 713,000.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 57,212.96**

Benefit Cost Ratio	
Net Annual Benefit	$ 37,284.90
Annual Cost of Improvement	$ 57,212.96
B/C Ratio =	**0.65**

4.2.1 Crash Potential #1 (Local Roads) – Haggerty Road Crashes South of M-153

HSM Summary

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials - Cherry Hill Rd to Canterbury Circle							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes, $N_{observed}$** (crashes/year)	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency, $N_{expected}$**
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Cherry Hill to Canterbury Circle	1.827	0.529	1.298	5.6	0.840	0.394	4.112
Single-vehicle							
Cherry Hill to Canterbury Circle	0.477	0.086	0.390	1	0.810	0.722	0.622
Multiple-vehicle driveway-related							
Cherry Hill to Canterbury Circle	1.018	0.329	0.689	0	0.810	0.548	0.558
INTERSECTIONS							
Multiple-vehicle							
Single-vehicle							
COMBINED (sum of column)	3.322	0.944	2.378	6.600	--	--	5.292

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials- Cherry Hill Rd to Canterbury Circle					
(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**$N_{predicted}$**	**N_{ped}**	**N_{bike}**	**$N_{expected\ (VEHICLE)}$**	**$N_{expected}$**
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
	3.3	0.02	0.01	5.3	5.3
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
	0.9	0.02	0.01	1.5	1.5
Property damage only (PDO	$(4)_{COMB}$ from Worksheet 3A	--	--	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)
	2.4	0.0	0.0	3.8	3.8

Crash Potential #2 (Local Roads) Recommendation

Highway Safety Manual Calculations

4.2.2 Crash Potential #2 (Local Roads) – Existing Queuing at the Haggerty Road / Cherry Hill Intersection

Benefit-to-Cost Calculation

Haggerty Rd / Cherry Hill Roundabout			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	18.0	5.8	12.2

CMF - Convert Intersection to Roundabout	
Serious and Minor Injury	0.40
Property Damage Only	0.58

Change in Crashes		Cost Per Crash	Net Annual Benefit
Fatal & Injury	-3.48	$ 107,924.00	$ 375,575.52
Property Damage Only	-5.12	$ 3,690.00	$ 18,907.56
		Total =	**$ 394,483.08**

Annual Cost of Improvement	
Construction Cost	$ 1,590,000.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 127,585.71**

Benefit Cost Ratio	
Net Annual Benefit	$ 394,483.08
Annual Cost of Improvement	$ 127,585.71
B/C Ratio =	**3.09**

4.2.2 Crash Potential #2 (Local Roads) – Existing Queuing at the Haggerty Road / Cherry Hill Intersection

HSM Summary

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials - Haggerty / Cherry Hill Intersection							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes,** $N_{observed}$ (crashes/year)	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency,** $N_{expected}$
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Single-vehicle							
Multiple-vehicle driveway-related							
INTERSECTIONS							
Multiple-vehicle							
Cherry Hill	3.443	1.106	2.336	28	0.390	0.427	17.661
Single-vehicle							
Cherry Hill	0.243	0.068	0.175	0	0.360	0.920	0.223
COMBINED (sum of column)	3.686	1.174	2.512	28.250	--	--	17.884

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials Haggerty Rd / Cherry Hill Rd Intersection					
(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**$N_{predicted}$**	**N_{ped}**	**N_{bike}**	$N_{expected\ (VEHICLE)}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
	3.7	0.01	0.06	17.9	17.9
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
	1.2	0.01	0.06	5.7	5.8
Property damage only (PDO	$(4)_{COMB}$ from Worksheet 3A	--	--	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)
	2.5	0.0	0.0	12.2	12.2

Crash Potential #3 (Local Roads) Recommendation

Highway Safety Manual Calculations

4.2.3 Crash Potential #3 (Local Roads) – WB Cherry Hill Queuing at Haggerty Road Intersection

Benefit-to-Cost Calculation

Haggerty Rd / Cherry Hill Roundabout			
	Total	**Fatal & Injury**	**PDO**
Expected Crash Frequency (crashes/year)	18.0	5.8	12.2

CMF - Install flashing beacon as advance warning	
All Crash Types	0.73

Change in Crashes		**Cost Per Crash**	**Net Annual Benefit**
Total Crashes	-4.86	$ 20,734.00	$ 100,767.24
		Total =	**$ 100,767.24**

Annual Cost of Improvement	
Construction Cost	$ 13,750.00
Discount Rate	5.00%
Service Life (year)	20
Annual Cost =	**$ 1,103.34**

Benefit Cost Ratio	
Net Annual Benefit	$ 100,767.24
Annual Cost of Improvement	$ 1,103.34
B/C Ratio =	**91.33**

4.2.3 Crash Potential #3 (Local Roads) – WB Cherry Hill Queuing at Haggerty Road Intersection

HSM Summary

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials - Haggerty / Cherry Hill Intersection							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes,** $N_{observed}$ (crashes/year)	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency,** $N_{expected}$
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
ROADWAY SEGMENTS							
Multiple-vehicle nondriveway							
Single-vehicle							
Multiple-vehicle driveway-related							
INTERSECTIONS							
Multiple-vehicle							
Cherry Hill	3.443	1.106	2.336	28	0.390	0.427	17.661
Single-vehicle							
Cherry Hill	0.243	0.068	0.175	0	0.360	0.920	0.223
COMBINED (sum of column)	3.686	1.174	2.512	28.250	--	--	17.884

Worksheet 3C -- Site-Specific EB Method Summary Results for Urban and Suburban Arterials Haggerty Rd / Cherry Hill Rd Intersection					
(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**$N_{predicted}$**	**N_{ped}**	**N_{bike}**	$N_{expected\ (VEHICLE)}$	$N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(8)_{COMB}$ Worksheet 3A	(3)+(4)+(5)
	3.7	0.01	0.06	17.9	17.9
Fatal and injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(2)_{COMB}$ from Worksheet 3B	$(3)_{COMB}$ from Worksheet 3B	$(5)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$	(3)+(4)+(5)
	1.2	0.01	0.06	5.7	5.8
Property damage only (PDO	$(4)_{COMB}$ from Worksheet 3A	--	--	$(5)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$	(3)+(4)+(5)
	2.5	0.0	0.0	12.2	12.2

Crash Potential #4 (Local Roads) Recommendation

Highway Safety Manual Calculations

4.2.4 Crash Potential #4 (Local Roads) – Merging for SB Lilley Traffic South of M-153

Benefit-to-Cost Calculation

No Crash History for Lilley Road in this Report

APPENDIX D
Study Team Handouts
(See Attached Electronic Files)