Final Report On The Analyses Of Traffic Accidents

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#8. Semi-Annual Reports on Total Accident: Trends, Types & Analysis of " Before & After" Studies
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Trends, Types, & Analysis of "Before & After" Studies

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Abstract

This report contains the results of an analysis of traffic accidents in the City of Troy, Michigan, where the Sydney Coordinated Adaptive Traffic System (SCATS) was deployed as part of a federal demonstration program. The analyses includes a trend analysis and a comparison with a control city.

The SCATS controllers were installed in 1992 and 1993, and the analyses are based on traffic accident data from 1989 through 1995. These data, along with data on intersection geometry and traffic volume were entered in an Interactive Traffic Accident Geographic Information (ITAGI) system to assist in the analyses and to display the results.

There were small changes in overall accident frequency at various subsets of intersections, but there was no statistically significant increase or decrease in system-wide total or injury accidents after the installation of SCATS.

There was a significant reduction in turn-related accidents following the SCATS deployment This was partially due to the change in signal phasing, but this reduction was also found where the signal phasing was not changed.

There was a large, and statistically significant reduction in the severity of the injuries sustained in the injury accidents. The number of severe (incapacitating) injuries was reduced by more than 50 percent.

The results of other stratifications of the data are discussed in the report.

INTRODUCTION

The Sydney Coordinated Adaptive Traffic System (SCATS) controllers were installed in the City of Troy during 1992-1993. They were initially placed at five intersections of the mile roads in June 1992, and at an additional 34 similar intersections in November 1993. This report presents an evaluation of the deployed SCATS based on accident data for the period 1989-1995. These analyses include a trend analysis and before-and-after analyses, using a control group from outside the test site. For the outside control, the suburb of Farmington Hills was selected based on its similarity to Troy. Both cities are mature suburbs with well developed arterial street systems and similar development characteristics.

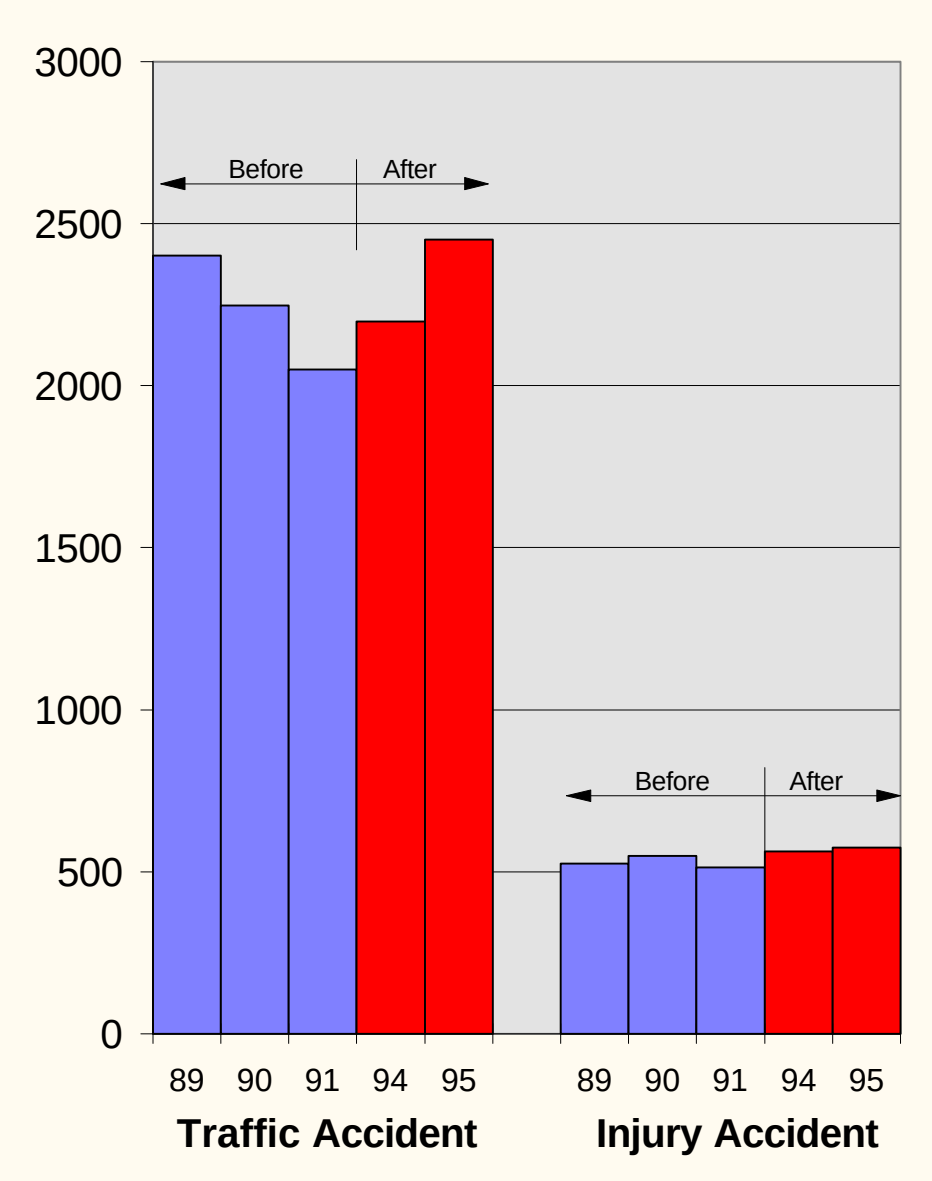
Accident data for the years 1989 through 1995 were obtained from the State of Michigan Accident Master File prepared by the Michigan State Police. The intersection accidents were categorized by angle, turn, rear-end and others. The definitions of these types of accidents as coded by the Michigan State Police are listed in Table 1.

In reviewing the accident report forms for the analyses being conducted, it became clear that the accident type coded by the Michigan State Police did not accurately capture the crash sequence. In many cases the code was based on the positions of the vehicle at the point of impact. Thus, a left turning vehicle that was struck on the passenger side by an oncoming vehicle would often be coded as an angle accident rather than a left turn accident. To address this problem, the accidents were recoded based on driver intent and the direction of travel of the involved vehicles. For example, if a driver was westbound, intending to turn left and they were stuck by an eastbound vehicle, the accident type code was changed from an angle accident to a turn accident.

Table 1: Definitions of Types of Accidents

Accident Type	Meaning	Angle	Turn	Rearend	Others
000	Miscellaneous Vehicle				X
010	Overturn				X
020	Hit Train				X
030	Hit Parked Vehicle				X
048	Backing				X
049	Parking				X
050	Pedestrian				X
060	Fixed Object				X
070	Other Object				X
080	Animal				X
090	Bicycle				X
141	Head-on				X
144	Angle Straight	X			
147	Rear-End			X	
244	Angle Turn		X		
342	Side Swipe Same				X
345	Rear End Left Turn		X		
346	Rear End Right Turn		X		
440	Other Drive				X
444	Angle Drive	X			
447	Rear-End Drive			X	
543	Side-Swipe Opposite				X
545	Head-On Left-Turn		X		
645	Dual Left-Turn		X		
646	Dual Right-Turn		X		

Figure 1: The Number of Total Accidents & Injury Accidents (1989-1995)



ANALYSES

The analyses performed on the accident data can be classified into six categories:

1. Changes in total accidents in the City of Troy before and after SCATS deployment.
2. Changes in accidents at the major intersections in the City of Troy before and after SCATS deployment.
3. Changes in accident types, before and after SCATS deployment.
4. Changes in the percentage of accidents occurring during peak hour traffic or adverse weather conditions before and after SCATS deployment.
5. Changes in accidents as a function of geometry and left-turn control before and after SCATS deployment.
6. Changes in accidents at selected intersections before and after SCATS deployment.

The data required for these analyses, including traffic characteristics, accidents, traffic volumes, level of service, and average travel speed, were entered in the Interactive Traffic Accident Geographic Jnformation (ITAGI) System. From this data format, statistical analysis for any specified intersection or group of intersections can be conducted. This system also provides a convenient format for displaying the data graphically.

Changes in Overall Accidents

A trend analysis of all accidents occurring in the City of Troy from 1989 to 1995 was prepared to provide the broadest overview of changes in the number of accidents.

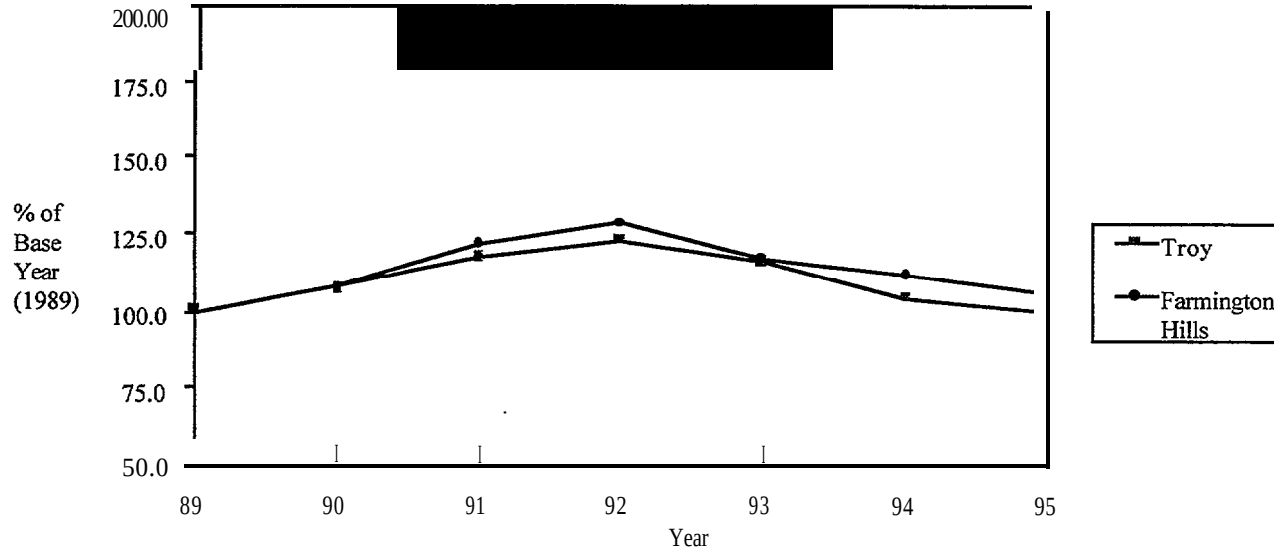
Figure 1 depicts the total accidents for the major arterial street system in Troy for the years 1989, 1990, 1991, 1994, and 1995. Data for 1992 and 1993 are not shown as these are the years when the SCATS was installed.

Statistical testing was not conducted on these trends, because the data is not controlled for the effect of extraneous factors, such as changes in the geometry, control strategy, volume, and weather. Signal phasing changes and altered geometries at many of the major intersections, prevent a true before-and-after analysis from being performed. For example, when the SCATS controllers were installed, a protected left-turn phase was also added at many intersections. Since protected left-turn phases are not unique to SCATS control, it is not possible to separate the SCATS effect from the effect of other changes at the citywide level.

Comparison with Farmington Hills

As described above, it is difficult to attribute changes in accidents over time to a single factor, such as the implementation of SCATS. Changes in weather, volumes, and other factors are all known to effect accidents. Because the SCATS deployment area included the entire city, it was not possible to compare changes in accidents at SCATS and non-SCATS intersections within Troy. Therefore, the City of Farmington Hills was selected as a control site. Farmington Hills has an arterial street system and development characteristics similar to Troy. The trend in citywide accidents was similar to the trend in Troy (Figure 2). This data represents accidents on

Figure 2: Total Accidents: Troy vs. Farmington Hills (1989-1995)



all streets in the two cities, not just the accidents on major arterials, as shown in Figures 3 and 4.

The conclusion from this overview of accident trends is that while there was an increase in the annual number of accidents and injury accidents after SCATS was install& this increase was not statistically different than that experienced in Farmington Hills, where SCATS was not deployed.

Total Accident Changes at the Major Intersections

Since the SCATS is an intersection related system, an analysis was conducted to determine if the accident trend at the intersections where SCATS controllers were installed was similar to that for the city as a whole. Figure 3 presents data for the five major intersections where SCATS was installed in June 1992. At these intersections, the number of accidents decreased by 30 percent between 1989 and 1991. In 1993, the frequency of accidents remained at the 1991 level, but in 1994 and 1995, there was an increase in accidents, with the frequency increasing to about the same level as the pre-SCATS period. Injury accidents at these intersections increased in 1993, and then decreased slightly in 1994 and 1995.

Figure 4 shows the trend for accidents at the 39 major intersections where SCATS controllers were installed during 1992- 1993. These include the five intersections shown in Figure 3, plus the locations where SCATS was installed in the second half of 1993. Both the total accidents and the injury accidents showed an increase in 1994-1995, compared to the pre-SCATS period. However, as discussed later, the severity of the injuries decreased after SCATS was installed.

Figure 3: Number of Total Accidents & Injury Accidents (1989-1995)
(Intersections in the City of Troy)

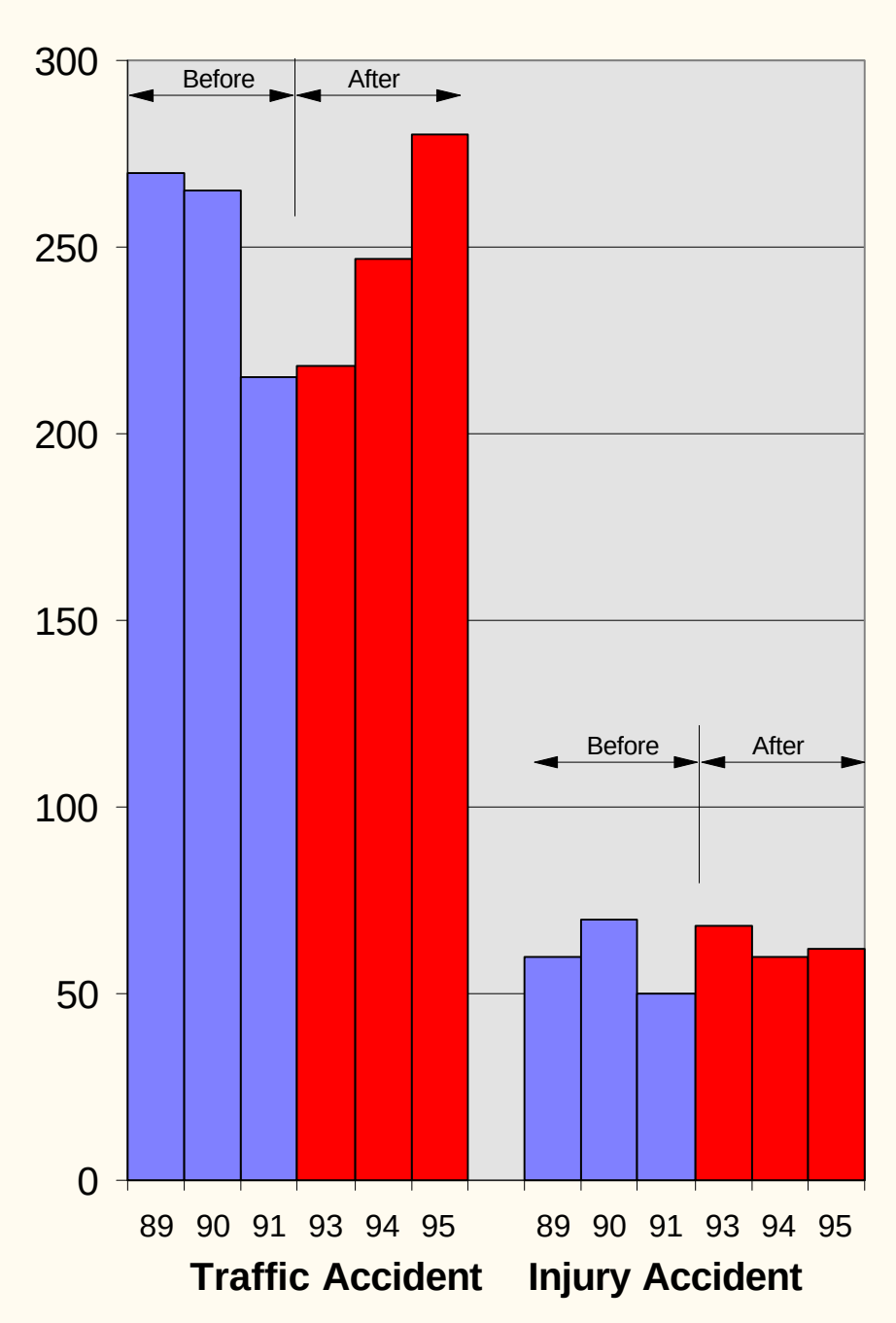
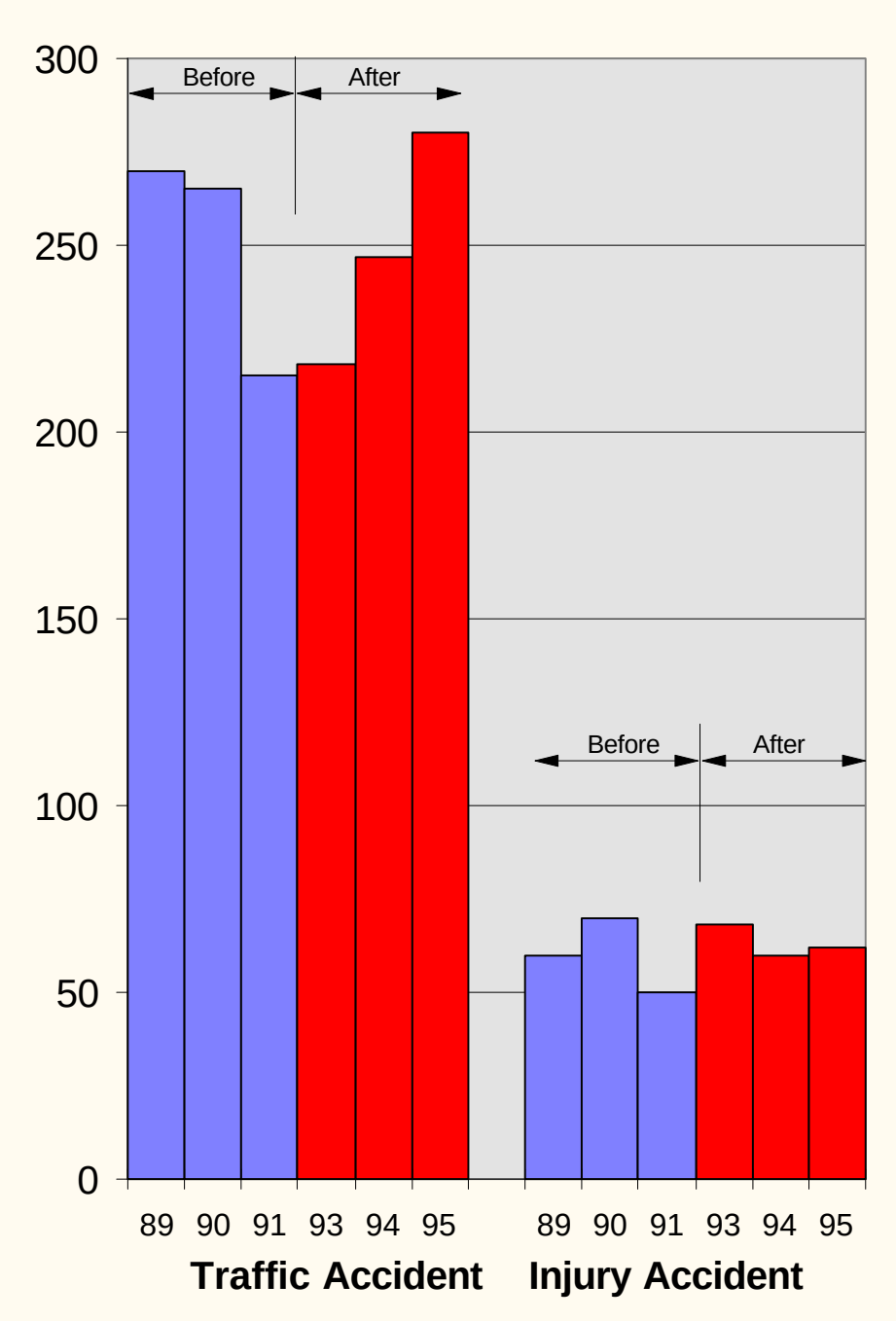


Figure 4: Number of Total Accidents & Injury Accidents (1989-1995)
(39 Intersections in the City of Troy)



X2 Test for Intersection Accidents in Farmington Hills and Troy

A statistical analysis (X2 test) was conducted to compare the change in accidents at the major intersections in Troy (SCATS controlled) with the major intersections in Farmington Hills (non-SCATS controlled). Table 2 shows the results of the chi-squared analysis. The conclusion from the analysis of intersection accidents are:

- There was an increase in both total accidents and injury accidents at the SCATS controlled intersections. This phenomenon was similar to that for the city as a whole.
- The increase in intersection accident frequency per year was greater in Troy than in Farmington Hills in 1994 and 1995, but the difference was not statistically significant.

Table 2: Chi-Square Analysis of Intersection Accidents

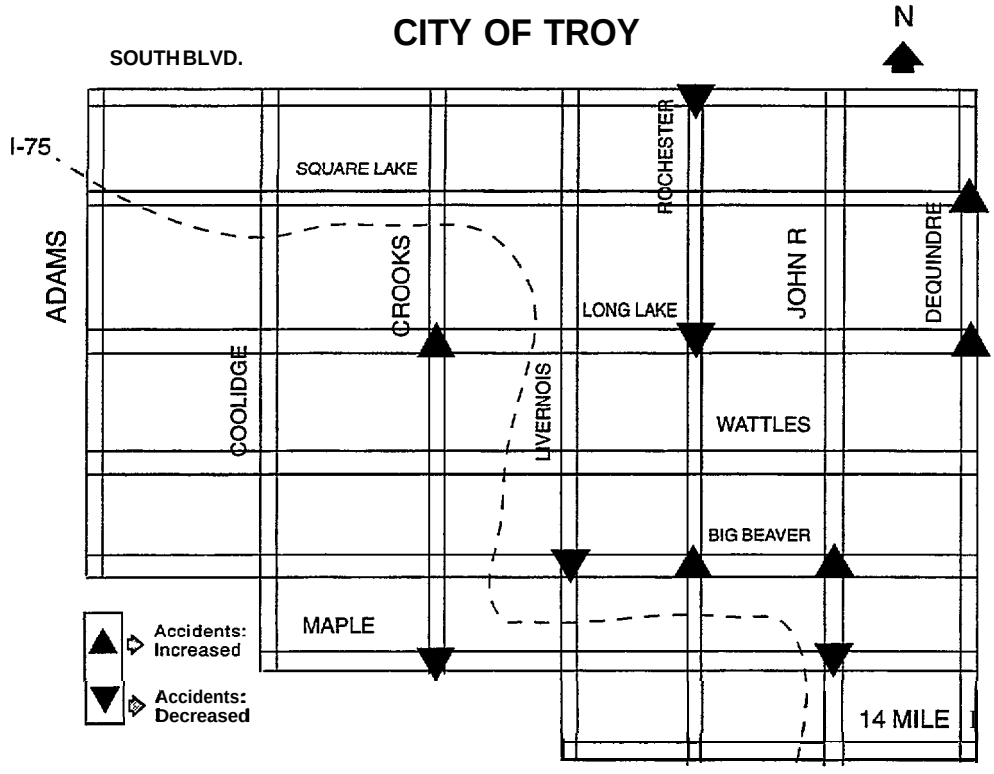
Comparison Year	Troy	Farmington Hills
1988-1991	2,835	3,553
1994-1995	1,431	1,847

Chi-Square = 0.46 Chi-Square Critical (a=0.05) =3.84

Accident Shifts and Changes in Type After SCATS Installation

Figure 5 is a map showing the 39 SCATS controlled intersections in the City of Troy. Also shown on this figure are the location of the five intersections which showed the greatest increase (and decrease) in accident frequency between the before and after period. Figures 6 through 17 illustrate comparisons of accident characteristics by various strata, including time of day (peak hour and off-peak hour), types of accidents (angle, turn, rear-end, and others), severity of injury accidents (possibly injured, non-incapacitating, and incapacitating), and weather conditions (clear or cloudy, fog, rain, snow, and unknown). These analyses were conducted for all major intersections, and then repeated for the five intersections with the greatest increase and the greatest decrease in accidents.

Figure 5: Locations of the Five Intersections with the Greatest Increase and Decrease in Accident Frequency after SCATS was Installed



Figures 6, 7 and 8 show the time of day that accidents occurred. The peak hours for this study are defined as the hours from 7-9 a.m. and 4-6 p.m. While no statistical test was conducted, there does not appear to be any signifkant shifts in the percentage of accidents occurring during the peak period.

Figure 6: Time of Traffic Accidents - All Intersections

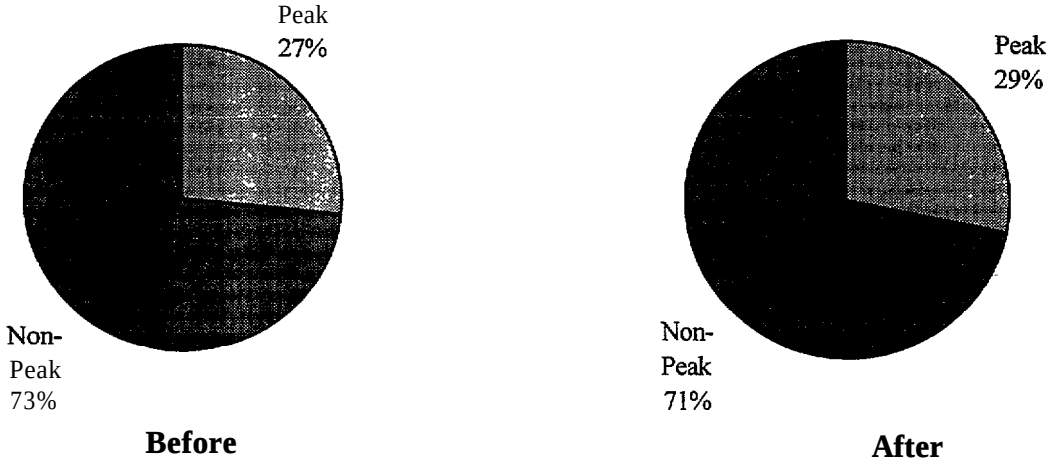


Figure 7: Time of Traffic Accidents - Five Intersections Where Accidents Increased

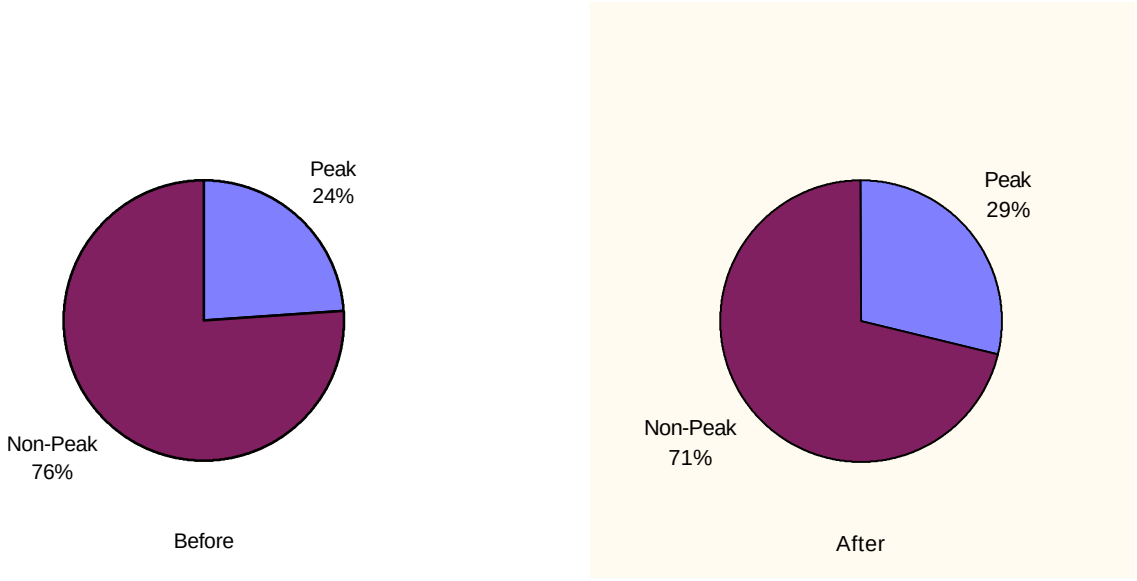
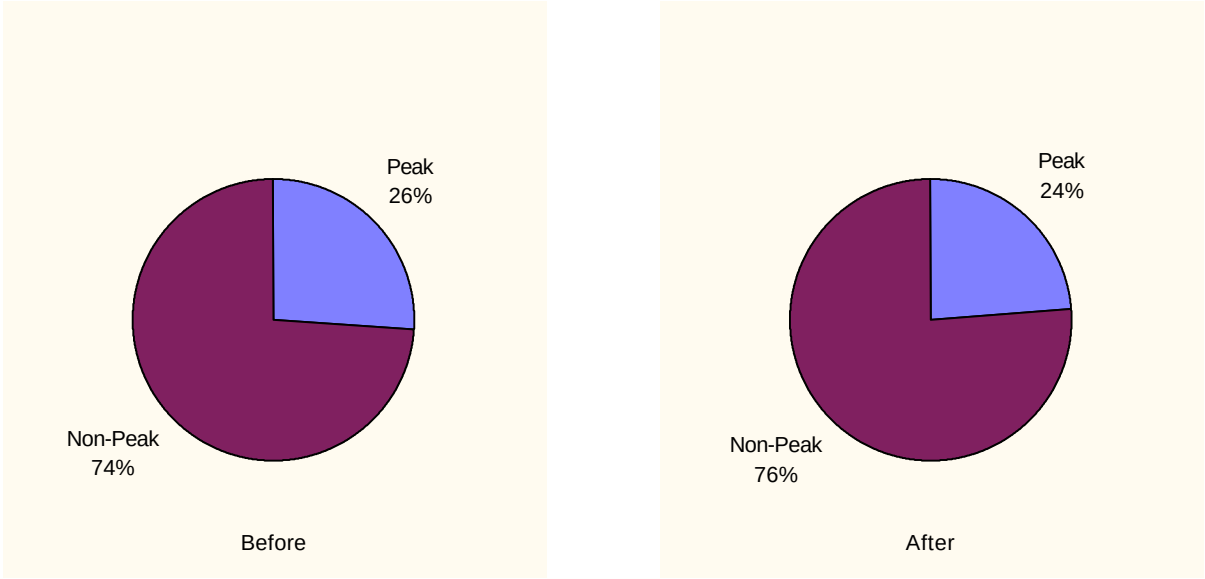


Figure 8: Time of Traffic Accidents - Five Intersections Where Accidents Decreased



The type of accidents before and after SCATS are shown in Figures 9 through 11. At the three intersection groupings, turn accidents decreased by 16, 11, and 15 percent, after SCATS was installed. The percentage in all other categories increased with rear-end accidents showing the largest increase for all intersections under SCATS control.

Figure 9: Types of Traffic Accidents - All Intersections

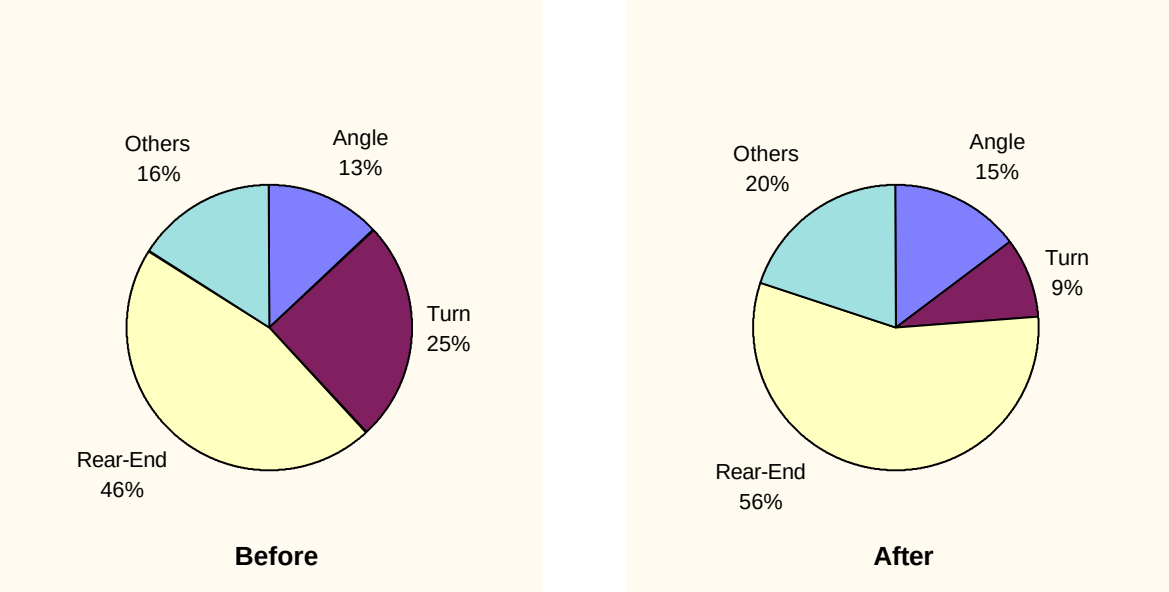


Figure 10: Types of Traffic Accidents - Five Intersections Where Accidents Increased

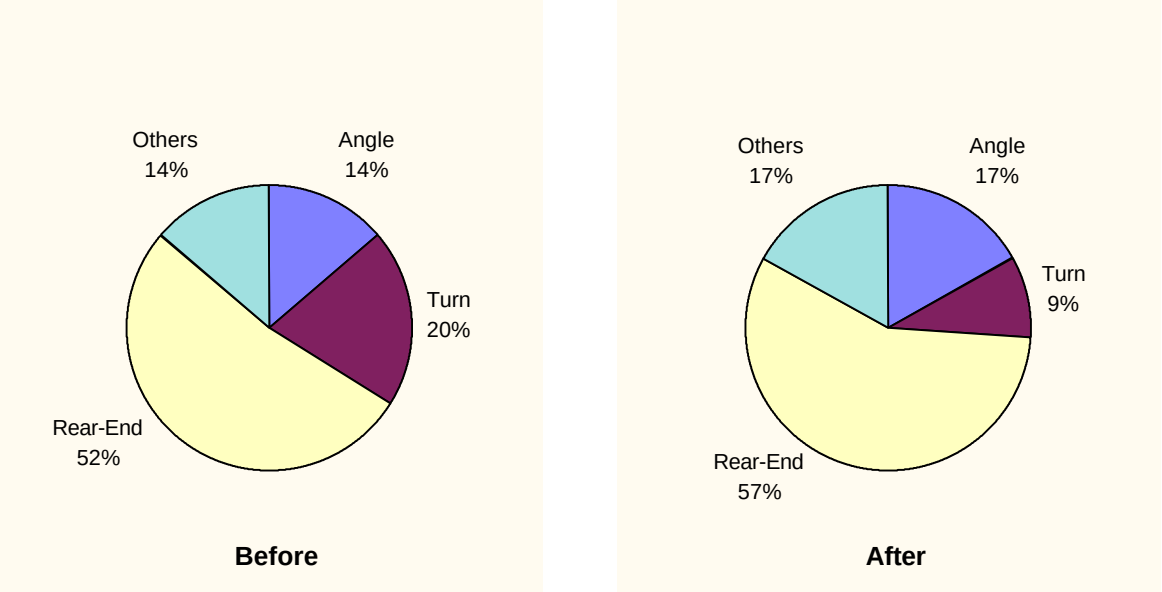
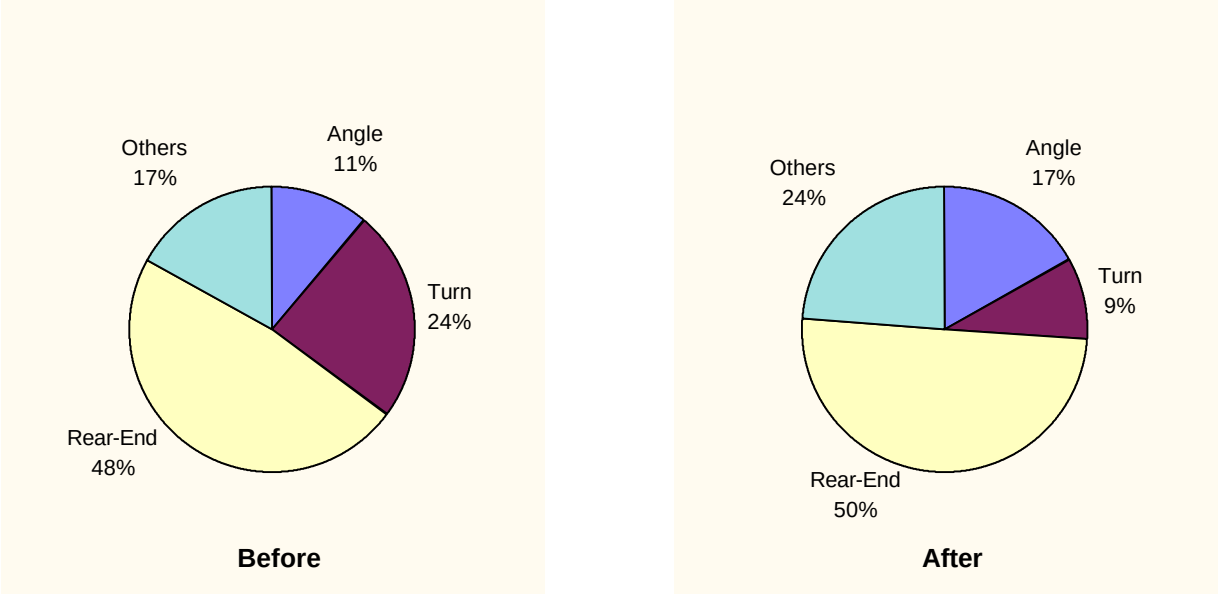


Figure 11: Types of Traffic Accidents - Five Intersections Where Accidents Decreased



Figures 12 through 14 show the effect of SCATS on the severity of injury accidents. The most severe category (incapacitating injury) decreased by more than 50 percent in all three intersection groups. Non-incapacitating injuries decreased by over 25 percent for all intersections under SCATS control, while remaining constant for both of the two subgroups.

The least severe type of injury accident increased in each of the three groups. These results show a positive impact of SCATS on accident severity. The reduced severity may be the result of a shift in the percentage of accidents from turning accidents to rear-end accidents.

Figure 12: Severity of Traffic Accidents - All Intersections

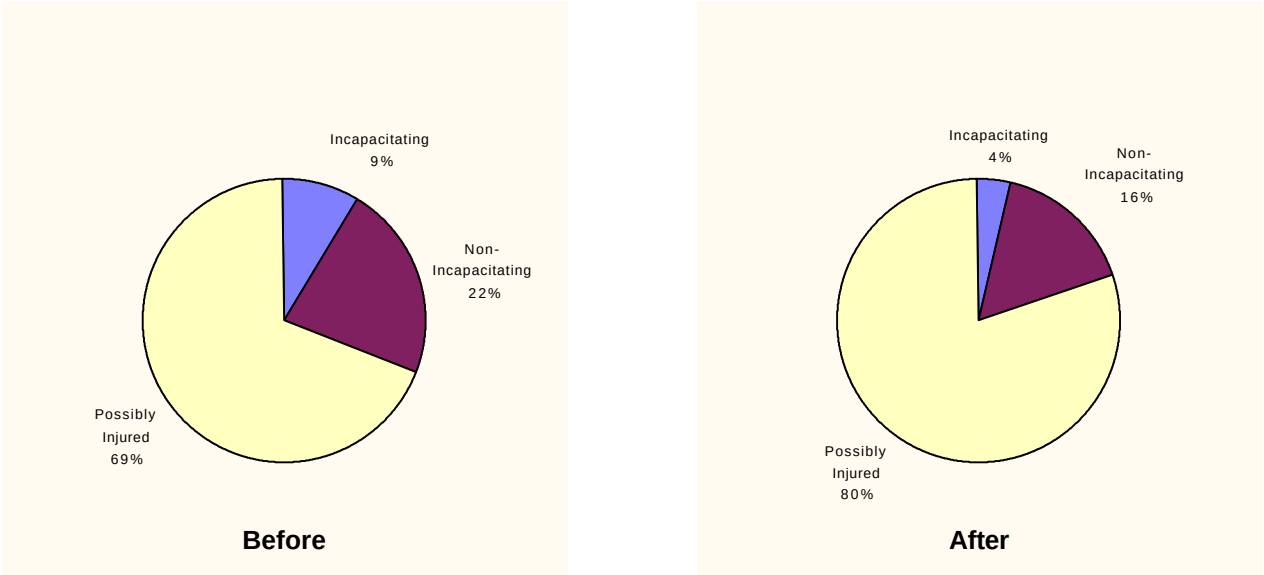


Figure 13: Severity of Traffic Accidents - Five Intersections Where Accidents Increased

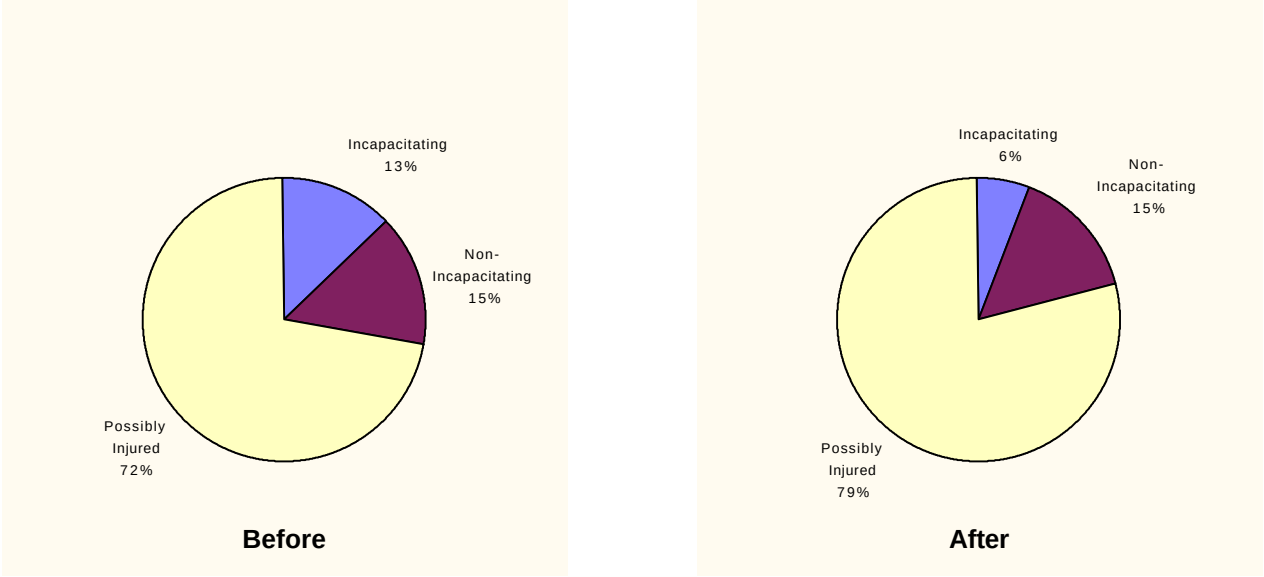
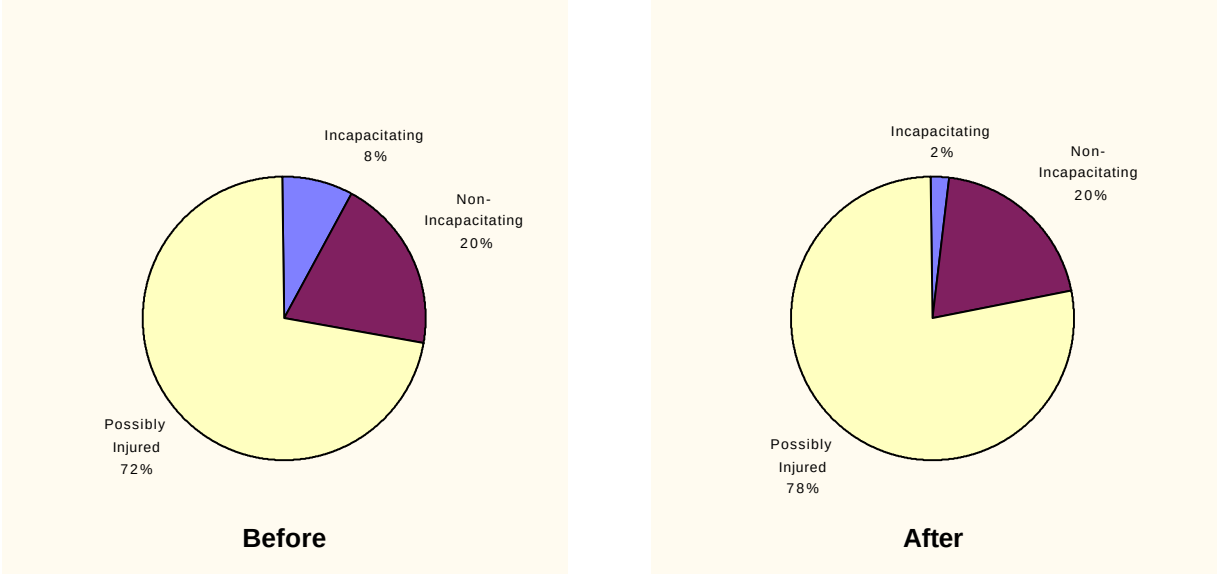


Figure 14: Severity of Traffic Accidents - Five Intersections Where Accidents Decreased



Figures 15 through 17 show that SCATS installation had no significant impact on accidents due to weather conditions. Only minor changes were noticed.

Figure 15: Weather Condition - All Intersections Under SCATS

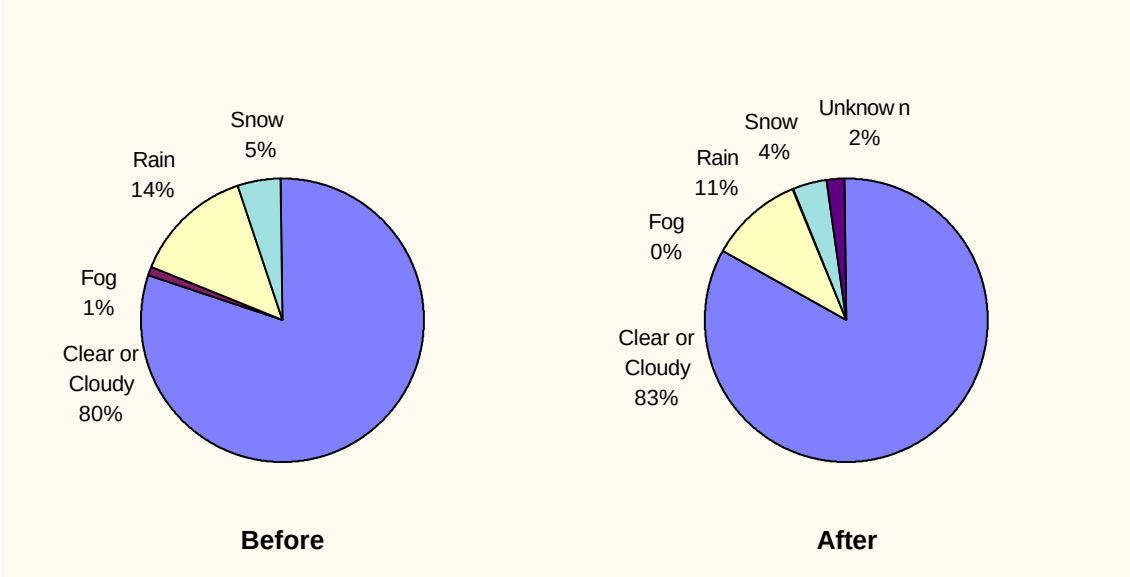


Figure 16: Weather Condition - Five Intersections Where Accidents Increased

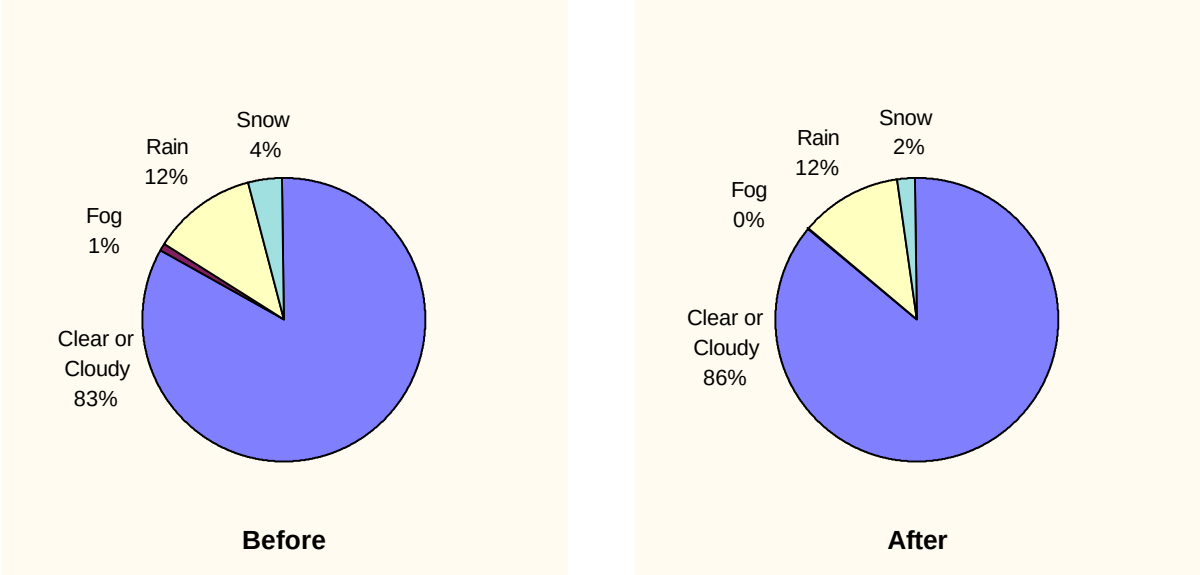
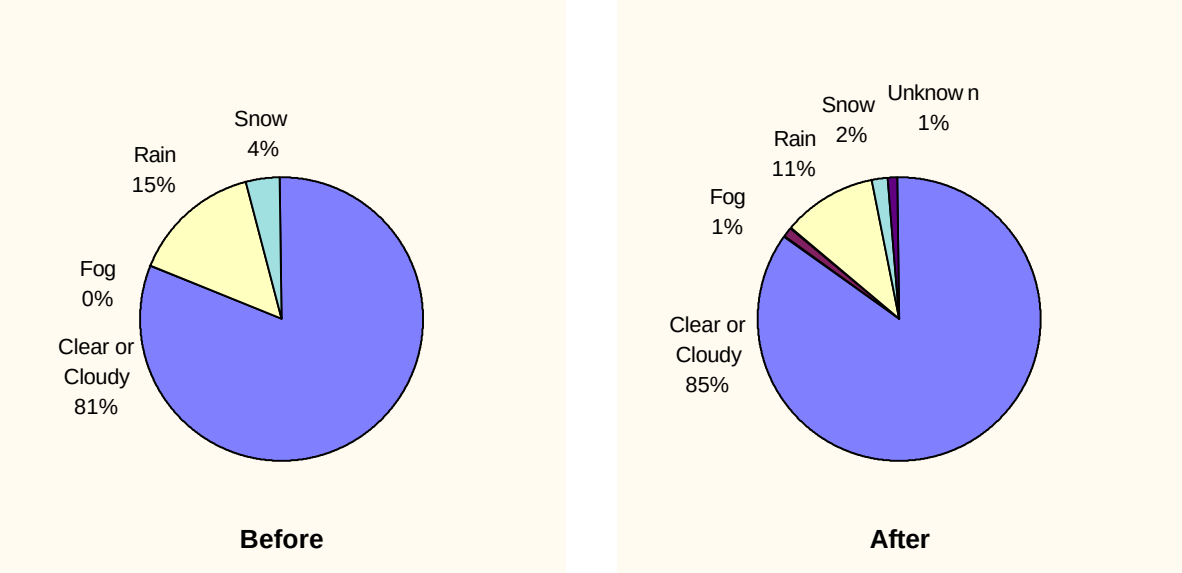


Figure 17: Weather Condition - Five Intersections Where Accidents Decreased



Changes in Geometry and Left-turn Control Before and After SCATS Installation

One of the common threats to validity of an accident analysis is that of competing explanations. In the City of Troy, this threat exists because geometric changes and/or left turn control changes were made at some of the intersections being studied. Thus, a change in the accident frequency might be attributed to SCATS, to the change in geometry or control, or to a combination of the two changes.

Left-turn Control Analysis

In an attempt to isolate the effect of changes in left-turn controls, subsets of the 39 SCATS-controlled intersections were analyzed. The intersections contained in each of these subsets are listed in Table 3.

Group 1: No Change in Control or Geometry

Table 4 shows the results of the T-test of the difference in the average number of accidents per month for the intersections where no left-turn control or geometry changes were made during the study period. The average number of total accidents and the average number of turn accidents per month is shown in Figure 18. The results for total accidents is consistent with the citywide data. There was a slight, but not statistically significant, increase in total accidents after SCATS was deployed This was accompanied by a significantdecrease in the average number of turn accidents per month. All of these intersections except Long Lake and Coolidge are boulevard locations with indirect left turns.

Table 3: Intersection Groupings

Intersections with No Change in Control or Geometry:

Big Beaver & Coolidge
Big Beaver & Crooks
Big Beaver & Livemois
Big Beaver & Rochester
Big Beaver & John R
Long Lake & Coolidge
Long Lake & Crooks
Square Lake & Crooks

Intersections Where the Left-Turn Control Was Changed from Permissive to Permissive/Protected:

Wattles & Adams
Wattles & Coolidge
Wattles & Crooks
Wattles & Livemois
Wattles & John R
Long Lake & Dequindre
Square Lake & Coolidge
Long Lake & Adams
Wattles & Dequindre
Long Lake & John R

Intersections Where the Left-Turn Control Was Changed from Permissive/Protected to Protected:

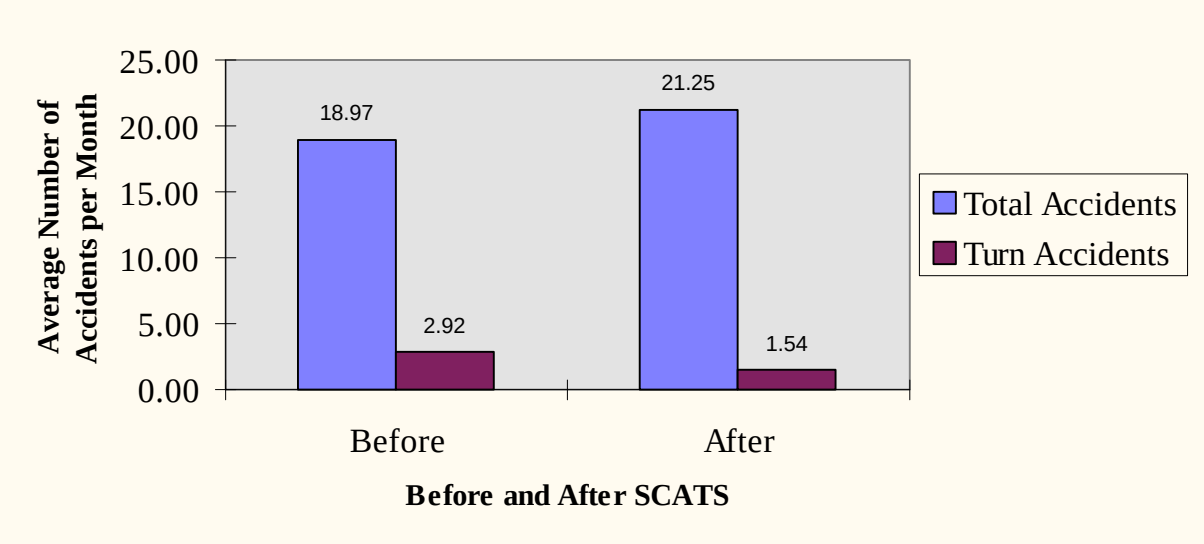
Maple & Coolidge
Maple & Crooks
Maple & Livemois
Maple & Rochester
Maple & John R.
Big Beaver & Adams
Wattles & Rochester
Long Lake & Rochester

Table 4: No Change in Control or Geometry *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	18.97		
After	24	21.25	0.10	No
Turn Accidents				
Before	36	2.92		
After	24	1.54	0.04	Yes

*Units = Average Number of Accidents Per Month, α=0.05

Figure 18: No Change in Control or Geometry



Group 2: Change from Permissive to Permissive/Protected

For the intersections where the left-turn control was changed, the before period represents the months before the change was made, and the after period represents the months that the change was in effect. Permissive means that there was no left-turn phase in the signal cycle. Protected means that left-turns are prohibited except during the left-turn phase (green arrow), and permissive/protected means that there is a protected left-turn phase, but drivers can turn left during the through phase for their direction of travel after yielding to oncoming vehicles. In Michigan, this is denoted by a flashing red signal display over the left-turn lane.

When comparing the average number of total accidents per month between permissive and permissive/protected left-turn control, we found no significant difference (significance level a=0.05), as shown in Table 5. Once again there is a slight, but not statistically significant, increase in total accidents between the before and after period.

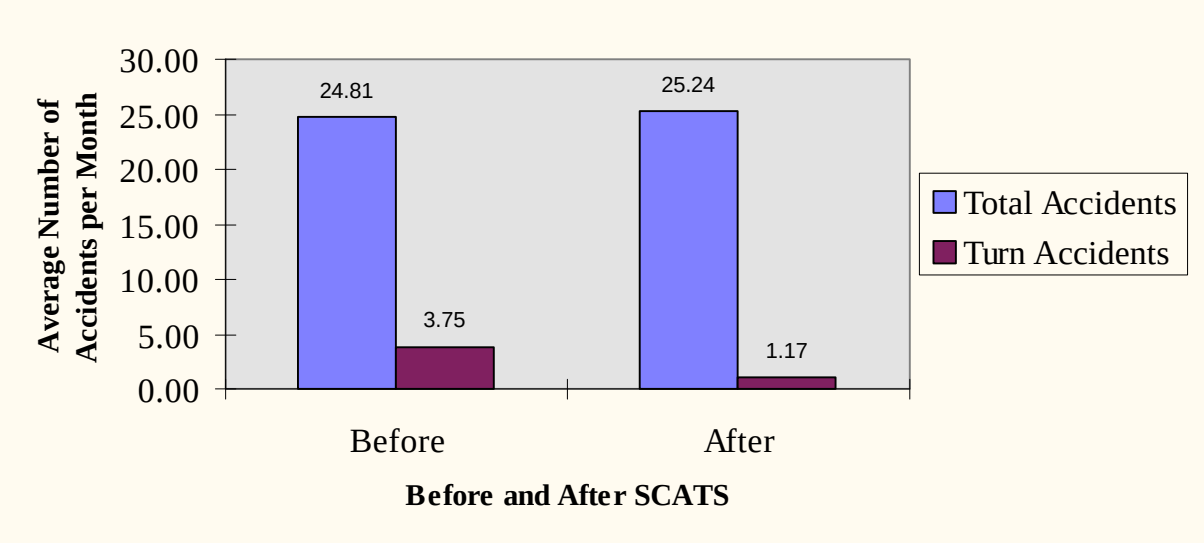
There was a significant difference between the before and after periods in the average turn accidents per month for this group of intersections. Figure 19 corresponds to Table 5.

Table 5: Left-Turn Control Changes - Permissive to Permissive/Protected *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	24.81		
After	24	25.24	0.69	No
Turn Accidents				
Before	36	3.75		
After	24	1.17	0.04	Yes

*Units = Average Number of Accidents Per Month, α=0.05

Figure 19: Similar Control Changes - Permissive to Permissive/Protected



Group 3: Change from Permissive/ Protected to Protected

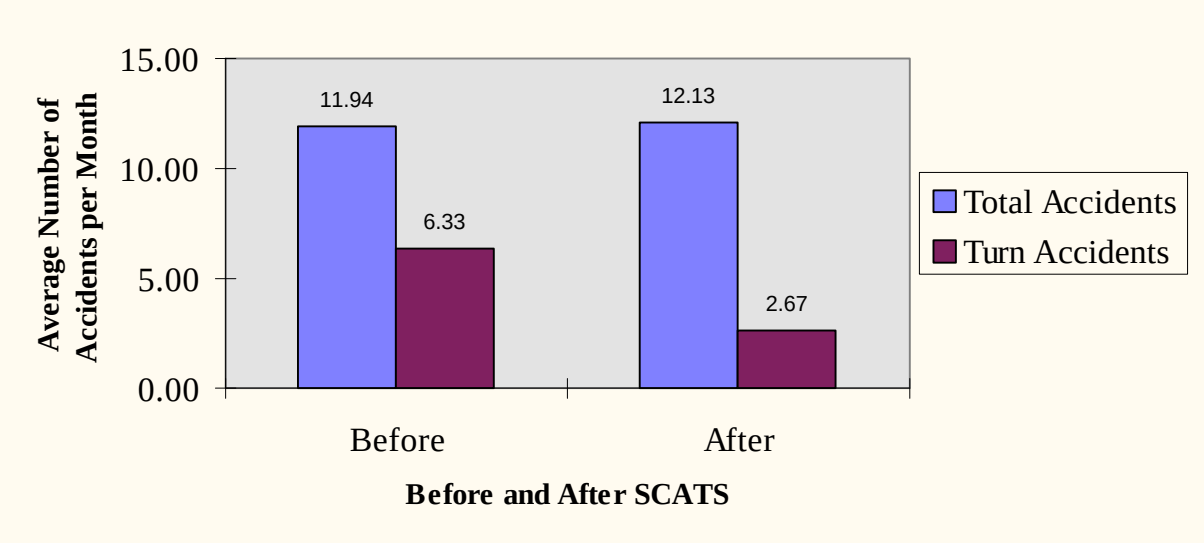
The results of the tests were similar to the group 1 and 2 results. There was a slight increase in total accidents per month, and a statistically significant decrease in turn accidents (Table 6 and Figure 20). These results are not unexpected, as intersections with protected left turns generally experience fewer left-turn accidents than intersections with permissive control.

Table 6: Left-Turn Control Changes - Permissive to Permissive/Protected *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	11.94		
After	24	12.13	0.88	No
Turn Accidents				
Before	36	6.33		
After	24	2.67	0.04	Yes

*Units = Average Number of Accidents Per Month, α=0.05

Figure 20: Similar Control Changes - Permissive/Protected to Protected



Geometry and Accidents Before and After SCATS

One of the objectives in conducting this study was to determine if there were conditions or locations which could be used to predict that SCATS would have a positive or negative effect on safety. It is conceivable that even if there were no safety impacts on the city as a whole, there could be specific geometric conditions where the impact was either positive or negative. To test this hypothesis, the intersections were stratified into five groups based on geometry. These groups are shown in Table 7.

Table 7: Intersection Groupings

Intersections with Similar Geometry:

LT: 1 Lane; TH: EB-l,WB-1, SB-2, NB-2 Lanes
Wattles & Coolidge
Wattles & Crooks
Wattles & Livemois
Long Lake & John R
Square Lake & Rochester
South Blvd. & Livemois
South Blvd. & Rochester

LT: 1 Lane; TH: 2 Lanes
Maple & Coolidge
Maple & Crooks
Maple & Livemois
Maple & Rochester
Maple & John R
Wattles & Livemois
Maple & Coolidge

LT: 0 Lanes; TH: 2 Lanes
Big Beaver & Livernois
Big Beaver & Rochester

LT: 0 Lanes; TH: EB-3, WB-2 SB-2, NB-2 Lanes
Big Beaver & Coolidge
Big Beaver & Crooks

LT: 1 Lane; TH: 1 Lane
Wattles & Adams
Wattles & Dequindre
Long Lake &Adams
Square Lake & Coolidge
Square Lake & Livemois
Square Lake & John R
Square Lake & Dequindre
South Blvd. & Adams
South Blvd. & Crooks
South Blvd. & John R

The results of the analysis of intersections stratified by the geometry at the intersections are shown in Tables 8 through 12. Figures 21 through 25 correspond with these tables. The only geometric configuration group to experience a significant change in the average total accident frequency after installation of SCATS were intersections with one left turn lane and one through lane (one-tailed t-test, a = 0.05). These intersections showed an increase in total accidents as illustrated in Table 11 and Figure 24. As a group, these intersections are among the lowest volume intersections where SCATS was deployed.

Table 8: Left-Turn Control Changes - Permissive to Permissive/Protected *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	24.56		
After	24	26.63	0.26	No

*Units = Average Number of Accidents Per Month, α=0.05

Figure 21: Intersections with Similar Geometry - LT: 1 Lane; TH: 2 Lanes

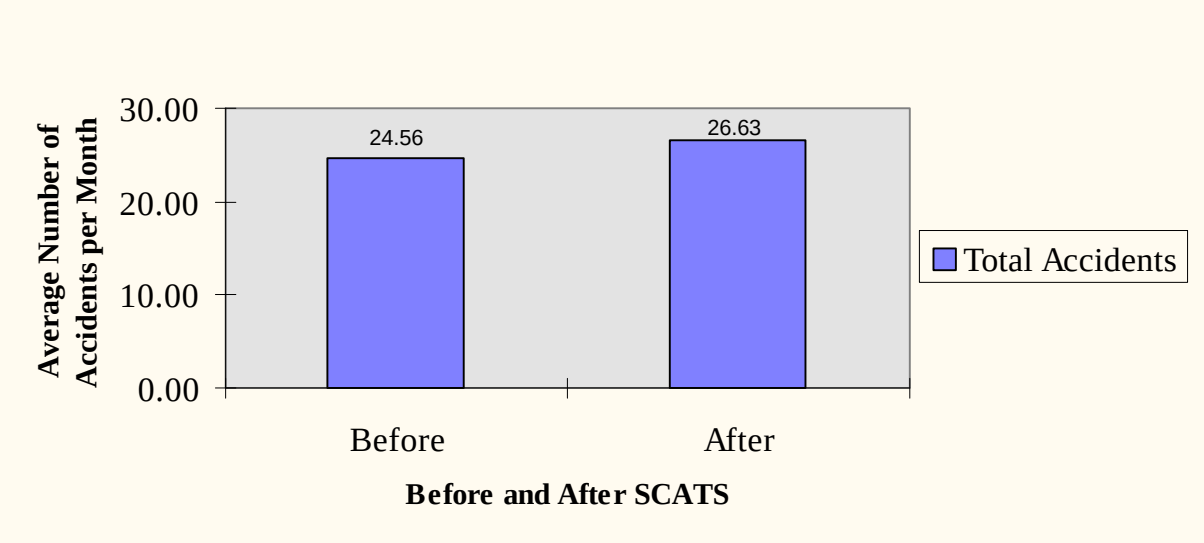


Table 9: Similar Geometry - LT: 0 Lane, TH: 2 Lanes*

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	7.97		
After	24	9.33	0.075	No

*Units = Average Number of Accidents Per Month, α=0.05

Figure 22: Intersections with Similar Geometry - LT: 0 Lanes; TH: 2 Lanes

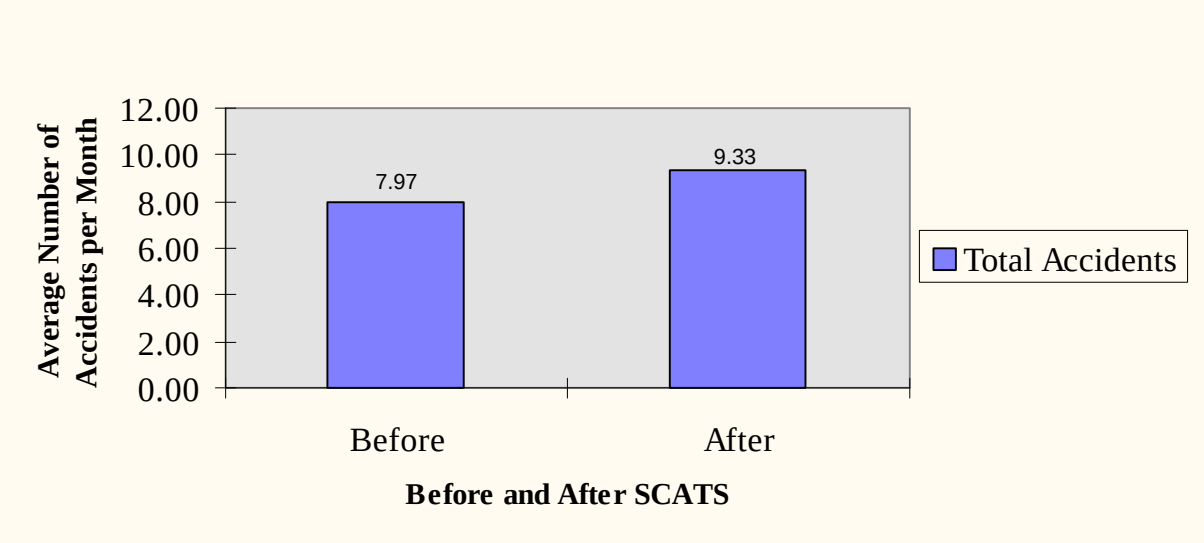


Table 10: Similar Geometry - LT: 0 Lane, TH: EB-3; WB-2; SB-2; NB-2 *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	5.31		
After	24	5.79	0.44	No

*Units = Average Number of Accidents Per Month, α=0.05

Figure 23: Intersections with Similar Geometry - LT: 0 Lanes; TH: EB-3, WB-2, SB-2, NB-2 Lanes

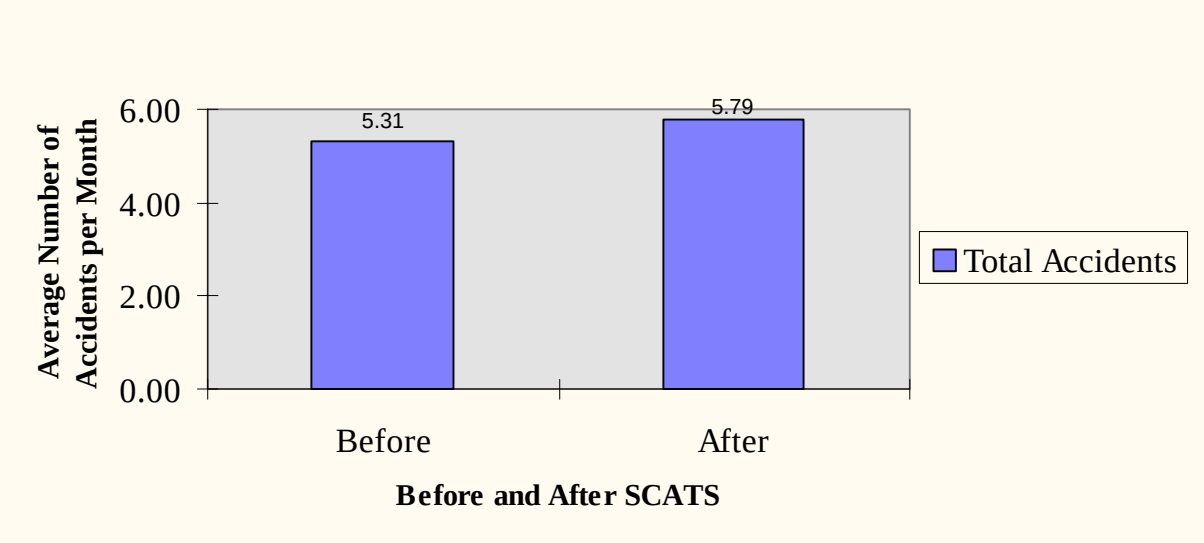


Table 11: Similar Geometry - LT: 1 Lane, TH: 1 Lane *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	4.92		
After	24	6.08	0.048	No

*Units = Average Number of Accidents Per Month, α=0.05

Figure 24: Intersections with Similar Geometry - LT: 1 Lane; TH: 1 Lane

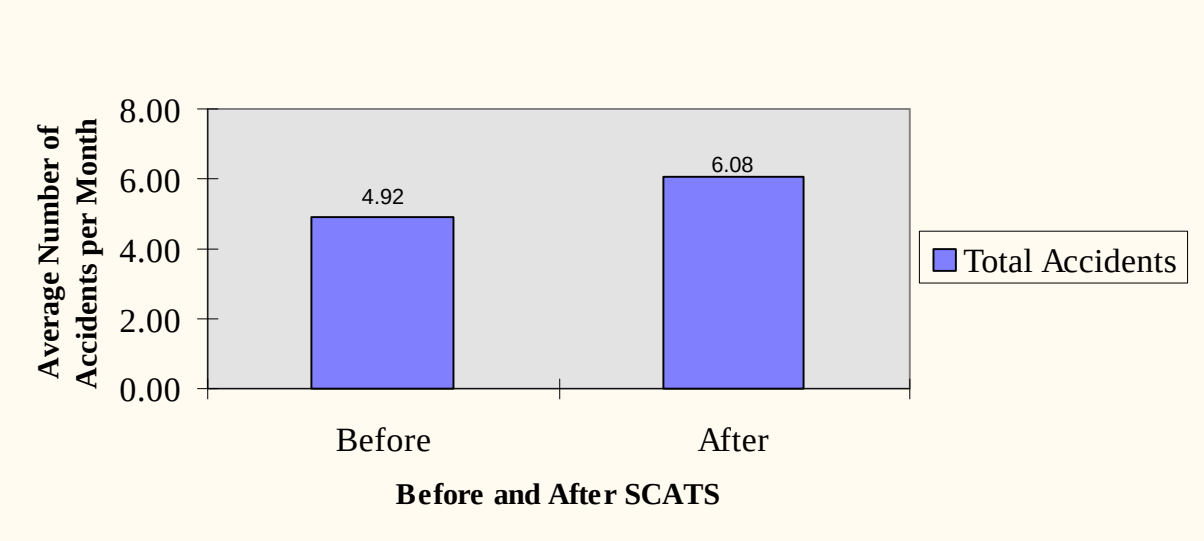


Table 12: Similar Geometry - LT 1 Lane, TH: EB-1 ; WB-1; SB-2; NB-2 *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	10.31		
After	24	10.08	0.048	No

*Units = Average Number of Accidents Per Month, α=0.05

Figure 25: Intersections with Similar Geometry - LT: 1 Lane; TH: EB-1, WB-1, SB-2, NB-2, Lanes

Changes at selected intersections before and after SCATS installation

Representatives of the Road Commission for Oakland County (RCOC) were asked to select two corridors where they were interested in a comparison of the accident frequency. They selected the John R. and Adams Road corridors. The intersections along these two corridors are listed in Table 13. The results of this analysis is shown in Table 14 and Figure 26. These two corridors were virtually identical in the two time periods.

Table 13: Intersections in the Selected Corridors

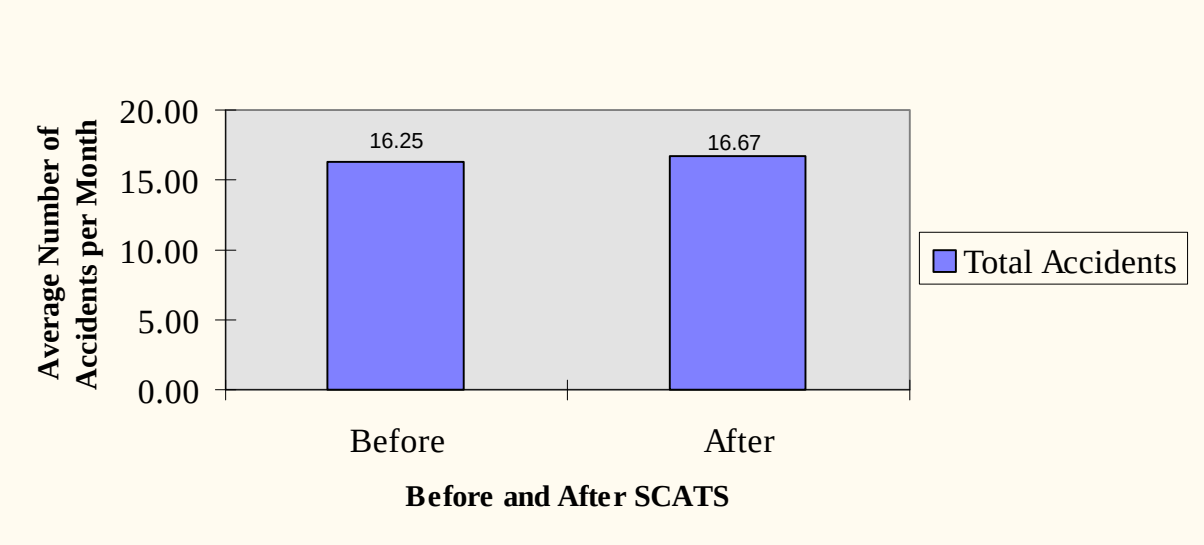
Maple & John R	Big Beaver &Adams
Big Beaver & John R	Wattles & Adams
Wattles & John R	Long Lake & Adams
Long Lake & John R	Square Lake &Adams
Square Lake & John R	South Blvd. &Adams
South Blvd. & John R	

Table 14: Selected Corridors *

	Months	Mean	P-Value	Significant
Total Accidents				
Before	36	16.25		
After	24	16.67	0.76	No

*Units = Average Number of Accidents Per Month, α=0.05

Figure 26: Selected Intersections.



While most of the categories tested showed an increase in total accidents, there was a significant decrease in the number of turn related accidents in the post-SCATS period. For the 39 major intersections, there was a decrease of 121 turn-related accidents per year (a 60 percent reduction) as shown in Table 15. The 18 intersections where the left-turn control was modified accounted for 75 fewer turn-related accidents per year, and the 11 intersections where the geometry was changed accounted for an additional reduction of 29 turn-related accidents.

However, even the ten intersections where there was no change in the geometry or left-turn control strategy experienced a decrease in turn-related accidents. That reduction (46 percent) is assumed to be attributable to SCATS.

Table 15: Change In Turn Related Accidents

	Average Turn Accidents Per Year			
Group	**Before**	**After**	**Decrease**	**Percent Decrease**
All Intersections	201	80	121	60
Change in Control				
Permissive to Protected	76	32	44	58
Permissive/Protected to Permissive	45	14	31	69
Change in Geometry	45	15	29	64
No Change in Geometry or Control	35	19	16	46

CONCLUSIONS

The intent of this study was to determine the impacts of SCATS on traffic accidents in the City of Troy. Although small changes in overall accident frequencies were observed for different intersection groups studied, there was no systematic change in total accident frequency after SCATS was installed.

There was a significant reduction in turn-related accidents following the deployment of SCATS. This reduction was partially the result of changes in the left-turn control strategy, but there was a reduction in this type of accident even where no change was made in the left-turn controls.

The change in accident type (from turn accidents to rear-end accidents) resulted in a large decrease in the number of severe injuries experienced annually. The number of incapacitating injuries was reduced by more than 50 percent following the deployment of SCATS and the implementation of changes in geometry and left-turn control at selected intersections.

Farmington Hills was used as a control site to compare the changes in the number of accidents occurring after SCATS was implemented in 1993. There was no statistically significant difference between the total number of intersection accidents for the SCATS controlled (Troy) and non-SCATS controlled (Farmington Hills) intersections, when comparing the 'before" and "after" periods.

Different accident characteristics were also studied, such as time of day and weather conditions. Comparisons were made for all intersections and for two subsets of the intersections. The first subset was composed of the five intersections that exhibited the largest increase in accident frequency after SCATS was installed, and the second subset consisted of the five intersections that exhibited the greatest decrease in accident frequency following the installation of SCATS.

SCATS did not have a significant impact on the time of day or weather condition under which the accidents occurred for any of the groups.

An analysis was performed to determine the change in total accidents at selected intersection groups. The test was performed for all intersections where there was no change in control or geometry, and for intersections with similar control changes. There were no significant change in the total accident frequency at any of these intersection groups.