An Evaluation of High-Visibility Crosswalk Treatment - Clearwater, Florida

REPORT NO. FHWA-RD-00-105 August 2001

U.S. Department of Transportation
Federal Highway Administration
Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

Pedestrian & Bicycle Safety

FOREWORD

The FHWA's Pedestrian and Bicycle Safety Research Program's overall goal is to increase pedestrian and bicycle safety and mobility. From better crosswalks, sidewalks and pedestrian technologies to growing educational and safety programs, the FHWA's Pedestrian and Bicycle Safety Research Program strives to pave the way for a more walkable future.

This study was part of a larger Federal Highway Administration research study investigating the effectiveness of innovative engineering treatments on pedestrian safety. Crosswalks are among the treatments used to help pedestrians cross streets safely, but sometimes merely marking a crosswalk is not enough. This study examined the effect of a novel overhead illuminated crosswalk sign and high-visibility ladder style crosswalk in Florida. It is hoped that readers also will review the reports documenting the results of the related pedestrian safety studies.

The results of this research will be useful to transportation engineers, planners, and safety professionals who are involved in improving pedestrian safety and mobility.

Michael F. Trentacoste
Director, Office of Safety Research
and Development

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3 Recipient's Catalog No.
FHWA-RD-00-105		

4. Title and Subtitle	5. Report Date
AN EVALUATION OF HIGH-VISIBILITY CROSSWALK TREATMENTS—CLEARWATER, FLORIDA	August 2001
	6. Performing Organization Code
7. Author(s) Marsha Nitzburg and Richard L. Knoblauch	8. Performing Organization Report No.
9. Performing Organization Name and Address Center for Applied Research, Inc. 10213 Forest Lake Drive Great Falls, VA 22066-3608	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTFH61-92-C-00138
12. Sponsoring Agency Name and Address Office of Safety R&D Federal Highway Administration 6300 Georgetown Pike McLean, VA 22101-2296	13. Type of Report and Period Covered Research Report July 1, 1996 - October 31, 1999 14. Sponsoring Agency Code

15. Supplementary Notes

Contracting Officer's Technical Representative (COTR): Carol Tan Esse
The prime contractor for this study was the University of North Carolina Highway Safety Research Center

16. Abstract

A novel overhead illuminated crosswalk sign and high-visibility ladder style crosswalk were evaluated in Clearwater, Florida. Using an experimental/control design, the effect of the novel treatments on driver and pedestrian behavior was determined. A significant 30 percent to 40 percent increase in daytime driver yielding behavior was found. A smaller (8 percent) and statistically insignificant increase in nighttime driver yielding behavior was observed. A large (35 percent) increase in crosswalk usage by pedestrians was noted along with no change in pedestrian overconfidence, running, or conflicts. It was concluded that the high-visibility crosswalk treatments had a positive effect on pedestrian and driver behavior on the relatively narrow low-speed crossings that were studied. Additional work is needed to determine if they will also have a desirable effect on wider, higher-speed roadways.

17. Key Words	18. Distribution Statement
Pedestrians, safety, crosswalks, high-visibility crosswalks	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19 Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	19	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

TABLE OF CONTENTS

Page

LIST OF FIGURES AND TABLES

OVERVIEW

This research was conducted by the Center for Applied Research, Inc., as part of a subcontract from The University of North Carolina Highway Safety Research Center. Task Order 11, Evaluation of Pedestrian Facilities, was part of Federal Highway Administration research project DTFH61-92-C-00138, Pedestrian and Bicyclist Safety - Administrative and Technical Support.

OBJECTIVES

The overall objective was to evaluate the effect of a novel illuminated overhead crosswalk sign and high-visibility ladder style crosswalk markings on driver and pedestrian behavior at nonsignalized intersections in Clearwater, Florida. One aspect of the field data collection effort was to determine if pedestrians were more likely to cross where there was an illuminated overhead crosswalk sign and ladder crosswalk markings. A second aspect of the study was to determine if drivers would yield more often to pedestrians using this novel pedestrian facility. A third aspect of the study was to determine if pedestrians use more, less, or the same amount of caution as well as whether they cross more aggressively, forcing drivers to yield. Nighttime observation sessions were conducted in order to better evaluate the effectiveness of the illuminated overhead crosswalk sign.

METHOD

Experimental Sites

Four crossing locations near the Gulf of Mexico beach in Clearwater, Florida, were evaluated. Because the installation of the treatments was already completed, a before and after evaluation was not possible. Therefore, an experimental and control evaluation procedure was used. The two experimental sites had illuminated overhead crosswalk signs and high-visibility ladder crosswalk markings. In addition, standard crossing signs (MUTCD W11A) were located at the crossings. Both experimental sites were nonsignalized “T” intersections located on a low-speed major arterial used for beach traffic. The treatments were installed because local business owners felt that pedestrians needed help in crossing the street. There was no pedestrian crash problem at either location. The total cost of each installation was $15,000, including materials and labor, considerably less than a traffic signal. One of the control locations was a mid-block crossing with two standard parallel crosswalk markings. It was located on the same arterial about 0.8 km (0.5 mi) south of the experimental sites. Standard crossing signs (MUTCD W11and W11A) were located in advance of and at the mid-block crossing. The second control site was a four-leg nonsignalized intersection with no marked crosswalks with no advance warning signs. It was located on another low-speed major arterial, one block east of the experimental sites.

Site 1: S. Gulfview Boulevard at 3rd Street—Experimental
Site 3: S. Gulfview Boulevard at 5th Street—Experimental

The experimental sites located at S. Gulfview Boulevard at 3rd Street and S. Gulfview Boulevard at 5th Street were within 244 m (800 ft) of each other. They were nearly identical in design characteristics and use. Both sites were stop-controlled "T" intersections. South Gulfview Boulevard was a north/south major arterial through street with a posted speed limit of 40 km/h (25 mi/h). There was one southbound exclusive left-turn lane at the intersections. Just north of the sites there was metered, restricted RV and motorcycle parking in the southbound direction. The stop-controlled cross streets, 3rd Street and 5th Street, were two way roadways with a posted speed limit of 40 km/h (25 mi/h).

Pedestrian facilities installed at the south legs of S. Gulfview Boulevard included 2.4-m- (8-ft-) wide, high-visibility ladder crosswalks and pedestrian refuge islands measuring 1.5 m (5 ft). At both sites, the refuge island was perpendicular to the crosswalk markings. Three crossing signs (MUTCD W11A-2) were located on both sides of the roadway and on the refuge islands. In addition, a novel internally illuminated overhead crosswalk sign was suspended directly over the crosswalks in the middle of the intersections. The rectangular signs were bright yellow with bold black letters that said "CROSSWALK." At night, two large lamps shined onto the crosswalk markings and onto pedestrians crossing the roadway. Sidewalks were installed on both sides of the street. Except for sidewalks there were no pedestrian facilities on the stop controlled north legs of the intersections, and the crossings were unmarked.

Both experimental sites were in the heart of a beach community and resort area where pedestrians traveled to the beach on the Gulf of Mexico. Numerous motels, restaurants, and shops were located on the east side of the street; parking lots and the beach were to the west. Pedestrian and vehicular traffic was nearly continual all day until about midnight. Figure 1 shows the experimental overhead crosswalk sign and crosswalk markings during daylight. Figure 2 shows the illuminated crosswalk sign and downward facing lamps at night.

Site 2: Coronado Drive at 3rd Street—Control

The intersection of Coronado Drive and 3rd Street was one of two control sites. Site 2 was located one block east of the experimental sites and was a four-leg intersection that was stop-controlled on 3rd Street. A pedestrian bench and bus stop were located on the northeast side of the intersection. There were no other pedestrian facilities (except for sidewalks) at this location, and the crosswalks were unmarked.

Figure 1. Experimental Site—Daylight, Gulf-
view Boulevard at 5th Street, Looking South.

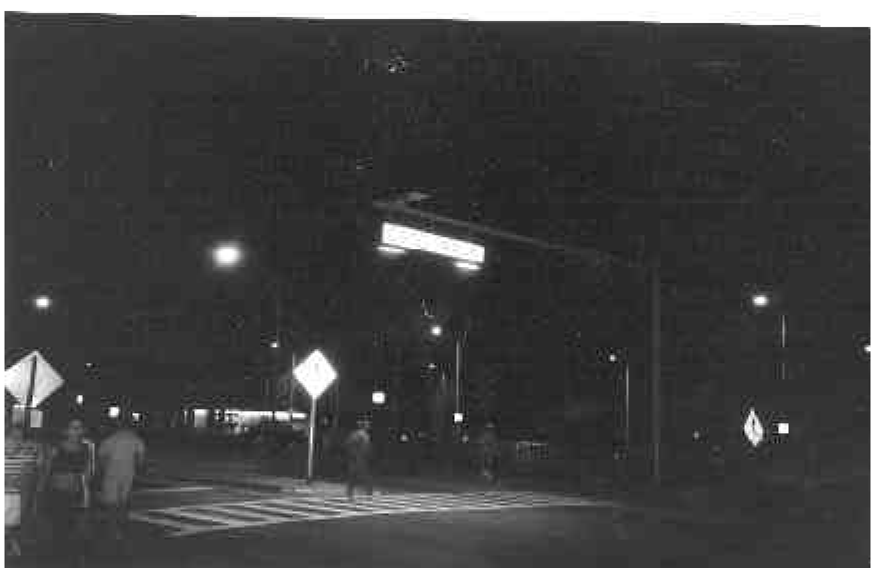

Figure 2. Experimental Site—at Night,
Gulfview Boulevard at 3rd Street, Looking South.

Coronado Drive was a north/south arterial through street with one lane in each direction, no turn lanes, no refuge island, and a posted speed limit of 40 km/h (25 mi/h). The stop-controlled cross street, 3rd Street, was a two-way road with one lane in each direction. Parking was not permitted on any of the four legs of the intersection. Numerous motels and restaurants and some private cottages were located nearby. Pedestrian and vehicular traffic was nearly continual all day until midnight and was beach and vacation oriented. Control Site 2 is shown in Figure 3.

Site 4: S. Gulfview Boulevard - Control

The other control site was a mid-block marked crosswalk location on S. Gulfview Boulevard about 0.8 km (0.5 mi) south of experimental Site 1. Gulfview Boulevard was a major arterial with one southbound through lane and one southbound lane turning into a miniature golf course parking lot. There was neither a raised median nor a refuge island. There was one northbound through lane and the speed limit was 40 km/h (25 mi/h). There were sidewalks on both sides of the street, and the crosswalk was marked with standard parallel lines. Curb cuts were provided at both sides of the crossing. There were two crosswalk signs (MUTCD W11A), one facing each direction posted at the marked crosswalk, as well as advance warning signs (MUTCD W11s) upstream from the crosswalk.

Parking was not permitted on S. Gulfview Boulevard on either side of the roadway. The vehicular traffic consisted of local residents and vacationers staying at the numerous hotels near the site. There was beach access, and many restaurants were located at the site. Pedestrians were walking to shops, hotels, restaurants, and the miniature golf facility located at the marked crosswalk. Pedestrian and vehicular traffic was continuous during the day until midnight. Figure 4 shows a view of control Site 4. Although neither control site had a refuge island, they were the best available control locations.

EXPERIMENTAL PROCEDURE

A team of two researchers collected data at the two experimental and two control sites during daytime and nighttime hours over a 10-day period during March 1997. Four different observational studies were scheduled to control for possible time of day and day of week differences. Each of the four sites had 9 to 10 h of daylight data collection. In addition, experimental Site 1 and control Site 4 had 4 h of nighttime data collected each, between the hours of 7:00 p.m. and 10:00 p.m.

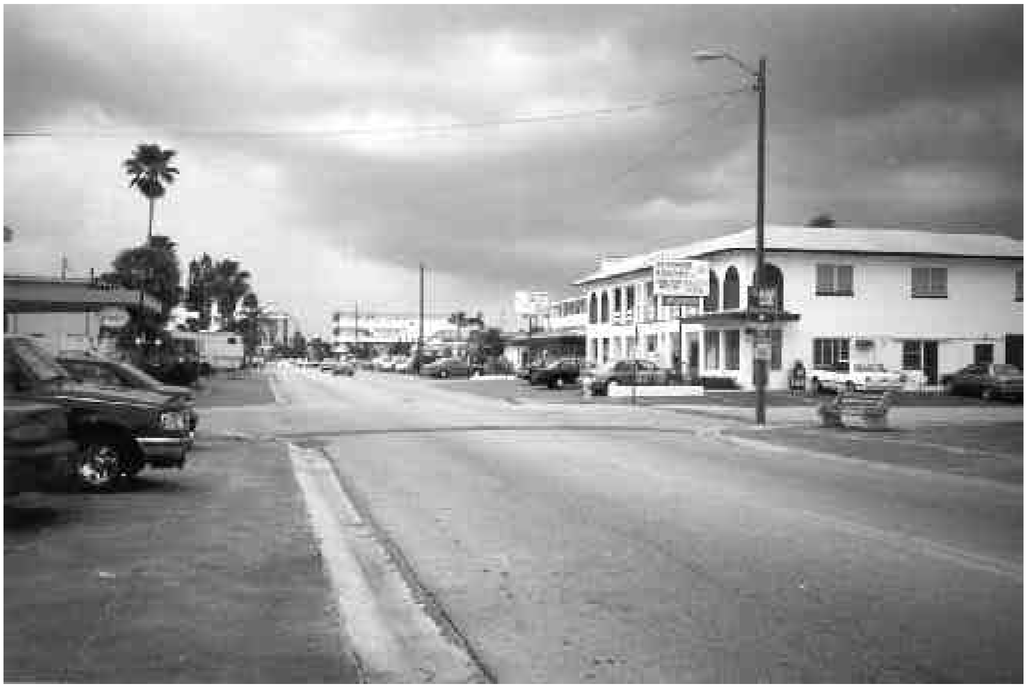

Figure 3. Control Site 2,
Coronado Drive at 3rd Street, Looking South.

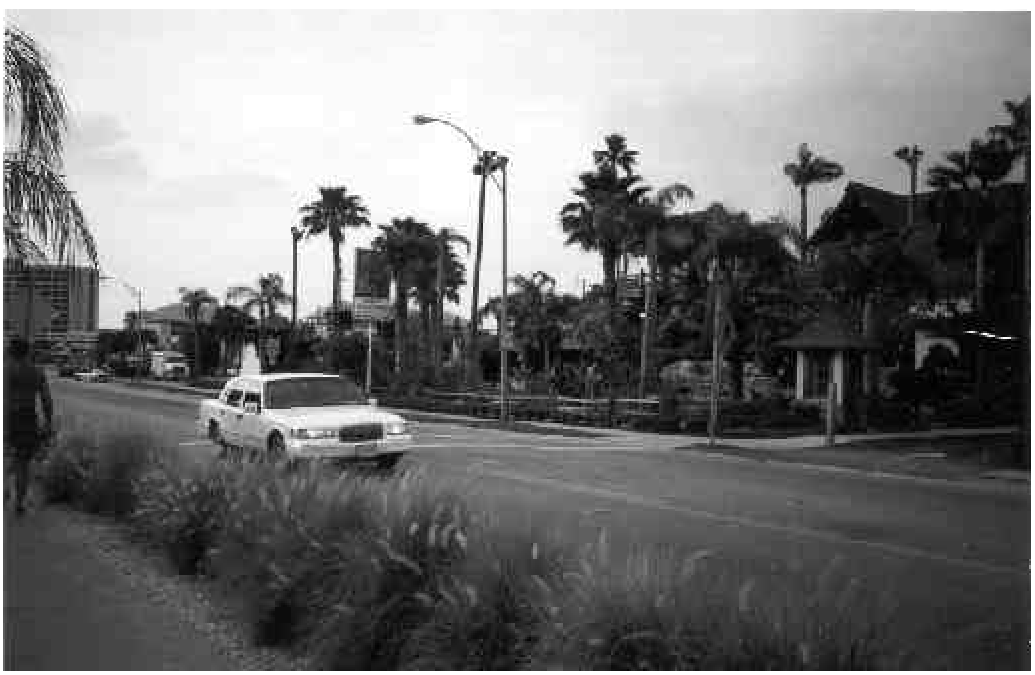

Figure 4. Control Site 4,
Mid-Block S. Gulfview Boulevard, Looking North.

The team drew detailed site drawings that included measurements of roadway and distances to various buildings, street furniture, and trees. The study zones for each site were determined in advance. Other zones were created and labeled on the data collection forms in order to track pedestrian origin, destination, and various pedestrian behaviors. Data were collected using pencil and data forms or by audio tape recording. The data were transferred to data forms after leaving the field.

Traffic volume counts, including turning movements, were collected hourly, and time headways (traffic gaps) were measured and recorded hourly at each site to provide information about each data collection session.

Following is a summary of the three procedures that were conducted.

Pedestrian Entry/Magnet Study

The objective of the Pedestrian Entry/Magnet study was to determine if pedestrians tended to cross at or near intersections where the illuminated overhead pedestrian crosswalk sign and high-visibility ladder crosswalk markings were installed. Information was gathered to determine if the novel pedestrian facilities were used more than the standard crosswalk locations. An experimental and control design was used.

End zones were created at each site 61 m (200 ft) upstream and downstream from the crosswalks. The precise location and numbers of pedestrians entering the roadway to cross at two experimental sites and two control sites were recorded. All pedestrians entering the roadway within the study zones, whether crossing alone or in groups, were recorded. The number of people within each group was recorded. The number of pedestrians that used pedestrian facilities and those who entered at mid-block or further away from the intersections were counted.

Right of Way and Staged Pedestrian Studies

The primary objective of the Right of Way and Staged Pedestrian studies was to determine how often drivers yield the right of way to pedestrians attempting to cross at nonsignalized intersections where high-visibility ladder crosswalk markings were used in combination with an illuminated overhead crosswalk sign. Another objective of the Right of Way study was to determine how often pedestrians forced the right of way, requiring drivers to stop, and whether conflicts were caused. An experimental and control study design was used.

Observations were made at the marked and unmarked crossings at the intersection. At the mid-block control site, observations were made near the crosswalk markings. The number of drivers that passed the pedestrian attempting to cross was recorded. Once the crossing began, the number of drivers that did not yield during the second half of the crossing was also recorded.

The first pedestrian or group of pedestrians arriving at any of the crosswalks at a site was targeted for observation during the Right of Way study. The Staged Pedestrian study consisted of a team member posing as a pedestrian. To ensure consistency, the same team member always served as the pedestrian. Observations took place only when no other pedestrians were at any of the crosswalks. The staged pedestrian took one step out in the roadway and waited for drivers to yield the right of way. The staged pedestrian initiated the observation by timing entry into the roadway with the presence of a vehicle approaching either of the site's end zones. Drivers could clearly see the pedestrian and had ample time and distance to yield. The staged pedestrian did not force drivers to stop. Once the crossing began, the researcher continued across the roadway and stopped and waited if traffic was present during the second half of the crossing.

Other data items recorded for the Right of Way study included the age and number of people in the group of target pedestrians, the travel path during crossing, and any running or rushing. Other data items recorded for both studies included the use of pedestrian refuge islands and any incidence of conflicts.

Daytime data were collected for the Right of Way study at all experimental and control sites. Only nighttime data were collected for the Staged Pedestrian study at one experimental and one control site.

Pedestrian Profile Study

There were two primary objectives of this study. First, the study was conducted to determine if pedestrians were more likely to cross in the crosswalk where high-visibility ladder markings and an illuminated overhead crosswalk signs were installed. A second objective was to observe the safety measures pedestrians take before and during their crossings and whether conflicts occur. By using an experimental/control study design, this study evaluated any behavioral difference pedestrians exhibited where different levels of pedestrian facilities existed.

Data were collected using an audio tape recorder so the researcher could continually observe pedestrian behavior before and during roadway crossings. Groups as well as lone pedestrians were observed using all crosswalks at the study sites. Pedestrian age and number in group were identified. Pedestrian origin/destination information and travel path were recorded by using site diagrams that were divided into zones in advance. Looking behavior as well as traffic observations were recorded. Other behaviors of focus for this study were yielding by drivers, pedestrians who forced the right of way, running or rushing, and pedestrian and driver conflicts.

RESULTS

The various field procedures produced a number of measures of the possible effects of the high-visibility crosswalk markings and the illuminated overhead crosswalk sign. The following will be discussed:

- Vehicle Volumes
- Traffic Gaps
- Driver Yielding Behavior—Daytime
- Driver Yielding Behavior—Nighttime
- Pedestrians Using the Crosswalk
- Pedestrians Looking Behavior
- Pedestrians Forcing Right of Way
- Pedestrians Running, Using the Refuge Island, and Pedestrian/Vehicle Conflicts

Vehicle Volumes

Vehicle volume and vehicle heading (traffic gap) were measured each hour during the data collection effort. This information was collected to identify any differences between the experimental and control locations other than the experimental treatments (crosswalks, signs, and overhead lighting) that were installed at the experimental locations.

The northbound and southbound traffic volumes at the four test sites are shown in Table 1. The hourly volumes ranged from 427.2 to 718.9 vehicles per hour (vph) southbound and from 542.4 to 584.7 vph northbound. An Analysis of Variance found no significant difference for the northbound traffic ($F(3,36) = 0.243$) and a significant difference between the southbound traffic ($F(3,36) = 8.215$, $p = 0.000$). Sites 1, 3, and 4 were all on S. Gulfview Boulevard while Site 2 was on Coronado so the difference is not surprising. Southbound Coronado is apparently not quite as busy. From a pedestrian's viewpoint, however, all four sites are very busy roadways.

Table 1. Clearwater: Traffic Volumes.

Site No.	Site Type	Traffic Volumes (VPH)			
		Southbound		Northbound	
		Mean	Std Dev	Mean	Std Dev
1	Experimental: high-visibility crosswalk, refuge island	718.9	154.84	584.7	122.86
2	Control: no crosswalk markings—intersection	427.2	109.57	566.4	175.53
3	Experimental: high-visibility crosswalk, refuge island	626.7	150.69	548.0	70.74
4	Control: standard crosswalk marking—mid-block	663.6	147.08	542.4	104.74

Traffic Gaps

Vehicle volumes and the characteristic of the vehicle flow (spacing) both affect the gaps in traffic available for crossing. The vehicle gap data collected at all four test sites are presented in Table 2. Gaps were classified as adequate for crossing if the size of the gap allowed for a safe crossing assuming a 1.05 m/s (3.5 ft/s) walking speed. The percentage of adequate gaps ranged from 1.2 percent at Site 1 (experimental) to 10.1 percent at Site 2 (control). A Chi-square (3,N = 2,208) = 71.38 was significant at the 0.000 level. Although the sites are significantly different in terms of available gaps, none of the sites have very many safe crossing opportunities because of the nature of the relatively high traffic volumes. At all four locations pedestrians must wait quite some time before there is an adequate gap to cross safely. Clearly, some kind of intervention is needed to facilitate safe pedestrian crossings. Subsequent discussion will address the effect of the high-visibility pedestrian crosswalks and overhead lighting on driver and pedestrian behavior in an effort to determine if they improved the ability of pedestrians to safely cross these very busy roadways.

Table 2. Clearwater: Traffic Gaps.

Site No.	Site Type	Traffic Gaps	
		N	% Adequate
1	Experimental: high-visibility crosswalk, refuge island	691	1.2%
2	Control: no crosswalk markings—intersection	537	10.1%
3	Experimental: high-visibility crosswalk, refuge island	353	4.8%
4	Control: standard crosswalk marking—mid-block	627	1.9%

Driver Yielding Behavior—Daytime

The Right-of-Way study was conducted to determine the effect of crosswalk markings on driver yielding behavior. Daytime yielding behavior was collected at all four of the sites in Clearwater. Two of the crosswalks had experimental high-visibility crosswalk markings and overhead signs and lighting. One of the control locations had standard crosswalk markings while the second control site had unmarked crosswalks. The right- of-way procedure involved having one member of the data collection team taking one step out into the roadway and waiting for the approaching driver to stop and yield the right of way. The data in Table 3 show the percentage of trials when the first vehicle approaching the pedestrian yielded to the pedestrian in the first half of the crossing, in the second half of the crossing, and during both halves of the crossing combined. For the first half of the crossings, drivers at the two experimental sites yielded in 30.2 percent and 39.7 percent of the trials, respectively. At the two control sites, the yielding occurred on only 0 percent and 6.3 percent of the trials. The Chi-square (3,N=234) = 36.52 was significant at the 0.000 level. For the second half of the crossing, an even greater percentage of the drivers stopped. At the two experimental sites, 59.5 percent and 40.0 percent of the drivers stopped. At the control locations, yielding occurred in 11.1 percent of the drivers who stopped at Site 2, while 53.8 percent stopped at Site 4. The Chi-square (3,N=166) = 9.21 was significant at the 0.027 level. The value for the combined crossings were 2.8 percent and 20.0 percent at the control sites and 43.2 percent and 40.3 percent at the experimental sites. The Chi-square (3,N=400) = 33.18 was significant at the 0.000 level. Apparently, the experimental treatments, high-visibility crosswalks and refuge islands result in a significant increase in drivers yielding to crossing pedestrians.

Table 3. Clearwater: Percentage of Vehicles Stopping for Pedestrians—Daylight.

Site No.	Site Type	Percentage of First Vehicles Stopping		
		1st Half of Crossing	2nd Half of Crossing	Both Halves of Crossing
1	Experimental: high-visibility crosswalk, refuge island	30.2%	59.5%	43.2%
2	Control: no crosswalk markings—intersection	0.0%	11.1%	2.8%
3	Experimental: high-visibility crosswalk, refuge island	39.7%	40.8%	40.3%
4	Control: standard crosswalk marking—mid-block	6.3%	53.8%	20.0%

Driver Yielding Behavior—Nighttime

The Staged Pedestrian study was conducted to determine how often drivers yield the right of way to pedestrians attempting to cross. Nighttime driver yielding behavior was collected at two of the sites in Clearwater. Site 1, the experimental site, was a “T” intersection on S. Gulfview with high-visibility pedestrian crosswalks and overhead crosswalk lighting. Site 4, the control site, was a mid-block crosswalk on S. Gulfview with a standard pedestrian crosswalk. The staged pedestrian procedure involved having one member of the data collection team taking one step out into the roadway and waiting for the approaching driver to stop and yield the right of way. The data in Table 4 show the percentage of trials when the first vehicle approaching the staged pedestrian yielded to the staged pedestrian in the first half of the crossing, in the second half of the crossing, and during both halves of the crossing combined. For the trials involving the first half of the crossing, 17.5 percent of the drivers at the experimental location and 11.5 percent of the drivers at the control site yielded to the pedestrian. The Chi-square (1,N=161) = 1.126 indicates that this difference is not significant. There was less of a difference in yielding during the second-half crossings: 38.2 percent of the drivers of the experimental site versus 35.7 percent at the control site. The Chi-square (1,N=62) = 0.042 was also not significant. Although 25.3 percent of the drivers at the experimental site and 16.7 percent of the drivers at the control site yielded when both halves of the crossing were combined, the Chi-square (1,N=223) = 2.478 was also not significant.

It was hypothesized that the experimental treatment—high-visibility crosswalk and overhead crosswalk sign and lighting—would produce an increase in pedestrian visibility and the number of drivers yielding to crossing pedestrians. Although there was an increase in driver yielding behavior, none of the increases observed were found to be statistically significant.

Table 4. Clearwater: Percentage of Vehicles Stopping for Pedestrians—Nighttime.

Site No.	Site Type	Percentage of First Vehicles Stopping		
		1st Half of Crossing	2nd Half of Crossing	Both Halves of Crossing
1	Experimental: high-visibility crosswalk, refuge island	17.5%	38.2%	25.3%
4	Control: standard crosswalk markings—mid-block	11.5%	35.7%	16.7%

Pedestrian Looking Behavior

It has long been contended by those opposed to marking pedestrian crosswalks that pedestrians act more carelessly when the crosswalks are marked because they feel the crosswalk markings provide an increased measure of protection. To check this hypothesis, the looking behavior of pedestrians crossing was observed in both the experimental (high-visibility markings) and control (either unmarked crosswalks or crosswalks with standard markings) locations. As described, the observation procedure involved two observers: one recording the pedestrians looking behavior and the other noting the presence of approaching vehicles. The vehicle volumes at all the sites were such that very few of the pedestrians crossed when no vehicle was approaching the crosswalk. Therefore, the data shown in Table 5 represent the looking behavior of pedestrians crossing when there was at least one vehicle approaching. At the two experimental sites, 88.2 percent and 93.3 percent of the pedestrians looked at least once toward approaching traffic. At the control location, 76.5 percent and 100 percent of the pedestrians were observed looking at traffic. A Chi-square (3,N=186) = 6.183 was not significant, indicating no difference in pedestrian looking behavior at the experimental and control locations.

Table 5. Clearwater: Pedestrians Looking at Least Once While Crossing.

Site No.	Site Type	Pedestrians Who Looked at Least Once	
		N	%
1	Experimental: high-visibility crosswalk, refuge island	68	88.2%
2	Control: no crosswalk markings—intersection	17	76.5%
3	Experimental: high-visibility crosswalk, refuge island	90	93.3%
4	Control: standard crosswalk marking—mid-block	11	100.0%

Pedestrians Using the Crosswalk

The objective of the pedestrian entry/magnet study was to determine if pedestrians would use the experimental locations to a greater extent than the control locations. Table 6 shows the percentage of pedestrians who stayed in the crosswalk for the first half of the crossing and for the second half of the crossing. The data for the first half of the crossings show relatively high usage rates (92.9 percent and 91.1 percent) for both experimental sites.

One of the two control sites (Site 4), the mid-block crosswalk, also had very high usage rates (98.0 percent). This is not surprising since the crosswalks were unmarked. The other control site (Site 2) had a very low usage rate (56.5 percent). All of the crosswalks had lower usage rates for the second half of the crossing. This is probably because the pedestrians felt they could safely leave the marked crosswalk to complete the final part of their crossing. Nevertheless, second- half crosswalk usage rates were higher at the experimental sites with the high-visibility treatments: 77.6 percent at Site 1 and 82.3 percent at Site 3, versus 39.1 percent at Site 2 and 72.5 percent at Site 4. The Chi-squares (3,N=209) = 31.403 for the first-half crossings and (3,N=211) = 17.763 for the second-half crossings were both significant at the 0.000 level. Pedestrians are more likely to use high-visibility crosswalks than crosswalks marked with standard markings or unmarked crosswalks.

Table 6. Clearwater: Percentage of Pedestrians Using the Crosswalk for the 1st and 2nd Half of the Crossing.

Site No.	Site Type	Percentage of Pedestrians Using Crosswalk	
		1st Half of Crossing	2nd Half of Crossing
1	Experimental: high-visibility crosswalk, refuge island	92.9%	77.6%
2	Control: no crosswalk markings—intersection	56.5%	39.1%
3	Experimental: high-visibility crosswalk, refuge island	91.1%	82.3%
4	Control: standard crosswalk marking—mid-block	98.0%	72.5%

Forced Right of Way

The objective of the Right of Way study was to determine how often pedestrians forced the right of way by requiring drivers to stop and whether this behavior resulted in pedestrian-vehicle conflicts. Table 7 shows the percentage of crossings where the first pedestrian or group of pedestrians forced the right of way during the first half of the crossing and during the second half of the crossing. It should be remembered that both experimental sites had mid-crossing refuge islands. The data for the first-half crossings show that from 3.8 percent (experimental Site 3) to 8.7 percent (control Site 2) of the crossings involved forced right of way. The small numbers of observations involved precludes the use of a Chi-square. The data from the second half of the crossings showed variability from 0 percent at Site 2 to 15.7 percent at Site 4; however, the Chi-square (3,N=211) = 4.469 was not significant. Even though both experimental sites had median refuge islands, the pedestrians continued to force the right of way to the same or a greater extent (Site 3) than they did from the curb. The highest percentage of forced right-of-way crossing occurred at the mid-block control site with the standard crosswalk markings. There is no evidence that the pedestrian accommodations— high-visibility crosswalks and lighting—resulted in increased pedestrian confidence or aggressiveness.

Table 7. Clearwater: Pedestrian Forced Right of Way.

Site No.	Site Type	Pedestrian Forced Right of Way	
		1st Half of Crossing	2nd Half of Crossing
1	Experimental: high-visibility crosswalk, refuge island	8.6%	8.6%
2	Control: no crosswalk markings—intersection	8.7%	0.0%
3	Experimental: high-visibility crosswalk, refuge island	3.8%	11.4%
4	Control: standard crosswalk marking—mid-block	7.8%	15.7%

Pedestrians Running, Using the Refuge Island, and Having Conflicts With Vehicles

Part of the pedestrian profile study involved observing whether the crossing pedestrians ran during some or all of their crossing, used the refuge island, or had a conflict with an approaching vehicle. These data are shown in Table 8. Although running behavior was most common at control Site 4 (17.6 percent), it was similarly high (13.9 percent) at experimental Site 3. The other two sites had relatively low incidences of pedestrian running behavior. Not surprising, the Chi-square (3,N=211) = 7.487 does not reach significance. The high-visibility treatments appear to have no effect on the presence or absence of pedestrians running across the road. Only the experimental sites had refuge islands but data on their use were observed to provide some additional descriptive information. A fifth of the pedestrians at Site 1 and a third of the pedestrians at Site 2 divided their crossing into two distinct crossing events and waited at the refuge island for at least one vehicle to pass. Also shown in Table 8 are the pedestrian-vehicle conflict data. No pedestrian-vehicle conflicts were observed at Sites 1, 2, or 3 and only one occurred at the other control site. The data do not support the hypothesis that high-visibility crosswalk treatments result in an increase in pedestrian-vehicle conflicts. High-visibility crosswalk treatments do not have an effect on either pedestrian running frequency or on the occurrence of pedestrian-vehicle conflicts.

Table 8. Clearwater: Percentage of Pedestrians Who:
Ran and/or Rushed Across the Road, Used the Refuge Island, or
Had Conflict With a Moving Vehicle.

Site No.	Site Type	Percentage of Pedestrians Who:		
		Ran and/or Rushed	**Used the Refuge Island**	**Had a Conflict**
1	Experimental: high-visibility crosswalk, refuge island	3.4%	19.0%	0%
2	Control: no crosswalk markings—intersection	4.3%	NA	0%
3	Experimental: high-visibility crosswalk, refuge island	13.9%	32.9%	0%
4	Control: standard crosswalk marking—mid-block	17.6%	NA	2%

DISCUSSION

Vehicle volume and traffic gap data were collected to characterize the study locations and confirm comparability between the experimental and control sites. Although statistically significant differences were found in the southbound traffic volumes and in the traffic gaps, it is believed that these differences do not represent a meaningful difference between the experimental and control locations. All the locations are very busy and have very few safe crossing opportunities for pedestrians. It is reasonable to attribute any differences between the experimental and control sites to the experimental treatments and not to the relatively minor differences in vehicle volumes and traffic gaps.

Significant differences between the experimental and control locations were found in driver daytime yielding behavior. Drivers were 30 percent to 40 percent more likely to yield at the experimental locations. This effect is the result of the entire treatment (i.e., warning signs, overhead crosswalk sign, and the high-visibility crosswalk markings). It is, of course, not possible to determine how the various aspects of the treatment combined to produce this effect. A small (8 percent) but insignificant increase in driver nighttime yielding behavior was found at the experimental sites with the illuminated crosswalks. Apparently, the experimental treatments did not increase nighttime driver yielding to the same extent as they did during daylight. Interestingly, driver nighttime yielding was much less frequent than daytime yielding. It is not known exactly what conditions led to the reduced incidence of driver yielding behavior at night; reduced vehicle volumes, reduced pedestrian volumes, and changes in pedestrian and/or driver demographics are all possible contributors.

An examination of pedestrian looking behavior found no differences between the experimental and control locations. This suggests that pedestrians are not any less careful in a high-visibility crosswalk.

Very large and statistically significant differences were found in the percentage of pedestrians using the crosswalks. For the more comparable crosswalks located at intersections (Sites 1, 2, and 3), 35 percent or more of the pedestrians crossing used the more highly visible crosswalks. This suggests that pedestrians may feel that a highly visible crosswalk may provide an additional margin of safety and that they went out of their way to use them. Although pedestrians may feel safer, there is no evidence that they act overconfident or overly aggressive in the high-visibility crosswalks. The forced Right of Way study found no significant incidence of pedestrians forcing the right of way in the high-visibility crosswalks.

Finally, there was also no evidence of increased pedestrian overconfidence, as indicated by pedestrians running and/or rushing in the crosswalks or the occurrence of pedestrian-vehicle conflicts.

In summary, the high-visibility crosswalks resulted in significant increases in both driver daytime yielding behavior and the percentage of pedestrians using the crosswalk. Additionally, there was no evidence of increased pedestrian overconfidence or aggressiveness associated with these crosswalks. It can be concluded that the high-visibility pedestrian crosswalks apparently have a positive effect on pedestrian and driver behavior at the two locations studied. It is hoped that the high-visibility crosswalks will also result in improved safety. The study locations were relatively narrow, low-speed crossings. Additional research is needed to determine how the high-visibility crosswalks might work on wider streets with higher operating speeds.