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16. Abstract

This research report describes the first year activities and preliminary findings of a two-year research study to investigate the impacts of access management treatments.

The first objective of the research is to estimate the impacts of access management techniques through field data collection at selected sites in Texas and to perform simulation of traffic performance. Preliminary findings of one such case study are provided in this report. Further case studies will be investigated in the second year of this research. Simulation will also be performed in the second year of this research on theoretical scenarios. The theoretical scenarios are intended to assist TxDOT in alternatives analysis. Two additional case study locations will also be simulated in the second year of the study.

The second objective of the research is to estimate the safety benefits of access management treatments by investigating crash data from select corridors where access management treatments have been installed. A key part of this analysis is the assessment of the crash information used in the analysis. This report includes preliminary analysis of crash analysis from one case study corridor, and researchers anticipate investigation of at least four additional case study locations in the second year of the research study.

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ESTIMATING THE IMPACTS OF ACCESS MANAGEMENT TECHNIQUES: METHODOLOGY AND PRELIMINARY FINDINGS

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DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation. The engineer in charge of this project was William L. Eisele (P.E. #85445).

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- Ms. Pam Rowe: report preparation; and
- Ms. Casey Toycen: VISSIM programming and data collection.

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CHAPTER 1

INTRODUCTION

Traffic volumes and congestion have increased in recent years, particularly on arterial streets. The primary purpose of arterial streets is the movement of vehicles, while providing necessary access to residential and commercial developments. If unlimited access is provided directly from businesses and/or residences to arterial streets, average speeds decrease, and the capacity of the arterial diminishes. Frequent access also presents safety concerns by providing more locations for potential conflicts of vehicles' paths. Solutions in the past have involved building relief routes to the arterial. It is very common, however, for the same problems to eventually occur on the relief route. In some cases, tertiary relief routes have also been built.

A better, more cost efficient alternative to building relief routes is incorporating access management techniques into the design of arterials. This practice is most successful when originally included in the design of the arterial, but it can also be applied through retrofit projects on existing roads. By using access management techniques such as raised medians, turn lanes, auxiliary lanes, median opening spacing, and driveway spacing, the public investment in the arterial is protected by preserving its function of moving vehicles. Such design methods also provide a safer street for the motoring public by decreasing the potential number of conflict points occurring at intersections.

In recent years, there has been increased interest in access management principles and techniques in Texas. Several Texas Department of Transportation (TxDOT) district and division staff members have expressed a desire to have access management guidelines in place to help them design arterial facilities and to help manage access locations. Recent research performed by the Texas Transportation Institute (TTI) identified recommended guidance of geometric criteria for different access management techniques by access classification. The research project upon which this report is based is intended to estimate the impacts of access management techniques.

1.1 PROJECT OBJECTIVES

The primary objectives of this research effort include the following:

1. Estimate the impacts of access management techniques through field data collection at selected sites in Texas and simulation of traffic performance. Simulation will also be performed on theoretical scenarios. These scenarios will be created for use by TxDOT after completion of the research project.

2. Estimate the safety benefits of access management treatments by investigating crash data from selected sites in Texas and Oklahoma where access management treatments are installed. A key part of the crash analysis will be assessing the quality of the crash information used in the analysis.

These objectives both focus on estimating the impacts of access management treatments—either by simulation of traffic performance or by investigating crash data. In the first year of the research project, the research team focused on portions of both objectives. Simulation of one corridor was performed, and preliminary findings are included in this report. It should be noted that the simulation findings are preliminary because the research team has learned more about the abilities and limitations of the micro-simulation package Verkehr in Städten Simulation (Traffic in Cities-Simulation) (VISSIM). The research team may re-evaluate the Texas corridor in the second year of the study. The reader is encouraged to review section 2.3 of this report for more information regarding the preliminary nature of the findings in this report. Further simulation will be performed along two corridors in the second year of the study. The research team is also developing theoretical scenarios that TxDOT can use in alternatives analysis of various arterial street configurations with access management treatments.

The second objective was also addressed in the first year of the study. Extensive quality assurance of the crash data along one study corridor in College Station, Texas, was performed, and the preliminary findings are presented in this report. Preliminary findings of crash trends are also reported for this location where a two-way left-turn lane (TWLTL) was replaced with a raised median. Discussion is provided of other locations where crash data were collected, and analysis will continue into the next year of the study.

1.2 PROJECT PROCEDURE

During the first year of the research project, the research team completed several portions of tasks identified in the project. These are described below.

1.2.1 Identify Relevant Literature

The task to review the state-of-the-practice was removed from the original work proposal due to a reduction in the project budget. However, the research team needed to review some literature related to crash studies. The research team was also familiar with references on the subject necessary for the analysis.

1.2.2 Identify Analysis Tools and Prioritize Access Management Techniques

This second task in the original proposal was also removed due to budget reductions. The literature review was intended to identify many different simulation models and/or procedures for use in quantifying the benefits of access management techniques. The research team chose to use the VISSIM microscopic simulation software package based upon its ability to model median treatments along arterial streets. The research team also investigated relevant literature on the VISSIM model as part of this task.

This task was intended to determine which access management techniques would be investigated in the research project. This was achieved through project advisory group meetings. The primary access management treatments to be investigated were raised medians and driveway consolidations.

1.2.3 Identify Study Corridors and Perform Data Collection

This task was also partially completed in the first year of the research project. Case study locations were identified for both the simulation and crash studies. Researchers collected field data at one case study location to investigate the operational improvement alternatives due to access management techniques by simulation. Crash data were collected at four locations for the crash analysis.

1.2.4 Analyze and Summarize Case Study

The coding and operation of the VISSIM software is quite extensive. However, preliminary findings along one of the corridors being investigated through simulation are provided in this report (see section 2.3 for limitations). Researchers also performed quality control of the crash data at one case study location in the first year of this research project, and it will continue into next year on the remaining study corridors. Preliminary crash study information is provided in this report and will also continue into the second year of the research project.

1.2.5 Perform Sensitivity Analysis

This task is intended to be performed for varying traffic conditions and access management treatments for which field case study locations could not be identified. Because not all access management treatments and differing traffic conditions will be found in the case studies, this analysis is intended to "fill the gaps" between the conditions that could be analyzed directly from the actual case study locations and other situations of interest. At the end of the first year of this study, the research team met with TxDOT staff to identify the most useful scenarios to create in a VISSIM environment for TxDOT's future use with alternatives analysis. Of the inputs needed by VISSIM, traffic characteristics, scenarios, and other inputs of particular use to TxDOT were identified. The scenarios for the sensitivity analysis will be more fully developed in the second year of the research.

Finally, many detailed steps are required for the operation of VISSIM. The research team developed a more simplified list of steps for use with accompanying default values and necessary inputs for application of the scenarios by TxDOT.

1.3 REPORT ORGANIZATION

This report is organized into five chapters, as described below:

- Chapter 1, **Introduction.** This chapter presents an introduction to the research topic, objectives, and procedures.
- Chapter 2, **Simulation Methodology and Preliminary Findings.** This chapter discusses the VISSIM model used for simulation of traffic performance with access management treatments. This chapter also presents preliminary findings of a case study analysis.
- Chapter 3, **Crash Analysis Methodology and Findings.** This chapter discusses the quality assurance that was performed on the crash data obtained for the sites that were selected for the estimation of the safety benefits of access management treatments. Preliminary findings are also presented from one case study location.
- Chapter 4, **Preliminary Findings and Discussion.** This chapter describes the recommendations and discussion related to the findings and ongoing activities discussed in the report.
- Chapter 5, **References.** This chapter lists the references used in this report.

CHAPTER 2

SIMULATION METHODOLOGY AND PRELIMINARY FINDINGS

This chapter describes the simulation performed in VISSIM to evaluate the traffic operation along select corridors in Texas before and after the implementation of access management treatments. Three case studies are described. One case study location was completed in the first year of the study, and preliminary findings of the analysis are included. Discussion of the remaining two corridors includes descriptions of the case study locations. They will be simulated further in the second year of this research project.

In addition to the three case study locations that are simulated in VISSIM, theoretical corridors will be developed on which the impacts of different access management treatments will be assessed. TxDOT will be able to use the corridors to analyze alternatives for differing traffic operations. The theoretical corridors will be investigated further in the second year of this research project.

2.1 SIMULATION CASE STUDY LOCATIONS

Researchers identified three case study locations for simulation analysis in Texas. Simulation will be performed on traffic performance before and after access management alternatives are implemented. The three case study locations are:

- Texas Avenue in College Station,
- 31st Street in Temple, and
- Broadway Road in Tyler.

These case study locations are described in further detail in the sections that follow.

2.2 VISSIM MODEL

VISSIM is a microscopic, time step, and behavior-based model developed to simulate urban traffic and transit operations (*1*). This modeling tool was chosen for its unique ability to simulate the specific, complex multiple-conflict points and dynamics associated with the TWLTL arterial environment. The research team used the model to quantify the performance measures of travel time and delay along the study corridors.

VISSIM is an ideal tool for modeling the change from a TWLTL to a raised median because of the dynamic routing system, which is unique to VISSIM. When a route is taken away (i.e., a left-turn movement is eliminated when a raised median is installed), the vehicle automatically finds the next shortest route, which is the next median opening. VISSIM can also animate the simulation. Therefore, the user visually identifies any problems occurring in the model and checks the model for accuracy. This is also an informative tool that the public can easily see and understand.

Although VISSIM is a good tool for modeling, it cannot optimize signal timings. Whenever changes in traffic volumes or roadway geometrics are made, the user must optimize the signal timings, allowing maximum flow of vehicles through the intersection. Comparing the incremental benefits of various alternatives is more accurate when all the scenarios have optimized signal timings.

2.2.1 Inputs and Coding

The first step in creating the model was gathering the necessary data. The research team obtained an aerial photograph of the site for use as the background in VISSIM. Researchers manually collected the necessary geometrics such as lane configurations, lane widths, driveway widths, distance between driveways, and lengths of dedicated lanes. They also collected traffic volumes on the mainlanes and turning movement counts at the signalized intersections and the driveways along the corridor. These counts were taken during the noon and evening peak hours.

Researchers also obtained signal timings for the signalized intersections on the corridor. Finally, the team completed travel time runs using the floating-car method (*2*) in both directions on the corridor during the peak hour. The data collected during the travel times runs were used in the calibration process.

Research team members input all the information gathered into VISSIM, which is often a tedious task. For a new user, this can be a very time-consuming process. However, as the user becomes more familiar with the procedures, this stage of the modeling procedure becomes easier and less time-consuming. For a more detailed description of the inputs and coding process, refer to the VISSIM simulation procedure in Appendix A.

2.2.2 Testing and Calibration

Once the model was completed, it was tested and calibrated. Researchers reviewed the on-screen animation and model outputs to determine the model's accuracy in simulating field operations. The user then viewed the on-screen animation to check the realism of queue lengths. Computer operators then compared the travel time outputs to those collected with the field travel times runs. Speed distributions were altered slightly so that the model's travel times would be similar to the travel times collected in the field.

2.3 DISCUSSION OF PRELIMINARY SIMULATION FINDINGS

The simulation findings provided in this report are preliminary, as indicated in several locations throughout this report. While the VISSIM model appears to be a very promising micro-simulation tool for simulating access management treatments, there is a steep learning curve for analysts. The research team continues to learn more about the model, and may re-evaluate the findings of this report in the second year of this research effort.

One specific consideration within VISSIM is the fact that micro-simulation results should be based on numerous runs of the same conditions along a corridor. The preliminary travel time and delay findings provided in this report are the result of one simulation run. Final results should be based on several operational runs from which an average can be taken due to the numerous operational complexities occurring along a given corridor and because VISSIM is a random model. One other consideration is the manner in which VISSIM routes vehicles, especially when U-turns are present, and the research team will look further at this when investigating the theoretical corridors (see section 2.7) in the second year of the research project.

2.4 TEXAS AVENUE (BRYAN) CASE STUDY LOCATION

2.4.1 General Description

Texas Avenue is a five-lane major arterial with a continuous two-way left-turn lane. The major traffic generators along this section of Texas Avenue include fast-food restaurants, a drug store, a bank, office buildings, and a shopping center anchored by a large video store. Various retail and commercial developments also exist along this section. Currently, a TWLTL serves as the median treatment along this section of Texas Avenue. Figure 2-1 shows the study site between the two arrows along Texas Avenue. The northbound view of the Texas Avenue corridor is shown in Figure 2-2 from the Villa Maria signalized intersection. Figure 2-3 shows the TWLTL along Texas Avenue with the Villa Maria intersection in the background.

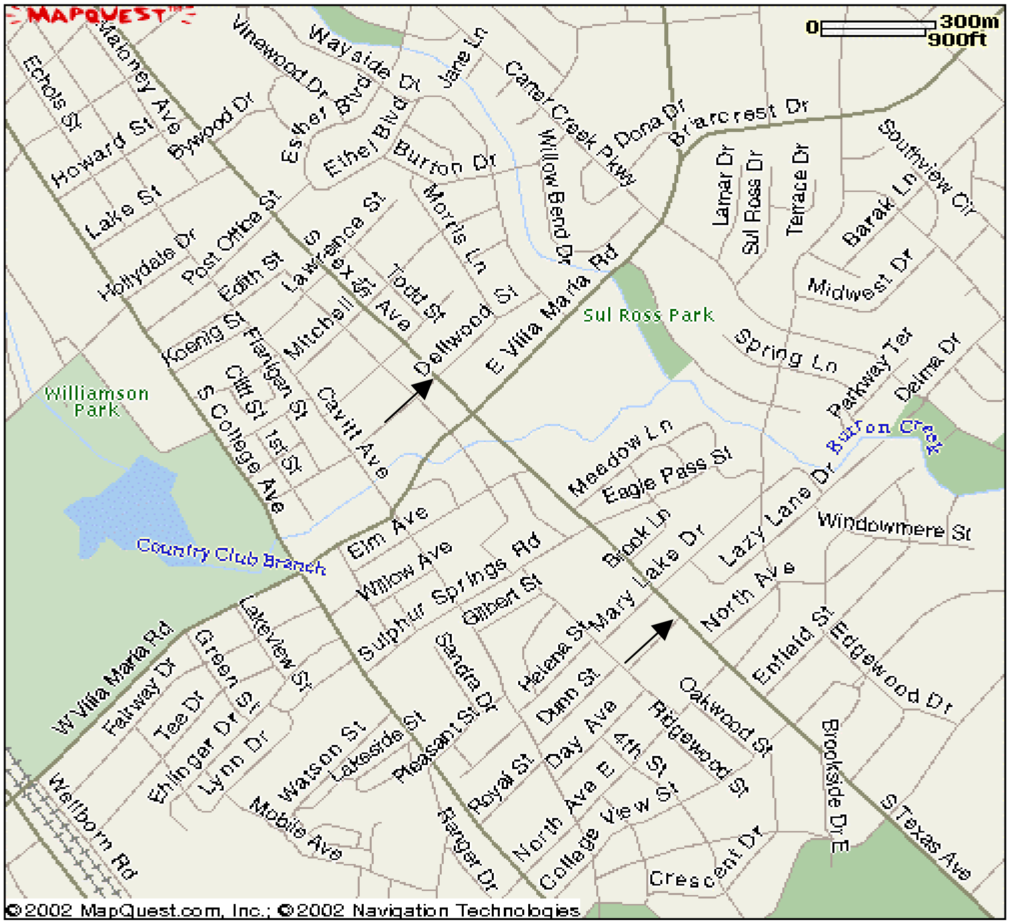

Figure 2-1. Texas Avenue Study Site in Bryan, Texas, Used for Operational Analysis (Map Provided by MapQuest.com, Inc.).

Figure 2-2. Texas Avenue Facing North from Villa Maria.

Figure 2-3. Texas Avenue Facing North with Villa Maria in the Background.

2.4.2 Traffic Operations Analysis

The research team performed a traffic operations analysis on Texas Avenue between Dunn Street and Dellwood Street. This is a 0.55-mile section. The subsequent sections describe the data collection, traffic demand, analysis procedures, and preliminary findings.

Data Collection

Researchers collected traffic volume data on Texas Avenue between Dunn Street and Dellwood Street in March and April of 2002. They also collected average daily traffic (ADT) data on Texas Avenue at two locations using tube counters south of Dunn Street and north of Dellwood Street. The ADT on Texas Avenue north and south of Villa Maria was approximately 18,200 and 16,600, respectively. Researchers collected noon and evening turning movement counts at the intersections of Texas Avenue and Villa Maria Road and Texas Avenue and Sulphur Springs/Eagle Pass Road. They also took turning movement counts at all of the driveways between Dunn Street and Dellwood Street. The team videotaped traffic on the corridor and later reduced the data to obtain specific counts.

Traffic Demand

Researchers evaluated existing and proposed conditions using existing traffic volumes. The noon peak hour consisted of the highest mainlane and driveway traffic volumes; therefore, the team used the noon peak hour volumes for the operational analysis.

For the raised median condition, existing traffic volumes were rerouted to alternative routes to reach their destination. For example, a left-turning motorist that was prohibited by the installation of the raised median would first turn right and then make a U-turn at the first median opening.

Vehicle Conflict Points

As part of this study, researchers conducted an evaluation of vehicle conflict points for existing and proposed conditions. Existing conditions of Texas Avenue consist of a five-lane arterial with a TWLTL. At the intersections of Texas Avenue with Villa Maria Road and Eagle Pass/ Sulphur Springs Road, there is a transition to a conventional left-turn lane.

Previous research suggests that a TWLTL providing access to numerous driveways can be a safety problem due to the numerous conflict points (*3*). Table 2-1 presents an estimate of the existing conflict points based on the type and number of intersections and driveways on Texas Avenue between Dunn Street and Dellwood Street.

The proposed condition consists of a raised median between Dunn Street and Dellwood Street with full median openings north of Dellwood Street, between Villa Maria Road and Sulphur Springs Road, at Sulphur Springs Road, and at Dunn Street. Table 2-2 summarizes the estimated conflict points for the proposed condition. The proposed condition reduces the number of potential conflicts from 756 to 297, approximately 60 percent.

Table 2-1. Texas Avenue Existing Conflict Points.

Roadway Section Type[1]	Number of Intersection[2] Types along Study Corridor	Conflict Points per Intersection	Number of Lanes	Total Conflict Points
T-Intersection (TWLTL)	40	13	5	520
T-Intersection (RM)	0	2	5	0
T-Intersection (RMO)	0	11	5	0
RMO only	0	5	5	0
Dellwood Intersection	1	46	5	46
Villa Maria Intersection	1	52	5	52
Sulphur Springs Intersection	1	46	5	46
Mary Lake Intersection	1	46	5	46
Dunn Intersection	1	46	5	46
Total				756

[1] TWLTL is a two-way left-turn-lane. RM is a raised median. RMO is a raised median opening.
[2] Intersections include both public streets and private driveways.

Table 2-2. Texas Avenue Proposed Condition Conflict Points.

Roadway Section Type[1]	Number of Intersection[2] Types along Study Corridor	Conflict Points per Intersection	Number of Lanes	Total Conflict Points
T-Intersection (TWLTL)	0	13	5	0
T-Intersection (RM)	38	2	5	76
T-Intersection (RMO)	4	11	5	44
RMO only	1	5	5	5
Dellwood Intersection	1	4	5	4
Villa Maria Intersection	1	52	5	52
Sulphur Springs Intersection	1	56	5	56
Mary Lake Intersection	1	4	5	4
Dunn Intersection	1	56	5	56
Total				297

[1] TWLTL is a two-way left-turn-lane. RM is a raised median. RMO is a raised median opening.
[2] Intersections include both public streets and private driveways.

Analysis Procedure

Researchers used VISSIM to model 1) existing conditions, 2) optimized existing conditions, 3) proposed conditions with a raised median, 4) proposed future (higher volumes) conditions with a raised median, and 5) future conditions (higher volumes) with the current TWLTL along Texas Avenue. The following sections describe the details of the five conditions. The VISSIM simulation model evaluated travel time and delay along the Texas Avenue corridor under each of the five conditions.

<u>1. Existing Condition</u>. Texas Avenue is a five-lane arterial roadway with a TWLTL as the center lane. The corridor is 0.55 miles in length. The driveway density is 40 and 50 driveways per mile on the east and west side of Texas Avenue, respectively. The existing signal timings

were collected from the City of Bryan and used in this model. Figure 2-4 shows the approximately location of streets and driveways.

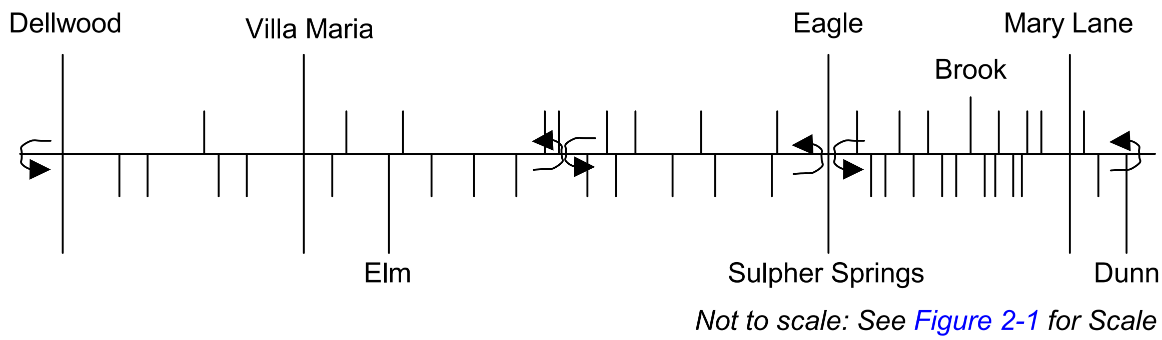

Figure 2-4. Schematic to Illustrate Approximate Driveway, Street, and U-turn Locations for Operational Scenarios.

2. Optimized Existing Conditions. In the optimized condition, the existing geometry on Texas Avenue remains the same, but the signal timings at the two signalized intersections on the corridor were optimized using SYNCHRO, a signal optimization software.

3. Proposed Condition with a Raised Median. In the proposed condition, a raised median replaces the TWLTL. U-turn median openings are located approximately 660 feet spacing from the signalized intersections. U-turns are allowed at the median openings north and south of Villa Maria Road and at the intersection of Texas Avenue and Sulphur Springs Road. The U-turn locations are approximated in Figure 2-4. Because of the existing high volumes at the intersection of Texas Avenue and Villa Maria Road, U-turns are not allowed at this intersection. The U-turns are rerouted at the median openings located north and south of Villa Maria Road. The signal timings were also optimized in the proposed condition.

4. Proposed Future Condition with a Raised Median. Researchers increased the volumes along Texas Avenue to analyze how Texas Avenue may operate in the future. The volumes were increased by 20 percent, which equates to approximately 2 percent per year for 10 years. The increase resulted in approximately 400 additional vehicles on Texas Avenue during the peak

hour. The future condition was analyzed with the five-lane cross section with a center raised median. The high traffic volumes at the intersection of Texas Avenue and Villa Maria Road required mitigation to continue allowing traffic flow through the intersection. Therefore, dual left-turn lanes were added on the south, east, and west approaches of the intersection. Dual left-turn lanes are currently present on the north approach. The signal timings were also optimized in both of the future conditions. The median spacings are the same as for the proposed condition (#3).

5. Future Conditions with a TWLTL. This condition is the same as #4 above except that a TWLTL replaces the raised median.

Preliminary Findings

Table 2-3 summarizes the preliminary findings related to the travel time analysis. From the existing condition to the optimized condition, the travel time decreased overall. Therefore, optimizing the signal timings does lower the travel times on the corridor. This illustrates the importance of signal optimization as a low-cost improvement. Travel times increase slightly in the proposed condition. This phenomenon can be attributed to an overall increase in traffic on the corridor, as some U-turning vehicles must travel farther to reach their destination. Delay is also likely to increase at the intersections. An increase in delay is expected at the Texas Avenue and Eagle Pass/Sulphur Springs intersection because of additional U-turning traffic. Delay is also expected to increase at the Texas Avenue and Villa Maria intersection due to a greater number of vehicles traveling through the intersection to reach median openings located north and south of the intersection. Because mitigation was necessary at the intersection of Texas Avenue and Villa Maria, it is difficult to compare the existing conditions to the future conditions. Therefore, the proposed future condition (with a raised median) is compared to the future condition (with a TWLTL). Travel times were lower overall when comparing the proposed future condition with a raised median to the future condition with a TWLTL. On northbound Texas Avenue, the average travel time is 22 seconds less for the proposed future condition, which includes a raised median. However, on southbound Texas Avenue the travel times increase by 5.6 seconds for the proposed future condition. Overall, travel times are decreased on the corridor by 11 seconds in the future when the raised median is present. This is an 11 percent decrease in travel time. Clearly, these are small differences. It should be indicated that these findings may become more substantial at higher ADTs. The reader should review Section 2.3, which describes the potential limitations of these preliminary findings in more detail.

Table 2-3. Texas Avenue Preliminary Travel Time Analysis Findings[1].

Condition	Average Travel Time (seconds/vehicle)		
	Northbound[2]	Southbound[3]	Entire Corridor[4]
1. Existing (TWLTL)	92.7	108.8	100.0
2. Optimized (TWLTL)	86.6	98.3	92.2
3. Proposed (RM)	115.9	104.9	112.0
4. Proposed Future (RM)	102.3	100.4	100.0
5. Future (TWLTL)	124.3	94.8	110.8

[1] See section 2.3 for more information regarding the potential limitations of these preliminary findings.
[2] Northbound traffic from Dunn to Dellwood along Texas Avenue.
[3] Southbound traffic from Dellwood to Dunn along Texas Avenue.
[4] Directional travel times were weighted by the directional volume to obtain delay times along the corridor.

Table 2-4 presents the delay analysis preliminary findings. From the existing condition to the optimized condition, the average delay decreases overall. Therefore, optimizing the signal timings does reduce delay along the corridor. Similar to the travel times, the preliminary findings give the appearance that average delay increases in the proposed condition. This fact can be attributed to an overall increase in traffic on the corridor, as some U-turning vehicles must travel farther to reach their destination. Delay is also likely to increase at the intersections due to additional vehicles performing U-turns at the Texas Avenue and Sulphur Springs Street intersection and the additional through volumes at the Texas Avenue and Villa Maria intersection. On northbound Texas Avenue, the proposed future condition (raised median is present) results in 2.5 seconds more delay than the future condition with the TWLTL. Obviously, this is a negligible difference. On southbound Texas Avenue, the proposed future condition (raised median is present) results in 18.1 seconds less delay than the future condition (TWLTL is present). Overall, there is a reduction in delay of 9.1 seconds when the raised median is present in the future. This equates to an approximately 22 percent decrease in delay with the raised median.

Table 2-4. Texas Avenue Preliminary Average Delay Analysis Findings[1].

Condition	Average Delay (seconds/vehicle)		
	Northbound[2]	Southbound[3]	Entire Corridor[4]
1. Existing (TWLTL)	51.7	30.2	40.0
2. Optimized (RM)	40.2	24.1	31.8
3. Proposed (RM)	48.0	54.6	52.2
4. Proposed Future (RM)	40.5	43.8	41.9
5. Future (TWLTL)	38.0	61.9	51.0

[1] See section 2.3 for more information regarding the potential limitations of these preliminary findings.
[2] Northbound traffic from Dunn to Dellwood along Texas Avenue.
[3] Southbound traffic from Dellwood to Dunn along Texas Avenue.
[4] Directional delays were weighted by the directional volume to obtain delay time along the corridor.

As with the travel time findings, the delay per vehicle findings indicate negligible differences between the raised median and TWLTL conditions. The research team may re-evaluate the Texas Avenue corridor in the second year of the study to further investigate the potential issues and considerations identified in section 2.3.

2.4.3 Discussion

Managing left-turn movements with the proposed median can reduce the number of potential conflict points by approximately 60 percent and possibly reduce angular and head-on crash potential along the case study corridor investigated here. The proposed raised median, however, limits access and results in more traffic at the signalized intersections due to rerouting U-turn traffic. The increase in traffic may also require additional capacity at the intersection along with optimizing signal timing.

Based on the analysis of this corridor, there are small differences in the travel time and delay between the existing and proposed conditions. For the proposed condition, when the raised median is present, the preliminary findings appear to show a slight increase in travel time and delay overall. This situation is attributed to an overall increase in traffic on the corridor, as some U-turning vehicles must travel farther to reach their destination. Delay may also increase slightly at the intersections. An increase in delay is expected at the Texas Avenue and Sulphur Springs Street intersection because of the additional U-turning traffic. Delay is also expected to increase at the Texas Avenue and Villa Maria intersection due to an increase in vehicles traveling through the intersection to reach median openings located north and south of the intersection. Though these findings are preliminary, they appear to indicate that with the installation of raised medians, geometric intersection improvements should be anticipated.

Adding 20 percent to the traffic volumes, which equates to approximately 10 years of growth at 2 percent growth per year, requires mitigation at the intersection of Texas Avenue and Villa Maria. Based on the analysis, installing a raised median on Texas Avenue would decrease future travel times by 11 seconds (11 percent), and delays by 9 seconds (22 percent) on the corridor.

Finally, it should be indicated that while the VISSIM micro-simulation tool appears to be valuable for analysis of transportation improvements including access management, there is extensive time needed to become familiar with the software and its internal operation. The research team continues to better understand the operation of the VISSIM software throughout this research project. Therefore, the research team may re-evaluate these Texas Avenue findings in the second year of this study. The reader is encouraged to review section 2.3 for additional related information regarding the VISSIM micro-simulation.

2.5 31ST STREET (TEMPLE) CASE STUDY LOCATION

2.5.1 General Description

The second case study corridor is in Temple, Texas, on 31st Street, from Canyon Creek Road to the Colonial Mall entrance. This road segment is a five-lane arterial that includes a TWLTL. A wide variety of land uses abut 31st Street, including single-family residences, apartment complexes, stand-alone retail stores, shopping centers, and office buildings. Figure 2-5 depicts the northern end of the corridor, where most of the retail establishments are located. Figure 2-6 shows the southern end of the corridor, which is characterized by single-family residences, with driveways intersecting 31st Street, as well as apartment complexes.

Figure 2-5. Southbound 31st Street at Colonial Mall Entrance.

Figure 2-6. Northbound 31st Street, North of Canyon Creek Road.

2.5.2 Traffic Operations Analysis

A traffic operations analysis has begun for 31st Street. The subsequent sections describe the data collection, and traffic demand.

Data Collection

The research team collected traffic volume data on 31st Street from Canyon Creek Road to the Colonial Mall entrance using video cameras. The videotaping included all turning and through movements at every street and driveway intersection for 1 ¾ -hour noontime and evening periods. Researchers reduced the video data to turning movement counts at each unsignalized intersection and to through and turning movement counts at each signalized intersection. By reviewing videotapes of each period, the team determined that the evening was the peak period to use.

Traffic Demand

Data input for this corridor simulation began at the end of this project year and will continue in fiscal year 2003, when results will be available.

2.6 BROADWAY AVENUE (TYLER) CASE STUDY LOCATION

2.6.1 General Description

The third case study corridor is along Broadway Avenue (US 69), between Loop 323 and Chimney Rock Drive in Tyler, Texas. This road currently has three through lanes in each direction and a TWLTL. Adjacent land uses include residential, office, commercial, and retail; however, there are no single-family residential driveways intersecting Broadway Avenue. Figures 2-7 and 2-8 show the three lanes in each direction and the TWLTL along with the mix of land uses along the corridor.

Figure 2-7. Broadway Avenue Facing North to Chimney Rock Signalized Intersection.

Figure 2-8. Broadway Avenue Facing South at Chimney Rock Signalized Intersection.

2.6.2 Traffic Operations Analysis

Data Collection

The research team will use videotapes of traffic from a previous project to determine traffic counts necessary for the computer simulation, which will occur in fiscal year 2003.

2.7 THEORETICAL CORRIDORS

In the second year of this study, the research team will create theoretical corridors for analysis. While the actual case study locations presented here are valuable in providing an assessment of the impacts of access management treatments, simulation of additional scenarios is necessary. These additional scenarios will be useful to TxDOT staff for alternatives analysis. Researchers met with TxDOT in the first year of this study to identify the most useful scenarios for their typical needs. Access management treatments, such as raised median installation and driveway consolidation, will be investigated for different traffic volume levels as part of this work.

CHAPTER 3

CRASH ANALYSIS METHODOLOGY AND FINDINGS

This chapter describes the crash analysis performed at four case study locations in Texas. This analysis provides an estimate of the safety of corridors after the installation of access management techniques. Researchers investigated three locations where a raised median was installed to replace TWLTLs and two locations where raised medians were added to undivided roads. One notable finding of this part of the project is that crash data accuracy, availability, and usefulness vary greatly among agencies. For instance, it can be quite difficult, if not impossible, to obtain crash data going back more than 10 years. Further details are provided in each case study discussion.

3.1 CRASH ANALYSIS CASE STUDY LOCATIONS

Researchers identified five case study locations for crash analysis in Texas, as well as one in Oklahoma. The five case study locations are:

- Texas Avenue in College Station,
- Loop 281 in Longview,
- Call Field Road in Wichita Falls,
- Grant Avenue in Odessa, and
- 71st Street in Tulsa, Oklahoma.

Researchers studied the Texas Avenue corridor first, in order to develop and refine the analysis process that might be used on all case study corridors. Therefore, this report includes detailed information about the Texas Avenue corridor. These case study locations are described in further detail in the sections that follow.

3.2 TEXAS AVENUE (COLLEGE STATION) CASE STUDY LOCATION

3.2.1 General Description

The first case study corridor is along Texas Avenue in College Station, Texas. Researchers investigated changes in crash characteristics along Texas Avenue from 0.2-mile south of George Bush Drive to 0.2-mile north of University Drive. Prior to the retrofit, Texas Avenue was a five-lane roadway with a TWLTL. In 1996, Texas Avenue was widened to six lanes and the TWLTL was converted to a raised median. The land use on the east side of Texas Avenue is mainly commercial. There are many traffic generators such as a large home electronics store, bookstore, and restaurants and retail shops. Figure 3-1 shows the study site between the two arrows along Texas Avenue. The campus of Texas A&M University borders the west side of Texas Avenue. Figure 3-2 and Figure 3-3 show the raised median treatment along this portion of Texas Avenue and has only one main entrance to the campus along this portion of the study corridor.

Researchers gathered crash data for the time period from January 1993 to June 2000 for the study site. This study section was examined as an entire corridor and at specific locations. The subsequent sections describe the data collection, traffic demand, analysis procedures, and preliminary results. Portions of the Texas Avenue case study location discussion are excerpted from reference *4*.

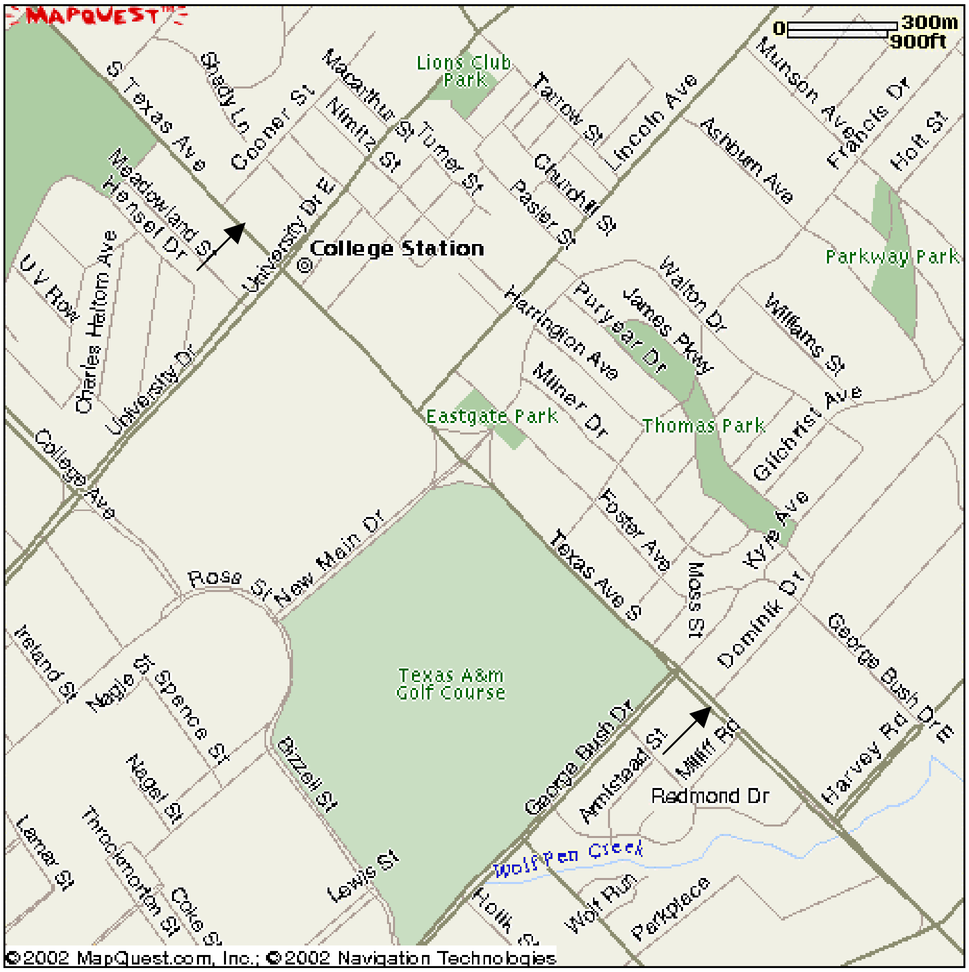

Figure 3-1. Texas Avenue Study Site in College Station, Texas, Used for Crash Analysis (Map Provided by MapQuest.com, Inc.).

Figure 3-2. Raised Median Treatment on Texas Avenue Showing Cross Section.

Figure 3-3. Raised Median Treatment on Texas Avenue Showing Median Openings.

3.2.2 Data Collection

Crash data were obtained from the Accident Records Bureau (ARB) of the Texas Department of Public Safety (DPS) in Austin. Coded crash data refers to crash information contained in the DPS mainframe database. Currently, this information consists of all the data from the original crash reports, with the exception of crash sketches and the exact wording of narratives, for the most recently processed 10-year timeframe. For quality control purposes, original crash reports retained by DPS were also collected and studied. Between the coded and original records and through the insight of personnel working at the ARB, researchers were able to investigate the accuracy of the crash-reporting process in the State of Texas. The authors will take the readers step by step through the crash-reporting process, summarize the quality of the process, and describe the specifics of the data collection.

Crash-Reporting Process

Crash reports are the beginning of the crash-reporting process. In the State of Texas, crash reports are submitted on two possible forms, the ST-2 and the ST-3 (see Appendix B).

The ST-2 is used less often and is sent directly to the ARB by one or more of the participants in the crash. This form is used when there is no police involvement, or when the police do not plan to report the crash and the motorists involved still desire an official record. The ST-2 is more commonly referred to as the "blue form," due only to the color of the form. The form contains all the applicable information of the crash including location, vehicle identification, damage, and casualties.

When local agency police do not report a crash, drivers have the right and the responsibility to report their traffic incident to the DPS with a blue form. State law places the onus on the driver for reporting a crash that takes place on a public roadway and not the policing authority. In most cases, if a police officer(s) stops at the scene of a crash, a report will be submitted. In property damage only (PDO) cases where the total property damage is estimated to be less than $1,000 and no injuries were involved, the drivers may request that police not fill out a crash report because the drivers intend to report the incident and are peaceably exchanging insurance and contact information. PDOs mean no injuries occurred, and there was only vehicular and/or roadway facility damage. In some cases, research will use equivalent property damage only (EPDO) to include injuries, by adding the associated costs from the injuries to the PDO for comparison and statistical purposes. The authors of this report will not use EPDOs. If the police are not involved at the crash scene, the drivers may file a crash report either directly through the local police or through DPS. If the crash is a PDO not exceeding $1,000 and no traffic citations or criminal proceedings are warranted, it is highly unlikely the police will report the crash, even if the drivers involved try to report one. In that specific instance, the police will suggest that the drivers submit a blue form to DPS for reporting purposes.

Crash-reporting trends are the common reason behind the fewer number of blue form crash reports. Regardless of the legal responsibility of drivers to report crashes, the current tendency of motorists is not to report crashes that do not involve injuries, criminal charges and/or property damage exceeding $1,000, because drivers wish to avoid higher insurance rates (*5*,*6*).

The police in the State of Texas use the ST-3 to record crashes. The ST-3 contains all the same information as the blue form, except in more detail. This form has a location for the reporting officer to sketch the crash and to write summary comments. These comments are based upon statements of individuals involved and on the officer's professional assessment of the crash scene. One benefit of the ST-3 is that the officer's comments should offer a more accurate and unbiased point-of-view of the incident. The police form also includes citation, weather, and road data. Weather conditions, road data, and crash sketches may be submitted on the blue form in the driver narrative section; however, the ST-3 offers a less biased crash assessment because drivers invariably will respond in their favor for insurance purposes. Once the officer's crash investigation is complete, the crash record will be submitted to the local police department.

Local crash processing varies in length and detail based upon the needs and goals of the local policing authority. In College Station, Texas, the local police input certain data from the crash report to a local database. The database contains information such as the crash location and the overall severity of the crash. Overall crash severity is one way in which crashes are categorized.

The most severe disposition of individuals involved in the crash is associated with the overall crash severity. For instance, in a crash with four possible injuries and one incapacitating injury, the crash will have an overall severity of incapacitating injury. For example, a police officer records a person complaining of a sore neck as a possible injury. Non-incapacitating injuries consist of obvious scrapes and bruises that would not physically disable a person at the scene, while an incapacitated person would have a broken limb or have excessive bleeding that would require minimal movement and a pressure bandage (e.g., a tourniquet). A copy of a printout of crash data offered through the College Station Police Department (CSPD) is in Appendix B. After the data is input, the records are stored on file in the CSPD Records Department, and a copy is shipped to the ARB. The whole process usually takes about 10 business days.

As the ST-2 and ST-3 reports arrive at the ARB, the files are immediately sorted, and the processing begins. The whole process can be equated to an assembly line. The initial steps include the date stamping of the incoming files and sorting by county. In the next stage, the records are separated into three categories. For the purposes of this report, the categories will be referred to as Group I, II and III.

The crash reports are placed into the different groups based upon the cause of the crash, the location of the crash, the estimated replacement/repair costs involved, and the overall crash severity. Group I contains crashes that involve PDOs less than $1,000 and crashes that do not occur on the roadway (i.e., crashes in a private parking lot). Group II includes PDOs equal to or in excess of $1,000 and in which the vehicles were not towed from the scene. The Group III category consists of all crashes that take place on a public roadway that include injuries and/or PDOs equal to or in excess of $1,000 in which the vehicles were towed. Group I crashes are the least likely to be reported.

Within the grouping stage, certain information is marked on the records for later coding to an individual's traffic history/driving record. All traffic violations are coded to a driver's traffic history for state and insurance reasons. The at-fault driver(s) in a crash has the crash coded to his/her record solely for the purposes of the state. Drivers not at fault in a crash do not have the crash added to their personal driving records. One example of a driver not at fault is a driver of a vehicle that is rear-ended at a stoplight. The motorist to whom the rear-ending is attributed is the one who has the crash coded to his/her personal driving record. Another example is a driver who crashed as the motorist evaded an animal on the roadway. However, it is possible to be at fault in a crash and not receive a traffic citation. For example, one case in which a driver at fault will not have his/her driving record affected is when the crash does not occur on a roadway but on private property instead, such as a parking lot.

The state and the insurance agencies use a driver's personal traffic history for different purposes. The state will use this information to invalidate a driver's license or to aid in criminal proceedings. Insurance agencies will use the information to analyze their client's policy to validate premium changes or policy cancellation. However, insurance agencies only have limited access to the data. They can only retrieve the last three years worth of data and only data including traffic citations. The crash data is not available. The only crash data that an individual's insurance agent receives is what he/she submits in an insurance claim.

The coding of crash data into a DPS mainframe is the next step in the crash-reporting process. This phase is only for Group II and III. Group I records are not included because they are the least likely to be reported and the least severe.

The first step and the longest step in the coding occurs with the handwritten coding. During this phase, the coding of the records is broken down into different stages. The reports are coded in an assembly-line fashion with ARB staff coding only certain information as the record passes through. For instance, a specific person would be tasked to code only the driver data onto a hardcopy sheet.

Once the coding phase is complete, the sheets are input through a dual data entry method. While in the earlier stages there are varying levels of checks to minimize data entry errors, the dual data entry method is one of the best ways to reduce mistakes. Two different people input the data into a computer; the computers compare the records; matching records are set aside for the final mainframe upload; and the records that do not match are set aside for checking.

One further note should address the fact that the ARB is further working to improve the crash-reporting system with the Crash Record Information System (CRIS). DPS is working with TxDOT to fund this new system that will help automate the reporting process and make the information more accessible in a timely manner. Members of the ARB are assisting transportation engineering and planning by getting the crash data to different agencies that try to make informed infrastructure safety improvements. CRIS will further enhance the abilities of the ARB and of any other agencies that require such information. A copy of a CRIS newsletter is located in Appendix B.

There is a more in-depth description of the crash-reporting process in outline format in Appendix B. Figure 3-4 is a flowchart representation of the above crash-reporting process.

Data Collection Efforts

The authors retrieved their data through various resources. They obtained primary data, the coded and original crash reports, from the ARB. After defining the study corridor, the researchers compiled the coded crash data using a TTI CD-ROM supplied by the ARB. To collect the original crash reports, the applicable reference information, such as the date of the crash and the county where the crash occurred, were submitted directly to the ARB. The other components of the data collection effort were the annual average daily traffic (AADT) counts and the roadway layout before and after the retrofit. TxDOT supplied both of these items. AADT values will be discussed later in the "Traffic Demand" portion of this section of the report. The roadway layout will be discussed in the "Crash Analysis Procedure" that follows the traffic demand discussion.

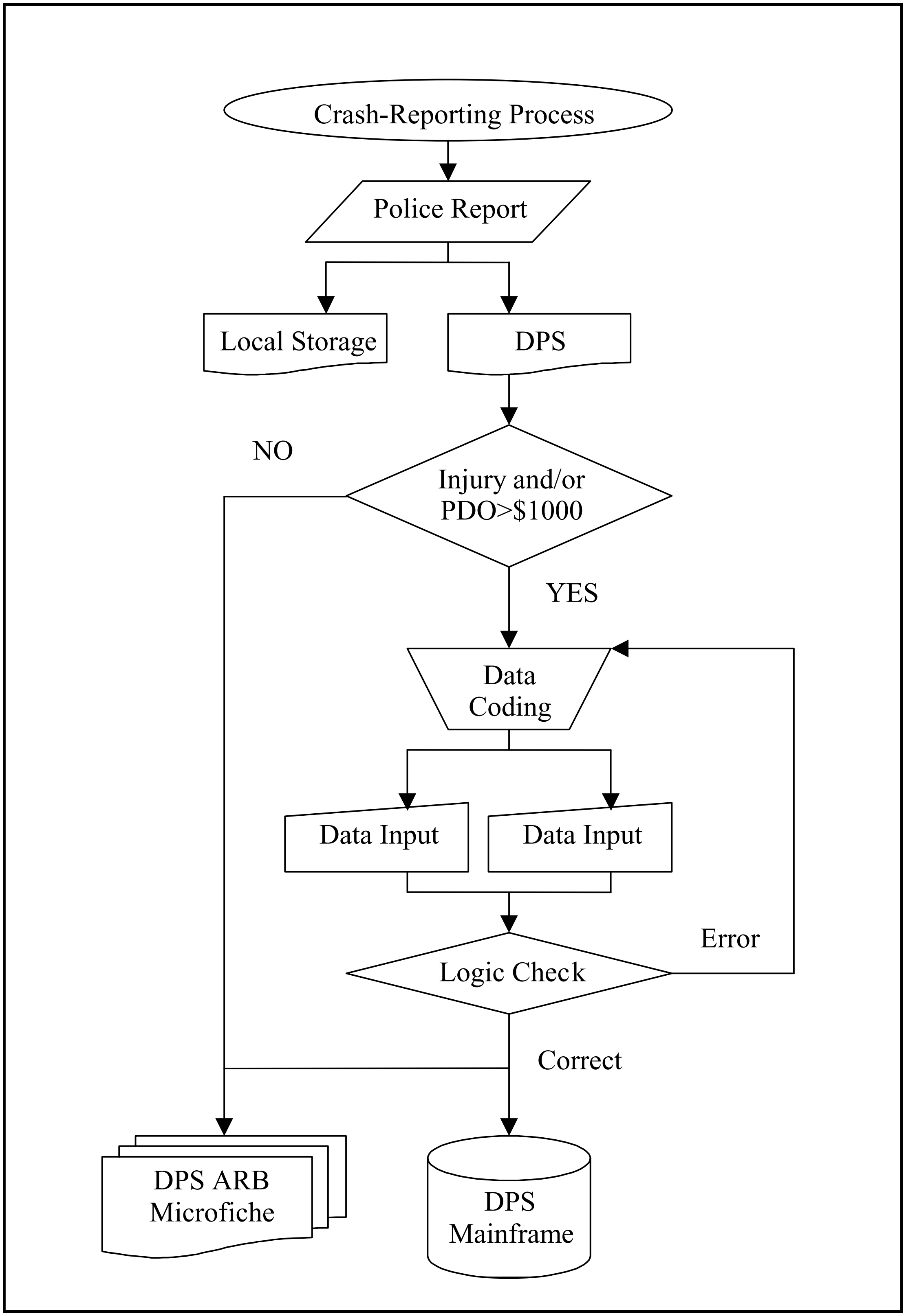

Figure 3-4. Crash-Reporting Process Flowchart.

It should be noted that crash data eventually used for the before-construction analysis were from January 1993 to December 1994. The data used for the after-construction period were from July 1998 to June 2000. Researchers selected the before-data timeframe because in July 1995 only PDO crashes where the vehicle had to be towed from the scene were in the crash records for PDO. If there was no injury or the vehicle was not towed, then there was not a crash record. The before data were filtered appropriately to ensure comparisons to the after-construction data were consistent. Researchers used the above timeframe for the after period because June 2000 were the latest data available, and the construction of the raised median was concluded in June 1998.

Summary of Crash-Reporting Errors

The main areas of concern for crash-reporting errors stem from the location, orientation, crash type, and severity of the incident. After carefully looking through over 1,014 individual crash reports, the researchers feel confident in indicating location inaccuracies are the most prevalent. In some instances, both law enforcement and the coding staff of the ARB made data entry errors. The mistakes were minor and were not attributed to negligence. The authors assess that there is a considerably low quantity of crash-reporting errors, and by using the original crash reports, the errors encountered may all be corrected.

The researchers first looked directly at the coding errors that occurred within the ARB. Out of 1,014 records studied, only 29 errors (3 percent) were recorded between the data contained by the DPS mainframe and the data provided by the original police reports. Of the 29 coding mistakes, eight dealt with the original written coding stage by someone who was unfamiliar with the peculiarities of College Station. For example, SH 30 is Harvey Road, and FM 2818 is Harvey Mitchell Parkway. There was a crash that occurred at Harvey Mitchell Parkway but was coded for Harvey Road. For someone from College Station, the error is obvious; however, it is far more probable that someone who is unfamiliar with the area may unknowingly code the information incorrectly. Of those errors that did occur, the original crash report removed any doubt as to the location of the crash.

Of the remaining errors, 20 were related to coding the incorrect primary road at an intersection crash, and only one was related to the crash type. The coding mistakes for the primary roadway are the least significant, because the mistakes are based upon the authors' interpretation of the data and not on the ARB coding rules. The ARB defines the primary roadway as the one that has designation seniority. In other words, in a crash at the intersection of Texas Avenue and University Drive, the primary roadway will be Texas Avenue because it is a state highway, and University Drive is a farm-to-market road. The researchers believe if the crash does not occur in the intersection (i.e., an off-setting reference distance is supplied that places the crash outside of the intersection), then the crash should be coded on the roadway on which it occurs. Hence, the errors were calculated accordingly.

The other source of error in crash reporting originates with the crash report submitted by the police. The police reports studied for this project contained more than enough additional information to enable the researchers to clarify and verify any perceived discrepancies in the reporting of location, orientation, crash type, or severity of a crash. In their investigation, the researchers did find erroneous reference distances used by the reporting officer(s). For example, one police officer recorded a crash 100 feet south of Dominik Drive. After further investigation, the researchers were able to determine through other reported information that the crash occurred 600 feet south of Dominik Drive. The reported orientation, crash type, and crash severity data overall appeared to not contain errors. Researchers looked at errors of this type from the perspective of internal discrepancies within the report itself. For instance, it would be considered an error if a police officer had coded the crash severity with a death, but he/she did not record a death with any one of the drivers or non-drivers.

The milepost position of a crash along the main roadway, as coded by DPS, is another potential error related to crash location. This error also occurs in the handwritten coding stage; however, this fault cannot be solely attributed to the ARB, nor is it considered a significant problem. Because driveway openings themselves can be on the order of approximately 40 feet themselves, accuracy of 0.01 or 0.001 of a mile (53 or 5 feet) is desirable. In the field, it would be a daunting, if not impossible, task for officers to relay that level of accuracy by handwritten methods for the entire State of Texas using current methods. Technologies such as global positioning systems

(GPS) might be used in the future to identify the crash location relative to known objects (e.g., traffic signs, center of curve radius). A comparison between all crash records comparing the police report locations and the milepost locations from the TxDOT location map were adjusted to within 5 feet to ensure the location accuracy was provided.

Common errors that were expected, but could not be verified, were related to the exact number of vehicles involved, and the true intentions and compounding causes attributing to the crash. In one instance, a vehicle was traveling southbound in the outside lane approaching traffic congestion associated with the Texas Avenue and George Bush Drive signal. The motorist attempted to move into the adjacent lane to avoid the longer queue of cars and sideswiped another vehicle. No comments or inferences were made by the drivers or the reporting officer. Answers to questions such as “did the driver miss his/her blind spot,” “was the other driver speeding or changing lanes,” and “did either party have additional stimuli distracting him/her from driving” are typically unknown, due to inaccurate eyewitness reporting and drivers providing false information for the sake of avoiding incrimination contribute to data errors (*6*).

In summary, the error calculations in regard to the quality control aspect of the study were limited to the miscalculations in the milepost location of the crashes along the main roadway.

In the above calculations, the revised data section refers to the reduction in the original raw data. The reduction included removing all data records containing errors that could not be attributed to DPS mistakes. These errors consisted of data input errors in the original police report, and data the DPS coded for the wrong roadway possibly resulted from lack of familiarity with the crash location. These cases dealing with the DPS coding the wrong roadway were not included because it was difficult to ascertain the intent of the coding officer. The coding of a wrong roadway occurred approximately 3 percent of the time.

Overall, these findings are promising and seem to indicate a robust data set for crash analysis along Texas Avenue. The authors did look at coded data collected locally by the College Station Police Department. The local data files were not used because the information was not detailed enough for this study’s purposes.

3.2.3 Traffic Demand

The traffic volumes were retrieved for use in generating section and intersection crash rates that will be addressed later in the crash analysis of Texas Avenue. Table 3-1 presents the AADT values used for the rate calculations. These values originated from the data collection efforts of TxDOT. The values for the entering volumes listed in Table 3-2 were calculated assuming a 50/50 directional split. These values were used to formulate the total entering volumes for the intersection rate calculations.

Table 3-1. AADT Counts.

Year	AADT (vehicles/day)					
	Texas Avenue North of University Drive	University Drive West of Texas Avenue	University Drive East of Texas Avenue	Texas Avenue between University Drive and George Bush Drive	George Bush Drive West of Texas Avenue	Texas Avenue South of George Bush Drive
	MP 4.950[1]	MP 6.621[1]	MP 6.716[1]	MP 5.700[1]	MP 3.232[1]	MP 6.056[1]
1993	26,000	34,000	31,000	40,000	22,000	39,000
1994	25,000	34,000	29,000	42,000	22,000	41,000
1998[2]	22,500	35,500	32,000	38,500	26,500	42,000
1999[2]	25,500	38,500	34,500	43,000	28,000	46,500
Before	25,500	34,000	30,000	41,000	22,000	40,000
After	24,000	37,000	33,250	40,750	27,250	44,250

[1] MP is an abbreviation of milepost that refers to a location along a roadway as used in Roadway Inventory (RI) logbooks by TxDOT.
[2] Indicates that the timeframe goes from July of that year through June of the next.

Table 3-2. Entering Traffic Volumes.

Year	Entering Traffic Volumes (vehicles/day)							
	Vehicles Entering the Intersection of Texas Avenue and George Bush Drive				Vehicles Entering the Intersection of Texas Avenue and University Drive			
	EB[1]	WB[1]	NB[1]	SB[1]	EB[1]	WB[1]	NB[1]	SB[1]
1993	11,000	11,000	19,500	20,000	17,000	15,500	20,000	13,000
1994	11,000	11,000	20,500	21,000	17,000	14,500	21,000	12,500
1998[2]	13,250	13,250	21,000	19,250	17,750	16,000	19,250	11,250
1999[2]	14,000	14,000	23,250	21,500	19,250	17,250	21,500	12,750
Before	11,000	11,000	20,000	20,500	17,000	15,000	20,500	12,750
After	13,625	13,625	22,125	20,375	18,500	16,625	20,375	12,000

[1] EB = eastbound; WB = westbound; NB = northbound; and SB = southbound.
[2] Indicates that the timeframe goes from July of that year through June of the next.

3.2.4 Crash Analysis Procedure

This section discusses the use of crash diagrams, crash rates, and the various statistical calculations that were performed in the crash analysis.

Crash Diagrams

Crash diagrams are an integral part of conducting a crash analysis. Crash diagramming is a standard technique that enables researchers to pinpoint locations with high crash volumes and to visually associate the representative crash types with their location. Researchers generate crash diagrams by placing each individual crash on a plane-view schematic of the study location according to the crash type, location, and whether there was an injury involved. Figure 3-5 below, from the chapter on, “Traffic Accident Studies,” of the ITE *Manual of Traffic Engineering*, was used by the authors to produce the crash diagrams. This figure was essential in the diagramming process.

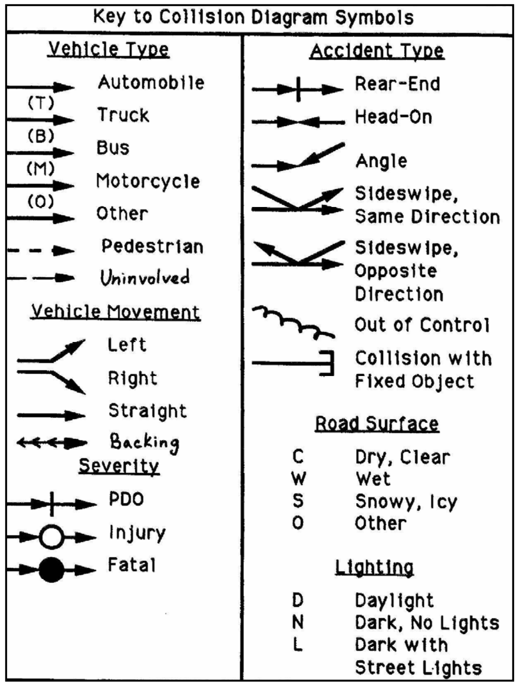

Figure 3-5. Crash Diagram Symbols (*6*).

Figures 3-6 and 3-7 show two examples of the researcher's crash diagrams for this study. Each tally mark represents one crash.

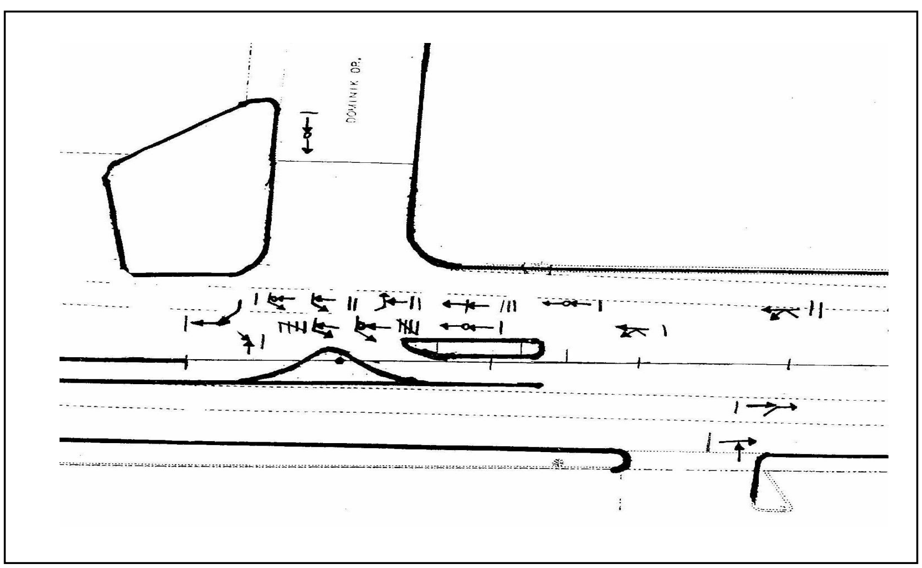

Figure 3-6. Before Period at Texas Avenue and Dominik Drive.

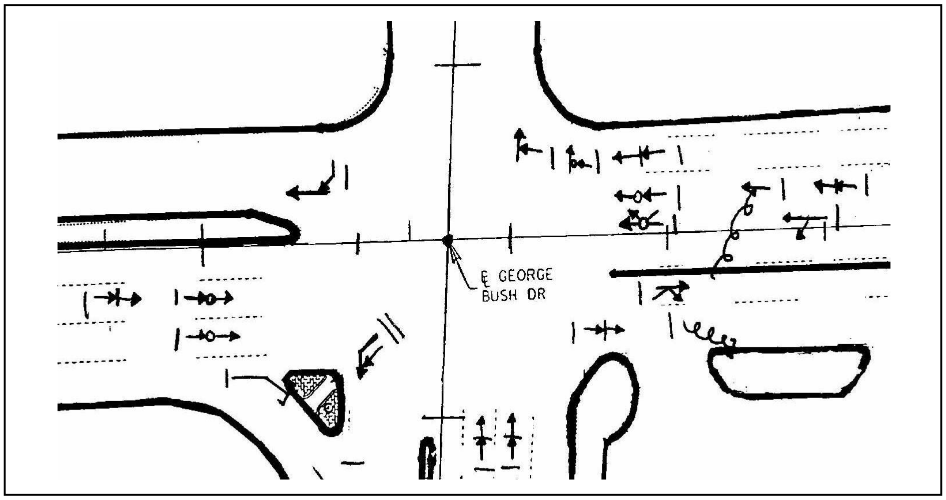

Figure 3-7. Before Period at Texas Avenue and George Bush Drive.

Crash Rates

Crash rates were used to describe the change in crash impacts from the "before" period to the "after" period. The crash rates equalize the calculated values between the before-and-after periods by taking into account the traffic volumes and the timeframe of the before period and the after period. The intersection rates were calculated for the intersections of Texas Avenue and University Drive, and Texas Avenue and George Bush Drive. These intersections were selected because they are the two intersections with the highest traffic volumes along the corridor. A filtering process was used to determine which crashes should be attributed to the intersections. First, all crash reports were collected of crashes that occurred within 0.2-miles north, south, east, and west of the center of the intersection. Next, each report was analyzed in detail to determine if the cause of the crash could be attributed to the intersection. For example, a rear-end crash that occurred due to a driver stopping for the signal was attributed to the intersection. However, a sideswipe crash that occurred after the vehicles left the intersection was not attributed to the intersection. The crashes that were attributed to the intersection were included in the calculation of the intersection crash rates. The other type of crash rate that was calculated was a section rate. The section consisted of the 0.7-mile section of Texas Avenue between the intersections of University Drive and George Bush Drive. Table 3-3 summarizes the locations of the intersections and sections that were used to calculate crash rates.

Table 3-3. Milepoint Locations Used to Calculate the Intersection and Section Crash Rates.

Location	Texas Avenue and University Drive	Section	Texas Avenue and George Bush Drive
Milepoints	5.85-6.25	5.2-5.9	4.92-5.32

The "before" period was a 2-year period from January 1993 to December 1994, due to the change in the crash-reporting threshold that occurred in 1995. The "after" period was the 2-year period from July 1998 to June 2000. Equations 3-1, 3-2, and 3-3 were used to calculate the crash rates and percent change values (*6*).

$$RSP = \frac{1{,}000{,}000C}{365TV} \qquad (3\text{-}1)$$

$$RSEC = \frac{100{,}000{,}000C}{365TVL} \qquad (3\text{-}2)$$

$$\%Change = \frac{A - B}{B} * 100 \qquad (3\text{-}3)$$

Where:

RSP = Rate of the spot (intersection);

RSEC = Rate of the roadway section;

C = Total number of crashes for the associated location and timeframe;

T = Time frame in years;

V = Annual Average Daily Traffic counts entering the study location;

L = Length of the section of roadway under investigation;

A = Value of the after rate/absolute number; and

B = Value of the before rate/absolute number.

Summary Statistics and Statistical Analyses

The authors totaled many of the crash data to compare and analyze the before-and-after periods. The resulting values are broken down into the following categories: timeframe, location, total crashes, individual crash types, total injuries, and individual injury types. These summary values are in tables in Appendix C and were statistically analyzed using percent changes between the before-and-after periods and by testing the summary values of the before-and-after periods for significance. The percent changes have already been discussed in the "Crash Rates" section of this report. The *z*-statistic used in safety analyses is introduced in the text *Traffic Engineering* (*5*). In all of the following tables, researchers used the percent change equation (Equation 3-8). The *p*-value of the significance test is also provided in many of the tables in this report. When it is <0.05, there is a significant difference between the before-and-after crashes at the $\alpha = 0.05$ level of significance. The *z*-statistic used is shown in Equation 3-4 when $A + B > 20$ observations.

$$Z = \frac{|A - B|}{\sqrt{A + B}} \tag{3-4}$$

Where: A = Value of the after rate / absolute number;

B = Value of the before rate / absolute number; and

Z = Test statistic from which the *p*-value is looked up in a normal distribution table.

Alternatively, if the sum of A and B is greater than five observations and less than or equal to 20 observations, Equation 3-5 can be used as the test statistic to determine the associated *p*-value (*7*).

$$Z = \frac{A - B - 1}{\sqrt{A + B}} \tag{3-5}$$

Finally, for sample sizes less than or equal to five, two Poisson distributions can be compared using the *F*-statistic shown in Equation 3-6 (*7*). In Equation 3-6, X_1 and X_2 are replaced by A and B as in Equation 3-5 ensuring that $X_1 > X_2$.

$$F = \frac{X_1}{X_2 + 1} \tag{3-6}$$

3.2.5 Crash Analysis Results

The results of the crash analysis are summarized in the following sections.

Vehicle Conflict Points

As part of this study, researchers conducted an evaluation of vehicle conflict points for existing and proposed conditions. Before the installation of the raised median, the conditions on Texas Avenue consisted of a five-lane arterial with a TWLTL. At the intersections of Texas Avenue with George Bush Drive and University Drive, there is a transition to a conventional left-turn lane.

Previous research suggests that a TWLTL providing access to numerous driveways can be a safety problem because of the numerous conflict points. Table 3-4 presents an estimation of conflict points based on the type and number of intersections and driveways along the study corridor.

The "after" geometry consists of a raised median between University Drive and George Bush Drive, with median openings at 10 locations. Table 3-5 summarizes the estimated conflict points for the "after" condition. The "after" condition reduces the number of potential conflicts 812 to 602, approximately 26 percent.

Table 3-4. Total Conflict Points along Texas Avenue for the Before Period.

Roadway Section Type[1]	Number of Intersection[2] Types along Study Corridor	Conflict Points Per Intersection	Number of Lanes	Total Conflict Points
T-Intersection (TWLTL)	42	13	5	546
T-Intersection (RM)	9	2	5	18
T-Intersection (RMO)	0	11	5	0
T-Intersection (C)	1	11	5	11
RMO only	4	5	5	20
4-Way Intersection (Mi)	1	46	5	46
4-Way Intersection (GB)	1	40	5	40
4-Way Intersection (NM)	1	46	5	46
4-Way Intersection (U)	1	85	5	85
Total				812

[1] TWLTL is a two-way left-turn lane. RM is a raised median. RMO is a raised median opening. C is a channelized raised median treatment. Mi, GB, NM and U stand for Miliff Road, George Bush Drive, New Main and University Drive, respectively.

[2] Intersections include both public streets and private driveways.

Table 3-5. Total Conflict Points along Texas Avenue for the After Period.

Roadway Section Type[1]	Number of Intersection[2] Types along Study Corridor	Conflict Points Per Intersection	Number of Lanes	Total Conflict Points
T-Intersection (TWLTL)	7	13	5	91
T-Intersection (TWLTL)	4	15	7	60
T-Intersection (RM)	27	2	7	54
T-Intersection (RMO)	7	13	7	91
T-Intersection (C)	0	11	7	0
RMO only	1	5	7	5
RMO only	7	7	7	49
4-Way Intersection (Mi)	1	54	7	54
4-Way Intersection (GB)	1	64	7	64
4-Way Intersection (NM)	1	59	7	59
4-Way Intersection (U)	1	75	7	75
Total				602

[1] TWLTL is a two-way left turn-lane. RM is a raised median. RMO is a raised median opening. C is a channelized raised median treatment. Mi, GB, NM and U stand for Miliff Road, George Bush Drive, New Main and University Drive, respectively.
[2] Intersections include both public streets and private driveways.

This section presents summaries of the data and findings, describing the findings of the crash study as a whole. This discussion also covers the Texas Avenue/University Drive and Texas Avenue/George Bush Drive intersections, and finally the effect of the closure of access to Dominik Drive.

Crashes. Table 3-6 shows the reduction in the total number of crashes, comparing all crashes reported in the "after" period and the same types of crashes in the before period. An approximately 59 percent reduction in crashes occurred over the entire Texas Avenue corridor.

Table 3-6. Summary of Crash Reduction on the Texas Avenue Corridor.

Time Period	Texas Avenue Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900[1]	Intersection of Texas Avenue & University Drive
Before	435	102	194	107
After	178	35	93	53
Percent Change	-59.1	-65.7	-52.1	-50.5
p-value[2]	<0.0001	<0.0001	<0.0001	<0.0001

[1] MP is an abbreviation of milepost that refers to a location along a roadway as used in Roadway Inventory (RI) logbooks by TxDOT. MP 5.200 to MP 5.900 refers to the roadway section from approximately 500 feet north of George Bush Drive to 300 feet south of University Drive along Texas Avenue. This section of the roadway was used for the section crash rates discussed later in the report.

[2] A p-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

When a raised median is installed, one should expect reductions of certain types of crashes, such as head-on and angular. This phenomenon is due to the physical separation of opposing traffic that the raised median provides and the resulting prohibition of left-turn movements. It is possible that when a raised median is installed, other types of crashes, such as rear-ends and sideswipes, may increase. These types of crashes can be attributed to an increase in vehicles stopping near a median opening or vehicles changing lanes to get to a median opening. In particular this can happen if the median opening was not adequately designed. For instance if the length of the median opening was not long enough to accommodate the number of vehicles that were using it then this may result in rear-end crashes. Sideswipe crashes could occur if the median opening were located too close to an intersection. Figure 3-8 shows the number of crashes in the before-and-after-period along the corridor.

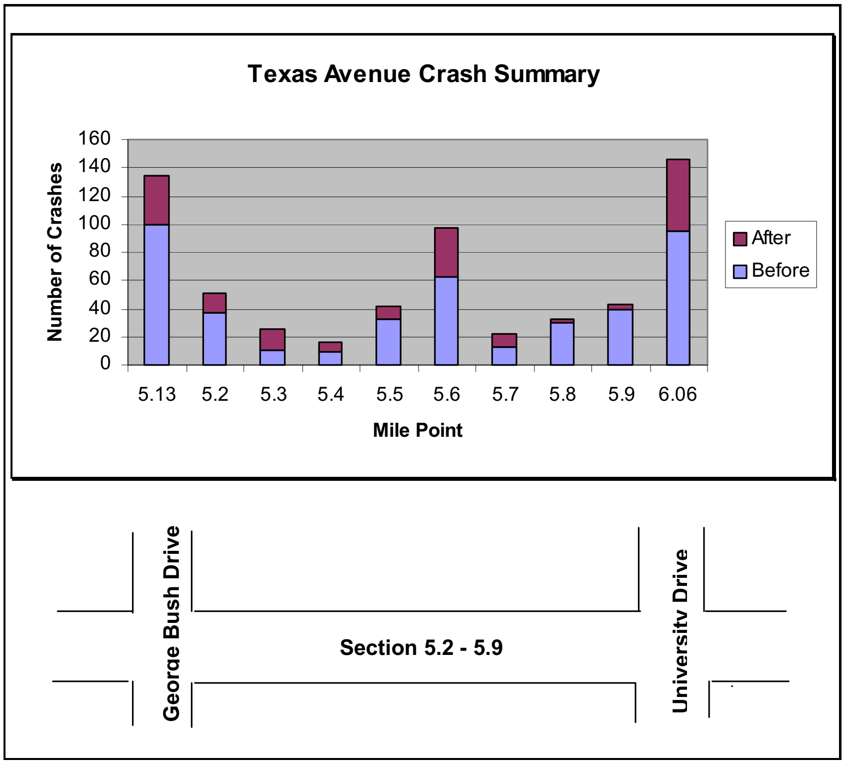

Figure 3-8. Texas Avenue Crash Summary.

Table 3-7 and Figure 3-9 display the number of crashes by crash type. All of the crash types were reduced, with the exception of single-vehicle crashes. Each single-vehicle crash record was investigated, and the researchers determined that these crashes were not caused by the raised median. The increase in the single-vehicle crashes appears to be an anomaly. As indicated with the statistical tests shown, the reduction in rear-ending, sideswipe, and right angle was statistically significant at the α=0.05 level of significance.

Table 3-7. Summary of Crashes by Crash Type.

Time Period	Rear-Ending	Sideswipe	Right-Angle	Head-On	Single-Vehicle	Other
Before	282	27	107	4	7	8
After	113	9	42	1	13	0
Percent Change	-59.9	-66.7	-60.7	-75.0	85.7	-100.0
p-value[1]	<0.0001	0.0026	<0.0001	No statistical difference	0.2628	0.0028

[1] A *p*-value of <0.05 indicates a statistical difference at the $\alpha = 0.05$ level of significance. No value is given when the sample size is low and Equation 3-6 is used.

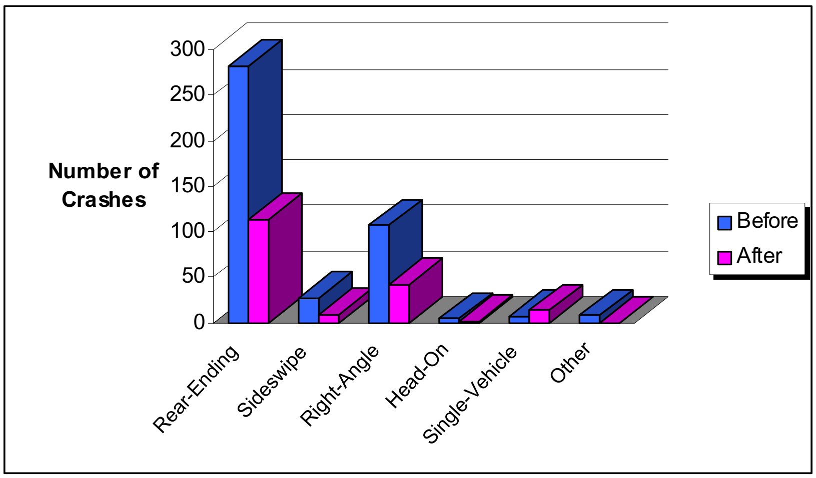

Figure 3-9. Texas Avenue Crash Type Summary.

The authors included a study of the effects of the closure of left-in-left-out traffic of a T-intersection along the study corridor. The closure was at Dominik Drive, a local road intersecting with the east side of Texas Avenue approximately 300 feet south of George Bush Drive. Figure 3-10 is taken from Dominik Drive approaching Texas Avenue, showing the raised median and sign restricting left turns. While the authors expected to find rear-ending, sideswipe, right angle, and head-on crashes for this intersection, the data revealed only right-angle crashes.

Figure 3-10. Raised Median Restricting Left Turns at Dominik Drive.

There were sideswipes associated with the TWLTL along the study corridor, but none occurred at the intersection of Dominik Drive and Texas Avenue (see Table 3-8). In one case, a motorist exited a private drive south of Miliff Road and proceeded to use the TWLTL to travel northbound on Texas Avenue. Using the TWLTL, the driver gained speed to enter the main inside lane and sideswiped another vehicle. This specific location was not included in the raised median retrofit, and a virtually identical crash occurred in both the before-and-after study timeframes. Sideswipes decreased by 67 percent for the entire corridor, and this drop was statistically significant (see Table 3-8).

Table 3-8. Sideswipe Crashes.

Time Period	Texas Avenue Corridor	Intersection of Texas Avenue & Dominik Drive
Before	27	0
After	9	0
Percent Change	-66.7	0
p-value[1]	0.0026	N/A

[1] A *p*-value of <0.05 indicates a statistical difference at the $\alpha = 0.05$ level of significance.

It was also found that the specific location of Dominik Drive at Texas Avenue in the before period was channelized for left-turn traffic; hence, the chance for a head-on crash was minimal. The authors reiterate that a raised median will remove the chance of a head-on crash in the center lane, while a TWLTL does not have the physical means to reduce the opportunity for a head-on crash.

Another scenario that the authors investigated was in relation to the proximity of Dominik Drive and the adjacent signalized intersection of Texas Avenue and George Bush Drive (see Figure 3-11). One of the initial concerns of the authors revolved around rear-ending crashes. While TWLTLs decrease the number of roadway conflict points by removing turning traffic from the mainlanes, some motorists will still take advantage of the traversable TWLTL. For example, drivers have unprohibited access to private driveways and public streets and will drive into the TWLTL immediately following a signalized intersection in the opposite direction of travel. Along with the two left-turn lanes on northbound Texas Avenue, there is less than 150 feet of southbound turn-lane to Dominik Drive and less than 150 feet of roadway between the intersection and the turn lane. Traffic could queue into the George Bush Drive intersection causing a rear-end crash; a rear-end crash could occur as a result of a motorist on George Bush Drive turning right going southbound onto Texas Avenue and trying to weave across traffic when southbound Texas Avenue has the right-of-way (ROW); or a rear-end crash could occur because of southbound, left-turning, George Bush Drive vehicles attempting to access Dominik Drive. While these weaving maneuvers more than likely occurred, there were no crashes attributed to such scenarios.

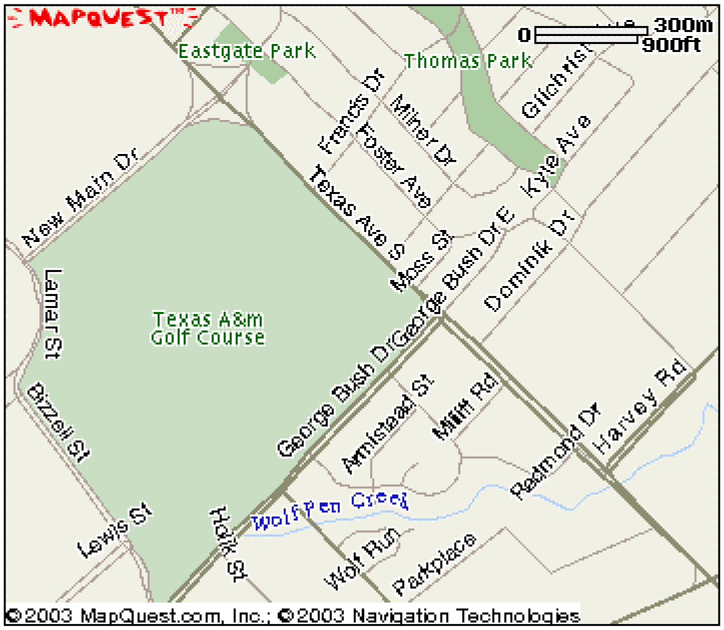

Figure 3-11. Map Showing Dominik Drive and Surrounding Street Network (Map Provided by MapQuest.com, Inc.).

The authors then investigated crash migration (which occurs when crashes due to turning maneuvers can no longer occur where turning maneuvers become prohibited and occur at other intersections) in relation to the adjacent signalized intersection, and they included an investigation of Texas Avenue south of Dominik Drive (see Figure 3-11). The motorists who would have tried to turn left onto Dominik Drive from the southbound lanes of Texas Avenue, would have performed one of the following: 1) traveled south down Texas Avenue, or 2) turned right from the eastbound traffic on George Bush Drive, or 3) turned left from the westbound traffic on George Bush Drive. The third scenario is the least likely to have occurred, because many motorists would have taken an alternate route avoiding backtracking after going through the signalized intersection. The two other routes offered after the retrofit are eastbound George Bush Drive past Texas Avenue or the U-turn allowed at the end of the raised median and the beginning of the TWLTL south of Dominik Drive.

The next set of drivers to consider are those turning left onto Texas Avenue from Dominik Drive. The most likely rerouting path for them would be westbound on George Bush Drive to Texas Avenue or eastbound/southbound on George Bush Drive as it turns to intersect Harvey Road.

Harvey Road (SH 30) runs east and west and intersects Texas Avenue south of the study corridor.

Both left-in and left-out motorists had to reroute, but the authors did not see any corresponding increases in crashes north or south of Dominik Drive along Texas Avenue. Right-angle crashes decreased by 56 percent south of Dominik Drive, and there was the expected 100 percent reduction at Dominik Drive (see Table 3-9). At the adjacent signalized intersection of George Bush Drive and Texas Avenue, both the total crashes and the crash rates dropped by 66 and 70 percent, respectively. These findings appear to indicate that crashes are not migrating, and it appears that the raised median has reduced crashes.

Table 3-9. Right-Angle Crashes.

Time Period	Texas Avenue Corridor	Intersection of Texas Avenue & Dominik Drive	MP 6.190 to MP 6.255[1]
Before	107	16	16
After	42	0	7
Percent Change	-60.7	-100	-56
p-value[2]	<0.0001	<0.0001	0.0602

[1] MP is an abbreviation of milepost that refers to a location along a roadway as used in Roadway Inventory (RI) logbooks by TxDOT. MP 6.190 to MP 6.255 refers to the roadway section from approximately 600 feet south of George Bush Drive to 1100 feet south of George Bush Drive along Texas Avenue.

[2] A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance.

Crash Rates. As indicated earlier, the authors studied the before-and-after crash rates using Equations 3-1 and 3-2. Table 3-10 contains the summary of the crash rates and the associated percent change. There was an overall reduction in the crash rates at the two major intersections along the study corridor and for the section of roadway between the intersections.

Table 3-10. Summary Crash Rates[1].

Time Frame	Texas Avenue & George Bush Drive	Texas Avenue & University Drive	MP 5.200 to MP 5.900[2]
Before	2.2	21.0	4.3
After	0.7	11.0	1.8
Percent Change	-69.5	-46.0	-57.0

[1] Equations 3-1 and 3-2 were used to determine crash rates at an intersection and roadway section, respectively.
[2] MP is an abbreviation of milepost that refers to a location along a roadway as used in Roadway Inventory (RI) logbooks by TxDOT. MP 5.200 to MP 5.900 refers to the roadway section from approximately 500 feet north of George Bush Drive to 300 feet south of University Drive along Texas Avenue.

Injuries. Another common effect of the installation of a raised median is the reduction in the crash severity. This is due to the decrease in head-on collisions and right-angle crashes, which are typically the most severe types of crashes. Table 3-11 displays a summary of the numbers of injuries by severity level in the before-and-after-periods. Possible injuries reduced from 206 to 141, which was a statistically significant 32 percent reduction. Incapacitating injuries dropped statistically from 14 in the before period to 1 in the after period, an approximately 93 percent reduction. There was a small (non-statistically significant) increase in the number of non-incapacitating injuries, but this shift in injury type may be due to the reduction in overall severity.

Table 3-11. Summary of Injuries.

Time Period	Possible Injury[1]	Non-Incapacitating Injury[1]	Incapacitating Injury[1]
Before	206	48	14
After	141	50	1
Percent Change	-31.6	4.2	-92.9
p-value[2]	<0.0001	0.5959	0.0005

[1] The various injury classifications were defined in the "Crash-Reporting Process" of this chapter.
[2] A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance.

Figures 3-12 and 3-13 graphically represent the injuries only as a percentage of total injuries. Table 3-11, Figure 3-12, and Figure 3-13 illustrate a significant reduction in crash severity.

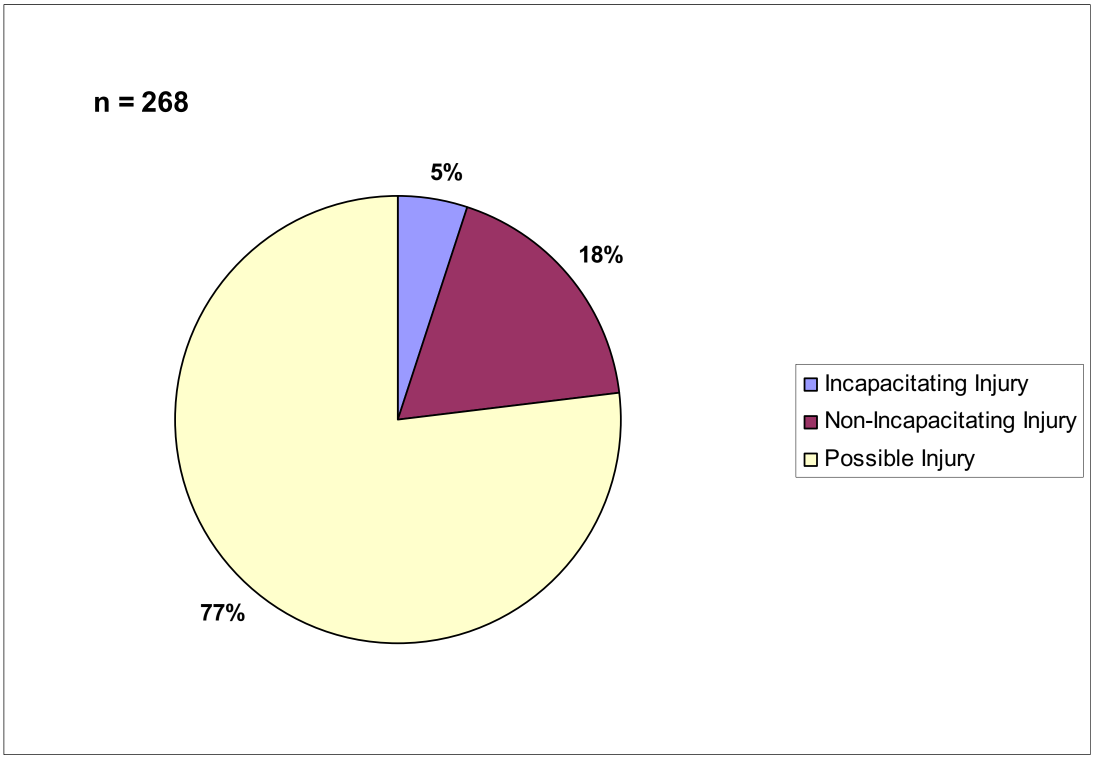

Figure 3-12. Summary of Injuries in the Before Period for the Texas Avenue Corridor.

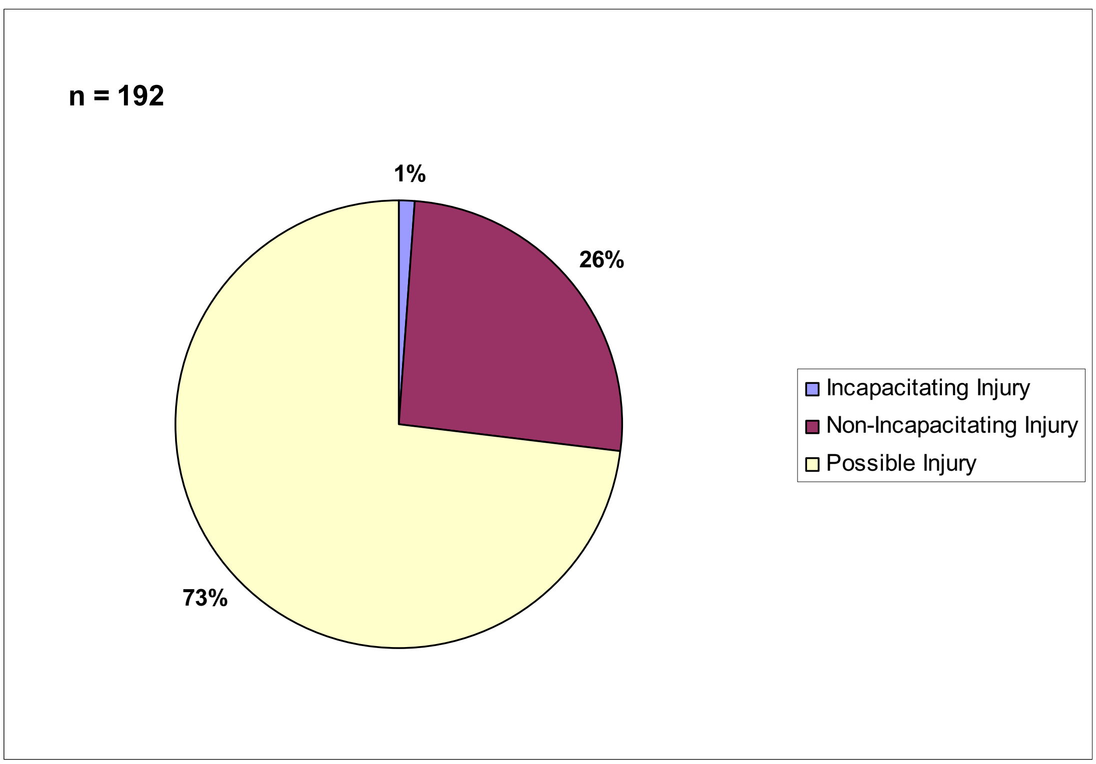

Figure 3-13. Summary of Injuries in the After Period for the Texas Avenue Corridor.

3.2.6 Comparison Group

There are many different factors that can make a simple "before-and-after" study unreliable. The most serious threat to the validity of the results of a "before-and-after" study is the lack of control of potentially confounding factors (*8*). The underlying assumption behind a "before-and-after" study is that the reduction in crashes from the "before" period to the "after" period is attributed to the treatments. The following list describes confounding factors that, if not accounted for, may make the results of a before-and-after study unreliable (*8*).

1. Traffic, weather, road user behavior, vehicle fleet, and other factors change over time. Therefore the reduction in crashes or severity of crashes may be due to the change in these factors.
2. Besides the treatment in question, there may be other treatments or programs that have been implemented during either of the study periods.
3. The number of property damage only crashes is affected by the cost of repairs and will change gradually over time.
4. The probability of reportable crashes being reported may be changing with time. This could be due to a change in insurance rates.
5. The treated section of roadway may have been chosen for treatment because of an unusually high number of crashes in the past. If so, the past crash history is "unusual." An "unusual" location may not be the best predictor of what would be expected in the future if the treatment had not been applied.

To eliminate some of these factors that make the underlying assumption in the "before-and-after" study questionable, a comparison group was used. A comparison group is applied to control all the confounding factors that cannot be easily estimated. One study describes how it is reasonable to assume that a large comparison group, i.e., one in which the annual count of crashes is at least several hundred, included the effects of all factors that may produce changes over time in the long-term expected number of crashes (*9*).

The comparison group used for this study was the total number of reported crashes in College Station, Texas. This group was chosen because it was large enough to be statistically significant. The study site is located in College Station, Texas; therefore, any confounding factors which would have affected the study site would be encompassed in the comparison group. Figure 3-14 displays a summary of crashes for the comparison group.

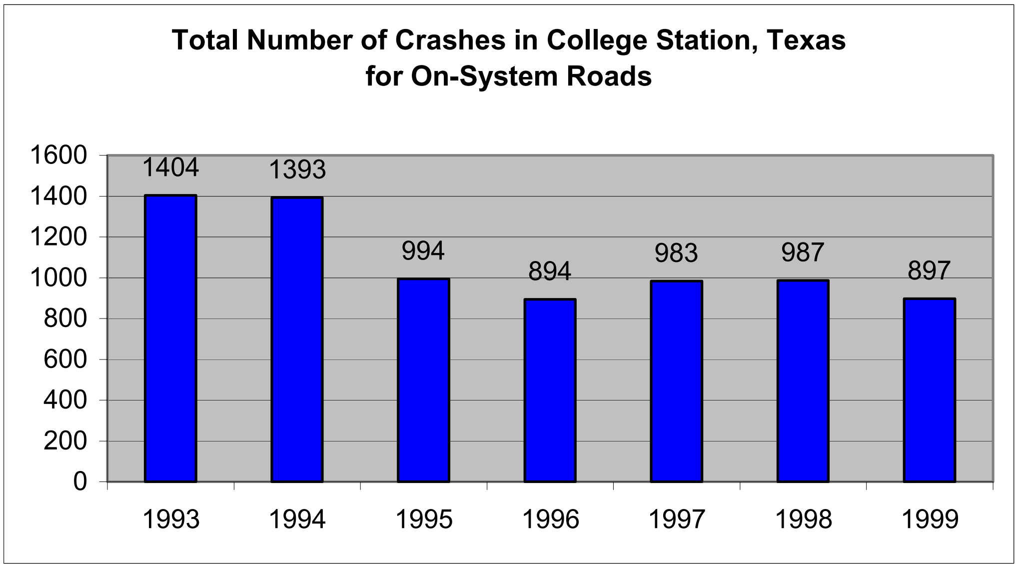

Figure 3-14. Summary of Crashes in the Comparison Group.

As mentioned previously, there was a change in the crash-reporting threshold in June 1995. After June 1995, only crashes resulting in an injury, or PDO crashes where the vehicle required towing from the scene had to be reported. Because of this, when comparing the total number of crashes in a 2-year period prior (1993-1994) to 2-year period after 1995 (1996-1997), there is an approximate 33 percent reduction in reported crashes. To make the comparison from the "before" period to the "after" period, the total number of crashes for the comparison group in the "before" period were reduced by 33 percent. The crashes that occurred on the section of Texas Avenue that was studied were removed from the comparison group. A summary of this comparison is shown in Table 3-12.

Table 3-12. Summary of Comparison of Texas Avenue Corridor to Comparison Group.

	Texas Avenue Corridor	Comparison Group
Crashes in the Before Period	435	2,362
Reduced Crashes in the Before Period	N/A[1]	1,582
Expected Crashes in the After Period	465	-
Crashes in the After Period	178	1,706

[1] Crashes in the "before" period for the Texas Avenue were previously filtered to reflect the change in the change in the crash-reporting threshold.

The crashes in the comparison group increased by approximately 7 percent from the "before" period to the "after" period. Therefore, it would be expected that there would also be a 7 percent increase in crashes along the Texas Avenue corridor if there had not been any mitigation. However, there was approximately a 60 percent reduction in total crashes on the Texas Avenue corridor. Therefore, it appears confounding factors have not caused any part in the reduction of crashes from the "before" to the "after" period for the Texas Avenue corridor. Therefore, the reduction in crashes may be attributed to the raised median treatment, and not to other confounding factors such as weather, vehicle fleet, driver behavior, cost of car repairs, inclinations to report crashes, etc. Further research is needed to determine why there has been an increase in crashes in College Station. This may be due to the population increase and/or to younger drivers though the research team did not investigate this possibility.

3.2.7 Recommendations and Discussion

It appears that along the Texas Avenue corridor studied here that crashes and crash severity were reduced by the raised median retrofit. The reduction of the crashes and the crash severity suggests that the overall roadway safety was improved.

Closing left-turn access reduces conflict points and virtually removes the opportunity of right-angle and head-on crashes. The removal of left-turn possibilities at Dominik Drive eliminated right-angle crashes completely at that location. Left-turning traffic was redirected and gained access through other means. Redirected traffic flows may result in crash migration; however, the authors do not believe this occurred along this case study. However, even with the original crash reports, it was difficult to ascertain the intent and/or the destination of the drivers.

Consequently, the researchers studied the crash characteristics of the whole corridor, and in particular, right-angle crashes and crashes at the adjacent controlled intersection, George Bush Drive at Texas Avenue. The authors investigated the adjacent signal because motorists may reroute eastbound on George Bush Drive east of Texas Avenue to gain access to Dominik Drive. The crashes for the whole corridor reduced by 59 percent and at the adjacent signal by 50 percent. Right-angle crashes south of Dominik Drive (a location that would offer a driver the opportunity to make a U-turn and then a right-turn to gain access to Dominik Drive) reduced by 56 percent. It appears from these findings that crash migration did not occur and that the rerouted paths by the use of a raised median resulted in a crash reduction and safer roadway.

3.3 LOOP 281 (LONGVIEW) CASE STUDY LOCATION

3.3.1 General Description

The second case study corridor is Loop 281 in Longview, Texas, between FM 63 (McCann Road) and Spur 502 (Judson Road). This road segment was comprised of three through-lanes in each direction, as well as a flush median that varied in width from a typical TWLTL to more than 30 feet. In the widest parts, vehicles would pull out from a driveway and line up several abreast, waiting for acceptable gaps in which to complete left-turn movements. The raised median project developed turn bays for full and directional turning movements (see Figure 3-15). In addition, the raised median closed numerous left-turn opportunities that previously existed.

Figure 3-15. Loop 281 in Longview.

3.3.2 Crash Analysis

The Texas Department of Public Safety provided crash reports dating back to 1992, approximately four years before the median was built in late 1996. This data set will allow the research team to conduct a before-and-after-crash analysis of the corridor. The reports include details about the number, severity, and locations of crashes on Loop 281. To date, the research team has begun to categorize the crashes by type, location, etc. During fiscal year 2003, the researchers will perform analysis with these data, as was done for the Texas Avenue corridor.

3.4 CALL FIELD ROAD (WICHITA FALLS) CASE STUDY LOCATION

3.4.1 General Description

The third case study corridor is along Call Field Road, in Wichita Falls, Texas. This segment of Call Field Road, prior to improvements, had a five-lane cross-section, including a TWLTL and is less than one-half mile in length. The adjacent land uses are primarily strip shopping centers with a few stand-alone businesses. There are several driveways and two side streets that intersect Call Field Road between the two end points of the segment (Kemp Blvd. and Lawrence Road). One of the side streets, Faith Road, is an unsignalized intersection, while the other one, Rhea Road, is signalized. The raised median closed left-turn opportunities at Faith Road, as well as some driveways, as shown in Figure 3-16.

Figure 3-16. Call Field Road in Wichita Falls.

3.4.2 Crash Analysis

Since Call Field Road is not a state-maintained road, the research team obtained crash data from the Wichita Falls Police Department. These data appear to be very useful, though they do not necessarily contain the level of detail that the DPS reports usually have, nor are they in the same format. The research team will, at a minimum, be able to develop trends in crash type, severity, and number. Researchers have begun to categorize these data and will perform in-depth analysis in fiscal year 2003.

3.5 GRANT AVENUE (ODESSA) CASE STUDY LOCATION

3.5.1 General Description

The fourth case study corridor is along Grant Avenue (US 385) in Odessa, Texas. Before installation of the raised median, this road segment was undivided with two lanes of traffic in both directions of travel, as well as angle-in parking for adjacent buildings. The abutting land uses include retail stores and office buildings. The 1992 road improvements changed the parking to parallel and separated the directions of travel with a raised median that features left-turn bays at each street intersection (see Figure 3-17).

Figure 3-17. Grant Avenue (US 385) in Odessa.

3.5.2 Crash Analysis

Data Collection

Texas DPS provided crash reports dating back to 1992, which coincidentally is both the median construction year and the first year for which crash data are available. At the time of this report, the research team does not anticipate being able to obtain crash data prior to 1992 but will continue to explore opportunities in fiscal year 2003. Researchers will perform analysis on the available data.

3.6 71st STREET (TULSA, OKLAHOMA) CASE STUDY LOCATION

3.6.1 General Description

This study also includes an analysis of 71st Street, between Lewis and Memorial, in Tulsa, Oklahoma. This 4-mile segment was previously comprised of one through-lane in each direction. The road improvements included adding two through-lanes in each direction, as well as the raised median. Figure 3-18 shows 71st Street at Memorial.

Figure 3-18. 71st Street at Memorial Drive in Tulsa, OK.

3.6.2 Crash Analysis

Data Collection

The Oklahoma Department of Transportation provided relatively detailed crash data for this corridor. Again, the research team discovered differences in format and detail among various agencies that provide crash data. Initially the research team requested data for a portion of the road segment to determine usefulness. Reviews performed to date indicate that the data are useful, and additional data for the remainder of the corridor have been requested.

CHAPTER 4

PRELIMINARY FINDINGS AND DISCUSSION

4.1 TRAFFIC FLOW IMPACTS

Based on the preliminary micro-simulation findings along the Texas Avenue corridor, there appear to be small differences in the travel time and delay between the existing (TWLTL) and proposed conditions (raised median). The proposed condition suggests a slight increase in travel time and delay overall. This situation is likely attributed to an overall increase in traffic on the corridor, as some U-turning vehicles must travel farther to reach their destination. Delay may also increase slightly at the intersections. An increase in delay is expected at the Texas Avenue and Eagle Pass/Sulphur Springs intersection because of the additional U-turning traffic. Delay is also expected to increase at the Texas Avenue and Villa Maria intersection due to an increase in vehicles traveling through the intersection to reach median openings located north and south of the intersection. Though these findings are preliminary, they appear to indicate that with the installation of raised medians, geometric intersection improvements should be anticipated.

Adding 20 percent to the traffic volumes, which equates to approximately 10 years of growth, requires mitigation at the intersection of Texas Avenue and Villa Maria. Based on this preliminary VISSIM simulation, installing a raised median on Texas Avenue would decrease future travel times by 11 seconds (11 percent) and delays by 9 seconds (22 percent) on the corridor. This is not expected to be significant; however, beyond approximately 10 years (20 percent traffic growth), the raised median would be expected to provide additional travel time and delay reduction. This will be further investigated with the theoretical corridors in the second year of the study. In addition, the research team may re-evaluate the Texas Avenue corridor in the second year of the study to further investigate the potential issues and considerations identified in section 2.3 that highlights potential limitations of the preliminary VISSIM findings.

4.2 SAFETY IMPACTS

The preliminary findings from one corridor along Texas Avenue suggest that, in general, crash rates and severity tended to decrease after the raised median was installed. In the first year of this project, the most in-depth crash analysis and methodology development was performed on the Texas Avenue corridor in College Station. With the statistical analysis process being refined and fully utilized for that corridor, the research team will continue to use it on the other corridors described in this report.

Every time that left-turns in or out of an intersection are removed, at a minimum, conflict points are removed. Conflict points were reduced 26 percent in the retrofit project studied along Texas Avenue. The removal of conflict points reduces the number of opportunities for vehicle paths to cross. Crashes involving left-turning vehicles are typically head-on or right-angle, which can be the most severe in terms of injuries and property damage.

4.3 CRASH DATA AVAILABILITY AND RELIABILITY

The investigations of this research project demonstrate that the crash data format and availability vary among agencies. The Texas Department of Transportation provides relatively consistent crash reports and summaries, from which much useful information can be obtained. When working with off-state-system roads, however, one must usually rely on a local city or other entity to provide crash data. The total number of crashes and types of crashes will always provide insightful and fundamental information about the safety of a corridor. However, the consistency and usefulness of locally provided data details will make some data more useful than others for statistical analysis. Data provided by other states will vary, as well, as has been experienced with the Tulsa, Oklahoma, case study. However, even the basic numbers of crashes and types can provide useful information, in addition to the details included in crash reports and summaries.

4.4 FUTURE RESEARCH

During fiscal year 2003, the research team will continue to analyze the corridors described in this report, as well as others that lend themselves to investigation. An aggregation of statistical findings of all case studies will provide useful information related to safety benefits of implementing access management techniques. The research team will also document detailed accounts of the variety of crash data that are available from various agencies and provide recommendations for improving consistency in reporting.

CHAPTER 5

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APPENDIX A

VISSIM Simulation

VISSIM SIMULATION PROCEDURE

General Process

1. Obtain an aerial photograph of the roadway for use as your background in VISSIM.
2. Obtain roadway geometrics such as number of lanes, lane widths, and driveway widths, distance between driveways, length of dedicated turn lanes, etc.
3. Collect traffic volumes such as mainlane counts, intersection turning movements, and driveway volumes and turning movements.
4. Obtain any intersection signal timings.
5. Perform travel-time runs from the beginning to the end of the corridor during the peak hour. This information will be used later to calibrate the model.
    a) The peak hour was selected as the hour with the combination of the highest mainlanes, intersection, and driveway traffic volumes.

Creating the Network

1. Input the background into VISSIM.
    a) Scale the drawing using a measurement taken in the field, and save the scale.
2. Draw links for main roads and driveways.
    a) Make separate links for each segment of roadway.
    b) Do not draw links across intersections – you will connect these with connectors in the next step.
    c) Space driveways according to the aerial photograph, if possible. If not the distances can be scaled off from your field measurements.
3. Draw connectors.
    a) Connect each of the links across the intersection with connectors.
    b) Connect all right and left turns on and off of the main road with connectors.

c) For left-turn connectors onto a multi-lane road, connect the left-turn in the left-most lane.

The following steps should be completed for one driveway at a time until that driveway is operating well.

4. Enter stop signs.
   a) Place stop signs before any connectors.
5. Enter priority rules.
   a) Use gap times of 3.0 – 4.0 seconds for right-turn movements.
   b) Use gap times of 4.5 – 5.5 seconds for left-turn movements.
   c) Note: You may have to vary these depending on the roadway widths.
6. Enter mock traffic volumes.
   a) It is recommended to enter a high volume such as 100 vehicles per hour at each driveway so you can see any potential conflicts.
7. Simulate.
   a) Watch for any collisions.
   b) Update priority rules until there are no collisions.
8. Move on to the next driveway.
9. Complete steps 4-7 again.

After all of the driveways are operating without collisions, move on to the following steps.

Change the traffic volumes to the actual volumes.

1. Use the routing decision tool to direct the vehicles where to go.
   Be careful of putting a routing decision too close to a connector; the vehicle may miss the connector and you will receive an error message.

2. Input traffic signals.

   The traffic signals in VISSIM use National Electrical Manufacturers Association (NEMA) phasing. VISSIM does not have the capability to optimize signal timing. To optimize the signals, you will need to use software such as SYNCHRO, if you have more than one signal. Highway capacity software could also be used if there is only one signal or there is no coordination between the signals.

3. Evaluations.

   VISSIM has the capability to collect data such as average delay, stopped delay, number of stops, queue length, travel time, emissions, intersection delay, etc. You must set up parameters during which you want to collect data. If you want to collect an hour of data, researchers recommend simulating from 0-3900 seconds and collecting data from 300-3900 seconds. This will allow time for the network to become saturated with vehicles before the data collection begins.

4. Output.

   VISSIM has the capability to determine the following values during simulation – travel time, total delay, intersection delay, queue length, number of stops, etc. See the VISSIM manual for a complete description of outputs. The user must designate what values he/she wants as output. The output is separated into text files that can be easily placed into a spreadsheet to evaluate.

5. Calibration.

   After obtaining the initial output from the model, it is necessary to calibrate the model to adequately predict the traffic conditions in the field. In this step, you will be using the travel time data that you collected in the field. Compare the average travel times to the travel times output by VISSIM. If there are significant differences in the travel times, you can change the speed distributions in VISSIM until the travel times are similar.

APPENDIX B

Crash-Reporting Process

POLICE CRASH REPORT DOCUMENTS

TEXAS PEACE OFFICER'S ACCIDENT REPORT ST-3 (Eff. 9/1/01) MAIL TO: ACCIDENT RECORDS, TEXAS DEPARTMENT OF PUBLIC SAFETY, PO BOX 4087, AUSTIN, TX 78773-0351

PLACE WHERE ACCIDENT OCCURRED

COUNTY ____ CITY OR TOWN ____ SHOW ONLY IF INSIDE CITY LIMITS

IF ACCIDENT WAS OUTSIDE CITY LIMITS, INDICATE DISTANCE FROM NEAREST TOWN ____ MILES ☐ NORTH ☐ S ☐ E ☐ W OF ____ CITY OR TOWN

LOC. ____

DO NOT WRITE IN THIS SPACE

DPS NO.

LOC. ____

CODE ____

SEVERITY ____

FAT. REC. ____

DR. REC. ____

ROAD ON WHICH ACCIDENT OCCURRED ____ BLOCK NUMBER / STREET OR ROAD NAME / ROUTE NUMBER OR STREET CODE — CONSTR. ZONE ☐ YES ☐ NO SPEED LIMIT ____

INTERSECTING STREET OR RR X'ING NUMBER ____ BLOCK NUMBER / STREET OR ROAD NAME / ROUTE NUMBER OR STREET CODE — CONSTR. ZONE ☐ YES ☐ NO SPEED LIMIT ____

NOT AT INTERSECTION ____ ☐ FT. ☐ MI. ☐ N ☐ S ☐ E ☐ W OF ____ SHOW MILEPOST OR NEAREST INTERSECTING NUMBERED HIGHWAY. IF NONE, SHOW NEAREST INTERSECTING STREET OR REFERENCE POINT.

DATE OF ACCIDENT ____ 20____ DAY OF WEEK ____ HOUR ____ ☐ A.M. ☐ P.M. IF EXACTLY NOON OR MIDNIGHT, SO STATE

UNIT NO. 1 - MOTOR VEHICLE VEHICLE IDENT. NO. ____ IF BODY STYLE = VAN OR BUS, INDICATE SEATING CAPACITY ____

YEAR MODEL ____ COLOR & MAKE ____ MODEL NAME ____ BODY STYLE ____ LICENSE PLATE ____ YEAR / STATE / NUMBER

DRIVER'S NAME ____ LAST / FIRST / MIDDLE / ADDRESS (STREET, CITY, STATE, ZIP) PHONE NUMBER ____

DRIVER'S LICENSE ____ STATE / NUMBER / CLASS/TYPE DOB ____ MO / DAY / YEAR RACE ____ SEX ____ OCCUPATION ____

SPECIMEN TAKEN (ALCOHOL/DRUG ANALYSIS) 1-BREATH 2-BLOOD 3-OTHER 4-NONE 5-REFUSED ☐ ALCOHOL/DRUG ANALYSIS RESULT ____ PEACE OFFICER, EMS DRIVER, FIRE FIGHTER ON EMERGENCY? ☐ YES ☐ NO

LESSEE ☐ OWNER ☐ ____ NAME (ALWAYS SHOW LESSEE IF LEASED, OTHERWISE SHOW OWNER) / ADDRESS (STREET, CITY, STATE, ZIP)

LIABILITY INSURANCE ☐ YES ☐ NO ____ INSURANCE COMPANY NAME / POLICY NUMBER VEHICLE DAMAGE RATING ____

UNIT NO. 2 - MOTOR VEHICLE ☐ TRAIN ☐ PEDALCYCLIST ☐ TOWED ☐ PEDESTRIAN ☐ OTHER ☐ VEHICLE IDENT. NO. ____ IF BODY STYLE = VAN OR BUS, INDICATE SEATING CAPACITY ____

YEAR MODEL ____ COLOR & MAKE ____ MODEL NAME ____ BODY STYLE ____ LICENSE PLATE ____ YEAR / STATE / NUMBER

DRIVER'S NAME ____ LAST / FIRST / MIDDLE / ADDRESS (STREET, CITY, STATE, ZIP) PHONE NUMBER ____

DRIVER'S LICENSE ____ STATE / NUMBER / CLASS/TYPE DOB ____ MO / DAY / YEAR RACE ____ SEX ____ OCCUPATION ____

SPECIMEN TAKEN (ALCOHOL/DRUG ANALYSIS) 1-BREATH 2-BLOOD 3-OTHER 4-NONE 5-REFUSED ☐ ALCOHOL/DRUG ANALYSIS RESULT ____ PEACE OFFICER, EMS DRIVER, FIRE FIGHTER ON EMERGENCY? ☐ YES ☐ NO

LESSEE ☐ OWNER ☐ ____ NAME (ALWAYS SHOW LESSEE IF LEASED, OTHERWISE SHOW OWNER) / ADDRESS (STREET, CITY, STATE, ZIP)

LIABILITY INSURANCE ☐ YES ☐ NO ____ INSURANCE COMPANY NAME / POLICY NUMBER VEHICLE DAMAGE RATING ____

DAMAGE TO PROPERTY OTHER THAN VEHICLES

OBJECT / NAME AND ADDRESS (STREET, CITY, STATE, ZIP) OF OWNER / FEET FROM CURB / $ DAMAGE ESTIMATE

LIGHT CONDITION ☐	WEATHER ☐☐	SURFACE CONDITION ☐	TYPE ROAD SURFACE ☐	DESCRIBE ROAD CONDITIONS (INVESTIGATOR'S OPINION)
1-DAYLIGHT 2-DAWN 3-DARK-NOT LIGHTED 4-DARK-LIGHTED 5-DUSK	1-CLEAR/CLOUDY 6-SMOKE 2-RAINING 7-SLEETING 3-SNOWING 8-HIGH WINDS 4-FOG 9-OTHER 5-BLOWING DUST ____	1-DRY 2-WET 3-MUDDY 4-SNOWY/ICY 5-OTHER ____	1-BLACKTOP 2-CONCRETE 3-GRAVEL 4-SHELL 5-DIRT 6-OTHER ____	

IN YOUR OPINION, DID THIS ACCIDENT RESULT IN AT LEAST $1,000.00 DAMAGE TO ANY ONE PERSON'S PROPERTY? ☐ YES ☐ NO

CHARGES FILED

NAME ____ CHARGE ____ CITATION NUMBER ____

NAME ____ CHARGE ____ CITATION NUMBER ____

TIME NOTIFIED OF ACCIDENT ____ DATE / HOUR M HOW ____ TIME ARRIVED AT SCENE OF ACCIDENT ____ DATE / HOUR M

TYPED OR PRINTED NAME OF INVESTIGATOR ____ DATE REPORT MADE ____ IS REPORT COMPLETE ☐ YES ☐ NO

SIGNATURE OF INVESTIGATOR ____ ID NO. ____ DEPARTMENT ____ DIST/AREA ____

Figure B-1. Page 1 of a ST-3, Police Crash Report.

SOLICITATION (SOL)	EJECTED	CODE FOR TYPE RESTRAINT USED	AIRBAG CODE	HELMET USE	CODE FOR INJURY SEVERITY	ALCOHOL/DRUG ANALYSIS (COMPLETE IF CASUALTIES NOT IN MOTOR VEHICLE)
INDICATES PERSON'S DESIRE TO RECEIVE CONTACT FROM PERSONS SEEKING PROFESSIONAL EMPLOYMENT AS/FOR AN ATTORNEY, CHIROPRACTOR, PHYSICIAN, SURGEON, PRIVATE INVESTIGATOR, OR ANY OTHER PERSON REGISTERED OR LICENSED BY A HEALTH CARE REGULATORY AGENCY. Y=O.K. TO SOLICIT N=NO SOLICITATION	A-NOT APPLICABLE Y-YES N-NO P-PARTIALLY U-UNKNOWN	A-SEATBELT & SHOULDER STRAP B-SEATBELT & NO SHOULDER STRAP C-CHILD RESTRAINT E-SHOULDER STRAP ONLY N-NONE	Y-DEPLOYED N-NO DEPLOYMENT U-UNKNOWN IF DEPLOYED	1-WORN-DAMAGED 2-WORN-NOT DAMAGED 3-WORN-UNK IF DAMAGED 4-NOT WORN 9-UNKNOWN IF WORN	K-KILLED A-INCAPACITATING INJURY B-NON INCAPACITATING C-POSSIBLE INJURY N-NOT INJURED	1-BREATH 2-BLOOD 3-OTHER 4-NONE 5-REFUSED

UNIT NO. 1 — DAMAGE RATING ______ — TOWED DUE TO DAMAGE ☐ YES ☐ NO — VEHICLE REMOVED TO ______ BY ______

COMPLETE ALL DATA ON ALL OCCUPANTS' NAMES, POSITIONS, RESTRAINTS USED, ETC.; HOWEVER, IT IS NOT NECESSARY TO SHOW ADDRESSES UNLESS KILLED OR INJURED

ITEM NO.	OCCUPANT'S POSITION	NAME (LAST NAME FIRST)	ADDRESS (STREET, CITY, STATE, ZIP)	SOL	EJECTED	TYPE RESTRAINT USED	AIRBAG	HELMET	AGE	SEX	INJURY CODE
1	DRIVER	SEE FRONT									
2											
3											
4											
5											

UNIT NO. 2 (COMPLETE ONLY IF UNIT NO. 2 WAS A MOTOR VEHICLE) — DAMAGE RATING ______ — TOWED DUE TO DAMAGE ☐ YES ☐ NO — VEHICLE REMOVED TO ______ BY ______

COMPLETE ALL DATA ON ALL OCCUPANTS' NAMES, POSITIONS, RESTRAINTS USED, ETC.; HOWEVER, IT IS NOT NECESSARY TO SHOW ADDRESSES UNLESS KILLED OR INJURED

ITEM NO.	OCCUPANT'S POSITION	NAME (LAST NAME FIRST)	ADDRESS (STREET, CITY, STATE, ZIP)	SOL	EJECTED	TYPE RESTRAINT USED	AIRBAG	HELMET	AGE	SEX	INJURY CODE
6	DRIVER	SEE FRONT									
7											
8											
9											
10											

COMPLETE IF CASUALTIES NOT IN MOTOR VEHICLE

PEDESTRIAN, PEDALCYCLIST ETC.	CASUALTY NAME (LAST NAME FIRST)	CASUALTY ADDRESS (STREET, CITY, STATE, ZIP)	SOL	TYPE SPECIMEN TAKEN	RESULT	HELMET	AGE	SEX	INJURY CODE

DISPOSITION OF KILLED AND/OR INJURED — IF AMBULANCE USED, SHOW

ITEM NUMBERS	TAKEN TO	BY	TIME NOTIFIED	TIME ARRIVED AT SCENE	NO. ATTENDANTS INCLUDING DRIVER

COMPLETE THIS SECTION IF PERSON KILLED

ITEM NUMBER	DATE OF DEATH	TIME OF DEATH	ITEM NUMBER	DATE OF DEATH	TIME OF DEATH	ITEM NUMBER	DATE OF DEATH	TIME OF DEATH

INVESTIGATOR'S NARRATIVE OPINION OF WHAT HAPPENED (ATTACH ADDITIONAL SHEETS IF NECESSARY)

DIAGRAM ☐ ONE WAY ☐ TWO WAY ☐ DIVIDED — ◯ INDICATE NORTH

FACTORS AND CONDITIONS LISTED ARE THE INVESTIGATOR'S OPINION

FACTORS/CONDITIONS CONTRIBUTING

UNIT 1	1	2	3
UNIT 2	1	2	3

OTHER FACTORS/CONDITIONS MAY OR MAY NOT HAVE CONTRIBUTED

UNIT 1	1	2
UNIT 2	1	2

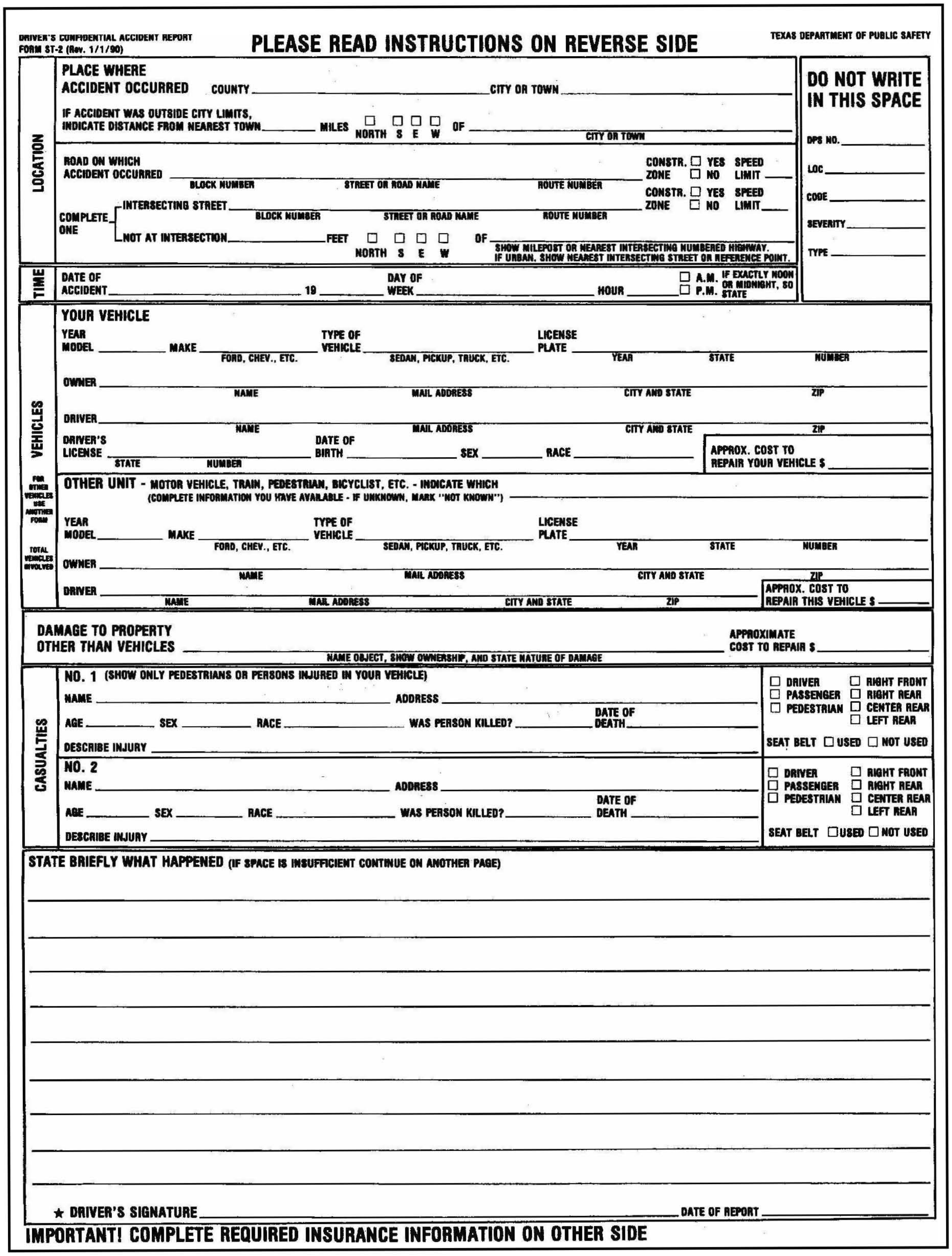
TRAFFIC CONTROL

0-NO CONTROL OR INOPERATIVE
1-OFFICER OR FLAGMAN
2-STOP AND GO SIGNAL
3-STOP SIGN
4-FLASHING RED LIGHT
5-TURN MARKS
6-WARNING SIGN
7-RR GATES OR SIGNALS
8-YIELD SIGN
9-CENTER STRIPE OR DIVIDER
10-NO PASSING ZONE
11-OTHER CONTROL ______

1. ANIMAL ON ROAD - DOMESTIC
2. ANIMAL ON ROAD - WILD
3. BACKED WITHOUT SAFETY
4. CHANGED LANE WHEN UNSAFE
5. DEFECTIVE OR NO HEADLAMPS
6. DEFECTIVE OR NO STOP LAMPS
7. DEFECTIVE OR NO TAIL LAMPS
8. DEFECTIVE OR NO TURN SIGNAL LAMPS
9. DEFECTIVE OR NO TRAILER BRAKES
10. DEFECTIVE OR NO VEHICLE BRAKES
11. DEFECTIVE STEERING MECHANISM
12. DEFECTIVE OR SLICK TIRES
13. DEFECTIVE TRAILER HITCH
14. DISABLED IN TRAFFIC LANE
15. DISREGARD STOP AND GO SIGNAL
16. DISREGARD STOP SIGN OR LIGHT
17. DISREGARD TURN MARKS AT INTERSECTION
18. DISREGARD WARNING SIGN AT CONSTRUCTION
19. DISTRACTION IN VEHICLE
20. DRIVER INATTENTION
21. DROVE WITHOUT HEADLIGHTS
22. FAILED TO CONTROL SPEED
23. FAILED TO DRIVE IN SINGLE LANE
24. FAILED TO GIVE HALF OF ROADWAY
25. FAILED TO HEED WARNING SIGN
26. FAILED TO PASS TO LEFT SAFELY
27. FAILED TO PASS TO RIGHT SAFELY
28. FAILED TO SIGNAL OR GAVE WRONG SIGNAL
29. FAILED TO STOP AT PROPER PLACE
30. FAILED TO STOP FOR SCHOOL BUS
31. FAILED TO STOP FOR TRAIN
32. FAILED TO YIELD ROW - EMERGENCY VEHICLE
33. FAILED TO YIELD ROW - OPEN INTERSECTION
34. FAILED TO YIELD ROW - PRIVATE DRIVE
35. FAILED TO YIELD ROW - STOP SIGN
36. FAILED TO YIELD ROW - TO PEDESTRIAN
37. FAILED TO YIELD ROW - TURNING LEFT
38. FAILED TO YIELD ROW - TURN ON RED
39. FAILED TO YIELD ROW - YIELD SIGN
40. FATIGUED OR ASLEEP
41. FAULTY EVASIVE ACTION
42. FIRE IN VEHICLE
43. FLEEING OR EVADING POLICE
44. FOLLOWED TOO CLOSELY
45. HAD BEEN DRINKING
46. HANDICAPPED DRIVER (EXPLAIN IN NARRATIVE)
47. ILL (EXPLAIN IN NARRATIVE)
48. IMPAIRED VISIBILITY (EXPLAIN IN NARRATIVE)
49. IMPROPER START FROM PARKED POSITION
50. LOAD NOT SECURED
51. OPENED DOOR INTO TRAFFIC LANE
52. OVERSIZE VEHICLE OR LOAD
53. OVERTAKE AND PASS INSUFFICIENT CLEARANCE
54. PARKED AND FAILED TO SET BRAKES
55. PARKED IN TRAFFIC LANE
56. PARKED WITHOUT LIGHTS
57. PASSED IN NO PASSING ZONE
58. PASSED ON RIGHT SHOULDER
59. PEDESTRIAN FAILED TO YIELD ROW TO VEHICLE
60. SPEEDING - UNSAFE (UNDER LIMIT)
61. SPEEDING - OVER LIMIT
62. TAKING MEDICATION (EXPLAIN IN NARRATIVE)
63. TURNED IMPROPERLY - CUT CORNER ON LEFT
64. TURNED IMPROPERLY - WIDE RIGHT
65. TURNED IMPROPERLY - WRONG LANE
66. TURNED WHEN UNSAFE
67. UNDER INFLUENCE - ALCOHOL
68. UNDER INFLUENCE - DRUG
69. WRONG SIDE - APPROACH OR IN INTERSECTION
70. WRONG SIDE - NOT PASSING
71. WRONG WAY - ONE WAY ROAD
72. DRIVER INATTENTION - (CELL/MOBILE PHONE USE)
73. ROAD RAGE
74. OTHER FACTOR (WRITE ON LINE BELOW)

Figure B-2. Page 2 of a ST-3, Police Crash Report.

DPS CRASH REPORT DOCUMENTS



DRIVER'S CONFIDENTIAL ACCIDENT REPORT
FORM ST-2 (Rev. 1/1/90)

PLEASE READ INSTRUCTIONS ON REVERSE SIDE

TEXAS DEPARTMENT OF PUBLIC SAFETY

LOCATION

PLACE WHERE ACCIDENT OCCURRED COUNTY ____ CITY OR TOWN ____

IF ACCIDENT WAS OUTSIDE CITY LIMITS, INDICATE DISTANCE FROM NEAREST TOWN ____ MILES ☐ NORTH ☐ S ☐ E ☐ W OF ____ CITY OR TOWN

ROAD ON WHICH ACCIDENT OCCURRED ____ BLOCK NUMBER ____ STREET OR ROAD NAME ____ ROUTE NUMBER

CONSTR. ZONE ☐ YES ☐ NO SPEED LIMIT ____

COMPLETE ONE
- INTERSECTING STREET ____ BLOCK NUMBER ____ STREET OR ROAD NAME ____ ROUTE NUMBER
- NOT AT INTERSECTION ____ FEET ☐ NORTH ☐ S ☐ E ☐ W OF ____ SHOW MILEPOST OR NEAREST INTERSECTING NUMBERED HIGHWAY. IF URBAN, SHOW NEAREST INTERSECTING STREET OR REFERENCE POINT.

CONSTR. ZONE ☐ YES ☐ NO SPEED LIMIT ____

DO NOT WRITE IN THIS SPACE

DPS NO. ____
LOC ____
CODE ____
SEVERITY ____
TYPE ____

TIME

DATE OF ACCIDENT ____ 19 ____ DAY OF WEEK ____ HOUR ____ ☐ A.M. ☐ P.M. IF EXACTLY NOON OR MIDNIGHT, SO STATE

VEHICLES

YOUR VEHICLE

YEAR MODEL ____ MAKE ____ FORD, CHEV., ETC. TYPE OF VEHICLE ____ SEDAN, PICKUP, TRUCK, ETC. LICENSE PLATE ____ YEAR ____ STATE ____ NUMBER

OWNER ____ NAME ____ MAIL ADDRESS ____ CITY AND STATE ____ ZIP

DRIVER ____ NAME ____ MAIL ADDRESS ____ CITY AND STATE ____ ZIP

DRIVER'S LICENSE ____ STATE ____ NUMBER DATE OF BIRTH ____ SEX ____ RACE ____

APPROX. COST TO REPAIR YOUR VEHICLE $ ____

FOR OTHER VEHICLES USE ANOTHER FORM

TOTAL VEHICLES INVOLVED

OTHER UNIT - MOTOR VEHICLE, TRAIN, PEDESTRIAN, BICYCLIST, ETC. - INDICATE WHICH (COMPLETE INFORMATION YOU HAVE AVAILABLE - IF UNKNOWN, MARK "NOT KNOWN") ____

YEAR MODEL ____ MAKE ____ FORD, CHEV., ETC. TYPE OF VEHICLE ____ SEDAN, PICKUP, TRUCK, ETC. LICENSE PLATE ____ YEAR ____ STATE ____ NUMBER

OWNER ____ NAME ____ MAIL ADDRESS ____ CITY AND STATE ____ ZIP

DRIVER ____ NAME ____ MAIL ADDRESS ____ CITY AND STATE ____ ZIP

APPROX. COST TO REPAIR THIS VEHICLE $ ____

DAMAGE TO PROPERTY OTHER THAN VEHICLES ____ NAME OBJECT, SHOW OWNERSHIP, AND STATE NATURE OF DAMAGE

APPROXIMATE COST TO REPAIR $ ____

CASUALTIES

NO. 1 (SHOW ONLY PEDESTRIANS OR PERSONS INJURED IN YOUR VEHICLE)

NAME ____ ADDRESS ____

AGE ____ SEX ____ RACE ____ WAS PERSON KILLED? ____ DATE OF DEATH ____

DESCRIBE INJURY ____

☐ DRIVER ☐ PASSENGER ☐ PEDESTRIAN ☐ RIGHT FRONT ☐ RIGHT REAR ☐ CENTER REAR ☐ LEFT REAR

SEAT BELT ☐ USED ☐ NOT USED

NO. 2

NAME ____ ADDRESS ____

AGE ____ SEX ____ RACE ____ WAS PERSON KILLED? ____ DATE OF DEATH ____

DESCRIBE INJURY ____

☐ DRIVER ☐ PASSENGER ☐ PEDESTRIAN ☐ RIGHT FRONT ☐ RIGHT REAR ☐ CENTER REAR ☐ LEFT REAR

SEAT BELT ☐ USED ☐ NOT USED

STATE BRIEFLY WHAT HAPPENED (IF SPACE IS INSUFFICIENT CONTINUE ON ANOTHER PAGE)

★ DRIVER'S SIGNATURE ____ DATE OF REPORT ____

IMPORTANT! COMPLETE REQUIRED INSURANCE INFORMATION ON OTHER SIDE

Figure B-3. Page 1 of a ST-2, DPS "Blue Form."

PLEASE READ ALL INSTRUCTIONS CAREFULLY

THIS FORM CONTAINS TWO SEPARATE REPORTS WHICH WILL BE DESTROYED AFTER COMPLETION OF ALL PROCESSING

The driver of a motor vehicle involved in an accident not investigated by a law enforcement officer and resulting in injury to or death of any person, or damage to the property of any one person, including himself, to an apparent extent of at least Five Hundred Dollars ($500), shall within ten (10) days after such accident complete and forward these reports in accordance with the instructions below. These reports are not required when an accident is investigated by a law enforcement officer unless specifically requested by authority of Section 4, Texas Motor Vehicle Safety-Responsibility Act (Article 6701h, Vernon's Texas Civil Statutes).

INSTRUCTIONS FOR COMPLETING DRIVER'S CONFIDENTIAL ACCIDENT REPORT (FORM ST-2)
(On other side of this form)

NOTE: The Driver's Confidential Accident Report (Form ST-2) is classified by law as privileged and for confidential use in accident prevention purposes.

1. The report on the other side of this sheet should be prepared and signed by the driver; however, if the driver is unable to make the report for some valid reason, the report may be submitted by another person with a notation as to the reason the driver could not report.
2. Print all names and addresses. Include sufficient information for "Location" and "Time" so that exact date and place of accident may be determined. Answer all questions to the best of your knowledge. If unable to answer any question, mark "not known."
3. If the "other unit" is a pedestrian, bicycle, train or other non-motor vehicle, please specify and show the name of pedestrian, bicyclist, etc. on line labeled "Driver."
4. If accident involved a fixed object, describe it fully, show its exact location and state whether it was protected by flags, painting and/or lights.
5. The narrative description of the accident should contain a brief statement of the facts regarding the accident. If additional space is needed, use a full size sheet of paper for continuation.
6. An accurate original signed report will avoid the necessity for a supplemental report.

TEXAS MOTOR VEHICLE ACCIDENT INSURANCE INFORMATION (FORM SR-21) Rev. 4-88

IMPORTANT

Note: Under certain conditions, Section 5 of the Texas Motor Vehicle Safety-Responsibility Act (V.T.C.S. 6701h) requires suspension of driver's license, registration receipts and license plates of uninsured motorists involved in motor vehicle accidents resulting in bodily injury or death, or damages to the property of any one person of at least $1,000.00. The Accident Insurance Information (Form SR-21) is a public document.

1. This report may be prepared and signed by **either** the driver or owner of the involved vehicle.
2. Accurate, complete reporting of at least minimum liability insurance coverage will avoid additional correspondence and prevent possible suspension of your driving and registration privileges.
3. If garage estimates are attached to non-injury accidents, processing will be expedited.

DID YOU HAVE AT LEAST $20,000/40,000 BODILY INJURY AND $15,000 PROPERTY DAMAGE LIABILITY INSURANCE IN EFFECT ON THE DATE OF THE ACCIDENT? ☐ YES ☐ NO

If the above is answered "Yes" answer all the items in the box below.

Date of Accident ____________ Place of Accident ______________________________
City or Town County

Make of Vehicle
Involved in Accident ____________ Year ________ Type ________ Vehicle Identification No. ____________

______________________________ Owner's Name ______________________________
Name of Your Liability Insurance Co. (Not the Agent)

Owner's Address ______________________________

Policy No. ______________________________ Driver's Name ______________________________

☐ Owner
______________________________ ☐ Driver Driver's Address ______________________________
Usual Signature

If your vehicle was operating under Texas Railroad Commission Carrier Authority, give No. ______________

When completed, mail this form to: STATISTICAL SERVICES BUREAU
TEXAS DEPARTMENT OF PUBLIC SAFETY
BOX 4087. AUSTIN. TEXAS 78773-0001

Figure B-4. Page 2 of a ST-2, DPS "Blue Form."

OUTLINE OF THE CRASH-REPORTING PROCESS

1. The police file a report (a blank version of the most recent format of a police crash report, ST-3, for the State of Texas is in Figures B-1 and B-2).
2. Local Records
    a. Hard copies are kept on file for approximately two to five years (three years for the College Station Police Department; see Figure B-5).
    b. Depending on the size of the police department and the internal desires of the department to computerize their crash-reporting system, some departments will code some of the information from the crash reports into their own internal database.
3. The report is shipped within approximately 10 days to the ARB of the DPS. The sending of the records may vary based upon the severity of the crash, the investigation required, any coding and/or logging filed within the local police department, and any backlogs in the overall process at that department.
4. The ARB receives the crash reports directly from the police department through the federal mail system.
    a. In 1997, the DPS began to improve the antiquated crash report filing process. Currently, DPS and TxDOT are combining their efforts to create and fund a new, more automated crash-reporting system: the Crash Records Information System. Ms. Cathy Cioffi is the project manager (Figures B-6 and B-7 are a copy of a CRIS newsletter).
5. The records are processed in an assembly line fashion, with specific people focusing on particular sections.
    a. The initial decision is made about whether or not to code a crash to a particular person's driving history (i.e., rear-ending = yes, hitting a tree while swerving from an animal = no).
    b. The files are then sorted for further coding/processing.
        i. Before July 1995, all crashes were coded. Not all crashes are reported. Hence, only reported crashes may be coded, and this limitation should be expressed and understood in any study.

College Station Police Department

Texas Accidents

ID	K1	C2	C3	C4	C5	C6	C7	C8
1	01/07/1998	1300	900	TEXAS	WALTON DR	North	Clear	Possible Injury
2	01/14/1998	1540	700	TEXAS	WALTON DR	North	Clear	Non-Injury
3	01/17/1998	0834	0	TEXAS	BRENTWOOD DR	*missing*	Clear	Non-Incapacitating
4	01/18/1998	1742	0	TEXAS	VALLEY VIEW DR-CS	*missing*	Clear	Non-Injury
5	01/19/1998	1826	1500	TEXAS	MILLIFF RD	South	Clear	Non-Injury
6	01/22/1998	2238	800	TEXAS	UNIVERSITY DR	South	Clear	Non-Injury
7	01/23/1998	2120	0	TEXAS	RICHARDS ST	*missing*	Clear	Non-Injury
8	01/23/1998	2310	700	TEXAS	LIVE OAK ST-CS	South	Clear	Non-Injury
9	01/23/1998	1714	700	TEXAS	LIVE OAK ST-CS	South	Clear	Possible Injury
10	01/28/1998	1655	0	TEXAS	GEORGE BUSH DR	*missing*	Clear	Non-Injury
11	01/29/1998	1620	0	TEXAS	HARVEY MITCHELL PW S	*missing*	Clear	Possible Injury
12	01/30/1998	1226	900	TEXAS	LINCOLN AV	South	Clear	Non-Injury
13	01/30/1998	1015	1300	TEXAS	MOSS ST-CS	North	Clear	Non-Injury
14	02/05/1998	0641	1000	TEXAS	*missing*	*missing*	Clear	Non-Injury
15	02/06/1998	1735	1000	TEXAS	WALTON DR	South	Clear	Non-Injury
16	02/08/1998	1438	1300	TEXAS	GILCHRIST AV	*missing*	Clear	Possible Injury
17	02/10/1998	1410	1050	TEXAS	WALTON DR	*missing*	Clear	Non-Incapacitating
18	02/16/1998	0958	1500	TEXAS	MILLIFF RD	*missing*	Raining	Non-Injury
19	02/18/1998	1440	1000	TEXAS	WALTON DR	South	Raining	Non-Incapacitating
20	02/19/1998	2220	500	TEXAS	UNIVERSITY DR	*missing*	Clear	Non-Injury
21	02/19/1998	2100	500	TEXAS	UNIVERSITY DR	*missing*	Clear	Non-Injury
22	02/23/1998	0856	700	TEXAS	UNIVERSITY DR	South	Clear	Possible Injury
23	02/25/1998	1335	700	TEXAS	LONE STAR DR	South	Clear	Non-Injury
24	02/27/1998	1615	800	TEXAS	LIVE OAK ST-CS	South	Clear	Non-Injury
25	02/28/1998	1430	1080	TEXAS	WALTON DR	*missing*	Clear	Non-Injury
26	02/28/1998	2202	700	TEXAS	LIVE OAK ST-CS	South	Clear	Non-Injury
27	03/03/1998	0752	1400	TEXAS	GEORGE BUSH DR	North	Clear	Non-Injury
28	03/05/1998	2130	800	TEXAS	LIVE OAK ST-CS	*missing*	Clear	Non-Injury
29	03/06/1998	2257	500	TEXAS	UNIVERSITY DR	*missing*	Clear	Incapacitating
30	03/06/1998	1509	0	TEXAS	REDMOND DR	*missing*	Clear	Non-Injury
31	03/07/1998	1629	600	TEXAS	LIVE OAK ST-CS	South	Clear	Possible Injury
32	03/07/1998	2140	1400	TEXAS	GEORGE BUSH DR	South	Clear	Non-Injury
33	03/09/1998	1411	500	TEXAS	UNIVERSITY DR	South	Clear	Non-Incapacitating
34	03/12/1998	2120	700	TEXAS	*missing*	*missing*	Raining	Non-Injury
35	03/12/1998	2158	700	TEXAS	UNIVERSITY DR	South	Raining	Non-Injury
36	03/13/1998	1310	1500	TEXAS	HARVEY	North	Clear	Possible Injury
37	03/14/1998	1320	1000	TEXAS	WALTON DR	South	Raining	Non-Injury
38	03/16/1998	1229	1500	TEXAS	REDMOND DR	South	Clear	Possible Injury
39	03/18/1998	1239	1000	TEXAS	WALTON DR	South	Clear	Possible Injury
40	03/21/1998	0112	1000	TEXAS	WALTON DR	*missing*	Clear	Possible Injury
41	03/24/1998	1135	500	TEXAS	UNIVERSITY DR	*missing*	Clear	Non-Injury
42	03/25/1998	2303	1400	TEXAS	GEORGE BUSH DR	*missing*	Clear	Possible Injury
43	03/25/1998	1705	1500	TEXAS	HARVEY	North	Clear	Non-Injury

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Figure B-5. College Station Police Department (CSPD) Crash Data File.

CRIS NEWSLETTER

CRIS Project Newsletter

Volume 1, Issue 1

What is CRIS?

Crash Records Information System

The crash records information system (CRIS) project is a joint initiative between the Department of Public Safety (DPS) and the Texas Department of Transportation (TxDOT). The vision of the project is to implement a new crash records information system that will provide enhanced efficiencies to capture, manage and disseminate timely and accurate data to parties who need it to improve the safety of the Texas roadways.

Accident data is used to evaluate the effectiveness of safety programs and obtain funding to support traffic safety. This data is also critical for state and local transportation project planning and prioritization, highway and railroad crossing safety evaluation, identification of target areas for enhanced law enforcement, and for traffic safety studies.

The system in use today was designed in the 1970's using technologies available at that time that do not meet the needs of DPS, TxDOT or other local and state agencies in 2002. The result is a system that is manually intensive and untimely in it's reporting capabilities.

The CRIS Project includes the redesign of the current accident /crash records system resulting in the creation of a new crash records information system. This may include designing linkages to other components of the traffic records system and other systems.

The CRIS project is utilizing the DPS Concurrent Engineering Methodology (CEM) to manage and document the project. A steering committee comprised of DPS and TxDOT stakeholders provide guidance. Sponsors for the project are Frank Elder, Assistant Chief-Driver License Division, Carol Rawson, Deputy Director-Traffic Operations and Bob Burroughs, Major-Traffic Law Enforcement.

CRIS Project Steering Committee

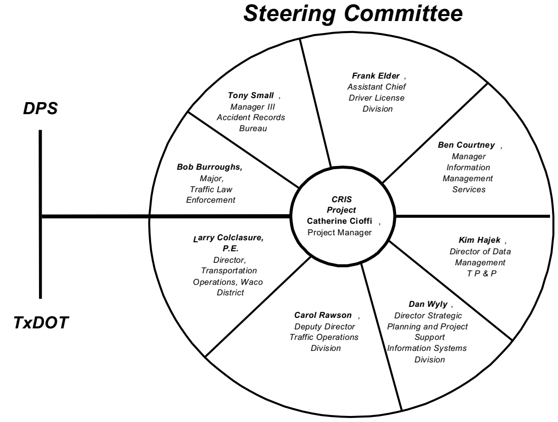
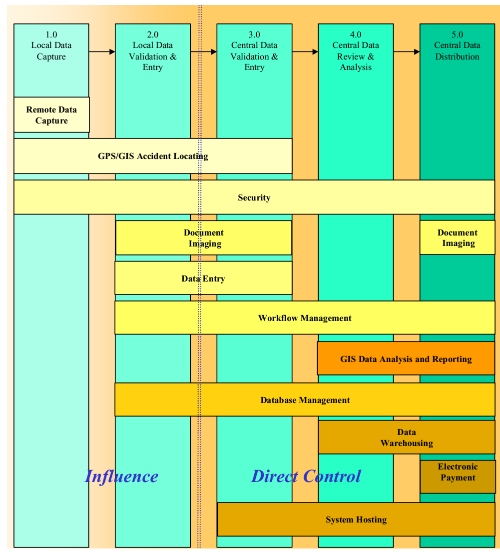


Figure B-6. Page 1 of a Crash Records Information System (CRIS) Newsletter.

Currently, we have a vendor conducting a Study & Recommend assisting the CRIS Steering Committee in making a solution approach decision. The vendor will deliver a Findings and Recommendation Report in August that will include a recommended solution approach and a cost benefit analysis.

The project will take a phased approach to implementation. A Request for Offer (RFO) for the next phase of the project is expected to go out by the end of the 4th quarter 2002. The project is expected to move into the design and implementation phase by the end of the 1st quarter 2003.

The five CRIS process areas and potential technologies are graphically depicted below:



Special thanks to Rick Pearson and Tony Zamarripa of the Accident Records Bureau for their imagination and creativity in the design of the CRIS project logo.

If you are interested in receiving quarterly CRIS updates or have questions about the project, please contact:

Cathy Cioffi
CRIS Project Manager
(512) 424-5436
Catherine.cioffi@txdps.state.tx.us

Figure B-7. Page 2 of a Crash Records Information System (CRIS) Newsletter.

   ii. As of July 1995, non-injury crashes that do not result in property damage of greater than $1,000 (i.e., tow-away crashes will exceed this and are the usual criteria for coding property damage only crashes) are no longer coded. Also, only injured passengers are coded. Before, all passengers were coded.
   iii. Both coded and non-coded records are stored on microfilm at the same time. They are transferred to microfilm after the coding process is complete, and the records are uploaded into the DPS mainframe.

c. Files to be coded will be further classified and numbered.
   i. The coding process is completed using in-house written documents.
   ii. These documents will be sent to another department for input into the DPS mainframe database. CD-ROMs may be made for a particular county for use outside of the DPS.
      1. These CDs are made upon request. The CDs contain the data in a data stream format. This format is impossible to read without the appropriate codebook. Furthermore, it is still difficult to read without the proper formatting software. Texas Transportation Institute uses a statistical analysis software package, called SAS. This program converts the data stream into a user-friendlier format that may be imported into spreadsheet software such as Microsoft Excel.
      2. The format contains column headers, and virtually all of the data are in numeric coding that is fairly easy to understand by anyone who has a copy of the coding sheets.
   iii. The applicable information is also coded to the driving records of the motorists involved in a crash. A crash is only coded to someone's personal driving record if he/she is at fault and/or that person received a traffic citation.

d. The coding process is filled with checks and editing.
    i. A double input method is used, whereby two individuals enter the same information, and a computer compares the records to find possible errors.
    ii. The computer will only allow certain ranges of information to be entered in certain fields to reduce errors. For example, some entries may only allow text while some may only allow numbers and other entries may only allow one number while others allow up to three digits.

e. Record A contains the summarized crash report information including the location, number of vehicles involved, type of crash, orientation, and other information.

f. Record B contains the driver's and the vehicle's descriptive information.
    i. This includes whether the drivers were injured, drunk, and/or considered at-fault.
    ii. The vehicle description comprises of vehicle make and model information and whether a vehicle defect could be attributed to the crash.

g. Record C contains only the information for the passengers in the vehicles involved and any pedestrians, cyclists, or additional people involved (non-injured passengers are not coded, but the total people inside each vehicle is listed).

h. All of the records are kept in the mainframe database, and hard copies of the reports are kept on file and organized by county and date in the ARB.
    i. Paper hard copies are transferred to microfilm hardcopies and held for 10 years. The records are destroyed after 10 years.
    ii. DPS has an internal seven-digit coding system for referencing within the data in the mainframe or on CD.
        1. The DPS coding is reused at the beginning of every new 10-year period.
        2. The seven-digit code is not used in pulling actual records from the stored microfilm filing system.
        3. The seven-digit code is also coded with the driver's individual traffic record for referencing purposes.

i. Comments:
    i. The whole process takes approximately 18 months.
    ii. The actual milepost locations are accessed by the use of the roadway inventory logbook sheets generated by TxDOT. The logbook shows the mileposts of cross streets and important curb cuts (e.g., a fire station) along a particular roadway.
    iii. The mainframe information is updated when the coding process is complete. In particular, the ARB uses a 13-month system to assess any editing issues discovered through the data entry process and to address any additional unforeseen delays.
    iv. There is another form, known as the "blue form," that may be submitted directly to DPS by individuals who were in a crash that was not reported by local law enforcement. A copy of the blue form is shown in Figure B-3. Depending on the crash location, severity, and whether there were any violations involved (i.e., hit-and-run violation), the local police department may or may not record the crash in their own database. State law puts the responsibility on the drivers involved to report the crash and not the police department. Only crashes on public roadways must be reported (e.g., parking lot crashes are not recorded) by motorists.
    v. The information in the database has been used in the past to better plan police officer route scheduling to ensure timely response to crash-prone areas.

APPENDIX C

Crash Analysis Data

SUMMARY CRASH DATA FOR THE TEXAS AVENUE STUDY CORRIDOR

The following tables contain the summary of the data collected for the Texas Avenue study corridor. Some clarifying notes for all of the tables are listed below.

1. The data for 2000 include only crashes through June.

2. (*) Indicates that the exact timeframe for the year in question started in July of that year and ran through June of the following year. Consequently, 1998* actually stands for the timeframe of July 1998 to June of 1999.

3. The Before category covers January 1993 through December of 1994.

4. The After category covers July 1998 through June of 2000.

5. The data for 1993-95 reflect the changes in July 1995, in which the state no longer requires PDOs less the $1,000.

6. The Texas corridor category indicates the study area from roughly 0.2-miles north and south of George Bush Drive along Texas Avenue and includes crashes along George Bush Drive that are attributed to the signalized intersection.

7. Milepost 5.200 to MP 5.900 refers to the roadway section from approximately 500 feet north of George Bush Drive to 300 feet south of University Drive along Texas Avenue.

8. % Change B-C indicates the change from the before period to the construction period.

9. % Change C-A indicates the change from the construction period to the after period.

10. % Change B-A indicates the change from the before period to the after period.

Table C-1. Total Crashes.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	1,006	228	469	271
1993	220	42	98	57
1994	215	60	96	50
1995	125	40	54	25
1996	109	23	47	34
1997	116	22	62	31
1998	98	16	52	35
1999	87	20	43	25
2000	36	5	17	14
1998*	88	15	48	26
1999*	90	20	45	27
Before	435	102	194	107
Construction	264	50	127	85
After	178	35	93	53
%Change B-C	-39.3	-51.0	-34.5	-20.6
%Change C-A	-32.6	-30.0	-26.8	-37.6
%Change B-A	-59.1	-65.7	-52.1	-50.5
p-value (B-A)[1]	<0.0001	<0.0001	<0.0001	<0.0001

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

Table C-2. Total People.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	3,303	843	1,533	890
1993	740	140	345	205
1994	500	286	345	169
1995	416	143	186	82
1996	403	92	68	128
1997	319	68	181	89
1998	267	44	137	104
1999	231	58	113	70
2000	107	12	56	43
1998*	221	38	126	67
1999*	259	60	130	85
Before	1,240	426	690	374
Construction	838	175	399	280
After	480	98	256	152
%Change B-C	-32.4	-58.9	-42.2	-25.1
%Change C-A	-42.7	-44.0	-35.8	-45.7
%Change B-A	-61.3	-77.0	-62.9	-59.4
p-value (B-A)[1]	<0.0001	<0.0001	<0.0001	<0.0001

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

Table C-3. Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	2300	541	1097	636
1993	490	94	225	128
1994	500	145	229	111
1995	276	94	120	56
1996	261	57	115	85
1997	261	52	146	74
1998	232	40	121	92
1999	191	48	94	55
2000	89	11	47	35
1998*	194	35	110	58
1999*	210	49	107	66
Before	990	239	454	239
Construction	624	123	305	215
After	404	84	217	124
%Change B-C	-37.0	-48.5	-32.8	-10.0
%Change C-A	-35.3	-31.7	-28.9	-42.3
%Change B-A	-59.2	-64.9	-52.2	-48.1
p-value (B-A)[1]	<0.0001	<0.0001	<0.0001	<0.0001

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance.

Table C-4. Non-Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	1003	302	436	254
1993	250	46	120	77
1994	320	141	116	58
1995	140	49	66	26
1996	142	35	55	43
1997	58	16	35	15
1998	35	4	16	12
1999	40	10	19	15
2000	18	1	9	8
1998*	27	3	16	9
1999*	49	11	23	19
Before	570	187	236	135
Construction	214	52	94	65
After	76	14	39	28
%Change B-C	-62.5	-72.2	-60.2	-51.9
%Change C-A	-64.5	-73.1	-58.5	-56.9
%Change B-A	-86.7	-92.5	-83.5	-79.3
p-value (B-A)[1]	<0.0001	<0.0001	<0.0001	<0.0001

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

Table C-5. Fatalities.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	0	0	0	0
1993	0	0	0	0
1994	0	0	0	0
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
1998*	0	0	0	0
1999*	0	0	0	0
Before	0	0	0	0
Construction	0	0	0	0
After	0	0	0	0
%Change B-C	N/A	N/A	N/A	N/A
%Change C-A	N/A	N/A	N/A	N/A
%Change B-A	N/A	N/A	N/A	N/A
p-value (B-A)[1]	N/A	N/A	N/A	N/A

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

Table C-6a. Non-Injured Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	1782	425	835	496
1993	399	76	176	107
1994	421	126	187	92
1995	225	78	96	43
1996	188	40	84	62
1997	186	37	102	62
1998	167	27	88	70
1999	126	33	62	36
2000	70	8	40	24
1998*	137	24	82	40
1999*	151	33	78	48
Before	820	202	363	199
Construction	445	88	215	165
After	288	57	160	88
%Change B-C	-45.7	-56.4	-40.8	-17.1
%Change C-A	-35.3	-35.2	-25.6	-46.7
%Change B-A	-64.9	-71.8	-55.9	-55.8
p-value (B-A)[1]	<0.0001	<0.0001	<0.0001	<0.0001

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

Table C-6b. Possibly Injured Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	368	84	190	102
1993	69	16	34	19
1994	58	13	32	16
1995	37	11	19	9
1996	52	14	24	14
1997	49	6	30	10
1998	43	8	24	13
1999	48	14	23	14
2000	12	2	4	7
1998*	40	8	18	12
1999*	42	14	21	12
Before	127	29	66	35
Construction	121	22	66	33
After	82	22	39	24
%Change B-C	-4.7	-24.1	0.0	-5.7
%Change C-A	-32.2	0.0	-40.9	-27.3
%Change B-A	-35.4	-24.1	-40.9	-31.4
p-value (B-A)[1]	<0.0016	0.3270	0.0086	0.1528

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance.

Table C-6c. Non-Incapacitated Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	130	31	61	32
1993	16	2	10	2
1994	16	6	8	2
1995	11	5	3	2
1996	19	2	6	9
1997	25	9	13	2
1998	19	5	9	6
1999	17	1	9	5
2000	7	1	3	4
1998*	17	3	10	6
1999*	17	2	8	6
Before	32	8	18	4
Construction	53	13	22	14
After	34	5	18	12
%Change B-C	65.6	62.5	22.2	250.0
%Change C-A	-35.8	-61.5	-18.2	-14.3
%Change B-A	6.3	-37.5	0.0	200.0
p-value (B-A)[1]	0.8026	0.2670	N/A	0.0802

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance.

Table C-6d. Incapacitated Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	20	1	11	6
1993	6	0	5	0
1994	5	0	2	1
1995	3	0	2	2
1996	2	1	1	0
1997	1	0	1	0
1998	3	0	0	3
1999	0	0	0	0
2000	0	0	0	0
1998*	0	0	0	0
1999*	0	0	0	0
Before	11	0	7	1
Construction	5	0	2	3
After	0	0	0	0
%Change B-C	-54.5	N/A	-71.4	200.0
%Change C-A	-100.0	N/A	-100.0	-100.0
%Change B-A	-100.0	N/A	-100.0	-100.0
p-value (B-A)[1]	<0.0001	N/A	0.0026	No statistical difference

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-7a. Non-Injured Non-Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	703	230	294	159
1993	204	35	97	64
1994	268	124	94	43
1995	110	38	52	18
1996	94	23	38	27
1997	27	10	13	7
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
1998*	0	0	0	0
1999*	0	0	0	0
Before	472	159	191	107
Construction	119	33	51	34
After	0	0	0	0
%Change B-C	-74.8	-79.2	-73.3	-68.2
%Change C-A	-100.0	-100.0	-100.0	-100.0
%Change B-A	-100.0	-100.0	-100.0	-100.0
p-value (B-A)[1]	<0.0001	<0.0001	<0.0001	<0.0001

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

Table C-7b. Possibly Injured Non-Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	234	61	109	75
1993	36	10	18	10
1994	43	13	18	13
1995	24	10	10	7
1996	34	9	12	12
1997	26	5	17	7
1998	26	4	12	8
1999	31	9	16	11
2000	14	1	6	7
1998*	20	3	12	7
1999*	39	10	18	15
Before	79	23	36	23
Construction	71	15	32	23
After	59	13	30	22
%Change B-C	-10.1	-34.8	-11.1	0.0
%Change C-A	-16.9	-13.3	-6.3	-4.3
%Change B-A	-25.3	-43.5	-16.7	-4.3
p-value (B-A)[1]	0.0892	0.0950	0.4592	0.8808

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance.

Table C-7c. Non-Incapacitated Non-Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	56	9	27	17
1993	9	1	4	3
1994	7	3	3	1
1995	2	0	2	0
1996	14	3	5	4
1997	4	1	4	1
1998	8	0	4	3
1999	8	1	2	4
2000	4	0	3	1
1998*	7	0	4	2
1999*	9	1	4	4
Before	16	4	7	4
Construction	22	4	10	7
After	16	1	8	6
%Change B-C	37.5	0.0	42.9	75.0
%Change C-A	-27.3	-75.0	-20.0	-14.3
%Change B-A	0.0	-75.0	14.3	50.0
p-value (B-A)[1]	No statistical difference	No statistical difference	No statistical difference	0.7490

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-7d. Incapacitated Non-Drivers.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	10	2	6	3
1993	1	0	1	0
1994	2	1	1	1
1995	4	1	2	1
1996	0	0	0	0
1997	1	0	1	0
1998	1	0	0	1
1999	1	0	1	0
2000	0	0	0	0
1998*	0	0	0	0
1999*	1	0	1	0
Before	3	1	2	1
Construction	2	0	1	1
After	1	0	1	0
%Change B-C	-33.3	-100.0	-50.0	0.0
%Change C-A	-50.0	N/A	0.0	-100.0
%Change B-A	-66.7	-100.0	-50.0	-100.0
p-value (B-A)[1]	No statistical difference	No statistical difference	No statistical difference	No statistical difference

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-8a. Rear-Ending Crashes.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	631	181	315	198
1993	137	37	68	37
1994	145	49	70	39
1995	73	32	31	17
1996	64	18	28	25
1997	69	15	39	24
1998	60	11	34	25
1999	58	17	31	18
2000	25	2	14	13
1998*	55	10	32	19
1999*	58	15	33	22
Before	282	86	138	76
Construction	162	38	81	63
After	113	25	65	41
%Change B-C	-42.6	-55.8	-41.3	-17.1
%Change C-A	-30.2	-34.2	-19.8	-34.9
%Change B-A	-59.9	-70.9	-52.9	-46.1
p-value (B-A)[1]	<0.0001	<0.0001	<0.0001	<0.0001

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance.

Table C-8b. Sideswipe Crashes.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	44	6	13	14
1993	17	1	1	8
1994	10	2	5	3
1995	5	2	1	0
1996	2	1	1	0
1997	1	0	0	0
1998	4	0	2	1
1999	5	0	3	2
2000	0	0	0	0
1998*	7	0	4	2
1999*	2	0	1	1
Before	27	3	6	11
Construction	3	1	1	0
After	9	0	5	3
%Change B-C	-88.9	-66.7	-83.3	-100.0
%Change C-A	200.0	-100.0	400.0	N/A
%Change B-A	-66.7	-100.0	-16.7	-72.7
p-value (B-A)[1]	0.0026	No statistical difference	0.5286	0.0142

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-8c. Right-Angle Crashes.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	268	25	115	48
1993	58	2	25	11
1994	49	5	17	6
1995	35	3	17	6
1996	37	1	16	8
1997	35	5	19	6
1998	28	4	13	8
1999	17	2	6	3
2000	9	3	2	0
1998*	20	4	9	4
1999*	22	4	7	2
Before	107	7	42	17
Construction	83	7	40	19
After	42	8	16	6
%Change B-C	-22.4	0.0	-4.8	11.8
%Change C-A	-49.4	14.3	-60.0	-68.4
%Change B-A	-60.7	14.3	-61.9	-64.7
p-value (B-A)[1]	<0.0001	No statistical difference	<0.0001	0.0220

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-8d. Head-On Crashes.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	9	2	5	1
1993	0	0	0	0
1994	4	2	2	0
1995	1	0	0	0
1996	0	0	0	0
1997	3	0	3	0
1998	0	0	0	0
1999	0	0	0	0
2000	1	0	0	1
1998*	0	0	0	0
1999*	1	0	0	1
Before	4	2	2	0
Construction	3	0	3	0
After	1	0	0	1
%Change B-C	-25.0	-100.0	50.0	N/A
%Change C-A	-66.7	N/A	-100.0	N/A
%Change B-A	-75.0	-100.0	-100.0	N/A
p-value (B-A)[1]	No statistical difference	No statistical difference	No statistical difference	No statistical difference

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-8e. Single-Vehicle Crashes.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	42	12	17	7
1993	3	1	2	0
1994	4	2	1	1
1995	8	2	4	1
1996	6	3	2	1
1997	7	2	1	1
1998	6	1	3	1
1999	7	1	3	2
2000	1	0	1	0
1998*	6	1	3	1
1999*	7	1	4	1
Before	7	3	3	1
Construction	12	4	2	3
After	13	2	7	2
%Change B-C	71.4	33.3	-33.3	200.0
%Change C-A	8.3	-50.0	250.0	-33.3
%Change B-A	85.7	-33.3	133.3	100.0
p-value (B-A)[1]	0.2628	No statistical difference	0.3422	No statistical difference

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the α=0.05 level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-8f. Other Crashes.

Time Period	Texas Corridor	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
Total	12	2	4	3
1993	5	1	2	1
1994	3	0	1	1
1995	3	1	1	1
1996	0	0	0	0
1997	1	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
1998*	0	0	0	0
1999*	0	0	0	0
Before	8	1	3	2
Construction	1	0	0	0
After	0	0	0	0
%Change B-C	-87.5	-100.0	-100.0	-100.0
%Change C-A	-100.0	N/A	N/A	N/A
%Change B-A	-100.0	-100.0	-100.0	-100.0
p-value (B-A)[1]	0.0136	No statistical difference	No statistical difference	No statistical difference

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-9. Injuries with Respect to Restraint Use for Drivers.

Time Period	Injury Category	Lap & Shoulder	Lap Only	Shoulder Only	Airbag	None
Before	Total	919	10	4	7	50
	Non-injury	773	10	1	2	34
	Possible	122	0	1	1	3
	Non-Incapacitating	20	0	1	4	7
	Incapacitating	4	0	1	0	6
After	Total	351	0	0	35	18
	Non-injury	263	0	0	13	12
	Possible	69	0	0	10	3
	Non-Incapacitating	19	0	0	12	3
	Incapacitating	0	0	0	0	0
p-value[1]	Non-injury	<0.0001	0.0044	No statistical difference	0.0098	<0.0001
	Possible	0.0005	No statistical difference	No statistical difference	0.0114	No statistical difference
	Non-Incapacitating	0.8728	No statistical difference	No statistical difference	0.0802	0.0232
	Incapacitating	No statistical difference	No statistical difference	No statistical difference	No statistical difference	0.0514

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.

[1]A *p*-value of <0.05 indicates a statistical difference at the $\alpha=0.05$ level of significance. No value is given when the sample size is low and Equation 3-6 is used.

Table C-10. Crash Rates.

Time Frame	Intersection of Texas Avenue & George Bush Drive	MP 5.200 to MP 5.900	Intersection of Texas Avenue & University Drive
1993	1.9	4,475	2.5
1994	2.6	4,175	2.2
1995	1.6	2,192	1.0
1996	0.9	1,908	1.4
1997	0.9	2,634	1.3
1998	0.7	2,499	1.5
1999	0.8	2,014	1.0
2000	0.4	1,321	1.0
1998*	1.2	4,554	2.1
1999*	1.5	3,823	2.0
Before	2.2	4,321	2.3
Construction	1.0	2,693	1.8
After	0.7	2,084	1.0
%Change B-C	-53.7	-37.7	-25.0
%Change C-A	-33.5	-22.6	-40.8
%Change B-A	-69.3	-51.8	-55.6

See the other notes at the beginning of this appendix to clarify any of the abbreviations or other marks that are not defined here.