Before-and-After Safety Study of Roadways Where New Medians Have Been Added

Final Report

Contract No. BDK80 977-18

December 2012

Prepared by:

Lehman Center for Transportation Research
Florida International University

In collaboration with:

Research Center
Florida Department of Transportation

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Prepared by:

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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation.

METRIC CONVERSION CHART

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

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16. Abstract

The main objective of this study was to evaluate the safety impact of median conversion from two-way left-turn lanes (TWLTLs) to raised medians in Florida. Based on segment length and data availability, 18 locations totaling 17.51 miles were selected for before-and-after analysis. Police reports of all the crashes before and after median conversion were reviewed to correct miscoded crash types and obtain additional detailed crash information. The safety performance of individual locations varied in terms of crash type and crash severity. Overall, the results showed a 30.3 percent reduction in the total crash rate after median conversion. Median conversion was particularly effective in reducing rear-end, angle, left-turn, and right-turn crash rates. Further review of three locations that performed particularly poorly revealed that the majority of crashes that occurred after conversion could not be attributed directly to raised medians.

Several median and roadway design features were evaluated. Of the four types of median openings, uni-directional median opening on a four-lane facility was the safest and full median opening with left-turn bays on both directions on a six-lane facility was the least safe. Further, compared to four-lane facilities, crash rates at median openings on six-lane facilities were consistently higher. Median conversion was found to result in a greater overall safety benefit for six-lane facilities compared to four-lane facilities. Specific safety issues of raised medians examined in this study included vehicles directly hitting the median curb, median crossover crashes, and pedestrian crashes. Of the 2,436 crashes that occurred at the 18 locations after median conversion, 48 (2.0 percent) involved vehicles directly hitting the median curb, and 38 (1.6 percent) involved vehicles crossing over the median. Of the 46 pedestrian crashes that occurred after median conversion, none were hit while standing on the raised median.

Another main objective of this study was to document the experience of businesses on corridors that were recently converted from TWLTLs to raised medians and their involvement in the public information process. On-site interviews of businesses at ten roadway segments were conducted and responses from 151 businesses were included in the analysis. A majority of the responding businesses preferred TWLTLs to raised medians for better access and ease of truck deliveries. Two-thirds of the responding businesses thought that raised medians were safer than TWLTLs. Of the 151 businesses, 40 indicated that they were informed of public hearings on the raised median construction projects. Of these, only 13 indicated that they attended at least one public hearing.

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EXECUTIVE SUMMARY

The main objective of this project is to address the following three questions:

1. What safety impacts have been realized and can be documented as the result of conversion from two-way left-turn lanes (TWLTLs) to raised medians on state roads in Florida?
2. What was the safety performance of raised medians under different roadway and median design features, such as number of lanes, speed limits, and types of median opening?
3. What was the experience of businesses on roadways that were recently converted from TWLTLs to raised medians, and what was their involvement in the public information process?

Roadway segments that have been converted from TWLTLs to raised medians were identified by comparing the segments' median types in 2005 and 2010 Roadway Characteristics Inventory (RCI) datasets. A total of 78 locations were identified and their construction periods were requested. Based on segment length and data availability, 18 locations totaling 17.51 miles were selected for before-and-after analysis. Police reports of all the crashes up to a maximum of 36 months before and after the median construction were downloaded and reviewed. The review focused on identifying the correct crash type and the underlying crash patterns. Close to one-fifth (18.7 percent) of crash types were determined to be incorrectly coded in the police reports. Median crossover, right-turn, and left-turn crashes were found to be miscoded the most often.

Before-and-After Comparisons

The before-and-after comparisons were performed based on crash rates for both individual locations and all locations combined. The comparisons were also performed for different crash types, crash severity, and facility types as they relate to number of lanes and speed limit. The Poisson test was performed for each of the comparisons.

Overall, the total crash rate across all locations was reduced from 3.618 crashes per million vehicle miles (MVM) to 2.523 crashes per MVM after median conversion, representing a 30.3 percent reduction in total crash rate. The reductions in crash rate of rear-end, angle, left-turn, right-turn, and total crashes were statistically significant; the crash rate reductions for sideswipe, pedestrian, and bicycle crashes were statistically insignificant. There were too few head-on crashes to yield reliable conclusions. In terms of crash severity, there was a statistically significant reduction in property damage only (PDO) and injury crash rates. No significant reduction in fatal crash rate was observed after median conversion. Further, reduction in crash rate was observed at both four-lane and six-lane urban arterial facilities and at low-speed and high-speed roadways.

Site-Specific Review

Of the 18 locations analyzed, six locations where safety either improved or deteriorated significantly were selected for site-specific review. Of the three locations that either worsened or improved only slightly, the 1.019-mile section on West Tennessee Street in Leon County did

particularly poorly; the median conversion resulted in 133.5 percent increase in total crash rate. This four-lane urban arterial experienced over 400 percent increase in rear-end crash rate and over 200 percent increase in left-turn crash rate. However, from the review of police reports, it was observed that a majority of crashes in the after period could not be attributed directly to the conversion.

Of the remaining two locations, the 1.268-mile section along West Okeechobee Road in Miami-Dade County experienced a reduction in total crash rate of 10.7 percent. Again, very few crashes after median conversion could be attributed directly to the raised median. Further, of the 181 crashes that occurred after the conversion, only three occurred at median openings.

Finally, the 0.910-mile section on US 1 in St. Lucie County experienced a 17.3 percent reduction in total crash rate after conversion from a TWLTL to a raised median. Angle, left-turn, and sideswipe crashes were completely eliminated after conversion. As expected, the conversion resulted in an increase in rear-end crash rate. Also, bicycle crash rate increased; however, the increase could not be attributed directly to the median conversion.

The three locations that improved significantly had a minimum of 47.8 percent reduction in total crash rate after conversion. In general, the three locations experienced a reduction in most of the crash types. However, the location along Biscayne Blvd. in Miami-Dade County experienced an unusually high 516.2 percent increase in right-angle crash rate after the conversion; review of police reports of these crashes revealed no direct impact of raised medians on these crashes. Further, this location experienced nine crashes at the full median opening.

Evaluation of Specific Design Features and Safety Concerns

The safety performance of four types of median openings at four-lane and six-lane facilities was evaluated. Police reports were reviewed to identify crashes that were directly related to median openings. The results showed that uni-directional median opening on a four-lane facility was the safest and full median opening with left-turn bays on both directions on a six-lane facility was the least safe. Among the three types of full median openings, the “bi-directional median opening with center island” type was found to be the safest. Further, compared to four-lane facilities, crash rates at median openings on six-lane facilities were consistently higher.

Before-and-after crash summary statistics showed that four-lane urban arterials had a mere 4.7 percent reduction in total crash rate after conversion, while six-lane facilities experienced a 37.2 percent reduction. From these statistics, it could be inferred that conversion resulted in a greater overall safety benefit for six-lane facilities compared to four-lane facilities. At four-lane facilities, conversion resulted in a reduction in crash rate for all crash types except for rear-end, pedestrian, and other crashes. Specific reasons for increase in crash rates of these crash types could not be identified. However, review of police reports indicated that a majority of this increase could not be attributed directly to median conversion. Similarly, low-speed and high-speed roadways were analyzed separately; after conversion, total crash rates at low-speed and high-speed roads reduced by 31.8 percent and 26.5 percent, respectively.

Compared to TWLTLs, raised medians often do not provide enough lateral clearance for errant vehicles. Therefore, one of the safety concerns of constructing raised medians is the frequency of vehicles that directly hit the median curb before stopping or resulting in secondary crashes. Of the 2,436 crashes that occurred at the 18 locations after median conversion, only about 2.0 percent involved vehicles directly hitting the median curb; 31.3 percent of these crashes occurred at signalized intersections. A majority of these crashes were not severe. Additionally, of the 2,436 crashes that occurred after median conversion, 1.6 percent involved vehicles crossing over the median. Further, four-lane facilities were found to have a greater proportion of median crossovers compared to six-lane facilities. At all locations combined, a total of 46 pedestrian crashes occurred after median conversion. Further, none of these 46 pedestrians were hit while standing on the raised median.

Interviews of Businesses

A total of ten locations that were recently converted from TWLTLs to raised medians were identified. Of the 426 businesses that existed at these ten locations, 151 businesses responded to the interviews. Of the 151 businesses, 82 were at midblock locations without median openings (i.e., with limited access), 42 were at midblock locations with median openings, and 27 were at signalized intersections. The interview focused on two major areas: perception of businesses about raised medians and involvement of businesses in public hearing processes.

Major concerns about conversion from TWLTLs to raised medians include access to businesses; feasibility of truck deliveries; impact of conversion on number of customers, traffic congestion, and property access; and safety. The interview, therefore, focused on these concerns, and on the businesses' involvement in public hearing processes.

A majority of the responding businesses preferred TWLTLs to raised medians mainly because TWLTLs provide more access. Several businesses preferred raised medians if they were well designed with sufficient number of median openings. Several businesses mentioned that there was a decrease in traffic after conversion from TWLTLs to raised medians, and the main reason was accessibility.

Only a small percentage of businesses located near signalized intersections believed that medians had an impact on their businesses. This is followed by businesses at midblock locations with median openings and, finally, businesses at midblock locations without median openings. Further, as expected, gas stations and auto-service-related businesses mentioned that raised medians had a major impact on their businesses. Also, a high majority of these business types (i.e., gas stations and auto-related businesses) preferred TWLTLs to raised medians.

Of the 88 responding businesses, 55 (62.5 percent) thought that customers were less likely to visit their business after conversion; not surprisingly, a majority (30) of these 55 businesses were at midblock locations with no direct access (i.e., no median opening). Similarly, of the 78 responding businesses, 21 (26.9 percent) were under the impression that truck deliveries were adversely affected by raised medians. Again, a majority (16) of these 21 businesses were at midblock locations without median openings.

Among the businesses at midblock locations without direct access, 41.5 percent thought that the number of customers decreased after conversion. A relatively high 62.2 percent indicated that access to their property decreased with median construction, and only 20.7 percent believed that traffic congestion increased after conversion.

The statistics of businesses at midblock locations with median opening and near signalized intersections were similar; about one-third of the businesses in each category thought that the number of customers decreased after conversion. A relatively high percentage of businesses believed that traffic congestion increased, mainly because of increased U-turn activity. In terms of access to property, just over half of these businesses believed that access decreased after raised median construction.

Of all the responding businesses, 66.7 percent thought that raised medians were safer than TWLTLs. Among the businesses near signalized intersections, 73.3 percent perceived raised medians to be safer. Businesses identified better access management and improved pedestrian and vehicle safety as the two main reasons to consider raised medians as being safer than TWLTLs. However, some businesses were under the impression that more crashes had occurred after the construction of raised medians.

Of the 151 businesses, 40 indicated that they were informed of public hearings on the raised median construction projects, while 65 indicated that they were not informed of the scheduled public hearings. Of the 40 businesses that were informed of the public hearings, only 13 indicated that they attended at least one public hearing. Of these, five considered the sessions to be helpful, and an equal number of businesses considered them to be not helpful. Also, seven of these businesses suggested that the officials should listen to the public.

Summary of Key Findings

Based on the before-and-after analysis of 18 locations in this study, it was found that:

- Close to one-fifth (18.7 percent) of crash types were determined to be incorrectly coded in the police reports. This inaccuracy, if not corrected, could skew the results of the safety performance evaluation.

- Overall, a 30.3 percent reduction in total crash rate was observed after conversion from a TWLTL to a raised median. Based on the corrected crash types, the reductions in crash rate of rear-end, angle, left-turn, right-turn, and total crashes were statistically significant; the crash rate reductions for sideswipe, pedestrian, and bicycle crashes were statistically insignificant. There were too few head-on crashes to yield reliable conclusions. In terms of crash severity, there was a statistically significant reduction in PDO and injury crash rates.

- Review of three locations that performed particularly poorly after median conversion revealed that a majority of crashes in the after period could not be attributed directly to raised medians.

- Based on median-opening-related crashes, uni-directional median opening on a four-lane facility was found to be the safest and full median opening with left-turn bays on both directions on a six-lane facility was found to be the least safe. For example, for four-lane facilities, annual crash rate per median opening at full median openings with left-turn bays on both directions (0.094 median-opening-related crashes) is over seven times the annual crash rate per median opening at uni-directional median openings (0.013 median-opening-related crashes).

- After conversion from TWLTLs to raised medians, four-lane facilities experienced a 4.7 percent reduction in total crash rate compared to 37.2 percent reduction on six-lane arterials.

- Of the 2,436 crashes that occurred at the 18 study locations after median conversion through December 2010, only 2.0 percent (48 crashes) were caused by vehicles hitting the median curb. Further, 38 of these 48 crashes crossed over the median.

- The before-and-after pedestrian crash statistics showed a 28.9 percent reduction in pedestrian crash rate after median conversion, from 63 crashes in the before period to 46 crashes in the after period. Of these 46 crashes, none of the pedestrians were hit while standing on the raised median.

From the on-site interview responses from 151 businesses located along the ten corridors that were recently converted from TWLTLs to raised medians, it was found that:

- Of the 63 responding businesses, 66.7 percent thought that raised medians were safer than TWLTLs. Among the businesses located near signalized intersections, 73.3 percent perceived raised medians to be safer. Businesses identified better access management and improved pedestrian and vehicle safety as the two main reasons to consider raised medians as being safer than TWLTLs.

- A majority of businesses (68.0 percent) that preferred TWLTLs cited accessibility as the main reason for their preference. Likewise, a majority of businesses (61.5 percent) that preferred raised medians cited safety as the main reason for their preference.

- Only a small percentage of businesses located near signalized intersections believed that medians had an impact on their businesses. This is followed by businesses at midblock locations with median openings and, finally, by businesses at midblock locations without median openings. Further, as expected, gas stations and auto-service-related businesses mentioned that raised medians had a major impact on their businesses.

- Of the 151 businesses, 40 indicated that they were informed of public hearings on the raised median construction projects, while 65 indicated that they were not informed of the scheduled public hearings. Of the 40 businesses that were informed of the public hearings, only 13 indicated that they attended at least one public hearing.

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LIST OF ACRONYMS/ABBREVIATIONS

AADT	Annual Average Daily Traffic
CAR	Crash Analysis Reporting
DOT	Department of Transportation
DUI	Driving Under Influence
EB	Empirical Bayes
EMS	Emergency Medical Services
F+I	Fatal and Injury
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
HSM	Highway Safety Manual
MP	Mile Post
MVM	Million Vehicle Miles
NB	Negative Binomial
NCHRP	National Cooperative Highway Research Program
NTOR	No Turn On Red
PDO	Property Damage Only
RCI	Roadway Characteristics Inventory
RRFB	Rectangular Rapid Flashing Beacon
RTM	Regression-to-the-Mean
TRB	Transportation Research Board
TWLTL	Two-Way Left-Turn Lane

CHAPTER 1
INTRODUCTION

1.1 Research Needs

The *Access Management Manual* (TRB 2003) from the Transportation Research Board (TRB) identified the following as the most common types of median treatments to provide both mobility and accessibility on secondary roads and arterial streets:

- Undivided median: A painted median that does not prevent vehicles from crossing the median.
- Two-way left-turn lane (TWLTL): A continuous lane between opposing lanes of traffic to allow traffic to make left turns from both the directions.
- Raised median: A median consisting of a physical barrier that separates opposing lanes of traffic.

Table 1-1 summarizes the advantages and disadvantages of the two most frequently used median treatments, raised medians and TWLTLs (Koepke and Levinson 1992).

Table 1-1: Advantages and Disadvantages of Raised Medians and TWLTLs (Koepke and Levinson 1992)

Raised Medians	
Advantages	**Disadvantages**
• Discourage strip development. • Allow better control of land uses by local government. • Reduce number of conflicting maneuvers at driveways. • Provide driver-pedestrian refuge. • If continuous, restrict access to right turns only. • Reduce crashes in midblock areas. • Provide positive separation of opposition traffic recess.	• Reduce operational flexibility for emergency vehicles. • Increase left-turn volumes at median openings. • Increase travel time and circuity for some motorists. • May increase crashes at openings. • Limit direct access to property. • Operating speed usually limited to 45 mph.
TWLTLs	
Advantages	**Disadvantages**
• Make use of "odd-lanes". • Reduce left turns from through lanes. • Provide operational flexibility for emergency. • Safer than roads with no left-turn lanes. • Facilitate detours. • Provide positive separation of opposition traffic recess.	• Encourage random access. • Could illegally be used as a passing lane. • No refuge for pedestrians. • Poor visibility of markings. • High maintenance cost. • Operate poorly under high volume of through traffic. • Allow head-on collisions.

The Florida Department of Transportation (FDOT) has had a policy to install raised medians in most new multilane highway projects since the 1990's. It requires all multilane projects over 40 mph in design speed to have a restrictive median. Section 2.2.2 of the Plans Preparation Manual Volume 1 (Topic # 625-000-007) states that "all other multilane facilities (i.e., facilities having

design speeds ≤ 40 mph) are required to include sections of raised or restrictive median for enhancing vehicular and pedestrian safety, improving traffic efficiency, and attainment of the standards of the Access Management Classification of that highway system" (FDOT 2006a).

This FDOT policy was based on both national and statewide study results showing the benefits of raised medians, as compared to TWLTLs. However, most studies have been done with data that did not look at individual crash reports. These crash reports are a key to determining more specific benefits, and even some shortcomings, of the design of the new medians.

In addition, the business community is known to be wary of such median conversions due to fears that they will make their businesses less accessible. As a result of this belief, new legislation has been passed to assure communication with the elected officials of the cities and counties in which the improvements are made. FDOT has tried to involve the business community to inform them of the changes, as well as to get their advice on certain design changes to better serve their customers and truck deliveries.

FDOT desires to have an in-depth review of the public process, which would include interviews with the businesses potentially impacted to identify how the businesses originally believed the project would impact their business and if that belief was shown to be true. Information on how successful or involved the businesses were with the public information process could help to determine potential improvements to existing public process and reveal how current business managers think the medians have impacted them.

1.2 Project Objective

The main objective of this project is to address the following three questions:

1. What safety impacts have been realized and can be documented as the result of conversion from two-way left-turn lanes (TWLTLs) to raised medians on state roads in Florida?
2. What was the safety performance of raised medians under different roadway and median design features, such as number of lanes, speed limits, and types of median opening?
3. What was the experience of businesses on roadways that were recently converted from TWLTLs to raised medians, and what was their involvement in the public information process?

1.3 Report Organization

The rest of the report is organized as follows. Chapter 2 includes a comprehensive review of existing literature on the safety and operational performance of TWLTLs and raised medians, and the impact of median treatments on affected businesses and communities. Chapter 3 summarizes the data collection and preparation effort and the review of police reports. Chapter 4 focuses on before-and-after safety evaluation of locations that were converted from TWLTLs to raised medians. Chapter 5 includes site-specific review of the locations where safety either improved or deteriorated significantly after conversion. Chapter 6 includes safety evaluation of raised medians for different roadway and median design features. It also examines three specific

safety concerns related to raised medians. Chapter 7 discusses the results from the interviews of businesses affected by conversion from TWLTLs to raised medians. Finally, Chapter 8 provides a summary of this project effort and the relevant findings and conclusions.

CHAPTER 2
LITERATURE REVIEW

This chapter provides a review of existing literature on (1) the safety and operational performance evaluation of TWLTLs and raised medians, and (2) the impacts of median treatments on affected businesses and communities. The influence of various geometric and access management features such as signal density, left-turn traffic volume, U-turn activity, etc. on the performance of various median treatments is first discussed. Studies that specifically evaluated the impact of median conversion from a TWLTL to a raised median are summarized. Finally, the existing literature on public perception on the economic impact and the performance of median treatments is summarized.

2.1 Performance Evaluation of Various Median Treatments

Performance evaluation of access management techniques depends on several factors, such as travel time, average speed, delay, and safety. Connelly et al. (2010) researched, developed, and tested several performance measures to evaluate the operational and safety performance of access management techniques; the authors recommended the following performance measures:

- crashes per million vehicle miles (MVM),
- percent of signals with spacing at or above standard distance,
- percent of commercial entrance permits issued that meet access management spacing standards,
- percent of median openings with left-turn lanes, and
- percent of localities with a corridor access management plan.

The following sections briefly discuss the existing literature on these performance measures and their relation to median treatments. Further, other factors that influence the safety and operational performance of raised medians and TWLTLs are also discussed.

2.1.1 Overall Safety Performance

In a cross-sectional study based on statewide data from Florida, Long et al. (1993) concluded that urban four-lane arterials with raised medians experienced a 16.8 percent lower crash rate compared to those installed with TWLTLs. A similar study by Hadi et al. (1995) reported that the safety of a median type decreased in the following order: flush-unpaved median (grass), raised curb, crossover resistance or barrier median, and TWLTL.

Parsonson et al. (1993) evaluated the safety performance of a 4.34-mile six-lane arterial section on Memorial Drive, Dekalb County, Georgia which was converted from a TWLTL to a raised median; the improvement was estimated to have prevented about 300 crashes and about 150 injuries in one-year period. The authors also observed a 37 percent and 48 percent reduction in total and injury crash rates, respectively.

Papayannoulis et al. (1999) analyzed 264 roadway segments from Delaware, Illinois, Michigan, New Jersey, and Wisconsin, and found that TWLTLs had a 20 percent reduction in total crash

rate, while raised medians had a 40 percent reduction compared to undivided arterials. A number of other studies have documented similar results (Maze and Plazak 1997; Gluck et al. 1999; Gattis et al. 2005; Parsonson et al. 2000; Eisele and Frawley 2005).

Parsonson et al. (2000) analyzed the safety performance of raised medians and TWLTLs over time. The authors observed that the safety gap between raised medians and TWLTLs widened with time. Compared to sections with TWLTLs, safety was found to be increasing at a faster rate for sections with raised medians, and so, the percent difference in crash rate at sections with raised medians and with TWLTLs was increasing.

Some studies, however, have documented an increase in crash rate after conversion from TWLTLs to raised medians. Schultz et al. (2007) observed a 43 percent increase in total crash rate after the conversion of raised median on University Parkway, Utah. However, the authors observed encouraging trends in terms of right-angle crashes (over 50 percent of total crashes in the three-year before period were right-angled, while the percentage dropped to 43 percent in the two-year after period). Schultz and Lewis (2006) observed a decrease in the proportion of fatal and severe injury crashes, leading to a 17 percent reduction in the total annual crash costs. Squires and Parsonson (1989) concluded that TWLTLs could be safer than raised medians on six-lane arterials with low traffic and few concentrated access points. Phillips (2004) observed a higher proportion of fatal crashes at locations with raised medians compared to their TWLTL counterparts (0.55 percent versus 0.20 percent).

2.1.2 Conversion from a TWLTL to a Raised Median

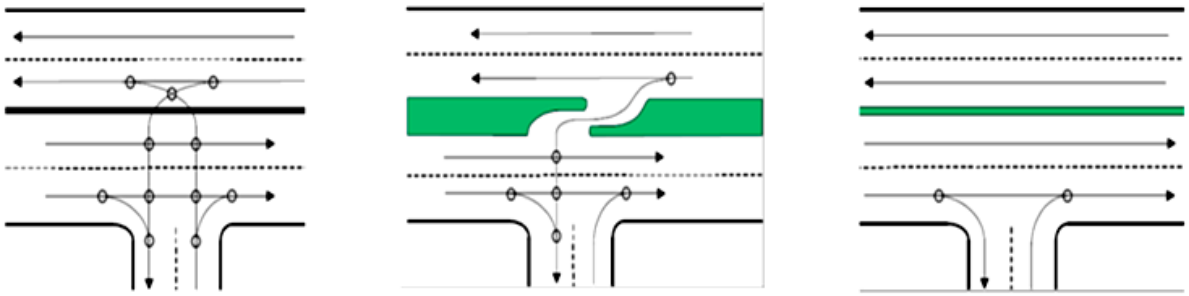
Based on the review of the existing literature on the safety performance of raised medians, Bonneson and McCoy (1997b) identified that conversion from a TWLTL to a raised median reduced total crashes by about one-third. Maze and Plazak (1997) evaluated the safety effect of conversion from a TWLTL to a raised median in the cities of Ankeny and Clive in Iowa. The authors found that the crash rates were reduced by 36.5 percent and 41.7 percent in the two cities, respectively. Bonneson and McCoy (1997b) criticized that these results were from the studies that have not accounted for the regression-to-the-mean (RTM) effect and, therefore, the actual reduction in crashes could be up to 15 percent lesser depending on the analysis period and crash frequency. Eisele and Frawley (2005) identified road widening and other roadway improvements concurrent with the raised median installation to considerably improve safety.

Recent studies have accounted for the RTM bias by using the advanced Bayesian analyses. For example, the recently released Highway Safety Manual (HSM) recommends using empirical Bayes (EB) analysis for all the steps in the roadway safety management process, especially for network screening and countermeasure selection and evaluation (American Association of State Highway and Transportation Officials 2010). Lyon et al. (2008) evaluated the safety effectiveness of TWLTLs based on the before-and-after analysis using the EB approach. Schultz et al. (2011) used the hierarchical Bayesian approach to evaluate the safety performance of raised medians. The authors conducted location specific and combined analysis on five sites on both total and severe crash frequencies. After installing raised medians, crash frequencies of total and severe injury crashes were reduced by 39 percent and 44 percent, respectively.

2.1.3 Operational Performance

Restrictive medians help in both low and high traffic situations; however, the benefits are greater at locations with heavy traffic (FDOT 2006b). On roadways operating at or near capacity, TWLTLs might not help in reducing congestion due to lack of sizeable gaps in approaching traffic stream to permit left-turn movements. This might further result in potential increase in crash frequency and severity (Squires and Parsonson 1989; Nemeth 1976).

Maze et al. (2000) indicated that conflict points give a measure of exposure which is an indirect measure of safety. Figure 2-1 shows an example of the number and location of conflict points when a driveway intersects with a four-lane roadway. Of the three scenarios (i.e., undivided, divided with a directional median, and divided with a raised median), undivided roadway has as many as eleven major conflict points while the divided roadway with a raised median is the safest with just two major conflict points. A directional median is also acceptable as it gives access to left-turning traffic without totally compromising with safety.



(a) **(b)** **(c)**

a) Eleven traffic conflict points exist on a four-lane undivided highway.
b) Six traffic conflict points exist on a four -lane highway with directional median.
c) Two traffic conflict points exist on a four -lane divided highway.

Figure 2-1: Traffic Conflict Points When a Driveway Intersects Different Types of Median Treatments (Maze et al. 2000)

Among the three scenarios, raised medians (i.e., divided highways) were safer as they result in fewer and more concentrated conflict points which could be better accommodated at signalized intersections (Squires and Parsonson 1989; Azzeh et al. 1975). This scenario of having more concentrated conflict points often result in shifting of crashes to midblock locations and signalized intersections, and therefore, the overall safety due to median construction might be overestimated. Even when crash frequencies at midblock intersections are included in the analysis, Squires and Parsonson (1989) found that safety performance could be overestimated because of shifting of conflicts to other surrounding intersections.

With higher volumes of opposing traffic, Squires and Parsonson (1989) identified left-turn movements to be safer at concentrated points such as those provided by raised medians. Bonneson and McCoy (1997a, 1997b) determined that raised curb median treatments were associated with fewer crashes than TWLTLs for roads with traffic volumes greater than 20,000 vehicles per day. For similar reasons, Parsonson (1990) recommended raised median

constructions on roadway segments with projected traffic between 24,000 and 28,000 vehicles per day.

2.1.4 Turning Movements

Operational efficiency of an arterial is usually improved by restricting left turns, and thus reducing potential conflict points. Bonneson and McCoy (1997b) developed the following access impact model to evaluate the effect of a change in midblock left-turn treatment on adjacent land uses:

$$AI = \frac{\sum_{i=1}^{N_p} U_{i,(k,L)} m_i}{\sum_{i=1}^{N_p} m_i} \quad (2\text{-}1)$$

where,

AI = access impact index for the arterial with a specified midblock left-turn treatment;
$U_{i,(k,L)}$ = weighted utility index of property i based on a change in left-turn storage L and access k;
m_i = "mass" of property i (i.e., number of driveways, frontage length, or square footage); and
N_p = number of individual properties along both sides of the arterial.

Gattis et al. (2005) noted that TWLTLs could offer the best left-turn storage on roadways with significant left-turn volumes. However, when raised medians replace TWLTLs, direct left-turn movements were replaced with relatively safer indirect left-turn treatments, such as right-turn followed by U-turn, at a median opening or at a signalized intersection (Lu et al. 2001; Liu et al. 2007). Lu et al. (2005) compared the severity of conflicts and found that the overall severity of right-turn followed by U-turn related conflicts was significantly lower than that of direct left-turn related conflicts. Gluck et al. (1999) identified a 20 percent and 35 percent reduction in crash rates when direct left-turns from driveways were replaced with right-turn/U-turn treatments at unsignalized and signalized intersections, respectively. Figure 2-2 shows the conflict rates for direct left-turn and right-turn followed by U-turn movements.

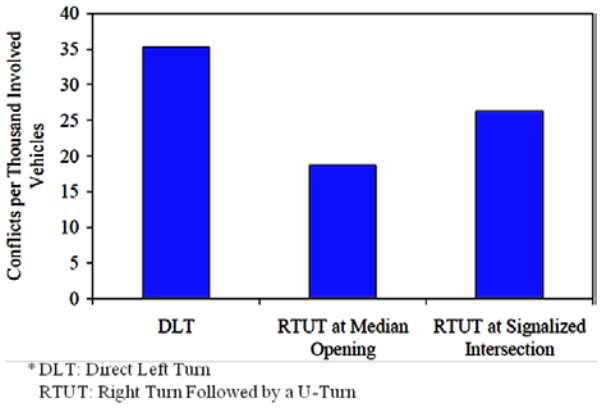


Figure 2-2: Conflict Rates for Direct Left-Turn and Right-Turn Followed by U-Turn Movements (Liu et al. 2007)

A comparison of conflict rates in Figure 2-2 shows that right turns followed by U-turns at median openings are the safest maneuvers followed by right turns followed by U-turns at signalized intersections. Besides safety, Liu et al. (2007) compared travel time and delay between direct and indirect left-turn movements, and found that indirect left-turn movements did not increase delay if an opportunity for U-turn movement was provided at the downstream.

Several access management techniques including restricted medians and medians with directional openings have increased U-turn activity compared to undivided segments and segments with TWLTLs. Dixon et al. (1999) concluded that the performance of the raised median treatment is excellent except at locations with significant U-turn activity as U-turn activity is assumed to increase on roadways with raised medians. However, contradicting statements were found in the literature. Bonneson and Mccoy (1998) found that drivers tended to avoid U-turns by switching to alternate routes when the delay due to this route diversion was less than the delay as a result of U-turn at the downstream.

Bonneson and McCoy (1998) stated that improved safety and operational performance were a function of U-turn activity at intersections. Carter et al. (2005) concluded that U-turns did not have a large negative safety effect on signalized intersections. Levinson et al. (2005) also observed similar results for unsignalized intersections (i.e., at median openings). Liu et al. (2008) found that the width of median opening along with critical gap and follow-up time constrain the capacity of U-turn movements. Liu et al. (2007) documented that vehicles making U-turns at median openings with wide medians (median nose width ≥ 21 ft) have larger critical gap and follow-up time than those making U-turns at median openings with narrow medians (median nose width < 21 ft).

2.1.5 Median Openings

Raised medians physically separate traffic on both directions and access to U-turns are provided at median openings. Figure 2-3 shows the most commonly used conventional and directional median openings. Levinson et al. (2005) noted that locations often have a combination of median openings to accomplish specific goals.

Levinson et al. (2005) analyzed 806 unsignalized median openings in seven states and found that the urban arterial corridors experienced an average of 0.41 U-turn-plus-left-turn crashes per median opening per year; and the rural arterial corridors experienced an average of 0.20 U-turn-plus-left-turn accidents per median opening per year. Zhou et al. (2003) conducted a four-year before-and-after analysis at a location that was converted from a traditional two-way opening to a directional median opening, and the results showed a 68 percent reduction in crashes with no additional crashes at the nearby median U-turn opening.

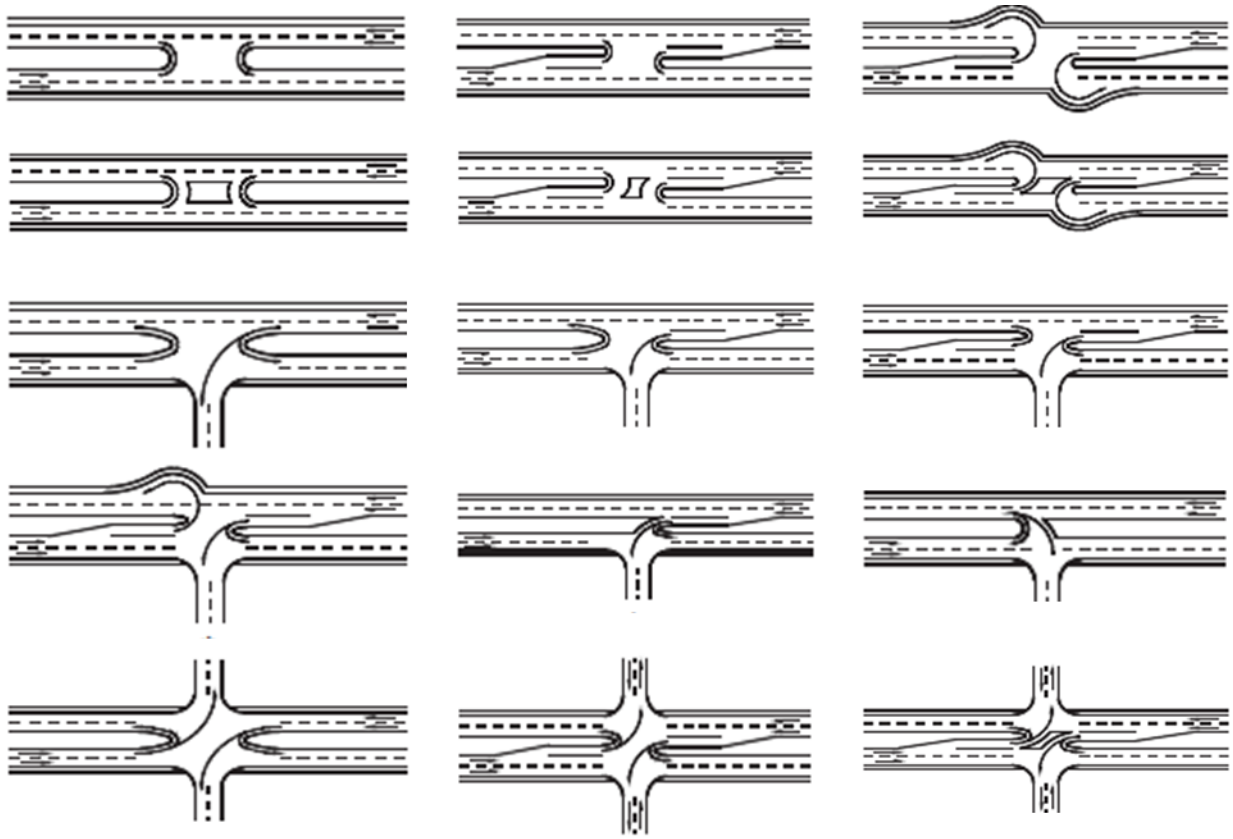


Figure 2-3: Typical Median Opening Designs (Levinson et al. 2005)

2.1.6 Access Density

Irrespective of the type of median treatment, increased access density increases crash rate (Gluck et al. 1999; Papayannoulis et al. 1999; Gattis et al. 2005). Papayannoulis et al. (1999) discussed that reduction in the number of access points improved safety and traffic flow by:

- reducing the number of conflicts,
- providing greater distance to anticipate and recover from turning maneuvers, and
- providing opportunities for improved design of turning lanes.

Table 2-1 shows crash rates in 100 MVM on roadways with TWLTLs and raised medians stratified by access density. From Table 2-1, it can be inferred that the difference between crash rates on roadways with TWLTLs and raised medians continues to increase with access density. This conclusion is also corroborated by Eisele and Frawley (2005), who stated that the relation between access density and crash rate was steeper on roadways without raised medians.

Table 2-1: Relation between Access Density and Safety (Gluck et al. 1999)

Access Points per Mile	Crash Rate on TWLTLs	Crash Rate on Raised Medians	Reduction in Crash Rate for Raised Medians vs. TWLTLs
< 20	3.4	2.9	-0.5
20 to 40	5.9	5.1	-0.8
40 to 60	7.4	6.5	-0.9
> 60	9.2	8.2	-1.0

* Crash rates are per 100 MVM.

However, varying results were reported in several other studies. On roadways with medium access density (20-40 access points per mile), Gattis et al. (2005) observed that narrow medians have lower crash rate compared to TWLTLs. Phillips (2004) observed that TWLTLs appeared to be safer on roadways with over 25 driveways/mile and low traffic volumes. Squires and Parsonson (1989) also made similar observations. Bretherton (1994) considered TWLTLs to be safer on arterials with fewer than 60 commercial driveways per mile, and raised medians were considered to be safer for higher levels of development. Due to contradicting results on the relation between median treatment type and access density, Gattis et al. (2005) expected the comparison of crash rates for different median types using data stratified by access density to yield meaningful conclusions.

2.1.7 Crash Prediction Models

Several safety performance models of various access management techniques have been developed in the past decade. Squires and Parsonson (1989) used regression equations to predict crash rate on four-lane and six-lane arterials with either a TWLTL or a raised median by considering signal, driveway, and approach densities. Similarly, Bonneson and McCoy (1997a) developed Negative Binomial (NB) models to evaluate the safety performance of midblock left-turn treatments (i.e., undivided, TWLTLs, and raised medians) by considering the influence of annual average daily traffic (AADT), through lane flow rate, percentage of left-turning traffic, number of access points (or driveway density), number of through and turn lanes, speed limit, cross-section width, land use, and on-street parking. Phillips (2004) generated Poisson regression models for four-lane segments with either a raised median or a TWLTL using traffic volume, geometric characteristics, land use data, and collision data; AADT, segment length, land use, left-turn treatment, driveway density, and approach density were considered to be influential.

Recently, Schultz et al. (2010) predicted the relation between median type, physical roadway characteristics, and safety in terms of crash severity and collision type. A statistically significant relationship was observed between crash rates and signal density, land use, speed limit, and median type. Based on these relationships, a decision tree was generated (as shown in Figure 2-4) to determine the most appropriate access management technique. The model showed that (Schultz et al. 2010):

- Every additional signal per mile resulted in 0.92 crashes per MVM.
- Segments with commercial land use, on average, resulted in an additional 1.23 crashes per MVM compared to the segments with adjacent residential land use.

- Presence of a raised median corresponded to a reduction of 1.23 crashes per MVM.
- A 10 mph increase in the posted speed limit corresponded to a reduction of less than 0.71 crashes per MVM. However, this conclusion was based on roadways with 35 and 45 mph.

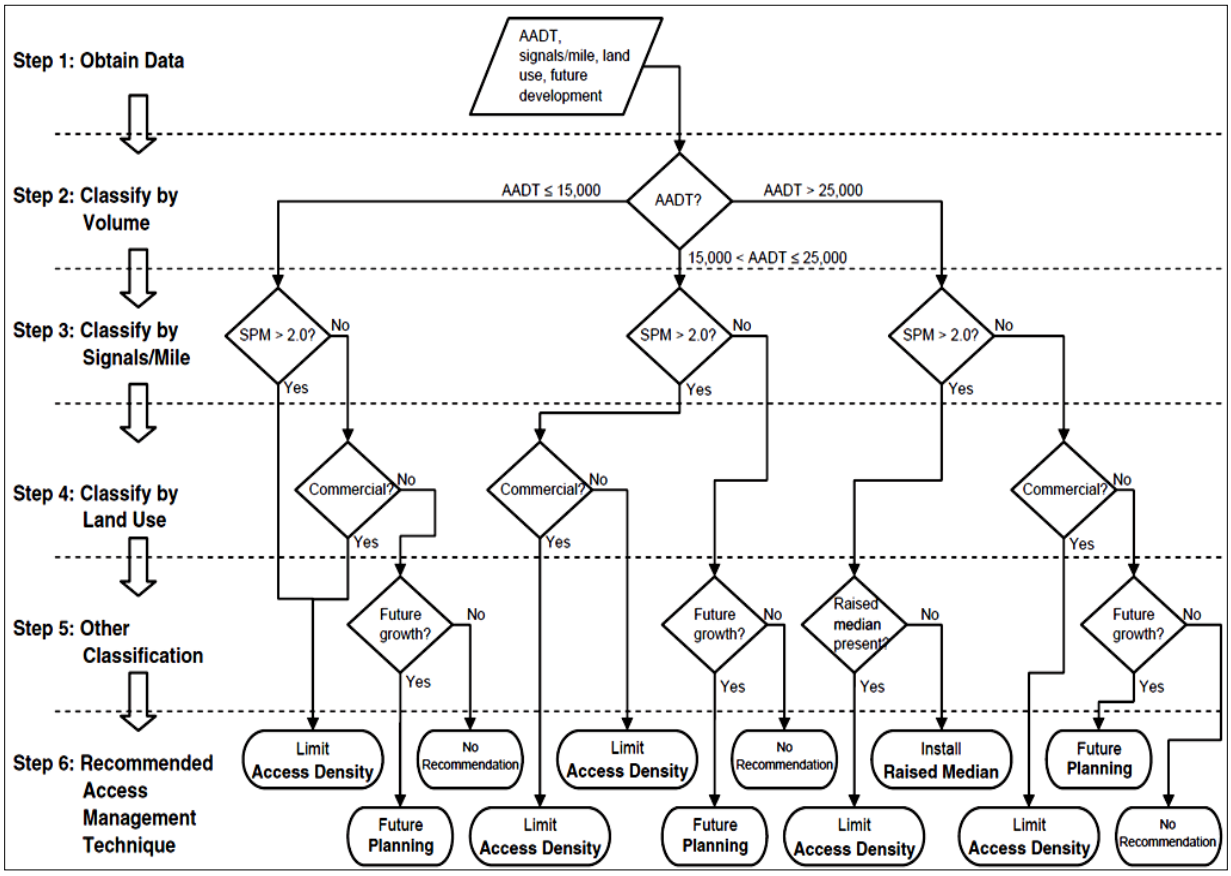


Figure 2-4: Decision Tree for Determining Recommended Access Management Techniques (Schultz et al. 2009)

Schultz et al. (2010) developed stepwise regression equations to relate independent variables to collision type. Table 2-2 identifies statistically significant variables for different collision types.

Mauga and Kaseko (2010) developed multivariate regression models to relate geometric and access management features to traffic safety at midblock sections. The authors considered signal spacing, density of median openings, density of cross roads, driveway density, AADT, speed limit, number of through lanes, and land use for total crashes, by crash type and crash severity. The results showed a 23.2 percent reduction in crash rate for raised medians compared to TWLTLs.

For the combined model, signal spacing, driveway density, and median type (raised median versus TWLTL) have statistically significant impact on crash rates. For the raised median model, signal spacing, driveway density, and the density of median openings have statistically significant impact. For the TWLTL model, signal spacing, driveway density, and the density of

cross roads have significant impact. Mauga and Kaseko (2010) also included a detailed discussion on the safety performance of raised medians and TWLTLs by crash type and crash severity.

Table 2-2: Relationships between Independent Variables and Crash Rate by Collision Type (Schultz et al. 2010)

Variable	Right-angle	Rear-end	Sideswipe	Opposite-direction	Single-vehicle	Other
Signals/mile	+	+	+			
AADT/lane	-	+			-	-
Commercial	+		+			+
Residential		-		+		-
Speed limit		-			-	-
Raised median	-					
TWLTL				+		
Accesses/mile			+			

Note: "+" indicates a positive relationship; "-" indicates a negative relationship; and blank cells indicate no relationship.

Gattis et al. (2005) documented that a possible correlation existed between median type and land use environment. Independent of the type of median treatment, crash frequency was found to be higher on arterials adjacent to businesses as compared to those adjacent to residential areas. Bonneson and McCoy (1998) related this pattern to higher left-turning volumes near businesses. Lyon et al. (2008) found that the installation of TWLTLs on rural two lane roads was a cost effective treatment to address high frequency of rear-end collisions involving a lead vehicle desiring to make a left turn.

In summary, studies have shown different reductions and distributions by crash severities and crash types, and different correlations among the geometric characteristics. These studies have often given contradictory results, most likely due to one or more of the following: high variability in crash data, variations in crash reporting thresholds, fewer number of crashes, inconsistencies in the target crash types identified for the analysis, and differences in analysis approaches (for e.g., before-and-after analysis versus cross-sectional analysis) (Bonneson and McCoy 1997b).

2.1.8 Florida-Specific Case Studies

The following are the case studies from Florida that are relevant to median treatments and access management projects:

- Hillsborough Avenue Access Management Project upgraded a six-lane with TWLTL segment to a six-lane roadway with a raised median. The project installed 2.5 miles of raised median impacting 170 driveways and side streets. The project resulted in significant safety improvements with more controlled access. This project had an increased pedestrian and bicycle crashes which was considered as an anomaly (Hsu and Bowman 2010).
- Sunken Gardens, located on the east side of US 92 in St. Petersburg, Florida was

upgraded from a four-lane roadway with a TWLTL to a four-lane roadway with a raised median (i.e., a raised pedestrian refuge area) and crosswalks at the midblock locations. A Rectangular Rapid flashing Beacon (RRFB) was also installed for additional pedestrian safety. In the first week after the improvements, over 900 crossings were reported with over 85 percent of motorists yielding to pedestrians (Federal Highway Administration).

2.2 Impact of Access Management on Drivers, Businesses, and Communities

Even though physical improvements to a roadway improve its safety and efficiency, these enhancements are not often perceived as acceptable solutions by the public. Williams (1999) related typical public concerns about the construction of a raised median to economic impacts on businesses, access for delivery vehicles, safety of U-turns, circuity of access, and neighborhood accessibility. For obvious reasons, public with direct access to arterials favor TWLTLs while residents with access to midblock intersections support raised medians. Dixon et al. (1999) observed that a feature perceived as strength by one citizen group is often considered as a weakness by others, often making the decision difficult for the state Department of Transportation (DOT). A survey conducted by Plazak et al. (1998) found that businesses often equate reductions in the number of driveways and other direct access ways with loss of sales, thus opposing improvements that involve more restrictive treatments such as raised medians.

2.2.1 Impact of Access Management on Businesses in Florida

Florida has been one of the few states that are proactive in incorporating access management strategies. FDOT completed several projects in assessing the impact of roadway improvements on adjacent businesses. The following are the relevant excerpts from several studies done in Florida since early 1990s:

- About 30 percent of the business owners felt that the projects had at least a small detrimental impact on their businesses (including declines in sales, truck delivery difficulties, etc.) while the motorists were very supportive of the projects (Ivey and Walls 1995).
- "Destination businesses, such as doctors, specialty retail stores, and service-oriented businesses, are not affected by access management modifications. Interviews with both customers and business owners have shown that most people have no problem making a slightly longer trip, including U-turns, to access destination businesses. Even though passer-by businesses, such as convenience stores, gas stations, and fast food restaurants may be impacted more by access management modifications, studies have shown that even passer-by businesses are not negatively impacted as long as reasonable access is provided" (FDOT).
- Over three-quarters of the surveyed drivers felt safer on access managed highways and 84 percent of them felt traffic moved better (Ivey and Walls 1995).

In regards to access management projects, both Plazak et al. (1998) and Eisele and Frawley (2000) observed that the perception of business owners was worse than reality in terms of property value, sales, etc. Also, customers ranked property access much lower than service or quality, implying that most businesses could overcome restricted access by offering good and

reliable services to their customers. However, Bonneson and McCoy (1997b) considered this conclusion to be dependent on the type of business as auto-related businesses such as gas stations are extremely access-dependent. Table 2-3 provides more details on the perceived effect of left-turn restrictions on specific businesses. Similar results, to a lesser detail, were documented by Eisele and Frawley (2000).

Table 2-3: Perceived Effect of Left-Turn Restrictions on Businesses Based on Interviews (Weisbrod and Neuwirth 1998)

Business Type	Midblock Location	Location with Left-Turn Access
Fast Food Delivery	Positive	Positive
Electrical Supplies	None	Positive
Bowling Alley, Regional Mall		Positive
Auto Repair		Positive or None
Carpet Store	None	None
Beauty/Hair Salon, Bread Baking Company, Car Dealership, Diner, Interior Decorating, Health Food Store, Hotel, Mobile Home Sales, Museum, Tire Sales/Service, Trailer Park, Video Store, Wholesale Lumber	None	
Copy Service, Sports Equipment		None
Supermarket	None or Negative	Positive
Motel, Restaurant	None or Negative	
Real Estate Broker	Negative	Positive
Department Store	Negative	Positive or None
Art Gallery, Audio/Car Stereo, Bicycle Shop, Building Supplies, Deli/Sandwich Shop, Fast Food, Ice Cream/Yogurt Shop, Industrial/Agricultural Equipment, Oil Changing, Service, Fast Food, Fishing Supplies, Flea Market, Garden/Lawn Supplies, Gift Shop, Gourmet Food, Party Supplies, Pawn Shop, Pharmacy, Recreational Vehicle Sales, Used Car Dealership	Negative	
Auto Parts/Supplies, Gas Station	Negative	None

2.2.2 Public Involvement in Median Projects

Williams (1999) surveyed a representative sample of FDOT district offices and identified the following specific problems with the public involvement process for raised median constructions:

- public hearings involved the conceptual design hearings, which were often significantly different from the actual final designs;
- the actual median construction might start years after the proposed project's public hearing, and the affected businesses might change;
- public hearings were often contentious and did not provide a constructive forum for addressing property owner concerns;

- public involvement during design was required only for major design changes and median construction was not often considered a major design change;
- inconsistencies in applying median opening standards or overly strict interpretation of standards had reduced agency credibility in some cases, and there was a need for clear guidelines regarding the appropriate level of flexibility; and
- in some areas inadequate local government support for median projects and access management increased the difficulty of working with the public on these issues.

Williams (1999) also concluded that a proactive approach to public involvement is the best way to address public concerns. The author put forth the following recommendations to the state agencies on the public involvement in median projects:

- State agencies should ensure that the median construction projects receive adequate attention at the appropriate phases of project development and production.
- Public involvement should begin in planning and project development phase, and again in the design phase.
- Public hearings should not be the sole forum for public involvement. Other avenues such as letters and workshops should also be included.
- The reasons for median improvements have to be strongly communicated to the public.
- Coordination and consistency in decision making is crucial to establish and maintain credibility with the public.
- Feedback and supporting documents on the key issues have to be given to the public.
- All communications should be well documented.

2.2.3 Public Concerns about Roadway Enhancements

Based on three detailed case studies in Georgia, Dixon et al. (1999) reviewed public comments and identified five basic areas of concern regarding functional enhancement of arterials. These concerns are discussed below:

1. *Total Project Opposition:* Public believes that road improvements might lead to additional traffic, adversely impacting neighborhood. These improvements are believed to encourage cut-through traffic.

2. *Design Based on Abutting Land Use:* Public's greatest concern is the impact of improvements on the adjacent property. TWLTLs are acceptable for commercial property while medians help preserve the "residential character" of the neighborhood. Medians, if installed, are expected to be aesthetically pleasing.

3. *Access Constraints:* TWLTLs are preferred by businesses as they can have unlimited two-way access to their property, while raised medians cut the access.

4. *Safety:* Public perceive TWLTLs as "suicide lanes" resulting in an increased number of head-on collisions. Medians address this safety concern, however, might result in faster traffic and the increased U-turn activity increase the vehicles' exposure. Pedestrian safety is better in case of medians as raised medians could act as refuge areas.

5. *Cost:* TWLTL might require a slightly narrower right of way compared to a 20 ft median. Maintenance cost of landscaped median is greater than its TWLTL counterpart.

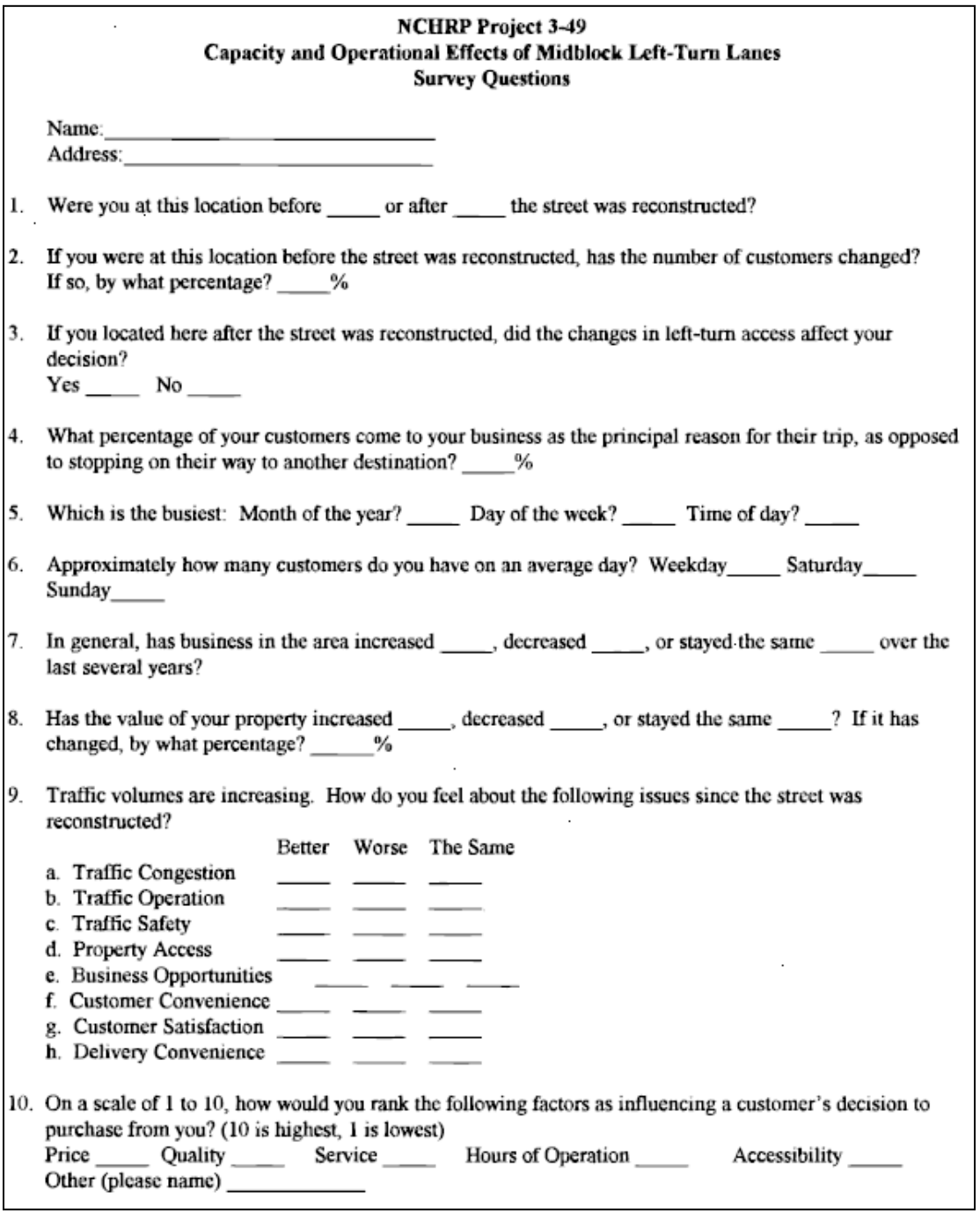
As part of the National Cooperative Highway Research Program (NCHRP) 3-49 project, Bonneson and McCoy (1997b) conducted a public opinion survey at the following four locations to determine the public perception of access management:

1. Oakland Park Boulevard, Fort Lauderdale, Florida: converted from a six-lane raised median with opening every 330 ft to a six-lane raised median facility with median opening every 660 ft.
2. Merritt Island Parkway, Merritt Island, Florida: converted from a four-lane TWLTL to a six-lane raised median with opening every 660 ft.
3. Roosevelt Road, Wheaton/Glen Ellyn, Illinois: converted from a four-lane undivided roadway to a four-lane TWLTL facility.
4. Port Washington Road, Mequon, Wisconsin: converted from a four-lane undivided roadway to a six-lane raised median facility with a median opening every 330 ft.

Figure 2-5 gives the list of survey questions; the questionnaire focused on the impact of access management on the businesses. From the survey responses, the business owners of non-auto-related services believed that customers rank property access much lower in importance when compared to service or quality. Regarding the access, the business representatives believed that median openings should be provided as frequently as possible on divided arterials.

Maze and Plazak (1997) interviewed businesses and motorists along five business corridors in Iowa where access management occurred, and it was found that the study corridors performed better in terms of sales compared to their surrounding communities. The following are the relevant results:

- There were no particular business categories that consistently decreased. Businesses with passer-by traffic did not appear to be affected in a significantly different manner than all other businesses.
- The rates of business turnover in the study corridors ranged from about 2.6 percent to 10 percent per year, a range comparable to the state average.
- With one exception, retail sales for businesses within the case study corridors significantly outpaced sales in their respective communities.
- There do not appear to have even been any significant short-term declines in retail activity associated with the access management projects.
- About 85 percent of the responding business owners indicated that their sales had increased, stayed the same, or that they were uncertain about the impact. Only five percent of the responding businesses reported a decline in sales activity.
- About 19 percent of the responding business owners mentioned that their customers complained about limited access.
- Over 90 percent of the surveyed motorists had a favorable opinion of the roadway improvements. The vast majority agreed that the improved roadways are safer, operate better, and are easier to drive on.



NCHRP Project 3-49
Capacity and Operational Effects of Midblock Left-Turn Lanes
Survey Questions

Name:_____
Address:_____

1. Were you at this location before _____ or after _____ the street was reconstructed?

2. If you were at this location before the street was reconstructed, has the number of customers changed? If so, by what percentage? _____%

3. If you located here after the street was reconstructed, did the changes in left-turn access affect your decision?
   Yes _____ No _____

4. What percentage of your customers come to your business as the principal reason for their trip, as opposed to stopping on their way to another destination? _____%

5. Which is the busiest: Month of the year? _____ Day of the week? _____ Time of day? _____

6. Approximately how many customers do you have on an average day? Weekday_____ Saturday_____ Sunday_____

7. In general, has business in the area increased _____, decreased _____, or stayed the same _____ over the last several years?

8. Has the value of your property increased _____, decreased _____, or stayed the same _____? If it has changed, by what percentage? _____%

9. Traffic volumes are increasing. How do you feel about the following issues since the street was reconstructed?

	Better	Worse	The Same
a. Traffic Congestion	_____	_____	_____
b. Traffic Operation	_____	_____	_____
c. Traffic Safety	_____	_____	_____
d. Property Access	_____	_____	_____
e. Business Opportunities	_____	_____	_____
f. Customer Convenience	_____	_____	_____
g. Customer Satisfaction	_____	_____	_____
h. Delivery Convenience	_____	_____	_____

10. On a scale of 1 to 10, how would you rank the following factors as influencing a customer's decision to purchase from you? (10 is highest, 1 is lowest)
    Price _____ Quality _____ Service _____ Hours of Operation _____ Accessibility _____
    Other (please name) _____

Figure 2-5: Survey Questionnaire (Bonneson and McCoy 1997b)

Maze and Plazak (1997) found that the motorists and the affected business owners at the five study corridors were favorable about the roadway improvements. The authors also identified the following concerns and cautions:

- The access management projects were likely to be more effective in reducing property damage only (PDO) crashes than in reducing fatal and severe injury crashes. Nevertheless, their injury prevention potential was significant.
- The operational impacts of these treatments might be lost to subsequent traffic increases.
- Few businesses, that mostly attract passer-by traffic, were expected to experience long-term decline in sales. Also, some types of businesses might likely receive customer complaints.
- A minority of business owners and managers (up to 30 percent on some projects) would not be supportive of access management projects along their corridors even if the projects were clearly needed for traffic operations and safety reasons.
- A minority of motorists would not support the improvements.

2.2.4 Analysis of Economic Impact of Access Management

Gluck et al. (1999) associated the economic impact of installing limited access raised medians with the following factors:

- the size and type of each abutting land use at the locations where left-turn access will be reduced/removed,
- the reliance of businesses on passer-by traffic,
- left-turning traffic volume,
- the average purchase per vehicle (or person), and
- economic trends for the surrounding areas.

Two most frequently accepted practices for estimating the economic impacts of median treatment are a before-and-after evaluation and a post facto evaluation. Before-and-after evaluation primarily deals with collecting and analyzing site data before and after the median construction (i.e., data are collected twice, once before and once after). Post facto evaluation is performed when the economic analysis of median is required after it is constructed (i.e., data are collected only once). Eisele and Frawley (1999) provided a logical structure to the process of comprehensive economic analysis using the following steps:

- identify sites (cities) with potential corridors,
- identify corridor characteristics,
- contact sources of information,
- inventory businesses and establishments along the subject corridor,
- obtain information about businesses,
- prioritize businesses to be surveyed,
- collect data by personal interviews, and
- analyze and summarize data.

Of all the aforementioned steps, data collection and analysis are complex and are project-specific driven primarily by study period and project goals. Even though most of the analyses are project-specific, Eisele and Frawley (1999) identified summary statistics on the following areas to result in comprehensive and well researched conclusions:

- impacts on passer-by traffic or “impulse buyers”;
- impacts on importance of access to customers;
- impacts on regular customers;
- impacts on number of employees, property values, crashes, and traffic volume;
- impacts on customers per day and gross sales;
- impacts on traffic congestion, traffic safety, property access, business opportunities, customer satisfaction, and delivery convenience; and
- business owners’ extent of public involvement.

2.3 Summary

This chapter focused on the safety and operational performance evaluation of arterial streets that were converted from TWLTLs to raised medians. Additionally, it also summarized the existing literature on the impacts of median treatments on affected businesses and communities. While most studies have found that conversion from a TWLTL to a raised median reduced crash rate, a few studies have concluded otherwise. Several studies have documented a reduction in crash rate between 23 percent and 41 percent when roadways were converted from a TWLTL to a raised median. On the other hand, one study has reported a 43 percent increase in total crash rate after the median construction and another study reported a higher proportion of fatal collisions at locations with raised medians compared to TWLTL sections. Moreover, studies have shown different reductions and different distributions by crash severities and crash types, and different correlations among the geometric characteristics.

Public acceptance is important for the success of any public project, arterial improvements through access management are no exception. Regardless of proven engineering benefits of access-managed arterials, public are often against the improvements mainly due to misconceptions about access limitations to their properties. A proactive approach to public involvement is the best way to address public concerns. Further, Eisele and Frawley (2000) observed that the perception of business owners is worse than reality in terms of property value, sales, etc. Also, customers rank property access much lower than service or quality, implying that most businesses could overcome restricted access by offering good and reliable services to their customers. However, this conclusion is dependent on the type of business as auto-related businesses are extremely access-dependent.

CHAPTER 3
DATA PREPARATION

This chapter describes the efforts undertaken to identify study locations where a TWLTL was converted to a raised median. These study locations are used in both before-and-after analysis and to identify corridors for conducting interviews of businesses. This chapter also describes an effort undertaken to review police reports to verify and correct miscoded crash types.

3.1 Identification of Study Locations

The FDOT's Roadway Characteristics Inventory (RCI) database was used to identify roadway locations with raised medians that have been converted from TWLTLs. Study locations were identified by comparing the segments with TWLTL in 2005 RCI database with the segments with raised median in 2010 RCI database.

A total of 2,675 segments with TWLTL were extracted from 2005 RCI database, and 2,597 segments with raised median were extracted from 2010 RCI database. The two extracted datasets from 2005 and 2010 were then matched based on the median change. Since an increased number of smaller segments were generated, these smaller sections were aggregated into longer segments based on 2010 data. As a result, a total of 225 roadway segments that were converted from a TWLTL to a raised median were identified. These roadway segments were further compared with the state road database and those that are located on the off-system roads were removed. Segments shorter than 200 ft were also removed. Finally, a total of 78 segments were considered for further analysis. Table 3-1 shows the selected 78 segments by district.

Table 3-1: District-wise Categorization of the Selected 78 Segments

District	Number of Roadway Segments	Counties
1	12	Charlotte, Collier, Lee, Pork, Sarasota
2	5	Alachua, Duval, Putnam
3	12	Bay, Escambia, Leon, Okaloosa, Santa Rosa
4	13	Broward, Indian River, Martin, Palm Beach, St. Lucie
5	18	Sumter, Marion, Orange, Seminole, Volusia, Osceola
6	4	Miami-Dade
7	14	Citrus, Hillsborough, Pinellas
Total	**78**	

The construction periods of the 78 roadway segments were requested from the district offices to determine the before and after periods for analysis. However, the construction periods were available for only 35 locations. Table 3-2 lists the locations with construction dates.

Table 3-2: Locations with Construction Dates

Dist.	County	Street Name	Roadway ID	Begin Mile Post (MP)	End Mile Post (MP)	Seg Len (mi)	Construction Begin Date	Construction End Date
1	Polk	N Florida Ave	16210000	1.156	1.259	0.103	12/7/2009	1/14/2010
1	Polk	N Florida Ave	16210000	2.365	3.004	0.639	8/11/2010	9/23/2010
1	Sarasota	S Tamiami Trail	17010000	14.895	14.966	0.071	7/8/2002	3/1/2005
1	Sarasota	N Tamiami Trail	17020000	0.068	0.422	0.354	9/1/2000	6/15/2007
1	Sarasota	Fruitville Rd	17040000	0.619	4.203	3.584	1/13/2006	9/29/2006
2	Duval	University Blvd. W	72014000	1.454	1.842	0.388	3/1/2004	12/23/2004
2	Duval	Mayport Rd/SR A1A	72230000	0.444	0.527	0.083	2/1/2008	12/31/2008
3	Bay	SR 77	46060000	9.038	9.317	0.279	6/7/2010	8/2/2010
3	Escambia	N Davis Hwy	48070000	5.677	6.191	0.514	4/4/2005	10/18/2006
3	Escambia	W Navy Blvd.	48080060	1.227	1.476	0.249	11/21/2008	6/14/2010
3	Leon	Capital Cir SW	55002000	7.968	8.090	0.122	12/2/2002	4/29/2004
3	Leon	Capital Cir NW	55002000	9.714	10.662	0.948	9/26/2005	9/4/2007
3	Leon	W Tennessee St	55060000	3.547	4.566	1.019	3/14/2005	7/17/2006
3	Leon	US 27	55080000	3.371	4.888	1.517	8/1/2006	9/6/2007
3	Santa Rosa	Florida Historic State Road 1	58010000	16.053	16.313	0.260	8/2/2004	10/13/2007
3	Santa Rosa	SR 87	58040000	18.124	18.258	0.134	8/2/2004	10/13/2007
4	Broward	E Hillsboro Blvd.	86120000	6.290	6.385	0.095	7/31/2006	12/10/2006
4	Broward	NE 4th Ave	86170000	0.000	0.129	0.129	8/8/2006	9/19/2007
4	Broward	W Hallandale Beach Blvd.	86200000	3.510	3.630	0.120	5/19/2008	3/6/2009
4	Broward	Davie Blvd.	86210000	0.076	0.190	0.114	3/3/2008	1/22/2009
4	Indian River	US 1	88010000	7.952	8.012	0.060	3/6/2006	8/31/2007
4	Martin	SE Monterey Rd	89092000	1.214	1.314	0.100	5/8/2006	10/6/2006
4	Palm Beach	Southern Blvd./SR 80	93120000	12.245	12.427	0.182	2/2/2005	10/29/2008
4	Palm Beach	S Main St. / E SR 80	93130000	0.000	0.290	0.290	4/30/2007	3/24/2008
4	Palm Beach	Dr. Martin L. King Jr Blvd.	93310000	21.925	22.010	0.085	11/12/2007	2/18/2010
4	St. Lucie	S 4th St. / US 1	94010000	10.784	11.694	0.910	7/21/2008	6/22/2009
5	Sumter	SR 35	18010000	27.925	28.094	0.169	3/31/2009	1/13/2011
5	Marion	SW 17th St	36004000	0.803	1.117	0.314	12/3/2007	4/18/2009
5	Marion	SW College Road	36100000	15.080	15.223	0.143	1/9/2006	8/25/2006
5	Marion	W Silver Springs Blvd.	36110000	22.573	22.722	0.149	1/9/2006	7/30/2007
5	Orange	Semoran Blvd.	75003000	5.009	7.426	2.417	1/30/2008	11/3/2008
5	Orange	S Orange Blossom Trail	75010000	3.418	4.775	1.357	3/8/2004	2/15/2007
5	Orange	N Orange Blossom Trail	75020000	4.735	5.077	0.342	8/9/2009	3/15/2010
6	Miami-Dade	Biscayne Blvd.	87030000	18.057	19.261	1.204	10/5/2004	7/30/2006
6	Miami-Dade	S Okeechobee Rd	87090000	10.412	11.680	1.268	10/4/2004	1/30/2006
7	Citrus	US 41	02010000	11.685	11.819	0.134	4/28/2005	1/31/2007
7	Citrus	N Suncoast Blvd.	02030000	13.688	13.940	0.252	11/3/2006	8/3/2007
7	Hillsborough	SR 43 / US 301	10010000	16.144	17.270	1.126	3/16/2009	12/21/2009
7	Hillsborough	E Hillsborough Ave	10030000	0.000	0.295	0.295	7/30/2007	1/14/2008
7	Hillsborough	E Hillsborough Ave	10030000	0.415	0.900	0.485	7/30/2007	1/14/2008
7	Hillsborough	E Hillsborough Ave	10030000	1.064	1.262	0.198	7/30/2007	1/14/2008
7	Hillsborough	E Hillsborough Ave	10030000	1.511	2.166	0.655	7/30/2007	1/14/2008
7	Hillsborough	E Hillsborough Ave	10030000	2.360	3.014	0.654	7/30/2007	1/14/2008
7	Hillsborough	Adamo Dr	10110000	0.111	0.195	0.084	4/1/2008	7/28/2008
7	Hillsborough	Causeway Blvd.	10250000	3.259	3.304	0.045	2/4/2008	8/2/2010

3.1.1 Before-and-After Analysis

For before-and-after safety analysis, a minimum of 12 months is usually required for before and after periods (excluding the buffer period). In addition, a few months before and after the construction period are usually excluded considering potential pre-construction activities and the fact that some drivers may need time to adjust to the new treatment and resume normal travel patterns. For this analysis, one month prior to the start of the construction period and three months after the end of the construction period were excluded.

The FDOT's Crash Analysis Reporting (CAR) system was used to identify crashes that occurred at the study locations. Since the police reports were available only from January 2003 to December 2010, only the locations with construction period between February 2004 and September 2009 were included in the before-and-after analysis. Also, when available, a maximum of 36 months of crash data before and after construction were used. Based on these criteria, 18 locations were selected for before-and-after analysis. Table 4-1 in Chapter 4 lists these 18 study locations. Appendix A provides the street and satellite maps of each of the 18 study locations.

3.1.2 Interviews of Businesses

Besides the before-and-after safety analysis, this project also aims to document the opinions of the affected businesses along the corridors that were recently converted from TWLTLs to raised medians. From the pool of median improvement sites, locations with a significant number of customer-oriented abutting business establishments were selected for on-site visits to conduct interviews of businesses. Only those locations where raised medians have been recently constructed (later than January 2009) were short-listed. The selection of locations with more recent median construction increased the chances that the abutting businesses had been opened since before median conversion and that the businesses owners or managers could better recollect their experience with the prior roadway conditions and involvement in public information process. Based on the construction dates listed in Table 3-2, ten locations were selected for conducting the interviews. Table 3-3 lists the ten interview sites along with the number of potential businesses at these locations. Appendix B provides the street and satellite maps of each of the ten study locations.

Table 3-3: Number of Potential Businesses at Each Location

Roadway Name	Roadway ID	Potential Businesses
US 301 (Riverview, FL)[a]	10010000	73
S 4th St/ US 1 (Ft. Pierce, FL)[b]	94010000	100
E Hillsboro Blvd. (Deerfield Beach, FL)[a]	86120000	13
N Orange Blossom Trail (Orlando, FL)[b]	75020000	13
Semoran Blvd. (Orlando, FL)[a]	75030000	145
N Florida Ave (Lakeland, FL)[b,c]	16210000	36
N Florida Ave (Lakeland, FL)[b,d]	16210000	3
Davie Blvd. (Davie, FL)[b]	86210000	26
West Hallandale Beach Blvd. (Hallandale, FL)[a]	86200000	9
SR 77 (Panama City, FL)[b,e]	46060000	8
Total		**426**

[a] Locations are six-lane facilities.
[b] Locations are four-lane facilities.
[c] Segment is from MP 1.156 to MP 1.259; [d] Segment is from MP 2.365 to MP 3.004.
[e] Conducted the interviews through telephone.

3.2 Review of Police Reports

Police reports were available for download from the Hummingbird web system hosted on FDOT's Intranet. At the time of this study, police reports were available for the years 2003 through 2010. The police reports for the before and after periods for all of the 18 locations were downloaded and reviewed to verify the crash type and to identify the underlying contributing causes. Based on the illustrations and descriptions available in the police reports, the correct crash type is recorded and used in the analysis in this study. Figures 3-1 and 3-2 give two examples of rear-end and right-turn crashes miscoded as head-on crashes, respectively.

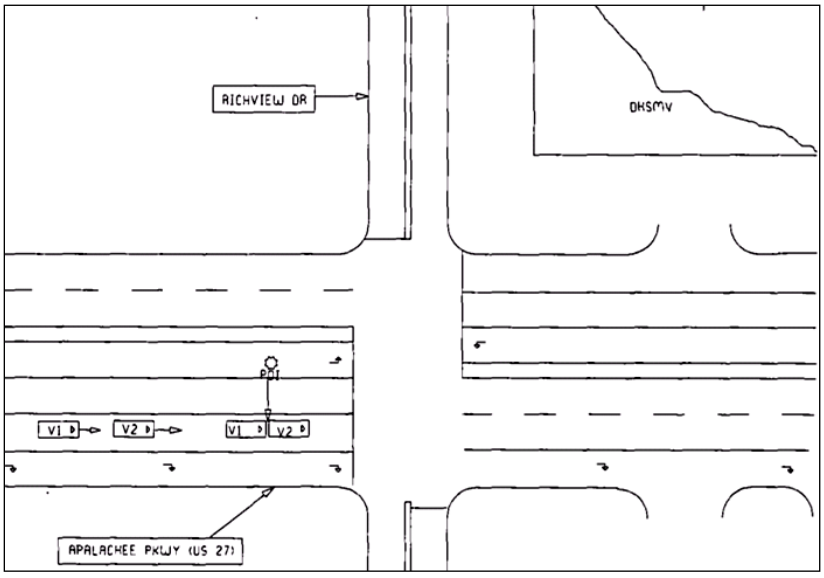


Figure 3-1: Crash ID: 718723770; Rear-End Crash Miscoded as a Head-On Crash

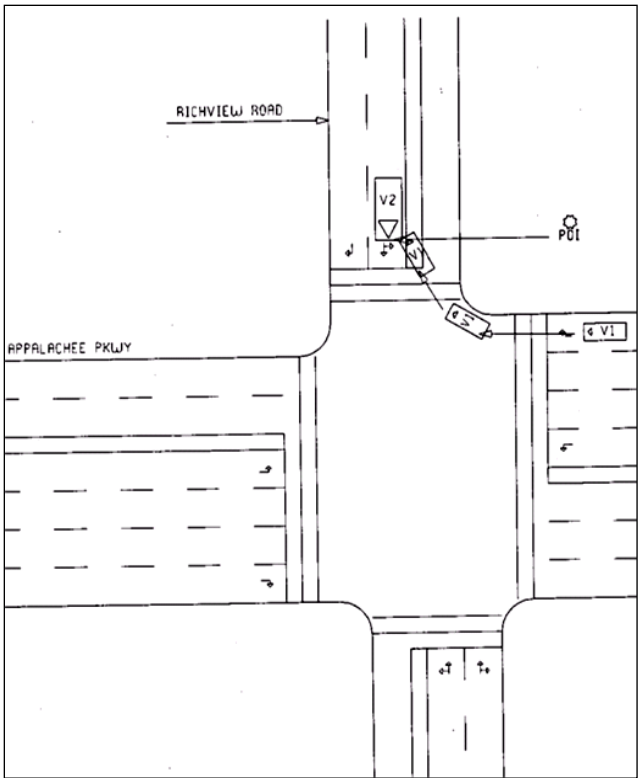


Figure 3-2: Crash ID: 718271850; Right-Turn Crash Miscoded as a Head-On Crash

Table 3-4 gives the distribution of the coded and corrected crash type for the more frequent crash types. For example, the table shows that police officers had identified 676 angle crashes in the police reports. However, through review of the illustrative sketches and descriptions in the police reports, only 402 were identified as having been correctly coded as angle crashes, while the remaining 274 crashes should have been coded as head-on (3), left-turn (183), median crossover (4), rear-end (22), right-turn (33), and sideswipe (29). Similarly, police officers had coded 100 head-on crashes. However, only 25 of these crashes were correctly coded as head-on, while the remaining 75 crashes were actually angle (20), left-turn (15), median crossover (3), rear-end (35), and right-turn (2). After all the crash types were corrected, for example, there were a total of 560 angle crashes (instead of 676), including 402 (or 71.8 percent) that were correctly coded and 158 (or 28.2 percent) that were corrected.

Table 3-4 also shows that a high 63.2 percent of median crossover crashes were coded incorrectly, followed by right-turn and left-turn crashes at 57.9 percent and 40.0 percent, respectively. Of the 107 right-turn crashes, 33 crashes were incorrectly coded by police officers as angle crashes. Similarly, 183 of 557 left-turn crashes were incorrectly coded as angle crashes. Likewise, seven of 19 median crossover crashes were incorrectly coded as either angle or head-on crashes.

Table 3-4: Distribution of the Coded and Corrected Crash Type

		Crash Type Coded in Police Reports							Total Crashes WITH Corrected Crash Type	Percent Corrected
		Angle	Head-On	Left-Turn	Median Crossover	Rear End	Right-Turn	Side-swipe		
Corrected Crash Type	Angle	402	20	38		37	5	58	560	28.2%
	Head-On	3	25						28	10.7%
	Left-Turn	183	15	334		4		21	557	40.0%
	Median Crossover	4	3	1	7	2		2	19	63.2%
	Rear-End	22	35	1		1486	1	12	1557	4.6%
	Right-Turn	33	2			10	45	17	107	57.9%
	Sideswipe	29		6		6	2	189	232	18.5%
Total Crashes WITHOUT Corrected Crash Type		676	100	380	7	1545	53	299	3060	18.7%

3.3 Summary

This chapter described the efforts undertaken to identify study locations where a TWLTL was converted to a raised median. Study locations were identified by comparing the segments with TWLTL in 2005 RCI database with the segments with raised median in 2010 RCI database. A total of 78 segments were considered for further analysis, of which, construction periods were available for 35 locations.

A minimum of 12 months and a maximum of 36 months of crash data were used for before-and-after analysis. Also, one month prior to the start of the construction period and three months after the end of the construction period were excluded. Based on the availability of police reports, 18 locations with 17.51 miles were selected for before-and-after analysis. Further, police reports of all crashes at the 18 study locations before and after median construction were downloaded and reviewed to verify and correct miscoded crash types. In this process, the crash types of 18.7 percent of crashes were corrected.

From the pool of locations that were recently converted from TWLTLs to raised medians, locations with a significant number of customer-oriented abutting business establishments were selected for on-site visits to conduct interviews of businesses. A total of ten locations were selected for conducting the interviews.

CHAPTER 4
BEFORE-AND-AFTER COMPARISONS

This chapter includes several comparisons of crash experience before and after conversion of TWLTLs to raised medians. The comparisons are based on the 18 locations listed in Table 4-1. These locations, totaling 17.51 miles, were selected for their availability of construction periods as well as for having at least 12 months of crash data before and after their median conversion. The comparisons are performed based on crash rates (i.e., number of crashes per MVM) for both individual locations and all locations combined. The comparisons are also performed for different crash types and crash severity levels.

Table 4-1: Study Locations

Dist.	Roadway Name	County	Roadway ID	Begin MP	End MP	Segment Length (mi)	Construction	
							Begin Date	End Date
3	Florida Historic SR 1	Santa Rosa	58010000	16.053	16.313	0.260	8/2/2004	10/13/2007
4	South Main Street	Palm Beach	93130000	0.000	0.290	0.290	4/30/2007	3/24/2008
4	US 1	St. Lucie	94010000	10.784	11.694	0.910	7/21/2008	6/22/2009
5	SW 17th Street	Marion	36004000	0.803	1.117	0.314	12/3/2007	4/18/2009
7	N Suncoast Blvd.	Citrus	2030000	13.688	13.940	0.252	11/3/2006	8/3/2007
7	E Hillsborough Ave	Hillsborough	10030000	0.000	0.295	0.295	7/30/2007	1/14/2008
7	E Hillsborough Ave	Hillsborough	10030000	0.415	0.900	0.485	7/30/2007	1/14/2008
7	E Hillsborough Ave	Hillsborough	10030000	2.360	2.840	0.480	7/30/2007	1/14/2008
1	Fruitville Rd	Sarasota	17040000	0.619	4.203	3.584	1/13/2006	9/29/2006
3	N Davis Hwy	Escambia	48070000	5.667	6.191	0.524	4/4/2005	10/18/2006
3	Capital Cir NW	Leon	55002000	9.714	10.662	0.948	9/26/2005	9/4/2007
3	W Tennessee St	Leon	55060000	3.547	4.566	1.019	3/14/2005	7/17/2006
3	Apalachee Pkwy/US 27	Leon	55080000	3.371	4.888	1.517	8/1/2006	9/6/2007
5	Semoran Blvd.	Orange	75003000	5.009	7.426	2.417	1/30/2008	11/3/2008
5	S Orange Blossom Trail	Orange	75010000	3.418	4.775	1.357	3/8/2004	2/15/2007
6	Biscayne Blvd.	Miami-Dade	87030000	18.057	19.261	1.204	10/5/2004	7/30/2006
6	W Okeechobee Rd	Miami-Dade	87090000	10.412	11.680	1.268	10/4/2004	1/30/2006
2	University Blvd. W	Duval	72014000	1.454	1.842	0.388	3/1/2004	12/23/2004
Total						**17.51**		

4.1 Before-and-After Comparison for All Crashes for Individual and All Locations

Table 4-2 shows the overall before-and-after summary statistics at the 18 locations based on crash rate. The table shows that 15 out of 18 locations experienced a reduction in crash rate after median conversion. Of the three locations with an increase in crash rate after median conversion, one had a modest increase in crash rate of 16.5 percent, while the other two increased by 56.1 percent and 133.5 percent, respectively. Overall, the total crash rate across all locations was reduced from 3.618 crashes per MVM to 2.523 crashes per MVM after median conversion, representing a 30.3 percent overall crash rate reduction.

Table 4-2: Summary Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	5	11,560	2.879	35	13	10,454	4.493	56.1%
4	Palm Beach	South Main Street	93130000	4	0.290	36	15	18,340	2.576	30	15	18,887	3.001	16.5%
4	St. Lucie	US 1	94010000	4	0.910	36	86	38,930	2.217	15	26	34,154	1.834	-17.3%
5	Marion	SW 17th Street	36004000	4	0.314	36	24	36,625	1.906	17	3	23,000	0.803	-57.8%
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	21	31,524	2.414	36	1	27,500	0.132	-94.5%
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	98	57,020	5.321	32	30	49,850	2.096	-60.6%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	152	56,424	5.073	32	74	51,101	3.068	-39.5%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	103	50,301	3.896	32	55	45,473	2.589	-33.5%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	331	50,239	1.679	36	251	46,992	1.361	-18.9%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	71	35,690	4.623	36	62	39,516	2.734	-40.8%
3	Leon	Capital Cir NW	55002000	6	0.948	32	204	27,093	8.160	36	85	26,224	3.122	-61.7%
3	Leon	W Tennessee St	55060000	4	1.019	26	40	31,725	1.565	36	111	27,234	3.653	133.5%
3	Leon	US 27	55080000	4	1.517	24	144	31,394	4.142	36	158	29,889	3.182	-23.2%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	832	54,338	5.785	22	351	49,732	4.364	-24.6%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	95	49,100	3.348	36	160	48,638	2.214	-33.9%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	145	43,200	4.364	36	135	44,985	2.276	-47.8%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	115	51,787	2.742	36	181	53,163	2.452	-10.6%
2	Duval	W University Blvd.	72014000	4	0.388	14	37	50,122	4.468	36	93	50,925	4.298	-3.8%
Total					**17.51**		**2518**		**3.618**		**1804**		**2.523**	**-30.3%**

[a] Segment is from MP 0.000 to 0.295; [b] Segment is from MP 0.415 to 0.900; [c] Segment is from MP 2.360 to 2.840.
[d] Analysis period is in months.

4.2 Overall Before-and-After Comparison by Crash Type

This section focuses on before-and-after crash data analysis for the following crash types: head-on, rear-end, angle, left-turn, right-turn, sideswipe, pedestrian, and bicycle crashes. The Poisson Comparison of Mean Test is used to determine if the crash reduction is statistically significant (i.e., significantly better, significantly worse, or no significant change). The following formula for the Poisson test based on a 95-percent confidence level is used (Laughland et al. 1975):

$$R = \frac{2.326 \times \sqrt{b' - 0.16} - 0.35}{b'} \times 100 \quad (4\text{-}1)$$

where R is the minimum significant percent reduction and b' is the adjusted total number of crashes before project implementation, calculated as follows:

$$b' = total\ \#\ of\ crashes\ in\ before\ period \times \frac{(AADT\ in\ after\ period) \times (Days\ in\ after\ period)}{(AADT\ in\ before\ period) \times (Days\ in\ before\ period)} \quad (4\text{-}2)$$

At a 5-percent significance level, the change is considered significant if the actual percent change in crash rate is equal to or greater than R. Likewise, if the actual percent change in crash rate is less than R, the crash rate is considered to have no significant change.

Table 4-3 gives the results from the Poisson test for each crash type. From the table, it is concluded that the reductions in crash rate of rear-end, angle, left-turn, right-turn, and total crashes are statistically significant at 5-percent significance level; while the crash rate reductions for sideswipe, pedestrian, and bicycle crashes are statistically insignificant. The statistical significance for head-on crashes was not performed due to its very low number of crashes in the before period. Before-and-after crash statistics on median crossover crashes are not provided as the analysis does not yield meaningful results. Very few crashes in the before period were coded as "median crossovers" because of the absence of a median (i.e., a physical barrier) in the before period. Further, "other" crash types are also not analyzed, as no definitive conclusions could be drawn because of the diversity of crash types included in the "others" category.

Table 4-3: Summary Statistics by Crash Type

Crash Type	Crash Rate[a] in the Before Period	Crash Rate[a] in the After Period	Percent Change in Crash Rate	R Value Based on Poisson Test	Significance
Head-On[b]	0.027	0.014	-48.8%	---	---
Rear-End	1.374	1.140	-17.0%	7.4%	Significantly reduced
Angle	0.595	0.354	-40.5%	11.4%	Significantly reduced
Left-Turn	0.684	0.225	-67.1%	10.6%	Significantly reduced
Right-Turn	0.112	0.074	-33.9%	27.0%	Significantly reduced
Sideswipe	0.214	0.178	-17.0%	19.1%	No significant change
Pedestrian	0.091	0.064	-28.9%	30.1%	No significant change
Bicycle	0.078	0.074	-4.5%	34.0%	No significant change
All Crashes	**3.618**	**2.523**	**-30.3%**	**4.6%**	**Significantly reduced**

[a] Crash rate is in crashes per MVM.
[b] Sample size is too small.

4.3 Overall Before-and-After Comparison by Crash Severity

Using the same hypothesis testing procedure described in Section 4.2, Table 4-4 compares the overall changes in PDO, injury, and fatal crash rates for all the 18 study locations. Statistics on fatal and injury (F+I) crashes are also included in the table. Reduction in crash rate after raised median conversion is observed at all crash severity levels. Injury crash rate has the maximum reduction (34.1 percent) while the PDO crash rate has the minimum reduction (25.8 percent). Similar to the analysis by crash type, the Poisson test is performed to determine if the differences in crash rate before and after median construction is significant for each severity level. At a 5-percent significance level, it can be concluded that there is a statistically significant reduction in PDO and injury crash rates.

Table 4-4: Summary Statistics by Crash Severity

Crash Severity	Crash Rate[a] in the Before Period	Crash Rate[a] in the After Period	Percent Change in Crash Rate	R Value Based on Poisson Test	Significance
PDO	1.650	1.224	-25.8%	6.8%	Significantly reduced
Injury	1.941	1.279	-34.1%	6.4%	Significantly reduced
Fatal	0.027	0.021	-22.2%	60.8%	No significant change
F+I	1.969	1.299	-34.0%	6.3%	Significantly reduced
Total	**3.618**	**2.523**	**-30.3%**	**4.6%**	**Significantly reduced**

[a] Crash rate is in crashes per MVM.

4.4 Before-and-After Comparison of Individual Crash Types

Tables 4-5 through 4-20 show the before-and-after crash statistics by location and by crash severity for each major crash type. Conversion from TWLTLs to raised medians is expected to reduce head-on, angle, left-turn, and right-turn crash rates. The data show similar results. Head-on crashes were completely eliminated at 13 of 18 locations. The overall head-on crash statistics show a 48.8 percent reduction in crash rate after conversion. Further, severe head-on crashes were also reduced significantly; conversion resulted in a 73.5 percent reduction in F+I crash rate.

As expected, the overall left-turn crash statistics show a high 67.1 percent reduction in crash rate after conversion; half of the locations had over 85 percent reduction in left-turn crash rate after conversion. This reduction could be attributed to the increase in the concentration of left-turn and U-turn movements at median openings and signalized intersections. Similar to head-on crashes, severe left-turn crash rate (F+I) reduced by 70.6 percent.

The overall angle crash statistics show a 40.5 percent reduction in angle crash rate after median conversion. In terms of severity, angle crash rate of F+I crashes reduced by 35.9 percent. Similarly, conversion resulted in a 33.9 percent reduction in right-turn crash rate. One location recorded a 516.1 percent increase in right-turn crash rate in the after period. However, unlike head-on, angle, and left-turn crashes, F+I crash rate of right-turn crashes reduced by only 7.5 percent after conversion.

Conversion from TWLTLs to raised medians is expected to shift crashes to signalized intersections and also increase the less severe rear-end crashes. After conversion, a 17.0 percent reduction in rear-end crash rate is observed. The percent changes in rear-end crash rates at the locations varied significantly. For example, at one location, a maximum reduction of 80.0 percent is observed in the rear-end crash rate after median conversion, while at another location, a 404.8 percent increase in rear-end crash rate is observed after median conversion. Similarly, a 17.0 percent reduction in sideswipe crash rate is observed. Of the 18 locations, seven locations had an increase in sideswipe crash rate in the after period. In fact, two locations recorded an increase in sideswipe crash rate of 528.1 percent and 244.5 percent in the after period.

Conversion from TWLTLs to raised medians is expected to improve pedestrian safety as raised medians provide pedestrian refuge areas. Overall, conversion resulted in a 28.9 percent reduction in pedestrian crash rate. However, some locations experienced an increase in pedestrian crash rate. Further, conversion resulted in a 70.4 percent increase in pedestrian fatality crash, from four fatalities in the before period to seven in the after period. Section 6.2.3 examines specific pedestrian crashes in detail. In addition to the reduction in pedestrian crash rates after conversion, the locations experienced a 4.5 percent reduction in bicycle crash rate.

Table 4-5: Head-On Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	0	11,560	0.000	35	0	10,454	0.000	--
4	Palm Beach	South Main Street	93130000	4	0.290	36	0	18,340	0.000	30	0	18,887	0.000	--
4	St. Lucie	US 1	94010000	4	0.910	36	0	38,930	0.000	15	0	34,154	0.000	--
5	Marion	SW 17th Street	36004000	4	0.314	36	0	36,625	0.000	17	0	23,000	0.000	--
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	0	31,524	0.000	36	0	27,500	0.000	--
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	2	57,020	0.109	32	0	49,850	0.000	-100.0%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	0	56,424	0.000	32	0	51,101	0.000	--
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	0	50,301	0.000	32	1	45,473	0.047	--
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	3	50,239	0.015	36	2	46,992	0.011	-28.7%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	1	35,690	0.065	36	0	39,516	0.000	-100.0%
3	Leon	Capital Cir NW	55002000	6	0.948	32	2	27,093	0.080	36	0	26,224	0.000	-100.0%
3	Leon	W Tennessee St	55060000	4	1.019	26	0	31,725	0.000	36	0	27,234	0.000	--
3	Leon	US 27	55080000	4	1.517	24	0	31,394	0.000	36	1	29,889	0.020	--
5	Orange	Semoran Blvd.	75003000	6	2.417	36	7	54,338	0.049	22	3	49,732	0.037	-23.4%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	1	49,100	0.035	36	0	48,638	0.000	-100.0%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	0	43,200	0.000	36	0	44,985	0.000	--
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	3	51,787	0.072	36	3	53,163	0.041	-43.2%
2	Duval	W University Blvd.	72014000	4	0.388	14	0	50,122	0.000	36	0	50,925	0.000	--
Total					**17.51**		**19**		**0.027**		**10**		**0.014**	**-48.8%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-6: Head-On Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	8	42.1%	0.011	7	70.0%	0.010	-14.8%
Injury	10	52.6%	0.014	3	30.0%	0.004	-70.8%
Fatal	1	5.3%	0.001	0	0.0%	0.000	-100.0%
F+I	11	57.9%	0.016	3	30.0%	0.004	-73.5%
Total	**19**	**100.0%**	**0.027**	**10**	**100.0%**	**0.014**	**-48.8%**

Table 4-7: Rear-end Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	3	11,560	1.727	35	1	10,454	0.346	-80.0%
4	Palm Beach	South Main Street	93130000	4	0.290	36	4	18,340	0.687	30	4	18,887	0.800	16.5%
4	St. Lucie	US 1	94010000	4	0.910	36	26	38,930	0.670	15	14	34,154	0.987	47.3%
5	Marion	SW 17th Street	36004000	4	0.314	36	13	36,625	1.032	17	2	23,000	0.536	-48.1%
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	2	31,524	0.230	36	1	27,500	0.132	-42.7%
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	34	57,020	1.846	32	10	49,850	0.699	-62.2%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	41	56,424	1.368	32	14	51,101	0.580	-57.6%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	19	50,301	0.719	32	12	45,473	0.565	-21.4%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	161	50,239	0.817	36	113	46,992	0.613	-25.0%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	30	35,690	1.953	36	38	39,516	1.676	-14.2%
3	Leon	Capital Cir NW	55002000	6	0.948	32	97	27,093	3.880	36	40	26,224	1.469	-62.1%
3	Leon	W Tennessee St	55060000	4	1.019	26	9	31,725	0.352	36	54	27,234	1.777	404.8%
3	Leon	US 27	55080000	4	1.517	24	50	31,394	1.438	36	79	29,889	1.591	10.6%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	309	54,338	2.149	22	180	49,732	2.238	4.2%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	30	49,100	1.057	36	73	48,638	1.010	-4.5%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	64	43,200	1.926	36	54	44,985	0.911	-52.7%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	41	51,787	0.977	36	77	53,163	1.043	6.7%
2	Duval	W University Blvd.	72014000	4	0.388	14	23	50,122	2.777	36	49	50,925	2.265	-18.5%
Total					**17.51**		**956**		**1.374**		**815**		**1.140**	**-17.0%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-8: Rear-end Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	429	44.9%	0.616	395	48.5%	0.553	-10.4%
Injury	526	55.0%	0.756	420	51.5%	0.588	-22.3%
Fatal	1	0.1%	0.001	0	0.0%	0.000	---
F+I	527	55.1%	0.757	420	51.5%	0.588	-22.4%
Total	**956**	**100.0%**	**1.374**	**815**	**100.0%**	**1.140**	**-17.0%**

Table 4-9: Angle Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	1	11,560	0.576	35	1	10,454	0.346	-40.0%
4	Palm Beach	South Main Street	93130000	4	0.290	36	1	18,340	0.172	30	4	18,887	0.800	366.1%
4	St. Lucie	US 1	94010000	4	0.910	36	18	38,930	0.464	15	0	34,154	0.000	-100.0%
5	Marion	SW 17th Street	36004000	4	0.314	36	4	36,625	0.318	17	0	23,000	0.000	-100.0%
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	6	31,524	0.690	36	0	27,500	0.000	-100.0%
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	19	57,020	1.032	32	8	49,850	0.559	-45.8%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	36	56,424	1.201	32	24	51,101	0.995	-17.2%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	42	50,301	1.589	32	18	45,473	0.847	-46.7%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	20	50,239	0.101	36	20	46,992	0.108	6.9%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	18	35,690	1.172	36	8	39,516	0.353	-69.9%
3	Leon	Capital Cir NW	55002000	6	0.948	32	15	27,093	0.600	36	12	26,224	0.441	-26.5%
3	Leon	W Tennessee St	55060000	4	1.019	26	9	31,725	0.352	36	13	27,234	0.428	21.5%
3	Leon	US 27	55080000	4	1.517	24	16	31,394	0.460	36	31	29,889	0.624	35.7%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	137	54,338	0.953	22	42	49,732	0.522	-45.2%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	15	49,100	0.529	36	23	48,638	0.318	-39.8%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	29	43,200	0.873	36	13	44,985	0.219	-74.9%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	22	51,787	0.525	36	27	53,163	0.366	-30.3%
2	Duval	W University Blvd.	72014000	4	0.388	14	6	50,122	0.725	36	9	50,925	0.416	-42.6%
Total					**17.51**		**414**		**0.595**		**253**		**0.354**	**-40.5%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-10: Angle Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	197	47.6%	0.283	110	43.5%	0.154	-45.6%
Injury	216	52.2%	0.310	142	56.1%	0.199	-36.0%
Fatal	1	0.2%	0.001	1	0.4%	0.001	-2.7%
F+I	217	52.4%	0.312	143	56.5%	0.200	-35.9%
Total	**414**	**100.0%**	**0.595**	**253**	**100.0%**	**0.354**	**-40.5%**

Table 4-11: Left-Turn Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	0	11,560	0.000	35	3	10,454	1.037	--
4	Palm Beach	South Main Street	93130000	4	0.290	36	4	18,340	0.687	30	0	18,887	0.000	-100.0%
4	St. Lucie	US 1	94010000	4	0.910	36	15	38,930	0.387	15	0	34,154	0.000	-100.0%
5	Marion	SW 17th Street	36004000	4	0.314	36	1	36,625	0.079	17	0	23,000	0.000	-100.0%
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	4	31,524	0.460	36	0	27,500	0.000	-100.0%
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	26	57,020	1.412	32	3	49,850	0.210	-85.2%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	27	56,424	0.901	32	23	51,101	0.953	5.8%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	22	50,301	0.832	32	6	45,473	0.282	-66.1%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	53	50,239	0.269	36	30	46,992	0.163	-39.5%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	14	35,690	0.912	36	3	39,516	0.132	-85.5%
3	Leon	Capital Cir NW	55002000	6	0.948	32	60	27,093	2.400	36	4	26,224	0.147	-93.9%
3	Leon	W Tennessee St	55060000	4	1.019	26	5	31,725	0.196	36	18	27,234	0.592	202.9%
3	Leon	US 27	55080000	4	1.517	24	28	31,394	0.805	36	12	29,889	0.242	-70.0%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	158	54,338	1.099	22	6	49,732	0.075	-93.2%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	31	49,100	1.093	36	7	48,638	0.097	-91.1%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	14	43,200	0.421	36	16	44,985	0.270	-36.0%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	11	51,787	0.262	36	22	53,163	0.298	13.6%
2	Duval	W University Blvd.	72014000	4	0.388	14	3	50,122	0.362	36	8	50,925	0.370	2.1%
Total					**17.51**		**476**		**0.684**		**161**		**0.225**	**-67.1%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-12: Left-Turn Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	162	34.0%	0.233	66	41.0%	0.092	-60.3%
Injury	310	65.1%	0.445	94	58.4%	0.131	-70.5%
Fatal	4	0.8%	0.006	1	0.6%	0.001	-75.7%
F+I	314	66.0%	0.451	95	59.0%	0.133	-70.6%
Total	**476**	**100.0%**	**0.684**	**161**	**100.0%**	**0.225**	**-67.1%**

Table 4-13: Right-Turn Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	0	11,560	0.000	35	1	10,454	0.346	--
4	Palm Beach	South Main Street	93130000	4	0.290	36	3	18,340	0.515	30	0	18,887	0.000	-100.0%
4	St. Lucie	US 1	94010000	4	0.910	36	5	38,930	0.129	15	1	34,154	0.071	-45.3%
5	Marion	SW 17th Street	36004000	4	0.314	36	0	36,625	0.000	17	0	23,000	0.000	--
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	2	31,524	0.230	36	0	27,500	0.000	-100.0%
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	1	57,020	0.054	32	1	49,850	0.070	28.7%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	5	56,424	0.167	32	1	51,101	0.041	-75.2%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	3	50,301	0.113	32	1	45,473	0.047	-58.5%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	19	50,239	0.096	36	11	46,992	0.060	-38.1%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	2	35,690	0.130	36	0	39,516	0.000	-100.0%
3	Leon	Capital Cir NW	55002000	6	0.948	32	5	27,093	0.200	36	4	26,224	0.147	-26.5%
3	Leon	W Tennessee St	55060000	4	1.019	26	4	31,725	0.156	36	0	27,234	0.000	-100.0%
3	Leon	US 27	55080000	4	1.517	24	5	31,394	0.144	36	4	29,889	0.081	-44.0%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	19	54,338	0.132	22	6	49,732	0.075	-43.5%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	0	49,100	0.000	36	5	48,638	0.069	--
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	1	43,200	0.030	36	11	44,985	0.185	516.2%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	3	51,787	0.072	36	2	53,163	0.027	-62.1%
2	Duval	W University Blvd.	72014000	4	0.388	14	1	50,122	0.121	36	5	50,925	0.231	91.4%
Total					**17.51**		**78**		**0.112**		**53**		**0.074**	**-33.9%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-14: Right-Turn Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	58	74.4%	0.083	34	64.2%	0.048	-42.9%
Injury	20	25.6%	0.029	19	35.8%	0.027	-7.5%
Fatal	0	0.0%	0.000	0	0.0%	0.000	--
F+I	20	25.6%	0.029	19	35.8%	0.027	-7.5%
Total	**78**	**100.0%**	**0.112**	**53**	**100.0%**	**0.074**	**-33.9%**

Table 4-15: Sideswipe Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	0	11,560	0.000	35	0	10,454	0.000	--
4	Palm Beach	South Main Street	93130000	4	0.290	36	1	18,340	0.172	30	1	18,887	0.200	16.5%
4	St. Lucie	US 1	94010000	4	0.910	36	7	38,930	0.180	15	0	34,154	0.000	-100.0%
5	Marion	SW 17th Street	36004000	4	0.314	36	0	36,625	0.000	17	0	23,000	0.000	--
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	2	31,524	0.230	36	0	27,500	0.000	-100.0%
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	5	57,020	0.271	32	1	49,850	0.070	-74.3%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	12	56,424	0.400	32	2	51,101	0.083	-79.3%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	3	50,301	0.113	32	4	45,473	0.188	65.9%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	22	50,239	0.112	36	22	46,992	0.119	6.9%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	4	35,690	0.260	36	7	39,516	0.309	18.5%
3	Leon	Capital Cir NW	55002000	6	0.948	32	10	27,093	0.400	36	9	26,224	0.331	-17.3%
3	Leon	W Tennessee St	55060000	4	1.019	26	3	31,725	0.117	36	3	27,234	0.099	-15.9%
3	Leon	US 27	55080000	4	1.517	24	7	31,394	0.201	36	4	29,889	0.081	-60.0%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	48	54,338	0.334	22	22	49,732	0.274	-18.1%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	1	49,100	0.035	36	16	48,638	0.221	528.1%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	12	43,200	0.361	36	7	44,985	0.118	-67.3%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	11	51,787	0.262	36	20	53,163	0.271	3.3%
2	Duval	W University Blvd.	72014000	4	0.388	14	1	50,122	0.121	36	9	50,925	0.416	244.5%
Total					**17.51**		**149**		**0.214**		**127**		**0.178**	**-17.0%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-16: Sideswipe Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	111	74.5%	0.159	98	77.2%	0.137	-14.1%
Injury	38	25.5%	0.055	29	22.8%	0.041	-25.7%
Fatal	0	0.0%	0.000	0	0.0%	0.000	--
F+I	38	25.5%	0.055	29	22.8%	0.041	-25.7%
Total	**149**	**100.0%**	**0.214**	**127**	**100.0%**	**0.178**	**-17.0%**

Table 4-17: Pedestrian Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	0	11,560	0.000	35	0	10,454	0.000	--
4	Palm Beach	South Main Street	93130000	4	0.290	36	0	18,340	0.000	30	0	18,887	0.000	--
4	St. Lucie	US 1	94010000	4	0.910	36	0	38,930	0.000	15	0	34,154	0.000	--
5	Marion	SW 17th Street	36004000	4	0.314	36	0	36,625	0.000	17	0	23,000	0.000	--
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	0	31,524	0.000	36	0	27,500	0.000	--
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	2	57,020	0.109	32	2	49,850	0.140	28.7%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	9	56,424	0.300	32	0	51,101	0.000	-100.0%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	1	50,301	0.038	32	2	45,473	0.094	148.9%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	12	50,239	0.061	36	11	46,992	0.060	-2.0%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	1	35,690	0.065	36	1	39,516	0.044	-32.3%
3	Leon	Capital Cir NW	55002000	6	0.948	32	0	27,093	0.000	36	2	26,224	0.073	--
3	Leon	W Tennessee St	55060000	4	1.019	26	0	31,725	0.000	36	1	27,234	0.033	--
3	Leon	US 27	55080000	4	1.517	24	2	31,394	0.058	36	4	29,889	0.081	40.0%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	27	54,338	0.188	22	11	49,732	0.137	-27.2%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	0	49,100	0.000	36	1	48,638	0.014	--
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	7	43,200	0.211	36	7	44,985	0.118	-44.0%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	1	51,787	0.024	36	2	53,163	0.027	13.6%
2	Duval	W University Blvd.	72014000	4	0.388	14	1	50,122	0.121	36	2	50,925	0.092	-23.4%
Total					**17.51**		**63**		**0.091**		**46**		**0.064**	**-28.9%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-18: Pedestrian Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	6	9.5%	0.009	3	6.5%	0.004	-51.3%
Injury	53	84.1%	0.076	36	78.3%	0.050	-33.9%
Fatal	4	6.3%	0.006	7	15.2%	0.010	70.4%
F+I	57	90.5%	0.082	43	93.5%	0.060	-26.6%
Total	**63**	**100.0%**	**0.091**	**46**	**100.0%**	**0.064**	**-28.9%**

Table 4-19: Bicycle Crash Statistics by Study Location

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[d]	No. of Crashes	Mean AADT	Crash Rate	Period[d]	No. of Crashes	Mean AADT	Crash Rate	
3	Santa Rosa	Florida Historic SR 1	58010000	2	0.260	19	0	11,560	0.000	35	1	10,454	0.346	--
4	Palm Beach	South Main Street	93130000	4	0.290	36	0	18,340	0.000	30	1	18,887	0.200	--
4	St. Lucie	US 1	94010000	4	0.910	36	3	38,930	0.077	15	2	34,154	0.141	82.4%
5	Marion	SW 17th Street	36004000	4	0.314	36	1	36,625	0.079	17	0	23,000	0.000	-100.0%
7	Citrus	N Suncoast Blvd.	2030000	6	0.252	36	0	31,524	0.000	36	0	27,500	0.000	--
7	Hillsborough	E Hillsborough Ave	10030000[a]	6	0.295	36	1	57,020	0.054	32	3	49,850	0.210	286.0%
7	Hillsborough	E Hillsborough Ave	10030000[b]	6	0.485	36	3	56,424	0.100	32	2	51,101	0.083	-17.2%
7	Hillsborough	E Hillsborough Ave	10030000[c]	6	0.480	36	1	50,301	0.038	32	3	45,473	0.141	273.3%
1	Sarasota	Fruitville Rd	17040000	6	3.584	36	20	50,239	0.101	36	17	46,992	0.092	-9.1%
3	Escambia	N Davis Hwy	48070000	6	0.524	27	0	35,690	0.000	36	2	39,516	0.088	--
3	Leon	Capital Cir NW	55002000	6	0.948	32	1	27,093	0.040	36	0	26,224	0.000	-100.0%
3	Leon	W Tennessee St	55060000	4	1.019	26	1	31,725	0.039	36	1	27,234	0.033	-15.9%
3	Leon	US 27	55080000	4	1.517	24	2	31,394	0.058	36	1	29,889	0.020	-65.0%
5	Orange	Semoran Blvd.	75003000	6	2.417	36	18	54,338	0.125	22	14	49,732	0.174	39.1%
5	Orange	S Orange Blossom Tr	75010000	6	1.357	14	0	49,100	0.000	36	2	48,638	0.028	--
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	3	43,200	0.090	36	2	44,985	0.034	-62.7%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	0	51,787	0.000	36	1	53,163	0.014	--
2	Duval	W University Blvd.	72014000	4	0.388	14	0	50,122	0.000	36	1	50,925	0.046	--
Total					**17.51**		**54**		**0.078**		**53**		**0.074**	**-4.5%**

[a] Segment is from MP 0.000 to MP 0.295; [b] Segment is from MP 0.415 to MP 0.900; [c] Segment is from MP 2.360 to MP 2.840. [d] Analysis period is in months.

Table 4-20: Bicycle Crash Statistics by Crash Severity

Crash Severity	Before			After			Percent Change in Crash Rate
	No. of Crashes	Percent of Total Crashes	Crash Rate	No. of Crashes	Percent of Total Crashes	Crash Rate	
PDO	6	11.1%	0.009	5	9.4%	0.007	-18.9%
Injury	44	81.5%	0.063	46	86.8%	0.064	1.8%
Fatal	4	7.4%	0.006	2	3.8%	0.003	-51.3%
F+I	48	88.9%	0.069	48	90.6%	0.067	-2.7%
Total	**54**	**100.0%**	**0.078**	**53**	**100.0%**	**0.074**	**-4.5%**

4.5 Summary

A before-and-after safety evaluation was conducted at 18 study locations that were converted from TWLTLs to raised medians. The analysis focused on the overall trend of total crashes before and after conversion and the before-and-after safety evaluation at each location by crash type and crash severity level. The Poisson test was performed on the crash rates in the before and after periods for each crash type and crash severity level.

Overall, the total crash rate across all locations was reduced from 3.618 crashes per MVM to 2.523 crashes per MVM after median conversion, representing a 30.3 percent reduction in total crash rate. The reductions in crash rate of rear-end, angle, left-turn, right-turn, and total crashes were statistically significant at 5 percent significance level; while the crash rate reductions for sideswipe, pedestrian, and bicycle crashes were statistically insignificant. Head-on crashes were too few in the before period to yield reliable conclusions. In terms of crash severity, there was a statistically significant reduction in PDO and injury crash rates, and no significant reduction in fatal crash rate was observed after median conversion.

As expected, after median conversion, the crash rate of total and severe head-on crashes reduced significantly. Further, head-on crashes were completely eliminated at 13 of 18 locations. Likewise, the overall left-turn crash statistics showed a high 67.1 percent reduction in crash rate after conversion. Similar to head-on crashes, severe left-turn crash rate (F+I) reduced by 70.6 percent.

After median conversion, the overall crash statistics showed a 40.5 percent and a 33.9 percent reduction in angle and right-turn crash rates, respectively. However, unlike head-on, angle, and left-turn crashes, F+I crash rate of right-turn crashes reduced by only 7.5 percent after conversion. Not surprisingly, conversion resulted in only a 17.0 percent reduction in rear-end crash rate. Similarly, a 17.0 percent reduction in sideswipe crash rate was observed.

Conversion from TWLTLs to raised medians is expected to improve pedestrian safety as raised medians provide pedestrian refuge areas. Overall, median conversion resulted in a 28.9 percent reduction in pedestrian crash rate. However, some locations experienced an increase in pedestrian crash rate. Further, median conversion resulted in a 70.4 percent increase in pedestrian fatality crash, from four fatalities in the before period to seven in the after period. Section 6.2.3 examines specific pedestrian crashes in detail. In addition to the reduction in pedestrian crash rates after conversion, the locations experienced a 4.5 percent reduction in bicycle crash rate.

CHAPTER 5
SITE-SPECIFIC REVIEW

This chapter focuses on the locations where safety either improved or deteriorated significantly after conversion from TWLTLs to raised medians. A total of six locations were identified for site-specific review. This analysis focuses on the before-and-after summary statistics by crash type. Further, for each location, detailed analysis of crash types that performed either particularly well or poorly is also included. Wherever applicable, at each location, the performance of different types of median openings is also discussed. Figure 5-1 shows an example of each of the four types of median openings.

The chapter also includes a special safety evaluation study on a 1.429-mile section on Apalachee Parkway in City of Tallahassee that was converted from a TWLTL to a raised median in 2002. The analysis was conducted separately because police reports were not available for review for the before period due to its older construction date of 2002.

5-1(a) A uni-directional median opening.

5-1(b) A bi-directional median opening with center island.

5-1(c) A full median opening with left-turn bays on both directions.

5-1(d) A full median opening with left-turn bay on only one direction.

Figure 5-1: Major Median Opening Types

5.1 Locations That Either Worsened or Improved Slightly

This section focuses on three locations that either worsened or improved only slightly after they were converted from TWLTLs to raised medians. For this analysis, it was determined that any location shorter than 0.3 miles would be excluded. Therefore, the three locations that are listed in Table 5-1 were chosen for site-specific review. Only one location (on West Tennessee Street in Leon County) worsened after being converted from a TWLTL to a raised median. The following sections discuss the safety performance of this location and two other locations that improved only slightly after conversion.

5.1.1 Roadway ID: 55060000; Segment Length: 1.019 miles

The 1.019-mile section on West Tennessee Street in Leon County was converted from a TWLTL to a raised median in 2006. For this analysis, 26 months of crash data before conversion and 36 months of crash data after conversion were used. The location is a four-lane urban arterial with three major signalized intersections. The location has four bi-directional median openings with center islands, two full median openings with left-turn bays on both directions, one full median opening with left-turn bay on one direction, and one uni-directional median opening.

Table 5-2 gives the before and after crash statistics by crash type. The location experienced 40 crashes in the 26 months before conversion and 111 crashes in the 36 months after conversion; conversion from a TWLTL to a raised median resulted in a 133.5 percent increase in total crash rate. Of all the crash types, rear-end and left-turn crash rates increased the most, by 404.8 percent and 202.9 percent, respectively. However, it is observed that a majority of these crashes occurred at the three signalized intersections.

From Table 5-2, it is observed that the crash rate of angle crashes increased by 21.5 percent after conversion. Review of police reports of all angle crashes found that all the nine angle crashes in the before period were at signalized intersections. Similarly, 12 of the 13 angle crashes in the after period were also at signalized intersections; the other angle crash was at a median opening. Further, from the illustrative sketches of the 13 angle crashes in the after period, none of them were found to involve vehicle making U-turn at intersections. Therefore, these crashes could not be attributed directly to the raised median at this location.

After the construction of raised median, the left-turn crash rate increased by 202.9 percent. Four of the five left-turn crashes in the before period were at signalized intersections, while the fifth left-turn crash was at a non-state road near an intersection. Similarly, 16 of the 18 left-turn crashes in the after period occurred at signalized intersections, while the remaining two occurred at median openings.

Table 5-1: Locations That Either Worsened or Improved Slightly

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[a]	No. of Crashes	Mean AADT	Crash Rate	Period[a]	No. of Crashes	Mean AADT	Crash Rate	
3	Leon	W Tennessee St	55060000	4	1.019	26	40	31,725	1.565	36	111	27,234	3.653	133.5%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	21	115	51,787	2.742	36	181	53,163	2.452	-10.6%
4	St. Lucie	US 1	94010000	4	0.910	36	86	38,930	2.217	15	26	34,154	1.834	-17.3%

[a] Analysis period is in months.

Table 5-2: Before-and-After Crash Statistics on Roadway ID 55060000

Crash Type	Before (26 months)		After (36 months)		Percent Change in Crash Rate
	Crash Number	Crash Rate	Crash Number	Crash Rate	
Angle	9	0.352	13	0.428	21.5%
Left-Turn	5	0.196	18	0.592	202.9%
Right-Turn	4	0.156	0	0.000	--
Rear-End	9	0.352	54	1.777	404.8%
Sideswipe	3	0.117	3	0.099	-15.9%
Collision with Bicycle	1	0.039	1	0.033	-15.9%
Collision with Pedestrian	0	0.000	1	0.033	--
Median Crossover	0	0.000	3	0.099	--
Other	9	0.352	18	0.592	68.3%
Total	**40**	**1.565**	**111**	**3.653**	**133.5%**

After the construction of raised median, the rear-end crash rate increased by 404.8 percent, from 9 crashes in the 26 months before conversion to 54 crashes in the 36 months after conversion. Only 22.2 percent of right-turn crashes in the before period (i.e., 2 of 9) were at signalized intersections, while a disproportionately high 72.2 percent of right-turn crashes in the after period (39 of 54) occurred at signalized intersections. The signalized intersections at this location did not prohibit U-turn activity. In other words, drivers can make legal U-turns at the signalized intersections.

The general notion is that limiting access to businesses and properties (for example, conversion from a TWLTL to a raised median) increases U-turn activity. It implies that signalized intersections might experience an increase in the crash frequency on the leftmost lane. However, it was not the case at this location, since a majority of rear-end crashes near signalized intersections occurred on the rightmost lane. These statistics indicate that the raised medians resulted in an increase in rear-end crashes at signalized intersections. However, a majority of this increase (i.e., 404.8 percent) could not be linked to median conversion.

Besides the above discussed crash types, pedestrian and bicycle crashes are a concern as they are often very severe. Review of the police reports revealed that none of the pedestrian and bicycle crashes were related to the raised median. Table 5-2 also shows that the location experienced three median crossover crashes after the raised median construction. Of these three crashes, two occurred at intersections and were not related to the raised median separating the traffic on both directions. Figure 5-2 gives the illustrative sketch of the median crossover crash that occurred at a midblock location.

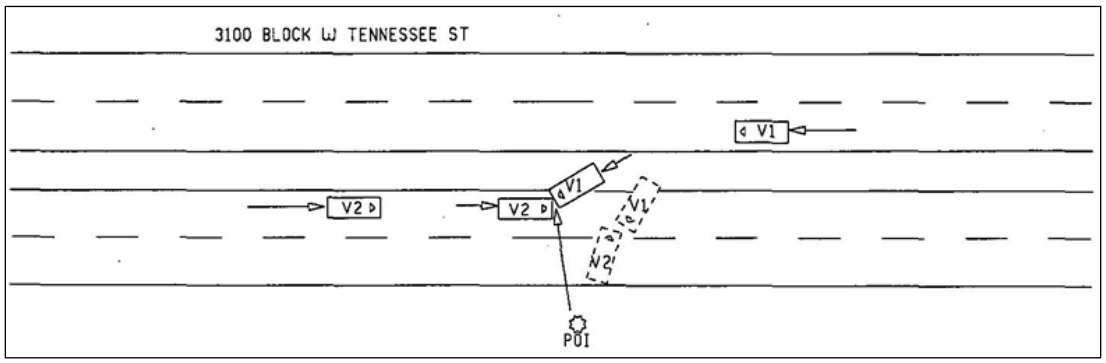
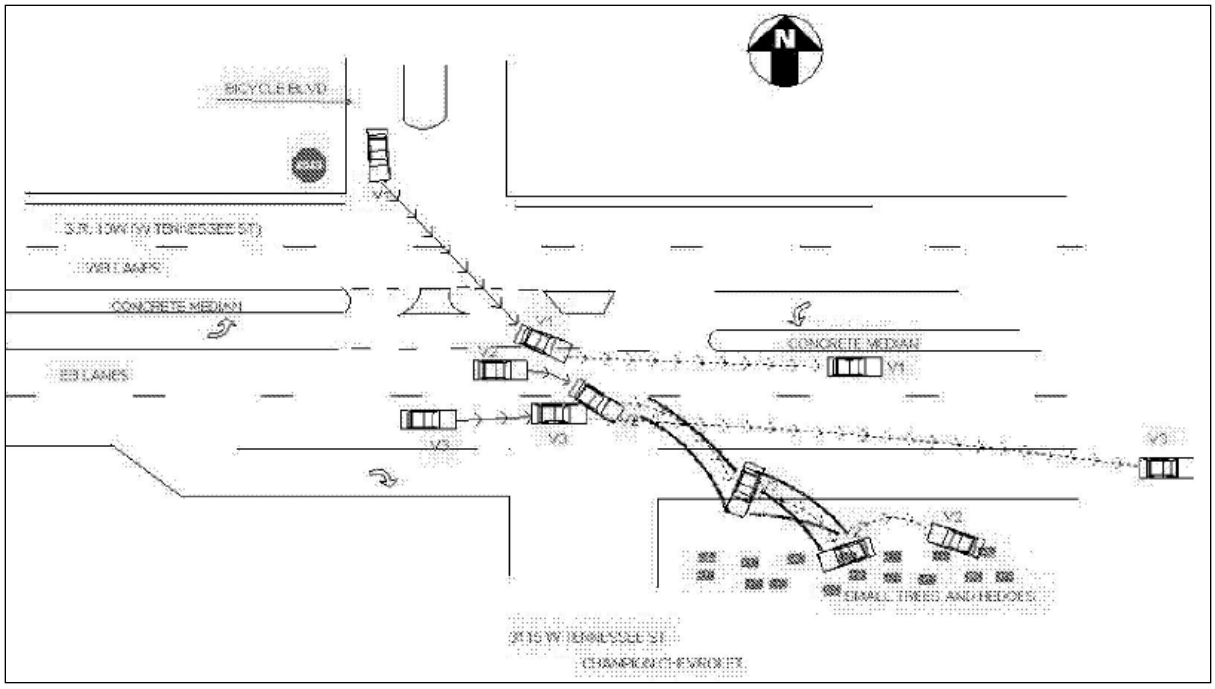
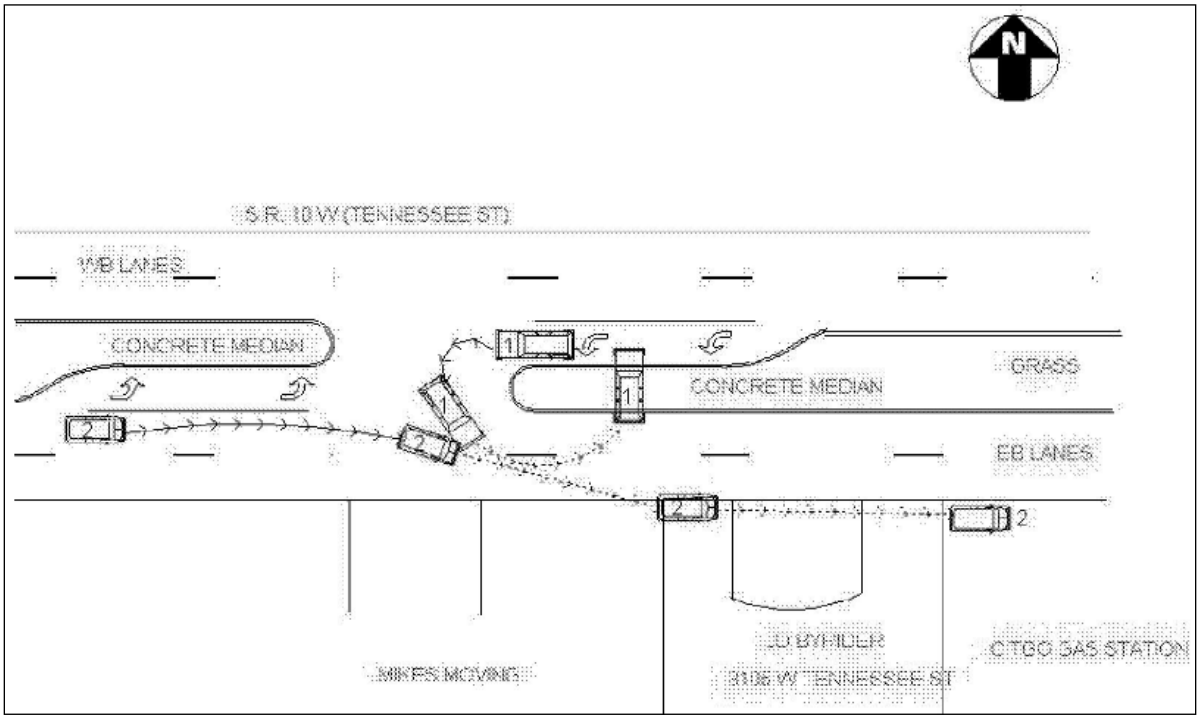


Figure 5-2: Median Crossover Crash at Midblock on Roadway ID 55060000 (Crash ID: 718606110)

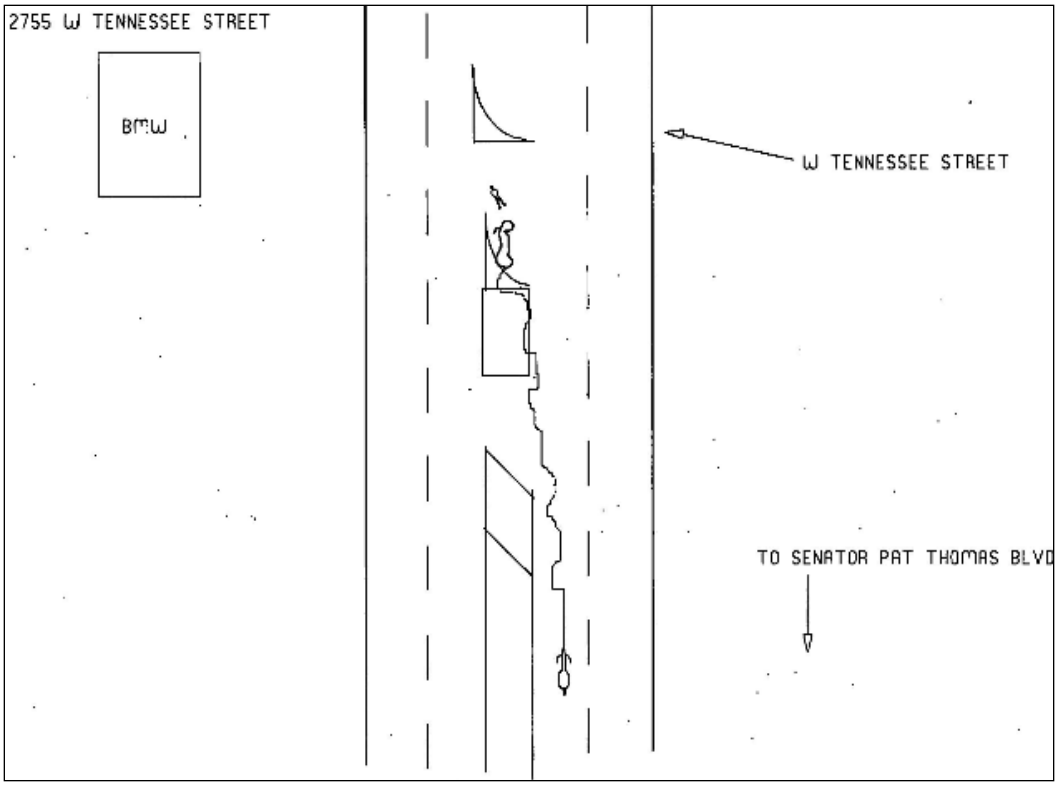
Of the 111 crashes that occurred after the construction of the raised median, only four occurred at median openings. Figure 5-3 gives the illustrative sketches of these four crashes.



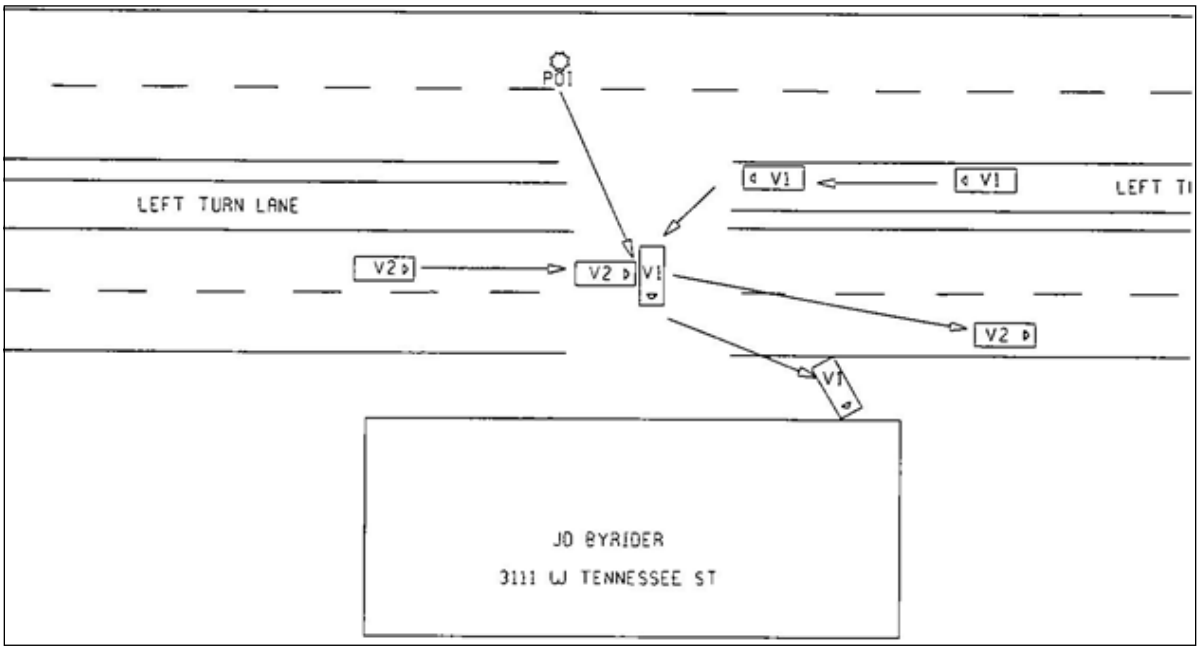
5-3(a) Crash at a Median Opening on Roadway ID 55060000 (Crash ID: 770124140)



5-3(b) Crash at a Median Opening on Roadway ID 55060000 (Crash ID: 770103640)



5-3(c) Crash at a Median Opening on Roadway ID 55060000 (Crash ID: 718863200)



5-3(d) Crash at a Median Opening on Roadway ID 55060000 (Crash ID: 718783510)

Figure 5-3: Crashes at Median Openings on Roadway ID: 55060000

In summary, even though this 1.019-mile section experienced a 133.5 percent increase in total crash rate, a majority of this increase could not be attributed directly to the presence of raised

median. Of all the crash types, a significant increase in crash rate was observed only for angle, left-turn, and rear-end crashes. However, only a few of these crashes occurred at midblock locations. Additionally, of the 111 crashes that occurred after the conversion to raised median, only four occurred at median openings.

5.1.2 Roadway ID: 87090000; Segment Length: 1.268 miles

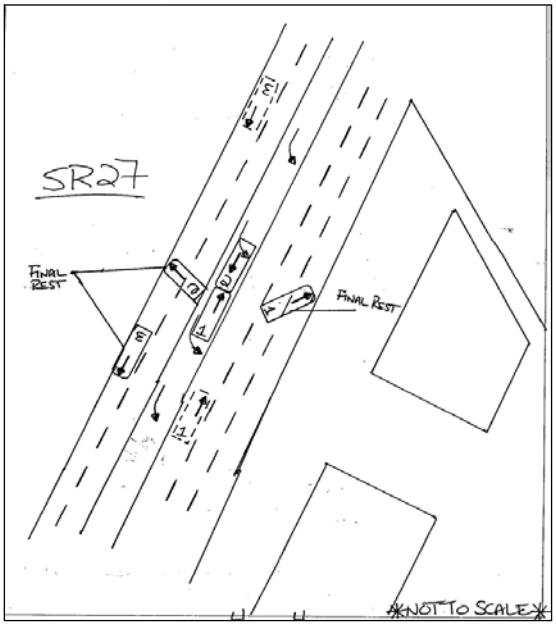
The location along West Okeechobee Road in Miami-Dade County is 1.268 miles long with three signalized intersections. This urban arterial has businesses and accesses on one side and a river on the other side. The location has one uni-directional median opening and two full median openings with left-turn bay on one direction, constructed in 2006. At midblock locations, the location has wide medians with palm trees, and at signalized intersections, the medians are narrower. As shown in Table 5-3, the location experienced 115 crashes in the 21 months before conversion and 181 crashes in the 36 months after conversion. Overall, the location experienced a 10.6 percent reduction in total crash rate after conversion.

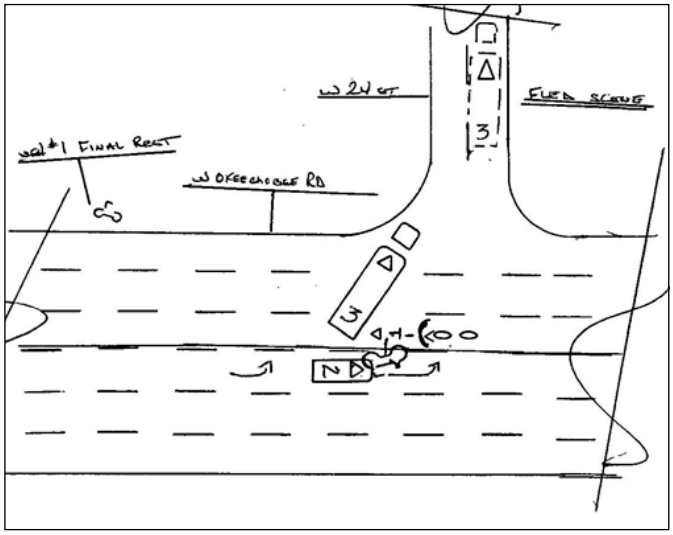
Table 5-3: Before-and-After Crash Statistics on Roadway ID 87090000

Crash Type	Before (21 months)		After (36 months)		Percent Change in Crash Rate
	Crash Number	Crash Rate	Crash Number	Crash Rate	
Head-On	3	0.072	3	0.041	-43.2%
Angle	22	0.525	27	0.366	-30.3%
Left-Turn	11	0.262	22	0.298	13.6%
Right-Turn	3	0.072	2	0.027	-62.1%
Rear-End	41	0.977	77	1.043	6.7%
Sideswipe	11	0.262	20	0.271	3.3%
Collision with Bicycle	0	0.000	1	0.014	--
Collision with Pedestrian	1	0.024	2	0.027	13.6%
Median Crossover	0	0.000	8	0.108	--
Other	23	0.548	19	0.257	-53.1%
Total	**115**	**2.742**	**181**	**2.452**	**-10.6%**

Of the three head-on crashes that occurred in the before period, two occurred at the location shown in Figure 5-4. The figure also shows the police sketches of these two head-on crashes. Note that the figure does not show the site characteristics at the time of these crashes. As shown in the figure, at this location, the TWLTL was converted into a raised median with a uni-directional median opening. After conversion, head-on crashes were eliminated at this location. Further, the three head-on crashes in the after period occurred at signalized intersections.

Location with Two Head-On Crashes That Occurred Before Conversion





Crash ID: 708720500 **Crash ID: 743397430**

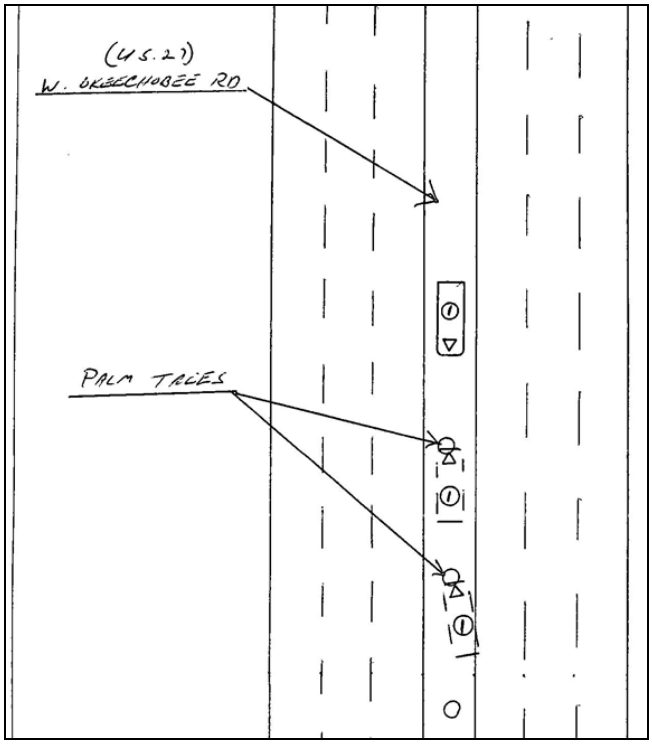
Figure 5-4: Head-on Crashes in the Before Period on Roadway ID 87090000

Based on the percent change in crash rate, left-turn, rear-end, sideswipe, and pedestrian crash rates increased after conversion. Of the 11 left-turn crashes in the before period, eight were near signalized intersections and three occurred when drivers attempted to turn left either from or into a driveway at midblock locations. Of the 22 left-turn crashes in the after period, only two

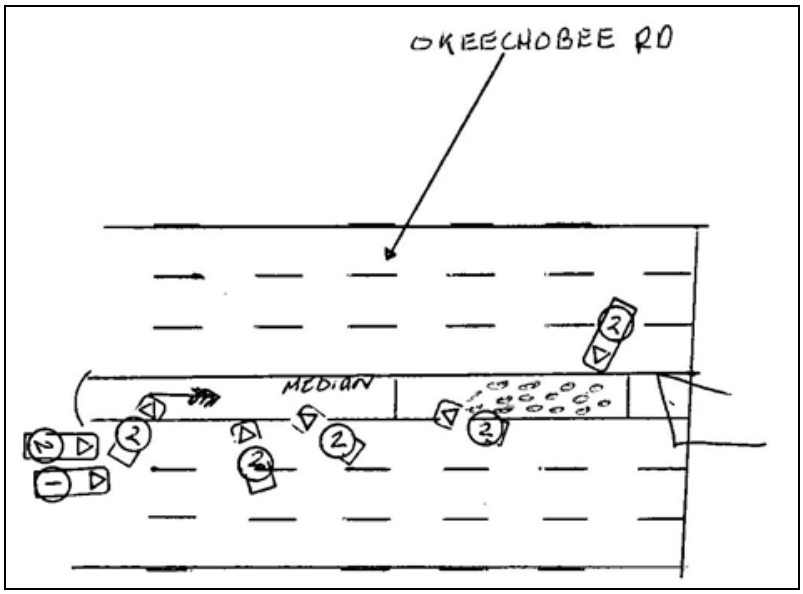
occurred at a full median opening with left-turn bay on one direction, while the rest occurred at signalized intersections. Therefore, even though conversion from a TWLTL to a raised median increased left-turn crash rate by 13.6 percent, only two crashes could be attributed directly to conversion.

Unlike the study location on Roadway ID 55060000 that experienced a very high increase in the rear-end crash rate after conversion, this location on Roadway ID 87090000 experienced a 6.7 percent increase in the rear-end crash rate, from 41 rear-end crashes in the 21 months before conversion to 77 rear-end crashes in the 36 months after conversion. Of the 41 crashes in the before period, 27 (i.e., 65.8 percent) occurred at signalized intersections, while 60 of 77 rear-end crashes (77.2 percent) occurred at intersections in the after period.

Of the 27 angle crashes that occurred after the raised median construction, only two occurred at median openings; none of the other 25 angle crashes could be attributed directly to conversion. Further, the increase in pedestrian crash rate could not be attributed directly to conversion. Also, eight median crossover crashes occurred after median conversion, and as expected, there were none before the raised median conversion. Of these eight median crossover crashes, three occurred at intersections, where the raised medians were narrower. Figure 5-5 gives examples of median crossover crashes at locations with wider medians.



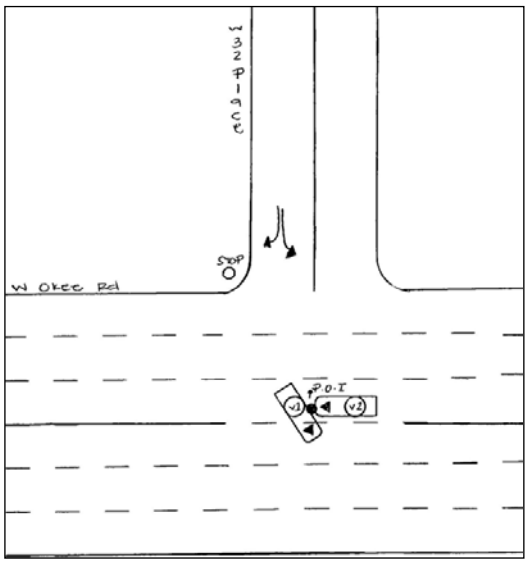
5-5(a) Crash ID: 764436750

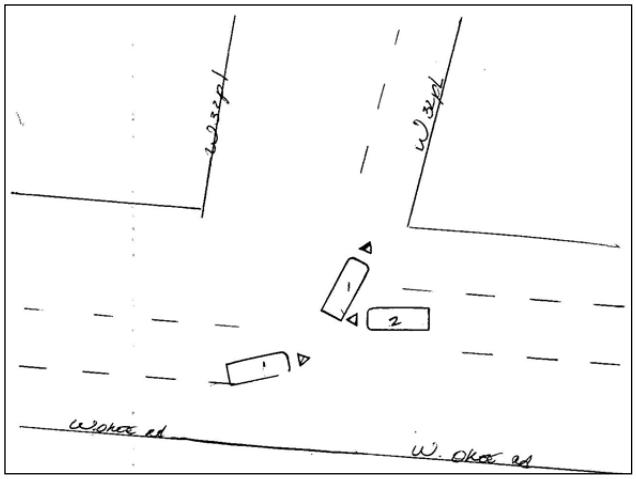


5-5(b) Crash ID: 744723240

Figure 5-5: Examples of Median Crossover Crashes at Locations with Wide Medians on Roadway ID 87090000

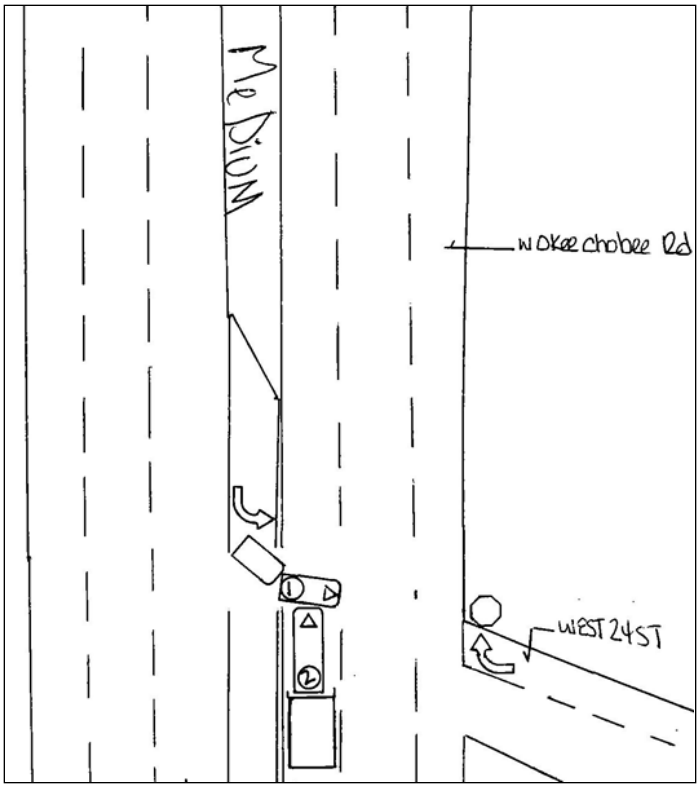
Of the 181 crashes that occurred in the 36 months after conversion, only three crashes (as shown in Figure 5-6) occurred at median openings. In summary, even though this location experienced only a 10.6 percent reduction in total crash rate, a majority of crashes that occurred in the after period could not be attributed directly to conversion.





Crash ID: 724095760 **Crash ID: 724051470**

5-6(a) At Full Median Opening with Left-turn Bay on One Direction



Crash ID: 911475230
5-6(b) At Uni-directional Median Opening

Figure 5-6: Crashes at Median Openings on Roadway ID 87090000

5.1.3 Roadway ID: 94010000; Segment Length: 0.910 miles

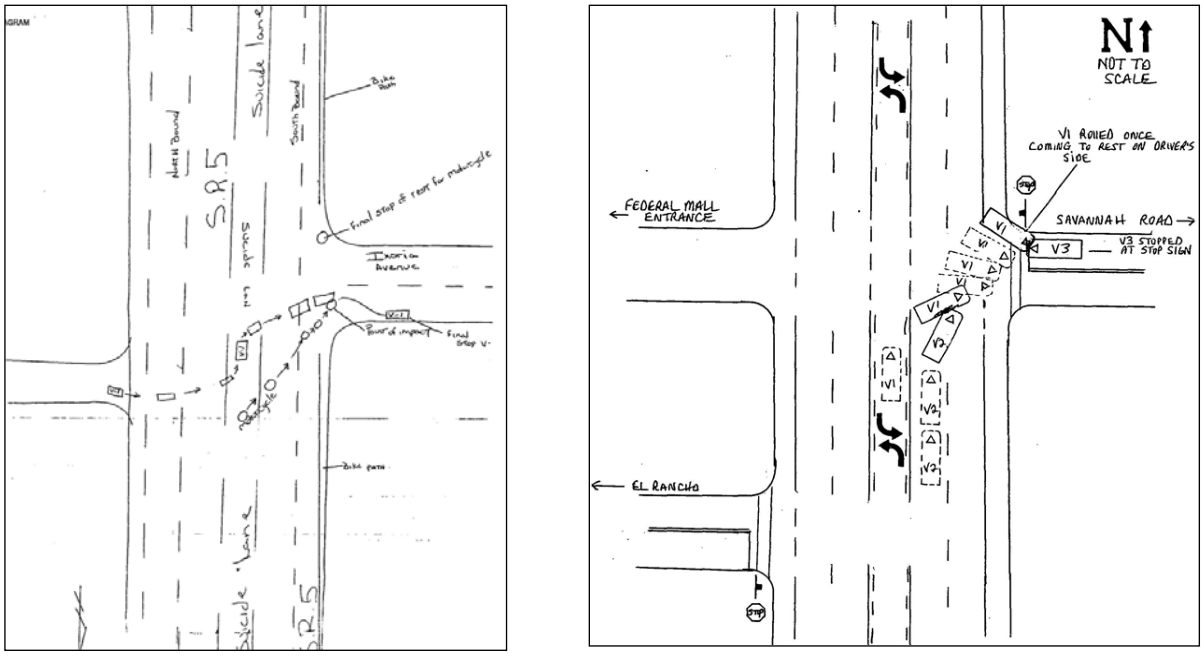
The 0.910-mile study location is on S 4th Street/US 1 in St. Lucie County where the raised median was constructed in 2006. The location experienced 86 crashes in the 36 months before conversion and 26 crashes in the 15 months after conversion. The location experienced a 17.3 percent reduction in total crash rate after median conversion. The location has two signalized intersections, two uni-directional median openings, and two bi-directional median openings with center islands. The location also has bike lanes along the entire stretch. Table 5-4 gives the before-and-after crash statistics at this location by crash type.

Even though the location experienced 17.3 percent reduction in total crash rate after median conversion, the location experienced a 47.3 percent increase in the rear-end crash rate and a 82.4 percent increase in the bicycle crash rate. A total of three bicycle crashes were reported in the before period, and two were reported in the after period; resulting in a high 82.4 percent increase in bicycle crash rate after conversion. Review of police reports of all the five bicycle crashes revealed that vehicles on the side street struck bicycles on the bike lanes. In other words, the increase in bicycle crash rate in the after period could not be attributed directly to median conversion.

Table 5-4: Before-and-After Crash Statistics on Roadway ID 94010000

Crash Type	Before (36 months)		After (15 months)		Percent Change in Crash Rate
	Crash Number	Crash Rate	Crash Number	Crash Rate	
Angle	18	0.464	0	0.000	--
Left-Turn	15	0.387	0	0.000	--
Right-Turn	5	0.129	1	0.071	-45.3%
Rear-End	26	0.670	14	0.987	47.3%
Sideswipe	7	0.180	0	0.000	--
Collision with Bicycle	3	0.077	2	0.141	82.4%
Collision with Pedestrian	0	0.000	0	0.000	--
Median Crossover	0	0.000	1	0.071	--
Other	12	0.309	8	0.564	82.4%
Total	**86**	**2.217**	**26**	**1.834**	**-17.3%**

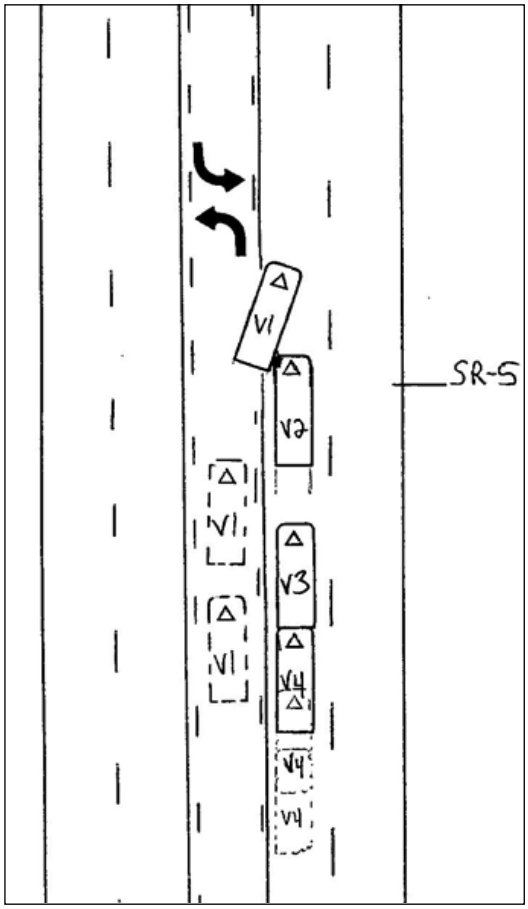
After the raised median conversion, the right-turn crash rate reduced by 45.3 percent, from five right-turn crashes in the before period to only one right-turn crash in the after period. Of the five crashes in the before period, police sketches were unavailable for two crashes; of the remaining three, two were directly related to TWLTLs. Figure 5-7 gives the illustrative sketches of these two crashes. The crash pattern of the only right-turn crash in the after period could not be accurately determined because of lack of illustrative sketch in the police report.



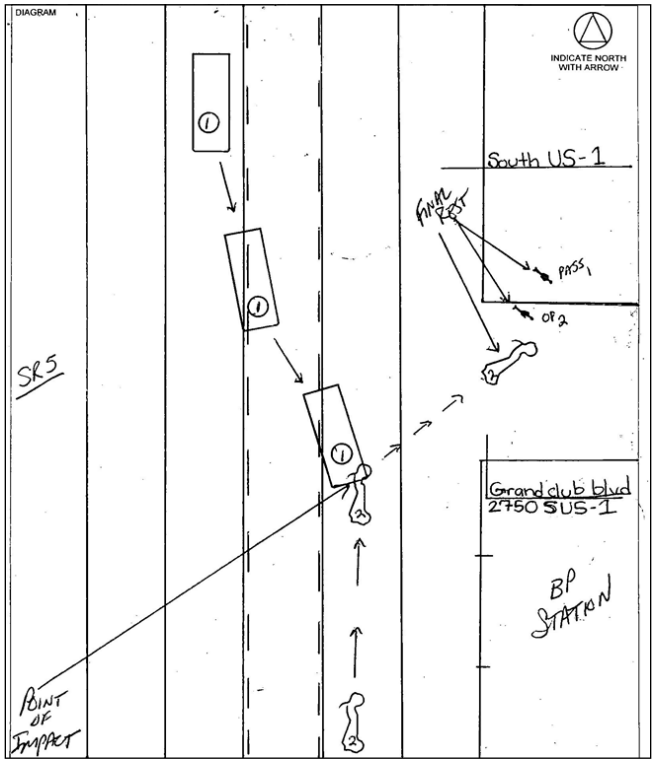
Crash ID: 089614840 **Crash ID: 756712010**

Figure 5-7: Right-Turn Crashes That Were Related to TWLTLs on Roadway ID 94010000

From Table 5-5, it is observed that angle, left-turn, and sideswipe crashes were completely eliminated after the construction of raised medians. Of the 18 angle crashes that occurred in the before period, eight were directly related to TWLTLs, five occurred at signalized intersections, three crashes did not have an illustrative sketch, and the rest (i.e., 2) were not related to TWLTLs. Figure 5-8 gives two examples of angle crashes that were related to TWLTLs that occurred at this location.



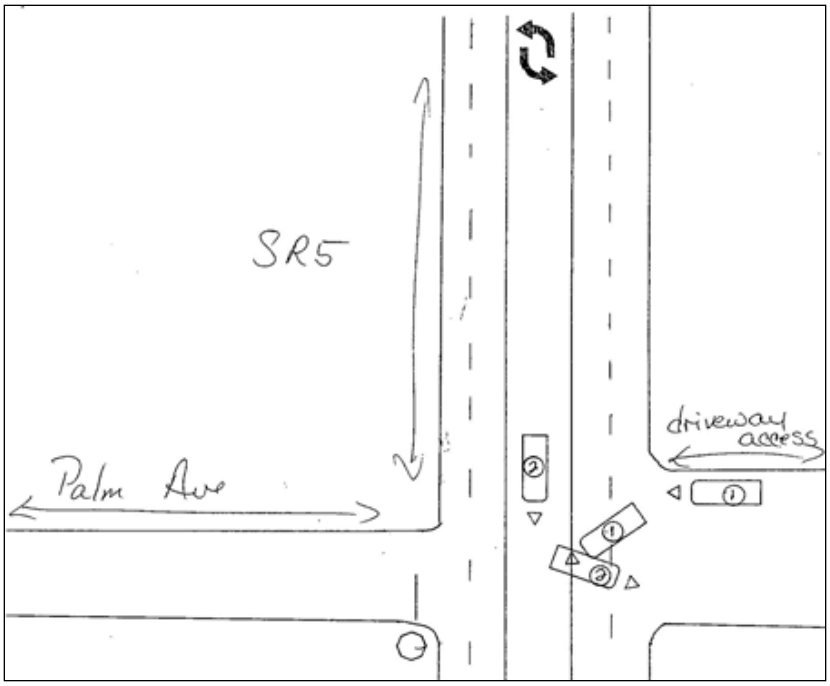
Crash ID: 756711880



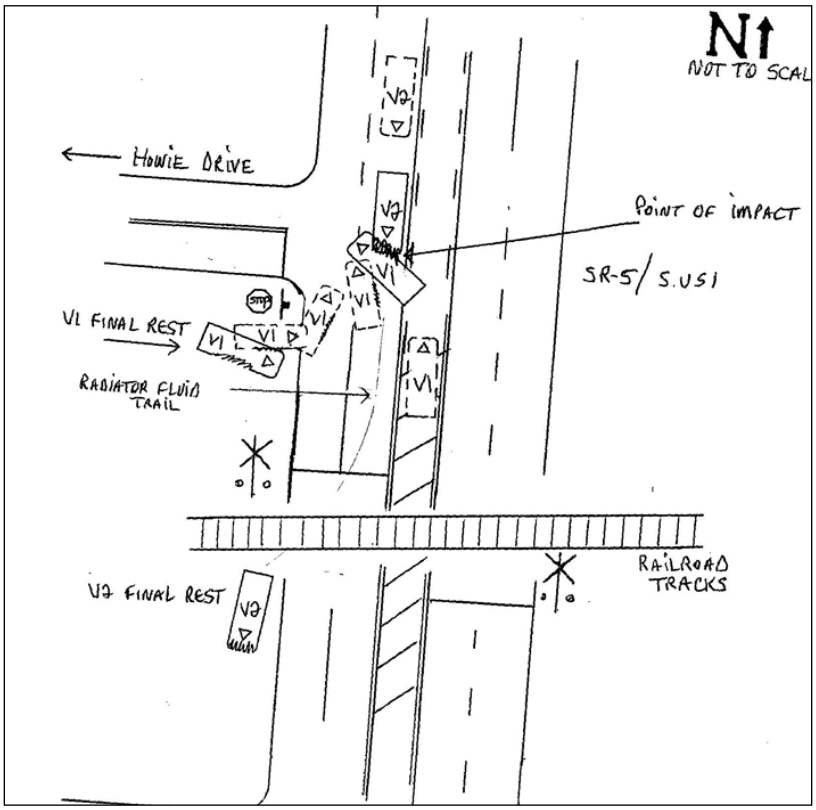
Crash ID: 756731240

Figure 5-8: Examples of Angle Crashes That Were Related to TWLTLs on Roadway ID 94010000

Similarly, of the 15 left-turn crashes that occurred before conversion from a TWLTL to a raised median, a majority (i.e., 12) were directly related to TWLTLs. Figure 5-9 gives two examples of left-turn crashes that were related to TWLTLs.



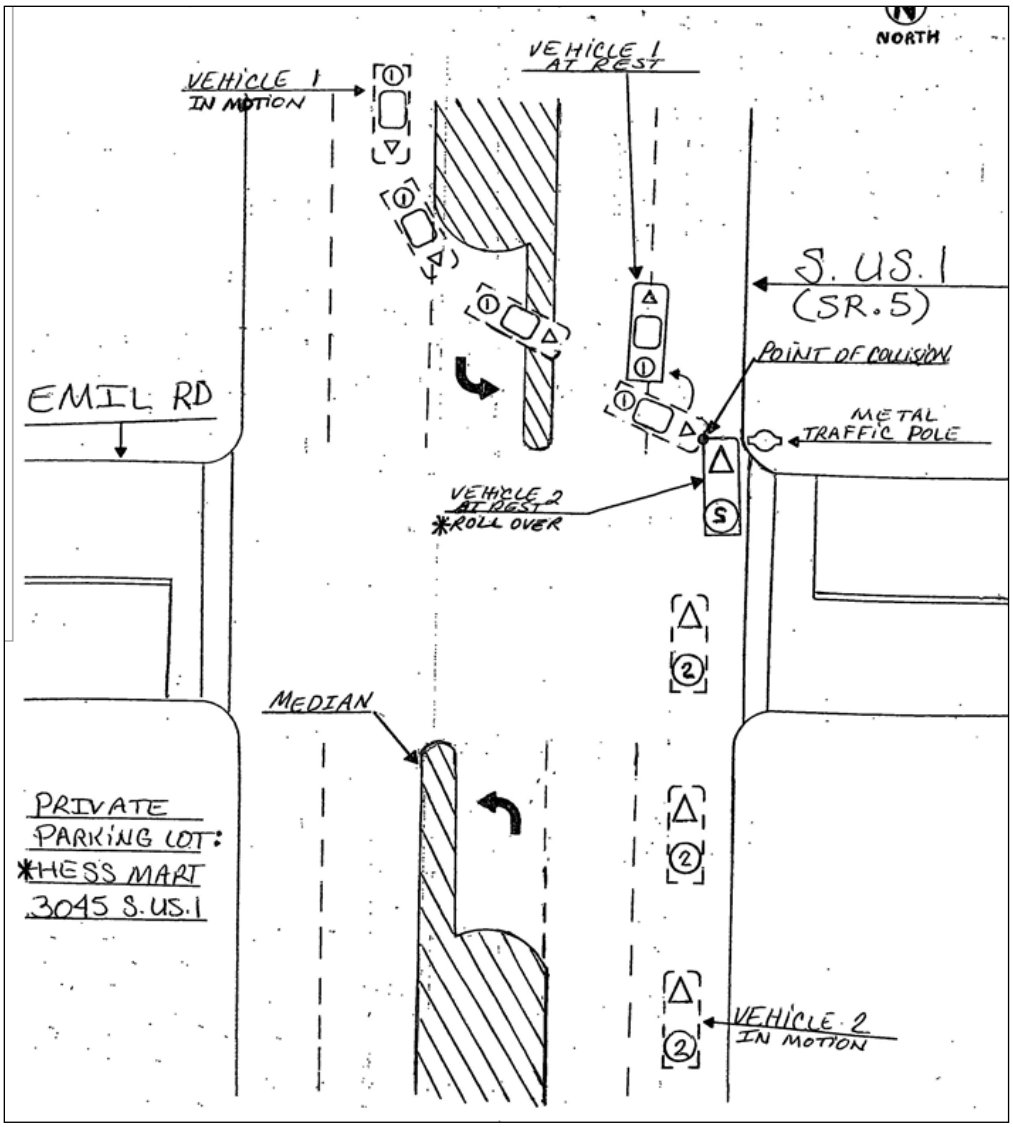
Crash ID: 756734450



Crash ID: 756703740

Figure 5-9: Examples of Left-Turn Crashes That Were Related to TWLTLs on Roadway ID 94010000

Of the 26 crashes that occurred after conversion, only one crash occurred at a median opening; however, it was a hit-and-run crash, and therefore, the crash pattern could not be determined. Further, only one crash resulted in a median crossover. Figure 5-10 shows the illustrative sketch from the police report.



Crash ID: 904378420

Figure 5-10: Median Crossover Crash at Roadway ID 94010000

In summary, the 0.910-mile section on US 1 in St. Lucie County experienced a 17.3 percent reduction in total crash rate after conversion from a TWLTL to a raised median. Angle, left-turn, and sideswipe crashes were completely eliminated after conversion. As expected, median conversion resulted in an increase in the rear-end crash rate. Even though there was an increase in the bicycle crash rate, the increase could not be attributed directly to median conversion.

5.2 Locations That Improved Significantly

This section focuses on three locations that improved significantly after they were converted from TWLTLs to raised medians. Table 5-5 lists the three locations chosen for site-specific review. In addition to summary statistics by crash type, detailed analysis of crash types that performed either particularly well or poorly is also included.

5.2.1 Roadway ID: 55002000; Segment Length: 0.948 miles

This 0.948-mile section on Capital Circle NW Road in Leon County is a six-lane urban arterial with three signalized intersections and two uni-directional median openings. The location was converted from a TWLTL to a raised median in 2007. After conversion, the location experienced a 61.7 percent reduction in total crash rate, with 204 crashes in the 32 months before conversion and 85 crashes in the 36 months after conversion. Table 5-6 gives the before-and-after crash summary statistics by crash type.

The head-on crashes were totally eliminated after conversion; of the two head-on crashes that occurred prior to conversion, one occurred at an intersection while the other was directly related to the TWLTL (as shown in Figure 5-11).

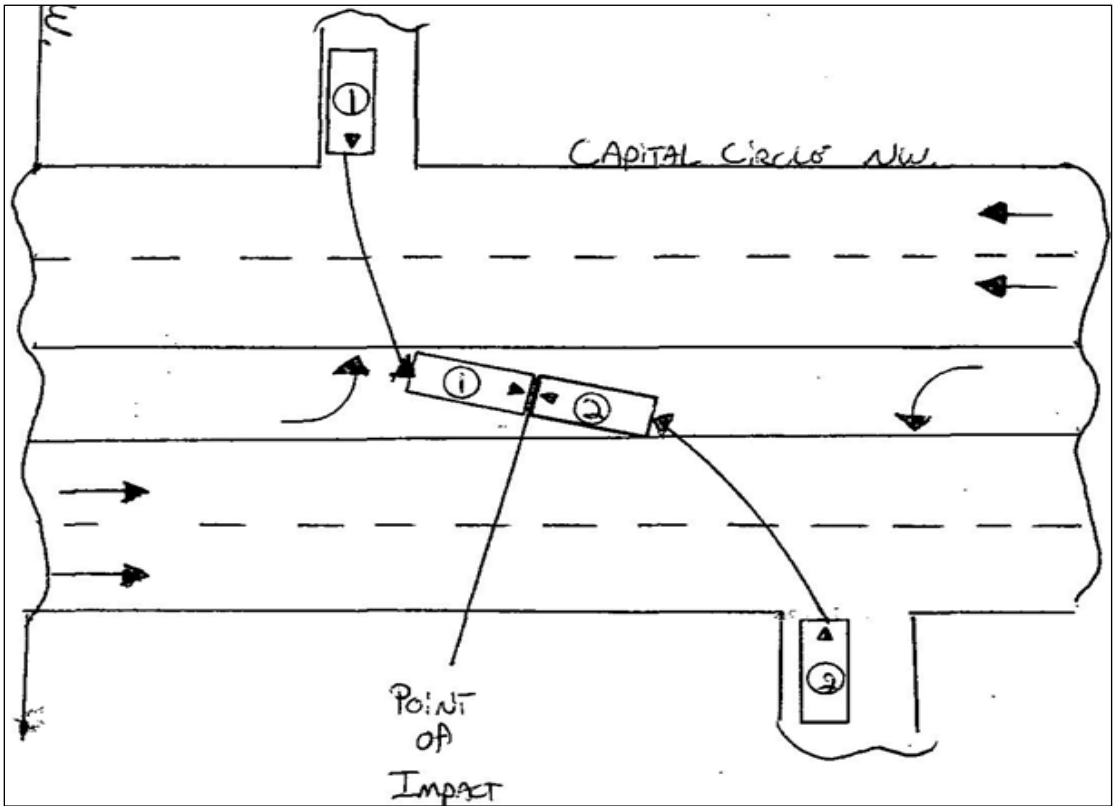


Figure 5-11: Head-On Crash That Was Related to TWLTL on Roadway ID 55002000 (Crash ID: 700445740)

Table 5-5: Locations That Improved Significantly

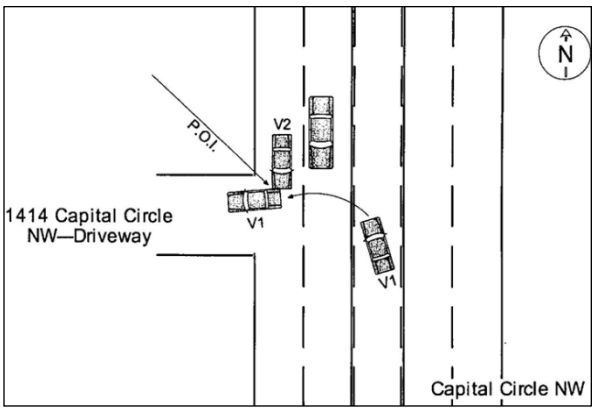
Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. len. (mi)	Before				After				Percent Change in Crash Rate
						Period[a]	No. of Crashes	Mean AADT	Crash Rate	Period[a]	No. of Crashes	Mean AADT	Crash Rate	
3	Leon	Capital Cir NW	55002000	6	0.948	32	204	27,093	8.160	36	85	26,224	3.122	-61.7%
5	Marion	SW 17th Street	36004000	4	0.314	36	24	36,625	1.906	17	3	23,000	0.803	-57.8%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	21	145	43,200	4.364	36	135	44,985	2.276	-47.8%

[a] Analysis period is in months.

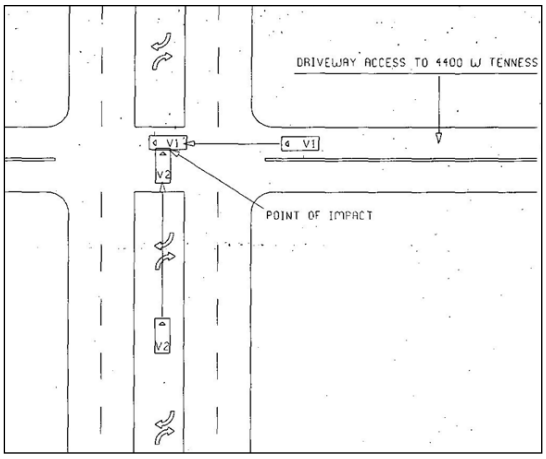
Table 5-6: Before-and-After Crash Statistics on Roadway ID 55002000

Crash Type	Before (32 months)		After (36 months)		Percent Change in Crash Rate
	Crash Number	Crash Rate	Crash Number	Crash Rate	
Angle	15	0.600	12	0.441	-26.5%
Head-on	2	0.080	0	0.000	--
Left-Turn	60	2.400	4	0.147	-93.9%
Right-Turn	5	0.200	4	0.147	-26.5%
Rear-End	97	3.880	40	1.469	-62.1%
Sideswipe	10	0.400	9	0.331	-17.3%
Collision with Bicycle	1	0.040	0	0.000	--
Collision with Pedestrian	0	0.000	2	0.073	--
Median Crossover	0	0.000	3	0.110	--
Other	14	0.560	11	0.404	-27.8%
Total	**204**	**8.160**	**85**	**3.122**	**-61.7%**

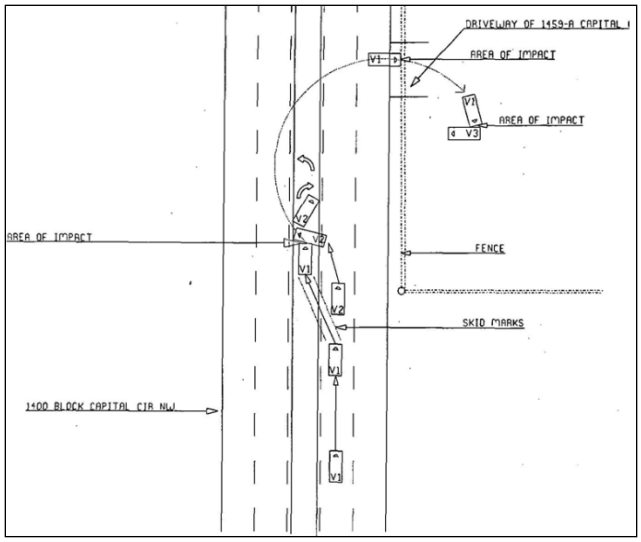
After median conversion, angle crash rate reduced by 26.5 percent. Of the 15 angle crashes in the before period, only three were directly related to TWLTLs. Of the 12 angle crashes in the after period, only one crash involved the raised median. Figure 5-12 gives the illustrative sketches of these angle crashes on TWLTLs (i.e., in the before period) and at the raised median (i.e., in the after period).



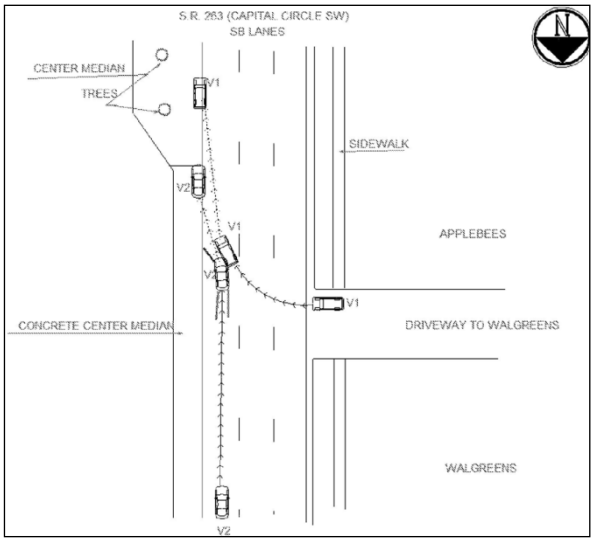
Crash ID: 758054090
Related To TWLTL



Crash ID: 716260470
Related To TWLTL



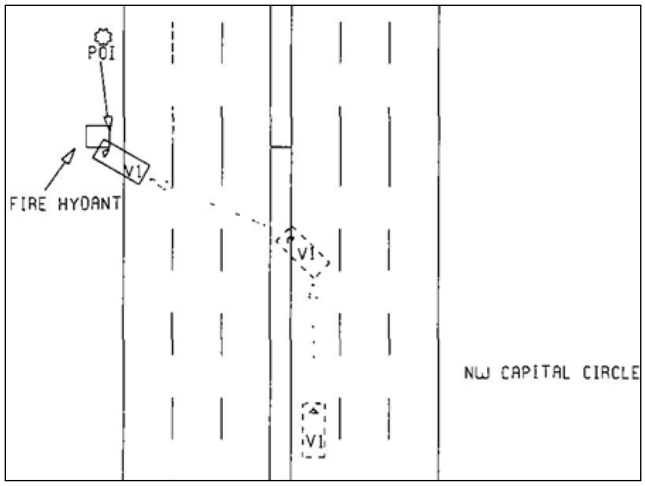
Crash ID: 718010450
Related To TWLTL



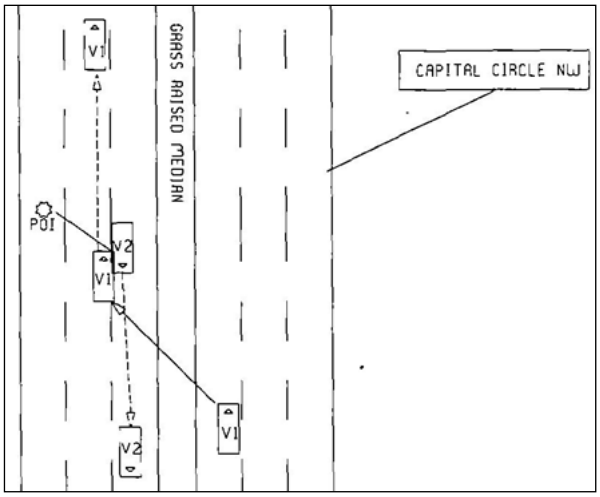
Crash ID: 770124450
Related to Raised Median

Figure 5-12: Angle Crashes on Roadway ID 55002000

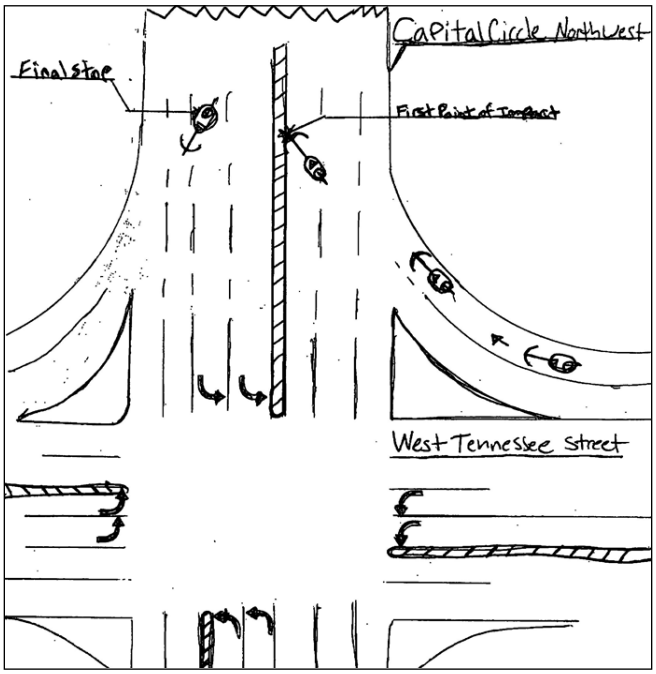
In total, three median crossover crashes occurred in the after period. From the police reports, it is found that these three crashes occurred at locations with narrow medians. Figure 5-13 gives the illustrative sketches of these three median crossover crashes.



Crash ID: 718704720



Crash ID: 718721050



Crash ID: 905751510

Figure 5-13: Median Crossover Crashes on Roadway ID 5002000

After conversion, the location experienced a 93.9 percent reduction in left-turn crash rate, from 60 left-turn crashes in the 32 months before conversion to four left-turn crashes in the 36 months after conversion. Of these four crashes that occurred after conversion, only one crash (as shown in Figure 5-14) occurred at a median opening, while the rest occurred at signalized intersections. In addition to the crash shown in Figure 5-14, another crash, shown in Figure 5-15, occurred at the median opening.

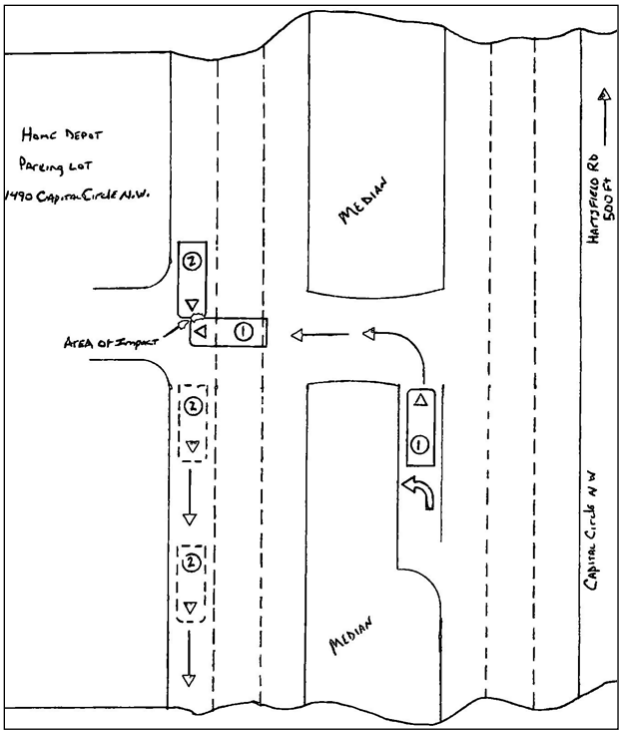


Figure 5-14: Left-Turn Crash at Uni-directional Median Opening on Roadway ID 5002000 (Crash ID: 905798380)

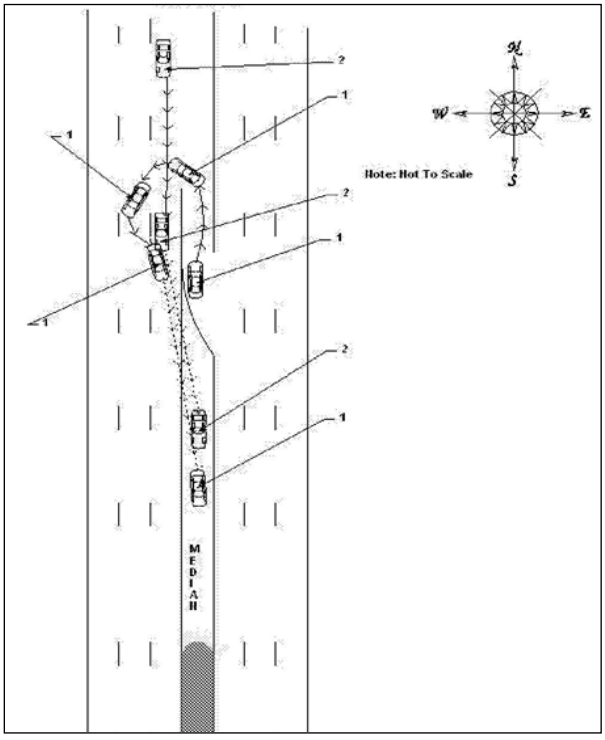


Figure 5-15: Crash at Uni-directional Median Opening on Roadway ID 5002000 (Crash ID: 770091780)

In summary, this study location on Capital Circle NW Road was converted from a TWLTL to a raised median in 2007. The location experienced a 61.7 percent reduction in total crash rate after conversion. Crash rates of all crash types except pedestrian and median crossover crashes decreased after conversion. The greater reduction in total crash rate after the conversion could be the result of fewer median openings. Further, this location has only uni-directional median openings. The location also has a combination of wider and narrower medians. The signalized intersections are also well designed with right-turn flares and crosswalks. Additionally, the location has continuous bike lanes and sidewalks. The location also has bus bays (also called off-line bus stops) to enhance mobility and reduce traffic congestion.

5.2.2 Roadway ID: 36004000; Segment Length: 0.314 miles

The 0.314-mile section along SW 17th Street in Marion County was converted from a TWLTL to a raised median in 2009. The location is a four-lane urban arterial with no median openings. After conversion, the location experienced a 57.8 percent reduction in total crash rate. Table 5-7 gives the summary statistics by crash type before and after conversion. Only three crashes occurred in the 17 months after conversion. Compared to the before period, angle, left-turn and bicycle crashes were totally eliminated. Since this location is short, crash patterns could not be identified.

Table 5-7: Before-and-After Crash Statistics on Roadway ID 36004000

Crash Type	Before (36 months)		After (17 months)		Percent Change in Crash Rate
	Crash Number	Crash Rate	Crash Number	Crash Rate	
Angle	4	0.318	0	0.000	--
Left-Turn	1	0.079	0	0.000	--
Rear-End	13	1.032	2	0.536	-48.1%
Collision with Bicycle	1	0.079	0	0.000	--
Other	5	0.397	1	0.268	-32.6%
Total	**24**	**1.906**	**3**	**0.803**	**-57.8%**

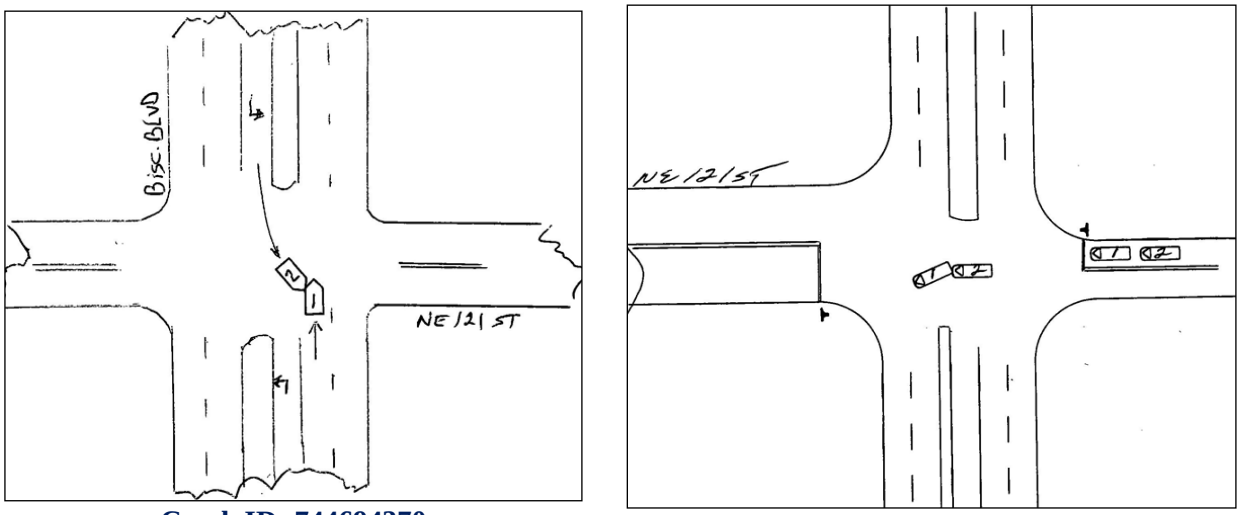
5.2.3 Roadway ID: 87030000; Segment Length: 1.204 miles

Table 5-8 gives the summary crash statistics by crash type at the 1.204-mile section on Biscayne Blvd. in Miami-Dade County. The location was converted from a TWLTL to a raised median in 2006. After conversion, the location observed a 47.8 percent reduction in total crash rate. This four-lane urban arterial has six signalized intersections, two uni-directional median openings, and one full median opening with left-turn bays on both directions.

Table 5-8: Before-and-After Crash Statistics on Roadway ID 87030000

Crash Type	Before (21 months)		After (36 months)		Percent Change in Crash Rate
	Crash Number	Crash Rate	Crash Number	Crash Rate	
Angle	29	0.873	13	0.219	-74.9%
Left-Turn	14	0.421	16	0.270	-36.0%
Right-Turn	1	0.030	11	0.185	516.2%
Rear-End	64	1.926	54	0.911	-52.7%
Sideswipe	12	0.361	7	0.118	-67.3%
Collision with Bicycle	3	0.090	2	0.034	-62.7%
Collision with Pedestrian	7	0.211	7	0.118	-44.0%
Median Crossover	1	0.030	0	0.000	--
Other	14	0.421	25	0.422	0.0%
Total	**145**	**4.364**	**135**	**2.276**	**-47.8%**

Table 5-8 shows that the crash rates of several crash types decreased after conversion. However, right-turn crashes increased significantly (516.2 percent). Review of police reports of these crashes revealed no direct impact of raised medians on these crashes. However, this location experienced nine crashes at the full median opening. Figure 5-16 gives examples of these crashes.



Crash ID: 744694370 **Crash ID: 744682420**

Figure 5-16: Examples of Crashes at Median Openings on Roadway ID 87030000

5.3 Before-and-After Safety Evaluation: A Special Study on Apalachee Parkway

As a special study, three-year and five-year before-and-after safety performance evaluations of a 1.429-mile roadway section on the Apalachee Parkway in City of Tallahassee, Florida, were conducted. The study location was converted from a TWLTL to a raised median in 2002. The analysis was conducted separately because police reports were not available for review for the before period due to its older construction date of 2002. The full study is included in Appendix C and the main findings from the analysis are summarized below:

- The yearly crash rates had three visibly distinct trends. There is a significant drop in crash rates in the years 1990 and 2003. The drop in crash rate in 1990 is the result of a change in the reporting threshold. The year 2003 corresponds to the year right after the median conversion.
- After the median conversion, a reduction of about 50 percent in total crash rates is observed in both three-year and five-year before-and-after analyses.
- Both the three-year and the five-year before-and-after analysis showed a reduction in crash rates of total, rear-end, left-turn, angle, right-turn, sideswipe, and bicycle crashes after the median conversion.
- Using a three-year before-and-after analysis, an increase in head-on crash rates is observed after the construction of raised median. As this increase is counterintuitive, the police reports were examined and it was found that all except one of these crashes were incorrectly coded.
- Both the three-year and the five-year before-and-after analysis showed a reduction in crashes rates of PDO and injury crashes after the median conversion. There were no fatal crashes during the analysis period.

5.4 Summary

This chapter focused on the site-specific review of locations where safety either improved or deteriorated significantly after conversion from TWLTLs to raised medians. The analysis focused on the before-and-after summary statistics by crash type. The analysis also included review of crash types that performed either particularly well or poorly after median conversion.

Even though median conversion resulted in either increase or only slight decrease in total crash rate at some locations, illustrative sketches and descriptions in police reports revealed that a majority of crashes in the after period at these locations could not be attributed directly to median conversion. Significant percentages of crashes involving turning traffic (i.e., left-turn, right-turn, and angle crashes) were eliminated by the conversion. Also, very few crashes occurred at median openings. Not surprisingly, crashes near signalized intersections increased after the conversion. However, very few of these crashes could be attributed directly to median construction. At some locations, rear-end crashes increased, especially at intersections. Again, from the review of police reports, very few of these crashes could be attributed to median conversion. A majority of pedestrian and bicycle crashes were either near signalized intersections or on sidewalks or bike lanes, and were not related to the conversion.

At many locations, median conversion resulted in a significant reduction in total crash rate. These locations were found to have fewer median openings; locations with uni-directional median openings resulted in relatively fewer crashes. Locations with well designed median openings and signalized intersections had greater reductions after median conversion.

Lastly, a special study on the safety performance of the 1.429-mile section on the Apalachee Parkway in City of Tallahassee, Florida was conducted. The location was converted from a TWLTL to a raised median in 2002. Overall, a 50 percent reduction in total crash rate is observed in the after period. Both the three-year and the five-year before-and-after analysis showed a reduction in crash rates of total, rear-end, left-turn, angle, right-turn, sideswipe, and bicycle crashes after the median conversion.

CHAPTER 6
EVALUATION OF SPECIFIC DESIGN FEATURES AND SAFETY CONCERNS

This chapter is divided into two main sections. The first section focuses on evaluating specific design features of raised medians. The safety performance of different median opening types is discussed in detail. It also includes the performance evaluation of raised medians by roadway design features, including number of lanes and speed limit. The second section focuses on the following three potential safety concerns related to raised medians: vehicles that hit median curbs, median crossover crashes, and pedestrian crashes.

6.1 Median and Roadway Design Features

This section focuses on the median and roadway design features that effect the safety performance of raised medians. First, the safety performance of different median openings is evaluated. Next, before and after crash statistics are compared for four-lane and six-lane facilities by crash type, crash severity, and lighting condition. Similarly, low-speed and high-speed roadways are also analyzed.

6.1.1 Median Opening Type

The 18 study locations have the following four types of median openings (as shown in Figure 5-1):

1. Uni-directional median opening.
2. Bi-directional median opening with center island.
3. Full median opening with left-turn bays on both directions.
4. Full median opening with left-turn bay on one direction.

For each study location, crashes that occurred at median openings after the location was converted from a TWLTL to a raised median were identified by reviewing the police reports. Note that only those crashes that could be attributed directly to the median opening are included in this analysis. For example, crashes involving vehicles making U-turn at median openings, crashes involving vehicles making a left turn from a side street, etc. were identified as median-opening-related crashes. Table 6-1 gives the crash rate at four-lane and six-lane facilities by median opening types. In this table, for each facility type, crash rate is calculated as the number of crashes related to median openings per exposure. The exposure is the total number of median openings multiplied by the number of years from conversion date to December 2010.

In total, 5.54 miles of four-lane urban arterials have 23 median openings, and 11.72 miles of six-lane urban arterials have 36 median openings. From Table 6-1, it is clear that the uni-directional median opening on a four-lane facility is the safest with a crash rate of 0.013 median-opening-related crashes/median opening/year. Not surprisingly, among the four median opening types, the full median opening with left-turn bays on both directions is the least safe. For the four-lane facility, crash rate at this opening type (0.094) is over seven times the crash rate at uni-directional median opening (0.013). Among the full median openings, bi-directional median opening with center island was found to be the safest.

Crash rates at median openings on six-lane facilities are very similar to crash rates at four-lane facilities. However, compared to the four-lane facilities, crash rates are consistently high for the six-lane arterials, mainly because vehicle exposure is higher for six-lane facilities compared to four-lane sections. Figure 6-1 also gives the crash rates at different median opening types at four-lane and six-lane urban arterials.

Table 6-1: Crash Rate at Median Openings by Opening Type and Roadway Facility

Median Opening Type	Four-Lane Facility			Six-Lane Facility		
	No. of Crashes	No. of Median Openings	Crash Rate[a]	No. of Crashes	No. of Median Openings	Crash Rate[a]
Uni-directional median opening	3	8	**0.013**	13	14	**0.020**
Bi-directional median opening with center island	3	5	**0.020**	30	14	**0.046**
Full median opening with left-turn bay on one direction	7	5	**0.047**	14	3	**0.099**
Full median opening with left-turn bays on both directions	14	5	**0.094**	43	5	**0.183**

[a] Crash rate is in median-opening-related crashes/median openings/year.

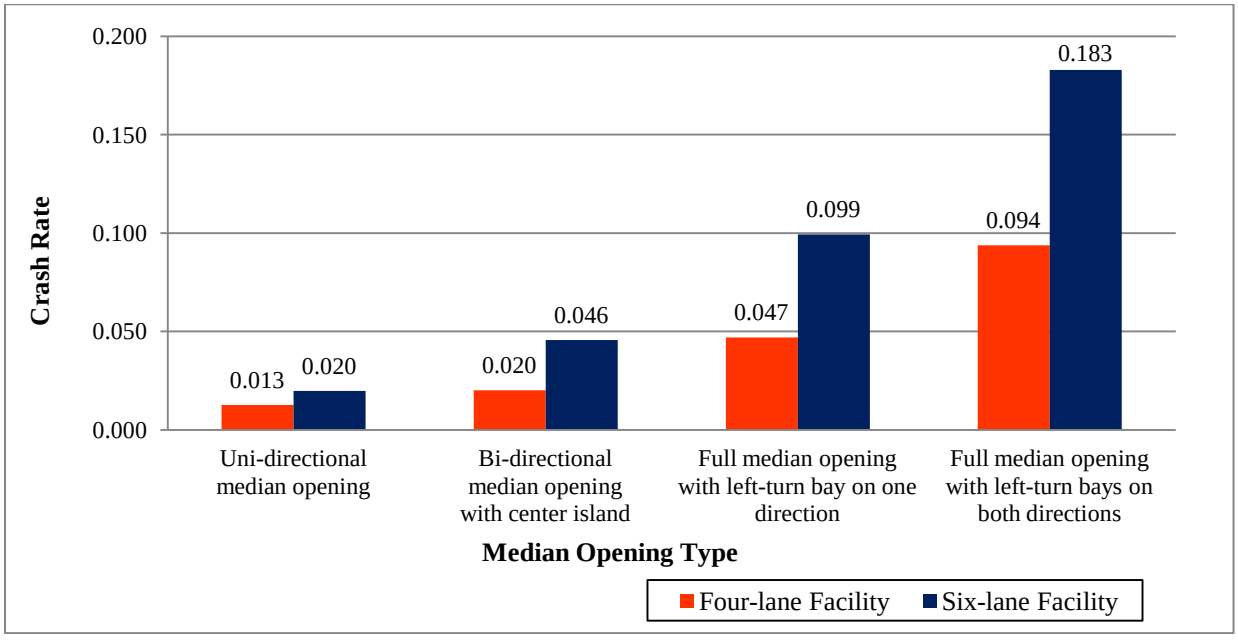


Figure 6-1: Crash Rate at Different Median Opening Types by Roadway Facility

6.1.2 Number of Lanes

A total of 5.54 miles of four-lane urban arterials and 11.72 miles of six-lane urban arterials were converted from TWLTLs to raised medians. Tables 6-2 and 6-3 give crash summary statistics by crash type, crash severity, and lighting condition at four-lane and six-lane facilities, respectively.

Further, Figures 6-2 through 6-4 show the percent change in crash rates at four-lane and six-lane arterial facilities by crash type, crash severity, and lighting condition, respectively.

Compared to four-lane facilities, six-lane facilities experienced a significantly greater reduction in total crash rate after conversion from TWLTLs to raised medians; four-lane facilities experienced a 4.7 percent reduction in total crash rate, while six-lane arterials experienced a reduction of 37.2 percent. Even though a greater reduction in fatal crash rate (47.2 percent) is observed on four-lane facilities, six-lane arterials experienced a relatively high 41.8 percent reduction in F+I crash rate. Since raised medians provide pedestrian refuge areas, pedestrian crash rate is expected to decrease after median conversion. On six-lane facilities, a reduction in pedestrian crash rate of 40.4 percent is observed. On the contrary, pedestrian crash rate increased on four-lane facilities after median conversion. At both four-lane and six-lane facilities, reduction in crash rate is observed after median conversion at all lighting conditions; however, greater reductions at each lighting condition are observed on six-lane facilities.

Table 6-2: Summary Crash Statistics at Four-lane Urban Arterials

	Before		After		Percent Change in Crash Rate
	No. of Crashes	Crash Rate	No. of Crashes	Crash Rate	
Crash Type					
Head-On[a]	0	0.000	1	0.006	---
Rear-End	187	1.193	249	1.399	17.3%
Angle	83	0.529	69	0.388	-26.8%
Left-Turn	69	0.440	52	0.292	-33.6%
Right-Turn	19	0.121	21	0.118	-2.6%
Sideswipe	31	0.198	21	0.118	-40.3%
Pedestrian	9	0.057	14	0.079	37.0%
Bicycle	10	0.064	8	0.045	-29.5%
Others	78	0.498	91	0.511	2.8%
Total Crashes	**486**	**3.100**	**526**	**2.955**	**-4.7%**
Crash Severity					
PDO	234	1.493	250	1.404	-5.9%
Injury	247	1.575	273	1.534	-2.6%
Fatal	5	0.032	3	0.017	-47.2%
F+I	252	1.607	276	1.551	-3.5%
Total Crashes	**486**	**3.100**	**526**	**2.955**	**-4.7%**
Lighting Condition					
Daylight	344	2.194	380	2.135	-2.7%
Dusk	15	0.096	17	0.096	-0.2%
Dawn	7	0.045	4	0.022	-49.7%
Dark with Street Light	107	0.682	119	0.669	-2.0%
Dark without Street Light	6	0.038	3	0.017	-56.0%
Unknown	7	0.045	3	0.017	-62.3%
Total Crashes	**486**	**3.100**	**526**	**2.955**	**-4.7%**

[a] Sample size is too small.

Table 6-3: Summary Crash Statistics at Six-lane Urban Arterials

	Before		After		Percent Change in Crash Rate
	No. of Crashes	Crash Rate	No. of Crashes	Crash Rate	
Crash Type					
Head-On	19	0.035	9	0.017	-52.3%
Rear-End	766	1.425	565	1.058	-25.8%
Angle	330	0.614	183	0.343	-44.2%
Left-Turn	407	0.757	106	0.199	-73.8%
Right-Turn	59	0.110	31	0.058	-47.1%
Sideswipe	118	0.220	106	0.199	-9.6%
Pedestrian	54	0.100	32	0.060	-40.4%
Bicycle	44	0.082	44	0.082	0.6%
Others	230	0.428	189	0.354	-17.3%
Total Crashes	**2027**	**3.772**	**1265**	**2.369**	**-37.2%**
Crash Severity					
PDO	912	1.697	620	1.161	-31.6%
Injury	1101	2.049	634	1.187	-42.0%
Fatal	14	0.026	11	0.021	-20.9%
F+I	1115	2.075	645	1.208	-41.8%
Total Crashes	**2027**	**3.772**	**1265**	**2.369**	**-37.2%**
Lighting Condition					
Daylight	1464	2.724	820	1.536	-43.6%
Dusk	59	0.110	30	0.056	-48.8%
Dawn	29	0.054	12	0.022	-58.4%
Dark with Street Light	422	0.785	360	0.674	-14.1%
Dark without Street Light	40	0.074	37	0.069	-6.9%
Unknown	13	0.024	6	0.011	-53.5%
Total Crashes	**2027**	**3.772**	**1265**	**2.369**	**-37.2%**

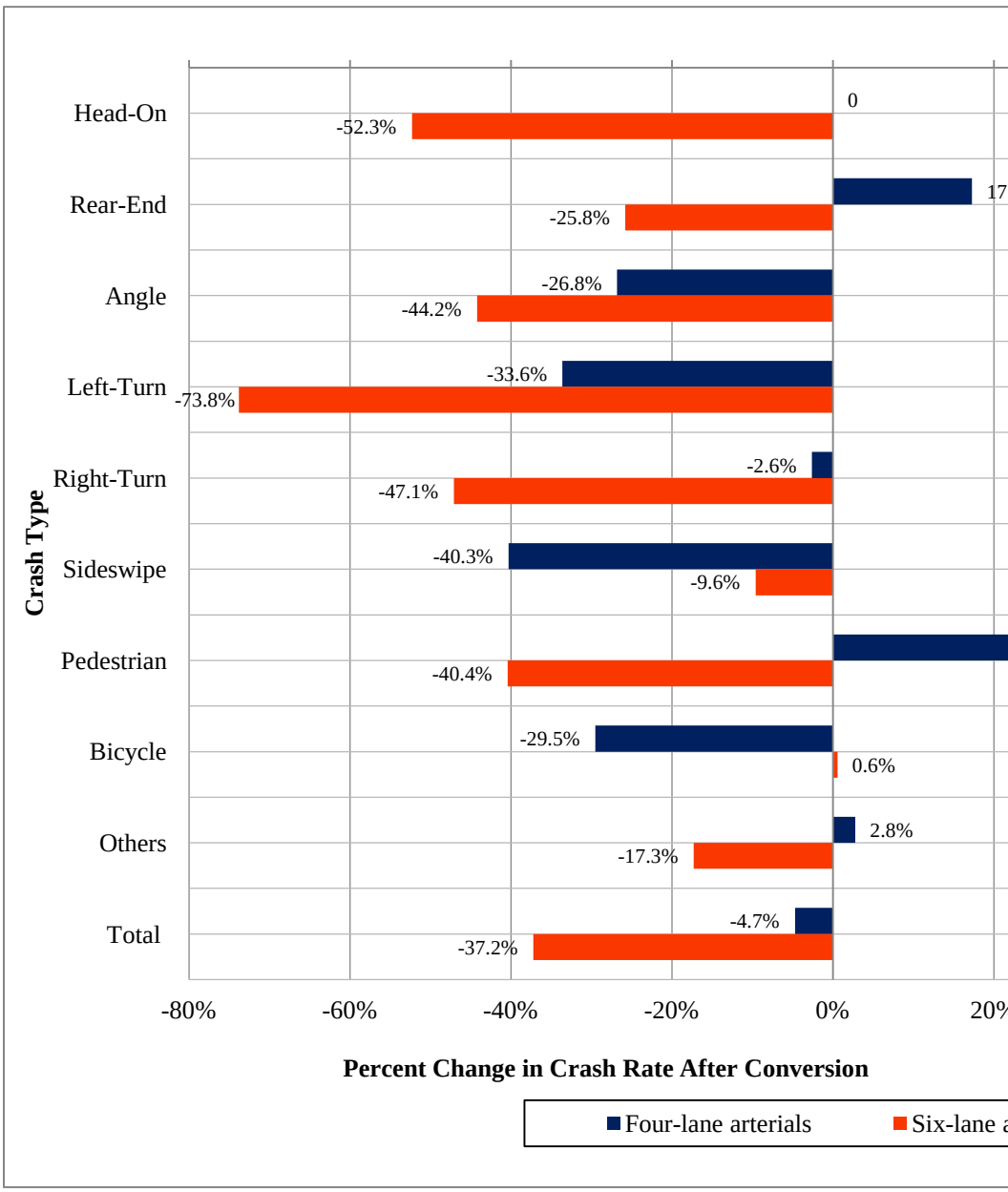


Figure 6-2: Percent Change in Crash Rate After Conversion by Crash Type and Facility Type

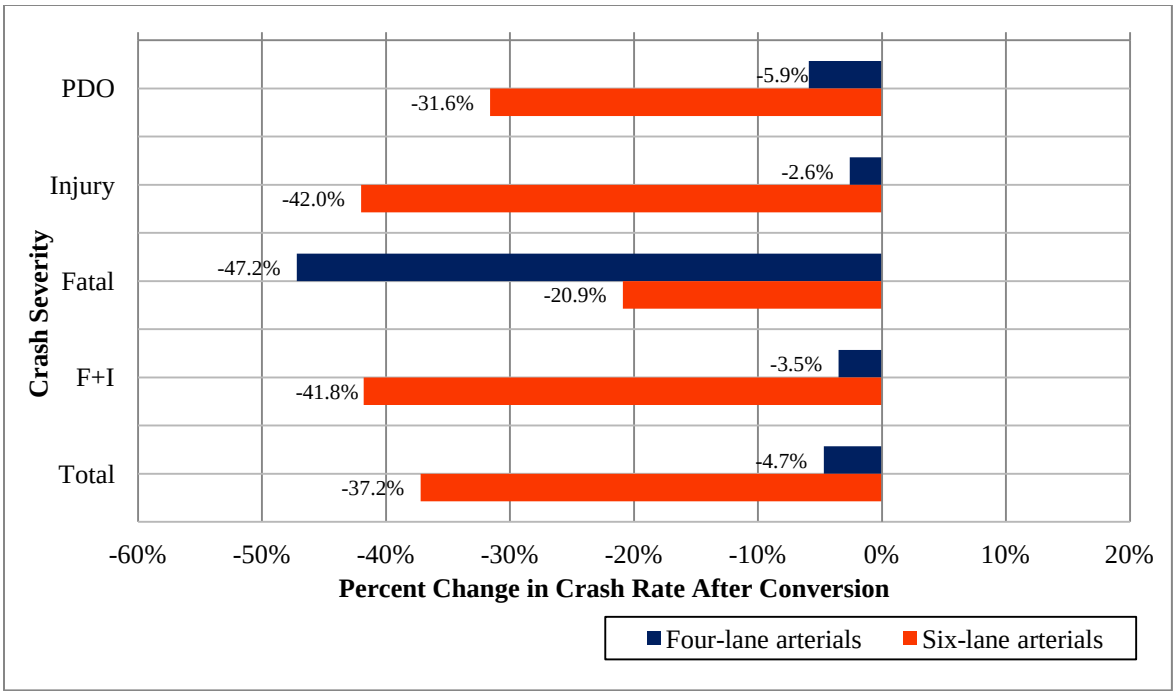


Figure 6-3: Percent Change in Crash Rate After Conversion by Crash Severity and Facility Type

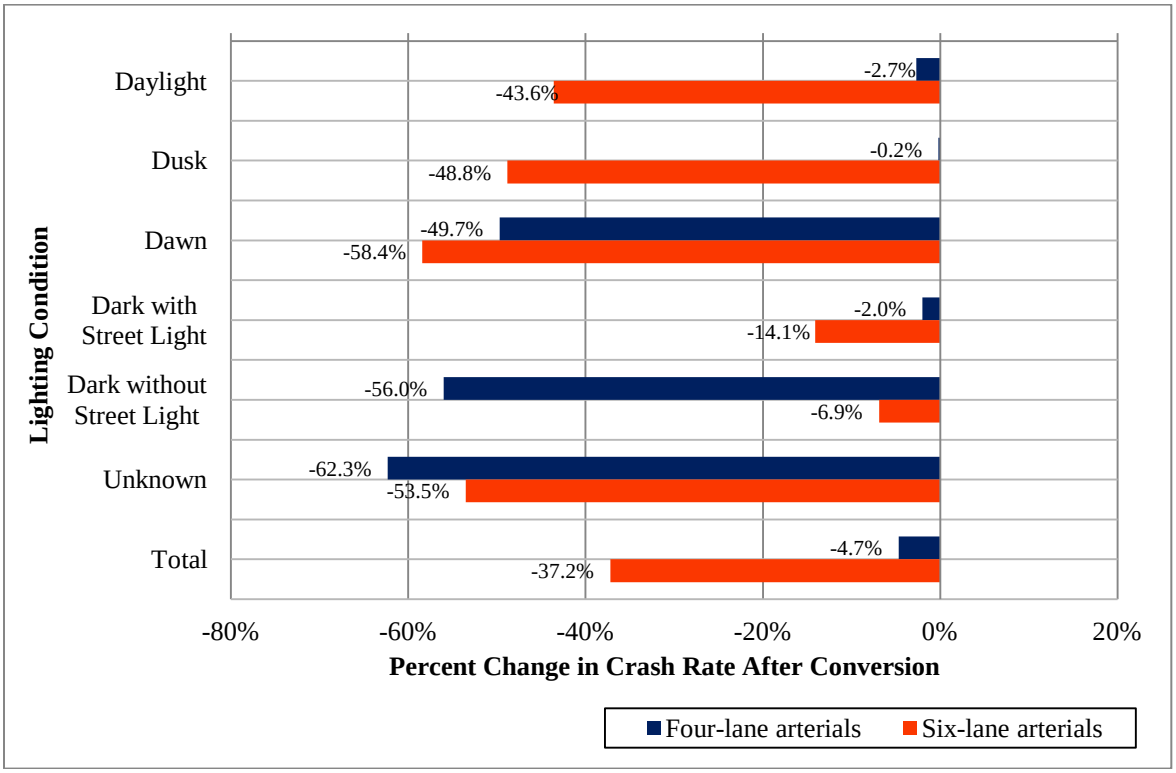


Figure 6-4: Percent Change in Crash Rate After Conversion by Lighting Condition and Facility Type

6.1.3 Speed Limit

For this analysis, the 18 study locations are divided into low-speed arterials (i.e., with speed limit either 35 or 40 mph) and high-speed arterials (i.e., with speed limit 45, 50, or 55 mph). Note that the classification is only based on speed limits and not on the facility type (i.e., four-lane or six-lane facilities). This categorization of low-speed and high-speed arterials is consistent with other studies, e.g., Nevarez-Pagan (2008). A total of 5.57 miles of low-speed arterials and 11.94 miles of high-speed arterials were converted from TWLTLs to raised medians. Tables 6-4 and 6-5 give crash summary statistics by crash type, crash severity, and lighting condition on low-speed and high-speed arterials, respectively. Further, Figures 6-5 through 6-7 show the percent change in crash rates on these arterials by crash type, crash severity, and lighting condition, respectively.

It can be seen from these figures that low-speed roadways experienced a 31.8 percent reduction in total crash rate after conversion and high-speed sections had a 26.5 percent reduction. On low-speed roadways, median conversion resulted in a reduction in crash rate for all crash types except sideswipe, pedestrian, and bicycle crashes. On the other hand, high-speed roadways experienced reduction in crash rate for all crash types.

Low-speed roadways had two fatal crashes after conversion, while there were none prior to median conversion. On the other hand, conversion resulted in a 28.4 percent reduction in fatal crash rate on high-speed arterials. Conversion on low-speed arterials resulted in reduction in total crash rate at all lighting conditions except dusk. After conversion, high-speed arterials had an 18.1 percent increase in total crash rate during night with no street lights.

Table 6-4: Summary Crash Statistics at Low-Speed Arterials

	Before		After		Percent Change in Crash Rate
	No. of Crashes	Crash Rate	No. of Crashes	Crash Rate	
Crash Type					
Head-On	3	0.015	1	0.004	-72.5%
Rear-End	132	0.682	121	0.516	-24.4%
Angle	50	0.258	28	0.119	-53.8%
Left-Turn	43	0.222	17	0.072	-67.4%
Right-Turn	7	0.036	8	0.034	-5.7%
Sideswipe	16	0.083	23	0.098	18.6%
Pedestrian	4	0.021	6	0.026	23.7%
Bicycle	8	0.041	10	0.043	3.1%
Others	21	0.108	21	0.089	-17.5%
Total Crashes	**284**	**1.467**	**235**	**1.001**	**-31.8%**
Crash Severity					
PDO	139	0.718	120	0.511	-28.8%
Injury	145	0.749	113	0.481	-35.7%
Fatal	0	0.000	2	0.009	---
F+I	145	0.749	115	0.490	-34.6%
Total Crashes	**284**	**1.467**	**235**	**1.001**	**-31.8%**
Lighting Condition					
Daylight	204	1.054	158	0.673	-36.1%
Dusk	2	0.010	4	0.017	65.0%
Dawn	3	0.015	2	0.009	-45.0%
Dark with Street Light	59	0.305	62	0.264	-13.3%
Dark without Street Light	16	0.083	8	0.034	-58.8%
Unknown	0	0.000	1	0.004	---
Total Crashes	**284**	**1.467**	**235**	**1.001**	**-31.8%**

Table 6-5: Summary Crash Statistics at High-Speed Arterials

	Before		After		Percent Change in Crash Rate
	No. of Crashes	Crash Rate	No. of Crashes	Crash Rate	
Crash Type					
Head-On	16	0.032	9	0.019	-41.2%
Rear-End	824	1.640	694	1.445	-11.9%
Angle	364	0.725	225	0.467	-35.3%
Left-Turn	433	0.862	144	0.300	-65.2%
Right-Turn	71	0.141	45	0.094	-33.7%
Sideswipe	133	0.265	104	0.217	-18.2%
Pedestrian	59	0.117	40	0.083	-29.1%
Bicycle	46	0.092	43	0.090	-2.2%
Others	288	0.573	265	0.552	-3.7%
Total Crashes	**2234**	**4.447**	**1569**	**3.267**	**-26.5%**
Crash Severity					
PDO	1009	2.008	755	1.572	-21.7%
Injury	1206	2.401	801	1.668	-30.5%
Fatal	19	0.038	13	0.027	-28.4%
F+I	1225	2.438	814	1.695	-30.5%
Total Crashes	**2234**	**4.447**	**1569**	**3.267**	**-26.5%**
Lighting Condition					
Daylight	1608	3.201	1052	2.191	-31.6%
Dusk	72	0.143	43	0.090	-37.5%
Dawn	33	0.066	14	0.029	-55.6%
Dark with Street Light	470	0.936	417	0.868	-7.2%
Dark without Street Light	31	0.062	35	0.073	18.1%
Unknown	20	0.040	8	0.017	-58.2%
Total Crashes	**2234**	**4.447**	**1569**	**3.267**	**-26.5%**

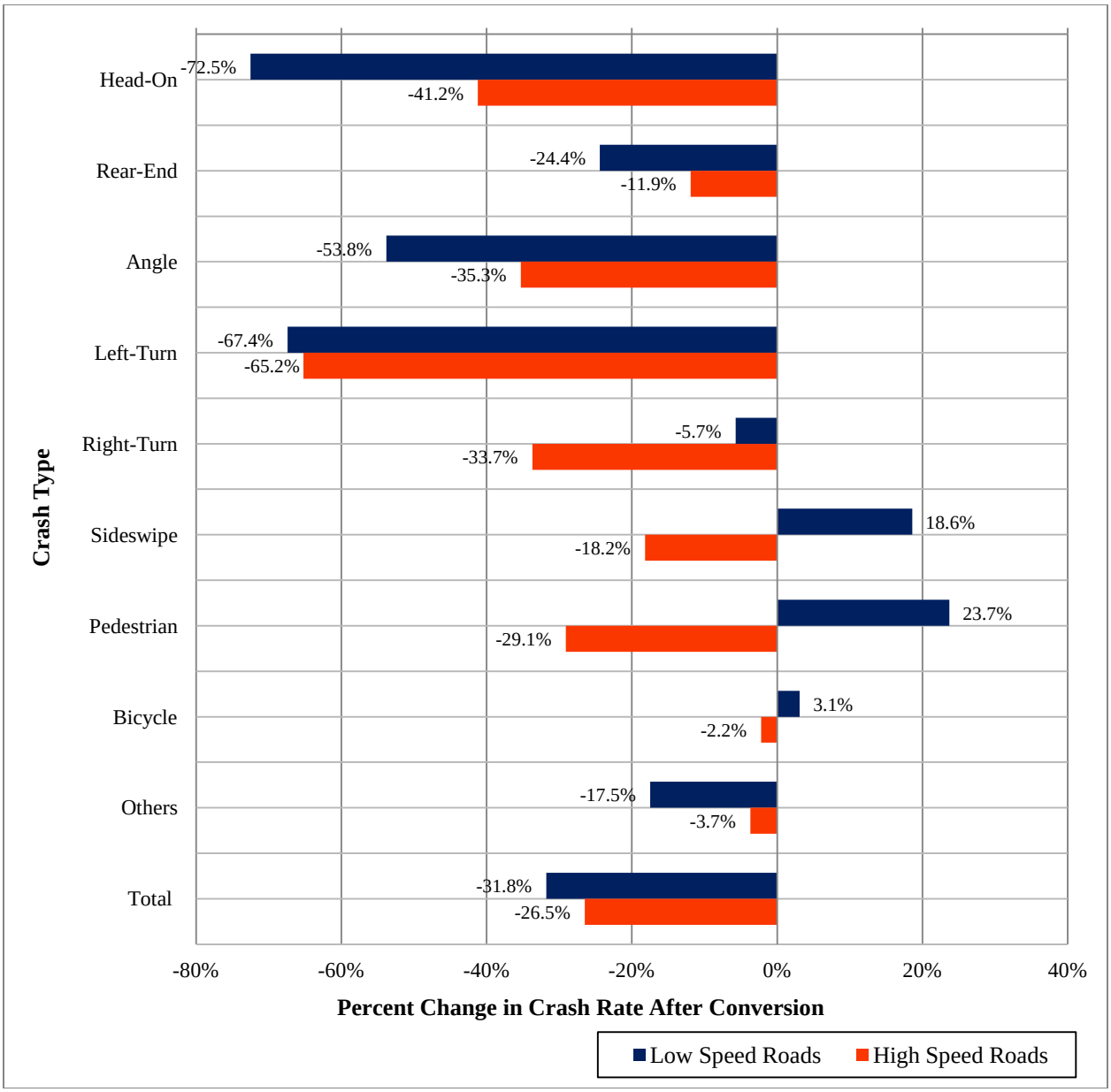


Figure 6-5: Percent Change in Crash Rate After Conversion by Crash Type and Speed Limit

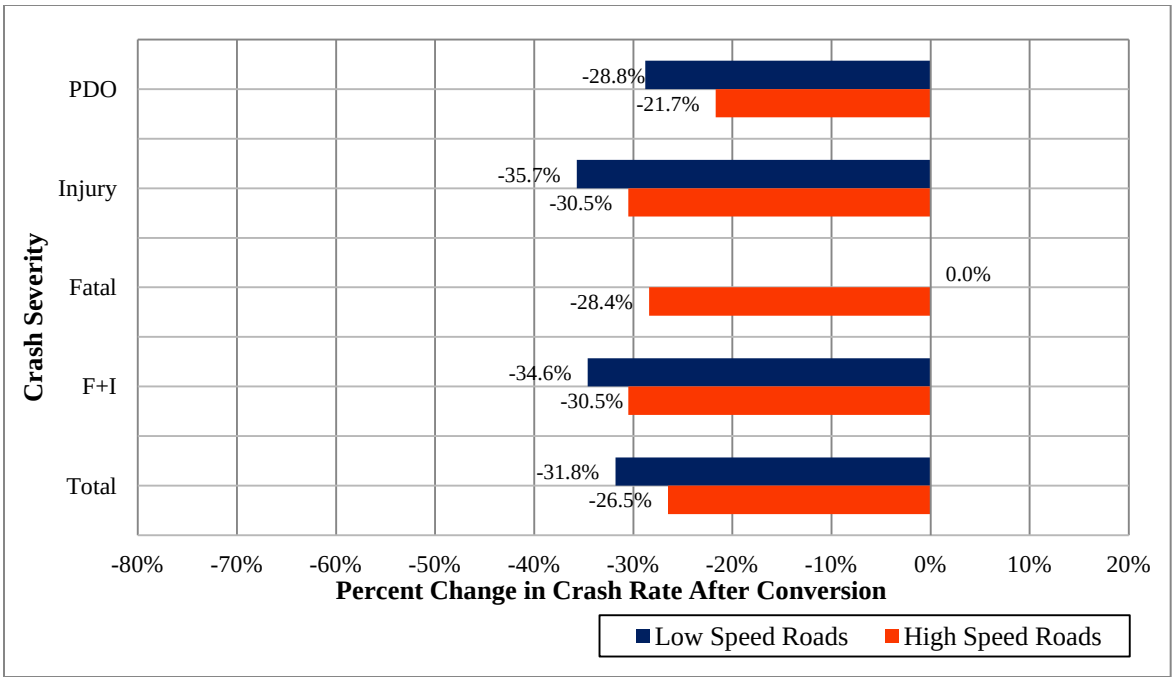


Figure 6-6: Percent Change in Crash Rate After Conversion by Crash Severity and Speed Limit

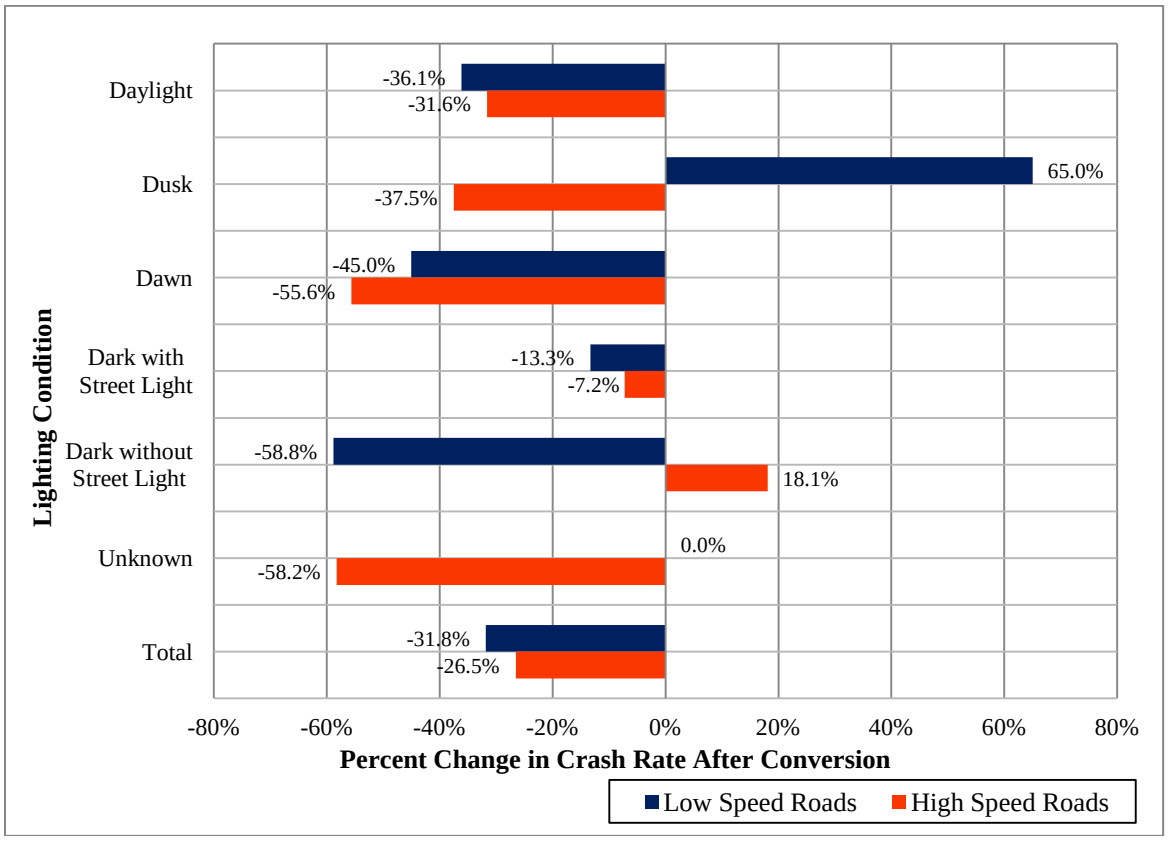


Figure 6-7: Percent Change in Crash Rate After Conversion by Lighting Condition and Speed Limit

6.2 Safety Concerns

This section focuses on three main safety concerns related to raised medians. First, summary statistics of vehicles that hit the median curb are provided. Second, median crossover crashes are analyzed. Third, pedestrian crashes are discussed in detail.

6.2.1 Vehicles Hitting Median Curb

On roadways with TWLTLs, errant vehicles have the opportunity to regain control before hitting any obstacle or oncoming traffic. However, raised medians often do not provide enough lateral clearance for errant vehicles. Therefore, one of the safety concerns of constructing raised medians is the frequency of vehicles that directly hit the median curb before stopping or resulting in secondary crashes.

Of the 2,436 crashes that occurred at the 18 locations from median construction date to December 2010, 48 crashes (i.e., 2.0 percent) involved vehicles directly hitting the median curb. Of these 48 crashes, 26 were PDOs while the remaining 22 resulted in an injury; there were no fatal crashes. When drug/alcohol involvement is examined, 39 crashes did not involve alcohol/drugs while 9 involved driving under influence (DUI). Table 6-6 gives the summary statistics by lighting condition, crash location, and crash severity at four-lane and six-lane facilities. About one-third of these crashes (31.3 percent) occurred near signalized intersections and the rest occurred at midblock locations. Compared to four-lane facilities, a slightly greater percentage of these crashes occurred near signalized intersections on six-lane facilities.

Table 6-6: Crash Statistics of Vehicles Hitting Raised Median Curb

	Four-lane Facilities		Six-lane Facilities		Total	
	No. of Crashes	Percent of Crashes	No. of Crashes	Percent of Crashes	No. of Crashes	Percent of Crashes
Lighting Condition						
Day Light	3	33.3%	16	41.0%	19	39.6%
Dusk	1	11.1%	3	7.7%	4	8.3%
Dark with Street Light	5	55.6%	18	46.2%	23	47.9%
Dark with No Street Light	0	0.0%	2	5.1%	2	4.2%
Total	**9**	**100.0%**	**39**	**100.0%**	**48**	**100.0%**
Crash Location						
Signalized Intersection	2	22.2%	13	33.3%	15	31.3%
Midblock Location	7	77.8%	26	66.7%	33	68.8%
All Locations	**9**	**100.0%**	**39**	**100.0%**	**48**	**100.0%**
Crash Severity						
PDO	3	33.3%	23	59.0%	26	54.2%
Injury	6	66.7%	16	41.0%	22	45.8%
Fatal	0	0.0%	0	0.0%	0	0.0%
Total	**9**	**100.0%**	**39**	**100.0%**	**48**	**100.0%**

6.2.2 Median Crossover Crashes

A crash is categorized as a median crossover crash if the errant vehicle crosses the raised median and reaches the opposite travel lane at any point during the crash. Of the 2,436 crashes that occurred at the 18 locations after median conversion through December 2010, 38 (or 1.6 percent) involved median crossover. Of these 38 crashes, 20 were PDOs and the rest resulted in injury crashes; there were no fatal crashes. Table 6-7 gives the summary statistics of median crossover crashes by lighting condition, crash location, and crash severity at four-lane and six-lane facilities. Comparing Tables 6-6 and 6-7, it can be seen that four-lane facilities had a greater proportion of median crossovers compared to six-lane facilities.

Table 6-7: Crash Statistics of Median Crossover Crashes

	Four-lane Facilities		Six-lane Facilities		Total	
	No. of Crashes	Percent of Crashes	No. of Crashes	Percent of Crashes	No. of Crashes	Percent of Crashes
Lighting Condition						
Day Light	6	42.9%	10	41.7%	16	42.1%
Dusk	1	7.1%	1	4.2%	2	5.3%
Dawn	1	7.1%	0	0.0%	1	2.6%
Dark with Street Light	6	42.9%	10	41.7%	16	42.1%
Dark with No Street Light	0	0.0%	3	12.5%	3	7.9%
Total	**14**	**100.0%**	**24**	**100.0%**	**38**	**100.0%**
Crash Location						
Signalized Intersection	5	35.7%	7	29.2%	12	31.6%
Midblock Location	9	64.3%	17	70.8%	26	68.4%
All Locations	**14**	**100.0%**	**24**	**100.0%**	**38**	**100.0%**
Crash Severity						
PDO	6	42.9%	14	58.3%	20	52.6%
Injury	8	57.1%	10	41.7%	18	47.4%
Fatal	0	0.0%	0	0.0%	0	0.0%
Total	**14**	**100.0%**	**24**	**100.0%**	**38**	**100.0%**

6.2.3 Pedestrian Crashes

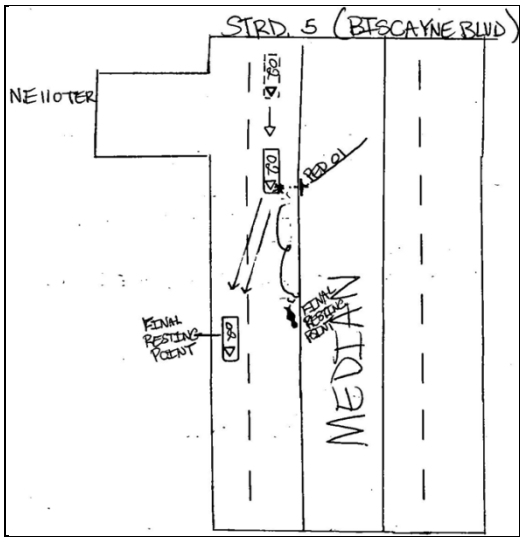
By providing pedestrian refuge areas, raised medians are considered a potential improvement to pedestrian safety. As discussed in Section 4.4, the before-and-after pedestrian crash statistics showed a 28.9 percent reduction in pedestrian crash rate after median conversion, from 63 crashes in the before period to 46 crashes in the after period. This section looks more closely at the 46 pedestrian crashes that occurred after median construction. Table 6-8 gives pedestrian crash statistics by crash severity and lighting condition at four-lane and six-lane facilities.

Table 6-8: Pedestrian Crash Statistics by Crash Severity and Lighting Condition

	Four-lane Facilities		Six-lane Facilities		Total	
	No. of Crashes	**Percent of Crashes**	**No. of Crashes**	**Percent of Crashes**	**No. of Crashes**	**Percent of Crashes**
Crash Severity						
PDO	0	0.0%	3	9.4%	3	6.5%
Injury	12	85.7%	24	75.0%	36	78.3%
Fatal	2	14.3%	5	15.6%	7	15.2%
F+I	14	100.0%	29	90.6%	43	93.5%
Total	**14**	**100.0%**	**32**	**100.0%**	**46**	**100.0%**
Lighting Condition						
Day Light	7	50.0%	17	53.1%	24	52.2%
Dusk	1	7.1%	0	0.0%	1	2.2%
Dawn	1	7.1%	0	0.0%	1	2.2%
Dark with Street Light	4	28.6%	15	46.9%	19	41.3%
Unknown	1	7.1%	0	0.0%	1	2.2%
Total	**14**	**100.0%**	**32**	**100.0%**	**46**	**100.0%**

A majority of the pedestrian crashes (32 of 46) occurred at six-lane facilities. Also, of the seven pedestrian fatalities, five occurred at six-lane facilities and two occurred at four-lane facilities. Compared to four-lane facilities, a higher percentage of pedestrian crashes on six-lane facilities occurred at night.

Of the 46 crashes, 21 occurred at signalized intersections, while the rest occurred at midblock locations. In nine crashes, pedestrians were hit on sidewalks, and were not related to the raised medians. When drug/alcohol involvement is examined, 36 crashes did not involve alcohol/drugs while 10 involved alcohol/drugs. Further, none of these 46 pedestrians were hit while standing on the raised median. However, several crashes resulted from pedestrians stepping in front of traffic from the raised median. Figure 6-6 gives three examples of such crashes.



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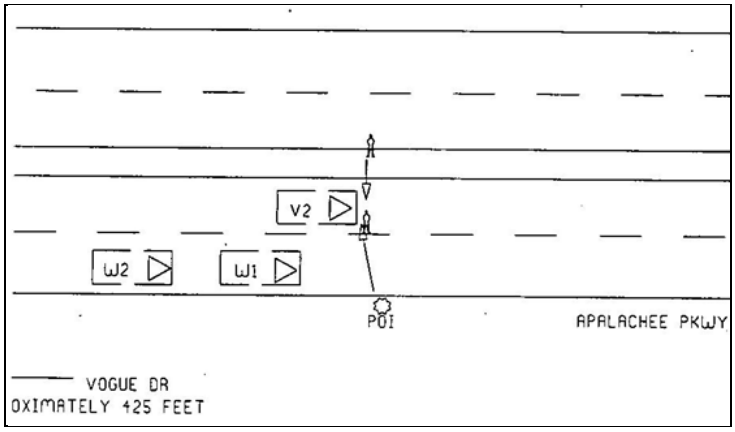

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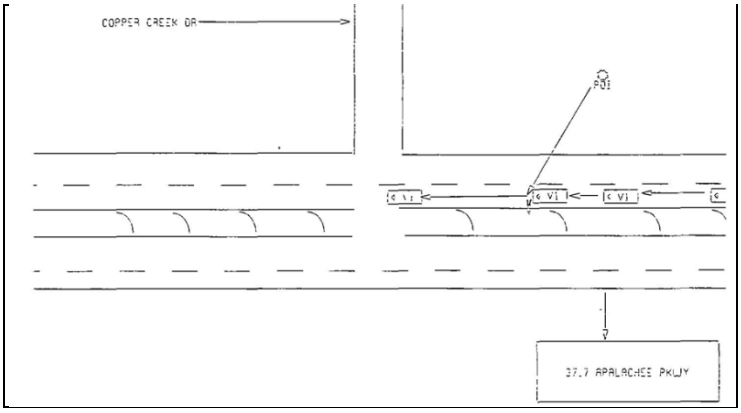

Crash ID: 718755990

Figure 6-8: Examples of Pedestrian Crashes That Could Be Attributed Directly to Raised Medians

6.3 Summary

This chapter focused on evaluating the specific median and roadway design features of raised medians. It also discussed three specific safety concerns related to raised medians. The safety performance of four types of median openings was evaluated at four-lane and six-lane facilities. Police reports were reviewed to identify crashes that were directly related to median openings. The results showed that uni-directional median opening on a four-lane facility was the safest, and the full median opening with left-turn bays on both directions on a six-lane facility was the least safe. Among the three types of full median openings, the "bi-directional median opening with center island" type was found to be the safest. Further, compared to four-lane facilities, crash rates at median openings on six-lane facilities were consistently higher.

Before-and-after crash summary statistics showed that four-lane urban arterials had a mere 4.7 percent reduction in total crash rate after conversion, while six-lane facilities experienced a 37.2 percent reduction. Similarly, low-speed and high-speed roadways were analyzed separately; after conversion, total crash rates at low- and high-speed roads reduced by 31.8 percent and 26.5 percent, respectively. At four-lane facilities, conversion resulted in a reduction in crash rate for all crash types except for rear-end, pedestrian, and other crashes. Specific reasons for increase in crash rates of these crash types could not be identified. However, review of police reports indicated that a majority of this increase could not be attributed directly to median conversion. From these statistics, it could be inferred that conversion resulted in a greater overall safety benefit for six-lane facilities compared to four-lane facilities.

Compared to TWLTLs, raised medians often do not provide enough lateral clearance for errant vehicles. Therefore, one of the safety concerns of constructing raised medians is the frequency of vehicles that directly hit the median curb before stopping or resulting in secondary crashes. Of the 2,436 crashes that occurred at the 18 locations after median conversion, only about 2.0 percent involved vehicles directly hitting the median curb; 31.3 percent of these crashes occurred at signalized intersections. A majority of these crashes were not severe. Additionally, of the 2,436 crashes that occurred after median conversion, 1.6 percent involved vehicles crossing over the median. Again, a majority of these crashes were not severe. Further, four-lane facilities had a greater proportion of median crossovers compared to six-lane facilities. At all locations combined, a total of 46 pedestrian crashes occurred after median conversion. Further, none of these 46 pedestrians were hit while standing on the raised median.

CHAPTER 7
INTERVIEWS OF BUSINESSES

This chapter summarizes the results and key findings of the interviews of businesses along the arterials that were recently converted from TWLTLs to raised medians. It first gives brief descriptions of the locations chosen to conduct the interviews. The descriptions also include interviewers' opinions about the impact of conversion on the existing businesses. The interview responses are then discussed under the following two sections:

1. business owners' perception of raised medians, and
2. business owners' involvement in public hearings.

As discussed in Chapter 3, a total of ten locations were identified as candidate sites for conducting the interviews of businesses. Table 7-1 gives the list of the interview sites. For each location, the table gives information on the facility type (i.e., four-lane or six-lane facilities). The table also lists the total number of businesses, businesses that did not qualify, businesses that refused to participate, and the number of businesses that qualified at each location. A total of 426 businesses were identified, of which 200 businesses qualified to participate in the interviews.

Table 7-1: Details of the Businesses at Each Location

Roadway Name	Businesses That Did Not Qualify (a)	Businesses That Refused to Participate (b)	Businesses That Qualified (c)	Businesses That are Included in Analysis	Total Businesses (a)+(b)+(c)
US 301 (Riverview, FL)[a]	18	12	43	34	73
S 4th St/ US 1 (Ft. Pierce, FL)[b]	31	3	66	41	100
E Hillsboro Blvd. (Deerfield Beach, FL)[a]	2	7	4	3	13
N Orange Blossom Trail (Orlando, FL)[b]	1	5	7	7	13
Semoran Blvd. (Orlando, FL)[a]	35	58	52	41	145
N Florida Ave (Lakeland, FL)[b,c]	1	2	0	0	3
N Florida Ave (Lakeland, FL)[b,d]	7	8	21	19	36
Davie Blvd. (Davie, FL)[b]	5	18	3	3	26
West Hallandale Beach Blvd. (Hallandale, FL)[a]	2	3	4	3	9
SR 77 (Panama City, FL)[b,e]	0	8	0	0	8
Total	**102**	**124**	**200**	**151**	**426**

[a] Locations are six-lane facilities.
[b] Locations are four-lane facilities.
[c] Segment is from MP 1.156 to MP 1.259; [d] Segment is from MP 2.365 to MP 3.004.
[e] Conducted the interviews through telephone.

7.1 Description of Individual Sites

As shown in Table 7-1, a total of ten locations were identified as candidate sites for conducting the interviews of businesses. The following sections give descriptions of nine of the ten study locations, along with interviewers' opinions. The description of the study location on SR 77 in

Panama City is not provided since the interviews of the eight businesses along this section were conducted through telephone.

7.1.1 US 301, Riverview, Florida

The overall perception of the businesses in the downtown area of Riverview was negative. Business owners were discontent with the median conversion and many mentioned that access to their businesses was limited. Moreover, owners also believed that the median was poorly designed (for example, a median opening was provided to a nonexistent road). In addition, large shopping centers did not have access to midblock openings; therefore, the owners explained that customers were deterred from entering the businesses.

The study location included signalized intersections that were over-designed for the existing traffic conditions because of recently built community homes. Further, the raised medians did not account for tractor trailer turning radii.

7.1.2 S 4th St/ US 1, Ft. Pierce, Florida

The interview process was fairly simple because the business owners, who were also the residents, were eager to voice their opinion. Many of the business owners wanted to speak to the interviewers and answer the interview questions to explain the impact of raised medians on their businesses.

The local community and business owners had a strong resentment toward the raised medians. Many owners commented on how the raised medians negatively affected business operations. The business owners believed that the raised medians resulted in businesses losing customers, and ultimately closing down. This trend was also evident with businesses that were established after conversion, and the owners believed that the medians prevented customers from accessing the businesses. However, there were still some owners who preferred raised medians to TWLTLs because they considered raised medians to be safer. Moreover, owners commented that crashes shifted to signalized intersections because of the increased U-turns, while unfamiliar drivers drove on top of the medians. Some owners believed that the medians have added aesthetic value to the area with lush landscaping.

From the roadway design and traffic operations perspective, it was observed that the median design made it difficult for trucks to access businesses. Further, making U-turns was found to be difficult as there were no sufficient midblock openings. Furthermore, the location might have sight distance issues with vehicles making left turns and U-turns; the lush landscaping obstructed the view of the turning vehicles.

7.1.3 East Hillsboro Blvd., Deerfield Beach, Florida

The construction of the raised medians has had little to no effect on the operations of the local businesses. The business owners explained that customers have access through the intersection, and mentioned that the safety issues were related to signal timing. They further clarified that the raised medians have had no impact on their businesses.

During the interview process, it was discovered that the business operations were then in off-season. The business owners explained that during the on-season (i.e., from October through March), the area will be overpopulated with tourists.

7.1.4 North Orange Blossom Trail and Semoran Blvd., Orlando, Florida

The Orlando area had two roadway segments that were selected for conducting the interviews. The first location was a 0.342-mile section on North Orange Blossom Trail in Orlando, FL. The businesses were located in a suburban area and were predominantly auto, food, and commercial. A majority of the business owners that were interviewed expressed that the medians have had little to no impact on their businesses. In addition, some business owners believed that the roadway was safer after the construction of raised medians, and preferred the raised medians. A few business owners mentioned that trucks have less accessibility, and this resulted in a decrease of truck driver customers.

The second roadway segment in Orlando was a 2.417-mile section on Semoran Blvd. in Orlando, FL. The impact of raised medians on business operations was observed to be evenly distributed. A majority of the owners believed that raised medians were safer than TWLTLs. These business owners felt that it was more difficult to access their businesses, but believed that raised medians were safer. Similarly, some business owners stated that the U-turn signs were confusing; some drivers were not sure whether they could or could not make a U-turn, often leading to drivers making illegal U-turns. Some owners expressed that the area had significant pedestrian movement, so the raised medians provided a refuge while crossing the street. Moreover, raised medians were considered to provide safety for students at the local community school.

The community, in general, believed that participating in public meetings was not useful. A majority of the business owners believed that community feedback was not considered in the planning process. Many voiced that they took the surveys prior to conversion from a TWLTL to a raised median, but felt that the information was ignored. The businesses that have been established recently (i.e., after the median conversion) also voiced similar opinions. The resentment toward the government and local municipalities was strong because some business owners refused to fill out the survey; some owners felt that they had no say in the outcome.

The raised medians at this location have few midblock openings, and U-turns were primarily allowed at signalized intersections. One interviewee thought that businesses foreclosures at this location were not due to the median construction, but to the poor economy.

7.1.5 North Florida Avenue, Lakeland, Florida

The Lakeland area had two roadway segments that were selected for conducting the interviews. One location was on North Florida Avenue from MP 1.156 to MP 1.259. This location consisted of few small businesses and a hospital. It also had a small shopping complex with only two businesses and another building with a recently established restaurant. The businesses either refused to participate in the survey or were not available.

The second location was on the same roadway from MP 2.365 to MP 3.004. The business owners at this location were very interested in talking to the interviewers and believed that the interviews would help for future projects. The business owners explained that U-turns were only possible at signalized intersections. These shifts in U-turns made the intersections more complex and unsafe. Both employees and business owners believed that signalized intersections should have "No Turn on Red" (NTOR). Also, a few owners voiced the issue that delivery trucks have difficulty entering the business establishments.

It should be noted that many business owners claimed that they did not receive the letter of the availability of the public hearings. However, they also noted that their landlords might have received the information it but did not pass it on to them.

7.1.6 Davie Blvd., Davie, Florida

The study location was approximately 0.17 miles long with no median openings. The location was composed primarily of small businesses. Several businesses went out of business; the business owners mentioned that the foreclosures were due to sluggish economy and not because of the median conversion.

7.1.7 West Hallandale Beach Blvd., Hallandale, Florida

The study location was a 0.11-mile stretch with no median openings. The location consisted of a combination of large franchises and small businesses. The section had delineators on the roadway segment; the business owners believed that the delineators were causing additional congestion. The business owners also believed that conversion from a TWLTL to a raised median decreased accessibility to their businesses.

7.2 Responses to Interviews

As discussed earlier, a total of ten locations that were recently converted from TWLTLs to raised medians were identified for conducting the interviews. The interview mainly focused on the business owners' perception of raised medians and their involvement in the public hearing process. The interview questions are given in Appendix D. The interview responses are analyzed under the following three subsections:

1. business type and location information,
2. business owners' perception of raised medians, and
3. business owners' involvement in public hearings.

7.2.1 Business Type and Location

A total of 426 businesses existed at the ten locations selected for conducting the interviews. Figure 7-1 gives the total number and types of businesses at the ten interview locations. Note that all the businesses are divided into the following types:

- auto services,

- business services,
- convenience stores,
- fast-food restaurants,
- gas stations,
- grocery stores,
- personal services,
- retail stores,
- sit-down restaurants, and
- others, such as storage facilities and pawn shops.

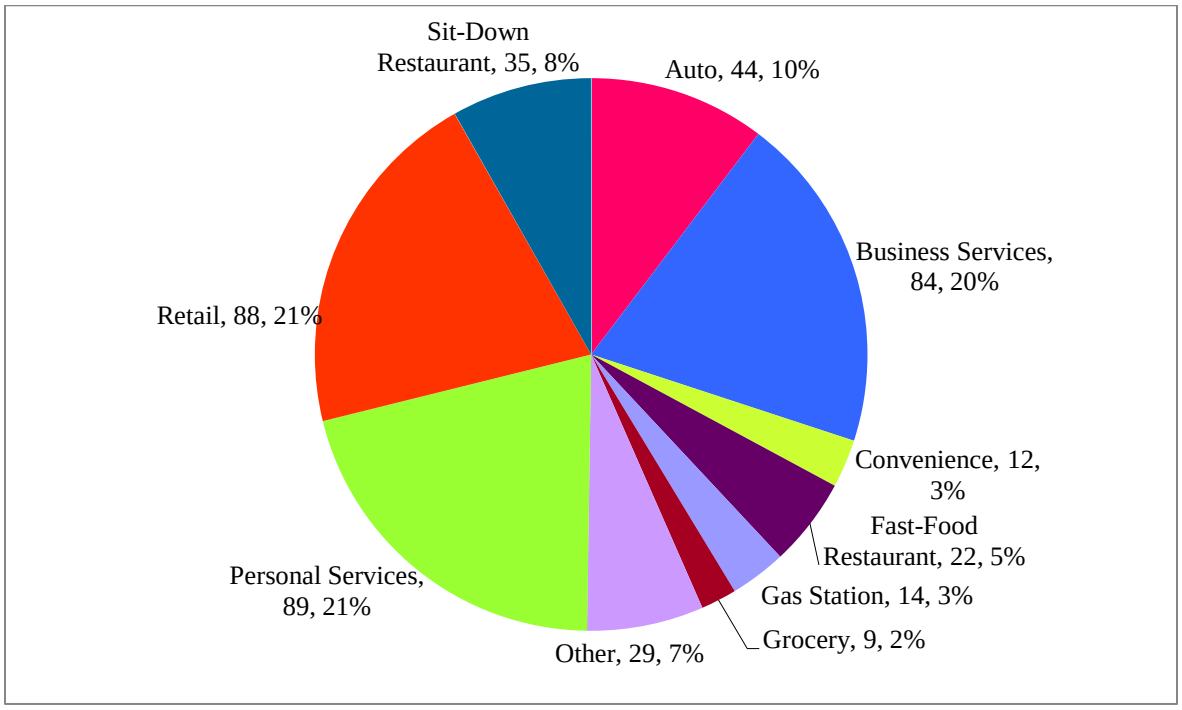

Figure 7-1: Businesses at the Interview Locations

Of the 426 businesses, 275 businesses were not included in the analysis due to one or more of the following reasons:

- business was recently established (i.e., after conversion from a TWLTL to a raised median),
- the interviewee was unaware of conversion, or
- the interviewee refused to participate.

In total, 151 (35.4 percent) qualified businesses participated in the interviews, and their responses are included in the analysis. Figure 7-2 gives the number of businesses by type that are included in the analysis.

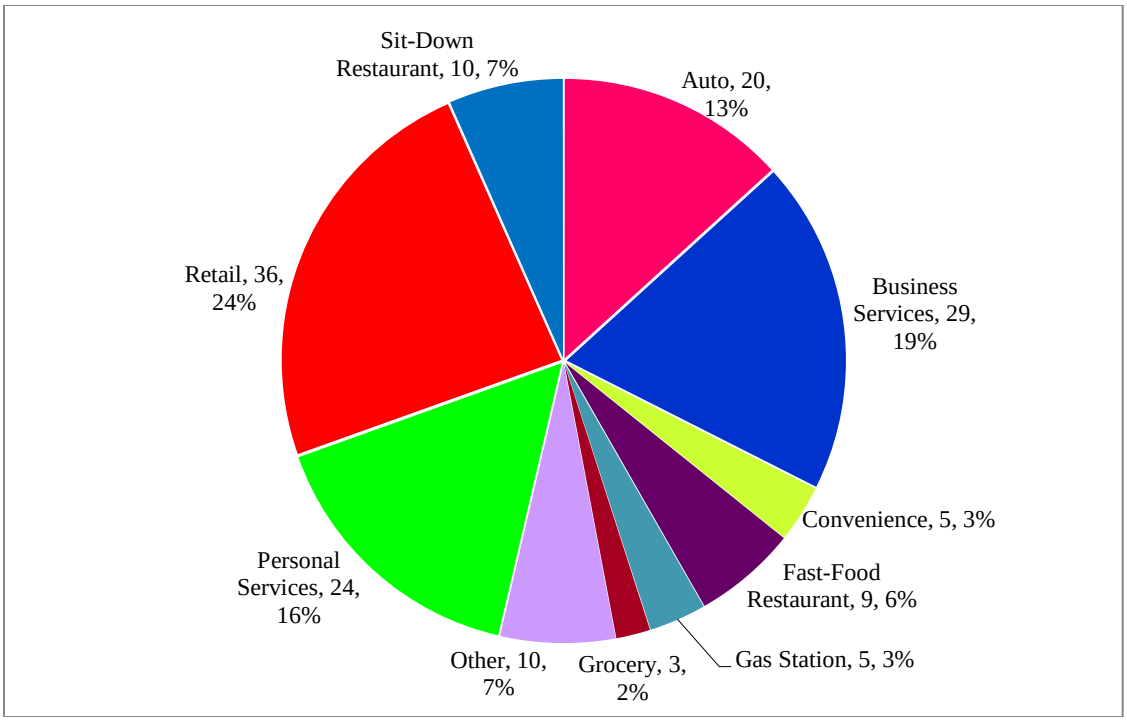

Figure 7-2: Businesses Included in the Analysis

Conversion from a TWLTL to a raised median mainly results in limited access to businesses. Businesses near signalized intersections are generally not affected by conversion since access to these businesses is through the intersection. Further, the effect of raised medians on businesses located at midblock locations is dependent on the access provided through median openings; businesses at midblock locations without median openings have very limited access. In other words, access to businesses at locations with raised medians decreases in the following order: signalized intersections, midblock locations with median openings, and midblock locations without median openings.

Table 7-2 gives the types of businesses included in the analysis by their location. Over half of the businesses that were included in the analysis (54.3 percent) were at midblock locations without median openings. That is, access to these businesses is provided at the downstream signalized intersection or at a median opening.

Table 7-2: Types of Businesses Included in the Analysis by Location

Business Type	Midblock with No Median Opening		Midblock with Median Opening		Signalized Intersection		Total (d)= (a)+(b)+(c)
	Number (a)	Percent of Total (a)/(d)	Number (b)	Percent of Total (b)/(d)	Number (c)	Percent of Total (c)/(d)	
Auto Services	15	75.0%	3	15.0%	2	10.0%	20
Business Services	15	51.7%	11	37.9%	3	10.3%	29
Personal Services	14	58.3%	4	16.7%	6	25.0%	24
Convenience Stores	2	40.0%	0	0.0%	3	60.0%	5
Fast-Food Restaurants	5	55.6%	3	33.3%	1	11.1%	9
Sit-Down Restaurants	4	40.0%	4	40.0%	2	20.0%	10
Gas Stations	0	0.0%	2	40.0%	3	60.0%	5
Grocery Stores	1	33.3%	1	33.3%	1	33.3%	3
Retail Stores	20	55.6%	11	30.6%	5	13.9%	36
Others	6	60.0%	3	30.0%	1	10.0%	10
Total	**82**	**54.3%**	**42**	**27.8%**	**27**	**17.9%**	**151**

7.2.2 Business Owners' Perception of Raised Medians

Q. Do you think there is a change in traffic after median construction? If so, why?

Table 7-3 gives the business owners' perception of change in traffic because of raised medians. After the construction of raised medians, 40 businesses believed that there was a change in traffic; on the other hand, a comparable number of businesses (33) believed that there was no change in traffic.

Table 7-3: Perception on Change in Traffic after Median Construction

Business Type	There is Change in Traffic After Median Construction	There is No Change in Traffic After Median Construction
Auto Services	8	4
Business Services	8	7
Personal Services	7	4
Convenience Stores	0	0
Fast-Food Restaurants	2	4
Sit-Down Restaurants	3	3
Gas Stations	1	0
Grocery Stores	1	1
Retail Stores	8	9
Others	2	1
Total	**40**	**33**

Table 7-4 gives the business owners' reasons for noticing change in traffic after conversion. Several businesses mentioned that there was a decrease in traffic after the construction of raised medians. A high 19 businesses at midblock locations mentioned that the traffic changed because

of lack of accessibility and inconvenience; on the other hand, only 4 businesses near signalized intersections quoted the same reason (i.e., lack of accessibility and inconvenience) for change in traffic.

Table 7-4: Business Owners' Reason for Change in Traffic after Median Construction

Reason for Change in Traffic	Midblock with No Median Opening	Midblock with Median Opening	Signalized Intersection	Total Businesses
Accessibility	5	5	2	12
Inconvenience	5	4	2	11
Less Customers	3	4	1	8
Major Impact	1	1	0	2
Not Sure	3	2	2	7
Total	**17**	**16**	**7**	**40**

Q. Do you believe your regular customers have remained about the same, are more likely, or have been less likely to visit your business due to the raised median?

Figure 7-3 gives the business owners' perception on change in number of regular customers after the construction of raised medians. Of the 147 businesses that responded, 88 mentioned that the raised medians had no influence on the number of customers that visited their businesses. In other words, the number of customers visiting their businesses remained the same before and after conversion from TWLTLs to raised medians. Over one-third of the responding businesses (55) thought that the customers were less likely to visit their business after conversion. Of the 82 businesses at midblock locations without median openings, 30 believed that the customers were less likely to visit their businesses, while 51 businesses thought that there was no change.

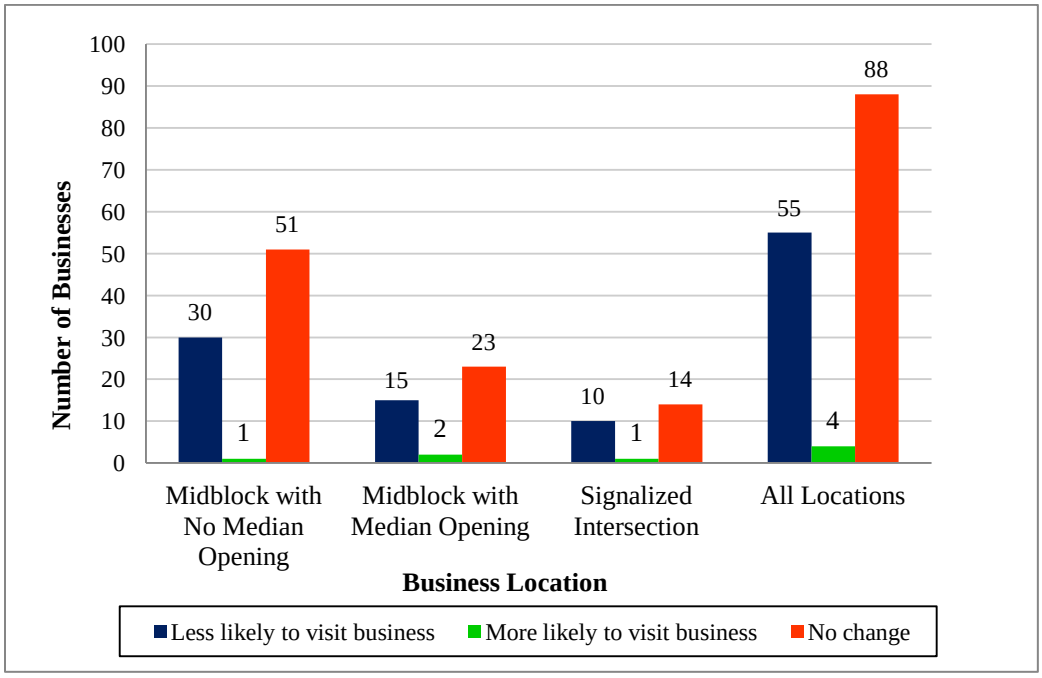

Figure 7-3: Perception on Change in Regular Customers After Median Construction

Q. Has the raised medians adversely affected truck deliveries to your business?

Access to delivery trucks is a main concern with access management as the construction of raised medians often limits truck accessibility. As shown in Figure 7-4, of the 78 responding businesses, 2 mentioned that they do not have truck deliveries; 21 businesses (i.e., 26.9 percent) mentioned that truck deliveries were adversely affected by raised medians. The rest of the businesses (55) had no problems/issues with accessibility to delivery trucks. As expected, a majority of the businesses who believed that truck deliveries were adversely affected by raised medians were located at midblock locations with no direct access through median openings or signalized intersections.

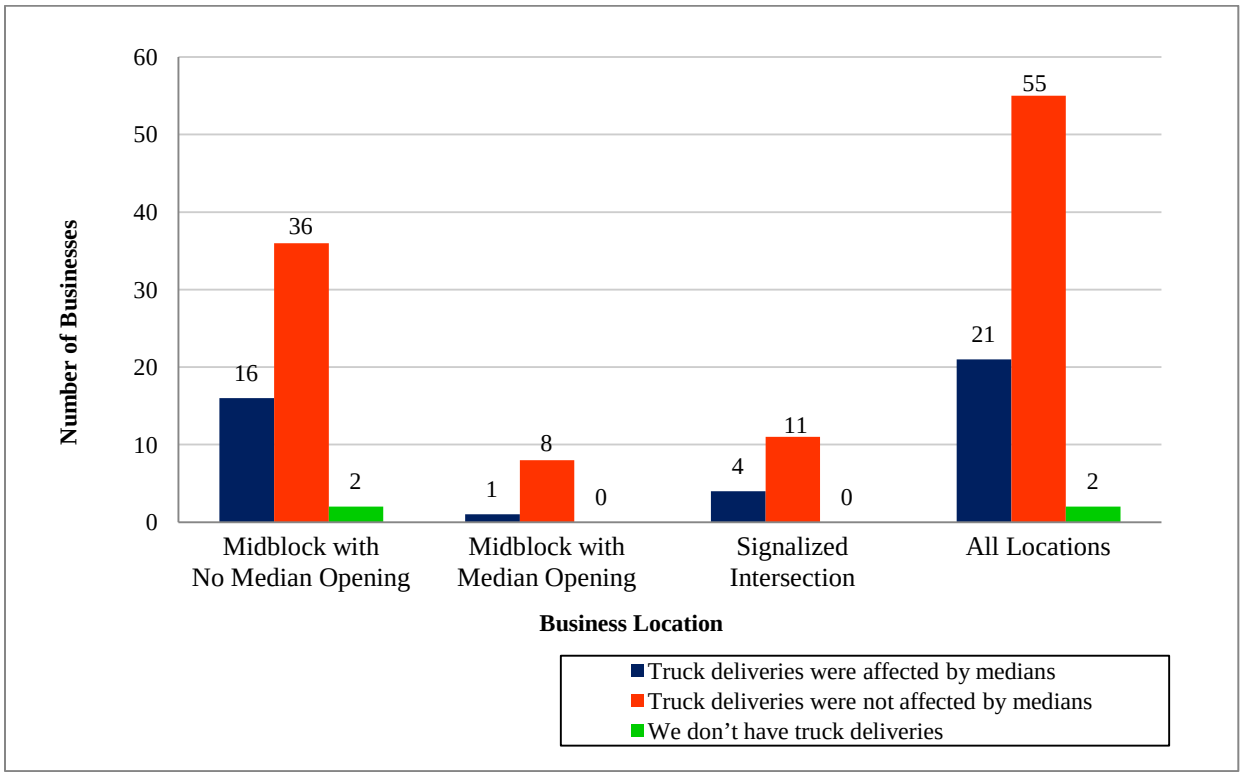

Figure 7-4: Effect of Raised Medians on Truck Deliveries

Q. After the median construction, how has the following changed? a) number of customers, b) traffic congestion, and c) property access.

The businesses rated the impact of raised medians on number of customers, traffic congestion, and property access using the following scale: *Increased or Improved*, *No Change*, *Decreased or Worsened*, and *Not Sure*. Table 7-5 gives the ratings of the businesses by their location.

After conversion from TWLTLs to raised medians, 37.3 percent of the responding businesses thought that the number of customers decreased. A relatively greater percentage of businesses at midblock locations with no direct access (i.e., with no median opening) (41.5 percent) believed that the number of customers decreased after conversion. These percentages are similar for businesses located near signalized intersections and at midblock locations with direct access

through median openings, at 33.3 percent and 31.7 percent, respectively. Over one-third of the businesses (54 out of 150) observed no change in the number of customers before and after the construction of raised medians. Also, several businesses were unable to determine if there had been a change in the number of customers after conversion.

Less than one-third of the responding businesses (30.0 percent) thought that traffic congestion worsened after conversion. The responses varied significantly based on the business location. As expected, 43.9 percent of businesses at midblock locations with median openings and 37.0 percent of businesses near signalized intersections believed that traffic congestion worsened. Very few businesses at midblock locations with no median openings (17 of 82) considered traffic congestion to have worsened after conversion. This is because of increased U-turn activity at median openings and signalized intersections.

Over half of the responding businesses (57.3 percent) thought that the raised medians decreased access to their property. Of the 150 responses, 57 thought that access to their property remained the same before and after conversion. Only three businesses thought that raised medians improved property access. As expected, a high 62.2 percent of businesses at midblock locations without median openings thought that access to their property decreased.

Table 7-5: Change in the Number of Customers, Traffic Congestion, and Property Access by Business Location

Business Location	Increased (a)	Remained Same (b)	Decreased (c)	Not Sure (d)	Total Responses (e)=(a)+(b)+(c)+(d)	Percent of Total That Worsened
Number of Customers						
Midblock with No Median Opening	5	28	34	15	82	41.5%[1]
Midblock with Median Opening	2	16	13	10	41	31.7%[1]
Signalized Intersection	1	10	9	7	27	33.3%[1]
All Locations	**8**	**54**	**56**	**32**	**150**	**37.3%[1]**
Traffic Congestion						
Midblock with No Median Opening	17	32	25	8	82	20.7%[2]
Midblock with Median Opening	18	12	9	2	41	43.9%[2]
Signalized Intersection	10	8	8	1	27	37.0%[2]
All Locations	**45**	**52**	**42**	**11**	**150**	**30.0%[2]**
Property Access						
Midblock with No Median Opening	1	28	51	2	82	62.2%[1]
Midblock with Median Opening	1	16	23	1	41	56.1%[1]
Signalized Intersection	1	13	12	1	27	44.4%[1]
All Locations	**3**	**57**	**86**	**4**	**150**	**57.3%[1]**

[1] calculated as (c)/(e); [2] calculated as (a)/(e).

Q. Do you think this roadway with raised median is safer than with TWLTL?

Figure 7-5 gives the business owners' perception of safety before and after conversion from TWLTLs to raised medians. Besides the percent of responding businesses, the figure also includes the number of responding businesses in parenthesis. Two-thirds of the responding businesses (66.7 percent) thought that raised medians were safer than TWLTLs. The percentages are very similar for businesses at midblock locations, at both with and without median openings. However, greater percentage of businesses near signalized intersections (73.3 percent) perceived raised medians to be safer than TWLTLs. Over one-fourth of the responding businesses (27.0 percent) thought that raised medians were not safer than TWLTLs. A small percentage of the responding businesses (6.3 percent) thought that there was no change in safety before and after conversion.

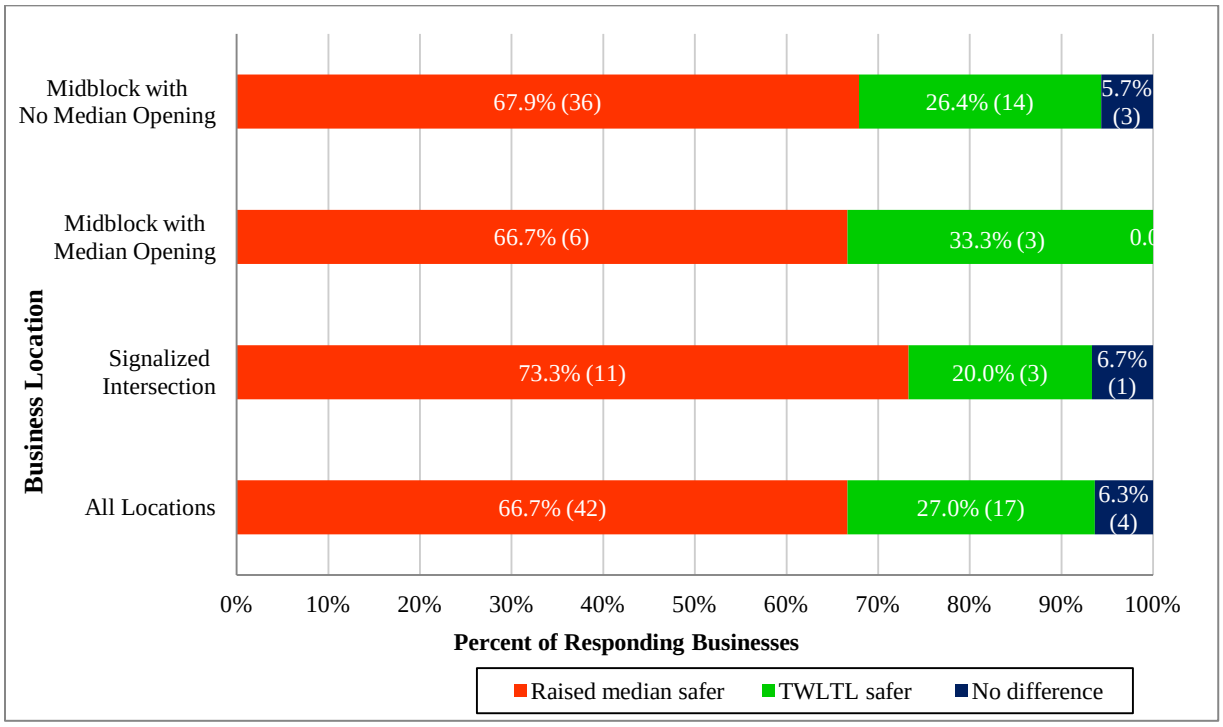

Figure 7-5: Perception of Safety Before-and-after Conversion

The following are the businesses' reasons for perceiving raised medians as safer compared to TWLTLs, where the number of businesses identifying each reason is indicated in parenthesis:

- raised medians have better access management (6),
- more crashes occurred before the construction of raised medians (4), and
- pedestrian safety improved after the construction of raised medians (1).

Again, the following are the businesses' reasons for perceiving raised medians as unsafe compared to TWLTLs, where the number of businesses identifying the reason is indicated in parenthesis:

- more crashes occurred after the construction of raised medians (9),
- U-turns increased after the construction of raised medians (4),
- TWLTLs had better access management (2), and
- raised medians are inconvenient (1).

Q. Do you perceive that the raised median has had a major impact, minor impact, or no impact on your business?

Figure 7-6 gives the business owners' perceived impact of raised medians on their businesses by business location. In the figure, the number in parenthesis gives the number of responding businesses. About half of the responding businesses (46.6 percent) thought that the medians had no impact on their business. Of the businesses at signalized intersections, 61.5 percent thought that the medians had no impact; this percentage is high compared to the businesses at midblock locations. Similarly, a smaller percentage of businesses near signalized intersections (15.4 percent) believed that medians had a major impact on their business. Among the businesses at midblock locations, a greater percentage of businesses at locations with no direct access through a median opening mentioned that medians had a major impact. These statistics show that the impact of raised medians on businesses is directly related to the access to the businesses, either through a median opening or a signalized intersection.

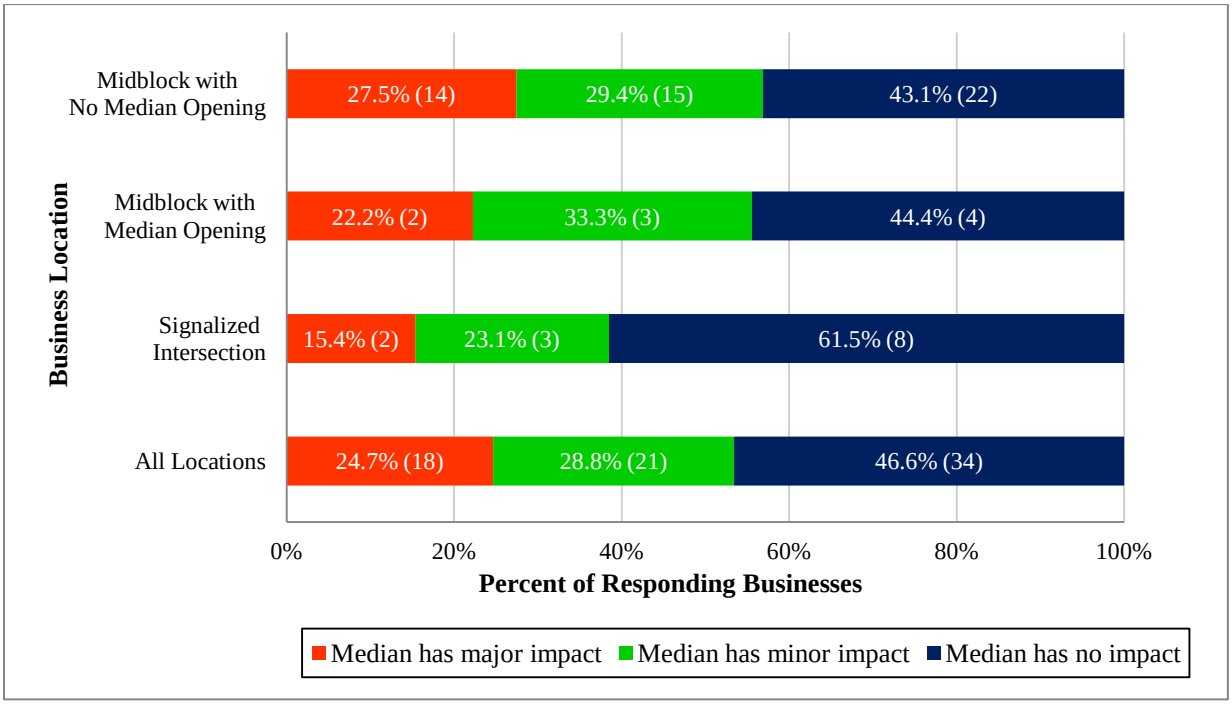

Figure 7-6: Impact of Raised Medians on Businesses by Business Location

Figure 7-7 gives the business owners' perceived impact of raised medians on their businesses by business type. Again, the number in parenthesis gives the number of responding businesses. Not surprisingly, a majority of gas stations and auto-service-related businesses thought that raised medians had a major impact on their businesses. On the other hand, a majority of business

services, such as, law firms, engineering firms, hospitals, etc., considered medians to have no impact on their businesses.

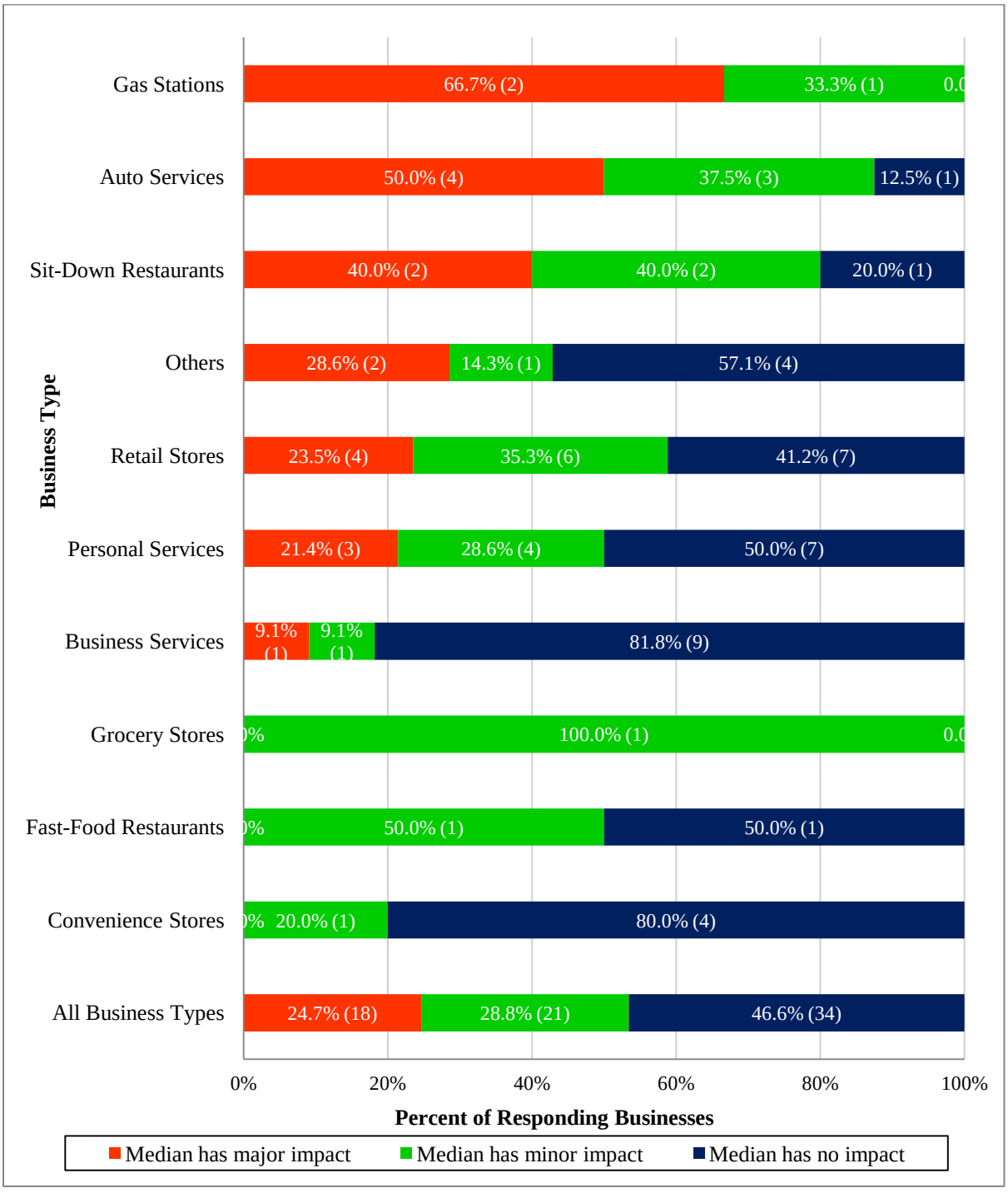

Figure 7-7: Impact of Raised Medians on Businesses by Business Type

Q. Do you prefer raised median or TWLTL? Why?

Figure 7-8 gives the percentage of businesses by their location and preference. Note that the number of responding businesses is given in parenthesis. Of the 148 responding businesses, 42.6 percent preferred raised medians while the rest (i.e., 57.4 percent) preferred TWLTLs. As expected, a relatively high 53.8 percent of businesses near signalized intersections preferred raised medians. This is because conversion from a TWLTL to a raised median does not generally impact access to the businesses at signalized intersections. Over two-thirds of businesses at midblock locations with direct access through median openings (67.5 percent) preferred TWLTLs to raised medians. This could be because a majority of these businesses believed that traffic congestion increased after conversion (as shown in Table 7-4).

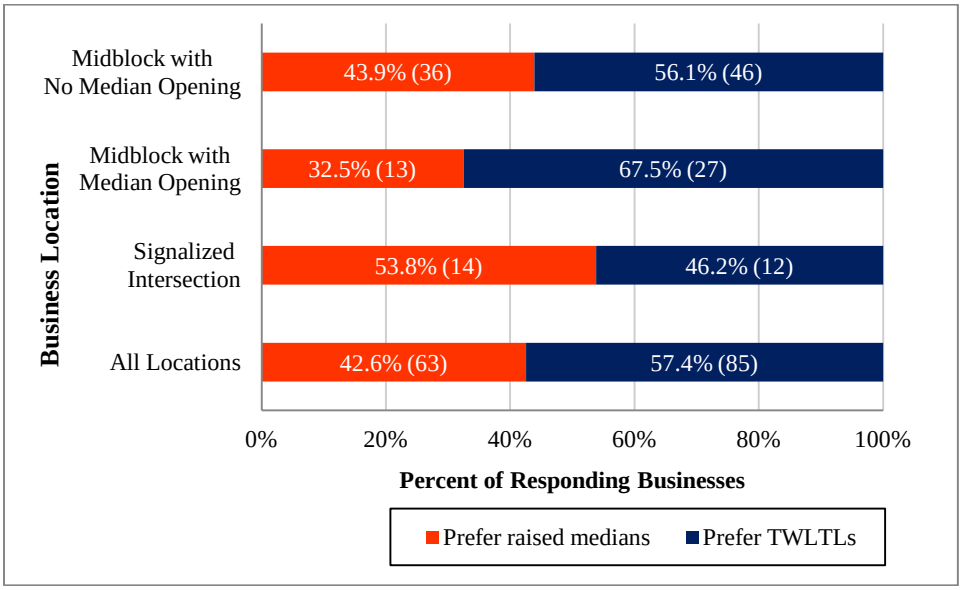

Figure 7-8: Preference of Raised Median or TWLTL by Business Location

Figure 7-9 gives the percentage of businesses by their type and preference. Again, the number of responding businesses is given in parenthesis. Over half of convenience stores and grocery stores preferred raised medians to TWLTLs; as expected, a majority of gas stations and auto services preferred TWLTLs. Except for the convenience stores, grocery stores, and personal service businesses (such as salon, spa, etc.), over 50 percent of all the other remaining business types preferred TWLTLs to raised medians.

Table 7-6 gives the reasons for preferring either a TWLTL or a raised median. A majority of businesses (49) preferred TWLTLs because of accessibility. Similarly, 11 businesses considered TWLTLs to be more convenient. Of the 52 businesses that preferred raised medians, 32 preferred because of improved safety. A significant number of businesses (14) preferred raised medians even though they considered raised medians to have no impact. Table 7-7 gives specific comments by businesses grouped by their preference (i.e., raised medians, TWLTLs, or no preference).

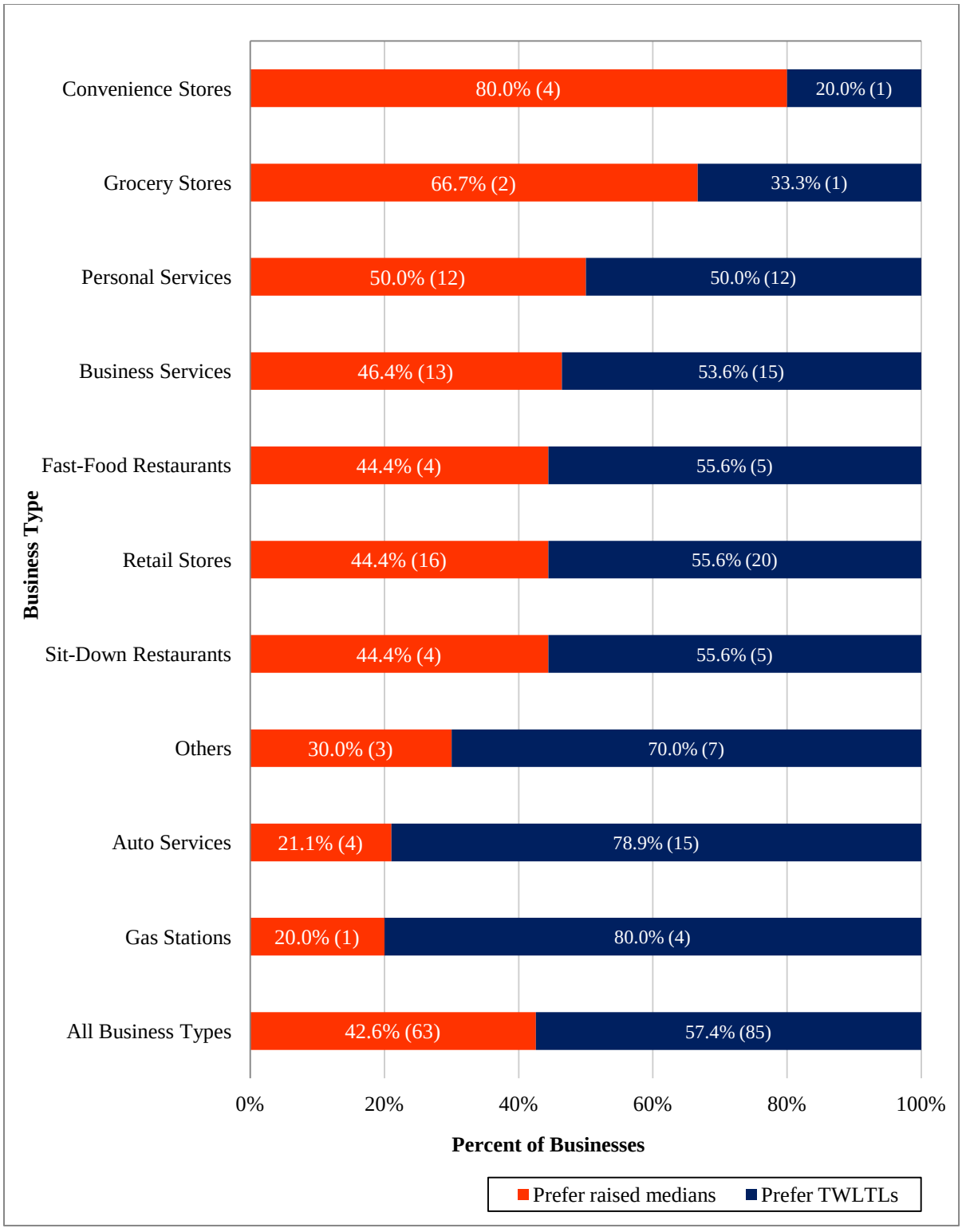

Figure 7-9: Preference of Raised Median or TWLTL by Business Type

Table 7-6: Business Owners' Reasons for Preference

Reason for Preference	Preferred Raised Median	Preferred TWLTL
Accessibility	0	49
Convenience	1	11
More Business	1	4
No Impact/No preference	14	0
Minor Impact	2	0
Poor Design of Median	0	1
Safety	32	7
Better Traffic Management	2	0
Total	**52**	**72**

Table 7-7: Business Owners' Comments by Location and by Preference

Comments from Business Owners Who Preferred Raised Medians	Comments from Business Owners Who Preferred TWLTLs	Comments from Business Owners Who Had No Preference
US 301, Riverview, Florida; Roadway ID: 10010000		
• No crash occurred in front of my business after conversion. • I understand the purpose of the median. • Owner requested access and was granted; I do not believe medians should be placed throughout the segment; it negatively affects Brandon Highway. • Semi trailers have difficulty entering; TWLTL was better. • Owner went to court to obtain a turn lane; added additional cost to the owner.	• U-turn activity has increased and increases travel distance. • Difficult to exit business; medians add 10 mins to travel time. • Emergency Medical Services (EMS) and fire truck cannot go through intersection. • Everything was better before raised median; raised medians are good for traffic, but bad for business. • Raised medians are good at certain places; medians need more openings. • Hassle for customers to access business. • Median impacts business negatively. • More accidents because of U-turns. • More dangerous; petitioned to state board; many businesses have closed down; overall negative impact. • No improvement in safety; does not like for business. • No normal access; the provided U-turn is poor design. • Not a wise decision to install median; no direct path. • Not safer because of U-turns; more rear-end crashes. • Median is causing accidents. • Safety hazard especially around Auto Zone; could have been designed better; speeds should have been reduced, but medians promote speeding.	• Difficult for EMS to enter. • Does not affect business at all. • Not sure of impact. • Overall no impact. • No impact and better business. • Raised median is a huge safety thing; not sure if it affects business.

Comments from Business Owners Who Preferred Raised Medians	Comments from Business Owners Who Preferred TWLTLs	Comments from Business Owners Who Had No Preference
	• Semi trucks have difficulty entering; TWLTL was better. • U-Turn is more dangerous; more potential for accidents. • Waste of money to install median.	
N Florida Avenue, Lakeland, Florida; Roadway ID: 16210000		
• Median construction was a waste of money. • Poor access.	• Difficult to exit the shopping center now; more traffic at the intersection; drivers are turning into the shopping center to make a left turn; the green time at the signal is not long enough. • Inconvenient to access; more cluttered; people riding on median. • Intersection hindering business; median is poorly designed; public were not considered. • Intersections are worst; should have NTOR; customer left business due to medians. • Loss of business; DOT removed opening to main road. • Poor design at intersections; have to provide midblock openings. • Terrible access management; bad for business. • The median construction affected truck business. • The original design was poorly designed. Many businesses on the East side were affected. They would prefer an access road into their business; After they remodeled the entrance, businesses picked up.	• Difficult for trucks to make a left turn; access is difficult; drivers do not follow the NTOR; more accidents.
N Orange Blossom Trail, Orlando, Florida; Roadway ID: 75020000		
• Removing bus parking affected the business to truck drivers; there are not enough bikes to have a separate bike lane, and it is not safe for the bicyclists.		
Semoran Blvd., Orlando, Florida; Roadway ID: 75030000		
• Median is safer for the school in the area. • Functional. • Intersection safety needs to be improved; please place NTOR signs. • Traffic light to make the U-turn is too long. • No better landscape; medians have been redone three times.	• Business has decreased by 50 percent. • Construction hurt their business; the trees cover the signs. • Drastic decrease in customers, prefer to have the median removed. • More accidents at the midblock; more illegal traffic for example turning left at a right turn only; U-turn signs are confusing as they are	• Do not like medians. • Inconvenient; access should be provided to shopping centers. • Median negatively affects business. • No impact.

Comments from Business Owners Who Preferred Raised Medians	Comments from Business Owners Who Preferred TWLTLs	Comments from Business Owners Who Had No Preference
• The constructed medians were not complete; would like for the medians to look nicer with vegetation. • The business has a lot of pedestrian and bus customers and so it is safer for our customers. • Have a new bus route to make it easier for our customers; prior to median construction, business was better but not safer. • The medians provide better sight distance now; major decrease in the number and the severity of accidents; the new medians make left turns easier; landlords are not forwarding the mail to business owners; the business owners feel as if they have no say in what goes on in the community. • There has been less accidents since the construction of the medians. • U-turns are difficult and not enough opportunities.	not clearly shown. • No change in safety. • No U-turn possible for a long distance and would like possible new left turn entrance. Received a letter about the construction but not about the public hearings. • Poor median design.	
E Hillsboro Blvd., Deerfield Beach, Florida; Roadway ID: 86120000		
• Poor traffic signaling.		
West Hallandale Beach Blvd., Hallandale, Florida; Roadway ID: 8620000		
• The roadway is safer but accessibility has decreased.	• More Traffic; dangerous for pedestrians; poor design.	• No impact. • Poor access; more dangerous.
Davie Blvd., Davie, Florida; Roadway ID: 86210000		
• Economy caused all foreclosures, not the median.	• Construction on 595 caused the business to lose some parking spaces.	• Difficult to access business. • Not enough space for U-turns in front of the businesses.
S 4th St/ US 1, Ft. Pierce, Florida; Roadway ID: 94010000		
• Better Safety • Customers go regardless of median • Nice, but more access is needed; increase in severity of accidents. • Restriction in sight distance • More U-turns	• Re-evaluate; poor design; it's a hassle. • Take it down; do not want it. • Business would do better without raised medians. • Cause inconvenience to customers. • High congestion; semi-trucks cannot enter. • Inconvenient. • Increase in accidents; accessibility issues. • Increase in accidents; increase in median crossovers.	• Better safety. • Inconvenient. • Inconvenient. • Increase in median crossovers; inconvenient; unsafe; confusing; terrible design. • No difference. • Poor design; dangerous; more accidents; bad engineering.

Comments from Business Owners Who Preferred Raised Medians	Comments from Business Owners Who Preferred TWLTLs	Comments from Business Owners Who Had No Preference
	• Fewer accidents. • Increase in median crossovers. • More accidents; poor design. • More turning bays are needed; dangerous; more accidents; like landscaping; poor sight distance. • More U-turns; unsafe. • Poor design; dangerous; more accidents; bad engineering. • Restriction in sight distance. • Safer; emergency vehicles cannot travel through. • Semi-trucks cannot enter. • Should be removed. • Terrible landscape; more accidents.	

7.2.3 Business Owners' Involvement in Public Hearings

Q. Were you informed of the availability of public hearings?

As shown in Figure 7-10, of the 151 businesses, 40 were informed of public hearings on the raised median construction project, while 64 were not informed of the scheduled public hearings. Also, a significant number of businesses (47) were not sure.

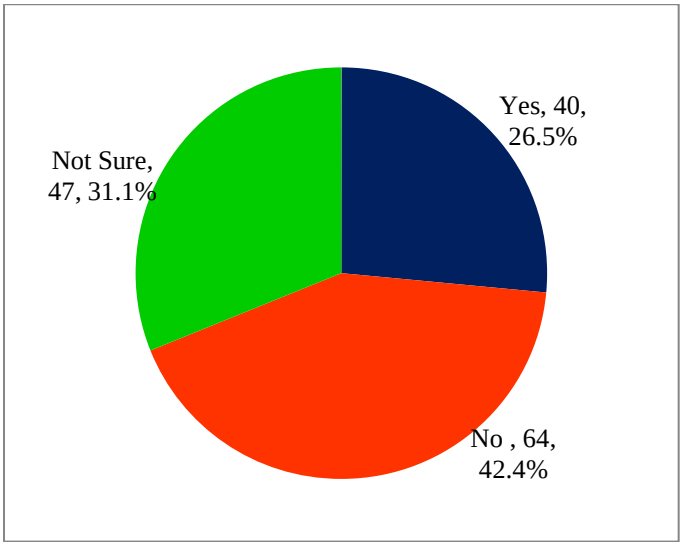

Figure 7-10: Informed of the Availability of Public Hearings

Q. Did you attend any public hearings for this median construction project? If yes, how many?

Of the 40 businesses that indicated that they were informed of public hearings, only 13 attended at least one public hearing. Slightly over half of the businesses (i.e., 21) that were aware of public hearings did not attend any. Of the 13, five considered the sessions to be helpful, and an

equal number of businesses considered them to be not helpful; two businesses thought that the sessions were somewhat helpful, while one was not sure. Seven of the 13 suggested that the officials should listen to the public. Of the 13 businesses that attended the hearings, 12 were informational and one was organized to collect public feedback.

7.3 Summary

A total of ten locations that were recently converted from TWLTLs to raised medians were identified. Of the 426 businesses that existed at these ten locations, 151 qualified businesses (i.e., businesses were established prior to conversion) responded to the interviews. The interview focused on two major areas: perception of business owners about raised medians and involvement of business owners in public hearing processes.

Major concerns about conversion from TWLTLs to raised medians include access to businesses; feasibility of truck deliveries; impact of conversion on number of customers, traffic congestion, and property access; and safety. The interview, therefore, focused on these concerns and on the business owners' involvement in public hearing processes.

A majority of the responding businesses preferred TWLTLs to raised medians mainly because TWLTLs provide more access. Only a small percentage of businesses located near signalized intersections believed that medians had an impact on their businesses. This is followed by businesses at midblock locations with median openings and, finally, by businesses at midblock locations without median openings. Further, as expected, gas stations and auto-service-related businesses mentioned that raised medians had a major impact on their businesses. Not surprisingly, a high majority of these business types (i.e., gas stations and auto-related businesses) preferred TWLTLs to raised medians.

Of the 88 responding businesses, 55 (62.5 percent) thought that customers were less likely to visit their business after conversion; not surprisingly, a majority (30) of these 55 businesses were at midblock locations with no direct access (i.e., no median opening).Similarly, of the 78 responding businesses, 21 (26.9 percent) were under the impression that truck deliveries were adversely affected by raised medians. In both cases, a majority of these responses were from businesses located at midblock locations without median openings.

Among the businesses at midblock locations without direct access, 41.5 percent thought that the number of customers decreased after conversion. A relatively high 62.2 percent indicated that access to their property decreased with median construction, and only 20.7 percent believed that traffic congestion increased after conversion. The statistics for businesses at midblock locations with median opening and near signalized intersections were similar; about one-third of the businesses in each category thought that the number of customers decreased after conversion. A relatively high percentage of businesses believed that traffic congestion increased, mainly because of increased U-turn activity. In terms of access to property, just over half of these businesses believed that access decreased after the raised median construction.

Of all the responding businesses, 66.7 percent thought that raised medians were safer than TWLTLs. Among the businesses near signalized intersections, 73.3 percent perceived raised

medians to be safer. Businesses identified better access management and improved pedestrian and vehicle safety as the two main reasons that raised medians were considered safer than TWLTLs.

Of the 151 businesses, 40 indicated that they were informed of public hearings on the raised median construction projects, while 65 indicated that they were not informed of the scheduled public hearings. Of the 40 businesses that were informed of the public hearings, only 13 indicated that they attended at least one public hearing. Of these, five considered the sessions to be helpful, and an equal number of businesses considered them to be not helpful. Also, seven of these businesses suggested that the officials should listen to the public.

CHAPTER 8
SUMMARY AND CONCLUSIONS

The main objective of this project is to address the following three questions:

1. What safety impacts have been realized and can be documented as the result of conversion from two-way left-turn lanes (TWLTLs) to raised medians on state roads in Florida?
2. What was the safety performance of raised medians under different roadway and median design features, such as number of lanes, speed limits, and types of median opening?
3. What was the experience of businesses on roadways that were recently converted from TWLTLs to raised medians and what was their involvement in the public information process?

Roadway segments that have been converted from TWLTLs to raised medians were identified by comparing the segments' median types in 2005 and 2010 RCI datasets. A total of 78 locations were identified and their construction periods were requested. Based on segment length and data availability, 18 locations totaling 17.51 miles were selected for before-and-after analysis. Police reports of all the crashes up to a maximum of 36 months before and after the median construction were downloaded and reviewed. The review focused on identifying the correct crash type and the underlying crash patterns. Close to one-fifth (18.7 percent) of crash types were determined to be incorrectly coded in the police reports. Median crossover, right-turn, and left-turn crashes were found to be miscoded the most often.

8.1 Before-and-After Comparisons

The before-and-after comparisons were performed based on crash rates for both individual locations and all locations combined. The comparisons were also performed for different crash types, crash severity, and facility types as they relate to number of lanes and speed limit. The Poisson test was performed for each of the comparisons. Table 8-1 shows that the total crash rate across all locations was reduced from 3.618 crashes per MVM to 2.523 crashes per MVM after median conversion, representing a 30.3 percent reduction in total crash rate. The reductions in crash rate of rear-end, angle, left-turn, right-turn, and total crashes were statistically significant at 5 percent significance level; the crash rate reductions for sideswipe, pedestrian, and bicycle crashes were statistically insignificant. There were too few head-on crashes to yield reliable conclusions. In terms of crash severity, there was a statistically significant reduction in PDO and injury crash rates, and no significant reduction in fatal crash rate was observed after median conversion.

8.2 Site-Specific Review

Of the 18 locations analyzed, six locations where safety either improved or deteriorated significantly were selected for site-specific review. Table 8-2 lists the six locations chosen for site-specific analysis. Of the three locations that either worsened or improved only slightly, the 1.019-mile section on West Tennessee Street in Leon County did particularly poorly; the median conversion resulted in 133.5 percent increase in total crash rate. This four-lane urban arterial

experienced over 400 percent increase in rear-end crash rate and over 200 percent increase in left-turn crash rate. However, from the review of police reports, it was observed that a majority of crashes in the after period could not be attributed directly to the conversion.

Table 8-1: Summary Statistics by Crash Type and Crash Severity

	Crash Rate[a] in the Before Period	Crash Rate[a] in the After Period	Percent Change in Crash Rate	R Value Based on Poisson Test	Significance
Crash Type					
Head-On[b]	0.027	0.014	-48.8%	---	---
Rear-End	1.374	1.140	-17.0%	7.4%	Significantly reduced
Angle	0.595	0.354	-40.5%	11.4%	Significantly reduced
Left-Turn	0.684	0.225	-67.1%	10.6%	Significantly reduced
Right-Turn	0.112	0.074	-33.9%	27.0%	Significantly reduced
Sideswipe	0.214	0.178	-17.0%	19.1%	No significant change
Pedestrian	0.091	0.064	-28.9%	30.1%	No significant change
Bicycle	0.078	0.074	-4.5%	34.0%	No significant change
All Crashes	**3.618**	**2.523**	**-30.3%**	**4.6%**	**Significantly reduced**
Crash Severity					
PDO	1.650	1.224	-25.8%	6.8%	Significantly reduced
Injury	1.941	1.279	-34.1%	6.4%	Significantly reduced
Fatal	0.027	0.021	-22.2%	60.8%	No significant change
F+I	1.969	1.299	-34.0%	6.3%	Significantly reduced
Total	**3.618**	**2.523**	**-30.3%**	**4.6%**	**Significantly reduced**

[a] Crash rate is in crashes per MVM.
[b] Sample size is too small.

Table 8-2: Locations Chosen for Site-Specific Analysis

Dist.	County	Roadway Name	Roadway ID	No. of Lanes	Seg. Len. (mi)	Before Crash Rate	After Crash Rate	Percent Change in Crash Rate
Locations That Either Worsened or Improved Slightly								
3	Leon	W Tennessee St	55060000	4	1.019	1.565	3.653	133.5%
6	Miami-Dade	W Okeechobee Rd	87090000	6	1.268	2.742	2.452	-10.6%
4	St. Lucie	US 1	94010000	4	0.910	2.217	1.834	-17.3%
Locations That Improved Significantly								
3	Leon	Capital Cir NW	55002000	6	0.948	8.160	3.122	-61.7%
5	Marion	SW 17th Street	36004000	4	0.314	1.906	0.803	-57.8%
6	Miami-Dade	Biscayne Blvd.	87030000	4	1.204	4.364	2.276	-47.8%

Of the two remaining locations, the 1.268-mile section along West Okeechobee Road in Miami-Dade County experienced a reduction in total crash rate of 10.7 percent. Again, very few crashes after the median conversion could be attributed directly to the raised median. Further, of the 181 crashes that occurred after the conversion, only three occurred at median openings.

Finally, the 0.910-mile section on US 1 in St. Lucie County experienced a 17.3 percent reduction in total crash rate after conversion from a TWLTL to a raised median. Angle, left-turn, and sideswipe crashes were completely eliminated after conversion. As expected, the conversion resulted in an increase in rear-end crash rate. Also, bicycle crash rate increased; however, the increase could not be attributed directly to the conversion.

The three locations that improved significantly had a minimum of 47.8 percent reduction in total crash rate after conversion. In general, the three locations experienced a reduction in most of the crash types. However, the location along Biscayne Blvd. in Miami-Dade County experienced an unusually high 516.2 percent increase in right-angle crash rate after conversion; review of police reports of these crashes revealed no direct impact of raised medians on these crashes. Further, this location experienced nine crashes at the full median opening.

8.3 Evaluation of Specific Design Features and Safety Concerns

The safety performance of four types of median openings at four-lane and six-lane facilities was evaluated. Police reports were reviewed to identify crashes that were directly related to median openings. The results showed that uni-directional median opening on a four-lane facility was the safest and full median opening with left-turn bays on both directions on a six-lane facility was the least safe. Among the three types of full median openings, the "bi-directional median opening with center island" type was found to be the safest. Further, compared to four-lane facilities, crash rates at median openings on six-lane facilities were consistently higher. Figure 8-1 gives the crash rates at different median opening types at four-lane and six-lane urban arterials.

Before-and-after crash summary statistics showed that four-lane urban arterials had a mere 4.7 percent reduction in total crash rate after conversion, while six-lane facilities experienced a 37.2 percent reduction. From these statistics, it could be inferred that conversion resulted in a greater overall safety benefit for six-lane facilities compared to four-lane facilities. At four-lane facilities, conversion resulted in a reduction in crash rate for all crash types except for rear-end, pedestrian, and other crashes. Specific reasons for increase in crash rates of these crash types could not be identified. However, review of police reports indicated that a majority of this increase could not be attributed directly to median conversion. Similarly, low-speed and high-speed roadways were analyzed separately; after conversion, total crash rates at low-speed and high-speed roads reduced by 31.8 percent and 26.5 percent, respectively.

Compared to TWLTLs, raised medians often do not provide enough lateral clearance for errant vehicles. Therefore, one of the safety concerns of constructing raised medians is the frequency of vehicles that directly hit the median curb before stopping or resulting in secondary crashes. Of the 2,436 crashes that occurred at the 18 locations after median conversion, only about 2.0 percent involved vehicles directly hitting the median curb; 31.3 percent of these crashes occurred at signalized intersections. A majority of these crashes were not severe. Additionally, of the 2,436 crashes that occurred after median conversion, 1.6 percent involved vehicles crossing over the median. Further, four-lane facilities were found to have a greater proportion of median crossovers compared to six-lane facilities. Table 8-3 gives median crossover crash statistics by crash severity at four-lane and six-lane facilities.

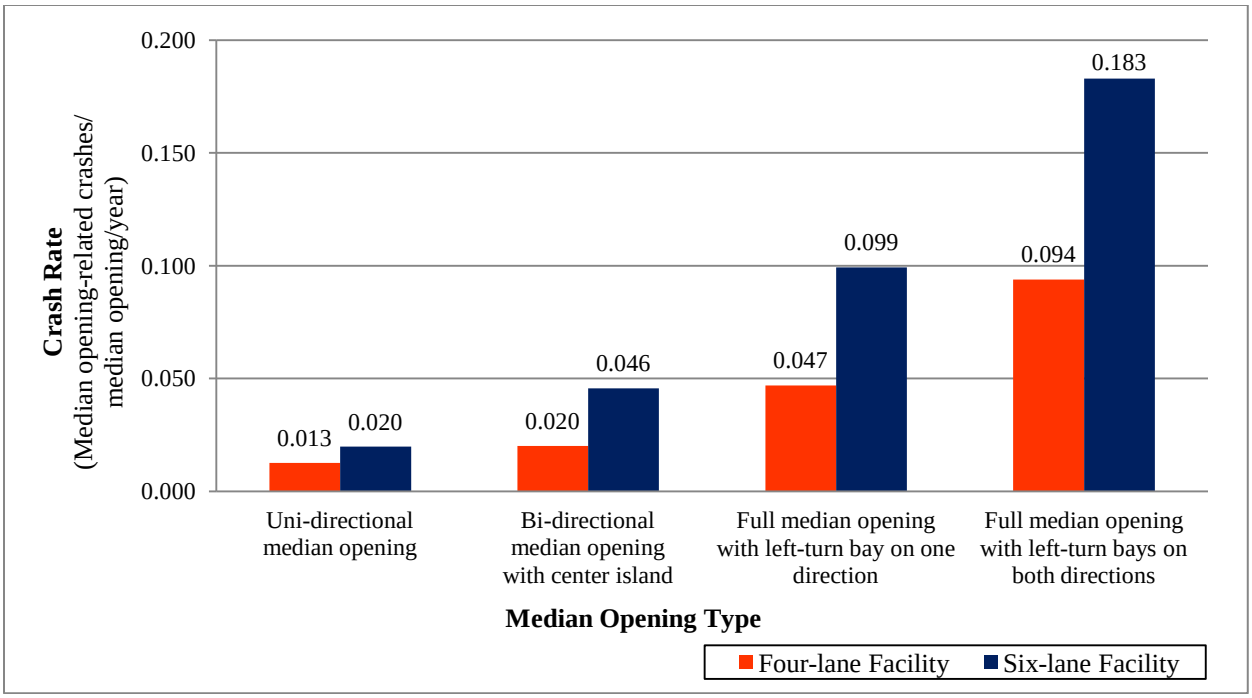

Figure 8-1: Crash Rate at Different Median Opening Types by Roadway Facility

Table 8-3: Median Crossover Crash Statistics by Crash Severity

Crash Severity	Four-lane Facilities		Six-lane Facilities		Total	
	No. of Crashes	Percent of Crashes	No. of Crashes	Percent of Crashes	No. of Crashes	Percent of Crashes
PDO	6	42.9%	14	58.3%	20	52.6%
Injury	8	57.1%	10	41.7%	18	47.4%
Fatal	0	0.0%	0	0.0%	0	0.0%
Total	**14**	**100.0%**	**24**	**100.0%**	**38**	**100.0%**

By providing pedestrian refuge areas, raised medians are considered a potential improvement to pedestrian safety. The before-and-after pedestrian crash statistics showed a 28.9 percent reduction in pedestrian crash rate after median conversion, from 63 crashes in the before period to 46 crashes in the after period. None of these 46 pedestrians were hit while standing on the raised median.

8.4 Interviews of Businesses

A total of ten locations that were recently converted from TWLTLs to raised medians were identified. Of the 426 businesses that existed at these ten locations, 151 businesses responded to the interviews. Of the 151 businesses, 82 were at midblock locations without median openings (i.e., with limited access), 42 were at midblock locations with median openings, and 27 were at signalized intersections. The interview focused on two major areas: perception of business owners about raised medians and involvement of business owners in public hearing processes.

Major concerns about conversion from TWLTLs to raised medians include access to businesses; feasibility of truck deliveries; impact of conversion on number of customers, traffic congestion, and property access; and safety. The interview, therefore, focused on these concerns and on the business owners' involvement in public hearing processes.

A majority of the responding businesses preferred TWLTLs to raised medians mainly because TWLTLs provide more access. Several businesses preferred raised medians if they were well designed with sufficient number of median openings. Several businesses mentioned that there was a decrease in traffic after conversion from TWLTLs to raised medians, and the main reason was accessibility.

Only a small percentage of businesses located near signalized intersections believed that medians had an impact on their businesses. This is followed by businesses at midblock locations with median openings and, finally, by businesses at midblock locations without median openings. Further, as expected, gas stations and auto-service-related businesses mentioned that raised medians had a major impact on their businesses. Also, a high majority of these business types (i.e., gas stations and auto-related businesses) preferred TWLTLs to raised medians.

Of the 88 responding businesses, 55 (62.5 percent) thought that customers were less likely to visit their business after conversion; not surprisingly, a majority (30) of these 55 businesses were at midblock locations with no direct access (i.e., no median opening). Similarly, of the 78 responding businesses, 21 (26.9 percent) were under the impression that truck deliveries were adversely affected by raised medians. Again, a majority (16) of these 21 businesses were at midblock locations without median openings.

Among the businesses at midblock locations without direct access, 41.5 percent thought that the number of customers decreased after conversion. A relatively high 62.2 percent mentioned that access to their property decreased with median construction, and only 20.7 percent believed that traffic congestion increased after conversion.

The statistics of businesses at midblock locations with median opening and near signalized intersections were similar; about one-third of the businesses in each category thought that the number of customers decreased after conversion. A relatively high percentage of businesses believed that traffic congestion had increased mainly due to increased U-turn activity. In terms of access to property, just over half of these businesses believed that access decreased after the raised median construction.

Of all the responding businesses, 66.7 percent thought that raised medians were safer than TWLTLs. Among the businesses located near signalized intersections, 73.3 percent perceived raised medians to be safer. Businesses identified better access management and improved pedestrian and vehicle safety as the two main reasons that raised medians were considered safer than TWLTLs. However, some businesses were under the impression that more crashes had occurred after the construction of raised medians. Table 8-4 gives the reasons for preferring either a raised median or a TWLTL.

Table 8-4: Business Owners' Reasons for Preferring Raised Median or TWLTL

Reason for Preference	Preferred Raised Median	Preferred TWLTL
Accessibility	0	49
Convenience	1	11
More Business	1	4
No Impact/No preference	14	0
Minor Impact	2	0
Poor Design of Median	0	1
Safety	32	7
Better Traffic Management	2	0
Total	**52**	**72**

Of the 151 businesses, 40 indicated that they were informed of public hearings on the raised median construction projects, while 65 indicated that they were not informed of the scheduled public hearings. Of the 40 businesses that were informed of the public hearings, only 13 indicated that they attended at least one public hearing. Of these, five considered the sessions to be helpful, and an equal number of businesses considered them to be not helpful. Also, seven of these businesses suggested that the officials should listen to the public.

8.5 Summary of Key Findings

Based on the before-and-after analysis of 18 locations in this study, it was found that:

- Close to one-fifth (18.7 percent) of crash types were determined to be incorrectly coded in the police reports. This inaccuracy, if not corrected, could skew the results of the safety performance evaluation.

- Overall, a 30.3 percent reduction in total crash rate was observed after the conversion from a TWLTL to a raised median. Based on the corrected crash types, the reductions in crash rate of rear-end, angle, left-turn, right-turn, and total crashes were statistically significant; the crash rate reductions for sideswipe, pedestrian, and bicycle crashes were statistically insignificant. There were too few head-on crashes to yield reliable conclusions. In terms of crash severity, there was a statistically significant reduction in PDO and injury crash rates.

- Review of three locations that performed particularly poorly after median conversion revealed that a majority of crashes in the after period could not be attributed directly to raised medians.

- Based on median-opening-related crashes, uni-directional median opening on a four-lane facility was found to be the safest and full median opening with left-turn bays on both directions on a six-lane facility was found to be the least safe. For example, for four-lane facilities, annual crash rate per median opening at full median openings with left-turn bays on both directions (0.094 median-opening-related crashes) is over seven times the

annual crash rate per median opening at uni-directional median openings (0.013 median-opening-related crashes).

- After conversion from TWLTLs to raised medians, four-lane facilities experienced a 4.7 percent reduction in total crash rate compared to 37.2 percent reduction on six-lane arterials.

- Of the 2,436 crashes that occurred at the 18 study locations after median conversion through December 2010, only 2.0 percent (48 crashes) were caused by vehicles hitting the median curb. Further, 38 of these 48 crashes crossed over the median.

- The before-and-after pedestrian crash statistics showed a 28.9 percent reduction in pedestrian crash rate after median conversion, from 63 crashes in the before period to 46 crashes in the after period. Of these 46 crashes, none of the pedestrians were hit while standing on the raised median.

From the on-site interview responses from 151 businesses located along the ten corridors that were recently converted from TWLTLs to raised medians, it was found that:

- Of the 63 responding businesses, 66.7 percent thought that raised medians were safer than TWLTLs. Among the businesses located near signalized intersections, 73.3 percent perceived raised medians to be safer. Businesses identified better access management and improved pedestrian and vehicle safety as the two main reasons to consider raised medians as being safer than TWLTLs.

- A majority of businesses (68.0 percent) that preferred TWLTLs cited accessibility as the main reason for their preference. Likewise, a majority of businesses (61.5 percent) that preferred raised medians cited safety as the main reason for their preference.

- Only a small percentage of businesses located near signalized intersections believed that medians had an impact on their businesses. This is followed by businesses at midblock locations with median openings and, finally, by businesses at midblock locations without median openings. Further, as expected, gas stations and auto-service-related businesses mentioned that raised medians had a major impact on their businesses.

- Of the 151 businesses, 40 indicated that they were informed of public hearings on the raised median construction projects, while 65 indicated that they were not informed of the scheduled public hearings. Of the 40 businesses that were informed of the public hearings, only 13 indicated that they attended at least one public hearing.

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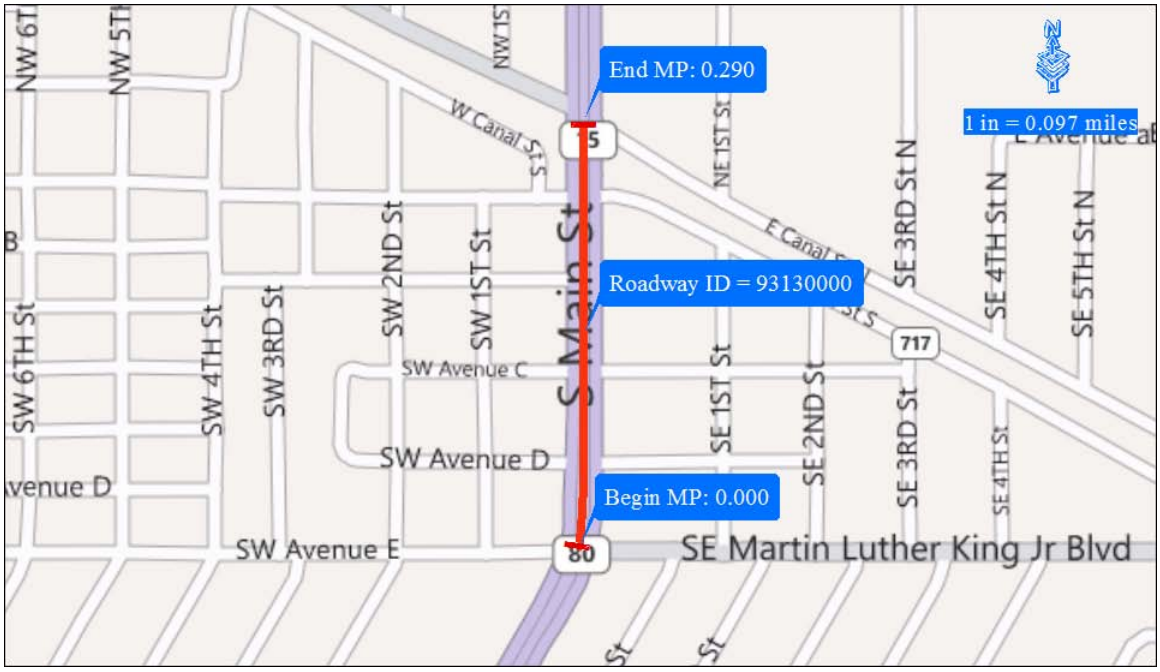
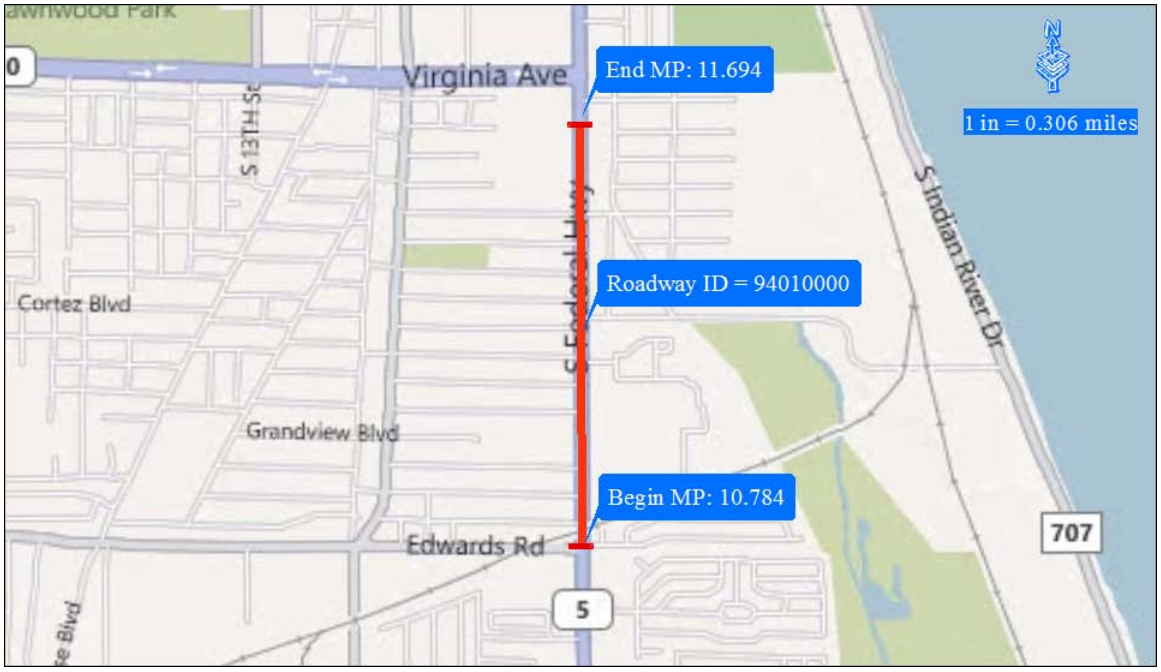
APPENDIX A
STREET AND SATELLITE MAPS OF STUDY LOCATIONS FOR BEFORE-AND-AFTER ANALYSIS

District 3: Caroline St. / US 90 (click for Google Maps location)
Roadway ID = 58010000, MP: 16.053 - 16.313 (Length = 1373 feet)
Construction Period: 8/2/2004 - 10/13/2007

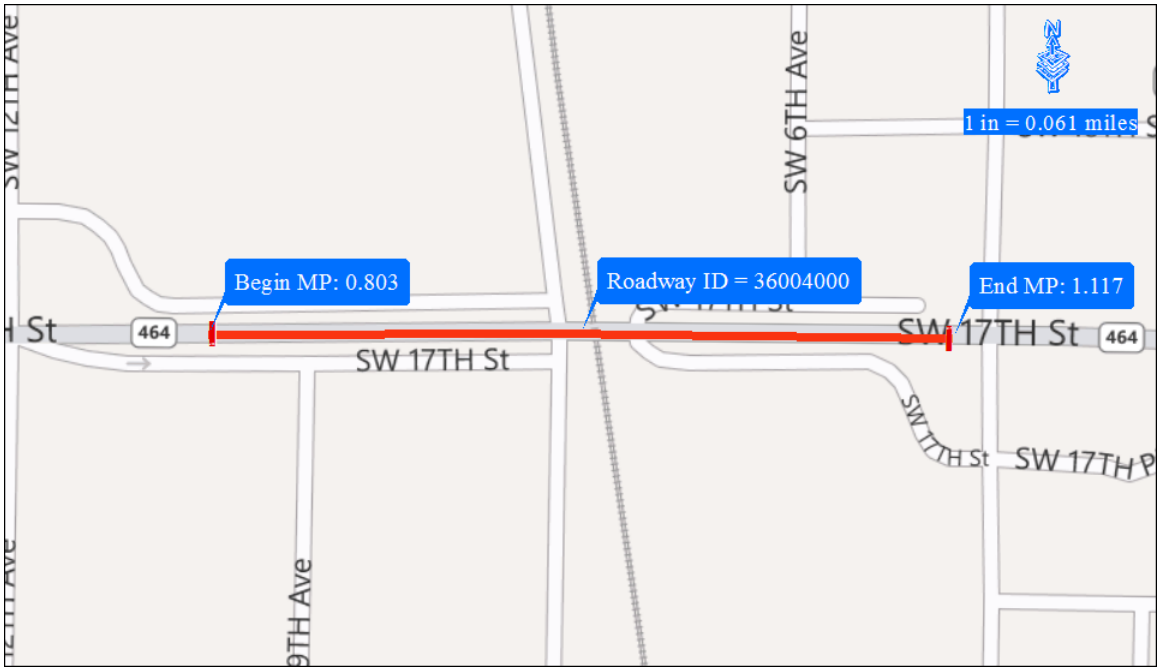
District 4: S Main St. / E SR 80 (click for Google Maps location)
Roadway ID = 93130000, MP: 0.000 - 0.290 (Length = 1531 feet)
Construction Period: 4/30/2007 - 3/24/2008



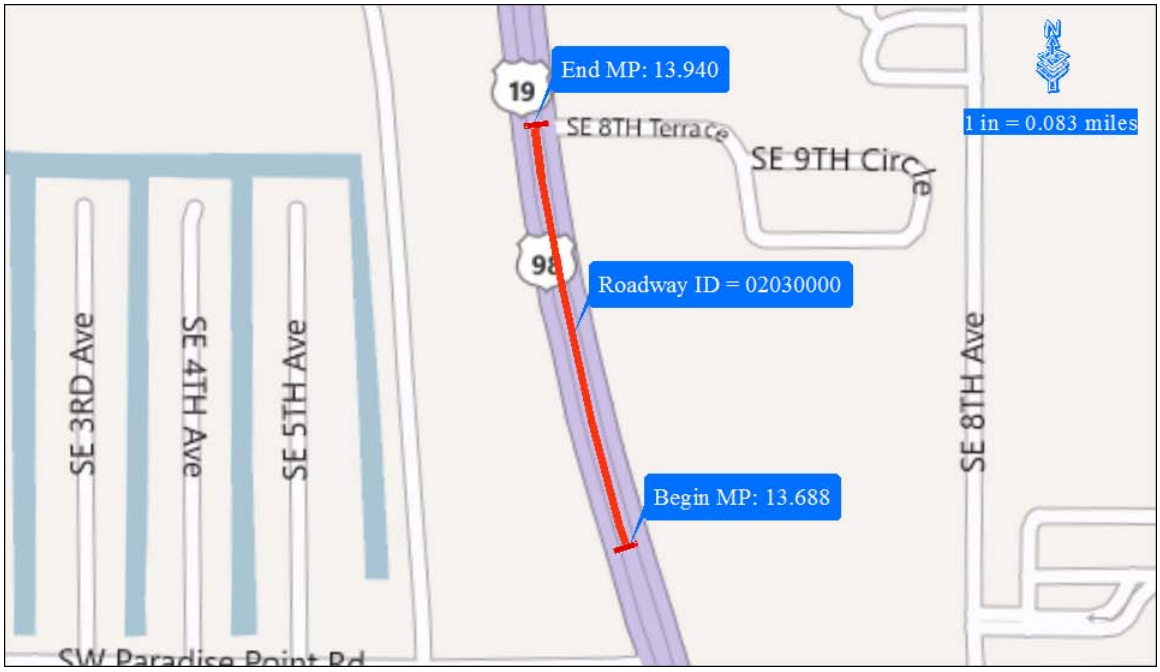
District 4: S 4th St. / US 1 (click for Google Maps location)
Roadway ID = 94010000, MP: 10.784 - 11.694 (Length = 4805 feet)
Construction Period: 7/21/2008 - 6/22/2009



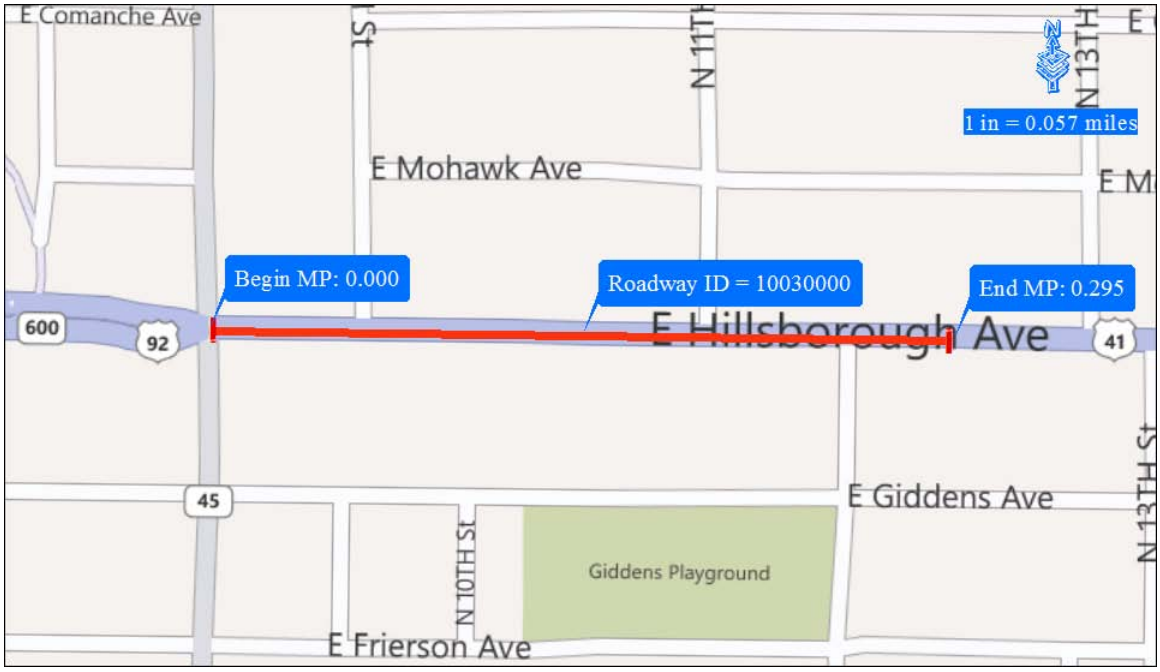
District 5: SW 17th St. (click for Google Maps location)
Roadway ID = 36004000, MP: 0.803 - 1.117 (Length = 1658 feet)
Construction Period: 12/3/2007 - 4/18/2009



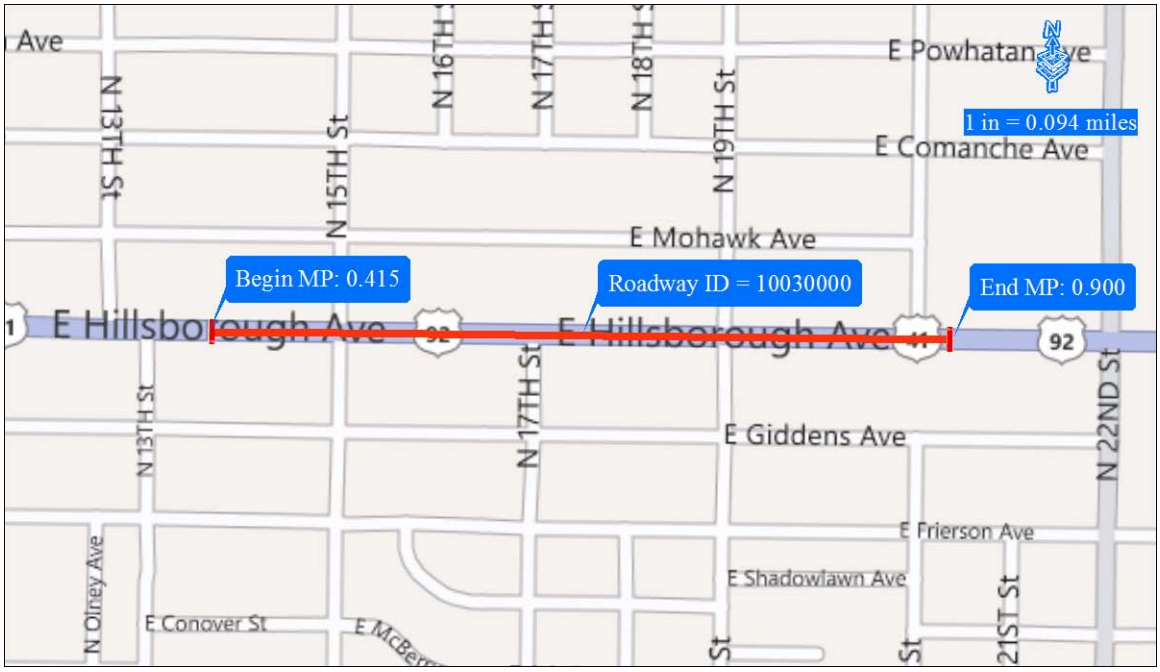
District 7: N Suncoast Blvd. (click for Google Maps location)
Roadway ID = 02030000, MP: 13.688 - 13.940 (Length = 1331 feet)
Construction Period: 11/3/2006 - 8/3/2007



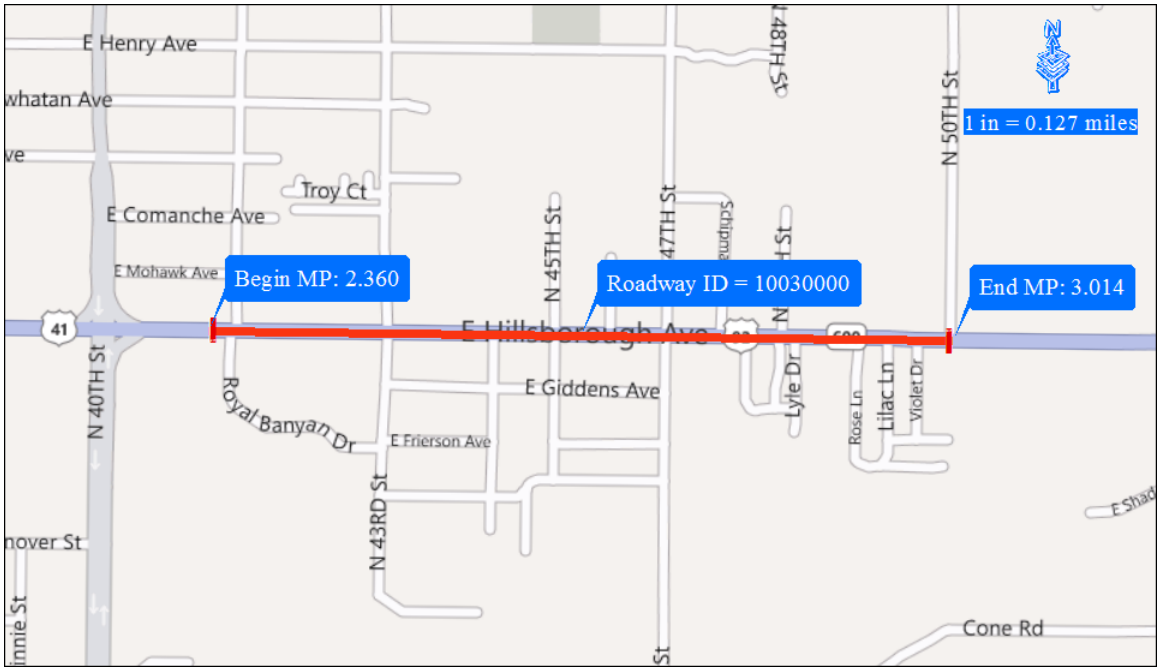
District 7: E Hillsborough Ave (click for Google Maps location)
Roadway ID = 10030000, MP: 0.000 - 0.295 (Length = 1558 feet)
Construction Period: 7/30/2007 - 1/14/2008



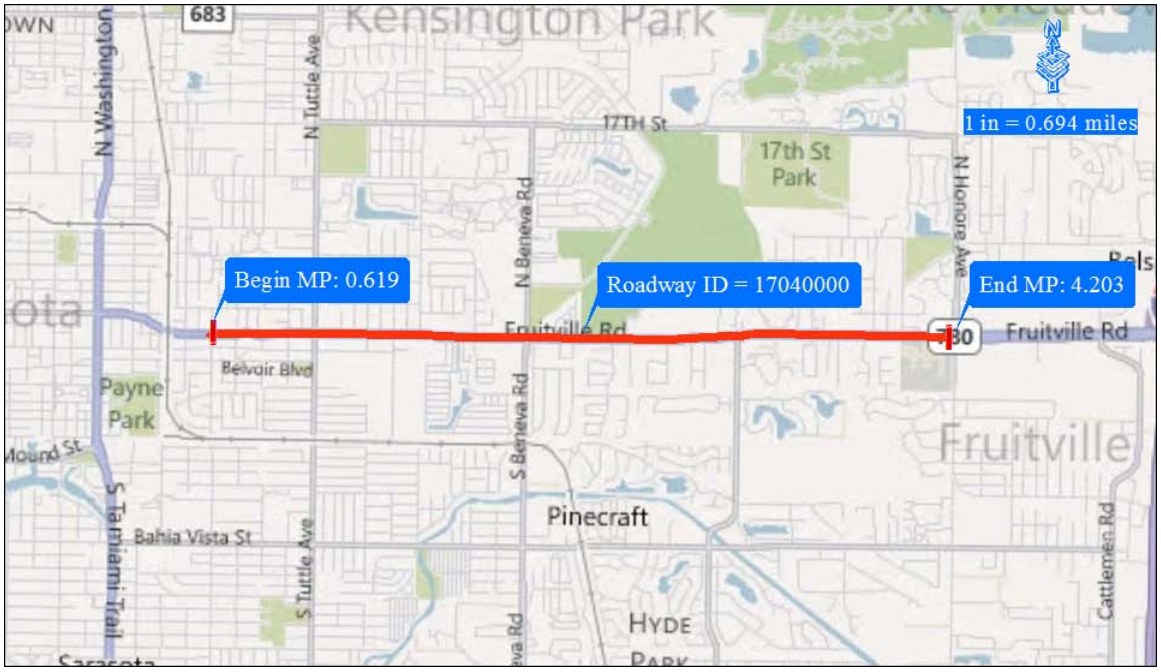
District 7: E Hillsborough Ave (click for Google Maps location)
Roadway ID = 10030000, MP: 0.415 - 0.900 (Length = 2561 feet)
Construction Period: 7/30/2007 - 1/14/2008

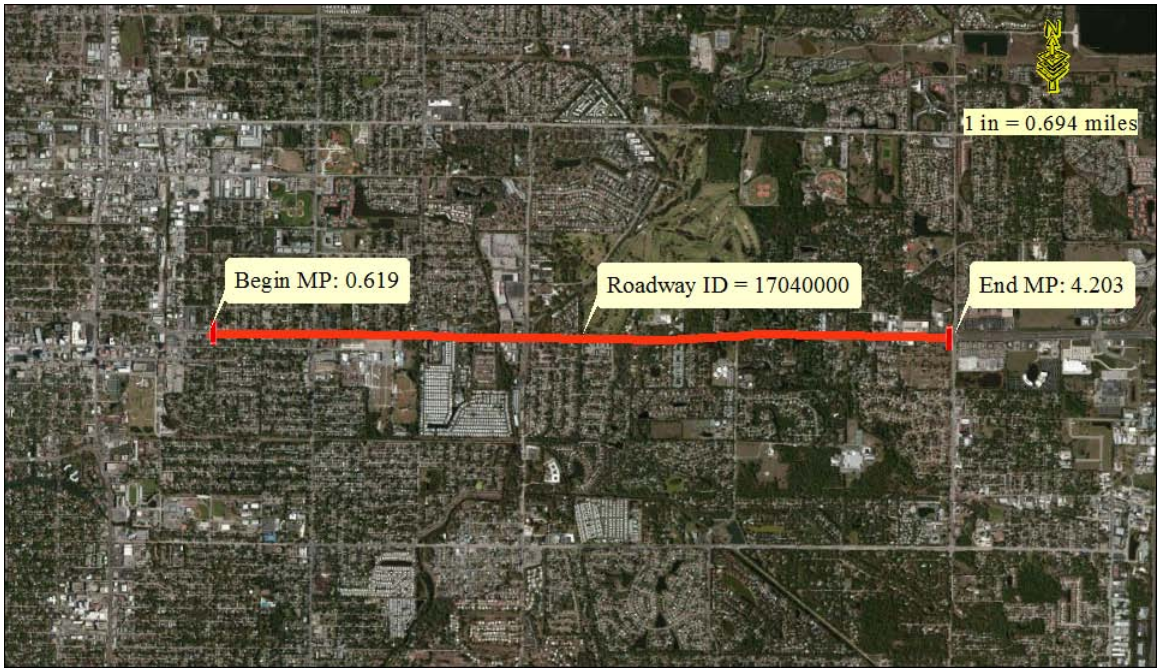


District 7: E Hillsborough Ave (click for Google Maps location)
Roadway ID = 10030000, MP: 2.360 - 2.840 (Length = 2534.4 feet)
Construction Period: 7/30/2007 - 1/14/2008

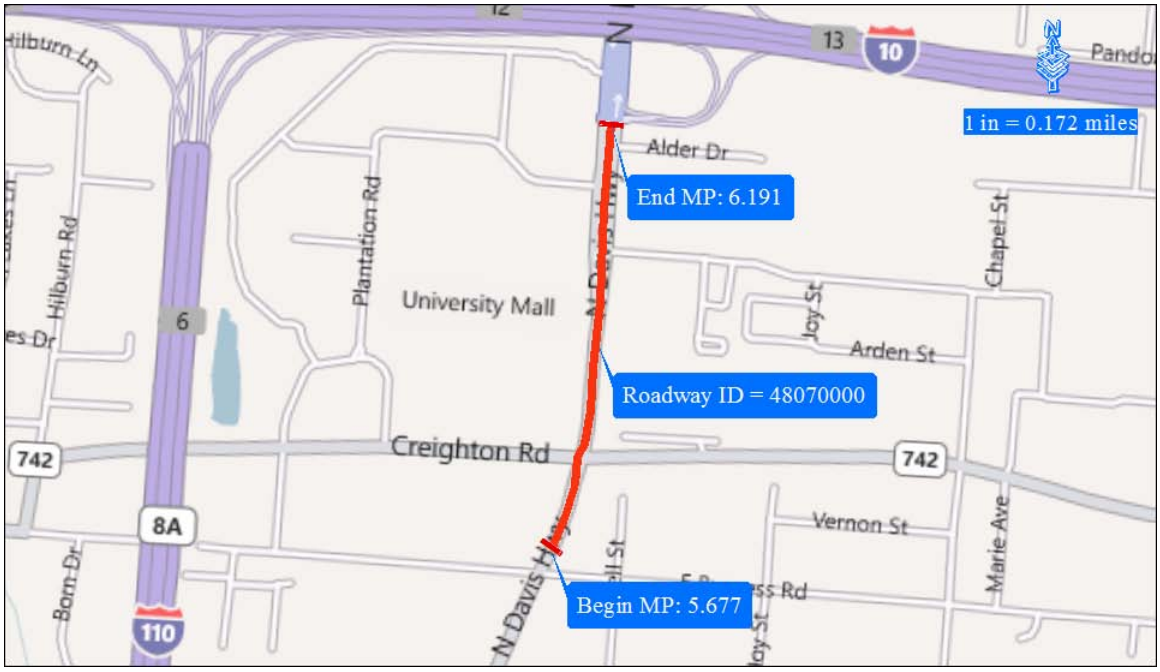


District 1: Fruitville Rd (click for Google Maps location)
Roadway ID = 17040000, MP: 0.619 - 4.203 (Length = 18924 feet)
Construction Period: 1/13/2006 - 9/29/2006

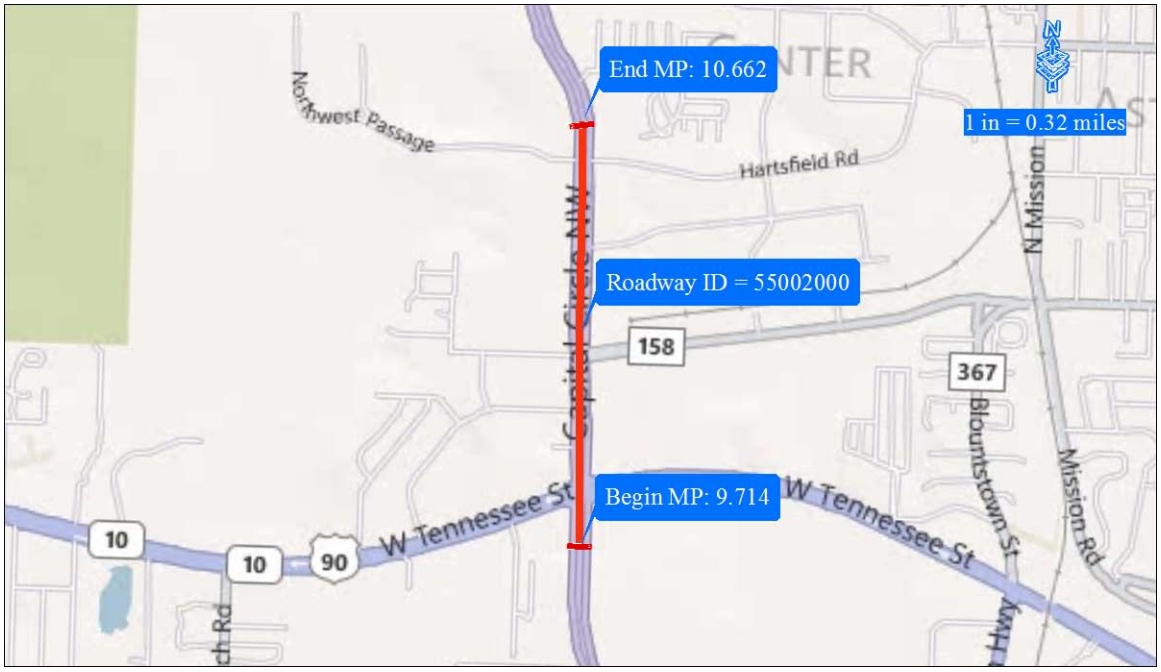




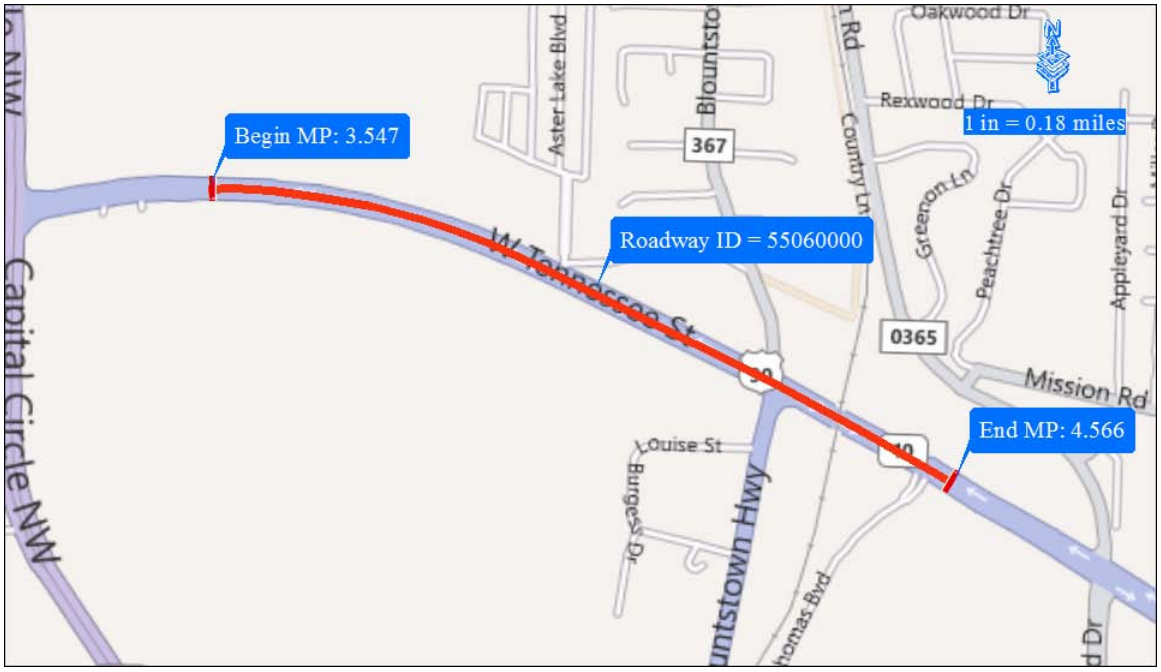
District 3: N Davis Hwy (click for Google Maps location)
Roadway ID = 48070000, MP: 5.677 - 6.191 (Length = 2714 feet)
Construction Period: 4/4/2005 - 10/18/2006

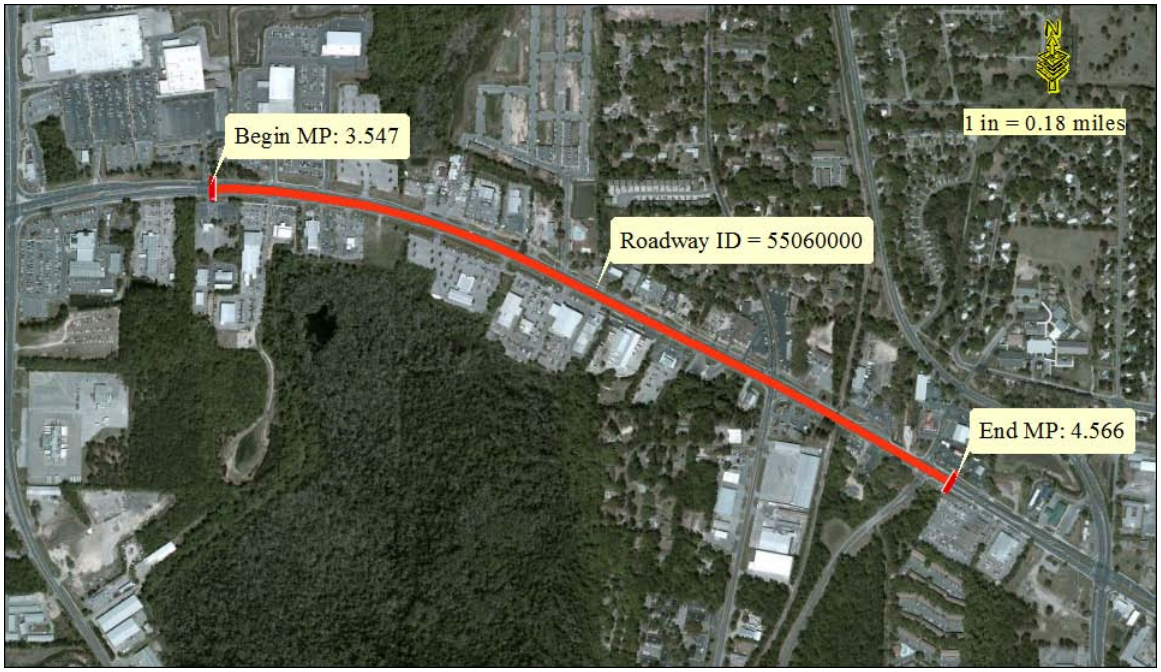


District 3: Capital Cir NW (click for Google Maps location)
Roadway ID = 55002000, MP: 9.714 - 10.662 (Length = 5005 feet)
Construction Period: 9/26/2005 - 9/4/2007



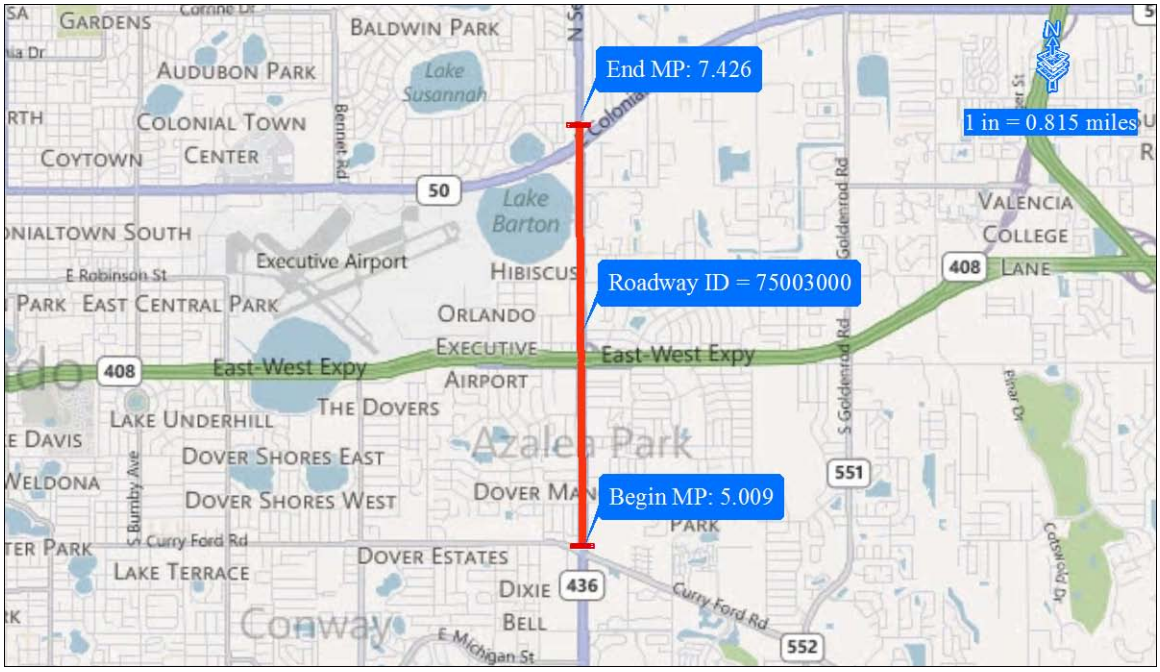
District 3: W Tennessee St. (click for Google Maps location)
Roadway ID = 55060000, MP: 3.547 - 4.566 (Length = 5380 feet)
Construction Period: 3/14/2005 - 7/17/2006

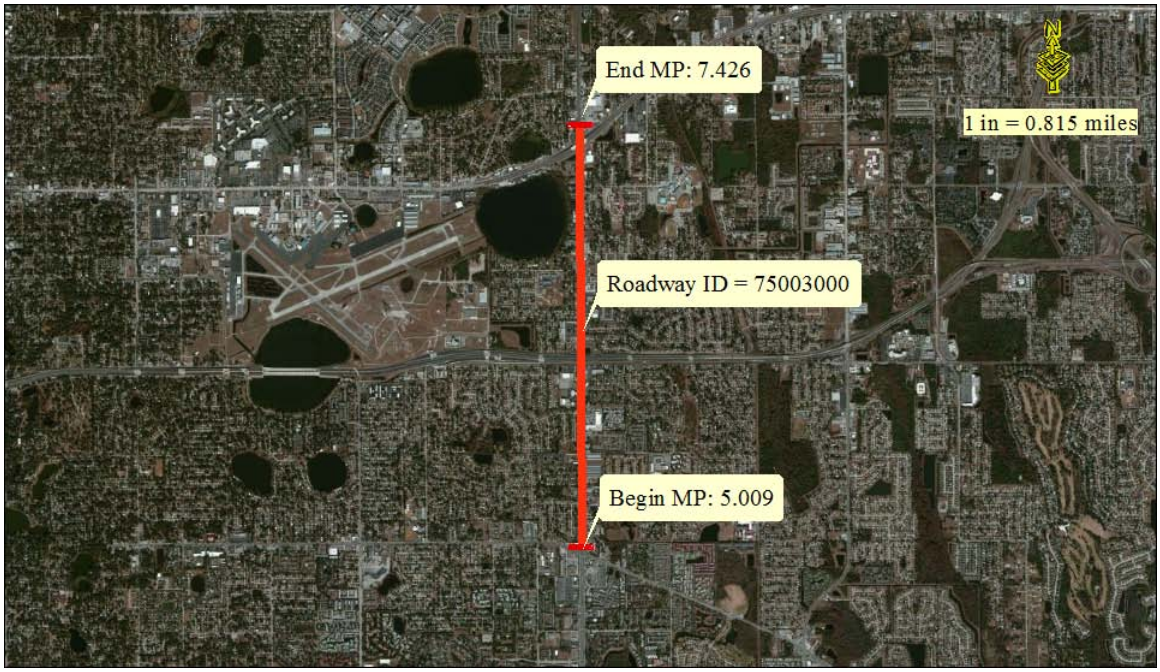




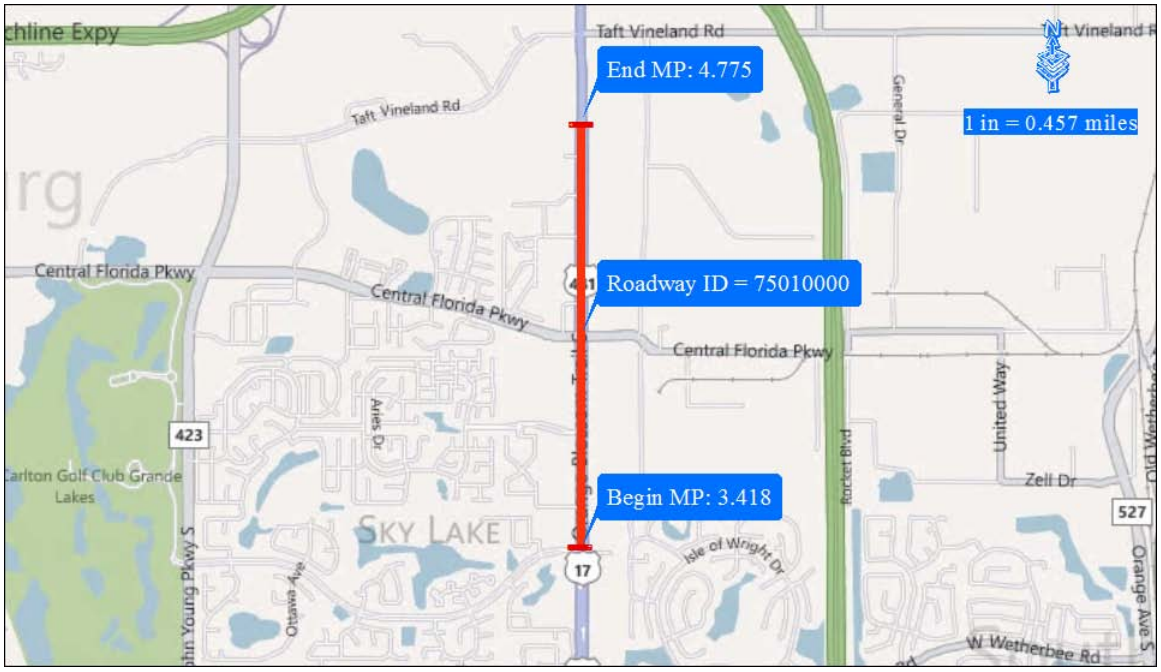
District 3: Apalachee Pkwy / US 27 (click for Google Maps location)
Roadway ID = 55080000, MP: 3.371 - 4.888 (Length = 8010 feet)
Construction Period: 8/1/2006 - 9/6/2007

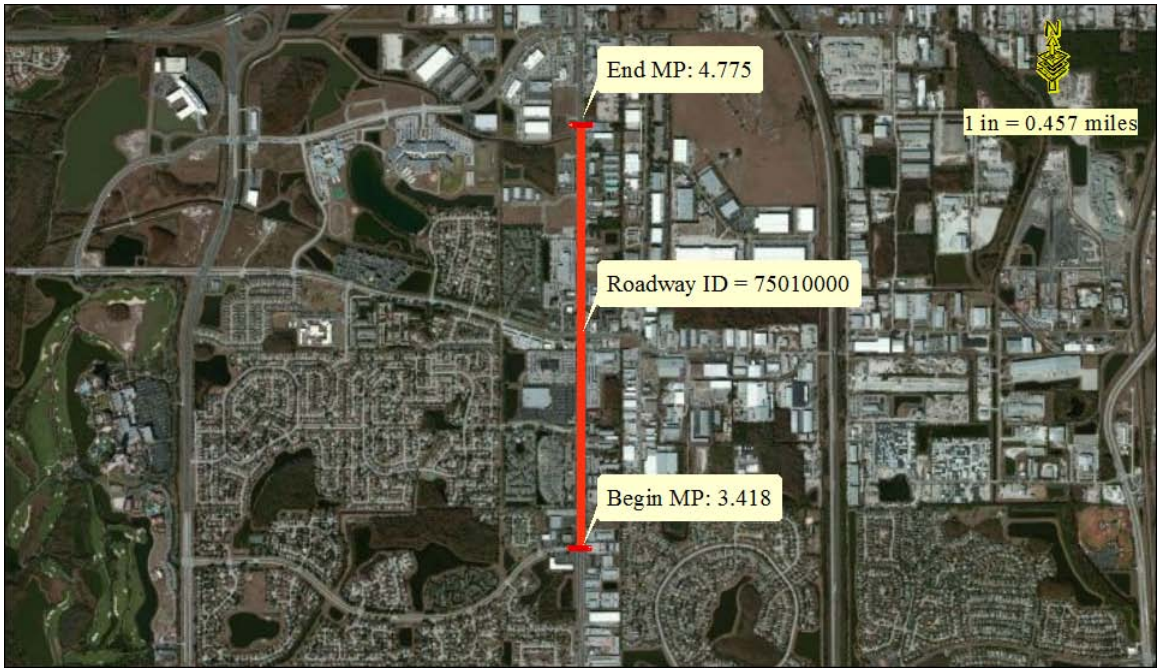
District 5: Semoran Blvd. (click for Google Maps location)
Roadway ID = 75003000, MP: 5.009 - 7.426 (Length = 12762 feet)
Construction Period: 1/30/2008 - 11/3/2008



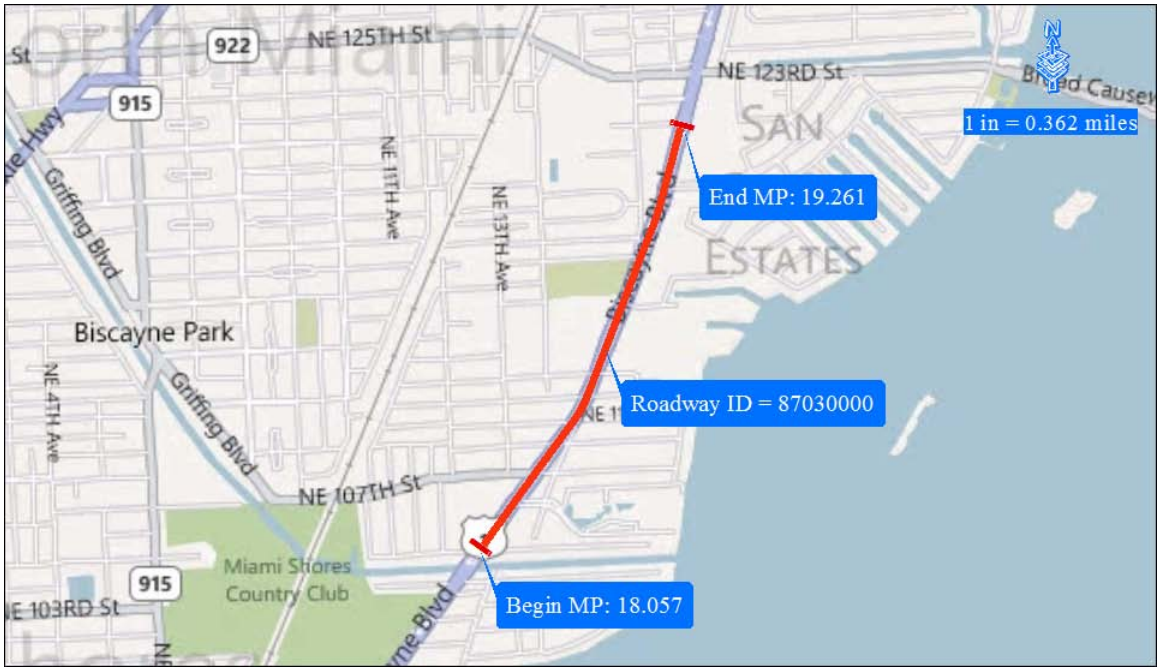


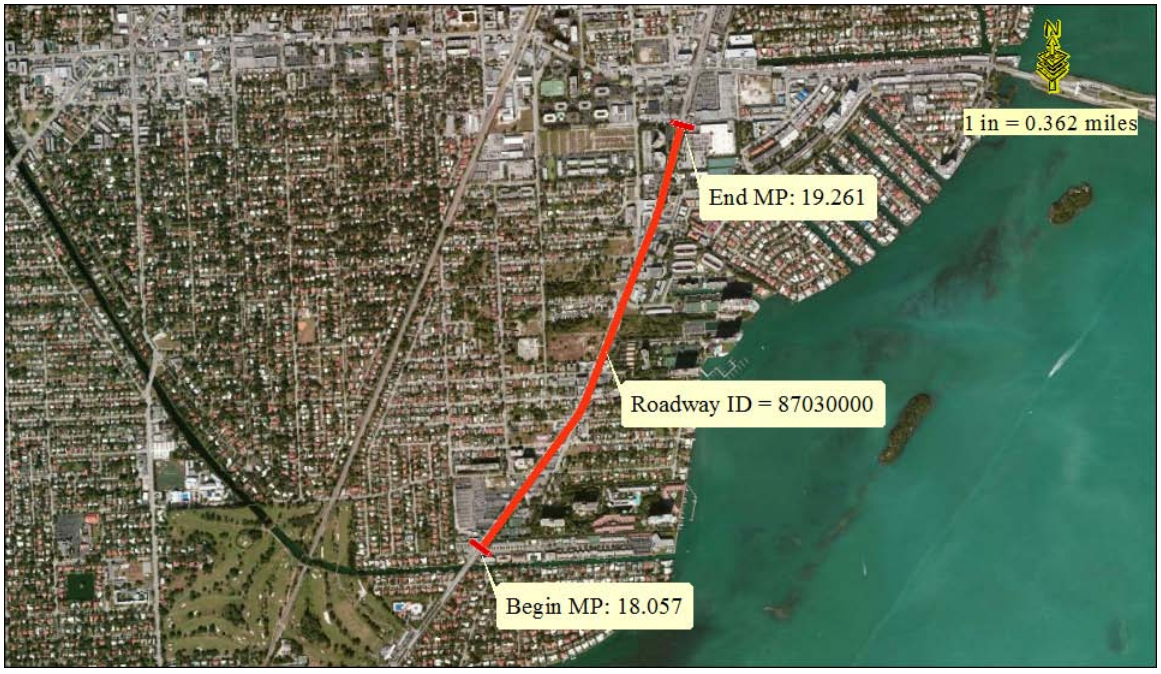
District 5: S Orange Blossom Trail / South Trail Circle (click for Google Maps location)
Roadway ID = 75010000, MP: 3.418 - 4.775 (Length = 7165 feet)
Construction Period: 3/8/2004 - 2/15/2007





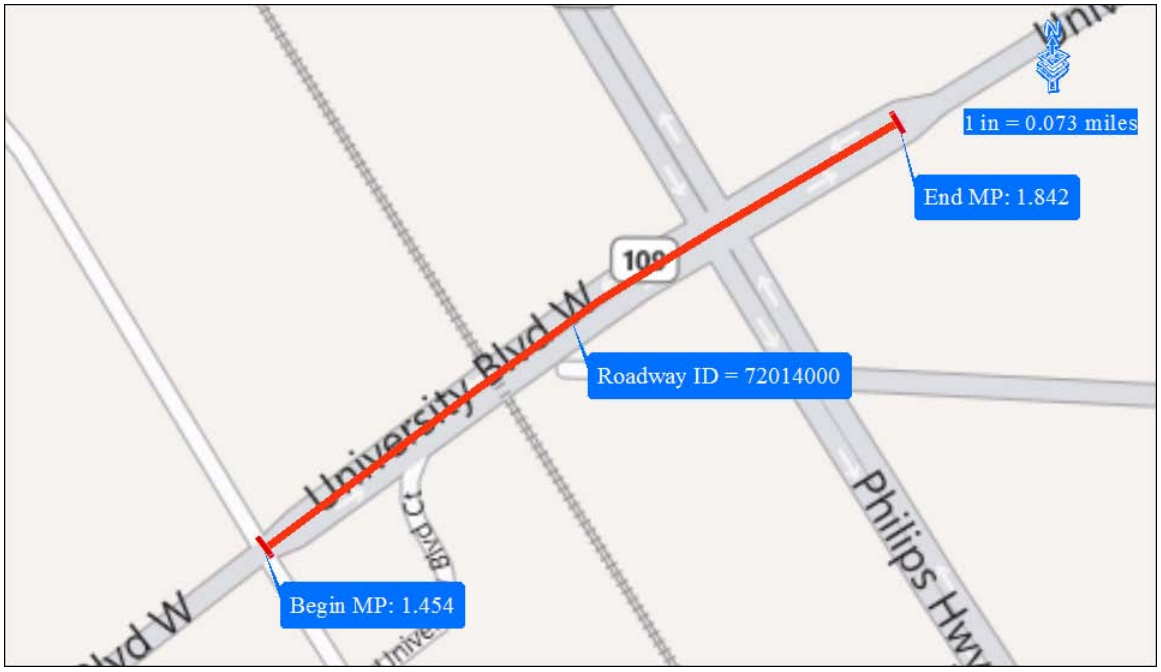
District 6: Biscayne Blvd. (click for Google Maps location)
Roadway ID = 87030000, MP: 18.057 - 19.261 (Length = 6357 feet)
Construction Period: 10/5/2004 - 7/30/2006

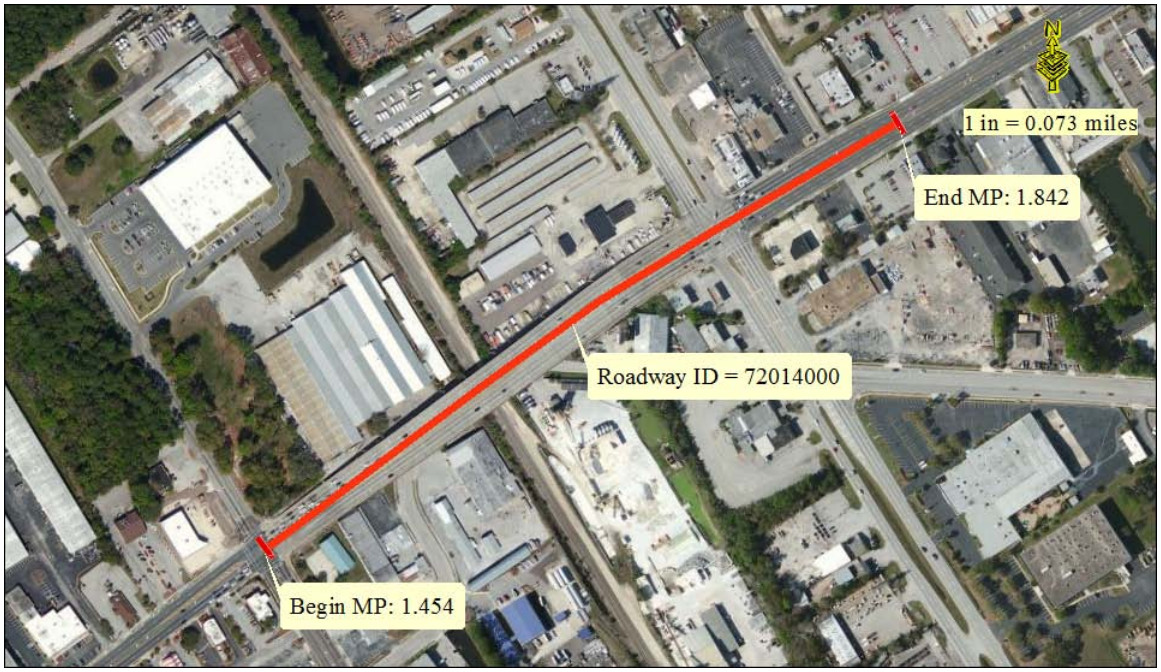




District 6: W Okeechobee Rd (click for Google Maps location)
Roadway ID = 87090000, MP: 10.412 - 11.680 (Length = 6695 feet)
Construction Period: 10/4/2004 - 1/30/2006

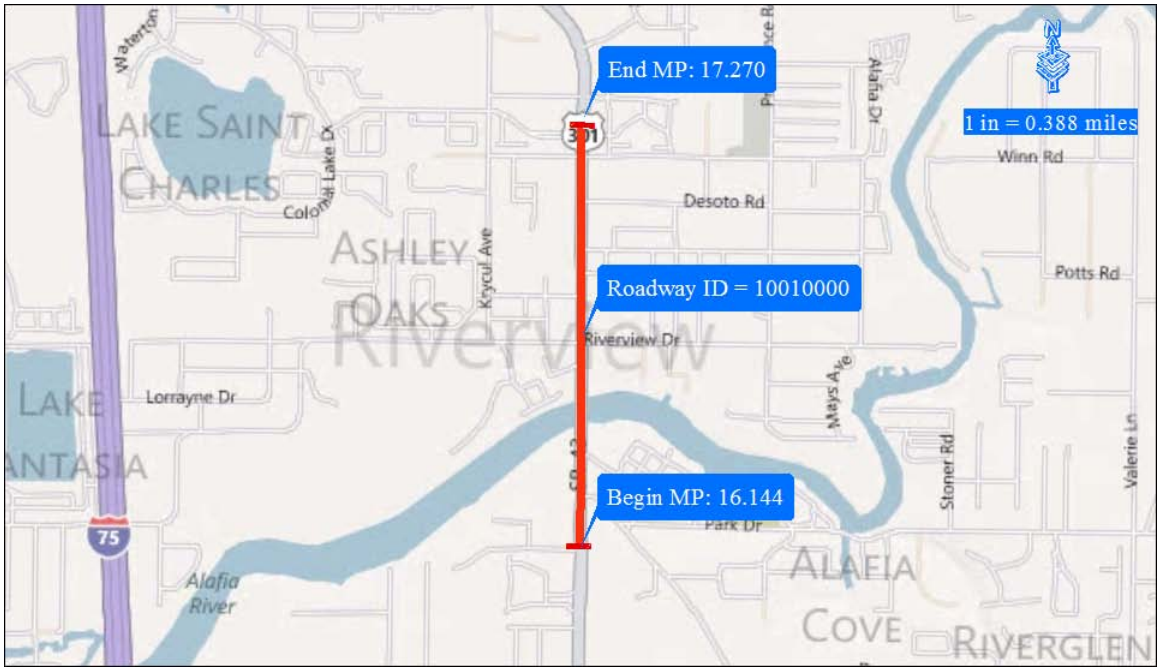
District 2: University Blvd. W (click for Google Maps location)
Roadway ID = 72014000, MP: 1.454 - 1.842 (Length = 2049 feet)
Construction Period: 3/1/2004 - 12/23/2004

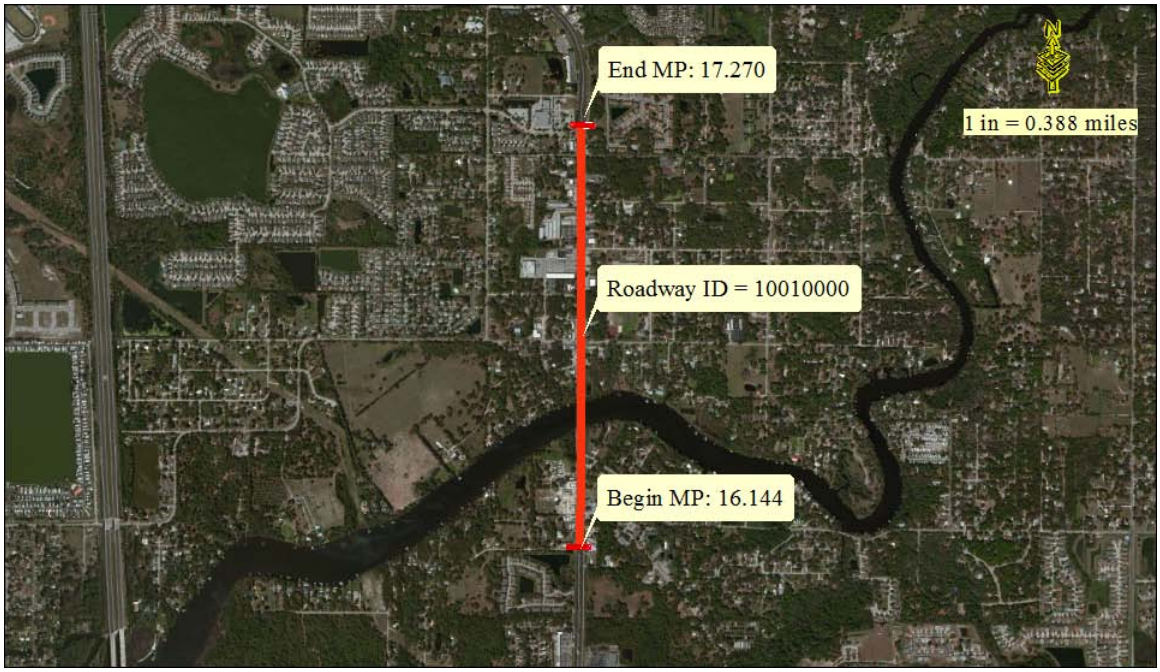




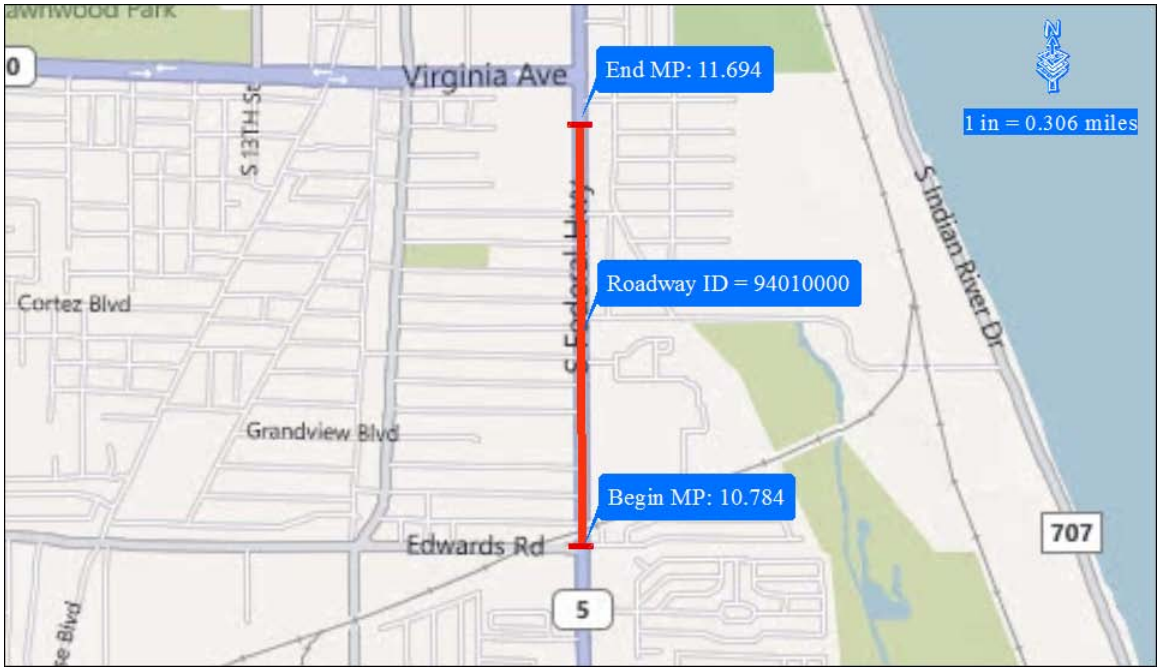
APPENDIX B
STREET AND SATELLITE MAPS OF STUDY LOCATIONS FOR INTERVIEWS OF BUSINESSES

District 7: SR 43 / US 301 (click for Google Maps location)
Roadway ID = 10010000, MP: 16.144 - 17.270 (Length = 5945 feet)
Construction Period: 3/16/2009 - 12/21/2009

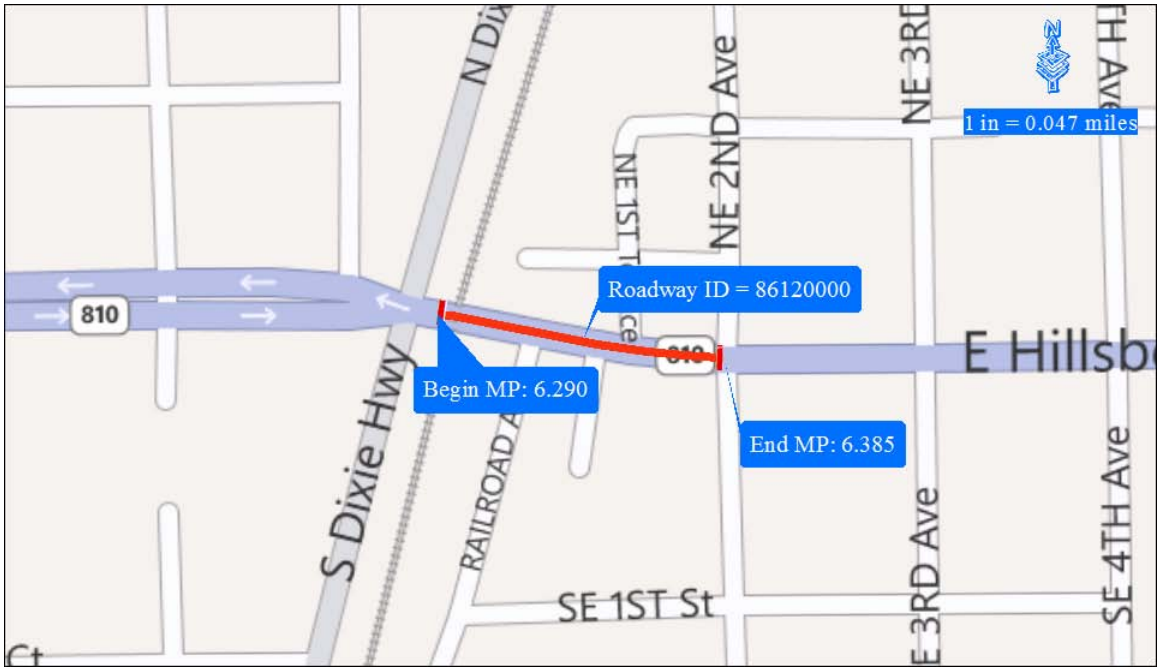




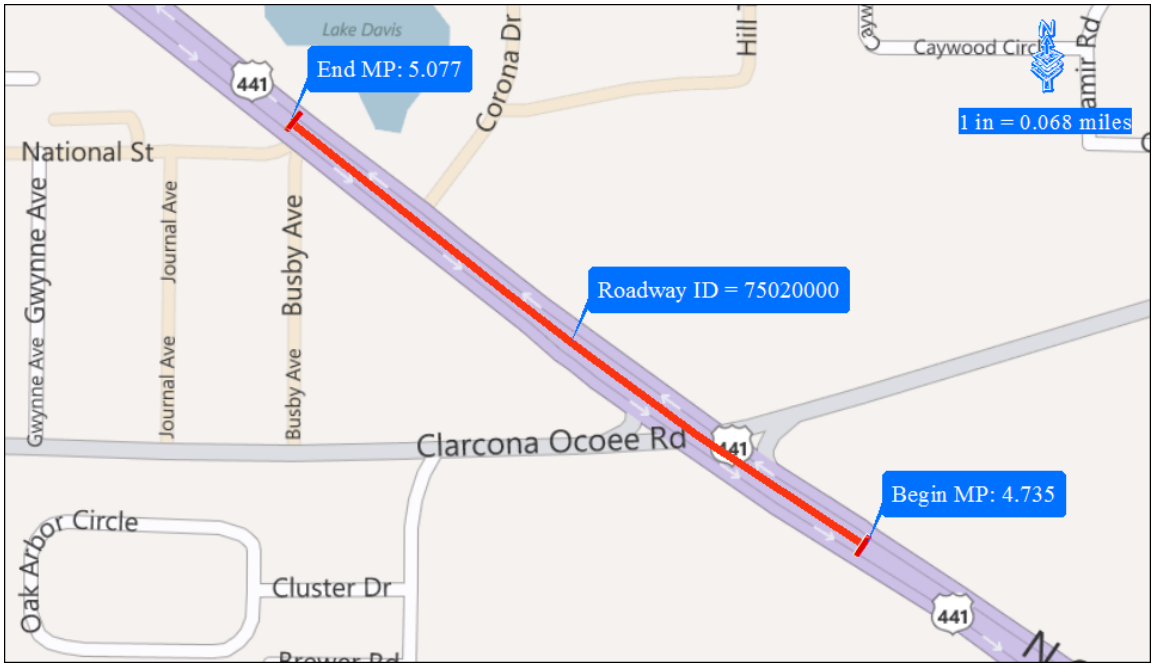
District 4: S 4th St. / US 1 (click for Google Maps location)
Roadway ID = 94010000, MP: 10.784 - 11.694 (Length = 4805 feet)
Construction Period: 7/21/2008 - 6/22/2009



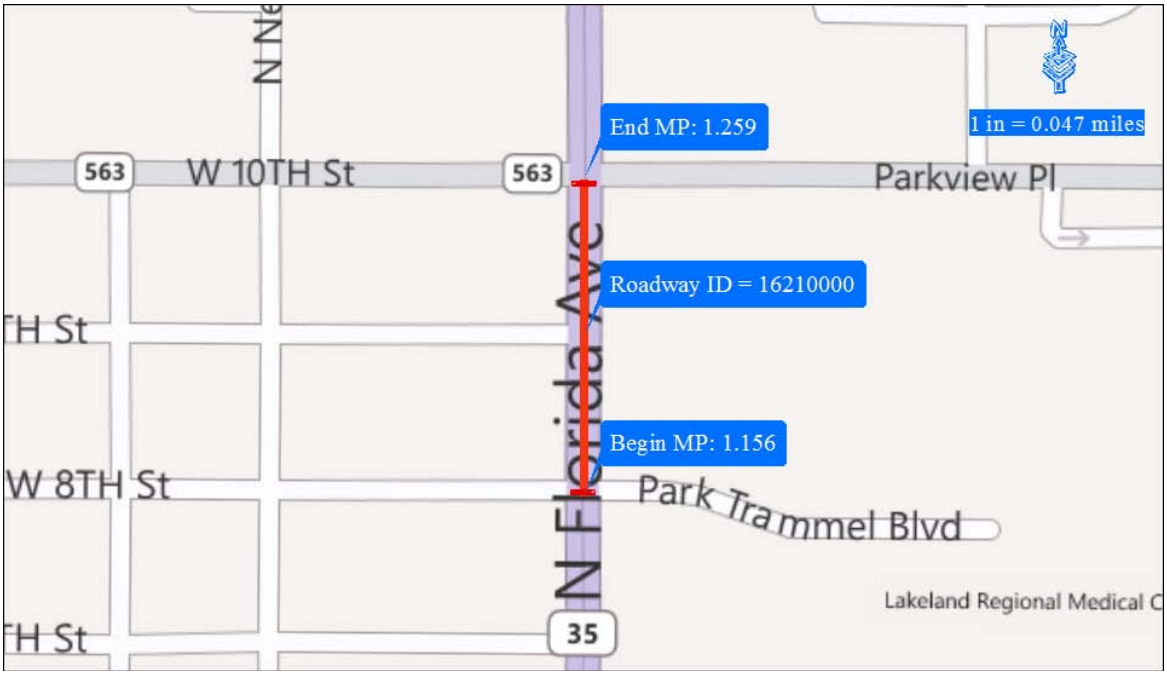
District 4: E Hillsboro Blvd. (click for Google Maps location)
Roadway ID = 86120000, MP: 6.290 - 6.385 (Length = 502 feet)
Construction Period: 7/31/2006 - 12/10/2006



District 5: N Orange Blossom Trail (click for Google Maps Location)
Roadway ID = 75020000, MP: 4.735 - 5.077 (Length = 1806 feet)
Construction Period: 8/9/2009 - 3/15/2010

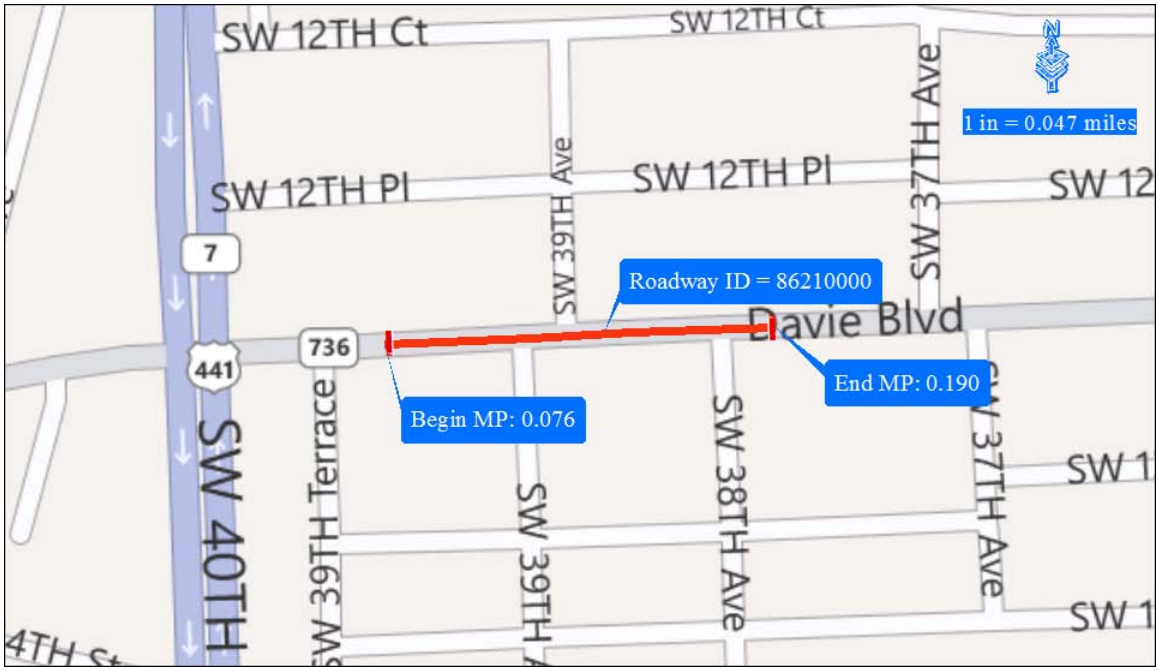


District 1: N Florida Ave (click for Google Maps location)
Roadway ID = 16210000, MP: 1.156 - 1.259 (Length = 544 feet)
Construction Period: 12/7/2009 - 1/14/2010

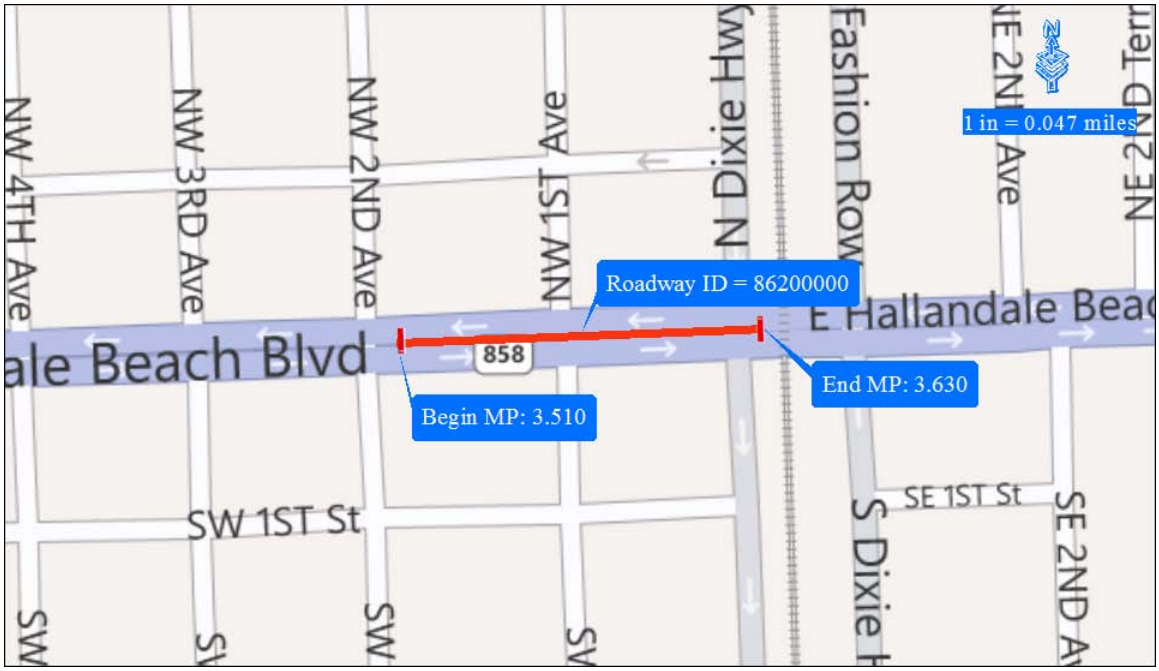


District 1: N Florida Ave (click for Google Maps location)
Roadway ID = 16210000, MP: 2.365 - 3.004 (Length= 3374 feet)
Construction Period: 8/11/2010 - 9/23/2010

District 4: Davie Blvd. (click for Google Maps location)
Roadway ID = 86210000, MP: 0.076 - 0.190 (Length = 602 feet)
Construction Period: 3/3/2008 - 1/22/2009



District 4: W Hallandale Beach Blvd. (click for Google Maps location)
Roadway ID = 86200000, MP: 3.510 - 3.630 (Length = 634 feet)
Construction Period: 5/19/2008 - 3/6/2009



District 3: SR 77 (click for Google Maps location)
Roadway ID = 46060000, MP: 9.038 - 9.317 (Length = 1473 feet)
Construction Period: 6/7/2010 - 8/2/2010

APPENDIX C
SPECIAL STUDY ON SAFETY PERFORMANCE OF RAISED MEDIANS ON APALACHEE PARKWAY

Introduction

The safety impacts of median conversion along a 1.429-mile section on the Apalachee Parkway on SR 20 in Tallahassee are evaluated. As mentioned earlier, this analysis was conducted separately because police reports were not available for review for the before period due to its older construction date of 2002.

The study section runs from MP 1.938 to MP 3.367 along the roadway with ID 55080000. Figure C-1 shows the map location of the section. Along this study section, a TWLTL was replaced with a raised median in 2002. Figure C-2 shows the condition of the roadway prior to the conversion to raised medians. Figure C-3 shows the current conditions with the raised medians.

In this study, the safety impacts of the median conversion are evaluated by comparing the crash rates before and after the median conversion. The comparisons are performed for different crash types and crash severity levels. As the HSM recommends three to five years for before and after analysis periods, the analysis is based on both the minimum (three-year) and the maximum (five-year) periods.

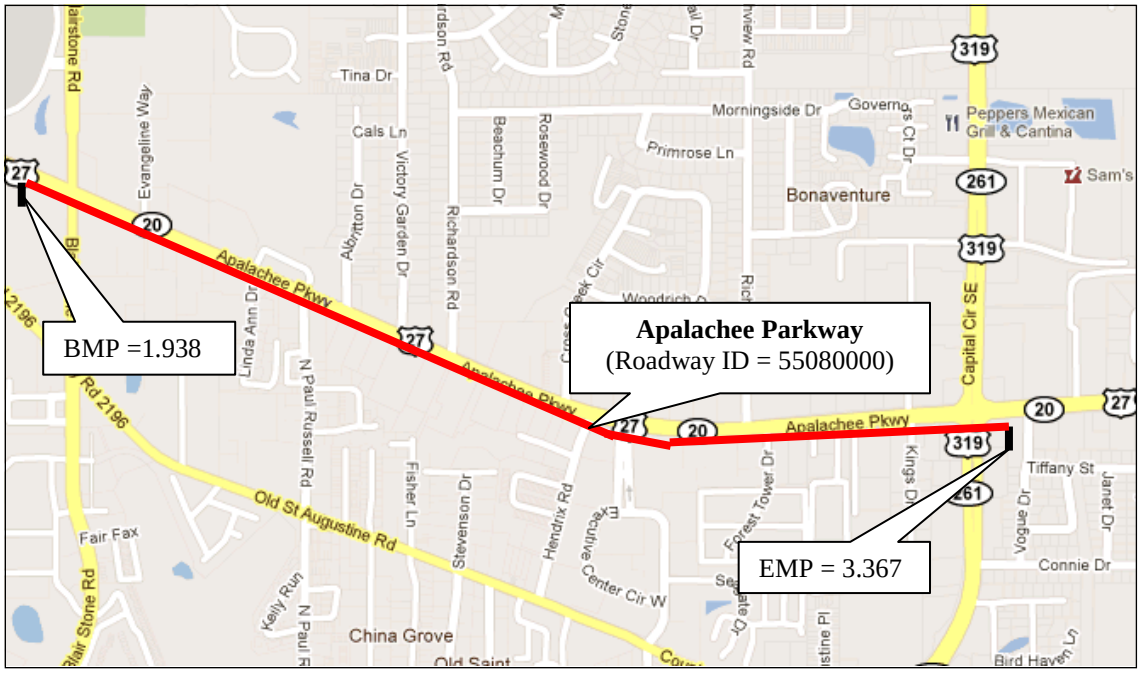


Figure C-1: Study Limits of Apalachee Parkway on SR 20

Figure C-2: Apalachee Parkway before 2002: with TWLTL

Figure C-3: Current Apalachee Parkway (2011): with Raised Medians

Trends in Crash Frequency, Rate, and Exposure from 1983 through 2010

Table C-1 gives the annual crash frequency, the annual total MVM, and the annual crash rates from 1983 through 2010. The annual crash frequency and total exposure in MVM are shown in Figures C-4 and C-5, respectively. Figure C-6 plots the annual crash rates over the entire period. The figure shows three time periods with three different average crash rates, with significant drops in crash rates occurring in the years 1990 and 2003. The sudden drop in crash rate in 1990 is the result of a change in the reporting threshold; and 2003 corresponds to the year right after the medians along the section were converted from TWLTLs to raised medians. For the before-and-after analysis that follows, one year before and one year after the median construction year (2002) are excluded from the analysis not only to exclude the construction period, but also the transition periods before and after the median construction.

Table C-1: Annual Crash Frequency, MVM, and Crash Rates

Year	Crash Frequency	MVM	Crashes per MVM (Crash Rate)
1983	103	11.34	9.08
1984	115	11.42	10.07
1985	151	11.43	13.21
1986	122	11.17	10.92
1987	132	10.18	12.97
1988	114	10.98	10.38
1989	154	11.27	13.66
1990	149	15.47	9.63
1991	85	16.47	5.16
1992	95	15.18	6.26
1993	71	13.04	5.44
1994	95	13.30	7.14
1995	129	14.60	8.83
1996	75	14.34	5.23
1997	110	15.91	6.91
1998	127	14.34	8.85
1999	117	16.17	7.24
2000	74	18.78	3.94
2001	99	20.34	4.87
2002	125	19.58	6.38
2003	79	21.48	3.68
2004	89	19.12	4.65
2005	64	20.24	3.16
2006	54	20.86	2.59
2007	44	21.38	2.06
2008	64	21.38	2.99
2009	41	15.65	2.62
2010	66	15.65	4.22

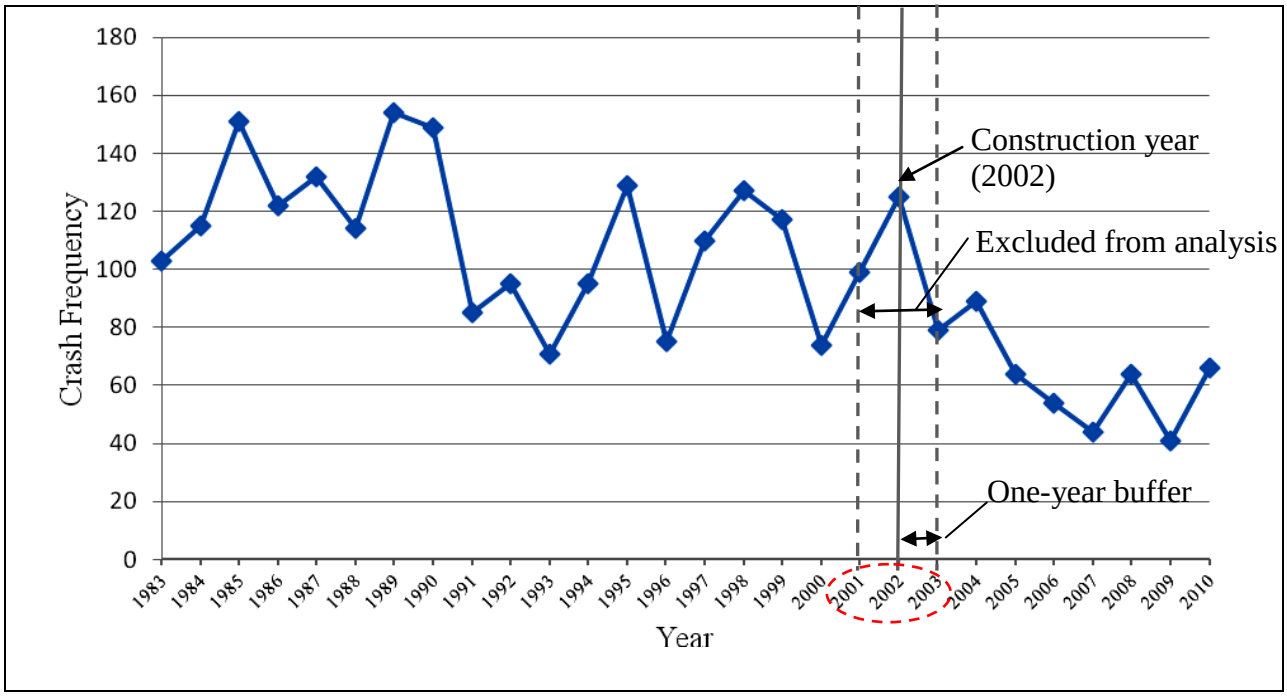


Figure C-4: Total Crash Frequency by Year

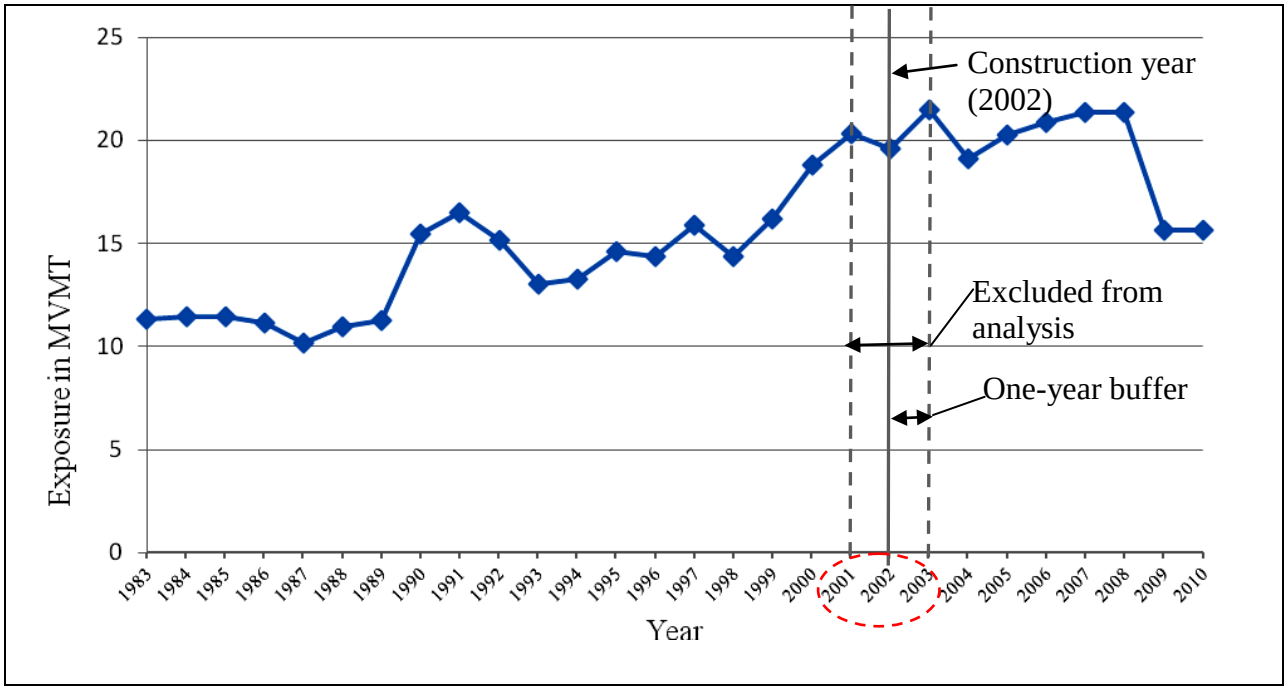


Figure C-5: Exposure in Million Vehicle Miles by Year

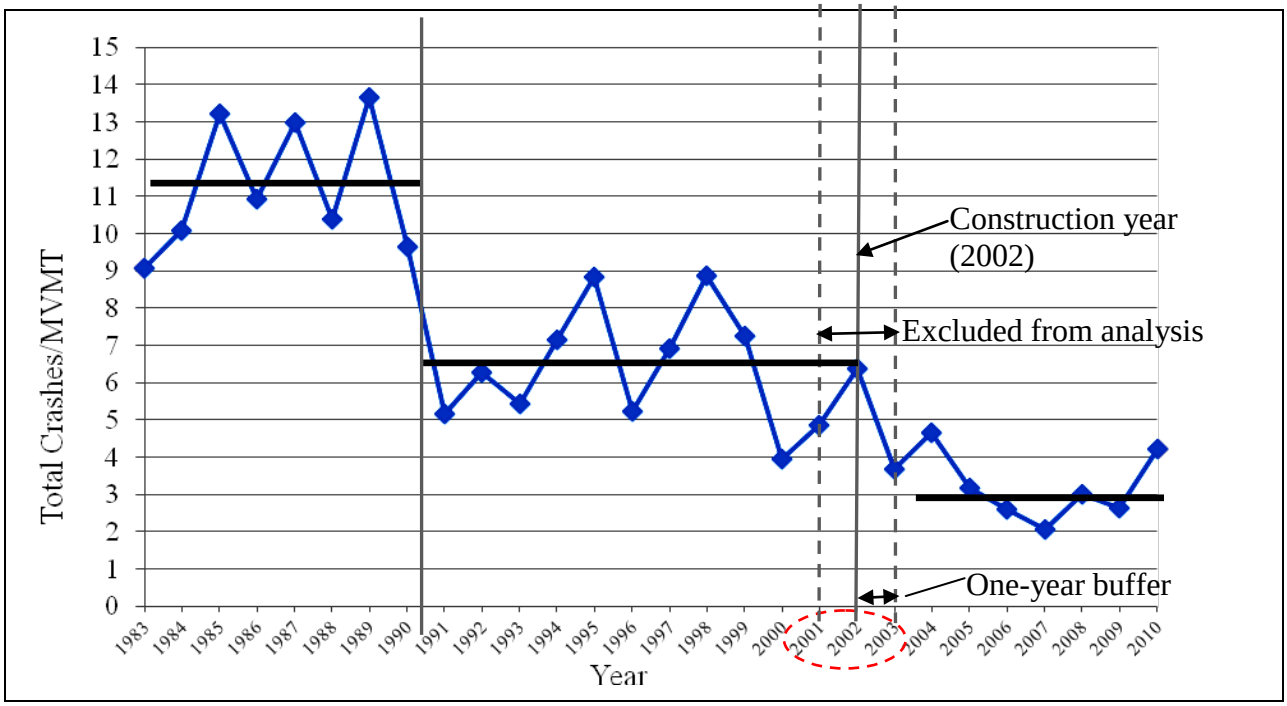


Figure C-6: Total Crash Rates by Year

Three-Year Before-and-After Analysis

Analysis of Crash Types

This section focuses on a three-year before-and-after crash analysis (i.e., 1998-2000 and 2004-2006) for different crash types. Table C-2 gives the crash rates and crash numbers by crash types along with the percent change in crash rate. Figure C-7 compares the three-year before and three-year after crash rates for each crash type.

The before-and-after statistics show significant reductions in crash rates for rear-end, angle, left-turn, right-turn, sideswipe, and bicycle crashes, with the left-turn crashes experienced the highest reduction (83.8 percent), followed by angle (51.0 percent), left-turn (50.1 percent), rear-end (44.3 percent), bicycle (27.1 percent), and sideswipe (14.7 percent) crashes. Overall, a reduction of 48.1 percent in total crashes was observed in the three-year after period. Note that the crash rates for bicycle crashes were too few to draw any conclusions (2 bicycle crashes in the before period and 2 in the after period). Similarly, pedestrian and fixed-object crashes were also too few to draw any reliable conclusions.

The statistics also show a slight increase in head-on crashes. This increase is unexpected as medians help to separate traffic in both directions except at locations with median openings. Specifically, there were four head-on crashes in 2004 (included in the three-year after period) and one in 2008. To verify the accuracy of these five head-on crashes, their police reports were examined. It was found that, of the five crashes coded as of the head-on crash type, three were actually rear-end crashes (all in 2004), one was an angle crash (in 2004), and one was a right-turn (in 2004, unrelated to median).

Table C-2: Percent Change in Crash Rates by Crash Type (Three-Year Analysis)

Crash Type	Before (1998-2000)		After (2004-2006)		Percent Change in Crash Rate
	Number	Rate	Number	Rate	
Rear-end	144	9.04	100	5.04	-44.3%
Angle	59	3.69	36	1.81	-51.0%
Left-turn	72	4.59	15	0.75	-83.8%
Right-turn	5	0.30	3	0.15	-50.1%
Sideswipe	19	1.20	20	1.02	-14.7%
Head-on	3	0.19	4*	0.21	8.6%
Bicycle	2	0.13	2	0.10	-27.1%
Pedestrian[+]	1	0.06	0	0.00	---
Fixed Object[+]	1	0.07	0	0.00	---
Run-off Road	0	0.00	0	0.00	---
Overturning	0	0.00	0	0.00	---
Median Crossover	0	0.00	0	0.00	---
Others	12	0.76	27	1.34	77.3%
Total	**318**	**20.03**	**207**	**10.41**	**-48.1%**

*at least 3 out of the 4 crashes were incorrectly coded as head-on crashes in the police reports.
[+]Same size is too small.

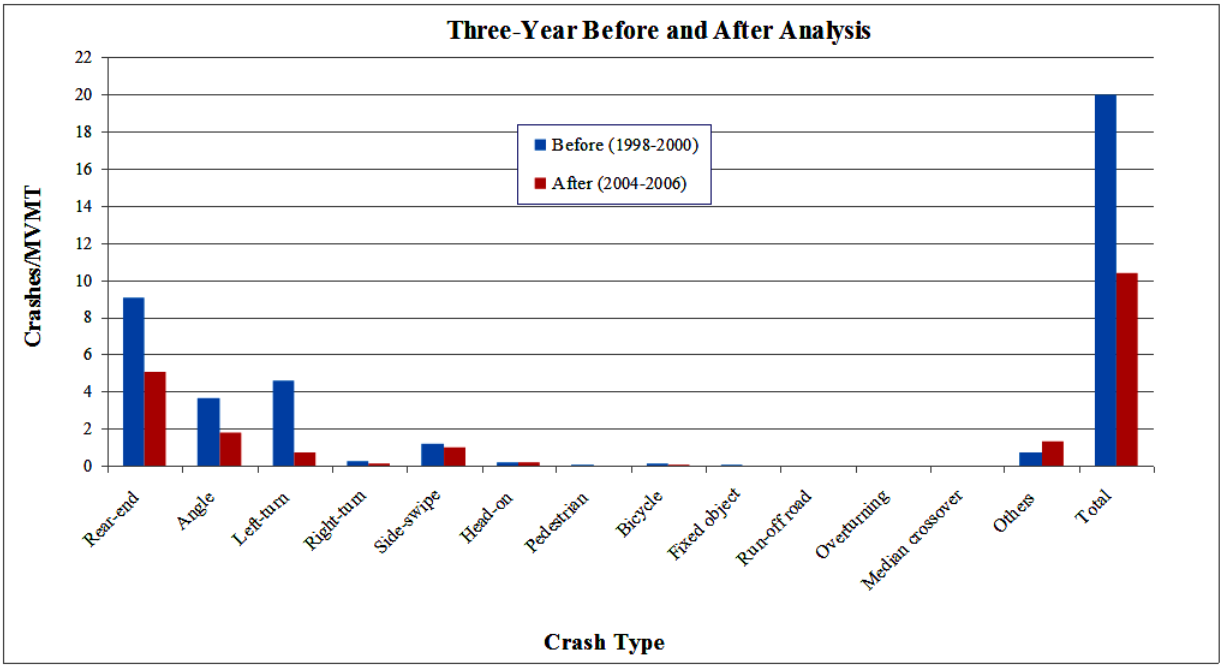


Figure C-7: Three-Year Before-and-After Analysis of Crash Rates by Crash Type

Analysis of Crash Severity

Table C-3 gives the three-year before (1998-2000) and three-year after (2004-2006) crash rates by severity level along with their percent changes in crash rates. The same crash rates are plotted in Figure C-8. There were no fatal crashes during the analysis period. The results show that the PDO and injury crash rates were reduced by 62.1 percent and 29.3 percent, respectively, after the conversion to raised medians.

Table C-3: Percent Change in Crash Rates by Crash Severity (Three-Year Analysis)

Crash Severity	Before (1998-2000)		After (2004-2006)		Percent Change in Crash Rate
	Number	Rate	Number	Rate	
PDO	179	11.45	86	4.34	-62.1%
Injury	139	8.58	121	6.06	-29.3%
Fatal	0	0.00	0	0.00	--
Total	**318**	**20.03**	**207**	**10.41**	**-48.1%**

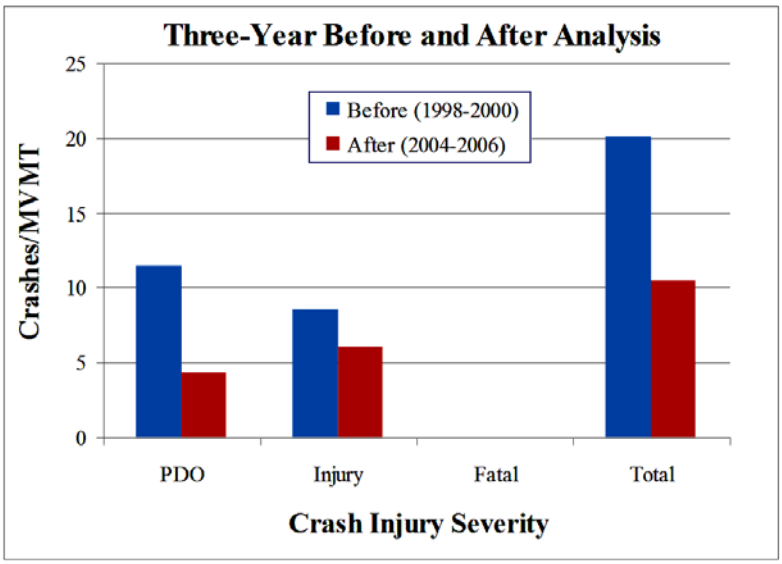


Figure C-8: Three-Year Before-and-After Analysis of Crash Rates by Severity

Five-Year Before-and-After Analysis

Analysis of Crash Types

This section focuses on a five-year before-and-after crash analysis for different crash types. Analysis is based on the five-year before period (1996-2000) and the five-year after period (2004-2008). Table C-4 gives the crash rates and crash numbers by crash types along with the percent change in crash rate. Figure C-9 plots the five-year before and after crash rates by crash type. The results show that left-turn crashes experienced the highest reduction (86.3 percent), followed by right-turn (65.2 percent), angle (56.1 percent), rear-end (44.3 percent), bicycle (43.3

percent) and sideswipe (21.9 percent) crashes. Overall, a reduction of 52.0 percent in total crashes was observed in the five-year after period.

Table C-4: Percent Change in Crash Rates by Crash Type (Five-Year Analysis)

Crash Type	Before (1996-2000)		After (2004-2008)		Percent Change in Crash Rate
	Number	Rate	Number	Rate	
Rear-end	218	13.91	158	7.75	-44.3%
Angle	95	6.04	54	2.65	-56.1%
Left-turn	116	7.46	21	1.03	-86.3%
Right-turn	9	0.57	4	0.20	-65.2%
Sideswipe	27	1.73	27	1.35	-21.9%
Bicycle	5	0.33	4	0.19	-43.3%
Head-on	5	0.33	5*	0.26	-21.3%
Pedestrian	2	0.13	3	0.14	7.7%
Fixed Object+	2	0.13	1	0.05	---
Run-off Road+	0	0.00	0	0.00	---
Overturning+	0	0.00	1	0.05	---
Median Crossover+	0	0.00	1	0.05	---
Others	24	1.54	36	1.76	14.0%
Total	**503**	**32.17**	**315**	**15.46**	**-52.0%**

*4 out of the 5 crashes were incorrectly coded as head-on crashes in the police reports.
+Crashes are too few to come to reliable conclusions.

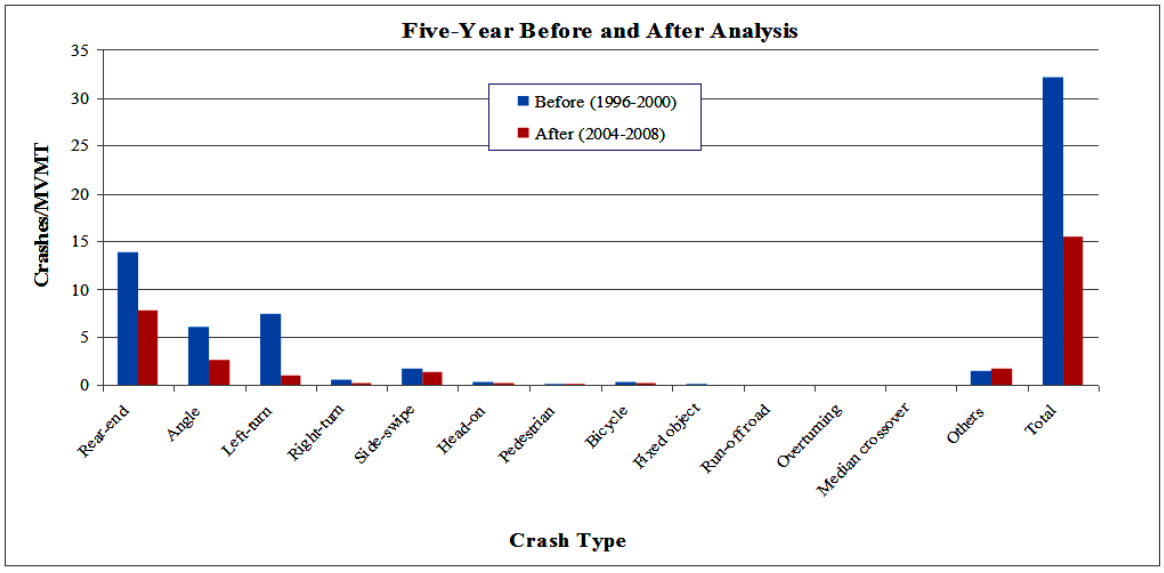


Figure C-9: Five-Year Before-and-After Analysis of Crash Rates by Crash Type

As mentioned earlier, the increase in head-on crashes were a result of miscoded crash type. Again, similar to those based on three-year periods, pedestrian and fixed-object crashes remain

too few to draw conclusions. However, one crash involving vehicle overturning and another involving median crossover are noted in the five-year after period.

Analysis of Crash Severity

Table C-5 gives the five-year before and five-year after crash rates and crash numbers by severity level, along with the percent changes in crash rates. Figure C-10 plots the crash rates by crash severity. The results show a significant reduction in the crash rates for both PDO (61.4 percent, compared to 62.1 percent based on three years) and injury (41.3 percent, compared to 29.3 percent based on three years) crashes after the median conversion. There were no fatal crashes during the analysis period.

Table C-5: Percent Change in Crash Rates by Crash Severity (Five-Year Analysis)

Crash Severity	Before (1996-2000)		After (2004-2008)		Percent Change in Crash Rate
	Number	Rate	Number	Rate	
PDO	265	17.06	134	6.59	-61.4%
Injury	238	15.12	181	8.87	-41.3%
Fatal	0	0.00	0	0.00	---
Total	**503**	**32.17**	**315**	**15.46**	**-52.0%**

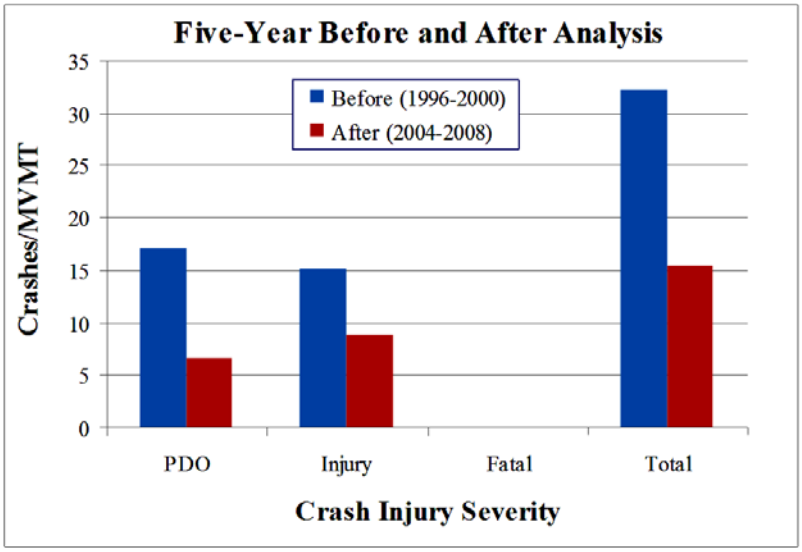


Figure C-10: Five-Year Before-and-After Analysis of Crash Rates by Severity

Summary

As a special study, three-year and five-year before-and-after safety performance evaluations of a 1.429-mile roadway section on the Apalachee Parkway were conducted. The study location was converted from a TWLTL to a raised median in 2002. The main findings from the analysis are summarized below:

- The yearly crash rates had three visibly distinct trends. There is a significant drop in crash rates in the years 1990 and 2003. The drop in crash rate in 1990 is the result of a change in the reporting threshold. The year 2003 corresponds to the year right after the median conversion.
- After the median construction, a reduction of about 50 percent in total crash rates is observed in both three-year and five-year before-and-after analyses.
- Both the three-year and the five-year before-and-after analysis showed a reduction in crash rates of total, rear-end, left-turn, angle, right-turn, sideswipe, and bicycle crashes after the median construction.
- The highest reduction in crash rates after the median construction is observed in left-turn crashes (over 80 percent reduction).
- Using a three-year before-and-after analysis, an increase in head-on crash rates is observed after the construction of raised median. As this increase is counterintuitive, the police reports were examined and it was found that all except one of these crashes were incorrectly coded.
- Some of the crash types were too few to come to reliable conclusions. These crash types include fixed object, run-off-the-road, overturning, and median crossover.
- There is an overall decreasing trend for both PDO and injury crash rates.
- Both the three-year and the five-year before-and-after analysis showed a reduction in crashes rates of PDO and injury crashes after the installation of raised medians. There were no fatal crashes during the analysis period.

APPENDIX D
SURVEY QUESTIONS ON THE IMPACT OF RAISED MEDIANS ON BUSINESSES

The survey is divided into two parts. Part 1 consists of general questions relating to location and type of businesses. It will be filled on-site by the interviewer. Part 2 includes specific questions about the impact of raised medians on each business. The interviewer will fill out the survey based on the responses from business owners. Additionally, the interviewer will ask for additional comments relevant to median construction.

PART 1: BY INTERVIEWER

1. What is the primary type of business?
    a. Retail
    b. Grocery
    c. Convenience
    d. Gas Station
    e. Fast-Food Restaurant
    f. Sit-Down Restaurant
    g. Bar
    h. Hotel
    i. Other: _____

2. Indicate the location of the nearest median opening that provides access to your business. In other words, how do the customers enter/exit your business: at a midblock median opening or through a street intersection?
    a. Midblock
    b. Street Intersection

PART 2: WITH BUSINESS MANAGERS/OWNERS

1. When did this business begin operations at this location? Month and Year

2. Does your business have more passer-by traffic or planned stop traffic? Passer-by customers are those customers that are not intending to stop at your particular business (i.e., impulse customers) as opposed to planned stops by customers that had intended on stopping at your business.

3. Do you believe your regular customers have remained about the same, are more likely, or have been less likely to visit your business due to the raised median?
    a. Less likely
    b. More likely
    c. Stayed about the same

4. Has the raised medians adversely affected truck deliveries to your business?

5. After the median installation, how has the following changed?
    a. Number of customers
    b. Traffic congestion
    c. Property access

    Rating:
    1- Increased or Improved
    2- No Change
    3- Decreased or Worsened
    4- Not sure

6. Do you think this roadway with raised median is safer than with TWLTL?

7. Do you perceive that the raised median has had a major impact, minor impact, or no impact on your business? If so, why?

8. Were you informed of the availability of public hearings?
    a. Yes
    b. No
    c. Not sure

9. Did you attend any public hearings for this median installation project?
    a. Yes. How many? _____
    b. No
    c. Not sure

10. If no, what is the reason: _____

11. If yes:
    a. What is the nature of the public hearings?
    b. Did you find the public hearings helpful?
    c. Do you have any suggestions to improve the public hearings?

12. At this location, do you prefer raised medians or the TWLTL? Why?
    _____
    _____
    _____

13. Any comments on the recently constructed raised median?
    _____
    _____
    _____