Chapter 4

ROAD SAFETY REVIEW: IMPLEMENTATION

4.1 INTRODUCTION

The road safety review process was applied to six roadways in the Town of Natick, Massachusetts. The selected roadways included:

- South Main Street;
- Glen Street;
- Walnut Street;
- Pine Street;
- Hartford Street; and
- Union Street.

As described in chapter three of this document, the road safety review procedure is broken down into three phases including office review, field review, and final report.

In the office review, the general characteristics of the sites and the roadways were described and a crash data analysis for each of the selected roadways was conducted. The crash reports analyzed comprised the five-year period from 1998 to 2003 and were extracted from the Natick Police Records Department.

In the field review, a road survey was completed for each of the six roadways observing and recording data on a variety of traffic-related categories including roadway characteristics, geometry, speed limits, sight distance, signage, and other traffic devices. During the field visit, videotapes were recorded and the checklists were revised to assure all essential elements were included. Using traffic classifiers, traffic volumes and speed data were collected for 72 hours and later analyzed using statistical software.

In the final report, the findings and recommendations from both the office and field review were summarized for each of the six selected roadways.

4.2 OFFICE REVIEW

4.2.1 Site Description

4.2.1.1 The Town of Natick, Massachusetts

The Town of Natick is located on the Charles and Concord river basins in the Central Region of the state of Massachusetts. Natick is situated about 18 miles southwest of Boston, 25 miles east of Worcester and borders Framingham on the west, Wayland and Weston on the north, Wellesley and Dover on the east, and Dover

and Sherborn on the south. Natick is considered an industrial suburb included in the Boston metro area. Figure 4-1 illustrates Natick location.

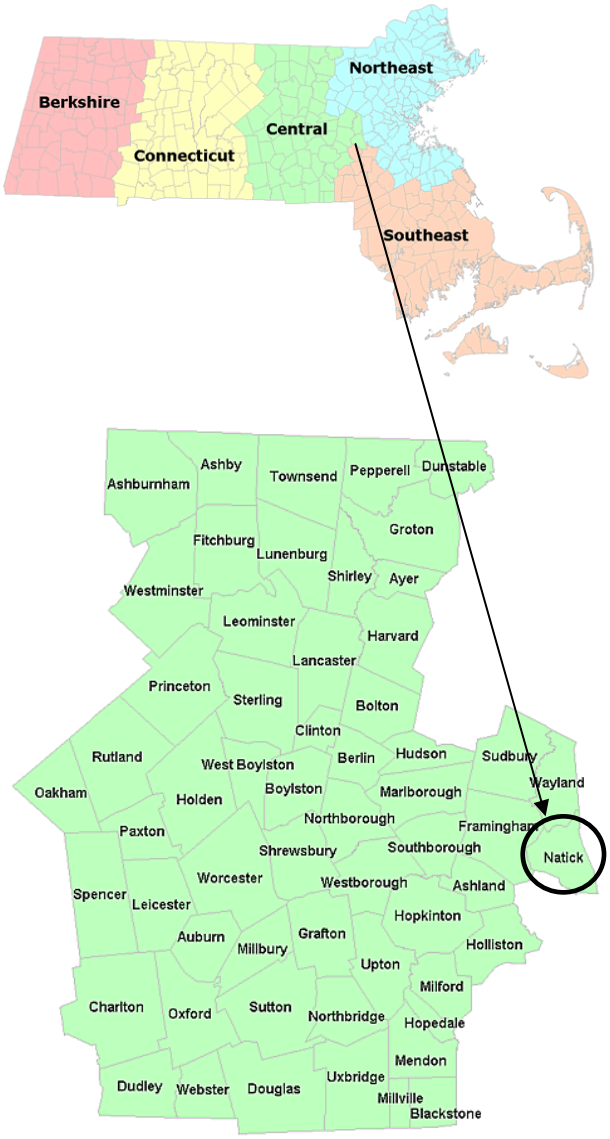

FIGURE 4-1 *Massachusetts Regions and Towns in the Central Region.*

In 1651, the Massachusetts Legislature granted this piece of land to Reverend John Eliot, a Puritan missionary who settled the Town of Natick with a group of converted Native Americans, the Praying Indians. The Town was named Natick for an Indian tribe and means "Place of Hills". In the 19th-century, Natick became a shoemaking center hosting numerous manufacturers and being one of the largest producers of boots and shoes.

In 2000, the total population in Natick was 32,170 with a median age of 38.2 years old. An overview of demographic characteristics is presented in Table 4-1.

TABLE 4-1 *Demographic Characteristics of the Town of Natick, Ma 2000 (US Census Bureau)*

Subject	Number	Percent
Total population	**32,170**	**100**
SEX AND AGE		
Male	15,216	47.3
Female	16,954	52.7
Under 5 years	2,370	7.4
5 to 9 years	2,124	6.6
10 to 14 years	1,903	5.9
15 to 19 years	1,421	4.4
20 to 24 years	1,219	3.8
25 to 34 years	4,981	15.5
35 to 44 years	6,058	18.8
45 to 54 years	4,532	14.1
55 to 59 years	1,619	5
60 to 64 years	1,335	4.1
65 to 74 years	2,350	7.3
75 to 84 years	1,650	5.1
85 years and over	608	1.9
Median age (years)	38.2	(X)

Subject	Number	Percent
Total population	**32,170**	**100**
18 years and over	24,769	77
Male	11,402	35.4
Female	13,367	41.6
21 years and over	24,166	75.1
62 years and over	5,384	16.7
65 years and over	4,608	14.3
Male	1,807	5.6
Female	2,801	8.7

4.2.1.2 Implemented roadways of the study

The study was conducted on six roadway segments in the Town of Natick, Massachusetts. These selected roadways were approximately one mile long, located in residential areas, and classified as collectors. The functional classification of roadways is based on the level of access and mobility that they present. While arterials have the highest level of mobility and local roads present important degree of land access, collectors offer approximately balanced service for both functions (ASSHTO, 2001).

The six roadways were unposted and governed by Massachusetts' prima facie speed limit law. The prima facie concept comes from the Latin expression "a first view", and a prima facie speed limit is understood as a speed limit above which the motorist is presumed to be driving unlawfully. The selected roadways were all located inside areas classified as thickly settled, which is defined by the Massachusetts General Law as the territory contiguous to any way where the houses are situated at such distances as will average less than two hundred feet between them for a distance of a quarter of a mile or over. The Massachusetts General Law specifies that exceeding 30 mph inside a thickly settled shall be prima facie evidence of unreasonable and improper speed.

The six roadway segments studied were included respectively in South Main Street, Glen Street, Walnut Street, Pine Street, Hartford Street and Union Street. The selected roadways and their total length are presented in Table 4-2.

TABLE 4-2 *Selected roadways of the study*

Natick Study Sites	Length (feet)	Length (meters)
South Main Street	9200	2804
Glen Street	6888	2099
Walnut Street	6500	1981
Union Street	8040	2451
Pine Street	5470	1667
Hartford Street	7437	2267
Union Street	8040	2451

The location of these roadways in the Town of Natick, Massachusetts, is illustrated in Figure 4-2.

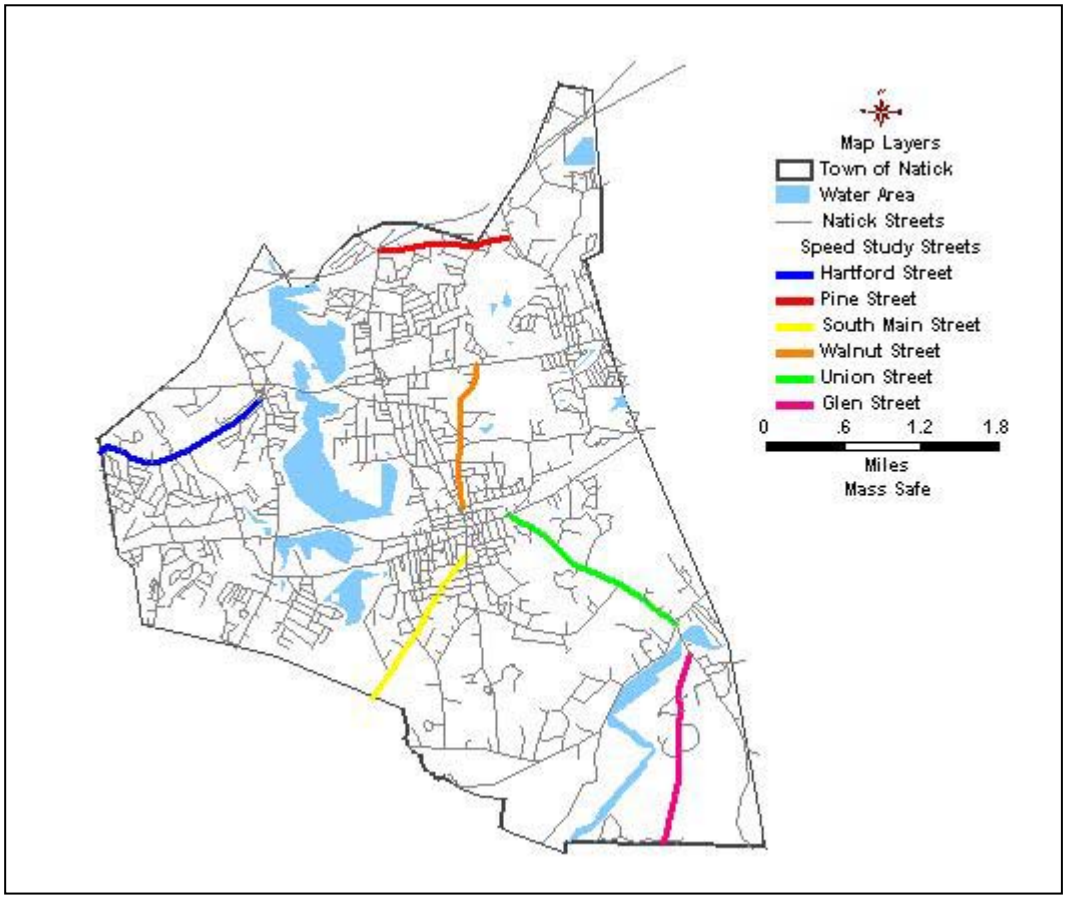

FIGURE 4-2 *Selected Roadways in the Town of Natick.*

4.2.2 Crash Data Analysis

The crash data for this review were provided by the Natick Police Records Department. A list of crashes on each of the six streets for the five-year period selected, 1998 to 2002, was extracted from their database.

The first task is to validate the data. The reports on these lists were filtered one by one, ensuring that the analyzed data are valid. Some of the dismissed reports were simply unavailable and others correspond to crashes located on neighboring streets not applying for the study. Once the obtained data were filtered, the crash analysis could be conducted.

4.2.2.1 Crash Rates

Crash rates were computed for each street. Crash rate computation consists of normalizing the crash data to facilitate its analysis and evaluation. The equation used to obtain crash rates accounts for the length of the street, the number of years analyzed, the number of crashes occurred during this time period on this street and the traffic volume of each street. Crash rates are expressed in terms of crashes per million vehicle miles and the equation to calculate them is the following:

$$R_{\text{sec}} = \frac{1,000,000 \times C}{365 \times T \times V \times L}$$

where

R_{sec}= crash rate for the section
C= number of reported crashes
T= time frame of the analysis
V= traffic flow, AADT (Annual Average Daily Traffic)
L= length of the section

Ideally, the time period of the volume data should match the time period of the crash data being analyzed. Five years of crash data were examined in this study, from 1998 to 2002 but, unfortunately, traffic volume data for all these years were not available.

The volume data used to compute crash rates were obtained from a conducted speed study. For Glen Street, Walnut Street, Pine Street and Union Street, traffic counts were completed on November 2002. For South Main Street and Hartford Street, the speed study was conducted later, with the volumes collected in April 2003. The length of time considered to compute traffic volumes was for all the cases 72 hours counted within weekdays, preferably between Tuesday and Friday to avoid weekend traffic. The crash rates for the six streets are presented in the table 4-3.

TABLE 4-3 *Crash Rates for the Six Streets Analyzed*

STREET	**Length** feet	**Length** miles	**Average Daily Traffic (ADT)** vehicles	**Number of Reported Crashes (1998-2002)**	**CRASH RATE** crashes per million vehicle miles
South Main Street	9200	1.74	8630	44	**1.60**
Glen Street	6888	1.30	3339	16	**2.01**
Walnut Street	6500	1.23	2685	33	**5.47**
Pine Street	5470	1.04	6049	18	**1.57**
Hartford Street	7437	1.41	13793	138	**3.89**
Union Street	8040	1.52	7361	52	**2.54**

Walnut Street was found the most critical roadway with a crash rate of 5.47. Hartford Street also showed a high crash rate with 3.89, and the rates for South Main Street and Pine Street were the lowest, 1.60 and 1.57 respectively.

4.2.2.2 Crash Data Classification

The crash reports obtained from the Natick Police Records Department were then examined in more detail. For each of the six streets, the reported crashes were classified individually in the following three ways: by location, by crash pattern, and by cause.

SOUTH MAIN STREET

The Natick Police Records database listed 89 crashes from 1998 to 2002 on South Main Street. The crash reports were checked one by one to ensure they were available and valid. After this preliminary selection, 44 out of the 89 were considered suitable and analyzed. The 45 dismissed reports included 19 that were unavailable.

During the five-year period analyzed the proportion of crashes involving personal injuries was 25 percent (11 out of 33) and no fatalities occurred. Table 4-4 and Figure 4-3 present these data.

TABLE 4-4 *Number of Crash Reports Analyzed on South Main Street*

	SOUTH MAIN STREET CRASH REPORTS 1998-2002		
year	Personal Injury	Property Damage	Total
1998	4	4	8
1999	3	7	10
2000	2	12	14
2001	0	7	7
2002	2	3	5
TOTAL	**11**	**33**	**44**

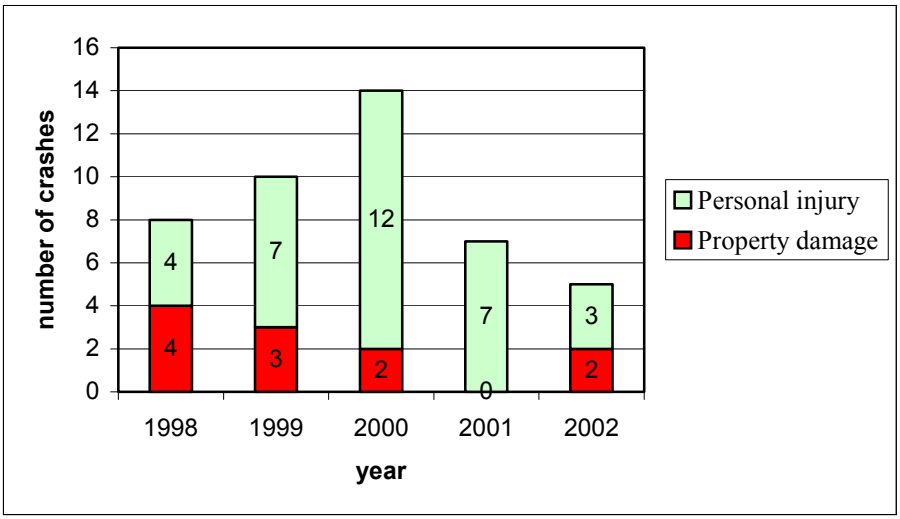

FIGURE 4-3 *Crash Count by year on South Main Street.*

An unusual situation was found in the South Main Street analysis that required consideration. On March 17, 2000, four crashes occurred at the same spot on the roadway, presenting the same pattern and probably for the same reason. They were head on crashes on a segment of South Main Street with apparently severe icy road surface conditions.

The first task was a location analysis. The results obtained on South Main Street indicated two high crash trend spots. The first site was located at the

intersection of Rockland Street and South Main Street, where 26 percent of analyzed crashes occurred. However, no personal injuries were reported at this spot. This intersection is situated at the top of a hill, which limits visibility. The second crash trend spot was found at the intersection with Circular Avenue and Curve Street, presenting 23 percent of all reported crashes and 45 percent of personal injuries that occurred during the five years studied.

The intersection with West Street on the south side, the intersection with Cottage Street on the north side, and the segment of South Main Street corresponding to numbers 95-100 showed minor proportion of crashes (14, 12, and 14 percent respectively), but a significant proportion of personal injuries. Figure 4-4 illustrates the results.

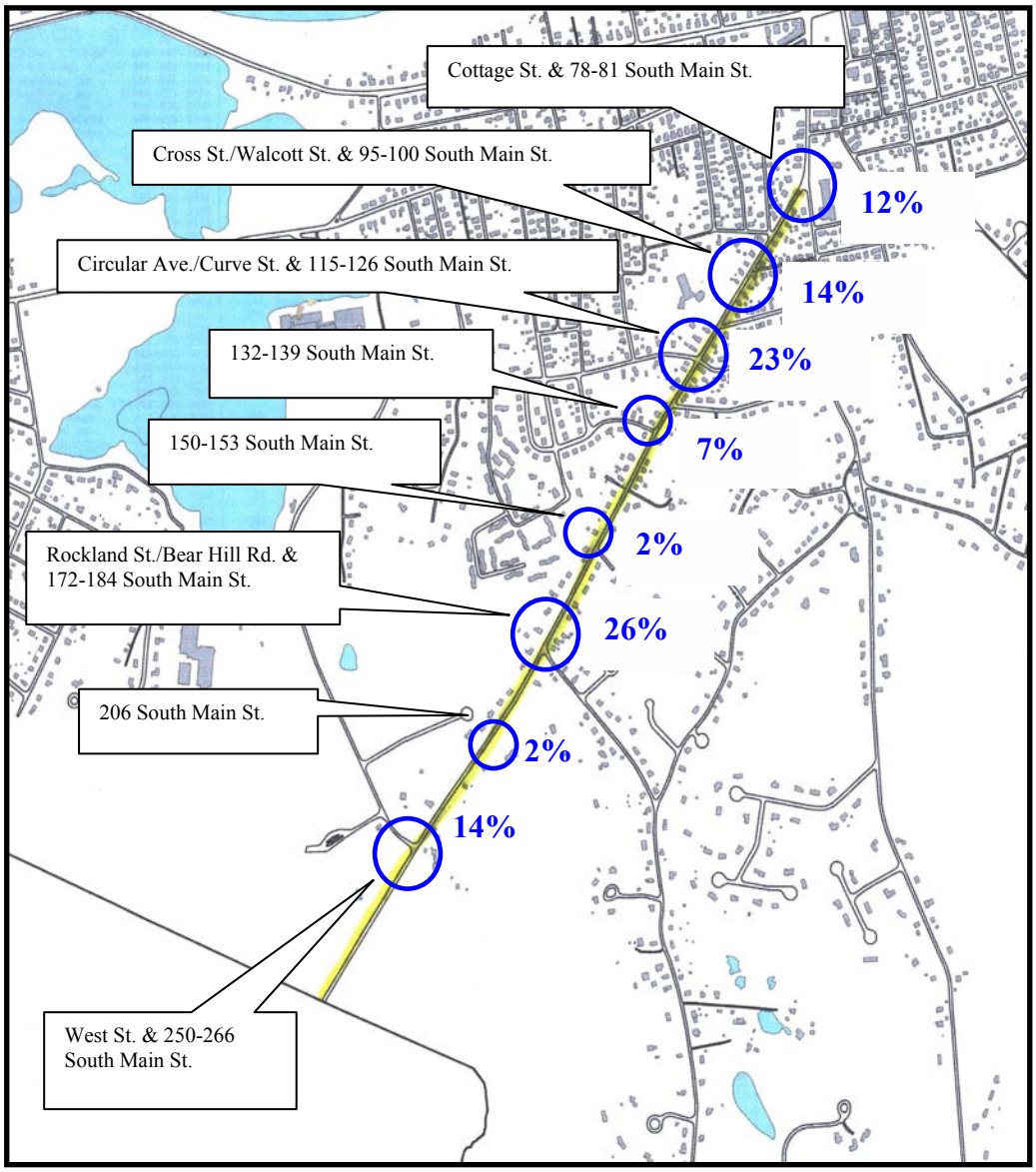

FIGURE 4-4 *Crash Data by Location on South Main Street.*

The second task was a crash pattern analysis. The results for this analysis showed almost equal proportion of crashes at intersections and on roadway sections. No crashes were reported out of the public roadway on South Main Street.

Angle crashes on intersections presented the highest proportion, corresponding to 44 percent of all reported crashes. Head on and rear end crashes on roadway sections accounted for 23 and 27 percent respectively. Rear end and head on crashes at intersections as well as angle crashes on roadway sections occurred in a minor proportion. Figure 4-5 shows the distribution of crashes by type of crash.

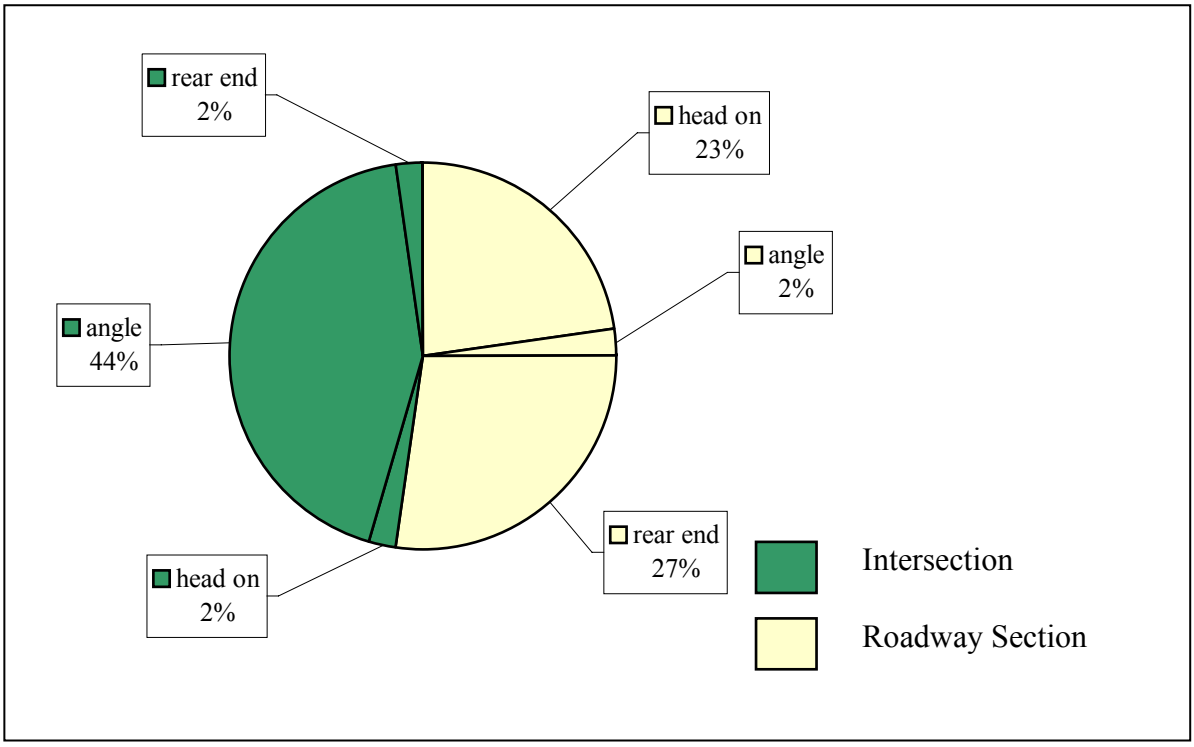

FIGURE 4-5 *Crash Data by Crash Pattern on South Main Street.*

The last analysis was by causation. On South Main Street, no crashes were found to report violation of lawful speed. However, considering unsafe-speed-related all situations where either failure to stop, vehicle conflicts due to speed issues or running off the roadway were reported, 64 percent of the total crashes may be affected by unsafe speeds. Vehicle conflicts such as failing to yield, misjudging speed or other issues that could be caused by speed variance, may account for 30 percent of the crashes and 35 percent of personal injuries.

Impaired driving was found the cause of only two percent of the total and improper maneuvers not related to speed, such as incorrect left turns, 18 percent. Other situations including icy road conditions or mechanical problems may have caused 16 percent.

GLEN STREET

The Natick Police Records database indicated 18 crashes occurred on Glen Street during the period between 1998 and 2002. In the preliminary selection, only one was unavailable and 16 were found valid and extracted to analyze.

None of the crashes reported fatalities and only one crash involved personal injuries, which represents six percent of the total. Table 4-2 and Figure 4-6 present the data examined.

TABLE 4-5 *Number of Crash Reports Analyzed on Glen Street*

	GLEN STREET CRASH REPORTS 1998-2002		
year	Personal Injury	Property Damage	Total
1998	1	3	4
1999	0	3	3
2000	0	2	2
2001	0	2	2
2002	0	5	5
TOTAL	**1**	**15**	**16**

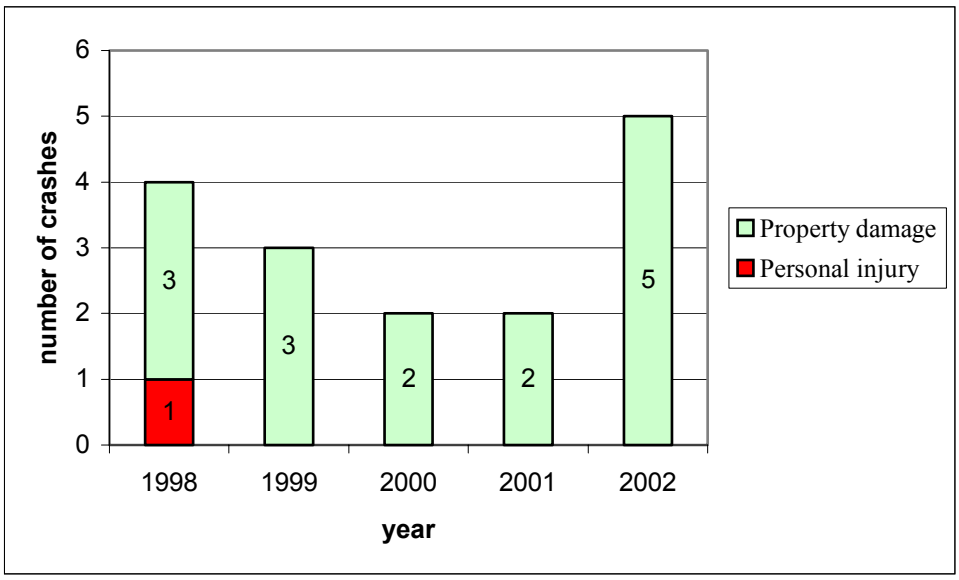

FIGURE 4-6 *Crash Count by year on Glen Street.*

The results obtained in the analysis by location on Glen Street did not show any conflictive spot along the street. The highest percentage was found at the intersection of Glen Street and Pleasant Street, corresponding to 22 percent of the total crashes analyzed. The intersection of Glen Street and Apple Ridge, on the south

of the street, represents 17 percent of the examined crashes, including the personal injury reported on 1998.

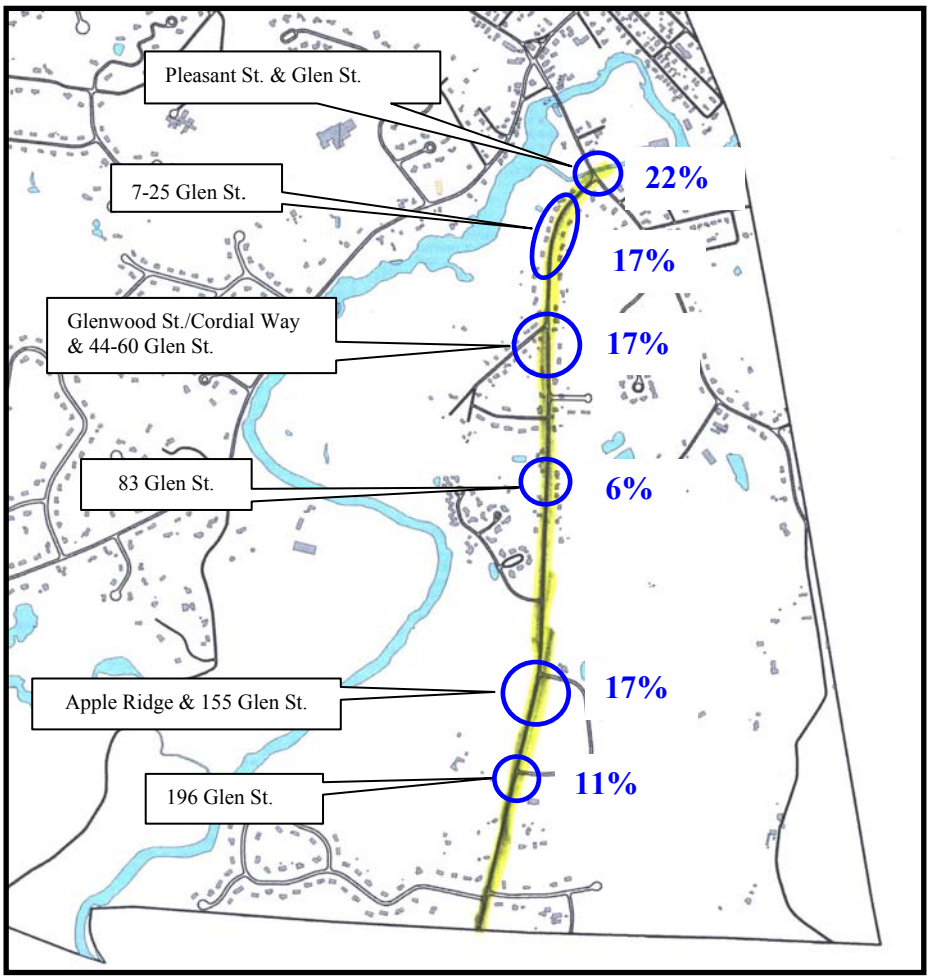

FIGURE 4-7 *Crash Data by Location on Glen Street.*

The results of the crash pattern analysis indicated a remarkable trend. Half of the reported crashes were found to be head on collisions on roadway sections being the most common case vehicles running off the roadway.

Rear end crashes on sections and angle crashes on sections and at intersections as well as crashes that occurred out of the public road, usually on private driveways, conformed the other half of the data. The results are presented in Figure 4-8.

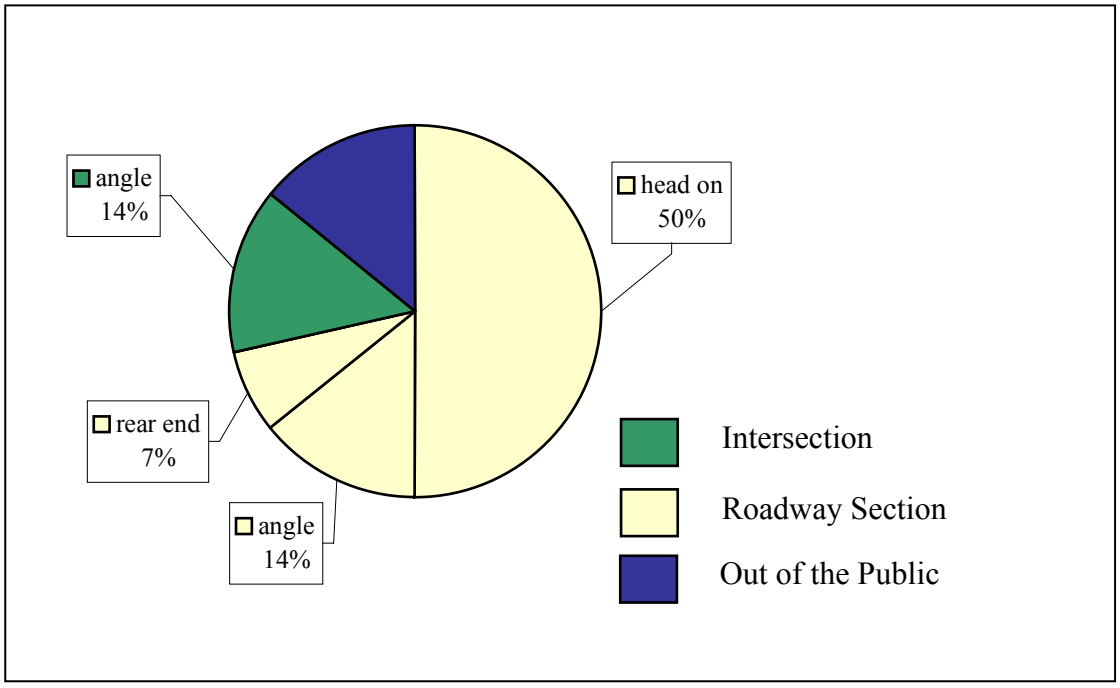

FIGURE 4-8 *Crash Data by Crash Pattern on Glen Street.*

In the causation analysis, no crashes reporting violation of lawful speed were found. However, inappropriate speed may be a contributing factor to some of the head on crashes occurred. Considering unsafe-speed-related all crashes reporting failure to stop, vehicle conflicts due to speed or running off the roadway, 36 percent of the crashes analyzed may be unsafe-speed-related. Particularly on Glen Street, the most common situation was found to be running off the roadway. However, icy road surface conditions may explain some of these crashes.

Impaired driving caused one crash, representing seven percent of the total analyzed, where the operator admitted to fall asleep on the wheel, and improper maneuvers such as backing up from driveway without caution on invading the opposite traffic lane accounted for 29 percent. The rest 29 percent was attributed to other causes such animals on the road or, as cited previously, icy road conditions.

WALNUT STREET

From 1998 to 2002, the total number of crashes on Walnut Street listed in the Natick Police Records database was 59. After a preliminary selection, 33 out of the 59 were pulled out and analyzed. The remaining 26 crashes include 17 unavailable and 9 unsuitable.

Out of the 33 reported crashes, four of them involved personal injuries, which corresponds to 12 percent, and none of them implied fatalities. Table 4-6 and Figure 4-9 illustrate these numbers.

TABLE 4-6 *Number of Crash Reports Analyzed on Walnut Street*

	WALNUT STREET CRASH REPORTS 1998-2002		
year	Personal Injury	Property Damage	Total
1998	1	7	8
1999	0	6	6
2000	1	6	7
2001	2	6	8
2002	0	4	4
TOTAL	**4**	**29**	**33**

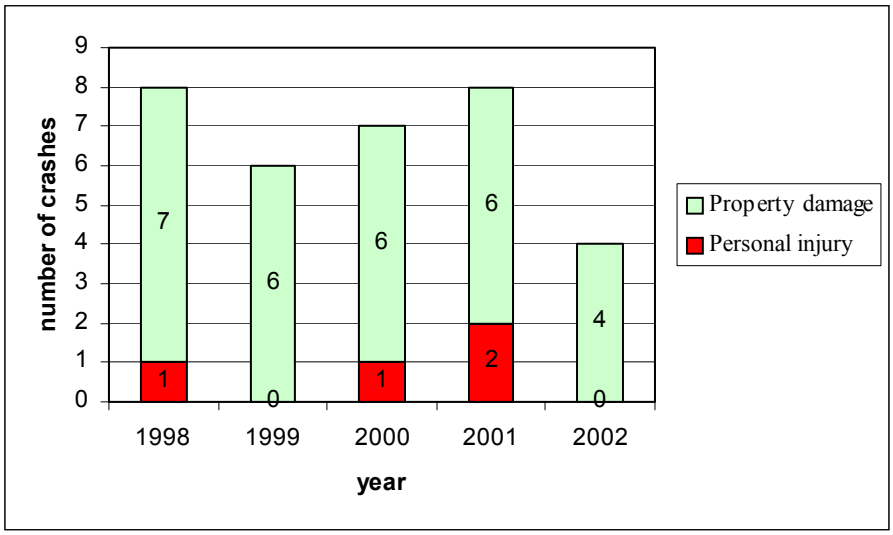

FIGURE 4-9 *Crash Count by year on Walnut Street.*

In the analysis by location, a high crash trend was identified at the intersection of Bacon Street and Walnut Street since the results obtained indicated that 45 percent of reported crashes occurred at this intersection. In addition to that, three out of the four personal injuries occurred during the five-year period analyzed took place at this spot. This intersection was definitely considered a dangerous spot on Walnut Street that needs to be further analyzed.

The intersection of Walnut Street and Shattuck Street presented 15 percent of all reported crashes and the intersection of Grove Street, Highland Street and Walnut accounted for 12 percent. Northbound, Walnut Street ends at a T-intersection with Worcester Street (Route 9) where 12 percent of all reported crashes took place.

While most of the crashes occurred at intersections, only three percent were situated on the curve roadway section. Figure 4-10 illustrates graphically the results obtained on Walnut Street.

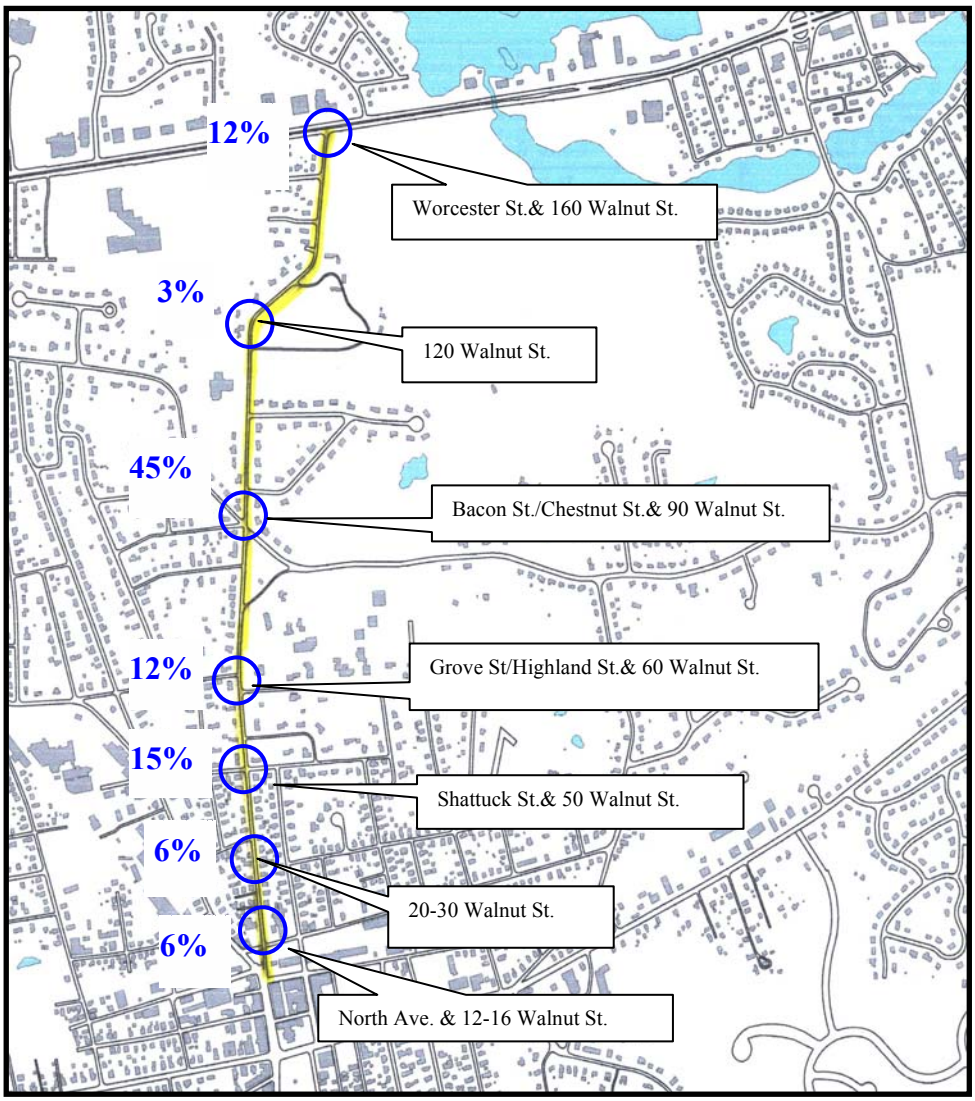

FIGURE 4-10 *Crash Data by Location on Walnut Street.*

In the analysis by crash pattern, Walnut Street showed significant results. More than 80 percent of all reported crashes occurred at intersections while only 15 percent were situated on roadway sections. Besides, 73 percent of the total were angle crashes at intersections and three out of the four personal injuries took place in crashes that presented this pattern.

Figure 4-11 shows the distribution of crashes by type of crash. Certainly, crashes at intersections represent the highest percentage of all.

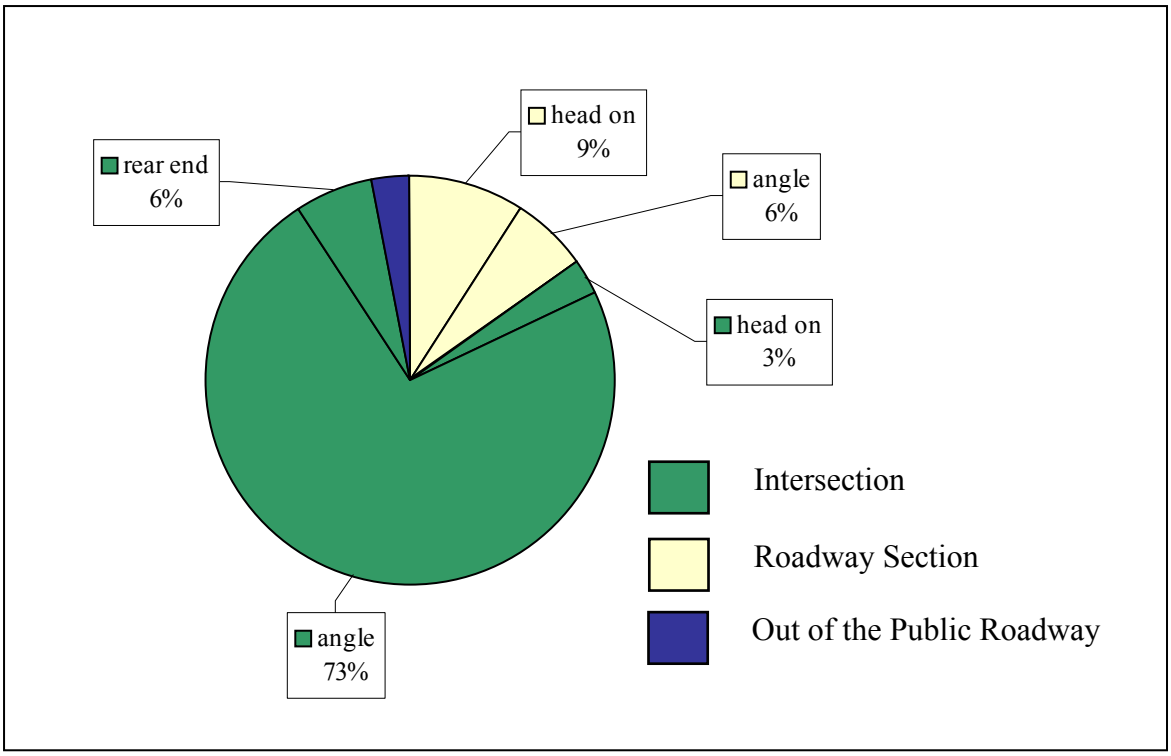

FIGURE 4-11 *Crash Data by Crash Pattern on Walnut Street.*

The third approach to analyze the crash data is by causation. On Walnut Street, from 1998 to 2002, no crashes reported violation of lawful speed. However, taking into consideration unsafe speed as an influencing factor on all crashes where the cause reported was failure to stop, vehicle conflicts due to speed issues or running off the roadway, 64 percent of all reported crashes on Walnut Street may be explained by unsafe speeds.

Improper maneuvers, such as incorrect left turns or driving on the wrong lane of the roadway, comprised 24 percent of all reported crashes during the five-year period of study. Impaired driving caused only nine percent of all crashes analyzed. However, half of all personal injuries occurred in crashes caused by operating under influence of alcohol.

PINE STREET

The Natick Police Records database shows 32 crash reports during the five-year period examined. After the preliminary selection, only 18 out of the 32 were selected to analyze. The other 14 reports were unavailable.

None of those crashes involved personal injuries or fatalities; the consequences reported were only property damage. Table 4-7 and Figure 4-12 present these data.

TABLE 4-7 *Number of Crash Reports Analyzed on Pine Street*

	PINE STREET CRASH REPORTS 1998-2002
year	Property damage
1998	2
1999	5
2000	5
2001	3
2002	3
TOTAL	**18**

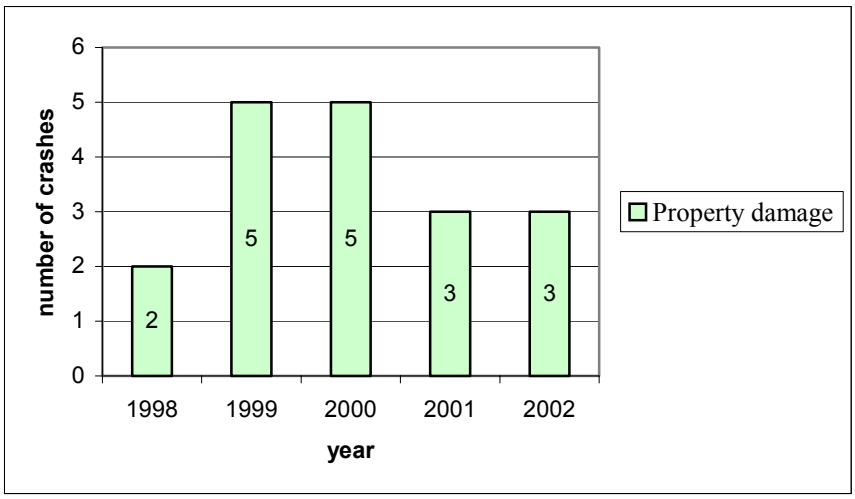

FIGURE 4-12 *Crash Count by year on Pine Street.*

In the crash analysis by location, Pine Street showed the highest crash trend at the two intersections that limit the street. Both have a T-geometry and vehicles traveling on Pine Street must yield the ongoing traffic when entering the intersection. The streets that delimit Pine Street are North Main Street on the west side and Oak Street on the East side.

From 1998 to 2002, 22 percent of reported crashes occurred at Pine Street with North Main Street and 33 percent at Pine Street with Oak Street. Another 22

percent took place on the roadway segment corresponding to the numbers 10-30 of Pine Street. Figure 4-13 illustrates graphically the results obtained on Pine Street.

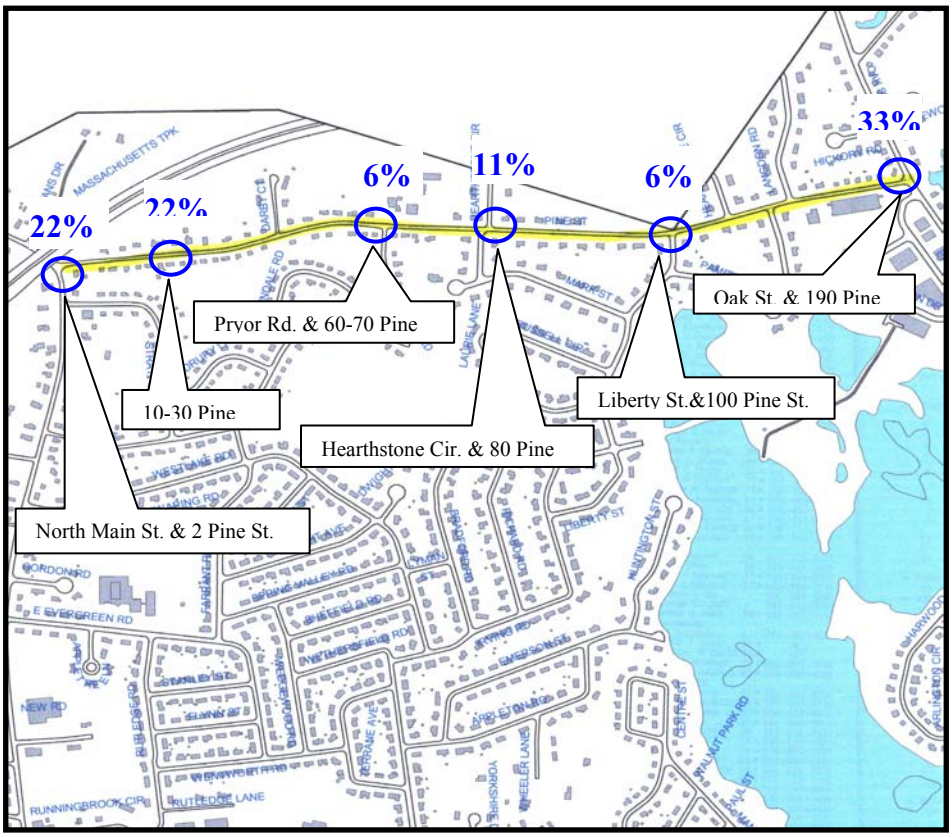

FIGURE 4-13 *Crash Data by Location on Pine Street.*

In the crash pattern analysis, the results for Pine Street showed that more than 60 percent of crashes occurred at intersections, almost 30 percent took place on roadway sections and the other ten percent out of the public roadway.

Rear end crashes and angle crashes at intersections occurred at a comparable percentage while angle crashes represented the highest proportion on roadway sections. Figure 4-14 shows the distribution of crashes by type of crash.

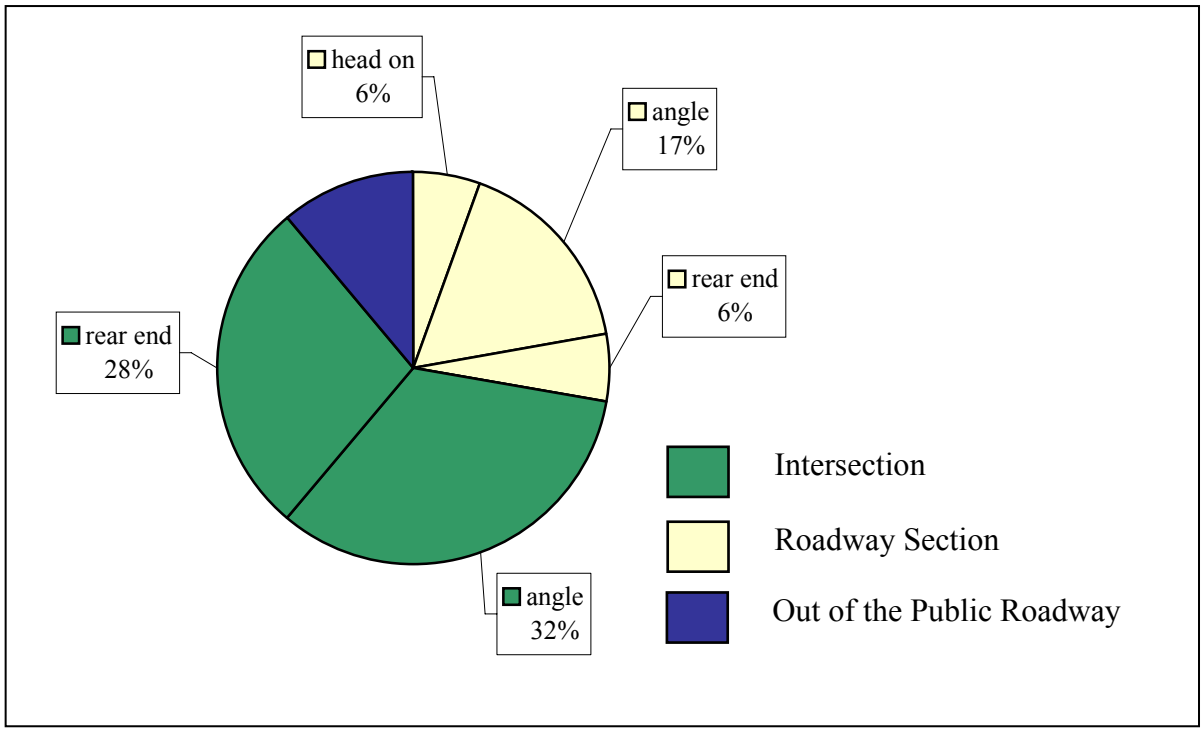

FIGURE 4-14 *Crash Data by Crash Pattern on Pine Street.*

In the analysis by causation on Pine Street, only one crash reported violation of lawful speed during the five-year period analyzed. However, considering unsafe speed as a contributing factor to crashes reporting problems to stop, vehicle conflicts explainable by speed or speed variance as well as running off the roadway, 67 percent of all reported crashes on Pine Street may be affected by unsafe speeds.

None of the reported crashes indicated impaired driving as a cause of the crash during the period time evaluated.

HARTFORD STREET

The Natick Police Records database listed 240 crash reports occurring on Hartford Street during the five-year period examined. After the preliminary selection, 138 were considered suitable and selected to analyze. This significant reduction was due to numerous crashes that reported Hartford Street as a landmark but indeed occurred on Speen Street or on the on-ramp to Worcester Road (Route 9). However, 45 crash reports were unavailable.

The proportion of crashes involving personal injuries was 17 percent, 24 out of the 138, and no fatalities occurred. Table 4-8 and Figure 4-15 present these data.

TABLE 4-8 *Number of Crash Reports Analyzed on Hartford Street*

	HARTFORD STREET CRASH REPORTS 1998-2002		
year	Personal Injury	Property Damage	Total
1998	6	19	25
1999	6	20	26
2000	3	26	29
2001	7	30	37
2002	2	19	21
TOTAL	**24**	**114**	**138**

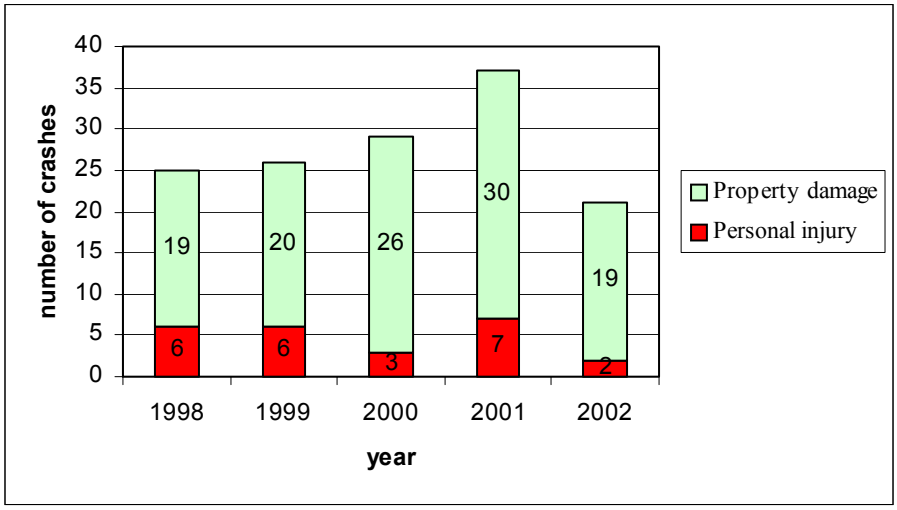

FIGURE 4-15 *Crash Count by year on Hartford Street.*

The results obtained in the analysis by location situated the highest crash trend spot at the intersection of Hartford Street with Boden Lane, where 27 percent of all reported crashes took place. Besides, 42 percent of personal injuries occurred in crashes at this location. This intersection is located on a curve section of the roadway with limited visibility.

The second conflictive point was the signalized T-intersection at Mill Street, accounting for 18 percent of all reported crashes and 17 percent of personal injuries. The next spot, presenting 15 percent of crashes and 13 percent of personal injuries, was found on one extreme of the roadway, at the intersection of Hartford Street with Speed Street.

The Hartford Street segment that includes the intersections with Cecil Road and with Barnesdale Road showed nine percent of reported crashes but 13 percent of personal injuries. Figure 4-16 shows graphically the results obtained on Hartford Street.

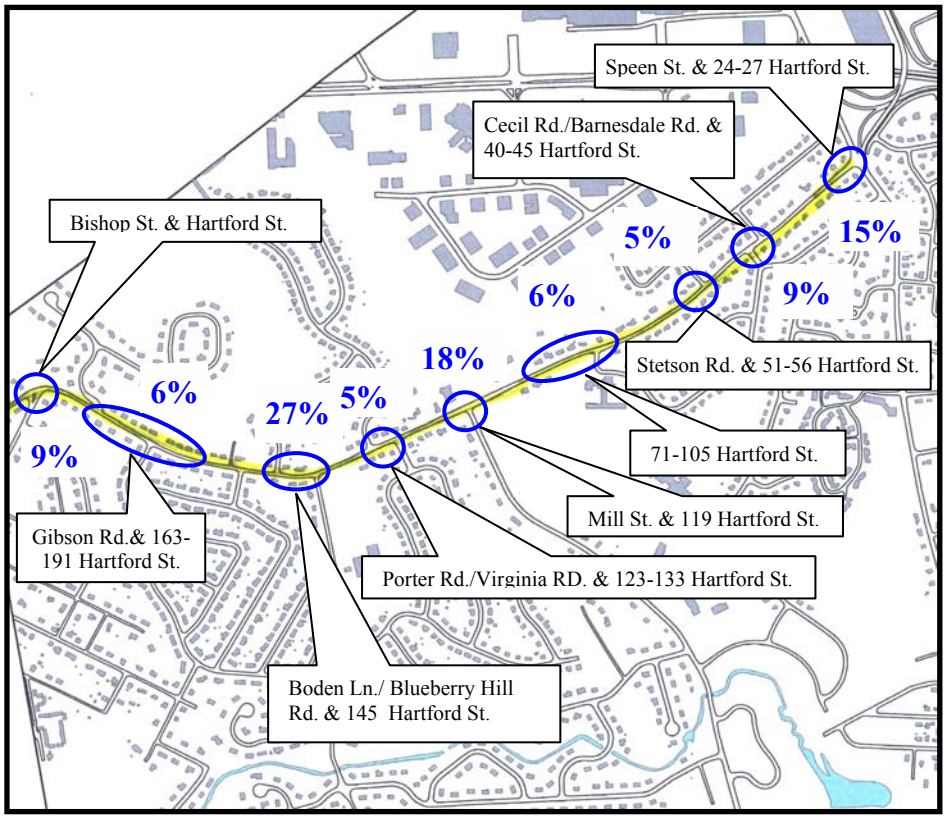

FIGURE 4-16 *Crash Data by Location on Hartford Street.*

Some interesting results were found when analyzing the data by crash pattern on Hartford Street. While on the other roadways intersections usually presented high proportion of crashes, on Hartford Street almost 60 percent of reported crashes occurred on roadway sections. Moreover, 70 percent of these were rear end crashes, which represented more than 40 percent of the total and accounted for almost 46 percent of all personal injuries. This result is almost certainly due to the congested traffic that Hartford Street experiences during peak hours.

Rear end crashes and angle crashes occurred at similar proportions at intersections, while head on crashes were minor. Figure 4-17 shows the distribution of crashes by type of crash.

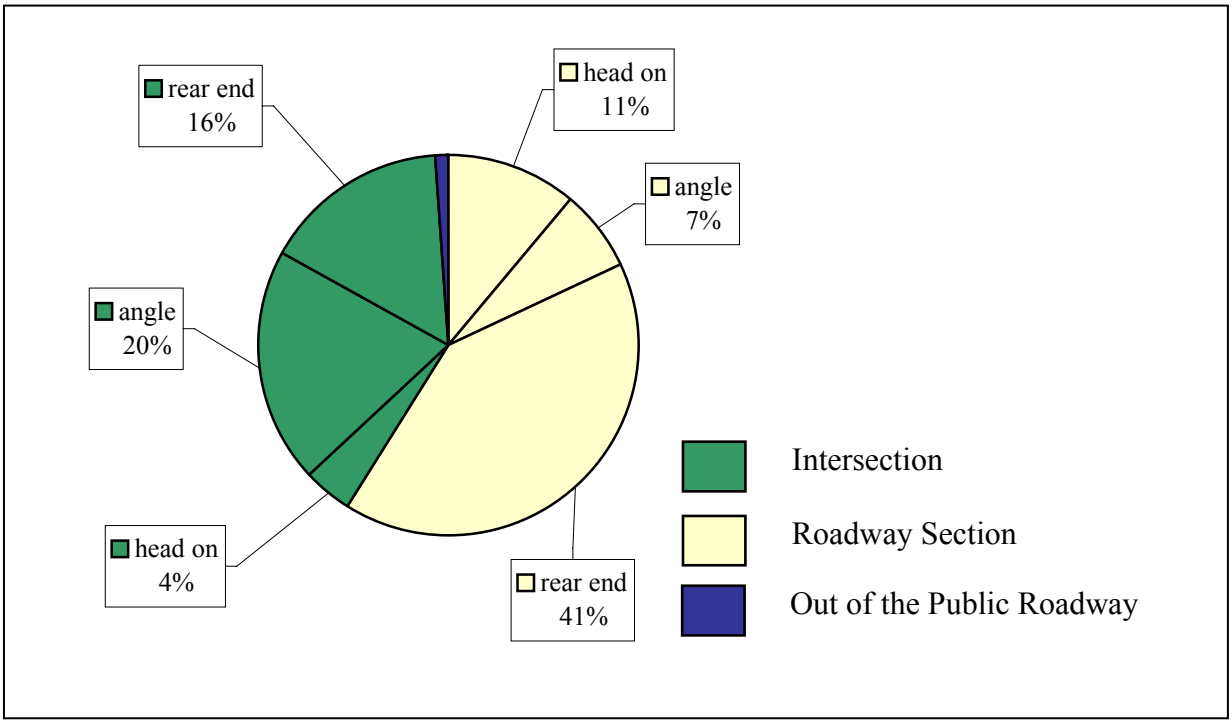

FIGURE 4-17 *Crash Data by Crash Pattern on Hartford Street.*

In the analysis by causation on Hartford Street, only two crash reports indicated violation of lawful speed as a cause of the crash. However, speed may affect more of them. Almost half of all reported crashes on Hartford Street from 1998 to 2002 reported some failure to stop, which was consistent with the amount of rear end crashes occurred. In addition, these crashes involved 60 percent of all personal injuries reported during this five-year period. The frequent heavy traffic on Hartford Street, that force vehicles to stop and go repetitively, may explain the significance of rear end crashes on this street.

Considering unsafe-speed-related all situations where either failure to stop, vehicle conflicts due to speed issues or running off the roadway were reported, 67 percent of the total were found to occurred under these conditions.

Impaired driving, which includes operating under alcohol influence or fatigue, was found to represent only one percent of the total. Improper maneuvers not involving speed issues could explain 20 percent of crashes and 12 percent was attributed to other causes such as icy road surface or mechanical problems.

UNION STREET

For Union Street, 96 crash reports were listed in the Natick Police Records database from 1998 to 2002. After the initial selection was conducted, 57 out of the 96 were found available and applicable to analyze. From the remaining 39, 10 were unsuitable and 29 were unavailable.

Only five out of the 57 reported crashes carried personal injuries, which represents a nine percent of the total. None of the reported crashes implied fatalities. Table 4-9 and Figure 4-18 present these data.

TABLE 4-9 *Number of Crash Reports Analyzed on Union Street*

	UNION STREET CRASH REPORTS 1998-2002		
year	Personal Injury	Property Damage	Total
1998	0	13	13
1999	2	8	10
2000	1	10	11
2001	0	8	8
2002	2	8	10
TOTAL	**5**	**47**	**52**

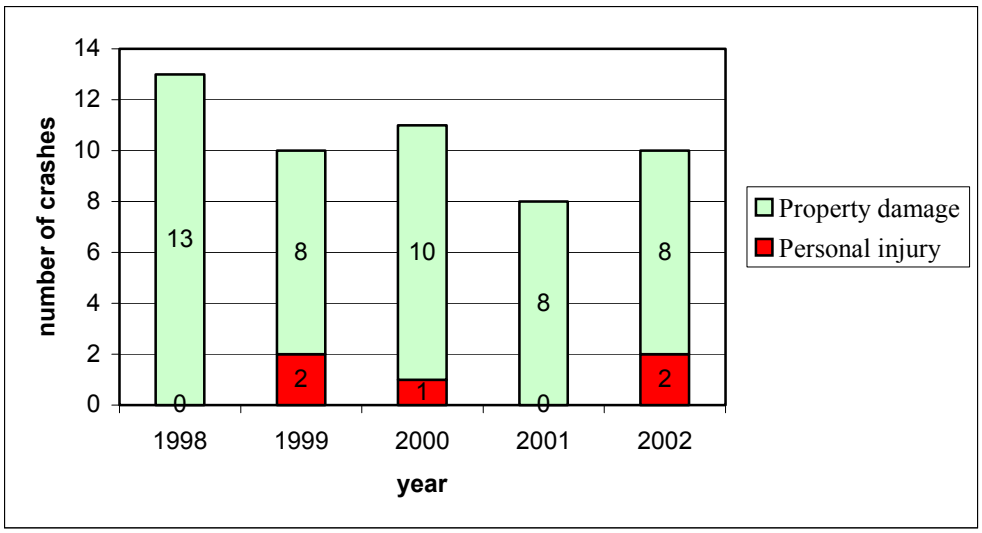

FIGURE 4-18 *Crash Count by year on Union Street.*

The first task was to analyze the reported crashes selected from the previous examination by location along the street. The results for Union Street show moderate spreading of crash trends.

The spot that presents the highest percentage of crashes was found at the intersection of Union Street with Woronoco Drive and the main entrance of the

Metrowest Medical Center. This intersection accounted for 23 percent of the reported crashes analyzed and, in addition to this number, six percent of the total were located on the parking lot of the Metrowest Medical Center.

The intersection of Union Street and East Central Street, northwest side, involved 17 percent of total reported crashes and the intersection of Union Street and Eliot Street, southeast side, 10 percent. Figure 4-19 illustrates graphically the results obtained on Union Street.

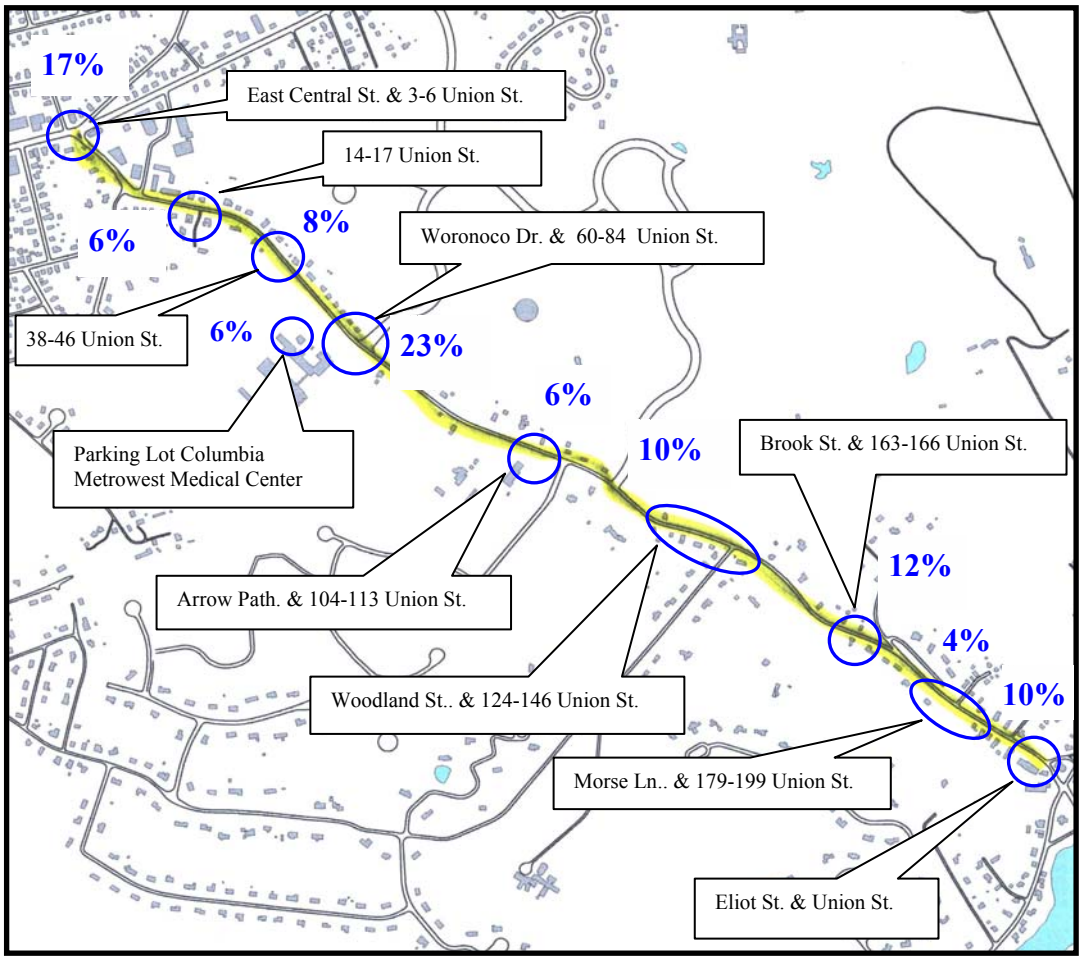

FIGURE 4-19 *Crash Data by Location on Union Street.*

The second analysis was by crash pattern. Union Street presented relatively well-distributed results. Half of reported crashes occurred at intersections, and these were primarily divided in rear end crashes and angle crashes, only two percent corresponded to head on crashes. The partition for crash types on roadway sections was also reasonable, head on crashes comprised the highest proportion and angle crashes the lowest. The results are illustrated in Figure 4-20.

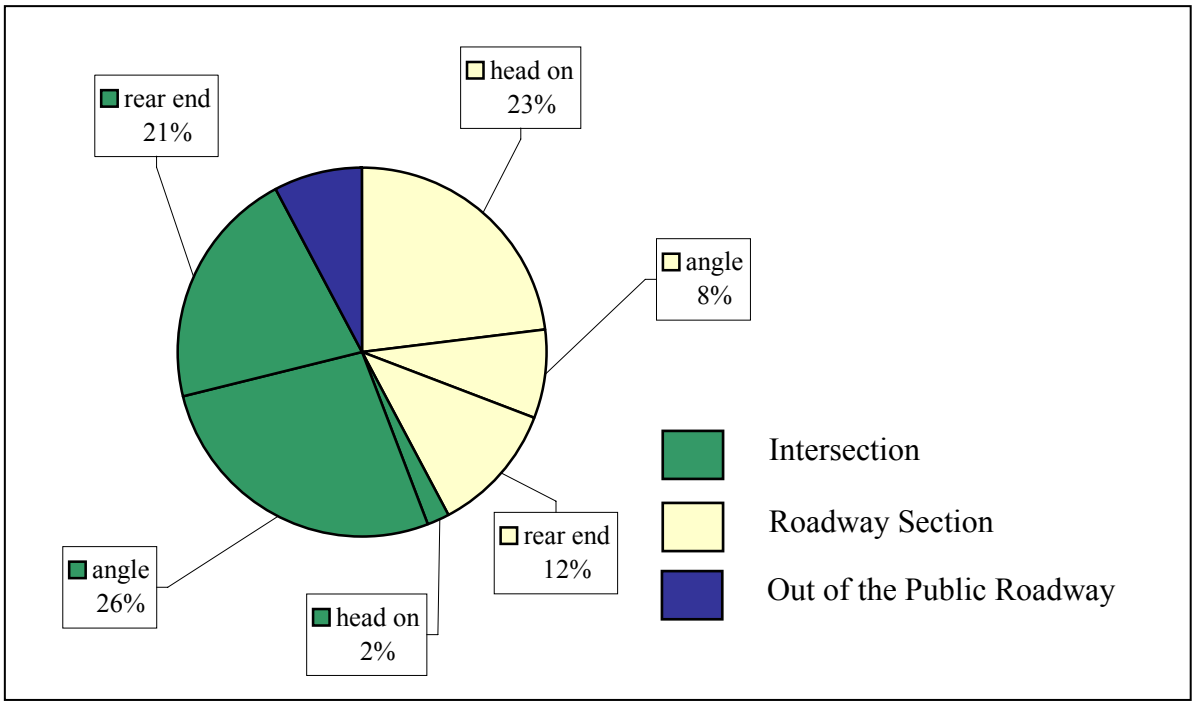

FIGURE 4-20 *Crash Data by Crash Pattern on Union Street.*

The last analysis was by causation. On Union Street, during the period analyzed, two crash reports indicated violation of lawful speed and only one reported driving under influence of liquor.

Considering unsafe-speed-related crashes that reported failing to stop or yield, vehicle conflicts as well as running off the roadway situations, 58 percent of all reported crashes on Union Street may be influenced by unsafe speeds. Besides, failure to stop was found the major cause involving half of those.

Improper maneuvers may have accounted for 23 percent of all reported crashes and one third of them were specifically caused by erroneous left turns.

Impaired driving was found to be the cause of only one of all reported crashes for the period of time analyzed, but it carried personal injuries.

4.3 FIELD REVIEW

4.3.1 Road Survey

The road survey of the six roadways was completed on May 2003. A field trip was conducted to review and document all the significant characteristics of the selected sites. All the major features and possible hazards were noted down and photographed. In addition, the roadways were videotaped while driving in both directions. Maps of the six roadways and the pictures taken during the field visit are included as Appendix B of this document.

The examined elements were broken down into four major areas including geometric design elements, traffic control devices, roadway activity, and environmental considerations. In this report, the relevant findings are presented for each of the six roadways.

SOUTH MAIN STREET

Geometric design elements

The speed limit on South Main Street was 30 mph although the operating speed was higher. The road alignment was found suitable for the operating speed as no dangerous curves or other hazards along the roadway were detected.

The amount of access points, such as driveways and intersections, was considerable but none of them was found particularly dangerous.

There was a vertical curve, with highest point close to Bear Hill Road, which presented visibility limitations. However, risky situations were not identified on this spot, as there were no nearby hazardous features. Picture S1 and S2 in Appendix B correspond to the vertical curve.

Lane width was typically 12 feet and one foot wide shoulders were provided all along South Main. Figure 4-21 shows a typical cross section of South Main Street.

FIGURE 4-21 *South Main Street Typical Cross Section.*

The typical cross section included granite curbing and sidewalks almost in the entire road segment. The sidewalk was only missed on the northbound side from West Street to Hunters Lane. Utility poles were situated on the southbound side from Cottage Street to Curve Street; from this point to the south, utility poles were placed on both sides. Some of them were located too close to the traveled way (see pictures S3, S4, and S8 in Appendix B).

The pavement was found in good condition as well as the granite curbing and the sidewalks.

Traffic Control Devices

South Main Street presented significant amount of signage. However, there were no traffic signals along the street. Signs were provided with breakaway supports as shown in picture S6 in Appendix B.

The existence of a school required specific signage. Flashing school zone signs indicating 20 mph speed limit during entering and exiting school hours and school zone warning signs were installed. Pictures S9 and S10 in Appendix B show school zone signage.

Although the speed limit was 30 mph and regulatory signs were posted indicating this limit, one regulatory speed limit sign showed 35 mph. The signage of South Main Street is presented in Figure 4-22.

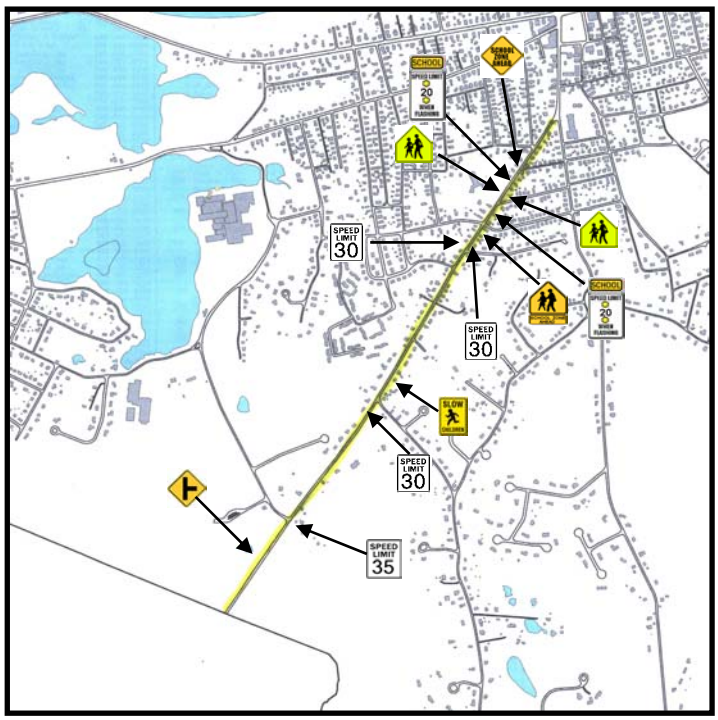

FIGURE 4-22 *South Main Street Signage.*

Longitudinal pavement markings included double solid yellow centerline and white edgelines all along the roadway and transversal markings included a satisfactory quantity of crosswalks. There were no additional delineators.

Roadway Activity

There were sidewalks on both sides in almost all the length of South Main Street and crosswalks were provided frequently. No separate facilities existed for cyclists.

A school situated between Curve Street and Floral Avenue required school zone warning signs and flashing school zone speed limits. An adequate number of crosswalks was identified in the vicinity of the school zone.

Parking was not allowed along South Main Street and public transport was frequent due to school buses activity.

Environmental Considerations

Natick is located in a severe winter region. Visibility was clearly reduced due to the accumulated snow on the roadside and the risk of icy road surface increased. Although sign visibility was found adequate during winter season, pavement markings became difficult to identify. Figure 4-23 shows a picture of South Main Street during winter months.

FIGURE 4-23 *South Main Street in Winter.*

GLEN STREET

Geometric design elements

Although the speed limit on Glen Street was 30 mph, the operating speed was considerable higher. Both vertical and horizontal alignments were found appropriate for the operating speed as the major part of the street presented a simple geometry, without vertical or horizontal curves.

Glen Street presented a small quantity of access points since there were not many driveways and intersections. None of them was found particularly hazardous.

The typical cross section included asphalt curbing and sidewalks only on the northbound side. Utility poles were also placed on the northbound side. Travel lanes typically measured 11 feet wide and shoulders less than one foot. One particularity of Glen Street was that the buildings were relatively separated from the traveled way. Besides, the houses were partially hidden by trees and plants, giving the perception that Glen Street was not a residential street. Figure 4-24 illustrated Glen Street cross section. The picture was taken heading south.

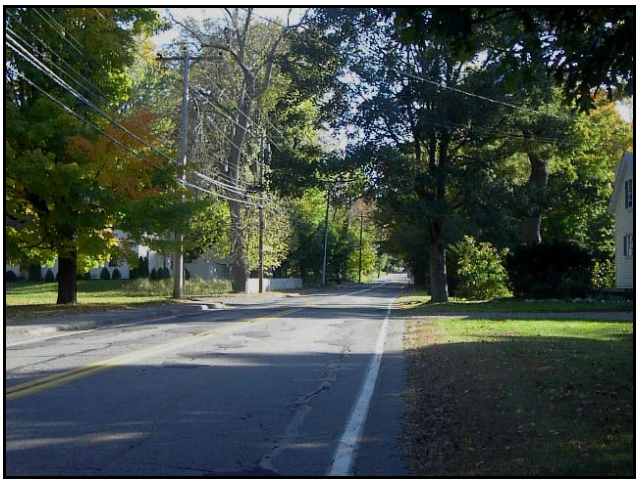

FIGURE 4-24 *Glen Street Typical Cross Section.*

The pavement was found deteriorated as a result of the inclement weather during the last winter, presenting roughness and numerous potholes. Picture G5 in Appendix B shows the current condition of pavement.

On the southbound side, a few trees situated in the clear zone were recognized as a possible hazard as well as a stonewall place near the Appleridge Drive intersection. Pictures G1 and G3 in Appendix B illustrate them.

Traffic Control Devices

Incongruence among regulatory speed limit signs was detected along Glen Street. Signs indicating 20 mph, 30 mph, and 35 mph as a speed limit were found on

a relatively short segment of roadway. Particularly, there were a 30 mph and a 35 mph speed limit signs situated just one opposite from the other.

The street did not contain traffic signals. A few children warning signs were found close to intersections. The signage of Glen Street is presented in Figure 4-25.

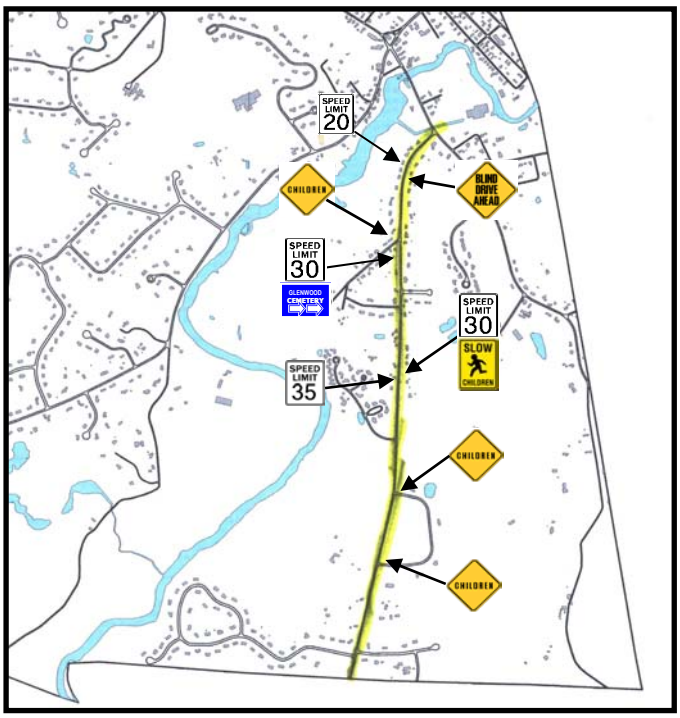

FIGURE 4-25 *Glen Street Signage.*

Pavement markings on Glen Street included double solid yellow centerline and white edgelines but due to the poor condition of the pavement, they were unclear.

Roadway Activity

Pedestrian activity on Glen Street was minor. Sidewalks were provided on the northbound side and not in the entire length of roadway. No crosswalks were found along the evaluated segment. No separate facilities for cyclists were identified.

Parking was not allowed and public transport and heavy vehicle activity were not significant.

Environmental Considerations

As cited for South Main Street, winter weather in Natick is severe. Snow and ice are factors that affect road safety conditions in a negative way. Particularly on Glen Street, road pavement was seriously damaged due to the inclement weather during last winter season.

WALNUT STREET

Geometric design elements

Two dangerous spots were identified along the geometry of Walnut Street. The intersection with Bacon Street which presented visibility issues and a severe curve located on the north side. The speed limit was established 30 mph, although on the curve and at the dangerous intersection there were warning signs and 20 mph advisory speed limit signs.

The intersection between Walnut Street and Bacon Street presented a hazardous layout. It operated as a two-way stop control intersection, being Walnut Street the right of way roadway. Figure 4-26 illustrates the intersection layout and the visibility issues.

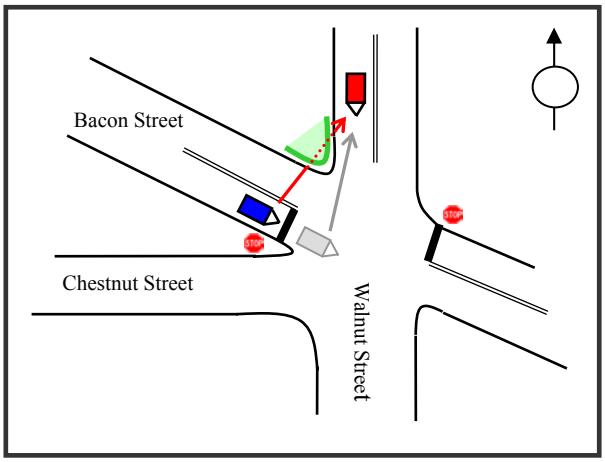

FIGURE 4-26 *Intersection of Walnut Street with Bacon Street.*

The acute angle between Bacon Street and Walnut Street and a fence obstructing the sight triangle reduced driver's visibility of conflicting vehicles, making the intersection a dangerous spot. Figure 4-26 shows graphically that the visibility is impeded at the stop bar, and vehicles need to move forward and stop again to view the conflicting traffic. Picture W14 in appendix B corresponds to this intersection.

The curve section was additionally delineated by chevron alignment markings and a wooden fence on the northbound side. A few safety issues were identified along this curved segment. Utility poles were placed in front of the fence and too close to the traveled way (see picture W9 in Appendix B) and a big tree was located in the clear zone on the southbound side exiting the curve (see picture W11 in Appendix B). However, because of the severity of the geometry, the curve seemed to be self regulated.

Granite curbing and sidewalks were provided almost all along Walnut Street. Only on the northbound side from Roundwood Road to Worcester Street sidewalks were missed. The curb measured approximately 0.6 feet wide and 0.5 feet high and the sidewalk width was four feet. Utility poles were placed on the southbound side

from Worcester Road to the curve, and on the northbound side on the rest of the street. A typical cross section is pictured in Figure 4-27. The picture was taken southbound near Shattuck Street.

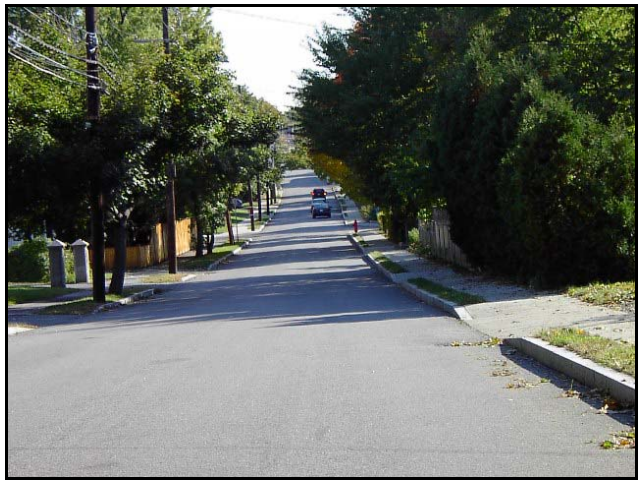

FIGURE 4-27 *Walnut Street Typical Cross Section.*

Travel lane width ranges between 10 feet and 12 feet. From the curve to Worcester Road (Route 9) the lanes are wider (11-12 feet) and on the south side, where no pavement markings were found, they become slightly narrow.

Traffic Control Devices

No traffic signals were installed on Walnut Street. There were no regulatory signs but frequent warning signs. Walnut Street signage is presented in Figure 4-28.

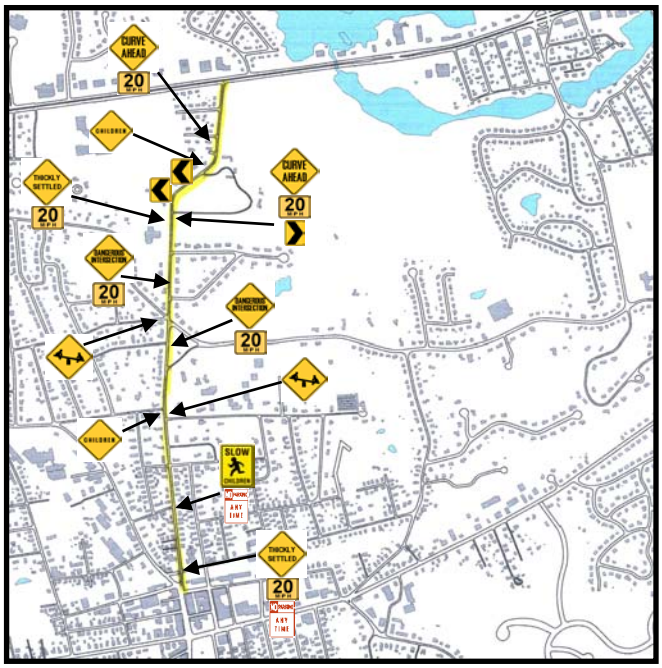

FIGURE 4-28 *Walnut Street Signage.*

Even tough the speed limit on Walnut Street was 30 mph, various advisory speed signs of 20 mph confused road users who believe the actual limit was 20 mph.

Three signs situated too close to the travel lane presented no breakaway support. Picture W18 in Appendix B shows one of this signs without breakaway support.

Longitudinal pavement markings along Walnut Street were found poor and irregular. There were no pavement marking at all from South Avenue to Bacon Street and only double solid yellow centerline from Bacon Street to Worcester Road (Route 9). Picture W1 and picture W17 in Appendix B show these situations.

Chevron alignment markings were provided on the curve as additional delineators. However, two of them were found hidden by plants on the southbound side, just before the curve to the left heading south. Picture W13 in Appendix B correspond to a chevron sign out of sight.

Roadway Activity

Pedestrian activity on Walnut Street was found moderate. Nice sidewalks, four feet wide and in good condition, were provided almost all along the street. An adequate number of pedestrian crossings were found along the street, mostly situated near intersections. A playground situated on the northbound side between Belvidere Street and Bacon Street presented warning signage to alert drivers. No separate facilities existed for cyclists.

Parking was restricted and heavy vehicle activity and public transport seemed very minor.

Environmental Considerations

Inclement weather and snow during winter months may increase risky situations. The visibility was reduced due to the accumulation of snow and the travel lane became narrower. A picture of Walnut Street in winter conditions is shown in Figure 4-29.

FIGURE 4-29 *Walnut Street in Winter.*

PINE STREET

Geometric design elements

Pine Street geometry did not present any hazardous features. The roadway was almost straight, and the only remarkable characteristic was a pronounced vertical curve with the lowest point situated approximately at Liberty Street.

The typical travel lane measured 10.2 feet and curbing and sidewalks were found at irregular intervals along the street.

From Main Street to Darby Court, asphalt curbing and sidewalks were provided on the eastbound side. Sidewalk width was four feet and curb height was 3.5 inches. A short road segment with granite curbing and sidewalk was found between Liberty Street and Pamela Road. A photograph of Pine Street cross section heading westbound is presented in Figure 4-30.

FIGURE 4-30 *Pine Street Typical Cross Section.*

Utility poles were located on the eastbound side, from Main Street to almost Pryor Road, then they were placed on the westbound side and later they moved back to the eastbound side, from Hearthstone Circle to the end of Pine Street.

The following hazardous features were identified on Pine Street: big rocks situated in the clear zone (see picture P5 and P6 in Appendix B), a breakaway support located immediately in front of a utility pole (see picture P9 in Appendix B), zones where the pavement was in bad conditions (see picture P10, P13, and P14 in Appendix B), a damaged fence in the clear zone (see picture P15), and an obstructed catch basin (see picture P16 in Appendix B).

Traffic Control Devices

Pine Street did not contain many signs and any traffic signals. There were thickly settled warning signs with 30 mph advisory speed limits signs, and regulatory signs for heavy vehicles. The signage of Pine Street is presented in Figure 4-31.

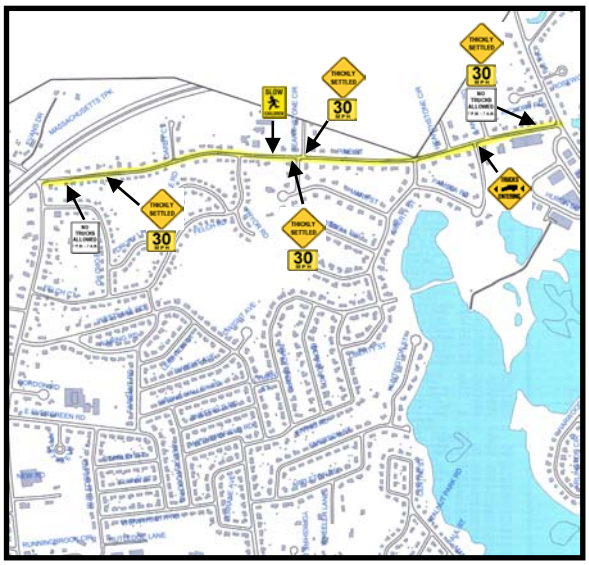

FIGURE 4-31 *Pine Street Signage.*

Longitudinal pavement markings on Pine Street included double solid yellow centerline and white edgelines.

Roadway Activity

Pine Street did not present much pedestrian activity. Sidewalk and crosswalks were difficult to find. The two segments provided with sidewalk were on the eastbound side, between Main Street and Darby Court and between Liberty Street and Pamela Road. No separate facilities existed for cyclists. Parking appeared to be permitted but heavy vehicle traffic was restricted during nighttime hours.

Environmental Considerations

The situation on Pine Street is similar to the previous streets evaluated. A picture of the previously cited vertical curve during the winter period is shown in Figure 4-32.

FIGURE 4-32 *Pine Street in Winter.*

HARTFORD STREET

Geometric design elements

Hartford Street geometry was characterized by a signalized intersection and a horizontal curve at Boden Lane with some visibility issues. A guardrail protecting the eastbound side of the curve and some chevron alignment marking delineated the curved segment. A crosswalk situated in the middle of the bent section and a couple of blind driveways made this curve a potential crash spot. Picture H11, H12 and H13 in Appendix B illustrate these issues.

Utility poles were situated approximately 4½ feet apart from the edge, on the westbound side from Cecil Road to the curve and on the eastbound side from the curve to the end of Hartford Street. Picture in Figure 4-33 illustrates Hartford Street typical cross section. The image was taken near Cecil Road heading westbound.

FIGURE 4-33 *Hartford Street Typical Cross Section.*

Travel lane width was 11½ feet and shoulders measured four feet from Speed Street to the curve and two and a half feet on the rest of the street. Nice sidewalks were provided almost all along Hartford Street complemented with granite curbing 0.5-0.6 feet high.

The T-intersection of Hartford Street and Mill Street was signalized. At this intersection, Hartford Street presented two lanes on the westbound approach; an exclusive left lane and a trough lane.

Some utility poles were placed too close to the traveled way as well as a big tree near Porter Road (see picture H14, H15 and H16 in Appendix B). A catch basin was found sunk in the pavement being a dangerous feature. A yellow big container placed on the catch basin prevented vehicles to drive trough it. Pictures H17 and H18 in Appendix B corresponded to the catch basin.

Traffic Control Devices

There was a traffic signal at the T-intersection of Hartford Street and Mill Street. The signal was found to operate correctly and was clearly visible to approaching motorists. Picture H6 in Appendix B shows the signalized intersection. Hartford Street signage is presented in Figure 4-34.

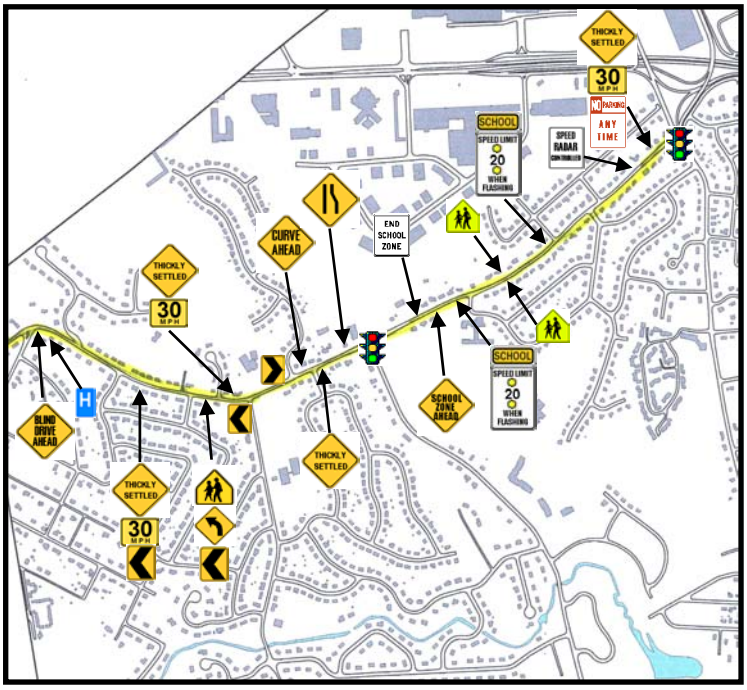

FIGURE 4-34 *Hartford Street Signage.*

The curved segment contained various warning signs alerting vehicles about the curve. Additionally, chevron alignment marking served as complementary delineators.

School zone signs, including pedestrian warning signs and flashing school zone speed limits, were provided near the school.

Pavement markings consisted of double solid yellow centerline, white edgelines four inches wide and various crosswalks approximately nine feet wide.

Roadway Activity

Pedestrian activity on Hartford Street was significant. Accordingly, sidewalks in good condition on both sides of the street and an adequate amount of crosswalks were provided. There were no separate facilities for cyclists.

Parking was not allowed on the entire street. A school bus stop safely located was identified near the school.

Environmental Considerations

The inclement weather experienced during winter months increase risky situations. Accumulations of snow narrowed the travel lane and reduced visibility. A picture of Hartford Street under that conditions is showed in Figure 4-35.

FIGURE 4-35 *Hartford Street in Winter.*

UNION STREET

Geometric design elements

A series of curves characterized the southeast section of Union Street. On this curve section, guardrails were installed to protect drivers from running off the road.

There was sidewalk all along the north-westbound side of Union Street with irregular intervals of granite curbing. Granite curbing was provided from Eliot Street to a point between Arrow Path and Woronoco Drive, and sidewalk without curbing was found along the remaining section. On the other side, sidewalk was provided only on the southeast part of the street, from Brook Street to the intersection with Eliot Street.

Utility poles were situated on the north-westbound side and some of them were placed too close to the traveled way. Picture U3 and U4 show utility poles in the clear zone.

Travel lanes were typically wider than 12 feet and approximately one foot wide shoulders were provided along the street. The pavement was found in bad condition. Figure 4-36 shows the Union Street cross section on the curve section.

FIGURE 4-36 *Union Street Typical Cross Section.*

Additionally, a few trees placed in front of a wooden fence on the south-eastbound side were found in the clear zone. Pictures U1 and U2 correspond to this location.

Traffic Control Devices

Union Street showed frequent warning signs but no regulatory signs. There were no traffic signals along the street but it started and ended at signalized intersections.

Curve warning signs were provided on the curve section. A flashing curve warning sign was installed on the south-eastbound side just before the curves began. As shown in picture U7 in Appendix B, the physical condition of these warning signs was poor.

Thickly settled warning signs posted together with 30 mph advisory speed limit signs were identified four times along Union Street. Figure 4-37 shows the street signage.

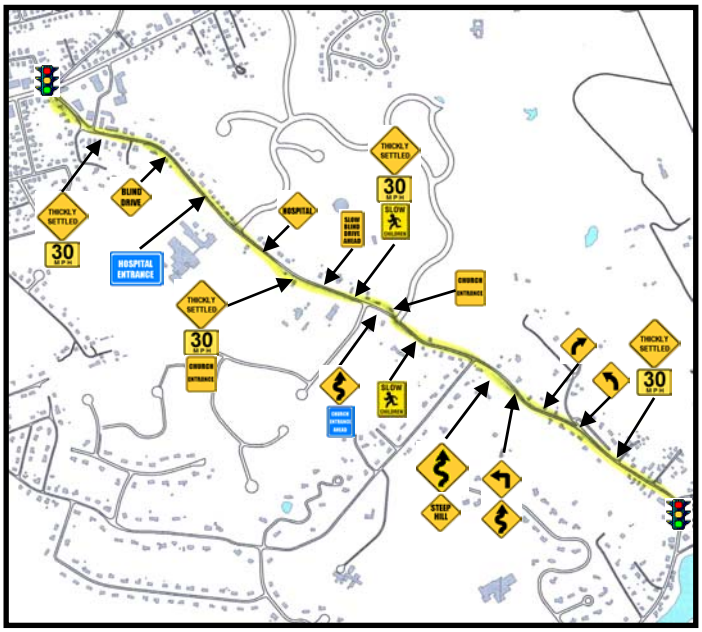

FIGURE 4- 37 *Union Street Signage.*

Double solid yellow centerline and white edgelines constituted the pavement markings. Even tough the existence of curves, no chevron alignment markings were provided. A few crosswalks, too sketchy, were provided near the churches and the hospital. Picture U8 in Appendix B shows a unclear crosswalk on Union Street.

Roadway Activity

Pedestrian activity on Union Street seemed to be moderate. Sidewalks were continuously provided on the north-westbound side and occasionally on the south-eastbound side. Crosswalks were identified near the churches and at the hospital entrance although they were found sketchy. Cyclists did not have separate facilities such as bike lanes.

Parking was not allowed and public transport and heavy vehicle activity were found low.

Environmental Considerations

As cited for the previous roadways, during winter season road conditions were poorer. The visibility was reduced, pavement markings became unclear, pavement quality decreased, and risky situations increased.

4.3.2 Checklists

During the road survey field trip, the road safety review checklists were completed for each of the six roadways. The checklist form used in the review is attached as Appendix A to this document. The completed checklists are not appended to this document because the written report contains sufficient explanation.

4.3.3 Speed Data

Speed studies were completed to determine the speed distribution of the traffic stream on the six roadways of the study. The data obtained from these studies were used to establish speed percentiles and speed variance, important factors to consider when making speed-related decisions.

4.3.3.1 Speed Data Collection

The speed studies were conducted using the pneumatic road tube method described in the previous chapter. The data were collected by road tubes placed across the road and connected to a traffic data recorder placed on the side of the roadway. The recorder used was the Trax I Counter/Classifier provided by JAMAR Technologies Inc.

The tube layout was consistent with that described in section 3.3.3.1 and picture in Figure 3-7. Four pneumatic tubes were needed in each layout which included two long tubes 60 feet long and two short tubes 40 feet long. The two long tubes were spaced eight feet along the road and the same distance was left between the short tubes. The short tubes were located six inches ahead of the long ones in the direction of traffic. This configuration ensured that vehicles crossing the lane with four tubes struck the short tubes first, providing lane separation in the data collection. A picture of the road tube layout is presented in Figure 4-39.

FIGURE 4-38 *Road Tube Layout.*

The speed data were collected in two sites on each street. The counters were numbered from one to 12 to identify the location. The location of the 12 counters, with two counters per street is presented in Figure 4-40.

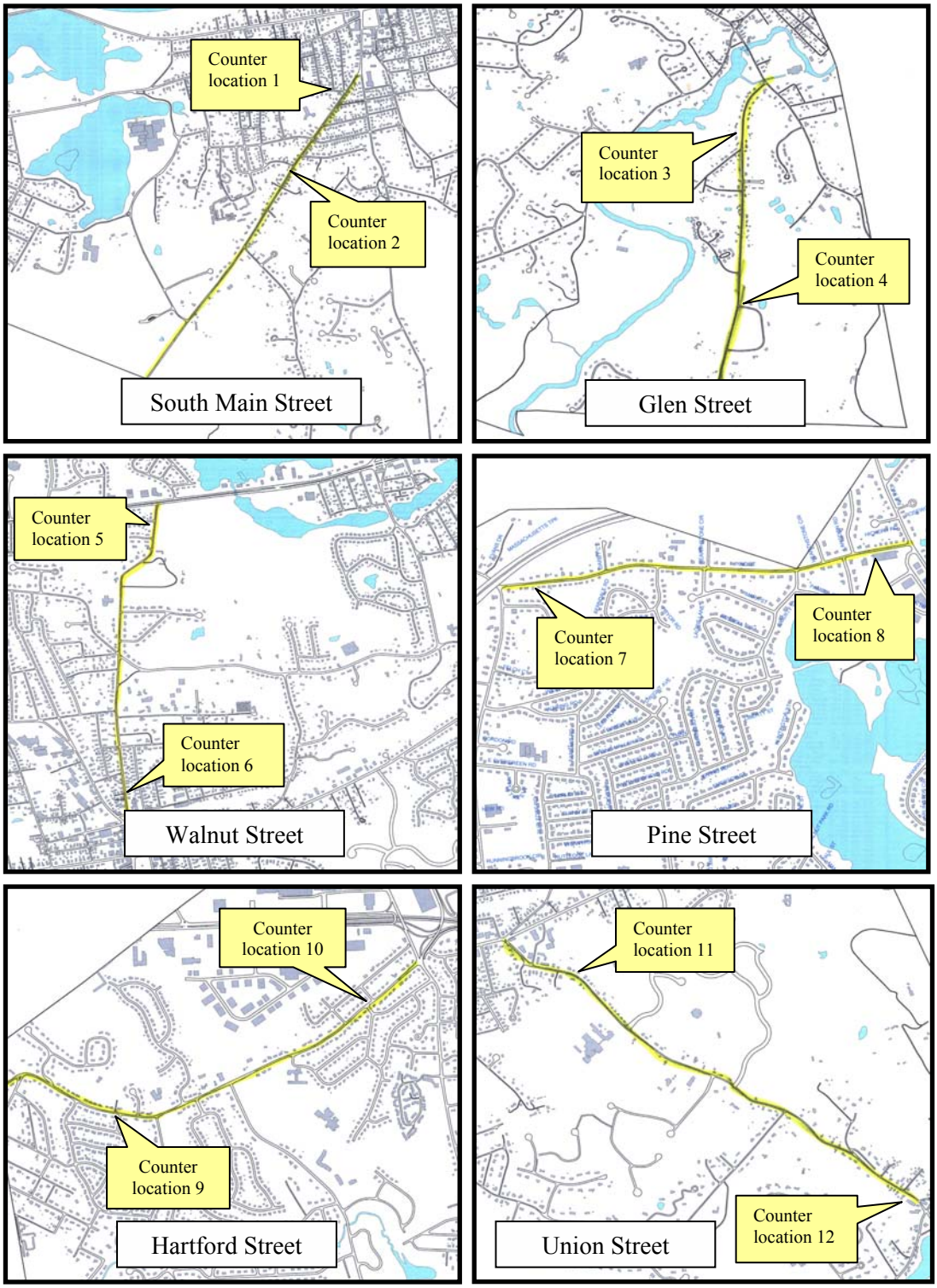

FIGURE 4-39 *Counter Locations on the Six Roadways.*

The collected data were downloaded and converted to an accessible Excel file using TRAXpro, which is a proprietary traffic data analysis software provided by

JAMAR Technologies Inc. The obtained data included traffic volumes, speeds, vehicle classifications, and gap. A sample of the data in Excel format is presented in Table 4-10.

TABLE 4-10 *Example of Obtained Data*

Veh. No.	Date	Time	Lane	Axles	Spec	Class	Length	Speed	Gap	Follow	Axle 1-2	Axle 2-3
1	4/15/2003	9:31:01 AM	2	2	2	2	97	23	1	405	97	
2	4/15/2003	9:31:03 AM	2	2	2	2	96	22	2	774	96	
3	4/15/2003	9:31:16 AM	1	3	12	4	312	24	16	6758	253	59
4	4/15/2003	9:31:25 AM	1	2	3	3	119	24	8	3379	119	
5	4/15/2003	9:31:25 AM	1	2	2	2	112	24	1	422	112	
6	4/15/2003	9:31:25 AM	1	2	2	2	118	31	1	546	118	
7	4/15/2003	9:33:02 AM	2	2	3	3	119	17	119	9999	119	
8	4/15/2003	9:33:06 AM	2	2	2	2	105	17	3	898	105	
9	4/15/2003	9:33:28 AM	2	2	3	3	119	16	22	6195	119	
10	4/15/2003	9:33:33 AM	2	2	2	2	111	18	4	1267	111	
11	4/15/2003	9:33:52 AM	1	2	3	3	122	21	144	9999	122	
12	4/15/2003	9:33:54 AM	1	2	3	3	120	21	1	370	120	
13	4/15/2003	9:33:57 AM	1	2	2	2	107	21	3	1109	107	
14	4/15/2003	9:34:09 AM	2	3	6	6	283	23	36	9999	229	54
15	4/15/2003	9:34:18 AM	2	2	2	2	107	30	8	4224	107	
16	4/15/2003	9:34:20 AM	2	2	3	3	130	29	3	1531	130	
17	4/15/2003	9:34:22 AM	1	2	2	2	108	25	25	9999	108	
18	4/15/2003	9:34:29 AM	2	2	2	2	102	25	8	3520	102	
19	4/15/2003	9:34:34 AM	1	2	3	3	137	18	11	3485	137	
20	4/15/2003	9:34:40 AM	1	2	3	3	120	28	5	2464	120	

The data appeared numbered in order of occurrence showing the date and exact time when the vehicle crossed the classifier setup. *Lane* is coded as 1 or 2 providing the direction of travel for the vehicle. Lane 1 refers to the lane covered by the two short tubes and the lane 2 refers to the lane covered by the long tubes.

Some characteristics of the vehicle could be identified. The *Axles* column gives the count of the number of axles on the vehicle. *Spec* refers to the axle specification used in Traxpro's classification of vehicles and *Class* refers to the vehicle classification based on the FHWA's classification system. JAMAR use 35 different specifications depending on the number and distance between axles and 13 classes of vehicles. The *length* column gives the length of a vehicle between the leading and trailing axles and is expressed in inches. The last columns in the table give detailed distances between axles for vehicles with more than two axles.

The other three columns refer to traffic stream characteristics. The *speed* column is the measured speed in miles per hour. *Gap* refers to the time interval (tail to nose) between one vehicle and its precedent in the same lane and is expressed in seconds. *Follow* refers to the space interval between one vehicle and its precedent in the same lane and is expressed in inches. This follow distance is the result of the speed multiplied by the gap.

4.3.3.1 Speed Data Analysis

The speed data analysis was conducted with data samples of 72 hours obtained from weekdays, preferably from Tuesday to Thursday. Among all the collected data, a valid data sample was selected for each of the 12 counters.

The first task in the analysis was to validate the samples. Since the data were collected by an automatic method, the free-flow speed was underestimated. The speed data were filtered excluding all the vehicles that indicated a gap of less than four seconds to eliminate from the sample possible situations without free-flowing conditions.

Using the statistical software Minitab, the filtered speed data were evaluated conducting a distribution analysis for the 12 samples. The output results from Minitab are attached to this document in the Appendix C.

Frequency distributions were presented by histograms. Histograms summarize graphically the distribution of the data set showing the number of vehicles observed for each speed group (one single speed value per group) and the shape of the distribution curve. The histograms for each of the 12 data sets could be found in Appendix C. The pace and the percentage of vehicles within the pace were extracted from the histograms.

The distribution analysis consists in fitting the normal distribution to the speed data sample, evaluating the goodness-of-fit of the distribution and estimating percentiles. Table 4-11 summarizes the results obtained from the analysis.

TABLE 4-11 *Results of the Distribution Analysis*[a]

		South Main Street		Glen Street		Walnut Street		Pine Street		Hartford Street		Union Street	
		Counter 1	Counter 2	Counter 3	Counter 4	Counter 5	Counter 6	Counter 7	Counter 8	Counter 9	Counter 10	Counter 11	Counter 12
Dispersion													
The average speed	**S**	33.51	37.72	34.90	39.89	32.14	28.72	36.57	32.05	34.97	33.18	33.47	32.56
The 85th percentile speed	P_{85}	37.90	42.52	39.46	44.60	36.72	33.67	41.69	36.28	39.35	37.87	37.52	36.97
The 95th percentile speed	P_{95}	40.47	45.34	42.14	47.36	39.41	36.58	44.70	39.75	41.92	40.62	39.91	39.55
The pace	**P**	29 - 39	33 - 43	30 - 40	35 – 45	27 - 37	24 - 34	32 - 42	27 - 37	30 - 40	28 - 38	28 - 38	28 - 38
Tendency													
The standard deviation	*s*	4.23	4.63	4.40	4.54	4.42	4.78	4.95	4.07	4.23	4.52	3.91	4.25
Percent vehicles within the pace	**p**	81.56%	78.84%	80.05%	80.43%	80.96%	74.15%	78.07%	83.61%	82.36%	81.37%	84.20%	81.13%

[a] speeds in miles per hour

The speed data were displayed in cumulative frequency curves to illustrate graphically the distribution. The data from the 12 counters were grouped by street adding together the data obtained from the two counters located on the same roadway. Separate cumulative frequency curves for each data set are attached in Appendix C. The resulting curves are presented simultaneously in Figure 4-41.

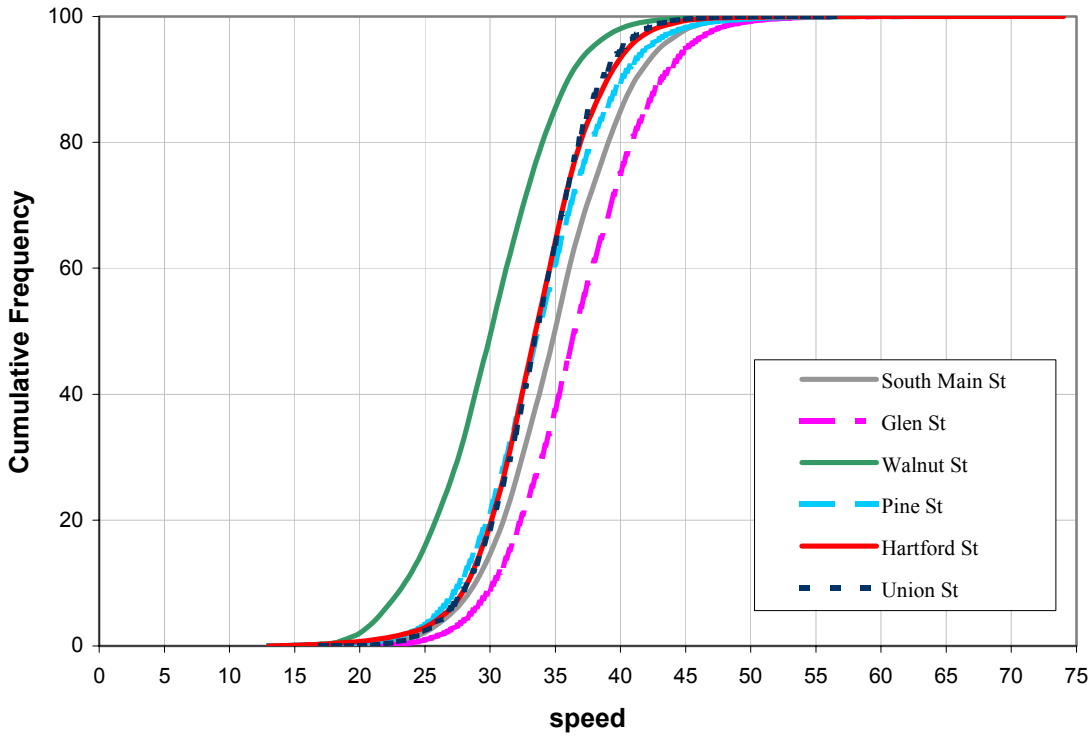

FIGURE 4-40 *Cumulative Frequency Distribution Curves.*

Figure 4-41 shows similar slopes among the six curves which corresponds to similar deviations among the speed distributions. The high percent of vehicles within the pace shown in Table 4-11 is consistent with the high slope of the curves in Figure 4-41.

The 85th percentile speeds range from 35 mph to 42 mph, higher than the speed limit for all six roadways.

4.4 FINAL REPORT

4.4.1 Summary of Procedure

The road safety review was completed on six roadways in the town of Natick, Massachusetts. The reviewed roadways were South Main Street, Glen Street, Walnut Street, Pine Street, Hartford Street, and Union Street. All of them were at least one mile long, located in residential areas classified as thickly settled by the Massachusetts General Law, and categorized as collectors. These roadways were unposted and governed by Massachusetts' prima facie speed limit law. The Massachusetts General Law specifies that exceeding 30 mph in a thickly settled zone shall be considered unreasonable and improper speed.

The road safety review process was conducted following the procedure specified in Chapter 3 of this document.

In the office review, a complete crash data analysis was completed for each of the six roadways. Five years of crash reports, from 1998 to 2002, were obtained from the Natick Police Records Department database and analyzed. Crash rates were computed for each street and the reported crashes were classified individually by location, by crash pattern, and by cause.

In the field review, a road survey was conducted for each of the six roadways. Various field trips, checklists, photographs and videotapes of the roadways were completed to review and document all the significant characteristics of the selected sites. In addition, speed studies were completed to determine the speed distribution of the traffic stream on the six roadways of the study.

A final report summarized the results obtained from the compiled data from the office and field reviews. Safety deficiencies were identified and recommendations were given.

4.4.2 Findings and Recommendations

TABLE 4-12 *Findings and Recommendations for South Main Street*

SOUTH MAIN STREET			
	OBSERVATION	**POSSIBLE COUNTERMEASURES**	**Level of risk**
1	Visibility limitations on the top of the vertical curve, at Rockland Street. High percentage of crashes at this spot, however not severe. South Main Street presented low crash rate.	Install warning signs to alert about the visibility limitations.	Medium
2	High percentage of crashes at the intersection with Circular Avenue and Curve Street. Visibility issues. South Main Street presented low crash rate	Install warning signs to alert about the intersection.	Medium
3	Utility poles in the clear zone.	Move the utility poles.	Medium
4	School zone.	Maintenance of the sidewalks and crosswalks during winter season.	Low
5	Operating speed higher than the speed limit. No high crash trend due to speeding. Road alignment suitable for the operating speed.	Revise speed limit.	Low

TABLE 4-13 *Findings and Recommendations for Glen Street*

GLEN STREET			
	OBSERVATION	**POSSIBLE COUNTERMEASURES**	**Level of risk**
1	Bad condition of pavement.	Repair pavement.	High
2	Inconsistence among regulatory speed limit signs. A 20 mph, 30 mph and 35 mph speed limit signs on a short segment of roadway.	Avoid incongruence. Use of advisory speed sign on curves.	High
3	Trees in the clear zone.	Move or remove the trees. Provide crash barriers as a shield.	Medium
4	Bad condition of the pavement markings.	Repaint pavement markings.	Medium
5	Stonewall in the clear zone.	Remove the wall. Provide crash barrier.	Low
6	Lack of sidewalks and crosswalks.	Provide sidewalks and crosswalks.	Low
7	Operating speed higher than the speed limit. No high crash trend due to speeding. Road alignment suitable for the operating speed.	Revise speed limit.	Low

TABLE 4-14 *Findings and Recommendations for Walnut Street*

WALNUT STREET			
	OBSERVATION	**POSSIBLE COUNTERMEASURES**	**Level of risk**
1	High crash trend at the intersection of Walnut Street and Bacon Street. Hazardous layout. Fence obstructing sight distance at the intersection. Walnut Street presented the highest crash rate.	Remove fence. Consider signalizing the intersection.	Intolerable
2	Large tree in the clear zone exiting the curve.	Move or remove the large tree. Provide crash barriers as a shield.	High
3	Chevron alignment markings hidden by plants.	Place chevron in a visible place. Improve maintenance of plants.	Medium
4	Utility poles in the clear zone in front of the fence.	Move the utility poles.	Medium
5	No breakaway support in three signs situated too close to the traveled way.	Provide breakaway supports.	Medium
6	Too many warning signs. The MUTCD advises that if used to excess, they lose effectiveness.	Reduce the number of warning signs. As an alternative use more visible crosswalks and traffic calming measures.	Low
7	Playground.	Maintenance of the sidewalks and crosswalks during winter season.	Low
8	Lack of pavement markings.	Paint pavement markings all along the street.	Low
9	Operating speed higher than the speed limit. No high crash trend due to speeding. Road alignment suitable for the operating speed except for the curved section.	Revise speed limit. Keep 20 mph advisory speed limit on the curved section of the roadway.	Low

TABLE 4-15 *Findings and Recommendations for Pine Street*

PINE STREET			
	OBSERVATION	**POSSIBLE COUNTERMEASURES**	**Level of risk**
1	Large rocks in the clear zone.	Remove these rocks.	Medium
2	Broken fence in the clear zone.	Remove broken fence.	Medium
3	Obstructed catch basin.	Clear catch basin.	Low
4	Zone with bad pavement.	Repair pavement.	Low
5	Lack of sidewalks and crosswalks.	Provide sidewalks and crosswalks.	Low
6	Operating speed higher than the speed limit. No high crash trend due to speeding. Road alignment suitable for the operating speed.	Revise speed limit.	Low

TABLE 4-16 *Findings and Recommendations for Hartford Street*

HARTFORD STREET			
	OBSERVATION	**POSSIBLE COUNTERMEASURES**	**Level of risk**
1	High percentage of crashes on the curve at the intersection of Hartford Street and Boden Lane. Hartford Street presented high crash rate.	Increase warning signs to alert about visibility problems. Consider signalizing the intersection.	High
2	High percent of rear end crashes due to large volumes of traffic, especially during peak hours. Hartford Street presented high crash rate.	Installing signs that notify motorist of the approaching area of congestion. Promote alternative roads to reduce the intensity of traffic. Discourage people from taking Hartford Street as a shortcut (e.g. traffic calming).	High
3	Blind crosswalk at the curve	Move crosswalk to a more visible site. Install a warning sign.	High
4	Blind driveway at the curve	Improve visibility considtion (e.g. trees obstructing sight). Provide warning signs.	High
5	Damaged catch basin	Repair catch basin.	Medium
6	Large tree in the clear zone	Move or remove the large tree. Provide crash barriers as a shield.	Medium
7	School zone.	Maintenance of the sidewalks and crosswalks during winter season.	Low
8	Operating speed higher than the speed limit. No high crash trend due to speeding. Road alignment suitable for the operating speed.	Revise speed limit.	Low

TABLE 4-17 *Findings and Recommendations for Union Street*

UNION STREET			
	OBSERVATION	POSSIBLE COUNTERMEASURES	Level of risk
1	High percentage of crashes at the intersection with Woronocco Drive and the main entrance of the Metrowest Medical center.	Improve signage. Consider signalizing the intersection.	Medium
2	Utility poles in the clear zone	Move the utility poles.	Medium
3	Trees in front of a wooden fence in the clear zone. The fence protects from a drop-off.	Move or remove the trees. Provide crash barriers as a shield. (e.g. move the fence in front of the trees)	Medium
4	Sketchy crosswalks, pavement lines are unclear	Repaint crosswalk lines. Consider other types more visible (e.g. zebra stripes).	Medium
5	Bad conditions of curve warning signage	Improve signage. Include some delineators (e.g. chevron alignment markings).	Low
6	Operating speed higher than the speed limit. No high crash trend due to speeding. Road alignment suitable for the operating speed.	Revise speed limit.	Low

4.4.3 Formal Statement

The roadways listed below have been reviewed following the procedure described in this document. The review has been carried out for the sole purpose of identifying any features that could be altered or removed to improve the safety of the roadway. The accompanied recommendations are put forward for consideration by the responsible authority.

Road safety reviewed roadways:

- South Main Street
- Glen Street
- Walnut Street
- Pine Street
- Hartford Street
- Union Street