Evaluating Outcomes of Raising Speed Limits on High Speed Non-Freeways

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16. Abstract
The purpose of this research was to assist in determining the potential impacts of implementing a proposed 65 mph speed limit on non-freeways in Michigan. Consideration was given to a broad range of performance measures, including operating speeds, traffic crashes and crash severity, infrastructure costs, fuel consumption, and travel times. Specifically, a prioritization strategy was developed to identify candidate MDOT non-freeway road segments possessing lower safety risks and potential infrastructure costs associated with raising the speed limit from 55 to 65 mph. Ultimately, approximately 747 miles of undivided and 26 miles of divided 55 mph non-freeways were identified as lower risk candidates, representing approximately one-eighth of the MDOT systemwide mileage posted at 55 mph. An economic analysis of the anticipated costs and benefits associated with the proposed speed limit increase was performed for these lower risk candidate segments, in addition to a systemwide estimate. As the travel time savings were expected to outweigh the fuel consumption costs, it was necessary to determine if these net operational benefits outweighed the expected infrastructure upgrade costs and increased crash costs. For roadways possessing horizontal and/or vertical alignments that are not compliant with a 65 mph speed limit, an unfavorable benefit/cost ratio would likely result due to the excessive infrastructure costs incurred during 3R (resurfacing, restoration, rehabilitation) or 4R (reconstruction) projects. Crashes were expected to increase for all implementation scenarios, with a particular increase in the risk of fatal and incapacitating injuries. Due to the substantially large infrastructure costs, application of the 65 mph speed limit is specifically not recommended for non-freeway segments requiring horizontal or vertical realignment to achieve design speed compliance. Even for segments where compliance with the increased design speed is maintained, careful consideration must be given to the potential safety impacts – particularly to fatal and injury crashes – that may result after increasing the speed limit.

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EXECUTIVE SUMMARY

Recently, speed limits on high speed roadways have trended upward nationwide, particularly for rural freeways and in western states. Between April 2011 and January 2014, at least 14 states have either increased maximum speed limits or are currently proposing to do so, with a majority of these increases involving rural freeways. With the trend of increasing speed limits continuing to expand throughout the United States, in early 2014, the Michigan state legislature introduced a series of bills that proposed several changes to statewide speed limit policies that would affect high-speed roadways throughout the state. In particular, a "Trunk Line General Speed Limit" of 65 mph has been proposed for non-limited access highways maintained by MDOT.

The purpose of this research was to assist the Michigan Department of Transportation (MDOT) and the State of Michigan in determining the potential impacts of implementing the proposed "Trunk Line General Speed Limit" of 65 mph. Consideration was given to a broad range of traffic safety, operational and economic performance measures, including operating speeds, traffic crashes and crash severity, infrastructure costs, fuel consumption, and travel times. Two primary objectives were established for this research, which included:

- Development of a prioritization strategy and quantitative risk assessment of candidate MDOT non-freeway road segments.
- Perform an economic analysis of the anticipated costs and benefits associated with speed limit increases on potential candidate MDOT non-freeway road segments, in addition to a systemwide estimate.

The important research findings related to these objectives are summarized in the following subsections.

PRIORITIZATION OF CANDIDATE NON-FREEWAY SEGMENTS

This research also identified a series of factors and associated criteria for selection of candidate MDOT non-freeway locations that possess comparatively lower safety risks and infrastructure costs associated with increasing the speed limit from 55 mph to 65 mph. The candidate selection criteria included safety, operational, and geometric based factors and utilized statewide non-freeway segment data from WSU's comprehensive sufficiency/crash database. Ultimately, approximately 747 miles of undivided and 26 miles of divided 55 mph non-freeways were identified as lower risk candidates, representing approximately one-eighth of the MDOT systemwide mileage posted at 55 mph. Approximately one-half of the undivided candidate mileage existed in the Superior Region, including numerous sections of US-2 and M-28, where in many cases, the 85^{th} percentile speeds were at or above 65 mph. Please refer to the full report for further details pertaining to the lower risk candidate segments.

NECESSARY INFRASTRUCTURE UPGRADES

Increasing the speed limit on high-speed non-freeway roadways would incur infrastructure upgrades and associated costs at various points throughout the life-cycle of the roadway. Generally speaking, increasing the non-freeway speed limit from 55 mph to 65 mph would initially require upgrading less costly components, such as passing zones and warning signage, with critical substandard geometric components typically upgraded during 3R (i.e., resurfacing, restoration, or rehabilitation), or 4R (i.e., reconstruction or new construction) projects.

Five representative case study segments were utilized to develop estimates of the 3R and 4R infrastructure costs associated with increasing the non-freeway speed limit from 55 mph to 65 mph. One segment was also provided with a consultant's initial infrastructure cost estimate. In general, it was found that infrastructure costs associated with a speed limit increase would be minimized for roadways possessing primary geometric features, specifically horizontal and vertical alignment, that already possess higher design speeds. Any additional vertical and/or horizontal alignment upgrades would incur substantial 3R or 4R project costs to achieve compliance with state and federal design speed requirements.

Assuming statewide implementation of 65 mph speed limits on all MDOT non-freeways currently posted at 55 mph, it was estimated that initial infrastructure upgrades would cost $57.4 million with an additional $1.19 billion in potential non-compliant geometric upgrade costs incurred during 3R or 4R projects. However, it is acknowledged that the statewide infrastructure cost estimate likely underestimates the true infrastructure costs, as it was not possible to estimate certain deficiencies that would require modification during 3R or 4R projects. Such items included substandard bridge widths, substandard vertical clearances, and wetland mitigation costs.

Limiting application of the 65 mph speed limit to include only lower risk candidate segments would substantially reduce these costs, as these segments do not include substantial amounts of non-compliant horizontal alignment. Such costs may be further reduced if the candidate locations are specifically selected such that major realignment will not be required. The minimum infrastructure costs would likely be incurred if the 65 mph speed limit is applied only to candidate sections of US-2 and M-28.

ROAD USER OPERATIONAL BENEFITS

Road user costs and benefits associated with increasing the non-freeway speed limit from 55 mph to 65 mph, including increased fuel consumption and reduced travel times, were also estimated. Assuming an increase in mean speeds of 3.4 mph associated with raising the speed limit from 55 to 65 mph, it was estimated that the value-of-time savings would outweigh the fuel consumption costs by a factor of 1.06 for heavy trucks and 2.98 for passenger vehicles. This equated to net user benefits of $0.0019/mile for trucks and $0.0113/mile for passenger vehicles.

TRAFFIC SAFETY IMPACTS

Increasing the non-freeway speed limit from 55 to 65 mph is expected to increase the overall crash rate by 3.3 percent, based on data from high-speed roadways in the state of Washington. Furthermore, the expected increase in vehicular operating speeds is expected to shift the crash severity distribution toward more severe crashes due to the additional energy dissipated during crashes at higher speeds. Combining this upward shift in the severity distribution with the expected overall 3 percent crash increase is expected to result in fatal, incapacitating injury (A-injury), non-incapacitating and possible injury (B/C-injury), and property damage only (PDO) crash rate, increases of 28.1 percent, 12.1 percent, 5.0 percent, and 2.7 percent, respectively.

Statewide implementation of the 65 mph speed limit on all 6,092 miles of 55 mph non-freeways is expected to result in an annual increase of 40.3 fatal crashes, 74.6 A-injury crashes, 175.2 B- or C-injury crashes, and 631.8 property damage crashes at an expected economic cost of $89.8 million annually. Substantially lower crash increases and associated costs are expected for scenarios involving either all or a subset of the lower risk candidate segments, as these segments only include segments with historical crash rates below the statewide averages. However, regardless of the implementation scenario, increasing the non-freeway speed limit from 55 mph to 65 mph is expected to increase fatal crashes, which contradicts Michigan's "Toward Zero Deaths" initiative.

Furthermore, the estimated crash increases are contingent on the assumption that the roadway design speeds will ultimately be made compliant with the 65 mph posted speed limit. Additional crashes and associated costs would likely result if the design speed are not eventually modified to be in compliance with the increased posted speed limit. Thus, the infrastructure investment that would be necessary to improve non-compliant geometric features is critical to prevent crashes that would likely otherwise occur if the non-compliant features were not improved.

BENEFIT/COST RATIO

Benefit/cost ratios were estimated considering implementation of the 65 mph speed limit on MDOT non-freeway roadways to determine if the infrastructure and crash costs outweighed the net road user operational benefits. Specifically, four potential implementation scenarios were considered, with the benefit/cost ratios estimated as follows:

- Lower risk candidate roadways with minimum infrastructure upgrade costs: B/C = 1.23
- Lower risk candidate roadways requiring no horizontal or vertical realignment: B/C = 1.12
- All lower risk candidate roadways, including vertical and horizontal realignment: B/C = 0.94
- All 55 mph MDOT non-freeway roadways statewide: B/C = 0.77

In general, routes possessing geometric features that typically comply with a 65 mph speed limit, particularly horizontal and vertical alignment, are expected to incur only low-cost 3R/4R geometric upgrades associated with a speed limit increase to 65 mph. Thus, a favorable benefit/cost ratio will likely be obtained for roadway segments with minimal critical geometric upgrades coupled with low crash occurrence. Conversely, roadways possessing horizontal and/or vertical alignment that is not compliant with a 65 mph speed limit would likely result in an unfavorable economic result due to the excessive infrastructure costs incurred during 3R or 4R projects. This suggests that discretion should be utilized when selecting non-freeway roadways where the speed limit will be increased to 65 mph, with particular consideration given to the design speed of existing critical geometric features (e.g., horizontal and vertical alignment) and historical crash occurrence.

It was not possible to estimate certain infrastructure deficiencies requiring modification during 3R or 4R projects, including substandard bridge widths or vertical clearances and wetland mitigation costs. Thus, the actual systemwide benefit/cost ratio is likely lower than 0.77.

RECOMMENDATIONS

Any proposed systemwide speed limit policy scenarios involving an increase in the maximum speed limit would undoubtedly result in substantial infrastructure costs associated with geometric modifications necessary to increase the design speed to comply with state and federal requirements at the time of 3R or 4R projects. The majority of the MDOT non-freeway trunkline network is currently designed for compliance with posted speed limits of 55 to 60 mph. Consequently, systemwide increases in the posted speed limit beyond these levels would likely result in geometric upgrade costs and economic crash costs that greatly outweigh the net user benefits, resulting in benefit/cost ratios below 1.0. Furthermore, even with a design exception, the costs associated with critical geometric alignment upgrades for design speed compliance should not be disregarded, as additional crashes and associated economic costs would likely result if the design speed is not modified to comply with the increased posted speed limit.

Consequently, to avoid costly geometric improvements during 3R or 4R projects, non-freeway speed limit increases to 65 mph should only be considered for lower risk candidate sections of roadway where design speed compliance is generally maintained. Specifically, segments that would require horizontal or vertical realignment to achieve design speed compliance during 3R or 4R projects should be excluded due to the substantially large infrastructure costs. However, even if design speed compliance can be maintained, careful detailed site specific consideration must be given to the potential safety impacts – particularly to fatal and injury crashes – that may result after increasing the speed limit. To those ends, it is recommended that comprehensive engineering and safety analyses be performed prior to any speed limit increase for those roadway segments under consideration.

CHAPTER 1:
INTRODUCTION

Recently, speed limits on high speed roadways have trended upward nationwide, particularly for rural freeways and in western states. Between April 2011 and January 2014, at least 14 states have either increased maximum speed limits or are currently proposing to do so, with a majority of these increases involving rural freeways. Additionally, the popularity of differential speed limits between passenger vehicles and heavy vehicles has diminished over time [*1*].

With the trend of increasing speed limits continuing to expand throughout the United States, in early 2014, the Michigan state legislature introduced SB 894-898 that proposes several changes to statewide speed limit policies [*2*]. As a follow up these same proposed changes were introduced on November 13, 2014 as HB 5962-5966 [*3*]. The house bills would create a new "Rural Freeway General Speed Limit" of 80 mph (currently 70 mph) and a new "Urban Freeway General Speed Limit" of 70 mph (currently 55 to 70 mph). The legislation also proposed to increase the maximum freeway speed limit for trucks and buses to 70 mph (currently 60 mph), thereby maintaining a differential speed limit between passenger vehicles and trucks/buses on rural freeways.

Additionally, speed limit increases on non-freeways are also proposed in HB 5962-5966 [*3*]. The bill proposes creation of a "Trunk Line General Speed Limit" of 65 mph for non-limited access highways maintained by MDOT. It also includes language for a "Maximum General Speed Limit" of 60 mph for county highways along with a "Maximum General Gravel Road Speed Limit" of 55 mph for gravel or unimproved highways (45 mph for counties with populations of 1,000,000 or more).

This research project initially focused on estimating potential policy impacts associated with changes to Michigan's differential speed limit for trucks and buses. A subsequent expansion of the project scope led to further assessment of the potential impacts of changes to freeway speed limits for all vehicles (passenger cars in addition to trucks and buses). Together, these issues formed the general scope of the phase 1 research, which is detailed in the report entitled: "*Evaluating the Impacts of Speed Limit Policy Alternatives*" [*1*].

Following the introduction of SB 894-898 in spring of 2014, the project scope was broadened in a second phase to include consideration of rural non-freeways to assess the impacts associated with the proposed 65 mph "Trunk Line General Speed Limit". Although a limited analysis of the non-freeway impacts was included in the Phase 1 report [*1*], a more comprehensive analysis was needed due to the extensive variability in the design characteristics that exist within the MDOT rural non-freeway roadway network.

MDOT maintains approximately 6,100 miles of non-freeways with posted speed limits of 55 mph. The overwhelming majority (approximately 5,685 miles [93.2 percent]) of the 55 mph non-freeway trunkline system is made up of two-lane, undivided highways. The remaining 55 mph non-freeway mileage consists of multilane roadways, split approximately evenly between undivided and divided roadways. A map of MDOT's non-freeway trunkline network is shown in Figure 1.

PROBLEM AND OBJECTIVES

The traffic safety research literature has shown traffic crashes, injuries and fatalities to be affected by mean (and 85th percentile) speeds, as well as by the variance in speeds. To this end, extensive research has been conducted to assess the impacts of speed limits for limited access facilities (i.e., interstates and other freeways). However, research on non-limited access facilities has been limited. Driver speed selection on non-limited access facilities is strongly affected by roadway geometry or cross-sectional characteristics, including horizontal/vertical alignment, shoulder width, presence of passing lanes, access point density, and other factors. Thus, research is needed to better understand the relationships between these characteristics and vehicular speeds, traffic crashes, injuries, and fatalities. This is particularly true in light of proposed increases to the speed limits of such facilities.

Figure 1. MDOT Non-Freeway Trunkline System by Existing Speed Limit

The purpose of this research was to assist MDOT and the State of Michigan in determining the potential impacts of implementing the suggested "Trunk Line General Speed Limit" of 65 mph. In order to determine the expected impact of the proposed 65 mph speed limit on Michigan's non-limited access highways, a careful analysis is required of a broad range of traffic safety, operational, and economic performance measures, which may include: mean and 85th percentile speeds, speed variance, traffic crashes and crash severity, infrastructure costs, fuel consumption, and travel times. The intent of this study is to help inform the ongoing debate related to proposed speed limit increase. To that end, two primary objectives have been established:

- Develop a prioritization strategy and quantitative risk assessment of candidate MDOT non-freeway road segments.
- Perform a detailed economic analysis of the anticipated costs and benefits associated with speed limit increases on a candidate sample of MDOT non-freeways, in addition to a statewide estimate.

TASK SUMMARY

The following tasks were performed in order to accomplish the research objectives. A full description of work performed as a part of this research is provided in the subsequent chapters.

- Literature Review for Two-Lane Highways: A comprehensive state-of-the-art review of research was performed to investigate the relationship between traffic speed, safety, and crash risk specifically for non-freeways. It should be noted that this literature review builds upon the prior summary of research provided within the report entitled: "Evaluating the Impacts of Speed Limit Policy Alternatives" which largely focused on freeway and differential speed limit policies [*1*].
- Roadway Inventory and Crash Data Collection: Traffic crash, injury, and fatality data relating to MDOT's non-freeway network was collected and merged with roadway inventory data (i.e., sufficiency database) to ascertain the effects of roadway geometric and cross-sectional characteristics.
- Field Speed Data Collection: Field speed data were collected from various non-freeway roadways throughout the state of Michigan. This includes highway sections currently posted at 55 mph, select segments currently posted at 65 mph in the Upper Peninsula, as well as speed reduction zones adjacent to cities and towns.
- Prioritization Process: A process was developed for selection of non-freeway segments that would be considered lower risk candidates for a speed limit increase. This included the development of performance measures and evaluation criteria for selecting such segments, considering safety, operations, and infrastructure cost impacts.
- Review Geometric Features of Select Segments: Geometric features were reviewed for select roadway segments in order to identify infrastructure improvements and associated

costs that may be required over the roadway life cycle in order to accommodate higher design speeds.

- Assess Need for Infrastructure Investment: Based on the review of geometric features, the need for such infrastructure investments was determined. This included the prioritization of features requiring improvement based on the specific needs of the affected roadway.
- Benefit-Cost Analysis of Investment Scenarios: A benefit/cost analysis was performed to estimate the impacts of the features requiring improvements compared to the net user benefits and traffic safety impacts. This included consideration of the necessary short-term and long-term infrastructure improvements, in addition to increased fuel consumption costs, travel time benefits, and changes to traffic crashes and injury/fatality risk.

CHAPTER 2:
REVIEW OF LITERATURE AND PRACTICE

The following review provides a historic overview of the relationship between speed and safety on two-lane highways. First, a general overview of the relationship between speed, risk and safety is provided which outlines the prior research performed in this area. The impacts of speed limits on traffic safety are an area that has generated much research, though a strong consensus has not emerged to the relationship between speed and safety. It should be noted that a more in-depth review of prior research, historical policy changes, and other findings is provided in the report entitled "*Evaluating the Impacts of Speed Limit Policy Alternatives*" [*1*]. Secondly, an examination of the characteristics of non-freeway highways that impact safety is also provided in order to assess the specific aspects of these roadways which should receive consideration in relation to a potential speed limit increase.

GENERAL OVERVIEW

Maximum speed limits are posted to inform drivers of the highest speed that is considered safe and reasonable for typical traffic, road, and weather conditions. Additionally, legislated speed limits establish a penalty for unreasonably high travel speeds. Numerous research studies have sought to examine the relationship between vehicle speeds and traffic safety, as well as the effects of posted speed limits on the frequency and severity of crashes.

Much of the research on the effect of speed limits was motivated by the initial passage of the Emergency Highway Energy Conservation Act in 1974, which mandated the 55 mph National Maximum Speed Limit (NMSL) on interstate highways in the United States. The initial reason for the change was to reduce fuel consumption in response to the Mid-East Oil Embargo. However, one issue that arose with the introduction of the NMSL was that observed driving speeds did not necessarily reflect the new lower speed limits. This was particularly true on interstate highways where posted speed limits were significantly below the design speeds of these roadways.

The speed limit issue was revisited by subsequent research and legislation. The 1987 passage of the Surface Transportation and Uniform Relocation Assistance Act (STURAA) permitted states to increase speed limits from 55 to 60 or 65 mph on interstate highways in rural areas with populations of less than 50,000. Following the enactment of the STURAA, a series of evaluation studies showed increases in traffic crashes and/or fatalities in states where the speed limit had been increased [*4-11*]. However, additional studies found either marginal or no changes in traffic safety [*12-14*], while a few studies found safety improvements after speed limit increases [*15, 16*].

On November 28, 1995, the National Highway System Designation Act of 1995 gave states complete freedom to set interstate speed limits. As a result of this legislation, many states have raised interstate speed limits to 70 mph or more, providing ample opportunity to observe the same highways under different speed limits and determine user responses to these limits. The repeal of the NMSL in 1995 led to a series of additional studies, which produced some negative [*17-19*] and neutral [*20*] safety findings, indicating that the increased speed limits did not have a positive effect on injury or fatality rates.

RELATIONSHIP BETWEEN SPEED, CRASH RISK, AND INJURY SEVERITY

Speed management has long been a concern of transportation agencies, dating back to research from the 1960's, which showed vehicles traveling excessively below or above the speed limit to be overrepresented in crashes on rural highways and interstates [*21,22*]. The earliest, and perhaps most cited work in this area is that of Solomon [*21*] and Cirillo [*22*]. Solomon [*21*] compared the estimated speed (from police crash reports) of 10,000 crash-involved vehicles with field-measured speeds from 29,000 control vehicles. Using these data, relative crash rates for 10-mph speed categories were estimated. The results, illustrated in Figure 2, present the crash involvement rate (per 100 million vehicle-miles of travel) with respect to travel speed (Figure 2a) and with respect to variation from the average speed of traffic under similar conditions (Figure 2b). Collectively, these figures suggest that crash risk (i.e. possibility of being in a crash) is greatest at very low speeds and very high speeds. Vehicles traveling approximately 6 mph above the average speed exhibited the lowest crash rates.

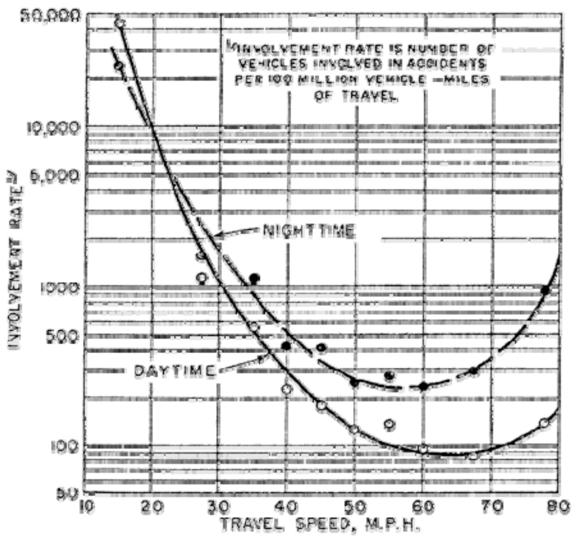


Figure 2a

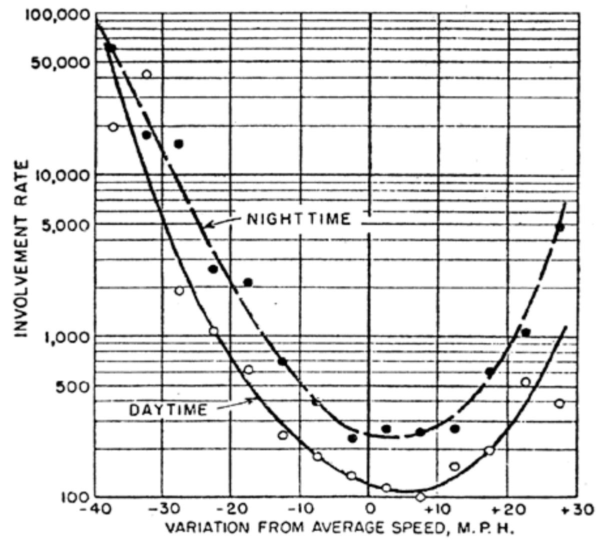


Figure 2b

Figure 2. Crash Rates by Travel Speed and Variation from Average Speed [*21*]

Subsequent research used speed data from traffic detectors, in combination with pre-crash speeds based on crash reconstruction, and found similar trends [*23*]. However, 44 percent of these crashes involved low-speed maneuvers (e.g., turning into or out of traffic) and an analysis of the data excluding these maneuvers demonstrated crash risks were much less pronounced at low speeds in comparison to prior research. This reflects one of the limitations of the work by Solomon [*21*] and Cirillo [*22*], which is that many of the lower speed crashes result from slower moving vehicles entering or exiting the roadway. Subsequent work by West and Dunn [*24*] shows that removing turning vehicles substantially mitigates the apparent risk at lower speeds as shown in Figure 3.

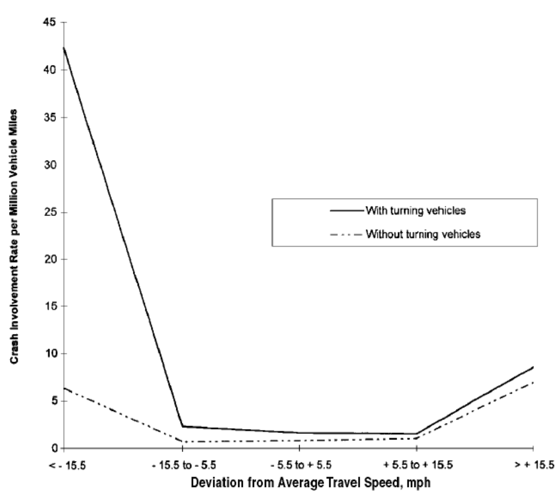


Figure 3. Crash Rates by Deviation from Average Speed [*24*]

Research in the United States by Garber and Gadiraju [*25*] examined data more closely at the road segment level. This research focused on three types of roadways with 55 mph speed limits: interstates, arterials, and major collectors. Results showed that roads with larger speed variance (that is, larger speed differentials between drivers) exhibited higher crash rates than roads with lower variance. Ultimately, Garber and Gadiraju [*25*] found that the relationship between speed limit and design speed was a key determinant of safety trends. Both crash rates and speed variance were lowest when speed limits were 5 to 10 mph below the road's design speed.

Additional work has shown that increases in average speed and speed variance each result in increased fatality rates [*26-31*]. The fact that fatalities increase with speed is unsurprising given the physics involved, which show the kinetic energy (i.e. energy of motion of an object, which is equal to the work the object would do if it were brought to a stop) [*32*] involved in a crash increases with speed (kinetic energy = 0.5 x mass x velocity^2) [*33*]. Nilsson [*34*] developed a "Power Model" whose purpose was to model the relationship between the number of people injured in a crash and speed as well the numbers of people fatally injured in a crash and speed. This model incorporates the concept of kinetic energy because increases in the amount of kinetic energy has an association with an increased risk of being in a crash, as well as a change in the outcomes of such crashes [*34*]. Analytical results suggest that a 5 percent increase in the mean speed will subsequently produce a 10 percent increase in the total amount of injury crashes, along with a 20 percent increase in the number of fatal crashes [*35*].

RELATIONSHIP BETWEEN SPEED LIMIT AND OPERATING SPEED

In addition to the safety impacts of speed limits, another area of substantive debate is how speed limits influence the actual speed selection behavior of drivers. According to the American Association of State Highway and Transportation Officials (AASHTO) [*36*], driving speeds are affected by the physical characteristics of the road, weather, other vehicles, and the speed limit. Among these, road design is a principal determinant of driving speeds. Geometric factors tend to have particularly pronounced impacts on crashes. Ultimately, many factors affect speed selection beyond just road geometry and posted limit as shown by prior research in this area [*37-50*]. Research has generally demonstrated that modifications of the posted speed limit result in changes in the observed mean and 85th percentile speeds that are less pronounced than the actual speed limit modifications. This has been true for cases where speed limits were decreased [*26, 51*] or increased [*11, 23-55*].

In one of the most extensive studies in this area, Parker [*56*] conducted a large-scale study from 1985 to 1992 to determine the impact that raising or lowering posted speed limits on non-limited access highways had on driver behavior. At the time of this study, the maximum speed limit on such roadways was 55 mph. Over the duration of the study, states and local authorities raised and lowered posted speed limits on short segments of roadways, typically less than two miles in length. Data on driver behavior and crashes were collected from 22 states. These included 100 sites along non-limited access highways where the speed limits were either raised or lowered and 83 control sites where there were no changes made to speed limits. The range of speed limit changes consisted of lowering the speed limit by 5, 10, 15, or 20 mph, or increasing the speed limit by 5, 10, or 15 mph, with only one change made at each site. Interestingly, the difference in speed after these changes was less than 1.5 mph on average. The study results clearly demonstrated that drivers select their speeds on non-limited access highways primarily on the basis of roadway geometry and traffic characteristics more than the posted speed limits [*56*].

Kockelman et al. [*57*] found that speed limit increases tend to increase vehicle operating speeds. On average, speed increases on high-speed roadways were generally less than half of the amount of the actual speed limit increase. Specifically, increasing the speed limit from 55 to 65 mph on non-freeway roadways was expected to increase operating speeds by approximately 3 mph. The author noted that average speed and speed variability was largely influenced by geometric and cross-sectional features and lane use characteristics, more so than posted speed limits.

The findings discussed above are largely reflective of driver opinions on speed limits as shown by recent surveys. Mannering [*58*] conducted a 2007 freeway user survey studying their normal driving speed on interstate highways that have posted speed limits of 55 mph, 65 mph, and 70 mph. On average, drivers reported driving 11 mph over the speed limit on roads posted 55 mph, 9 mph over the speed limit on roads posted 65 mph and 8 mph over the speed limit on roads posted 70 mph.

A national survey conducted by the United States Department of Transportation (USDOT) in 2003 [*59*] gathered information regarding driver attitudes and behaviors related to violating the speed limit and other unsafe driving behaviors. Results showed that most drivers believe they can drive 7 to 8 miles per hour above the posted speed limit before being pulled over. On average, drivers felt that the ideal speed limit for a highway would be approximately 67 mph. Approximately 40 percent of drivers stated they would drive over the speed limit on interstate highways even if the speed limits were increased by 10 mph. While 51 percent of drivers admitted to driving 10 mph over the posted speed limit, 68 percent felt that other drivers violating the speed limit were a danger to their own personal safety. Drivers reported that the most influential factors dictating their speed selection were weather, their perception of what speeds were "safe", the posted speed limit, traffic volume levels, and the amount of personal driving experience they had on a particular road [*59*]. Collectively, the available empirical data and information from drivers suggest that the posted speed limit has a relatively small influence on speed selection in general.

Work Zones Considerations

Working in close proximity to moving traffic is potentially hazardous but necessary when conducting roadwork. To alleviate potential risk, speed limits in work zones are typically reduced to more safely accommodate construction workers, as well as motorists. Compliance with posted work zone speed limits has been found to be a common issue and various countermeasures have been evaluated aimed at reducing speeds through work zones.

In a study of four work zones in Missouri, Bham and Mojtaba determined that construction activity in work zones significantly decreased the average speeds of passenger cars and trucks, by 3.5 and 2.2 mph, respectively, as compared to times of inactivity. Speeds remained above the posted speed limits regardless of whether activity was ongoing. Reduced lane widths were revealed to be the most effective factors in reducing average speeds [*60*].

It was also discovered that compliance dropped with a greater decrease from the usual speed limit to the posted work zone speed limit. In Missouri, a work zone speed limit of 50 mph saw even less compliance than when set at 60 mph [*60*], and a study conducted in Australia supported these findings [*61*]. Overall, several studies concluded that although certain measures can be taken to try and slightly reduce speeds, motorists will regulate their speed as they feel necessary [*62, 63*].

School Zone Considerations

Several studies have examined the effects of reduced speed zones, such as school zones. One study, conducted by McCoy and Heimann in Nebraska assessed compliance with the posted speed limit in school zones. They found that speeds in school zones were more heavily influenced by the road characteristics and the posted speed limit on the road on which the school zone was located than by the lower posted speed limit within the school zone [*64*]. Another study, which was conducted in Washington State, found that a higher approach speed near a school zone led to higher speeds within the school zone, depending on the type of signage used. If a "flashing light" sign was being used, then there was a greater compliance with the posted speed limit for the school zone [*65*]. A study conducted in Atlanta conducted by Young and Dixon found that overall, the use of school zone signage had little to no effect on driver behavior [*66*].

Pedestrian and Bicyclist Considerations

Another area of concern when discussing speed limits and vehicular speeds is pedestrian safety. There have been a number of studies that have examined the impacts of vehicle speeds and speed limits on pedestrian injury severity. Pasanen [*67*] found a direct relationship between the risk of pedestrian fatality and impact speeds. At impact speeds of 20 mph, the probability of pedestrian fatality was 5 percent. At 50 mph, nearly 100 percent of crash-involved pedestrians were fatally injured. Andersen [*68*] reported similar results, as did Leaf and Preusser [*69*], the results of which are shown in Figure 4.

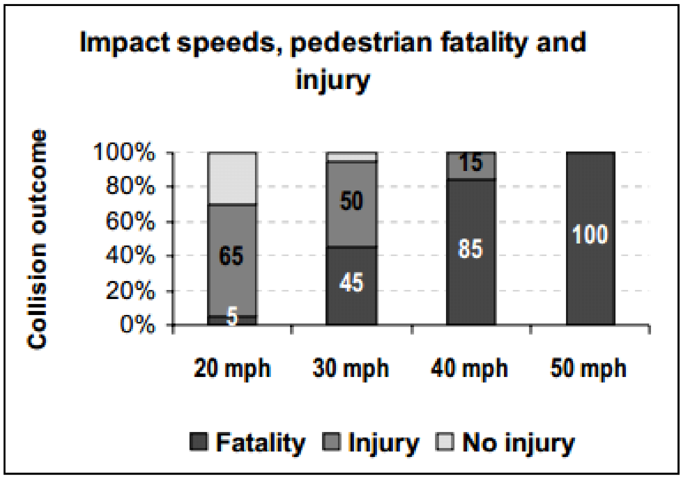


Figure 4. Effect of Impact Speed on Pedestrian Fatality and Injury [*68*]

One analysis using accident data from 1997 to 2002 in North Carolina determined which factors have the greatest effect on different severity outcomes for bicyclists involved in motor vehicle crashes. The outcomes included fatal, incapacitating, non-incapacitating and possible or no injury categories. There are several factors that influence the severity of an injury experienced by a bicyclist in a motor vehicle accident, but the factor that had the largest effect was when the speed of the vehicle prior to impact was more than 50 mph. This was found to increase the probability of a fatal crash by 16-fold. The "threshold effect", or the speed at which there is a great increase in the probability of a fatality in an accident for a bicyclist is 20 mph [*70*].

Another study, conducted in the United States, found that the two most important variables that affect non-motorist (i.e. pedestrians and bicyclists) injury severity are the age of the person and the speed limit on the roadway on which the accident occurred, as speed limits that are higher lead to higher injury severity levels [*71*]. The speed at which the driver is traveling appears to have a very strong effect on injury severity for both pedestrians and bicyclists.

NON-FREEWAY SPEED LIMIT POLICIES

The preceding sections outline a wide range of safety issues of importance in determining speed limit policies. While the extant research literature has generally shown that speed limit increases produce mixed results in terms of traffic safety impacts, many states have recently changed or considered changing their speed limit policies.

Ten states have recently increased speed limits along at least a portion of roadways since 2011. The majority of these increases occurred along interstate highways. In general, these increases were done selectively based upon traffic engineering, speed, and safety studies conducted by the state departments of transportation. This is an important distinction as not all segments of a particular roadway class are likely to be acceptable candidates for speed limit increases. In particular, segments with extensive horizontal or vertical curvature, sight distance limitations, or other features that may not comply with current design standards (e.g., design exceptions) may not be suitable for speed limit increases. Similarly, locations at which the 85^{th} percentile speed is currently in compliance with the existing speed limit or locations where there is a history of crashes may not be suitable candidates.

The maximum allowable speed limits for divided and undivided non-freeways vary throughout the United States. Currently, 27 states allow for higher posted speed limits for divided roadways than for undivided roadways while the remaining 23 states provide the same maximum speed limit for both roadway types. These maximum allowable posted speed limit ranges from 45 mph in Hawaii up to 75 mph in Texas for both divided and undivided roadways. The majority of states operate with 55 mph or 65 mph maximum posted speed limits. The current maximum allowable posted speed limits are presented in Figure 5 for divided roadways and Figure 6 for undivided roadways.

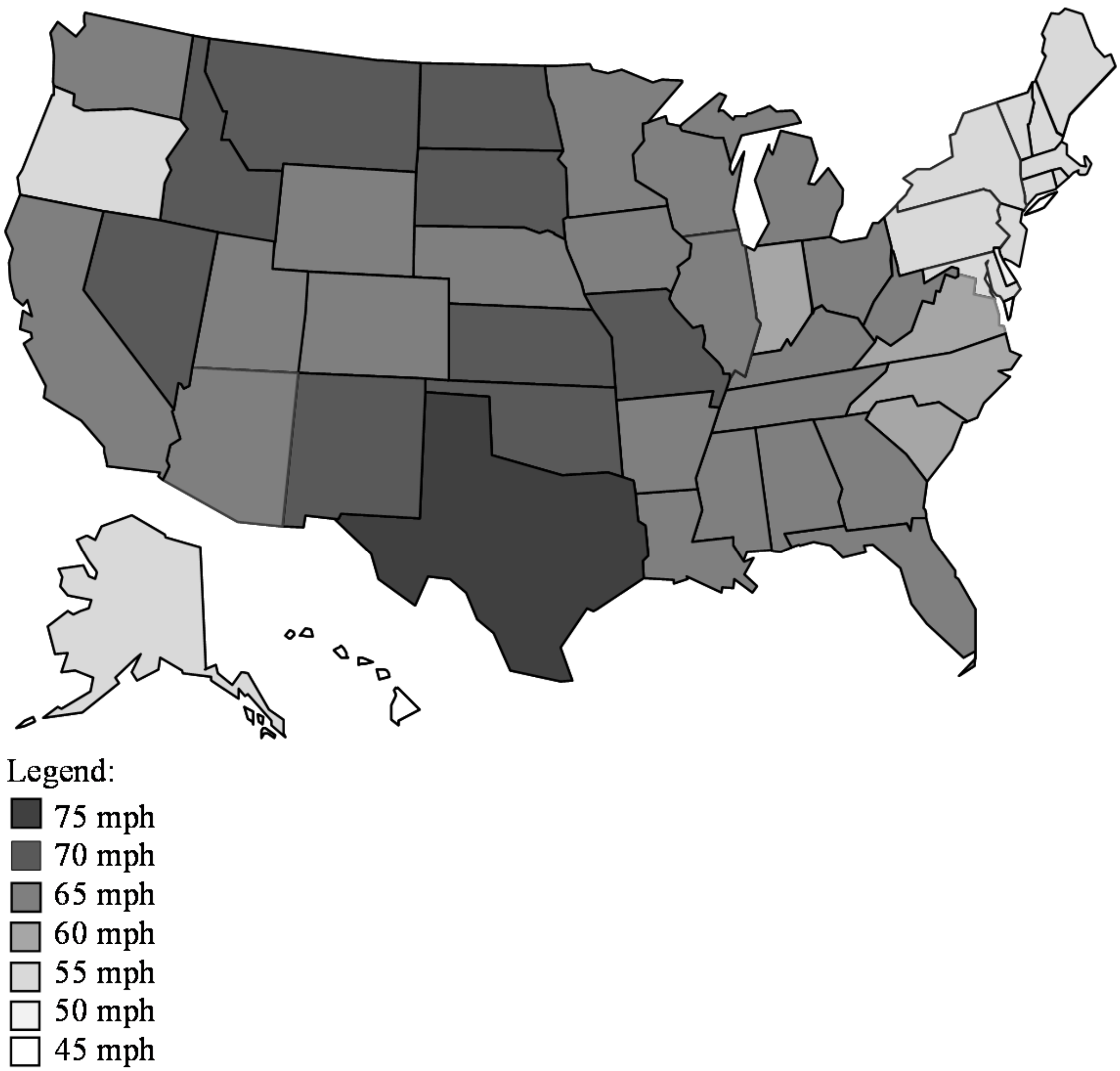


Figure 5. Maximum Allowable Posted Speed Limit on Divided Non-Freeways

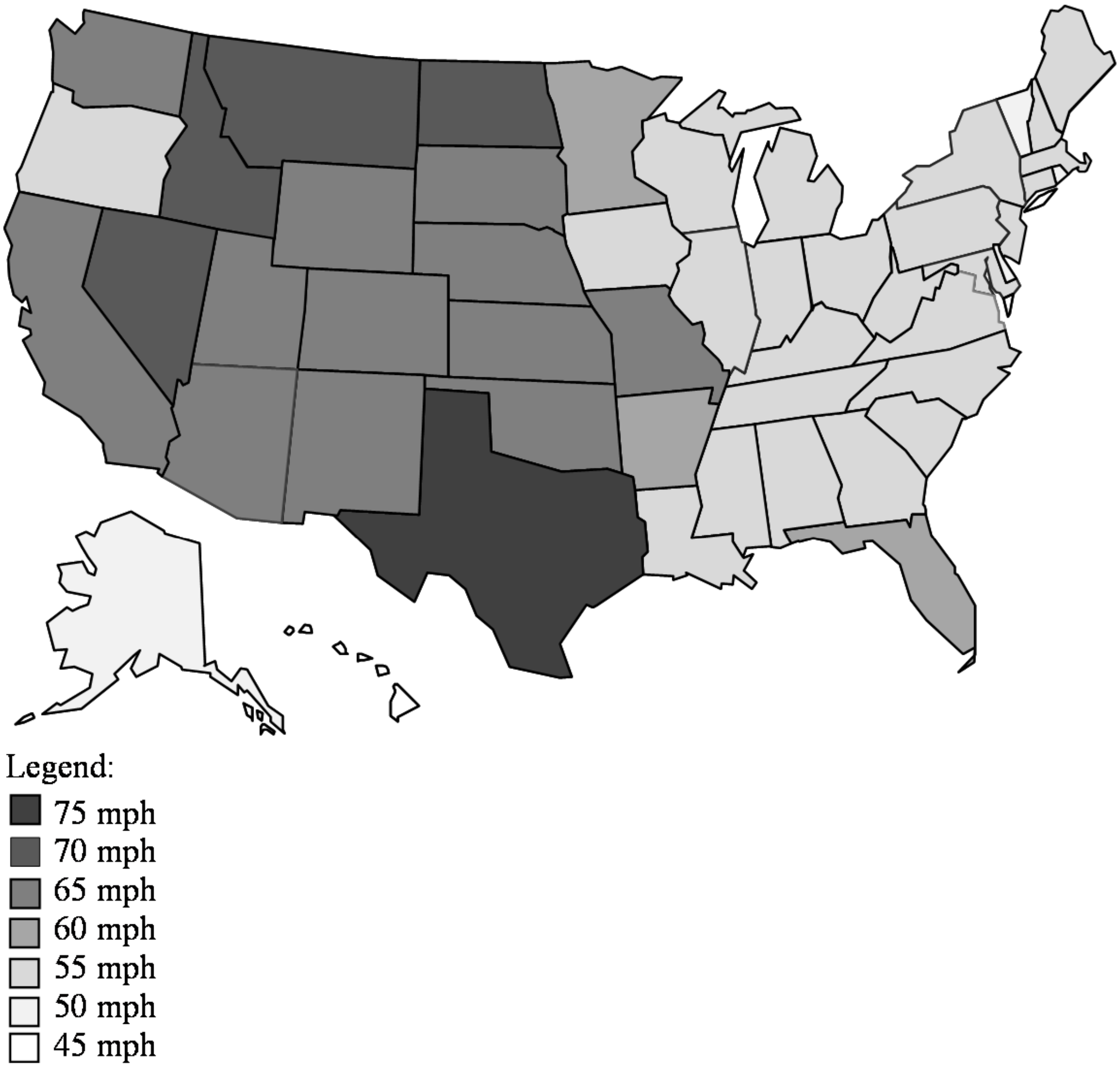


Figure 6. Maximum Allowable Posted Speed Limit on Undivided Non-Freeways

FACTORS AFFECTING NON-FREEWAY OPERATING SPEED

There have been several prior efforts to study the profile of operating speeds along several types of non-freeways. Specifically, the previous research in this area has focused on the investigation of the mean, 85th percentile, and standard deviation of observed speeds of vehicles traveling on non-limited access highways.

Two-Lane Highways

Several studies have generally demonstrated that horizontal alignment is a primary factor in the observed operating speeds along two-lane highways, as drivers tend to reduce speeds based on the degree of curvature [*42*, *72-79*]. Vertical alignment has also been shown to have a significant relationship with operating speeds along tangent sections; however this effect was only significant for crest vertical curves which involve limit sight distance [*80*]. Vehicular operating speeds along tangent sections of two-lane highways have been shown to be impacted by the posted speed limit, with speeds tending to increase as the posted speed limit increases [*45*]. Increasing the speed limit from 55 mph to 65 mph is expected to increase vehicular operating speeds by approximately 3 mph [*57*].

Multilane Non-Freeways

There have also been several prior studies relating to the operating speeds of multilane non-freeways [*72, 81, 82*]. In general, these studies have shown operating speeds to tend to increase with the posted speed limit on such highways [*81*]. Intuitively, operating speeds have also been shown to increase with the width of the clear zone [*82*]. Similar to the prior research on two-lane highways, operating speeds tended to reduce as the degree of horizontal curvature increases [*82*]. The number of access points also has a significant relationship with operating speeds on multilane highways as speeds tend to reduce as the density of access points increase [*83*]. Finally, multilane highways which include two-way left-turn lanes or median barriers resulted in lower observed operating speeds [*83*]. Similar to undivided roadways, increasing the speed limit from 55 mph to 65 mph is expected to increase vehicular operating speeds by approximately 3 mph [*57*].

Speed Reduction Zones

Another concern unique to rural non-freeway highways is the presence of speed reduction zones as such highways pass through as incorporated cities or towns. Guidance is provided for local agencies in NCHRP Report 737 for the implementation of such speed transition zones [*84*]. Several potential factors have been shown to affect drivers' selection of operating speeds as they enter speed reduction zones [*85, 86*]. Specifically, the magnitude of the speed reduction, reduction in lane width, paved shoulder width and lateral clearance tend to reduce operating speeds entering a speed reduction zone [*86*]. The number of total driveways as well as the introduction of a curb also tends to reduce operating speeds entering speed reduction zones [*86*].

FACTORS AFFECTING NON-FREEWAY SAFETY PERFORMANCE

As previously discussed, not all segments of a particular roadway class are likely to be acceptable candidates for speed limit increases given that certain elements may vary across segments. Therefore, raising the speed limit on non-freeway highways should be based upon the careful consideration of the factors which affect safety on such roadways. Given that Michigan's non-freeway trunkline highway system predominately involves rural, undivided two-lane highways, factors that affect safety on such highways are of critical concern. Engineering-related factors which impact safety along two-lane highway segments have been shown to include:

- Traffic volume;
- Horizontal and vertical alignment;
- Lane width, surface type, and associated pavement friction;
- Shoulder type and width;
- Roadside features such as side slopes, ditches, obstructions or utility poles; and
- Traffic control devices such as pavement markings, road signs, or rumble strips [*87*].

In the context of the proposed 65 mph "Trunk Line General Speed Limit" legislation, several roadway characteristics which affect the safety performance of non-freeways which can be considered on a systemwide basis are of specific interest when considering a potential speed limit increase.

Posted Speed Limit

The safety literature generally suggests that increasing the non-freeway speed limit would likely result in an increase in the overall crash rate and would also shift the severity distribution toward more severe crashes due to the increase in the energy dissipated during crashes due to vehicles traveling at higher speeds [*57*]. Specifically, Kockelman estimated that increasing the non-freeway speed limit from 55 mph to 65 mph would increase the total crash rate by 3.3 percent, and the probability of a fatality (assuming a crash had occurred) would increase by 24 percent. The injury crash risk was also expected to increase with increasing speed limits.

Horizontal Alignment

While the prior work has generally demonstrated that horizontal alignment decreases the observed vehicular speeds along both two-lane and multilane non-freeways, in a related manner horizontal alignment has also been shown to negatively impact the safety performance of such highways [*88*]. The majority of the prior safety evaluations have shown that accident frequency increases with the length or severity of horizontal curvature [*57, 89-92*].

Vertical Alignment

Similarly, vertical alignment has also been shown to impact the safety performance of non-freeways. Prior research has demonstrated that steeper vertical grades are associated with higher crash rates [*57, 88*]. It should be noted that while total crash rates increased with the degree of vertical curvature, data from the Kockelman study showed that injuries on steeper vertical curves tended to be less severe [*57*]. Prior work has also demonstrated that crash frequencies tended to increase along crest vertical curves where hidden horizontal curves, intersections, or driveways were present [*93*].

Access Point Density

Access management, or the location, spacing, and design of driveways and intersections, is regarded as one of the most critical elements in roadway planning or design [*88*]. This is particularly true for Michigan’s non-freeway trunkline system which is made up of non-limited access highways which allow for the presence of intersections or driveways along every segment. Several prior studies have demonstrated that as the density of access points (or the number of intersections and/or driveways per mile of highway) increases, the frequency of traffic crashes also increases [*88, 94, 95*]. This is due to the fact that intersections and/or driveways can lead to driving errors which may result in rear-end and/or sideswipe type crashes [*88*]. Specifically, the National Cooperative Research Program (NCHRP) Report 420 concluded that as access point density increased from 10 to 20 access points per mile, a 40 percent increase in crashes could be expected, while an increase to 40 access points per mile was associated with a potential doubling in the frequency of traffic crashes [*95*]. This concept is supported by the Michigan Access Management Guidebook which also suggests limiting the number of access points as a primary strategy for reducing common traffic problems [*96*].

Number of Lanes

The number of travel lanes has a significant impact on the safety performance of non-freeway facilities. Prior work by Kockelman demonstrated that roadways which include four or five travel lanes tend to experience higher crash rates than those facilities which involve two or three travel lanes [*57*].

Median Presence

Intuitively, the inclusion of a median on non-freeway high-speed facilities has been associated with a decrease expected crash rates. Kockelman showed the addition of a median was associated with an approximate 9 percent reduction in traffic crash rates, assuming all other characteristics being equal [*57*].

Lane Width

Intuitively, the width of travel lanes has also been shown to be related to the safety performance of both two-lane and multilane non-freeways [*88*]. Specifically, wider lanes have been associated with reductions in single-vehicle run-off-the-road, head-on, and sideswipe type crashes [*88*]. While the impact of travel lane width on traffic crashes varies with the associated traffic volume, the affect is most pronounced for roadways involving lane widths of nine feet or less. It should also be noted that the effect of lane width on safety performance is reduced for multilane highways as compared to two-lane highways. The safety performance impact is equal to approximately 75 percent and 50 percent to that of two-lane highways for undivided and divided multilane highways, respectively [*97*].

Shoulder Width

The width of paved shoulder along non-freeways has been shown to impact the frequency of similar crashes to that of travel lane widths [*88*]. While this effect is related to the associated traffic volume along such non-freeway highways, the frequency of traffic crashes tends to increase as paved shoulder widths are reduced below 6 feet. Further, this effect is more significant for roadways with greater than 2,000 vehicles per day and paved shoulder widths of two feet or less [*88*].

Passing Zones within Two-Lane Highways

While the presence, length, and location of passing zones on two-lane highways likely has an effect on the safety performance of two-lane highways, this effect has not been well-documented in the previous literature. In fact, the *Highway Safety Manual* notes the following treatments related to passing zones as having an unknown effect on traffic crashes:

- Different passing sight distances;
- Presence of access points/driveways around no-passing zones;
- Different lengths of no-passing zones;
- Different frequency of passing zones; and
- Passing zones for various weather, cross-section, and operational conditions [*88*].

GEOMETRIC DESIGN CRITERIA

In 1985, the FHWA designated 13 specific design elements as the necessary controlling criteria for roadway design [*93*]. These 13 design elements are recognized by the FHWA as having a significant impact on both safety and operations and form the basis for AASHTO and state design standards, including MDOT's *Michigan Road Design Manual* [*98*]. The FHWA's 13 controlling geometric elements include:

- Design speed;
- Lane width;
- Shoulder width;

- Bridge width;
- Structural capacity;
- Horizontal alignment;
- Vertical alignment;
- Grade;
- Stopping sight distance;
- Cross slope;
- Superelevation;
- Vertical clearance; and
- Horizontal clearance.

Any highway resurfacing, restoration, or rehabilitation (3R) or reconstruction/new construction (4R) projects on the National Highway System (NHS) must meet the accepted criteria for these 13 design elements [*93*]. MDOT also extends these requirements to 3R and 4R projects on non-NHS highways [*98*]. Given these requirements, any modification of the posted speed limit should consider these criteria to ensure that the roadway is still in conformance after the implementation of the new speed limit.

According the *Michigan Road Design Manual,* 3R projects would include work undertaken to extend the service life of an existing highway and enhance highway safety [*98*]. Examples of this type of work include:

- Resurfacing, milling or profiling, concrete overlays or inlays (without subbase removal);
- Lane and/or shoulder widening (no increase in the number of through lanes);
- Roadway base correction;
- Minor alignment improvements;
- Sight distance improvement;
- Intermittent grade modifications to correct deficiencies in the vertical alignment;
- Passing relief lanes;
- Roadside safety improvements;
- Signing, pavement marking and traffic signals installations;

- Intersection and railroad crossing upgrades;
- Pavement joint repair; and
- Crush and shape and resurfacing.

4R projects would include new construction or reconstruction work that goes beyond the extent of 3R projects, such as [*98*]:

- Complete removal and replacement of pavement (including subbase);
- Major alignment improvements;
- Adding lanes for through traffic;
- New roadways and /or bridges;
- Complete bridge deck or superstructure replacement; and
- Extensive grade modifications used to correct deficiencies in the vertical alignment.

It should be noted that although major infrastructure investment may not be necessary until a 3R or 4R project, an initial immediate investment will typically be necessary to evaluate and address certain critical inadequacies which result due to the increased posted speed. For example, raising the speed limit on any roadway would, as a minimum, initially necessitate installation of additional warning signs to treat deficient geometric conditions and/or relocation of existing advance warning signs. Horizontal curve locations where the newly increased speed limit exceeds the design speed may require additional signage, such as advance warning signs (including warning flashers where warranted), advisory speed plaques, and/or chevrons. In addition to signage, increasing the rural two-lane highway speed limit would require an engineering assessment of the adequacy of several speed-related geometric features, including (but not limited to): horizontal curvature (radius, superelevation), vertical alignment (grades, curvature), sight distances (stopping, decision, passing [two-lane roadways]), guardrail lengths, and lengths of auxiliary lanes and tapers. Additional details pertaining to the 13 controlling geometric criteria as related to MDOT geometric design procedures are provided in the infrastructure impact assessment portion of Chapter 6.

CHAPTER 3:
SPEED DATA ANALYSIS

As previously stated, the proposed 65 mph "Trunk Line General Speed Limit" legislation would likely impact several performance measures related to the speed profile of vehicular traffic on Michigan's non-freeway network. Specifically, raising the speed limit from 55 to 65 mph on certain highway segments is expected to impact the mean, 85^{th} percentile, and variance of speeds. Therefore, in order to determine the potential impact of such a speed limit increase, it was necessary to perform a comprehensive study of the existing speed profile for roadways which could potentially be impacted by this policy.

DATA COLLECTION

Spot-speed data were collected throughout the MDOT non-freeway roadway network posted 55 mph or higher. The data collection effort began at the end of July 2014 and was completed at the beginning of August 2014. This included the selection of 100 observation sites along non-freeway trunkline routes spread throughout all seven MDOT regions in an attempt to achieve a representative sample of non-freeway roadways. It should be noted that of the 100 observation sites, 32 were positioned at a speed reduction zone entering a city or town. At the speed reduction zone locations, vehicular speeds were captured at the speed limit sign displaying the reduced posted speed limit. Further, while sites were selected along flat, tangent segments to reduce the influence of geometric characteristics (e.g., horizontal and vertical alignment), six of the selected 32 speed reduction zone sites were located within a horizontal curve. For comparison purposes, an observation site located within the 65 mph section of US-2/US-41 in Delta County was included in the sample. A map of the 100 speed data collection sites is provided in Figure 7.

Speed data were collected using a LIDAR or RADAR gun. The data collector was positioned at a minor crossroad, driveway, or turnout. Data were only collected during uncongested daytime periods. Vehicles were randomly selected for speed measurement. Data were collected until either 50 passenger car observations were recorded for each direction or one hour had elapsed, whichever occurred first. Spot-speed measurements were also recorded separately for heavy trucks and buses. Video cameras were used to collect volume data during the study. An example of a typical field speed data set up is provided in Figure 8.

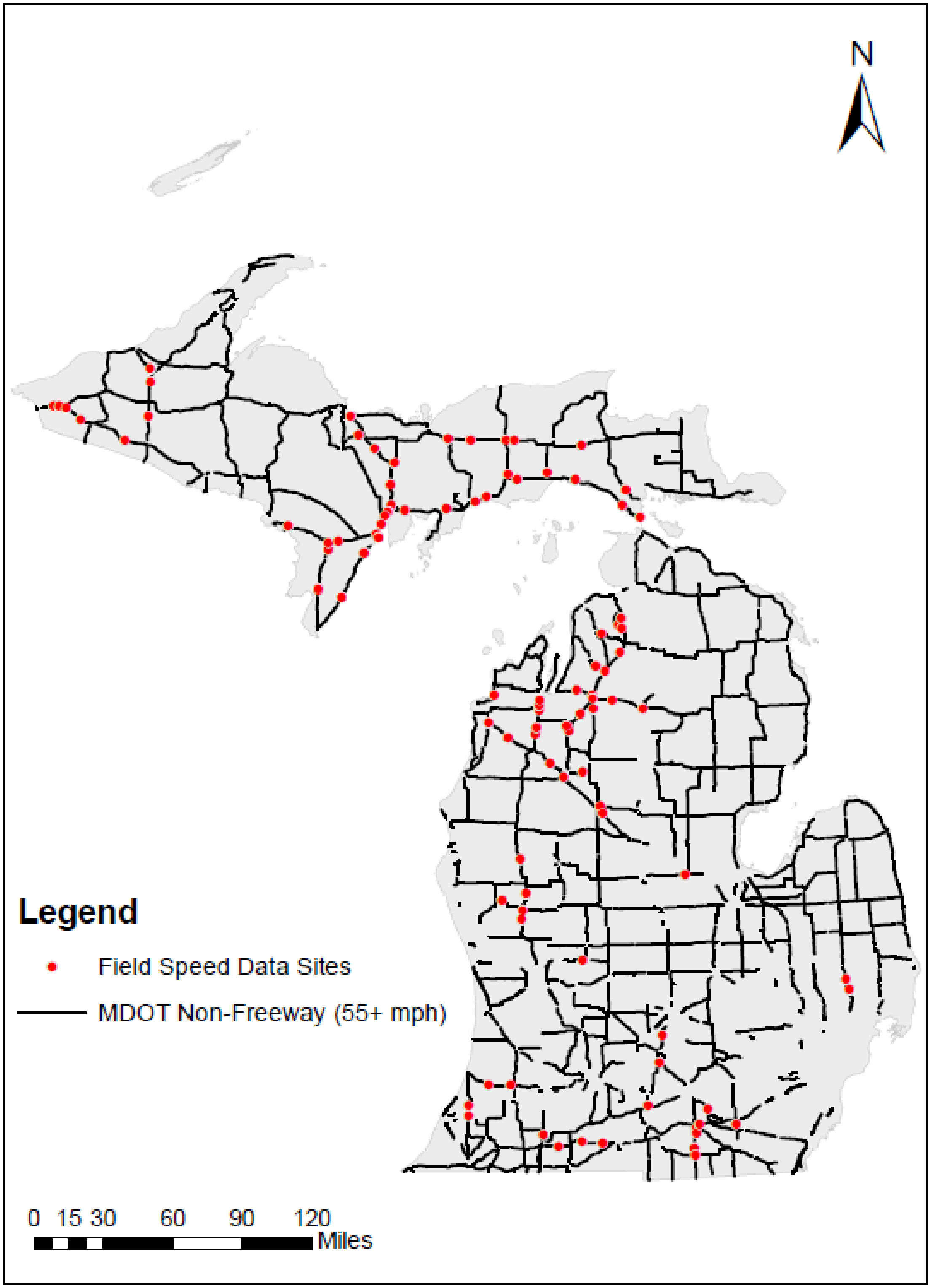


Figure 7. Map of Field Speed Data Measurement Sites

Figure 8. Example Field Observation Setup

In addition to the collection of field speed observations, data collectors also recorded several relevant characteristics of each site which may potentially affect observed speeds, including:

- Posted speed limit at the observation site;
- Presence of a speed reduction zone, including the travel direction to which the speed reduction zone applies;
- Number of travel lanes;
- Presence of a raised median; and
- Presence of a painted median or two-way left-turn lane.

Additionally, these data were combined with the MDOT sufficiency file which was used to acquire additional characteristics related to the upstream roadway and traffic conditions for analysis. The sufficiency file was queried for the segments immediately adjacent to the observation site, as well as within a five mile window in either direction of the observation site. Horizontal curvature and driveway data were also amended to the observed speed data via the methodology described later in this report. Ultimately, these data allowed for the determination of roadway and traffic characteristics occurring either upstream or downstream of each speed observation, including:

- Highway classification;
- Lane width and number of lanes;
- Median type and width;
- Shoulder type and width;
- AADT and commercial AADT estimates;
- Driveway frequency and density; and
- Presence of horizontal curvature.

Once field data collection was completed at all locations, the speed observations were aggregated and sample statistics were calculated. Mean speed, 85th percentile speed, and speed standard deviation were determined for passenger vehicles and heavy vehicles, both separately and combined, as displayed in Table 1. It should be noted that site by site sample statistics, including the percentage of vehicles exceeding the posted speed limit, as well as the percentage of vehicles exceeding the posted speed limit by 5 mph or 10 mph, are provided in Appendix 1.

Table 1. Summary of Field Speed Data

Vehicle Type	Posted Speed Limit (SRZ – Speed Reduction Zone)	Number of Sites	Number of Observations	Mean	85th Pct.	Std. Dev.	Percent Exceeding Speed Limit
Passenger Vehicles	35 MPH - SRZ Inbound	4	163	44.3	51.0	6.87	90.8%
	35 MPH - SRZ Outbound	4	157	46.4	56.6	8.19	93.0%
	40 MPH - SRZ Inbound	7	350	43.8	50.0	6.34	70.6%
	40 MPH - SRZ Outbound	7	350	46.3	52.0	6.02	82.9%
	45 MPH - SRZ Inbound	19	950	48.6	55.0	6.10	67.3%
	45 MPH - SRZ Outbound	19	950	51.1	57.0	5.89	82.8%
	50 MPH - SRZ Inbound	2	100	50.7	59.0	7.95	54.0%
	50 MPH - SRZ Outbound	2	100	51.7	60.0	7.08	53.0%
	55 MPH	**67**	**6,642**	**58.7**	**63.0**	**4.96**	**77.2%**
	65 MPH	1	100	64.5	70.0	5.45	43.0%
Trucks and Buses	35 MPH - SRZ Inbound	4	7	40.7	47.3	6.75	85.7%
	35 MPH - SRZ Outbound	4	12	46.1	51.7	7.09	91.7%
	40 MPH - SRZ Inbound	7	29	40.9	47.6	6.80	48.3%
	40 MPH - SRZ Outbound	7	48	44.6	50.0	5.34	75.0%
	45 MPH - SRZ Inbound	19	94	46.4	53.0	5.69	52.1%
	45 MPH - SRZ Outbound	19	81	48.1	55.0	6.67	66.7%
	50 MPH - SRZ Inbound	2	9	51.7	54.8	2.60	55.6%
	50 MPH - SRZ Outbound	2	9	53.1	59.2	5.58	66.7%
	55 MPH	**67**	**691**	**56.5**	**61.0**	**4.60**	**66.3%**
	65 MPH	1	26	59.2	63.3	5.19	3.8%
All Vehicles	35 MPH - SRZ Inbound	4	170	44.2	51.0	6.88	90.6%
	35 MPH - SRZ Outbound	4	169	46.4	56.0	8.10	92.9%
	40 MPH - SRZ Inbound	7	379	43.6	50.0	6.42	68.9%
	40 MPH - SRZ Outbound	7	398	46.1	52.0	5.96	81.9%
	45 MPH - SRZ Inbound	19	1,044	48.4	55.0	6.10	65.9%
	45 MPH - SRZ Outbound	19	1,031	50.8	57.0	6.00	81.5%
	50 MPH - SRZ Inbound	2	109	50.8	58.8	7.65	54.1%
	50 MPH - SRZ Outbound	2	109	51.8	60.0	6.95	54.1%
	55 MPH	**67**	**7,333**	**58.5**	**63.0**	**4.97**	**76.2%**
	65 MPH	1	126	63.4	70.0	5.78	34.9%

In total, 10,868 speed measurements were obtained across the 100 observation sites. This included a total of 7,333 speed measurements at 67 sites with a posted speed limit of 55 mph, 3,409 speed measurements at 32 speed reduction zone sites, as well as 126 speed measurements at the section of US-2/US-41, which is currently posted at 65 mph. A total of 9,862 and 1,006 speed measurements were taken for passenger vehicles and heavy vehicles, respectively.

For the sites with a posted speed of 55 mph, the aggregate passenger vehicle mean speed was 58.7 mph, with an 85th percentile speed of 63.0 mph. Further, trucks and buses were found to operate at a mean speed of 56.5 mph with an 85th percentile speed of 61.0 mph for those same sites. Approximately 77.2% of passenger vehicles were found to be exceeding the 55 mph speed limit, while 66.3% of trucks and buses were found to exceed the 55 mph speed limit. It should be noted that passenger vehicle speeds tended to vary slightly more than truck and bus speeds, with standard deviations of 5.0 mph and 4.6 mph, respectively.

US-2 / US-41 DIVIDED SEGMENT WITH 65 MPH POSTED LIMIT

The increased operating speeds for the US-2/US-41 65 mph section in the Upper Peninsula likely reflect the higher posted speed limit, as the mean observed speed and 85th percentile for passenger vehicles were 64.5 and 70.0 mph, respectively. This represents mean and 85th percentile speeds that are 5.8 mph and 7.0 mph greater, respectively, compared to the 55 mph sites statewide. Trucks and buses at the 65 mph section maintained a mean speed of 59.2 mph and 85th percentile speed of 63.3 mph, which were 2.7 mph and 2.3 mph greater, respectively, than those observed at the 55 mph sites statewide. While these results do provide some insight as to potential impact of the proposed “Trunk Line General Speed Limit”, they should be interpreted with caution as they may reflect the conditions at the singular 65 mph site in the Upper Peninsula which may not be representative of other MDOT non-freeway trunkline highways. Specifically, this section of highway includes four travel lanes (two in each direction) with a raised median. This is not representative of the MDOT non-freeway trunkline system which involves predominately two-lane, undivided highways. To better control for regional differences, the operating speeds at the 65 mph US-2/US-41 location were compared to all other Superior Region data collection locations with posted speed limits of 55 mph, with the results shown in Table 2.

Table 2. Comparison of Superior Region Operating Speeds – All Vehicles

Speed Limit	Number of Sites	Number of Lanes	Median Type	Field Observed Speeds				
				Obs.	Mean	85th	Std. Dev.	Pct. Exceeding Speed Limit
65	1	4	Divided	126	63.4	70.0	5.8	34.9%
55	25	2	Undivided	2,740	60.0	64.0	4.6	85.9%

The comparison provided in Table 2 demonstrates several potential differences related to the 65 mph posted speed limit. While no direct comparison can be made due to the differing roadway characteristics and relatively small sample, the mean operating speeds observed at the 65 mph site were approximately 3.4 mph greater than the two-lane, undivided 55 mph sites. The 85th percentile speed at the 65 mph site was 6 mph greater than that observed at the two-lane, undivided 55 mph sites. The standard deviation of the 65 mph site was slightly greater than that for the two-lane undivided sites. As expected, the percentage of vehicles exceeding the posted speed limit at the 65 mph site was much lower compared to the undivided Superior Region sites posted at 55 mph.

REGIONAL DIFFERENCES

An important consideration related to the comprehensive study of the existing speed profile is the observed regional differences in operating speeds across the state of Michigan. Given that roadway and traffic characteristics which affect operating speeds vary across MDOT regions, the speed profile within each region is likely to reflect the potential differences in conditions. Therefore, an important consideration in the determination of the potential impact of the proposed "Trunk Line General Speed Limit" involves the investigation of such regional differences. Statewide operating speeds, exclusive of the speed reduction zone and 65 mph sites, are provided by MDOT region for passenger vehicles in Figure 9 and for trucks and buses in Figure 10.

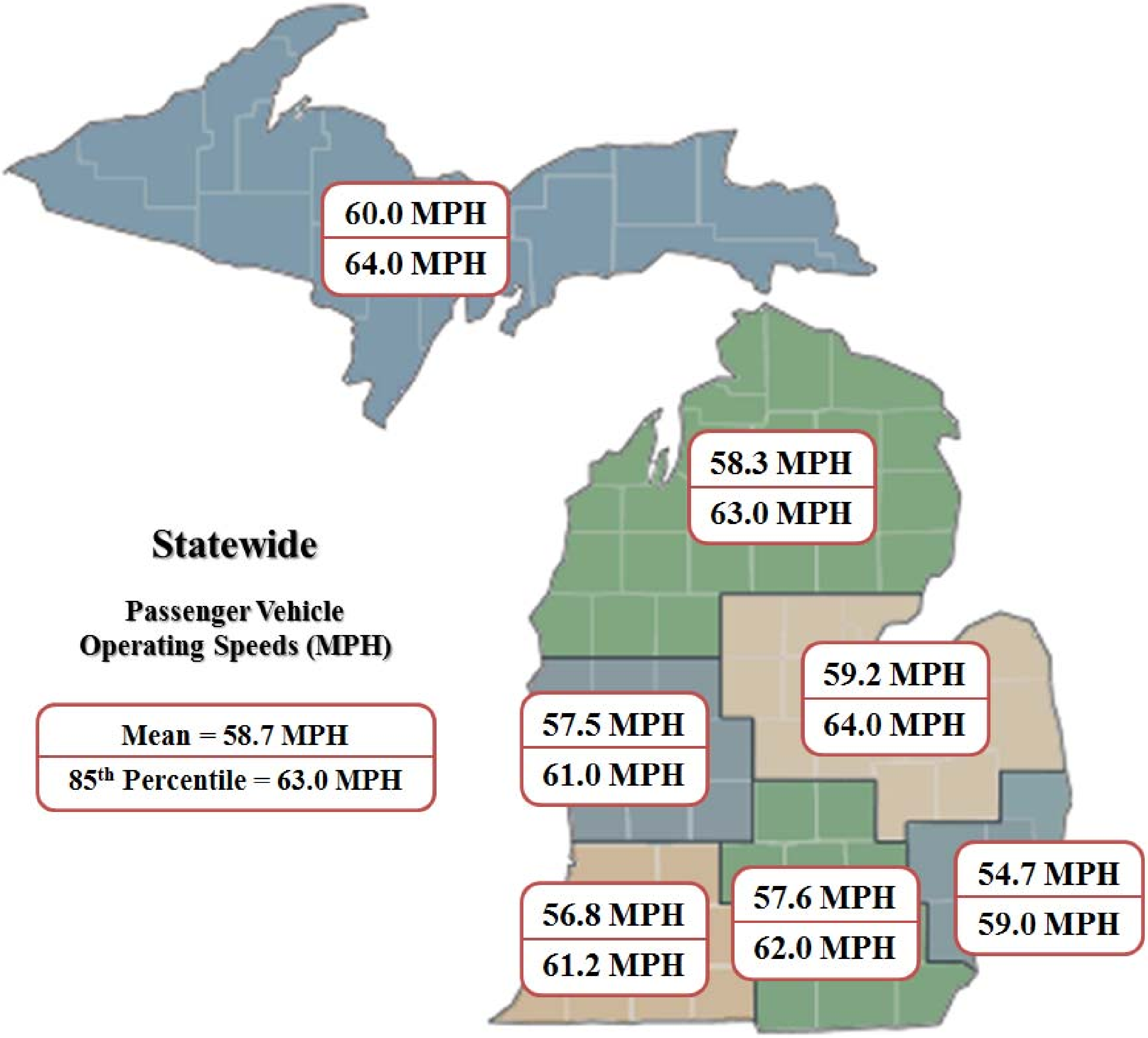


Figure 9. Statewide Non-Freeway Passenger Vehicle Operating Speeds by MDOT Region (55 mph sites only)

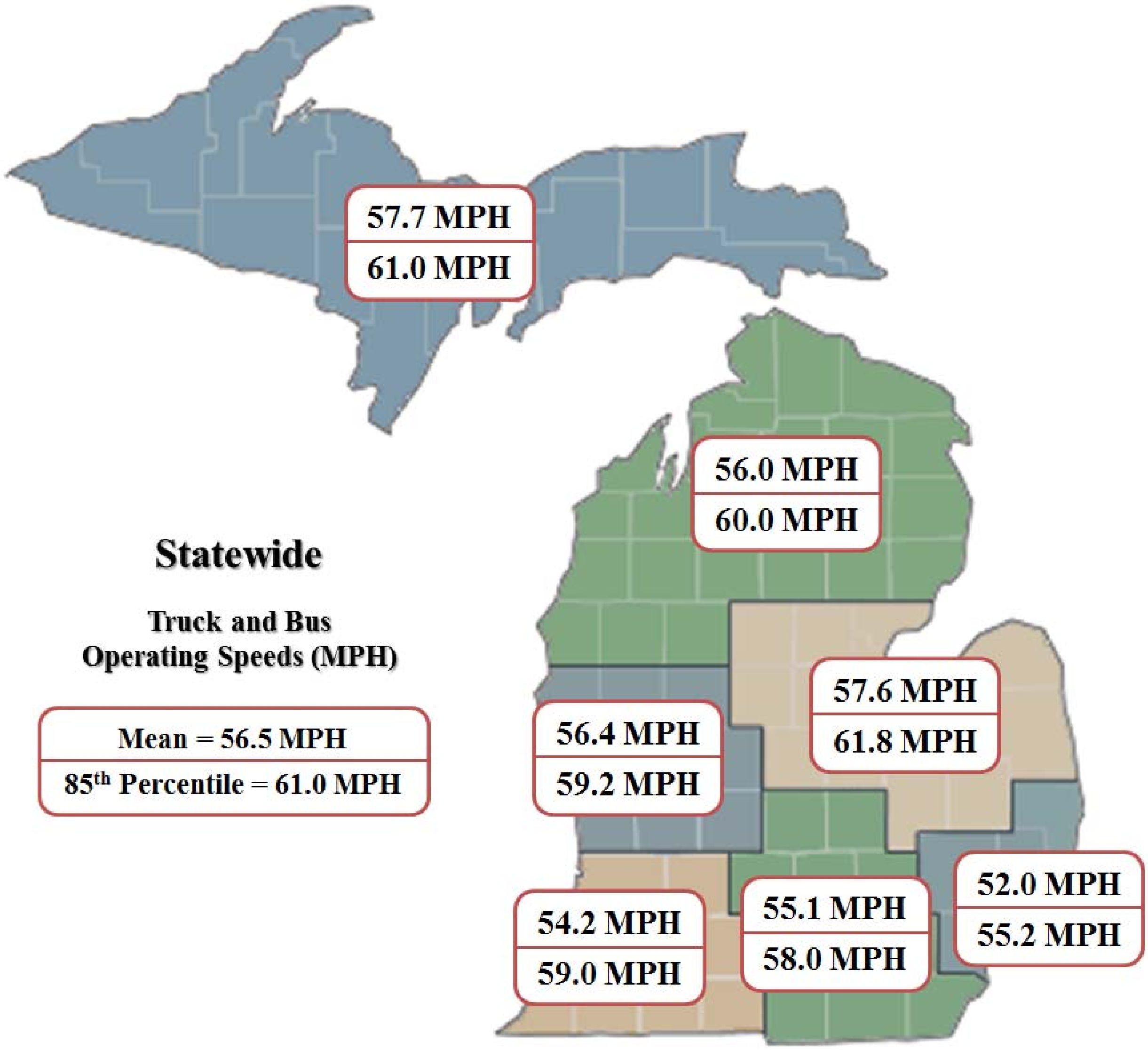


Figure 10. Statewide Non-Freeway Truck/Bus Operating Speeds by MDOT Region (55 mph sites only)

SPEED REDUCTION ZONES

An additional consideration critical to examining driver behavior in relation to the posted speed on non-freeways is the profile of vehicular speeds at speed reduction zones. Speed reduction zones, a common occurrence on Michigan's non-freeway trunkline system, are highway sections where the posted speed limit is reduced as vehicles are approaching a city or town. An example of such a speed reduction zone is provided in Figure 11, as M-86 is reduced from a posted speed limit of 55 mph to 45 mph as westbound traffic approaches the town of Centreville.

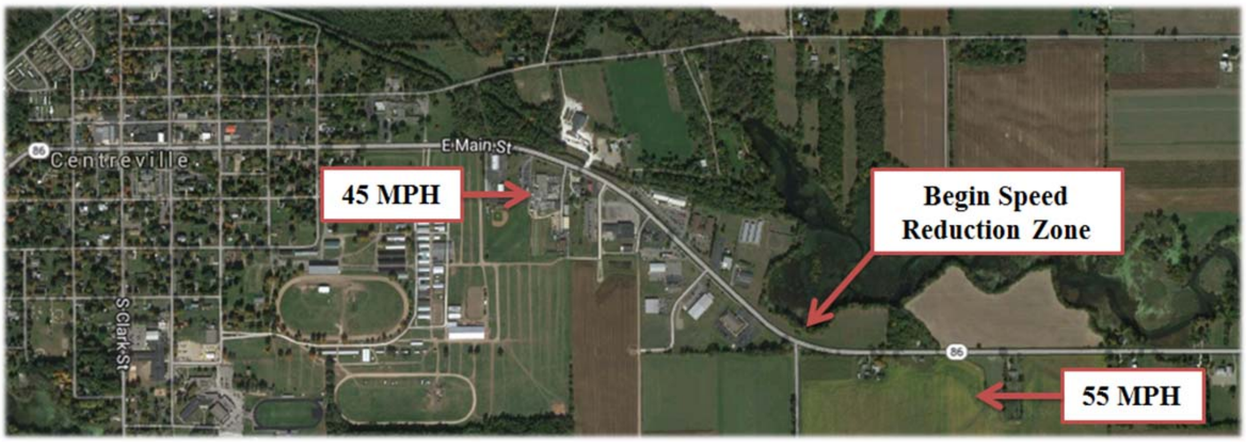


Figure 11. Speed Reduction Zone Site Example

As traffic approaches a city or town from a rural area along routes posted at 55 mph, drivers are informed of the upstream reduction in the posted speed by a *Michigan Manual of Uniform Traffic Control Devices* (MMUTCD) W3-5 or W3-5a sign (shown in Figure 12). A subsequent posted speed limit sign indicates the posted speed limit within the speed reduction zone.

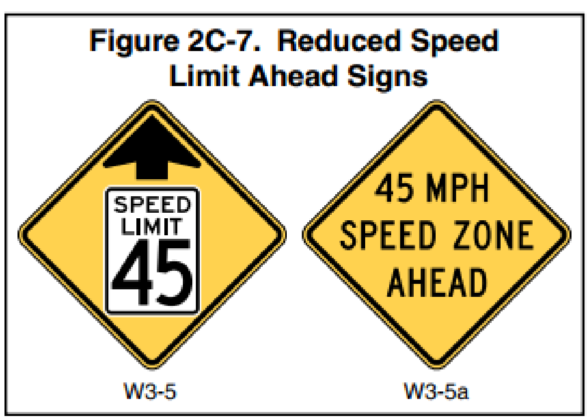
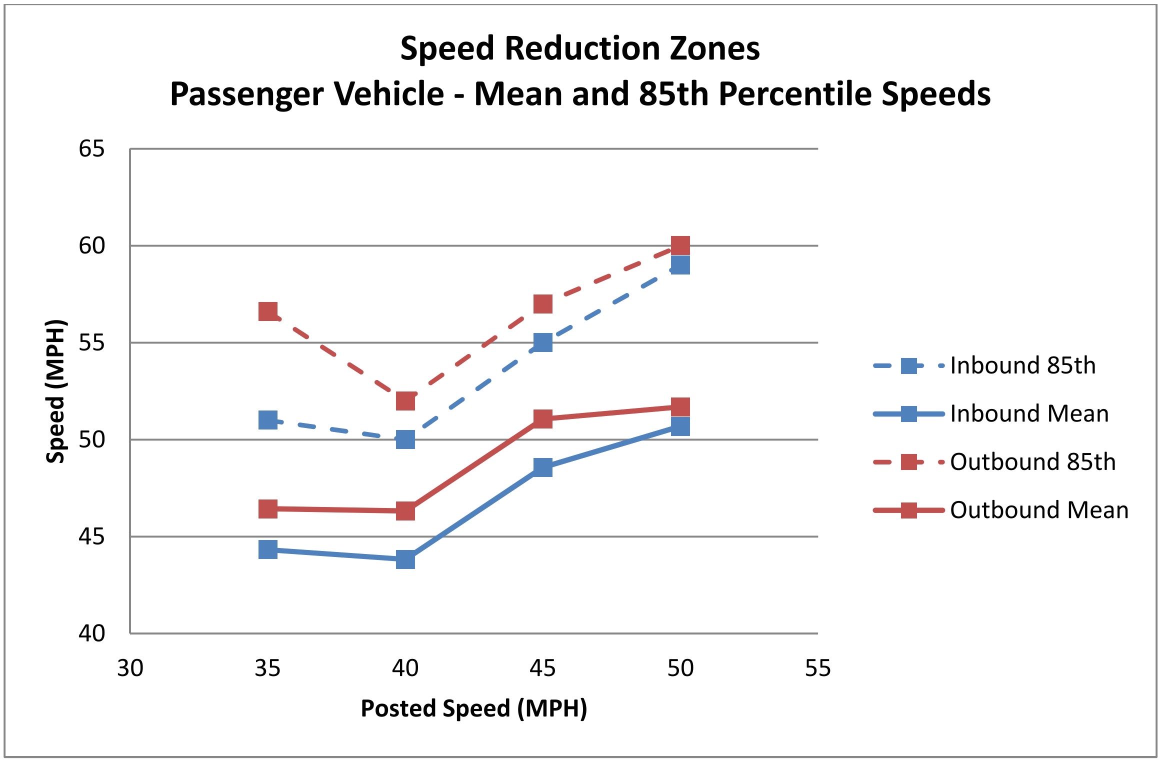


Figure 12. MMUTCD Figure 2-7 Reduced Speed Limit Ahead Signs [*99*]

Field speed measurements were performed as previously described at 32 speed reduction zone observation sites across the state of Michigan. It should be noted that speeds were observed directly at the location of the reduced posted speed limit sign, taking measurements both inbound (towards the reduction zone) and outbound (away from the reduction zone). The speed profile for vehicles inbound or outbound from a speed reduction zone, including mean and 85th percentile of speeds as well as the percentage of vehicles exceeding the speed limit, are shown in Table 3 as well as Figures 13 and 14 for passenger cars and heavy vehicles. It should be noted that speed reduction zones are categorized by the reduced posted speed within the reduction zone.

Table 3. Field Observed Speeds by Speed Reduction Zone Posted Speed

Speed Reduction Zone Posted Speed Limit (Inbound)	Inbound				Outbound			
	Obs.	Mean	85th	Percent Exceeding Speed Limit	Obs.	Mean	85th	Percent Exceeding Speed Limit
35	170	44.2	51.0	90.6%	169	46.4	56.0	92.9%
40	379	43.6	50.0	68.9%	398	46.1	52.0	81.9%
45	1,044	48.4	55.0	65.9%	1,031	50.8	57.0	81.5%
50	109	50.8	58.8	54.1%	109	51.8	60.0	54.1%



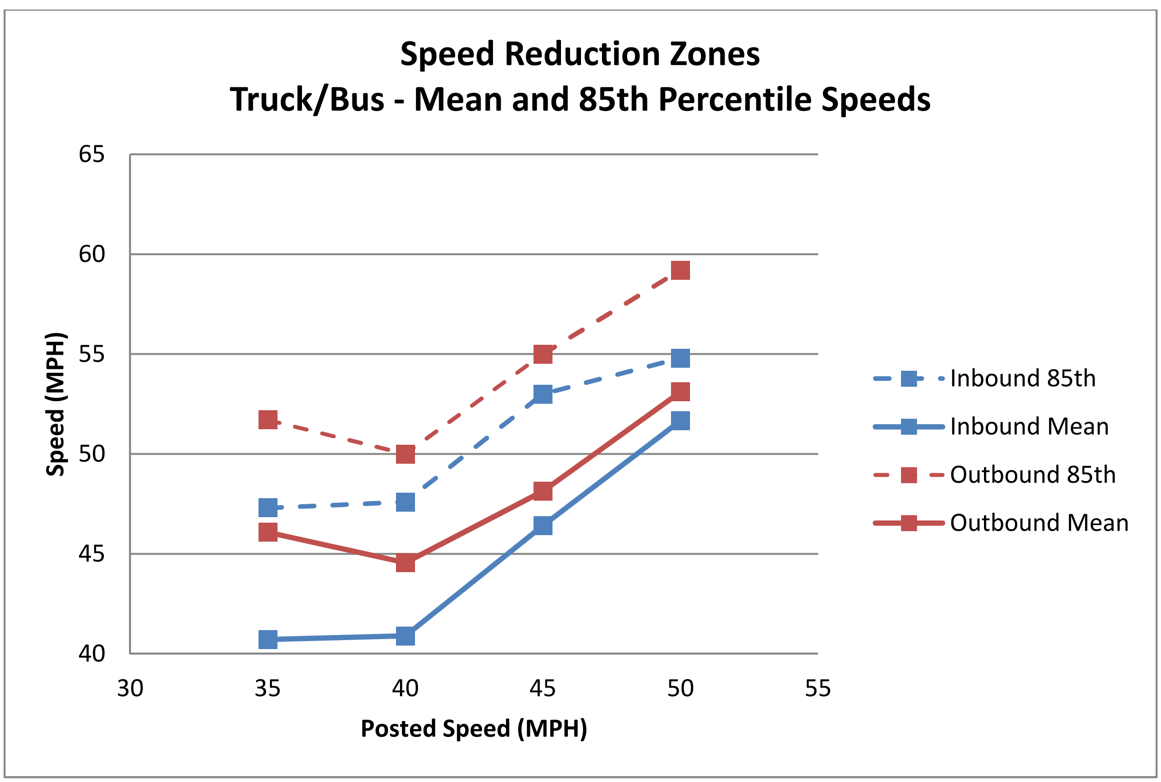
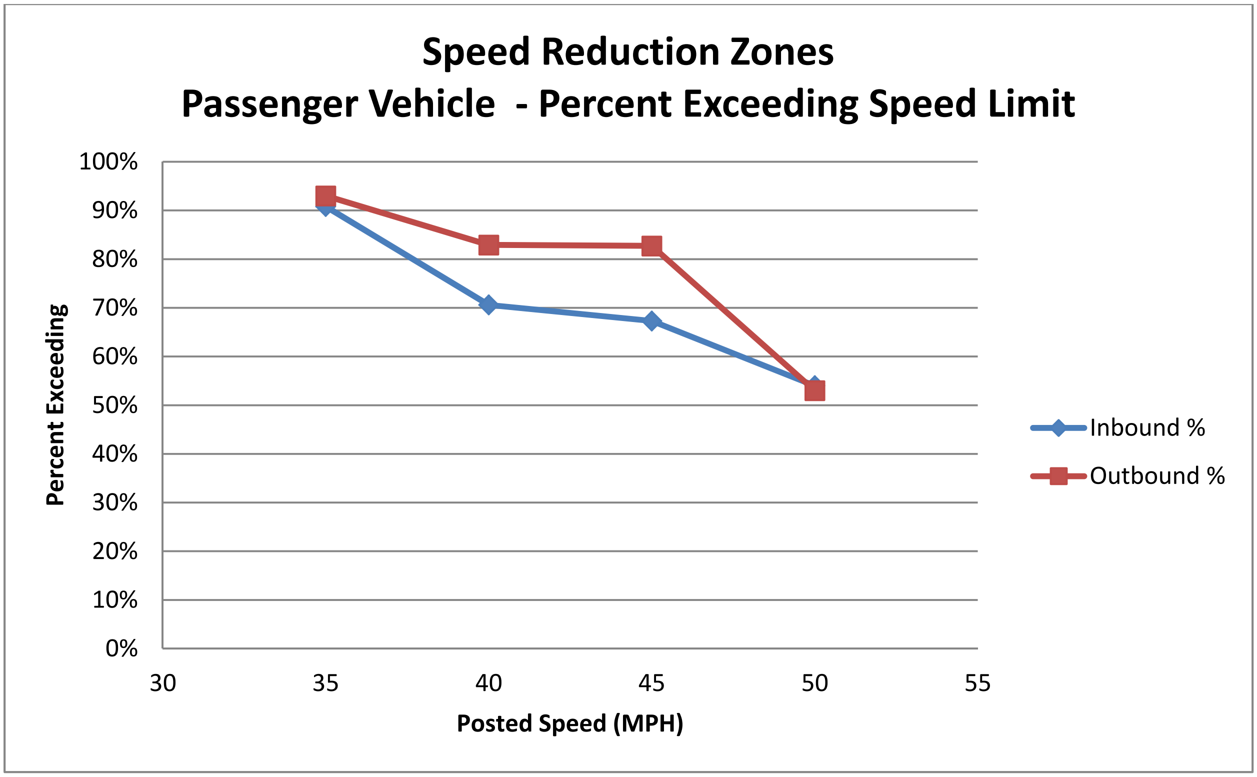


Figure 13. Speed Reduction Zone Mean Speed and 85th Percentile Speed by Posted Speed



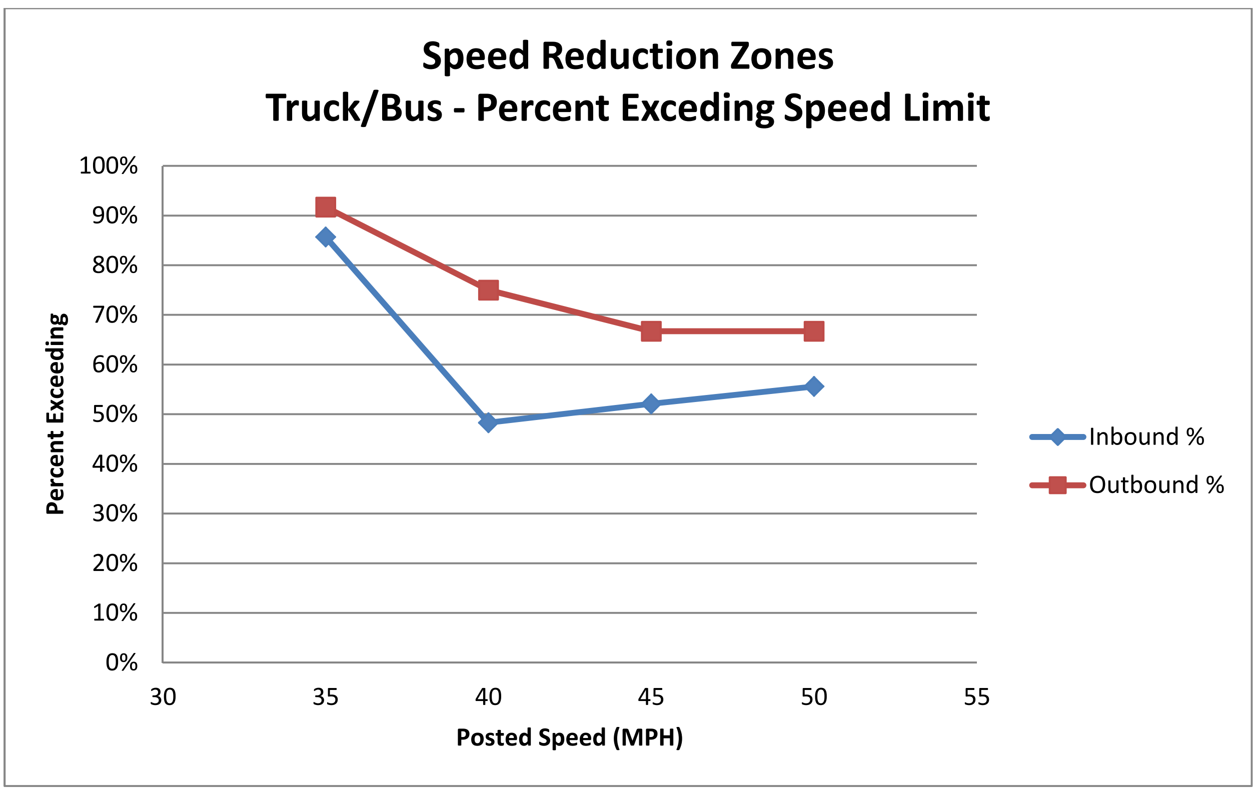


Figure 14. Speed Reduction Zone Percent Exceeding Speed Limit by Posted Speed

Intuitively, the mean and 85th percentile speeds for both vehicle types were consistently greater outbound (exiting the speed reduction zone) than for inbound (entering the speed reduction zone). This is a reflection of inbound drivers reducing their speeds as they exit the 55 mph zone and enter the reduced speed zone, while outbound drivers are increasing speed as they exit the reduced speed zone. Further, these effects are magnified for the sites which involved greater reductions in posted speed limit as compared to the 55 mph general speed limit (i.e. sites marked at 35 mph or 40 mph). This is also reflected in Figure 14 which shows a greater compliance with the speed limit for the sites which involve a smaller reduction in posted speed limit as compared to the 55 mph general speed limit. Passenger cars and heavy vehicles exhibited similar speed change trends in relation to speed reduction zones across all speed limits.

REGRESSION ANALYSIS

In order to develop a comprehensive understanding of the existing speed profile for Michigan's non-freeway network, it was necessary to examine the factors which affect observed speeds on such highways. Therefore, a multiple linear regression model was developed to examine those factors affecting the observed vehicular speeds measured at each location. The vehicular speed measured for each observation *i* is related to a series of covariates in a model of the following form:

$$Y_i = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \cdots + \beta_K X_{K,i}\ , \qquad (1)$$

where:

- Y_i = field measured speed (mph) for each observation *i*;
- β_0 = constant term;
- $\beta_1, \ldots, \beta_K$ = estimable parameters; and
- $X_{1,i}, \ldots, X_{K,i}$ = explanatory variables related to event i.

It should be noted that the model was limited to observations which were collected at sites with a posted speed limit of 55 mph as these sites provide a representative sample of the current operating speeds for Michigan's non-freeway trunkline system. Further, only the explanatory variables which had a statistically significant impact on observed speeds were ultimately included in the model. The linear regression model results are presented in Table 4.

Table 4. Linear Regression Model for 55 MPH Observation Sites (N=7,333)

Variable	Coefficient	Std. Error	P-Value
(Constant)	58.333	0.430	< 0.001
Number of Lanes (0 = 2 Lanes, 1 = 4 Lanes)	1.198	0.370	< 0.001
Painted Median / TWLTL (0 = None, 1 = Yes)	-4.988	0.495	< 0.001
North Region	-1.340	0.165	< 0.001
Grand Region	-1.752	0.278	< 0.001
Bay Region	3.702	0.595	< 0.001
Southwest Region	-3.347	0.254	< 0.001
University Region	-2.255	0.241	< 0.001
Metro Region	-5.479	0.506	< 0.001
Presence of Upstream Horizontal Curves within 5 Miles	-0.295	0.138	0.032
Presence of Upstream Passing Lane	0.304	0.155	0.050
Driveway Density	-0.033	0.007	< 0.001
Shoulder Width	0.148	0.041	< 0.001
Percentage of Commercial Vehicles	0.052	0.018	0.005
Directional Hourly Volume	0.001	0.000	0.021

Note: Superior Region represents baseline. Bay Region only included a single site.

As can be observed in Table 4, several explanatory factors significantly impact the operating speeds observed along Michigan's non-freeway network. Specifically, observed speeds were significantly greater along the multilane highway sites. This is likely a reflection of the functional class of such highways which typically favor less access and increased mobility. In a related manner, the presence of a two-way left-turn lane was correlated with a decrease in observed speeds. This is indicative of the road user experience along such highways where there is less separation from opposing traffic. The regional differences observed within these model results demonstrate the differences in mean speeds across each MDOT region. It should be noted that the coefficient for the Bay region may be inflated due to a smaller sample size of observations within that region.

The presence of any horizontal curve within five miles upstream of an observation site resulted in a significant reduction in observed speeds. While this result is intuitive, since drivers tend to reduce their speed in order to safely navigate horizontal curves, it does help to provide additional insight into the magnitude of this effect. Further, the presence of a passing lane upstream of the observation location tended to result in an increase in the observed speed measurements. The driveway density was also found to be negatively correlated with the observed speed measurements. This result demonstrates that as the number of access points along non-freeway segments increase, the expected vehicular speeds would tend to be reduced.

Additionally, as the width of the right shoulder increased, the observed vehicular speeds also tended to increase. This is again representative of the road user experience along such roadways, as the increased shoulder width provides a greater level of confidence for drivers due to the increased recovery area. The percentage of commercial vehicles also had a positive correlation with observed speeds, which may seem counterintuitive. However, this again is likely reflective of the functional class of the observation as commercial traffic tends to increase on highways of higher functional classifications. Similarly, as the directional hourly volume increases, the operating speeds tend to increase, again indicative of the highways which involve higher functional classifications which typical involve larger traffic volumes.

CHAPTER 4:
CRASH DATA ANALYSIS

In order to appropriately examine the expected impact of a 65 mph speed limit on Michigan's non-freeway network, it is critical to have a thorough understanding of the existing state of safety on such highways. Historical traffic crash data is also a critical component for identifying lower risk highway segments for a potential speed limit increase. Further, the expected economic benefit or disbenefit analysis for Michigan's road users should carefully consider the impact such an increase would have on the frequency or severity of traffic crashes. Therefore, the collection and analysis of historical traffic crash data for Michigan's non-freeway network was a central component to this study.

A comprehensive safety analysis was conducted using historical crash data from 2004 through 2013 for MDOT non-freeway roadways throughout Michigan. This analysis served several important purposes. First, the resultant statistical models provide details of how crash rates vary with respect to traffic volume and various roadway geometric data. These relationships are important when trying to ascertain the potential impacts of speed limit policy changes. To this end, these statistical models also provide tools that can be used by MDOT as part of a risk assessment process. This process could include examining the potential safety impacts of speed limit changes or identifying potential high-risk segments that would be least suitable for speed limit increases.

DATA COLLECTION

Data were collected for all non-freeway segments across the state for the ten-year period from 2004 through 2013. For each year, segment information was obtained from the MDOT sufficiency file, including:

- County and MDOT region
- Route designation and number
- Lane width and number of lanes
- Shoulder type and width
- Median type and width

- AADT and commercial AADT estimate (ten year average)
- Predominant posted speed limit
- Presence of a passing lane or signalized intersection within the segment
- Length of no-passing zone within the segment

These data were supplemented by additional sources, which included a geocoded driveway/access point database provided by MDOT, a horizontal curve database developed as a part of this project using GIS segment data, statewide elementary and middle school locations, and crash data from the Michigan State Police crash database.

For analysis purposes, two datasets were created. The first included details of all high-speed (posted at 55 mph and above), divided facilities with partial or no access control. These data are provided for each directional segment (i.e., separate records are maintained for each opposing direction of the divided facility). The dataset includes approximately 460 directional miles (i.e., 230 centerline miles) of divided highways over a total of 3,365 roadway segments.

The second database was comprised of high-speed (posted at 55 mph) undivided facilities, which included two-lane and four-lane segments. This sample included segments with passing relief lanes, as well as segments with continuous two-way left-turn lanes. The dataset includes approximately 6,000 miles of undivided highways over a total of 19,352 roadway segments.

Summary statistics for the samples of divided and undivided road segments are provided in Table 5. In general, the divided segments carried greater average daily traffic volumes (mean of 9,234 vehicles per day) than did the undivided segments (mean of 5,781 vehicles per day). The divided segments averaged 9.91 crashes per segment per year while the undivided segments averaged 12.70 crashes per segment per year.

Table 5. Summary Statistics for High-Speed Non-Freeways by Segment Type

	Divided (N=3,365)		Undivided (N=19,352)	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Segment Length (mi)	1.36	1.12	3.03	2.73
Annual Average Daily Traffic (veh/day)	9,233.71	5,898.01	5,781.38	4,673.71
Commercial AADT (veh/day)	490.63	313.28	338.10	282.46
Percent Trucks	0.06	0.04	0.07	0.04
Passing Lane Present	N/A	N/A	0.08	0.28
Percent No-Passing Zones	N/A	N/A	20.42	24.83
Two-Way Left-Turn Lane	N/A	N/A	0.07	0.26
Two Lanes	0.94	0.23	0.93	0.26
Three Lanes	0.03	0.18	N/A	N/A
Four Lanes	0.02	0.15	0.07	0.26
Urban Area	0.75	0.43	0.18	0.38
Rolling Terrain	1.03	0.17	1.39	0.49
Bay Region	0.10	0.30	0.16	0.36
Grand Region	0.28	0.45	0.10	0.30
Metro Region	0.13	0.34	0.02	0.15
North Region	0.01	0.10	0.24	0.43
Southwest Region	0.17	0.38	0.14	0.35
Superior Region	0.11	0.31	0.20	0.40
University Region	0.20	0.40	0.14	0.34
0-5 Access Points Per Mile	0.66	0.47	0.13	0.34
5-10 Access Points Per Mile	0.18	0.38	0.19	0.39
10-15 Access Points Per Mile	0.09	0.29	0.23	0.42
15-20 Access Points Per Mile	0.05	0.21	0.15	0.36
20-25 Access Points Per Mile	0.01	0.10	0.11	0.32
25-30 Access Points Per Mile	<0.01	0.06	0.07	0.25
30-35 Access Points Per Mile	<0.01	0.05	0.04	0.20
35-40 Access Points Per Mile	N/A	N/A	0.02	0.15
40-45 Access Points Per Mile	N/A	N/A	0.02	0.15
45-50 Access Points Per Mile	N/A	N/A	0.01	0.11
50+ Access Points Per Mile	N/A	N/A	0.02	0.13
Percent of Segment with R < 2640 ft	0.13	0.27	0.07	0.17
Percent of Segment with R < 1922 ft	0.06	0.21	0.04	0.13
Percent of Segment with R < 1568 ft	0.04	0.15	0.03	0.10
Percent of Segment with R < 1267 ft	0.02	0.11	0.02	0.08
Percent of Segment with R < 1008 ft	0.01	0.10	0.01	0.06
Percent of Segment with R < 797 ft	0.01	0.07	0.01	0.04
Percent of Segment with R < 612 ft	<0.01	0.05	<0.01	0.03
Percent of Segment with R < 464 ft	<0.01	0.05	<0.01	0.02
Total Annual Crashes on Segment	9.91	13.08	12.70	12.16

STATISTICAL METHODS

Once the database was assembled, a series of negative binomial regression models were estimated to examine how the annual number of crashes for a given segment changed as a function of segment characteristics. The negative binomial is a generalized form of the Poisson model. In the Poisson regression model, the probability of road segment *i* experiencing y_i crashes during a specific period (generally one year) is given by:

$$P(y_i) = \frac{EXP(-\lambda_i)\lambda_i^{y_i}}{y_i!},$$

where $P(y_i)$ is probability of segment *i* experiencing y_i crashes during the period and λ_i is equal to the segment's expected number of crashes, $E[y_i]$. Poisson regression models are estimated by specifying this Poisson parameter λ_i as a function of explanatory variables. The most common functional form of this equation is λ_i = EXP(βX_i), where X_i is a vector of explanatory variables (e.g., AADT, segment length, etc.) and β is a vector of estimable parameters.

The negative binomial model is derived by rewriting the Poisson parameter for each segment *i* as λ_i = EXP($\beta X_i + \varepsilon_i$), where EXP($\varepsilon_i$) is a gamma-distributed error term with mean 1 and variance α. The addition of this term allows the variance to differ from the mean as $VAR[y_i] = E[y_i] + \alpha E[y_i]^2$. The α term is also known as the over-dispersion parameter, which is reflective of the additional variation in crash counts beyond the Poisson model (where α is assumed to equal zero, i.e., the mean and variance are assumed to be equal). For both the divided and undivided segments, there was strong evidence of overdispersion. This is reflected by the summary statistics in Table 5, as well as the fact that the negative binomial model provided significantly improved fit as compared to the Poisson model for both datasets.

RESULTS AND DISCUSSION

Tables 6-8 provide results of the negative binomial regression models for directional divided roadways for total crashes, injury crashes, and fatal crashes. Similarly, Tables 9-11 provide results of the negative binomial regression models for undivided roadways for total crashes, injury crashes, and fatal crashes. Each model includes those variables that were statistically significant at a 95-percent confidence level or greater. For each variable, the resulting parameter estimate, standard error, t-statistic, and p-value are provided. When examining these results, a positive parameter estimate implies that an increase in that specific variable is associated with an increase in crashes while a negative parameter estimate implies that crashes have an inverse relationship with a specific variable.

For the directional divided segments, total and injury crashes increased in a nearly elastic manner with respect to traffic volume. A one-percent increase in traffic volume was associated with an approximately 0.9-percent increase in total and injury crashes on average. It should be noted that fatal crashes tended to be less related to traffic volume, as a one-percent increase in traffic volume was associated with an approximate 0.38 percent increase in fatal crashes. Crashes tended to be higher on segments located in urban areas, with this effect being more pronounced as the level of crash severity increases. For total and injury crashes, divided roadways in the Grand Region tended to observe more crashes than those in other regions. Similarly, the Bay and Southwest regions tended to observe less total and injury crashes than the divided facilities in other regions.

Several geometric characteristics also had a significant impact on the safety performance of such roadways. Divided segments which included four travel lanes tended to observe fewer total and injury crashes as compared to three lane segments. The number of access points per mile also had a significant impact on the frequency of total and injury crashes. Divided segments which involved 10-20 access points per mile observed an approximate 24-percent increase in total crashes and an approximate 27-percent increase in injury crashes. Further, divided segments which involved greater than 20 access points per mile observed an approximate 73-percent increase in total crashes and an approximate 96-percent increase in injury crashes. This is in general agreement with the prior research in this area which has shown driveway density to have a significant impact on the safety performance of such highways with affects more pronounced for roadways with driveway densities greater than 20 driveways per mile [*94*]. The presence of horizontal curvature also had a significant impact on the observed safety performance of these roadways, as an increase in the proportion of each segment which involved horizontal curvature was associated with an increase in total and injury crashes. Further, the magnitude of this effect increased as threshold for horizontal curvature decreased.

Table 6. Negative Binomial Total Crash Model for High-Speed, Directional Divided Road Segments

Variable	Parameter Estimate	Standard Error	t-statistic	p-value
(Intercept)	-6.68	0.2074	1,037.579	<0.001
LN(Annual Average Daily Traffic)	0.922	0.0234	1,545.966	<0.001
Four Lanes	-0.517	0.0822	39.569	<0.001
Grand Region	0.155	0.0309	25.041	<0.001
Bay Region	-0.317	0.048	43.689	<0.001
Southwest Region	-0.171	0.0395	18.762	<0.001
Urban Area	0.296	0.0347	73.078	<0.001
10-20 Access Points Per Mile	0.211	0.0349	36.799	<0.001
Over 20 Access Points Per Mile	0.549	0.0862	40.568	<0.001
Percent of Segment w/ Radii less than 2,640 ft.	0.209	0.0807	6.696	0.01
Percent of Segment w/ Radii less than 1,922 ft.	0.265	0.1084	5.955	0.015
Percent of Segment w/ Radii less than 1,008 ft.	0.922	0.1496	37.985	<0.001
Overdispersion parameter	0.312	0.0117	-	-

Table 7. Negative Binomial Injury Crash Model for High-Speed, Directional Divided Road Segments

Variable	Parameter Estimate	Standard Error	t-statistic	p-value
(Intercept)	-8.399	0.3304	646.208	<0.001
LN(Annual Average Daily Traffic)	0.895	0.0369	589.472	<0.001
Four Lanes	-0.485	0.1229	15.6	<0.001
Grand Region	0.295	0.045	43.02	<0.001
Bay Region	-0.286	0.0795	12.941	<0.001
Southwest Region	-0.175	0.0649	7.249	0.007
Urban Area	0.633	0.056	128.001	<0.001
10-20 Access Points Per Mile	0.239	0.0532	20.13	<0.001
Over 20 Access Points Per Mile	0.672	0.1203	31.234	<0.001
Percent of Segment w/ Radii less than 1,922 ft.	0.653	0.1305	25.034	<0.001
Percent of Segment w/ Radii less than 1,008 ft.	1.039	0.237	19.243	<0.001
Overdispersion parameter	0.427	0.0264	-	-

Table 8. Negative Binomial Fatal Crash Model for High-Speed, Directional Divided Road Segments

Variable	Parameter Estimate	Standard Error	t-statistic	p-value
(Intercept)	-7.813	1.4719	28.176	<0.001
LN(Annual Average Daily Traffic)	0.384	0.1661	5.334	0.021
Urban Area	0.875	0.2664	10.781	0.001
Overdispersion parameter	0.363	0.7975	-	-

Tables 9-11 present similar results for the high-speed, undivided road segments for total, injury, and fatal traffic crashes. For the undivided segments, injury and fatal crashes increased in a nearly elastic manner with respect to traffic volume. A one-percent increase in traffic volume was associated with an approximate 0.99-percent increase in injury crashes and 0.95-percent increase in fatal crashes on average. It should be noted that total crashes tended to be less related to traffic volume, as a one-percent increase in traffic volume was associated with an approximate 0.64 percent increase in total crashes. The percentage of commercial trucks within the traffic stream was associated with an increase in observed crashes across all severity levels. Further, this effect was more pronounced as the level of crash severity increases. The Grand, University, Bay, and Southwest regions tended to observe more crashes across all severity levels (as compared to the Superior and North regions). It should be noted that the Metro region tended to observe more total crashes (as compared to the Superior and North regions), however; this effect was not consistent across all severity levels. Roadways located within urban areas also tended to observe more total and injury crashes as compared to undivided facilities located within rural areas. The count of school facilities within 1,500 ft of each undivided segment tended increase the number of observed total and injury crashes.

Geometric characteristics again played a significant role in the safety performance of undivided facilities in Michigan. The presence of a two-way left-turn lane was associated with a significant increase in total and injury crashes, however; the presence of a two-way left-turn lane was also associated with a significant decrease in fatal crashes. Four lane, undivided facilities tended to observe significantly more crashes across all severity levels as compared to two-lane, undivided facilities. Further, this effect becomes more pronounced as the level of crash severity increases. The presence of horizontal curvature also tended to increase the observed number of injury and fatal crashes on undivided facilities, despite the fact that it did not play a significant role in the observed number of total crashes.

Similar to divided facilities, the density of access points significantly affected the safety performance of undivided roadways across all severity levels. Undivided segments which involved 5-15 access points per mile tended to observe approximately 20-percent more total crashes than those segments with less than five access points per mile. Further, undivided segments which involved greater than 15 access points per mile were associated with increases in observed crashes across all severity levels. Rolling terrain also generally increased crashes undivided highways.

Another consideration specific to the safety performance of undivided highways is the presence of no-passing zones as well as the availability of exclusive passing lanes. As the proportion of each segment with no-passing zones increases, the frequency of total and injury crashes also tended to increase. The presence of an exclusive passing lane along undivided roadway segments was associated with a decrease in the observed number of total and injury crashes. It should be noted that no-passing zones and passing lanes were not found to have a significant relationship with fatal crashes along the same undivided facilities.

Table 9. Negative Binomial Total Crash Model for High-Speed, Undivided Road Segments

Variable	Parameter Estimate	Standard Error	t-statistic	p-value
(Intercept)	-4.283	0.06	5,103.084	<0.001
LN(Annual Average Daily Traffic)	0.636	0.0068	8,751.595	<0.001
Percent No-Passing Zones	0.001	0.0002	42.762	<0.001
Passing Lane Present	-0.06	0.0151	15.706	<0.001
Rolling Terrain	0.032	0.0094	11.905	0.001
Urban Area	0.349	0.0127	756.387	<0.001
Two-Way Left-Turn Lane	0.209	0.0204	105.125	<0.001
Four Lanes	0.106	0.02	28.134	<0.001
Grand Region	0.219	0.0146	225.164	<0.001
University Region	0.122	0.0132	85.347	<0.001
Metro Region	0.118	0.0287	16.866	<0.001
Bay Region	0.116	0.0125	85.85	<0.001
Southwest Region	0.117	0.013	81.829	<0.001
Percent Trucks	0.799	0.1059	56.882	<0.001
Count of School Facilities	0.038	0.0084	20.763	<0.001
5-15 Access Points Per Mile	0.185	0.0142	169.49	<0.001
Over 15 Access Points Per Mile	0.214	0.0147	213.113	<0.001
Overdispersion parameter	0.181	0.003	-	-

Table 10. Negative Binomial Injury Crash Model for High-Speed, Undivided Road Segments

Variable	Parameter Estimate	Standard Error	t-statistic	p-value
(Intercept)	-9.163	0.1093	7,022.015	<0.001
LN(Annual Average Daily Traffic)	0.985	0.0122	6,471.485	<0.001
Percent No-Passing Zones	0.004	0.0004	119.582	<0.001
Passing Lane Present	-0.062	0.0252	5.989	0.014
Rolling Terrain	-0.044	0.0159	7.762	0.005
Urban Area	0.443	0.0197	505.573	<0.001
Two-Way Left-Turn Lane	0.105	0.0319	10.88	0.001
Four Lanes	0.199	0.0306	42.415	<0.001
Grand Region	0.231	0.0229	101.831	<0.001
University Region	0.17	0.0207	67.767	<0.001
Bay Region	0.105	0.0205	26.441	<0.001
Southwest Region	0.156	0.021	55.089	<0.001
Percent Trucks	1.051	0.188	31.261	<0.001
Count of School Facilities	0.033	0.013	6.519	<0.001
Percent of Segment w/ Radii less than 1,922 ft.	0.224	0.0886	6.402	0.011
Percent of Segment w/ Radii less than 1,008 ft.	1.042	0.2025	26.446	0.011
Over 15 Access Points Per Mile	0.141	0.0146	92.913	<0.001
Overdispersion parameter	0.173	0.0073	-	-

Table 11. Negative Binomial Fatal Crash Model for High-Speed, Undivided Road Segments

Variable	Parameter Estimate	Standard Error	t-statistic	p-value
(Intercept)	-12.426	0.4499	762.891	<0.001
LN(Annual Average Daily Traffic)	0.954	0.0496	369.502	<0.001
Rolling Terrain	0.161	0.0596	7.292	0.007
Two-Way Left-Turn Lane	-0.446	0.1555	8.21	0.004
Four Lanes	0.409	0.134	9.324	0.002
Grand Region	0.299	0.0945	10.038	0.002
University Region	0.277	0.0866	10.247	0.001
Bay Region	0.186	0.0852	4.77	0.029
Southwest Region	0.364	0.0847	18.449	<0.001
Percent Trucks	2.035	0.7532	7.299	0.007
Percent of Segment w/ Radii less than 1,008 ft.	1.669	0.7615	4.806	0.028
Over 15 Access Points Per Mile	0.132	0.0611	4.651	0.031
Overdispersion parameter	0.106	0.1107	-	-

CHAPTER 5:
PRIORITIZATION OF CANDIDATE NON-FREEWAY SEGMENTS

An important consideration related to the potential enactment of the "Trunk Line General Speed Limit" is the fact that not all segments of a particular highway class are likely to be acceptable candidates for a speed limit increase. This is because certain critical roadway or traffic characteristics may not be adequately designed to accommodate such an increase in speed limits. Therefore, appropriate implementation of a proposed "Trunk Line General Speed Limit" on the MDOT non-freeway trunkline network would likely involve implementation of a prioritization procedure to identify candidate highway segments that likely pose lower risks if the speed limit was raised from 55 mph to 65 mph. Therefore, a critical component to this study involved the prioritization of MDOT trunkline highway segments with a speed limit currently posted at 55 mph. A map of the 55 mph non-freeway trunkline network is displayed in Figure 15.

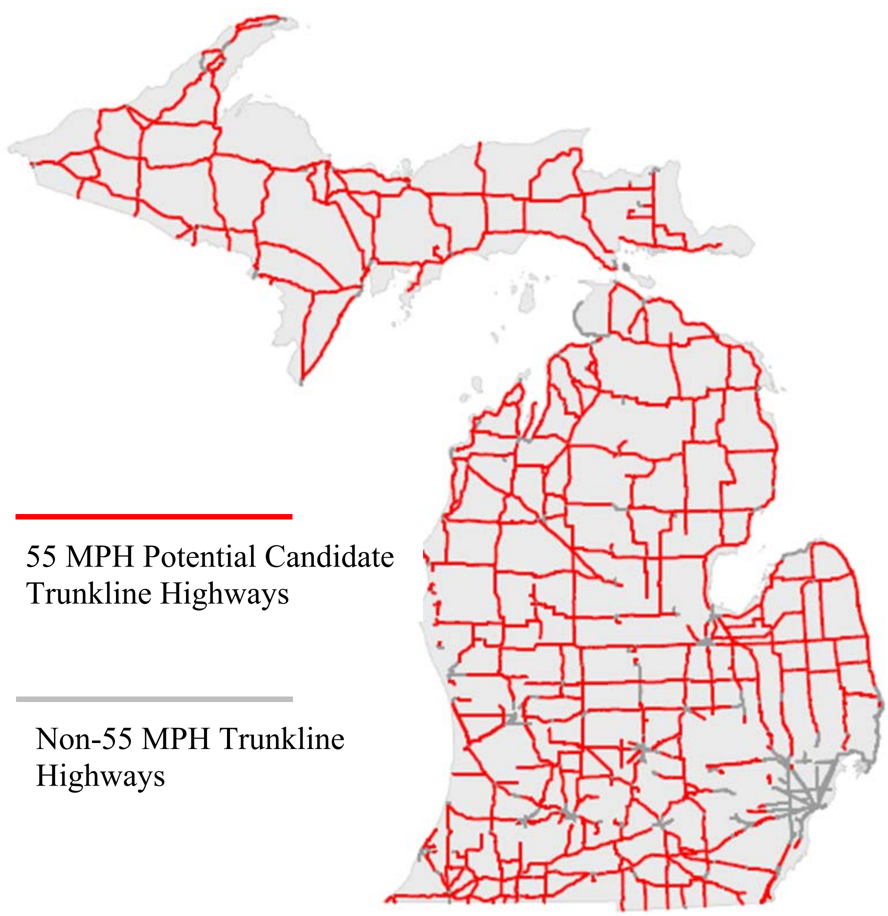


Figure 15. Potential Candidate 55 mph Non-Freeway MDOT Trunkline Highways

PRIORITIZATION CRITERIA

In order to determine MDOT trunkline highway segments currently posted at 55 mph which pose a lower risk for a potential increase to 65 mph, it was initially necessary to determine selection criteria to identify such segments. MDOT initially identified several potential factors that may be utilized when considering a particular highway segment for a potential speed limit increase [*100, 101*]. These factors included:

- Assessment of the current operating speeds (specifically 85th percentile),
- Comparison of the historical crash rates with the statewide average,
- Horizontal and vertical curvature,
- Population and/or driveway density,
- Average daily traffic and commercial average daily traffic,
- Level of service,
- Recent speed limit increase,
- Presence of pedestrians or bicyclists,
- Access points per mile,
- Within cities or villages,
- Passing opportunities,
- Lane width,
- Paved shoulder width,
- Total shoulder width, and
- Presence of school zone speed limits.

Several of these characteristics provided the basis for development of segment selection criteria for the purposes of determining low risk candidate segments for a 65 mph segment increase. Further, selection criteria were also determined after careful consideration of the research literature outlined in Chapter 2. It is important to note that the selection criteria developed as a part of this prioritization process focused on utilization of available systemwide data. Certain additional elements of candidate roadways should be investigated subsequent to the prioritization process, as outlined later in this chapter. In order to provide a comprehensive list of possible candidates for further investigation, the criteria were conservatively established in order to not be overly exclusive. The selection criteria utilized as a part of the prioritization process are summarized in Table 12 with support provided as follows:

- <u>Ten Year Historical Crash Rate:</u> The statewide 10-year average of the total, injury, and severe (fatal + A injuries) crash rates were calculated for all MDOT non-freeway trunklines posted at 55 mph. Separate statewide crash rates were calculated for undivided and divided roadways. These statewide averages were used as the primary initial criteria for inclusion of a non-freeway segment for further consideration. As increasing speed limits are expected to increase crash rates and crash severity [*57*], utilization of the statewide averages for total, injury, and severe crashes provides a reasonable threshold for exclusion of segments with poor safety performance at the current speed limit.

- Horizontal Curvature: The location, radii, and overall length of horizontal curves were determined for each roadway segment based on the process described in Chapter 4. This data was used to provide a count of curves with radii that were less than the minimum MDOT 3R design speed requirement for horizontal alignment assuming a 65 mph project speed limit. According to MDOT 3R Design Guidelines, 3R projects are afforded a 15 mph design speed allowance for horizontal alignment. Thus, for a 65 mph 3R project speed limit, horizontal curve radii must comply with 55 mph and 50 mph design speeds on NHS and non-NHS roadways, respectively [*98*]. Assuming the maximum superelevation of 7 percent, these design speeds translate to minimum curve radii of 1,008 ft and 797 ft for NHS and non-NHS 3R projects, respectively. Due to the increased risk for lane-departure crashes and the excessive costs associated with realigning substandard horizontal curves [*57*], roadway segments that included any horizontal curves with radii falling below the minimum 3R design threshold were subsequently removed from consideration.
- Speed Reduction Zones: In order to address the presence of incorporated cities or villages within each segment, the percentage of the overall segment length posted below 55 mph was determined. A threshold of 25 percent was determined to identify segments which included a significant proportion of mileage within incorporated areas. The 25 percent threshold was deemed appropriate as it will be desirable to minimize the implementation of 65 mph speed limits near speed reduction zones due to the likely increase in speeds (and potential crash risk) within the speed reduction zones.
- Presence of K-8 Schools: Given that systemwide data for the presence of school speed limit reduction zones was not readily available in a geocoded format, the count of K-8 school facilities within 1,500 ft. feet of each segment was utilized as a proxy measure and determined based on the process described within Chapter 4. Similar to municipal speed reduction zones, observed speeds in school zones are closely related to the posted speed limit on the adjacent roadway. Thus, it is desirable to avoid school areas when

considering segments on which the speed limit will be increased. To that end, segments which included one or more K-8 school facilities within 1,500 ft. were precluded from additional consideration.

- Signalized Intersections: The number of signalized intersections within each non-freeway segment was determined based on MDOT sufficiency data. Given the relationship between the presence of intersections and the safety performance of non-freeway highways described in Chapter 2, a threshold of 1.0 signalized intersection per 10 miles was considered a reasonable threshold to preclude an undivided segment from consideration. As the signal density was much greater for divided non-freeway segments, this threshold was reduced to 1.0 signalized intersection per two miles during prioritization of divided non-freeway roadways.
- Access Point Density: The number of access points per mile for each non-freeway segment was determined via the process described in Chapter 4. It should be noted that access points were defined as all commercial, residential, industrial, or other driveway types adjacent to the non-freeway network as provided by MDOT. As noted within the literature review and again within the MDOT non-freeway traffic crash analysis, access point density has been shown to have a significant negative impact on the safety performance of such highways at nearly all levels. However, this relationship is exacerbated at greater access point densities, as crash rates have been estimated to double as the access point density increases from 20 to 40 per mile [*95*]. Therefore, any segments which contained 20 or more access points per mile were excluded from further consideration.
- No-Passing Zones: A major concern to raising the posted speed limit on two-lane roadways includes the likely reduction of passing zone sections within segments due to the increased passing sight distance requirement. A reduction in passing zones may impact passing opportunities, which would likely impact both traffic operations and safety as a greater rate of vehicles remain queued behind slower moving vehicles. The percentage of no-passing zones within each segment was assessed from the MDOT sufficiency file. In order to prevent segments from being substantially impacted by a reduction in passing opportunities, segments with 40% or more of the mileage existing as a no-passing zones were excluded from further consideration.

- Lane Width: Lane widths for each segment were acquired from the MDOT sufficiency file. The literature suggested notably higher crash rates for undivided highways which involved lane widths less than 10 ft [*88*]. Therefore, any non-freeway segments which include lane widths of 10 feet or less were subsequently removed from consideration.
- Paved Shoulder Width: Paved shoulder widths for each segment were acquired from the MDOT sufficiency file. The width of paved shoulder has been shown to have effects similar to lane width on the safety performance of non-freeways. Substantially higher crash rates were observed for high-volume segments with paved shoulder widths of two feet or less [88]. Therefore, any non-freeway segments which included paved shoulder widths of less than three feet were subsequently removed from consideration.

Table 12. Criteria for Identification of Lower Risk Candidate Non-Freeway Segments

Factor	Criteria
Segment Length	UNDIVIDED: Minimum 8.0 mi. posted at 55 mph DIVIDED: Minimum 4.0 mi. posted at 55 mph
Total Crash Rate, 2004-2013	UNDIVIDED: Fewer than 252.58 crashes per 100M VMT* DIVIDED: Fewer than 219.73 crashes per 100M VMT**
Injury Crash Rate, 2004-2013	UNDIVIDED: Fewer than 35.80 crashes per 100M VMT* DIVIDED: Fewer than 44.74 crashes per 100M VMT**
Severe (K+A) Crash Rate, 2004-2013	UNDIVIDED: Fewer than 7.12 crashes per 100M VMT* DIVIDED: Fewer than 4.80 crashes per 100M VMT**
Horizontal Curvature	No curves with radii below 3R minimum design speed***
Speed Reduction Zones	Less than 25% of the total segment length below 55 mph
Proximity to K-8 Schools	Fewer than 1 per 10 miles
Signalized Intersections	UNDIVIDED: Fewer than 1 per 10 miles DIVIDED: Fewer than 1 per 2 miles
Access Point Density	Fewer than 20 driveways per mile
No-Passing Zones	Less than 40% of the segment in NPZ (undivided only)
Lane Width	Greater than 10 ft
Paved Shoulder Width	Greater than or equal to 3 ft

Note: Criteria apply only to segments posted at 55 mph except where noted otherwise

*Represents ten year (2004-2013) statewide average for MDOT 55 mph undivided trunklines

**Represents ten year (2004-2013) statewide average for MDOT 55 mph divided trunklines

***Based on minimum radius for 65 mph 3R project speed limit (NHS=55 mph curve design speed, non-NHS=50 mph curve design speed)

PRIORITIZATION RESULTS

The first step in the prioritization process was to aggregate the relevant segment data for the selection criteria assessment. This task was performed using WSU's comprehensive database that included combined data for MDOT's 55 mph non-freeway segments obtained from the MDOT sufficiency file, the MSP crash database, and other sources. It should be noted that the process for which these raw data were collected and combined is described in further detail in Chapter 4. It was determined that the most appropriate data aggregation scheme was to calculate and assess the selection criteria for each route on a county-by-county basis, using minimum segment lengths of 8.0 miles for undivided highways and 4.0 miles for divided highways. Shorter segment lengths were excluded from consideration as they were deemed impractical for implementation purposes. This aggregation scheme provided an appropriate level of analysis as it provided logical boundaries and reasonable segment lengths for further review and potential implementation.

From there, the non-freeway segments with total, injury, or fatal (K) plus A-injury crash rates greater than the statewide averages were removed from further assessment. The additional selection criteria were then applied to the remaining routes, resulting in a final set of candidate non-freeway segments that possessed lower risks from both a safety and infrastructure cost standpoint. Table 13 summarizes the non-freeway prioritization results, including the number of segments and total mileage for all MDOT non-freeway segments posted at 55 mph, segments that satisfied all crash rate criteria, and the lower risk candidate segments which satisfied all of the prioritization criteria. The complete list of 55 mph non-freeway segments, including selection criteria data and final prioritization status, is provided in Appendix 2.

Table 13. Summary of Prioritization Results for Undivided and Divided Highways

Category	Roadway Type	Number of Segments	Miles
All MDOT 55mph Non-Freeways	Undivided	370	5,882.5
	Divided	56	209.6
Segments Satisfying All Crash Rate Thresholds	Undivided	68	1,497.4
	Divided	7	43.4
Segments Satisfying All Selection Criteria (Lower Risk Candidates)	Undivided	29	747.2
	Divided	4	25.6

As displayed in Table 13, 5,882.5 miles of undivided and 209.6 miles of divided non-freeway with posted speed limits of 55 mph were initially considered as a part of the prioritization process. The application of the statewide crash rate criteria resulted in 1,497.4 miles of undivided highway and 43.4 miles of divided highway for further consideration. Ultimately, after application of all criteria, 747.2 miles of undivided highways and 25.6 miles of divided highways remained. These remaining non-freeway segments were considered lower risk candidates for further consideration of a 65 mph speed limit. Figure 16 displays a map of the resulting non-freeway segments that 1.) satisfied the crash rate criteria and 2.) satisfied all selection criteria (i.e., lower risk candidates). Tables 14 and 15 list the undivided and divided lower risk candidate non-freeway segments. Complete prioritization data for all segments is provided in Appendix 2.

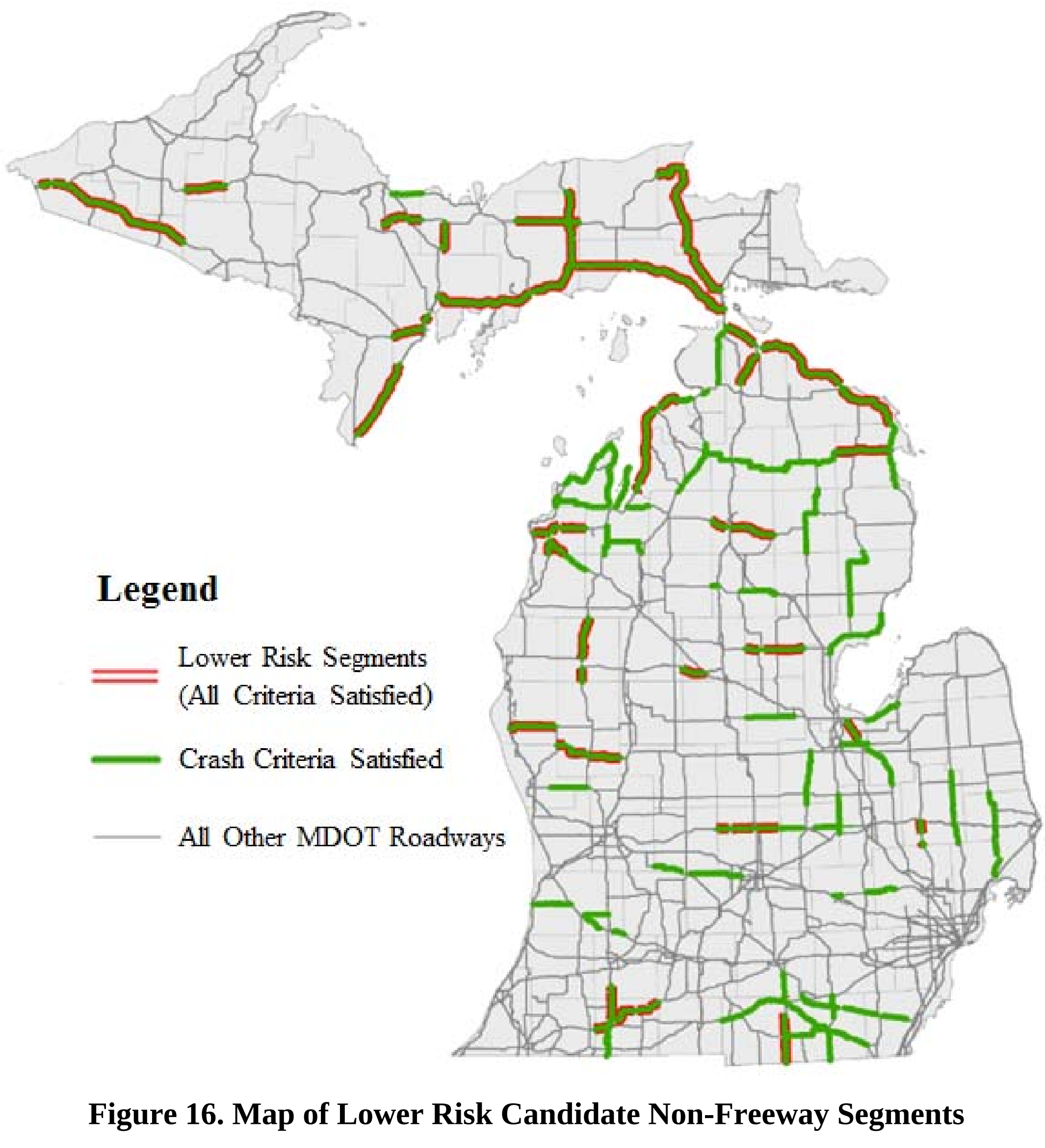


Figure 16. Map of Lower Risk Candidate Non-Freeway Segments

Table 14. Lower Risk Candidate Segments for Speed Limit Increase from 55 mph to 65 mph (Undivided)

						Operating Speeds			Crash Rate (per 100 MVMT)		
Region	Route	County	55 mph Mileage	AADT	CMV%	Mean	85th	St. Dev.	Total	Injury	K+A
1	US2	Delta	39.4	9,948	6.7%	60.3	65.3	5.4	215.8	23.2	5.7
1	US2	Gogebic	59.2	4,335	5.8%	57.3	61.7	5.4	184.1	24.3	6.5
1	US2	Mackinac	61.8	4,326	10.3%	59.4	63.4	5.1	153.8	21.7	6.6
1	US2	Schoolcraft	35.7	4,431	13.5%	58.2	62.0	4.3	192.9	16.5	4.5
1	M28	Houghton	15.3	1,565	10.8%	-	-	-	155.6	11.0	4.4
1	M28	Schoolcraft	23.8	2,140	9.9%	61.6	65.0	3.8	213.4	15.1	4.7
1	M35	Menominee	32.0	3,250	17.0%	58.9	63.0	6.6	211.7	26.3	4.6
1	M67	Alger	10.4	1,078	7.6%	58.4	62.0	4.7	240.0	19.5	0.0
1	M77	Schoolcraft	28.8	960	9.1%	60.7	65.6	4.6	223.0	19.5	3.6
1	M94	Marquette	14.3	1,739	4.2%	59.7	63.0	4.7	207.2	29.8	1.4
1	M123	Chippewa	49.5	980	3.8%	-	-	-	154.6	27.7	4.2
1	M123	Mackinac	18.4	1,587	3.9%	60.3	64.0	4.5	211.1	23.6	5.9
2	US23	Cheboygan	24.6	1,798	5.7%	-	-	-	217.9	28.7	3.1
2	US23	Presque Isle	52.3	2,060	5.0%	-	-	-	208.9	23.1	4.7
2	M27	Cheboygan	13.3	4,007	4.0%	-	-	-	248.8	30.6	4.8
2	US31	Antrim	23.7	5,659	4.7%	-	-	-	223.8	25.1	5.8
2	US31	Benzie	18.7	9,350	3.0%	57.0	61.0	4.0	146.9	18.3	3.2
2	US31	Charlevoix	17.1	6,805	4.8%	-	-	-	225.3	23.0	4.0
2	M32	Alpena	20.2	8,130	4.1%	-	-	-	214.6	28.4	3.7
2	M37	Lake	21.1	2,502	6.5%	-	-	-	243.9	21.5	6.2
2	M72	Crawford	23.1	4,049	4.6%	-	-	-	230.1	24.4	5.7
2	M115	Benzie	14.0	4,400	2.2%	-	-	-	242.3	23.2	4.6
3	M20	Oceana	17.7	2,431	5.5%	-	-	-	238.2	29.6	5.9
3	M82	Newaygo	23.1	7,601	4.8%	56.8	60.4	4.1	233.6	24.9	5.4
4	US10	Clare	8.7	3,736	12.6%	-	-	-	240.9	31.9	5.2
4	M61	Gladwin	20.1	7,225	3.1%	-	-	-	160.7	19.8	4.8
5	M60	St Joseph	23.2	3,892	9.8%	-	-	-	221.5	30.7	6.3
6	M21	Clinton	20.4	5,820	4.6%	-	-	-	231.8	25.3	3.5
6	US127	Hillsdale	17.6	5,388	11.3%	57.9	62.0	4.3	197.2	29.2	5.5

Note: Operating speeds collected at select locations using radar in July 2013.

Table 15. Lower Risk Candidate Segments for Speed Limit Increase from 55 mph to 65 mph (Divided)

						Operating Speeds			Crash Rate (per 100 MVMT)		
Region	Route	County	55 mph Mileage	AADT	CMV%	Mean	85th	St. Dev.	Total	Injury	K+A
4	M15	Bay	8.1	4,974	4.0%	.	.	.	113.8	26.2	3.8
4	M24	Lapeer	5.0	17,229	3.2%	.	.	.	140.4	17.9	3.6
5	US131	Kalamazo	4.0	19,595	7.4%	.	.	.	140.8	30.0	1.8
5	US131	St. Joseph	8.5	15,843	9.0%	58.9	63.2	18.9	108.5	19.8	3.2

Note: Operating speeds collected at select locations using radar in July 2013.

ADDITIONAL CONSIDERATIONS

As noted previously, certain important criteria could not be assessed on a systemwide basis due to a lack of available systemwide data. These additional criteria should be included within a project-level engineering and safety review for each candidate segment under consideration for the 65 mph speed limit, and include:

- Current operating speeds (specifically 85^{th} percentile speeds);
- Level of service;
- Recent increase in speed limit on the segment;
- Presence of pedestrian or bicycle traffic;
- Recreational, heritage, or historical route designation;
- Stopping sight distance;
- Vertical curvature design speed;
- Vertical grade;
- Bridge underclearance; and
- Bridge width.

Recent operating speed data were collected as a part of this study for many of the candidate segments (see Tables 14 and 15 and Appendix 1). In general, it may be most appropriate to select candidate segments with 85^{th} percentile speeds that are close to (or exceeding) 65 mph. While no specific lower limit is recommended for selection, it may be appropriate to exclude segments with existing 85^{th} percentile speeds below 60 mph. Considering only candidate segments where speed data were collected, the highest operating speeds were observed in the Superior Region. Specifically, the 85^{th} percentile speeds along candidate segments of M-28, US-2, and M-77 were at or above 65 mph (Table 14).

As will be explained in the assessment of infrastructure costs in Chapter 6, certain infrastructure components that are not compliant with a 65 mph speed limit may require modification during a 3R or 4R project [*98*]. While it was possible to identify systemwide non-compliant horizontal curves, other items, including vertical curves, bridge underclearance, and bridge width, could not be quantified using available datasets. Such infrastructure components should be included in a project-level review prior to final selection of segments where the speed limit will be increased.

It should also be noted that aggregating the non-freeway segment data in the manner described here creates potential discontinuities between candidate segments for cases where one or more of the criteria (including minimum segment length) were not met on the adjacent segment. Segment discontinuities may occur due to any of the following circumstances:

- Encountering a county border;
- Changing from undivided to divided segment (and vice-versa); or
- Convergence with one or more additional route(s).

Such discontinuities may potentially create a situation where the speed limit for a particular route alternates between 55 mph and 65 mph, which may be undesirable, particularly over short distances. Thus, to minimize discontinuities, the segments adjacent to each candidate segment should be reviewed to determine if extension of the 65 mph speed limit onto the adjacent segment is appropriate. For cases where the adjoining segment does not meet the minimum length criteria (but met the other criteria), it would be appropriate to extend the candidate onto the adjacent segment (i.e., continue the implementation of the increased posted speed limit). However, if the adjoining segment does not pass the additional criteria, MDOT should use discretion as to continuing the 65 mph segment. In particular, the presence of substandard 3R horizontal curves or substantially higher crash rates on the adjoining segment may preclude the adjacent segment from further consideration.

A review of the criteria for adjacent non-candidate segments was performed to identify potential extensions of the candidate segments displayed in Tables 14 and 15. Consideration was given to 55 mph segments, regardless of length, with crash rates that were not greater than 10 percent above the statewide averages and did not contain non-compliant 3R horizontal curvature. Using this process, the following potential candidate extension segments were identified:

- M-28 in Baraga County (extension from Houghton County)
- M-115 in Manistee and Wexford Counties (extension from Benzie County)
- M-72 in Kalkaska and Oscoda Counties (extension from Crawford County)
- US-31 in Manistee County (extension from Benzie County)

CHAPTER 6:
ECONOMIC ANALYSIS

One of the primary objectives of this research was to determine the economic impacts associated with raising the maximum speed limit from 55 mph to 65 mph on MDOT non-freeway roadways. In order to satisfy this objective, a comprehensive benefit/cost evaluation was conducted for MDOT non-freeway roadways. The first step in the process was to identify potential economic factors that may be positively (i.e., benefit) or negatively (i.e., cost) impacted by a speed limit increase during a typical roadway life cycle, including both agency and non-agency costs and benefits. Only tangible costs and benefits that were expected to directly result from an increase in speed limit from 55 mph to 65 mph were considered, including:

- Infrastructure upgrades,
- Fuel consumption,
- Travel time, and
- Traffic crashes.

INFRASTRUCTURE IMPACTS

Increasing the speed limit on high-speed non-freeway roadways will incur infrastructure upgrades and associated costs throughout the roadway life-cycle. Generally speaking, increasing the speed limit from 55 mph to 65 mph will require upgrading certain components of non-freeway infrastructure at three different points within the roadway life-cycle, which include:

- Initially,
- During a resurfacing, restoration, or rehabilitation (3R) project, and
- During a reconstruction or new construction (4R) project.

Initial Modifications

Increasing the posted speed limit on non-freeways would initially require an engineering assessment to determine the adequacy of critical geometric features with respect to the new speed limit. It will be necessary to modify certain components either before or shortly after the speed limit increase goes into effect. On two-lane roadways, which comprise approximately 93 percent of the MDOT non-freeway mileage with 55 mph speed limits, initial modifications associated with an increase to 65 mph would typically include the following:

- <u>Speed Limit Signage:</u> Modification of the speed limit signage is perhaps the only infrastructure component that would require modification on all roadways included in the speed limit increase. Speed limit sign upgrades could be carried out by MDOT or contractors and would typically involve replacing the sign or simply covering the speed number with a new overlay.
- <u>Passing/No-Passing Zones</u>: Increasing the speed limit from 55 to 65 mph would lengthen the necessary passing sight distance by 20 percent (from 1,000 ft to 1,200 ft) and require subsequent extension of no-passing zones, in some eliminating passing zones that are at or near the minimum necessary length. In addition to adding/extending no-passing zone pavement markings, this would necessitate either repositioning or adding the following signs: "Pass with Care", Do Not Pass", and "No Passing Zone".
- <u>Warning Signs:</u> Increasing non-freeway speed limits would also require installation of new warning signs or relocation of existing advance warning signage at curves, limited sight distances areas, intersections, lane drop/merge areas, and other locations. For example, horizontal curve locations where a newly increased speed limit exceeds the design speed could require new or enhanced warning signage.
- <u>Tapers:</u> Increasing non-freeway speed limits from 55 to 65 mph would increase the merging taper length by 18 percent (from 660 ft to 780 ft). For non-freeways, this would specifically impact the ends of passing relief/climbing lanes and lane drops. It would be necessary to adjust the pavement markings and advance warning signage accordingly. For passing/climbing lanes, the additional taper length can be achieved simply by restriping the merging taper into the passing lane by 120 ft, thereby shortening the passing lane by the same distance. Lane shift tapers would also be similarly impacted by increasing speed limits - particularly shifting tapers for left-turn lanes.
- <u>Traffic Signal Clearance Intervals:</u> Immediate revision of yellow and red clearance intervals at traffic signals would also be required to accommodate the increased speed limit on the intersection approaches.
- <u>Speed Reduction Zones:</u> It would also be necessary to review and potentially modify the signage on the approach to municipal speed zones and school speed zones.

Other infrastructure upgrades, such as guardrail extensions, clear zone expansions, and horizontal or vertical realignment, were not considered as a part of the initial costs, since such costs would typically be incurred during design speed improvements made at the 3R or 4R project stage, as described in later sections. It should also be noted that recent changes to MDOT's guardrail runout length calculation have potentially diminished the need for guardrail extensions on many non-freeways associated with a potential speed limit increase. An estimate of the costs necessary to perform the initial non-freeway infrastructure upgrades associated with a speed limit increase from 55 mph to 65 mph is detailed by way of a case study in the subsections that follow.

Case Study

A consultant was engaged to provide estimate for a hypothetical speed limit increase on a 6.31 mile section of M-37 from M-115 to 4 Road in Wexford County. This section was selected as it represented a typical candidate section of non-freeway roadway for which recent engineering drawings were available. The section included two slight horizontal curves, numerous vertical curves, and a river crossing. Approximately 28 percent of the segment was striped as no-passing zones, which is slightly greater than the statewide average of 22 percent no-passing zones on MDOT two-lane rural highways. A single passing relief lane of approximately 6,500 ft was present in the northbound direction.

The consultant's estimate was intended to establish a typical initial unit cost per mile associated with a speed limit increase from 55 mph to 65 mph that could be broadly applied to candidate MDOT non-freeway roadways. To that end, in addition to providing an estimate of total construction costs, estimates for project evaluation and engineering design hours were also included. The initial modifications considered within this estimate included:

- Speed limit signage,
- Passing/no-passing zone signage and pavement markings,
- Merging taper elongation and sign relocation at the passing relief lane, and
- Warning signage at horizontal curves and limited sight distance areas.

As with any project related to upgrading the warning signing or sight distance related features, the initial infrastructure cost estimate began with a review of the project corridor to collect details related to the existing site conditions. The existing condition data was then used to evaluate the site to determine the impact of increasing the speed limit from 55 mph to 65 mph on the following infrastructure characteristics:

- Sight Distance
  - Stopping sight distance,
  - Decision sight distance,
  - Passing sight distance, and
  - Intersection sight distance.
- Signing
  - Replacement of speed limit signs,
  - Addition of advisory/warning signs,
  - Addition or relocation of passing zone signs, and
  - Relocation of lane drop sign at termination of passing relief lane.
- Pavement Marking
  - Passing/no-passing zones in need of modification, and
  - Merging taper restriping at termination of passing relief lane.

The consultant time requirements for project evaluation and design engineering/construction plan preparation were also estimated as follows:

- Project Evaluation (48 hours [7.6 hours/mile])
  - Sight distance assessment = 40 hours, and
  - Signing/pavement markings assessment = 8 hours.
- Design Engineering/Plan Preparation (87 hours [13.8 hours/mile])
  - Signing design = 54 hours,
  - Pavement marking layout = 27 hours, and
  - Temporary traffic control plans = 6 hours.

Cost Estimate

Construction costs were estimated for the aforementioned infrastructure elements to be added or upgraded based on the quantities estimated for the 6.31 mile project section. The construction costs also included estimates for temporary traffic control implementation, mobilization, and staking/layout. Construction engineering costs associated with the project were estimated at 10 percent of the construction contract amount. Project evaluation and design engineering costs were estimated using a loaded hourly rate of $110/hr. MDOT staffing for project evaluation and design engineering was estimated at 20 percent of the consultant costs for these tasks. Initial costs for multilane undivided roadways were also estimated using these costs by eliminating the costs related to passing sight distance modifications. A breakdown of all estimated costs associated with this hypothetical signing and marking upgrade project is provided in Table 16.

Table 16. Cost Estimate for Initial Roadway Modifications

Item	Estimated Costs for Proposed M-37 Project (6.31 miles)	Estimated Costs per Centerline Mile	
		2-lane Undivided	Multilane Undivided
Construction Contract Costs:			
Signs	$21,000	$3,328	$1,665
Pavement Markings	$9,200	$1,458	$365
Temporary Traffic Control (15%)	$4,530	$717	$305
Mobilization (10%)	$3,020	$477	$200
Staking/Layout (2%)	$600	$100	$40
Contingency (8%)	$2,420	$381	$165
Construction Contract Subtotal	$40,770	$6,461	$2,740
Construction Engineering (10% of Contract)	$4,077	$646	$274
Project Evaluation (7.6 hrs/mi for 2-lane)	$5,280	$837	$356
Design Engineering (13.8 hrs/mi for 2-lane)	$9,570	$1,517	$631
MDOT PE/DE (20% of Consultant PE/DE)	$2,970	$471	$197
TOTAL	**$62,667**	**$9,932**	**$4,198**

The estimated initial cost per centerline mile of 2-lane undivided roadway was $9,932. This cost diminished to $4,198 for multilane undivided roadway due to the elimination of the passing sight distance assessment and subsequent passing zone modifications. Applied to the systemwide MDOT 55-mph segment mileage of 5,685 two-lane and 197 multilane undivided miles, the initial systemwide upgrade costs associated with the increase from 55 mph to 65 mph speed limits was estimated at $57,290,426.

The costs displayed in Table 16 may be considered slightly conservative due to the relatively short segment length for such work. Typical segment lengths for such projects would likely be on the order of 20 miles or more, which would typically decrease the project unit costs per mile compared to those presented here. However, this may be at least partially offset by the lack of any major horizontal curvature or speed reduction zones within this sample roadway segment. Increasing the number of horizontal curves would have a direct impact on initial costs associated with adding/modifying curve-related warning signs/delineators, in addition to possibly increasing costs related to assessment and modification of passing/no-passing zones. Similarly, modifications to speed reduction zone signage on the approach to a community or school would present a modest increase to the overall signing costs. Further, this roadway section did not include any traffic signals, which would require modification to the traffic signal clearance interval timings at locations where the speed limit was increased. However, it was assumed that such work would typically be performed by MDOT and the associated costs would be relatively small in comparison to other initial costs. It is reasonable to assume that these unaccounted for costs would be included within the 13 percent contingency that was included within this sample cost estimate shown in Table 16.

There may be circumstances on certain non-freeway roadway segments, where the speed limit signs are the only initial upgrade costs. This is particularly true for divided roadway segments with higher design speeds. The cost to perform speed limit sign upgrades was estimated based on the statewide freeway speed limit sign replacement associated with the 2006 speed limit policy change in Michigan. Assuming agency forces would again be utilized to upgrade the speed limit signs, this cost was estimated at $730 per centerline mile in 2014 dollars. Note that this cost included sign materials, labor, and traffic control, and did not include replacement of the sign post or modification of the sign location. Overlaying the signs with new speed limit numbers rather than fully replacing the signs would reduce the cost by an estimated 75 to 80 percent.

3R/4R Project Modifications

Chapter 3 of the *Michigan Road Design Manual* serves as MDOT's standard policy for roadway alignment and geometric design [*98*]. This manual provides minimum guidelines associated with 3R and 4R projects for the 13 controlling design elements designated by the FHWA, which include: design speed, lane width, shoulder width, bridge width, structural capacity, horizontal alignment, vertical alignment, grade, stopping sight distance, cross slope, superelevation, vertical clearance, and horizontal clearance.

Design Speed Requirements

Increasing the posted speed limit would likely have little impact on the requirements for the controlling geometric elements until initiating a 3R or 4R project, at which point the design speed must be in compliance with the posted speed limit that would prevail after project completion [*98*]. As a general rule for 3R and 4R projects, the minimum design criteria must be met for each critical design element. Substandard geometric elements would require modification unless a design exception is obtained through the approval process established by the FHWA, which includes a crash assessment relative to the type and location of the particular geometric element.

The *Michigan Road Design Manual* includes separate design criteria for National Highway System (NHS) and Non-NHS roadways, the latter of which generally include less-stringent design requirements. For roadways on the NHS, the design speed for both 3R and 4R projects is to be 5 mph greater than the posted speed limit for the project [*98*]. This requirement also applies to non-NHS 4R projects, although non-NHS 3R projects only require that the design speed be equal to the posted speed limit. It should be noted that the MDOT design speed requirements are generally more stringent than the FHWA federal aid roadway requirements, for which the design speed must equal the project speed limit on 3R/4R projects.

The minimum design guidelines that are utilized during a 3R project are intended to enhance safety while minimizing economic burden, as it is typically not cost effective to require levels of design that would be utilized during new and major reconstruction (4R) projects. Thus, 3R project design requirements for the controlling geometric design elements are typically less extreme than 4R requirements. Perhaps the most significant relaxation of the minimum design criteria for 3R projects relate to horizontal and vertical alignment and stopping sight distances, each of which may remain unchanged during a 3R project as long as the design speed is not more than 15 mph below the project design speed (20 mph below for vertical alignment on non-NHS routes) [*98*]. This implies that horizontal and vertical curves and stopping sight distance may be maintained for a 3R project with a 65 mph posted speed limit as long as the particular element is designed for at least 55 mph on NHS routes and 50 mph on non-NHS routes (45 mph for vertical alignment on non-NHS). Thus, for non-freeways with excessive horizontal and vertical curvature, the costs related to geometric upgrades to achieve design speed compliance will typically be considerably lower for 3R projects compared to 4R projects. However, if a high crash concentration exists in the proximity of the particular geometric feature, then the 4R design standards would apply. Other accommodations, such as guardrail runout length extensions, clear zone expansions, superelevation increases, and extension of auxiliary lanes and/or tapers, would typically be required during a 3R project to achieve compliance with the increased design speed.

4R projects include reconstruction of the roadway and roadbed. Such projects may involve a 1-to-1 replacement of the existing roadway, while other projects may include the addition of lanes or changes to the roadway cross-section or alignment. All 4R projects are to be designed to the current geometric design standards provided in the *Road Design Manual.* Where 3R projects were afforded relaxation of certain critical design speed requirements, namely horizontal alignment, vertical alignment, and stopping sight distance, each of the critical geometric criteria must either achieve the project design speed or be granted a design exception. For example, horizontal curves with existing design speeds that are less than the 4R project design speed may require realignment if the superelevation cannot be increased. Similarly, horizontal and vertical curves with inadequate stopping sight distances may also require realignment.

In general, the expected infrastructure costs associated with increasing speed limits on a particular non-freeway section is directly related to the extent of substandard geometric features with respect to the roadway design speed required for 3R or 4R projects. Geometric upgrades that expand the footprint of the existing roadway will impose right-of-way, environmental, social, mobility, and construction quantity impacts that often substantially exceed the cost of performing such upgrades within the existing roadway footprint. Although attainment of design exceptions allows for other mitigation strategies to be utilized aside from full roadway realignment, MDOT cannot expect to frequently receive such exceptions, particularly for locations with high crash frequency and bridge vertical clearance, which is not allowed to be reduced when it is substandard. Thus, increasing the statewide statutory speed limit on rural non-freeways will undoubtedly increase reconstruction costs far beyond that which would be incurred based on the current 55 mph speed limit. Budgetary burdens will occur on many road reconstruction projects, particularly where geometric alignment issues are present, which will likely be prohibitive in certain cases.

Case Study Segment Characteristics

A series of case studies have been prepared to demonstrate the potential impacts of rural non-freeway speed limit increases on critical geometric elements during 3R or 4R projects. To ensure the availability of recent design plans, the case study locations were selected from recent 3R and 4R roadway projects. Five two-lane undivided roadway segments were ultimately selected to illustrate the range of potential geometric modifications and associated costs related to increasing the speed limit on potential candidate non-freeway segments. Details of the selected roadway segments are provided in Table 17.

Table 17. Non-Freeway Case Study Segments

Route	Location Description	Length	Work Description	County
M-28	East of Raco Airfield	5.40	Rubblize and HMA Resurface	Chippewa
M-35	Stony Point to Jimtown Road	9.46	Mill and HMA Overlay	Menominee
M-37	M-115 to 4 Road	6.31	Crush and Shape, HMA Resurface	Wexford
M-82	M-120 to Industrial Drive	3.14	Mill and HMA Overlay	Newaygo
US-2	Delta County Line to M-149	4.10	Mill and HMA Overlay	Schoolcraft

The project design drawings were reviewed for each location to determine the incremental increase in 3R and 4R project costs that would be associated with upgrading any of the controlling design features to the new design speed for a 65 mph posted speed limit. These costs were considered to be above and beyond the costs to perform such a project assuming the current 55 mph speed limit. In addition to an assessment of the 13 controlling criteria, additional safety features were also considered projects, including repaving merging and shifting tapers to the appropriate length during a 4R project and improving intersection sight distance at 3R or 4R projects. Table 18 presents a summary of the necessary upgrades to critical geometric features found within each of the five locations.

Table 18. Impacts to Geometric Elements Associated with Speed Limit Increase from 55 to 65 mph for 3R or 4R Projects

Route	Horiz. Realign -ment	Increase Super-elevation/ Shoulder Grading	Vertical Realign-ment	Guardrail Additions/ Extensions	Extend Merging Taper*	Intersection Safety Upgrade*	Bridge Widening/ Other
M-28	None	None	None	None	4R	None	None
M-35	None	3R or 4R	None	3R or 4R	None	None	None
M-37	None	None	4R	3R or 4R	4R	None	None
M-82	None	None	4R	3R or 4R	None	3R or 4R	None
US-2	None	None	None	3R or 4R	None	None	None

*In addition to 13 controlling criteria

The design upgrades and associated costs required for design speed compliance during 3R/4R projects are discussed in greater detail for the five case studies as follows:

- Horizontal Curvature Upgrades: None of the roadways required horizontal curve realignment to achieve design speed compliance at either a 3R or 4R project, although M-35 did require additional superelevation and shoulder re-grading, at a cost of approximately $190,000 per mile of superelevation increase on a two-lane non-freeway.
- Vertical Curvature Realignment: Vertical curvature realignment is also a costly upgrade, although generally not as costly as horizontal realignment. The M-82 and M-37 locations were found to possess substandard vertical alignment that met the current design speed, but would not meet a 70 mph design speed and would require realignment. The cost to realign these vertical curves for a 65 mph posted speed limit was estimated at $800,000.
- Guardrail Extensions/Additions: Guardrail extensions and/or additions were necessary at four of the five roadways to satisfy the increased clear zone requirement (not a design exceptionable item) associated with an increased design speed for a 3R or 4R project. This was the most commonly impacted 3R or 4R geometric feature with an average estimated additional cost of $3,300 per project mile to upgrade to 65 mph speed limit.
- Merging Taper Extensions: Although initial adjustments to merging tapers may be performed by restriping the taper into the passing relief lanes (thereby reducing the passing lane length), it would be necessary during a 4R project to reestablish the passing lane and pave an extended merging taper. Such costs would be expected during 4R projects at the M-28 and M-37 sites, at a cost of $24,000 per taper.
- Intersection Sight Distance Upgrade: Although intersection upgrades are also not included within the 13 controlling geometric criteria, safety upgrades are prudent where intersection sight distance is substandard based on the design speed. M-82 was expected to incur turn lane additions during a 3R/4R project at a cost of $197,000 to mitigate intersection sight distance issues brought on by the speed limit increase.
- Bridge Widening and Other Upgrades: Other potential 3R/4R design upgrades associated with an increased speed limit, including bridge widening, bridge under clearance, cross slopes, and lane/shoulder widening were not required for any of the chosen projects. It should be noted that bridge widening and vertical clearance adjustments, while relatively uncommon, would present very large costs, where required.

Case Study Cost Estimate

Construction costs were estimated for the aforementioned infrastructure elements based on the quantities estimated for each of the five case studies. Only those costs related to achieving compliance with the increased design speed associated with a 65 mph speed limit were included. Simply put, only those design features that were compliant with the 55 mph speed limit but not compliant with the 65 mph speed limit were considered. The construction costs also included estimates for temporary traffic control implementation, mobilization, staking/layout, and contingencies, which, collectively, were typically estimated at 40 percent of the estimated construction item costs. Construction engineering and design engineering costs were each estimated at 10 percent of the construction contract amount. A breakdown of all estimated costs associated with increasing the posted speed limit for 3R and 4R projects is provided in Table 19.

Table 19. Additional 3R/4R Project Costs Associated with Raising Speed Limits from 55 to 65 mph

Route	Length (mi.)	Super-elevation/ Shoulder Grading	Vertical Realign-ment**	Guardrail Additions/ Extensions	Extend Merging Taper**	Intersec-tion Safety Upgrade	Other Items*	TOTAL COST	TOTAL COST PER MILE
M-28	5.40	$0	$0	$0	$24,000	$0	$16,320	$40,320	$7,467
M-35	9.46	$162,750	$0	$19,500	$0	$0	$123,930	$306,180	$32,366
M-37	6.31	$0	$800,000	$18,500	$48,000	$0	$589,220	$1,455,720	$230,700
M-82	3.14	$0	$800,000	$34,400	$0	$197,000	$701,352	$1,732,752	$551,832
US-2	4.10	$0	$0	$21,200	$0	$0	$14,416	$35,616	$8,687
TOTAL	28.41	$162,750	$1,600,000	$93,600	$72,000	$197,000	$1,445,238	$3,570,588	-
PER MILE	1.0	$5,729	$56,318	$3,295	$2,534	$6,934	$50,438	$125,680	-

*Includes: mobilization, staking/layout, temp. traffic control, project contingencies, construction engineering, and design engineering.
**Only applies to 4R projects

Horizontal Realignment Cost Estimate

One important limitation to these cost estimates was that none of the case studies included a substandard horizontal curve requiring realignment at either the 3R or 4R project stage. It is important to note that 3R and 4R projects must be considered differently during cost estimation, which is described as follows:

- <u>4R Projects</u>: During a 4R project, each horizontal curve is reconstructed regardless of the design speed. Thus, horizontal curve realignment costs during a 4R project only include *the incremental cost increase* associated with constructing the curve off of the existing roadbed. This cost has been estimated at $1.67 million per mile of realigned two-lane roadway above and beyond the cost of reconstructing the curve on the existing alignment. This estimate includes right-of-way costs, but excludes other potential costly items such as wetland mitigation. Further, it was also assumed that this cost would apply to curves that would require 4R realignment with a 55 mph posted speed limit due to the additional length of curve and right-of-way costs for 65 mph posted speed limit.

- <u>3R Projects</u>: Horizontal curve realignment during a 3R project must consider the *total curve reconstruction cost* because the curve would not otherwise require reconstruction during a 3R project if not for the design speed deficiency. The total off-alignment curve reconstruction cost has been estimated at $5.0 million per mile of realigned two-lane roadway. This estimate represents the additional 3R project cost for realigning a design speed deficient curve and includes all paving and roadbed material costs, in addition to right-of-way costs. It excludes other costs, such as those associated with wetland mitigation. Additionally, it was also assumed that the $1.67 million per mile realignment cost would also apply to curves that would require 3R realignment with a 55 mph posted speed limit due to the additional length of curve and right-of-way costs necessary for 65 mph posted speed limit

WSU's systemwide horizontal curvature database was queried to determine the total length of MDOT undivided roadway mileage currently posted at 55 mph that possess a radius less than that required for compliance with 3R or 4R design speeds for 1.) 65 mph posted speed limit and 2.) 55 mph posted speed limit. Assuming maximum superelevation (7 percent), the minimum radii requirements were as follows:

- 65 mph posted speed limit:
  - 1,922 ft. radius for 4R compliance with a 70 mph design speed;
  - 1,008 ft. radius for 3R NHS compliance with a 55 mph design speed;
  - 797 ft. radius for 3R non-NHS compliance with a 50 mph design speed;
- 55 mph posted speed limit:
  - 1,267 ft. radius for 4R compliance with a 60 mph design speed;
  - 612 ft. radius for 3R NHS compliance with a 45 mph design speed; and
  - 465 ft. radius for 3R non-NHS compliance with a 40 mph design speed.

The systemwide MDOT 55 mph undivided roadway mileage falling below aforementioned radii thresholds are displayed in Table 20. The total of the additional realignment quantities and costs associated with an increase in project speed limit from 55 mph to 65 mph represents the incremental impact associated with the increased speed limit during 3R or 4R projects. The total systemwide unit costs per mile were calculated based on the total MDOT 55 mph undivided roadway mileage (5882.5 miles).

Table 20. MDOT Systemwide 3R/4R Horizontal Realignment Costs Associated with 65 mph Speed Limit on Undivided Roadways

	Horiz. Curves with Non-Compliant Radius for 55 mph Project Speed Limit			Additional Horiz. Curves with Non-Compliant Radius for 65 mph Project Speed Limit			Additional Cost to Realign Horiz. Curves Associated with Speed Limit Increase from 55 to 65 mph	
Project Type	Curve Count	Curve Length (mi.)	Cost Incr. @ 65 mph*	Curve Count	Curve Length (mi.)	Cost Incr. @ 65 mph**	System-wide Cost	Systemwide Cost per mi. of Undivided Non-Freeway
3R	45	5.1	$8.5M	145	26.7	$133.5M	$142.5M	$24,250
Additional 4R	368	80.7	$134.8M	231	80.4	$134.3M	$269.1M	$45,750
3R + 4R	**413**	**85.8**	**143.3M**	**376**	**107.1**	**$267.8M**	**$411.6M**	**$70,000**

Note: Curve data queried from MDOT undivided roadway segments with 55 mph current posted speed limits (total statewide mileage = 5882.5).
*Additional 3R/4R cost to provide further realignment at 65 mph for curves substandard at 55 mph speed limit = $1.67M per realigned centerline mile.
**Additional 3R cost to reconstruct two-lane horizontal curve on new alignment = $5.0M per realigned centerline mile. Additional 4R cost to reconstruct two-lane horizontal curve on new alignment = $1.67M per realigned centerline mile.

Table 20 presents several interesting findings. First, there are 413 curves covering 85.5 roadway miles that currently do not meet the 4R project design speed (60 mph) based on the current 55 mph speed limit. Based on the MDOT *Road Design Manual,* each of these curves would require realignment during a 4R project regardless of whether the posted speed limit was 55 mph or 65 mph. Thus, the incremental realignment costs associated with a speed limit increase to 65 mph would include the additional right-of-way costs and additional length of curvature, among other costs. An additional 376 curves covering 107.1 miles of roadway were compliant for a 55 mph project speed limit, but were not compliant based on a 65 mph project speed limit. Of these curves, 26.7 miles would be considered non-compliant for a 3R project and would incur the most severe incremental cost increases, as neither reconstruction nor realignment would have been necessary assuming a 55 mph project speed limit.

Systemwide, approximately 3.3 percent of the MDOT 55 mph undivided roadway mileage includes a horizontal curve that would be impacted by with an increase in project speed limit from 55 mph to 65 mph. Simply put, this equates to approximately 1 mile of affected roadway per 30.5 miles of undivided MDOT trunkline. The additional costs to realign these curves during a 3R or 4R project assuming a 65 mph speed limit were estimated at approximately $411.6 million, or $70,000 per mile of undivided MDOT trunkline. Note that these horizontal realignment costs only assume the incremental increases above and beyond those that would be incurred for the same 3R/4R projects based on a 55 mph speed limit.

Life Cycle Cost Estimate

The initial upgrade costs and additional 3R and 4R project costs were utilized to develop life cycle infrastructure cost estimates associated with increasing the speed limit from 55 to 65 mph on non-freeway roadways. It was assumed that most roadways would experience a 3R project prior to a 4R project, and the corresponding costs related to the speed limit increase would not be repeated during a 4R project. 4R costs would often involve more substantial geometric upgrades, such as vertical realignment, that would go beyond the upgrade costs incurred during an earlier 3R project. However, if a 4R project preceded a 3R project, it was assumed that the 3R costs would instead be encumbered during the 4R project in addition to the other 4R costs. Thus, the life cycle costs represented the cumulative total of the initial upgrade costs plus the 3R and 4R costs associated with the increased speed limit.

Several different infrastructure unit cost estimates were calculated based on the case studies, which are described as follows:

- <u>Minimum Upgrades:</u> M-28 and US-2 displayed the lowest life cycle infrastructure costs, which included only low-cost 3R/4R geometric upgrades, such as additional guardrail or merging taper extensions, in addition to the initial upgrade costs. This was not unexpected, as these roadways typically include primary geometric features designed to accommodate a 65 mph speed limit. As such, these roadways were considered to represent the baseline minimum costs associated with increasing the speed limit to 65 mph.

- Case Study Average: The five case studies generally displayed geometric deficiencies, including superelevation, intersection sight distance, merging tapers, and clear zones, that would be broadly representative of systemwide candidate segments for a speed limit increase to 65 mph. However, the vertical realignment costs expected at the M-37 and M-82 sites may preclude these locations (and similar locations) as candidates for a speed limit increase to 65 mph. Therefore, the average case study infrastructure costs were computed both with and without the vertical realignment costs.
- Case Study Average plus Horizontal Realignment Costs: Although none of the five case studies were expected to require horizontal realignment during a 3R or 4R project, it was necessary to estimate such costs in order to generate a systemwide cost estimate. Such costs were estimated based determination of the statewide non-compliant horizontal curvature mileage on undivided 55 mph roadways, based on the procedure described in the preceding subsection. Assuming a 65 mph trunkline speed limit, the additional costs to realign all non-compliant curves statewide during 3R or 4R projects were estimated at approximately $411.6 million, or $70,000 per mile of undivided non-freeway currently posted at 55 mph (5,882.5 miles). These costs were added to the case study infrastructure costs to provide a more accurate estimate of the costs associated with implementation of the 65 mph speed limit on MDOT non-freeways.

It is important to note that certain geometric deficiencies, such as horizontal and vertical realignment, bridge widening, bridge vertical clearance improvements, were not included within the case studies and could not be quantified from available statewide. Furthermore, additional realignment-related costs, such as wetland mitigation, could not be quantified. Therefore, the statewide infrastructure cost estimate and corresponding benefit/cost ratio (presented later) is considered conservatively high.

A breakdown of the itemized increased life cycle costs (per mile) associated with an increase in speed limit from 55 mph to 65 mph are presented in Table 21. Table 21 also displays the annualized life cycle costs based on a 3 percent discount rate over a 25 year design life (15 years for initial upgrade costs). These costs will be utilized in the benefit/cost analysis described in a later section.

Table 21. Additional Infrastructure Life Cycle Costs Associated with Raising Speed Limits from 55 to 65 mph on Undivided MDOT Roadways

Route	Length	Initial Upgrade Costs per mile*	Additional 3R Project Costs per mile	Additional 4R Project Costs per mile (in addition to 3R upgrades)	TOTAL ADDITIONAL INFRASTRUCTURE COSTS PER MILE	ANNUALIZED ADDITIONAL INFRASTRUCTURE COSTS PER MILE
M-28	5.40	$9,932	$0	$7,467	$17,399	$1,260
M-35	9.46	$9,932	$32,366	$0	$42,298	$2,690
M-37	6.31	$9,932	$4,925	$225,775	$240,632	$14,080
M-82	3.14	$9,932	$123,806	$428,026	$561,764	$32,522
US-2	4.10	$9,932	$8,687	$0	$18,619	$1,330
Minimum Upgrades**					$17,925	$1,290
Case Study Average, Excluding Major Realignment					$79,345	$4,818
Case Study Average, Including Vertical Realignment					$135,613	$8,050
Case Study Average, Including Vertical and Horizontal Realignment***					$205,613	$12,070

Note: Averages are weighted by road segment length
*Applies to two-lane undivided roadways only. Initial costs would typically be lower for multilane roadways.
**Based on the weighted average infrastructure life cycle costs for M-28 and US-2. Considers only initial upgrade costs plus low-cost geometric upgrades, such as additional guardrail, and merging taper extensions
***Includes statewide average additional unit cost for horizontal curve realignment at 65 mph vs. 55 mph speed limit.

FUEL CONSUMPTION IMPACTS

Fuel consumption for vehicles traveling on uninterrupted high-speed roadways is function of several factors, including air resistance, which is largely impacted by speed and aerodynamics, and tire rolling resistance, which is largely impacted by weight. Nearly all vehicles are more fuel efficient at lower highway speeds, as air resistance begins to have a greater negative impact on fuel economy with increasing speeds. The literature suggests that heavy trucks consume approximately 7 miles per gallon (mpg) at 55 mph and flat terrain, and fuel economy decreases by approximately 0.1 mpg for every 1 mph increase in travel speed above 55 mph [*102-104*]. For passenger vehicles traveling at 55 mph, the current average fuel economy is approximately 31 mph and fuel economy decreases by 0.4 mpg for every 1 mph increase in travel speed above 55 mph [*105*]. Costs associated with vehicle maintenance, repair, and depreciation are not included due to the lack of evidence relating such costs to increasing travel speeds within the speed ranges assumed here.

In order to estimate the impact of a proposed speed limit increase on fuel economy, it was necessary to determine the increase in average travel speeds that would be expected to occur as a result of the speed limit increase. The mean speeds were estimated separately for passenger vehicles and heavy trucks based on the field speed measurements collected on 67 MDOT non-freeway roadway segments with 55 mph speed limits. The mean speeds associated with an increase in the speed limit to 65 mph were assumed to increase by 3.4 mph based on a comparison of mean speeds between the 65 mph and 55 mph segments in the Superior Region. Kockelman found similar increases in mean speeds associated with 10 mph speed limit increases on high-speed roadways [*57*]. Table 22 presents truck mean speeds and passenger vehicle mean speeds for assumed for non-congested conditions on 55 mph and 65 mph non-freeway roadways. The mean speed data were then utilized to estimate the fuel economy for trucks and passenger vehicles, which are also displayed in Table 22. In general, increasing the non-freeway speed limit from 55 to 65 mph was expected to decrease fuel economy by 4.6 percent and 5.0 percent for passenger vehicles and heavy trucks, respectively.

Table 22. Fuel Economy on Non-Freeways based on Mean Speed, by Speed Limit and Vehicle Type

Truck Speed Limit (mph)	Estimated Truck Mean Speed (mph)	Estimated Truck Fuel Economy (mpg)
55	56.5	6.85
65	59.9	6.51
Passenger Veh. Speed Limit (mph)	Estimated Passenger Veh. Mean Speed (mph)	Estimated Passenger Veh. Fuel Economy (mpg)
55	58.7	29.52
65	62.1	28.16

It was also necessary to estimate annual vehicle miles traveled (VMT) and average fuel costs. The 2013 VMT for each road segment utilized was computed for both commercial and non-commercial vehicles using the MDOT sufficiency segment length and AADT. The average diesel cost in Michigan for the 12-month period from December 2013 through December 2014 was $4.00 per gallon, while the average regular unleaded gasoline cost was $3.50 per gallon [*106*]. Using these values, the annual increased fuel consumption costs associated with increasing the posted speed limit were estimated using the following method:

$$\textit{Annual Fuel Consumption Cost Increase} =$$
$$(\textit{VMT / Fuel Economy}_{55mph} - \textit{VMT / Fuel Economy}_{65mph}) * \textit{Fuel Unit Cost (\$/gallon)}$$

TRAVEL TIME IMPACTS

Any observed increases in the vehicle operating speeds will result in travel time savings for motorists. It was first necessary to determine average hourly value-of-time estimates for typical users of the Michigan highway network. MDOT provides separate value-of-time unit estimates for passenger vehicles and commercial trucks for use with the Construction Congestion Cost (CO3) estimation software [*107*]. The MDOT value-of-time unit estimates are based on the FHWA publication *Life-Cycle Cost Analysis in Pavement Design* [*108*] and are currently displayed in 2012 dollars. It was necessary to index these values to current conditions using a ratio of the 2014 to 2012 first-half Consumer Price Indices (CPI), as follows: 236.384 / 228.850 = 1.033 [*109*]. These value-of-time unit costs for 2014 were computed as follows:

- Passenger vehicle: $18.28 per hour per vehicle
- Heavy truck: $32.25 per hour per vehicle

From there, it was necessary to determine the annual net decrease in travel time that would be expected to occur after increasing speed limits statewide. These values may be estimated based on the estimated change in mean speeds displayed in Table 22 along with the annual vehicle-miles traveled during uncongested conditions. The increases in speed expected for passenger vehicles and heavy trucks on non-freeways was expected to decrease travel times and associated costs by 5.5 percent for passenger vehicles and 5.7 percent for heavy trucks. The annual statewide value-of-time savings associated with increasing the posted speed limit were estimated using the following method:

$$\text{Annual Travel Time Benefit} = \left(VMT / \text{Mean Speed}_{65mph} - VMT / \text{Mean Speed}_{55mph}\right) * \text{User Cost (\$/veh-hour)}$$

TRAFFIC CRASH IMPACTS

The safety literature generally suggests that increasing the non-freeway speed limit from 55 to 65 mph would likely result in an increase in the overall crash rate and would also shift the severity distribution toward more severe crashes due to the increase in the energy dissipated during crashes due to vehicles traveling at higher speeds. However, predicting the magnitude of such impacts to crash frequencies and severities associated with a speed limit increase from 55 to 65 mph in Michigan presented several challenges. First, since no undivided roadways in Michigan possess posted speed limits greater than 55 mph, it was not possible to examine before-and-after trends. Furthermore, inconsistencies between the non-freeway roadway network characteristics and non-fatal crash reporting practices throughout the United States limit the state-to-state comparability of crash and severity data.

Kockelman [*57*], presented perhaps the most thorough recent investigation of crash-related impacts associated with increasing speed limits on high-speed rural roadways. Using Highway Safety Information System (HSIS) data from the state of Washington, models for crash occurrence and injury severity were developed using data from high-speed roadways (including divided and undivided roadways) to predict the impacts of increasing the speed limit for a variety of scenarios, including 55 to 65 mph. For this particular scenario and assuming typical increases in operating speeds after the speed limit increase, Kockelman predicted that crashes would increase by 3.3 percent and the probability of a fatality (assuming a crash had occurred) would increase by 24 percent. Similar changes in the probability of A, B, C, and PDO crashes were also predicted as 8.5 percent, 4.8 percent, 0 percent, and -0.6 percent, respectively. Kockelman's crash occurrence and crash severity model results were applied to the MDOT non-freeway crashes occurring from 2004 to 2013 to develop estimates associated with a speed limit increase from 55 to 65 mph on non-freeways for several implementation scenarios, as described in the benefit/cost analysis section that follows.

As the estimated annual crash increases are based on a cross-sectional analysis of the crash and severity data for roadways posted at 55 or 65 mph, it is assumed that typical design speeds and associated geometric conditions generally exist within each particular class of roadway. To that end, in order for these estimates to be used for prediction of crashes associated with speed limit increases in Michigan, it must be assumed that the roadway design speeds are in compliance with the increased posted speed limit. Additional crashes and associated costs would undoubtedly result if the design speed is not ultimately modified to be in compliance with the increased posted speed limit. Thus, the infrastructure investment that would be necessary to improve non-compliant geometric features is "buying down" the crashes that would otherwise occur due if the non-compliant features were not improved.

From there, it was necessary to estimate the unit costs per crash based on the crash severity. The National Safety Council (NSC) estimates for the economic costs of each fatality (per person killed), injury (per person injured, by severity type), and property damage crash were utilized as the basis for the crash cost calculation [*110*]. The economic costs estimates were indexed from 2012 to 2014 dollars using a 1.033 multiplier based on a ratio of the respective CPIs [*109*]. The NSC economic costs consider only the tangible costs of motor-vehicle crashes, which include wage and productivity losses, medical expenses, administrative expenses, motor vehicle damage, and employers' uninsured costs. The estimates do not include additional comprehensive costs, such as lost quality of life, which would greatly increase the crash cost estimates.

As the NSC only provides fatal and injury costs on a per-person basis (property damage costs are provided per crash), it was necessary to convert these values to costs per crash. The 2004-2013 non-freeway crash data were utilized to determine the number of persons within each severity category (i.e, K,A,B,C) per fatal and injury crash. The NSC costs were then applied accordingly to determine a composite cost per crash for each crash severity level. These values are displayed in Table 23 along with the NSC economic costs per killed/injured person.

Table 23. Economic Crash Costs, by Severity Level

Severity	Cost Per Person, 2012 [*110*]	Cost Per Person, 2014	Cost Per Crash, 2014
Fatality	$1,410,000	$1,456,530	$1,693,476
Incapacitating Injury (A-Injury)	$69,200	$71,484	$120,526
Non-Incapacitating Injury (B-Injury, C-Injury)	$15,971	$16,498	$38,455
Property Damage	N/A	N/A	$9,194

The annual statewide crash costs (or benefits) were estimated for each speed limit scenario using the following method:

$$\textit{Annual Crash Cost Increase} =$$
$$(\textit{Expected Annual Crashes}_{65mph} - \textit{Expected Annual Crashes}_{55mph}) * \textit{Crash Cost (\$/crash)}$$

BENEFIT/COST ANALYSIS

Benefit/cost ratios were computed to assess the economic viability of the proposed speed limit increase on MDOT non-freeways. For each economic component, the costs or benefits were based on the estimated incremental changes attributed to increasing the non-freeway speed limit from 55 mph to 65 mph. Cost estimates related to life cycle infrastructure upgrades to achieve compliance with state and federal 3R/4R design speed requirements were based on unit cost estimates generated using data provided by MDOT, which have been described in detail in the previous sections. It is also important to note that the estimated increase in crashes associated with an increase in speed limit from 55 mph to 65 mph assumes that the roadway design speed complies with the increased posted speed limit. Additional crashes and associated costs would undoubtedly result if the design speed is not ultimately modified to be in compliance with the increased posted speed limit. Benefit/cost ratios associated with increasing the non-freeway speed limit from 55 to 65 mph were computed for each case study segment (based on the entire segment length within the particular county) in addition to the following scenarios:

- <u>Scenario 1: Increase Speed Limit on Lower Risk Candidates with Minimal Infrastructure Costs:</u> This scenario considered raising the speed limit from 55 to 65 mph only on roadway segments with geometric features that typically comply with a 65 mph speed limit, with the expectation that such roadways would incur only low-cost 3R/4R geometric upgrades as a result of a speed limit increase, such as additional guardrail or merging taper extensions, in addition to the initial upgrade costs. Calculation of the benefit/cost ratio was based solely on the M-28 and US-2 lower risk candidate segments due to the low expected infrastructure upgrade costs, which were estimated from the respective case study project segments.
- <u>Scenario 2: Increase Speed Limit on Lower Risk Candidates with No Horizontal or Vertical Realignment</u>: For this scenario, it was assumed that MDOT would utilize discretion to increase speed limits only on lower risk roadway segments that would not require major horizontal or vertical realignment during 3R or 4R projects. The infrastructure costs were represented by the weighted average of the five case study infrastructure life cycle costs, excluding costs to realign vertical curvature (no horizontal realignment costs were incurred in the case studies). A subset of the lower risk candidates likely requiring no 3R or 4R realignment was utilized to calculate the benefits

and costs for this scenario. Although no major alignment costs are expected, typical 3R/4R upgrades for such roadways may include superelevation, intersection sight distance, merging tapers, clear zone modifications including guardrail extensions.

- Scenario 3: Increase Speed Limit on All Lower Risk Candidates: This scenario considered raising the speed limit from 55 mph to 65 mph on lower risk candidate roadway segments, inclusive of segments where vertical and/or horizontal realignment would likely be required during a 4R project (3R realignment was not expected for the lower risk candidates). The infrastructure costs were represented by the weighted average of the five case study infrastructure life cycle costs (including vertical realignment costs), in addition to the estimated horizontal realignment costs for the 4R non-compliant curves existing within the candidate segments. Although it is acknowledged that the level of vertical realignment upgrades cannot be accurately estimated for the lower risk candidate segments using the available data, these segments were considered geometrically similar to the case study segments for cost estimation.
- Scenario 4: Increase Non-Freeway Speed Limit Systemwide: This scenario included raising the speed limit from 55 mph to 65 mph on all MDOT non-freeway roadway segments systemwide that are currently posted at 55 mph. The infrastructure costs were represented by the weighted average of the five case study infrastructure life cycle costs, plus the average statewide unit cost for horizontal curve realignment during 3R or 4R projects. Calculation of the benefit/cost ratio was based on all MDOT non-freeway roadways with 55 mph posted speed limits. It is acknowledged that this scenario likely underestimates the statewide infrastructure costs, as it was not possible to estimate other deficiencies that would require modification during a 3R or 4R project, including substandard bridge widths or vertical clearances and wetland mitigation costs. Thus, the resulting systemwide benefit/cost ratio is considered to be overestimated.

Utilizing the procedures described in the preceding sections for calculation of the itemized costs and benefits, separate benefit/cost ratios were computed for each of the aforementioned non-freeway speed limit increase scenarios as follows, with results displayed in Table 24 and 25:

$$\frac{B}{C} = \frac{Travel\ Time\ Savings}{Fuel\ Consumption\ Increases + Infrastructure\ Cost\ Increases + Crashes\ Increases}$$

Table 24. Benefit/Cost for 65 mph Speed Limit Implementation on Case Study Segments

Segment*	Affected Mileage	Travel Time Benefit	Fuel Cost	Infrastructure Cost	Crash Cost	B/C
M-28, Chippewa County	43.5	($589,606)	$266,796	$54,834	$209,277	1.11
M-35, Menominee County	32.0	($755,791)	$379,989	$86,024	$196,016	1.14
M-37, Wexford County	26.7	($468,074)	$219,314	$375,612	$435,894	0.45
M-82, Newaygo County	23.1	($1,133,982)	$440,528	$750,217	$423,873	0.70
US-2, Schoolcraft County	35.7	($1,127,567)	$534,232	$47,458	$360,385	1.20

Note: All monetary values are annualized 2014 dollars. All case study segments were undivided two-lane roadways.
*Each case study segment was expanded to include the entire 55 mph segment within the respective county.

Table 25. Benefit/Cost for 65 mph Non-Freeway Speed Limit Implementation Scenarios

65 mph Speed Limit Implementation Scenario	Affected Mileage	Travel Time Benefit	Fuel Cost	Infra-structure Cost	Crash Cost	B/C
Scenario 1: M-28 and US-2 Candidate Segments (Minimum Infrastructure Upgrades)*	235.1	($6.21 M)	$2.74 M	$0.30 M	$2.00 M	1.23
Scenario 2: Lower Risk Candidates Not Requiring Vertical or Horizontal Realignment**	512.6	($14.15 M)	$5.84 M	$2.47 M	$4.34 M	1.12
Scenario 3: All Lower Risk Candidates***	772.8	($20.59 M)	$8.52 M	$7.02 M	$6.34 M	0.94
Scenario 4: All MDOT 55mph Non-Freeways****	6,092.2	($183.45 M)	$73.74 M	$73.53 M	$89.77 M	0.77

Note: All monetary values are annualized 2014 dollars.
* Infrastructure costs based on average for US-2 and M-28 case study segments, which included the lowest infrastructure costs.
** Infrastructure costs based on case study average, exclusive of major realignment
*** Infrastructure costs based on case study average (including vert. realignment) + 4R horiz. realignment for candidates
**** Infrastructure costs based on case study average (including vert. realignment) + systemwide 3R/4R horiz. realignment

The benefit/cost results displayed in Table 25 provides several interesting findings. Not surprisingly, limiting the 65 mph speed limit to the candidate M-28 and US-2 segments showed the most favorable B/C. This is because these routes possess geometric features that typically comply with a 65 mph speed limit and are expected to incur only low-cost 3R/4R geometric upgrades associated with a speed limit increase to 65 mph. The B/C ratio for this scenario was estimated at 1.23, suggesting that the travel time savings outweigh the costs related to increased fuel consumption, infrastructure modification, and crashes. A favorable economic result is also obtained if the 65 mph speed limit is applied to lower risk candidate segments that will not incur horizontal or vertical realignment costs during 3R or 4R projects. However, increasing the speed limit to 65 mph on all lower risk candidate segments would be expected to incur horizontal and vertical realignment costs during a 4R project, which would decrease the B/C to 0.94. As expected, the B/C ratio (0.77) for all statewide non-freeway roadways was the least favorable scenario, as the infrastructure and crash costs would be proportionally higher than those estimated for the lower risk candidate segments. Collectively, these results suggest that discretion should be utilized when selecting non-freeway roadway segments where the speed limit would be increased from 55 mph to 65 mph. Specifically, consideration should only be given to roadway segments with low historical crash rates coupled with minimal critical geometric upgrade costs.

CHAPTER 7:

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Research was performed to assess the impacts associated with the proposed "Trunkline General Speed Limit" policy on MDOT non-freeway roadways. The salient findings and conclusions from the research are summarized as follows.

Non-Freeway Operating Speeds

Analysis of field speed data collected at 67 MDOT non-freeway locations statewide with posted speed limits of 55 mph, found a statewide passenger vehicle mean and 85th percentile speed of 58.7 and 63.0 mph. The statewide mean and 85th percentile speeds for trucks and buses were 56.5 mph and 61.0 mph, respectively. Speeds were generally higher in the North and Superior Regions compared to southern portions of the state. The passenger vehicle 85th percentile speeds along many sections of rural undivided highways in the Superior Region, particularly along M-28 and US-2, were at or above 65 mph. Speed data were also collected at the 65 mph segment on US-2/US-41 in the Superior Region to estimate the difference in operating speeds between 55 mph segments and 65 mph segments. Comparison of the operating speeds between this 65 mph segment and all 55 mph segments in the Superior Region, found mean speeds on the 65 mph segment to be 3 to 4 mph greater than those on the 55 mph segments. Although this comparison is not truly reflective of increasing the speed limit from 55 to 65 mph, the differences were similar to increases reported elsewhere after raising the speed limit [*57*].

Factors Affecting Crashes on MDOT Non-Freeways

Analysis of crashes on MDOT non-freeway segments found that crash rates tended to be higher in the Grand Region and lower in the North and Superior Regions. Other factors leading to higher crash rates for non-freeway segments included:

- Greater truck volumes,
- Greater access point density,
- Fewer passing zones,
- Fewer passing relief lanes,
- Horizontal curvature,
- Urban areas,
- Rolling terrain,
- Two-way left-turn lanes,
- Schools near the segment, and
- Greater number of lanes (undivided),

Prioritization of Candidate Non-Freeway Segments

This research also identified a series of factors and associated criteria for selection of candidate MDOT non-freeway locations that possess comparatively lower safety risks and infrastructure costs associated with increasing the speed limit from 55 mph to 65 mph. The candidate selection criteria included safety, operational, and geometric based factors and utilized statewide non-freeway segment data from WSU's comprehensive sufficiency/crash database. Ultimately, approximately 747 miles of undivided and 26 miles of divided 55 mph non-freeways were identified as lower risk candidates, representing approximately one-eighth of the MDOT systemwide mileage posted at 55 mph. Approximately one-half of the undivided candidate mileage existed in the Superior Region, including numerous sections of US-2 and M-28, where in many cases, the 85th percentile speeds were at or above 65 mph. The lower risk candidate segments are summarized in Table 26. Additional details on the lower risk candidate segments may be found in Tables 14 and 15 and Appendix 2.

Table 26. Lower Risk MDOT Non-Freeway Candidate Segments for 65 mph Speed Limit

Undivided Segments				Divided Segments			
Region	Route	County	Mileage*	Region	Route	County	Mileage*
1	US2	Delta	39.4	4	M15	Bay	8.1
1	US2	Gogebic	59.2	4	M24	Lapeer	5.0
1	US2	Mackinac	61.8	5	US131	Kalamazoo	4.0
1	US2	Schoolcraft	35.7	5	US131	St. Joseph	8.5
1	M28	Houghton	15.3				
1	M28	Schoolcraft	23.8				
1	M35	Menominee	32.0				
1	M67	Alger	10.4				
1	M77	Schoolcraft	28.8				
1	M94	Marquette	14.3				
1	M123	Chippewa	49.5				
1	M123	Mackinac	18.4				
2	US23	Cheboygan	24.6				
2	US23	Presque Isle	52.3				
2	M27	Cheboygan	13.3				
2	US31	Antrim	23.7				
2	US31	Benzie	18.7				
2	US31	Charlevoix	17.1				
2	M32	Alpena	20.2				
2	M37	Lake	21.1				
2	M72	Crawford	23.1				
2	M115	Benzie	14.0				
3	M20	Oceana	17.7				
3	M82	Newaygo	23.1				
4	US10	Clare	8.7				
4	M61	Gladwin	20.1				
5	M60	St Joseph	23.2				
6	M21	Clinton	20.4				
6	US127	Hillsdale	17.6				

*Mileage currently posted at 55 mph

Infrastructure Costs

Increasing the speed limit on high-speed non-freeway roadways would incur infrastructure upgrades and associated costs at various points throughout the life-cycle of the roadway. Generally speaking, increasing the non-freeway speed limit from 55 mph to 65 mph would initially require upgrading less costly components, such as passing zones and warning signage, with critical substandard geometric components typically upgraded during 3R or 4R projects.

Five representative case study segments were utilized to develop estimates of the 3R and 4R infrastructure costs associated with increasing the non-freeway speed limit from 55 mph to 65 mph. One segment was also provided with a consultant's initial infrastructure cost estimate. In general, it was found that infrastructure costs associated with a speed limit increase would be minimized for roadways possessing primary geometric features, specifically horizontal and vertical alignment, that are already designed to accommodate higher design speeds. Any additional vertical and/or horizontal alignment upgrades would incur substantial 3R or 4R project costs to achieve compliance with state and federal design speed requirements. The itemized estimated infrastructure life cycle costs for four potential implementation scenarios of the 65 mph speed limit on MDOT non-freeways are provided in Table 27. It is acknowledged that these infrastructure cost estimates likely underestimate infrastructure costs, particularly for the statewide estimate, as it was not possible to estimate certain deficiencies that would require modification during 3R or 4R projects, including substandard bridge widths or vertical clearances and wetland mitigation costs.

Table 27. Estimated Increased Infrastructure Life Cycle Costs for 65 mph Non-Freeway Speed Limit Implementation Scenarios

65 mph Speed Limit Implementation Scenario	Affected Mileage	Initial Upgrades	Vertical Realignment	Horizontal Realignment	Other Geometric Upgrades*	TOTAL	PER MILE
M-28 and US-2 Candidate Segments	235.1	$2.3 M	$0	$0	$1.9 M	$4.2 M	$17,925
Lower Risk Candidate Segments; Excluding Major Realignment	512.6	$4.8 M	$0	$0	$35.6 M	$40.4 M	$78,842
All Lower Risk Candidate Segments	772.8	$7.3 M	$43.5 M	$13.9 M	$53.6 M	$118.3 M	$153,042
All MDOT 55mph Non-Freeways	6,092.2	$57.4 M	$342.8 M	$426.5 M	$422.9 M	$1.25 B	$205,110

*Excluding bridge-related upgrades

Assuming statewide implementation of 65 mph speed limits on all MDOT non-freeways currently posted at 55 mph, it was estimated that initial infrastructure upgrades would cost $57.4 million with an additional $1.19 billion in potential non-compliant geometric upgrade costs incurred during 3R or 4R projects. However, application of the 65 mph speed limit only on lower risk candidate segments would substantially reduce these costs, as these segments do not include substantial amounts of non-compliant horizontal curvature. Such costs may be further reduced if the candidate locations are specifically selected such that major realignment will not be required. The minimum infrastructure costs would likely be incurred if the 65 mph speed limit is applied only to candidate sections of US-2 and M-28.

Road User Operational Benefits

Road user costs and benefits associated with increasing the non-freeway speed limit from 55 mph to 65 mph, including increased fuel consumption and reduced travel times, were also estimated. Assuming that non-freeway mean speeds would increase by 3.4 mph after raising the speed limit to 65 mph, it was estimated that the value-of-time savings would outweigh the fuel consumption costs by a factor of 1.06 for heavy trucks and 2.98 for passenger vehicles. This equated to net user benefits of $0.0019/mile for heavy trucks and $0.0113/mile for passenger vehicles. These net user benefits were similar to those estimated by Kockelman [*57*].

Traffic Safety Impacts

Increasing the non-freeway speed limit from 55 to 65 mph is expected to increase the overall crash rate by 3.3 percent, based on data from high-speed roadways in the state of Washington [*57*]. Furthermore, the expected increase in vehicular operating speeds is expected to shift the crash severity distribution toward more severe crashes due to the additional energy dissipated during crashes at higher speeds. Combining this upward shift in the severity distribution with the expected overall 3 percent crash increase would result in fatal, incapacitating injury (A-injury), non-incapacitating/possible injury (B&C-injury), and PDO crash rates increasing by 28.1 percent, 12.1 percent, 5.0 percent, and 2.7 percent, respectively [*57*]. The estimated annual increase in crashes (by severity) for the four 65 mph speed limit implementation scenarios were determined based on the 2004 - 2013 crash rates and are displayed in Table 28 along with the associated economic costs.

Table 28. Estimated Crash Increases for 65 mph Non-Freeway Speed Limit Implementation Scenarios

65 mph Speed Limit Implementation Scenario	Affected Mileage	Estimated Annual Increase in Crash Occurrence*					ANNUAL COST**
		Fatal	Incapacitating Injury (A-Injury)	Non-Incapacitating Injury (B-Injury, C-Injury)	Property Damage	TOTAL	
M-28 and US-2 Candidate Segments	235.1	0.9	1.9	2.7	15.1	20.6	$2.0 M
Lower Risk Candidate Segments; Excluding Major Realignment	512.6	1.9	3.9	7.6	37.3	50.7	$4.3 M
All Lower Risk Candidate Segments	772.8	2.8	5.5	11.2	53.1	72.6	$6.3 M
All MDOT 55mph Non-Freeways	6,092.2	40.3	74.6	175.2	631.8	921.9	$89.8 M

*Assumes the following percent crash rate increases: Fatal = 28.1%, A-injury = 12.1%, B/C-injury = 5.0%, PDO = 2.7%
**Assumes 2014 economic costs only based on the following unit costs per crash: Fatal = $1,693,476; A-injury = $120,526; B/C-injury = $38,455; PDO = $9,194

Statewide implementation of the 65 mph speed limit on all 6,092.2 miles of 55 mph non-freeways is expected to result in an annual increase of 40.3 fatal crashes, 74.6 A-injury crashes, 175.2 B- or C-injury crashes, and 631.8 property damage crashes at an expected economic cost of $89.8 million annually. Substantially lower crash increases and associated costs are expected for scenarios involving either all or a subset of the lower risk candidate segments, as these segments only include segments with historical crash rates below the statewide averages. However, regardless of the implementation scenario, increasing the non-freeway speed limit from 55 mph to 65 mph is expected to increase fatal crashes, which contradicts Michigan's "Toward Zero Deaths" initiative [*111*]. Furthermore, the estimated crash costs do not include comprehensive costs, such as lost quality of life, which would greatly increase the cost estimates.

The estimated crash increases shown in Table 28 are contingent on the assumption that the roadway design speeds will ultimately be made compliant with the 65 mph posted speed limit. Additional crashes and associated costs would likely result if the design speed is not ultimately modified to be in compliance with the increased posted speed limit. Thus, the infrastructure investment that would be necessary to improve non-compliant geometric features is critical to prevent crashes that would otherwise occur if the non-compliant features were not improved.

Benefit/Cost Ratio

Benefit/cost ratios were estimated considering implementation of the 65 mph speed limit on MDOT non-freeway roadways to determine if the infrastructure and crash costs outweighed the net road user operational benefits. Specifically, four potential implementation scenarios were considered, with the benefit/cost ratios estimated as follows:

- Lower risk candidate roadways with minimum infrastructure upgrade costs: B/C = 1.23
- Lower risk candidate roadways requiring no horizontal or vertical realignment: B/C = 1.12
- All lower risk candidate roadways, including vertical and horizontal realignment: B/C = 0.94
- All 55 mph MDOT non-freeway roadways statewide: B/C = 0.77

In general, routes possessing geometric features that typically comply with a 65 mph speed limit, particularly horizontal and vertical alignment, are expected to incur only low-cost 3R/4R geometric upgrades associated with a speed limit increase to 65 mph. Thus, a favorable benefit/cost ratio will likely be obtained for roadway segments with minimal critical geometric upgrades coupled with low crash occurrence. Conversely, roadways possessing horizontal and/or vertical alignment that is not compliant with a 65 mph speed limit would likely result in an unfavorable economic result due to the excessive infrastructure costs incurred during 3R or 4R projects. This suggests that discretion should be utilized when selecting non-freeway roadway segments where the speed limit would be increased to 65 mph, with particular consideration given to the design speed of existing critical geometric features (e.g., horizontal and vertical alignment) and historical crash occurrence.

It was not possible to estimate certain infrastructure deficiencies requiring modification during 3R or 4R projects, including substandard bridge widths or vertical clearances and wetland mitigation costs. Thus, the actual systemwide benefit/cost ratio is likely lower than 0.77.

RECOMMENDATIONS

Any proposed systemwide speed limit policy scenarios involving an increase in the maximum speed limit would undoubtedly result in substantial infrastructure costs associated with geometric modifications necessary to increase the design speed to comply with state and federal requirements at the time of a 3R or 4R project. The majority of the MDOT non-freeway trunkline network is currently designed for compliance with posted speed limits of 55 to 60 mph.

Consequently, systemwide increases in the posted speed limit beyond these levels would result in geometric upgrade costs and economic crash costs that would greatly outweigh the net user benefits, resulting in benefit/cost ratios below 1.0. Furthermore, even with a design exception, the costs associated with critical geometric alignment upgrades for design speed compliance should not be disregarded, as additional crashes and associated economic costs would likely result if the design speed is not modified to comply with the increased posted speed limit.

Consequently, to avoid costly geometric improvements during 3R or 4R projects, non-freeway speed limit increases to 65 mph should only be considered for lower risk candidate sections of roadway where design speed compliance is generally maintained. Specifically, segments that would require horizontal or vertical realignment to achieve design speed compliance during a 3R or 4R project should be excluded due to the substantially large infrastructure costs. However, even if design speed compliance can be maintained, careful detailed site specific consideration must be given to the potential safety impacts – particularly to fatal and injury crashes – that may result after increasing the speed limit. To those ends, it is recommended that comprehensive engineering and safety analyses be performed prior to any speed limit increase for those roadway segments under consideration.

Appendix 1

Field Speed Data Collection Summary

Appendix 1: Field Speed Data Collection Summary

55 MPH Speed Limit Sites

Route	Nearest Intersection	County	Reg.	Passenger Cars N	Passenger Cars Mean	Passenger Cars 85th	Truck / Bus N	Truck / Bus Mean	Truck / Bus 85th	All Vehicles N	All Vehicles Mean	All Vehicles 85th	Std. Dev.	% Exceeding Speed Limit	% Exceeding Speed Limit +5 mph	% Exceeding Speed Limit +10mph
M - 28	Danaher Rd	Luce	1	100	61.72	65.15	4	58.00	61.55	104	61.58	65.00	3.77	94.2%	60.6%	14.4%
M - 28	Soo Junction Rd	Luce	1	100	60.20	64.00	15	58.60	61.80	115	59.99	63.00	4.50	86.1%	40.9%	11.3%
M - 28	Branch Rd	Schoolcraft	1	100	61.93	65.00	7	58.14	61.00	107	61.68	65.00	3.83	94.4%	61.7%	11.2%
M - 32	Atlas Electric Dr	Charlevoix	1	100	55.82	61.00	10	52.80	56.00	110	55.55	60.65	5.16	53.6%	15.5%	0.9%
M - 35	I Ln	Delta	1	100	61.44	65.00	31	57.45	60.50	131	60.50	64.00	5.04	90.8%	46.6%	9.2%
M - 35	Harbor Point Rd	Menominee	1	100	59.70	64.00	23	57.43	61.70	123	59.27	63.00	4.47	80.5%	34.1%	5.7%
M - 67	Kalio Rd	Alger	1	100	58.45	62.00	15	58.20	61.00	115	58.42	62.00	4.70	75.7%	33.9%	3.5%
M - 77	Camp 23 Rd	Schoolcraft	1	100	60.75	66.00	4	60.00	63.20	104	60.72	65.55	4.55	84.6%	48.1%	15.4%
M - 94	CR 545 S	Marquette	1	89	59.53	63.00	17	60.53	63.60	106	59.69	63.00	4.69	83.0%	39.6%	7.5%
M - 117	Raski Rd	Mackinac	1	100	61.33	65.00	11	61.36	64.00	111	61.33	64.00	3.85	93.7%	51.4%	9.9%
M - 123	Worth Rd	Mackinac	1	100	60.53	64.15	5	54.80	59.40	105	60.26	64.00	4.45	86.7%	45.7%	10.5%
US - 2	Z Rd	Delta	1	100	60.96	65.15	16	56.88	60.75	116	60.40	65.00	4.78	85.3%	46.6%	12.9%
US - 2	US Forest Service Rd	Gogebic	1	100	59.75	63.00	12	60.67	65.35	112	59.85	63.00	4.45	89.3%	35.7%	8.9%
US - 2	Damon Lake Rd	Gogebic	1	60	61.12	65.15	6	58.17	64.00	66	60.85	65.00	4.74	84.8%	56.1%	13.6%
US - 2	Brevort Lake Rd.	Mackinac	1	100	58.71	63.00	7	55.71	60.10	107	58.51	63.00	5.72	77.6%	29.0%	9.3%
US - 2	Borgstrom Rd	Mackinac	1	100	59.90	63.00	15	57.60	60.00	115	59.60	63.00	4.49	80.9%	41.7%	6.1%
US - 2	Quarry Rd	Mackinac	1	100	61.07	65.15	15	60.07	62.90	115	60.94	65.00	4.73	93.9%	45.2%	14.8%
US - 2	Townline Rd	Schoolcraft	1	100	58.72	62.00	8	55.88	59.90	108	58.51	62.00	4.17	81.5%	28.7%	2.8%
US - 2	CR 442	Schoolcraft	1	100	57.53	62.00	14	58.29	61.00	114	57.62	62.00	4.53	77.2%	29.8%	1.8%
US - 2*	Baker Blackjack Rd	Gogebic	1	100	55.50	60.00	10	50.50	56.00	110	55.05	60.00	5.99	51.8%	12.7%	2.7%
US - 2/41	Hansen Ln	Menominee	1	100	58.99	64.00	5	58.40	60.00	105	58.96	63.40	4.35	81.9%	36.2%	4.8%
US - 2/41*	P Dr	Delta	1	100	60.55	69.00	10	48.80	53.25	110	59.48	67.00	8.26	64.5%	47.3%	20.0%
US - 41	CR 15	Delta	1	100	61.21	64.00	9	59.56	61.00	109	61.07	64.00	3.52	93.6%	58.7%	11.0%
US - 41	CR OOF	Marquette	1	100	61.58	64.15	5	62.00	64.00	105	61.60	64.00	4.17	92.4%	62.9%	7.6%
US - 41	19 Rd	Menominee	1	100	58.44	61.15	13	58.46	60.20	113	58.44	61.00	3.45	82.3%	27.4%	1.8%
US - 41	36.5 Rd	Menominee	1	100	59.82	63.15	5	59.80	63.20	105	59.82	63.40	4.20	86.7%	41.9%	5.7%
US - 45	Erickson Rd	Ontonagon	1	100	60.11	64.00	16	56.25	59.00	116	59.58	63.00	4.24	83.6%	39.7%	5.2%

Appendix 1: Field Speed Data Collection Summary

55 MPH Speed Limit Sites

Route	Nearest Intersection	County	Reg.	Passenger Cars N	Passenger Cars Mean	Passenger Cars 85th	Truck / Bus N	Truck / Bus Mean	Truck / Bus 85th	All Vehicles N	All Vehicles Mean	All Vehicles 85th	Std. Dev.	% Exceeding Speed Limit	% Exceeding Speed Limit +5 mph	% Exceeding Speed Limit +10mph
US - 45	Old Hwy 45	Ontonagon	1	100	61.46	65.00	13	56.54	62.20	113	60.89	65.00	5.06	87.6%	56.6%	10.6%
M - 22	CR 610	Benzie	2	100	54.33	58.00	1	50.00	50.00	101	54.29	58.00	6.12	30.7%	5.0%	2.0%
M - 37	Payne Trucking Dr	Grand Traverse	2	100	57.29	61.00	5	54.40	55.80	105	57.15	61.00	3.95	66.7%	21.0%	1.9%
M - 37	S Buckley Rd	Grand Traverse	2	100	59.28	63.00	5	59.20	61.80	105	59.28	63.00	3.64	87.6%	37.1%	6.7%
M - 37	Grouse Rd	Grand Traverse	2	100	56.06	60.00	12	52.92	56.35	112	55.72	59.35	4.62	54.5%	8.9%	2.7%
M - 37*	Chums Village Dr	Grand Traverse	2	100	50.72	56.00	5	45.00	47.80	105	50.45	56.00	5.46	18.1%	1.0%	0.0%
M - 55	Blodgett Rd	Missaukee	2	100	60.04	64.15	7	58.86	60.10	107	59.96	64.00	3.68	92.5%	38.3%	9.3%
M - 61	20th Ave	Osceola	2	100	59.74	63.00	16	56.44	58.75	116	59.28	63.00	5.46	80.2%	30.2%	6.9%
M - 66	Cool Rd	Kalkaska	2	100	59.80	64.00	9	58.00	61.00	109	59.65	64.00	4.17	90.8%	40.4%	4.6%
M - 72	Dockery Rd	Kalkaska	2	100	59.31	62.00	6	57.17	58.25	106	59.19	62.00	3.27	89.6%	31.1%	2.8%
M - 72	Baker Rd	Kalkaska	2	100	60.31	64.00	10	58.60	60.00	110	60.15	64.00	3.48	91.8%	40.0%	4.5%
M - 75	Topolinski Rd	Charlevoix	2	100	56.75	60.00	0	N/A	N/A	100	56.75	60.00	3.68	69.0%	11.0%	1.0%
M - 88	Del Mason Rd	Antrim	2	100	60.28	65.00	5	59.60	62.80	105	60.25	64.40	4.27	86.7%	46.7%	10.5%
M - 113	Gleaner Hall Rd	Grand Traverse	2	100	58.25	63.00	15	57.27	60.00	115	58.12	63.00	4.65	74.8%	26.1%	5.2%
M - 115	Colfax Rd	Manistee	2	99	55.33	61.00	7	51.00	55.20	106	55.05	61.00	5.36	51.9%	16.0%	0.9%
M - 115	13 Mile Rd	Osceola	2	100	61.44	65.00	10	55.90	58.65	110	60.94	65.00	4.43	93.6%	53.6%	10.0%
M - 115	S 27 Rd	Wexford	2	100	60.21	64.15	11	57.55	59.50	111	59.95	64.00	4.11	90.1%	39.6%	6.3%
US - 31	Demerly Rd	Benzie	2	100	57.26	61.00	13	54.85	58.40	113	56.98	61.00	4.04	69.9%	15.9%	0.9%
US - 131	Sandy Hill Rd	Antrim	2	100	61.83	65.00	5	57.40	59.80	105	61.62	65.00	4.05	96.2%	61.9%	13.3%
US - 131	Bauman Rd	Charlevoix	2	100	59.37	62.00	3	58.67	60.50	103	59.35	62.00	3.09	87.4%	36.9%	2.9%
US - 131	Elliot Rd	Grand Traverse	2	100	59.62	63.00	22	57.23	60.00	122	59.19	63.00	3.40	86.9%	33.6%	3.3%
US - 131	Larson Rd	Kalkaska	2	100	59.99	64.00	12	56.25	57.70	112	59.59	63.00	3.73	90.2%	33.0%	8.9%
M - 37	28th St	Newaygo	3	100	57.86	61.00	9	56.33	58.00	109	57.73	61.00	3.30	70.6%	18.3%	1.8%
M - 37	Hayes Rd	Newaygo	3	94	58.06	61.00	6	56.00	57.75	100	57.94	61.00	4.01	73.0%	25.0%	5.0%
M - 44	Bartonville Rd	Ionia	3	100	57.30	62.00	13	56.46	59.40	113	57.20	62.00	4.72	68.1%	22.1%	3.5%
M - 82	South Comstock Rd	Newaygo	3	100	56.83	60.15	5	56.60	60.80	105	56.82	60.40	4.13	64.8%	15.2%	1.9%
M - 20*	South Shannon Dr	Midland	4	100	59.21	64.00	16	57.56	61.75	116	58.98	63.00	3.92	87.9%	31.0%	4.3%

Appendix 1: Field Speed Data Collection Summary

55 MPH Speed Limit Sites

				Passenger Cars			Truck / Bus			All Vehicles						
Route	Nearest Intersection	County	Reg.	N	Mean	85th	N	Mean	85th	N	Mean	85th	Std. Dev.	% Exceeding Speed Limit	% Exceeding Speed Limit +5 mph	% Exceeding Speed Limit +10mph
M - 43	37th St	Van Buren	5	100	58.25	62.00	6	52.50	54.25	106	57.92	62.00	4.29	72.6%	22.6%	2.8%
M - 86	Webb Rd	Branch	5	100	56.51	60.15	11	54.55	60.50	111	56.32	60.50	4.35	61.3%	15.3%	0.9%
M - 99	J Dr S	Calhoun	5	100	56.19	61.00	11	54.09	58.00	111	55.98	60.50	4.65	53.2%	15.3%	1.8%
M - 140	Territorial Rd	Berrien	5	100	53.58	59.00	12	51.75	56.00	112	53.38	58.00	5.48	36.6%	4.5%	1.8%
US - 131**	Heimbach Rd	St Joseph	5	100	59.43	64.00	20	56.15	61.00	120	58.88	63.15	4.34	80.0%	38.3%	3.3%
M - 50	Palmer Rd	Jackson	6	100	55.68	59.15	7	53.14	56.00	107	55.51	59.00	3.75	43.9%	9.3%	0.9%
M - 52	Taylor Rd	Lenawee	6	100	59.73	63.00	3	54.67	56.10	103	59.58	63.00	3.88	89.3%	36.9%	5.8%
M - 99	Buck Hwy	Eaton	6	100	57.19	61.00	18	55.50	57.45	118	56.93	61.00	4.01	69.5%	16.9%	1.7%
M - 99**	Rossman Hwy	Eaton	6	100	58.68	64.15	8	53.75	57.90	108	58.31	63.95	5.84	66.7%	28.7%	11.1%
US - 12	Cement City Hwy	Lenawee	6	100	56.97	61.00	5	56.40	59.80	105	56.94	61.00	3.51	67.6%	17.1%	1.0%
US - 127	Stewart Rd	Hillsdale	6	100	58.12	62.00	9	55.67	58.00	109	57.92	62.00	4.30	76.1%	28.4%	3.7%
US - 127	Rogers Rd	Lenawee	6	100	57.20	61.00	12	55.67	59.40	112	57.04	61.00	3.84	64.3%	17.9%	1.8%
M - 53	Hatties Ln	Macomb	7	100	54.74	59.00	20	52.00	55.15	120	54.28	58.00	3.85	39.2%	2.5%	0.0%

* Multilane undivided segment

** Multilane divided segment

Appendix 1: Field Speed Data Collection Summary

Speed Reduction Zones

Route	Intersection	County	Reg.	Speed Limit	Direction	Passenger Cars N	Passenger Cars Mean	Passenger Cars 85th	Truck / Bus N	Truck / Bus Mean	Truck / Bus 85th	All Vehicles N	All Vehicles Mean	All Vehicles 85th	Std. Dev.	% Exceed Speed Limit	% Exceed Speed Limit +5 mph	% Exceed Speed Limit +10 mph
M - 28	Blank St	Alger	1	50	Inbound	50	44.72	51.00	2	50.50	51.55	52	44.94	51.00	5.85	21.2%	1.9%	0.0%
M - 28	Blank St	Alger	1	50	Outbound	50	46.52	50.00	4	50.50	55.50	54	46.81	50.05	4.85	14.8%	3.7%	1.9%
M - 28	Railroad St	Schoolcraft	1	50	Inbound	50	56.66	61.00	7	52.00	55.00	57	56.09	60.60	4.61	84.2%	54.4%	15.8%
M - 28	Railroad St	Schoolcraft	1	50	Outbound	50	56.86	62.00	5	55.20	58.00	55	56.71	62.00	4.92	92.7%	61.8%	25.5%
M - 35*	14th Ave S	Delta	1	45	Inbound	50	45.26	49.65	7	40.43	44.40	57	44.67	48.60	4.76	42.1%	8.8%	1.8%
M - 35*	14th Ave S	Delta	1	45	Outbound	50	47.00	52.65	4	41.40	44.80	54	46.49	52.00	5.70	61.8%	21.8%	3.6%
US - 2	Wisconsin Ave	Delta	1	35	Inbound	50	40.88	46.65	1	37.00	37.00	51	40.80	46.50	5.19	86.3%	52.9%	19.6%
US - 2	Wisconsin Ave	Delta	1	35	Outbound	50	39.10	43.00	2	34.00	35.40	52	38.90	43.00	4.53	80.8%	40.4%	7.7%
US - 2	Glenwood Dr	Schoolcraft	1	45	Inbound	50	53.74	58.00	6	55.83	60.50	56	53.96	58.00	4.37	100%	76.8%	28.6%
US - 2	Glenwood Dr	Schoolcraft	1	45	Outbound	50	51.82	57.00	5	55.80	58.60	55	52.18	57.00	5.22	89.1%	63.6%	30.9%
US - 2**	7th Ave	Dickinson	1	40	Inbound	50	50.72	56.00	3	48.33	53.50	53	50.58	56.00	6.18	94.3%	77.4%	49.1%
US - 2**	7th Ave	Dickinson	1	40	Outbound	50	43.76	50.00	4	40.25	44.20	54	43.50	50.00	5.51	70.4%	38.9%	13.0%
US - 2**	Tamarack Ave	Gogebic	1	40	Inbound	50	37.58	42.65	6	31.33	34.50	56	36.91	42.00	5.33	30.4%	1.8%	0.0%
US - 2**	Tamarack Ave	Gogebic	1	40	Outbound	50	44.12	51.00	5	40.60	46.40	55	43.80	51.00	5.62	70.9%	34.5%	18.2%
US - 2**	E Pierce St	Gogebic	1	40	Inbound	50	46.12	52.00	1	52.00	52.00	51	46.24	52.00	6.12	76.5%	54.9%	25.5%
US - 2**	E Pierce St	Gogebic	1	40	Outbound	50	49.68	56.65	8	42.50	45.00	58	48.69	55.45	6.84	87.9%	63.8%	36.2%
US - 2**	S Second St	Mackinac	1	45	Inbound	50	50.66	55.30	1	50.00	50.00	51	50.65	55.00	4.51	88.2%	45.1%	15.7%
US - 2**	S Second St	Mackinac	1	45	Outbound	50	53.80	60.00	4	54.00	59.10	54	53.81	60.00	7.18	83.3%	66.7%	42.6%
US - 2/41**	N Lakeshore Dr	Delta	1	45	Inbound	50	56.30	61.00	6	47.17	52.75	56	55.32	60.75	5.28	96.4%	76.8%	58.9%
US - 2/41**	N Lakeshore Dr	Delta	1	45	Outbound	50	54.78	60.00	5	47.60	52.80	55	54.13	60.00	5.74	90.9%	74.5%	41.8%
US - 2/41**	N 30th St	Delta	1	45	Inbound	50	54.26	58.00	6	47.67	53.25	56	53.55	58.00	4.97	94.6%	75.0%	39.3%
US - 2/41**	N 30th St	Delta	1	45	Outbound	50	57.22	61.65	4	52.00	56.65	54	56.83	61.05	5.02	98.1%	88.9%	64.8%
US - 41	CR G 12	Menominee	1	40	Inbound	50	40.34	45.00	4	42.50	44.65	54	40.50	45.05	4.45	50.0%	14.8%	1.9%
US - 41	CR G 12	Menominee	1	40	Outbound	50	42.84	50.00	1	44.00	44.00	51	42.86	50.00	6.67	58.8%	31.4%	13.7%
US - 41	E Rd 39.25	Menominee	1	35	Inbound	50	49.38	53.00	4	43.75	48.65	54	48.96	53.00	5.54	100%	96.3%	72.2%
US - 41	E Rd 39.25	Menominee	1	35	Outbound	50	54.12	59.00	5	49.40	52.00	55	53.69	59.00	5.23	100%	100.0%	96.4%

Appendix 1: Field Speed Data Collection Summary

Speed Reduction Zones

Route	Intersection	County	Reg.	Speed Limit	Direction	Passenger Cars N	Passenger Cars Mean	Passenger Cars 85th	Truck / Bus N	Truck / Bus Mean	Truck / Bus 85th	All Vehicles N	All Vehicles Mean	All Vehicles 85th	Std. Dev.	% Exceed Speed Limit	% Exceed Speed Limit +5 mph	% Exceed Speed Limit +10 mph
US - 41**	Cherry Creek Rd	Marquette	1	45	Inbound	50	49.24	53.00	3	45.00	45.70	53	49.00	53.00	3.56	77.4%	41.5%	1.9%
US - 41**	Cherry Creek Rd	Marquette	1	45	Outbound	50	50.78	54.00	0	N/A	N/A	50	50.78	54.00	3.75	92.0%	58.0%	6.0%
US - 45	4th St	Ontonagon	1	35	Inbound	32	39.06	46.05	1	30.00	30.00	33	38.79	45.60	6.11	72.7%	27.3%	15.2%
US - 45	4th St	Ontonagon	1	35	Outbound	27	42.04	47.10	1	50.00	50.00	28	42.32	47.95	4.93	92.9%	60.7%	25.0%
M - 37	Timberlane Tr	Wexford	2	45	Inbound	50	52.58	58.65	10	49.50	53.00	60	52.07	57.15	5.85	88.3%	65.0%	20.0%
M - 37	Timberlane Tr	Wexford	2	45	Outbound	50	51.54	55.00	3	48.67	54.80	53	51.38	55.20	5.24	88.7%	67.9%	15.1%
M - 37**	Hartman Rd	Gnd. Traverse	2	45	Inbound	50	49.04	54.00	6	46.00	50.50	56	48.71	54.00	5.37	71.4%	42.9%	8.9%
M - 37**	Hartman Rd	Gnd. Traverse	2	45	Outbound	50	52.24	57.00	2	48.50	48.85	52	52.10	57.00	5.55	84.6%	59.6%	28.8%
M - 72	Old M - 72	Kalkaska	2	45	Inbound	50	43.90	47.00	5	42.40	44.40	55	43.76	47.00	3.31	27.3%	3.6%	0.0%
M - 72	Old M - 72	Kalkaska	2	45	Outbound	50	46.08	50.00	2	46.00	48.10	52	46.08	50.00	3.76	59.6%	9.6%	0.0%
M - 72*	S Au Sable Tr	Crawford	2	45	Inbound	50	53.54	58.65	4	51.50	54.65	54	53.39	58.05	4.80	96.3%	74.1%	29.6%
M - 72*	S Au Sable Tr	Crawford	2	45	Outbound	50	50.76	57.65	6	44.50	50.75	56	50.93	57.00	6.80	82.1%	55.3%	25.0%
M - 115	40 3/4 Rd	Wexford	2	40	Inbound	50	45.22	49.65	4	40.75	42.00	54	44.89	49.05	4.40	81.5%	48.1%	9.3%
M - 115	40 3/4 Rd	Wexford	2	40	Outbound	50	46.46	51.65	9	45.44	49.40	59	46.31	51.30	4.65	91.5%	47.5%	20.3%
US - 131	Wabash Ave	Antrim	2	45	Inbound	50	45.66	48.65	4	45.25	46.55	54	45.63	48.05	4.27	48.1%	9.3%	3.7%
US - 131	Wabash Ave	Antrim	2	45	Outbound	50	53.14	57.00	9	51.00	54.40	59	52.81	57.00	4.16	100%	71.2%	27.1%
US - 131	Cherry Hill Rd	Charlevoix	2	45	Inbound	50	47.32	53.65	1	42.00	42.00	51	47.22	53.50	6.17	62.7%	23.5%	9.8%
US - 131	Cherry Hill Rd	Charlevoix	2	45	Outbound	50	53.68	59.00	0	N/A	N/A	50	53.68	59.00	5.25	94.0%	74.0%	36.0%
US - 131	1st St	Kalkaska	2	45	Inbound	50	47.52	52.00	5	46.00	48.00	55	47.38	52.00	4.23	65.5%	27.3%	1.8%
US - 131	1st St	Kalkaska	2	45	Outbound	50	44.46	47.65	5	43.20	47.00	55	44.35	47.90	4.58	38.2%	5.5%	3.6%
M - 37	E State Rd	Newaygo	3	40	Inbound	50	44.22	48.00	5	44.20	46.20	55	44.22	48.00	3.90	83.6%	36.4%	7.3%
M - 37	E State Rd	Newaygo	3	40	Outbound	50	48.84	52.00	11	46.00	51.00	61	48.33	52.00	4.21	95.1%	77.0%	36.1%
M - 37**	W John St	Newaygo	3	45	Inbound	50	42.98	47.00	6	42.17	46.00	56	42.89	47.00	3.95	25.0%	0.0%	0.0%
M - 37**	W John St	Newaygo	3	45	Outbound	50	47.76	52.65	6	43.83	49.75	56	47.34	52.00	4.52	64.3%	21.4%	3.6%
M - 53	Amherst Ln	Lapeer	4	40	Inbound	50	42.58	47.00	6	41.17	44.00	56	42.43	47.00	4.47	67.9%	26.8%	0.0%

Appendix 1: Field Speed Data Collection Summary

Speed Reduction Zones

Route	Intersection	County	Reg.	Speed Limit	Direction	Passenger Cars N	Passenger Cars Mean	Passenger Cars 85th	Truck / Bus N	Truck / Bus Mean	Truck / Bus 85th	All Vehicles N	All Vehicles Mean	All Vehicles 85th	Std. Dev.	% Exceed Speed Limit	% Exceed Speed Limit +5 mph	% Exceed Speed Limit +10 mph
M - 53	Amherst Ln	Lapeer	4	40	Outbound	50	48.56	53.00	10	47.60	51.30	60	48.40	53.00	4.85	93.3%	75.0%	31.7%
M - 43	Eastwood Ln	Van Buren	5	45	Inbound	50	49.64	54.00	3	46.00	52.00	53	49.43	54.20	4.60	79.2%	43.4%	7.5%
M - 43	Eastwood Ln	Van Buren	5	45	Outbound	50	51.16	56.00	7	51.14	54.10	57	51.16	56.00	4.42	94.7%	57.9%	17.5%
M - 86	Shimmel Rd	St Joseph	5	45	Inbound	50	42.60	46.00	3	41.67	43.10	53	42.55	46.00	3.39	18.9%	1.9%	0.0%
M - 86	Shimmel Rd	St Joseph	5	45	Outbound	50	51.54	55.00	4	50.75	53.85	54	51.48	55.00	4.06	92.6%	66.7%	13.0%
M - 86	S Burr Oak Rd	St Joseph	5	45	Inbound	50	43.52	49.00	2	46.00	51.60	52	43.62	49.00	5.41	40.4%	9.6%	1.9%
M - 86	S Burr Oak Rd	St Joseph	5	45	Outbound	50	49.96	54.65	5	43.80	48.40	55	49.40	54.00	5.42	76.4%	41.8%	10.9%
M - 140	Dan Smith Rd	Berrien	5	35	Inbound	31	47.16	50.00	1	43.00	43.00	32	47.03	50.00	5.07	100%	93.8%	62.5%
M - 140	Dan Smith Rd	Berrien	5	35	Outbound	30	49.80	57.65	4	47.00	52.10	34	49.47	57.05	6.03	100%	94.1%	76.5%
US - 127	Hemlock St	Hillsdale	6	45	Inbound	50	45.26	50.00	8	45.00	47.00	58	45.22	49.45	4.47	46.6%	12.1%	1.7%
US - 127	Hemlock St	Hillsdale	6	45	Outbound	50	47.94	52.65	4	41.25	43.20	54	47.44	52.05	5.02	64.8%	24.1%	9.3%
US - 127	Manitou Rd	Lenawee	6	45	Inbound	50	49.78	54.00	8	47.63	51.90	58	49.48	54.00	4.49	81.0%	34.5%	10.3%
US - 127	Manitou Rd	Lenawee	6	45	Outbound	50	53.66	59.00	5	53.20	57.80	55	53.62	59.00	5.00	94.5%	70.9%	38.2%

65 MPH Speed Limit Site

Route	Intersection	County	Reg.	Passenger Cars N	Passenger Cars Mean	Passenger Cars 85th	Truck / Bus N	Truck / Bus Mean	Truck / Bus 85th	All Vehicles N	All Vehicles Mean	All Vehicles 85th	Std. Dev.	% Exceeding Speed Limit	% Exceeding Speed Limit +5 mph	% Exceeding Speed Limit +10mph
US - 2/41**	Days River Rd	Delta	1	100	64.45	70.00	26	59.23	63.25	126	63.37	70.00	5.78	34.9%	6.3%	0.8%

* Multilane observation site
** Multilane divided roadway observation site

Appendix 2

Prioritization Results for MDOT 55 mph Non-Freeway Segments

(Refer to Table 12 for Prioritization Criteria)

Appendix 2: Prioritization Results for MDOT 55 mph Non-Freeway Segments

Lower Risk 55 mph UNDIVIDED Segments
(All Selection Criteria Satisfied; 8.0 mi. Minimum Length)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi.	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
1	2	Delta	39.4	9948	No	No	4.6%	12.0	0.3	0.3	7.7%	0.0%	0.0%	215.77	23.24	5.67
1	2	Gogebic	59.2	4335	No	No	8.6%	3.4	0.3	0.3	9.1%	0.0%	0.0%	184.07	24.32	6.47
1	2	Mackinac	61.8	4326	No	No	5.8%	7.5	0.0	0.2	0.8%	0.0%	0.0%	153.76	21.67	6.64
1	2	Schoolcraft	35.7	4431	No	No	6.2%	11.4	0.0	0.0	6.3%	0.0%	0.0%	192.86	16.48	4.48
1	28	Houghton	15.3	1565	No	No	0.0%	5.0	0.0	0.0	0.0%	0.0%	0.0%	155.64	11.04	4.42
1	28	Schoolcraft	23.8	2140	No	No	1.7%	2.1	0.0	0.0	1.5%	0.0%	0.0%	213.41	15.06	4.67
1	35	Menominee	32.0	3250	No	No	11.3%	16.2	0.0	0.0	7.5%	1.0%	0.0%	211.72	26.33	4.61
1	67	Alger	10.4	1078	No	No	7.7%	10.9	0.0	0.0	13.5%	5.1%	0.0%	239.98	19.46	0.00
1	77	Schoolcraft	28.8	960	No	No	9.0%	6.3	0.0	0.0	1.7%	1.3%	0.0%	223.01	19.55	3.55
1	94	Marquette	14.3	1739	No	No	28.1%	5.6	0.0	0.0	9.1%	8.0%	0.0%	207.23	29.81	1.42
1	123	Chippewa	49.5	980	No	No	25.3%	9.5	0.0	0.2	0.0%	9.3%	0.0%	154.56	27.66	4.21
1	123	Mackinac	18.4	1587	No	No	9.8%	3.4	0.0	0.0	0.0%	0.0%	0.0%	211.09	23.56	5.89
2	23	Cheboygan	24.6	1798	No	No	13.8%	17.1	0.0	0.0	16.9%	0.0%	0.0%	217.85	28.73	3.13
2	23	Presque Isle	52.3	2060	No	No	6.1%	13.0	0.0	0.0	8.0%	0.0%	0.0%	208.85	23.07	4.71
2	27	Cheboygan	13.3	4007	No	No	24.9%	19.2	0.0	0.0	20.6%	9.8%	0.0%	248.85	30.64	4.84
2	31	Antrim	23.7	5659	No	No	12.7%	14.4	0.0	0.0	6.3%	0.0%	0.0%	223.75	25.08	5.77
2	31	Benzie	18.7	9350	No	No	27.9%	16.0	0.0	0.0	20.9%	2.8%	0.0%	146.91	18.26	3.20
2	31	Charlevoix	17.1	6805	No	No	4.7%	10.8	0.0	0.0	14.2%	0.0%	0.0%	225.28	23.00	3.99
2	32	Alpena	20.2	8130	No	No	0.0%	18.3	0.5	0.0	9.6%	0.0%	0.0%	214.62	28.36	3.69
2	37	Lake	21.1	2502	No	No	16.1%	10.9	0.0	0.9	3.5%	1.5%	0.0%	243.91	21.46	6.24
2	72	Crawford	23.1	4049	No	No	10.4%	14.3	0.4	0.0	10.1%	0.0%	0.0%	230.06	24.36	5.68
2	115	Benzie	14.0	4400	No	No	25.8%	10.3	0.0	0.0	4.6%	0.0%	0.0%	242.29	23.25	4.65
3	20	Oceana	17.7	2431	No	No	1.1%	11.6	0.0	0.0	2.7%	0.0%	0.0%	238.18	29.55	5.91
3	82	Newaygo	23.1	7601	No	No	33.8%	15.3	0.4	0.4	15.2%	0.9%	0.0%	233.55	24.87	5.38
4	10	Clare	8.7	3736	No	No	13.8%	10.7	0.0	0.0	8.4%	0.0%	0.0%	240.88	31.90	5.21
4	61	Gladwin	20.1	7225	No	No	3.5%	14.2	0.5	0.0	5.2%	0.0%	0.0%	160.67	19.78	4.83
5	60	St Joseph	23.2	3892	No	No	19.0%	12.9	0.0	0.4	16.3%	3.1%	0.0%	221.50	30.71	6.26
6	21	Clinton	20.4	5820	No	No	8.3%	9.8	0.0	0.5	14.4%	0.0%	0.0%	231.84	25.28	3.54
6	127	Hillsdale	17.6	5388	No	No	17.6%	10.3	0.0	0.0	6.1%	2.2%	0.0%	197.22	29.23	5.46

55 mph UNDIVIDED Segments Satisfying Historical Crash Criteria Only
(8.0 mi. Minimum Length; Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
1	28	Marquette	11.2	6915	No	No	1.8%	24.2	0.9	0.0	30.3%	0.0%	0.0%	125.26	24.54	3.39
2	22	Leelanau	53.4	3246	No	Some	55.8%	19.6	0.2	0.2	20.3%	23.2%	4.0%	201.05	30.02	6.00
2	23	Alpena	21.5	6600	No	No	9.3%	38.3	0.0	1.4	20.1%	0.0%	0.0%	176.84	29.44	4.33
2	31	Emmet	27.8	7448	No	No	14.4%	10.8	0.4	1.4	28.8%	0.0%	0.0%	212.15	28.97	6.09
2	32	Montmorency	30.7	3461	No	No	28.0%	16.1	0.0	0.3	2.4%	8.3%	3.1%	204.96	23.12	4.87
2	32	Otsego	27.0	5259	No	No	63.0%	13.5	0.4	1.9	7.3%	12.2%	2.3%	178.81	33.07	5.92
2	33	Oscoda	27.1	3357	No	No	62.8%	15.9	0.0	1.5	4.4%	1.4%	1.4%	228.47	30.03	6.85
2	37	Grand Traverse	29.2	6852	No	No	65.8%	18.2	0.7	0.3	2.5%	11.4%	1.5%	199.68	35.12	6.07
2	55	Roscommon	15.8	5504	No	No	21.5%	11.4	0.0	0.0	34.7%	3.5%	0.0%	155.01	19.25	3.46
2	65	Iosco	28.8	3041	No	No	30.9%	13.0	1.0	0.0	6.5%	3.6%	0.0%	165.46	21.99	4.12
2	72	Grand Traverse	8.4	14981	No	Some	15.5%	10.7	2.4	1.2	12.1%	0.0%	0.0%	179.67	33.45	6.32
2	72	Leelanau	21.7	4688	No	No	42.3%	10.7	0.9	0.0	3.0%	6.5%	1.4%	217.17	30.08	6.92
2	113	Grand Traverse	15.8	5273	No	No	35.4%	11.5	0.0	1.3	4.6%	5.6%	0.0%	231.30	25.89	5.18
2	115	Manistee	9.7	2643	No	No	16.4%	8.7	0.0	1.0	0.0%	0.0%	0.0%	230.49	32.11	5.73
2	131	Antrim	19.5	6450	No	No	2.1%	7.1	0.0	1.0	9.5%	0.0%	0.0%	132.08	22.42	5.11
3	46	Muskegon	14.0	6638	No	Some	5.7%	0.5	1.4	0.0	36.9%	0.2%	0.2%	186.42	30.10	5.22
3	50	Ionia	10.4	3607	No	Yes	30.4%	14.1	0.0	1.9	7.1%	2.9%	2.9%	218.13	31.94	5.45
4	13	Genesee	13.5	5862	No	No	3.7%	15.4	2.2	0.0	7.7%	0.0%	0.0%	192.87	33.47	6.69
4	15	Tuscola	15.3	5660	No	No	13.7%	24.5	0.0	1.3	13.5%	0.0%	0.0%	168.72	31.13	6.12
4	20	Midland	18.1	15593	No	Some	0.0%	30.5	2.8	0.6	16.4%	0.0%	0.0%	155.76	34.90	5.52
4	23	Arenac	26.1	8513	No	No	1.9%	29.3	0.8	0.0	11.5%	2.7%	0.0%	206.67	23.25	5.34
4	25	Tuscola	13.1	4760	No	No	8.4%	17.6	0.0	0.0	7.5%	1.7%	1.7%	161.62	27.32	6.83
4	52	Saginaw	17.8	6315	No	No	24.1%	27.1	0.6	0.0	12.9%	0.0%	0.0%	222.69	22.96	4.98
4	53	Lapeer	24.9	10139	No	No	19.7%	19.8	1.6	0.0	10.1%	0.0%	0.0%	193.66	33.53	6.66
4	81	Saginaw	9.7	10216	No	No	0.0%	15.3	0.0	1.0	10.3%	2.0%	0.8%	103.97	23.10	3.04
5	89	Allegan	23.9	6686	No	No	21.3%	20.1	0.0	0.8	27.1%	0.0%	0.0%	186.21	28.50	5.07

Appendix 2: Prioritization Results for MDOT 55 mph Non-Freeway Segments

55 mph UNDIVIDED Segments Satisfying Historical Crash Criteria Only
(8.0 mi. Minimum Length; Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
5	131	St Joseph	14.2	7318	No	Some	18.3%	8.7	1.4	0.0	21.0%	0.0%	0.0%	91.07	17.72	2.66
5	222	Allegan	8.9	8598	No	No	0.0%	15.6	0.0	2.3	12.9%	0.0%	0.0%	200.52	28.51	4.83
6	12	Hillsdale	23.1	6727	No	No	44.2%	16.5	0.0	0.0	10.7%	1.9%	0.0%	225.29	31.04	6.01
6	21	Shiawassee	17.2	7644	No	No	9.3%	22.0	1.2	0.0	22.6%	0.0%	0.0%	213.46	31.57	6.40
6	34	Lenawee	14.8	4571	No	No	37.0%	53.1	0.7	0.0	20.6%	5.1%	0.0%	221.05	35.23	5.81
6	43	Eaton	16.4	14046	No	No	4.3%	14.8	2.4	0.6	28.9%	0.0%	0.0%	233.02	35.78	4.92
6	50	Lenawee	21.9	7488	No	No	5.9%	50.1	2.7	0.0	14.4%	1.2%	0.0%	201.67	32.74	7.05
6	50	Monroe	13.3	8150	No	No	4.5%	20.1	0.0	0.0	15.3%	0.0%	0.0%	140.10	27.70	5.33
6	52	Lenawee	18.2	4462	No	No	5.0%	50.8	1.7	0.0	29.2%	0.0%	0.0%	179.79	31.39	4.27
6	127	Jackson	8.6	14397	No	No	14.0%	9.1	2.3	0.0	0.0%	0.0%	0.0%	149.91	25.30	5.43
6	223	Lenawee	33.2	10129	No	No	40.6%	16.8	1.5	0.9	14.0%	6.3%	0.0%	160.04	35.12	5.97
7	19	Macomb	9.9	9151	No	No	9.1%	0.0	1.0	0.0	34.4%	0.0%	0.0%	124.45	27.52	3.53
7	19	St Clair	16.0	4492	No	No	48.9%	17.8	0.0	0.0	18.4%	4.7%	1.6%	195.97	35.45	4.43

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
1	2	Dickinson	15.7	8036	No	No	19.7%	11.9	1.3	0.0	27.9%	3.6%	0.0%	387.02	26.13	5.97
1	2	Iron	38.3	2810	No	No	15.1%	6.7	0.0	0.0	14.6%	2.4%	0.0%	410.13	26.25	4.52
1	2	Menominee	18.5	5578	No	No	9.7%	9.7	0.0	1.6	6.2%	0.0%	0.0%	290.38	28.89	6.32
1	8	Dickinson	1.8	4926	No	No	16.3%	12.0	0.0	5.4	20.7%	12.5%	0.0%	340.10	55.15	4.60
1	26	Houghton	34.3	3818	No	Some	34.4%	8.4	0.3	1.5	20.1%	9.5%	2.0%	272.14	40.57	11.83
1	26	Keweenaw	22.8	1017	Some	Yes	85.3%	10.2	0.0	0.0	4.9%	46.9%	14.2%	151.91	43.62	18.05
1	26	Ontonagon	15.5	1331	No	No	30.9%	4.8	0.0	0.0	0.0%	8.8%	0.0%	230.63	31.45	7.49
1	28	Alger	39.2	3651	No	No	8.7%	7.9	0.0	0.3	7.7%	0.0%	0.0%	180.24	33.48	10.53
1	28	Baraga	11.6	1818	No	No	10.3%	5.7	0.0	0.0	0.0%	0.0%	0.0%	270.66	20.40	4.08
1	28	Chippewa	43.5	1852	No	No	3.9%	6.9	0.0	0.0	0.0%	0.0%	0.0%	196.68	33.79	8.45
1	28	Gogebic	10.6	1518	No	No	6.6%	3.2	0.0	0.0	10.9%	2.8%	0.0%	188.34	36.45	6.08
1	28	Luce	31.3	2674	No	No	12.5%	19.0	0.0	0.0	0.0%	0.0%	0.0%	292.48	35.54	11.17
1	28	Ontonagon	39.4	1639	No	No	3.6%	8.1	0.0	0.8	1.0%	0.0%	0.0%	338.18	25.39	8.46
1	35	Delta	34.1	2695	No	No	10.0%	11.1	0.0	0.3	21.3%	0.0%	0.0%	376.84	20.77	3.61
1	35	Marquette	38.2	2806	Some	No	43.2%	8.4	0.0	0.0	9.2%	23.4%	3.1%	297.92	50.19	8.50
1	38	Baraga	8.5	3899	No	No	3.5%	9.5	0.0	0.0	11.2%	0.0%	0.0%	375.25	13.56	1.13
1	38	Houghton	12.3	561	No	No	32.5%	12.5	0.0	0.0	0.0%	0.0%	0.0%	700.72	49.55	7.08
1	38	Ontonagon	18.0	934	No	No	1.1%	7.0	0.0	0.0	5.7%	2.3%	0.0%	403.72	26.33	7.31
1	41	Alger	11.1	1850	No	No	10.8%	9.4	0.0	0.0	0.0%	0.0%	0.0%	462.93	50.08	14.89
1	41	Baraga	45.6	4669	No	No	6.8%	7.1	0.0	0.7	1.7%	1.8%	0.0%	231.78	30.45	7.20
1	41	Delta	16.2	2340	No	No	3.7%	6.4	0.0	0.0	0.0%	0.0%	0.0%	411.00	29.86	3.56
1	41	Houghton	19.7	5220	No	No	13.2%	18.0	0.0	0.5	43.2%	4.2%	0.0%	279.88	36.90	12.12
1	41	Keweenaw	17.2	1156	No	No	57.5%	2.1	0.0	0.0	47.8%	15.2%	0.0%	191.10	23.13	9.05
1	41	Marquette	46.6	8651	No	No	9.7%	8.6	0.9	0.2	15.7%	1.7%	0.0%	187.99	33.74	7.39
1	41	Menominee	35.8	3977	No	No	7.8%	14.4	0.3	0.3	15.3%	0.0%	0.0%	377.15	34.34	8.92
1	45	Gogebic	10.4	1643	No	No	19.3%	3.1	0.0	0.0	16.6%	0.0%	0.0%	240.20	23.47	8.28
1	45	Ontonagon	40.6	1171	No	No	15.3%	9.4	0.0	0.0	4.1%	1.7%	1.1%	513.60	47.82	15.94

Appendix 2: Prioritization Results for MDOT 55 mph Non-Freeway Segments

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
1	48	Chippewa	39.7	696	No	No	9.6%	10.1	0.0	0.8	0.0%	5.1%	0.0%	413.28	27.42	2.94
1	64	Gogebic	20.9	521	No	No	25.8%	10.6	0.0	0.0	6.2%	8.7%	0.0%	254.25	23.65	2.96
1	64	Ontonagon	34.0	1113	No	No	7.9%	14.1	0.0	0.3	3.5%	0.0%	0.0%	345.26	20.65	7.43
1	69	Delta	5.2	1185	No	No	28.7%	10.3	0.0	0.0	0.0%	5.2%	0.0%	1222.83	56.01	9.33
1	69	Dickinson	25.3	1114	No	No	39.5%	8.8	0.0	0.4	0.0%	10.5%	0.0%	599.43	24.54	4.72
1	69	Iron	9.4	1682	No	No	20.2%	12.4	0.0	0.0	12.9%	0.0%	0.0%	710.65	47.26	10.91
1	69	Menominee	17.9	856	No	No	26.2%	7.4	0.0	0.0	0.0%	0.0%	0.0%	627.43	35.10	15.36
1	73	Iron	8.2	1061	No	No	49.0%	9.1	0.0	0.0	0.0%	32.0%	5.3%	842.52	85.54	21.38
1	77	Alger	12.9	492	No	No	20.1%	5.5	0.0	0.0	0.0%	2.9%	0.0%	381.82	39.25	17.84
1	80	Chippewa	3.6	2305	No	No	19.7%	19.4	0.0	0.0	55.1%	0.0%	0.0%	463.91	16.28	0.00
1	94	Alger	26.9	1493	No	No	20.1%	7.6	0.0	0.7	0.0%	2.8%	1.4%	226.37	29.85	9.95
1	94	Schoolcraft	31.0	774	No	No	17.4%	6.3	0.0	0.0	9.1%	2.2%	0.0%	473.95	28.61	6.22
1	95	Dickinson	28.6	2843	No	No	12.2%	8.8	0.7	0.0	10.7%	0.0%	0.0%	453.86	20.77	4.09
1	95	Marquette	19.8	2163	No	No	17.2%	5.9	0.0	1.0	0.0%	0.0%	0.0%	301.78	33.30	6.24
1	117	Luce	4.5	1805	No	No	8.9%	15.5	0.0	0.0	0.0%	0.0%	0.0%	315.94	38.69	12.90
1	117	Mackinac	10.0	1596	No	No	5.0%	12.5	0.0	2.0	0.0%	0.0%	0.0%	258.09	23.60	2.95
1	123	Luce	26.2	1719	No	Some	46.3%	13.7	0.0	0.0	7.1%	8.7%	0.8%	179.44	35.32	13.36
1	129	Chippewa	26.7	3328	No	No	7.9%	12.0	0.4	1.1	5.3%	0.0%	0.0%	322.95	31.88	6.63
1	129	Mackinac	5.0	2022	No	No	24.1%	18.7	0.0	0.0	0.0%	0.0%	0.0%	396.97	4.93	0.00
1	134	Chippewa	20.4	779	No	No	29.4%	13.1	0.0	1.0	2.3%	10.1%	0.6%	647.42	47.60	19.04
1	134	Mackinac	28.2	2155	No	No	12.1%	9.9	0.0	0.0	0.0%	0.0%	0.0%	377.97	29.17	10.71
1	141	Baraga	9.6	1072	No	No	13.6%	3.2	0.0	0.0	0.0%	3.9%	0.0%	267.48	25.89	2.88
1	141	Dickinson	1.1	6735	No	No	61.0%	7.0	17.4	0.0	0.0%	15.3%	15.3%	529.41	109.19	13.24
1	141	Iron	24.7	1818	No	No	0.0%	4.7	0.0	0.0	0.0%	0.0%	0.0%	325.50	19.67	5.71
1	149	Schoolcraft	10.6	371	No	No	31.1%	11.8	0.0	0.0	0.0%	19.5%	4.8%	889.15	41.04	27.36
1	183	Delta	15.3	845	No	No	47.1%	14.6	0.0	0.0	6.6%	16.2%	3.0%	482.37	50.20	15.28
1	189	Iron	6.2	2369	No	No	68.2%	7.6	0.0	0.0	20.9%	13.6%	0.0%	538.64	41.89	5.98

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
1	203	Houghton	8.6	923	No	No	48.9%	6.9	0.0	0.0	52.2%	19.6%	1.0%	413.83	38.62	16.55
1	221	Chippewa	1.5	1294	No	No	13.4%	10.0	0.0	0.0	41.3%	0.0%	0.0%	161.04	24.78	0.00
1	553	Marquette	17.7	6356	No	No	26.0%	6.1	0.0	0.0	9.9%	8.8%	0.0%	138.02	28.18	8.67
2	10	Lake	26.0	3651	No	No	10.4%	8.6	0.0	0.0	3.6%	0.0%	0.0%	225.73	29.90	8.50
2	10	Mason	12.2	10536	No	No	8.2%	21.6	1.6	0.0	25.7%	0.0%	0.0%	402.74	67.33	12.70
2	10	Osceola	23.9	5883	No	No	15.1%	10.3	0.4	0.0	11.7%	0.0%	0.0%	292.26	32.31	9.35
2	18	Crawford	8.7	773	No	No	16.1%	5.3	0.0	0.0	0.0%	0.0%	0.0%	253.84	23.69	3.38
2	18	Roscommon	27.6	2468	Some	No	35.9%	12.0	0.0	0.0	11.1%	6.1%	0.4%	273.80	29.56	6.30
2	22	Benzie	20.3	1606	No	No	58.1%	7.7	0.0	0.0	32.1%	21.1%	6.3%	203.28	37.75	8.71
2	22	Manistee	17.8	1822	No	No	44.9%	14.3	0.0	0.0	7.0%	27.4%	11.5%	359.13	27.14	7.57
2	23	Alcona	25.7	2451	No	No	14.8%	29.8	0.0	0.0	4.2%	0.0%	0.0%	269.77	23.04	6.72
2	23	Iosco	21.7	5203	No	No	5.5%	45.1	0.5	0.5	29.1%	0.0%	0.0%	219.30	36.74	7.99
2	30	Ogemaw	7.5	2814	No	No	8.0%	14.0	0.0	0.0	8.6%	0.0%	0.0%	358.43	37.54	10.90
2	31	Grand Traverse	18.0	14403	No	No	30.0%	14.5	4.4	0.6	42.3%	1.6%	0.0%	231.15	52.63	7.34
2	31	Manistee	23.9	5955	No	No	12.5%	18.4	0.8	1.3	17.7%	3.6%	0.0%	272.33	35.29	6.42
2	31	Mason	22.9	9927	No	No	14.9%	21.6	1.3	0.4	4.1%	0.0%	0.0%	269.94	40.31	9.17
2	32	Antrim	11.7	2073	No	No	54.6%	7.4	0.0	0.0	0.0%	28.0%	16.1%	261.19	46.32	14.15
2	32	Charlevoix	3.8	1905	No	No	55.4%	11.9	0.0	0.0	34.3%	19.3%	3.1%	283.68	16.45	12.33
2	33	Cheboygan	16.3	3097	No	No	28.3%	14.3	0.0	0.0	0.0%	3.0%	0.0%	293.32	43.28	8.24
2	33	Montmorency	24.1	2166	No	No	10.0%	11.0	0.0	0.0	0.0%	0.7%	0.7%	280.08	19.28	3.40
2	33	Ogemaw	23.1	3365	No	No	17.3%	12.6	0.9	0.0	4.8%	0.0%	0.0%	268.42	33.75	8.83
2	33	Presque Isle	10.9	2021	No	No	2.7%	10.0	0.0	1.8	2.2%	0.0%	0.0%	277.97	17.49	3.89
2	37	Wexford	26.7	3190	No	No	13.9%	9.6	0.0	0.7	5.7%	2.2%	0.0%	239.40	28.89	9.29
2	42	Missaukee	7.3	1499	No	No	51.7%	10.5	0.0	0.0	0.0%	6.6%	6.6%	337.34	34.90	9.31
2	42	Wexford	2.4	3123	No	No	40.9%	17.6	0.0	0.0	30.1%	15.7%	0.0%	134.37	22.40	14.93
2	55	Iosco	16.9	4797	No	No	3.5%	18.2	1.2	2.4	9.7%	0.0%	0.0%	331.21	27.92	2.96
2	55	Manistee	25.1	3264	No	No	12.0%	12.2	0.4	0.0	0.0%	0.0%	0.0%	260.73	20.76	4.08

Appendix 2: Prioritization Results for MDOT 55 mph Non-Freeway Segments

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
2	55	Missaukee	23.3	4224	No	No	0.0%	13.6	0.0	0.0	2.9%	0.0%	0.0%	235.47	29.53	9.67
2	55	Ogemaw	23.1	4719	No	No	17.8%	20.6	0.9	0.4	4.6%	0.5%	0.5%	307.20	35.90	7.80
2	55	Wexford	19.4	3236	No	No	25.8%	11.0	0.0	0.0	17.4%	0.0%	0.0%	322.88	31.95	7.15
2	61	Osceola	3.9	853	No	No	0.0%	7.9	0.0	0.0	0.0%	0.0%	0.0%	174.14	5.62	5.62
2	65	Alcona	21.0	1398	No	No	16.2%	8.3	0.0	0.0	0.0%	1.3%	0.0%	398.27	26.73	5.35
2	65	Alpena	25.5	1481	No	No	0.0%	13.1	0.0	0.0	0.0%	0.8%	0.0%	358.29	19.31	4.00
2	65	Presque Isle	7.8	1118	No	No	2.6%	14.6	0.0	0.0	16.0%	0.0%	0.0%	792.22	25.45	9.54
2	66	Antrim	15.6	1836	No	No	18.6%	9.8	0.0	0.0	0.0%	1.2%	0.0%	332.29	23.30	5.07
2	66	Charlevoix	11.4	3762	No	No	55.0%	17.2	0.0	0.0	25.6%	10.6%	0.0%	495.50	40.92	5.95
2	66	Kalkaska	14.1	1708	No	No	14.2%	12.3	0.0	0.0	0.0%	0.0%	0.0%	284.02	33.79	10.56
2	66	Missaukee	23.7	2951	No	No	11.8%	11.3	0.8	0.0	14.3%	2.7%	0.0%	299.25	31.13	9.13
2	66	Osceola	23.3	1955	No	No	12.5%	11.2	0.0	0.0	4.2%	1.4%	0.0%	335.94	20.17	4.61
2	68	Cheboygan	24.8	4938	No	No	21.0%	13.6	0.0	1.2	5.2%	0.0%	0.0%	215.47	24.92	7.64
2	68	Emmet	2.3	6339	No	No	13.2%	32.0	0.0	0.0	18.3%	0.0%	0.0%	216.05	22.05	4.41
2	68	Presque Isle	21.7	1952	No	No	7.8%	11.6	0.0	0.9	8.6%	0.0%	0.0%	485.05	32.99	6.11
2	72	Alcona	33.0	1250	No	No	3.9%	9.2	0.0	0.6	0.9%	0.0%	0.0%	467.49	21.82	7.48
2	72	Kalkaska	24.9	7548	No	No	16.1%	11.1	0.0	0.8	2.9%	0.0%	0.0%	160.99	22.82	7.51
2	72	Oscoda	19.8	2107	No	No	9.1%	8.8	0.5	0.0	8.7%	0.0%	0.0%	272.28	22.51	3.63
2	75	Charlevoix	8.2	3963	No	No	9.8%	22.9	0.0	3.7	33.6%	6.6%	0.0%	282.37	44.87	6.96
2	75	Roscommon	3.5	3212	No	No	5.7%	17.6	0.0	0.0	8.6%	0.0%	0.0%	254.35	30.52	0.00
2	88	Antrim	22.0	1806	No	No	55.0%	17.5	0.0	0.0	16.1%	18.7%	8.7%	415.50	39.93	9.10
2	93	Crawford	9.1	2989	No	Some	20.8%	8.0	1.1	0.0	4.8%	4.0%	0.0%	252.74	25.90	5.36
2	109	Leelanau	6.8	1136	No	No	47.1%	18.5	0.0	0.0	0.0%	21.6%	0.0%	148.87	3.54	0.00
2	115	Osceola	18.2	4914	No	No	11.5%	8.6	0.0	0.0	0.0%	0.0%	0.0%	246.98	39.58	12.58
2	115	Wexford	28.5	7237	No	No	9.8%	8.4	0.7	0.0	5.6%	0.0%	0.0%	212.63	28.92	7.30
2	116	Mason	5.5	2047	No	No	34.8%	10.8	0.0	0.0	26.2%	20.3%	0.0%	388.34	42.90	4.52
2	131	Charlevoix	12.2	7306	No	No	11.4%	8.8	0.0	0.0	7.7%	0.0%	0.0%	266.77	39.74	3.26

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
2	131	Emmet	4.2	10064	No	No	75.7%	18.0	2.4	0.0	26.5%	0.0%	0.0%	280.57	57.86	13.46
2	131	Grand Traverse	7.0	6409	No	No	0.0%	3.6	0.0	0.0	0.0%	0.0%	0.0%	180.90	38.46	7.83
2	131	Kalkaska	19.9	6825	No	No	9.0%	7.2	0.5	0.5	9.1%	0.0%	0.0%	168.16	32.80	7.55
2	131	Wexford	15.3	5195	No	No	31.4%	11.8	0.7	0.0	30.8%	0.0%	0.0%	268.90	38.70	7.50
2	157	Roscommon	1.2	518	No	No	25.1%	4.2	0.0	0.0	0.0%	17.7%	17.7%	249.80	83.27	0.00
2	186	Grand Traverse	2.5	2450	No	No	32.1%	18.5	0.0	0.0	0.0%	0.0%	0.0%	270.99	41.69	0.00
2	204	Leelanau	7.2	3166	No	No	15.2%	16.8	0.0	1.4	100.0%	6.2%	0.0%	256.59	19.41	4.31
2	211	Presque Isle	4.4	1107	No	No	0.0%	15.8	0.0	0.0	13.6%	0.0%	0.0%	658.88	37.38	14.02
2	212	Cheboygan	0.7	528	No	No	82.5%	28.9	0.0	0.0	0.0%	23.0%	23.0%	297.71	74.43	0.00
3	11	Kent	6.3	19230	No	No	36.8%	29.4	9.6	8.0	67.3%	0.0%	0.0%	309.59	71.31	9.84
3	11	Ottawa	1.8	8379	No	No	0.0%	31.9	0.0	0.0	0.0%	0.0%	0.0%	276.37	64.92	12.98
3	20	Mecosta	28.6	3884	No	No	57.0%	16.4	1.0	0.7	14.1%	6.2%	3.9%	330.27	41.41	7.64
3	20	Newaygo	25.2	2582	No	No	23.4%	16.6	0.0	1.2	2.9%	2.5%	0.0%	251.91	25.45	8.23
3	21	Ionia	21.6	3742	No	No	50.9%	18.4	0.0	0.5	17.1%	4.1%	0.0%	374.82	34.88	8.58
3	21	Kent	6.9	13986	No	Some	36.3%	19.3	5.8	1.5	31.9%	0.0%	0.0%	202.54	43.99	7.09
3	31	Muskegon	1.0	4646	No	No	0.0%	29.6	0.0	0.0	67.2%	0.0%	0.0%	351.61	34.58	0.00
3	31	Oceana	14.4	3362	No	No	58.5%	15.9	0.0	0.0	21.2%	9.8%	1.3%	319.33	70.80	6.44
3	37	Kent	11.7	13157	No	No	21.4%	2.4	3.4	0.0	23.8%	0.0%	0.0%	217.81	48.81	9.55
3	37	Muskegon	5.3	9267	No	No	37.7%	17.5	0.0	0.0	0.0%	13.8%	5.6%	200.24	46.74	10.11
3	37	Newaygo	35.7	5049	No	No	48.1%	15.6	0.6	0.0	9.0%	7.0%	0.5%	227.99	36.11	10.27
3	44	Ionia	9.6	5611	No	No	5.2%	24.3	0.0	1.0	21.3%	2.3%	0.0%	246.45	26.90	8.17
3	44	Kent	8.7	9347	No	No	0.0%	17.7	1.2	1.2	27.0%	0.0%	0.0%	269.25	53.36	6.98
3	45	Kent	0.4	22244	No	Yes	0.0%	42.1	23.4	0.0	92.5%	0.0%	0.0%	1002.58	185.77	17.69
3	45	Ottawa	15.4	11129	No	No	25.3%	22.9	1.3	0.0	0.0%	1.8%	0.0%	197.17	38.52	8.01
3	46	Kent	8.5	6503	No	No	50.8%	21.6	1.2	0.0	13.2%	0.0%	0.0%	269.19	59.35	7.79
3	46	Montcalm	32.1	6498	No	No	8.1%	16.4	2.2	0.3	4.5%	0.0%	0.0%	291.82	39.23	8.99
3	50	Kent	8.6	5617	No	Some	22.1%	11.5	0.0	0.0	0.0%	0.0%	0.0%	238.35	45.93	8.72

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
3	57	Kent	13.6	13205	No	No	0.0%	16.3	2.9	0.0	0.0%	0.0%	0.0%	177.13	42.13	9.38
3	57	Montcalm	20.6	12668	No	No	1.9%	12.5	2.4	1.0	15.4%	0.0%	0.0%	289.17	41.50	8.43
3	66	Ionia	19.6	10115	No	No	14.3%	17.3	0.5	2.0	15.6%	0.0%	0.0%	263.40	34.47	8.16
3	66	Mecosta	22.7	2738	No	No	22.0%	12.1	0.9	2.2	5.2%	0.0%	0.0%	470.93	32.02	7.81
3	66	Montcalm	20.1	5497	No	No	22.4%	17.0	2.0	2.5	13.6%	0.0%	0.0%	387.06	37.10	6.41
3	82	Montcalm	2.6	3827	No	No	19.0%	13.7	0.0	0.0	0.0%	0.0%	0.0%	255.40	43.96	14.65
3	91	Ionia	2.1	7536	No	No	51.3%	19.1	4.7	0.0	0.0%	0.0%	0.0%	424.13	56.66	9.71
3	91	Montcalm	18.1	6793	No	No	33.2%	19.3	1.1	0.0	18.7%	0.0%	0.0%	351.12	50.41	12.02
3	104	Ottawa	5.2	11464	No	No	13.5%	24.6	3.9	0.0	33.6%	7.8%	0.0%	276.67	53.86	8.98
3	120	Muskegon	13.7	6489	No	No	27.7%	24.1	0.0	1.5	36.9%	9.7%	0.0%	228.74	55.70	13.01
3	120	Newaygo	6.5	5388	No	No	30.8%	15.9	0.0	0.0	7.2%	0.0%	0.0%	240.34	28.03	9.11
3	131	Mecosta	22.4	5602	No	No	40.7%	18.1	0.0	2.7	16.9%	11.3%	0.0%	396.20	54.91	11.02
4	10	Isabella	1.4	4952	No	No	55.4%	9.0	0.0	0.0	0.0%	0.0%	0.0%	155.47	32.73	4.09
4	13	Arenac	3.0	7824	No	No	0.0%	26.4	0.0	0.0	0.0%	0.0%	0.0%	227.29	61.01	17.94
4	13	Bay	20.3	10878	No	No	2.0%	42.3	3.0	1.5	30.0%	0.0%	0.0%	157.85	42.01	8.66
4	13	Saginaw	20.3	5564	No	Some	9.9%	20.8	0.0	0.0	22.9%	1.6%	0.0%	158.61	27.00	10.70
4	15	Genesee	20.2	10615	No	No	42.7%	34.7	2.5	0.0	18.9%	3.7%	0.0%	233.21	51.57	7.47
4	15	Saginaw	3.9	3875	No	No	43.9%	18.6	0.0	0.0	0.0%	7.9%	0.0%	131.29	49.47	5.71
4	18	Gladwin	27.6	3591	No	Some	37.0%	17.2	0.0	1.1	11.2%	2.8%	2.8%	246.46	29.24	7.95
4	18	Midland	6.0	4469	No	No	5.0%	13.1	0.0	0.0	0.0%	0.0%	0.0%	198.31	36.24	2.01
4	19	Huron	7.4	2315	No	No	10.8%	14.2	0.0	0.0	12.7%	0.0%	0.0%	643.83	29.67	7.42
4	19	Sanilac	35.3	2642	No	No	6.8%	17.0	0.0	0.9	4.1%	0.0%	0.0%	369.97	30.46	6.99
4	20	Isabella	20.0	9816	No	No	10.0%	20.9	2.0	1.0	16.8%	0.0%	0.0%	266.93	29.77	5.78
4	21	Genesee	2.5	11418	No	No	0.0%	52.8	8.1	0.0	33.4%	0.0%	0.0%	256.65	75.12	4.47
4	24	Lapeer	20.9	10869	No	No	24.4%	20.2	2.4	0.5	13.5%	0.0%	0.0%	238.04	44.38	7.58
4	24	Tuscola	25.1	3197	No	No	19.1%	12.8	0.8	0.0	14.0%	2.7%	0.0%	253.65	26.37	3.85
4	25	Bay	5.1	5520	No	No	11.7%	17.7	0.0	0.0	61.0%	0.0%	0.0%	205.72	45.00	14.69

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
4	25	Huron	54.6	2052	No	No	16.7%	16.9	0.0	0.2	30.6%	3.4%	0.6%	598.20	45.18	6.16
4	25	Sanilac	32.3	3961	No	No	12.1%	41.1	0.0	0.0	12.7%	0.0%	0.0%	341.86	34.66	8.78
4	30	Gladwin	28.5	3275	No	No	51.5%	12.2	0.0	0.0	0.0%	0.7%	0.0%	341.73	34.36	8.12
4	30	Midland	14.6	7556	No	No	16.4%	17.9	2.1	3.4	0.0%	4.9%	1.8%	200.94	38.43	5.76
4	33	Arenac	2.3	2817	No	No	30.4%	7.8	0.0	0.0	0.0%	0.0%	0.0%	294.20	46.28	3.31
4	46	Gratiot	21.1	7930	No	No	6.6%	20.5	1.9	0.5	11.8%	0.0%	0.0%	308.41	58.05	10.75
4	46	Saginaw	19.5	7706	No	No	8.7%	26.9	1.0	1.5	37.6%	0.0%	0.0%	151.93	30.12	7.86
4	46	Sanilac	25.4	3987	No	No	5.1%	14.9	0.4	1.2	10.6%	0.0%	0.0%	357.47	29.20	4.87
4	46	Tuscola	28.8	4227	No	No	7.6%	13.2	0.7	0.7	3.5%	0.0%	0.0%	241.56	29.60	8.71
4	47	Saginaw	7.8	17485	No	Some	0.0%	37.9	5.1	2.6	22.1%	0.0%	0.0%	182.51	33.62	5.20
4	53	Huron	24.6	3285	No	No	6.9%	19.1	0.4	1.6	14.8%	0.0%	0.0%	436.96	43.06	4.24
4	53	Sanilac	25.9	4821	No	No	4.6%	15.9	0.0	0.0	4.6%	0.0%	0.0%	266.32	33.07	9.38
4	54	Genesee	10.0	9045	No	Some	7.0%	36.0	6.0	0.0	57.5%	0.0%	0.0%	274.26	82.00	8.31
4	54	Saginaw	2.0	2773	No	No	0.0%	46.9	0.0	0.0	0.0%	0.0%	0.0%	242.37	52.27	19.01
4	57	Genesee	16.6	9746	No	No	5.4%	32.9	3.0	0.0	19.9%	0.0%	0.0%	201.26	49.44	5.67
4	57	Gratiot	23.7	4113	No	No	0.0%	7.7	0.0	0.8	0.0%	0.0%	0.0%	281.20	24.40	4.99
4	57	Saginaw	20.3	5030	No	No	0.0%	16.4	0.0	0.5	11.7%	0.0%	0.0%	218.25	28.32	8.31
4	61	Arenac	3.9	4562	No	No	0.0%	20.3	0.0	0.0	8.7%	0.0%	0.0%	313.75	42.49	8.17
4	61	Bay	6.0	1862	No	No	0.0%	11.3	0.0	0.0	0.0%	0.0%	0.0%	294.47	35.06	11.69
4	61	Clare	24.0	3493	No	No	11.7%	11.1	0.0	0.4	7.5%	2.1%	0.0%	311.22	30.68	8.00
4	65	Arenac	7.3	3365	No	No	9.6%	11.2	1.4	2.8	8.1%	0.0%	0.0%	291.94	25.67	6.42
4	81	Sanilac	0.9	3037	No	No	32.5%	14.1	0.0	0.0	0.0%	0.0%	0.0%	407.95	35.47	0.00
4	81	Tuscola	29.5	5751	No	No	14.6%	17.6	0.0	0.7	13.3%	0.0%	0.0%	318.04	34.14	6.53
4	83	Saginaw	12.2	6889	No	No	0.8%	23.3	2.5	0.0	17.1%	0.0%	0.0%	176.17	42.72	7.06
4	84	Bay	0.3	13982	No	No	100.0%	0.0	0.0	0.0	53.9%	99.7%	0.0%	131.51	0.00	0.00
4	84	Saginaw	1.7	18837	No	Yes	0.0%	23.5	5.7	0.0	46.5%	0.0%	0.0%	287.36	67.66	1.52
4	90	Lapeer	14.6	2988	No	No	10.3%	14.9	0.7	0.0	9.2%	0.0%	0.0%	330.39	33.67	4.91

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
4	90	Sanilac	20.4	4524	No	No	2.9%	14.7	0.0	1.5	14.0%	0.0%	0.0%	287.39	27.70	6.06
4	115	Clare	18.3	6050	No	No	6.6%	17.1	0.0	0.0	11.3%	0.0%	0.0%	220.94	29.78	7.26
4	127	Clare	2.3	3413	No	No	34.9%	34.5	0.0	0.0	63.5%	0.0%	0.0%	201.76	52.71	18.18
4	127	Gratiot	4.0	4542	No	No	27.8%	14.6	2.5	2.5	23.1%	6.7%	0.0%	555.24	73.84	7.38
4	138	Bay	5.4	2026	Some	Yes	0.0%	26.2	0.0	0.0	0.0%	0.0%	0.0%	239.47	57.80	8.26
4	138	Tuscola	12.6	1315	No	Some	7.1%	11.3	0.0	0.8	14.5%	0.0%	0.0%	226.42	56.20	9.63
4	142	Huron	33.8	3167	No	No	4.7%	14.6	0.3	1.2	10.6%	0.0%	0.0%	379.24	37.44	5.76
5	12	Berrien	21.7	6673	No	No	17.5%	14.5	1.8	4.6	7.4%	0.9%	0.0%	187.19	37.21	6.94
5	12	Branch	19.9	7673	No	No	18.1%	19.9	0.5	1.5	26.8%	0.8%	0.0%	293.78	34.56	6.71
5	12	Cass	24.6	6261	No	No	31.3%	22.0	0.0	0.0	7.1%	2.5%	0.0%	223.06	44.67	9.65
5	12	St Joseph	21.4	6255	No	No	23.3%	19.4	0.9	0.0	14.4%	1.8%	0.8%	216.38	42.85	9.38
5	31	Berrien	0.9	11765	No	Yes	0.0%	17.0	11.3	0.0	56.7%	0.0%	0.0%	181.03	52.08	9.92
5	37	Barry	29.3	8641	No	No	48.1%	17.7	1.4	0.0	11.6%	4.8%	0.0%	255.53	38.35	7.83
5	37	Calhoun	0.6	3829	No	No	50.0%	13.3	0.0	0.0	91.9%	0.0%	0.0%	364.27	48.57	12.14
5	40	Allegan	23.8	8660	No	No	15.9%	18.0	0.4	0.0	17.7%	0.0%	0.0%	213.75	37.25	5.99
5	40	Cass	18.0	2448	No	No	40.0%	11.5	0.0	0.0	5.2%	0.0%	0.0%	356.00	38.61	11.92
5	40	Van Buren	21.6	5579	No	No	30.5%	22.3	1.4	1.4	17.7%	4.3%	0.0%	272.47	47.04	8.84
5	43	Barry	30.9	3554	No	No	47.2%	17.2	0.3	0.3	8.7%	14.5%	5.1%	422.80	42.87	10.25
5	43	Kalamazoo	7.5	12500	No	No	59.8%	22.7	1.3	1.3	65.5%	1.9%	0.0%	176.20	36.94	3.45
5	43	Van Buren	26.0	6894	No	No	10.8%	18.8	0.8	0.4	8.8%	0.7%	0.3%	225.30	34.28	8.03
5	50	Barry	2.9	5774	No	No	24.3%	14.3	0.0	0.0	0.0%	22.9%	0.0%	170.02	22.42	7.47
5	51	Berrien	1.6	6552	No	No	0.0%	35.8	0.0	0.0	82.6%	0.0%	0.0%	178.92	22.06	7.35
5	51	Cass	13.4	4485	No	No	17.9%	25.9	0.0	0.0	16.0%	4.4%	0.0%	273.21	39.80	8.80
5	51	Van Buren	13.7	4296	No	No	8.7%	15.1	0.0	0.0	9.3%	2.1%	0.0%	228.59	30.45	7.96
5	60	Branch	8.0	3050	No	No	17.5%	12.3	0.0	1.3	0.0%	0.0%	0.0%	280.35	35.19	8.21
5	60	Calhoun	19.5	4023	No	No	6.7%	0.0	0.0	0.5	11.1%	0.0%	0.0%	257.85	24.28	5.58
5	60	Cass	20.4	4340	No	No	29.9%	16.3	0.0	0.0	14.7%	2.6%	0.0%	278.24	33.54	10.25

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
5	62	Berrien	2.2	7123	No	No	0.0%	11.5	0.0	0.0	0.0%	0.0%	0.0%	186.48	25.90	5.18
5	62	Cass	21.7	5593	No	No	34.2%	18.2	1.4	0.5	12.4%	13.6%	2.2%	254.30	38.24	7.49
5	63	Berrien	10.4	5657	No	No	66.4%	26.0	2.9	1.9	26.5%	2.4%	0.0%	293.80	57.72	6.76
5	66	Barry	24.3	2643	No	No	9.9%	13.0	0.0	0.0	5.9%	0.0%	0.0%	418.19	44.11	7.50
5	66	Branch	0.7	3955	No	No	0.0%	12.1	0.0	0.0	0.0%	0.0%	0.0%	257.06	55.08	27.54
5	66	Calhoun	17.0	7733	No	No	17.6%	0.0	1.8	0.6	21.0%	1.6%	0.0%	297.11	31.85	7.57
5	66	St Joseph	14.8	7604	No	No	10.8%	12.8	0.7	0.0	14.8%	6.0%	0.0%	267.22	38.45	8.72
5	69	Branch	2.8	3113	No	No	14.5%	12.7	3.6	0.0	26.2%	16.7%	0.0%	190.02	27.94	8.38
5	78	Barry	0.8	3206	No	No	73.5%	18.4	0.0	0.0	0.0%	0.0%	0.0%	279.06	19.25	9.62
5	78	Calhoun	2.7	3206	No	No	58.6%	0.0	0.0	0.0	0.0%	6.8%	0.0%	373.64	37.36	2.87
5	79	Barry	9.8	2418	No	No	13.3%	14.3	0.0	1.0	5.6%	2.5%	0.0%	452.20	48.42	7.75
5	86	Branch	13.0	2377	No	No	26.1%	13.8	0.0	0.0	0.0%	4.0%	0.0%	567.23	61.86	11.53
5	86	St Joseph	14.2	3351	No	No	15.5%	17.7	0.0	1.4	25.7%	3.3%	0.7%	303.93	29.08	6.58
5	89	Barry	1.1	5101	No	No	0.0%	20.5	0.0	0.0	0.0%	0.0%	0.0%	207.20	49.33	4.93
5	89	Calhoun	0.2	4801	No	No	40.2%	4.0	0.0	0.0	96.3%	0.0%	0.0%	391.86	87.08	0.00
5	89	Kalamazoo	12.4	4924	No	No	49.9%	13.3	2.4	4.0	3.8%	1.6%	0.0%	332.84	51.98	7.43
5	94	Calhoun	5.5	11680	No	No	21.9%	0.0	7.3	1.8	72.3%	0.0%	0.0%	258.94	47.44	2.96
5	94	Kalamazoo	0.5	20602	No	No	0.0%	0.0	22.2	0.0	53.3%	0.0%	0.0%	464.54	73.12	2.15
5	96	Calhoun	4.6	9931	No	No	21.6%	0.0	4.3	0.0	65.5%	0.0%	0.0%	185.77	26.69	5.45
5	96	Kalamazoo	11.1	6851	No	No	12.6%	15.7	0.9	0.9	24.0%	0.0%	0.0%	209.03	34.89	7.53
5	99	Calhoun	9.6	1652	No	No	31.3%	0.0	0.0	0.0	28.9%	0.0%	0.0%	605.41	33.28	3.17
5	103	St Joseph	3.1	3226	No	No	32.7%	13.4	0.0	0.0	0.0%	21.0%	0.0%	185.87	31.29	11.04
5	139	Berrien	15.6	7365	No	No	32.6%	23.9	1.3	0.6	43.8%	7.4%	0.4%	238.63	50.47	6.28
5	140	Berrien	27.5	2702	No	Some	36.8%	16.2	0.0	0.4	4.5%	2.1%	2.1%	259.71	51.03	8.45
5	140	Van Buren	7.6	5522	No	No	5.3%	32.8	0.0	2.6	10.0%	0.0%	0.0%	184.06	33.19	7.24
5	152	Cass	4.8	3119	No	No	66.8%	21.1	0.0	0.0	0.0%	17.9%	3.8%	191.39	35.89	10.47
5	152	Van Buren	1.0	3119	No	No	39.8%	26.8	0.0	0.0	65.6%	0.0%	0.0%	121.01	14.24	0.00

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
5	179	Allegan	5.0	7471	No	No	31.7%	19.4	0.0	0.0	17.6%	6.0%	0.0%	215.29	25.44	10.76
5	179	Barry	10.8	4744	No	No	9.2%	12.2	0.0	0.0	0.0%	13.0%	1.6%	285.83	48.31	11.50
5	196	Van Buren	1.3	4682	No	No	0.0%	31.7	15.9	0.0	67.0%	0.0%	0.0%	343.28	85.82	8.58
5	199	Calhoun	2.9	2584	No	Yes	57.9%	0.0	0.0	6.8	27.0%	18.6%	0.0%	554.19	41.67	8.33
5	216	Cass	2.2	2472	No	Yes	41.5%	12.0	0.0	0.0	22.5%	0.0%	0.0%	550.79	19.33	4.83
5	216	St Joseph	6.6	2859	No	Yes	47.1%	13.2	1.5	0.0	0.0%	8.7%	0.0%	365.70	31.86	6.37
5	217	Cass	1.7	3994	No	No	0.0%	0.6	0.0	0.0	0.0%	0.0%	0.0%	133.07	33.27	4.16
5	227	Calhoun	5.2	3023	Some	Yes	29.0%	0.0	0.0	1.9	24.4%	0.0%	0.0%	362.46	18.85	0.00
5	239	Berrien	1.1	5972	No	No	96.8%	17.6	8.8	0.0	0.0%	0.0%	0.0%	267.60	85.48	14.87
5	311	Calhoun	13.3	2517	Yes	Yes	33.2%	0.0	0.8	0.0	3.4%	6.6%	2.6%	414.80	34.57	12.48
6	12	Lenawee	20.4	8066	No	No	88.4%	32.4	2.9	0.0	6.0%	12.3%	2.2%	265.63	51.85	9.78
6	12	Washtenaw	13.3	19712	No	No	46.7%	10.8	3.8	1.5	37.4%	4.3%	0.0%	205.66	44.02	5.94
6	24	Monroe	21.5	9414	No	No	9.3%	19.4	6.1	0.9	17.1%	1.0%	0.0%	241.53	70.16	14.50
6	27	Clinton	7.3	7270	No	No	8.3%	14.7	4.1	0.0	39.9%	6.2%	0.0%	319.82	46.54	10.25
6	34	Hillsdale	10.6	3409	No	No	32.9%	17.7	1.9	2.8	0.0%	0.0%	0.0%	305.10	38.82	3.41
6	36	Ingham	16.4	2151	No	No	24.4%	16.1	0.0	0.0	21.8%	4.5%	0.0%	448.15	39.85	8.13
6	36	Livingston	11.3	3681	No	Yes	56.2%	22.9	0.0	0.9	51.9%	17.0%	2.3%	256.98	31.62	6.05
6	43	Ingham	6.6	9159	No	No	18.1%	23.1	3.0	1.5	73.9%	0.0%	0.0%	299.55	43.44	3.54
6	49	Hillsdale	21.3	1785	No	No	52.9%	12.1	0.0	0.0	14.4%	7.1%	1.5%	374.74	43.24	8.15
6	50	Eaton	26.0	3524	No	Some	19.2%	16.6	0.0	0.4	11.0%	0.0%	0.0%	350.27	46.68	11.33
6	50	Jackson	26.1	5718	No	No	49.8%	20.4	1.5	0.0	23.1%	3.8%	1.0%	329.16	50.04	8.88
6	52	Ingham	20.9	4811	No	No	7.2%	12.4	0.0	0.0	8.4%	1.0%	1.0%	232.79	32.27	7.20
6	52	Jackson	2.5	5272	No	No	24.1%	17.2	0.0	0.0	0.0%	22.1%	0.0%	257.94	29.76	7.94
6	52	Shiawassee	18.6	7933	No	No	19.9%	22.0	0.0	2.1	27.0%	0.0%	0.0%	276.46	33.57	7.01
6	52	Washtenaw	22.9	5603	No	No	30.5%	9.5	0.0	0.4	15.8%	6.8%	0.0%	236.10	37.00	6.65
6	59	Livingston	9.9	17441	No	No	13.2%	8.9	6.1	3.0	8.3%	0.0%	0.0%	304.50	55.62	6.95
6	60	Jackson	11.1	7884	No	No	31.5%	19.2	1.8	0.9	11.5%	2.4%	0.0%	371.23	61.01	7.42

Appendix 2: Prioritization Results for MDOT 55 mph Non-Freeway Segments

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
6	69	Clinton	2.2	7192	No	No	31.9%	18.2	0.0	0.0	12.5%	0.0%	0.0%	179.92	43.62	5.45
6	69	Eaton	2.3	5966	No	No	8.7%	27.3	0.0	4.3	52.7%	0.0%	0.0%	207.45	25.30	5.06
6	69	Shiawassee	8.1	4396	No	No	27.3%	13.2	1.2	0.0	0.0%	12.1%	0.0%	247.27	42.69	8.05
6	71	Shiawassee	5.4	5645	No	No	5.6%	15.4	0.0	0.0	48.9%	3.1%	0.0%	335.40	32.96	2.91
6	78	Eaton	6.2	3738	No	No	14.6%	16.2	0.0	1.6	14.0%	5.6%	0.0%	396.03	43.74	8.28
6	79	Eaton	11.2	2995	No	No	6.2%	15.9	0.0	0.0	8.5%	0.0%	0.0%	369.04	24.52	2.99
6	96	Clinton	2.8	10324	No	No	0.0%	18.6	3.5	0.0	26.4%	0.0%	0.0%	214.28	24.69	5.29
6	96	Livingston	2.5	24661	No	No	0.0%	21.6	12.2	8.2	56.8%	0.0%	0.0%	438.41	108.91	8.69
6	99	Eaton	7.5	5131	No	Some	14.7%	24.5	2.7	1.3	9.4%	0.0%	0.0%	392.24	62.60	10.22
6	99	Hillsdale	24.7	5989	No	No	6.9%	11.8	0.8	0.4	28.9%	1.4%	0.0%	361.11	40.01	6.16
6	99	Ingham	1.1	12089	No	Yes	0.0%	34.2	9.5	0.0	85.4%	0.0%	0.0%	512.70	107.83	12.21
6	99	Jackson	12.4	2561	No	No	33.2%	12.8	0.0	0.0	9.2%	5.2%	0.0%	463.07	48.17	8.76
6	100	Clinton	2.1	6434	No	No	33.1%	17.5	4.7	0.0	0.0%	0.0%	0.0%	261.84	35.28	5.57
6	100	Eaton	7.7	5547	No	Yes	40.3%	31.8	0.0	2.6	28.4%	0.0%	0.0%	376.78	55.53	11.25
6	106	Ingham	2.8	2321	No	Some	31.8%	18.7	0.0	0.0	22.2%	9.5%	0.0%	410.71	44.49	10.27
6	106	Jackson	14.2	2877	No	No	22.5%	14.7	0.0	0.0	27.4%	5.5%	0.0%	383.86	35.42	8.57
6	106	Livingston	2.8	1765	No	Yes	57.0%	12.9	0.0	0.0	28.7%	13.0%	7.0%	279.97	41.31	18.36
6	124	Jackson	6.2	2535	No	No	82.6%	25.4	0.0	0.0	6.4%	7.9%	0.0%	382.36	41.34	2.95
6	125	Monroe	10.7	5391	No	No	9.4%	28.3	4.7	4.7	46.8%	0.0%	0.0%	167.56	45.29	11.07
6	127	Clinton	1.8	5959	No	No	21.9%	6.6	5.5	0.0	13.8%	0.0%	0.0%	403.69	26.33	2.93
6	127	Lenawee	6.0	7708	No	No	33.4%	23.1	3.3	0.0	15.4%	4.1%	0.0%	224.51	32.45	7.95
6	153	Washtenaw	3.5	13468	No	No	56.8%	10.8	5.7	0.0	0.0%	0.0%	0.0%	160.41	38.06	4.08
6	156	Lenawee	8.7	1735	No	No	36.9%	35.9	0.0	0.0	18.5%	6.1%	0.0%	304.69	26.21	1.64
6	188	Eaton	2.8	802	No	Yes	61.0%	13.9	0.0	0.0	38.6%	25.4%	16.3%	473.63	70.17	8.77
6	223	Monroe	9.9	5833	No	No	9.1%	13.3	0.0	0.0	0.0%	4.7%	1.6%	135.64	33.18	7.81
7	14	Wayne	2.7	15123	No	No	89.9%	13.5	7.5	3.7	81.9%	20.8%	0.0%	241.60	51.90	4.18
7	15	Oakland	6.9	21209	No	No	36.2%	28.6	4.3	1.4	40.4%	6.4%	0.0%	214.13	42.70	4.74

Appendix 2: Prioritization Results for MDOT 55 mph Non-Freeway Segments

All Other MDOT 55 mph UNDIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	%NPZ	Access Pts./ mi	Signals/10 miles	Schools/10 miles	% Sgmt. <55mph	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
7	24	Oakland	1.8	24435	No	No	0.0%	9.8	10.9	5.5	66.4%	0.0%	0.0%	236.33	58.82	5.88
7	25	St Clair	3.8	7801	No	No	2.6%	26.3	0.0	5.2	70.3%	0.0%	0.0%	165.37	24.12	6.89
7	53	Macomb	4.8	18938	No	No	27.1%	0.0	4.2	0.0	41.0%	0.0%	0.0%	199.30	37.09	6.23
7	136	St Clair	16.1	3961	No	No	59.2%	19.1	0.6	1.2	10.7%	13.7%	3.9%	251.79	52.22	10.62
7	153	Wayne	3.0	17447	No	No	30.1%	21.4	10.0	3.3	88.2%	0.0%	0.0%	357.23	97.71	7.47

Lower Risk 55 mph DIVIDED Segments
(All Selection Criteria Satisfied; 4.0 mi. Minimum Length)

											% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT)		
Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	% Sgmt. <55mph	Access Pts. per mile	Signals/2 miles	Schools/10 miles			Total	Injury	K+A
4	15	Bay	8.1	4974	No	No	0.0%	14.9	0.5	0.0	0.0%	0.0%	113.83	26.22	3.84
4	24	Lapeer	5.0	17229	No	No	0.0%	14.9	0.0	0.0	0.0%	0.0%	140.37	17.86	3.63
5	131	Kalamazoo	4.0	19595	No	No	7.8%	11.4	0.5	0.0	0.0%	0.0%	140.83	29.97	1.81
5	131	St Joseph	8.5	15843	No	No	19.2%	6.5	0.9	0.6	1.4%	0.0%	108.46	19.77	3.20

55 mph DIVIDED Segments Satisfying Historical Crash Criteria Only
(4.0 mi. Minimum Length; Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	% Sgmt. <55mph	Access Pts. per mile	Signals/2 miles	Schools/10 miles	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
4	21	Genesee	4.9	5643	No	No	0.0%	32.6	1.2	4	0.0%	0.0%	195.78	42.21	3.59
6	59	Livingston	5.5	26887	No	No	0.0%	4.7	1.1	7.3	0.0%	0.0%	136.64	25.09	2.07
7	59	Oakland	7.3	29563	No	No	0.0%	7.9	1.1	4.8	0.0%	0.0%	184.89	32.46	1.92

All Other MDOT 55 mph DIVIDED Non-Freeway Segments (Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	% Sgmt. <55mph	Access Pts. per mile	Signals/2 miles	Schools/10 miles	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
1	2	Dickinson	1.0	9157	No	No	0.0%	16.1	4.0	0.0	30.5%	0.0%	380.22	34.05	5.67
1	2	Gogebic	0.3	4874	No	No	0.0%	9.4	0.0	0.0	0.0%	0.0%	301.18	33.46	0.00
1	41	Marquette	5.2	16246	No	No	23.5%	7.7	1.2	5.8	8.1%	1.1%	271.39	48.58	7.77
2	31	Cheboygan	0.7	3048	No	No	60.7%	0.0	0.0	0.0	38.6%	0.0%	146.96	12.25	0.00
2	55	Roscommon	1.4	2894	No	No	0.0%	0.0	0.0	0.0	12.9%	0.0%	277.12	58.00	12.89
3	21	Kent	3.3	20664	No	No	9.2%	16.9	1.2	6.0	0.0%	0.0%	211.54	34.98	3.33
3	31	Muskegon	3.2	22805	No	No	65.1%	0.0	2.5	0.0	10.2%	3.5%	278.47	67.15	7.59
3	31	Ottawa	19.2	26067	No	No	15.8%	2.4	1.0	1.3	0.0%	0.0%	205.58	45.35	5.16
3	37	Kent	12.2	26135	No	No	19.7%	8.4	1.5	0.0	0.0%	0.0%	266.36	60.21	4.01
3	44	Kent	7.6	33808	No	No	0.0%	8.5	1.4	5.3	0.0%	0.0%	253.03	52.70	3.88
3	45	Ottawa	6.0	23619	No	No	0.0%	18.4	0.7	3.3	0.0%	0.0%	226.36	40.31	4.11
3	66	Ionia	0.7	10619	No	No	0.0%	9.8	0.0	0.0	0.0%	0.0%	246.07	69.78	11.02
3	121	Ottawa	12.0	9552	No	No	5.0%	10.4	0.9	2.1	0.4%	0.4%	247.49	60.65	7.35
3	196	Ottawa	4.6	30270	No	No	16.1%	1.1	1.3	4.3	0.0%	0.0%	203.77	46.50	6.80
4	10	Isabella	0.6	4036	No	No	0.0%	0.0	0.0	0.0	22.0%	0.0%	296.82	67.46	13.49
4	15	Saginaw	2.1	4020	No	No	0.0%	11.7	0.0	0.0	0.0%	0.0%	108.99	31.14	3.11
4	46	Saginaw	2.6	14172	No	No	21.8%	26.3	1.2	11.6	0.0%	0.0%	194.28	46.11	13.53
4	84	Bay	1.9	13982	No	No	8.2%	16.3	0.0	0.0	0.0%	0.0%	91.76	17.57	0.98
4	84	Saginaw	1.0	16980	No	No	0.0%	9.0	2.0	0.0	0.0%	0.0%	231.67	50.09	9.39
4	127	Isabella	1.9	6708	No	No	0.0%	0.0	0.0	0.0	0.0%	0.0%	189.08	16.91	1.54
5	12	Berrien	6.6	11582	No	No	0.0%	3.2	0.0	0.0	0.0%	0.0%	216.04	42.64	7.11
5	12	Cass	0.2	12116	No	No	0.0%	0.0	0.0	0.0	0.0%	0.0%	111.20	0.00	0.00
5	31	Allegan	1.3	15056	No	No	38.3%	0.0	3.2	0.0	0.0%	0.0%	134.90	23.35	5.19
5	60	Calhoun	1.6	4195	No	No	0.0%	12.8	0.0	0.0	0.0%	0.0%	257.02	27.26	15.58
5	60	Cass	3.7	8052	No	No	0.0%	9.9	1.1	0.0	0.0%	0.0%	149.90	35.22	7.37

Appendix 2: Prioritization Results for MDOT 55 mph Non-Freeway Segments

All Other MDOT 55 mph DIVIDED Non-Freeway Segments
(Shading Indicates Failed Criteria)

Region	Route	County	Length	AADT	Lane ≤10 ft	Shldr. < 3 ft	% Sgmt. <55mph	Access Pts. per mile	Signals/2 miles	Schools/10 miles	% Mileage with Deficient 4R Curves	% Mileage with Deficient 3R Curves	10 Year Crash Rates (crashes/100MVMT) Total	Injury	K+A
5	60	St Joseph	0.5	6314	No	No	0.0%	7.4	0.0	0.0	34.9%	0.0%	222.46	74.15	24.72
5	63	Berrien	1.2	7500	No	No	0.0%	4.9	0.0	0.0	0.0%	0.0%	254.31	28.26	2.83
5	94	Berrien	2.2	3928	No	No	14.9%	0.0	0.0	0.0	23.1%	0.0%	262.65	72.78	12.66
5	94	Calhoun	0.5	17320	No	No	86.9%	2.2	0.0	0.0	50.2%	12.4%	44.57	10.28	0.00
5	94	Kalamazoo	2.9	9973	No	No	10.0%	0.0	1.4	0.0	28.1%	3.8%	347.66	57.26	12.27
5	96	Calhoun	0.3	16270	No	No	54.1%	3.2	0.0	0.0	51.5%	0.0%	290.92	51.95	10.39
6	12	Washtenaw	2.8	23719	No	No	0.0%	3.6	0.7	7.2	6.6%	0.0%	132.76	46.27	6.05
6	24	Monroe	1.9	6950	No	No	0.0%	13.3	0.0	0.0	0.0%	0.0%	238.16	64.59	12.11
6	27	Eaton	5.7	9249	No	No	0.0%	5.9	2.1	0.0	0.0%	0.0%	213.89	40.83	10.21
6	27	Ingham	1.2	6192	No	No	22.7%	6.5	1.6	8.1	27.5%	27.5%	672.39	169.00	32.36
6	50	Jackson	0.5	5825	No	No	56.7%	0.0	0.0	0.0	0.0%	0.0%	389.33	74.16	27.81
6	50	Monroe	2.3	15918	No	No	0.0%	49.0	0.9	8.8	0.0%	0.0%	217.05	53.39	6.13
6	69	Clinton	1.1	14564	No	No	0.0%	13.1	5.3	26.3	26.8%	0.0%	345.54	87.60	8.11
6	69	Ingham	2.5	11596	No	No	19.9%	13.5	2.4	0.0	0.0%	0.0%	260.38	61.48	8.14
6	75	Monroe	2.9	3172	No	No	0.0%	10.1	0.0	7.0	4.2%	4.2%	201.72	48.80	13.01
6	96	Livingston	0.4	15068	No	No	0.0%	0.0	0.0	0.0	55.0%	18.5%	210.41	36.28	0.00
6	99	Eaton	7.4	8288	No	No	0.0%	24.2	0.3	0.0	0.0%	0.0%	306.79	35.17	6.36
6	153	Washtenaw	1.6	9865	No	No	0.0%	0.0	2.5	0.0	59.8%	0.0%	224.03	62.00	4.23
7	5	Oakland	3.1	49655	No	No	28.9%	0.0	1.9	0.0	9.3%	1.2%	174.71	32.93	2.27
7	12	Wayne	7.3	34533	No	No	59.7%	21.1	1.6	1.4	1.5%	1.5%	231.14	51.88	5.13
7	24	Oakland	11.0	37249	No	No	58.1%	12.6	0.7	3.6	0.0%	0.0%	298.93	53.47	3.03
7	69	St Clair	0.9	8666	No	No	38.0%	0.0	2.2	11.2	24.6%	4.6%	27.73	7.92	0.00
7	75	Oakland	0.9	29970	No	No	75.6%	13.0	0.0	0.0	0.0%	0.0%	201.44	30.70	1.92
7	85	Wayne	3.9	11122	No	No	74.9%	9.5	1.5	5.2	0.0%	0.0%	199.80	44.33	7.49

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